Provenance and Geochronology of Lomonosov Ridge: A Contribution to the Geology and Tectonic History of the Arctic Ocean from Dredged Rock Samples

By

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Abstract

This thesis analyzes the OD2016-D2 dredge rock samples collected from a flank of Lomonosov Ridge, a major topographic feature in the Arctic Ocean. U-Pb- and Hf-isotopes were analyzed for 719 detrital zircon grains from ten sandstone samples using the Sensitive High-Resolution Ion Microprobe. The dredge rocks have similar detrital zircon U-Pb age distributions, a Neoproterozoic maximum depositional age, and Scandinavian provenance. Ten lithologies were defined from 176 samples and ten lithofacies from a selection of 96 samples to categorize the rocks and use as a basis for comparison. Two lithofacies associations are present: one indicates a tidal-influenced delta setting with fluvial input and the other indicates a tidal flat setting. The lithologies have similar heavy mineral assemblages, whole-rock geochemistry, and have a largely granitic component to their provenance. Overall, the results suggest that there are two Neoproterozoic units unconformably overlain by a possible Lower Paleozoic unit.

April 26, 2022

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Abbreviations and acronyms

AACM: Alaska–Chukotka microplate

ACEX: Arctic Coring Expedition

Amp: amphibole

BD: below detection limit

bHf: Hf mass fractionation value

BSE: Back-scattered electron

Bt: biotite

bYb: Mass fractionation values for Yb

CCGS LSSL: Canadian Coast Guard Ship Louis S. St-Laurent

CHUR: Chondritic uniform reservoir

CL: cathodoluminescence

EDS: Energy Dispersive Spectroscopy

GSC: Geological Survey of Canada

IB Oden: Swedish Icebreaker Oden (IB Oden)

IB: Ice breaker

ICPMS: ICP mass spectrometer

IRD: Ice–rafted detritus

MDA: maximum depositional age

MDS: multidimensional scaling

Ms: Muscovite

MSWD: mean squared weighted deviation

OD2016: Canada's 2016 Arctic Expedition on the Icebreaker Oden

OD2016-D2: Dredge site 2 (station number 0004). Samples from OD2016-D2 are abbreviated to a three-digit sample number (e.g. OD2016-D2-011 will be 011).

Opx: orthopyroxene

Qz: Quartz

Rt: Rutile

SEM: Scanning Electron Microscope

SHRIMP: sensitive high-resolution ion microprobe

TIB: Trans-Scandinavian Igneous Belt

TOC: total organic carbon

UNCLOS: United Nations Convention on the Law of the Sea

XRD: X-ray diffraction

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Chapter 1 Introduction

1.1 Background

Lomonosov Ridge is an 1800-km long ridge of continental crust extending across the Arctic Ocean that rises 3 km above the surrounding ocean floor (Fig. 1.1). The ridge separated from the northern margin of the Barents-Kara Shelf in the Cenozoic by seafloor spreading along Gakkel Ridge (Grantz et al. 2001). Currently, its basement rocks are primarily known from two dredged localities (Knudsen et al. 2017), as well as samples from a younger succession collected during the Arctic Coring Expedition (ACEX; Moran et al. 2006). This thesis investigates and interprets a new suite of dredged rocks collected from Lomonosov Ridge that provide additional baseline information regarding the geological evolution of the Arctic Ocean. The geological history of this region is poorly understood due to its remoteness and the logistical challenges with navigating sea ice and retrieving subsea samples. New interest in the Arctic has been driven by the United Nations Convention on the Law of the Sea (UNCLOS), in which countries may submit claims to sovereignty over the continental shelf that lies beyond 200 nautical miles based on bathymetric and geologic data (United Nations 1982). Improved understanding of Arctic geology is necessary for bordering countries to support their claims (Government of Canada 2019). These new dredge samples from Lomonosov Ridge provide the opportunity to contribute new age and provenance information to the Arctic research community, and to build on the framework understanding of the origin of Lomonosov Ridge basement rocks.

In 2016, Canada conducted a multidisciplinary scientific expedition across the Arctic Ocean in collaboration with Sweden using Canadian Coast Guard Ship *Louis S. St-Laurent* (CCGS LSSL) and the Swedish Icebreaker *Oden (IB Oden)* (Gårdfeldt and Lindgren 2017). The primary objective of the expedition was acquisition of geophysical and geological data to support

Canada's definition of an extended continental shelf as outlined by UNCLOS Article-76 protocol (UN General Assembly 1982). As part of this objective, seafloor dredge samples were collected to understand bedrock. Dredge Site 2 (OD2016-D2, Fig. 1.1, 89.271° N, 65.613° W) collected from the Amundsen Basin side of Lomonosov Ridge by *IB Oden* contained >650 kg of material (Gårdfeldt and Lindgren 2017). The majority of the collected rocks were primarily sedimentary and metasedimentary, characterized by angular surfaces, and are interpreted to have been collected from bedrock.

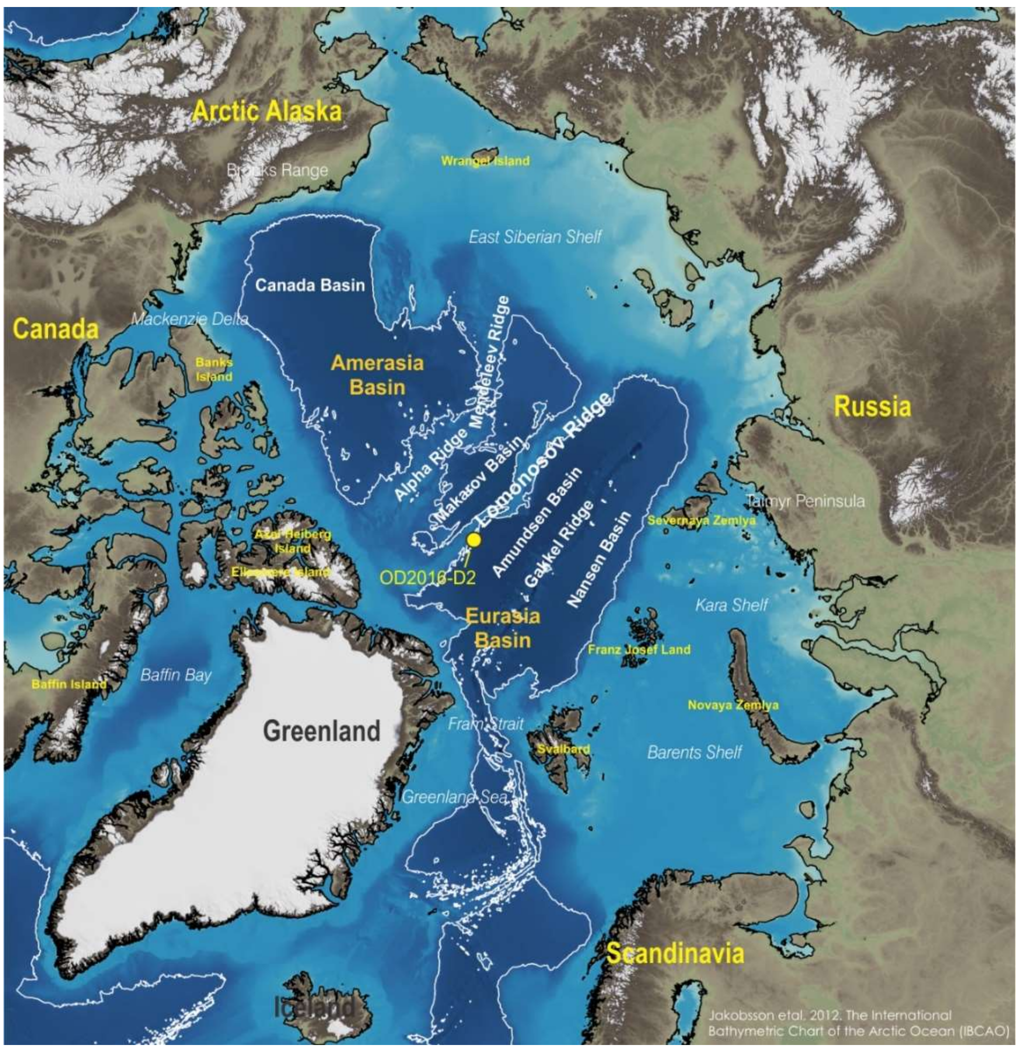


Figure 1.1 Bathymetric map of the Arctic Ocean showing locations referred to in this thesis. Modified from the International Bathymetric Chart of the Arctic Ocean (Jakobsson et al. 2012).

Lomonosov Ridge dredge site is at OD2016-D2 (Gårdfeldt and Lindgren 2017). The white bathymetric contours are at 2500 m water depth.

1.2 Purpose and Objectives of the Study

This thesis investigates the petrology, sedimentology, geochronology, and geochemistry of dredge rock samples collected from Lomonosov Ridge. Due to the nature of dredge rock collection, we cannot definitively determine any stratigraphic relationships between samples, the distribution of rocks collected from along the dredge profile, or how far laterally from the ship track that the dredge rocks were actually collected. The aim of this study is to provide first-order information on these rocks and attempt to determine their provenance and geological history, contributing to the knowledge of Arctic geological terranes and providing constraints for the tectonic evolution of the Arctic Ocean.

The main objectives of this study are to: 1) define lithologies to categorize and compare the OD2016-D2 dredge rocks; 2) define lithofacies for interpreting the sedimentary environments in which the rocks were deposited; 3) determine maximum depositional age of the OD2016-D2 dredge rocks using zircon U-Pb geochronology and Hf-isotopes and see how they compare with rocks of similar age from other Arctic geological terranes including: Svalbard, Franz Josef Land, Barents Shelf, north and eastern Greenland, north Scandinavia, and parts of Laurentia; 4) use petrography and scanning electron microscopy (SEM) analyses to assess the nature and degree of diagenesis and metamorphism; 5) Use electron microprobe (EMP) and whole rock geochemical analyses (WRA) for geochemical fingerprinting to find potential source rock-types, these data and the zircon geochronology will aid in subsequent paleoreconstructions.

1.3 Thesis Organization

The scientific findings of this thesis are presented and discussed in chapters 4 and 5. Each of these two chapters is an individual manuscript that is intended to be submitted externally to scientific journals; accordingly, there is some repetition of text and figures between theses chapters. References related to all chapters are listed at the end of this thesis.

Chapter 4 investigates detrital zircon grains from the OD2016-D2 dredge site. The goal of this chapter is to determine the maximum depositional age of the rocks and compare the detrital zircon ages from Lomonosov Ridge with those reported in the literature from Arctic terranes of early Paleozoic to Neoproterozoic age to determine potential zircon sources or analogous terranes. These include sedimentary and metasedimentary rocks from Svalbard, Franz Josef Land, Barents Shelf, north and eastern Greenland, north Scandinavia, and parts of Laurentia, such as the Pearya terrane.

Chapter 5 aims to understand the sedimentary depositional environment, potential source rocks, diagenetic history, and metamorphism of the OD2016-D2 rocks. To achieve these goals, rocks were categorized and analyzed through various methods listed in section 1.2 of this chapter. From the interpreted lithologies and lithofacies, three potential stratigraphic units were interpreted. Finally, Chapter 6 aims to summarize and synthesize the important discussion points from Chapters 4 and 5.

Chapter 2 Regional Geology

2.1 Lomonosov Ridge

Lomonosov Ridge (Fig. 1.1) is a 50–70 km wide geological feature of the Arctic Ocean that extends from Ellesmere Island to the East Siberian Shelf and rises 3 km above adjacent abyssal plains, dividing the Arctic Ocean into the Eurasia and Amerasia basins. On the Eurasia Basin side, Lomonosov Ridge is bounded by the Amundsen Basin, which separates it from the Gakkel Spreading Ridge. Within the Amerasia Basin, Lomonosov Ridge is bounded by the Makarov Basin which separates it from another bathymetric high named the Alpha-Mendeleev Ridge.

The Lomonosov Ridge is interpreted to be a sliver of continental crust that rifted from the Barents–Kara Shelf during the formation of the Eurasia Basin (Fig. 1.1) (Grantz et al. 2001, Brozena et al. 2003). The Eurasia Basin is situated on oceanic crust formed by Cenozoic oceanic seafloor spreading along the Gakkel Ridge, which is a northward extension of the Mid-Atlantic Ridge (Brozena et al. 2003). Estimates for timing of the initiation of seafloor spreading along the Gakkel Ridge are based on the recognition of seafloor spreading magnetic anomaly chron C25n (~58 Ma) (Brozena et al. 2003, Glebovsky et al. 2006). However, more recently, Funck et al. (2022) proposed that seafloor spreading initiated at chron C24n (54.0–52.6 Ma; Brozena et al. 2003) based on their crustal-scale velocity model from seismic refraction data.

2.2 Seismic Structure of Lomonosov Ridge

The geological structure of Lomonosov Ridge is known primarily from geophysical data, and seismic reflection analyses of the ridge have helped to reveal its continental nature. In the early 1990s, the German *R/V Polarstern* collected a seismic reflection line over Lomonosov Ridge which revealed a sedimentary succession, that was divided into three distinct units based on the internal geometry of the reflections and refraction velocity data (Jokat et al. 1992; 1995). The upper layer (~500 m) consists of nearly flat-lying strata, with velocities of less than 2.2 km/s interpreted to be Cenozoic strata deposited after Lomonosov Ridge subsided below sea level. This layer rests on a prominent unconformity, and below this unconformity are well-bedded strata tilted in several fault blocks, with seismic velocities ranging from 4.0 to 4.6 km/s (Jokat et al. 1992; 1995). These were interpreted as Mesozoic strata affected by extensional block-faulting that were then uplifted and eroded, possibly prior to the onset of seafloor spreading that led to the creation of the Eurasian Basin (Jokat et al. 1992; 1995, Grantz et al. 2001). The lowermost unit has no internal reflections, with seismic velocities ranging from 4.7 to 5.2 km/s (Jokat et al. 1995). The refraction data were unable to constrain the total thickness of this unit, but these rocks were interpreted to be metamorphosed sedimentary rocks or upper continental crust, possibly Proterozoic in age (Jokat et al. 1992; 1995).

Wide-angle seismic refraction profiles over Lomonosov Ridge conducted by the Geological Survey of Canada further provided constraints on the thickness of the different crustal layers and demonstrated a continental affinity for the ridge. The 1976 "LOREX" refraction experiment results (Mair and Forsyth 1982; Forsyth and Mair 1984) showed a ~5 km thick upper-crustal layer with a velocity of 4.7 km/s, equivalent with the Jokat et al. (1995) basal unit, and suggested that a significant component of Lomonosov Ridge consists of metamorphosed sedimentary rocks. Forsyth and Mair (1984) inferred the presence of a 15–20 km thick lower crustal unit with a velocity of 6.6 km/s. Such velocities are typical of crystalline lower continental crust rather than oceanic crust (e.g. Funck et al. 2004).

The 2006 "LORITA" refraction experiment (Jackson et al. 2010) was able to resolve details of the uppermost sedimentary succession. The results showed that there is a significant sedimentary basin (maximum thickness ~12 km) overlying thick, higher velocity crust. The upper two sedimentary layers (velocities of 2.1–2.2 km/s and 3.1–3.2 km/s) are interpreted to be Neogene to Holocene. These strata lie above an unconformity that separates them from the lower sedimentary unit (velocities of 4.3–5.2 km/s), a surface which is likely equivalent to the base-Eocene unconformity observed by Jokat et al. (1995). The thickness of the lower-crustal layer (velocities of 6.2–6.9 km/s) is highly variable (<10 km to ~20 km), but appears to be equivalent to the lower crustal layer defined by the LOREX experiment (Mair and Forsyth 1982) and consistent with Lomonosov Ridge being a continental fragment.

The 2004 Integrated Ocean Drilling Program Arctic Coring Expedition (ACEX) drill core (Moran et al. 2006; Fig. 1.1) recovered a continuous Cenozoic sedimentary record extending back to the Upper Paleocene that unconformably overlies poorly sampled Upper Cretaceous sandstones and mudstones. These sandstones and mudstones were interpreted to have been deposited in a shallow marine setting (Moran et al. 2006). In addition, the age of sedimentary rocks lying below the unconformity are older than the onset of seafloor spreading along Gakkel Ridge, which is interpreted to have resulted in separation of Lomonosov Ridge from the Barents Shelf.

Danish expeditions attempted to sample rocks from Lomonosov Ridge during the LOMROG-II (Marcussen 2011) and the LOMROG-III (Marcussen 2012) expeditions. The LOMROG-III expedition managed to collect rock sample during two dredges along the Eurasia Basin flank of Lomonosov Ridge. A total of 300 kg of metasedimentary and sedimentary rock samples were recovered. These angular rocks were interpreted as in-situ bedrock and included low-grade, metasedimentary, interlaminated, fine-grained arkosic sandstone and silty mudstone, and unmetamorphosed sandstones and siltstones. U-Pb detrital zircon age dates from grains derived from the metasedimentary rocks show dominantly Paleoproterozoic–Mesoproterozoic ages, a minor Archean population, a peak age at 1.6 Ga and no zircon ages of less than 1 Ga (Knudsen et al. 2017). The sedimentary rocks are considered to have been stratigraphically separated from the metasedimentary rocks by an unconformity as they contain detrital zircons with $^{236}U/^{208}Pb$ ages as young as ~500 Ma (Knudsen et al. 2017).

In summary, limited geological and geophysical data provide some information on the nature of bedrock comprising Lomonosov Ridge, a continental fragment that separated from the Barents Shelf due to seafloor spreading along the Gakkel Ridge at chron C24n (54.0–52.6 Ma; Brozena et al. 2003). The bedrock includes Proterozoic basement sampled during the LOMROG-III expedition (Marcussen 2012) that is subsequently overlain by Mesozoic strata, which is further unconformably overlain by Cenozoic sediments (Jokat et al. 1992; 1995). Despite this generalized understanding, there are still many unknowns regarding the formation of the bedrock of Lomonsov Ridge.

Chapter 3 Methods

3.1 Dredge Operations

In 2016, the Geological Survey of Canada conducted the multidisciplinary Oden Arctic Ocean 2016 expedition across the Arctic Ocean to acquire new data to support Canada's claim for an extended continental shelf under the United Nations Convention on the Law of the Sea (UNCLOS) Program using the *CCGS Louis S. St. Laurent* and the *Oden*. The Swedish Icebreaker *Oden* (IB *Oden*) was used for icebreaking support, multibeam data collection, sub-bottom profiling, seismic reflection acquisition, dredging and coring (Gårdfeldt and Lindgren 2017). A full description of the dredging operations can be found in Gårdfeldt and Lindgren (2017).

Potential dredge site targets were planned prior to the expedition based on available bathymetry data (Gårdfeldt and Lindgren 2017). The Amundsen Basin side of Lomonosov Ridge was targeted for dredging, as it was expected to have less sediment cover than the Alpha Ridge side (Fig. 3.1). Multibeam bathymetry mapping was conducted at each site to identify a high gradient (>25°) slope facing towards the ice floe drift direction. In total, five sites were chosen for surveying and dredging operations; however, collection of samples at two sites was aborted during cruise operations due to unfavourable ice conditions.

The choice to study dredge rocks was necessitated by the challenges associated with data collection in the Arctic Ocean. Sea ice makes sample collection difficult as it must be broken by icebreakers, and ice floes must be maneuvered around. Moving ice means that the ship cannot stay in place for extended periods of time, thus making it difficult to collect drill cores. Conversely, dredge rock samples pose a fundamental challenge in their interpretation. When sampling rocks from outcrop or drill core, the stratigraphic relationships are generally evident. However, dredge samples reflect rock material collected along distances of up to several kilometres and from water depth variations of hundreds of metres to over a kilometre. Additionally, ocean currents can cause the cable holding the dredge basket to be angled by several degrees, resulting in the actual dredge site possibly varying by up to hundreds of metres from the target. This means that the path of the dredge is known, but the precise location of the samples is not.

Dredge site 2, taken from a block on the edge of Lomonosov Ridge called Morozov Ridge, (Fig. 3.1) started on bottom at Latitude: 89.271 and Longitude: -65.613 at 3504 m water depth and ended at Latitude: 89.291 and Longitude: -63.237 at 2158 m water depth (Gårdfeldt and Lindgren 2017). . Due to IB *Oden* turning broadside in the wind, dredges could not be completed in open water. This necessitated docking IB *Oden* into the ice which was drifting towards the targeted slope prior to dredge deployment. The dredge was lowered to intercept the slope a few hundred metres above the base and to avoid sampling the talus scree, a feature which are commonly contaminated by ice rafted debris (IRD). A 700 kg depressor weight was attached to the line above the dredge bucket to help the bucket drag against the seafloor. The main dredge cable was neutrally buoyant in seawater so that tension could be monitored to determine where it was catching on the seafloor and potentially recovering rock. The dredge was pulled off the seafloor a few hundred metres before the top of the slope to avoid ice–rafted detritus (IRD). A full description of dredging methods can be found in Gårdfeldt and Lindgren (2017).

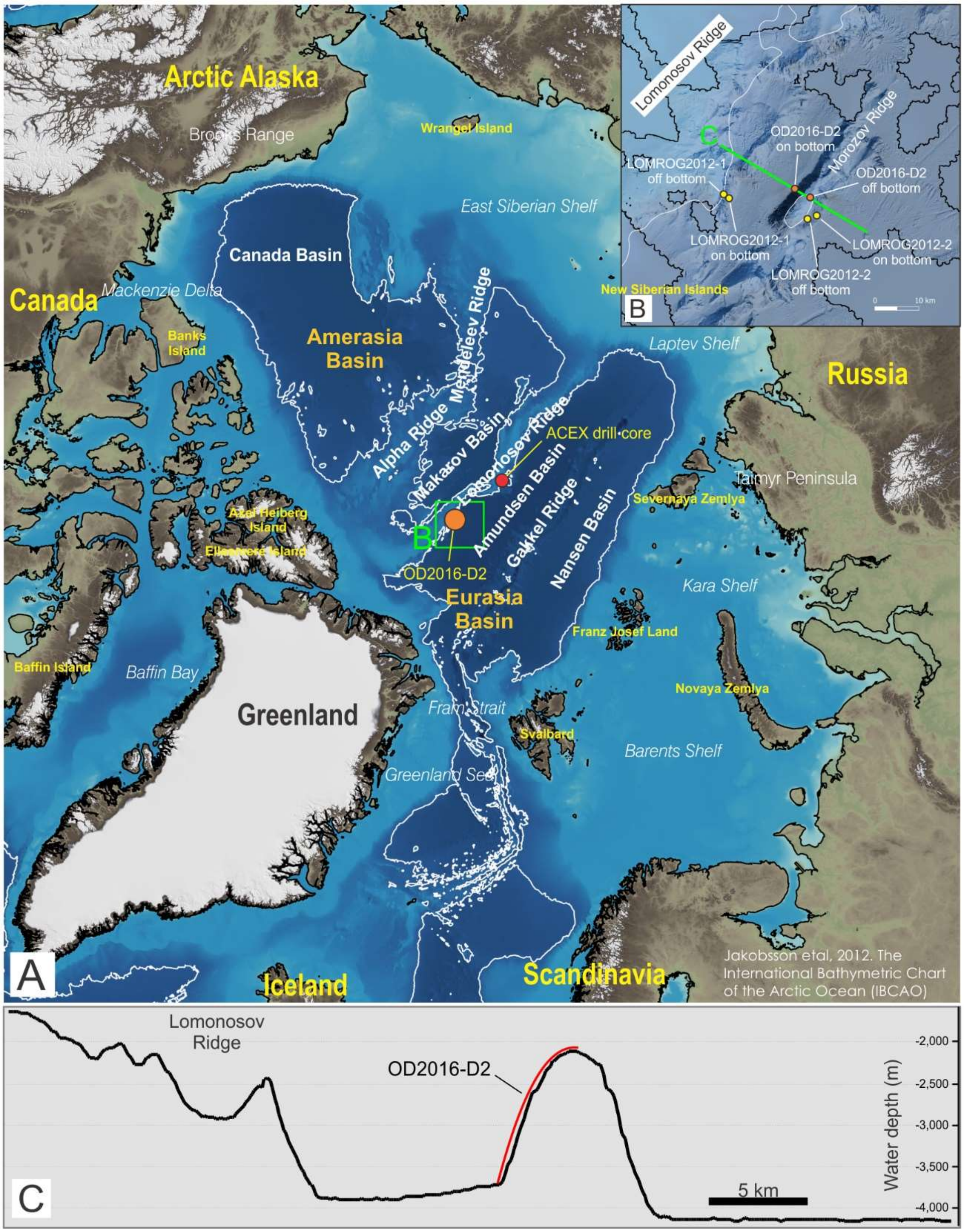


Figure 3.1 Location of Lomonosov Ridge dredge samples. A) Map of the Arctic Ocean showing the general location of the dredge site. The ACEX drill core location is taken from Moran et al. (2006). B) Multibeam bathymetry of the dredge site showing start and end points of the OD2016-

D2 and LOMROG-III dredge sites (Knudsen et al. 2017). C) Bathymetric cross section of the OD2016-D2 dredge site showing the large range in water depth covered (in red). The base map is from Jakobsson et al. (2012).

3.2 Sample preparation

Over 650 kg of material was recovered from the OD2016-D2 site. Rock samples were washed to remove any mud from their surfaces and then were sieved at -4 phi (1.6 cm) to segregate out small pebbles, which were not assessed. The dredge material included, by weight, ~20.9% material finer than 1.6 cm, ~0.3% ice-rafted detritus, ~1.6% manganese crusts, and ~77.2% (>550 kg) various angular fragments of sedimentary and metasedimentary rocks. The large quantity of angular and irregular rock fragments of similar lithology suggests that they are not IRD, but were derived from bedrock exposed along the dredge site (Fig. 3.1C).

Manganese crusts and IRD were identified for archival purposes and are not discussed at depth in this thesis. Manganese crusts coat most samples, up to 8 cm in thickness, suggesting these samples have been exposed at the seafloor for a considerable length of time. Some analyses were run prior to the assignment of lithologies and lithofacies, meaning that some analyses were not completed in a logical order (e.g. U-Pb detrital zircon ages were collected before the rocks were assigned lithologies). The samples were weighed and then photographed using a mounted camera with a Munsell colour scale.

3.2.1 Lithologies & Lithofacies

The recovered material was sorted by hand into ten main lithologies (1–10) based on grain size, colour, hardness, sedimentary structures, and crenulation cleavage. A total of 176 rock fragments were selected from nine of the ten lithologies and assigned sample numbers (lithology

7 is excluded; Appendix 1) to be used for further analysis. The full sample numbers from the OD2016 research expedition are represented by the full cruise name followed by the station number. In the case of dredge site 2 this is 2016ODEN-0004 and is represented in the text as OD2016-D2. For the purposes of this text, sample numbers are abbreviated in this study to the three-digit sample number (e.g. OD2016-D2-011 will be 011). From these samples, 96 were cut into slabs for viewing internal sedimentary structures so they could be classified into lithofacies based on interpretation of sedimentary structures and scanned for digital documentation. Photographs of the cut rock slabs can be found in Appendix 2.

3.3 Petrography

A total of 70 polished thin sections were made from 58 samples representing nine of the ten lithologies. These were used to determine mineralogy and for viewing sedimentary structures, variation in grain size, and other features of interest. The thin sections were photographed using a Zeiss microscope with a mounted camera at the Geological Survey of Canada - Atlantic Division (GSC-A). Photographs of the thin sections can be found in Appendix 3 and petrographic descriptions in Appendix 4.

3.4 Heavy mineral separation

Based on the presence of heavy minerals observed in thin section, four rock samples were selected for detrital heavy mineral separation from different lithologies (1, 2, 4, 5). Heavy minerals in sedimentary and metasedimentary rocks are typically of low abundance and using heavy mineral analysis can help constrain potential sediment sources (e.g. Tsikouras et al. 2011). The abundance of heavy minerals in the samples was relatively minor, except for zircon (Chapter 4).

The samples were processed at the GSC-A. First, they were crushed using a disc grinder to obtain sand-sized particles, which were then sieved to obtain the 63–177-micron fraction. This fraction provides a high concentration of heavy minerals, as heavy minerals, in general, are typically concentrated in the fine-grained sand and coarse silt fractions (Piper 1974). The light and heavy minerals were then separated using a sodium polytungstate aqueous solution at a specific gravity of 2.9. The resulting heavy mineral separates were used to create four polished thin sections for petrography and non-destructive mineral chemical analyses.

3.6 Zircon geochronology

3.6.1 Crushing and Mineral Separation

This study determined 718 detrital zircon grain U-Pb ages from ten OD2016-D2 dredge rock samples. Zircons were separated from 1–2 kg of pulverised rock by conventional crushing and grinding. Around 100–150 zircon grains from each of the ten samples were selected from the non-magnetic fraction. Extracted zircons were first imaged with SEM and cathodoluminescence (CL) imagery to obtain details regarding their grain size and shape (e.g. euhedral or rounded) and to identify any internal mineral growth zonation. U-Pb isotopic measurements were conducted using SHRIMP.

3.6.2 SHRIMP U-Pb analyses

SHRIMP analytical procedures followed those described by Stern (1997). A minimum of 55 to 84 detrital zircon grains of the 100–150 prepared were analysed from each sample for a total of 718 analyses. Zircons were cast in 2.5 cm diameter epoxy mounts along with fragments of the GSC laboratory standard zircon (z6266, with $^{206}Pb/^{238}U$ age = 559 Ma, Stern and Amelin 2003). Two zircon mounts were prepared and labelled IP875 and IP882. The mid-sections of the zircons were exposed by polishing using 9, 6, and 1 μm diamond compound, and the internal features of the zircons (such as zoning, structures, alteration, etc.) were characterized in back-scattered electron mode (BSE) utilizing a Zeiss Evo 50 scanning electron microscope. Mount surfaces were evaporatively coated with 10 nm of high purity Au. Analyses were conducted during two analytical sessions (875 and 882) using an ^{16}O- primary beam, projected onto the zircons at 10 kV. The count rates at eleven isotope masses including background were sequentially measured over 5 scans with a single electron multiplier and a pulse counting system with deadtime of 21 ns. Off-line data processing was accomplished using the Squid version 2.5 Excel plug-in for reduction and processing of machine data obtained from the SHRIMP. The 1σ external errors of $^{206}Pb/^{238}U$ ratios reported in a supplementary data table (Appendix 5) incorporate a minimum ±1.0 % error in calibrating the standard zircon (Stern and Amelin 2003). Pb isotopic values were monitored by analyses of an in-house standard with a $^{207}Pb/^{206}Pb$ age of 2679.6 ± 0.3 Ma; analytical sessions 875 and 882 yielded values of 2681 ± 4 and 2675 ± 3 Ma. No mass fractionation correction was applied to the data. The long-term value determined is 2677.5 ± 0.4 Ma (n = 288/305; standard error of measurement 95% confidence). External reproducibility is estimated at ±0.2%. The U-Pb ages of the detrital zircon grains can be found in Appendix 5, and photos of the zircon grain morphologies can be found in Appendix 6 (numbers refer to spot numbers in Appendix 5, circles represent analysis spots and circle colour of red and blue corresponds to different SHRIMP sessions).

3.6.3 Hafnium isotopes

In-situ Lu-Hf isotope analyses were conducted using a Photon excimer laser (193 nm) and a Neptune multi-collector ICP mass spectrometer (Thermo Scientific) at the Geological Survey of Canada. The Photon ablation cell was utilized within a He atmosphere and ablation products were carried in a He stream and mixed with Ar from an Aridus desolvater prior to introduction to the plasma. Data were dominantly acquired using a 34 μm beam diameter, with a small number of analyses at 26 μm based on the grain size of the target. The laser was operated at 7 to 8 Hz pulse repetition rate with a fluence of ~7.14 x 10^6 J/cm^2. These conditions resulted in a median total Hf beam of 12.5 V with a range from ~5–29 V. Analyses involved a pre-ablation on mass background measurement of 30–60 seconds followed by a 60–90 second acquisition interval. The ^{180}Hf intensity was monitored between analyses to return to background values prior to starting new analyses. The acquisition interval for data calculation was selected based on signal stability and was screened for possible intersection of inclusions and domains with different Hf isotopic compositions. The Hf-isotope data can be found in Appendix 7.

Seven masses were simultaneously collected in Faraday cups with 1011 Ω resistors, including ^{180}Hf, ^{179}Hf, ^{177}Hf, ^{176}Hf (^{176}Lu, ^{176}Yb), ^{175}Lu, ^{173}Yb, and ^{171}Yb. Data were evaluated in time-resolved mode to exclude intervals that intersected inclusions (very rarely observed). Interference of the ^{176}Lu and ^{176}Yb isotopes on ^{176}Hf was corrected based on the measured ^{175}Lu and ^{173}Yb values and accepted values of ^{173}Yb/^{171}Yb (1.132685) and ^{176}Yb/^{173}Yb (0.796218) and ^{176}Lu/^{175}Lu (0.02655) (Chu et al. 2002).

The Hf mass fractionation value (βHf) was calculated based on the exponential law (Russell et al. 1978) assuming a ^{179}Hf/^{177}Hf value of 0.7325. Mass fractionation values for Yb (βYb) were calculated from the measured ^{173}Yb/^{171}Yb ratio and applied as follows. The mean βYb value was calculated for the selected analytical interval and compared to the mean βHf value for the same interval. Using this ratio, a βYb value was calculated for each integration from the more precisely measured βHf value and applied to each integration. This approach assumes that changes in βYb and βHf fractionation during a single run are highly correlated, which can be demonstrated within the measurement errors. Lu isotopes were corrected assuming the mass fractionation values calculated for Yb. The $^{176}Yb/^{173}Yb$ and $^{176}Lu/^{175}Lu$ corrections were determined using synthetic Lu, Yb and Hf doped zircon standards MUN1 and MUN4 (Fisher et al. 2011). Analyses of the MUN4 standard zircon with elevated Yb/Hf yielded a value of 0.282107± 0.000013 (Appendix 8). Data were processed using Iolite™ data processing software (Woodhead et al. 2004; Hellstrom et al. 2008).

Accuracy and reproducibility were monitored by repeating analyses of four zircon standards (91500, Temora 2, 6266 and Mud Tank), each of which show good agreement with published data (Appendix 8; Woodhead and Hergt 2005; Wu et al. 2006; Blichert-Toft 2008). Elemental fractionation of Lu and Hf was monitored and corrected based on the sessional mean determined for the 6266 standard. Measured values during each analytical session were approximately 1% to 8% lower than accepted values with a reproducibility of approximately 3–5% at 95% confidence. A $^{176}Lu/^{177}Hf$ value of 0.00031 is determined for zircon 91500 relative to 6266, within uncertainty of the accepted value of 0.000309 (Blichert-Toft 2008).

Results from the four reference zircons, as well as the synthetic MUN zircon, indicate a small systematic bias in the $^{176}Hf/^{177}Hf$ ratio of ~ 0.000032 relative to recommended values (Appendix 8). The bias does not correlate with Yb/Hf or Lu/Hf ratios indicating that it is not a function of the interference correction method. Analyses of the $^{176}Hf/^{177}Hf$ JMC475 standard solution is also measured low with a value of 0.282147 ± 0.000003 (2σ). The $^{176}Hf/^{177}Hf$ data for unknowns is corrected to account for this small bias. The calculated internal measurement uncertainty accounts for the data distribution, low mean squared weighted deviation (MSWD) meaning a high probability of fit, and no additional external uncertainty was required.

Chondritic uniform reservoir (CHUR) values of $^{176}Lu/^{177}Hf = 0.0336$ and $^{176}Hf/^{177}Hf = 0.282785$ are from Bouvier et al. (2008). Depleted mantle model based on $^{176}Lu/^{177}Hf = 0.03902$ and $^{176}Hf/^{177}Hf = 0.28327$ and new crust model age calculations utilized values of Dhuime et al. (2011) ($^{176}Lu/^{177}Hf = 0.03781$ and $^{176}Hf/^{177}Hf = 0.28316$). ^{176}Lu decay constant of 1.867 x 10-11yr^{-1} was used (Söderlund et al. 2004).

3.6.4 Isoplot™

Concordia age was calculated using the Isoplot™ 4.15 Excel macro (Ludwig 2011). Concordia ages were used as they consider both the $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ uncertainties. The Concordia age gives a probability of the age being concordant instead of using an arbitrary discordance cut-off. This allows for grains with low U content and high uncertainty to be compared as they may have a large correlated error and still a >1% probability of being concordant. The Concordia age probability cut-off was at >1% probability of being concordant. AgeDisplay was used to make probability density distribution plots (Nemchin and Cawood 2005). A probability density distribution plot was used rather than a Kernel Density Estimate to prevent over-smoothing of the data. IsoplotR (Vermeesch, 2018) was used to create cumulative probability plots, as well as multidimensional scaling (MDS) plots using $^{206}Pb/^{238}U$ ages.

3.5 Analytical methods

3.5.1 Scanning Electron Microscope (SEM)

Scanning Electron Microscopy was completed on 14 samples representing lithologies 1 through 10, with the exception of lithology 7, using the MIRA3 TESCAN SEM at Saint Mary's University. A cobalt standard was used for calibration. The beam was focused at a distance of 17 mm above the sample stage, the voltage used was 20 kV, and the size of the analyzed spot was ~10 µm. Minerals in the samples were chemically analyzed by energy dispersive spectroscopy

(EDS) and high-resolution backscattered electron (BSE) images were acquired. A paragenetic sequence was established using the textural mineral relationships in the BSE images. SEM analyses can be found in Appendix 9 and analysis site photos can be found in Appendix 10.

3.5.2 Electron Microprobe (EMP)

Minerals chemistry was analyzed using polished thin sections of heavy mineral grains for three samples that were selected based on petrography, and was conducted at the Robert M. MacKay Electron Microprobe Laboratory at Dalhousie University using the JEOL JXA-8200 Electron Probe Micro-Analyzer equipped with five wavelength dispersive spectrometers (https://www.dal.ca/sites/electron-microprobe-lab.html). The beam current used was 20 nanoamperes, voltage of 15 kV, and beam size of 1 μm. Major elements analyzed for silicate minerals included: K, Ca, Ti, Cr, Na, Mg, Al, Fe, Mn, Si, P, Cl, F, Ba, and Sr. Tungsten was analyzed in the FeO-hydroxide minerals based on its presence in the SEM chemical analyses. A kaersutite standard was used for silicate minerals. Electron Microprobe analyses can be found in Appendix 11.

3.5.3 X-Ray Diffraction

The mineralogy of 51 OD2016-D2 samples, representing lithologies 1 through 10, with the exception of lithology 7, was determined by X-ray powder diffraction analysis (XRD) on bulk materials and clay-sized separates. The bulk samples were micronized using a McCrone mill with agate grinder in isopropyl alcohol or distilled water to obtain a 5–10 μm (silt) grain size. Bulk samples were then back pressed into an aluminum holder to produce randomly oriented samples. Clay-size separates were measured to 40 mg and used to make oriented mounts. X-ray patterns of the bulk oriented samples and clay-sized separates were recorded on a

Bruker D8 Advance Powder Diffractometer equipped with a Lynx-Eye Detector, Co Kα radiation set at 35 kV and 35 mA. The samples were re-analysed following saturation with ethylene glycol and a heat treatment (550 °C). Further details on methods, software used, and reference mineral pattern used to compare the OD2016-D2 samples can be found in Appendix 12 and XRD analyses can be found in Appendix 13.

3.5.4 Whole Rock Geochemistry (WRA)

Whole rock geochemical analysis was completed on 30 samples representing lithologies 1 through 10, with the exception of lithology 7, from the OD2016-D2 rocks. Samples selected were remnant powders leftover from processing the rocks for XRD. The powders were analysed using the WRA 4B2 major and trace element analysis by inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) by Activation Laboratory (ALS Global 2020). In this analytical method, the samples underwent lithium metaborate/tetraborate fusion and were then digested in a nitric acid solution before completion of ICP-OES and ICP-MS analyses. These analyses allow for geochemical classification of different source rock lithologies and interpretation of potential source rocks. Whole rock geochemical analyses can be found in Appendix 14.

Chapter 4 Proterozoic provenance of dredged bedrock from the Lomonosov Ridge, Arctic Ocean: new zircon U-Pb ages

4.1 Abstract

The Lomonosov Ridge is understood to be a microcontinental fragment that separated from the Barents Shelf during the early Cenozoic; however, the geological affinity of the Lomonosov Ridge bedrock remains uncertain. Over 650 kg of rock samples were collected from a dredge site on a flank of Lomonosov Ridge at water depths ranging from 2.2 to 3.5 km. The dredge samples are primarily low greenschist-facies rocks, including metasandstone and metasiltstone. Sensitive High-Resolution Ion Microprobe (SHRIMP) was used for U-Pb isotope analysis of 719 detrital zircon grains from ten dredge rock samples. U-Pb detrital zircon ages show an age range of lower Neoproterozoic to Paleoproterozoic, with peaks at 1.0–1.3 Ga and 1.5–1.65 Ga, and few Archean grains. Detrital zircon U-Pb ages are used to determine an overall maximum depositional age of 973 Ma and are compared with detrital zircon U-Pb ages of other sedimentary and metasedimentary rocks from the Arctic to find potential analogues and sources of provenance. In addition, Hf isotopes of zircon grains from four representative samples are used to constrain and compare geological affinity. Zircon age distributions are similar to some sedimentary and metasedimentary rocks from the Caledonide orogen in Baltica, based on multidimensional scaling analysis. Hf isotopes suggest similarities between Lomonosov Ridge detrital zircons and those of sedimentary and metasedimentary rocks from the Pearya terrane and northeast Baltica. On the basis of these data, the OD2016-D2 rocks are interpreted to have been deposited as sediments shed off of Baltica into a rift basin associated with the break up of Rodinia.

4.2 Introduction

Lomonosov Ridge is a 50–70 km wide morphological feature in the Arctic Ocean which extends from Ellesmere Island to the East Siberian Shelf (Fig. 4.1). It is interpreted to be a sliver of continental crust which rifted from the Barents–Kara Shelf during the formation of the Eurasia Basin (Fig. 4.2) (Grantz et al. 2001, Brozena et al. 2003). Eurasia Basin is situated on oceanic crust formed by Cenozoic oceanic seafloor spreading along the Gakkel Ridge, which is a northward extension of the Mid-Atlantic Ridge (Brozena et al. 2003). Estimates for timing of the initiation of rifting along the Gakkel Ridge are based on the recognition of seafloor spreading magnetic anomaly chron C25n (ca. 58 Ma) (Brozena et al. 2003, Glebovsky et al. 2006). However, more recently, Funck et al. (2022) proposed that seafloor spreading initiated at chron C24 (54.0–52.6 Ma; Brozena et al. 2003) based on their crustal-scale velocity model from seismic refraction data.

The bedrock provenance of Lomonosov Ridge remains unknown due to limited sampling. This study analyses detrital zircon grains from dredged metasedimentary rocks from the edge of Lomonosov Ridge near the North Pole (89.271° N, 65.613° W) (Fig. 4.1) collected during the Oden Arctic Ocean 2016 expedition at dredge site 2 (OD2016-D2) (Gårdfeldt and Lindgren, 2017). The goal of this study is to constrain the provenance of the OD2016-D2 dredge rocks by determining their detrital zircon U-Pb age distributions, maximum depositional age, and Hf isotope characteristics, and to compare them with rocks of similar age from other Arctic geological terranes. These terranes include early Paleozoic to Neoproterozoic sedimentary and metasedimentary rocks from Svalbard, Franz Josef Land, Barents Shelf, north and eastern Greenland, north Scandinavia, and parts of Laurentia such as the Pearya terrane.

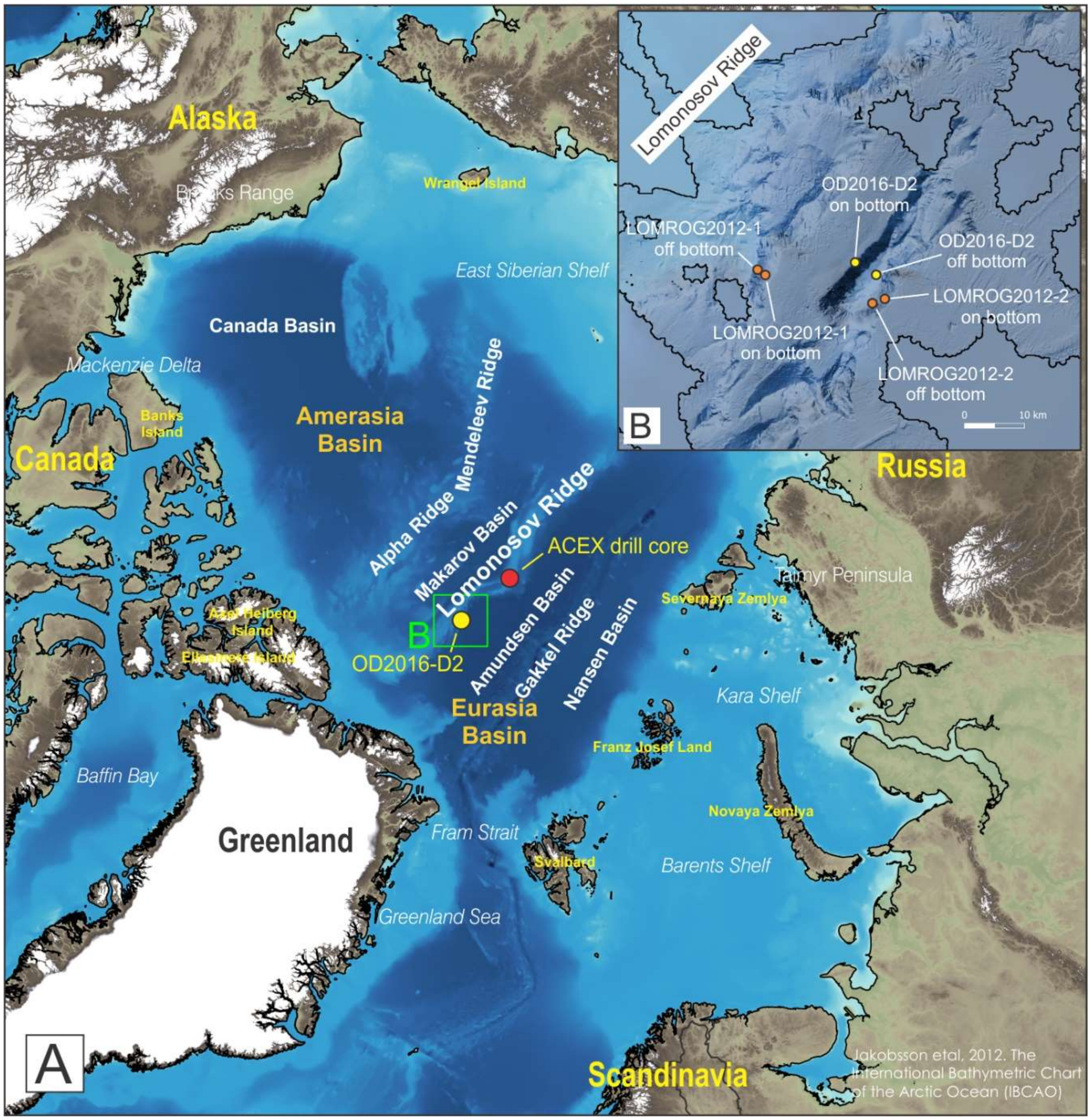


Figure 4.1. A) International Bathymetric Chart of the Arctic Ocean (Jakobsson et al. 2012). Lomonosov Ridge dredge site is at OD2016-D2 (Gårdfeldt and Lindgren 2017). The ACEX drill core location is taken from Moran et al. (2006). B) Bathymetric map at the dredge site showing the on- and off-bottom positions for the OD2016-D2 dredge site as well as the LOMROG2012-1 and -2 dredge sites (Marcussen 2012, Gårdfeldt and Lindgren 2017, Knudsen et al. 2017).

A similar study was completed on rocks from Lomonosov Ridge collected during the LOMROG-III expedition (Fig. 4.1) (Marcussen 2012, Knudsen et al. 2017) at a site located near the OD2016-D2 sample site of the present study. Recovered rock samples from the LOMROG-III expedition were angular and interpreted as in-situ bedrock. Two main rock types were reported: low grade, semi-pelitic metasedimentary rock of interlaminated arkosic sandstone and silty mudstone, and unmetamorphosed sandstone and siltstone with reduced feldspar content relative to their metasedimentary rocks. U-Pb detrital zircon ages from the metasedimentary rocks showed dominantly Paleoproterozoic–Mesoproterozoic ages, with a peak at 1.6 Ga, and a minor Archean population. No zircon ages were younger than 1 Ga. In contrast, U-Pb detrital zircon dates from the sedimentary rocks showed ages ranging from Paleozoic (~500 Ma) to Archean (2.8 Ga) (Knudsen et al. 2017). Knudsen et al. (2017) compared the detrital zircon age peaks from the metasedimentary rocks with other Arctic localities with a similar 1.6 Ga age peak, such as the Proterozoic Kalak Nappe Complex of northern Norway (Kirkland et al. 2007), the Cambrian Lontova Formation of Latvia to Finland (Isozaki et al. 2014), and the Proterozoic Krummedal sequence of East Greenland (Johnston et al. 2010, Knudsen et al. 2017) (Fig. 4.2). In contrast, the detrital zircons from the sedimentary rocks were interpreted to be sourced from the Timanide Orogen with mixed zircon provenance including Greenland, Svalbard, Norway, Novaya Zemlaya, and Siberia.

4.3 Geological Setting

4.3.1 Regional geology

Prior to the opening of the Eurasia Basin, Lomonosov Ridge would have been adjacent to Svalbard and Franz Josef Land (Fig. 4.1) and along strike from Northeast Greenland (Li et al. 2008). The continental cratons of Laurentia and Baltica were assembled during the

Mesoproterozoic as part of the Rodinia Supercontinent, which subsequently broke up in the early Neoproterozoic (Li et al. 2008). Associated sedimentary rocks include Neoproterozoic strata in Fennoscandia of Baltica, Svalbard, and northeast Greenland, which consist largely of platformal deposits that accumulated along cratonic margins and deep-marine sandstone and conglomerate units attributed to rift-related successions from the break-up of Rodinia (Nystuen et al. 2008). During the Early Paleozoic Caledonide orogeny, many of these successions were metamorphosed as a result of collision between Baltica, Svalbard and east-northeast Greenland following the closure of the Iapetus Ocean (McKerrow et al. 2000). These events took place prior to the formation of the Eurasia Basin and have implications for the nature of the bedrock comprising Lomonosov Ridge.

The Proterozoic–Paleozoic geological terranes of Scandinavia and the Baltic Shield contain various zircon-bearing rocks which have U-Pb dates that are relevant to this study (Fig. 4.2). The Archean Baltic Shield contains the oldest relevant terrane, the Svecofennian Orogenic belt (1800–2000 Ma) (Gorbatschev and Bogdanova 1993). This orogenic belt contains igneous intrusions including the Transscandinavian Igneous Belt (TIB, 1650–1850 Ma), the Gothian Igneous complex (1750–1550 Ma), and the Rapakivi granites (1650–1530 Ma) (Gorbatschev and Bogdanova 1993, Åhäll and Gower 1997). The TIB is comprised of several generations of granitoid rocks which were emplaced on the western side of the Svecofennian orogeny (Gorbatschev and Bogdanova 1993). The Gothian Igneous complex is a series of calc-alkaline magmatic units that formed west of the Svecofennian terrane and are related to the Gothian Orogen (Åhäll and Gower 1997). The later stages of the Gothian Orogeny coincided with the emplacement of the Rapakivi granites farther east in the Baltic Shield (Åhäll and Gower 1997). The Sveconorwegian Orogeny occurred between Baltica, Amazonia and Laurentia, from 1150–

900 Ma and various granitoid magmatic events occurred and are related to igneous units located in southern Scandinavia (Bingen et al. 2021). Finally, Paleozoic metasedimentary rocks in the Scandinavian Caledonides (Fig. 4.2) were metamorphosed during the Caledonian orogeny (Kirkland et al. 2007). In relation to these events, previous studies have analyzed detrital zircons in metasedimentary and metamorphic rocks from the central Scandinavian Caledonides that are interpreted to have been derived from the TIB and Sveconorwegian Orogeny (Gee et al. 2014). The northern Caledonides include the Kalak Nappe Complex (Fig. 4.2), which was originally deposited as sediments between 910 and 840 Ma (Kirkland et al. 2007, Zhang et al. 2016) and contains detrital zircons that are interpreted to have been derived from the Gothian Igneous Complex and Sveconorwegian Orogeny.

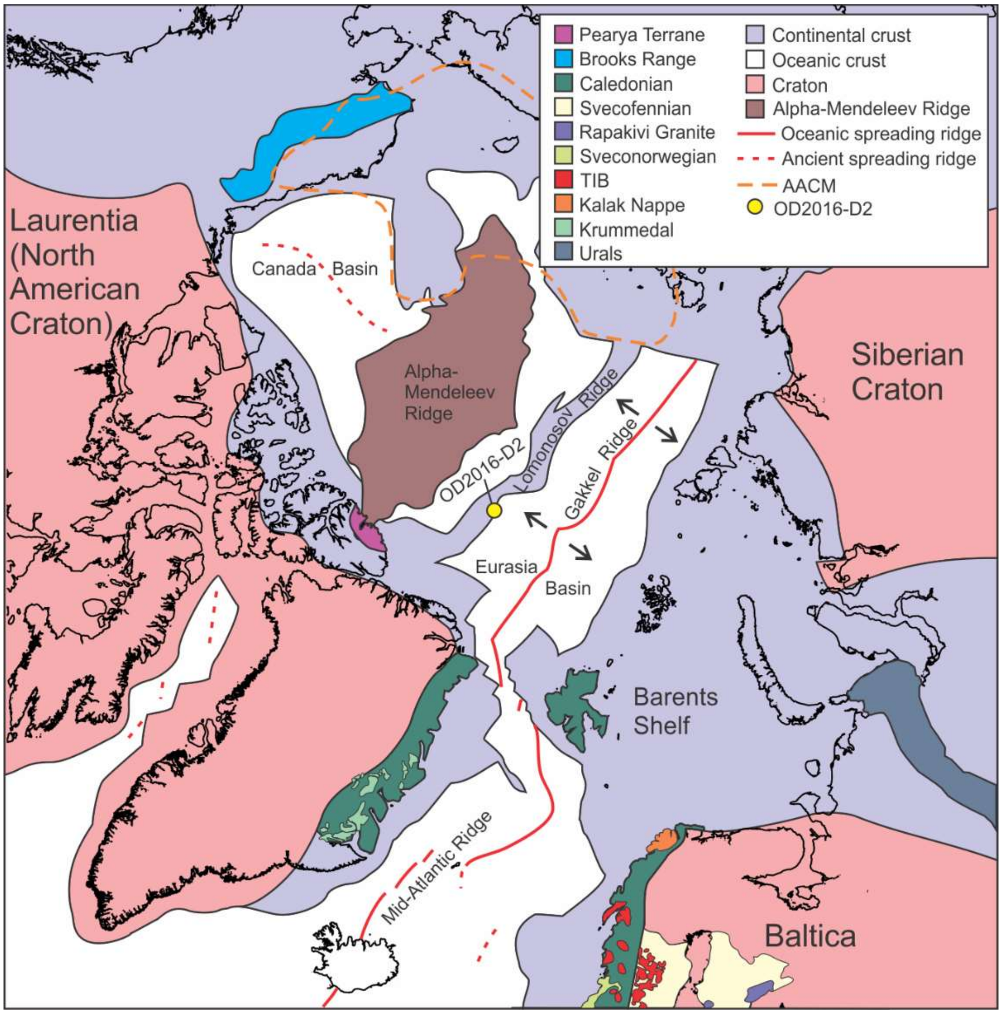


Figure 4.2. Simplified tectonic map of the Arctic, modified from Pease et al. (2014). Data in legend was obtained from several sources (Watt and Thrane 2001; Högdahl et al. 2004; Kirkland et al. 2007; Malone et al. 2014; Hoiland et al. 2018; Puchkov 1997).

4.3.2 Seismic stratigraphy

The German *R/V Polarstern* seismic reflection line 91090 collected over Lomonosov Ridge showed that the sedimentary succession can be divided into three distinct units based on the internal geometry of the reflections and refraction velocity data (Jokat et al. 1992; 1995). The upper unit (~500 m) consists of nearly flat-lying strata, with velocities of less than 2.2 km/s interpreted to comprise Cenozoic sediments deposited after the Lomonosov Ridge subsided below sea level. This unit overlies a prominent unconformity. Below this unconformity, the seismic sections showed well-bedded strata involved in a set of rotated fault blocks, with seismic velocities ranging from 4.0 to 4.6 km/s (Jokat et al. 1992; 1995). These were interpreted to be Mesozoic strata affected by extensional block-faulting that were then uplifted and eroded, prior to seafloor spreading and the creation of the Eurasian Basin (Jokat et al. 1992; 1995, Grantz et al. 2001). The lowermost unit has no internal reflections, with seismic velocities ranging from 4.7 to 5.2 km/s (Jokat et al. 1995). The refraction data do not reveal the total thickness of this unit, but these rocks were interpreted as either metamorphosed sedimentary rocks or upper continental crust, of possible Proterozoic age (Jokat et al. 1992; 1995).

The 2004 Integrated Ocean Drilling Program Arctic Coring Expedition (ACEX) drill core (Fig. 4.1) (Moran et al. 2006) confirmed the seismic interpretations of Joket et al. (1992, 1995). Approximately 400 m of Cenozoic hemipelagic and pelagic strata were recovered above a base-Eocene (~57 Ma) unconformity. The timing of this unconformity is consistent with the separation of Lomonosov Ridge from the Barents Shelf and formation of the Eurasia Basin. Upper Cretaceous sandstone and mudstone were recovered from below the unconformity and were interpreted to have been deposited in a shallow marine setting during early formation of the continental margin (Moran et al. 2006).

Wide-angle seismic refraction profiles over Lomonosov Ridge conducted by the Geological Survey of Canada provide constraints on the thickness of the different crustal layers and further support a continental affinity for Lomonosov Ridge. The 1976 "LOREX" refraction experiment results (Mair and Forsyth, 1982; Forsyth and Mair, 1984) showed a ~5 km thick upper-crustal layer with a velocity of 4.7 km/s that is equivalent with the Jokat et al. (1995) basal unit, and suggests that a significant component of Lomonosov Ridge consists of metamorphosed (Proterozoic?) sedimentary rocks. The results further showed the presence of a 15–20 km thick lower crustal unit with a velocity of 6.6 km/s. Such velocities are typical of crystalline lower continental crust rather than oceanic crust (e.g. Funck et al. 2004).

The 2006 "LORITA" refraction experiment results (Jackson et al. 2010) provided details of the uppermost sedimentary succession. There is a significant sedimentary basin (maximum thickness ~12 km) overlying thick, higher velocity crust. The upper two sedimentary layers (velocities of 2.1–2.2 km/s and 3.1–3.2 km/s) are interpreted to be an offshore extension of the Neogene to Holocene Arctic continental terrace wedge. There is an interpreted unconformity separating the lower sedimentary unit (velocities of 4.3–5.2 km/s) with the upper units that is likely equivalent with the base-Eocene unconformity observed by Jokat et al. (1995).

Beneath the low-velocity sedimentary succession, the crust of Lomonosov Ridge was found to consist of two distinct layers. The uppermost layer (velocities of 5.3–5.9 km/s) has thicknesses ranging from ~3 km to 8 km and a velocity that is consistent with metasedimentary rocks of late Proterozoic to early Paleozoic age from the onshore Sverdrup Basin at the same stratigraphic level (Jackson et al. 2010). The thickness of the lower-crustal layer (velocities of 6.2–6.9 km/s) is highly variable (<10 km to ~20 km), but is equivalent to the lower crustal layer defined by the LOREX study (Mair and Forsyth, 1982) and consistent with Lomonosov Ridge having a continental crustal structure.

4.4 Methods

4.4.1 Field operations

In 2016, the Geological Survey of Canada conducted the multidisciplinary Oden Arctic Ocean 2016 expedition across the Arctic Ocean to acquire new data to support Canada's Extended Continental Shelf Program using the *CCGS Louis S. St. Laurent* and the *Oden*. Dredge site OD2016-D2 from this cruise collected >650 kg of material (Gårdfeldt and Lindgren 2017). Details regarding the dredging operations can be found in Gårdfeldt and Lindgren (2017). Larger specimens that were considered representative were taken from the OD2016-D2 rocks and assigned sample numbers. Samples were then photographed and stored for later analysis. These rocks included heterolithic mudstone-siltstone and arkosic sandstone. The rocks were largely angular fragments, with approximately half the dredge composed of sandstones and < 1% of the rocks being clearly ice-rafted detritus. A total of ten sandstone samples identified within the dredge yield were selected for zircon dating. Sample numbers are preceded with the station number, but are abbreviated in this study as the three-digit sample number (e.g. OD2016-D2-011 is reported here as 011).

4.4.2 Petrography

The ten OD2016-D2 samples that were selected for detrital zircon U-Pb isotopic age dating were cut using a rock saw and photographed for documentation and description of sedimentary structures (Chapter 2). Polished thin sections were made for each dated sample for optical petrography. Mineralogy and metamorphic grade of the rocks were determined from petrography. Detrital mineral classification and abundance of detrital zircons were assessed to select suitable samples for isotopic dating. The thin sections were photographed under a petrographic microscope using ZEN™ software.

4.4.3 U-Pb and Lu-Hf analytical methods

4.4.3.1 Crushing and Mineral Separation

Zircon grains were separated from 1–2 kg of pulverised rock by conventional crushing and grinding; hydrodynamic separation on a Wilfley™ table; density separation using Methylene Iodide (3.3 g/cm³); and magnetic separation using a Frantz™ isodynamic separator at 1.8A and 10° ss. Around 100–150 zircon grains from each of the ten samples were selected from the non-magnetic fraction.

Extracted zircons were first imaged with SEM and cathodoluminescence (CL) imagery at the GSC to obtain details regarding their grain size and shape (e.g. euhedral or rounded) and to identify any internal mineral growth zonations. U-Pb isotopic measurements were conducted using the Sensitive High Resolution Ion Microprobe (SHRIMP).

4.4.3.2 SHRIMP U-Pb analyses

Zircons were cast in two 2.5 cm diameter epoxy mounts (IP875 and IP882) along with fragments of the GSC laboratory standard zircon (z6266, with $^{206}Pb/^{238}U$ age = 559 Ma, Stern and Amelin, 2003). The mid-sections of the zircons were exposed by polishing using 9, 6, and 1 µm diamond compound, and the internal features of the zircons (such as zoning, structures, alteration, etc.) were characterized in back-scattered electron mode (BSE) utilizing a Zeiss Evo 50 scanning electron microscope. Mount surfaces were evaporatively coated with 10 nm of high purity Au.

SHRIMP analytical procedures followed those described by Stern (1997). A minimum of 55 to 84 detrital zircon grains were analysed from each of the ten samples for a total of 718 analyses. Analyses were conducted during two analytical sessions (875 and 882) using an $^{16}O^-$ primary beam, projected onto the zircons at 10 kV. The count rates at eleven masses including background were sequentially measured over 5 scans with a single electron multiplier and a pulse counting system with deadtime of 21 ns. Off-line data processing was accomplished using SQUID version 2.5. The 1σ external errors of $^{206}Pb/^{238}U$ ratios reported in a supplementary data table (Appendix 5) incorporate a minimum ±1.0 % error in calibrating the standard zircon (Stern and Amelin, 2003). Pb isotopic values were monitored by analyses of an in-house standard with a $^{207}Pb/^{206}Pb$ age of 2679.6 ± 0.3 Ma; analytical sessions 875 and 882 yielded values of 2681 ± 4 and 2675 ± 3 Ma. No mass fractionation correction was applied to the data. The long-term value determined is 2677.5 ± 0.4 Ma (n = 288/305; standard error of measurement 95% confidence). External reproducibility is estimated at ±0.2%. Common Pb correction utilized the Pb composition of the surface blank (Stern, 1997).

4.4.3.3 Hafnium isotopes

In-situ Lu-Hf isotope analyses were conducted on samples 023, 047, 066, and 069 on the same zircon grains as the SHRIMP analysis, using a Photon excimer laser (193 nm) and a Neptune multi-collector ICP mass spectrometer (Thermo Scientific) at the Geological Survey of Canada. The Photon ablation cell was utilized within a He atmosphere and ablation products were carried in a He stream and mixed with Ar from an Aridus desolvater prior to introduction to the plasma. Data were dominantly acquired using a 34 µm beam diameter, with a small number of analyses at 26 µm based on the grain size of the target. The laser was operated at 7 to 8 Hz pulse repetition rate with a fluence of ~7.14 x 10^6 J/cm^2. These conditions resulted in a median total Hf beam of 12.5 V with a range from ~5–29 V. Analyses involved a pre-ablation background measurement of 30–60 seconds followed by a 60–90 second acquisition interval. The ^{180}Hf intensity was monitored between analyses to return to background values prior to starting new analyses. The acquisition interval for data calculation was selected based on signal stability and was screened for possible intersection of inclusions and domains with different Hf isotopic compositions.

Seven masses were simultaneously collected in Faraday cups with 1011 Ω resistors, including ^{180}Hf, ^{179}Hf, ^{177}Hf, ^{176}Hf (^{176}Lu, ^{176}Yb), ^{175}Lu, ^{173}Yb, and ^{171}Yb. Data were evaluated in time resolved mode to exclude intervals that intersected inclusions (very rarely observed). Interference of the ^{176}Lu and ^{176}Yb isotopes on ^{176}Hf was corrected based on the measured ^{175}Lu and ^{173}Yb values and accepted values of ^{173}Yb/^{171}Yb (1.132685) and ^{176}Yb/^{173}Yb (0.796218) and ^{176}Lu/^{175}Lu (0.02655) (Chu et al. 2002).

The Hf mass fractionation value (βHf) was calculated based on the exponential law (Russell et al. 1978) assuming a ^{179}Hf/^{177}Hf value of 0.7325. Mass fractionation values for Yb (βYb) were calculated from the measured ^{173}Yb/^{171}Yb ratio and applied as follows. The mean βYb value was calculated for the selected analytical interval and compared to the mean βHf value for the same interval. Using this ratio, a βYb value was calculated for each integration from the more precisely measured βHf value and applied to each integration. This approach assumes that changes in βYb and βHf fractionation during a single run are highly correlated, which can be demonstrated within the measurement errors. Lu isotopes were corrected assuming the mass fractionation values calculated for Yb. The ^{176}Yb/^{173}Yb and ^{176}Lu/^{175}Lu corrections were determined using synthetic Lu-, Yb- and Hf-doped zircon standards MUN1 and MUN4 (Fisher et al. 2011). Analyses of the MUN4 standard zircon with elevated Yb/Hf yielded a value of 0.282107± 0.000013 (Appendix 8). Data were processed using Iolite™ data processing software (Woodhead et al. 2004; Hellstrom et al. 2008).

Elemental fractionation of Lu and Hf was monitored and corrected based on the sessional mean determined for the 6266 standard. Measured values during each analytical session were approximately 1% to 8% lower than accepted values with a reproducibility of approximately 3–5% at 95% confidence. A $^{176}Lu/^{177}Hf$ value of 0.00031 is determined for zircon 91500 relative to 6266, within uncertainty of the accepted value of 0.000309 (Blichert-Toft, 2008).

Accuracy and reproducibility were monitored by repeating analyses of four zircon standards (91500, Temora 2, 6266 and Mud Tank), each of which show good agreement with published data (Appendix 8; Woodhead and Hergt 2005; Wu et al. 2006; Blichert-Toft, 2008). Results from the four reference zircons, as well as the synthetic MUN zircon, indicate a small systematic bias in the $^{176}Hf/^{177}Hf$ ratio of ~ 0.000032 relative to recommended values (Appendix 8). The bias does not correlate with Yb/Hf or Lu/Hf ratios indicating that it is not a function of the interference correction method. Analyses of the JMC475 solution also measured low, with a value of 0.282147 ± 0.000003 (2σ). The $^{176}Hf/^{177}Hf$ data for unknowns is corrected to account for this small bias. The calculated internal measurement uncertainty accounts for the data distribution, low mean squared weighted deviation (MSWD) meaning a high probability of fit, and no additional external uncertainty was required.

Chondritic uniform reservoir (CHUR) values of $^{176}Lu/^{177}Hf = 0.0336$ and $^{176}Hf/^{177}Hf = 0.282785$ are from Bouvier et al. (2008). Depleted mantle model based on $^{176}Lu/^{177}Hf = 0.03902$ and $^{176}Hf/^{177}Hf = 0.28327$ and new crust model age calculations utilized values of Dhuime et al. (2011) ($^{176}Lu/^{177}Hf = 0.03781$ and $^{176}Hf/^{177}Hf = 0.28316$). ^{176}Lu decay constant of 1.867 x 10-11yr^{-1} was used (Soderlund et al. 2004).

4.4.3.4 IsoplotTM

Concordia ages were calculated using the Isoplot™ 4.15 Excel macro (Ludwig 2011). Concordia ages were used as they consider both $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ uncertainties. The Concordia age gives a probability of the age being concordant instead of using an arbitrary discordance cut-off. This allows for grains with low U content and high uncertainty to be compared as they may have a large correlated error and still a >1% probability of being concordant. Age display was used to make probability density distribution plots (Nemchin and Cawood 2005). Probability density distribution plots are preferred to Kernel Density Estimate plots to prevent over-smoothing of the data.

IsoplotR (Vermeesch, 2018) was used to create cumulative probability plots as well as multidimensional scaling (MDS) plots based on the resulting $^{206}Pb/^{238}U$ ages. This MDS plot is a type of principal components analysis, which is a method of reducing dimensionality of large datasets. This type of principal component analysis is necessary to compare a large number of samples each with up to hundreds of analyzed zircons. This type of analysis reduces accuracy in the data, but allows for the dataset of detrital U-Pb ages to be plotted in a simple manner on a scatter diagram where the distance between points is based on how similar the principal components are. For the MDS plot, the data is first reduced by placing the U-Pb ages into 5 percentile bins and then samples are compared on a matrix by plotting them against each other, where samples that are more similar plotting closer to a 1:1-line (Vermeesch, 2018).

4.4.3.5 Maximum depositional age

The maximum depositional age (MDA) based on detrital zircon analyses is the maximum age of a rock in a stratigraphic interval as a rock cannot be older than its clastic components (Coutts et al. 2019). The MDA was calculated individually for each sample (see Table 4.1). The youngest zircons between samples were also used for calculating a MDA for the samples as a whole. For calculating the MDA, the method chosen is the youngest three zircons as described in Coutts et al. (2019). This method uses the weighted average, based on the grains probability of being concordant, of the youngest three zircons which overlap within 2σ uncertainty. The detrital zircon U-Pb data used for this calculation can be found in Appendix 5. A single outlier zircon grain showing a Concordia age of 493 Ma was not used in calculating the MDA of the samples.

4.5 Results

4.5.1 Petrography

The analyzed samples from OD2016-D2 comprise arkosic metasedimentary rocks including fine- to medium-grained metasandstone and metasiltstone to silty metamudstone (Fig. 4.3). The primary mineralogical composition is similar between samples and includes: quartz, albite, biotite, muscovite and chlorite. Well-defined laminae and gradational bedding are also present in the samples and are due to alternating grain size.

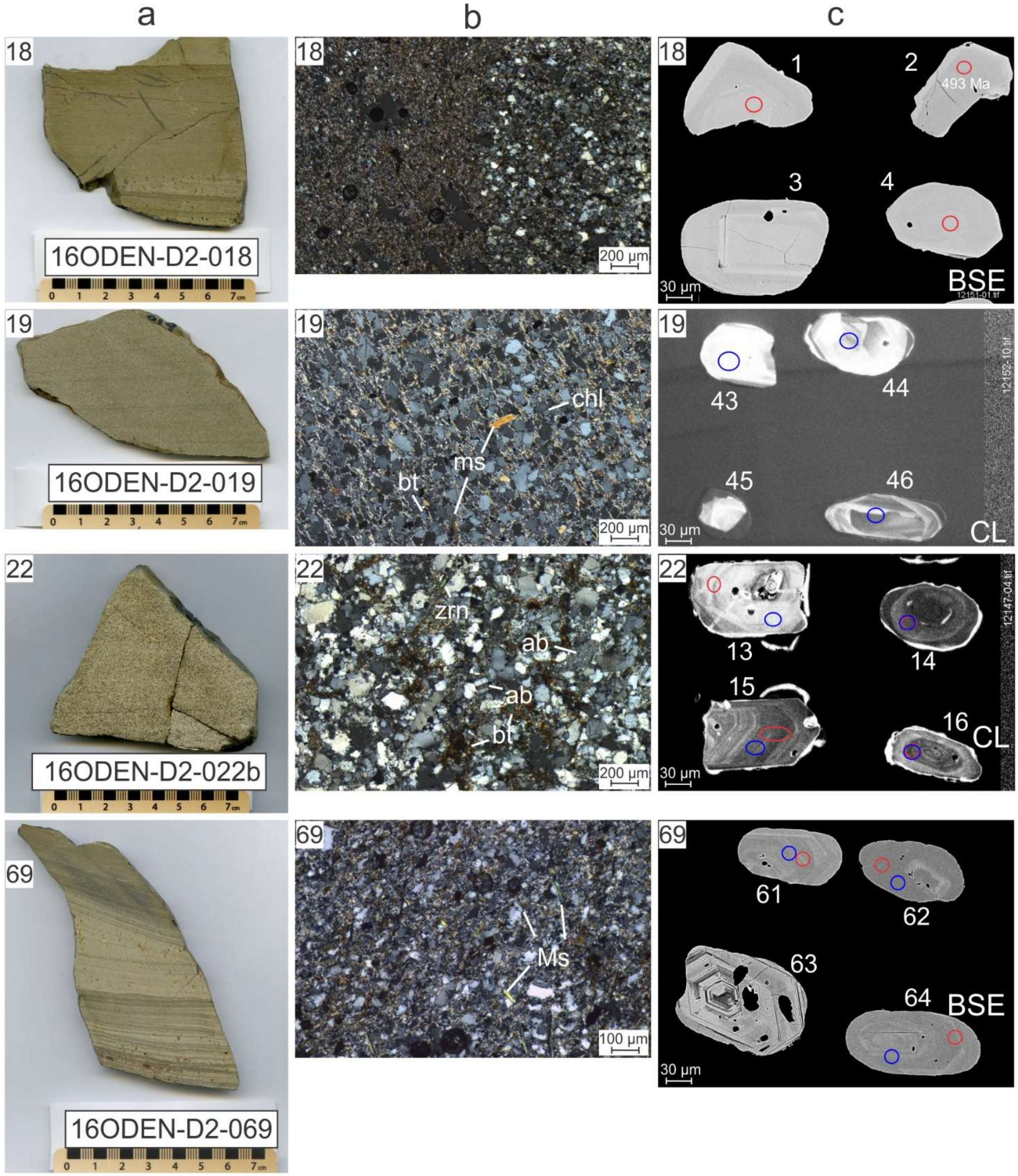


Figure 4.3. A) Photos of slabs cut from the hand specimens of select samples used for U-Pb zircon analysis. B) Petrographic photos of thin sections from the samples in cross-polarized light

showing mineralogy and the rock texture. C) SEM backscattered electron and CL images of analyzed zircon grains showing morphology and internal zonation. The ellipses in C show SHRIMP analysis spots, colour indicates a different session (red = session 1, blue = session 2). Minerals: ms = muscovite, bt = biotite, ab = albite, zrn = zircon, chl = chlorite.

Rock samples 016 (lab number: 12146), 018 (lab number: 12151) and 066 (lab number: 12154) possess similar lithological characteristics and are heterolithic metasedimentary sandstones alternating with metasiltstone and metamudstone. These samples show well-defined laminae (Fig. 4.3) varying from 0.1–5 mm thick. Detrital minerals include: quartz, muscovite, albite, biotite, and zircon. Detrital biotite grains are rare, ranging from 50–120 µm, and are usually partially altered to chlorite. Detrital muscovite (50–200 µm in length) may show plastic deformation. Other fine-grained muscovite shows parallel grain alignment in the interstitial matrix between quartz grains. Sample 016 has a low abundance of authigenic biotite, with grain sizes of 10–20 µm in clusters up to 60 µm across. Iron staining is commonly present in fractures.

Samples 022 (lab number: 12147), 023 (lab number: 12148), and 047 (lab number: 12150) are similar friable, massive metasandstones (Fig. 4.3). Detrital minerals include: quartz, muscovite, albite, biotite, and zircon. Detrital muscovite grains (200–500 µm in length) are present and some show plastic deformation. These samples have common authigenic biotite clusters up to ~200 µm, with individual grains up to ~100 µm. Sample 023 has an even higher abundance of authigenic biotite in the portion of the rock which has a darker colour.

Samples 030 (lab number: 12149), 037 (lab number: 12153), and 069 (lab number: 12155) are metasandstones showing well defined-laminations and cross-bedding (Fig. 4.3). Detrital minerals include: quartz, muscovite, albite, biotite, and zircon. Iron staining is commonly present in fractures. Detrital biotite is observed with grain sizes ranging from 40–60 µm, and are often partially altered to chlorite. Detrital muscovite grains vary from 60–200 µm, and in sample 030 one 800 µm detrital muscovite grain is present.

Sample 019 (lab number: 12152) appears to be a unique sample (Fig. 4.3), as it is a well-lithified metasandstone showing faint laminations unlike the massive and friable samples (022, 023, 047). Detrital minerals include: quartz, muscovite, albite, biotite, and zircon. Detrital muscovite grains (200–500 µm in length) may show plastic deformation. The fine-grained muscovite shows grain alignment in the interstitial matrix between quartz grains. This sample has a high abundance of clusters (~100 µm) of authigenic biotite, individual grains being ~20 µm.

4.5.2 Zircon grain morphology

Zircon grains morphology was determined from BSE imaging on all ten samples and additional cathodoluminescence (CL) imaging of samples 019, 022, 023, 047. Photos of the zircon grains can be found in Appendix 6. Grain size of the detrital zircon ranges from 50 to 170 µm. The majority of zircon grains show rounded edges and are rounded to well- rounded (e.g., Fig. 4.3). Interpretation of zircon textures was completed using the Atlas of zircon textures (Corfu et al. 2003). A variable degree of metamict alteration, representing local degradation of crystal structure, is observed in the zircons, ranging from minor (Fig. 4.3, 18c grain 1) to highly metamict (Fig. 4.3, 69c grain 63). Grains with oscillatory zoning (e.g: Fig. 4.3, 22c grain 15) occur in every sample. Epitaxial growth is present on some zircon grains (e.g: Fig. 4.3, 18c grain 1) and was avoided in the analyses. Zircons with xenocrystic cores and overgrowth rims are common in all samples. Zircons showing sector zoning are low in abundance in all samples.

4.5.3 U-Pb Dates

The youngest detrital zircon Concordia ages for the 10 samples are reported in Table 4.1. Samples 018 and 022 have MDA of <1000 Ma, and the rest of the samples each have MDA of >1000 Ma. Sample 018 yielded one grain with the youngest age at 493 ± 10 Ma (Fig. 4.3, 18c, spot 2), with the next youngest grain in this sample at 1113 ± 22 Ma. The 493 Ma age was not reproduced in over 700 analyses, and thus could represent a contaminant. Using this 493 Ma age, the MDA of sample 018 would be 938 Ma. Excluding the 493 Ma grain, the MDA of sample 018 is 1117 ± 15 Ma and the MDA range of the samples overall is from 977 ± 45 to 1129 ± 22 Ma (Table 4.1). The full zircon U-Pb data can be found in Appendix 5. The youngest zircons, excluding the 493 Ma age, between all 10 samples were used for calculating the MDA since what stratigraphy is represented by the dredge rock samples is unknown; this gives an MDA of 973 ± 37 Ma and will be referred to as the MDA throughout the test of this chapter.

Table 4.1: Age of youngest zircon and MDA for each sample, sorted by sample number. Filtered at 1% probability for Concordia age.

Lab number	Sample	Youngest Age – Concordia (Ma)	2σ Uncertainty (Ma)	MDA – Concordia Age (Ma)	2σ Uncertainty (Ma)
12146	016	1015	19	1032	17
12151	018	493	10	1117	15
12152	019	975	26	1015	28
12147	022	970	47	977	45
12148	023	982	25	1019	26
12149	030	1033	14	1067	16
12153	037	1096	23	1117	19
12150	047	1006	92	1013	51
12154	066	1062	20	1103	27
12155	069	1100	17	1129	22
-	All	-	-	973	37

The zircon age populations amongst the ten samples are similar, and the majority of grains had a >1% probability of concordance. The detrital zircon population records significant age peaks on probability density plots at 1.0–1.3 Ga and at 1.5–1.65 with lesser modes at 1.8–2.0 Ga and a scattering of Archean ages (Fig. 4.4). However, the relative proportion of detrital zircon Concordia ages at 1.0–1.3 Ga and at 1.5–1.65 Ga range varies between samples. Using this variation in abundance, the OD2016-D2 samples are divided into two groups. Group 1 has a higher relative abundance of zircons in the 1.0–1.3 Ga age and includes samples 016, 019, 022, 023, 066, and 069. Group 2 has a lower relative abundance and includes samples 018, 030, 037, and 047.

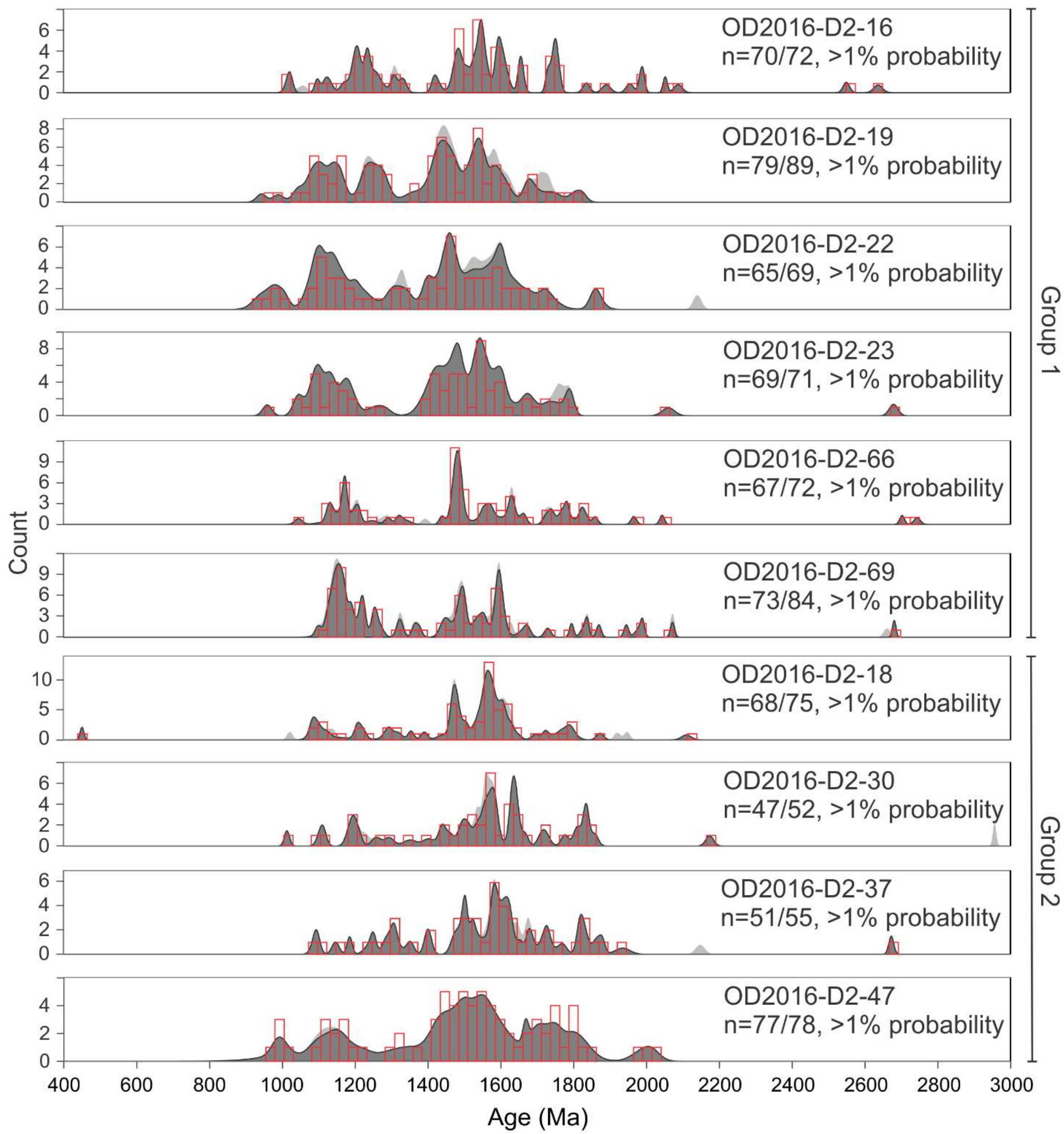


Figure 4.4. Concordia age probability density plot and frequency histogram. The plots were created in IsoplotR (Vermeesch 2018). The dark grey represents grains with a >1% probability and the light grey includes all zircon grains regardless of probability.

4.5.4 Hf Isotopes

Hf isotopic data were collected from a subset of four samples. The $^{\varepsilon}$Hf value of zircon is the difference between $^{176}Hf/^{177}Hf$ compared and the chondritic uniform reservoir (CHUR) at Earth's formation. Because ^{176}Lu decays to ^{176}Hf and ^{177}Hf is stable, the $^{\varepsilon}$Hf values increase over time for source models such as the New Crust (Island Arcs) and Depleted mantle reservoirs of Dhuime et al. (2011). Most zircon grains yielded positive epsilon Hf values indicating derivation from relatively juvenile protoliths. Zircon Hf isotopes will correspond to that of the melt from which they formed. Hf model ages represent when a melt partitioned from one of these models and are calculated using an average $^{176}Lu/^{177}Hf$ ratio of the crustal source (crustal evolution line in Figure 4.5). Model ages based on the New Crust (Island arc) model of Dhuime et al. (2011) are dominantly (i.e. clustered in Figure 4.5) in the range of 1.0 to 1.8 Ga.

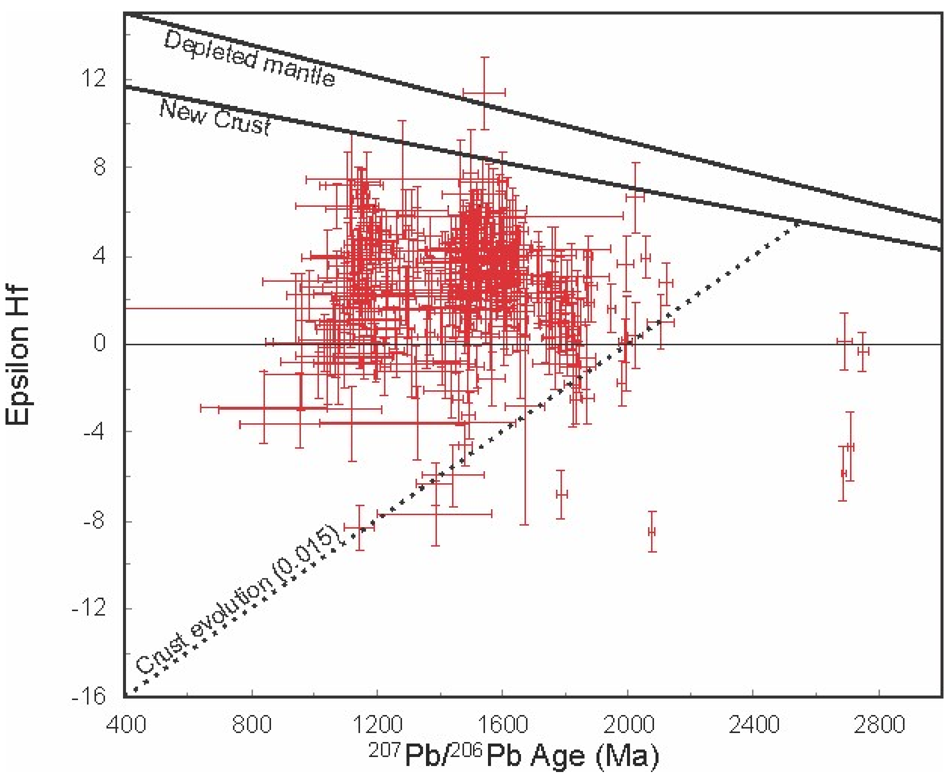


Figure 4.5. Epsilon Hf vs. Age (Ma). Model from Dhuime et al. (2011).

4.6 Discussion

4.6.1 Comparison with previous samples from Lomonosov Ridge

By combining the zircons from each group and plotting them on a probability density plot (Fig. 4.6). The difference in proportion of probable zircon Concordia ages in the 1.0–1.3 Ga age range between groups is visible. Group 1 (samples: 016, 019, 022, 023, 066, and 069; Fig. 4.6a) has a maximum peak which is double that of Group 2 (samples 018, 030, 037, and 047; Fig. 4.6b). Group 2 has notably fewer Archean grains than Group 1, although the peak is at ~2700 Ma for both.

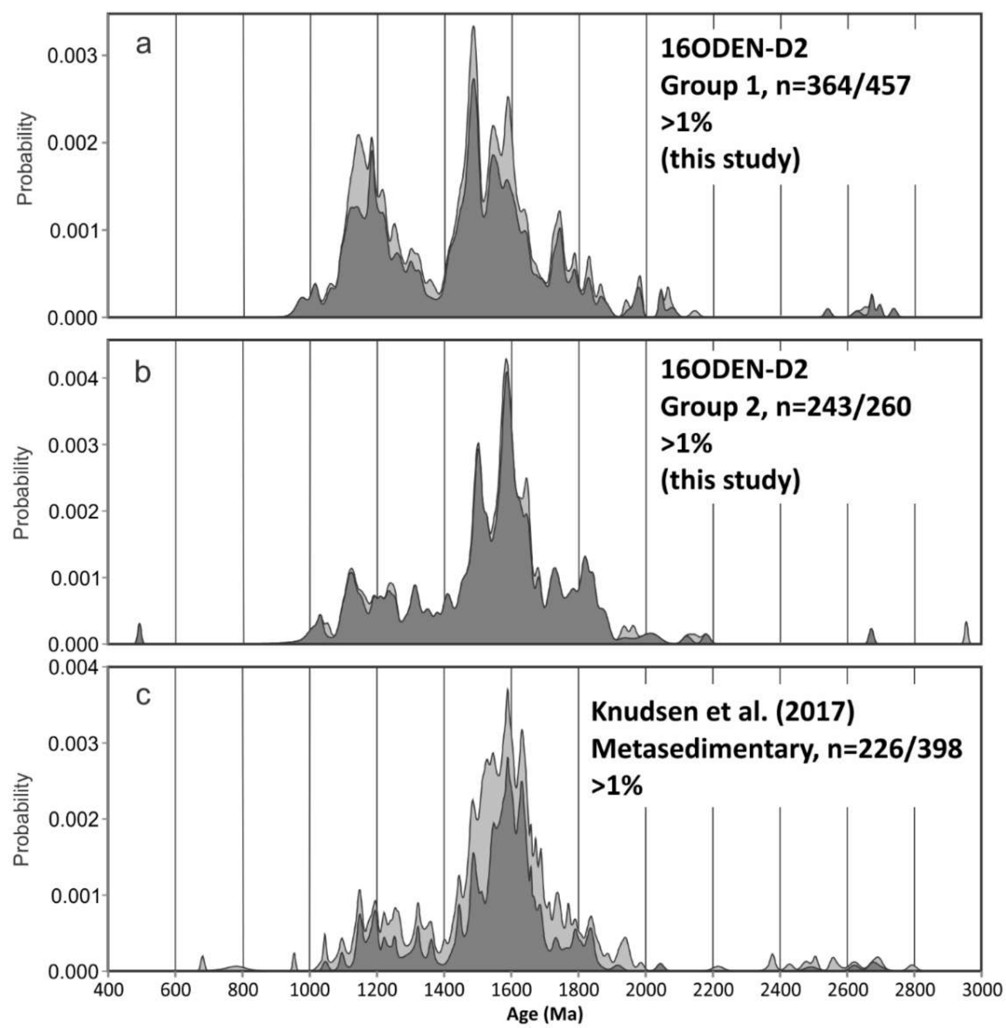


Figure 4.6. Concordia age distributions of detrital zircons for OD2016-D2 dredge samples and recalculated Concordia ages for the metasedimentary rocks from Knudsen et al. (2017). Light grey area represents zircons with <1% probability. Y-axis represents probability density.

Knudsen et al. (2017) analyzed one sedimentary and three metasedimentary samples from the LOMROG-III dredge for U-Pb zircon age dates. The sedimentary sample was found to contain Cambrian-aged zircons; the metasedimentary samples only contained Proterozoic zircon grains and are comparable to our samples. The samples in Group 2 (Fig. 4.6B) (samples: 018, 030, 037, and 047) have a similar age distribution to the metasedimentary samples reported in Knudsen et al. (2017). The presence of two separate groups for the OD2016-D2 rocks could indicate a slight shift in the source of detrital zircons, where Group 1 had a higher input of detrital zircons in the 1.0-1.3 Ga age range relative to the rocks in Group 2 (Fig. 4.6). It is likely that the Group 2 samples are from a similar stratigraphic level in Lomonosov Ridge as the Knudsen et al. (2017) metasedimentary samples, whereas the Group 1 samples were possibly collected from a different level.

The maximum depositional age of the OD2016-D2 samples is 973 ± 37 Ma, implying that the older zircon grains are reworked. Performing this same MDA calculation for the three samples from Knudsen et al. (2017) yields an MDA of 1124 ± 23 Ma, which is significantly older than that of the OD2016-D2 samples. This difference is likely due to the Knudsen et al. (2017) samples having no zircons with Concordia ages with probability >1% younger than 1048 ± 16 Ma. However, the MDA for the Knudsen et al. (2017) samples compares well with OD2016-D2 samples 037 (1117 ± 19 Ma), 066 (1103 ± 27 Ma), and 069 (1129 ± 22 Ma), which each have an MDA within 2σ uncertainty (Table 4.1) of the Knudsen et al. (2017) samples.

Cumulative probability plots (Fig. 4.7) are used to compare samples from OD2016-D2 with those from Baltica (Kirkland et al. 2011, Andresen et al. 2014, Gee et al. 2014, Põldvere et al. 2014, Zhang et al. 2016), the Urals (Miller et al. 2011) and samples collected by the LOMROG-III expedition from Lomonosov Ridge (Marcussen 2012; Knudsen et al. 2017). The $^{206}Pb/^{238}U$ ages are used for the cumulative probability plots as not all compared datasets have sufficient data to calculate a Concordia age. The cumulative density plots are filtered to only include zircons with >950 Ma $^{206}Pb/^{238}U$ ages to eliminate source dilution from younger grains.

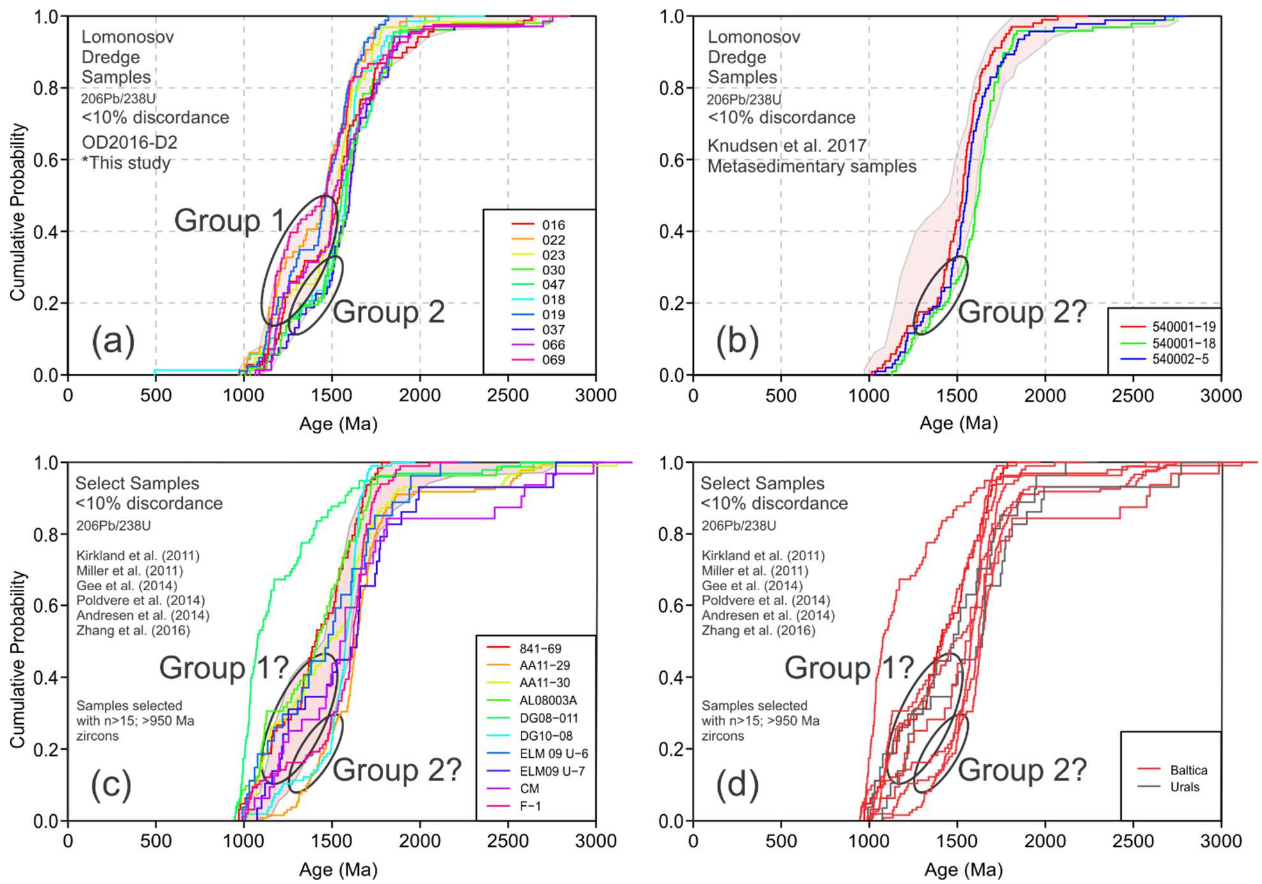


Figure 4.7. Cumulative probability plots (Gehrels 2012) of ^{206}Pb-^{238}U age distribution for OD2016-D2 dredge rocks (a). (b) Shows the data from Knudsen et al. (2017), (c) shows select samples with similar detrital zircon age distributions to the OD2016-D2 rocks, and (d) shows those same samples by origin. Samples with ≤15 detrital zircons were excluded. Black ellipses

are drawn around the previously discussed zircon groups for the OD2016-D2 samples and a pink polygon that encompasses the OD2016-D2 data has been added to each plot for comparison.

The $^{238}U/^{206}Pb$ zircon ages of the OD2016-D2 samples (Fig. 4.7a) show a similar distribution to the metasedimentary samples from Knudsen et al. (2017) (Fig. 4.7b). In particular, all samples show good correlation with the OD2016-D2 Group 2 samples. Select samples are compared to the OD2016-D2 samples on Figure 4.7c and include those derived from Baltica (Kirkland et al. 2011, Andresen et al. 2014, Gee et al. 2014, Zhang et al. 2016) and the Urals (Miller et al. 2011, Põldvere et al. 2014). Figure 4.7d recolours the same samples used on Figure 4.7c by region, and illustrates that the samples from Baltica overlap both groups and those from the Urals overlap Group 1 only.

4.6.2 Comparison with the circum-Arctic

Comparison of the results with various potential correlative rocks from the circum-Arctic. The regions looked at include: Baltica, Barents Shelf, Brooks Range, Laurentia, the Pearya terrane, the Urals, and other Lomonosov Ridge samples are made using multidimensional scaling (MDS) plots (Fig. 4.8). The MDS plot arranges points to show the degree of dissimilarity between samples, as such the axes have no units and only indicate how ‘similar’ individual samples are based on their zircon U-Pb age distribution. The zircon age signatures from Brooks Range, Baltica, Alaska– Chukotka microplate (AACM), and Laurentia are available from Hoiland et al. (2018). To better evaluate the data, four different age filters were applied to generate Figure 4.8a–d. The lower filter removed grains from the samples with ages younger than the cutoff age, so that younger grains would not skew the plots (cutoffs at 600, 900, and 950

Ma in Fig. 4.8). Samples with maximum depositional ages older than that of our Lomonosov Ridge samples were removed entirely to avoid skewing towards older rocks (cutoffs at 1000 and 1300 Ma in Fig. 4.8). Four plots were made to assess correlations at different cutoff values. The defined zircon groups do not form clusters on the MDS diagrams.

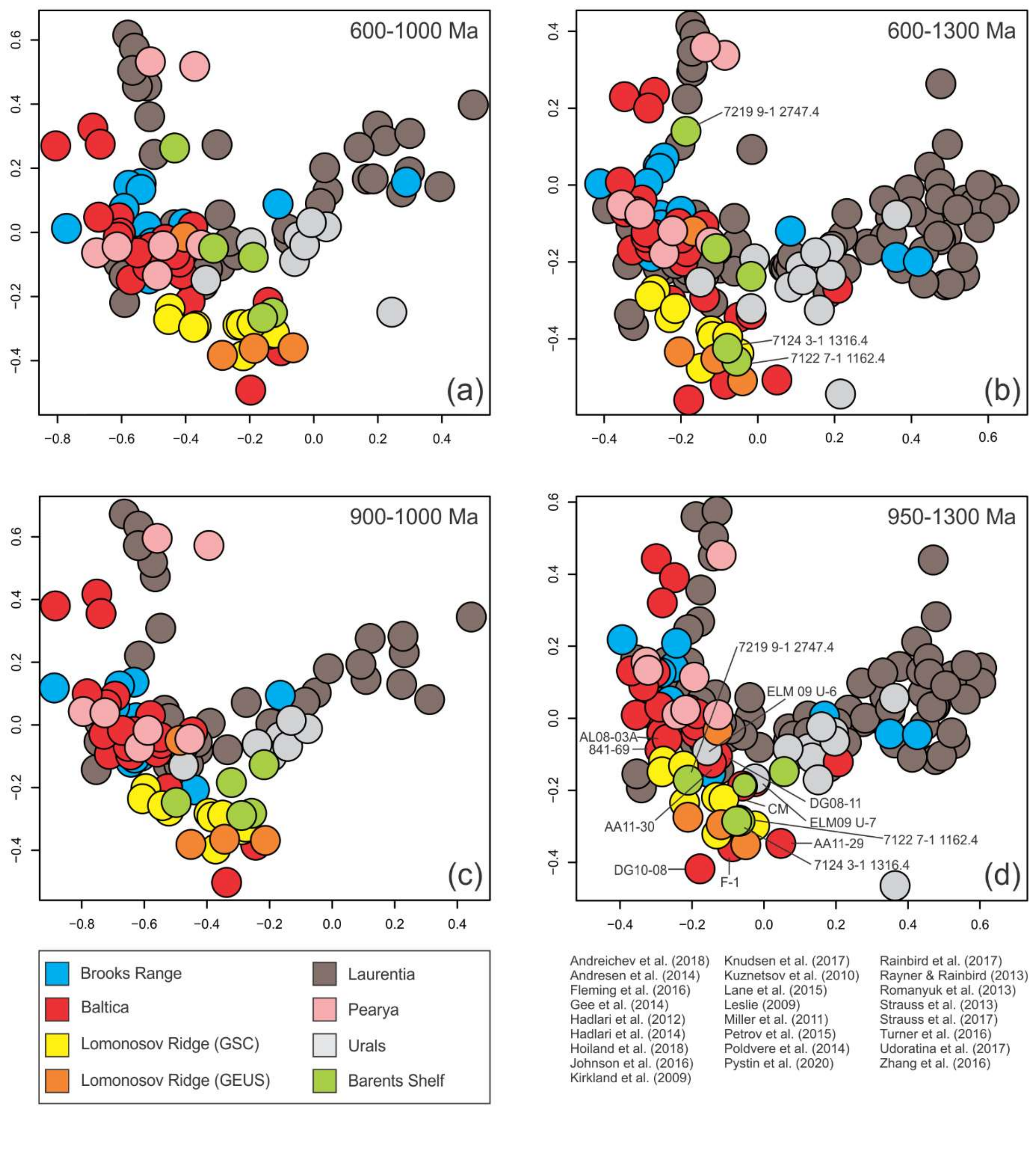


Figure 4.8. MDS plots showing dissimilarity/similarity of zircon ^{238}U-^{206}Pb ages from samples collected around the Arctic. These plots arrange the points to show the dissimilarity between samples, as such the axes have no units. Zircon U-Pb dates that are plotted were filtered for <10% discordance. Labelled points highlight individual sample numbers from the referenced papers. MDS plots a) uses cutoffs at 600 and 1000 Ma, b) uses cutoffs at 600 and 1300 Ma, c) uses cutoffs at 900 and 1000 Ma, and d) uses cutoffs at 950 and 1300 Ma.

On the MDS plots, the detrital zircons from Brooks Range, Laurentia, Pearya and Urals show a different distribution and high degree of dissimilarity compared with Lomonosov Ridge samples (Fig. 4.8). Conversely, detrital zircons from rock units of Baltica show greater similarity. The plot using the 950 and 1300 Ma cutoffs (Fig. 4.8d) was chosen as the main MDS plot to compare data with that of other authors, as 950 Ma captures our overall MDA (973 ± 37 Ma), and the highest MDA of sample 037 (1129 ± 22), and the 1.0–1.3 Ga age range peak (Fig. 4.4).

Detrital zircon signatures from Baltica include four samples from the central Scandinavian Caledonides: DG08-11, DG10-08, AL08-03A, and 841-69 from Gee et al. (2014) that are comparable to the OD2016-D2 samples. DG08-11 is from an Ediacaran–Cambrian shallow marine quartzite from the Vemdal Formation of the Lower Allochthon. From the middle allochthon, two Neoproterozoic(?) calc-silicate psammites (841-69, AL08-03A) and one Neoproterozoic schistose psammite (DG10-08) have the most similar age distribution to the OD2016-D2 samples (Fig. 4.8), as they plot closely. The late Paleoproterozoic detrital zircons in the central Scandinavian Caledonides are interpreted to have been derived mainly from granites of the Transscandinavian Igneous Belt (1650–1850 Ma) in the foreland autochthon.

Mesoproterozoic zircons (c. 950–1700 Ma) are typical of the Sveconorwegian Orogen of southwestern Scandinavia in the hinterland, with the dominant age peak ranging from 900–1150 Ma (Gee et al. 2014).

Also from Baltica, two Late Neoproterozoic (Ediacaran) samples (AA11-29, AA11-30) from the Dividal Group in northern Norway (Andresen et al. 2014) show similar zircon U-Pb age distribution to the Lomonosov Ridge samples (Fig. 4.8). The Dividal Group is part of the Caledonides (Fig. 4.2) and is an autochthonous succession of Neoproterozoic to Cambrian terrigenous sediments deposited along what is now western Baltica. These samples were interpreted to have sources including the Fennoscandian provinces (Fig. 4.2, Svecofennian, TIB, Gothian and Sveconorwegian) (Andresen et al. 2014).

Zhang et al. (2016) reported two metasedimentary samples, F-1 and F-3 (F-3 raw data not available), with similar age peaks from the Kalak Nappe complex in northern Finnmark, Norway (Baltica). The Kalak Nappe includes alluvial-fan and fluvial to shallow marine facies, as well as deeper-marine turbiditic sequences (Zhang et al. 2016). The samples F-1 and F-3 are inferred Neoproterozoic, low-grade metasedimentary rocks and have maximum depositional ages of 998 Ma and 1128 Ma, respectively. Sample F-1 shows nearly identical U-Pb age peaks to the Lomonosov Ridge samples and plots closely on the MDS diagram (Fig. 4.8). In contrast, the Zhang et al. (2016) samples from the Laksefjord Nappe Complex, south of the Kalak Nappe (Fig. 4.2) and separated by a regional fault, also have a Neoproterozoic maximum depositional age, but show dissimilar U-Pb age peaks with large Archean peaks. The source of the zircons in the Kalak Nappe is interpreted to have been derived from the Fennoscandian Shield based on Paleocurrent flow measurements and detrital zircon U-Pb ages (Zhang et al. 2016).

When plotting the younger lower Ordovician samples ELM09 U-6 and ELM09 U-7 (Miller et al. 2011) from the Polar Urals (Fig. 4.2, Urals) with only the detrital zircon grains with >950 Ma U-Pb ages, samples ELM09_U-6 and ELM09_U-7 have similar zircon populations to the OD2016-D2 samples (Fig. 4.8D). The >950 Ma U-Pb age detrital zircon grains in sample CM from the Cambrian sandstone of Tabasalu Klint, Estonia (Põldvere et al. 2014) yield a similar zircon distribution to the Lomonosov Ridge samples. Põldvere et al. (2014) suggested their Mesoproterozoic detrital zircon grains (1800–1400 Ma) were derived from the Svecofennian orogen, TIB, and the Rapakivi granites in central Baltoscandia, whereas their younger zircon grains (1400–1000 Ma) were derived from the Sveconorwegian basement in western Baltica (Miller et al. 2011).

Based on the above comparisons, we suggest that the detrital zircons from Lomonosov Ridge are sourced from Baltica and from similar Proterozoic sources. The distribution of U-Pb detrital zircon ages is most similar to that successions exposed in the Kalak Nappes. Potential sources for the OD2016-D2 rocks include: TIB (1650–1850 Ma), Gothian Igneous complex (1750–1550 Ma), Rapakivi granites (1650–1530 Ma), Sveconorwegian basement (950–1700 Ma), and Svecofennian orogen (1800–2000 Ma) (Gorbatschev and Bogdanova 1993; Åhäll and Gower 1997; Miller et al. 2011; Gee et al. 2014). The three samples (7122 7-1 1162.4, 7124 3-1 1316.4, and 7219 9-1 2747.4) from Fleming et al. (2016) are from Triassic sandstone of the Fruholmen Formation on the Barents Shelf and show the highest degree of similarity to the samples from Lomonosov Ridge. These samples do not share a similar heavy mineral fraction and are likely unrelated, however, the correlation is interesting.

4.6.3 Hafnium isotopes

The chondritic uniform reservoir (CHUR) is used to compare Lu-Hf data. Chur is undifferentiated and thus serves as a baseline for determining enrichment or depletion of Epsilon Hf. If the $^{176}Hf/^{177}Hf$ ratio of a sample is higher than CHUR the sample is enriched and vice versa. Because continental crust becomes enriched in trace elements, and the mantle depleted, the crust tends to have a higher abundance of ^{177}Hf which lowers the $^{176}Hf/^{177}Hf$ ratio and therefore also Epsilon Hf (Dhuime et al. 2011). A positive $^{\varepsilon}Hf$ means the zircons have a higher abundance of Hf isotopes relative to CHUR, suggesting a relatively juvenile source, as an evolved crustal source. Conversely, a crustal melt would be depleted in $^{\varepsilon}Hf$ relative to a chondritic source and show a negative $^{\varepsilon}Hf$ value. The Hf-isotope data derived from detrital zircons and can be used to help trace sediment sources. Our ability to identify sources is limited because there are few existing Hf-isotope data published of zircons from rocks around the Arctic. The samples labelled on Figure 4.8 are the most similar to those in this study, but all lack Hf-isotope data. For this reason, a comparison with other available data is made (Fig. 4.9), but future studies may help fill in this information gap and aid in interpretation of zircon provenance.

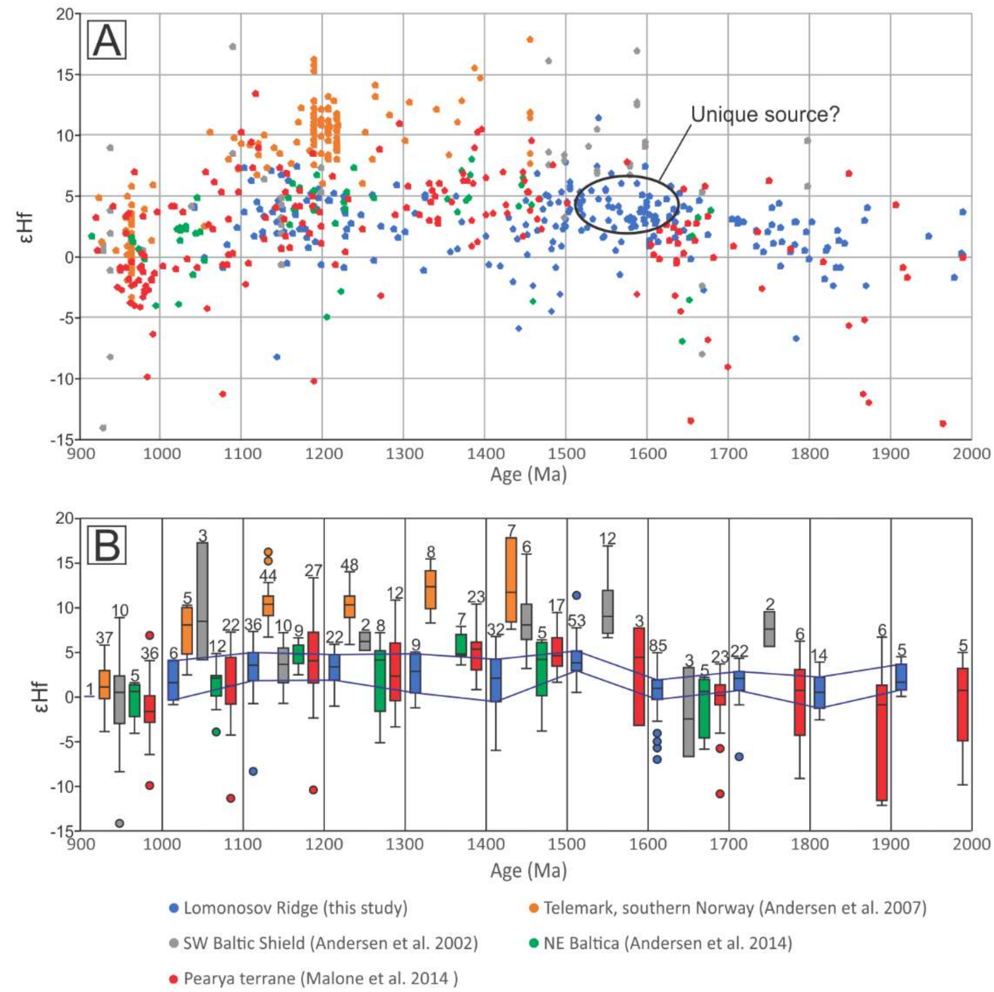


Figure 4.9. A) $^{\varepsilon}$Hf plot of zircon grains from available data. B) The box plot groups data in 100 myr intervals (eg. >900 and <1000), with number of grains above each box.

The samples available for comparison (Fig. 4.9) include the compilation by Andersen et al. (2002) from a variety of sources in the southwest Baltic Shield; samples from Mesoproterozoic granitic-granodioritic gneisses from Telemark, southern Norway (Andersen et al. 2007); sample AA12-1 from the Dividal Group in northeast Baltica (Andresen et al. 2014); and sample 08-132:M5, which is a quartzite from the Pearya Terrane in Laurentia (Malone et al. 2014). Lomonosov Ridge samples in Figure 4.9a have a unique $^{\varepsilon}$Hf signature between 1500–

1600 Ma that is not shared with the other zircon sources. Lomonosov Ridge samples show the most overlap with samples from northeast Baltica (AA12-1) and the Pearya terrane (08-132:M5). The Pearya terrane is an exotic terrane in Laurentia thought to have originated from Baltica (Trettin 1987, Knudsen et al. 2017). These comparisons show there are some similarities in Hf-isotopes with the Pearya terrane and the Dividal Group, which is consistent with the interpretation of a Baltica source. The Lomonosov Ridge samples show several differences at some age ranges from the rocks of southwest Baltica, though these samples from several sources grouped together. The $^{\varepsilon}$Hf distribution in zircons from Lomonosov Ridge is most similar to those of SW Baltica in the 1100–1200 Ma and 1600–1700 Ma age ranges, corresponding to samples from the young Telemark rhyolites, Sveconorwegian Tromoy arc fragment, Sveconorwegian granitic augengneiss, and TIB granites (Andersen et al. 2002).

4.6.4 Paleogeographic reconstruction

The Knudsen et al. (2017) Lomonosov Ridge metasedimentary samples are petrographically similar to our samples. Both suites of dredge rocks are primarily arkosic metasandstone and show a similar U-Pb zircon age distribution to Group 2 (Fig. 4.7). The sedimentary sample of Knudsen et al. (2017) is likely from a higher stratigraphic level based on the presence of Paleozoic zircons. Group 1 from the OD2016-D2 rocks may represent a shift in abundance of sources within Baltica, though these rocks may have been collected from a different stratigraphic interval, either above or below Group 2.

The ACEX drill core (Moran et al. 2006) shows that Lomonosov Ridge bedrock predates the Cretaceous, and therefore also the formation of the Eurasia Basin (Brozena et al. 2003, Glebovsky et al. 2006). The Early Neoproterozoic depositional age of the Lomonosov Ridge samples suggests they may have been deposited in a rift-basin during the rifting of Rodinia. The MDA of the OD2016-D2 rocks (973 ± 37 Ma) is somewhat older than the initial widespread rifting of Rodinia, which occurred between 825 Ma and 740 Ma (Li et al. 2008). The rifting of Rodinia would have been non-volcanic since there are no zircons representing the rift phase, as all dated zircons represent pre-Rodinian tectonic settings. Evidence of a Baltica provenance and the Neoproterozoic zircon ages suggest that Lomonosov Ridge samples may have been deposited near eastern Baltica in one of these early rift basins. There are, however, few constraints on where this sedimentary basin was located based on published reconstructions of Rodinia (Fig. 4.10) (Li et al. 2008).

Figure 4.10. Simplified map of Rodinia reconstruction showing the position of Baltica relative to other nearby cratons and Proterozoic passive margin deposits. Modified from Li et al. (2008).

Another possibility is that these rocks were deposited during formation of the Valhalla orogen which occurred between the latest Mesoproterozoic to mid-Neoproterozoic (1030–710 Ma) (Cawood et al. 2010). In the model of the formation of the Valhalla orogen, Baltica was positioned near the northern end of Greenland, closer to where Lomonosov Ridge is positioned relative to modern-day Greenland, and then later rotated to its position on figure 4.10 by around 1000 Ma. During this rotation, there was a northward opening of an ocean basin, the Asgard Sea, within which sedimentation occurred in two cycles from 1030–980 Ma and 910–870 Ma (Cawood et al., 2010). The first episode of sedimentation is consistent with the MDA from this study, with a similar Grenville-Sveconorwegian orogen source and lack of Archean grains in the associated rocks units of the Valhalla orogen.

4.7 Conclusions

Two separate groups of zircons are interpreted for the OD2016-D2 samples, with Group 1 having a higher abundance of 1.0–1.3 Ga zircon U-Pb ages. Zircons of Group 2 are more comparable to the metasedimentary rocks from the LOMROG-III dredge as reported by Knudsen et al. (2017). The two groups have similar maximum depositional ages and indicate a slight shift in relative contributions from source regions.

The MDA from the OD2016-D2 samples is 973 ± 37 Ma, and in some samples the youngest zircons are closer to 1100 Ma suggesting the maximum depositional age of these rocks is Neoproterozoic, or in some instances the uppermost Mesoproterozoic. This is only the maximum depositional age, does not necessarily indicate the time of deposition. Based on our current information and the lack of bioturbation in the OD2016-D2 rocks, we infer these rocks were deposited either during the late Proterozoic or possibly the early Phanerozoic.

The inferred Neoproterozoic depositional age of the dredge rocks suggests that the escarpment along which the OD2016-D2 dredge was collected was most likely exposed upper Proterozoic basement. The OD2016-D2 dredge rocks from Lomonosov Ridge have affinity with Baltica based on zircon U-Pb age distributions and Hf-isotopes. Most of the OD2016-D2 zircon grains yielded positive $^{\varepsilon}$Hf values indicating relatively juvenile protoliths. The zircon Lu-Hf data share similarities with northeast Baltica and the exotic Pearya terrane in Laurentia, suggesting similarities in the source. Based on the MDA and identified likely sources (TIB , Gothian Igneous complex, Rapakivi granites, Sveconorwegian basement, and Svecofennian orogen), deposition potentially occurred in a rift basin associated with the breakup of Rodinia.

Chapter 5 Provenance, sedimentary and post-depositional history of a Neoproterozoic metasedimentary arkose succession from Lomonosov Ridge, Arctic Ocean

5.1 Abstract

The bedrock comprising the Lomonosov Ridge, a major topographic feature in the Arctic Ocean, are poorly documented based on limited sampling and other geologic information. This chapter addresses this through analysis of OD2016-D2 dredge rock samples collected from a flank of Lomonosov Ridge at water depths ranging from 2.2 to 3.5 km. We define lithologies and lithofacies to categorize the rocks and attempt to better understand their provenance and depositional settings. A total of 96 rock samples were cut to view sedimentary structures, define lithofacies and interpret depositional environments. Whole rock geochemistry and detrital heavy minerals were used as indicators of provenance. Lithofacies analysis resulted in the definition of two lithofacies associations: one indicates a tidal-influenced deltaic setting with fluvial input and the other a tidal flat to shallow subtidal setting. Whole rock geochemical analysis allowed for comparison of trace elements between lithologies to identify possible source indicators and to investigate potential variation in source rocks between lithologies. Four rock samples were selected for heavy mineral separation at a specific gravity of 2.9, but these separates yielded limited tourmaline, amphibole, and orthopyroxene grains. These grains were analyzed using energy dispersive spectroscopy and high-resolution backscattered electron images on a Scanning Electron Microscope, as well as wave dispersive analysis using an Electron Microprobe. Three distinct bedrock units are proposed based on the results of this study and existing age constraints (see chapter 4). Overall, the suite of dredge rocks from Lomonosov Ridge shows that three

interpreted stratigraphic units were sampled, with mineral and chemical evidence showing a dominantly granitic source.

5.2 Introduction

Lomonosov Ridge (Fig. 5.1) is a 50–70 km wide geological feature within the Arctic Ocean that extends from Ellesmere Island to the East Siberian Shelf and rises 3 km above the adjacent abyssal plains. This separates the Eurasia and Amerasia basins and is interpreted to be a sliver of continental crust separated from the Barents Shelf during the opening of the Eurasia Basin by Cenozoic seafloor spreading along the Gakkel Ridge, a northward extension of the Mid-Atlantic Ridge (Grantz et al. 2001, Brozena et al. 2003). Estimates for the onset of seafloor spreading along the Gakkel Ridge are based on the recognition of seafloor spreading magnetic anomaly chron C25n (~58Ma) (Brozena et al. 2003, Glebovsky et al. 2006). In contrast, Funck et al. (2022) proposed that seafloor spreading initiated at chron C24 (54.0–52.6 Ma; Brozena et al. 2003) based on their crustal-scale velocity model from seismic refraction data.

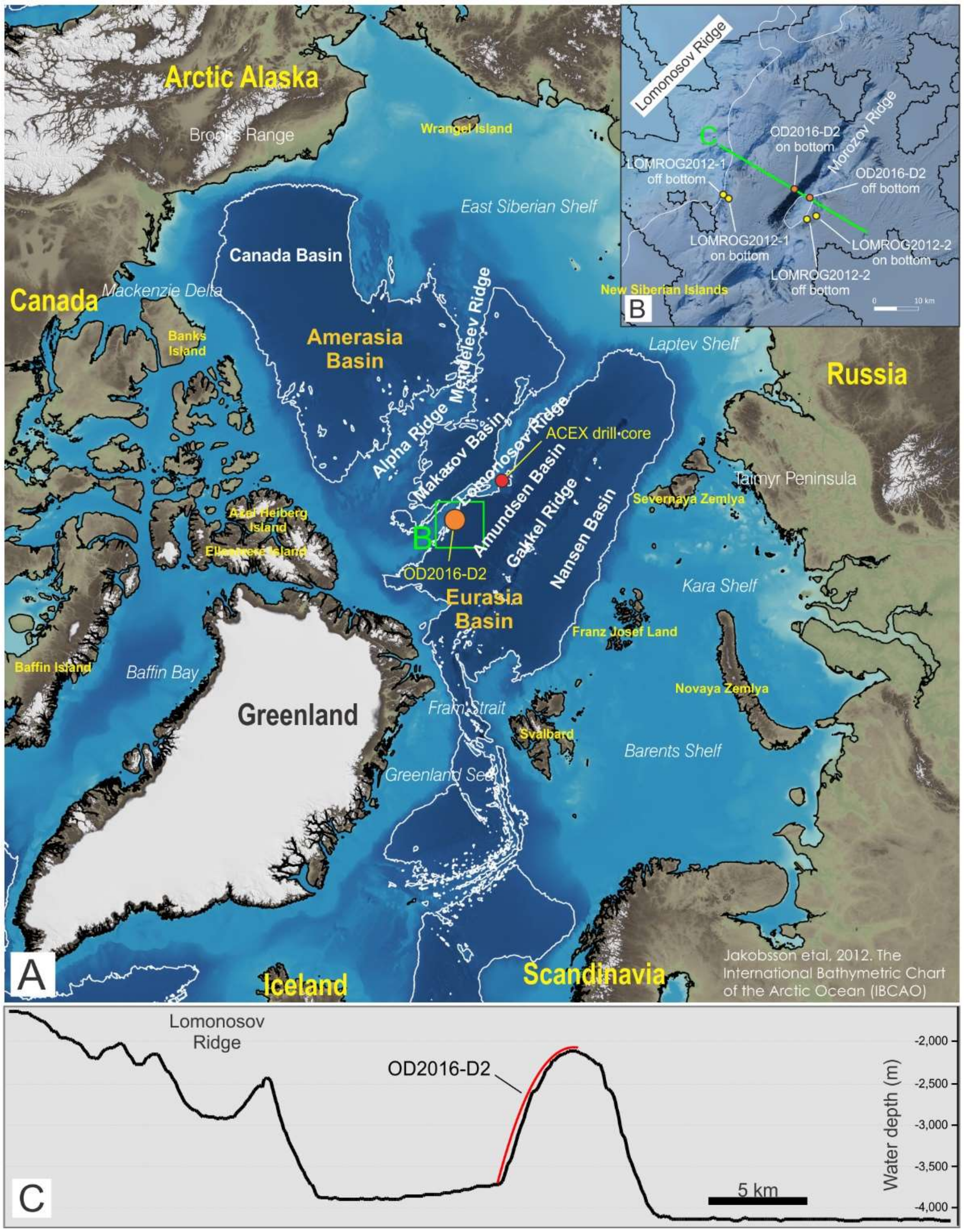


Figure 5.1. A) International Bathymetric Chart of the Arctic Ocean (Jakobsson et al. 2012). Lomonosov Ridge dredge site is at OD2016-D2 (Gårdfeldt and Lindgren 2017). The ACEX drill core location is taken from Moran et al. (2006). B) Bathymetric map at the dredge site showing the on- and off-bottom positions for the OD2016-D2 dredge site as well as the LOMROG-III-1 and -2 dredge sites (Marcussen 2012, Gårdfeldt and Lindgren 2017, Knudsen et al. 2017).

Despite the prominence and significance of the Lomonosov Ridge, the depositional history, tectonic setting, and provenance of the bedrock are still a major knowledge gap. This study analyses dredged sedimentary and metasedimentary rocks from the OD2016 research expedition that were recovered from a block on the edge of Lomonosov Ridge called Morozov Ridge near the North Pole (89.271° N, 65.613° W) (Gårdfeldt and Lindgren, 2017). In this study we use: 1) lithologies and lithofacies analyses to categorize and interpret depositional environments of the dredged rocks; 2) geochemical analysis of heavy mineral separates and whole rock geochemical analyses (WRA) to interpret provenance; 3) X-Ray Diffraction (XRD) to assess the presence of clay minerals and associated diagenetic processes; and 4) petrography using microscopy and SEM imaging to understand diagenesis, metamorphism, and provenance.

5.3 Geological Setting

Prior to the opening of the Eurasia Basin, the bedrock of Lomonosov Ridge would have been adjacent to Svalbard and Franz Josef Land and along strike from northeast Greenland (Jackson 1990). Considering the maximum depositional age of the OD2016-D2 rocks at 973 ± 37 Ma (Chapter 4), the sediments which eventually formed these rocks were being deposited around the time of the initial rifting of Rodinia, between 825 Ma and 750 Ma (Li et al. 2008). Rodinia was a supercontinent which assembled between 1300 Ma and 900 Ma (Li et al. 2008). The subsequent rifting of Rodinia between the Laurentian and Baltic cratons formed the Iapetus Ocean beginning as early as 750 Ma (Li et al. 2008). The Iapetus Ocean closed and the Caledonian Orogeny between the Laurentian and Baltic cratons occurred during the early- to mid-Paleozoic (McKerrow et al. 2000).

The geology of Lomonosov Ridge can be divided into three distinct units based on seismic reflection data and seismic refraction velocity data (Jokat et al. 1992; 1995). These units include Cenozoic strata resting unconformably above interpreted Mesozoic strata that infill prominent fault blocks within presumed Proterozoic basement (Jokat et al. 1992; 1995; Grantz 2001). Other studies such as Moran et al. (2006) documented Upper Cretaceous sandstones and mudstones recovered from Lomonosov Ridge by the 2004 Integrated Ocean Drilling Program Arctic Coring Expedition (ACEX) drill core, confirming the seismic interpretations of Joket et al. (1992, 1995) and demonstrating that Lomonosov Ridge is older than the Gakkel spreading ridge.

In 2012, the LOMROG-III expedition by the Geological Survey of Denmark and Greenland recovered two dredges from the flank of Lomonosov Ridge (Marcussen 2012). The LOMROG-III dredge 2 recovered rock material from ~5 km away from the OD2016-D2 dredge site (Fig. 5.1). These rocks are reported as metasedimentary rocks comprised of heterolithic, interlaminated, fine-grained arkosic sandstone and silty mudstone, and sedimentary sandstones and siltstones (Knudsen et al. 2017). These LOMROG-III samples have zircon U-Pb age distributions comparable to the OD2016-D2 rocks (Chapter 4). The maximum depositional age (MDA) using Concordia ages of the OD2016-D2 rocks is 973 ± 37 Ma and recalculating the data from Knudsen et al. (2017) yielded an older MDA of 1124 ± 23 Ma (Chapter 4).

In Chapter 4, the rocks found to be most similar to the OD2016-D2 rocks were Neoproterzoic sedimentary to metamorphic rocks from Baltica. The zircon age distributions of two metasedimentary rock samples, reported in Zhang et al. (2016), are similar to those from the metasedimentary successions in the Kalak Nappes in Scandinavia. These successions include alluvial-fan and fluvial to shallow marine facies, as well as deeper-marine turbiditic sequences

(Zhang et al. 2016). The zircon age peak distribution of the OD2016-D2 rocks in Chapter 4 is similar to metasedimentary and sedimentary rocks from Baltica. The interpreted sources of these rocks include orogenic events and subsequent magmatic events in the Baltic Shield. Source regions for the detrital zircons likely include: the Transscandinavian Igneous Belt (TIB) (1850–1650 Ma), Gothian Igneous complex (1750–1550 Ma), Rapakivi granites (1650–1530 Ma), Sveconorwegian basement (1700–950 Ma), and Svecofennian orogen (2000–1800 Ma) (Gorbatschev and Bogdanova 1993, Åhäll and Gower 1997, Miller et al. 2011, Gee et al. 2014).

5.4 Methods

5.4.1 Sample collection, lithology and lithofacies

Over 650 kg of material was recovered from the OD2016-D2 site (dredge site 2). Dredge site 2 starts on bottom at Latitude: 89.271 Longitude: -65.613 at 3504 m water depth and ends at Latitude: 89.291 Longitude: -63.237 at 2158 m water depth (Gårdfeldt and Lindgren 2017). Rock samples were washed to remove any mud from the surfaces and then were sieved at -4 phi (1.6 cm) to segregate out small pebbles which were not assessed. A total of 176 rock fragments were selected from nine of the ten lithologies and assigned sample numbers to be used for further analyses (Appendix 1). The dredge material included, by weight, ~20.9% material finer than 1.6 cm, ~0.3% ice-rafted detritus, ~1.6% manganese crusts, and ~77.2% (>550 kg) various angular fragments of metasedimentary rocks. The large quantity of angular and irregular rock fragments of similar lithology suggests that they are not ice-rafted detritus, but were derived from bedrock exposed along the dredge site (Fig. 5.1C).

The recovered material was sorted by hand into ten main lithologies (1–10) based on grain size, colour, hardness, sedimentary structures, and metamorphic overprinting (e.g. crenulation cleavage). Manganese crusts and ice-rafted detritus were identified for archival purposes and are not discussed in depth in this chapter. Manganese crusts coat most samples, up to 8 cm in thickness, suggesting these samples have been exposed at the seafloor for a considerable length of time. Some analyses were completed in 2016 prior to the assignment of lithologies in 2018 and lithofacies in 2019, which this accounts for the variable nature of lithologies represented in several analyses. The samples were weighed and then photographed using a mounted camera with a Munsell colour scale. From these samples, 96 were cut into slabs for viewing internal sedimentary structures so they could be classified into lithofacies and scanned for digital documentation (Appendix 2).

5.4.2 Petrography

A total of 70 polished thin sections were made from 58 samples representing nine of the lithologies. These were used to determine mineralogy and for viewing sedimentary structures, variation in grain size, and other features of interest. The polished thin sections were photographed using a Zeiss microscope with a mounted camera at the Geological Survey of Canada–Atlantic Division (GSC-A) (Appendix 3). Petrographic descriptions of the thin sections can be found in Appendix 4.

5.4.3 Heavy Mineral Separation

Four rock samples were selected for detrital heavy mineral separation from different lithologies (1, 2, 4, 5) based on the presence of heavy minerals observed in thin section. Heavy minerals in sedimentary and metasedimentary rocks are typically of low abundance and using heavy mineral analysis can help constrain potential sediment sources (e.g. Tsikouras et al. 2011). The abundance of heavy minerals in the samples was relatively low, except for zircon (see Chapter 4).

The samples were processed at the GSC-A. First, they were crushed using a disc grinder to obtain sand-sized particles, which were then sieved to obtain the 63–177-micron fraction. This fraction provides a high concentration of heavy minerals, as heavy minerals are typically concentrated in the fine-grained sand and coarse silt fractions (Piper 1974). The light and heavy minerals were then separated using a sodium polytungstate aqueous solution at a specific gravity of 2.9. The resulting heavy mineral separates were used to create four polished thin sections for petrography and non-destructive mineral chemical analyses.

5.4.4 Mineral Chemistry

5.4.4.1 Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy was completed on 14 samples representing lithologies 1 through 10, with the exception of lithology 7, using the MIRA3 TESCAN SEM at Saint Mary's University. A cobalt standard was used for calibration. The beam was focused at a distance of 17 mm above the sample stage, the voltage used was 20 kV, and the size of the analyzed spot was ~10 µm. Minerals in the samples were chemically analyzed by energy dispersive spectroscopy (EDS) and high-resolution backscattered electron (BSE) images were acquired. A paragenetic sequence was established using the textural mineral relationships in the BSE images.

5.4.4.2 X-Ray Diffraction

The mineralogy of 51 OD2016-D2 samples, representing lithologies 1 through 10, with the exception of lithology 7, was determined by X-ray powder diffraction analysis (XRD) on bulk materials and clay-sized separates. The bulk samples were micronized using a McCrone mill with agate grinder in isopropyl alcohol or distilled water to obtain a 5–10 µm (silt) grain size. Bulk samples were then back pressed into an aluminum holder to produce randomly oriented samples. Clay-size separates were measured to 40 mg and used to make oriented mounts. X-ray patterns of the bulk oriented samples and clay-sized separates were recorded on a

Bruker D8 Advance Powder Diffractometer equipped with a Lynx-Eye Detector, Co Kα radiation set at 35 kV and 35 mA. The samples were re-analysed following saturation with ethylene glycol and a heat treatment (550 °C). Further details on methods, software used, and reference mineral pattern used to identify the minerals present in the OD2016-D2 samples can be found in Appendix 12 and XRD analyses can be found in Appendix 13.

5.4.4.3 Whole Rock Geochemistry (WRA)

Whole rock geochemical analysis was completed on 30 samples representing lithologies 1 through 10, with the exception of lithology 7, from the OD2016-D2 rocks. Samples selected were remnant powders leftover from processing the rocks for XRD. The powders were analysed using the WRA 4B2 major and trace element analysis by inductively coupled plasma optical emission spectrometry (ICP-OES) and inductively coupled plasma mass spectrometry (ICP-MS) by Activation Laboratory (ALS global 2008). In this analytical method, the samples underwent lithium metaborate/tetraborate fusion and were then digested in a nitric acid solution before completion of ICP-OES and ICP-MS analyses. These analyses allow for geochemical classification of different source rock lithologies and for geochemical interpretation of source rock.

5.4.4.4. Electron Microprobe

Minerals chemistry was analyzed using polished thin sections of heavy mineral grains for three samples, decision was based on petrography, at the Robert M. MacKay Electron Microprobe Laboratory using the JEOL JXA-8200 Electron Probe Micro-Analyzer equipped with five wavelength dispersive spectrometers. The beam current used was 20 nanoamperes, voltage of 15 kV, and beam size of 1 µm. Major elements analyzed for silicate minerals included: K, Ca, Ti, Cr, Na, Mg, Al, Fe, Mn, Si, P, Cl, F, Ba, and Sr. Tungsten was analyzed in the FeO-hydroxide minerals based on its presence in the SEM chemical analyses. A kaersutite standard was used for silicate minerals.

5.5 Results

5.5.1 Lithology and Petrology

The ten lithologies are represented by arkosic to subarkosic metasedimentary rocks including sandstones, siltstones, and mudstones. Lithologies were differentiated primarily based on grain size, colour, texture, and crenulation cleavage, and a description of the lithologies can be found in Table 5.1. Representative photographs of nine of the ten lithologies are shown in Figure 5.2. Rock classification from Pettijohn et al. (1972) and the grain size classification is from Wentworth (1922).

Table 5.1: Table of the 10 lithologies and their descriptions.

Lithology	Description	Physical and other characteristics
Lithology 1 (Fig. 5.2a)	Light grey, fine- to medium-grained subarkosic sandstone	Massive, uneven or conchoidal fracturing, light grey, well consolidated, heavy mineral/dark coloured sand beds, iron-staining rare in fractures. Rocks comprising this lithology commonly have dendritic manganite coatings.
Lithology 2 (Fig. 5.2b)	Dark grey, muddy (20% clay to medium silt), fine- to medium-grained subarkosic sandstone	Massive to laminated, uneven or conchoidal fracturing, dark grey, mudstone laminae present, well consolidated, iron-staining rare in fractures. This lithology has a lower abundance of quartz and higher abundance of muddy matrix than lithology 1. Dendritic manganite is also less common compared to lithology 1.

Lithology 3 (Fig. 5.2c)	Silty mudstone to muddy medium-grained siltstone	Laminated, tan to grey, some laminae of very fine-grained sand, and scattered very fine-grained sand in muddy matrix, good fracture cleavage at 10-30° causing it to break into rhombs, pervasive iron-staining in fractures. On the faces of these rhombs, speckles of what appears to be manganite coating is common. Weathered surfaces are a tan-colour, and on fresh cut surfaces that do not correspond to a cleavage plane, the rock is dark grey in colour.
Lithology 4 (Fig. 5.2d)	Subarkosic-arkosic wacke; coarse siltstone to very-fine-grained sandstone	Laminated, tan-coloured, brittle fracture. The brittle fracture has variable angles, but usually ~60° ± 10° relative to bedding. Fractures and pores are infilled with iron-(hydr)oxide minerals (Fig. 5.3l).
Lithology 5 (Fig. 5.2e)	Very fine-grained subarkosic sandstone	Laminated, well consolidated, tan-coloured, fine-grained subarkosic sandstone, interlaminated with tan-coloured siltstone, poor to brittle cleavage. The sandstone commonly shows laminations and centimetre-scale crossbedding. Fractures and pore spaces are infilled with iron-(hydr)oxide minerals, with larger nodules in sandstone beds (Fig. 5.3l).
Lithology 6 (Fig. 5.2f)	Sandy mudstone to arkosic wacke	Bedded/planar laminated or massive, dark-grey mudstone, with a conchoidal fracture. In part of sample 027 (Fig. 5.2f), sand grains are more prevalent and the rock is classified as an arkosic wacke. Fractures and pores are infilled with iron- (hydr)oxide minerals.
Lithology 7 (not shown)	Mudstone	Dark grey, blocky mudstone. Cleavage planes are subparallel and occur in one orientation. This lithology may be associated with the mudstone layers often present as part of Lithology 2.
Lithology 8 (Fig. 5.2g)	Fine- to medium-grained subarkosic sandstone	Massive texture, and friable. Poorly consolidated subarkosic sandstones of various colours: light-grey, salt and pepper, beige, and dark grey.
Lithology 9 (Fig. 5.2h)	Interlaminated siltstone (~50%) and mudstone (~50%)	Finely interlaminated, light-coloured, sandy siltstone and dark coloured mudstone. Individual laminae are typically millimetre-scale in thickness.
Lithology 10 (Fig. 5.2i)	Interlaminatied subarkosic sandstone and sandy mudstone	Interlaminated mudstone and sandstone, with samples having prominent crenulation cleavage.

Based on thin section analyses, the major minerals within the ten lithologies are: quartz, metamorphic and detrital muscovite, authigenic biotite, and albite (Fig 5.3). Biotite is only found as a major mineral in lithologies 1, 2, 6, 8, and 10, as described below. Detrital feldspar grains show a variety of textures including albite twinning (Fig. 5.3a), carlsbad twinning, perthite twinning, and polysynthetic twinning. Albite grains commonly show sericite alteration with diagenetic rims (Fig. 5.3b). Detrital albite grains are low in abundance (<5%) in lithologies 3, 4 (except samples 024 and 025) and 9.

Figure 5.2. Examples of cut surfaces from all lithologies, excluding lithology 7. Descriptions of individual lithologies can be found in Table 5.1. Lithology 8 in 'g' has epoxy residue on the edges from rock cutting.

Quartz is the dominant mineral in all lithologies and with an abundance ranging from ~30–80%, with sandstone-dominant lithologies having high abundance and mudstone-dominated lithologies having low abundance. Quartz grains that are present in a muddy matrix are subangular to well-rounded, otherwise where grains are in contact with each other sutures here removed indication of grain rounding. Quartz suturing (Fig. 5.3a, b, c) is interpreted to be the main form of cementation in the rocks.

Rare detrital biotite grains which are present as individual grains (Fig. 5.3d) are typically disseminated throughout the matrix and are commonly partially altered to chlorite. Rare muscovite grains are elongate (typically 200–500 μm in length), show plastic deformation and are interpreted to be detrital in origin. Large (~100–400 μm) detrital chlorite grains are present in lithologies 3, 6, and 10, and as alteration product of detrital biotite or muscovite (Fig. 5.3f, 5.3i). More common are metamorphic authigenic mica grains which contrast in texture and abundance to the detrital grains. Authigenic biotite grains occur as ~100 μm clusters or masses of ~20 μm euhedral grains (Fig. 5.3e). Authigenic biotite is observed in lithologies 1, 2, 6, 8, and 10, and is only seen as minor occurrences in select samples from lithology 5. Fine-grained (30–50 μm) Euhedral muscovite grains that crenulation cleavage, and are found in mudstone intervals or muddy matrix in lithologies 1, 2, 4, and 5 (Fig. 5.3h, Sample 045). Euhedral, fine-grained (~10–30 μm) hydrothermal muscovite occurs in fractures or spaces between mineral grains, although these grains are only easily visible in SEM images. Fine-grained brown chlorite is present in all lithologies in variable abundances as an alteration product of mica grains.

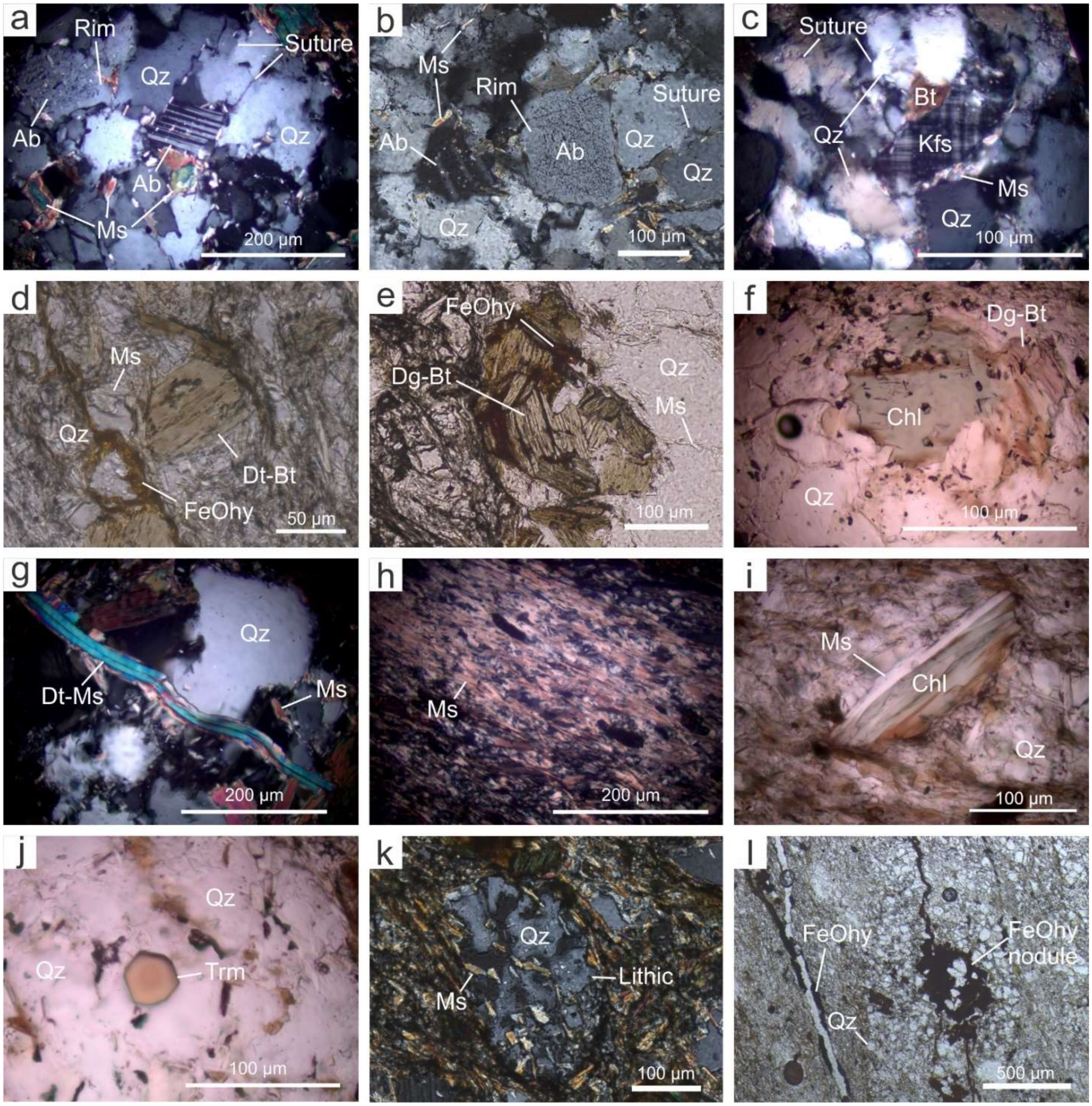


Figure 5.3. Petrographic thin section photographs. a) Detrital albite showing albite-twinning; b) diagenetic albite with an unaltered diagenetic rim; c) K-feldspar showing microcline twinning; d) rounded detrital biotite; e) authigenic biotite cluster; f) authigenic biotite with chlorite

alteration; g) deformed detrital muscovite; h) crenulated muscovite; i) detrital muscovite altering to chlorite; j) tourmaline grain; k) quartz and mica lithic clast; l) fractures containing iron-(hydr)oxide staining and an iron-(hydr)oxide nodule. Ab = albite, Dg-Bt = authigenic biotite, Dt-Bt = detrital biotite, FeOhy = iron- (hydr)oxide, Chl = chlorite, Kfs = K-feldspar, Lithic = lithic clast, Ms = muscovite, Dt-Ms = detrital muscovite, Qz = quartz, Rim = diagenetic rim, Suture = quartz suture, Trm = tourmaline.

Minor and trace minerals occur in varying abundance between samples. Detrital apatite and detrital zircon are present in all lithologies, and in samples 011 and 065 these minerals are concentrated in heavy mineral beds with ilmenite and TiO_2-minerals. Other minor (1–5%) and trace (<1%) minerals include ilmenite and TiO_2-minerals. Samples 011 and 109 of lithology 1, and sample 002 of lithology 2 additionally contain trace (<1%) amounts of detrital K-feldspar displaying cross-hatch twinning (Fig. 5.3c). Calcite is only found in pore spaces as a trace mineral in samples 001 and 011 of lithology 1. Trace detrital tourmaline (Fig. 5.3j) was observed in sample 050 of lithology 5. Fractures commonly contain iron staining, which is interpreted to be hydrothermal. Some iron-(hydr)oxide filled fractures are associated with iron-rich nodules which range from ~300 µm to mm scale (Fig. 5.3l). The iron-rich nodules preferentially occur in silt- or sand-sized layers, presumably due to greater permeability. Lithologies 2 and 4 contain trace amount of lithic clasts of a quartz-rich siltstone, which are interpreted to be intraclasts.

5.5.2 Lithofacies

Ten lithofacies (A-J) are defined based on sedimentary characteristics present in the rocks (Table 5.2). Lithofacies were grouped into two lithofacies associations based on co-occurrence of sedimentary structures (e.g. Fig. 5.4c) and the degree of similarity between facies that appear to show slight variations in the depositional setting.

Table 5.2: Summary of characteristics and interpretation of Lithofacies:

Description	Sedimentological Characteristics	Interpretation
Facies Association 1		Tidal-influenced delta
Facies A: Planar bedded, fine- to medium-grained sandstone Lithologies: 1, 2, 9	• Planar bedding (Fig. 5.4b) • Flat-lying, dark grey sandstone beds • Gradational contact with the massive mudstone of facies G • Herringbone cross-stratification (Fig. 5.4a)	• Planar bedding interpreted as low flow regime, but it is possible that these structures represent cross-sections of large cross-beds which cannot be recognized due to sample size • Bidirectional flow indicated by herringbone cross-stratification, suggesting a tidal influence in a subtidal setting
Facies B: Fine- to medium-grained sandstone with mudstone rip-up clasts Lithology: 1	• Dark grey, fining-upward, planar laminated sandstone beds • Tabular mudstone clasts (Fig. 5.4b, e) and discontinuous mudstone beds	• Mudstone rip-up clasts suggest intermittent high-energy conditions likely related to fluvial discharge
Facies C: Massive, fine- to medium-grained sandstone Lithologies: 1, 8	• Massive sandstone (Fig. 5.4f)	• Massive bedding may indicate periods of high sedimentation rates. A possible explanation could be a fluvial discharge within a deltaic setting
Facies D: Fine- to coarse-grained sandstone with mudstone laminations and thin beds (5-30% mudstone) Lithologies: 1, 2	• Flaser bedding (Fig. 5.4b, c) • Mudstone drapes • Dewatering structures are common in the form of small-scale sandstone dykes, flame structures, and loading structures	• Mudstone drapes likely produced during slack water periods suggesting tidal deposition • Dewatering structures suggest high depositional rates • Flaser bedding indicates tidal influence
Facies E: Fine- to medium-grained sandstone with current ripple cross-lamination Lithology: 2	• Centimetre-scale, current ripple cross-laminations that truncate each other (Fig. 5.4b)	• Current ripple cross-laminations suggest shallow water deposition under unidirectional flow
Facies F: Laminated mudstone and sandstone (50–80% mudstone and 20–50% sandstone) Lithologies: 2, 10	• Soft-sediment deformation (flame structures) is prevalent within interlaminated mudstone and sandstone • Some flaser to wavy bedding in sandstones • Sandstone dykes	• The mudstone was likely deposited during slack water periods in a tidal system • Soft-sediment deformation indicates high sedimentation rates

Facies G: Silty-sandy mudstone lacking internal structure (5–20% sandstone) Lithologies: 2, 6	• Massive mudstone, lacking internal structure • Dewatering of mudstone in the form of flame structures into overlying sandstones (Fig. 5.4e)	• Sands were deposited following slack water conditions over water-saturated mud • Massive mudstones could suggest deltaic conditions, possibly hypopycnal flows where plumes of mud that are less dense than seawater and settle out relatively rapidly
Facies Association 2:		Tidal flat and shallow subtidal
Facies H: Cross-bedded, fine- to medium-grained sandstone Lithologies: 4, 5, 9	• Cross laminated, the slight curvature suggests trough cross-bedding • Scour surfaces common (Fig. 5.4h, i, j)	• Cross-bedding indicates high-energy, unidirectional flow • Scour surfaces may indicate small channelized units.
Facies I: Alternating sandy siltstone and silty mudstone laminae Lithologies: 3, 4, 9	• Laminae appear cyclical in some samples • Some laminae form flaser to wavy bedding • Graded bedding with sharp contacts between beds • Scour surface sharply overlain by a sharp-based mudstone (Fig. 5.4j)	• Cyclicity of the mudstone and siltstone laminae suggest these are tidal rhythmites (Fig. 5.4h, i, k) in a tidal flat setting • Graded bedding reflects alternations in current strength • The sharp based mudstone suggest hyperpycnal flow. The sample in Figure 5.4j may be transitional with a more deltaic setting
Facies J: Weakly laminated, fine-grained silty mudstone Lithology: 4	• Poorly laminated • Possible pervasive diminutive *Phycosiphon* (Fig. 5.3j) in sample 043, which are not present in any other sample	• Siltstones with few preserved sedimentary structures may indicate rapid sedimentation • Rare bioturbation may suggest brackish-water conditions

Lithofacies Association 1 is interpreted to represent a tidally influenced delta front and includes facies A–G (Table 5.2, Fig. 5.4). The key features within this lithofacies association point to the presence of both tidal indicators and evidence of fluvial influx. The tidal component is indicated most strongly by herringbone cross-stratification and flaser and wavy bedding (Bhattacharya, 2010). Herringbone cross-stratification in facies A (Fig. 5.4a, b), indicates a bidirectional flow which could be achieved in a shallow-water tidal setting as current direction changes with ebb and flow conditions. Flaser bedding can be attributed to intermittent periods of flow, where tidal stands allow for layers of mud to be deposited. These features are the same as those described by Bhattacharya (2010) for tidal-influenced delta fronts, which are dominated by heterolithic strata, with prominent mud drapes, as well as bimodal cross-bedding.

Supporting evidence for fluvial influx is strongly suggested by the presence of mudstone rip-up clasts, massive bedding and soft-sediment deformation structures (Bhattacharya, 2010). Mudstone rip-up clasts (facies B) can be produced by distributary channels cutting through settled and packed interdistributary muds. These types of mudstone rip-up clasts are more likely to be tabular rather than rounded, indicating a short transport history. Both the massive sandstones (facies C) and soft-sediment deformation structures (facies G) require high sedimentation rates, such as those resulting from hypopycnal flows that are common in deltaic settings (MacEachern et al. 2005). These flows can result in thick accumulations that can be subsequently deformed due to their high-water content. The presence of cross lamination is also consistent with the nature of tidal-influenced deltaic deposits, which accumulate in tidal bars dissected by channels (Bhattacharya, 2010). The lack of observed bioturbations in the OD2016-D2 rocks is consistent with the Neoproterozoic age found in Chapter 4. Typical tidal-influenced deltaic deposits tend to exhibit bioturbation, but it may be more limited than other deltaic settings due to the mud-prone nature of the sediment and fluctuating environmental conditions (MacEachern et al. 2005; Bhattacharya, 2010).

Lithofacies Association 2 is interpreted to represent a shallow water tidal setting, including tidal flat deposits and is composed of Facies H–J (see Table 5.2; Fig. 5.4j-k). Facies H contains cross-bedding which indicates high-energy, unidirectional flow. These cross-beds appear to have a shallow angle and may represent trough cross-bedding within shallow channelized units. Facies I shows cyclical mudstone and sandstone that has the appearance of rhythmites and is interpreted to represent a tidal flat setting. These rhythmites, as well as the scour surfaces (Fig. 5.4 i, j) present throughout lithofacies association 2, are typical of tidal settings, as discussed by Dalrymple (2010). Facies J generally shows some preserved laminations, but in one sample (Fig. 5.4g) the facies includes abundant, diminutive *Phycosiphon* trace fossils.

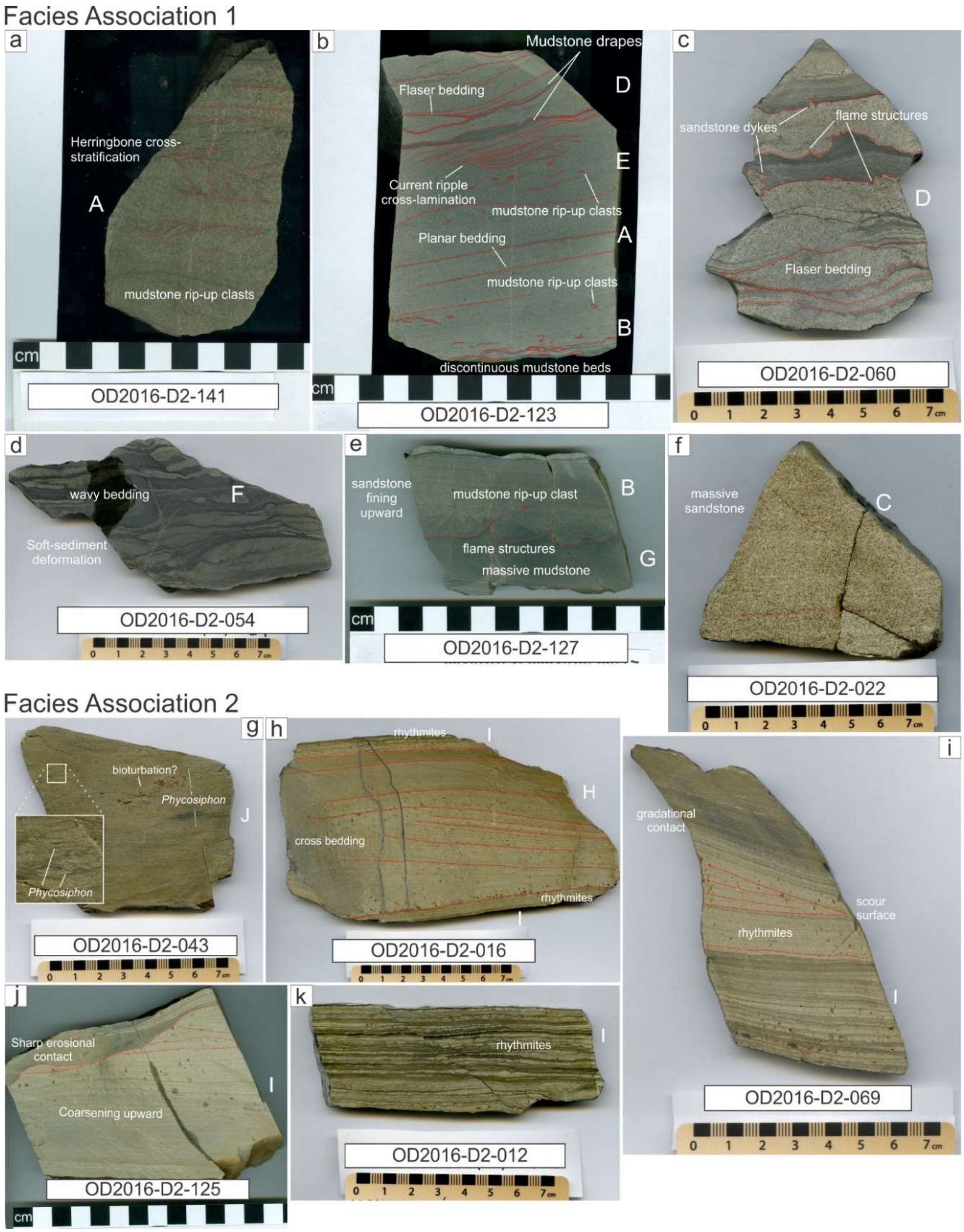


Figure 5.4. Examples of sedimentary structures in lithofacies associations 1 and 2. The facies letter is labelled next to the facies. Sedimentary features are labelled. Sample 123 in (b) shows a variety of sedimentary structures in the same rock.

5.5.3 Mineralogy and geochemistry

5.5.3.1 X-Ray Diffraction

Quantitative mineral analyses (wt%) were completed for 52 samples derived from Lomonosov Ridge using X-ray diffraction analysis (XRD). The data can be found in an unpublished report which is included as Appendix 12. The samples are very similar in their mineralogical composition. They are dominated by quartz (13–78 w%, mean=47 wt%) and muscovite (7–70 wt%, mean=32 wt%), with subordinate plagioclase (albite) (2–26 wt%, mean=16 wt%) and minor to trace chlorite (trace–12 wt%, mean=4 wt%). Samples 002 and 011 contain trace amounts of K-feldspar, 006 contains trace kaolinite, 001 contains minor calcite and sample 039 has abundant goethite. The two samples showing trace K-feldspar in XRD analysis are also those found to have K-feldspar in thin section. The goodness of fit for all samples is good to moderate with a mean value of 2.57.

The quantitative XRD results for sample 028 (lithology 6) are shown in figure 5.4. This sample was selected as a representative sample for minor amounts of mixed-layer clay minerals. There are X-ray peaks at about 15 Å and 8 Å, most probably a chlorite-smectite mixed-layer mineral. This mixed-layer mineral was also observed in samples 034, 068, and 073, as well as in trace abundances in samples 024, 026, 040, 043, 044, and 050. Based on detailed analyses of sample 028, the mixed-layer mineral was detected in the bulk fraction and not the clay-size fraction. Trace amounts of chlorite-smectite mixed-layer clays are also observed in six other samples.

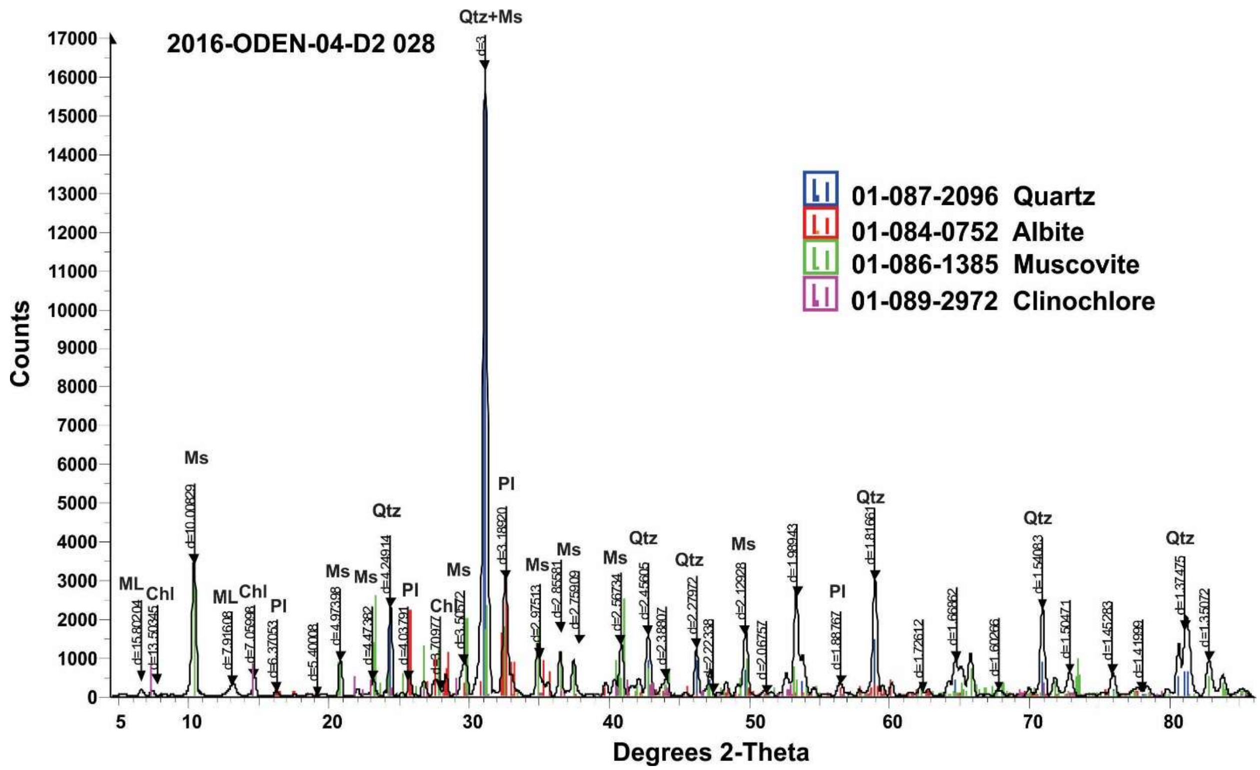


Figure 5.5. X-ray diffraction results (using Co Kα radiation) for search match using EVA software (Bruker AXS, Inc.) and ICDD database for sample 028. Chl = chlorite (clinochlore), Ms = muscovite, ML = mixed layer clay, Pl = albite, Qtz = quartz.

5.5.3.2 Mineral Chemistry

Mineral chemistry of biotite, muscovite, amphibole, orthopyroxene, and tourmaline was determined for 14 samples using EDS analysis on SEM. Additionally, quantitative chemical analyses of biotite, amphibole, and orthopyroxene were also collected for three samples using wave dispersive spectroscopy (WDS) on microprobe (Figures 5.6-5.10, Appendix 11, Table 5.3). These analyses are useful for distinguishing differences between detrital and authigenic mineral grains and comparing potential source rock types for detrital grains.

Table 5.3: Microprobe WDS analysis of selected orthopyroxene, amphibole and biotite mineral grains. Opx = orthopyroxene, Amp = amphibole, Bt = biotite, BD = below detection limit.

SAMPLE Wt%	011 Opx	011 Opx	011 Amp	011 Amp	011 Amp	011 Bt	029 Bt	029 Bt	Detection Limit
SiO_2	49.69	49.91	42.74	43.06	39.76	34.88	35.31	36.99	0.03
TiO_2	0.07	0.14	1.94	1.95	1.90	2.33	2.21	1.93	0.04
Al_2O_3	0.74	0.60	10.32	10.48	11.98	16.86	16.62	18.01	0.03
FeO_t	35.19	34.17	13.05	12.67	19.88	23.74	22.32	15.46	0.03
MnO	0.72	0.72	0.29	0.16	0.15	0.11	0.09	0.28	0.03
MgO	12.38	12.86	13.04	13.04	7.71	7.39	8.24	12.43	0.02
CaO	0.62	0.82	11.51	11.74	11.27	0.03	0.02	0.04	0.02
Na_2O	0.01	BD	1.81	1.53	1.46	0.04	0.02	0.07	0.02
K_2O	0.05	0.05	1.71	1.62	2.21	7.78	8.34	9.67	0.02
Cr_2O_3	BD	BD	0.01	BD	0.07	BD	0.02	0.06	0.04
Cl	BD	BD	0.39	0.26	0.72	0.02	0.01	0.07	0.02
F	BD	BD	0.72	0.35	0.48	0.07	0.06	0.25	0.05
TOTAL	99.47	99.26	97.54	96.87	97.59	93.26	93.26	95.27	

Biotite is most abundant in lithologies 1, 2, 6, 8, and 10, mostly as authigenic biotite (Fig 5.3e), whereas in the remaining lithologies, it is detrital and often partially altered to chlorite. For the analyzed samples, two clusters of biotite are present in the SEM data (Fig 5.6b). The biotite grains present in sample 002 from lithology 2 appear to be detrital grains in thin section and form a cluster with lower Fe/(Fe+Mg) than the cluster of authigenic biotite from the remaining lithologies. The authigenic biotite grains analyzed using WDS plot in similar clusters, and the outlier grain from lithology 5 is again a detrital biotite grain based on EDS imaging. The petrographically determined detrital biotite grains plot with a lower Fe/(Fe+Mg) ratio than the authigenic biotite in both the EDS (Fig. 5.6 a-c) and WDS (Fig. 5.6 d-f) plots. This helps in distinguishing the authigenic from detrital biotite.

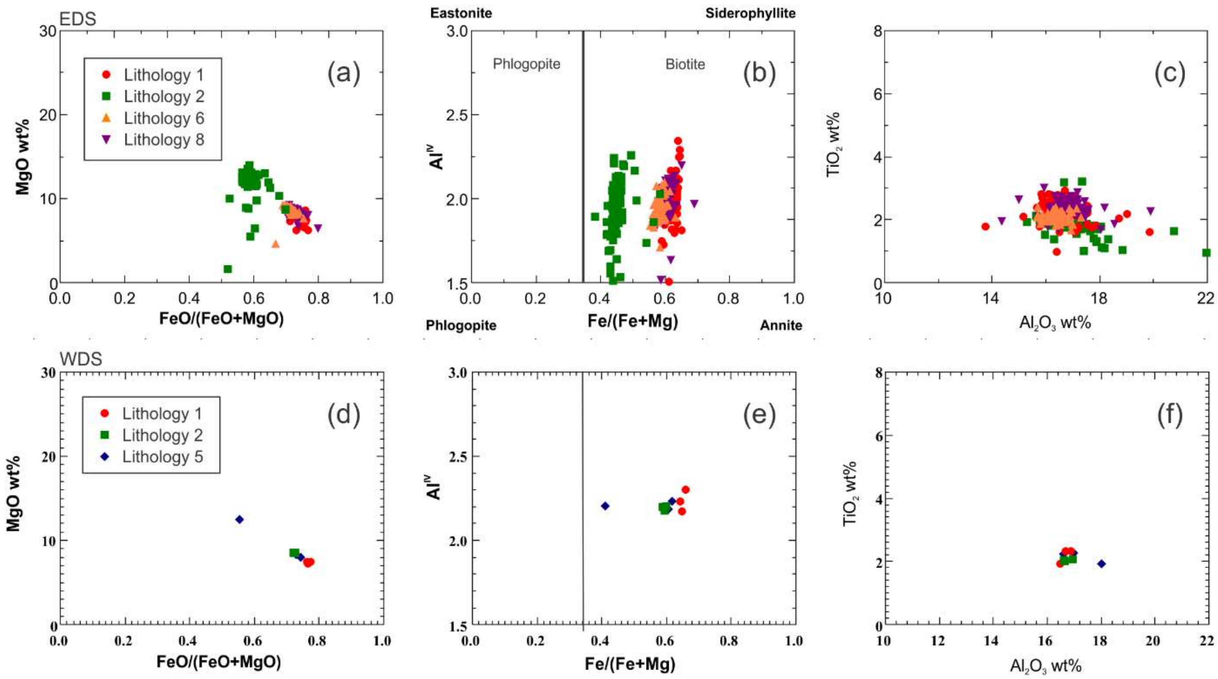


Figure 5.6. Biotite mineral plots. a-c) EDS mineral data from SEM, and d-f) WDS electron Microprobe data. The distinction between phlogopite and biotite is from Pe-Piper et al. (2009).

Muscovite grains show no significant difference in overall chemical composition between lithologies (Fig. 5.7a). Most of the analysed muscovite appear to be chemically secondary: diagenetically or hydrothermally altered, or metamorphic in origin, using the Miller et al. (1981) muscovite classification. Detrital muscovite grains can be derived from an igneous source and may be unaltered, which will plot as primary on Figure 5.7b. If muscovite grains were from a metamorphic source, underwent post-depositional metamorphism, or hydrothermal alteration, they will plot as secondary (Miller et al. 1981). The petrographically determined detrital muscovite grains (Fig. 5.3g) also plot as chemically secondary, suggesting that they have a metamorphic source or were affected by later hydrothermal alteration or partial metamorphism.

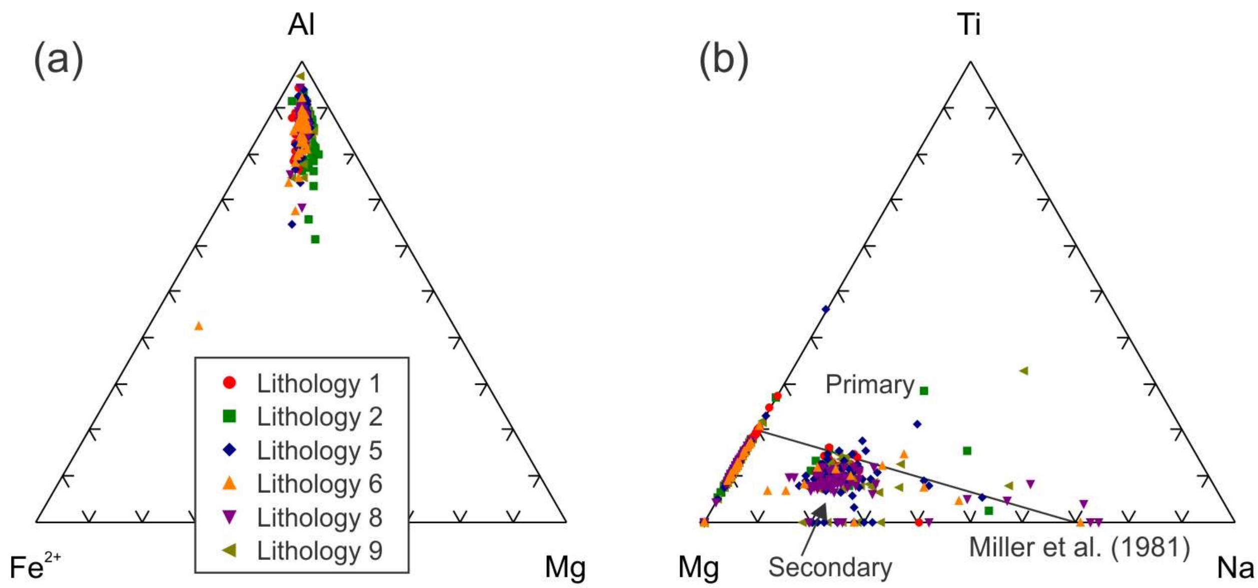


Figure 5.7. Plot of SEM muscovite analysis. a) Ternary diagram shows homogeneity between muscovite grains between lithologies. b) OD2016 samples showing mostly secondary nature, the ternary classification of muscovite is from Miller et al. (1981) and the primary vs. secondary line is from Pe-Piper et al. (2009).

SEM analysis of the heavy mineral separates identified a total of 156 zircons grains, compared to ten amphibole, seven orthopyroxene, and four tourmaline grains. No garnet was found. This dominance of zircon in the heavy mineral fraction is discussed below: it may indicate either a polycyclic source or diagenetic destruction of other less stable minerals.

Four tourmaline grains were only found in lithologies 2 and 5 and have been classified using fields from Henry and Guidotti (1985) and Kassoli-Fournaraki and Michailidis (1994) to define potential source rocks types (Fig. 5.8). One grain from lithology 5 was analyzed twice (explaining the fifth data point). Pe-Piper et al. (2009) in Lower Cretaceous sandstones from the Scotian Basin to distinguish tourmalines based on source type: type 1 representing a granitic source; type 2 representing metapelitic and calc-silicate sources; type 3 representing a meta-ultramafic source; and type 4 representing a metapelitic and psammitic source. Using this classification, the four tourmaline grains fit into all four of Pe-Piper et al.'s (2009) types. However, figure 5.8b shows the tourmalines are sourced from a mixture of Li-poor granites, and Ca-poor metapelite, Ca-poor metapsammite or type 3 (Pe-Piper et al. 2009). These results are based on only four tourmaline grains and thus the data are not statistically significant and interpretations should be considered with caution; however, the data appears to suggest granitic and metapelitic sources.

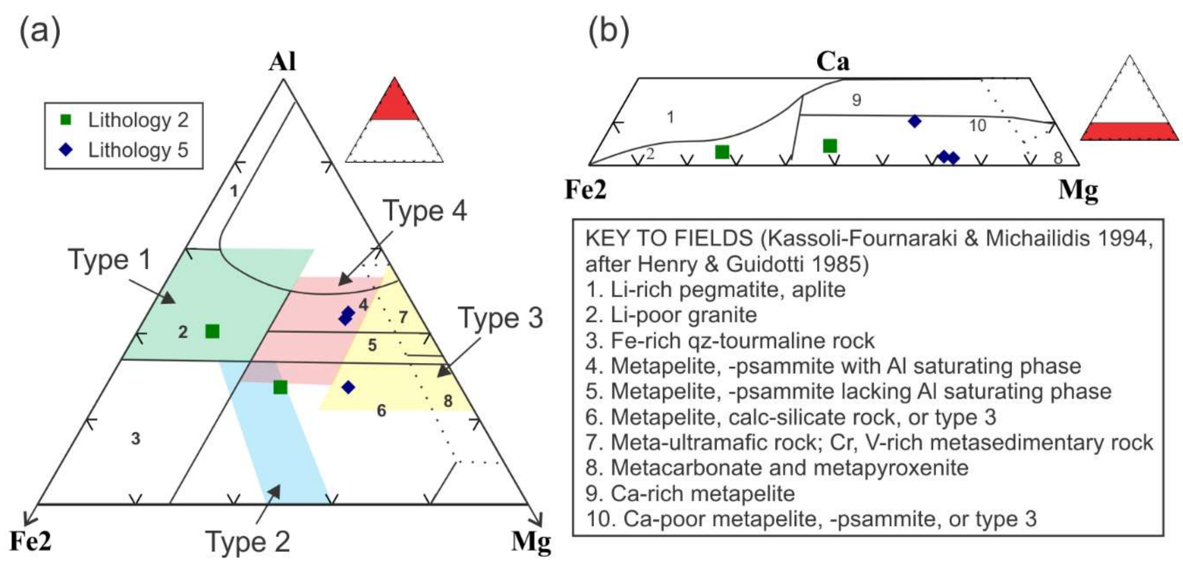


Figure 5.8. Tourmaline plots using SEM mineral chemistry. Fields from Henry and Guidotti (1985) and Kassoli-Fournaraki and Michailidis (1994), tourmaline types 1-4 from Pe-Piper et al. (2009).

A total of seven orthopyroxene grains from lithology 1 and lithology 4 were obtained from heavy mineral separation; no clinopyroxene was detected. Using the fields from Morimoto (1988), grains were found to encompass both the Mg-rich end member enstatite and Fe-rich end member ferrosilite (Fig. 5.9). Both enstatite and ferrosilite occur in lithology 4; whereas only ferrosilite was found to be present in lithology 1. The presence of these orthopyroxenes suggests there could be a granitic or gabbroic, or metamorphic component to the source. Due to the limited number of grains it is unknown whether clinopyroxenes might be present in the rocks, which may be more indicative of source.

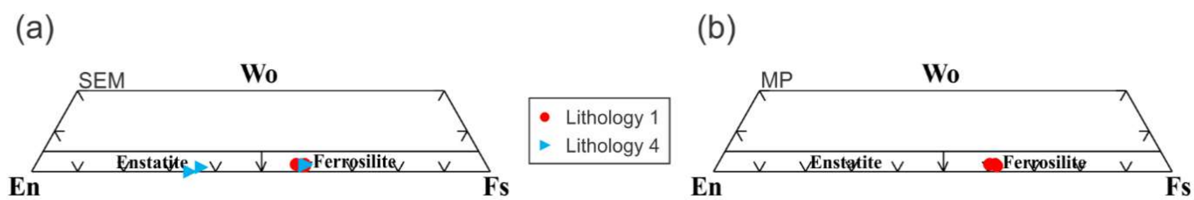


Figure 5.9. Orthopyroxene chemistry plot using: (a) SEM analyses, and (b) Microprobe WDS analyses. Fields for (a) and (b) from Morimoto (1988).

Detrital amphibole was found in lithologies 1, 6, and 8 (Fig. 5.10). The EDS data in figure 5.10a shows the amphibole grains are magnesiohornblende, whereas the WDS data taken from the same amphiboles are pargasite. Their high aluminum content suggests that they were crystallised in the range of 0.4–0.8 GPa (Fig. 5.10d). The WDS data (figure 5.10d) yield higher Al^{iv} than the SEM data. This pressure range for the given temperatures is similar to the formation conditions for hornblende in felsic plutons examined by Hammarstrom and Zen (1986).

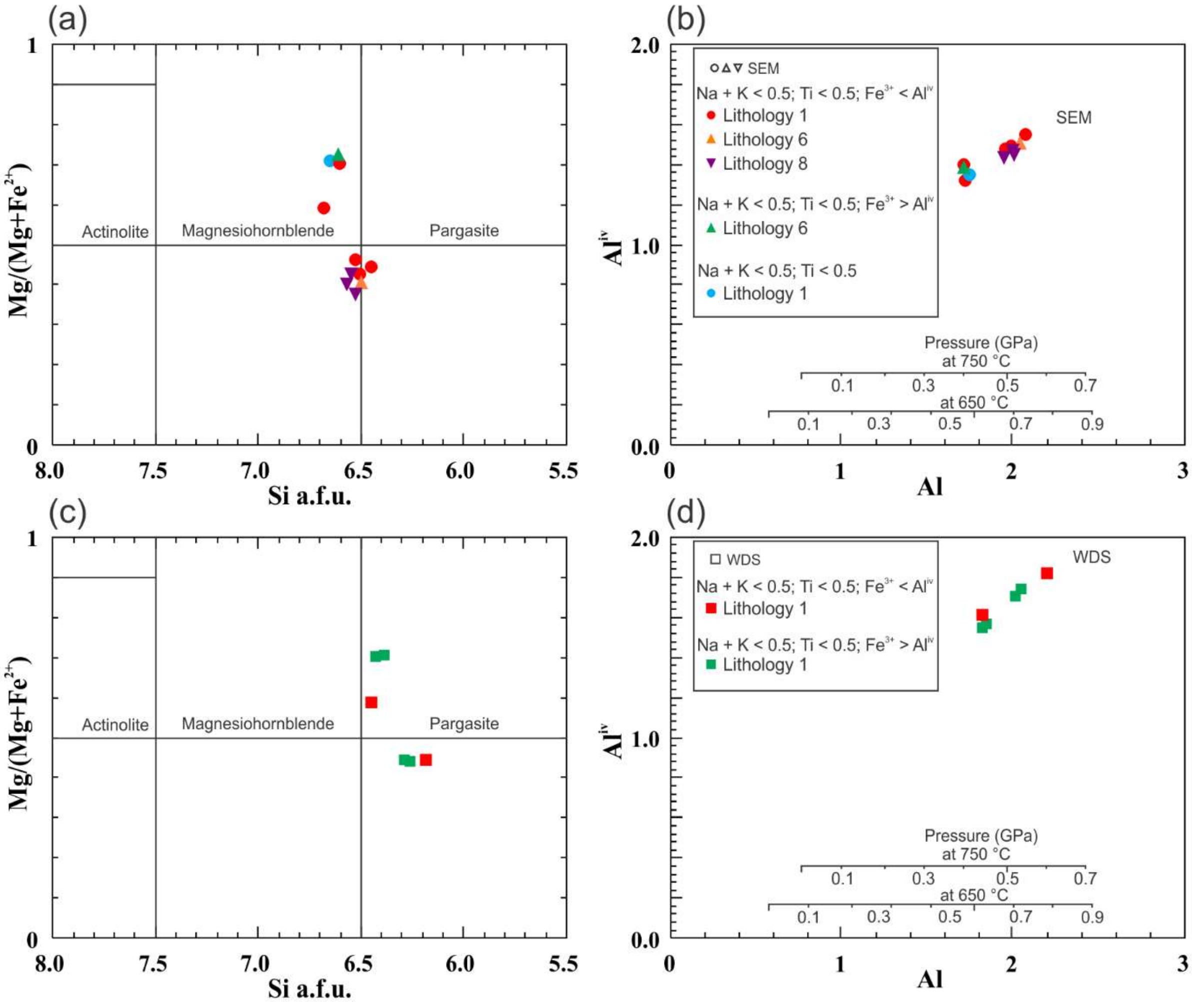


Figure 5.10. Amphibole mineral chemistry plots using: a-b) SEM EDS analyses, and c-d) WDS microprobe data. Al^{IV} vs. Al^{total} plot, with temperature and pressure bars adapted from Hammarstrom and Zen (1986) and Pe-Piper et al. (2009).

5.5.3.3 Whole Rock Geochemistry

Whole rock geochemistry of the OD2016-D2 samples (Appendix 14, Table 5.4) shows a consistent rare-Earth element (REE) fingerprint among the 30 analyzed samples comprising lithologies 1 through 10, except for 7 (not analyzed). Resultant REE plots (Fig. 5.11a, b) show a negative europium anomaly, which is consistent with the interpretation of a granitic source (Bhatia 1985).

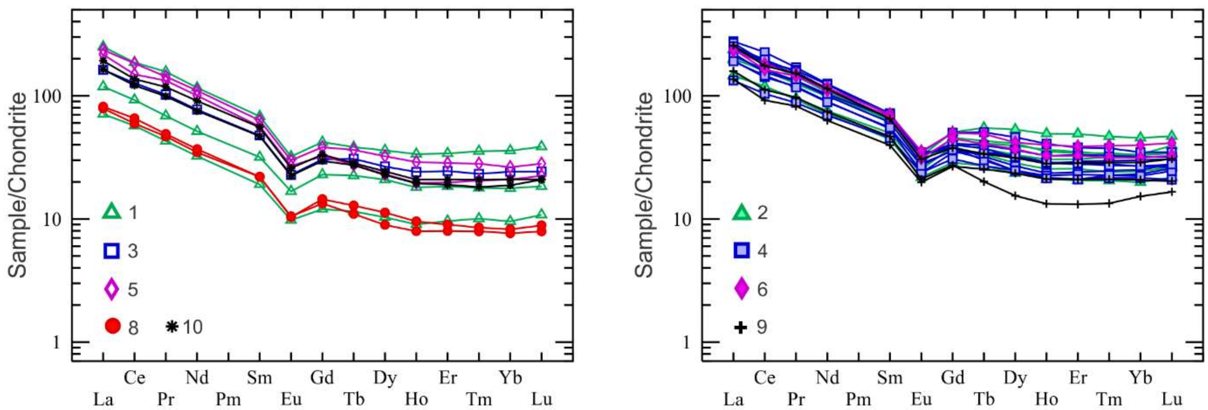


Figure 5.11. REE plots of the OD2016 samples. Lithologies were separated on the plots to make them more visible: on the left are lithologies 1, 3, 5, 8, and 10 and plots on the right include lithologies 2, 4, 6, and 9. Values for chondrite and primitive mantle are from Sun and McDonough (1989).

The elements Cr, Ni, and Mo are anomalously high in six samples; an order of magnitude or greater than the other samples (Table 5.4). Cr occurs primarily in mafic to ultramafic rocks and Mo occurs primarily in granitic rocks (Krauskopf & Bird, 1967), and as such it is unusual for them to be in high abundances together. These are, however, common elements in steel-alloys (Cunat 2004), and contamination from steel is a likely explanation. Any contamination would have been derived from breaking the samples with tools to sizes usable for processing and not from the McCrone mill as it uses agate crushing discs. Sample 22 shows an example of anomalously elevated Cr and Mo.

Table 5.2: Whole rock analyses and detection limit of representative rock fragments.

Major Elements (wt%)									
Sample	001	002	011	022	054	060	063	068	Detection Limit
Lithology	1	2	1	8	2	2	6	3	
SiO_2	78.68	58.96	83.29	84.78	69.97	73.24	52.28	61.12	0.01
TiO_2	0.35	0.943	0.303	0.196	0.635	1.287	1.206	0.805	0.001
Al_2O_3	7.29	17.48	7.22	6.1	11.98	8.51	23.28	17.68	0.01
$Fe_2O_{3(T)}$	3.52	7.04	2.83	3.23	7.84	11.04	6.09	6.65	0.01
MnO	0.072	0.056	0.02	0.024	0.057	0.073	0.041	0.054	0.001
MgO	0.91	3.92	0.48	0.84	2.19	1.5	2.02	1.88	0.01
CaO	2.57	0.34	0.09	0.14	0.32	0.21	0.39	0.17	0.01
Na_2O	1.97	0.36	1.21	1.41	1.46	1.19	1.28	2.57	0.01
K_2O	1.5	5.1	1.88	1.14	2.97	2.14	7.43	3.74	0.01
P_2O_5	0.09	0.23	0.03	0.07	0.2	0.14	0.28	0.13	0.01
LOI	2.52	3.95	1.09	1.96	2.55	0.87	4.13	3.77	
Total	99.45	98.38	98.43	99.9	100.2	100.2	98.43	98.56	0.01
Trace Elements (ppm)									
Nb	16.6	19	5.3	4.2	9.9	13.7	24.4	14	0.2
Mo	< 2	< 2	2	33	4	8	< 2	< 2	2
Zr	205	189	231	153	211	1250	334	162	1
Y	30.7	39.8	14.9	12.6	32.5	47.3	61.5	36.4	0.5
Rb	67	189	59	48	108	88	289	226	1
Sr	233	49	64	55	77	65	90	91	2
Ba	267	948	439	187	547	376	1619	559	2
U	1.78	2.42	1.75	0.79	2.09	3.52	3.69	2.04	0.01
Th	6.24	16	4.96	3.88	10.7	23.4	19.8	16.5	0.05
Pb	9	9	10	11	15	18	10	19	5
Hf	5.5	4.8	6	3.5	5.6	29.7	8.8	4.5	0.1
Sc	5	17	4	3	10	9	26	17	1
Cr	30	80	50	910	90	200	80	60	20
V	34	116	33	28	74	73	180	106	5
Ni	< 20	30	< 20	620	30	20	< 20	< 20	20
Ga	8	23	8	6	15	12	36	23	1
Zn	40	80	< 30	30	80	60	70	100	30
Cu	60	30	130	30	230	680	40	30	10
Co	5	18	3	10	12	11	8	8	1
La	28.1	56	16.8	18.7	34.3	56.7	55.1	38.5	0.05
Ce	56.5	113	34.9	36.4	73.1	121	111	77.6	0.05
Pr	6.52	13.6	4.08	4.44	8.85	13.7	14.2	9.69	0.01
Nd	24	51.4	15.1	16.2	33.4	49.8	54.2	36	0.05

Sm	4.85	9.94	2.91	3.36	6.77	9.58	10.8	7.27	0.01
Eu	0.97	1.77	0.566	0.608	1.26	1.93	2.05	1.32	0.005
Gd	4.7	7.89	2.47	2.74	5.9	8.26	10.2	6.25	0.01
Tb	0.84	1.25	0.43	0.41	1.01	1.39	1.83	1.15	0.01
Dy	5.29	7.22	2.62	2.27	5.96	8.43	10.6	6.76	0.01
Ho	1.02	1.44	0.51	0.45	1.19	1.72	2.25	1.36	0.01
Er	3.04	4.23	1.59	1.32	3.4	5.06	6.41	4.05	0.01
Tm	0.455	0.61	0.256	0.202	0.521	0.808	1	0.592	0.005
Yb	3.01	4.15	1.62	1.3	3.37	5.69	6.75	4.11	0.01
Lu	0.467	0.666	0.274	0.201	0.551	0.998	1.05	0.615	0.002

5.6 Discussion

5.6.1 Paleogeography

With a maximum depositional age of 973 ± 37 Ma (Chapter 4), the OD2016-D2 rocks may have been deposited during the breakup of Rodinia into a shallow rift basin. Due to the nature of dredge samples, there is uncertainty regarding the relationship between individual rock samples and between lithofacies associations. Lithofacies association 1 is interpreted to represent a tidally influenced delta front setting and lithofacies association 2 is interpreted to represent a shallow water tidal or tidal flat setting. Indicators of tidal influence in Lithofacies Association 1 include: flaser bedding and associated mudstone drapes, as well as herringbone cross-stratification; and in Lithofacies Association 2: flaser and wavy bedding, tidal rhythmites or alternating sand/silt and mud, as well as reactivation or scour surfaces (cf. Dalrymple, 2010).

Similar tidal facies have been previously described from Precambrian rocks. Klein (1971) studied the late Precambrian, Lower Fine-grained Quartzite of Islay, Scotland, and reported tidal flat and subtidal facies. His facies 1 is a quartzose sandstone interpreted to have been deposited in both shallow sub-tidal, tide-dominated and lesser lower tidal flat, intertidal environments. The sedimentary features observed include: massive bedding with planar geometry, planar and trough cross-bedding, mudstone drapes, wavy and flaser bedding, and herringbone cross-stratification

(Klein, 1970). Accordingly, facies 1 from Klein (1971) resembles Lithofacies Association 1 of the present study, including the presence of massive bedding in Facies C (Fig. 5.4f) and wavy and flaser bedding (Fig. 5.4b, c, d) and herringbone cross-stratification in our facies A (Fig. 5.4a).

The second facies described by Klein (1971) is a siltstone-mudstone facies, which was interpreted to have been deposited in an intertidal setting. These strata included lenticular-bedded mudstones that grade upward into alternating fine-grained sandstone and mudstone that resemble tidal bedding (Wunderlich 1970). These lenticular bedded mudstones likely formed by alternating tractional tidal current deposition of sand and slack-water suspension settled mud (Reineck and Wunderlich 1968). Klein (1971) also observed tidal bedded couplets, which are not observed in the OD2016-D2 rocks; however, this facies resembles our Lithofacies Association 2 based on the grain size and coarsening (Fig. 5.4j) and fining-upward units (Fig. 5.4i). The OD2016-D2 rocks also show alternating fine-grained sandstone and mudstone laminae which are interpreted as tidal rhythmites, with the alternation of the siltstone and mudstone beds appearing to be cyclical (Fig. 5.4k). This comparison between the Precambrian tidal facies of Klein (1971) and the OD2016-D2 samples shows that it is possible to form ancient tidal successions and would be consistent with the Neoproterozoic age found in Chapter 4.

Despite this clear comparison to the Lower Fine-grained Quartzite of Islay, Scotland, the presence of trace fossils presents some uncertainty regarding a Neoproterozoic age. There was no bioturbation or trace fossils are present in all but one of the lithofacies, and in a single rock sample (043). There is potential for other bioturbational structures to be present in discrete samples, but we have instead described these features as soft-sediment deformation in the form of flame structures or sand dykes. The *Phycosiphon* trace fossils (Fig. 5.4g) which are present in sample 043 of lithofacies J show that these rocks have been locally bioturbated. This sample lithologically matches that of other rocks of lithology 4 and their WRA chemistry shows no major differences between all samples, including 043. In the work by Crimes (1992), *Phycosiphon* was found in Middle Ordovician and later rocks. Similarly, Wetzel and Bromley (1994) indicated that this ichnofossil was present in Paleozoic strata to modern sediments and in shallow to deep marine settings. The oldest general trace fossil occurrences are late Neoproterozoic (younger than 560 Ma) and are typically horizontal, unbranched trails or burrows formed near the sediment surface, with more complex, deeper tiers forming later in the Cambrian (Jensen 2003; Jensen and Runnergar 2005). Accordingly, the present evidence suggests that the Proterozoic U-Pb zircon ages (Chapter 4) may not represent the depositional age, at least for this particular sample. If diminutive *Phycosiphon* is present, facies J in sample 043 may reflect a deeper subtidal environment, farther from fluvial input, due to the extent of reworking by the trace makers. Three alternative interpretations include: 1) the identification of *Phycosiphon* is incorrect and these rocks are older, as interpreted in Chapter 4; 2) there are two groups of rocks, and the one with *Phycosiphon* is younger than 560 Ma; or 3) there is the possibility that sample 043 is a piece of ice-rafted detritus, however the lithological and chemical characteristics are highly similar to the other rocks, so this is unlikely. No bioturbation is observed in Lithofacies Association 1, which may reflect the Neoproterozoic age of deposition (Chapter 4).

5.6.2 Provenance

Considering that the whole rock geochemistry of the OD2016-D2 samples is similar for all analyzed lithologies (Fig. 5.11), it is likely they have the same sources. The major mineral components of these rocks – quartz, albite, muscovite, and, in five lithologies, biotite – suggests the primary source material was felsic. The presence of both albite and K-feldspar in the rocks further implies a granitic source, as does the strong Eu anomaly in their whole rock geochemistry (Fig. 5.11) (cf. Bhatia 1985). Heavy mineral separation yielded poor recovery, but included hornblende, orthopyroxene, tourmaline, zircon, apatite, and ilmenite. The rare hornblende and orthopyroxene grains indicate an igneous or metamorphic source. The minerals garnet and spinel were not recovered which are normally reliable indicators of provenance (Tsikouras et al. 2011, Fleming et al. 2016). Although tourmaline is generally considered to be useful in provenance studies (Hinsberg 2011, Tsikouras et al. 2011), the small number of grains present makes it undiagnostic in this study; however, tourmaline and zircon are common minerals in granites and metapelites. Tourmaline chemistry, based on Figure 5.8a and using the classification from Pe-Piper et al. (2009), suggests a possible wide variety of sources are present including granites, metapelites, calcsilicates, and meta-ultramafic rocks. Figure 5.8b shows the tourmalines are sourced from a mixture of Li-poor granites, and Ca-poor metapelite, Ca-poor metapsammite or type 3 from Pe-Piper et al. (2009). These interpretations are consistent with the granitic source as interpreted in Chapter 4, though they reveal the source rock lithology also includes metamorphic rocks and mafic igneous rocks. A larger sample size of tourmalines would make any interpretation more statistically robust, so for now the data must be interpreted cautiously.

Using the interpreted Scandinavian source from Chapter 4, we discuss possible candidates for zircon source rocks and compare their mineralogy with that found in the heavy mineral separates of the present study. Many of the comparable zircon distributions were found in metasedimentary rocks from northern Norway, including those in the Kalak Nappe complex and the Dividal Group (Chapter 4). The OD2016-D2 samples which were discussed in Chapter 4 (and references therein) were interpreted to have sources including the Transscandinavian Igneous Belt, Gothian Igneous Complex, and rocks related to the Svecofennian and

Sveconorwegian orogenies (Andresen et al. 2014; Gee et al. 2014). There are too many granites among these to discuss all of them; however, we present some generalized mineralogy for the more extensive granitic units.

The Transscandinavian Igneous Belt (1850–1650 Ma) (Gee et al. 2014) is part of the Svecofennian Orogenic belt (2000–1800 Ma) (Gorbatschev and Bogdanova 1993) and most commonly contains alkali-calcic I- and A-type granites (Högdahl et al. 2004). These are quartz-monzogranitic to monzodioritic plutonic rocks that are flow-textured and coarse- to medium-grained. They mineralogically consist of quartz, K-feldspar, plagioclase, amphibole, biotite, ortho- and clinopyroxene, and rarely olivine (Högdahl et al. 2004). The Gothian Igneous Complex of similar age formed from arc-related magmatism during the Gothian orogeny (1.73–1.5 Ga) (Andersen et al. 2007). Various ages of granitic magmatism are present within the Gothian Igneous Complex and commonly include amphibole and orthopyroxene (Skar 2000), which are also present in heavy mineral separates. The Rapakivi granites include Early Proterozoic (1.65 Ga) A-type granites from southern Finland (Gorbatschev and Bogdanova 1993; Rämö and Haapala 1995; Åhäll and Gower 1997).

Post-kinematic granitoids (Central Finland Granitoid Complex) considered to be related to the Svecofennian orogeny (Elliott et al. 1998) and were emplaced in central Finland between 1.88–1.87 Ga. These plutons range from biotite and/or hornblende quartz monzonite to syenogranite. These mineralogically consist of quartz, feldspar, biotite, amphibole, ortho- and clinopyroxene, and rarely olivine (fayalite) (Elliott et al. 1998). Finally, the Sveconorwegian orogeny produced granitoid magmatic events in southern Scandinavia and is younger than the other three main identified potential sources, occurring between 900–1150 Ma (Bingen et al. 2021).

Based on previous correlations of zircons ages (Chapter 4) and the minerals present in the OD2016-D2 rocks, granites and metamorphic rocks from Scandinavia are the likely sources. The Eu-anomaly confirms granitoid rocks as part of the provenance. This interpretation is further supported by tourmaline grains showing a granite source. The source appears to be the same for all lithologies based on whole rock geochemistry (Fig. 5.11). Accordingly, granitoids and metasedimentary rocks from the Transscandinavian Igneous Belt, Gothian Igneous Complex, and rocks related to the Svecofennian orogeny and Sveconorwegian orogeny are the most likely sources. Mineral chemistry of tourmalines from these source areas could be compared as more data become available in an attempt to further specify source provenance.

A high abundance of detrital zircon grains were recovered from the OD2016-D2 rocks compared to the relatively few tourmaline, hornblende, and orthopyroxene. These latter minerals tend to be less chemically stable than zircon (Morton and Hallsworth 1994). The high abundance of zircon may then indicate a polycyclic supply, selectively eliminating less stable mineral grains from the original source rocks.

5.6.3 Diagenesis

The presence of authigenic biotite and chlorite suggests that these rocks were metamorphosed at greenschist facies (Fig. 5.3e), which is consistent with the metamorphic grade interpreted from the nearby LOMROG-III dredge rocks (Knudsen et al. 2017). Using the presence of authigenic biotite, we can distinguish the lithologies of higher-grade greenschist facies with biotite (1, 2, 6, 8, 10) from those of lower-grade greenschist facies with only chlorite (3, 4, 5, 9). The one exception to this is that lithology 5, which in certain samples contains traces of authigenic biotite. Authigenic biotite is interpreted to have formed in the lithologies which underwent slightly higher pressures and/or temperatures due to enhanced burial. Considering most textures in Figure 5.3 do not show evidence of structural deformation and the biotite are equant and do not show evidence of foliation, it is possible that they have formed from hydrothermal processes. These metasedimentary rocks may have been the result of the Caledonian Orogeny overprinting the area (Knudsen et al. 2017).

Wilkinson et al. (2001) showed that K-feldspar in various sedimentary basins declines in abundance with increasing depth, and is highly depleted between 3–4 km of burial depth and nearly absent below 4.5 km. Based on the lack of K-feldspar found in all but three of the OD2016-D2 samples (002, 011, and 109), it is reasonable to believe that the maximum burial depth of the strata was likely >3 km, possibly >4 km burial for most samples (Wilkinson et al. 2001). The duration of burial also may have affected the dissolution of K-feldspar (Milliken 1988). The OD2016-D2 rocks could be from different strata with the same source, with the presence of limited K-feldspar occurring somewhat higher in the stratigraphic section (Fig. 5.13a).

Mixed layer clays are present in 11 out of the 52 XRD samples (Fig. 5.9). Mixed layer clays occur as intermediate products of reactions involving end member clays (Środoń 1999). Although it was not determined which clay minerals are present (Appendix 12), their presence is evidence of either metamorphic or hydrothermal conditions (Środoń 1999). The two samples containing K-feldspar which were analysed for XRD analysis are not reported to contain mixed layer clays, so the significance of mixed-layer clays is unclear.

Orthopyroxene and amphibole are among the first minerals lost during weathering and diagenesis (Morton and Hallsworth 1994, 1999). These two minerals are present in both lithofacies associations, suggesting that the rocks may not have undergone a significant degree of diagenesis beyond the loss of K-feldspar. Orthopyroxene is present with K-feldspar, biotite and no observed chlorite in sample 011. Detrital orthopyroxene is also present in sample 024, which includes chlorite and few biotite grains. Garnet was not found in the rocks which suggests burial was >3.5 km (Morton and Hallsworth 1999). This burial depth would be consistent with the absence of K-feldspar in most of our rock samples. If garnet is present, it may occur in the samples which contain K-feldspar, however our sampling was not sufficient to observe it.

A paragenetic sequence has been proposed for the lithologies of Lomonosov Ridge based on petrographic relations between minerals (Fig. 5.12). The first part of the sequence (Fig. 5.12a) includes detrital mineral grains. Diagenesis caused K-feldspar to dissolve (Wilkinson et al. 2001); the mica matrix to recrystallize, forming chlorite, and the quartz grains sutured and formed overgrowths. Crenulation cleavage due to low grade metamorphism overprinted the rocks. Rutile and monazite are present in the samples and are not deformed suggesting they formed after the crenulation cleavage occurred. Fractures crosscutting the rocks and separating the sutured quartz shows the fractures occurred post-matrix recrystallization (Fig. 5.12b). The timing of these fractures is uncertain, though it is likely that that they formed during exhumation. A late iron-hydroxide mineralization infilling fractures occurred during or after fracturing. Calcite is present in few samples as filling pore space. With the eventual exposure on seafloor, manganese hydroxide crusts began to form on the outside of the samples, as they occur on the surfaces of the rocks.

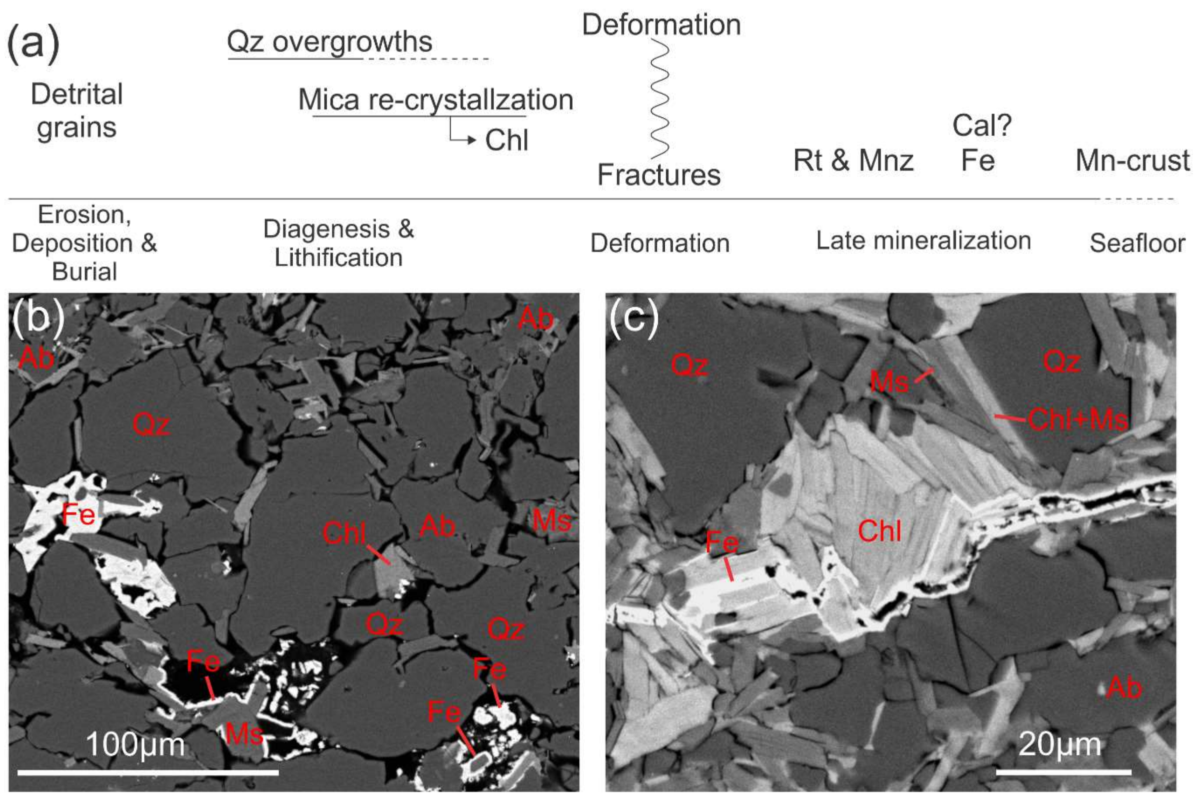
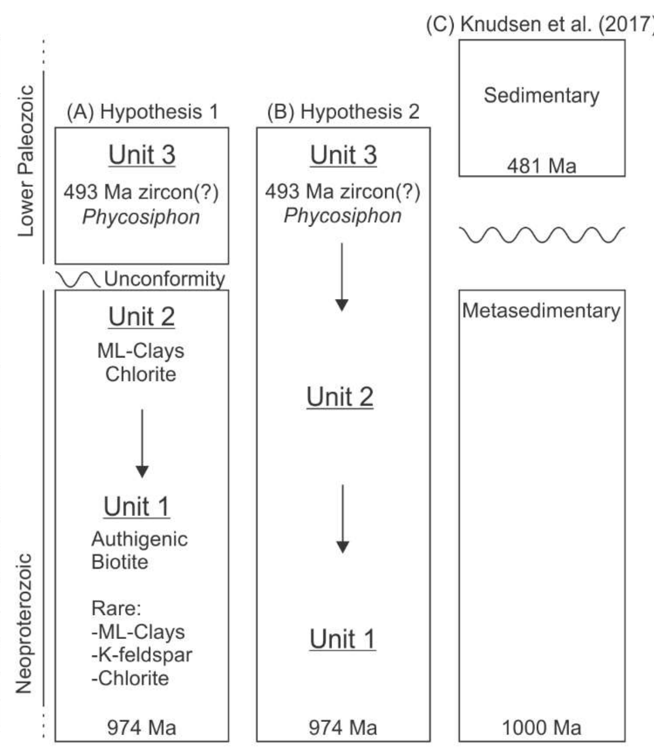


Figure 5.12. (a) Proposed paragenetic sequence from petrographic observations of Lomonosov Ridge SEM images, beginning with detrital mineral grains to exposure at seafloor and formation of ferromanganese crusts. (b, c) The SEM images here show iron (hydr)oxides both coating mineral grains (left) and filling fractures (right). Ab = albite, Chl = chlorite, Cal = calcite, Fe = iron-(hydr)oxide, Ms = muscovite, Qz = quartz, Rt = rutile, Mnz = monazite.

Based on the presence of authigenic biotite, we can separate the OD2016-D2 samples into two main stratigraphic units (Figure 5.13). Unit 1 is higher-grade greenschist facies than Unit 2 and contains authigenic biotite. Unit 2 is lower-grade greenschist facies based on the general lack of authigenic biotite and common presence of chlorite. In addition, a third unit can also be designated, Unit 3, in many respects similar to Unit 2, but may be much younger. Unit 3 includes sample 018, which contains a single anomalous detrital zircon U-Pb age of 493 Ma (Chapter 4), and sample 043 which has *Phycosiphon* trace fossils. The rocks in Unit 3 may be Lower Paleozoic age based on the 493 Ma age and the presence of *Phycosiphon* ichnofossils, which are not known from pre-Paleozoic strata (e.g. Crimes, 1992; Wetzel and Bromley, 1994). The other samples of Units 1 and 2 are void of bioturbation, which is otherwise very common in tidal facies from the Cambrian (e.g. Hantsoo et al. 2018). As such, Unit 3 is considered to be younger than Units 1 and 2, the latter units have a maximum depositional age of 973 ± 37 Ma (Chapter 4). A summary of the features present in each Unit can be found in Figure 5.13. The detrital zircon data are reported as $^{206}Pb/^{238}U$ ages filtered at <10% discordance for consistency with the data presented in Knudsen et al. (2017). Accordingly, in the OD2016-D2 samples, the anomalous zircon is 493 Ma and is interpreted to represent the maximum depositional age using the U/Pb ages is 974 Ma instead of 973 Ma with Concordia ages.

Summary

	Unit 1	Unit 2	Unit 3
Lithologies	1, 2, 6, 8, 10	3, 4, 5, 9	4
K-feldspar	1, 2		
Authigenic Biotite	1, 2, 6, 8, 10	5 (rare)	
Chlorite	Rare	Common	Common
ML-clays	10 (R)	3, 4 (C)	
Greenschist grade	Higher	Lower	Lower
Localized sheared muscovite (rare)	2, 10	4	
Alignment of muscovite matrix	1, 2, 10	4, 5	
Amphibole	1, 6, 8		
Orthopyroxene	1	4	
Tourmaline	2	5	
Facies Association	Delta front	Tidal flat	Marine
Phycosiphon			4 (043)
Zircons sampled	1, 8	4, 5	4
>493 Ma Zircon(?)			4 (018)
>970 Ma Zircon	1, 8		
>1000 Ma Zircon	8	4, 5	
Zircon groups	Independent of the Units		



= Lithology; (#) = sample number; R = Rare; C = Common; ML = Mixed-layer

Figure 5.13. Data summary by Unit and stratigraphic hypotheses for the dredge rocks from Lomonosov Ridge.

Based on the information from each of the three units, we can formulate models to explain the results and rock units sampled from Lomonosov Ridge. Hypothesis 1 (Fig. 5.13A) is that Units 1 and 2 are both representative of Neoproterozoic strata. Unit 1 has undergone a higher degree of burial, which accounts for the higher-grade greenschist facies metamorphism, and lower abundance of mixed-layer clays and chlorite. Comparatively, Unit 2 is from a stratigraphically higher interval than Unit 1 based on its near-lack of authigenic biotite implying lower-grade greenschist facies metamorphism. Units 1 and 2 are considered to be part of a continuous succession based on the similarities in source provenance and overall shallow-water tidal paleoenvironments. In the latter case, the presence of rare authigenic biotite in lithology 5 from Unit 2 may represent a transitional interval between units. Finally, Unit 3 appears to be much younger in age and represents Paleozoic strata. The presence of abundant *Phycosiphon* in sample 043 suggests a more distal paleoenvironment and more normal marine conditions that also contrast with the tidal settings of Units 1 and 2. If the maximum depositional age of Units 1 and 2 is correct, there is likely a significant stratigraphic gap between them and Unit 3, which may be explained by an unconformity, although strata representative of this gap may not have been sampled by the dredging process.

Hypothesis 2 (Fig. 5.13B) suggests that all three units represent continuous deposition, based on their lithological similarities. The WRA geochemistry shows no significant differences between any of the units, heavy minerals are relatively consistent between the units even with the poor recovery, and the zircon groups discussed in Chapter 4 are independent of the units.

However, hypothesis 2 does not adequately explain the disparity between the maximum depositional ages from zircon geochronology and the presence of *Phycosiphon* and the one anomalous zircon age. An alternative hypothesis that Unit 3 represents IRD is rejected because of the lithological similarities of these two samples as compared to all the other samples.

Knudsen et al. (2017) interpreted the tectonostratigraphy of the LOMROG-III dredge rocks from Lomonosov Ridge to comprise an unmetamorphosed sedimentary rock unit discordantly overlying metasedimentary arkose. Their sedimentary rocks do not appear to match any of our units based on the current data. Specifically, the detrital zircon U-Pb ages from the LOMROG-III sedimentary rocks have the youngest zircons of ~500 Ma, with a maximum depositional age (MDA) of 481 ± 12 Ma. The age peak distribution includes common 0.5–0.7 Ga zircon and is thus quite different from our sample 018, which contains the questionable 493 Ma detrital zircon grain, and implies a different provenance (Knudsen et al. 2017). Their sedimentary rocks are also reported to retain primary porosity and to have significantly less plagioclase than the metasedimentary rocks. Our Unit 3 rocks do not have these characteristics and still show low greenschist-facies, so we place below the sedimentary rocks of Knudsen et al. (2017).

The heterolithic metasedimentary samples of Knudsen et al. (2017) show primary bedding that is reported to be commonly folded with a well-developed schistosity oblique to bedding. Although in some OD2016-D2 rocks muscovite show crenulation cleavage (Fig. 5.3h) that appears to have similar metamorphic grade to the muscovite from Knudsen et al. (2017), the foliation is parallel to bedding. The petrographic descriptions of the LOMROG-III dredge rocks from Knudsen et al. (2017) are similar to that of the OD2016-D2 rocks. Both are suites of primarily arkosic sandstones and show a similar U-Pb zircon age distribution. Considering the similar petrography, detrital zircon U-Pb age peaks, and their close proximity (5–10 km for

LOMROG-III dredge 2 and ~20 km for dredge 1), we propose that the dredge rocks from OD2016-D2 and the metasedimentary rocks from LOMROG-III come from a similar succession. The development of schistosity oblique to bedding only in the LOMROG-III rocks may be due to closer proximity to normal faulting. This deformation was dated by Ar-Ar methods at 470.6 ± 7.2 Ma and 468 ± 28 Ma (Knudsen et al. 2017) in the middle Ordovician and probably predates the deposition of the LOMROG-III Paleozoic sedimentary rocks.

5.7 Conclusions

This research provides first order interpretations of the rock units in a relatively unknown area of the Arctic Ocean. A total of ten individual lithologies were identified from the dredged rocks. Two lithofacies associations are present from the interpreted sedimentology. Lithofacies association 1 is interpreted as a tidal-influenced delta with fluvial input, and lithofacies association 2 is interpreted as a tidal shallow water to tidal flat setting.

Phycosiphon trace fossils are present in one sample, which is interpreted to be in-situ. These trace fossils imply that this particular sample was originally deposited in the Early Paleozoic. Other interpretations for these trace fossils are: an incorrect identification of *Phycosiphon*; a second group of rocks younger than 560 Ma; or that this rock sample is ice-rafted detritus with similar lithological and chemical characteristics to the other dredge materials. Other features which could be trace fossils are more likely soft-sediment features.

The SEM analysis in these heavy mineral separates were 156 zircons grains, ten amphibole, seven orthopyroxene, and four tourmaline grains, in spite of zircon grains being avoided. This poor recovery of heavy minerals besides zircon may indicate a polycyclic source. Provenance for all lithologies is the same and includes a granitic component as suggested by geochemistry and petrography of detrital minerals, and a metapelitic component is further suggested by tourmaline analyses. This same type of source rock is suggested for all lithologies in spite of the petrological differences between them, which supports the interpretation of a variation in metamorphic grade. This difference can be seen by the presence abundance of chlorite in certain lithologies and authigenic biotite in others. Based on the absent to minimal K-feldspar, a burial depth of ca. 4 km or greater is likely.

The OD2016-D2 rocks can be separated into three stratigraphic units based on the degree of metamorphism, age, and presence of bioturbation. Unit 1 is higher-grade greenschist facies and includes authigenic biotite. This unit is likely gradationally overlain by Unit 2, which is lower-grade greenschist facies based on the lack of authigenic biotite and presence of chlorite and mixed-layer clays. Unit 3 is mineralogically similar to Unit 2, but contains *Phycosiphon* trace fossils that imply a much younger age, as well as the sample with the 493 Ma detrial zircon U-Pb age. Through comparison with the LOMROG-III rocks, the metasedimentary samples of Knudsen et al. (2017) are likely from a similar succession to Units 1 and 2, but their sedimentary rocks are likely younger than our Unit 3. Overall, this study has contributed to the understanding of the petrology, petrography, and deposition of the OD2016-D2 dredge rocks.

Chapter 6 Thesis Discussion

This chapter summarizes and synthesizes the important discussion points covered in Chapters 4 and 5 and presents a tectonostratigraphic interpretation.

6.1 Key findings

The U-Pb zircon ages of the OD2016-D2 samples are divided into two groups (Chapter 4): Group 1 (Fig. 4.6a) showing a higher peak at 1.0–1.3 Ga relative to Group 2. The samples in Group 2 (Fig. 4.6b) have a similar age distribution compared to the metasedimentary samples reported in Knudsen et al. (2017) and may be from the same stratigraphic level of Lomonosov Ridge. The presence of two distinct groups indicates variations in the source of detrital zircons. Using a multidimensional scaling (MDS) plot in Chapter 4, Figure 4.8, the U-Pb age distribution of detrital zircon grains from the OD2016-D2 are interpreted to have provenance related to Baltica, with sources including the Transscandinavian Igneous Belt, Gothian Igneous complex, Rapakivi granites, Sveconorwegian basement, and Svecofennian orogen.

The whole rock geochemistry of the OD2016-D2 samples (Chapter 5) shows relatively consistent element abundance between all analyzed lithologies (Fig. 5.11), which appears to indicate little variation in source rock for the analyzed samples beyond the shift in zircon age peaks denoted in Groups 1 and 2 (Chapter 4, Fig. 4.6). A strong Eu anomaly is present, which may imply a granitic source (cf. Bhatia 1985). The heavy minerals (Chapter 5) found in the OD2016-D2 samples include, hornblende and orthopyroxene grains that suggests an igneous or metamorphic source. The tourmaline chemistry (Fig. 5.8a) suggests a variety of source rocks including granites, metapelites, calcsilicates, and meta-ultramafic rocks, but the lack of stable indicator detrital minerals rules out the last group of rocks. The detrital minerals albite, biotite, K-feldspar, muscovite, quartz, and zircon are also consistent with a granitic or metapelitic source. A high abundance of detrital zircon grains relative to the other heavy minerals, together with their Concordia ages often being older than the overall maximum depositional age (MDA) may indicate they are polycyclic (Chapter 4).

The OD2016-D2 samples have been categorized in different ways based on detrital zircons, metamorphic grade, lithologies, and lithofacies. Samples are divided into three interpreted stratigraphic units (Chapter 5; Fig. 5.13). The MDA from Chapter 4 can be separated for the stratigraphic units in Chapter 5 based on sample lithologies (Table 6.1). Calculating the MDA from the youngest zircons of each unit yields a MDA of 973 ± 37 Ma for Unit 1 and a slightly older 1024 ± 16 Ma for unit 2. Unit 1 is interpreted to be stratigraphically older than Unit 2, so this difference in MDA may be the result of a slight shift in sediment source. These are both slightly younger than the MDA of 1124 ± 23 Ma calculated in Chapter 4 for the Knudsen et al. (2017) metasedimentary samples. Unit 3 is based on two rock samples with younger ages as described above based on the presence of *Phycosiphon* trace fossils present (Chapter 5) and a young 493 ± 10 Ma detrital zircon age (Chapter 4).

Table 6.1: Comparison of lithology, zircon age data, zircon groups, and stratigraphic units.

Sample	Lithology	Youngest Age – Concordia (Ma)	Uncertainty (Ma - 2 sigma)	MDA – Concordia Age (Ma)	2σ Uncertainty (Ma)	Zircon Group (Chapter 4)	Unit (Chapter 5)
018	4	493	10	938	13	2	3
016	4	1015	19	1032	17	1	2
030	5	1033	14	1067	16	2	2
037	5	1096	23	1117	19	2	2
066	4	1062	20	1103	27	1	2
019	1	975	26	1015	28	1	1
022	8	970	47	977	45	1	1
023	8	982	25	1019	26	1	1
047	8	1006	92	1013	51	2	1
069	5	1100	17	1129	22	1	1

Table 6.1 shows that the defined zircon groups occur in both units 1 and 2 and are therefore mutually exclusive of those units. Only one sample is interpreted from unit 3 and was assigned to group 2, so no trends can be observed; although, all three stratigraphic units are interpreted to have the same source. The zircon groups being exclusive of the interpreted stratigraphic units may indicate variation in source between the zircon groups was cyclical or that the stratigraphic units are interbedded, though this interbedded possibility is unlikely based on the difference in metamorphic grades. There may also be a sampling bias with which zircons were analyzed or the groups or units were defined incorrectly.

6.2 Tectonostratigraphy

In order to place the OD2016-D2 rocks in a tectonic context, their early Neoproterozoic age and Baltic affinity must be considered. Considering the MDA of 973 ± 37 Ma, rocks of Units 1 and 2 may have been deposited in a sedimentary basin that was associated with an early rifting stage of Rodinia. Widespread rifting of Rodinia began between 825 Ma and 740 Ma (Li et al. 2008). Accordingly, since 973 Ma represents the oldest possible age, it is plausible that the shallow-marine sediments were deposited in a seaway during early rifting and creation of accommodation space. However, no zircons are present in the OD2016-D2 samples that correlate with the timing of this rifting of Rodinia. Based on the interpretation of a Baltic provenance (Chapters 4 & 5), Units 1 and 2 may have been deposited near eastern Baltica during this rifting event, but this sedimentary basin cannot be constrained with the current data.

Another possibility is that these rocks were deposited during formation of the Valhalla orogen which occurred between the latest Mesoproterozoic to mid-Neoproterozoic (1030–710 Ma) (Cawood et al. 2010). In the model of the formation of the Valhalla orogen, Baltica was positioned near the northern end of Greenland, closer to where Lomonosov Ridge is positioned relative to modern-day Greenland, and then later rotated towards southern Greenland by around 1000 Ma. During this rotation, the Asgard Sea opened, within which sedimentation occurred in two cycles from 1030–980 Ma and 910–870 Ma (Cawood et al., 2010). The first episode of sedimentation is largely consistent with the MDA from this study, with a similar Grenville-Sveconorwegian orogen source and lack of Archean grains in the associated rocks units of the Valhalla orogen.

During this rifting of Rodinia, Unit 1 was deposited in a tidally influenced delta front setting sourced by a nearby river system. Subsequently, Unit 2 was deposited in a shallow subtidal or tidal flat setting. As the stratigraphic relationship between the dredge rocks is unknown, it is unclear if any major paleoenvironmental changes took place either between or within Units 1 and 2; however, it would appear that sediments prograded into the basin over time based on the upwards shallowing between Units 1 and 2. Both of these units then underwent burial as the basin subsided and likely additional sediments accumulated within the basin. As this is really unknown the Units may represent 1) a limited sampling of outcrops representing either 1+2 and 3 or 1, 2 and 3; or 2) a shallow basin in which sedimentation kept pace with subsidence resulting in sustained shallow marine conditions.

Much later, during the Ordovician, metamorphic overprinting of the Lomonosov Ridge was interpreted by Knudsen et al. (2017) based on muscovite Ar/Ar ages from two samples. The Ar/Ar dating showed mean ages of 470.6 ± 7.2 Ma (2σ) and 468 ±28 Ma (2σ), with age ranges between 487 to 424 Ma. Knudsen et al. (2017) argued that this timing was consistent with the Silurian–Devonian collision of Baltica with Laurentia, forming the Laurasia and the Caledonian Orogenic belt. They further illustrated similarities between Lomonosov Ridge and rocks from other parts of the Caledonian belt, indicating a common geological and tectonic history. If correct, this metamorphic overprinting of Lomonosov Ridge could represent an extension of the Caledonian Orogeny into the Arctic (Knudsen et al. 2017). This orogenic event likely resulted in uplift and development of a major unconformity above Units 1 and 2, which could account for age populations of detrital zircons in Units 2 and 3 (Chapter 5). In particular, Unit 3 appears to be Paleozoic age based on the presence of *Phycosiphon* trace fossils and the 493 Ma zircon age. If such an unconformable surface exists between Proterozoic and Paleozoic rocks, it does not appear to be resolved in the seismic stratigraphy in line LSL1410 (Funck et al. 2022); although imaging of their pre-rift rocks may not be adequate to resolve such features. The rocks of Unit 3 were then possibly deposited in a more distal, marine setting during the Early Paleozoic. Unit 3 otherwise shares the same WRA signature and zircon peaks as the other Units (Chapters 4 & 5). The Knudsen et al. (2017) single analyzed sedimentary sample shows a MDA of ~500 Ma and, considering that it has not been metamorphosed, it may be from a stratigraphically higher interval, but from a similar Lower Paleozoic succession. As with Units 1 and 2, these younger rocks underwent burial and diagenesis during the early stages of the formation of Pangea.

Units 1 to 3 were likely subaerially exposed prior to the onset of extension related to the breakup of Pangea in the region, which began at ca 195 Ma, forming the central Atlantic-rift (Frizon De Lamotte et al. 2015). The Gakkel Ridge is thought to be a late (~56 Ma; Brozena et al. 2003) extension of the Atlantic-rift (Brozena et al. 2003). This extension would have resulted in thinning of the continental crust, development of normal faults and infill of sub-aerial syn-rift strata prior to the separation of Lomonosov Ridge from the Barents Shelf at ~58 Ma (Jokat et al. 1992; Grantz et al. 2001, Brozena et al. 2003, Glebovsky et al. 2006, Funck et al. 2022). This rifting allowed for a regional unconformity to form, below which are the Mesozoic strata sampled by the ACEX drill core (Moran et al. 2006). Following lithospheric rifting between

Lomonosov Ridge and the Barents Shelf, seafloor spreading initiated at chron C24 (Funck et al. 2022). The eventual separation of Lomonosov Ridge from the Barents Shelf resulted in the formation of the Gakkel spreading ridge and the Eurasia Basin (Brozena et al. 2003, Glebovsky et al. 2006). During this post-rift phase, the Lomonosov Ridge subsided below sea-level and Cenozoic sedimentation began to cover the ridge. As sedimentation on the Makarov Basin side of Lomonosov Ride would have initiated before the opening of the Eurasia Basin and thus have a thicker sediment cover, the flanks on the Eurasia Basin side of the ridge were targeted for dredging in in order to sample bedrock during the LOMROG-II and -III and the OD2016 expeditions.

6.3 Suggestions for future work

A limitation of this study is that not all lithologies are captured with the zircon U-Pb age dating. The lithologies which have zircon data are 1 and 8 from the higher-grade greenschist facies, and 4 and 5 from the lower-grade greenschist facies. Additionally, the samples that were taken for zircon analyses were completely consumed and no further analyses can be completed on them. Because of this, the lithologies 1, 4, 5, and 8 for these dated samples were assigned largely on digital photographs and thin sections and may be inaccurate. The zircons appear to have been sampled from both lithofacies associations, but there may be differences between lithologies or lithofacies relationships that are still unknown. Further work should date representative samples from the remaining lithologies. Additional comparison of the OD2016-D2 detrital zircon ages should be made with other Arctic regions including: Svalbard, Franz Josef Land, and Novaya Zemlya.

Lithology 4 should be resampled for detrital zircons and additional trace fossils, considering it is the lithology which contains the anomalous detrital zircon U-Pb age (493 Ma) and *Phycosiphon* trace fossils. The poor recovery of heavy minerals may also be addressed with further heavy mineral sampling and analysis. Further samples could be cut for interpreting sedimentary structures and to find additional trace fossils which may help with determining the depositional age of Unit 3.

Chapter 7 Conclusions

- This research provides first order interpretations in a remote frontier. The OD2016-D2 dredge samples consist mostly of arkosic sandstones and siltstones, with fresh fractures indicating that most were broken off outcrops. Ten discrete lithologies were recognised. Two lithofacies associations are present. Lithofacies association 1 is interpreted as a tidal-influenced delta with fluvial input, and lithofacies association 2 as a shallow water tidal flat succession.
- *Phycosiphon* trace fossils are present in one sample (043) indicating an Early Paleozoic age (Cambrian or younger), and no other trace fossils were identified. The maximum depositional age for the OD2016-D2 rock samples as a whole is 973 ± 37 Ma, though in some samples the youngest single zircons are closer to 1100 Ma. The age of the arkosic sandstones and siltstones is thus likely Neoproterozoic.
- Two separate groups of detrital zircons are distinguished on the basis of their U-Pb ages: Group 1 has a higher abundance of 1200–1400 Ma ages relative to Group 2. The two groups have similar maximum depositional ages and indicate a slight shift in relative importance of different source regions. The detrital zircons have affinity with Baltica, based on their U-Pb age distribution and Lu-Hf isotope data shares similarities with northeast Baltica and the exotic Pearya terrane in Laurentia.
- Provenance for all lithologies is the same and includes a dominant granitic component as suggested by geochemistry and petrography of detrital minerals, and a metapelitic component suggested by the chemistry of some detrital tourmaline. The poor recovery of heavy minerals other than zircon may indicate a mostly polycyclic source for the zircon. Based on the absent to minimal K-feldspar, a maximum burial depth of ca. 4 km or

greater is likely. Such a thick deposit potentially accumulated in a rift basin associated with the breakup of Rodinia.

- The OD2016-D2 rocks can be separated into three stratigraphic units possibly deposited on the eastern side of Rodinia. Unit 1 is higher-grade greenschist facies and includes authigenic biotite. Unit 2 is lower-grade greenschist facies based on the lack of authigenic biotite and presence of only chlorite. Unit 3 is mineralogically similar to Unit 2, but contains *Phycosiphon* trace fossils and a zircon with a Concordia age of 493 Ma, implying that the unit is Paleozoic.
- Comparison between the OD2016-D2 and LOMROG-III samples suggests that there are four stratigraphic units: a Lower Paleozoic unit sampled only by LOMROG-III, a metamorphosed Paleozoic unit, and two Neoproterozoic metasedimentary units.

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Appendix 1: OD2016-D2 sample numbers.

Notes:

A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 078 is spilt into 4 pieces which are labelled 078-a, 078-b, etc.

Appendix 1. Sample numbers.

Cruise	Station	Dredge site	Sample number	Lithology	Lithofacies
OD2016	0004	2	0001	1	A
OD2016	0004	2	0002	2	F
OD2016	0004	2	0003	Manganese crust	
OD2016	0004	2	0004	1	A
OD2016	0004	2	0005	2	G
OD2016	0004	2	0006	1	B
OD2016	0004	2	0007	9	A
OD2016	0004	2	0008	9	
OD2016	0004	2	0009	1	
OD2016	0004	2	0010	2	
OD2016	0004	2	0011	1	A
OD2016	0004	2	0012	9	I
OD2016	0004	2	0013	Conglomerate	
OD2016	0004	2	0014	2	
OD2016	0004	2	0015	Manganese crust	
OD2016	0004	2	0016	4	H
OD2016	0004	2	0017	1	A
OD2016	0004	2	0018	4	I
OD2016	0004	2	0019	1	A
OD2016	0004	2	0020	4	I
OD2016	0004	2	0021	9	I
OD2016	0004	2	0022	8	C
OD2016	0004	2	0023	8	C
OD2016	0004	2	0024	4	I
OD2016	0004	2	0025	4	I
OD2016	0004	2	0026	4	I
OD2016	0004	2	0027	6	G
OD2016	0004	2	0028	10	F
OD2016	0004	2	0029	5	I
OD2016	0004	2	0030	5	H
OD2016	0004	2	0031	Dropstone	
OD2016	0004	2	0032	3	
OD2016	0004	2	0033	3	
OD2016	0004	2	0034	3	I
OD2016	0004	2	0035	1	B
OD2016	0004	2	0036	1	B
OD2016	0004	2	0037	5	H
OD2016	0004	2	0038	9	
OD2016	0004	2	0039	4	I
OD2016	0004	2	0040	10	F
OD2016	0004	2	0041	1	A
OD2016	0004	2	0042	1	

Appendix 1. Sample numbers.

Cruise	Station	Dredge site	Sample number	Lithology	Lithofacies
OD2016	0004	2	0043	4	J
OD2016	0004	2	0044	4	J
OD2016	0004	2	0045	2	D
OD2016	0004	2	0046	8	
OD2016	0004	2	0047	8	C
OD2016	0004	2	0048	6	
OD2016	0004	2	0049	1	C
OD2016	0004	2	0050	4	I
OD2016	0004	2	0051	Manganese crust	
OD2016	0004	2	0052	2	D
OD2016	0004	2	0053	Basalt	
OD2016	0004	2	0054	2	F
OD2016	0004	2	0055	Manganese crust	
OD2016	0004	2	0056	9	
OD2016	0004	2	0057	6	
OD2016	0004	2	0058	6	
OD2016	0004	2	0059	3	
OD2016	0004	2	0060	2	D
OD2016	0004	2	0061	1	
OD2016	0004	2	0062	Manganese crust	
OD2016	0004	2	0063	6	G
OD2016	0004	2	0064	6	
OD2016	0004	2	0065	1	D
OD2016	0004	2	0066	4	I
OD2016	0004	2	0067	5	
OD2016	0004	2	0068	3	I
OD2016	0004	2	0069	5	H
OD2016	0004	2	0070	5	
OD2016	0004	2	0071	5	
OD2016	0004	2	0072	4	J
OD2016	0004	2	0073	4	I
OD2016	0004	2	0074	1	
OD2016	0004	2	0075	3	
OD2016	0004	2	0076	1	B
OD2016	0004	2	0077	2	A
OD2016	0004	2	0078	5	
OD2016	0004	2	0078A	5	
OD2016	0004	2	0078B	5	
OD2016	0004	2	0078C	5	
OD2016	0004	2	0078D	5	
OD2016	0004	2	0079	9	
OD2016	0004	2	0080	9	H

Appendix 1. Sample numbers.

Cruise	Station	Dredge site	Sample number	Lithology	Lithofacies
OD2016	0004	2	0081	1	D
OD2016	0004	2	0082	9	
OD2016	0004	2	0083	4	
OD2016	0004	2	0084	4	
OD2016	0004	2	0085	4	I
OD2016	0004	2	0086	4	I
OD2016	0004	2	0087	8	
OD2016	0004	2	0088	8	
OD2016	0004	2	0089	5	
OD2016	0004	2	0090	Dropstone	
OD2016	0004	2	0091	9	
OD2016	0004	2	0092	Dropstone	
OD2016	0004	2	0093	8	
OD2016	0004	2	0094	Manganese crust	
OD2016	0004	2	0095	8	
OD2016	0004	2	0096	2	
OD2016	0004	2	0097	4	
OD2016	0004	2	0098	4	
OD2016	0004	2	0099	6	
OD2016	0004	2	0100	4	
OD2016	0004	2	0101	1	
OD2016	0004	2	0103	5	
OD2016	0004	2	0104	4	
OD2016	0004	2	0105	1	
OD2016	0004	2	0106	5	
OD2016	0004	2	0107	5	
OD2016	0004	2	0108	9	
OD2016	0004	2	0109	1	
OD2016	0004	2	0110	1	
OD2016	0004	2	0111	9	
OD2016	0004	2	0112	4	
OD2016	0004	2	0113	6	
OD2016	0004	2	0114	4	
OD2016	0004	2	0115	Manganese crust	
OD2016	0004	2	0116	Manganese crust	
OD2016	0004	2	0117	Manganese crust	
OD2016	0004	2	0118	Manganese crust	
OD2016	0004	2	0119	Manganese crust	
OD2016	0004	2	0120	Manganese crust	
OD2016	0004	2	0121	Manganese crust	
OD2016	0004	2	0122	Manganese crust	
OD2016	0004	2	0123	2	E

Appendix 1. Sample numbers.

Cruise	Station	Dredge site	Sample number	Lithology	Lithofacies
OD2016	0004	2	0124	4	
OD2016	0004	2	0125	4	H
OD2016	0004	2	0126	2	E
OD2016	0004	2	0127	2	G
OD2016	0004	2	0128	7	
OD2016	0004	2	0129	2	
OD2016	0004	2	0130	6	
OD2016	0004	2	0131	9	
OD2016	0004	2	0132	1	
OD2016	0004	2	0133	3	
OD2016	0004	2	0134	3	
OD2016	0004	2	0135	6	
OD2016	0004	2	0136	6	
OD2016	0004	2	0137	9	
OD2016	0004	2	0138	9	
OD2016	0004	2	0139	9	
OD2016	0004	2	0140	9	
OD2016	0004	2	0141	1	A
OD2016	0004	2	0142	1	C
OD2016	0004	2	0143	2	B
OD2016	0004	2	0144	1	A
OD2016	0004	2	0145	2	D
OD2016	0004	2	0146	1	A
OD2016	0004	2	0147	1	D
OD2016	0004	2	0148	2	B
OD2016	0004	2	0149	1	A
OD2016	0004	2	0150	1	A
OD2016	0004	2	0151	1	A
OD2016	0004	2	0152	1	D
OD2016	0004	2	0153	1	D
OD2016	0004	2	0154	1	A
OD2016	0004	2	0155	1	B
OD2016	0004	2	0156	2	B
OD2016	0004	2	0157	1	C
OD2016	0004	2	0158	1	D
OD2016	0004	2	0159	1	D
OD2016	0004	2	0160	2	A
OD2016	0004	2	0161	2	B
OD2016	0004	2	0162	2	D
OD2016	0004	2	0163	1	B
OD2016	0004	2	0164	2	D
OD2016	0004	2	0165	2	D

Appendix 1. Sample numbers.

Cruise	Station	Dredge site	Sample number	Lithology	Lithofacies
OD2016	0004	2	0166	1	D
OD2016	0004	2	0167	7	G
OD2016	0004	2	0168	2	A
OD2016	0004	2	0169	2	A
OD2016	0004	2	0170	1	D
OD2016	0004	2	0171	1	D
OD2016	0004	2	0172	2	D
OD2016	0004	2	0173	4	I
OD2016	0004	2	0174	4	I
OD2016	0004	2	0175	4	H
OD2016	0004	2	0176	4	I

Appendix 2: OD2016-D2 sample photographs.

Notes:

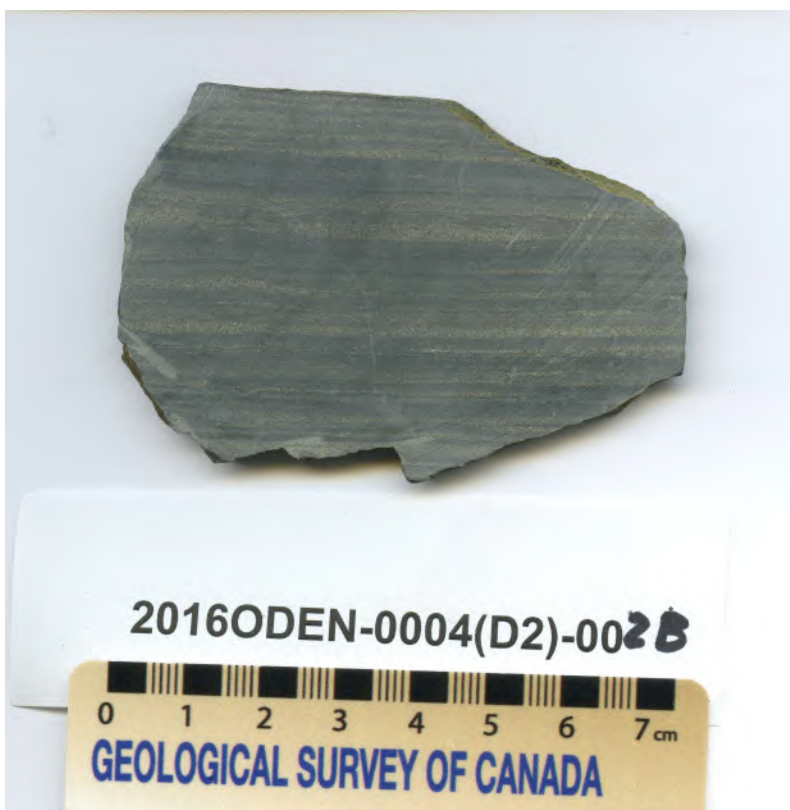
Samples numbers are as appears in NRCan archives: 2016ODEN-0004(D2) is the equivalent of the abbreviated OD2016-D2 which is used in publication. The 2016ODEN refers to the cruise and year, while the 0004 is the station number of Dredge 2.

A sample number succeeded by -1, or -2 indicates thin section number. Eg. 011-2 is the second thin section from sample 011.

A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 012 has been cut into two halves, one half is 012-a and the other half is 012-b.

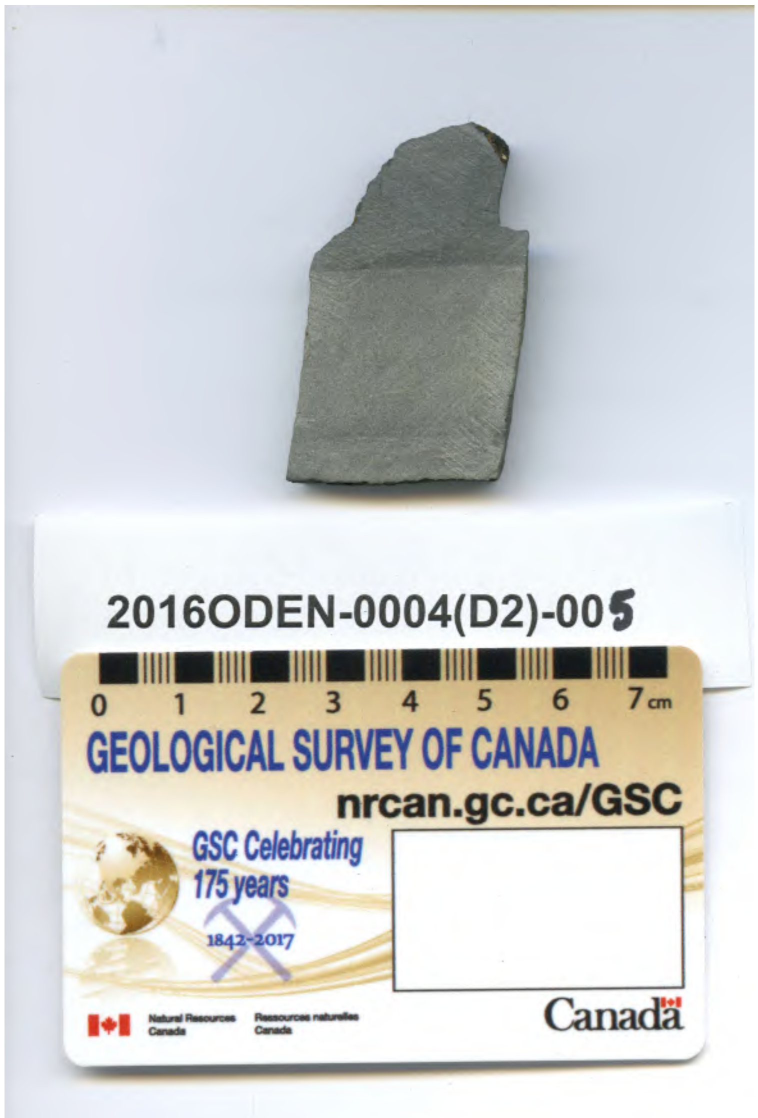
OD2016-D2-001A & 001B

OD2016-D2-002A & 002B



OD2016-D2-004

OD2016-D2-005



OD2016-D2-006

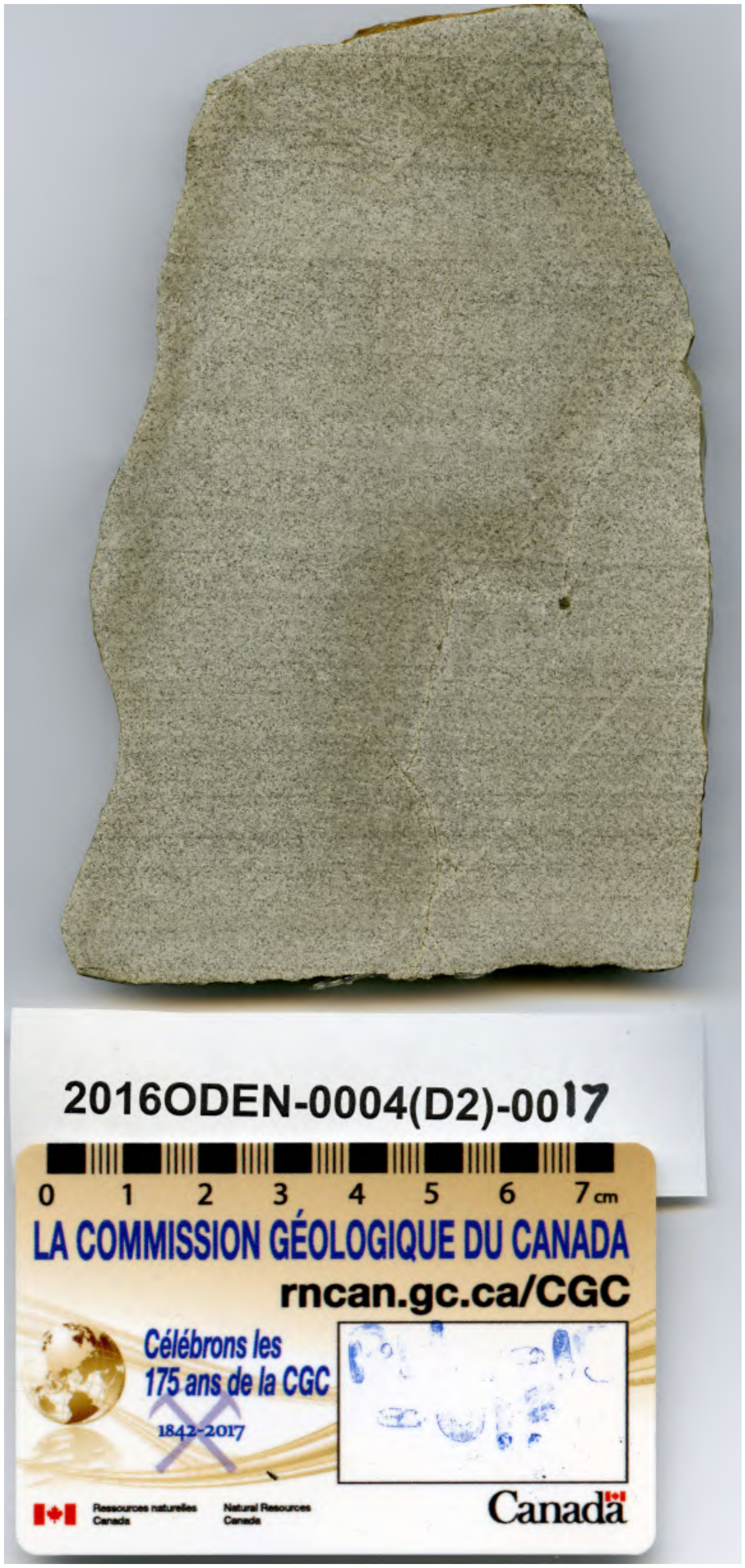
OD2016-D2-011

OD2016-D2-012A & 012B

OD2016-D2-013

OD2016-D2-016

OD2016-D2-017



OD2016-D2-018

OD2016-D2-019

OD2016-D2-020

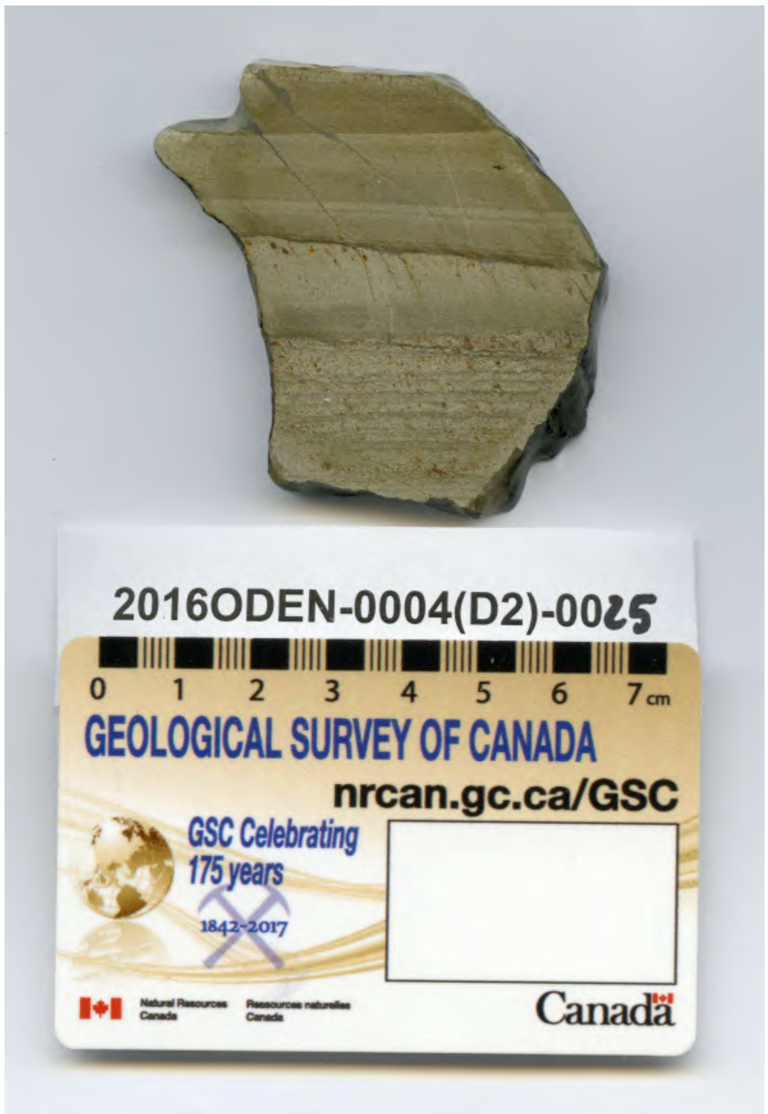
OD2016-D2-021

OD2016-D2-022A & 022B

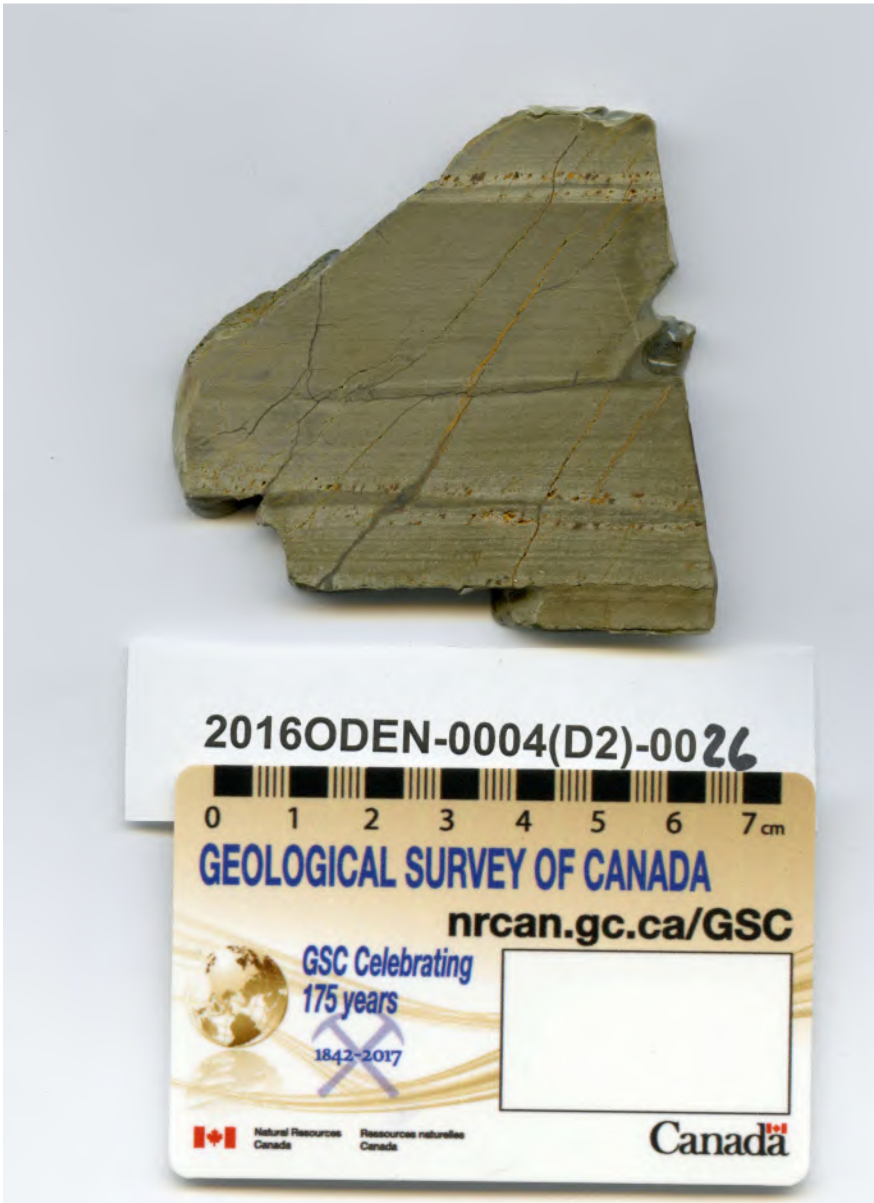
OD2016-D2-023A & 023B

OD2016-D2-024

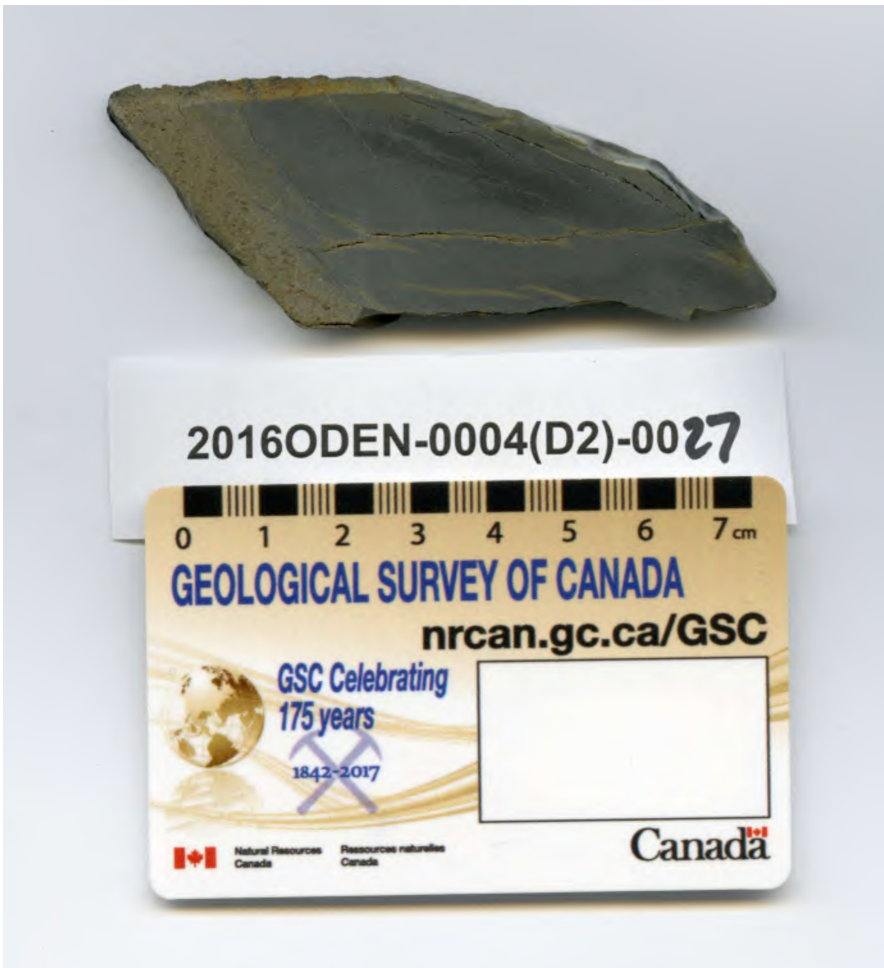
OD2016-D2-025



OD2016-D2-026



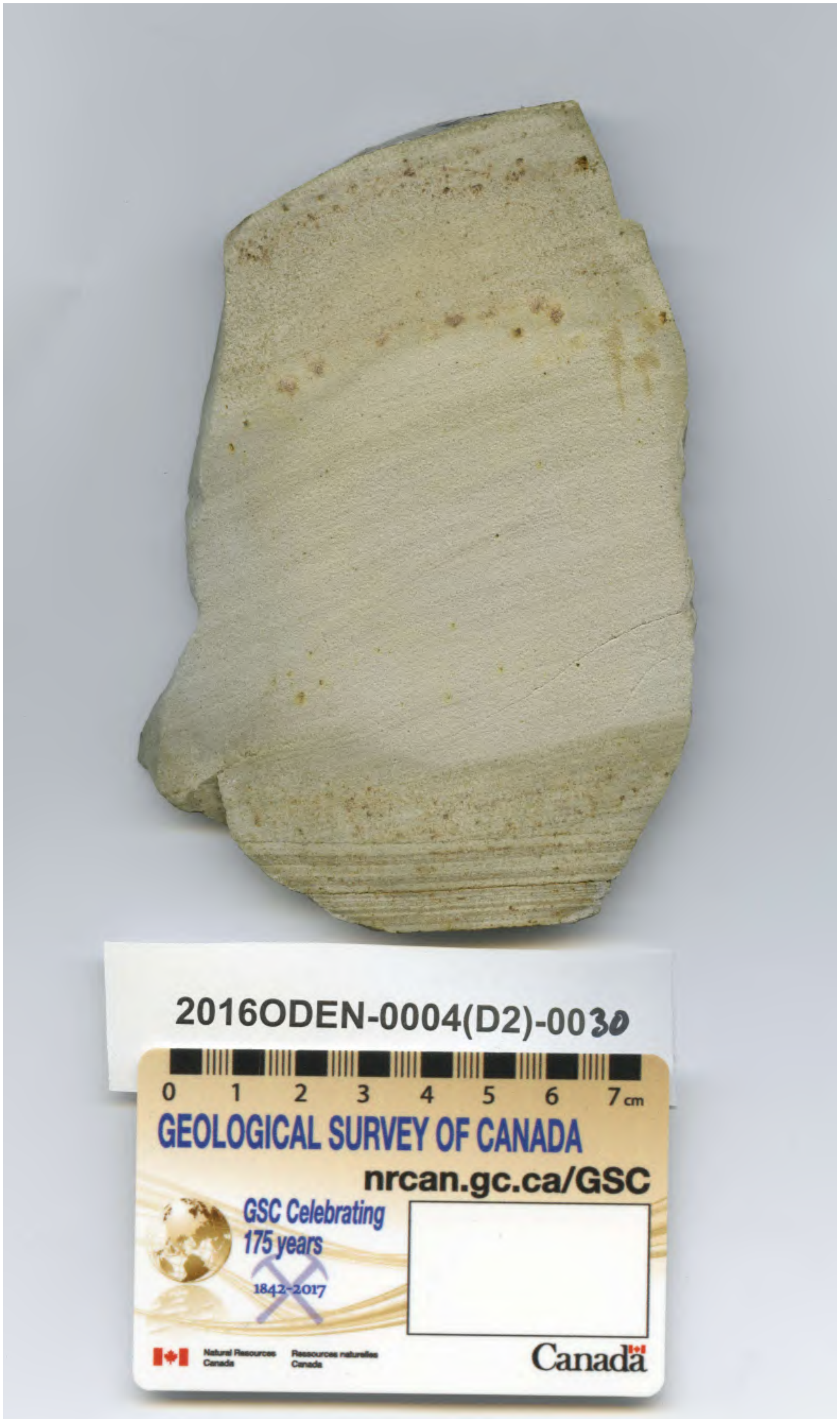
OD2016-D2-027



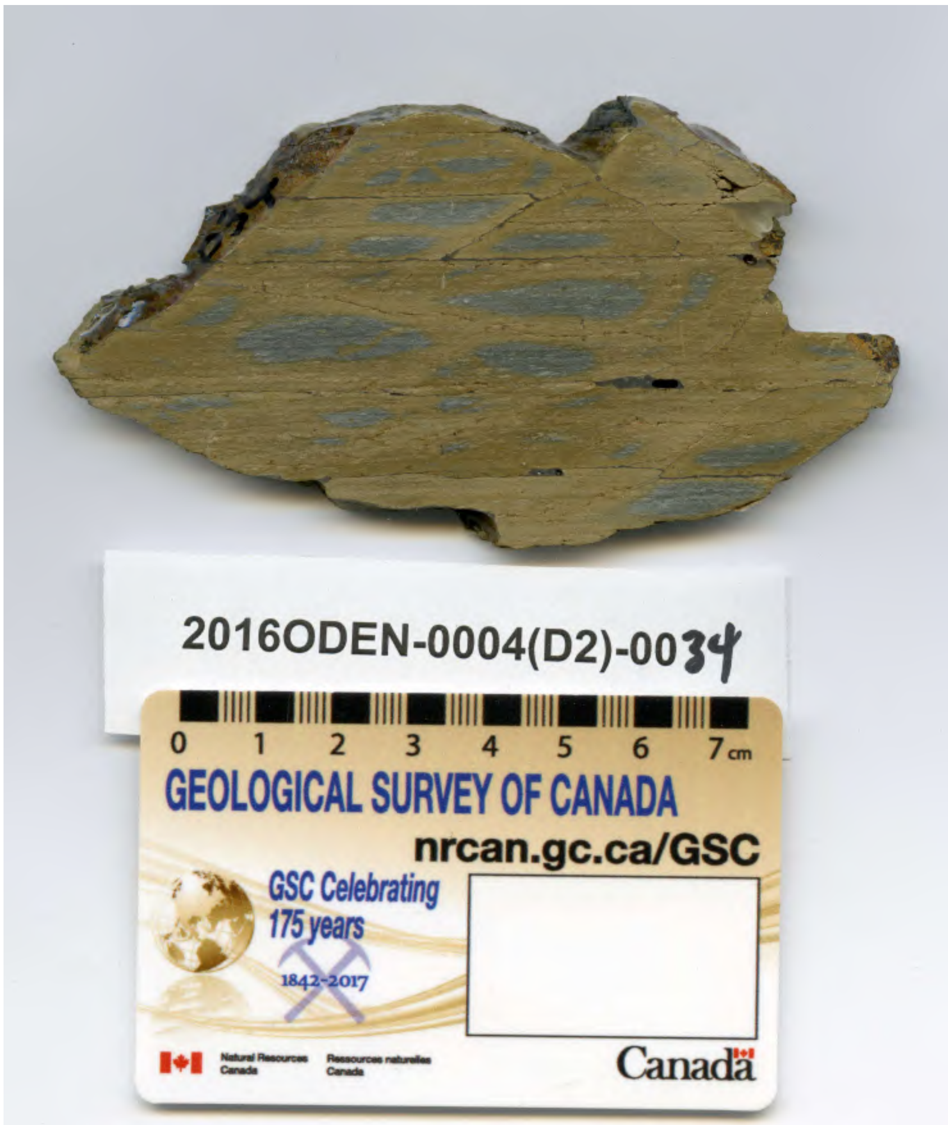
OD2016-D2-028

OD2016-D2-029

OD2016-D2-030

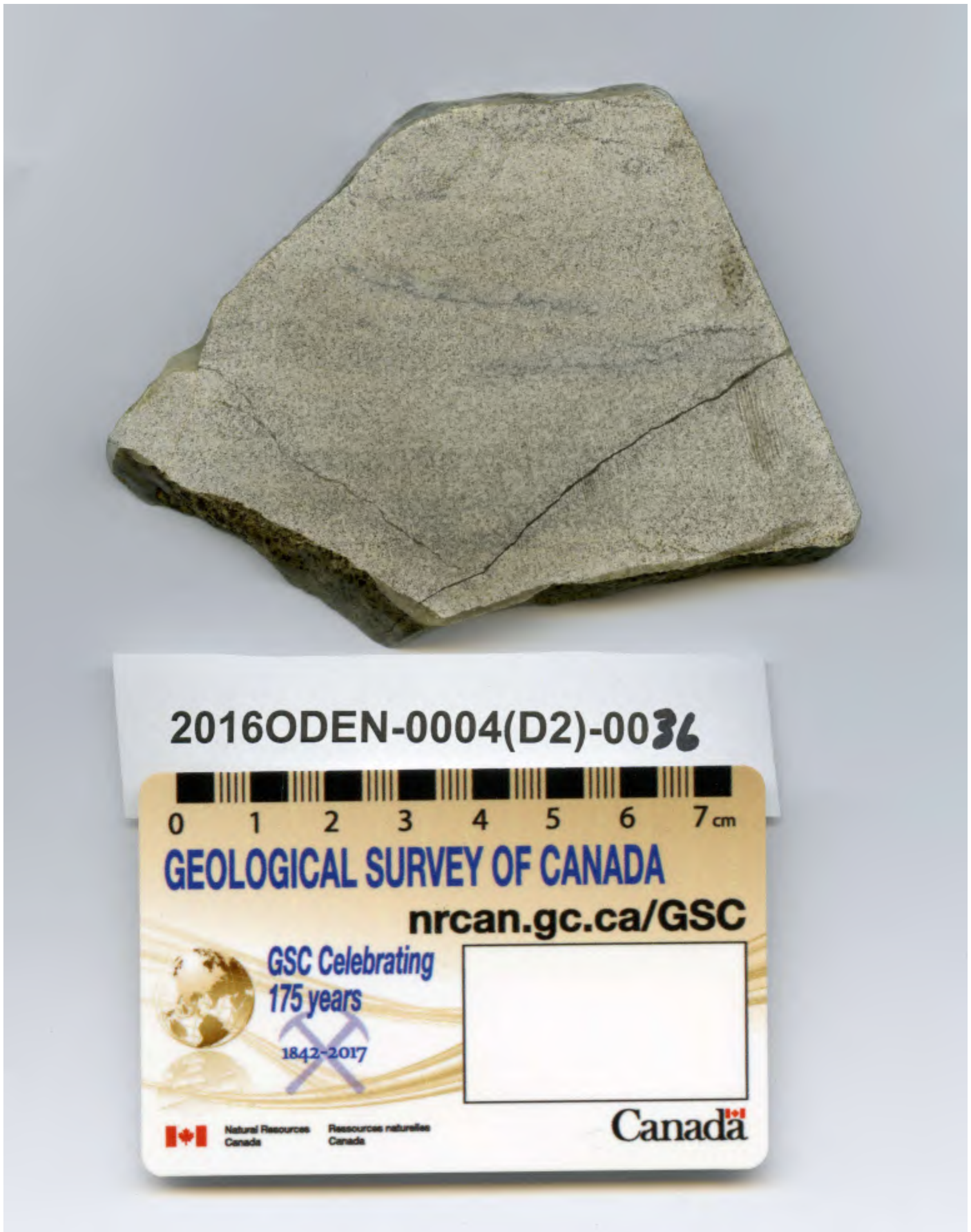


OD2016-D2-034



OD2016-D2-035

OD2016-D2-036

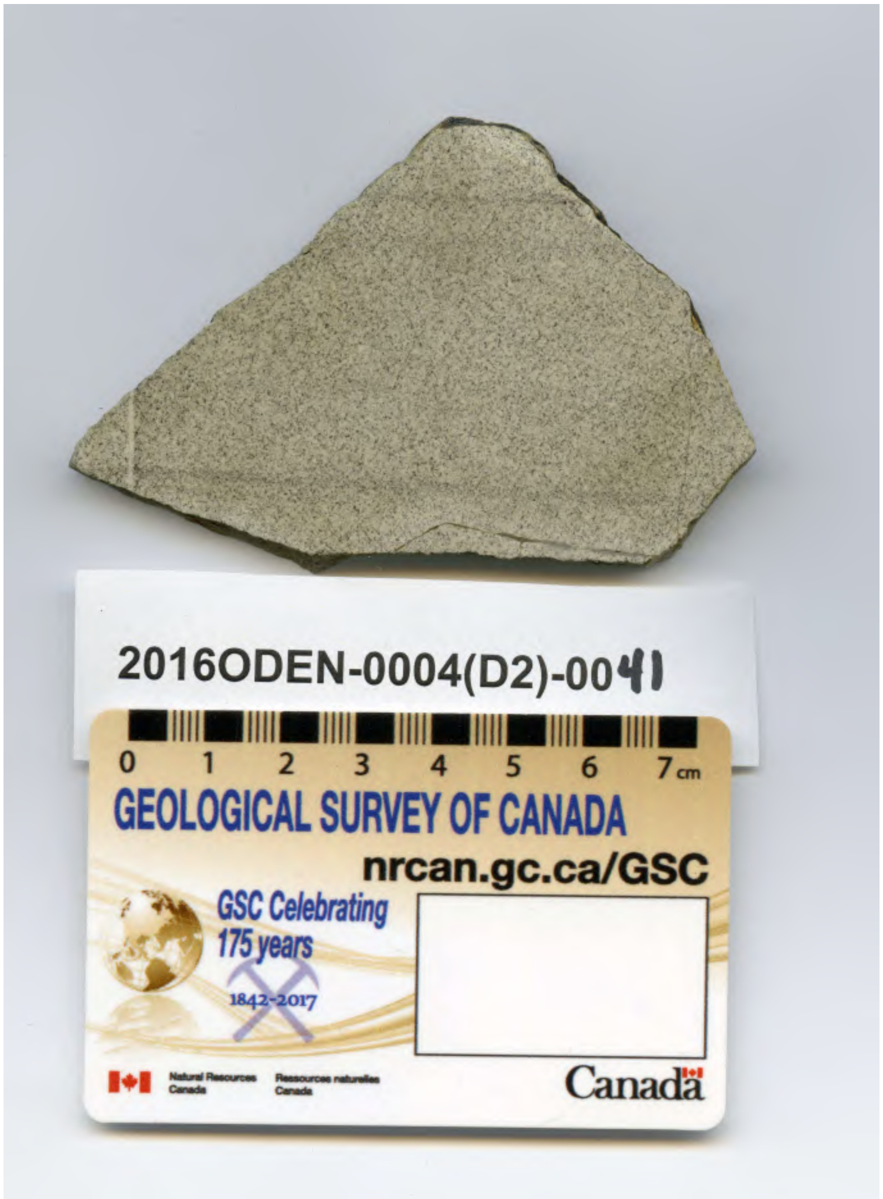


OD2016-D2-037

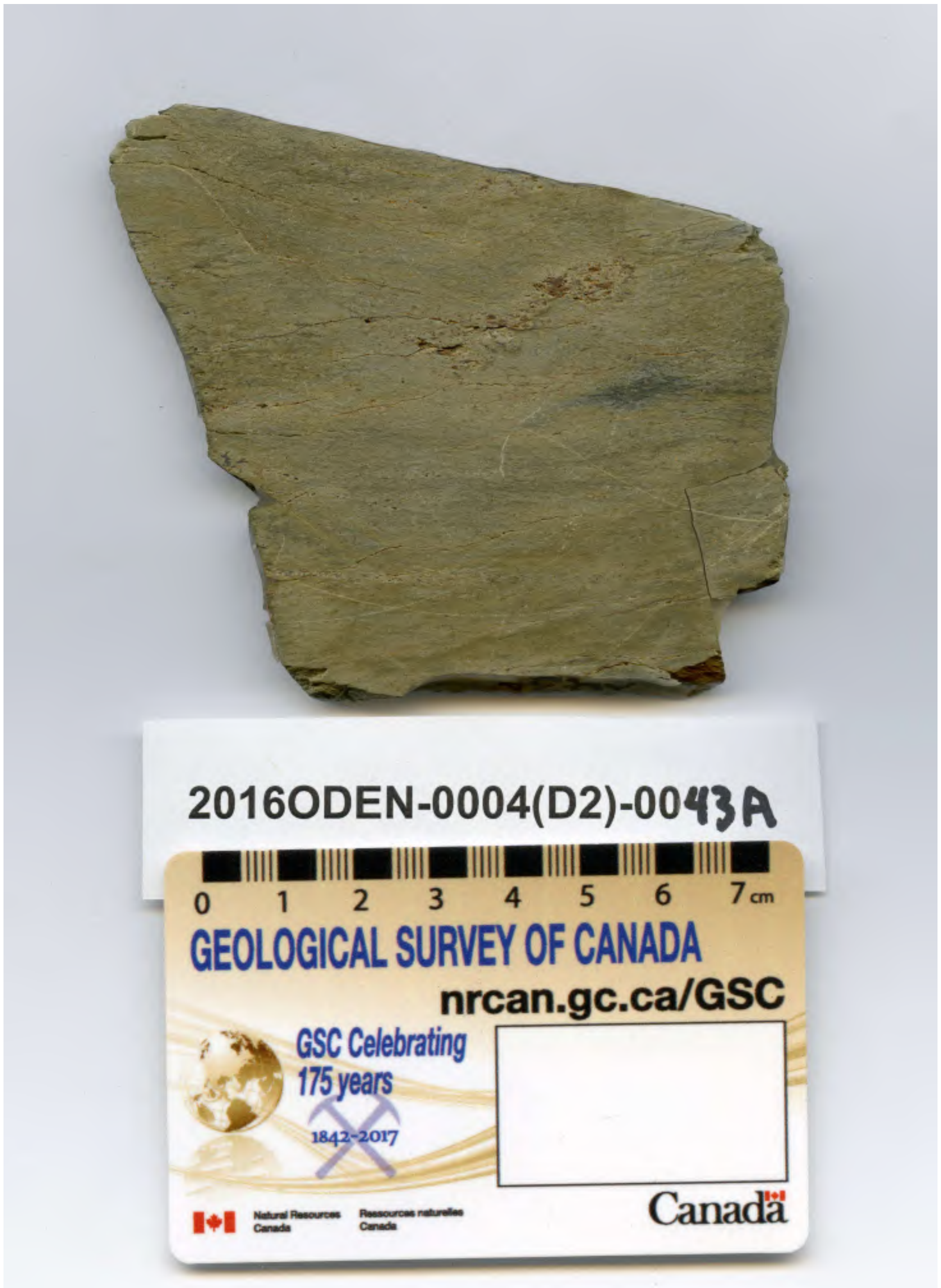
OD2016-D2-039

OD2016-D2-040

OD2016-D2-041

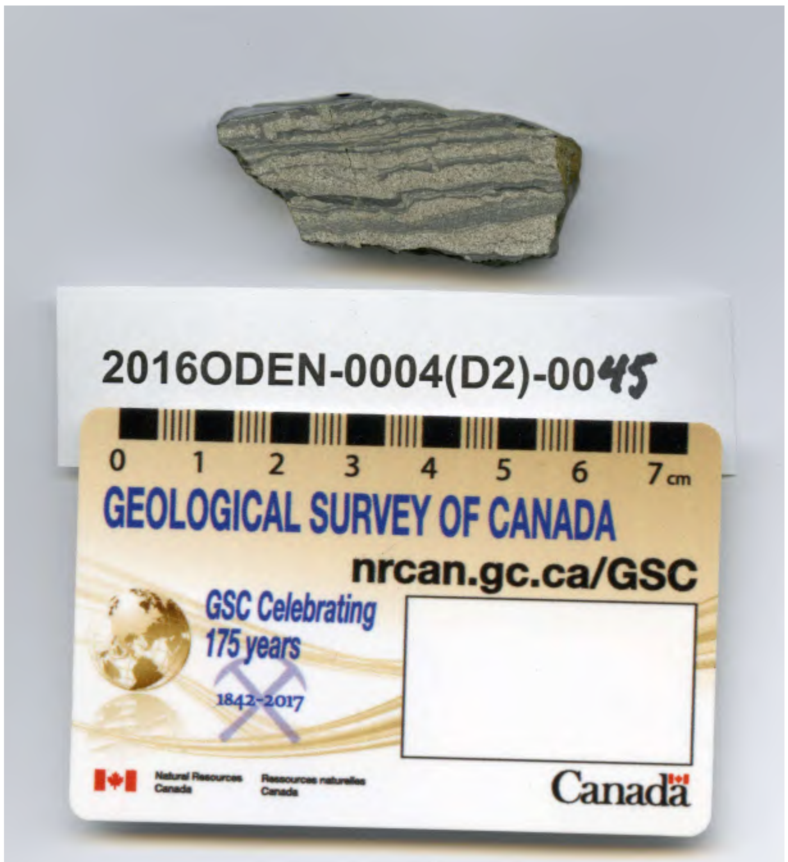


OD2016-D2-043A



OD2016-D2-044

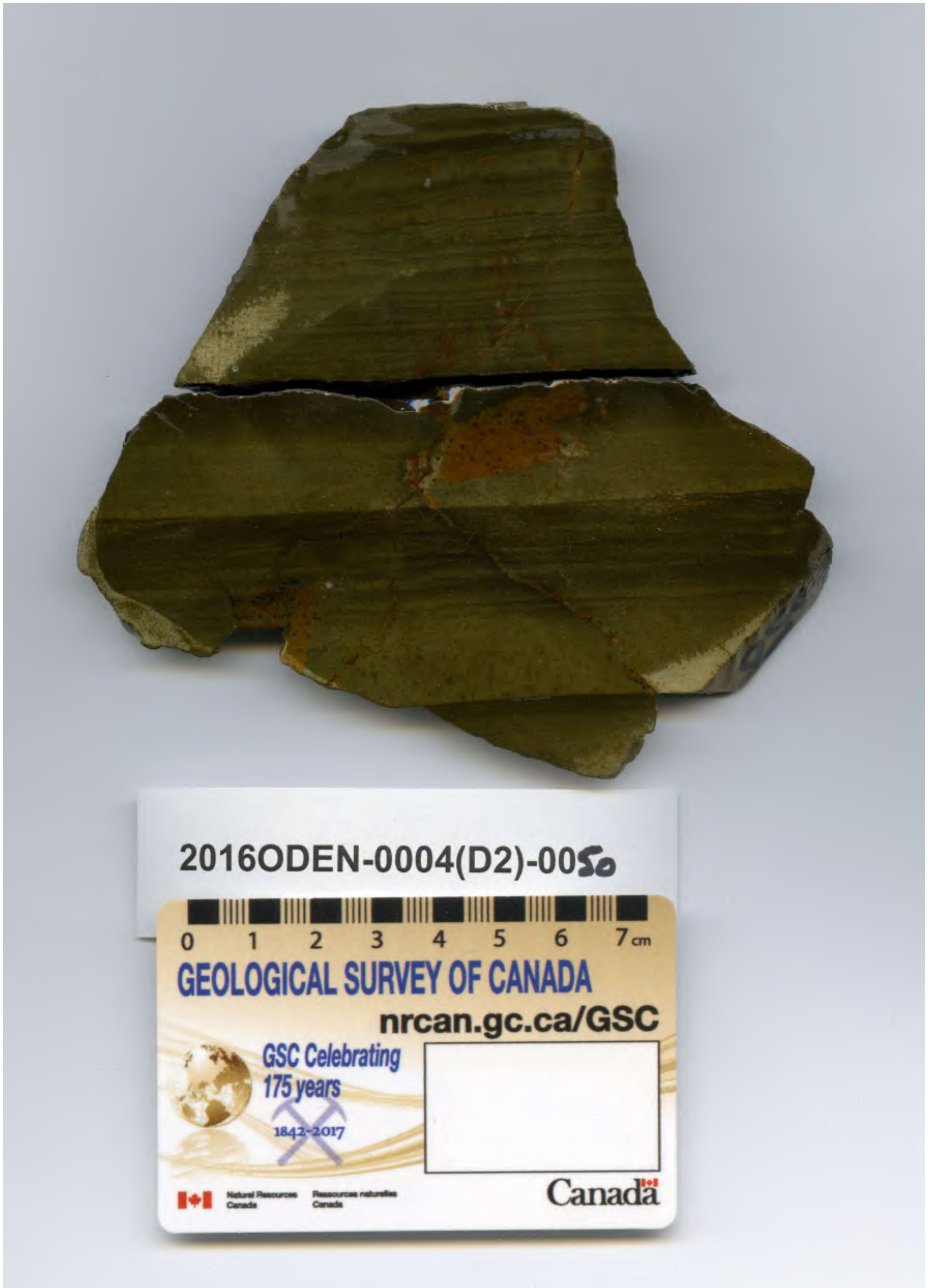
OD2016-D2-045



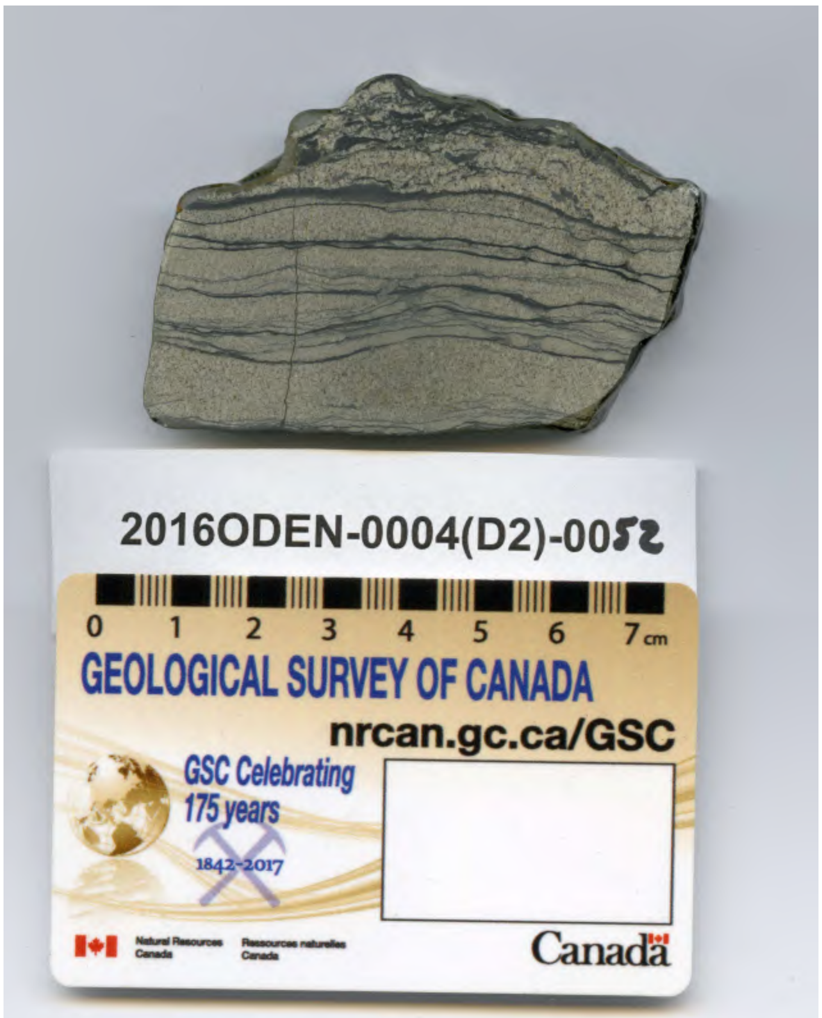
OD2016-D2-047

OD2016-D2-049

OD2016-D2-050



OD2016-D2-052



OD2016-D2-054

OD2016-D2-060

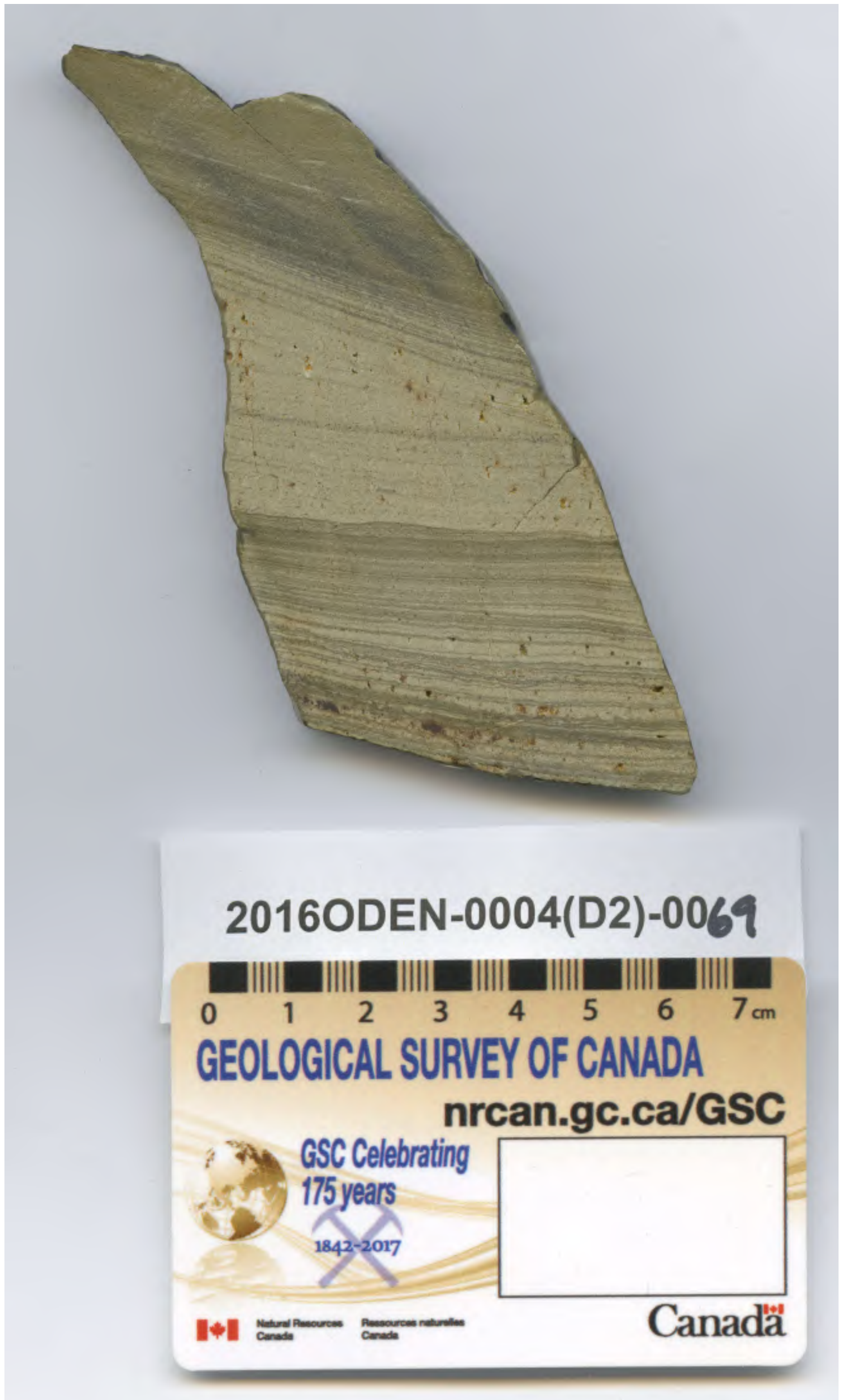
OD2016-D2-063

OD2016-D2-065

OD2016-D2-066

OD2016-D2-068

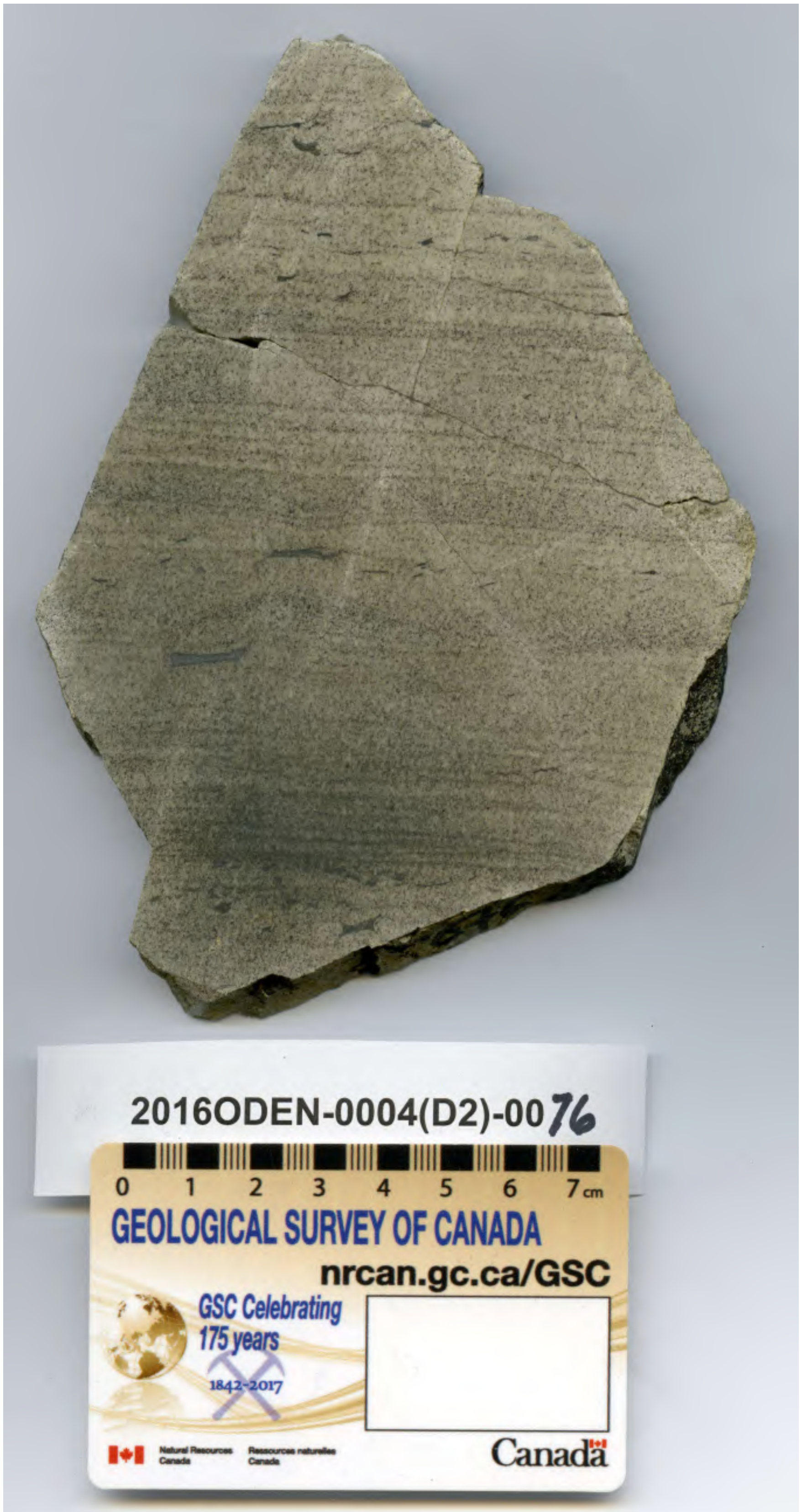
OD2016-D2-069



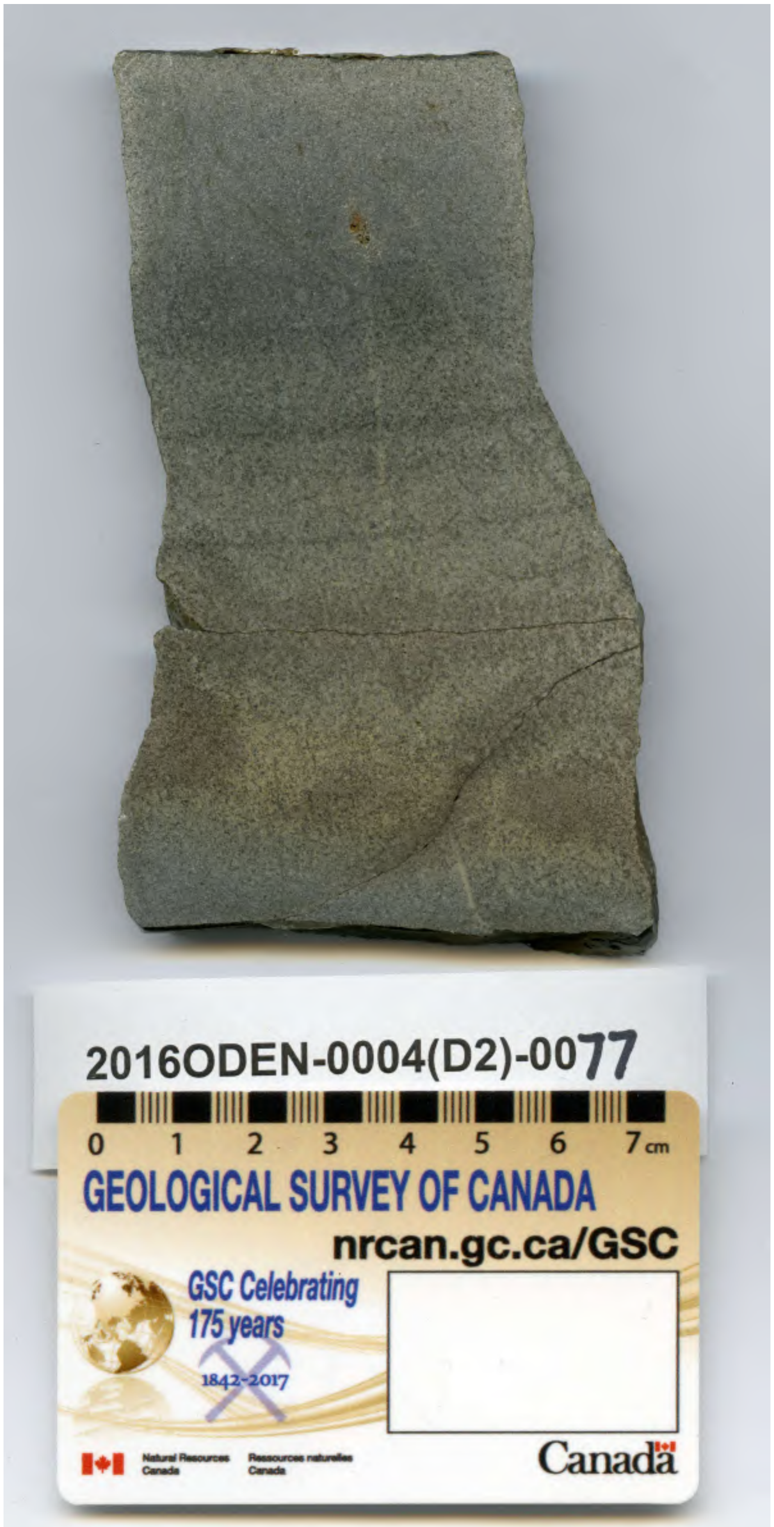
OD2016-D2-072

OD2016-D2-073

OD2016-D2-076



OD2016-D2-077



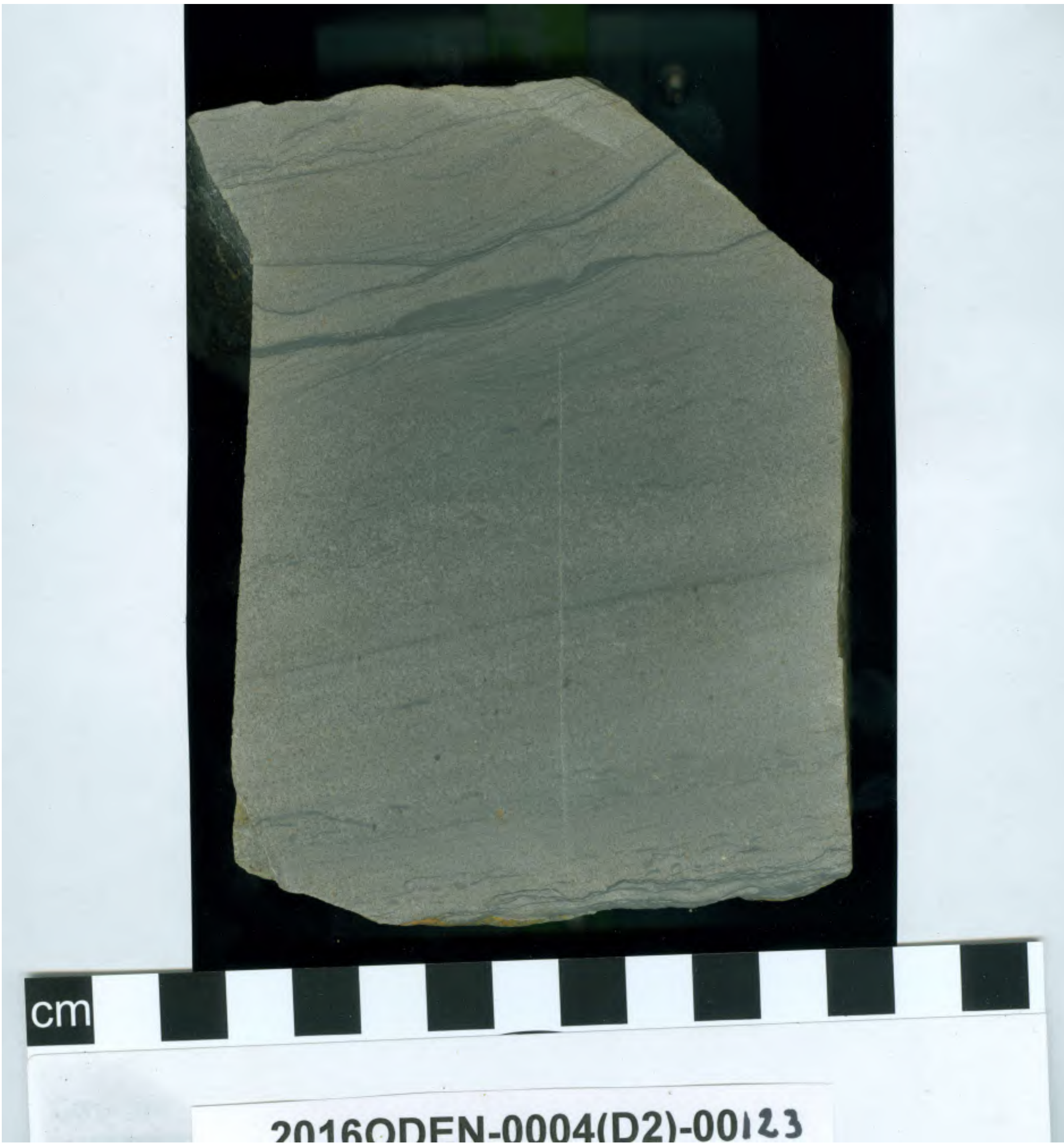
OD2016-D2-080

OD2016-D2-081-1 & 081-2

OD2016-D2-085

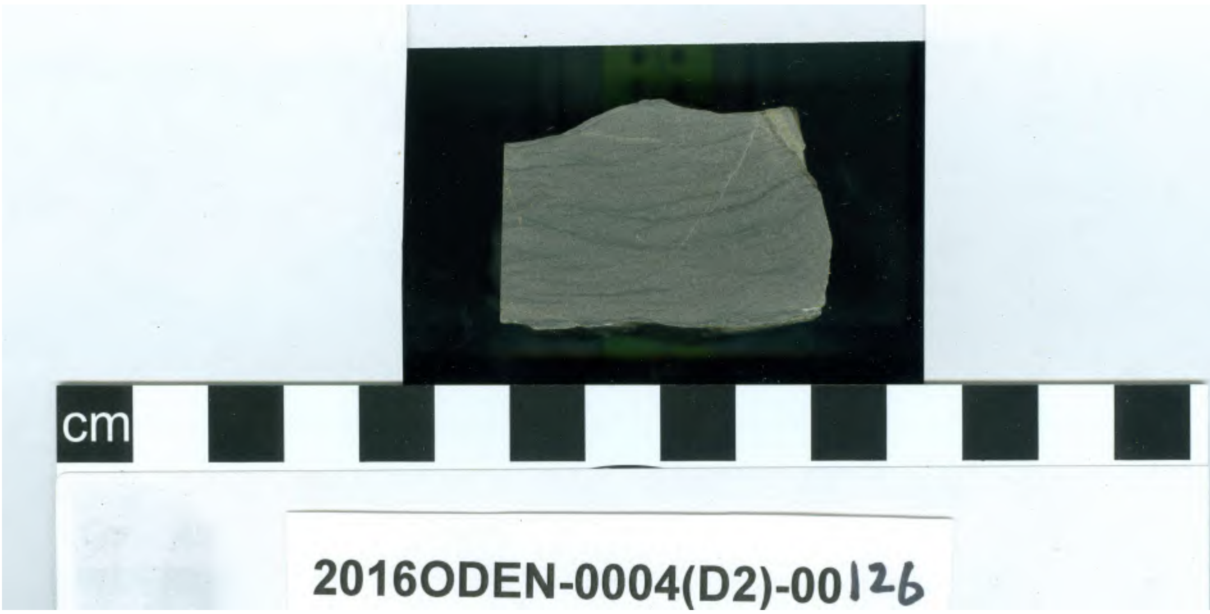
OD2016-D2-086

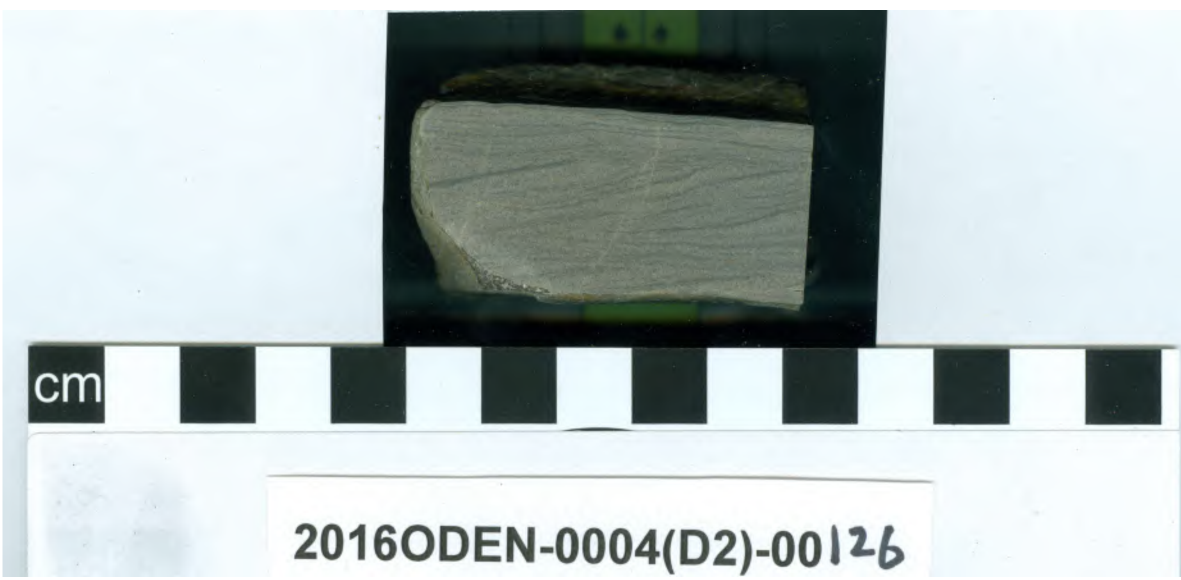
OD2016-D2-123



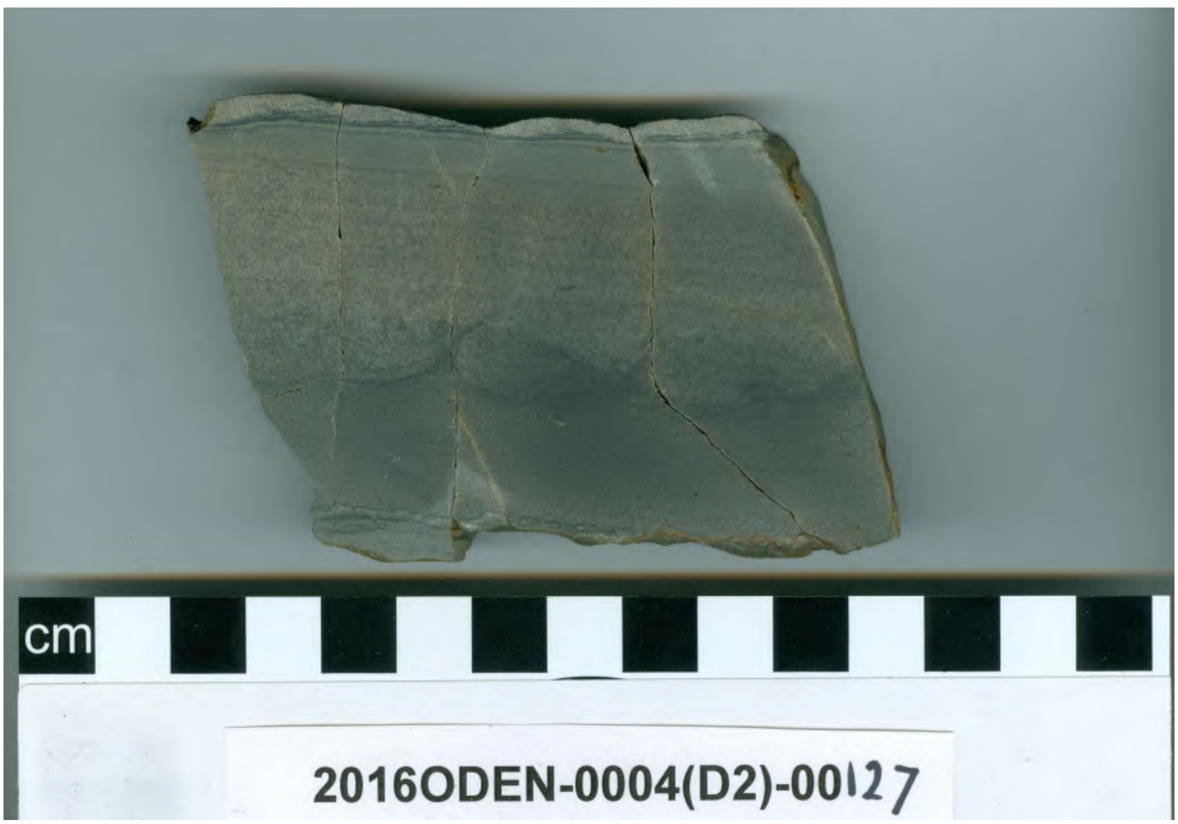
OD2016-D2-125

OD2016-D2-126





OD2016-D2-127



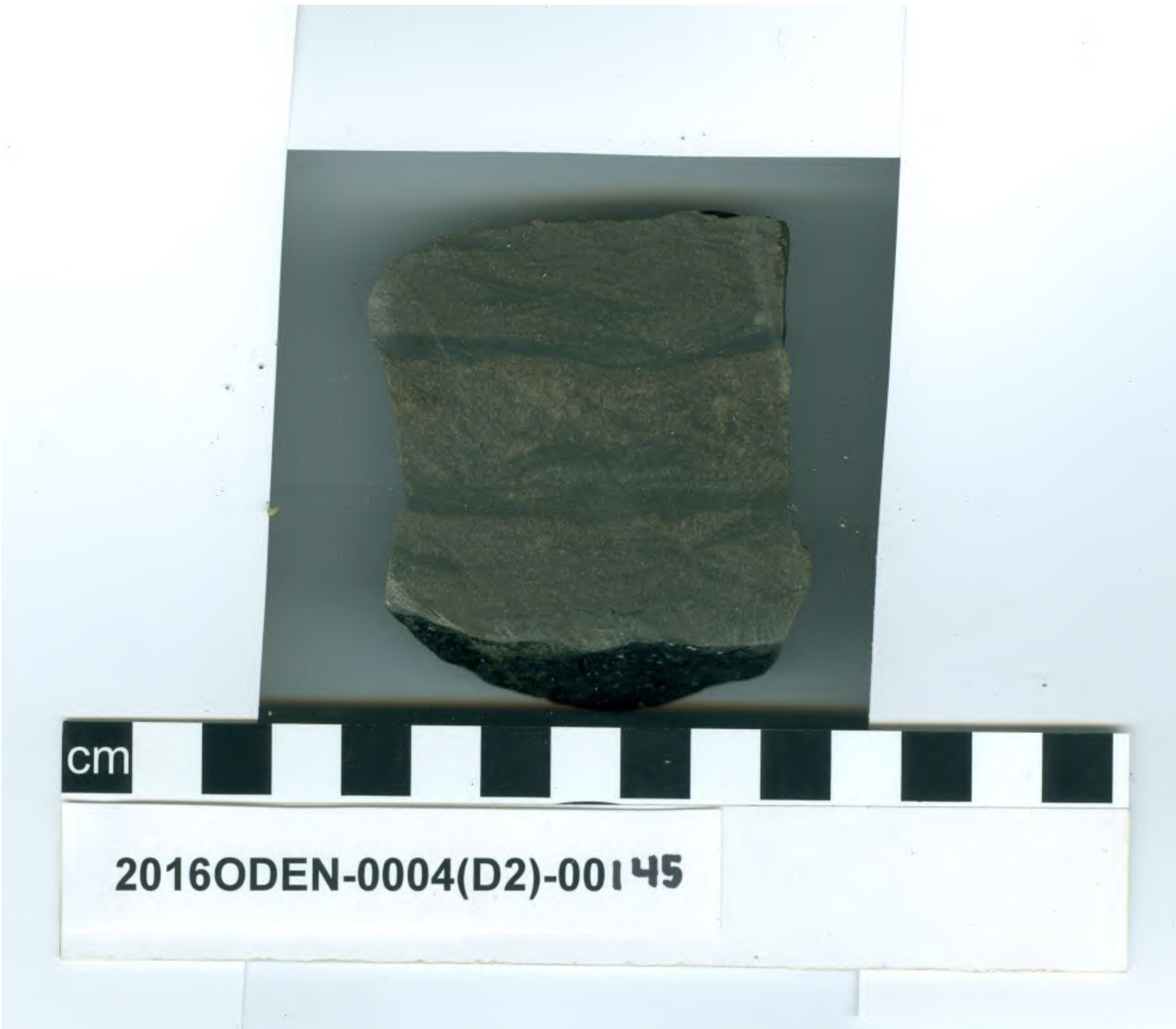
OD2016-D2-141

OD2016-D2-142

OD2016-D2-143

OD2016-D2-144

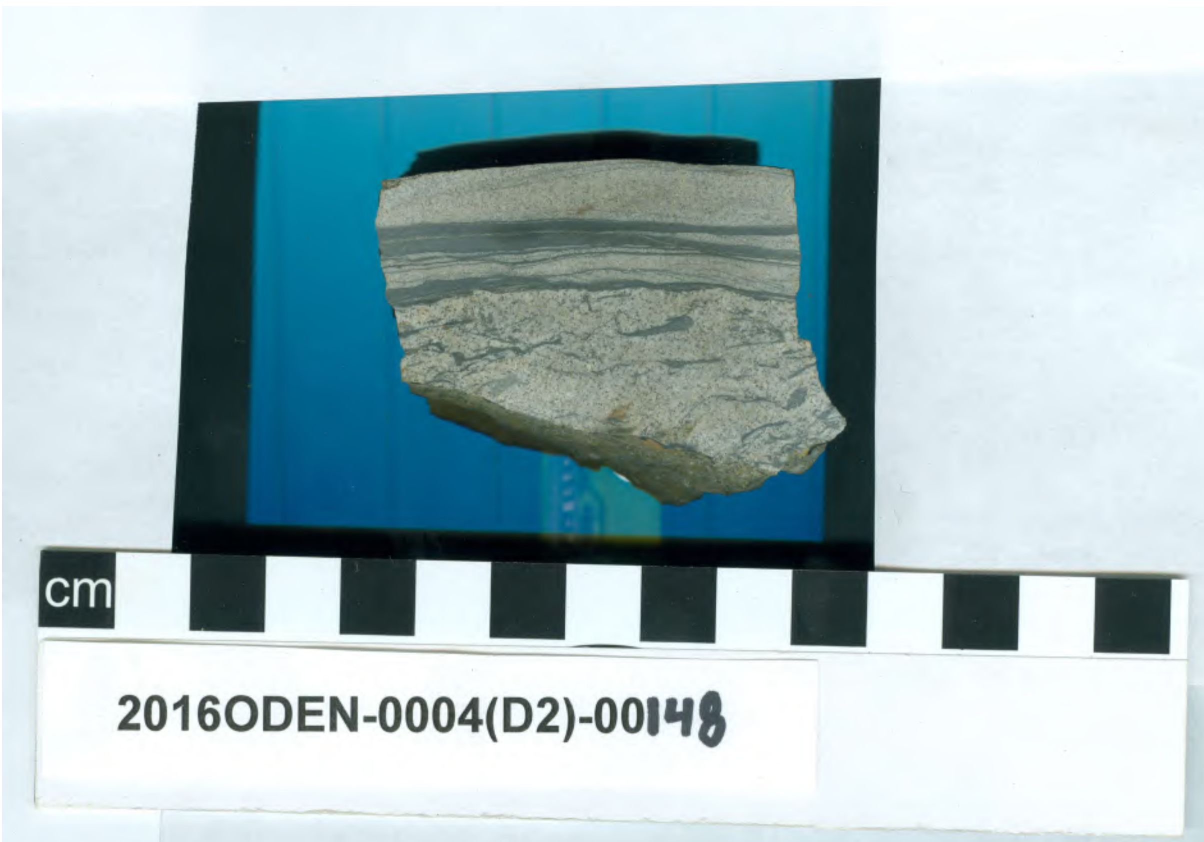
OD2016-D2-145



OD2016-D2-146

OD2016-D2-147

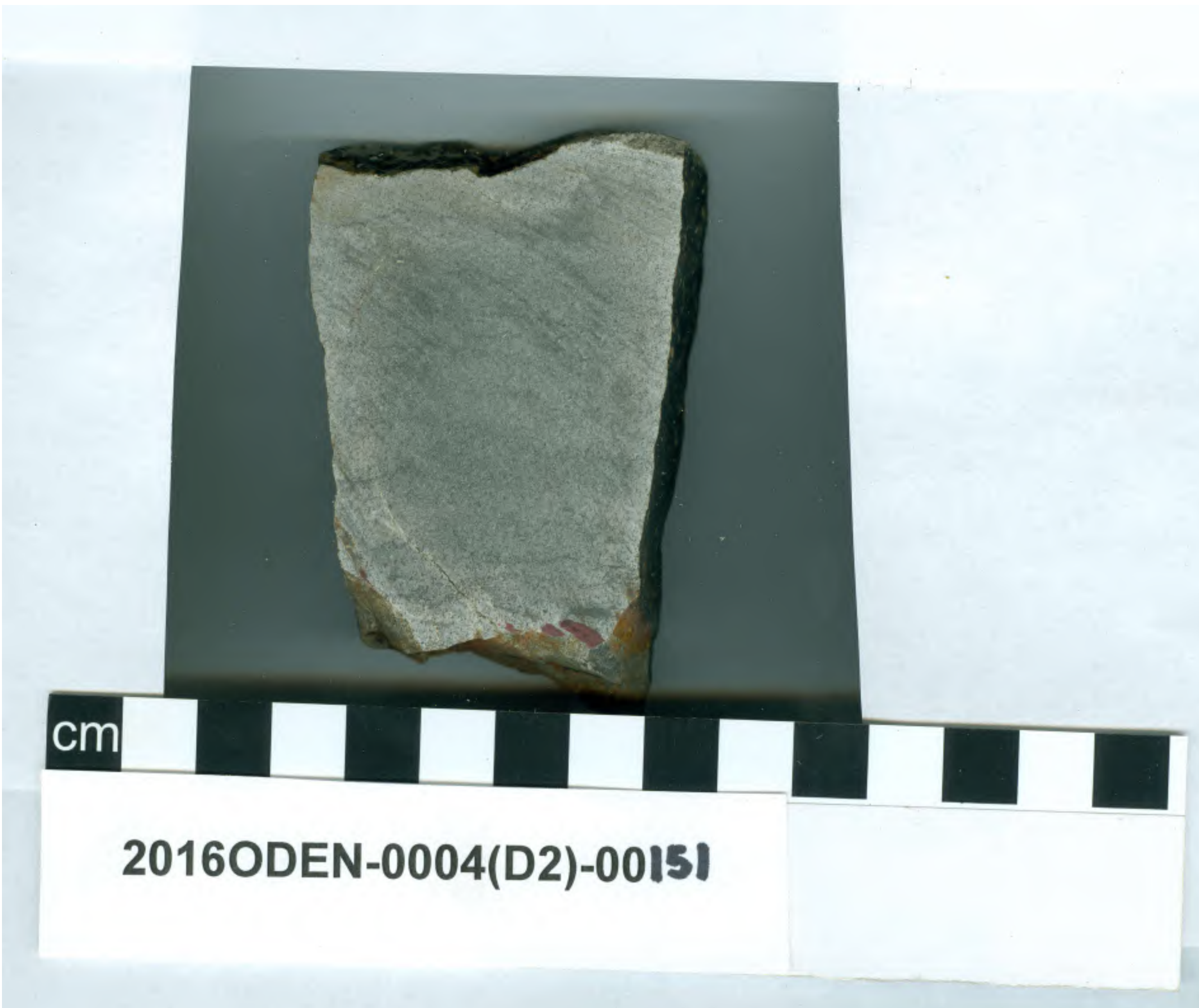
OD2016-D2-148



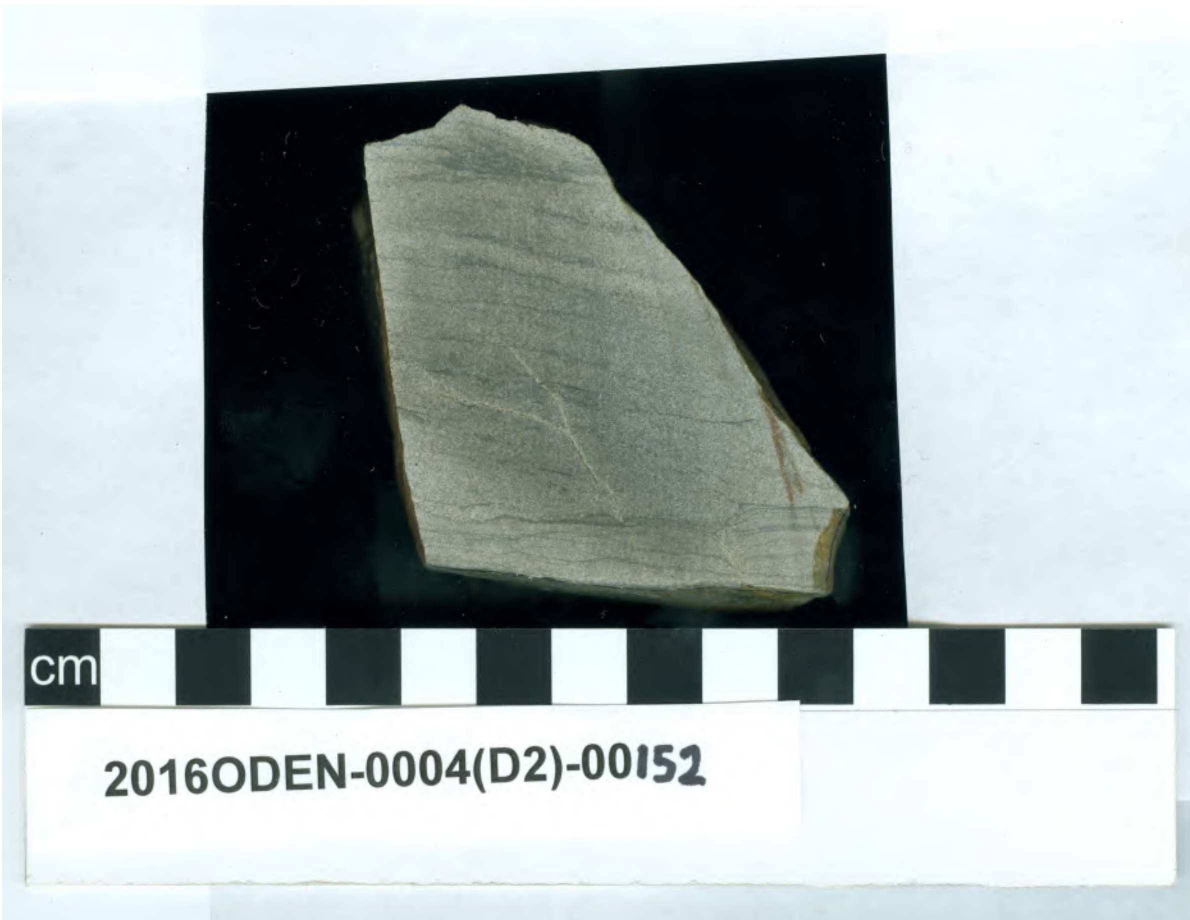
OD2016-D2-149

OD2016-D2-150

OD2016-D2-151



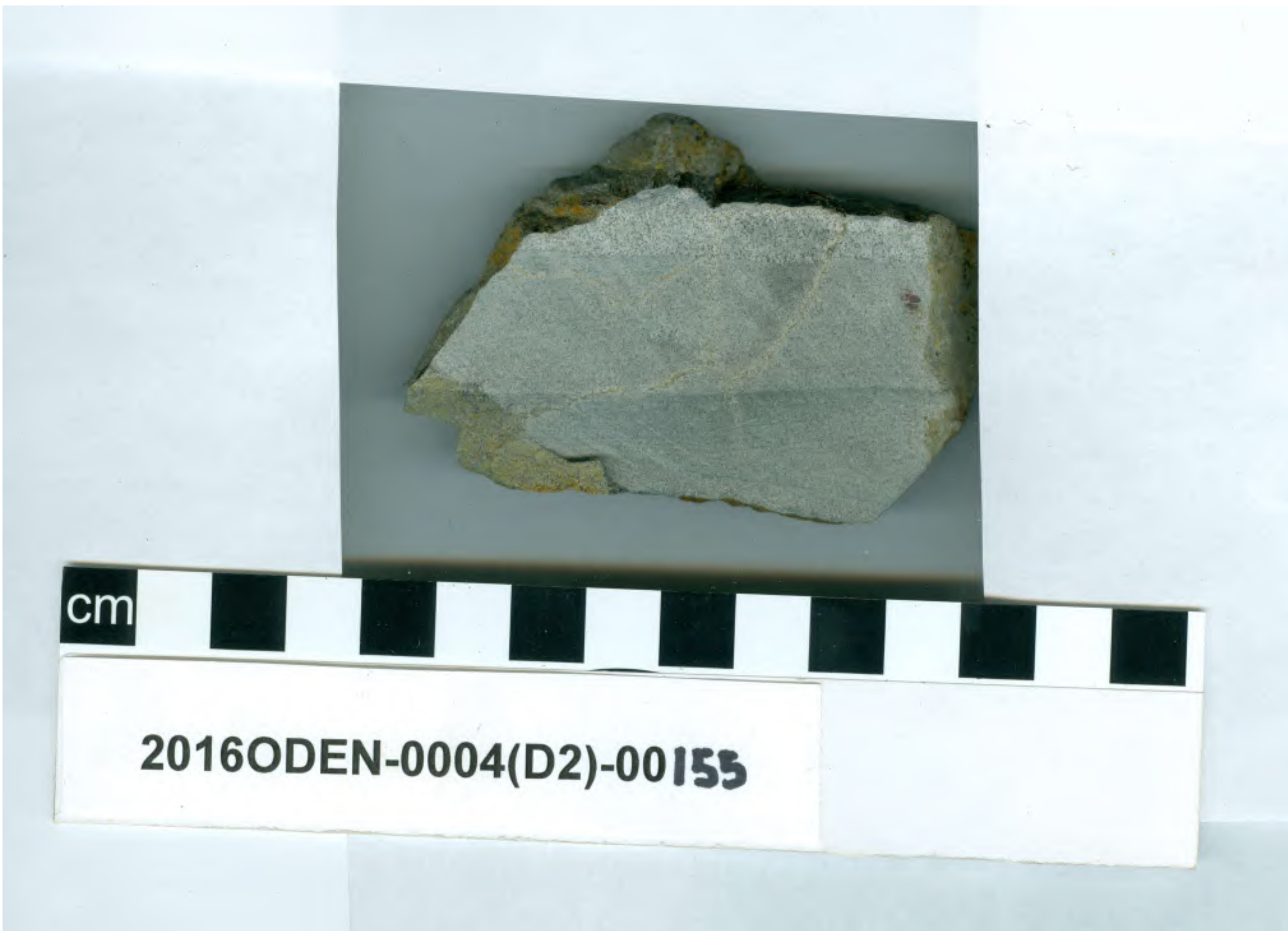
OD2016-D2-152



OD2016-D2-153

OD2016-D2-154

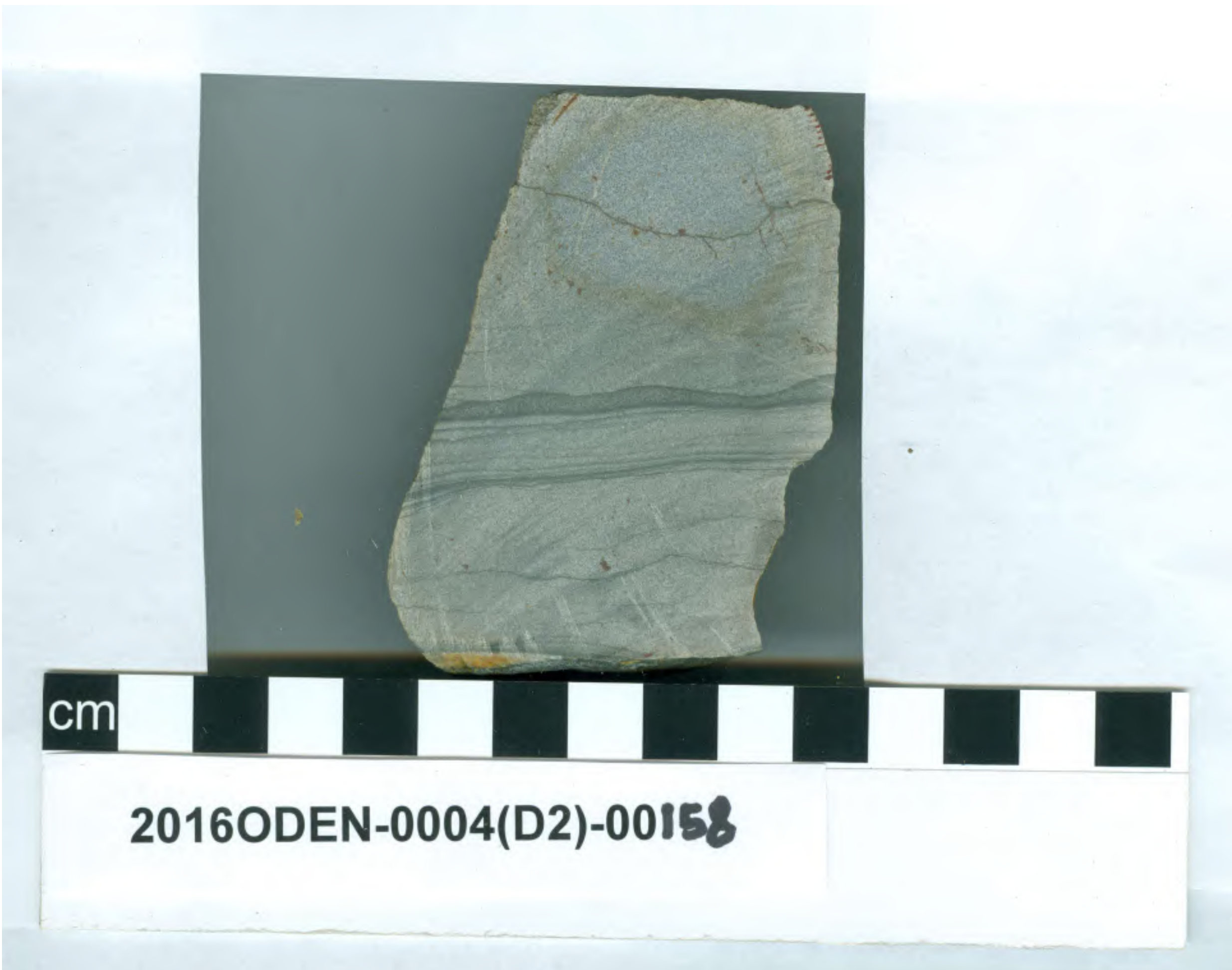
OD2016-D2-155



OD2016-D2-156

OD2016-D2-157

OD2016-D2-158



OD2016-D2-159

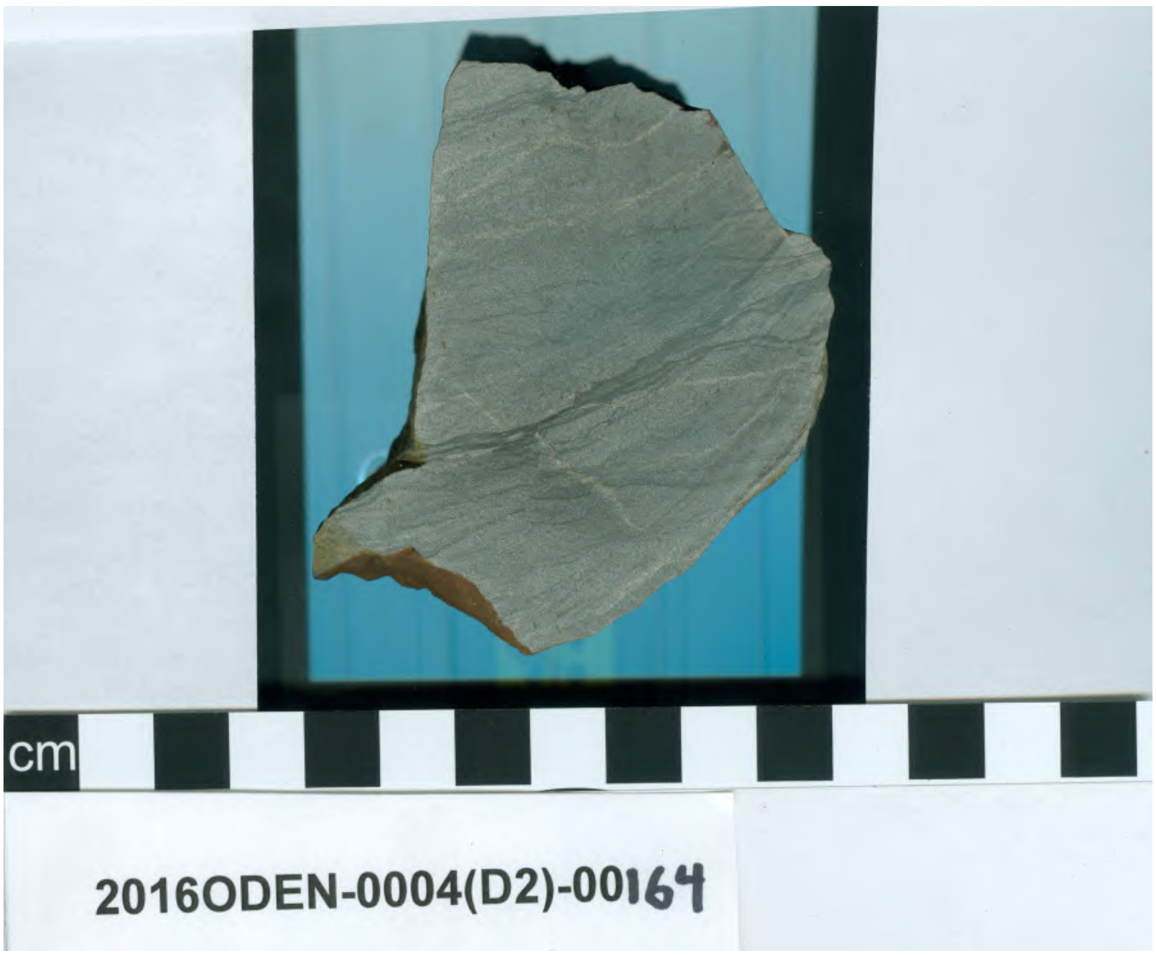
OD2016-D2-160

OD2016-D2-161

OD2016-D2-162

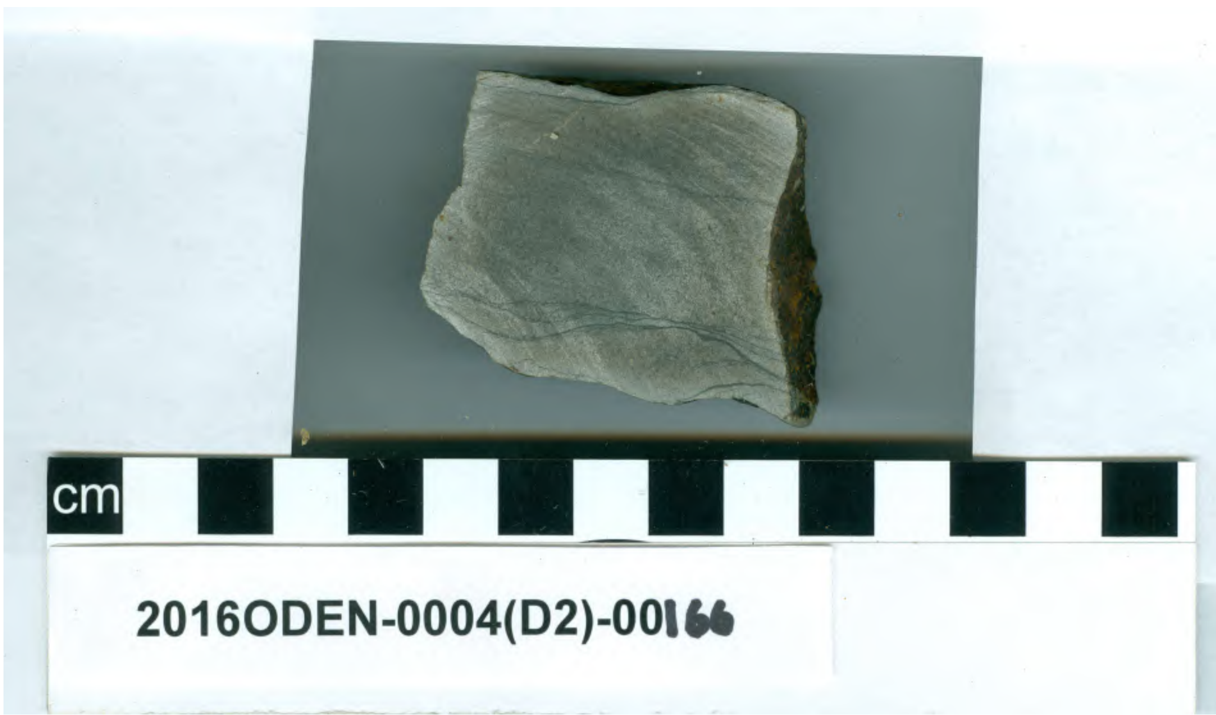
OD2016-D2-163

OD2016-D2-164

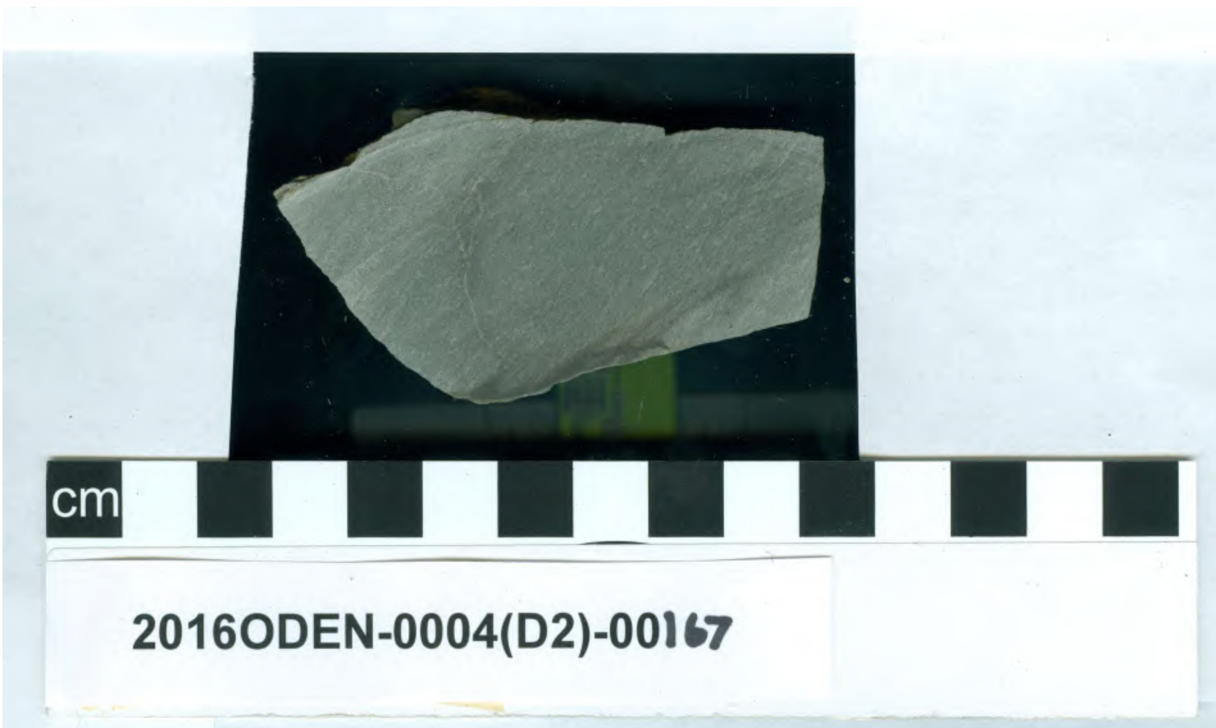


OD2016-D2-165

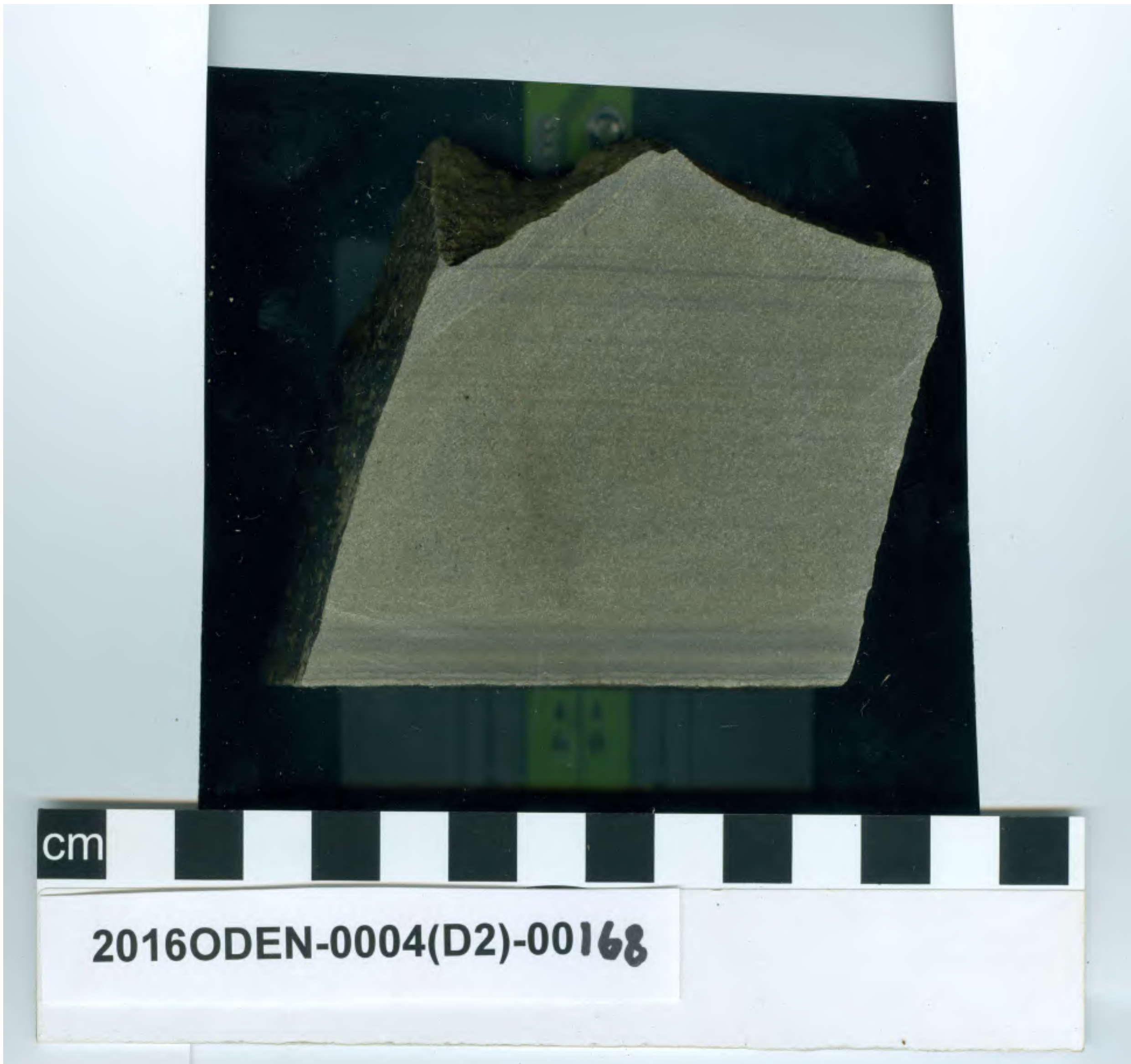
OD2016-D2-166



OD2016-D2-167



OD2016-D2-168



OD2016-D2-169

OD2016-D2-170

OD2016-D2-171

OD2016-D2-172

OD2016-D2-173

OD2016-D2-174

OD2016-D2-175

OD2016-D2-176

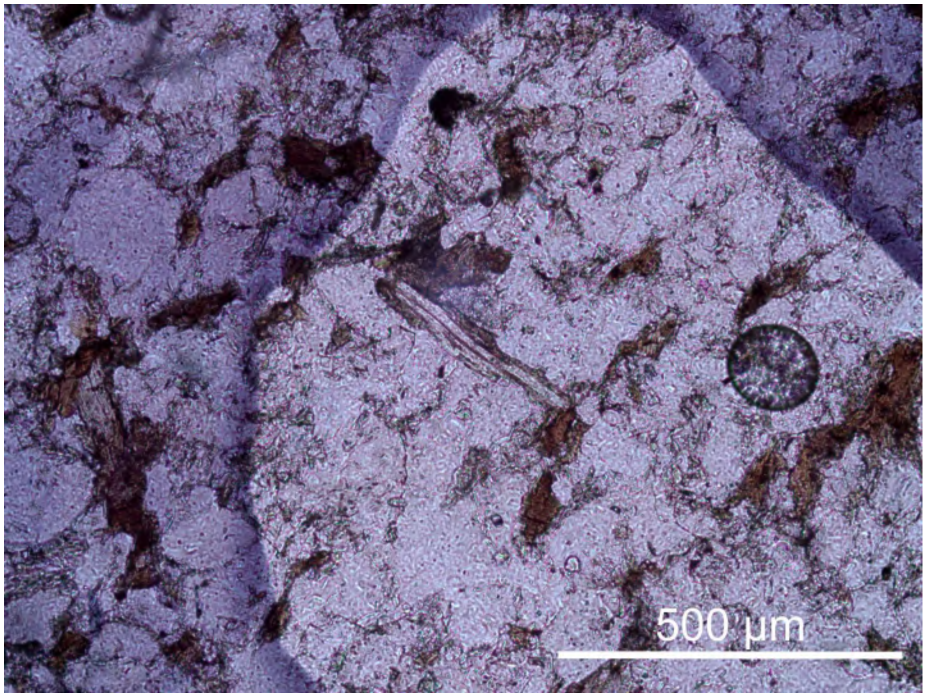
Appendix 3: OD2016-D2 petrographic photographs.

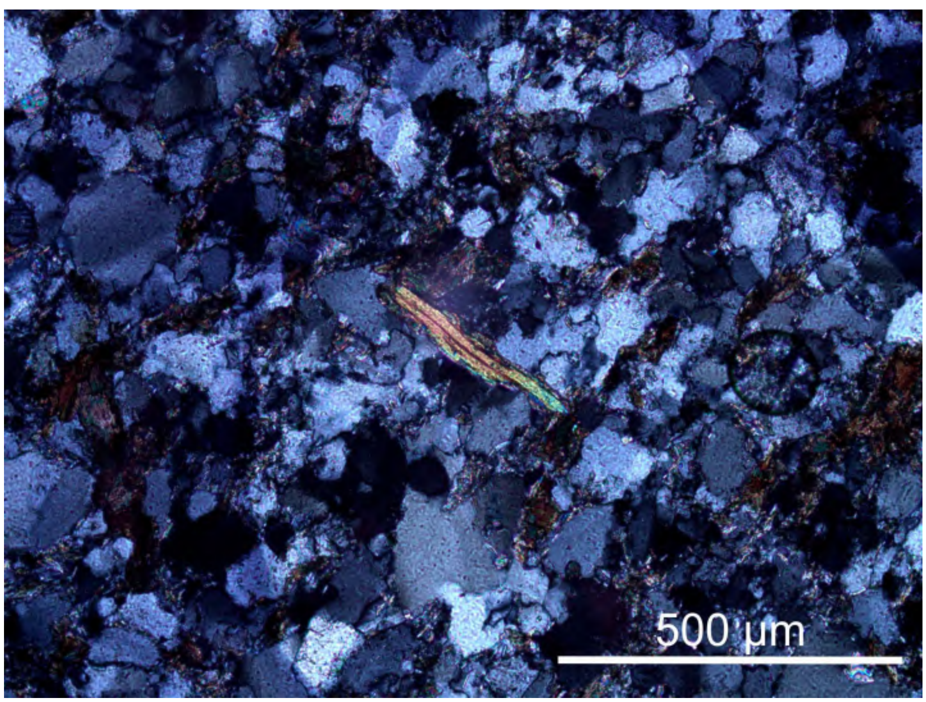
Notes:

A sample number succeeded by -1, or -2 indicates thin section number. Eg. 011-2 is the second thin section from sample 011.

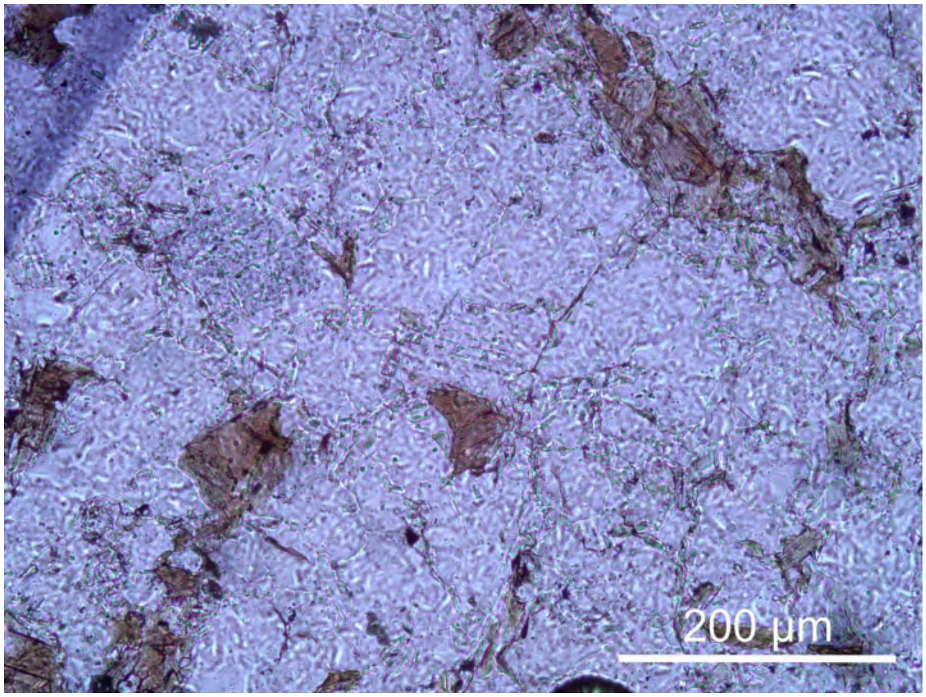
A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 012 has been cut into two halves, one half is 012-a and the other half is 012-b.

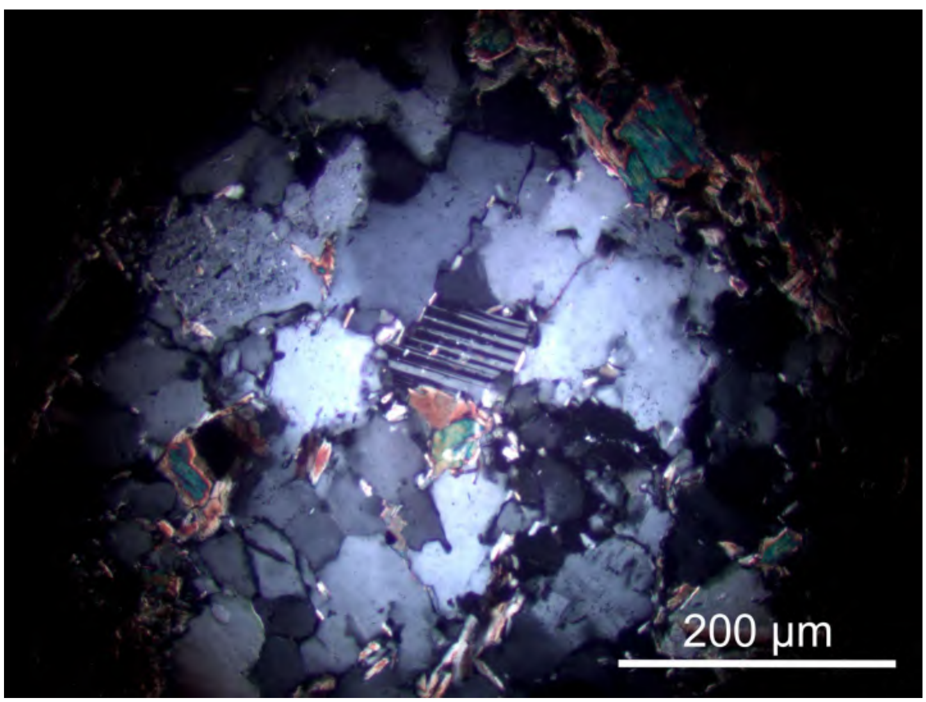
OD2016-001-1 detrital muscovite



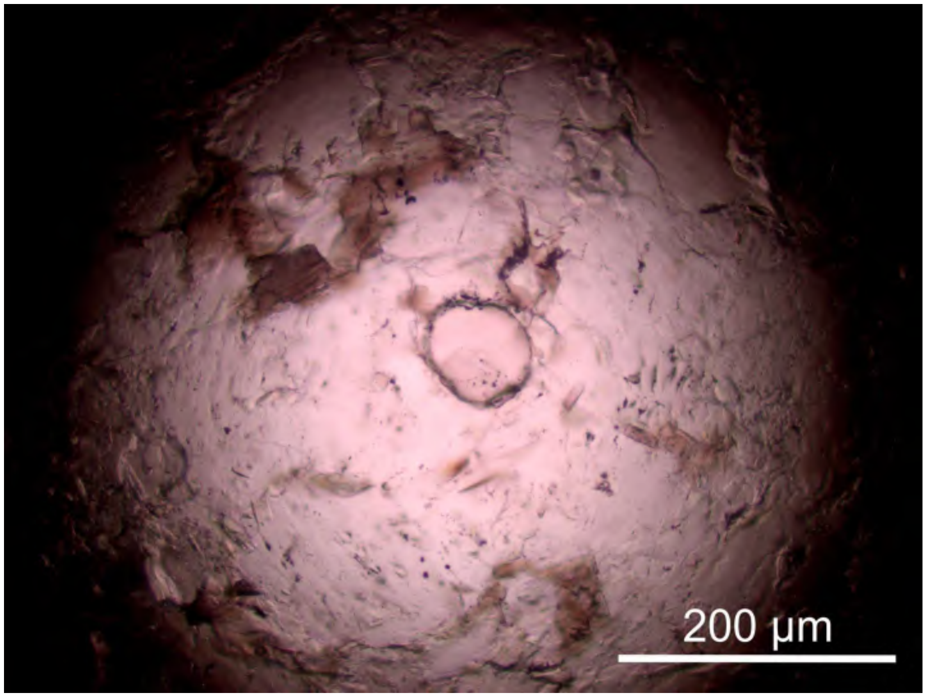


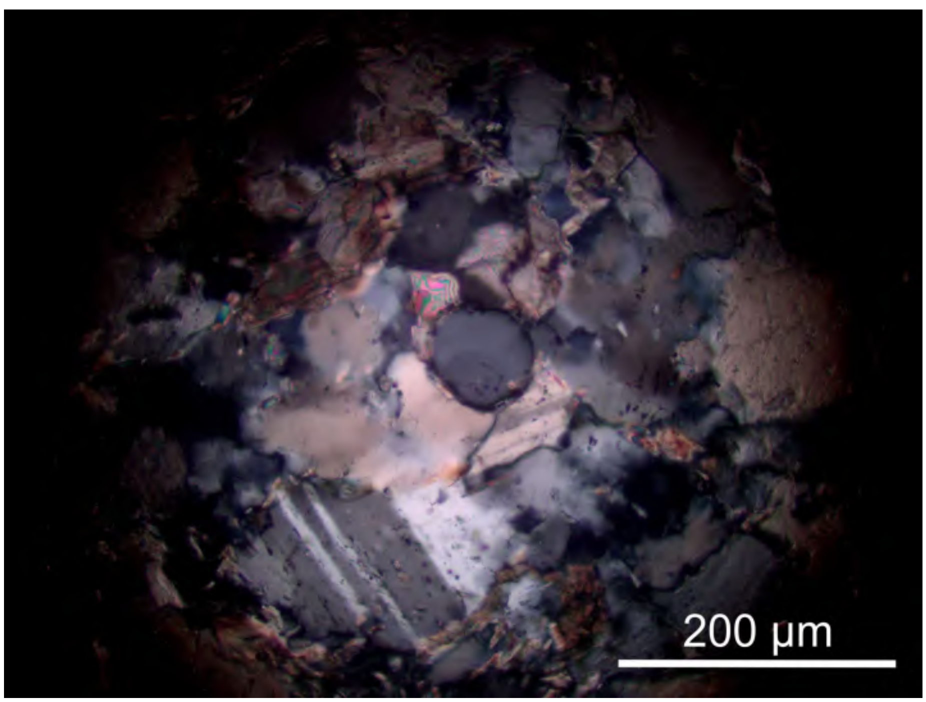
OD2016-001-1 albite twinning and diagenetic rim



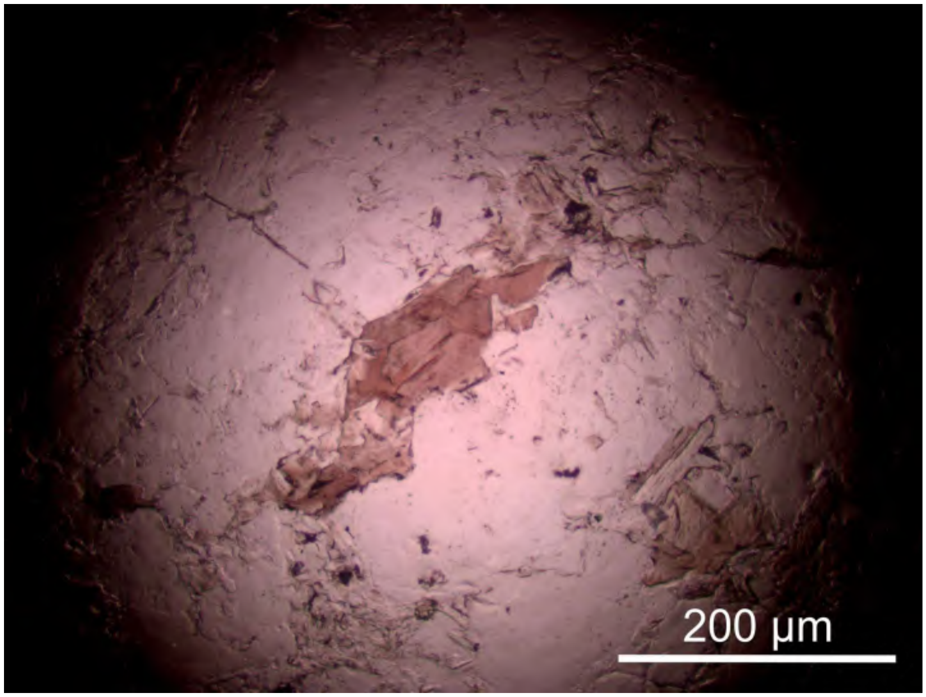


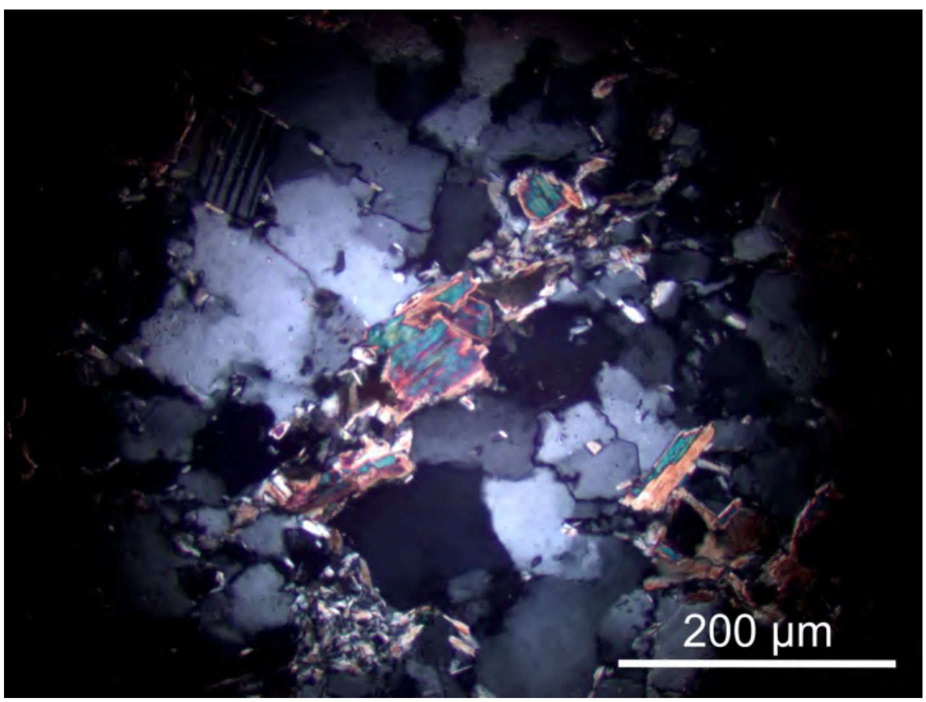
OD2016-001-1 apatite



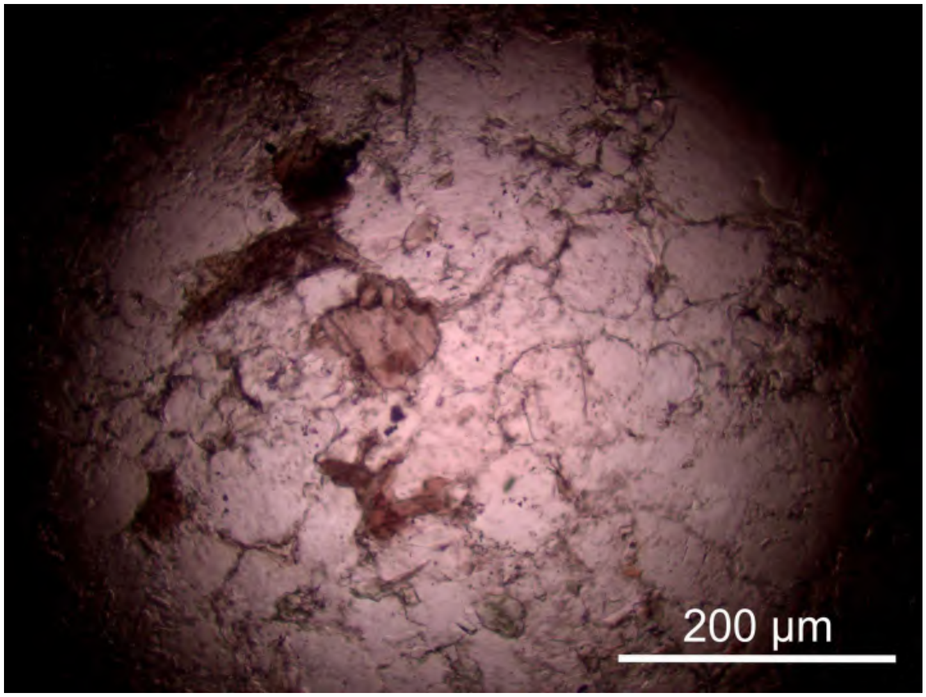


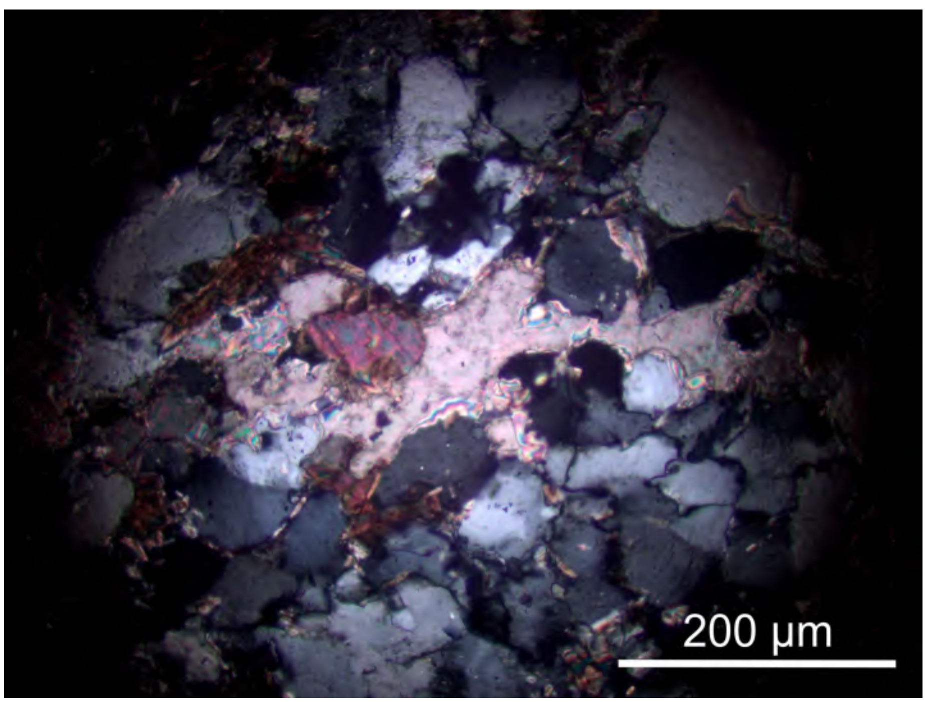
OD2016-001-1 biotite



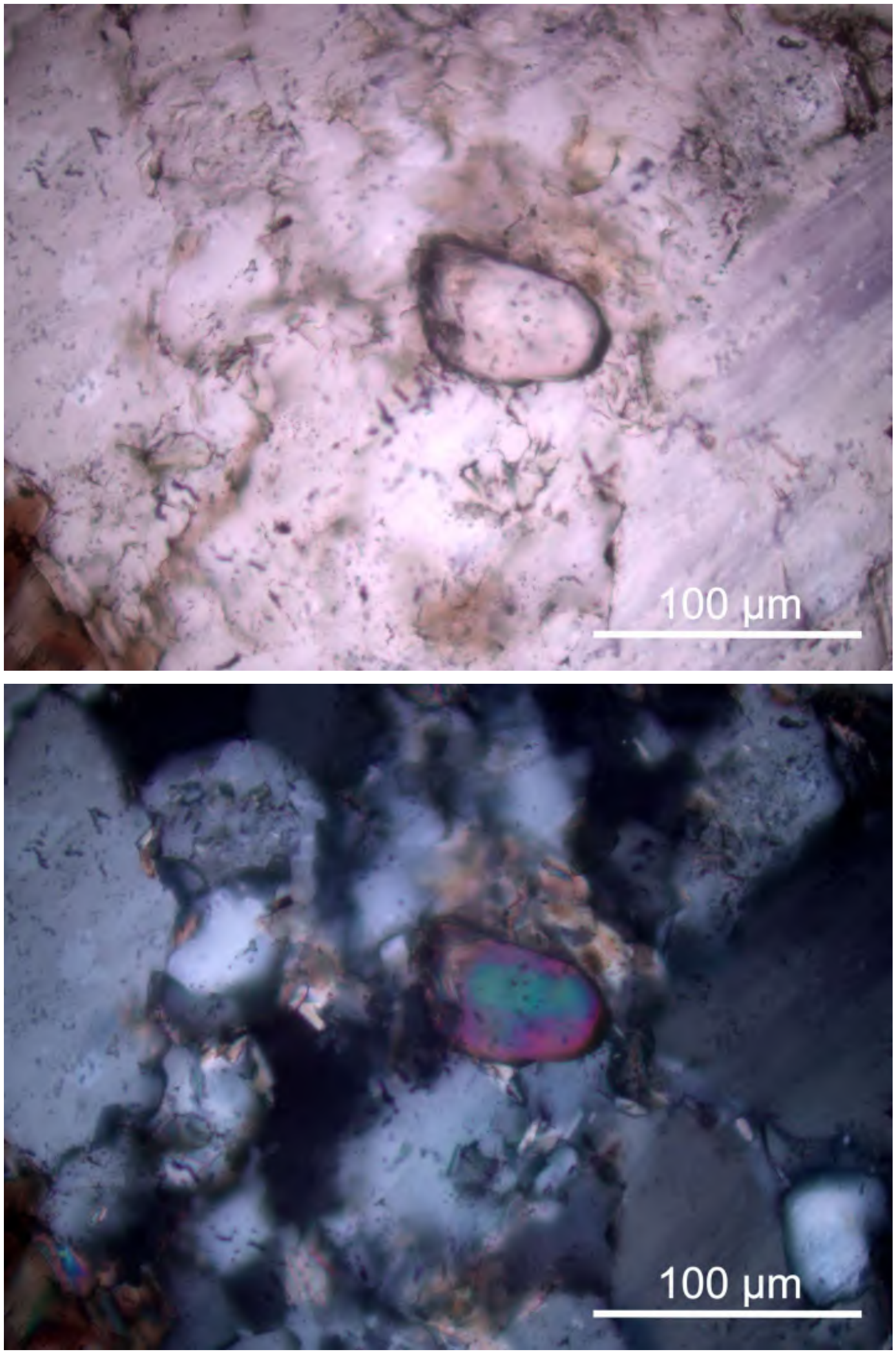


OD2016-001-1 calcite

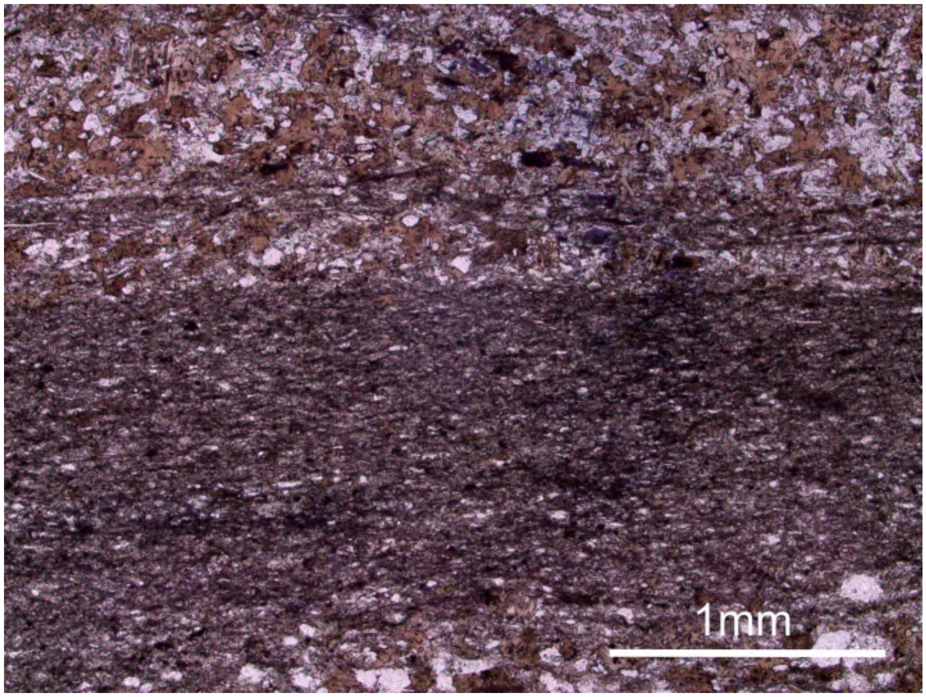


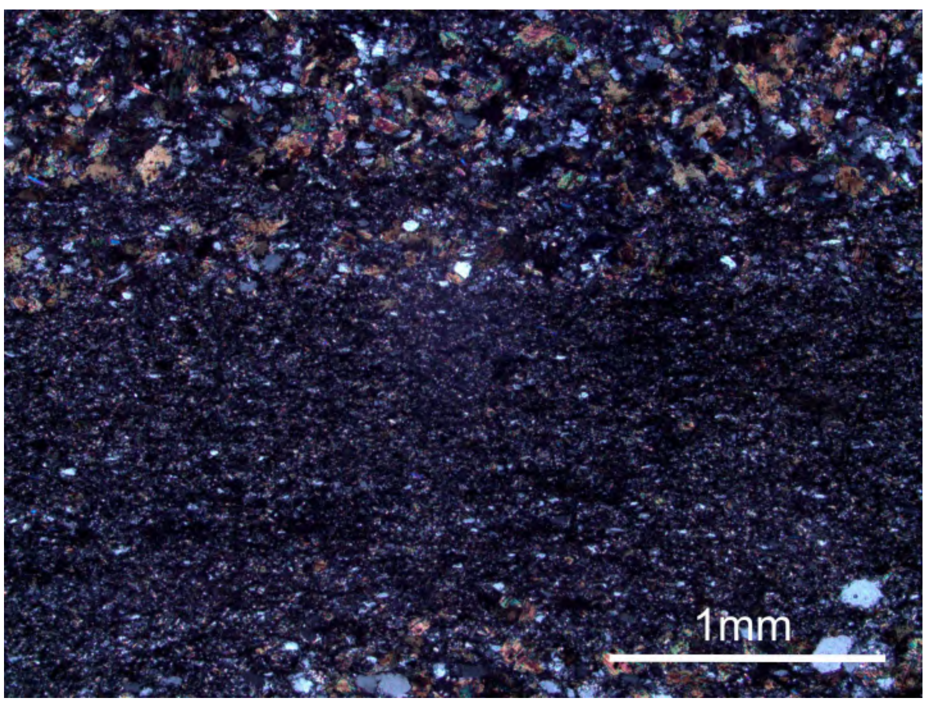


OD2016-001-1 zircon

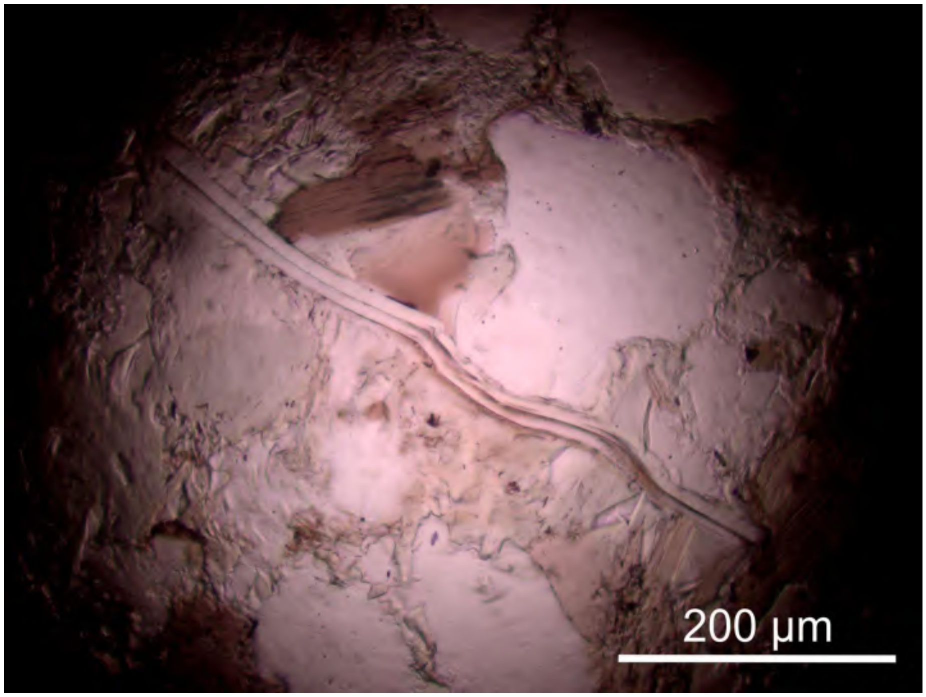


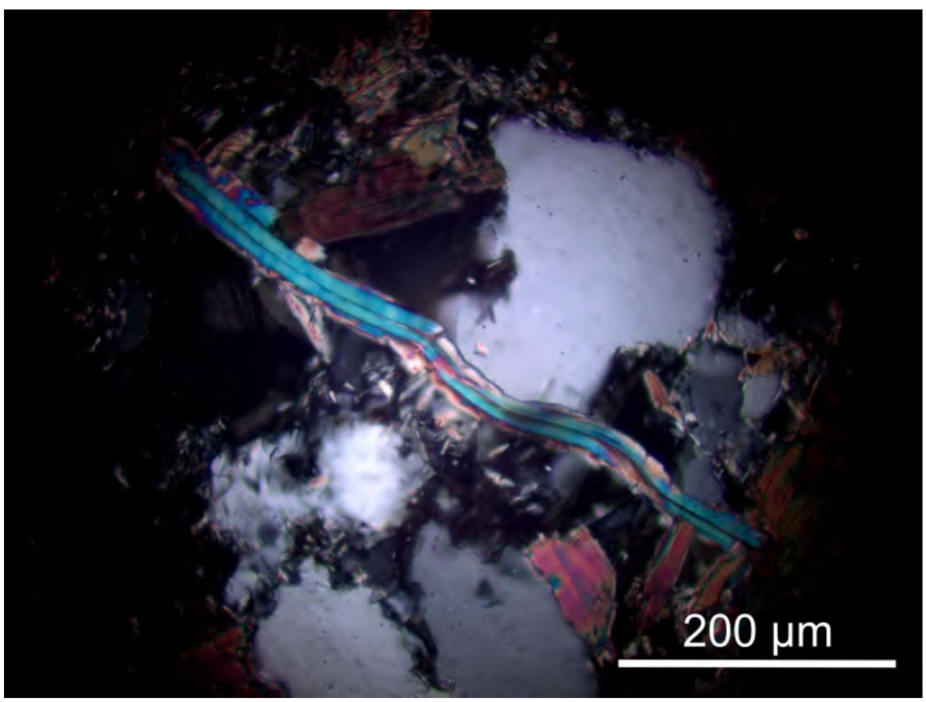
OD2016-002-1 aligned muddy matrix



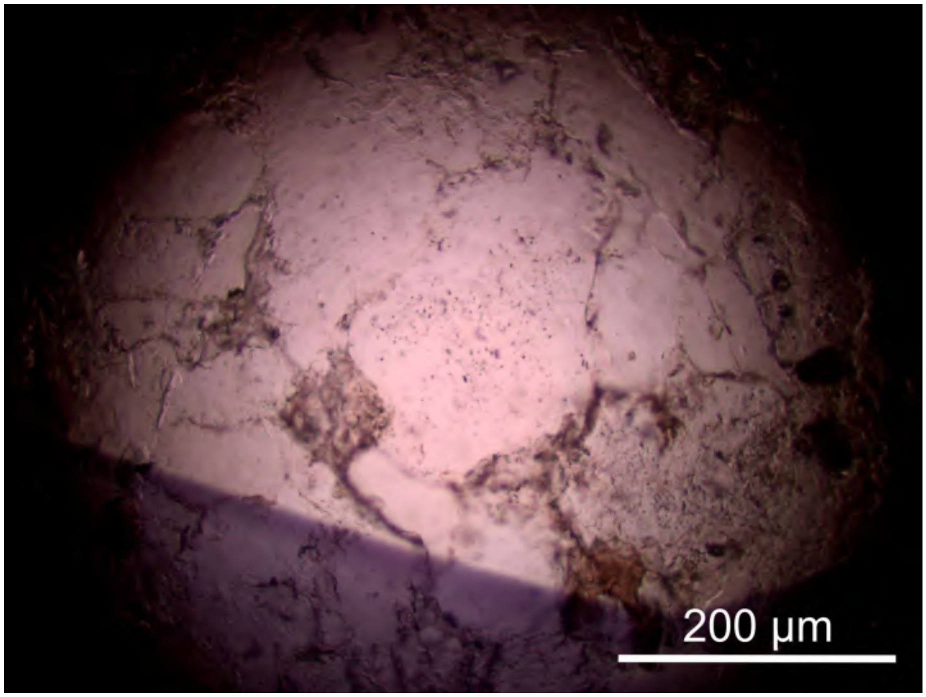


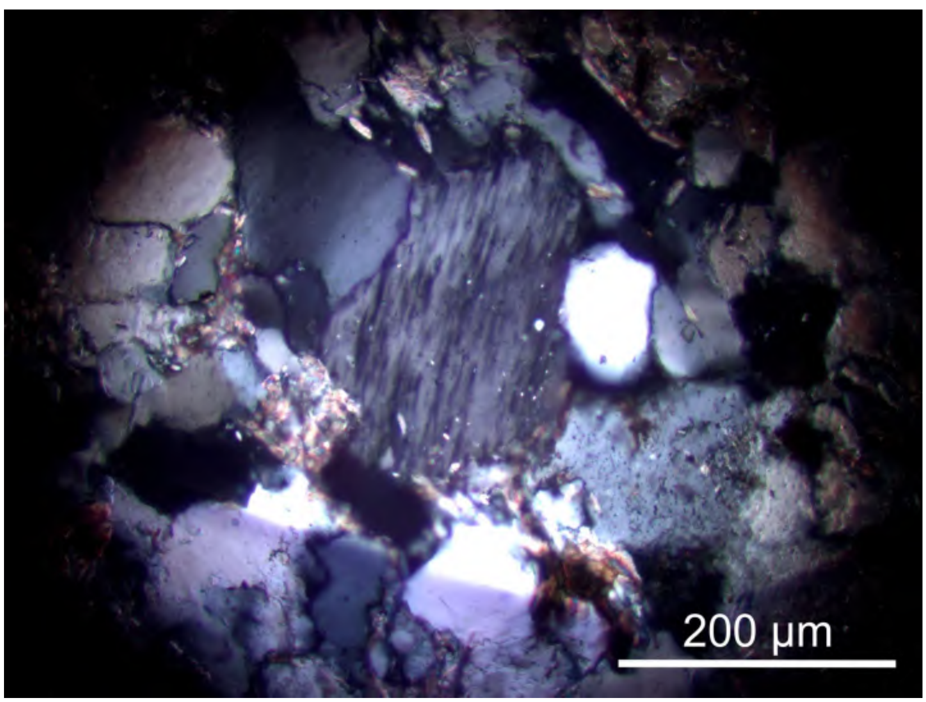
OD2016-002-1 detrital muscovite



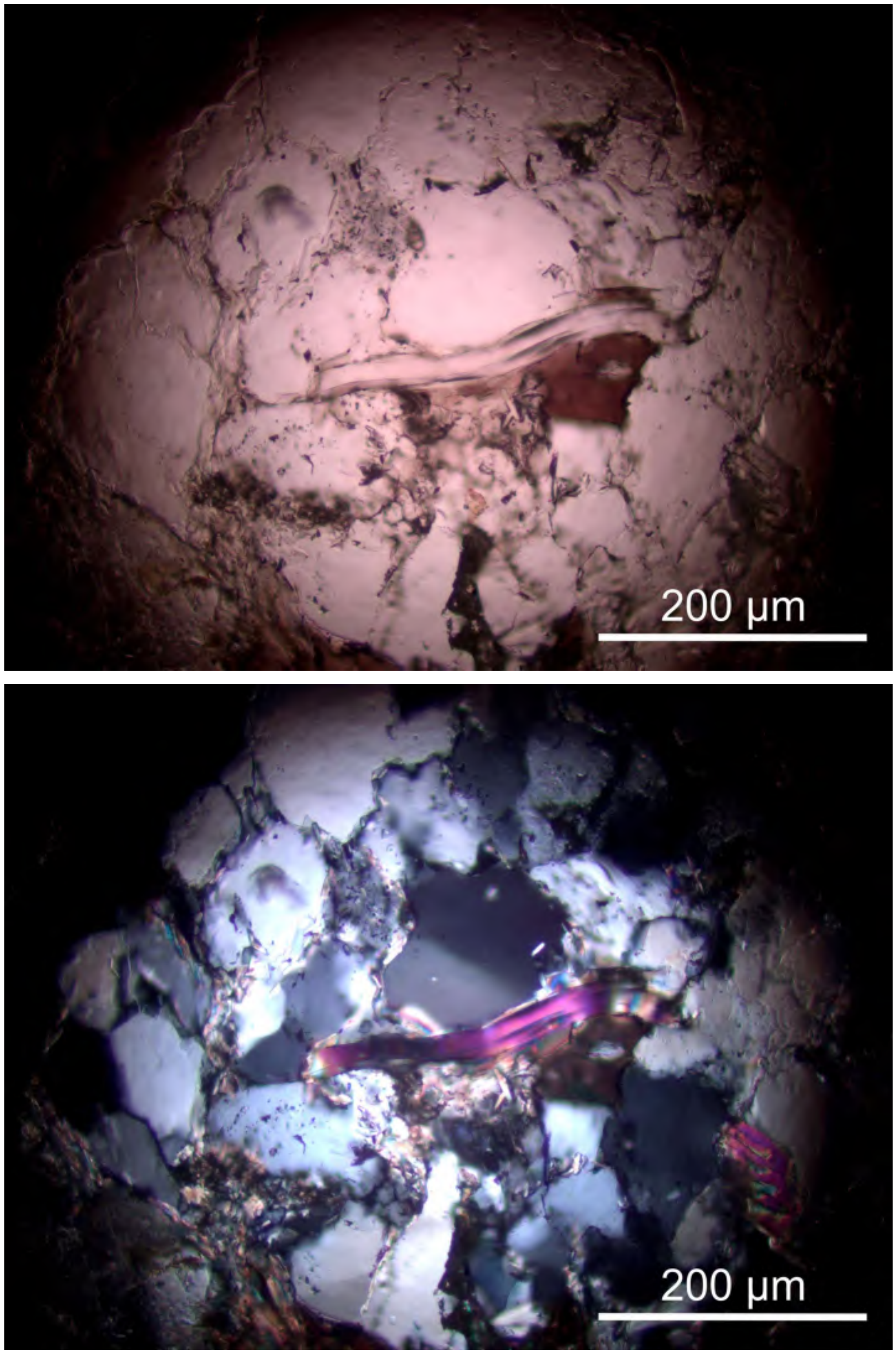


OD2016-004 perthite

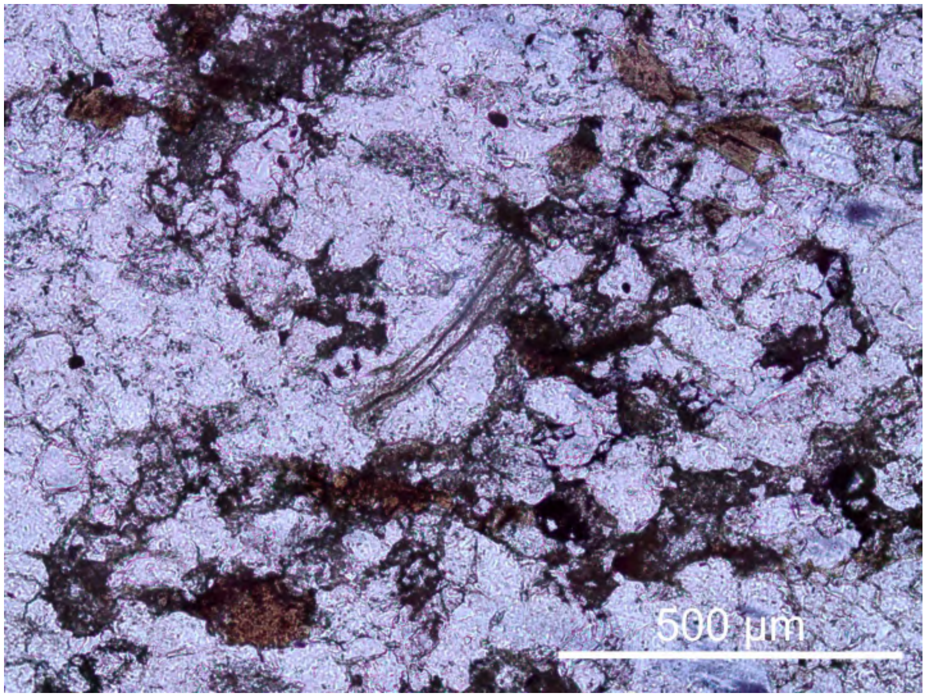


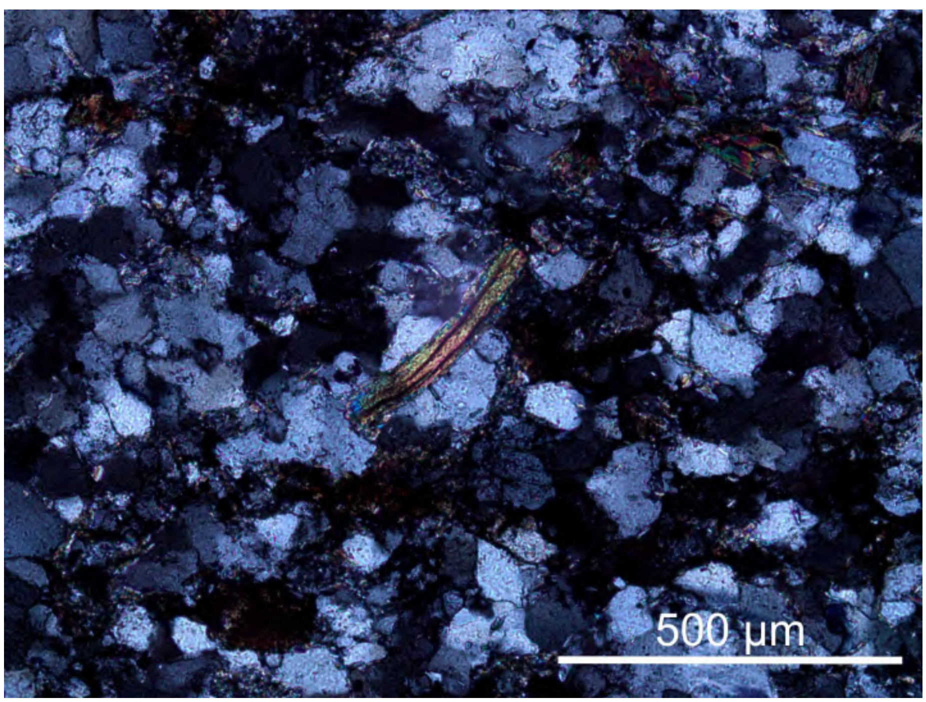


OD2016-004 detrital muscovite

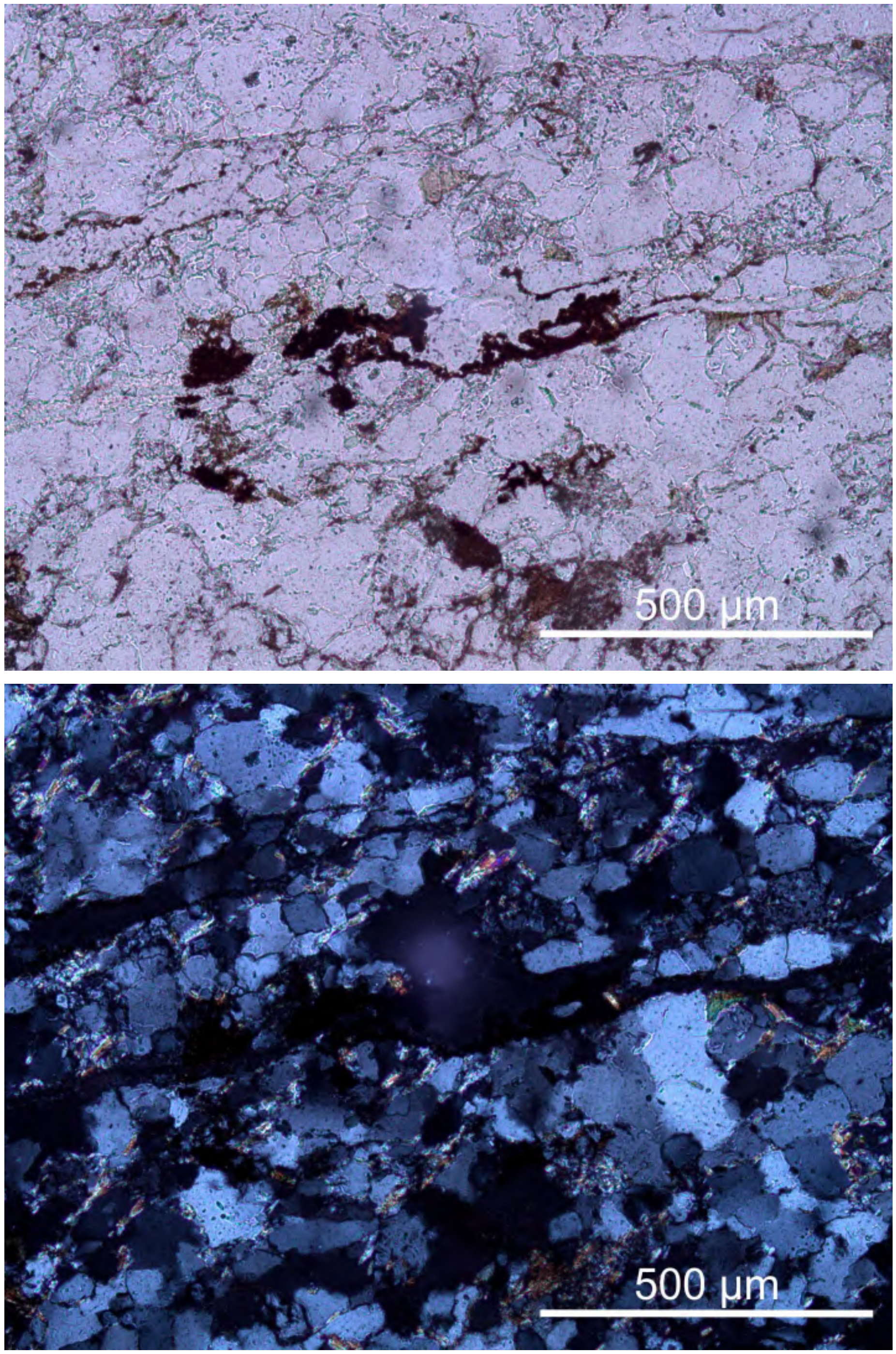


OD2016-006 detrital muscovite

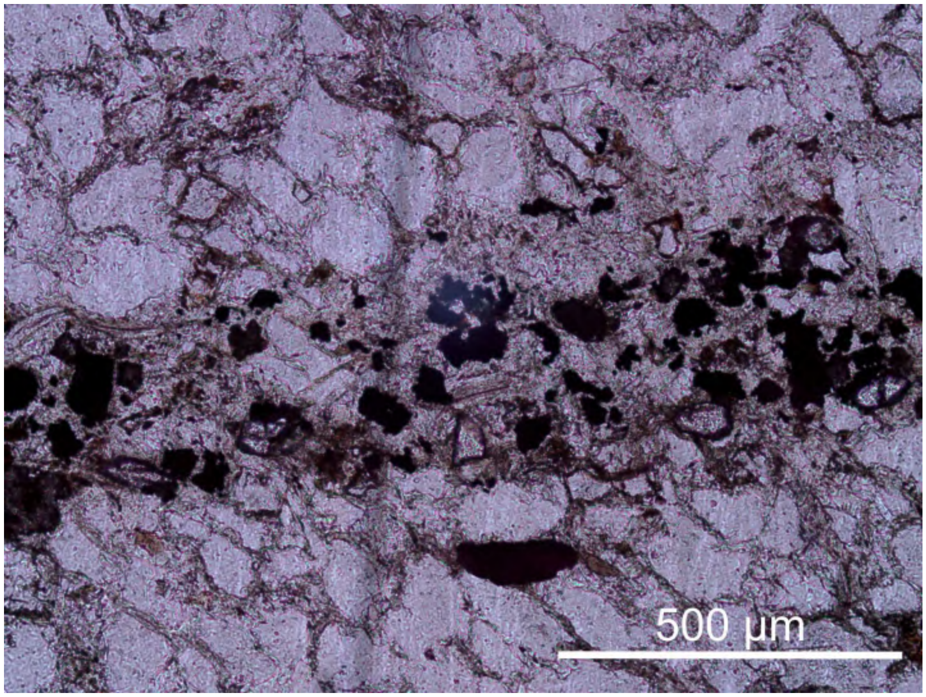


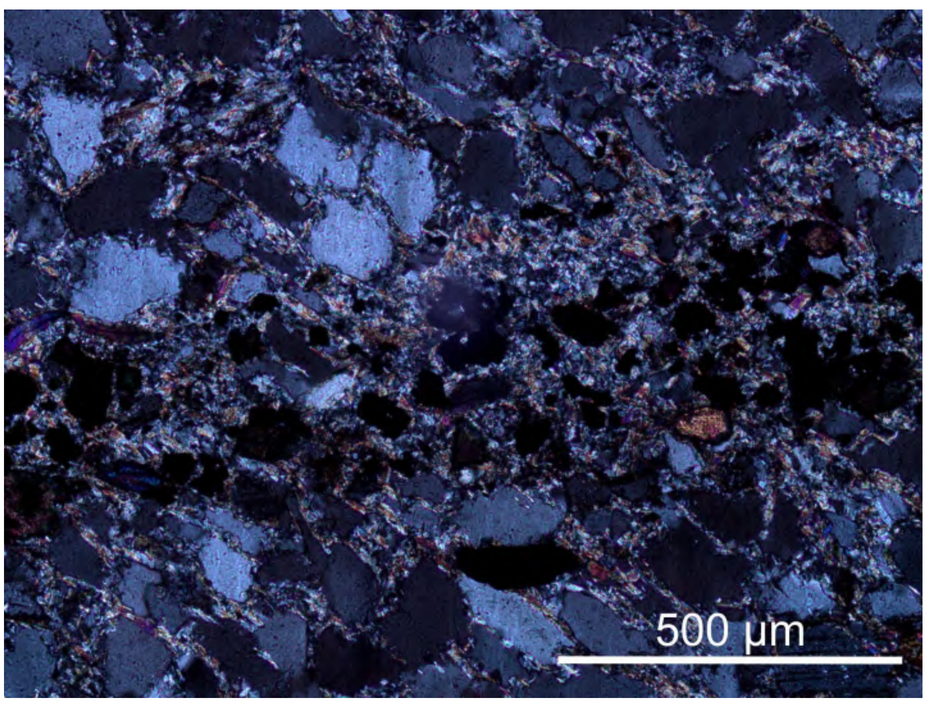


OD2016-006 iron staining along fracture

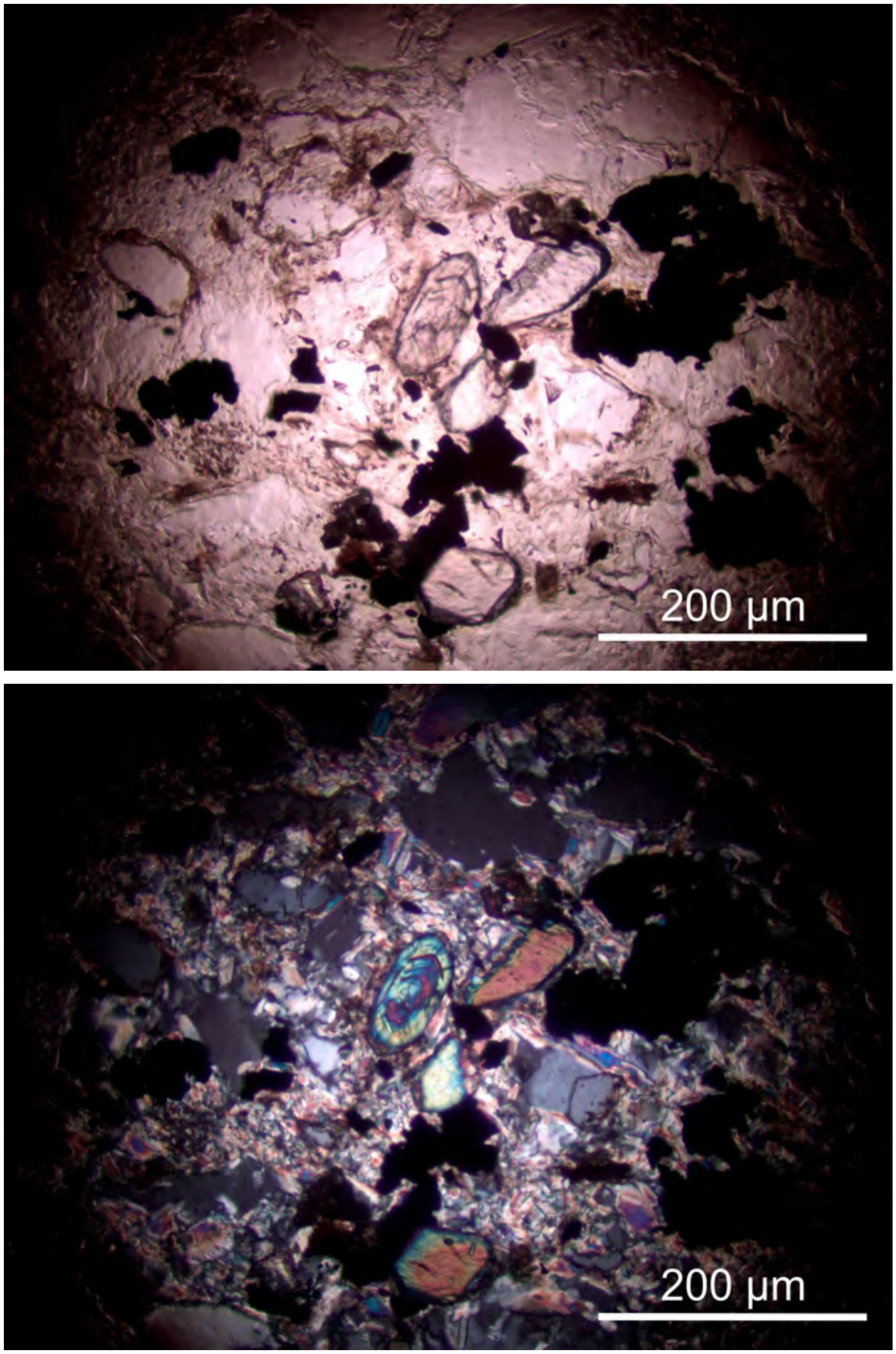


OD2016-011-1 heavy mineral bed

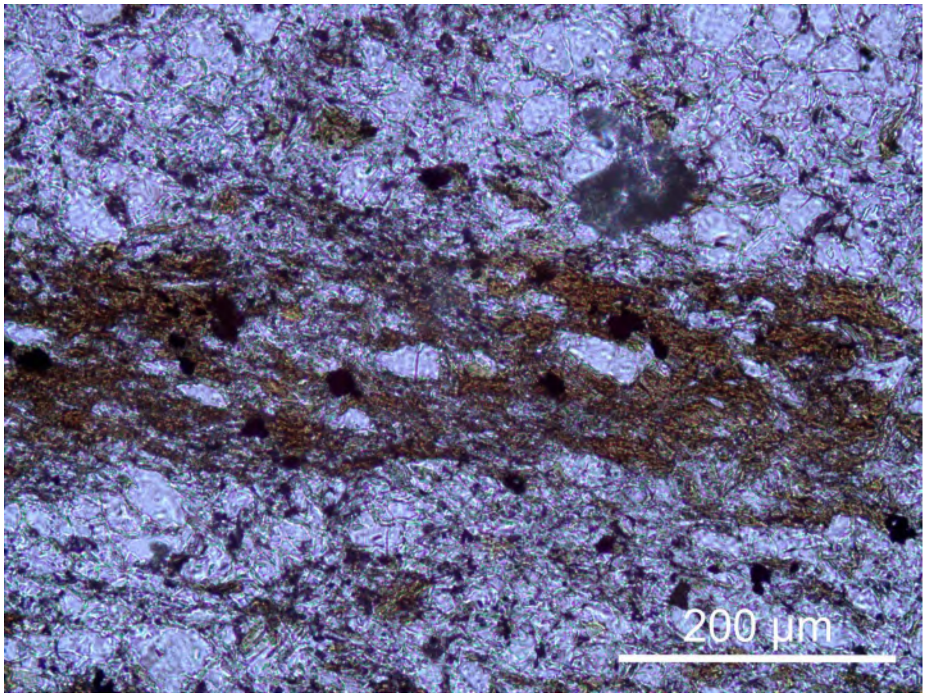


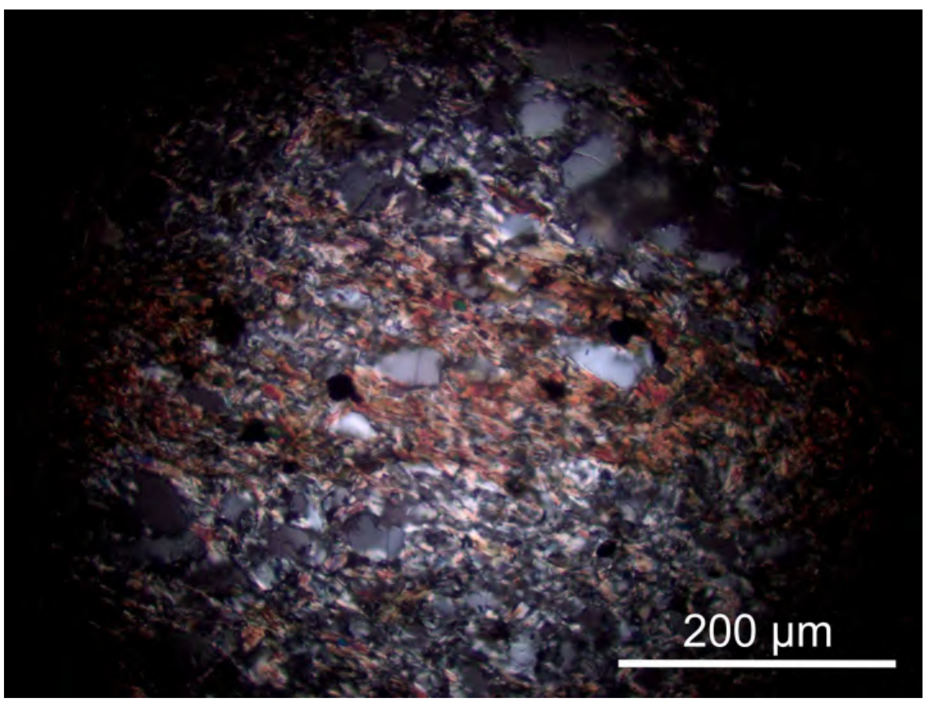


OD2016-011-1 heavy mineral bed

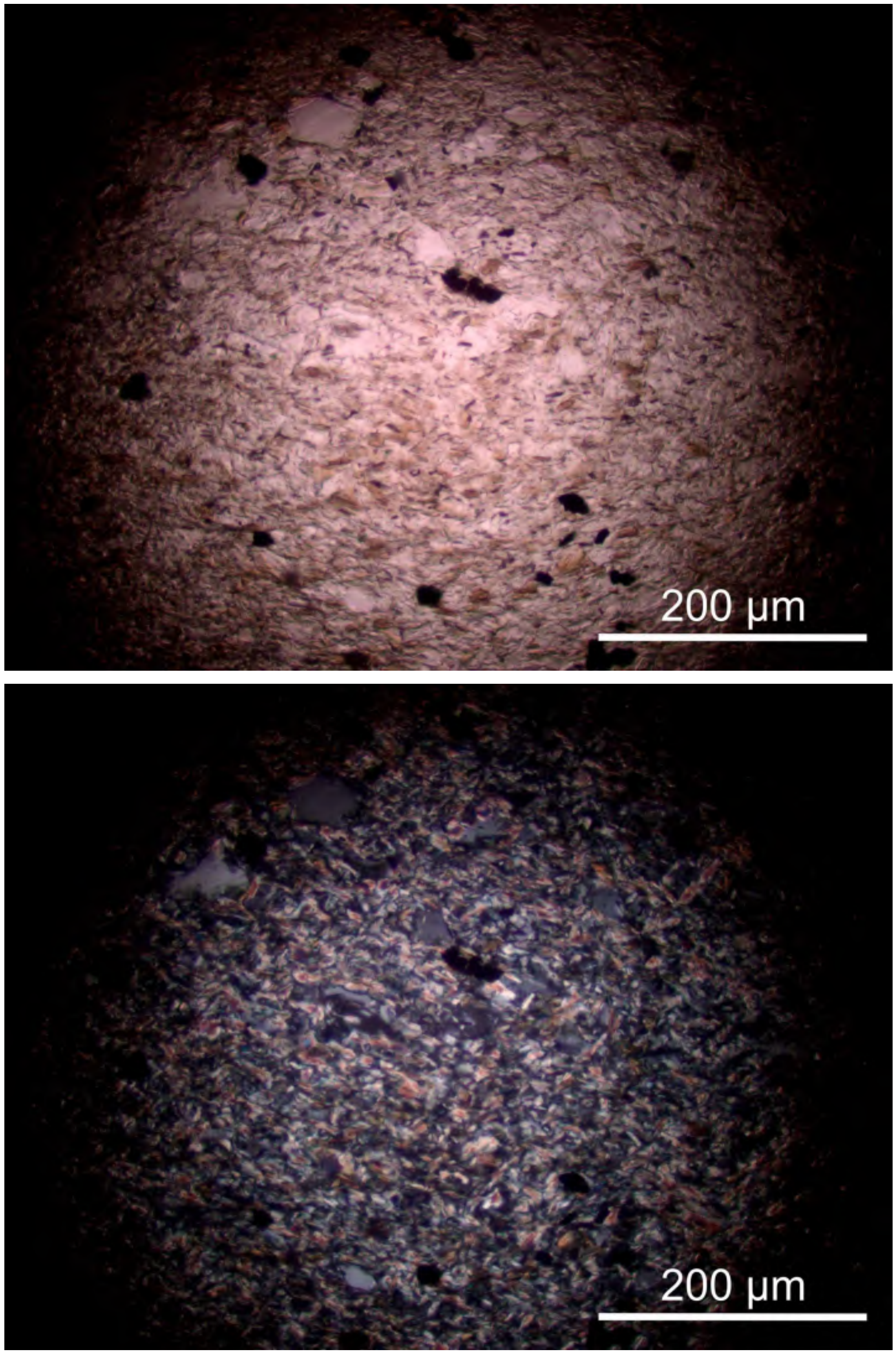


OD2016-012B biotite

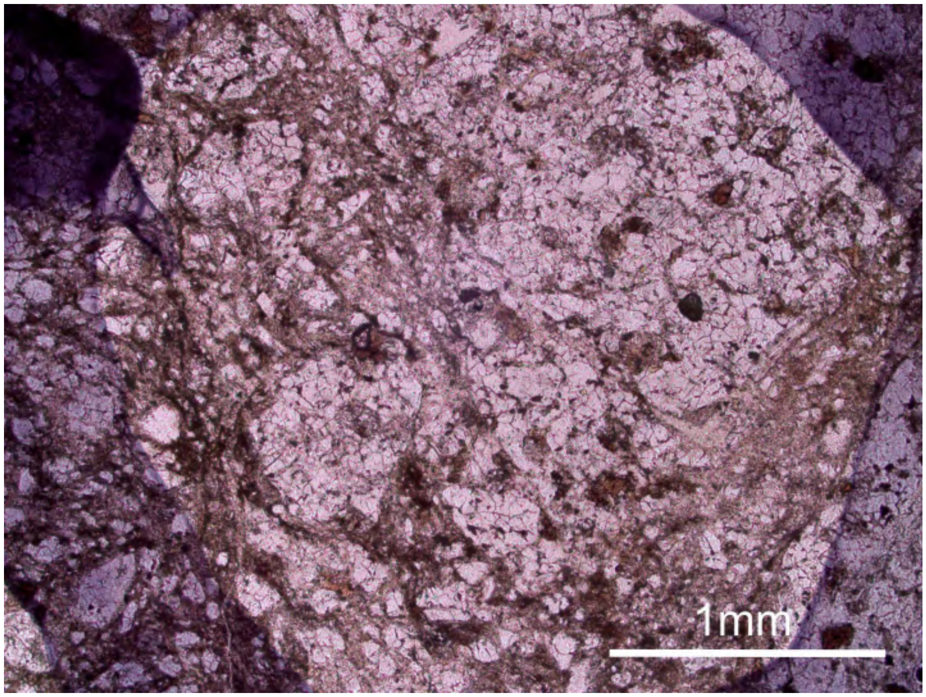


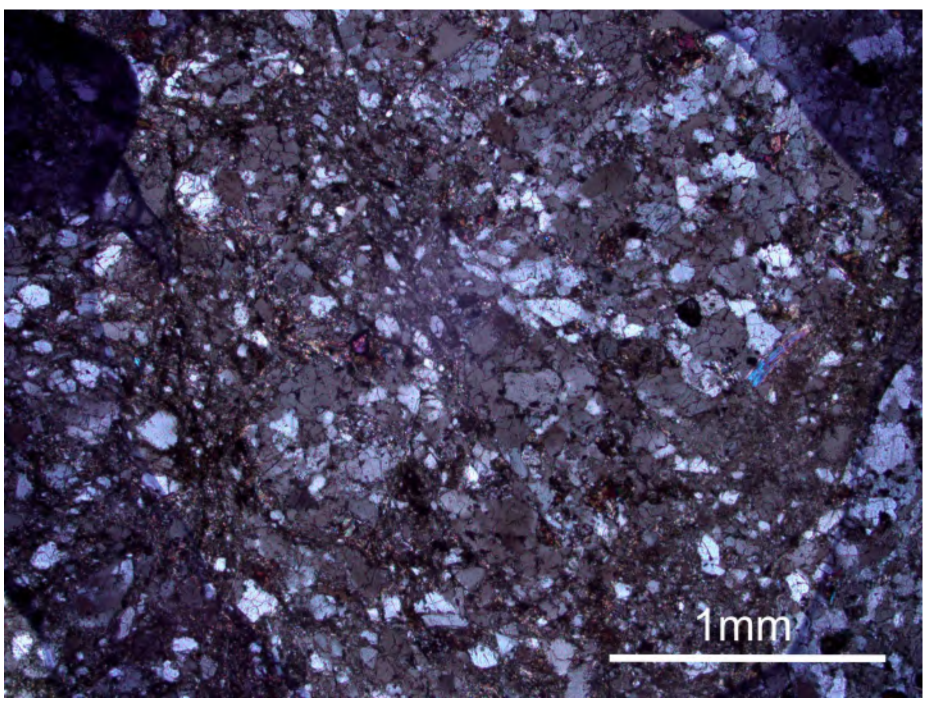


OD2016-012B muscovite showing grain alignment

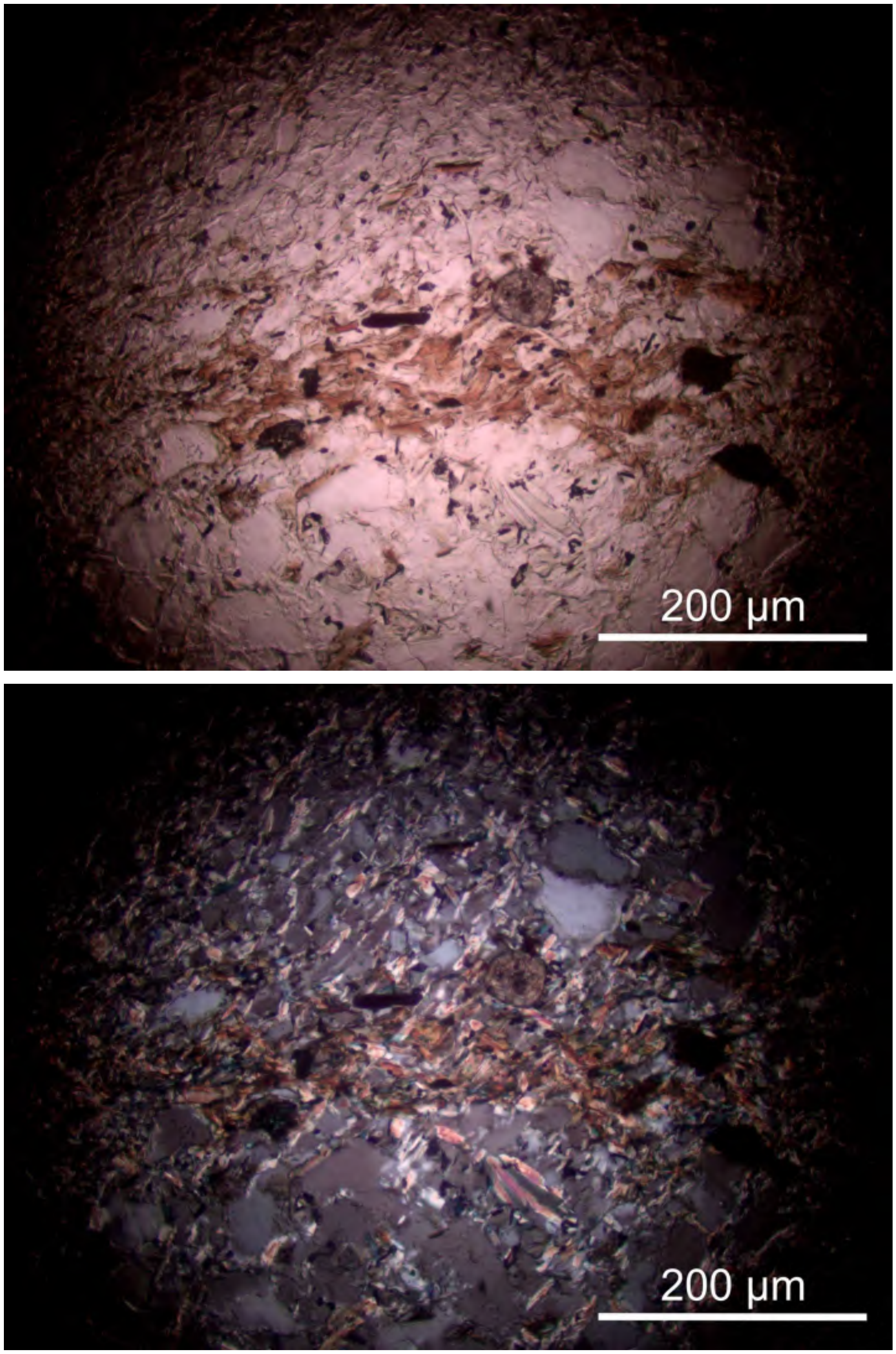


OD2016-013, zircon, muscovite, and lithic clast

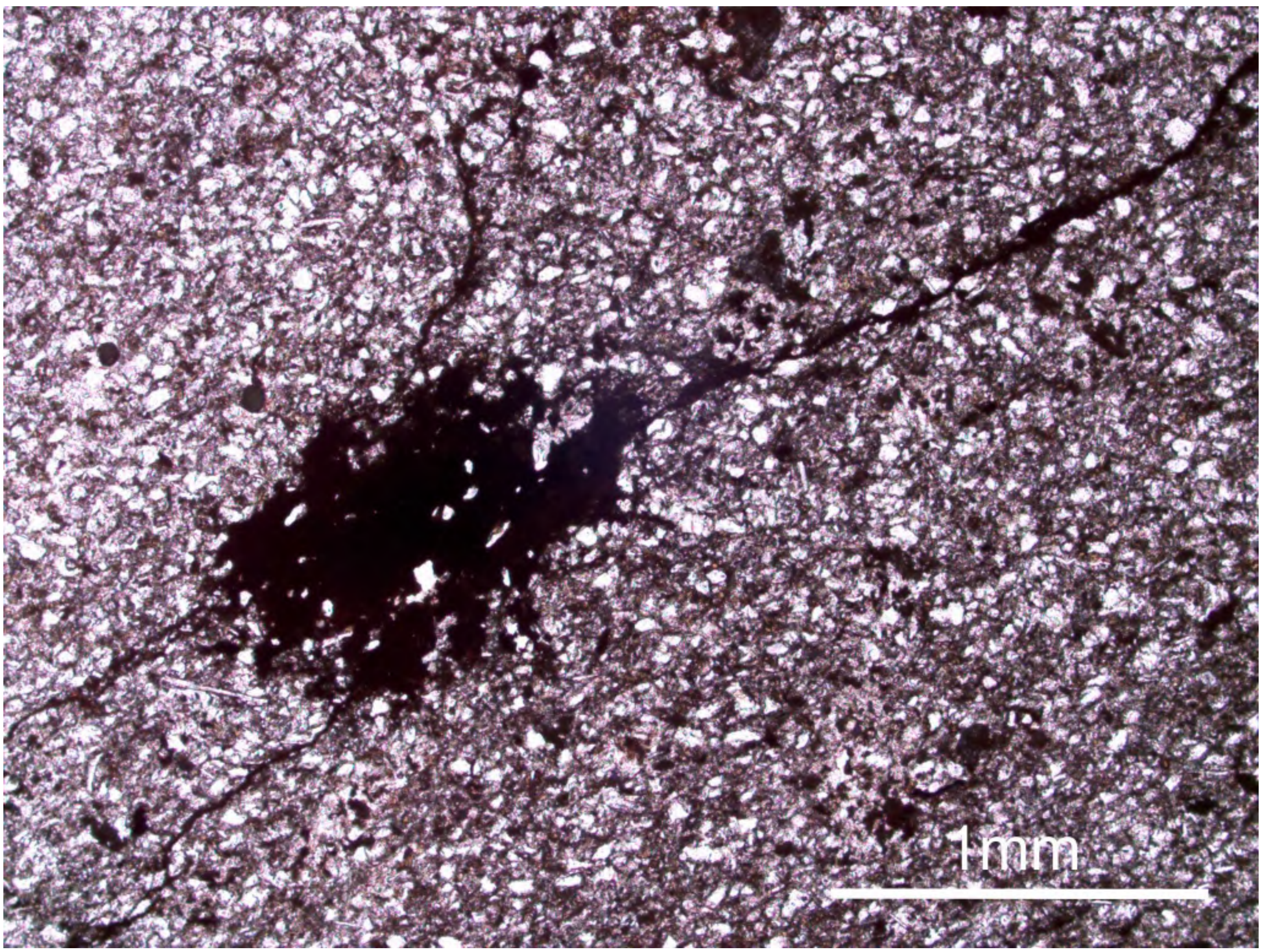




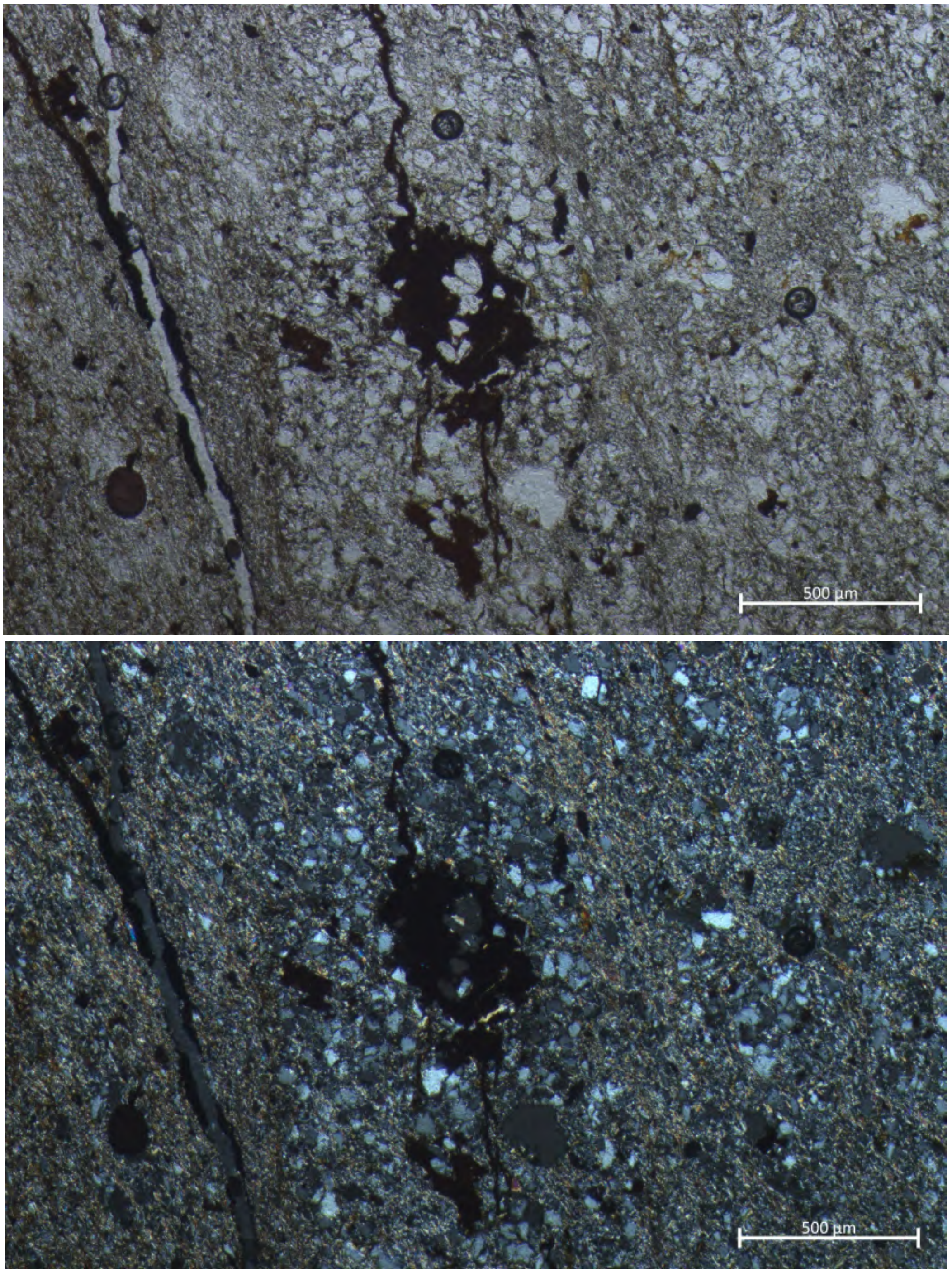
OD2016-016 shearing



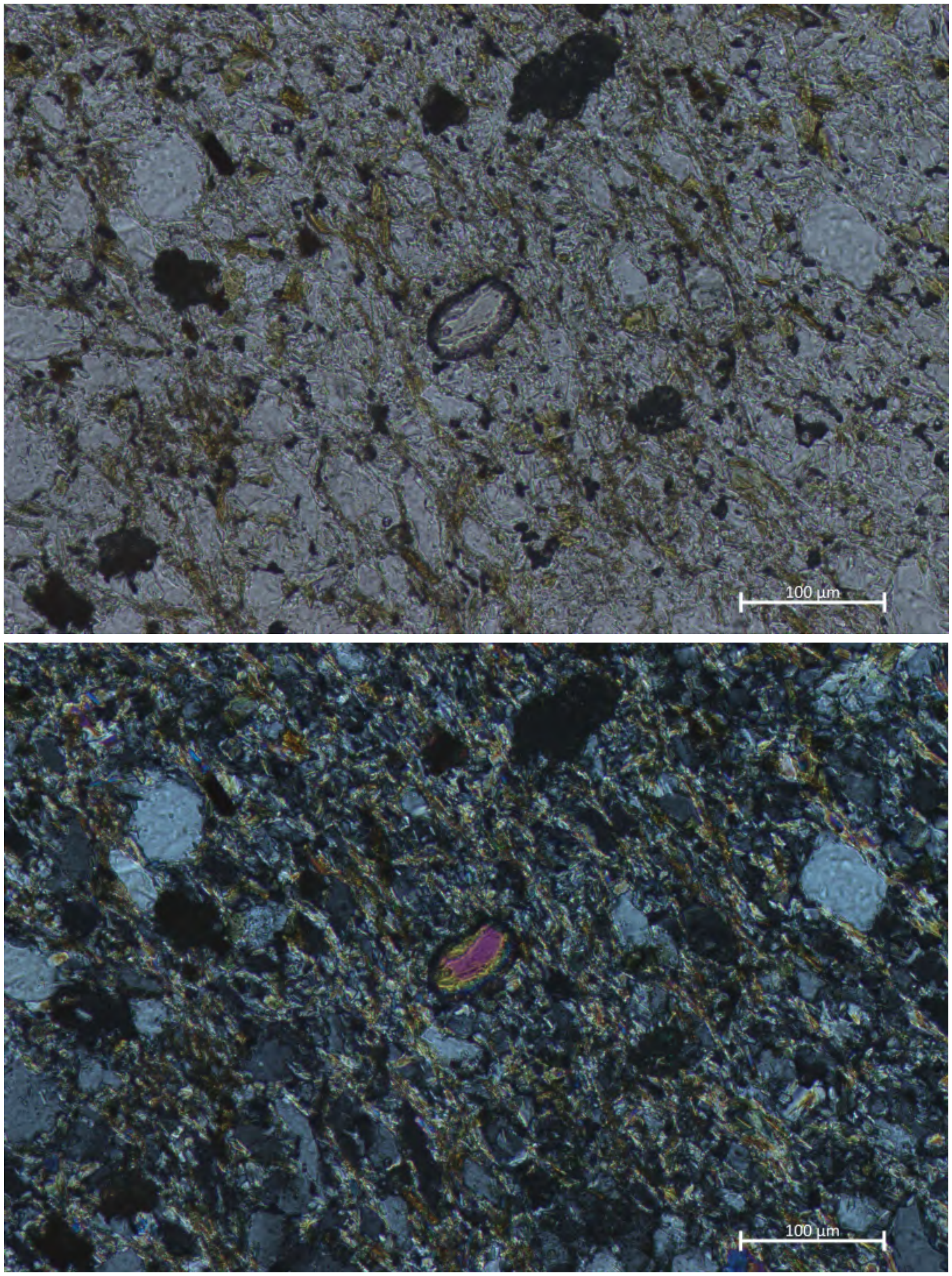
OD2016-016-2 iron nodule and stained fractures



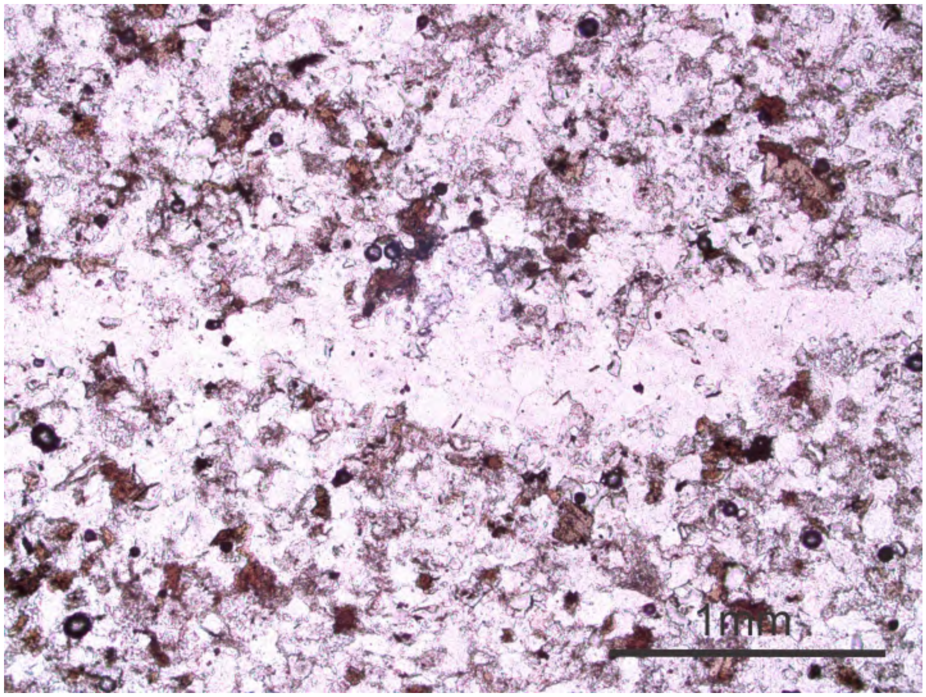
OD2016-016-2 iron nodule and stained fractures

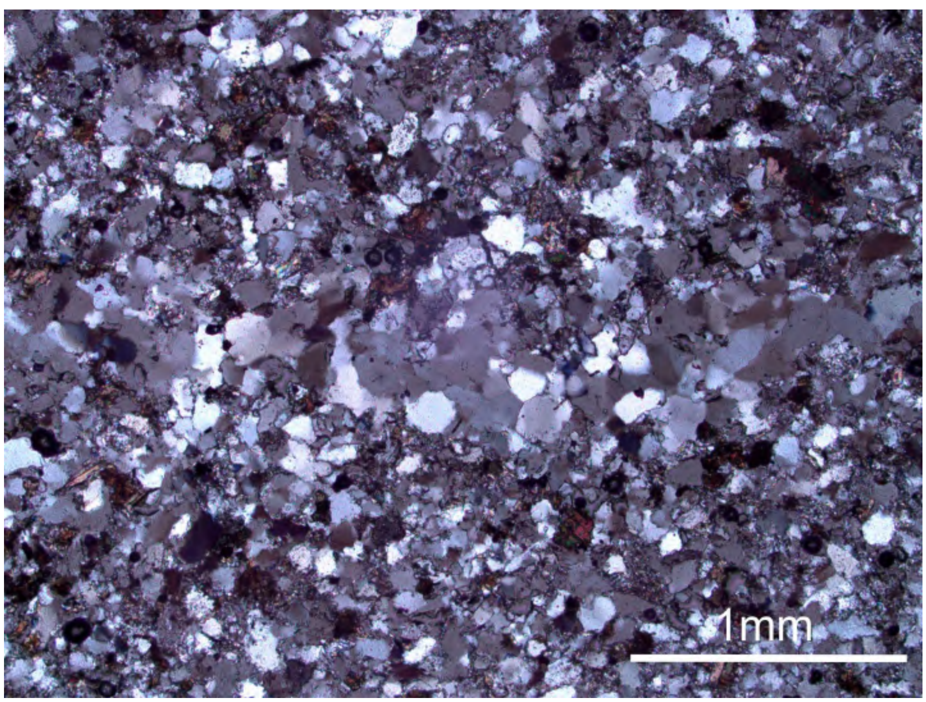


OD2016-016-2 detrital zircon

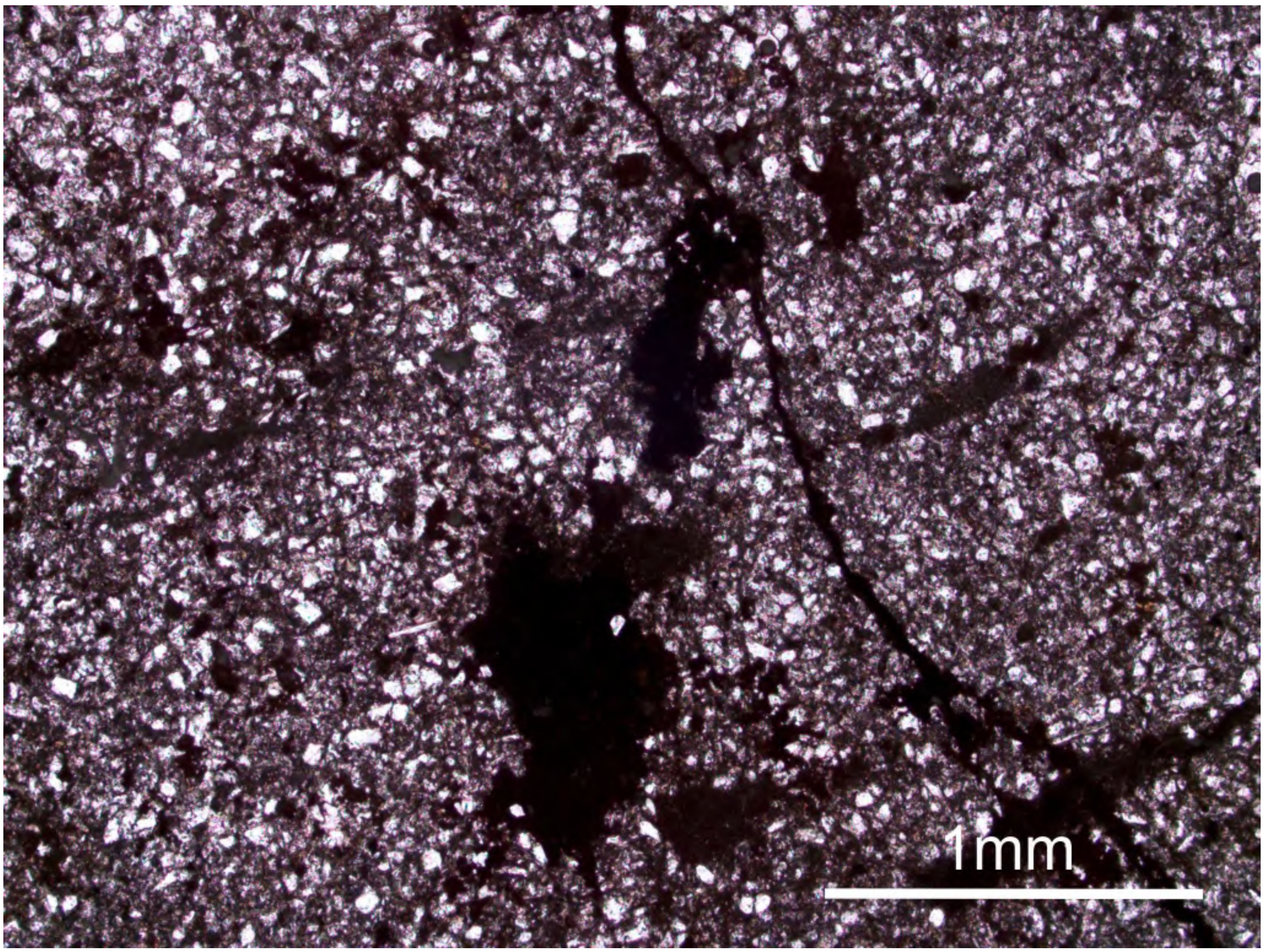


OD2016-017 quartz vein

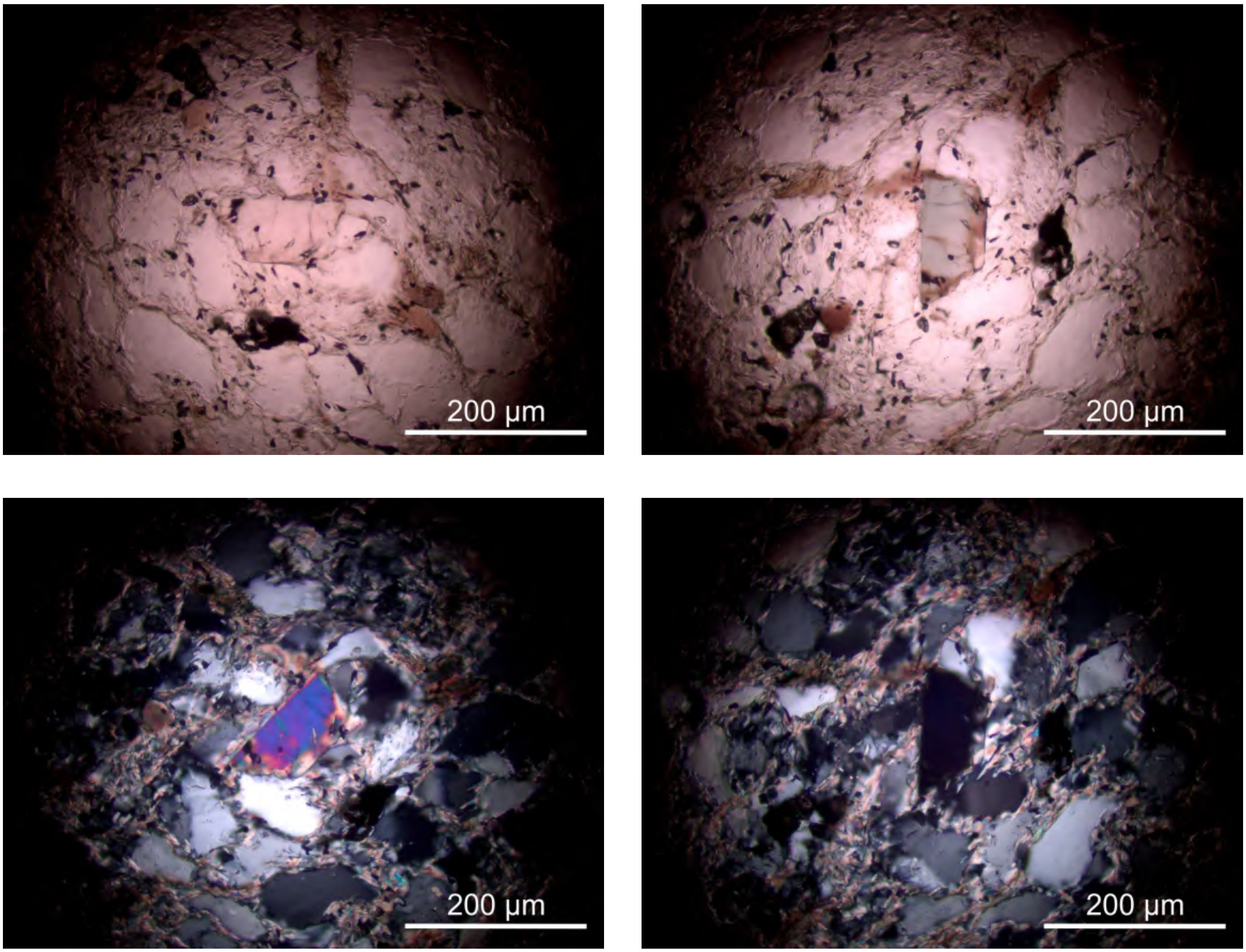




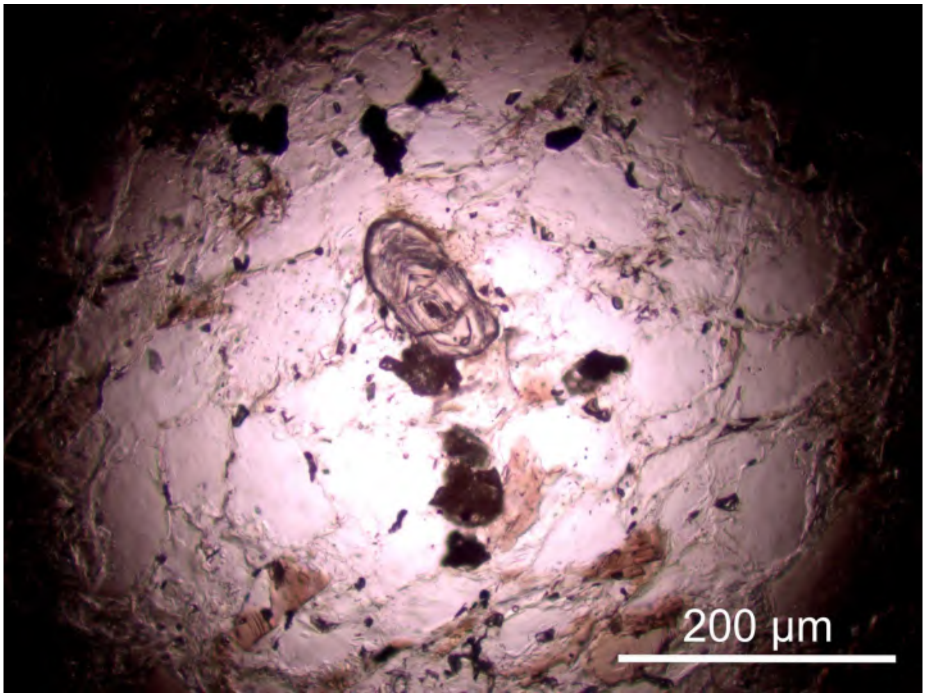
OD2016-018 iron nodules and fracture

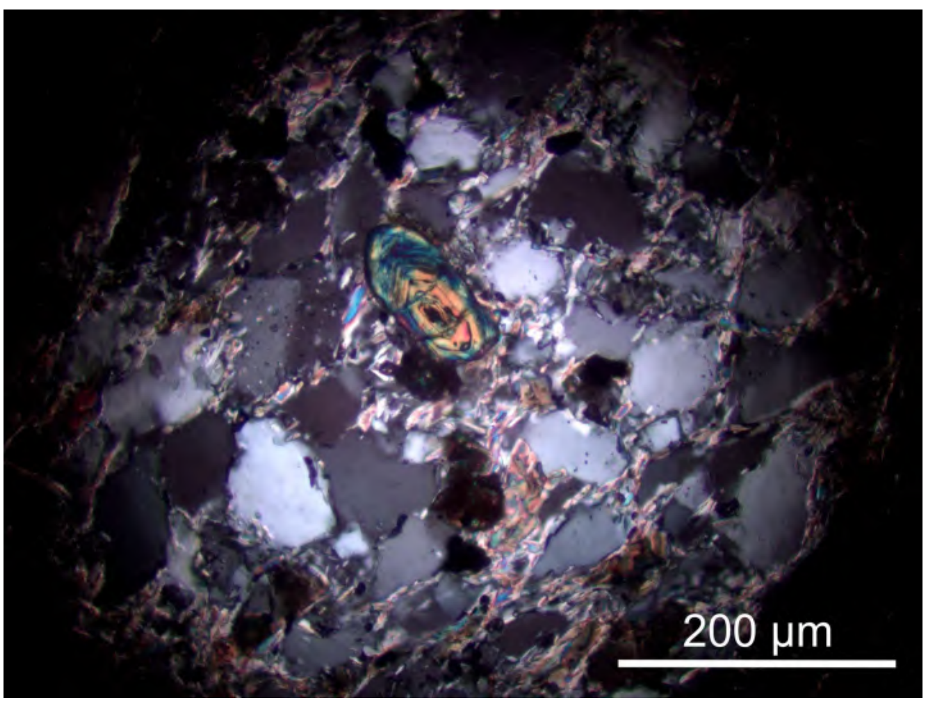


OD2016-019

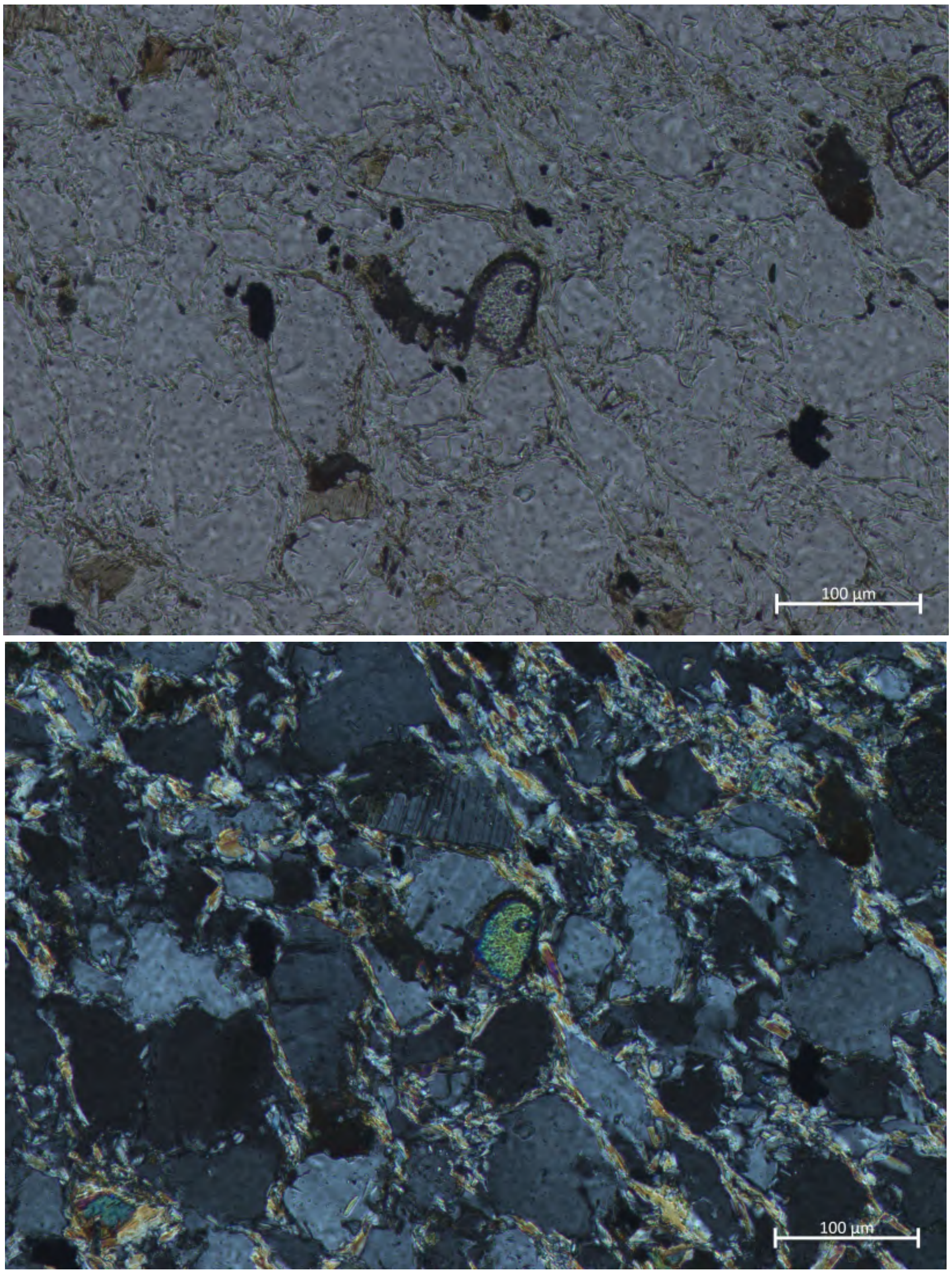


OD2016-019 zircon

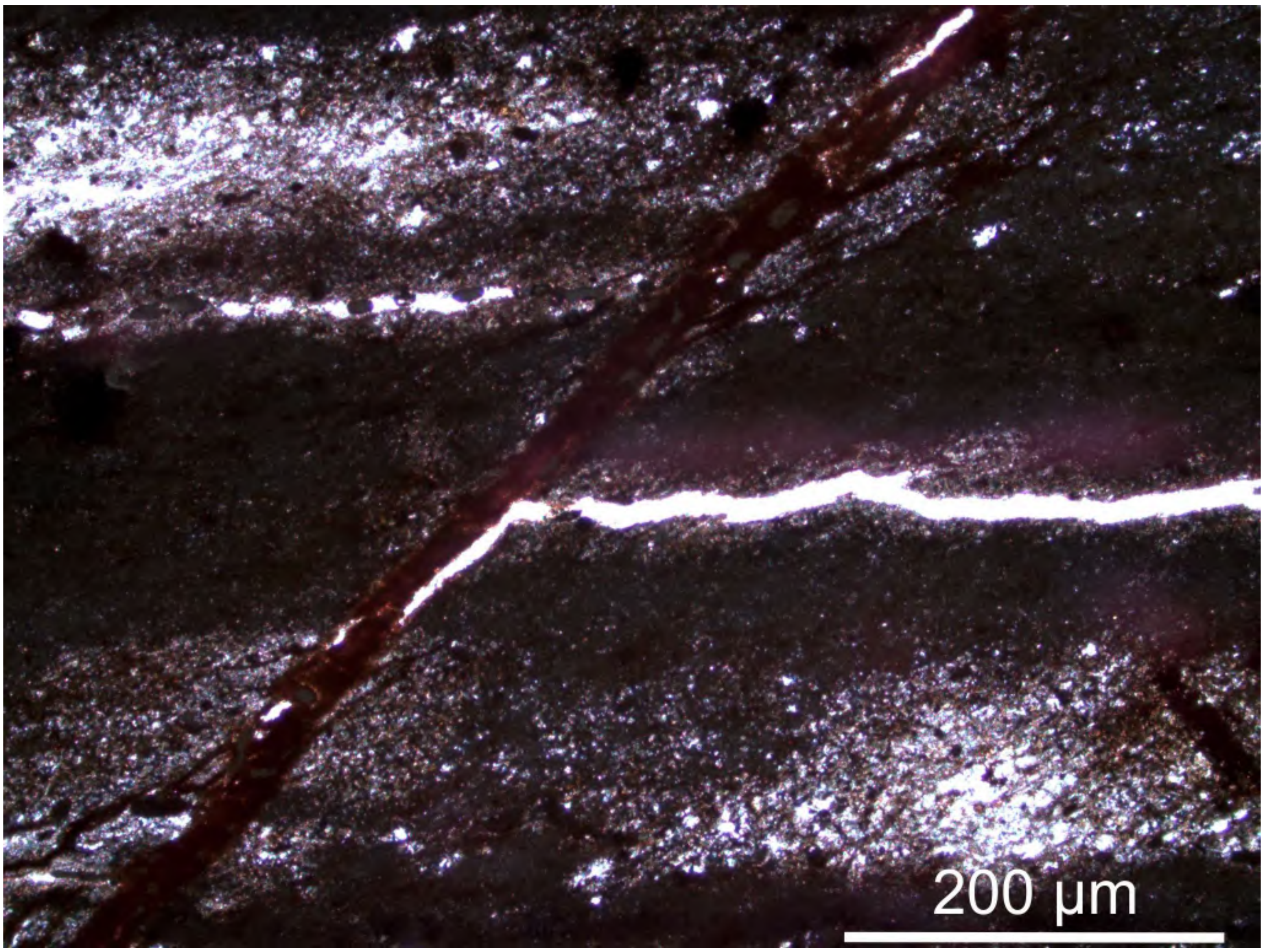




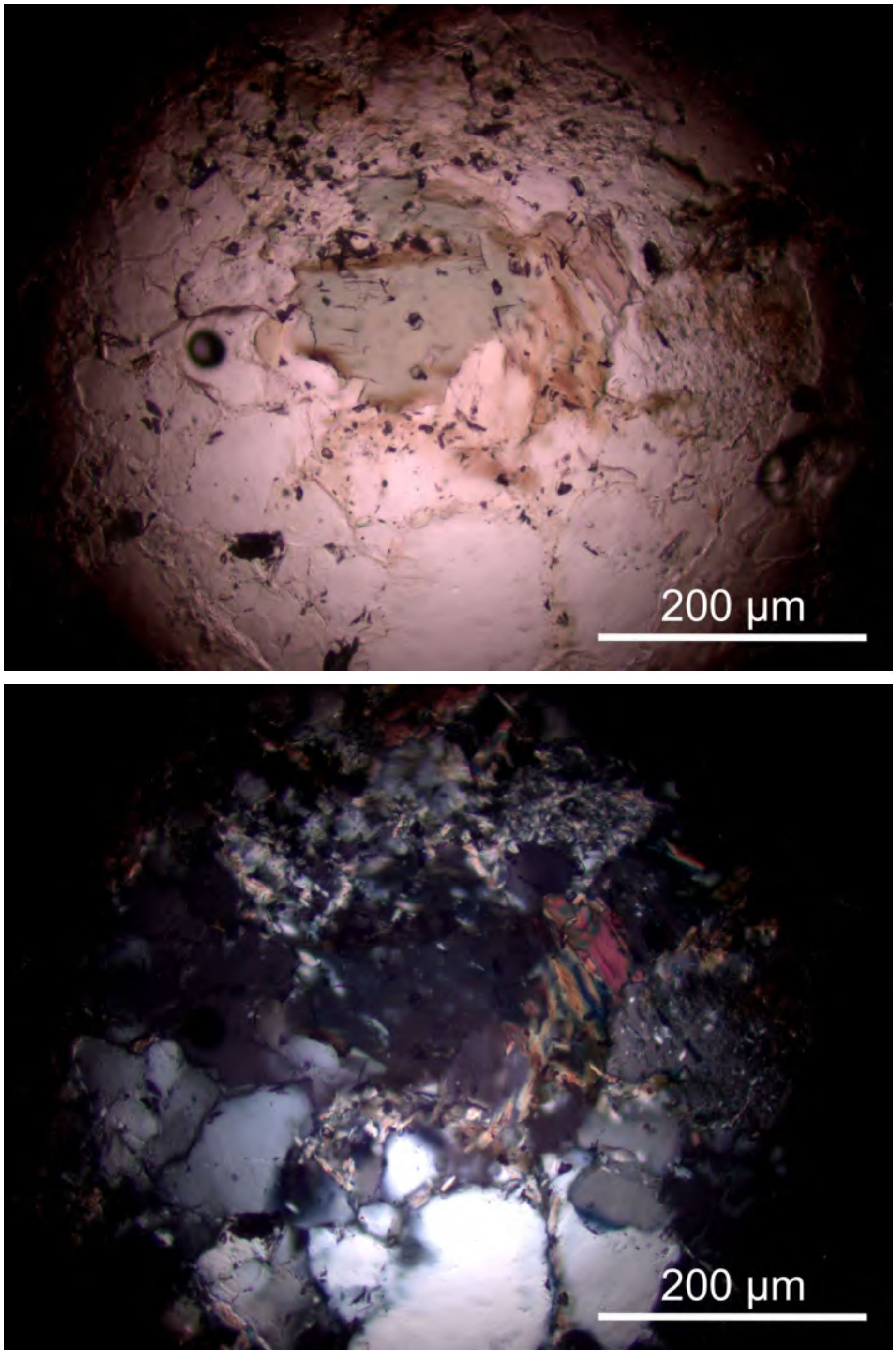
OD2016-019 detrital zircon



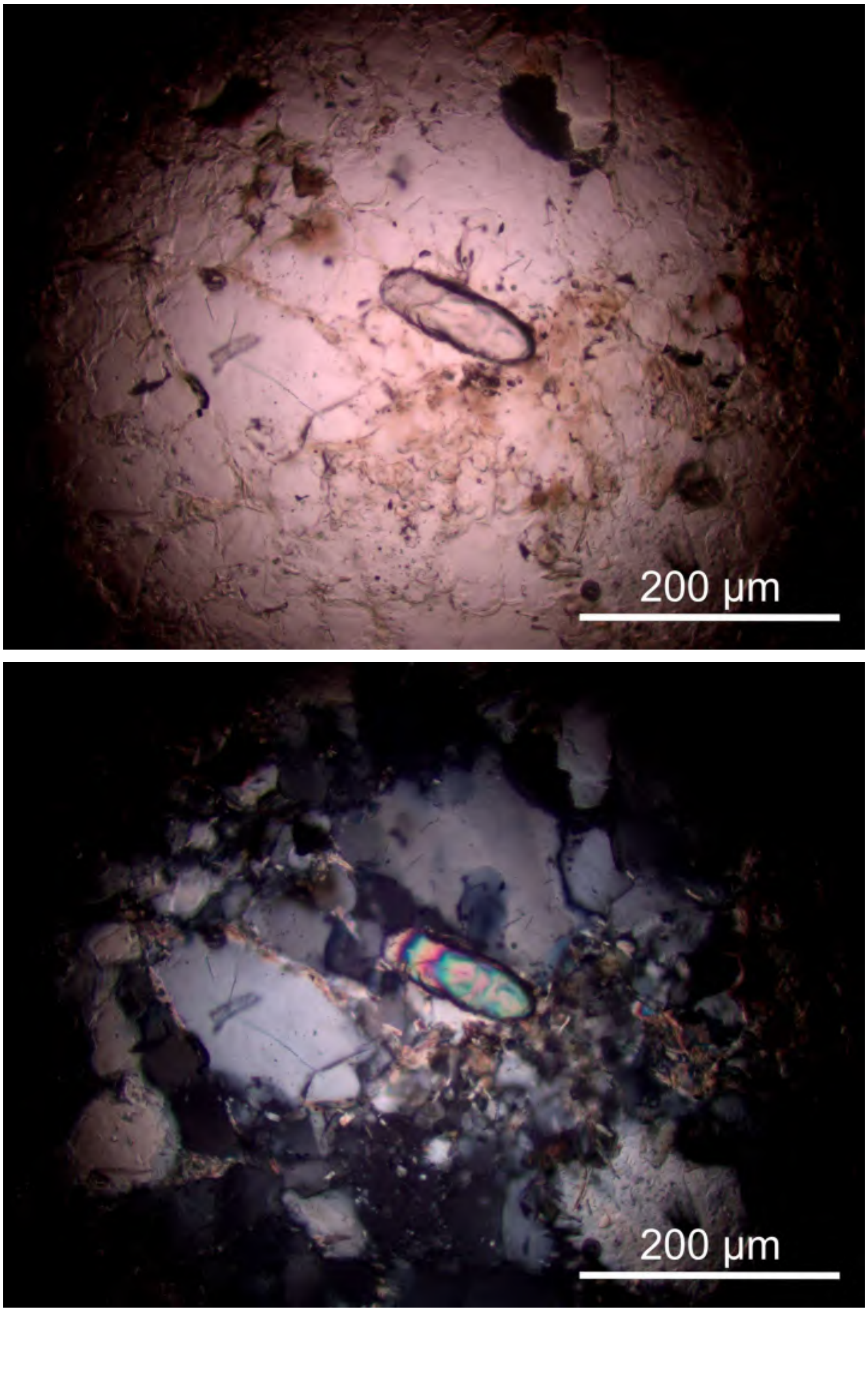
OD2016-020 facture cleavage with iron staining



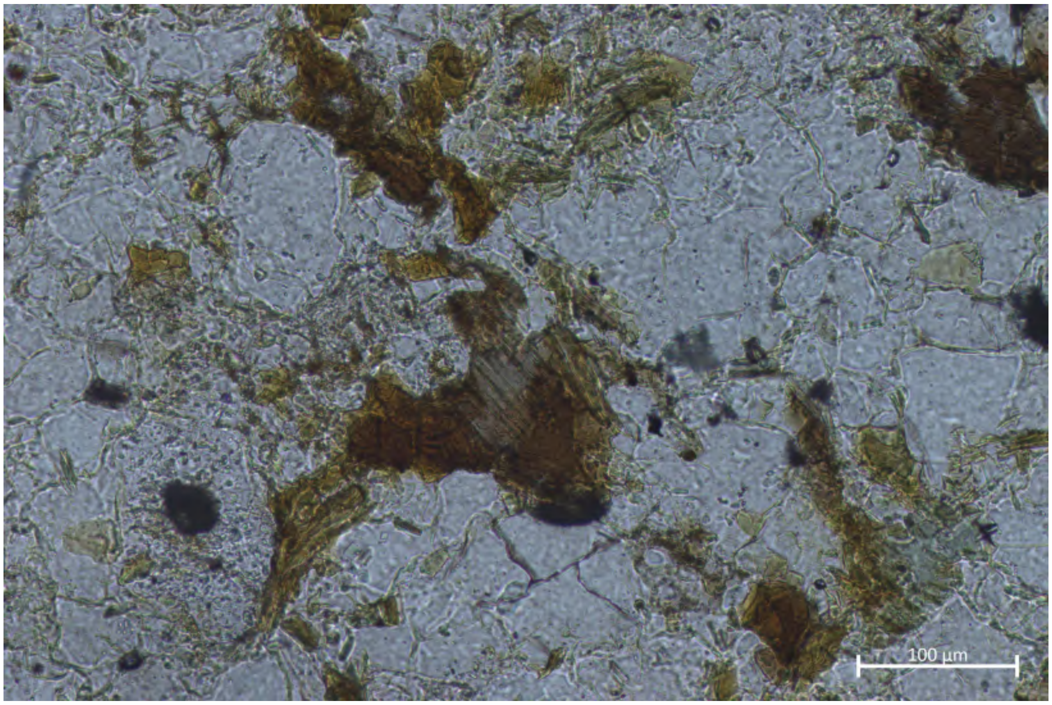
OD2016-022-1 biotite altering to chlorite

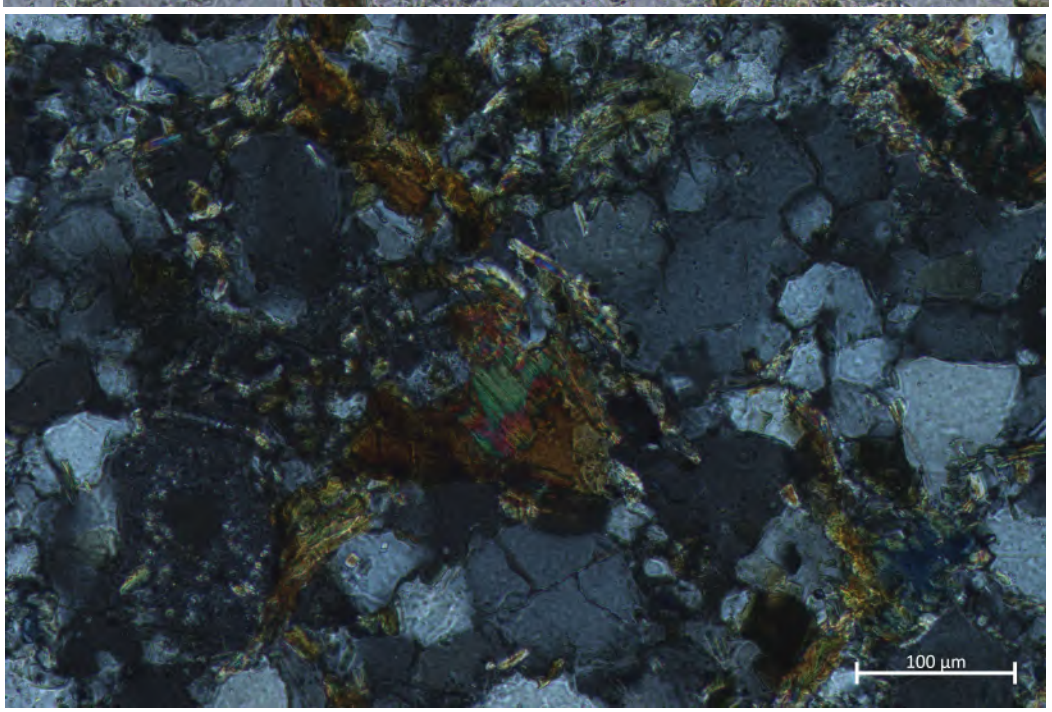


OD2016-022-1 zircon

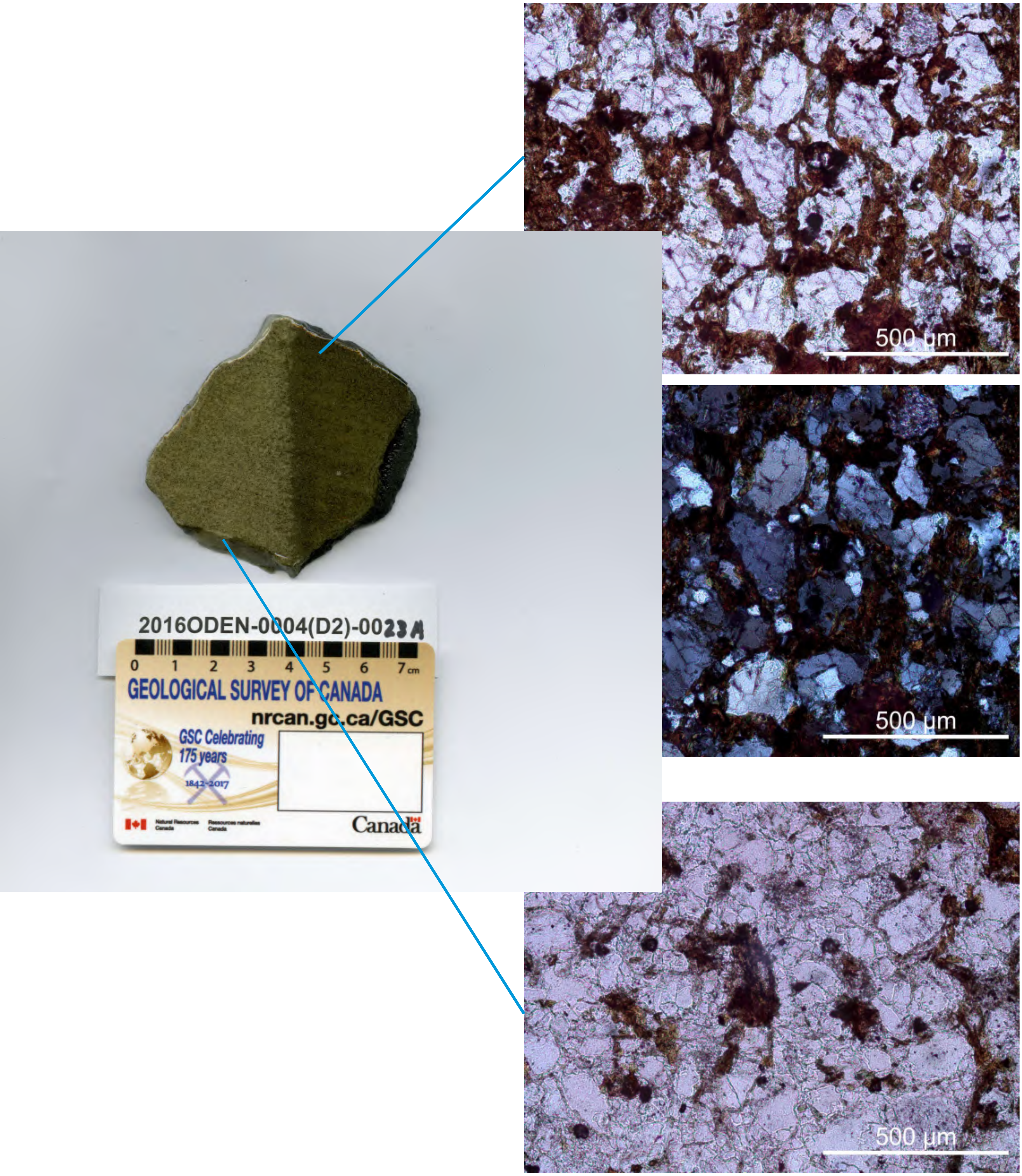


OD2016-022-1 authigenic biotite

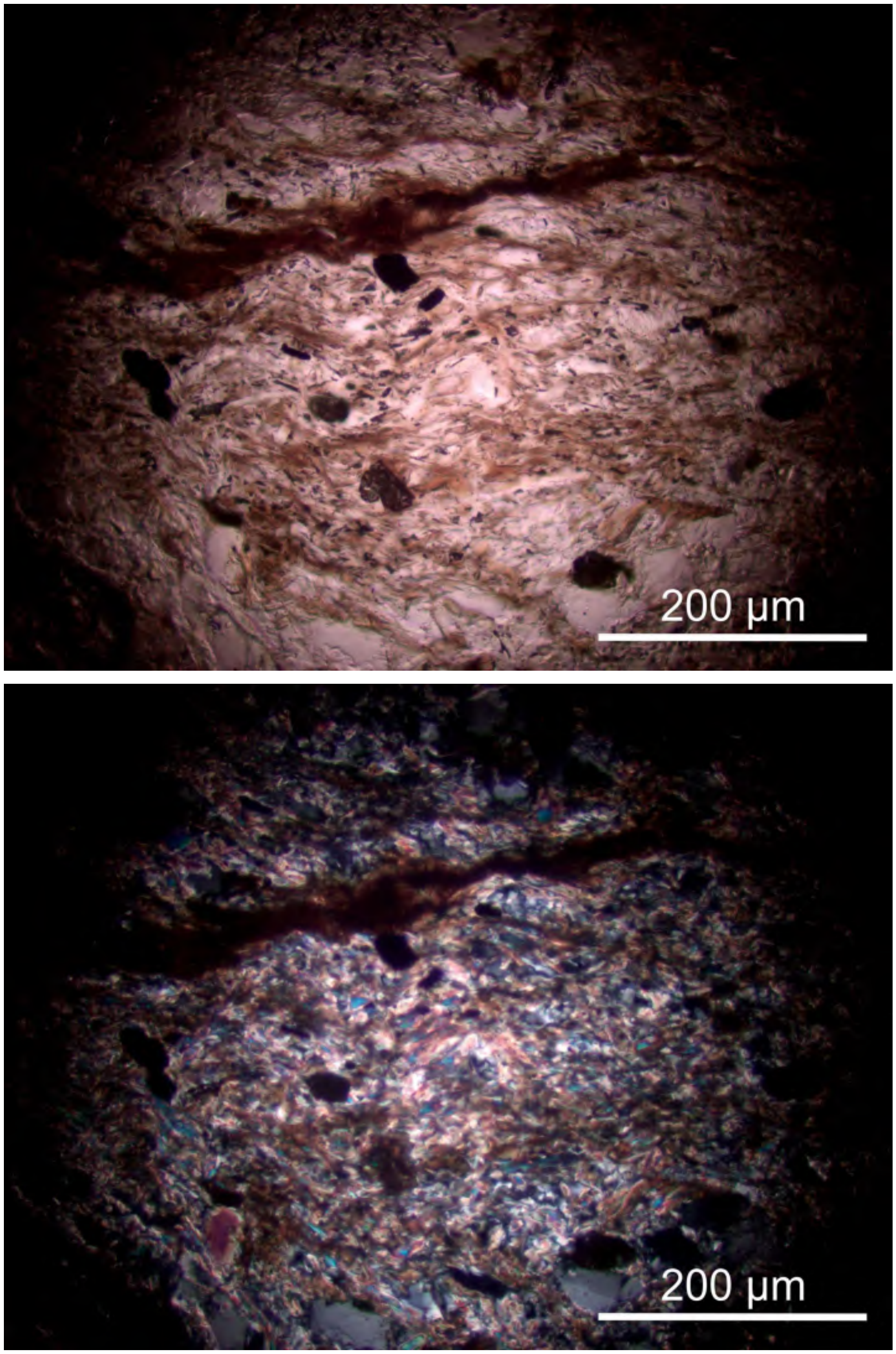




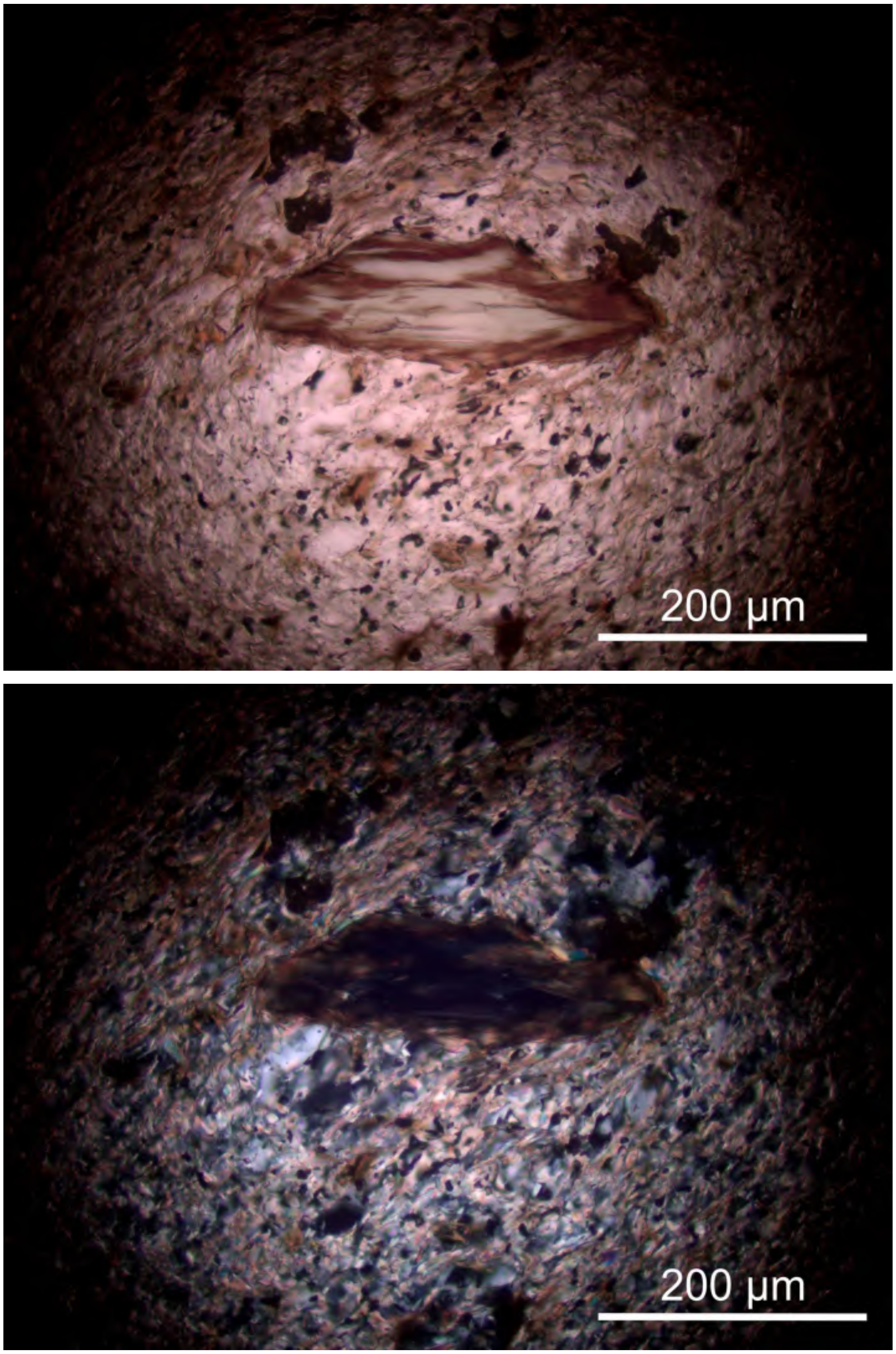
OD2016-023 biotite



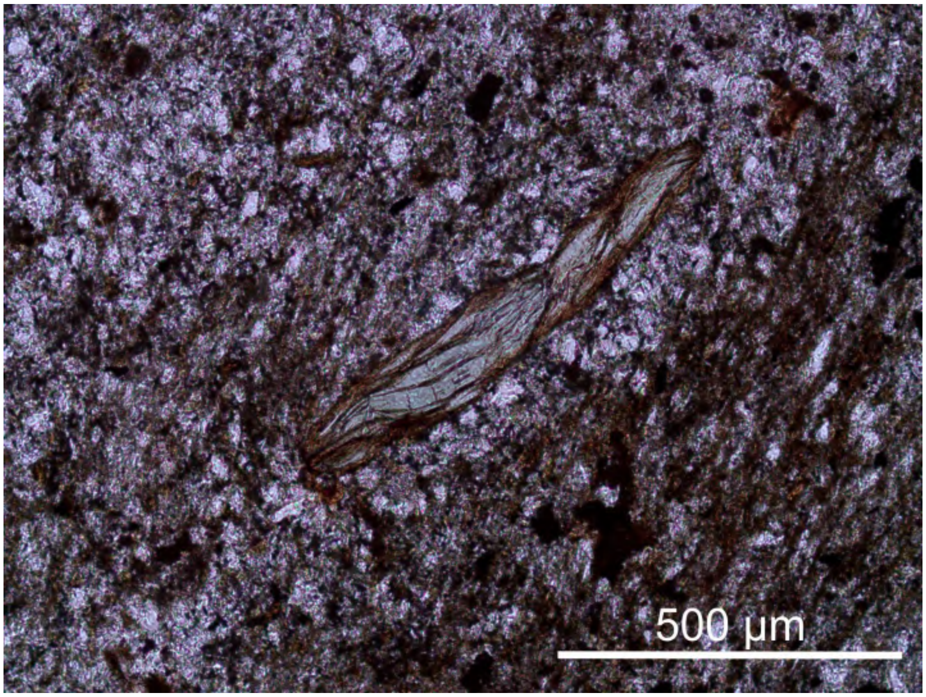
OD2016-024 shearing in muscovite

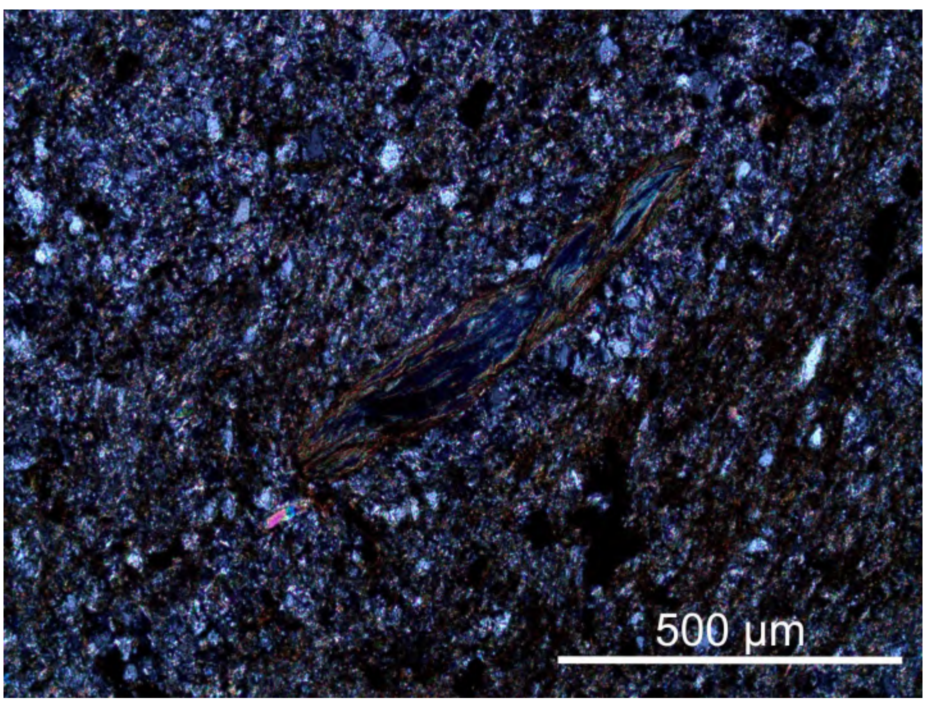


OD2016-025 detrital chlorite

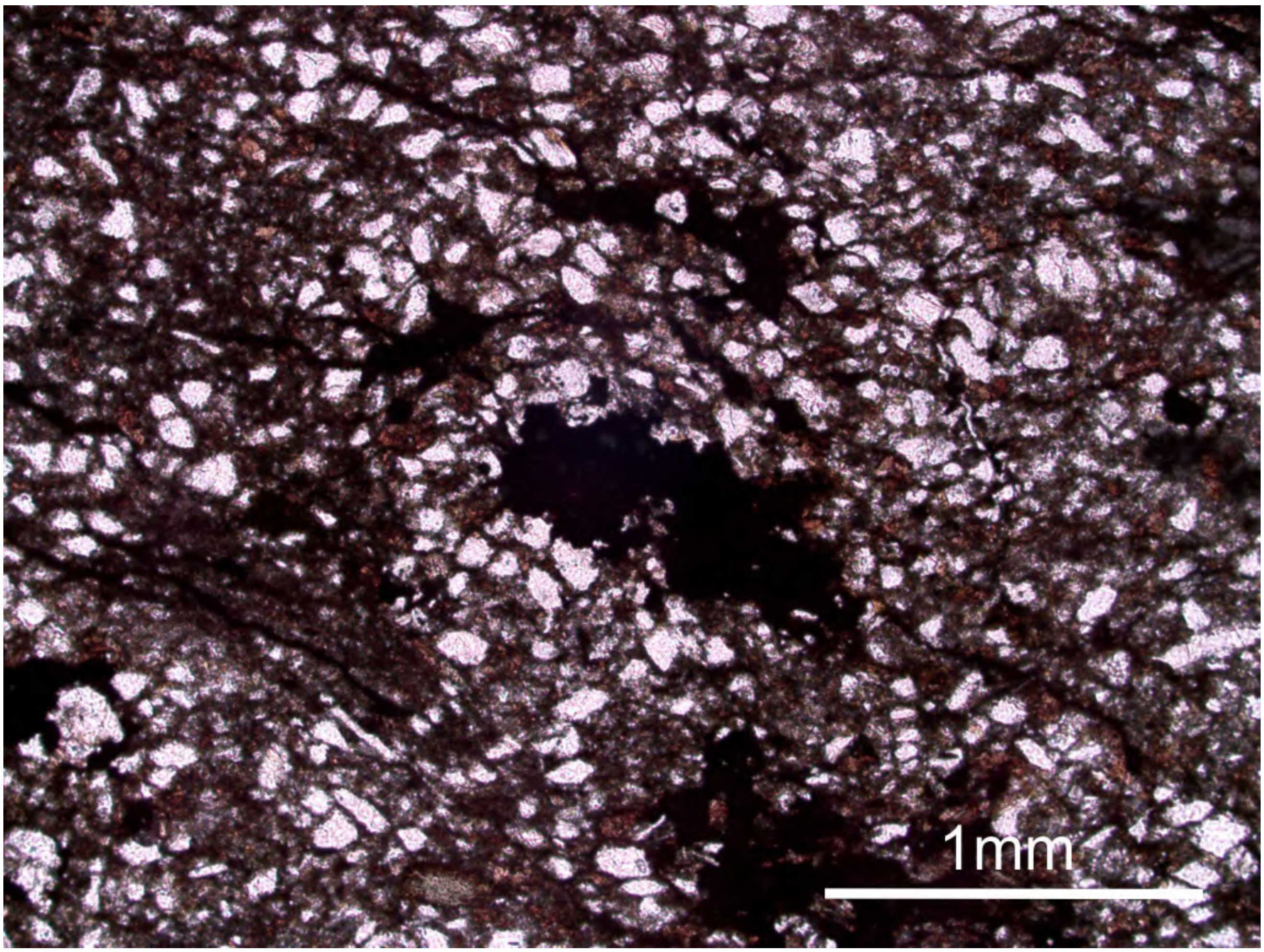


OD2016-026 detrital chlorite

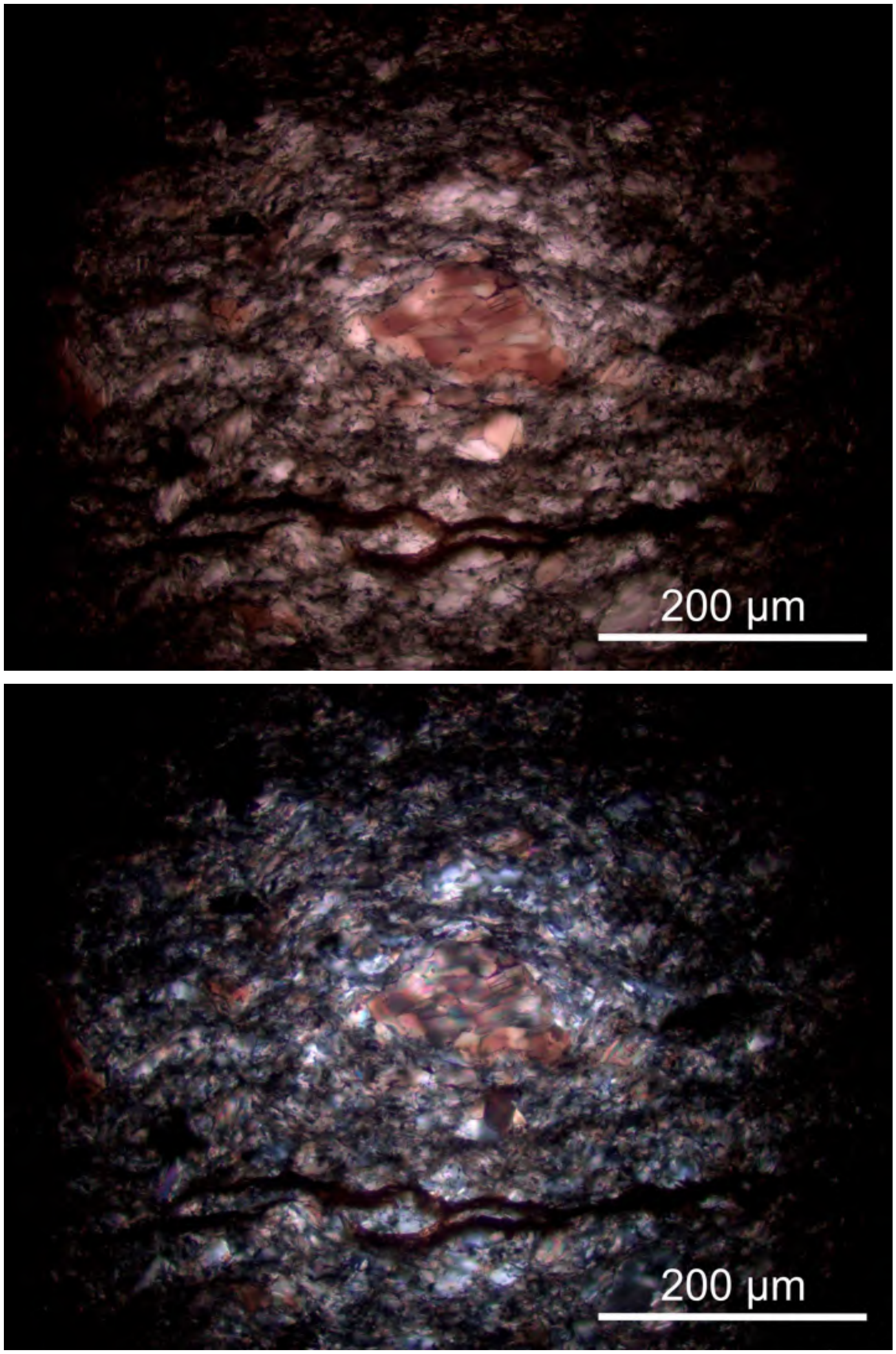




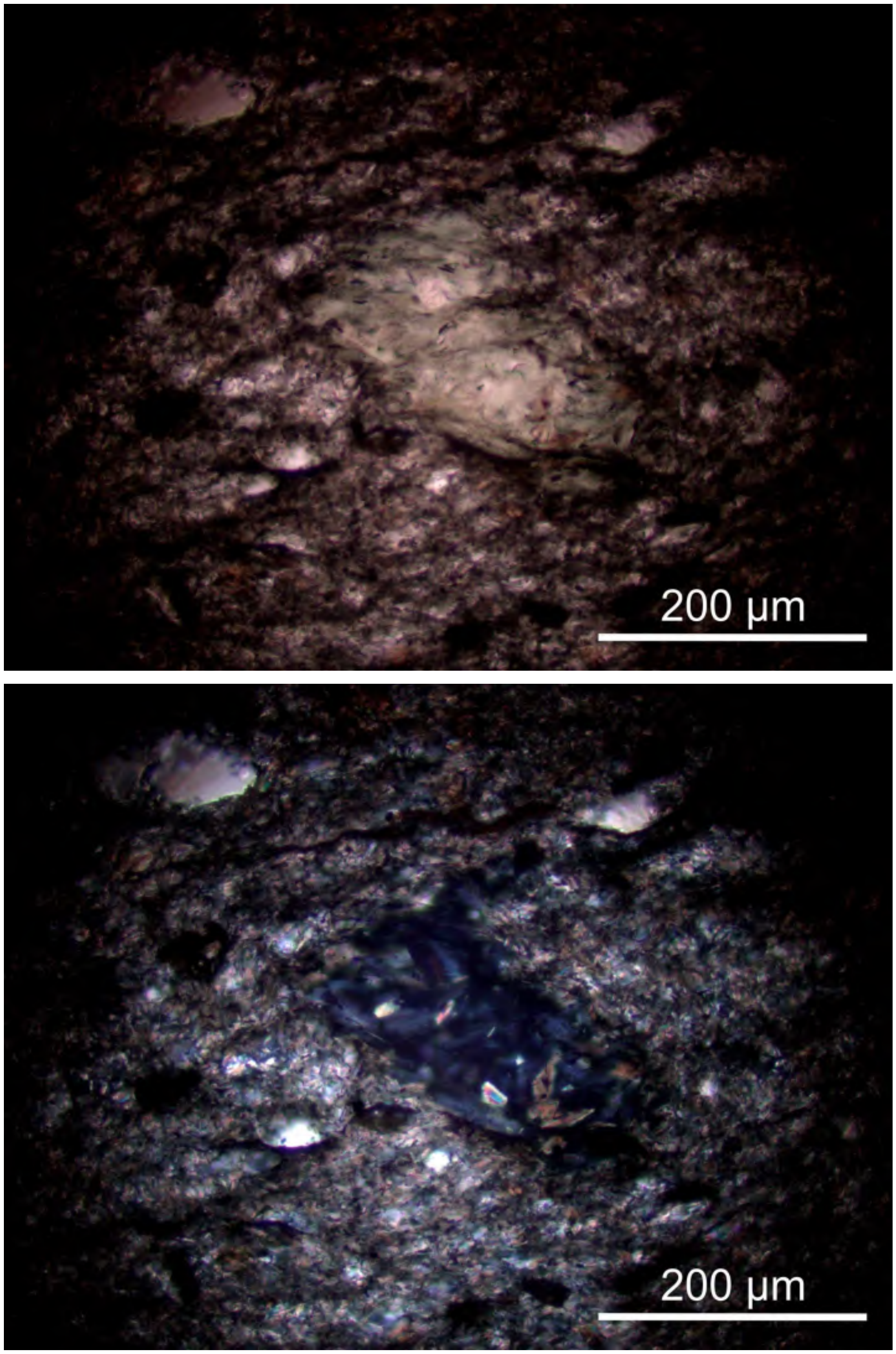
OD2016-027 iron nodules



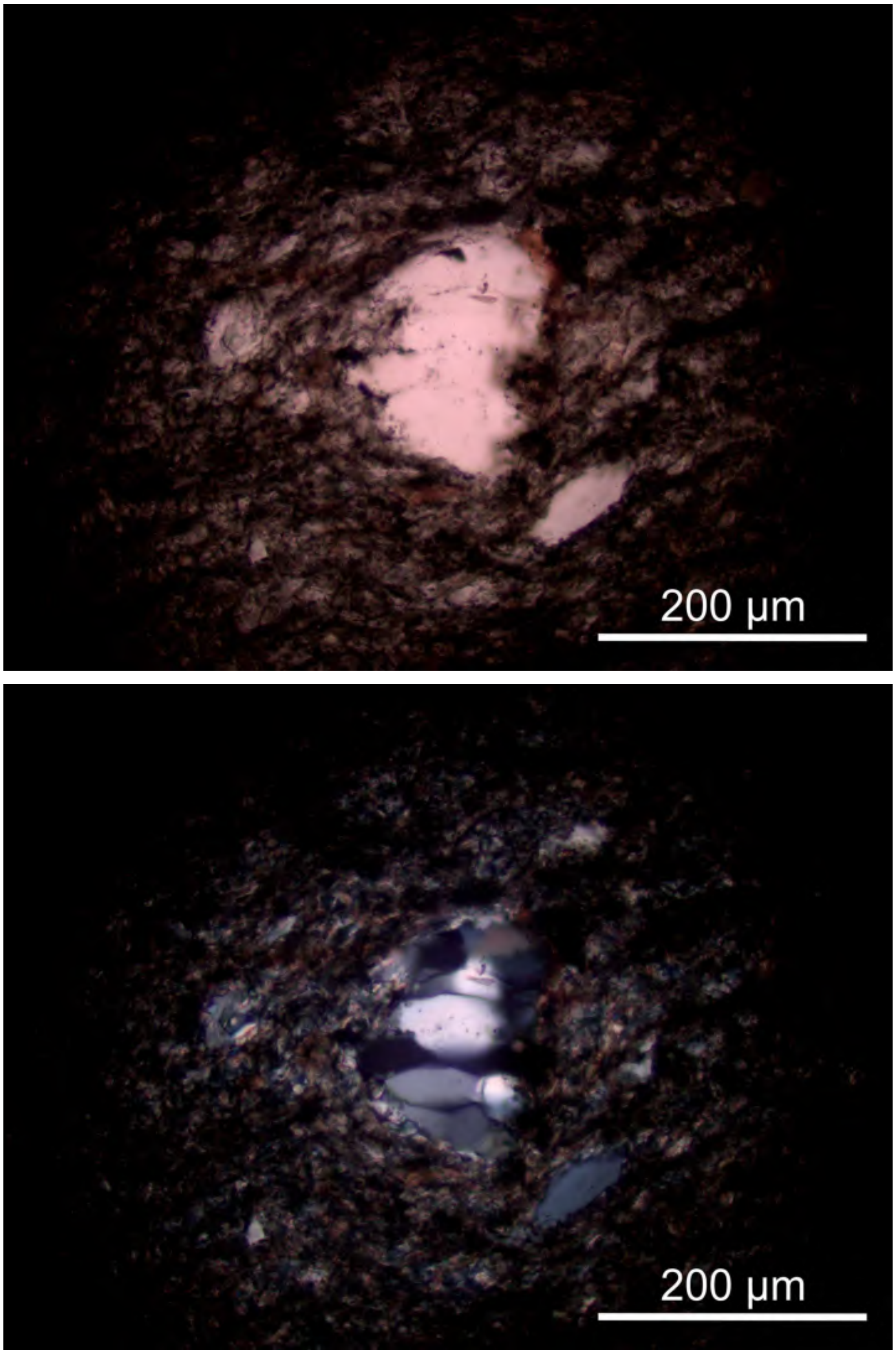
OD2016-027 biotite cluster



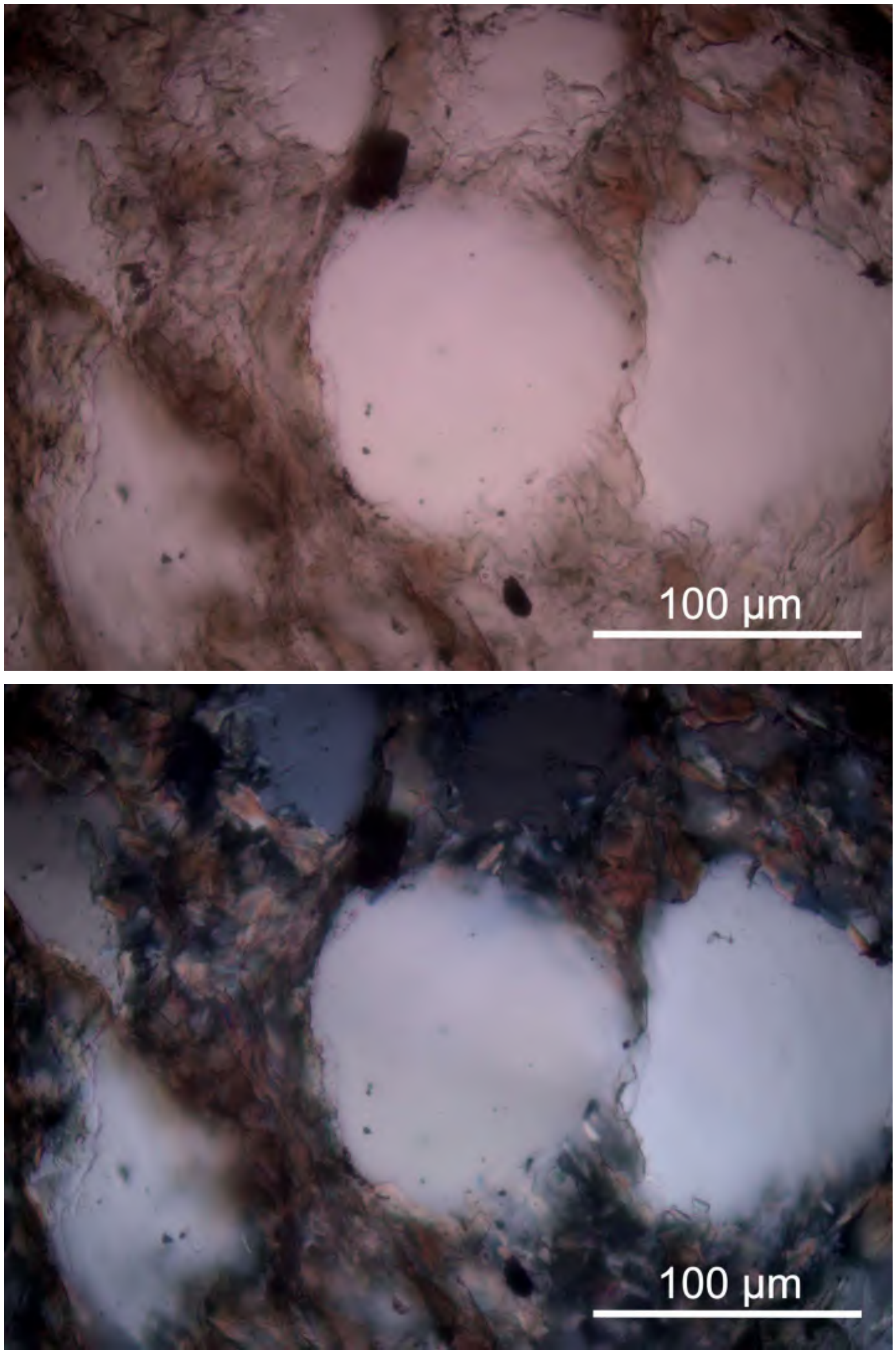
OD2016-027 chlorite



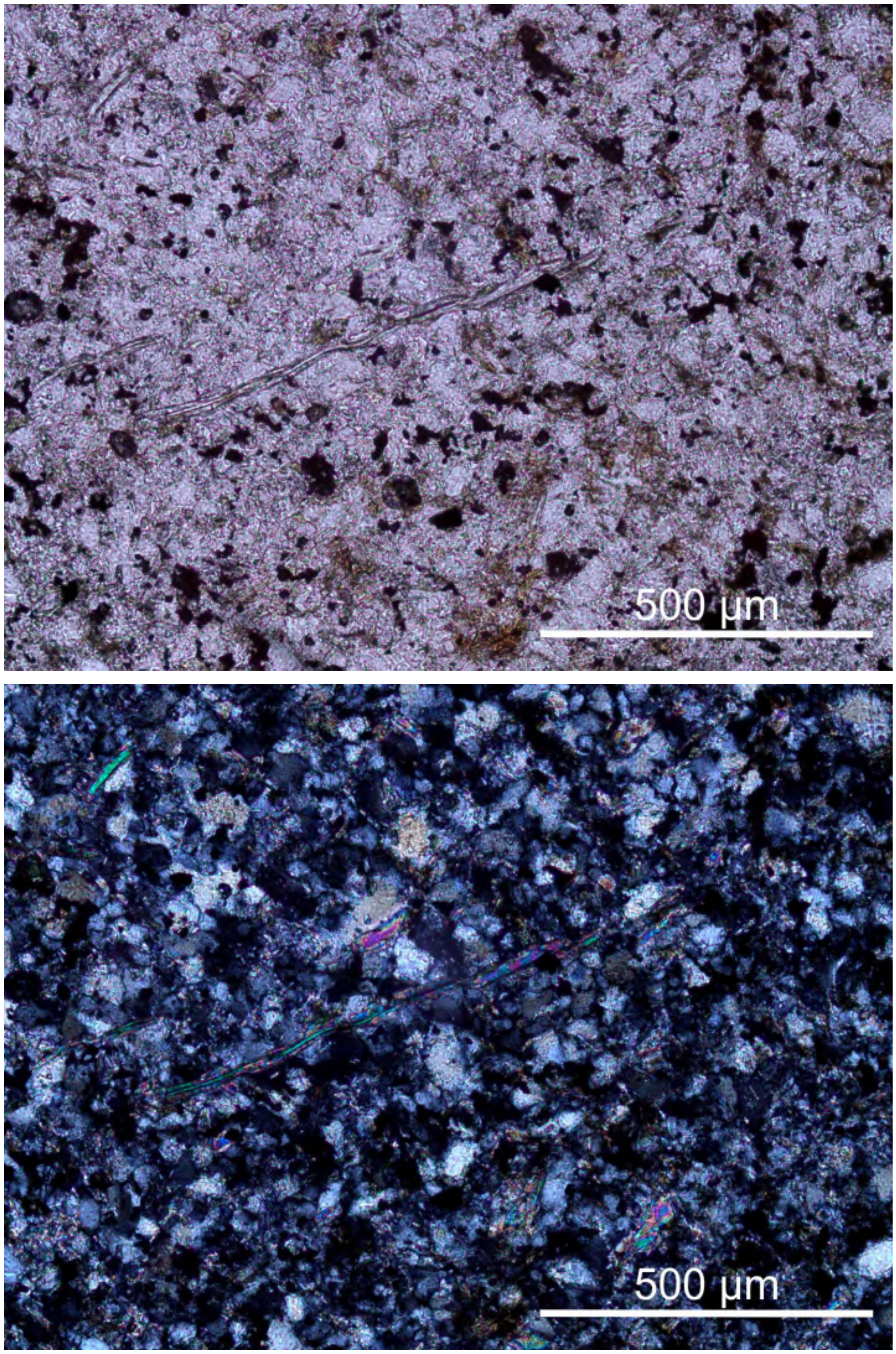
OD2016-027 quartz siltstone lithic clast



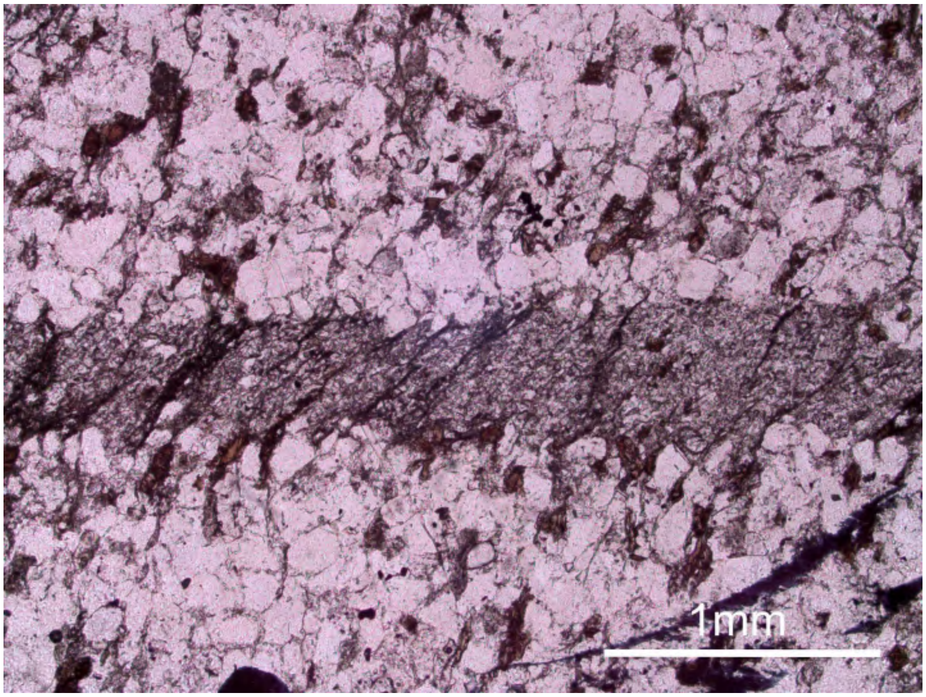
OD2016-027 well-rounded quartz

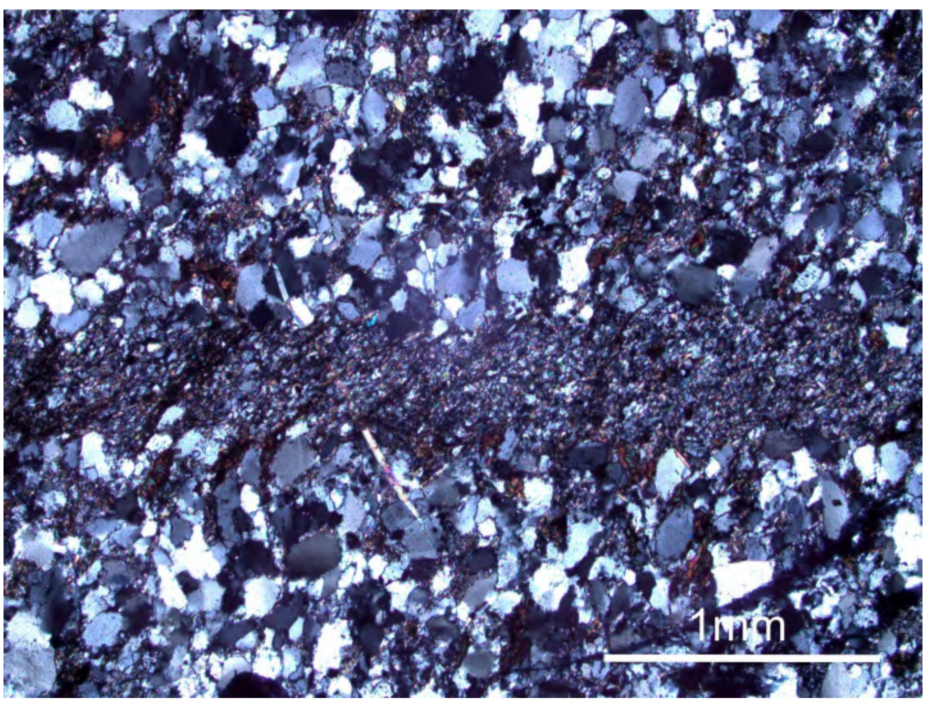


OD2016-030 detrital muscovite

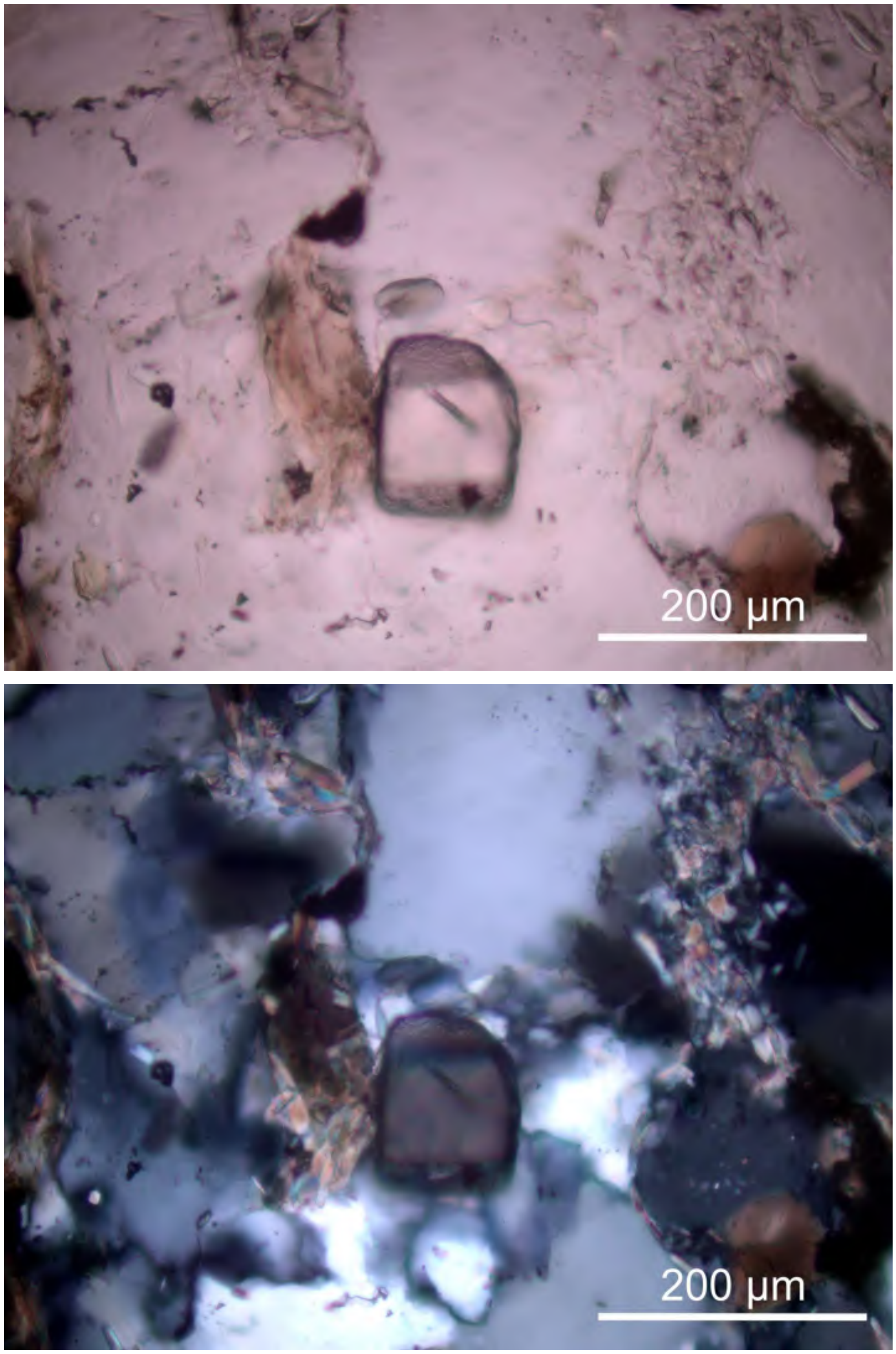


OD2016-035 shearing in mud wisp

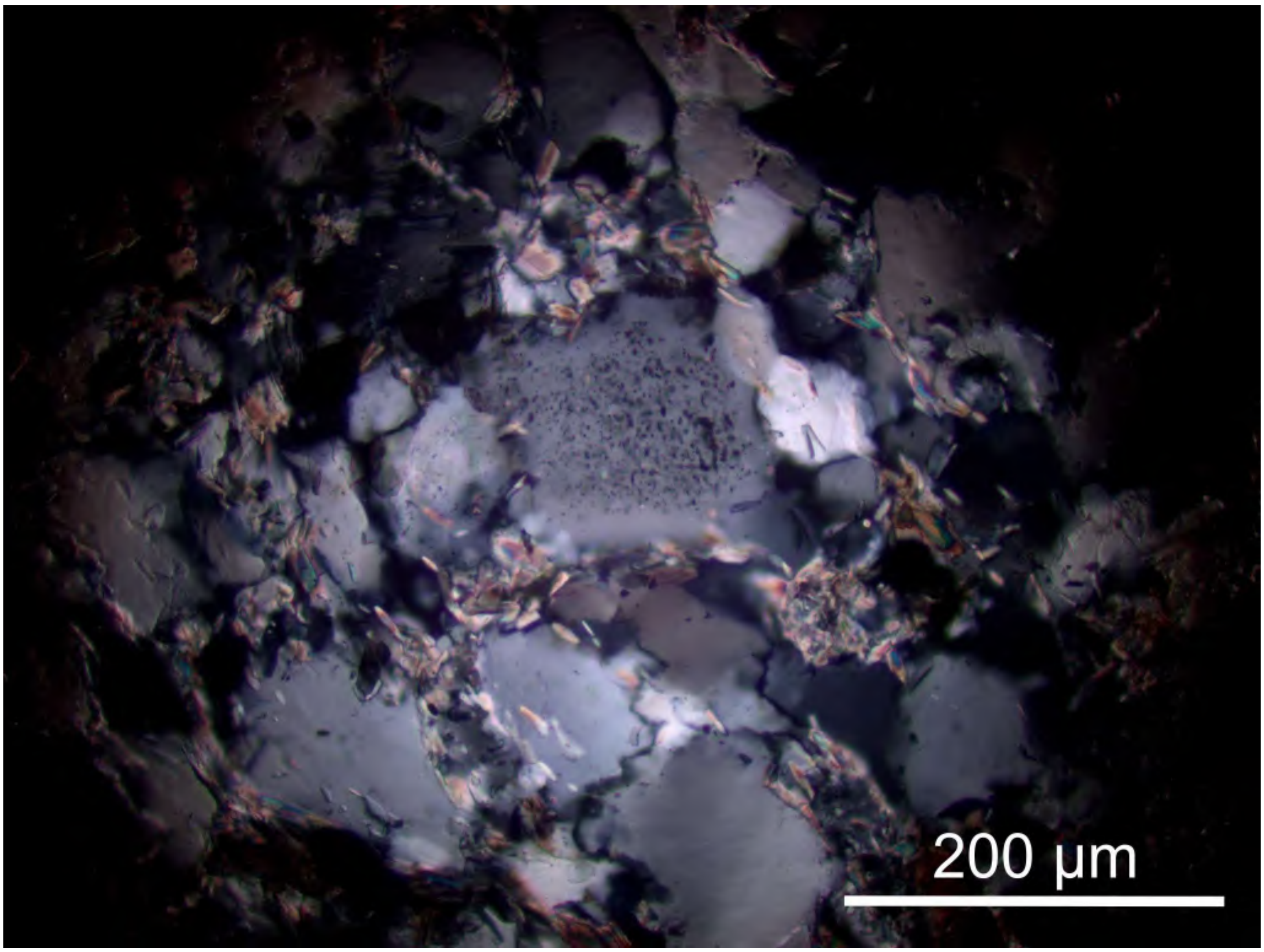




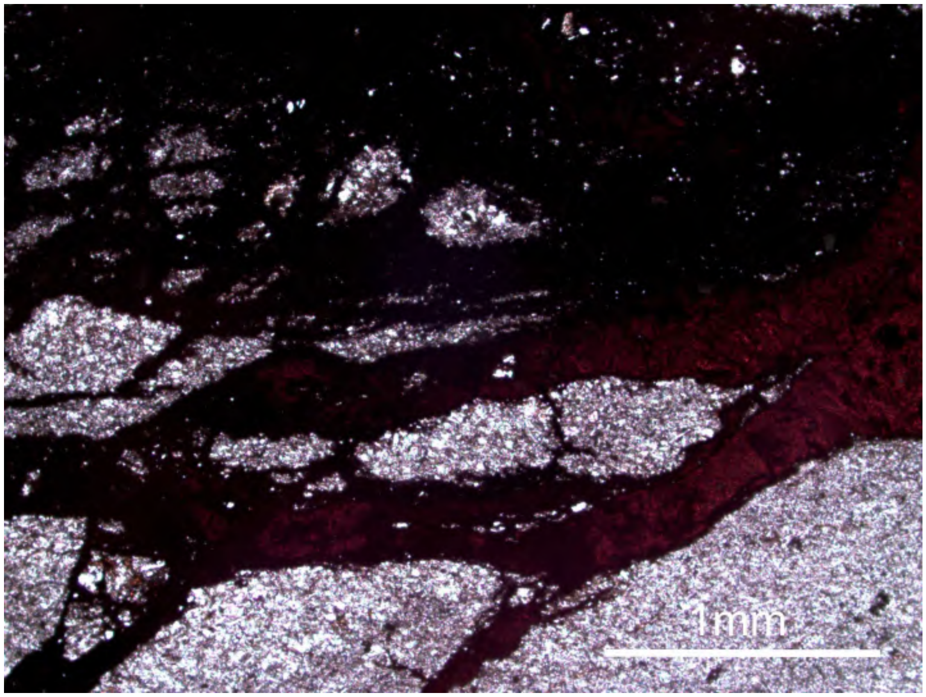
OD2016-036 zircon with inclusion

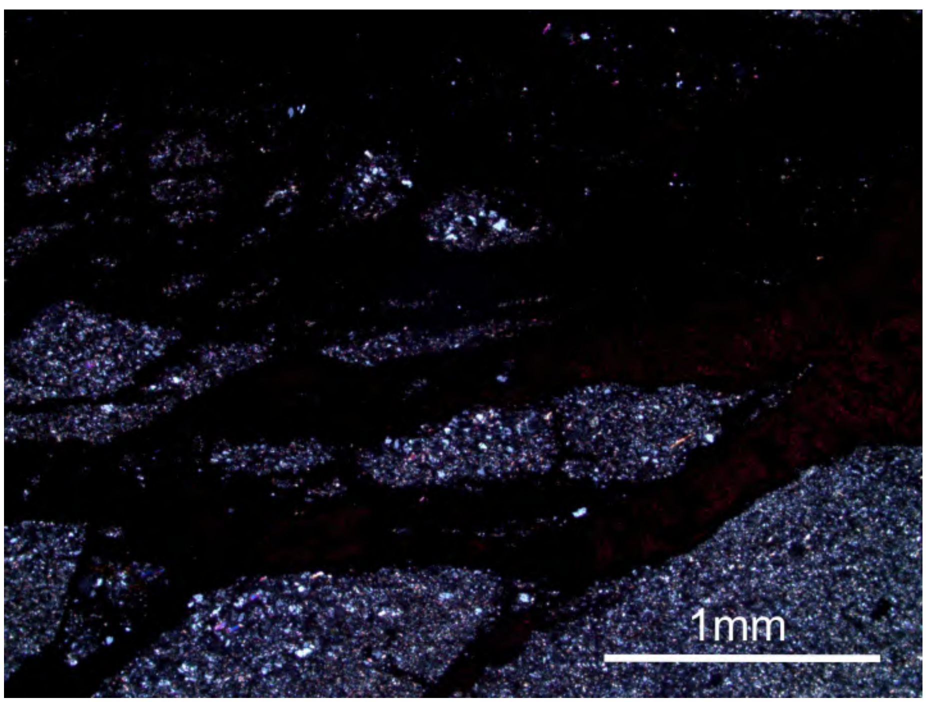


OD2016-036 albite with diagenetic rim

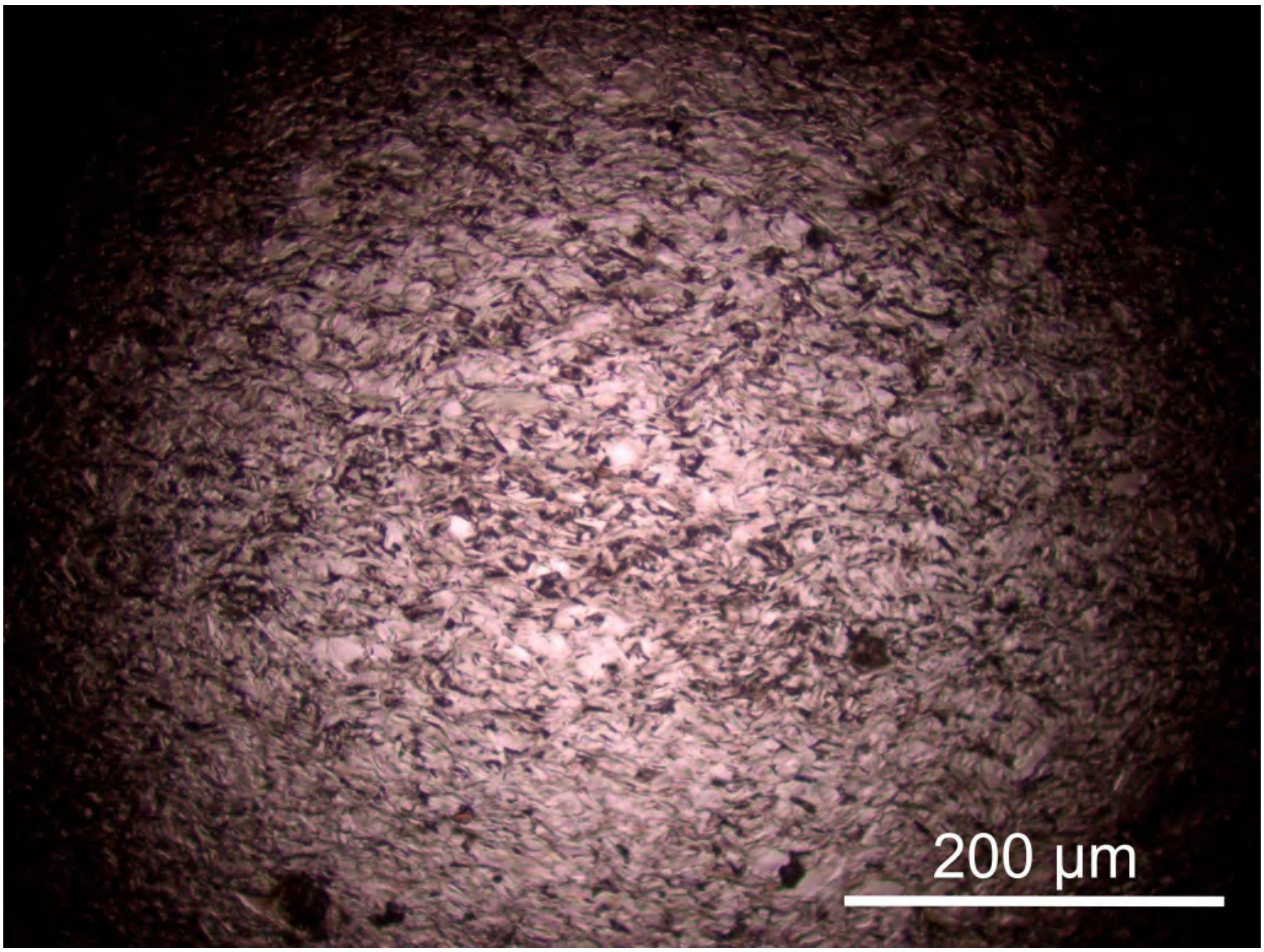


OD2016-039 iron filled fractures

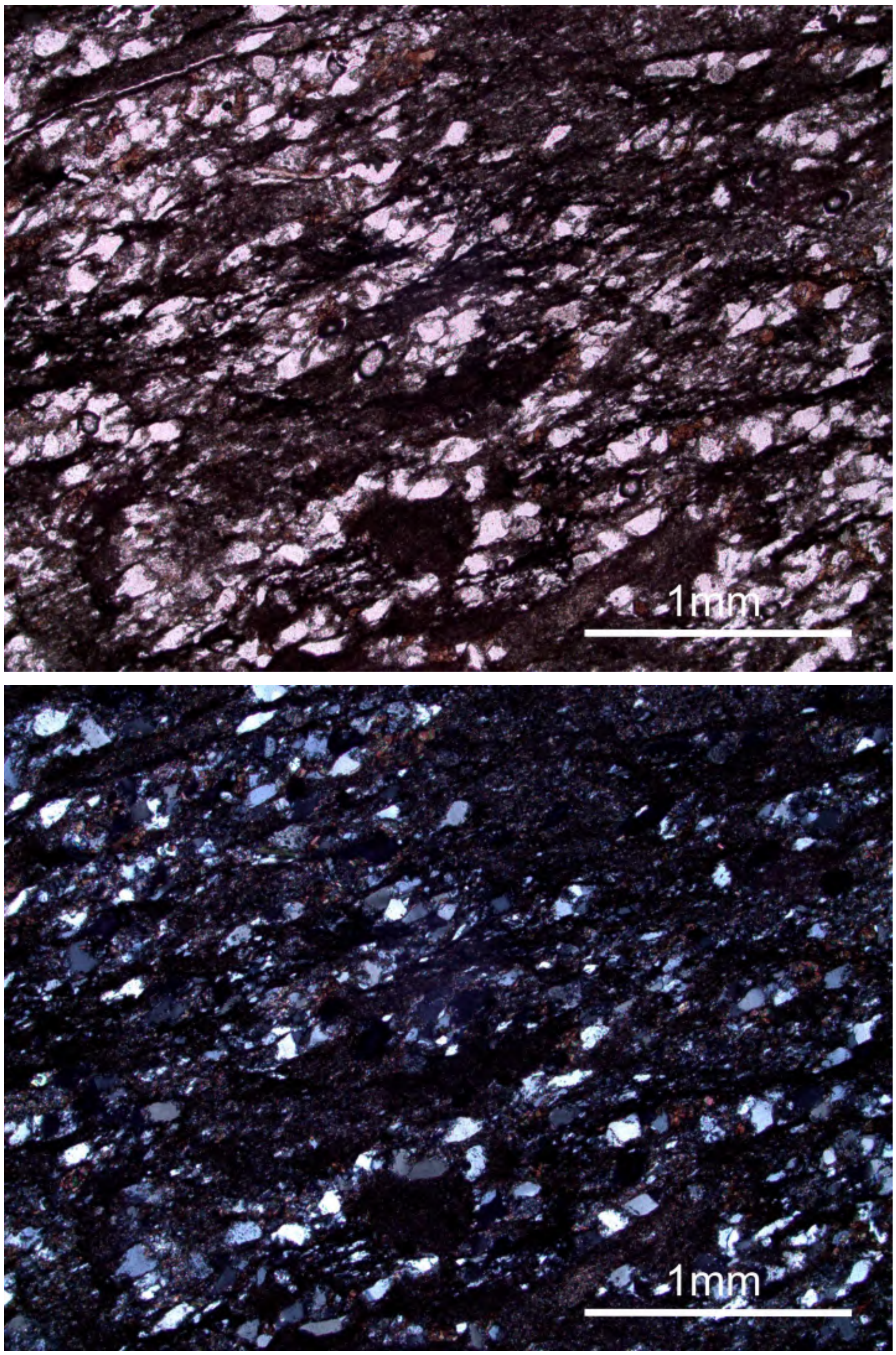




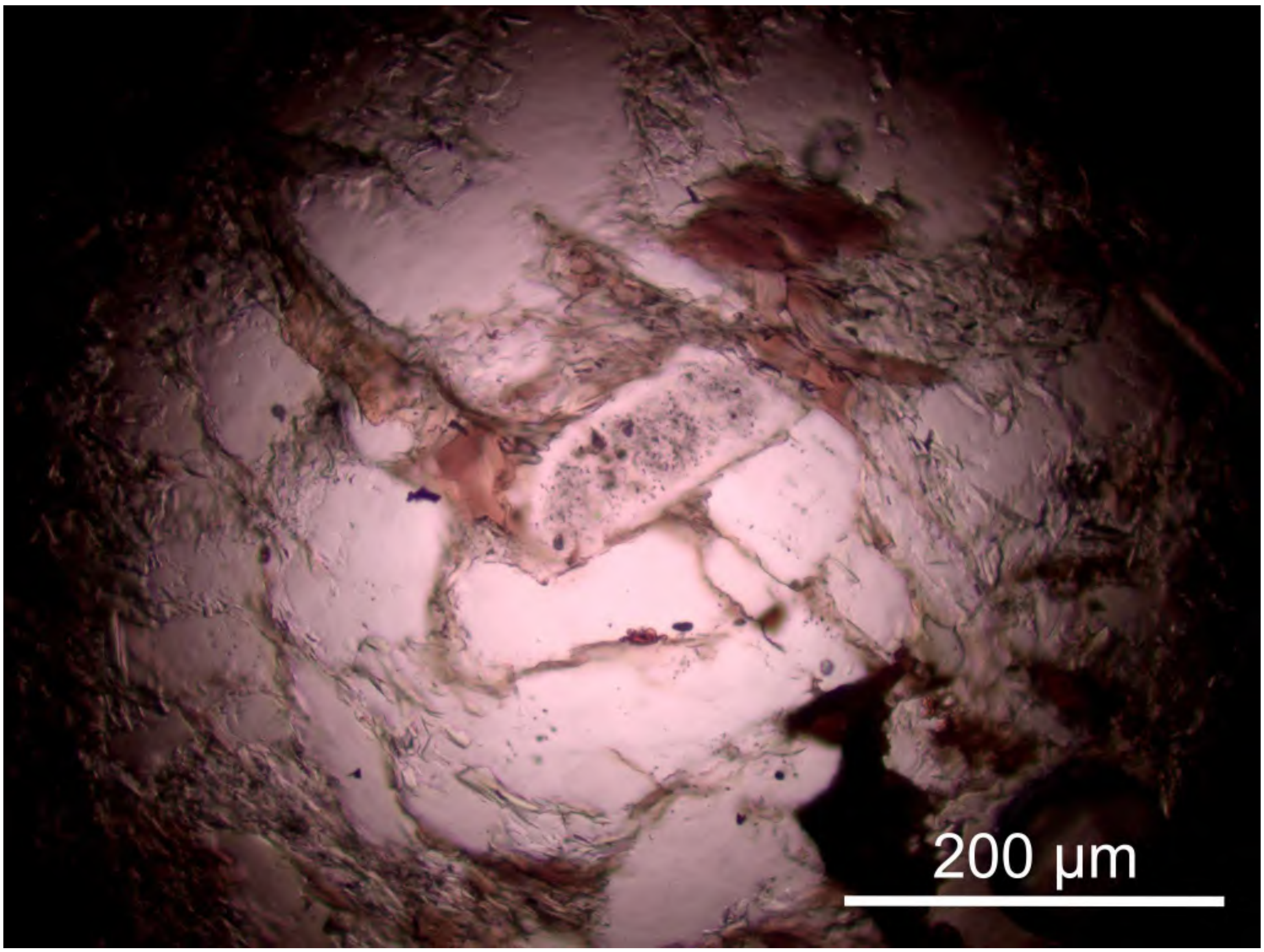
OD2016-039 metamorphic fabric in muscovite



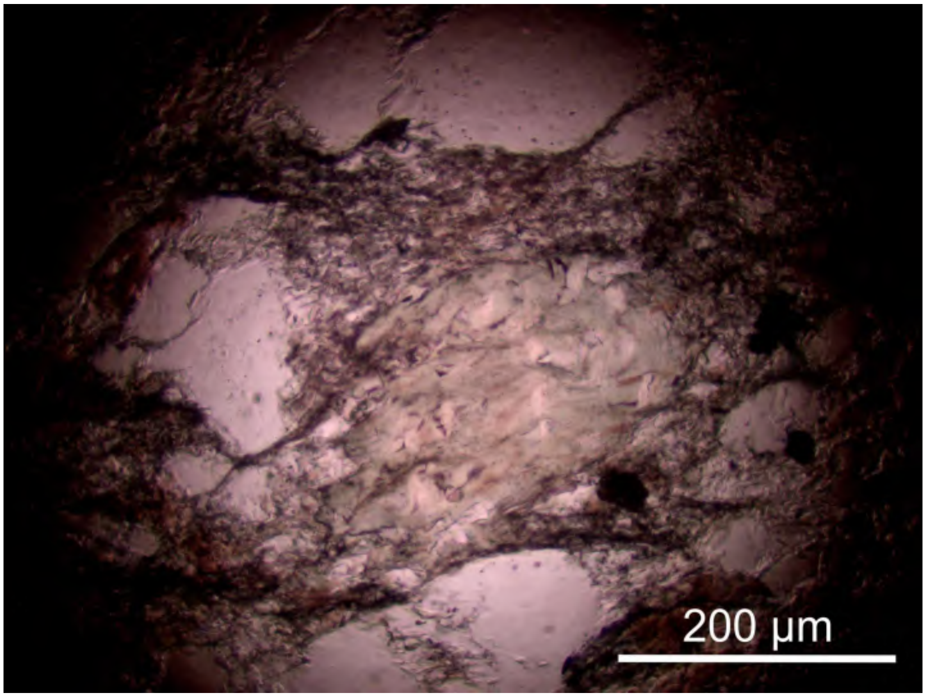
OD2016-040 shearing

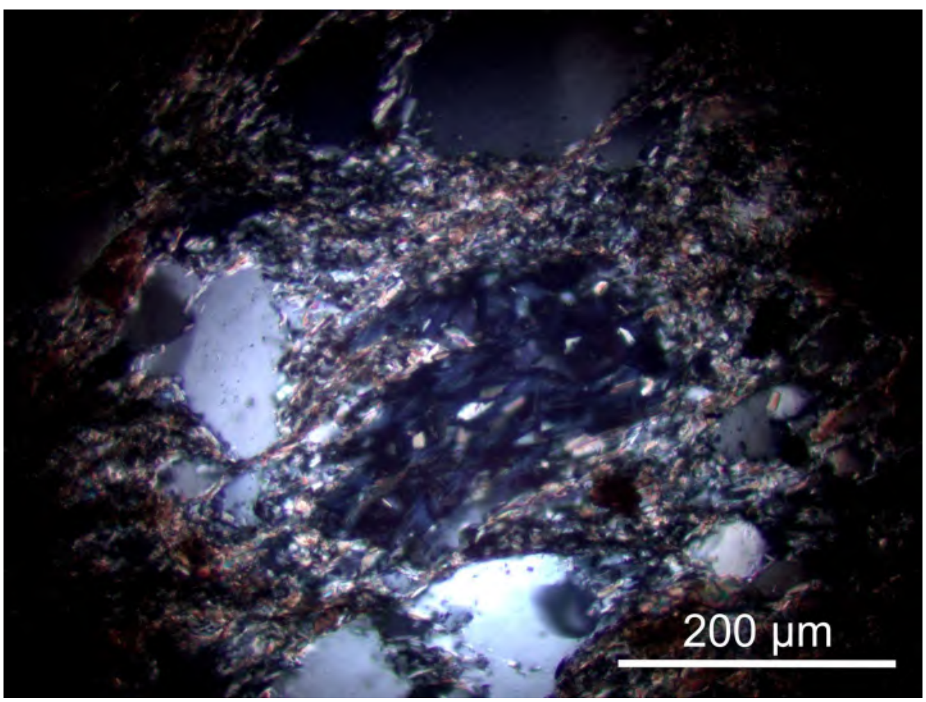


OD2016-040 albite diagenetic rim

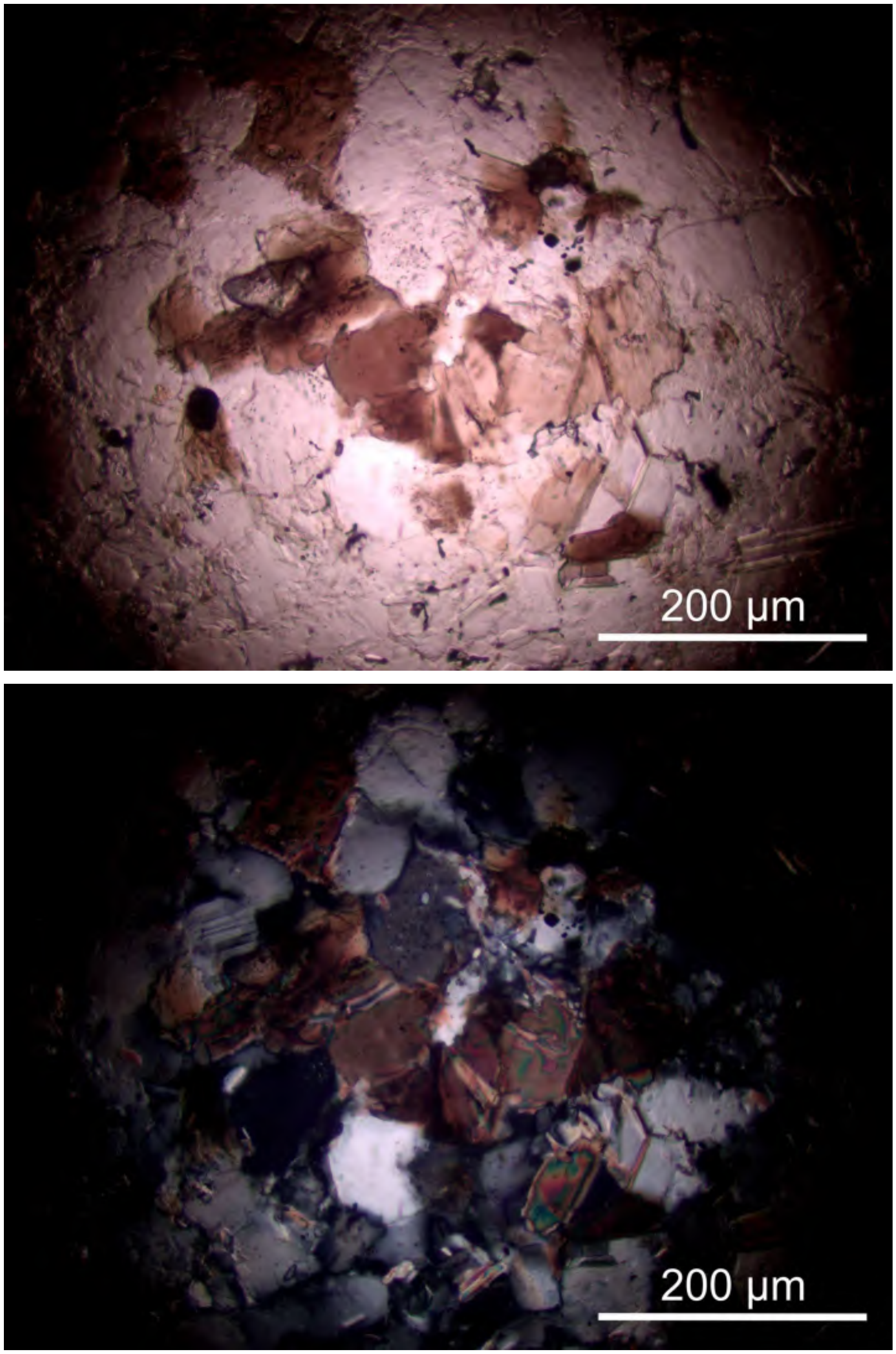


OD2016-040 chlorite

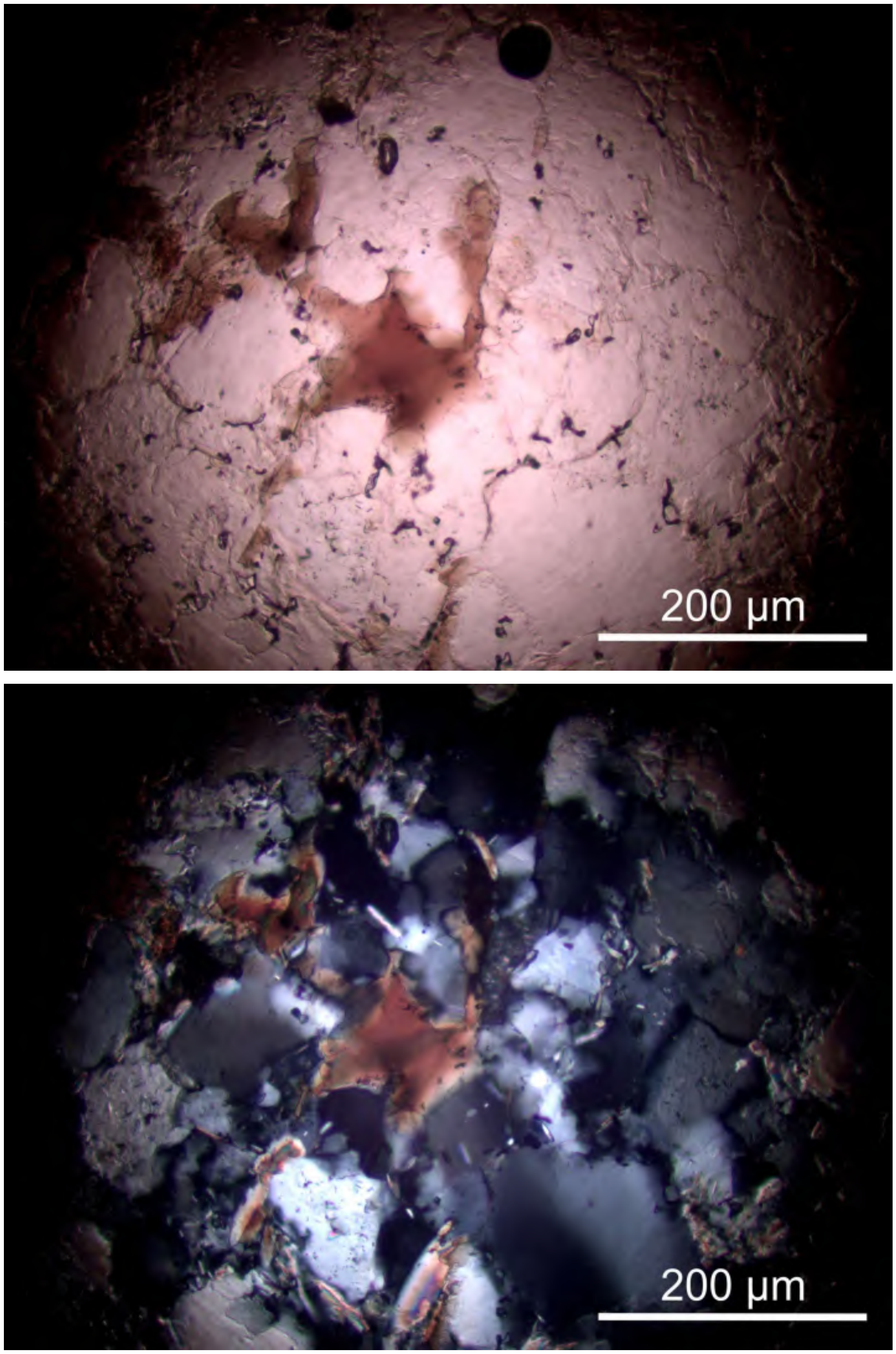




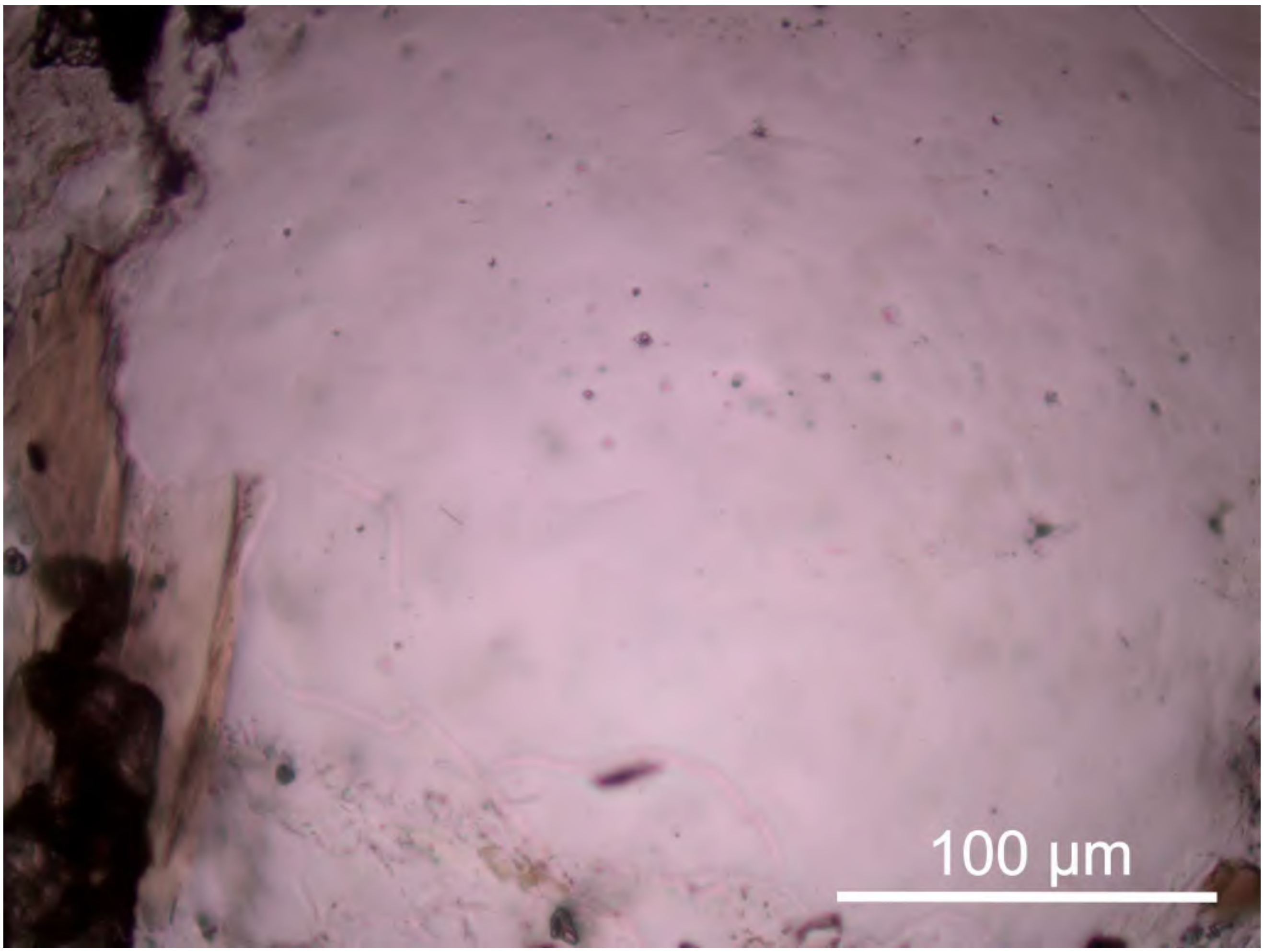
OD2016-041 authigenic biotite



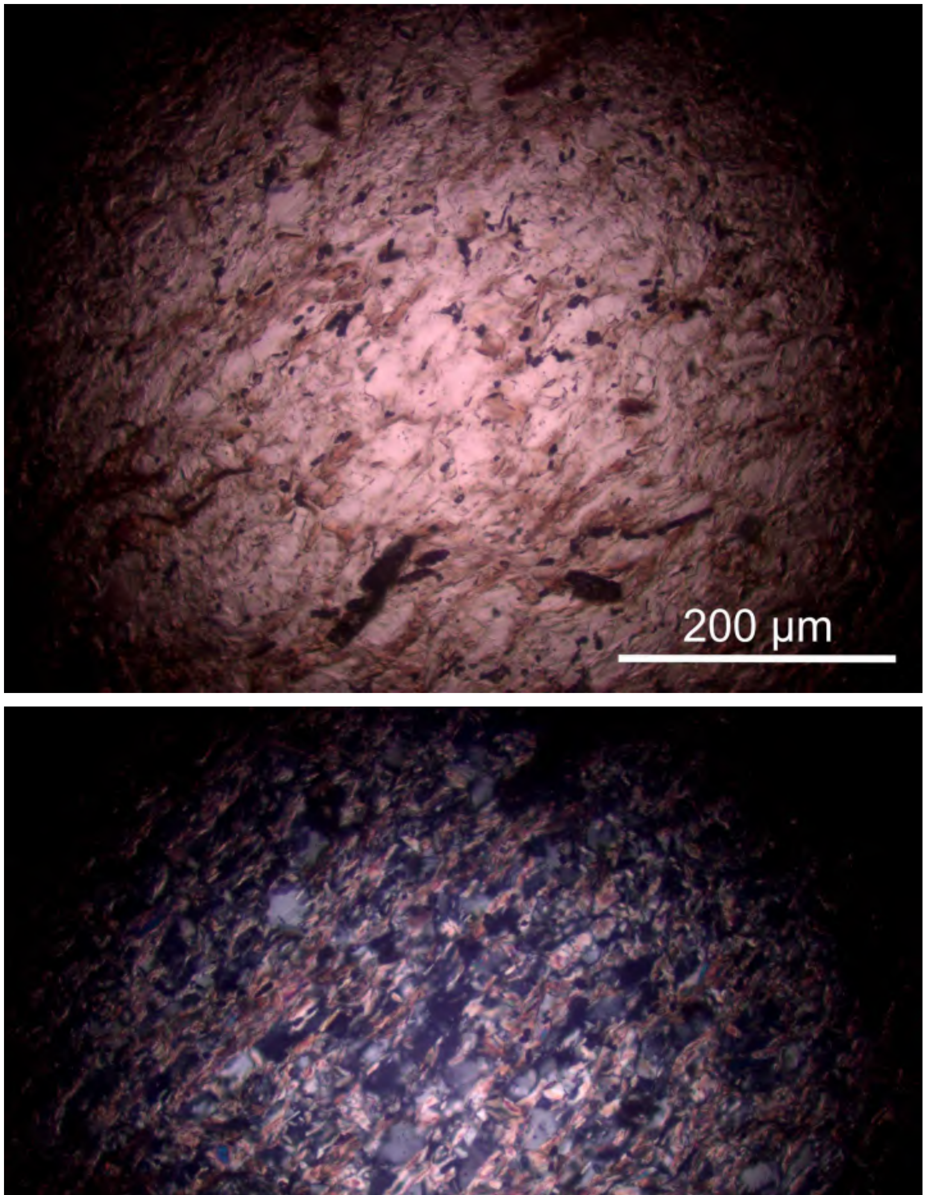
OD2016-041 authigenic biotite



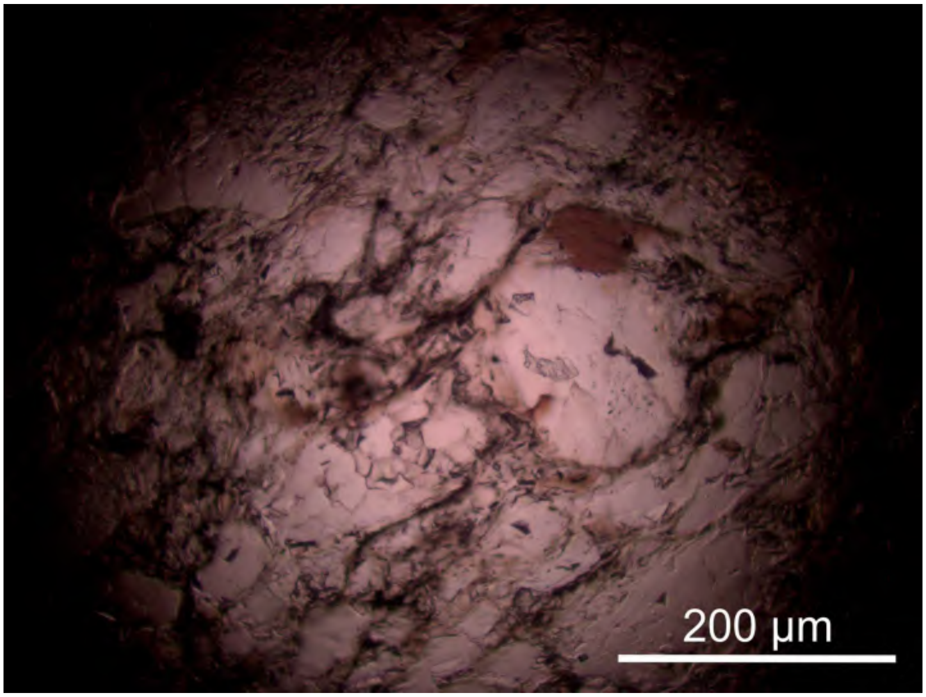
OD2016-041 fluid inclusion trail in quartz

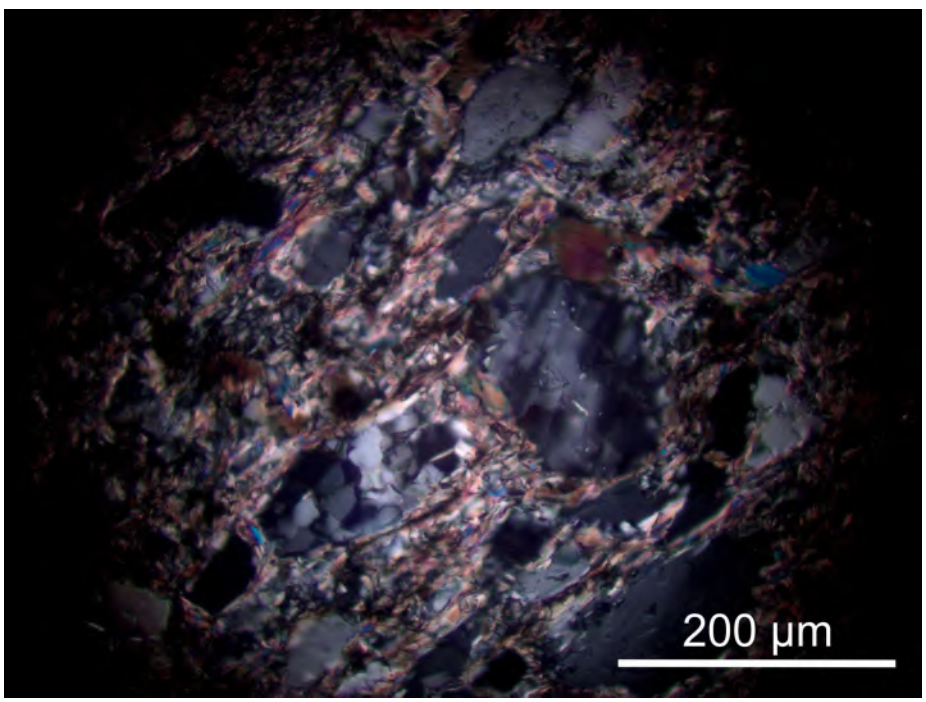


OD2016-041 metamorphic muscovite

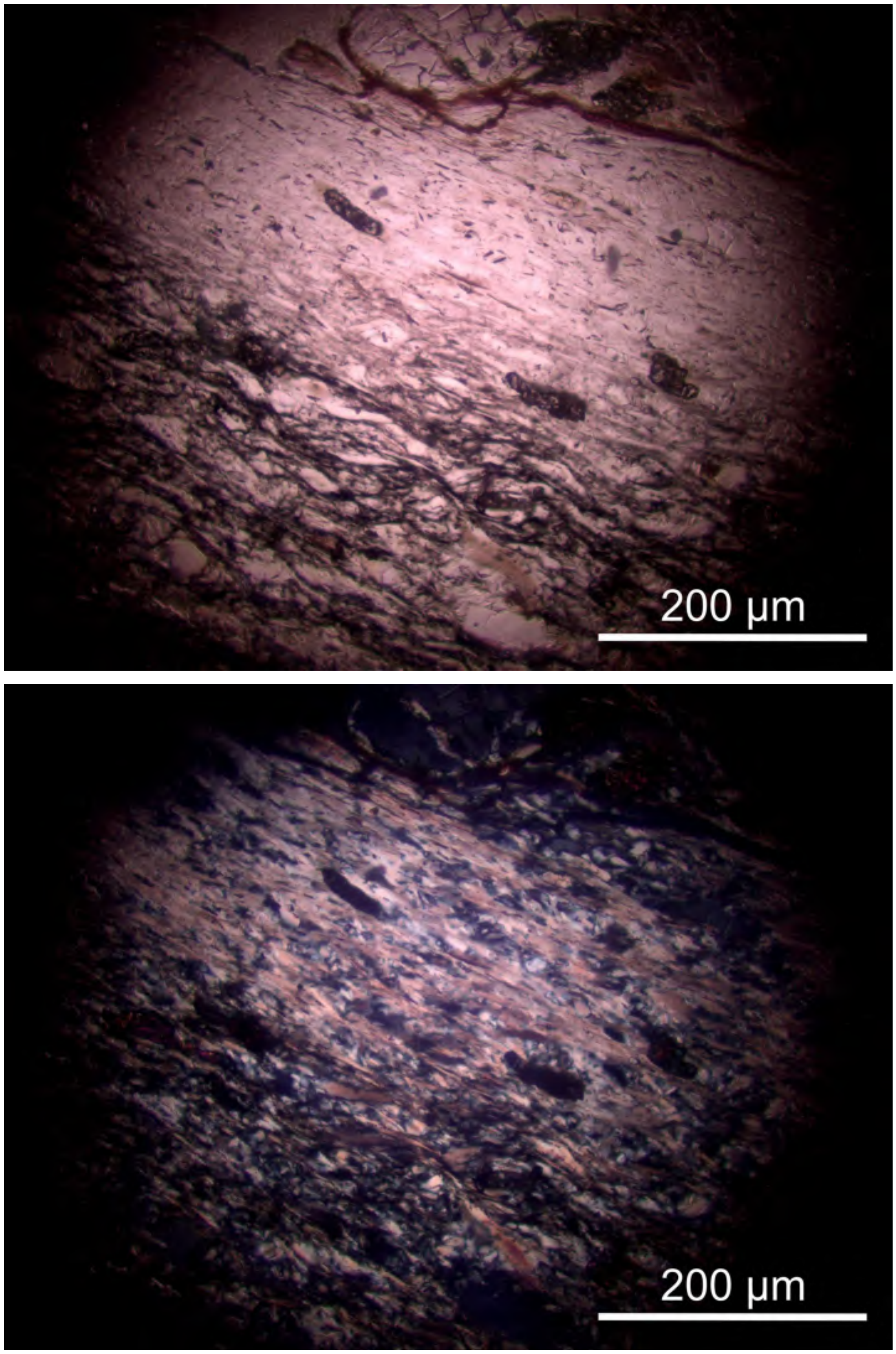


OD2016-045 lithic clast and perthite

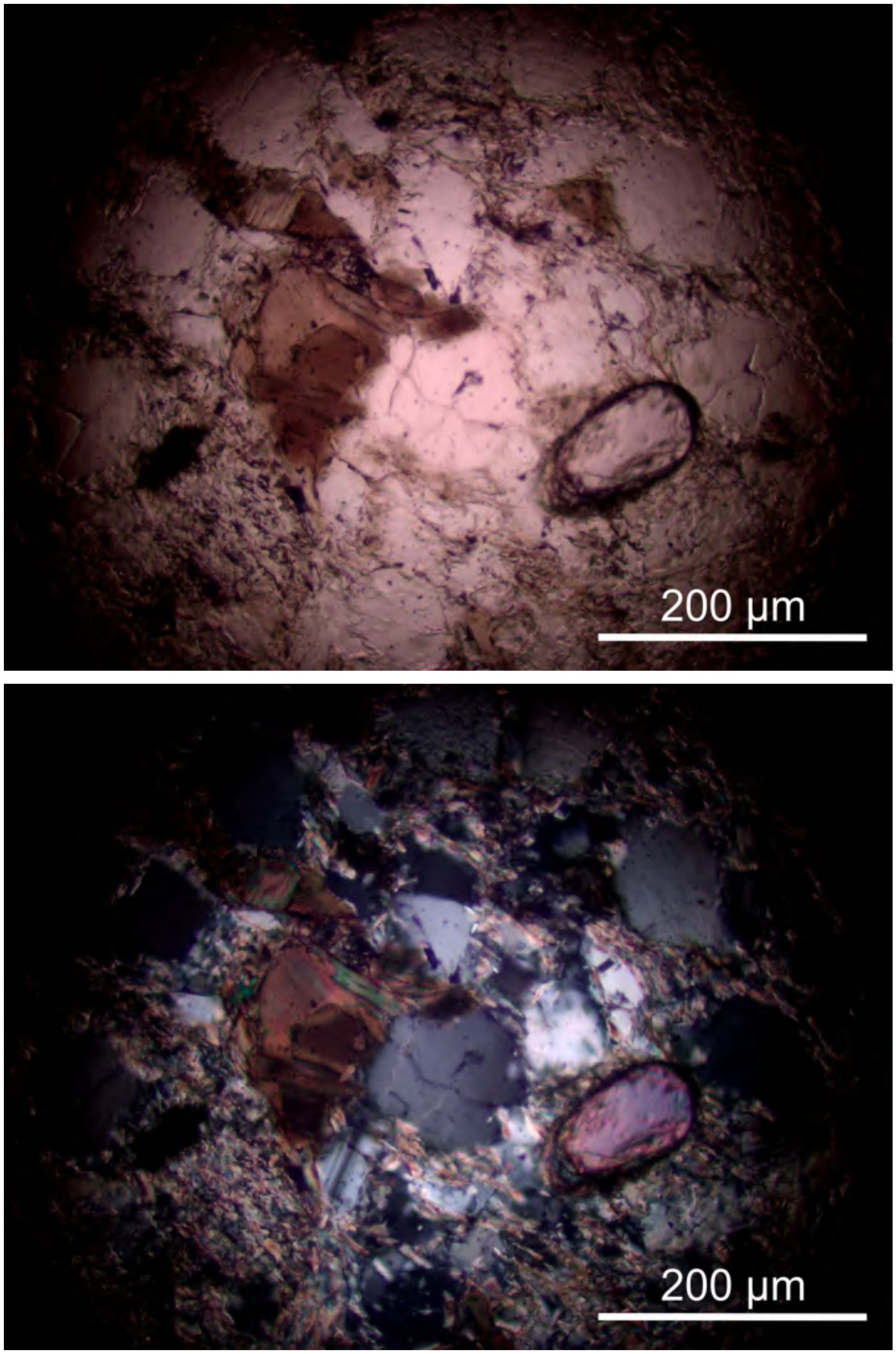




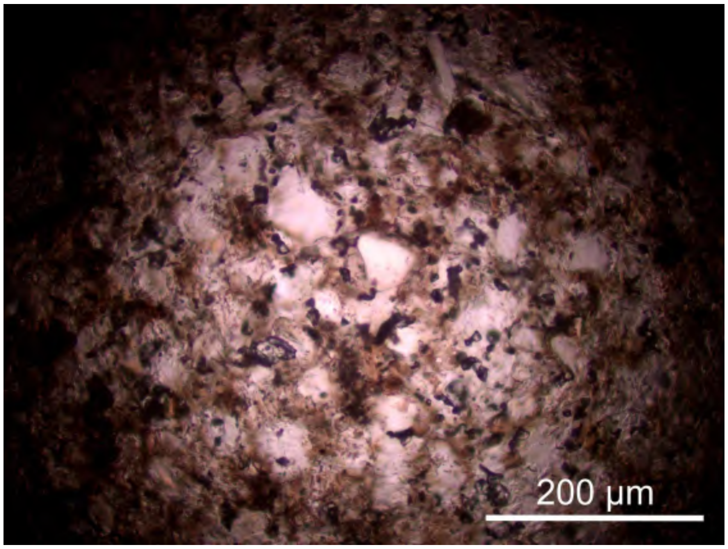
OD2016-045 metamorphic muscovite

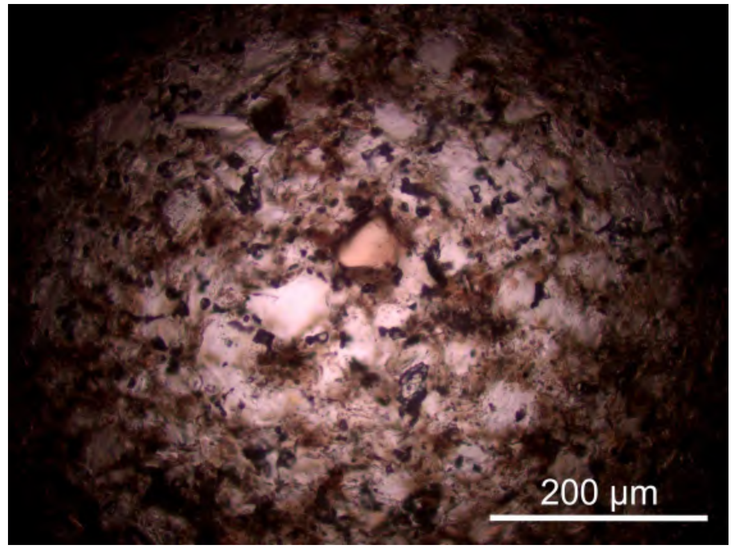


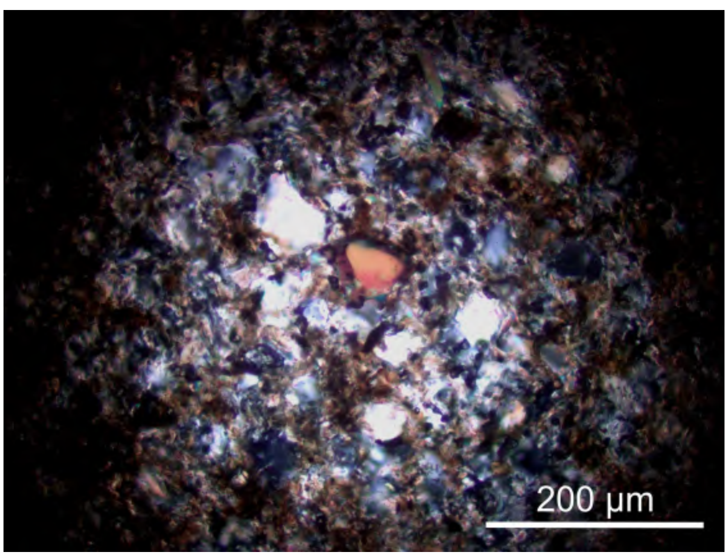
OD2016-045 zircon and biotite

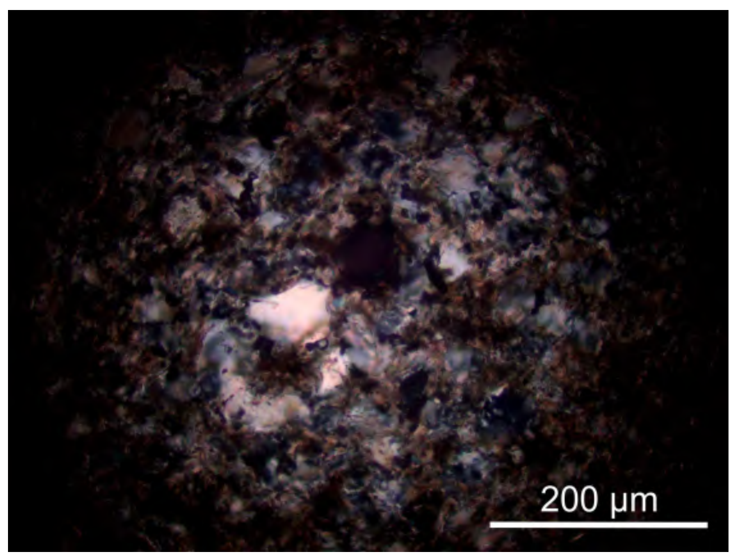


OD2016-050 tourmaline

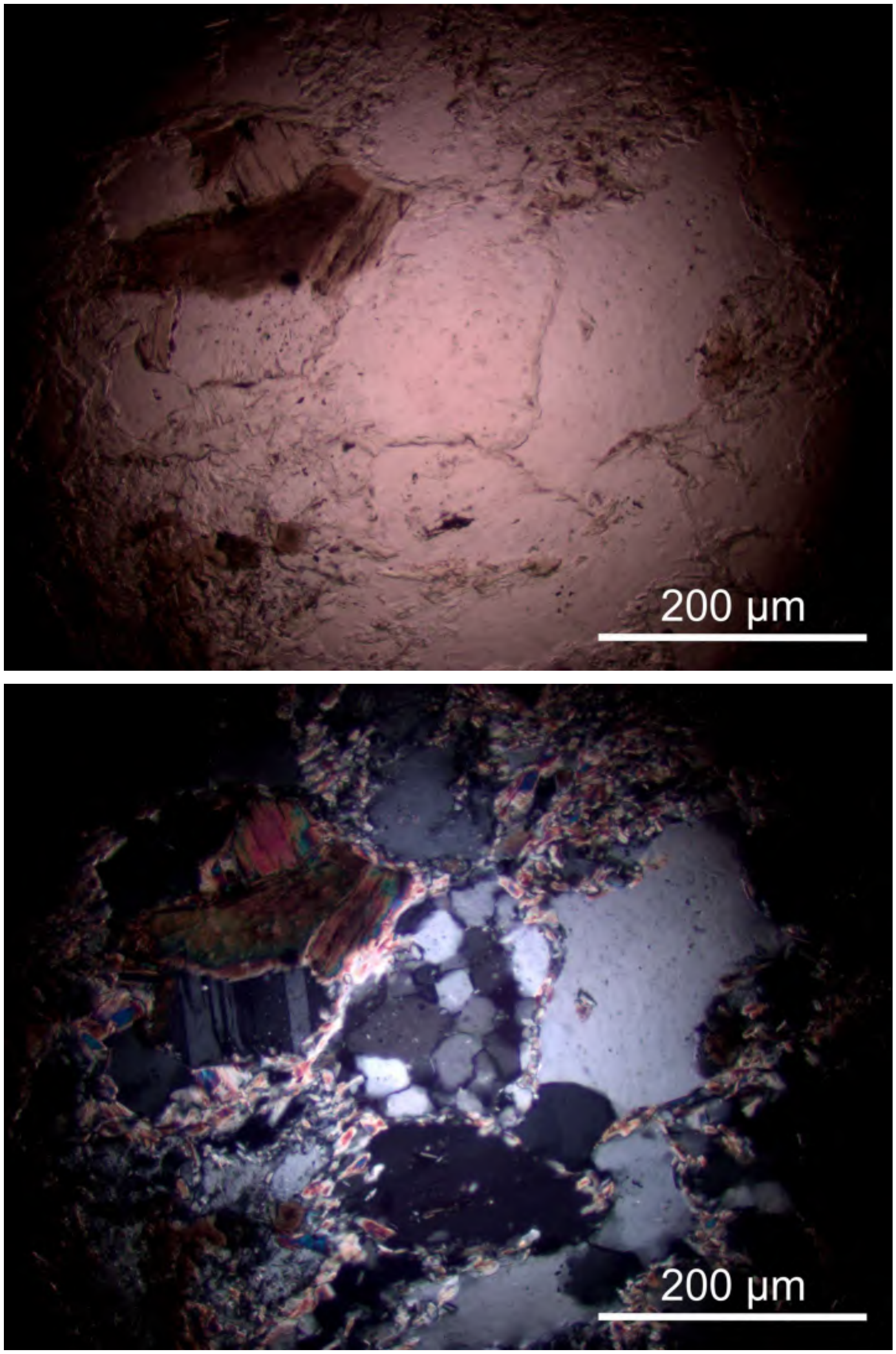




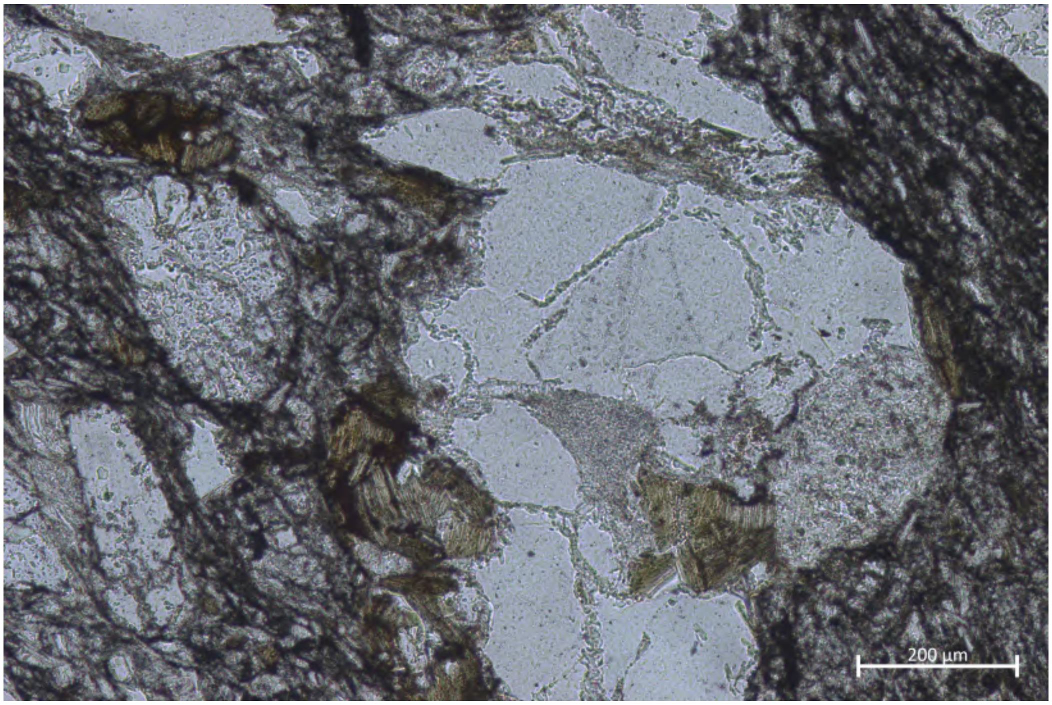


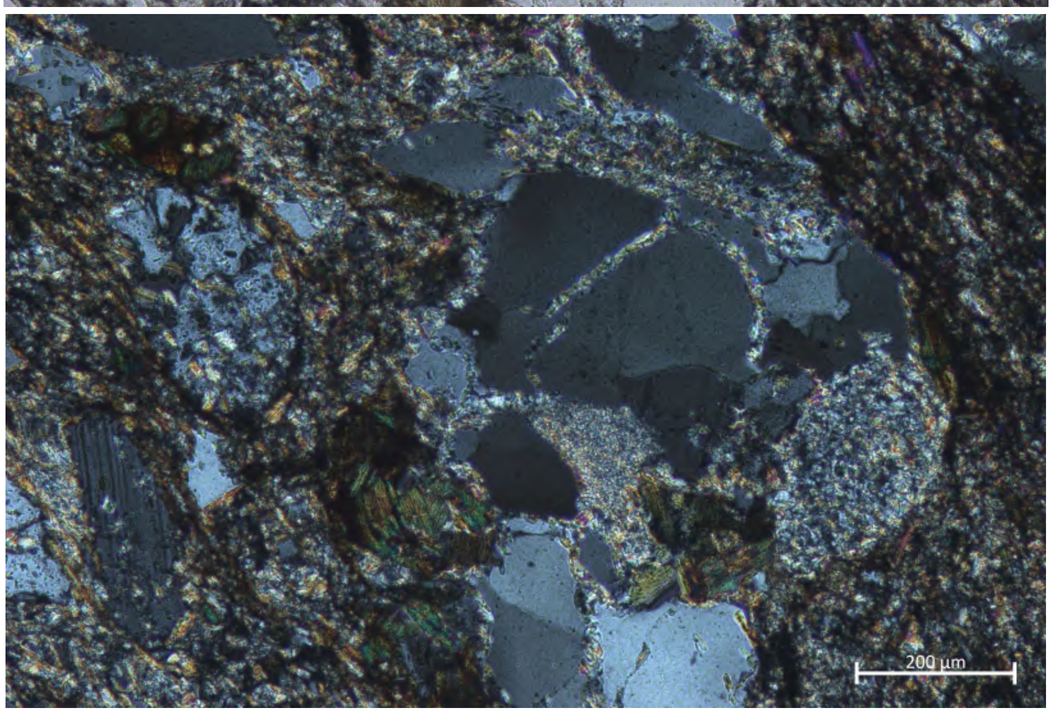


OD2016-052 lithic clast

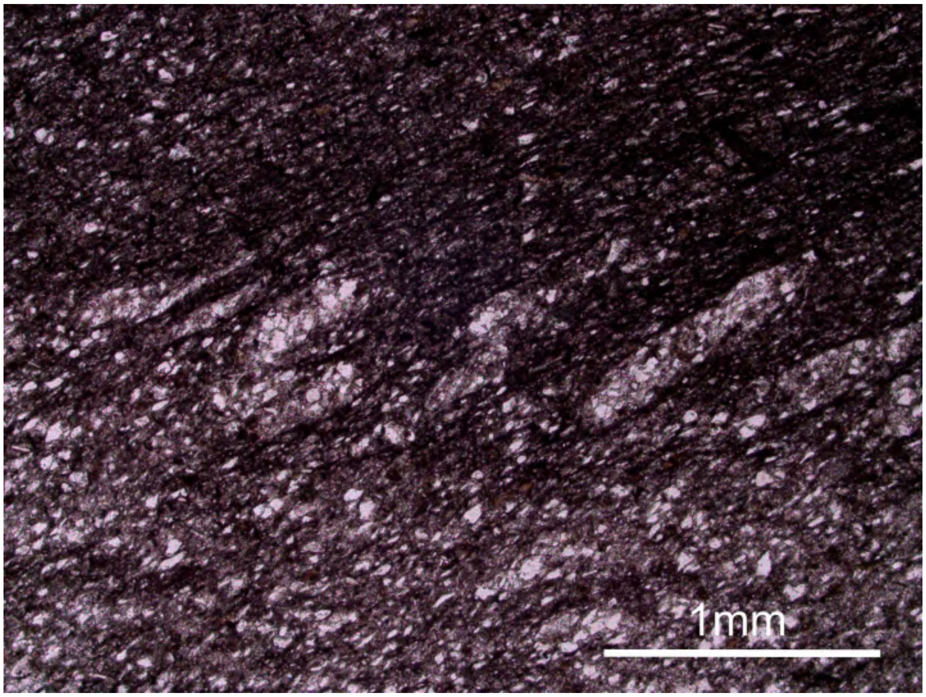


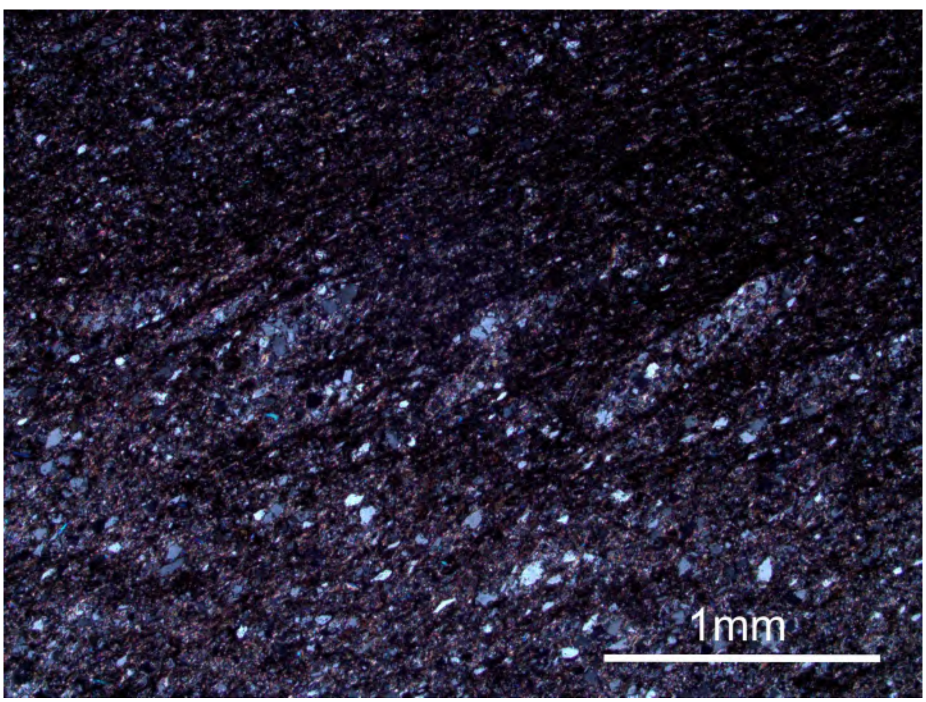
OD2016-052 lithic clast



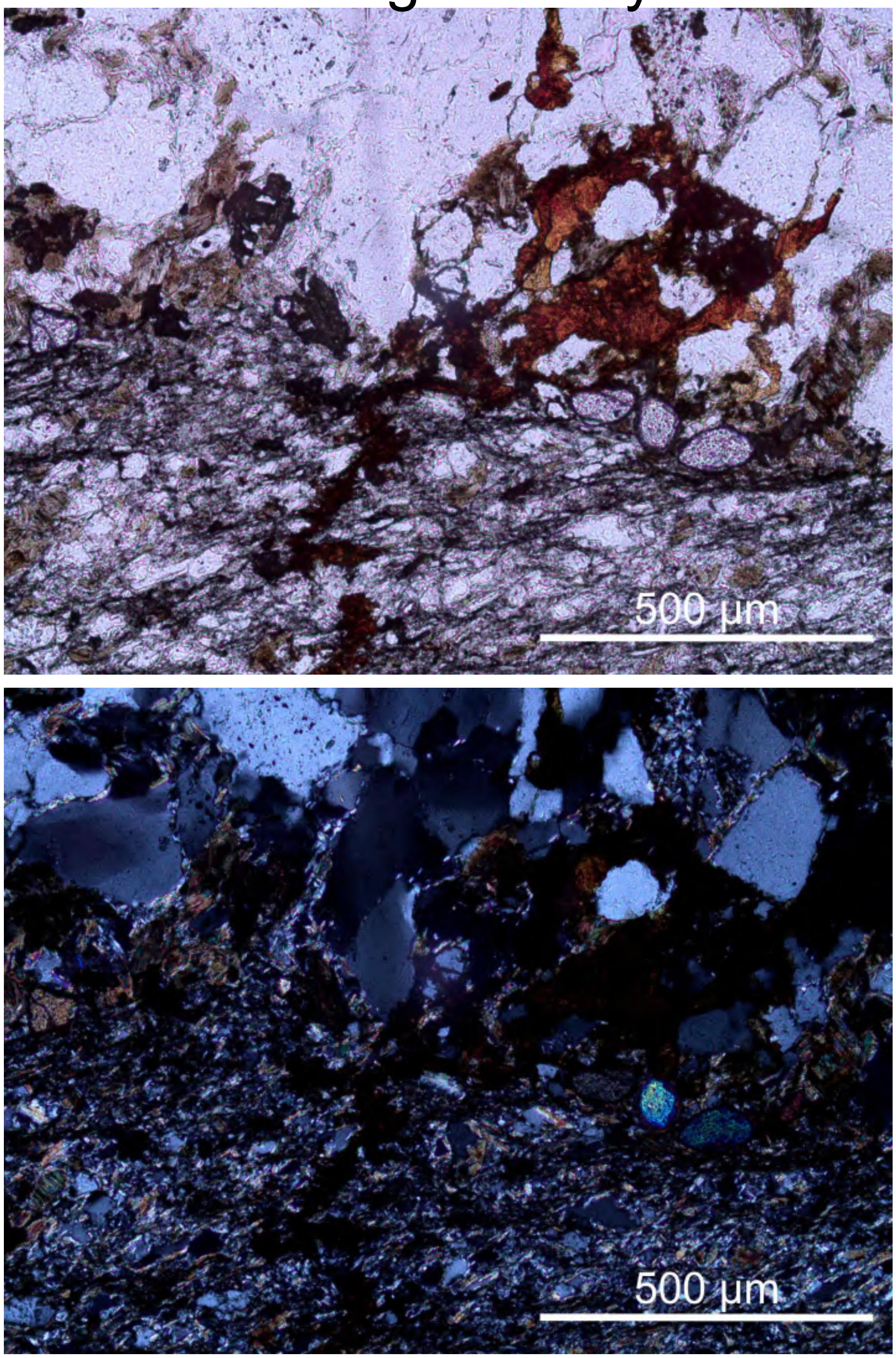


OD2016-060 quartz silt sheared into mud

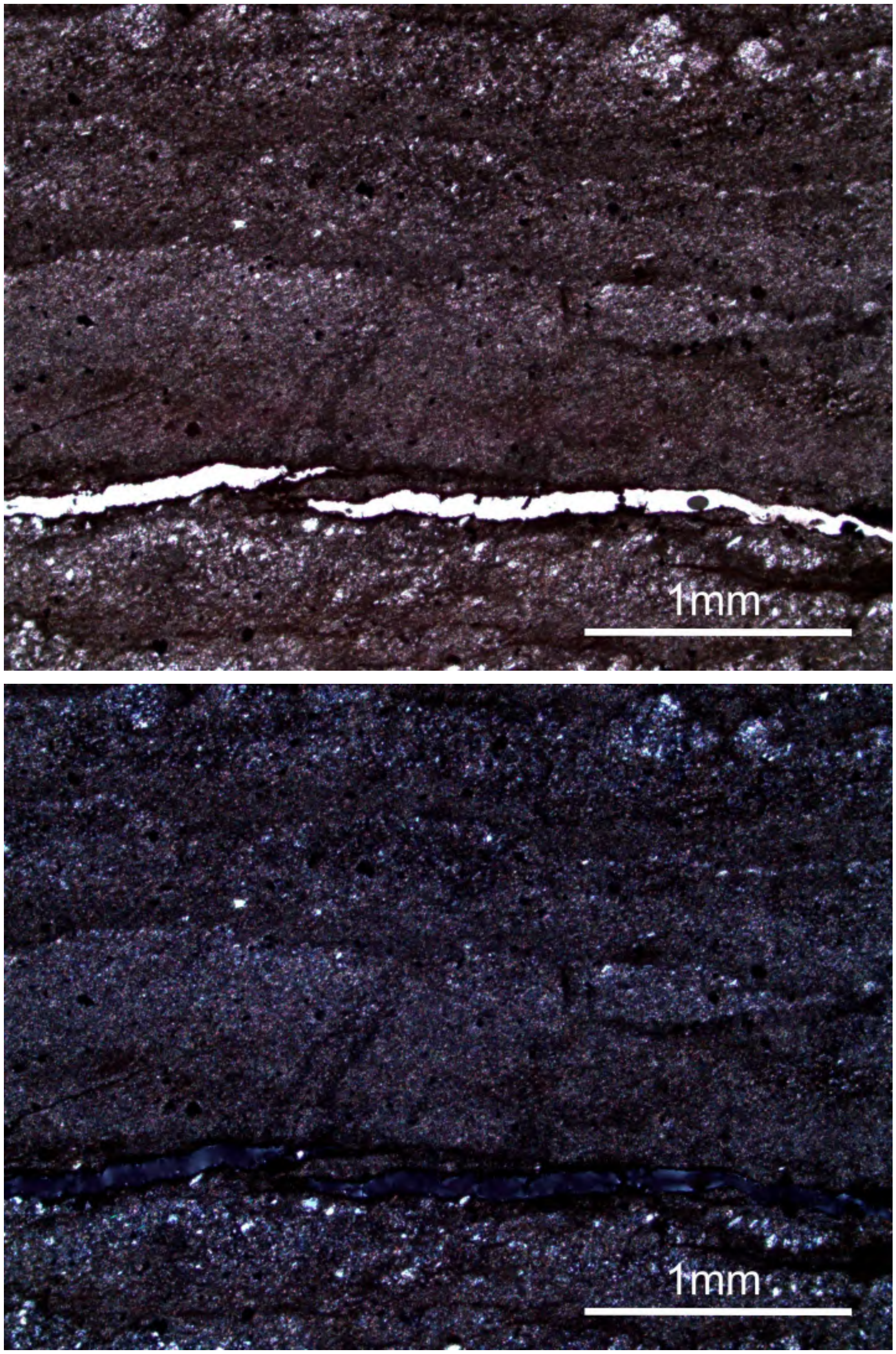




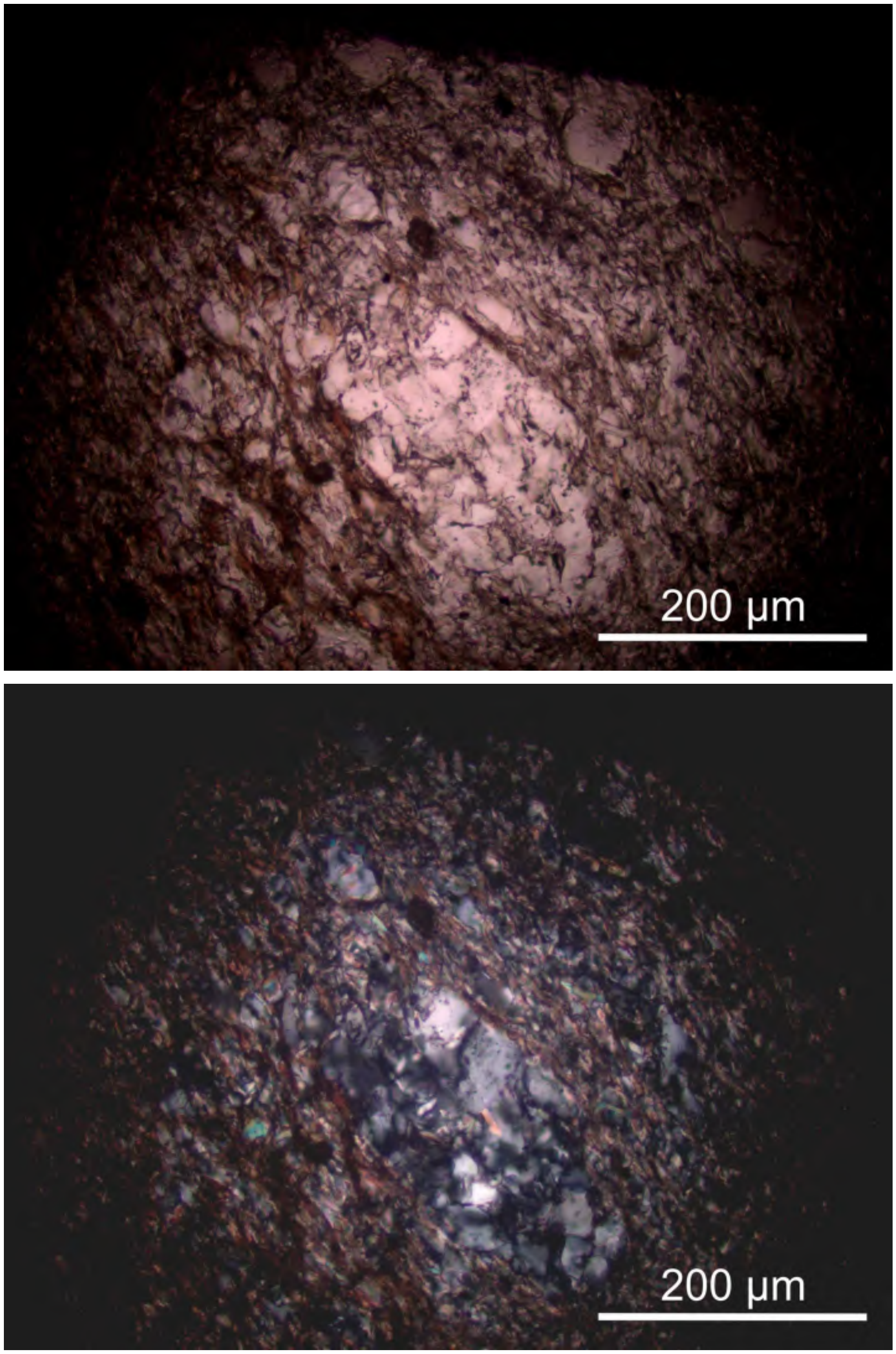
OD2016-060 heavy minerals abutting mud layer



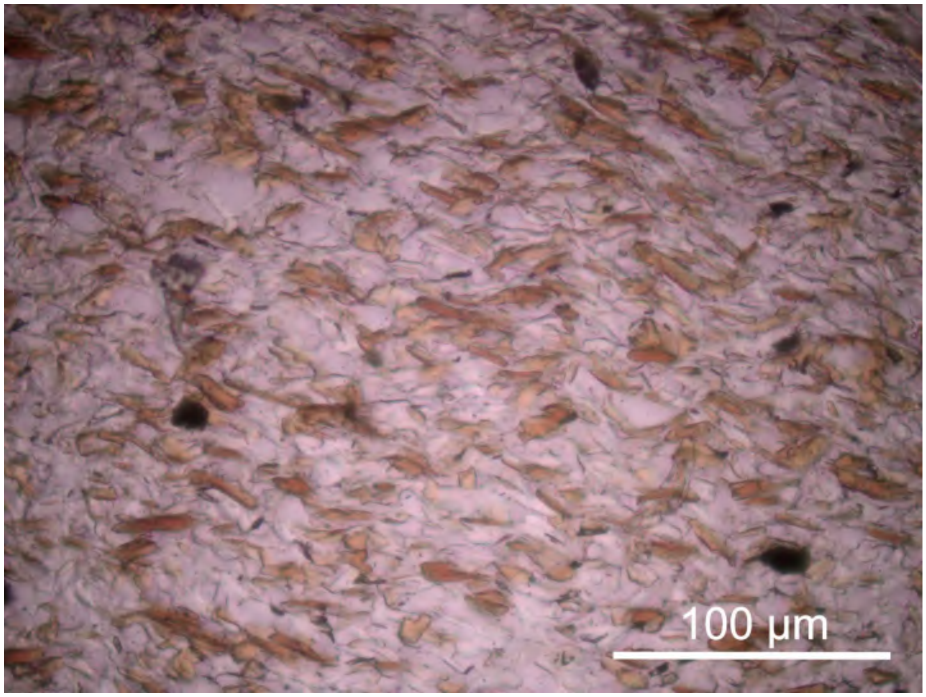
OD2016-066 graded bedding

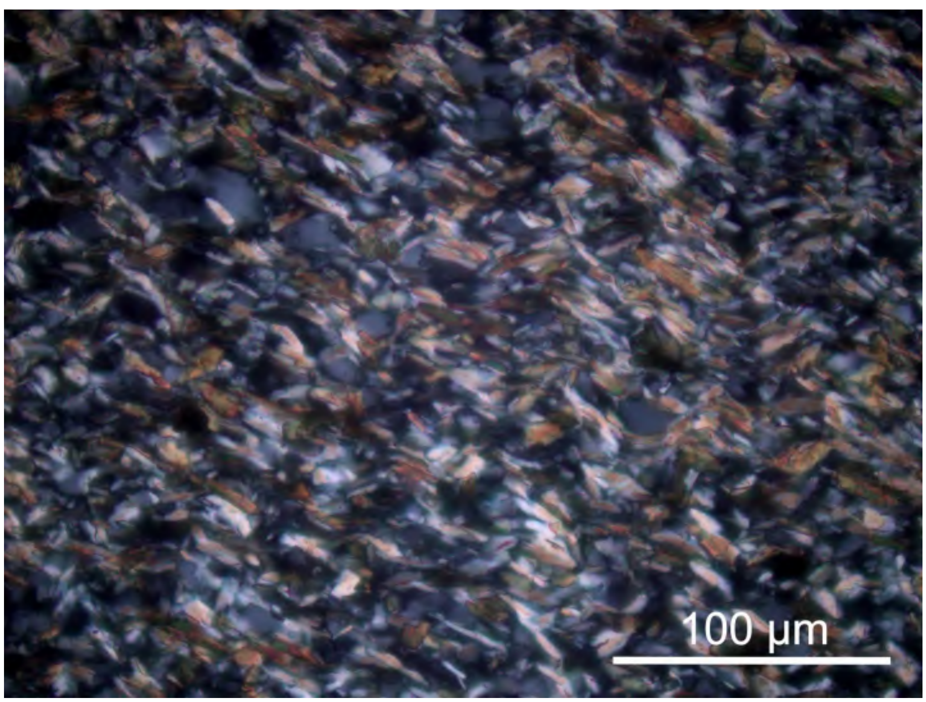


OD2016-068 lithic clast

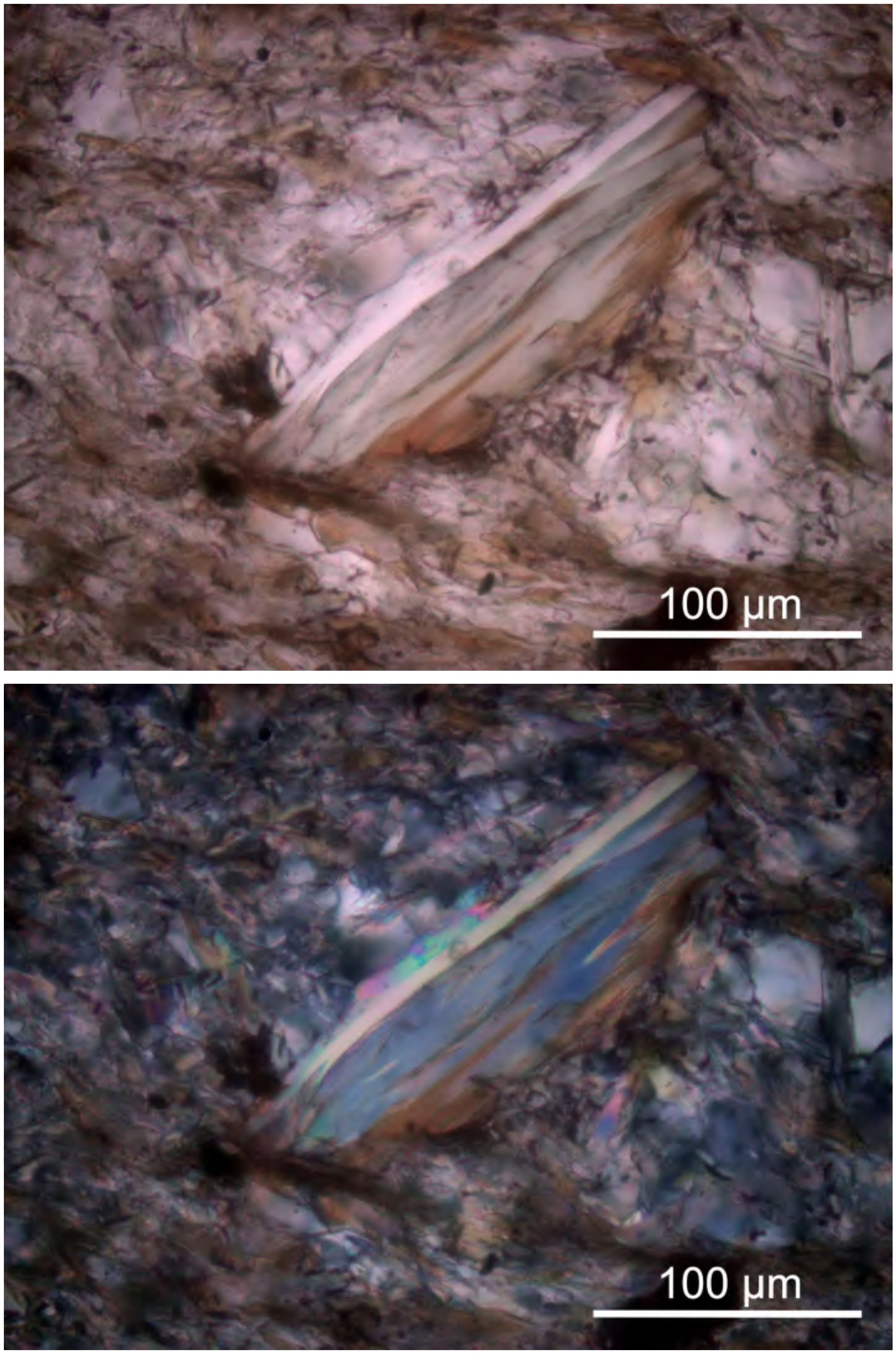


OD2016-068 metamorphic micas

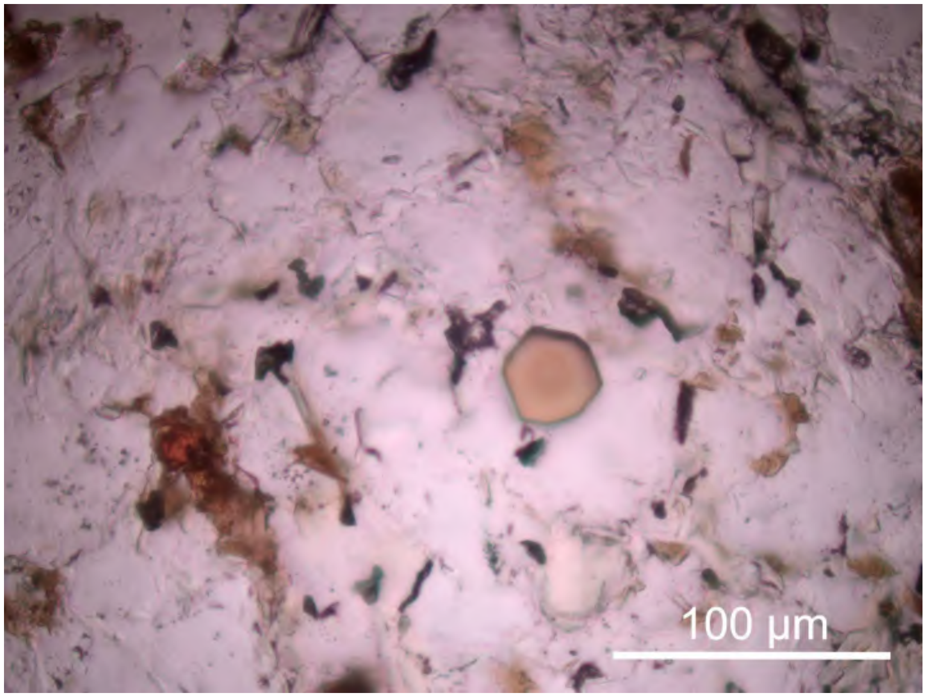


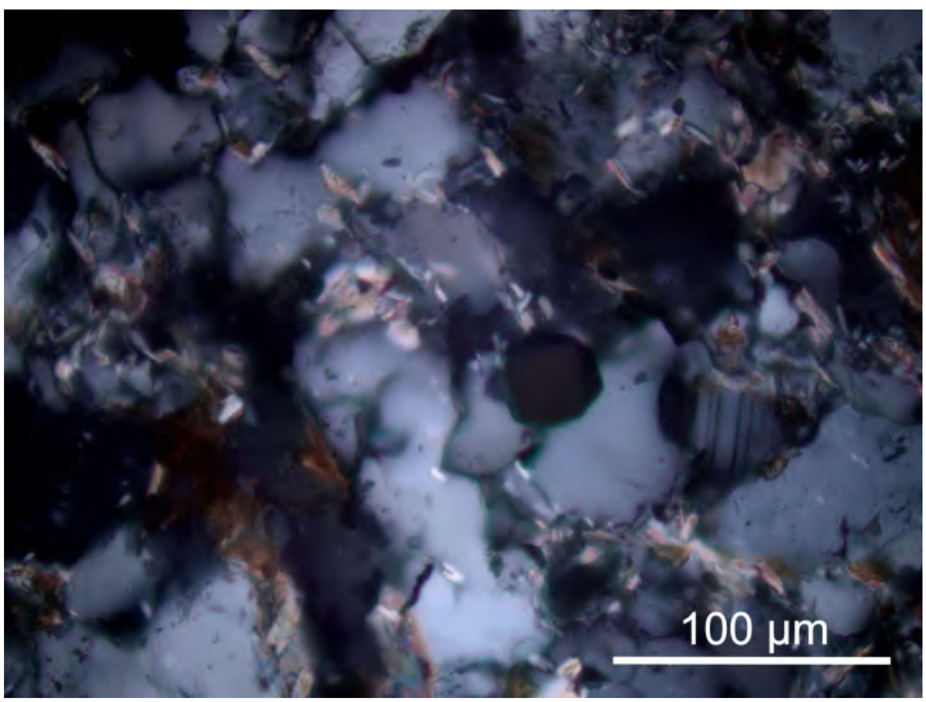


OD2016-068 muscovite altering to chlorite

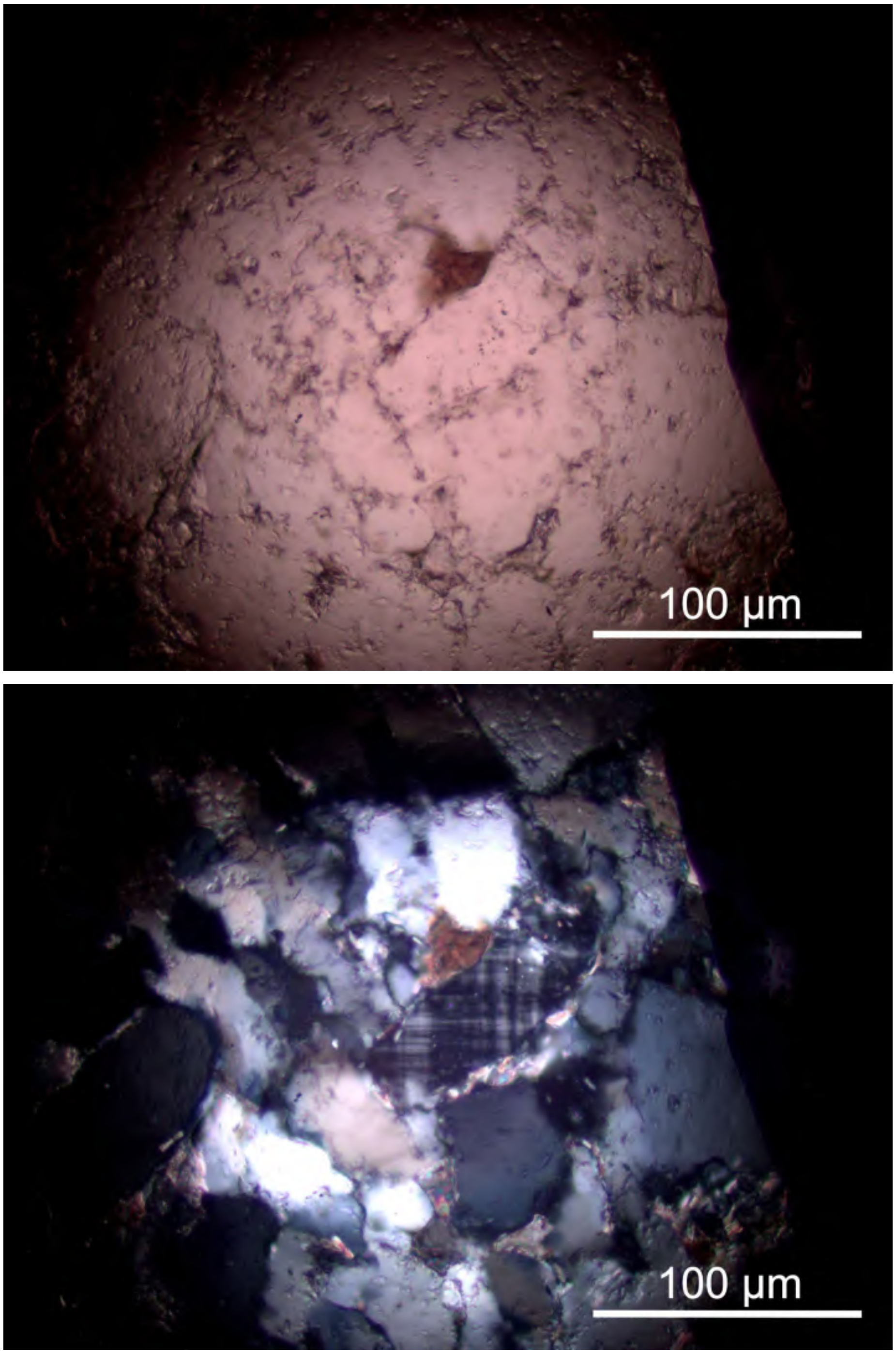


OD2016-069 tourmaline

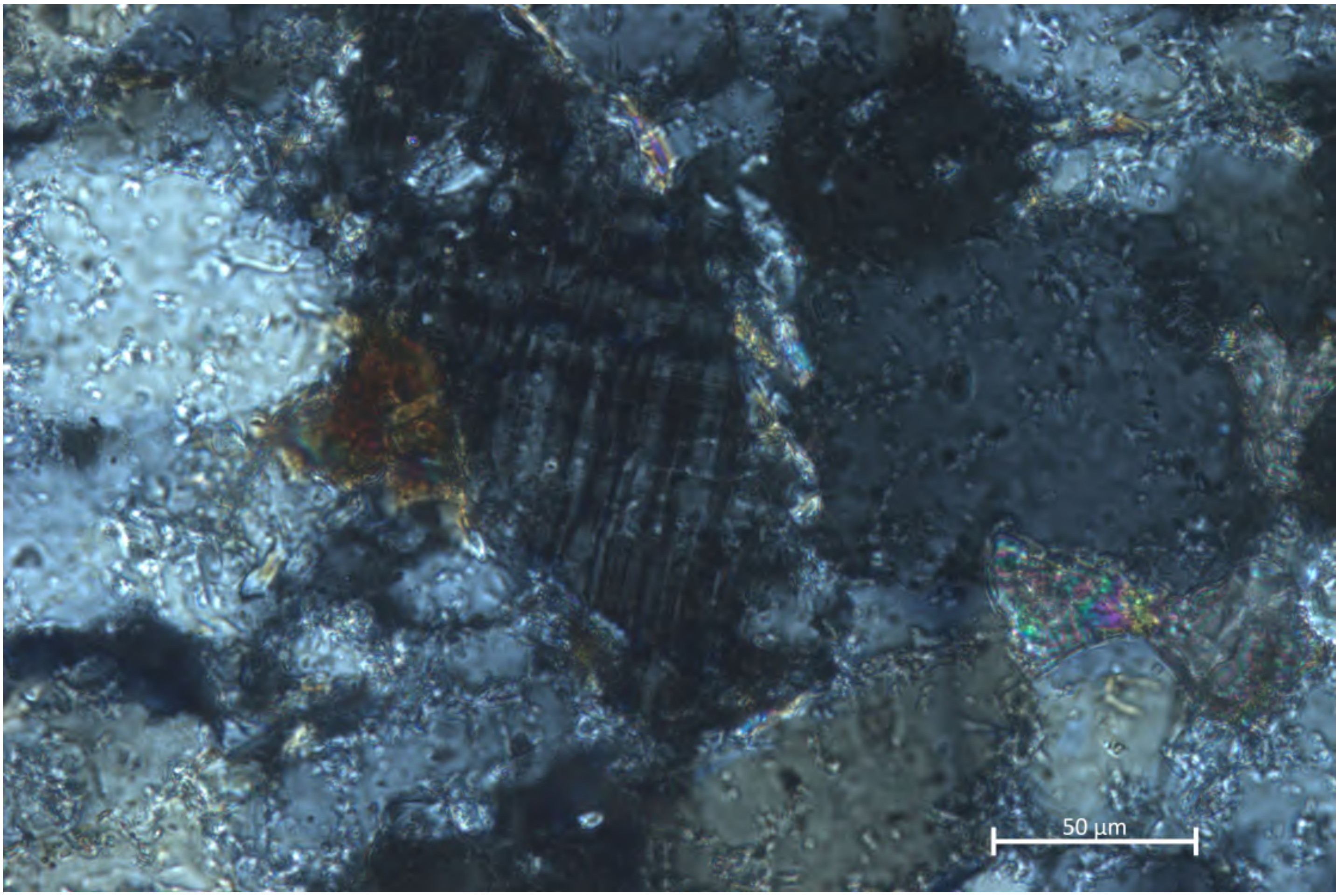




OD2016-109 k-feldspar microcline twinning



OD2016-109 k-feldspar microcline twinning



Appendix 4: OD2016-D2 petrographic descriptions.

Notes:

A sample number succeeded by -1, or -2 indicates thin section number. Eg. 011-2 is the second thin section from sample 011.

A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 012 has been cut into two halves, one half is 012-a and the other half is 012-b.

	Thin section number		OD2016-D2-001-1		Rock type	Lithology: 1
	Overall texture of rock		Depositional laminations		Subarkose sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	65%	150	Sutured quartz grains interpreted to act as cement	
2	Biotite	Metamorphic	20%	150	No clean biotite grains, rough looking texture. Occasionally altering to chlorite	
3	Muscovite	Detrital	trace	250	Large clean crystals sometimes bent around quartz grains	
4	Muscovite	Metamorphic	3%	30		
5	Albite	?	11%	100	Outer edges of some grains show less alteration to sericite. Possibly diagenetic overgrowths?	
6	Calcite	cement	1%		rare in patches filling pores	
7	Apatite		trace?		Not observed in this thin section	
8	Zircon	Detrital	trace	50-150		
Notes on fractures		No fractures observed				
Notes on new photographs or analyses needed			Some zircons and detrital muscovite			
Other notes						

	Thin section number		OD2016-D2-001-2		Rock type	Lithology: 1
	Overall texture of rock		Depositional laminations		Subarkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	65%	150	Sutured quartz grains interpreted to act as cement	
2	Biotite	Diagenetic	20%	150	No clean biotite grains, rough looking texture. Occasionally altering to chlorite	
3	Muscovite	Detrital	trace	250	Large clean crystals sometimes bent around quartz grains	
4	Muscovite	Diagenetic	4%	30		
5	Albite	Detrital	10%	100	Outer edges of some grains show less alteration to sericite. Possibly diagenetic overgrowths?	
6	Calcite	cement	1%		rare in patches filling pores	
7	Apatite		trace?			
8	Zircon	Detrital	trace	50-150		
Notes on fractures		No fractures observed				
Notes on new photographs or analyses needed			Some zircons and detrital muscovite			
Other notes						

	Thin section number		OD2016-D2-002-1		Rock type	Lithology: 2
	Overall texture of rock				Subarkosic alternating sandstone and muddy siltstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital?	15%	150	Coarse layers, quartz grains often sutured where touching	
2	Quartz	Detrital	25%	50	Fine grained layers	
3	Biotite	Metamorphic?	15%	150	Edges are often altering to chlorite	
4	Muscovite	Detrital?	Trace	200	Large clean crystals, elongate and skinny	
5	Muscovite	Diagenetic	1%	~15	Small muscovites within the fine grained layers. These muscovite act as the matrix	
6	Albite	Detrital	1%	100		
7	K-feldspar	Detrital	1%	100		
8	Apatite	Detrital?	Trace			
9	Zircon	Detrital	Trace			
10	Matrix		40%		Matrix appears to be largely composed of muscovite and quartz	
Notes on fractures						
Notes on new photographs or analyses needed						
Other notes			Appears to have undergone low grade metamorphism. Mineral grains aligned			
			Shearing present in matrix. Depositional layers of alternating sand and silt. Layer appear deformed			

	Thin section number		OD2016-D2-002-2		Rock type	Lithology: 2
	Overall texture of rock				Alternating sandstone and muddy siltstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital?	15%	150	Coarse layers, quartz grains often sutured where touching	
2	Quartz	Detrital	25%	50	Fine grained layers	
3	Biotite	Metamorphic?	15%	150	Edges are often altering to chlorite	
4	Muscovite	Detrital?	Trace	200	Large clean crystals, elongate and skinny	
5	Muscovite	Diagenetic	1%	~15	Matrix, shows some alignment	
6	Albite	Detrital	1%	100		
7	K-feldspar	Detrital	1%	100		
8	Apatite	Detrital?	Trace			
9	Zircon	Detrital	Trace			
10	Matrix		40%		Matrix appears to be largely composed of muscovite and quartz	
Notes on fractures						
Notes on new photographs or analyses needed						
Other notes			the long-axis of mineral grains in the fine grained layers are oriented parallel with the laminations. Depositional layers of alternating sand and silt. Layer appear deformed			

	Thin section number		OD2016-D2-004		Rock type	Lithology: 1
	Overall texture of rock		Massive rock texture		Arkose	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	Sutured, cementing the rock	
2	Biotite	Metamorphic?	10%	150	Anhedral grains filling spaces between quartz grains	
3	Muscovite	Detrital?	1%	150	Elongate large clean grains often bent around quartz	
4	Albite		15%	100	Polycline and carlsbad twins present. Perthite twinning labelled P on thin section	
5	Zircon		Trace	100		
6	Matrix		10%		Matrix appears to be composed of fine grained muscovite	
7	Apatite		trace			
Notes on fractures		Fractures appear to have small amounts of iron oxide				
Notes on new photographs or analyses needed			Some detrital muscovites			
Other notes			Grain size of non-matrix minerals are highly uniform			

	Thin section number		OD2016-D2-005		Rock type	Lithology: 2
	Overall texture of rock		Massive very fine grain sandstone contacting laminated silty mudstone			
	Silty mudstone					
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	20%	60	Quartz grains are present following horizontal laminations. Sub angular to rounded	
2	Muscovite	Detrital	3%	200	Long axis of muscovite grains is typically oriented parallel with horizontal laminations. Large clean crystals sometimes bent around quartz grains	
3	Albite	Detrital	2%	80	Albite twinning, rare perthite	
4	Biotite	Diagenetic?	10%		Sometimes altering to chlorite. Often present as clusters of small biotites or anhedral masses	
5	Matrix		65%		Composed of clay and mica minerals	
6	Zircon	Detrital	Trace			
	Thin section number		OD2016-D2-005			
	Fine grain sandstone					
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	50%	60	Sub angular to rounded	
3	Muscovite	Detrital	2%	150	Large clean crystals sometimes bent around quartz grains	
4	Albite	Detrital	3%	80		
5	Biotite	Diagenetic?	10%			
6	Matrix		35%			
7	Zircon	Detrital	Trace			
Notes on fractures		Fractures filled with iron oxide				
Notes on new photographs or analyses needed			Well rounded detrital grain which is possibly garnet marked on thin section. Colourless in ppl, isotropic in xpl, high relief, some inclusions -- Was apatite on C- axis			
Other notes						

	Thin section number		OD2016-D2-006		Rock type	Lithology: 1
	Overall texture of rock		Weak depositional lamination		Fine-grain sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	Suturing between quartz grains	
2	Biotite	Diagenetic?	5%		Biotites present as rough looking grains or clusters of small grains with edges bounded by quartz	
3	Muscovite	Detrital	3%	300	Large clean crystals sometimes bent around quartz grains	
4	Hornblende?	Detrital	Trace	100		
5	Albite		7%	100		
7	Zircon		Trace			
8	Matrix		15%		Clay and mica minerals	
Notes on fractures		iron staining in fractures				
Notes on new photographs or analyses needed			Some zircons and detrital muscovite			
Other notes			Low grade metamorphic			

	Thin section number		OD2016-D2-011-1		Rock type	Lithology: 1
	Overall texture of rock		Depositional laminations		Subarkose	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	subangular to rounded grains	
2	Biotite	Diagenetic?	1%	80	Clusters of small biotite grains and rough looking biotite grains	
3	Muscovite	Detrital	1%	150	Large clean crystals sometimes bent around quartz grains. In the muddy layer of the thin section the muscovites are oriented with long-axis parallel to laminations and at an abundance of ~5%	
4	Opaque mineral		1%	80	Concentrated in thin layers with zircons	
5	Albite	Detrital/diagenetic	10%	100	Albite twinning and diagenetic rims	
6	K-Feldspar	Detrital	Trace	100	Microcline twinning?	
7	Matrix		15%		Largely muscovite	
8	Zircon	Detrital	1%	60	Many more zircons than other samples. Heavily concentrated in the heavy mineral layers	

Notes on fractures						
Notes on new photographs or analyses needed			Layers of opaque minerals and zircons. Heavy mineral layers? May be worth looking into further			
Other notes			This sample would be a great candidate for zircon dating			

	Thin section number		OD2016-D2-011-2		Rock type	Lithology: 1
	Overall texture of rock		Depositional laminations		Subarkose	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	75%	150		
2	Biotite	Diagenetic?	2%	80	Clusters of small biotite grains and rough looking biotite grains	
3	Muscovite	Detrital	1%	200		
4	Opaque mineral		Trace	80		
5	Albite	Detrital/diagenetic	12%		Albite twins, perthite twins, diagenetic rims	
6	K-Feldspar	Detrital	trace			
7	Matrix		10%			
8	Zircon	Detrital	Trace			
9	Calcite	Hydrothermal?	Trace	80	Calcite filling pore spaces	
Notes on fractures						
Notes on new photographs or analyses needed			Calcite, diagenetic rims on albite, and perthite twinning should be photographed			
Other notes						

	Thin section number		OD2016-D2-012A		Rock type	Lithology: 9
	Overall texture of rock		Depositional laminations		Quartz wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	40	subangular to rounded grains	
2	Muscovite	Detrital	trace	150	Large clean crystals sometimes bent around quartz grains	
3	Opaque minerals	Diagenetic?	1%		Mostly small grains of dark minerals, occasionally present as larger clusters or ~150 micron nodules. They occur in both mud and silt layers	
4	Albite	Detrital	2%		albite twinning	
5	Mud/Matrix		67%		Muscovite and chlorite matrix. Brown staining	
6	Biotite	Detrital	trace	100	Large rough-looking grains altering to chlorite	
Notes on fractures		Fractures contain iron oxide staining				
Notes on new photographs or analyses needed						
Other notes		Mud layers sometimes contain quartz silt, but otherwise is too fine for petrographic description				
		The brown areas of the rock appear to be due to staining which doesn't turn up on SEM				

	Thin section number		OD2016-D2-012B-1		Rock type	Lithology: 9
	Overall texture of rock		Depositional laminations		Laminated mudstone and siltstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	40	subangular to rounded grains	
2	Muscovite	Detrital	trace	150	Large clean crystals sometimes bent around quartz grains	
3	Opaque minerals	Diagenetic?	1%		Mostly small grains of dark minerals, occasionally present as larger clusters or ~150 micron nodules. They occur in both mud and silt layers	
4	Albite		2%		albite twinning	
5	Mud/Matrix		67%			
Notes on fractures		Fractures contain iron oxide staining				
Notes on new photographs or analyses needed			Photo of metamorphic texture			
Other notes		Mud layers sometimes contain quartz silt, but otherwise is too fine for petrographic description				

	Thin section number		OD2016-D2-012B-3		Rock type	Lithology: 9
	Overall texture of rock		Depositional laminations		Laminated mudstone and siltstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	40	subangular to rounded grains	
2	Muscovite	Detrital	trace	150	Large clean crystals sometimes bent around quartz grains	
3	Opaque minerals	Diagenetic?	1%		Mostly small grains of dark minerals, occasionally present as larger clusters or ~150 micron nodules. They occur in both mud and silt layers	
4	Albite		2%		albite twinning	
5	Mud/Matrix		67%			
Notes on fractures		Fractures contain iron oxide staining				
Notes on new photographs or analyses needed						
Other notes		Mud layers sometimes contain quartz silt, but otherwise is too fine for petrographic description				
		This thin section has several 500 micron to 1mm iron clots				

	Thin section number		OD2016-D2-016-1		Rock type	Lithology: 5
	Overall texture of rock		Depositional laminations		Very fine subarkose	
	Very fine sandstone					

Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	50%	80	subangular to sub rounded. Some quartz suturing
2	Muscovite	Detrital	1%	150	Large clean grains
3	Biotite	Diagenetic	5%	40	Small disseminated grains altering to chlorite.
4	Zircon	Detrital	Trace	40	
5	Iron nodules	Hydrothermal?	1%	500	
6	Albite	Detrital	4%	80	
7	Matrix	Metamorphic?	30%		Fine grain muscovite and chlorite
Notes on fractures		Fractures filled with iron			
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-016-2		Rock type Lithology: 5
	Overall texture of rock		Depositional laminations		Very fine subarkose alternating with muddy siltstone
	Siltstone				
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	40%	50	sub-angular to sub-rounded
2	Muscovite	Detrital	1%	200	
3	Biotite	Diagenetic	2%	40	Occur as fine crystals disseminated between quartz grains or clusters of small crystals. Altering to chlorite
4	Zircon	Detrital	Trace		
5	Iron nodules	Hydrothermal?	5%	500	sub millimeter iron nodules
6	Matrix	Diagenetic/Metamorphic?	52%		Mica
	Thin section number		OD2016-D2-016-2		
	Very fine sandstone				
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	50%	80	sub-angular to sub-rounded
2	Muscovite	Detrital?	2%	200	Large clean grains
3	Biotite	Diagenetic	5%	60	Grains mostly oriented parallel to bedding. Altering to chlorite
4	Zircon	Detrital	Trace	60	
5	Iron nodules	Hydrothermal?	1%	300	sub millimeter iron nodules
6	Albite	Detrital/Diagenetic	2%	60	Albite twinning. Outer edges of grains sometimes show less alteration
7	Matrix	Metamorphic?	40%		Matrix of fine grain muscovite, often show alignment. Shear bands present
Notes on fractures		Fractures filled with iron			
Notes on new photographs or analyses needed			Photograph of shear bands		
Other notes		The siltstone portion of the rock shows graded bedding. As grain size increases the abundance of quartz increases as matrix decreases			

	Thin section number		OD2016-D2-017		Rock type Lithology: 1
	Overall texture of rock		Depositional laminations		Arkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	70%	150	Suturing between quartz grains
2	Biotite	Diagenetic?	15%	100	Often present as clusters of crystals or rough looking grains
3	Muscovite	Detrital	1%	150	Large clean crystals sometimes bent around quartz grains
4	Albite	Detrital/Diagenetic rims?	8%	100	Outer edges of grains show less alteration to sericite
5	Zircon	Detrital	Trace		
6	Matrix	Diagenetic?	5%		Quartz and mica matrix
7	Opaque minerals	Detrital?	1%		
Notes on fractures			Small fractures with iron		
Notes on new photographs or analyses needed					
Other notes		A thin quartz vein crosscuts this sample			

	Thin section number		OD2016-D2-018		Rock type Lithology: 4
	Overall texture of rock		Depositional laminations		Very fine subarkose alternating with muddy siltstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	Sub angular to sub rounded
2	Muscovite	Detrital	2%		Clean elongate muscovite grains sometimes bent
3	Biotite	Detrital?	2%	50	Few larger (detrital?) grains altering to chlorite. Mostly fine grained crystals, sometimes in clusters
4	Opaque minerals	?	3%		Some are rounded and may be detrital, others may be diagenetic or hydrothermal
5	Zircon	Detrital	Trace		
6	Iron nodules	Hydrothermal?	1%	400	Iron nodules sometimes connected to iron filled fractures
7	Matrix		60%		Fine grain micas and quartz
9	Albite		3%	60	
Notes on fractures			Fractures filled with iron		
Notes on new photographs or analyses needed					
Other notes			Alternating Silty and muddy layers		

	Thin section number		OD2016-D2-019		Rock type Lithology: 1
	Overall texture of rock		Depositional laminations		Arkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	60%	100	Sub angular to sub rounded
2	Muscovite	Detrital	3%	150	Large clean crystals sometimes bent
3	Biotite	Diagenetic?	5%	60	Altering to chlorite. Often present as clusters of small crystals
4	Albite	Detrital	9%		Albite twins. Altering to sericite, sometimes the outer edges appear less altered
5	Zircon	Detrital	Trace		
6	Matrix	Diagenetic?	20%		Largely muscovite matrix, grains often show alignment
7	Opaque minerals	Detrital?	3%		
Notes on fractures			Iron stained fractures		
Notes on new photographs or analyses needed			Good number of zircon grains, good potential for dating		
Other notes		Grains are partially matrix supported			

	Thin section number		OD2016-D2-020		Rock type Lithology: 4
	Overall texture of rock		Depositional laminations		Very fine subarkose alternating with silty mudstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	Subangular to subrounded. Quartz grains show suturing where they are touching
2	Muscovite	Detrital	1%	100	Clean elongate muscovite grains sometimes bent
3	Iron nodules	hydrothermal	2%	250	
4	Biotite	diagenetic?	5%	30	Often altered to chlorite. No clean biotite grains. Very small grains among matrix
5	Albite	Detrital	2%	60	Albite twins
6	Matrix		60%		Muddy matrix
7	Zircon	Detrital	Trace		
Notes on fractures			Fractures at 40 degree angles and filled with iron		
			iron staining in fractures pervades into the coarser layers		
			Iron staining follows contacts between mud and silt layers		
			iron from fractures appears to occasionally connect to iron nodules		
			Rare wispy sand beds with ~100 micron quartz grains		
Notes on new photographs or analyses needed					
Other notes			Alternating Silty and muddy layers		
			A large portion of the thin section is stained with iron		

	Thin section number		OD2016-D2-021		Rock type Lithology: 9
	Overall texture of rock		Depositional laminations		
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	21%	60	Some quartz grains show suturing
2	Muscovite	Detrital	trace	200	
3	Biotite	Diagenetic	5%		Fine grain rough looking crystals, sometimes in clusters of small clean crystals
4	Biotite	Detrital	Trace	100	Stubby grains altering to chlorite
5	Opaque minerals	Detrital?	2%		
6	Zircon	Detrital	Trace		
7	Iron nodules	Hydrothermal?	1%	300	Some nodules are mm scale. Typically present in silty layers
8	Matrix	Diagenetic?	68%		
9	Albite	Detrital	3%	40	Albite twinning and diagenetic rims
Notes on fractures			Fractures filled with iron staining		
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-022-1		Rock type Lithology: 8
	Overall texture of rock		Massive		Arkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz		65%	200	Suturing
2	Albite		11%	150	Albite and pericline, perthite, and carlsbad twins. Outer rims of grains may be diagenetic as they show less alteration.
4	Biotite		10%	100	Occuring as rough looking grains or clusters of clean crystals. Sometimes altering to chlorite
5	Zircon	Detrital	trace		
6	Muscovite	detrital	trace	300	Clean elongate muscovite grain
7	Opaque minerals		2%	50	
8	Matrix?		12%		Mostly white micas between mineral grains. Some grains have also completely altered to fine grain white mica
Notes on fractures			No fractures observed		
Notes on new photographs or analyses needed					
Other notes			On the side of the thin section opposite the label		many of the grains show a cracked appearance which is interpreted to be non-geological and caused by processing

	Thin section number		OD2016-D2-022-2		Rock type Lithology: 8
	Overall texture of rock		Massive		Arkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	65%	200	Suturing between quartz grains
2	Albite	Detrital/diagenetic	11%	150	Albite and pericline, perthite, and carlsbad twins. Outer rims of grains may be diagenetic as they show less alteration.
4	Biotite	Diagenetic	10%	100	Occuring as rough looking grains or clusters of clean crystals. Sometimes altering to chlorite
5	Zircon	Detrital	trace		
6	Muscovite	detrital	trace	300	Clean elongate muscovite grain
7	Opaque minerals		2%	50	
8	Matrix?		12%		Mostly white micas between mineral grains. Some grains have also completely altered to fine grain white mica
Notes on fractures			No fractures observed		
Notes on new photographs or analyses needed					
Other notes			On the side of the thin section opposite the label many of the grains show a cracked appearance which is interpreted to be non-geological and caused by processing		

	Thin section number		OD2016-D2-023		Rock type Lithology: 8
	Overall texture of rock		Massive, dark and light half of the rock		Subarkose
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	65%	150	Quartz suturing
2	Biotite	Diagenetic	25%	60	Variable sized clusters of clean crystals making up the matrix. Altering to chlorite
3	Albite	Detrital/Diagenetic	5%	150	Diagenetic rims
4	Muscovite	Detrital	Trace	120	Large clean crystals
5	Matrix	Diagenetic?	5%		fine grain muscovite matrix
6	Opaque minerals	Detrital?	Trace	50	
7	Zircon	Detrital	Trace		
Notes on fractures					
Notes on new photographs or analyses needed			Photo of variable biotite, weird zircon grain		
Other notes			The colouration in the rock is due to variable amounts of biotite		
			Shattered quartz appearance interpreted to be due to processing		

	Thin section number		OD2016-D2-024-2		Rock type Lithology: 4
	Overall texture of rock		Depositional , erosional surfaces		Very fine subarkose alternating with muddy siltstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	Sub angular to sub rounded
2	Muscovite	Detrital	1%	150	Clean elongate muscovite grains sometimes bent
3	Biotite	Diagenetic?	3%	40	few large grains, most grains are rough and sometimes occur in clusters
4	Opaque minerals	?	2%		
5	Zircon	detrital	Trace		
6	Iron nodules	hydrothermal?	3%	400	
7	Matrix	diagenetic?	50%		Fine grain micas (muscovite), shows localized shearing
8	Albite		10%		Albite and perthite twinning
Notes on fractures			Fractures filled with iron		
Notes on new photographs or analyses needed			Some S-C fabrics		
Other notes			Alternating Silty and muddy silt layers		

	Thin section number		OD2016-D2-025		Rock type Lithology: 4
	Overall texture of rock		Depositional laminations		Subarkose alternating with muddy siltstone and silty mudstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	40%	60	
2	Muscovite	Detrital	1%	150	Clean elongate muscovite grains sometimes bent
3	Biotite	Diagenetic?	5%	40	Altering to chlorite. Some grains are large and appear detrital
4	Opaque minerals	?	3%	60	
5	Zircon	detrital	trace		
6	Iron nodules	hydrothermal?	1%	400	
7	Matrix	diagenetic?	40%		Diagenetic muscovite, localized shearing
8	Albite		10%		Albite twins, occasional diagenetic rims
Notes on fractures			Fractures filled with iron and connect to the iron nodules		
Notes on new photographs or analyses needed					
Other notes		Thin section has sand layers alternating with muddy silt. Then a sharp contact to siltstone and another sharp contact from siltstone to mudstone			

	Thin section number		OD2016-D2-026		Rock type Lithology: 4

	Overall texture of rock		Depositional laminations		Laminated silty mudstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	
2	Muscovite	Detrital	1%	150	Clean elongate muscovite grains sometimes bent
3	Biotite	Metamorphic	5%		Altering to chlorite. Some grains are large and appear detrital. Most grains are rough looking
4	Opaque minerals	?	2%		
5	Zircon	detrital	trace		
6	Iron nodules	hydrothermal?	1%		
7	Matrix	Metamorphic	56%		Primarily metamorphic muscovite
8	Albite	detrital	5%		
Notes on fractures			Fractures filled with iron and connect to the iron nodules		
Notes on new photographs or analyses needed					
Other notes		Thin section has sand layers alternating with muddy silt. Then a sharp contact to siltstone and another sharp contact from siltstone to mudstone			
		Mica grains are aligned, show some foliation			
		Sample interpreted to be metamorphic			

	Thin section number		OD2016-D2-027		Rock type	Lithology: 6
	Overall texture of rock		Massive		Silty mudrock	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	6%	60	subangular to well rounded	
2	Biotite	Diagenetic	2%	40	Clusters of small crystals. The clusters as a whole are ~80 microns and arounded. Altering to chlorite	
3	Chlorite	Detrital?	1%	200	large rounded singular chlorite grains	
4	Albite	Detrital/diagenetic	1%	60	diagenetic rims	
5	Muscovite	Detrital	Trace	100	Large clean grains	
6	Lithic clasts	Detrital	Trace	100	Quartz siltstone and mudstone lithic clasts	
7	Matrix	Diagenetic?	90%		Biotite and muscovite matrix. Primarily muscovite	
8	Apatite	Detrital?	Trace		Visible in SEM	
9	Iron nodules	Hydrothermal	Trace	300	Often attached to iron stained fractures	
10	Opaque minerals	Detrital?	Trace	40		
Notes on fractures			small fractures with iron staining			
Notes on new photographs or analyses needed						
Other notes			Lithic clasts are easily spotted in this thin sections due to grains being suspended in a muddy matrix			
			Grains are matrix supported			

	Thin section number		OD2016-D2-028		Rock type	Lithology: 10
	Overall texture of rock		Depositional laminations		subarkosic muddy sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	35%	100	Angular to subrounded in mud. Where quartz grains touch there is often suturing	
2	Biotite	Diagenetic	5%	50	Clusters of small biotite grains	
3	Muscovite	Detrital	Trace	150	Large clean crystals	
4	Albite	Detrital/Diagenetic	5%	100	Diagenetic rims	
5	Matrix	Diagenetic	55%		Fine grain white mica and quartz	
7	Lithic clast	Detrital	Trace	100	Quartz siltstone and clots of fine grain white mica	
8	Zircon	Detrital	Trace	80		
Notes on fractures			No notable mineralization in fractures. All fractures are oriented in the same direction			
Notes on new photographs or analyses needed			Lithic clasts			
Other notes			Some layers contain more sand			

	Thin section number		OD2016-D2-029		Rock type	Lithology: 5
	Overall texture of rock		Depositional laminations		Subarkosic very fine sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	50%	60	Quartz suturing	
2	Muscovite	Detrital	5%	200	Clean elongate muscovite grains sometimes bent	
3	Albite	Detrital/diagenetic?	12%	60	Albite twining and occasional diagenetic rims	
4	Biotite	Detrital?	1%	60	Often altering to chlorite. Many grains rough looking, some clean crystals	
5	Matrix	Diagenetic	30%		Almost entirely fine grain muscovite	
6	Opaque minerals	Detrital?	1%	40		
7	Iron nodules	hydrothermal?	1%	300		
Notes on fractures			No fractures in thin secion			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-030		Rock type	Lithology: 5

	Overall texture of rock		Depositional laminations		Subarkosic very fine sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	60%	80	Quartz suturing	
2	Biotite	Detrital	1%	60	Euhedral crystals sometimes altering to chlorite, and some rough looking crystals	
3	Muscovite	Detrital	5%		Clean elongate muscovite grains sometimes bent	
4	Zircons	Detrital	Trace			
5	Albite	Detrital	3%	70	Albite twinning	
6	Iron nodules	hydrothermal?	1%	200		
7	Matrix		30%		Fine grain mica, mainly muscovite	
8	Zircon?	Detrital	Trace			
Notes on fractures			Iron filled fractures. Fractures tend to follow bedding			
Notes on new photographs or analyses needed			Possible detrital zircon and a very large (800 micron) detrital muscovite			
Other notes						

	Thin section number		OD2016-D2-034		Rock type	Lithology: 3
	Overall texture of rock		Wispy sand, angular fracturing, patches of grey		Arkosic wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	10%	50	Quartz grains occur as wisps of silt in the muddy matrix, where close together there is suturing. Some quartz grains in matrix subangular to subrounded.	
2	Chlorite	Detrital	trace	100	Large clean chlorite grain in grey matrix	
3	Brown muddy matrix		75%		Biotite for brown colouration?	
4	Grey muddy matrix		15%		Muscovite for grey colouration?	
5	Muscovite	Detrital	trace		typically present in sandy layers	
6	Biotite?	Diagenetic?	trace		Rough looking biotites in the brown muddy matrix	
7	Albite	Detrital	1%	50		
Notes on fractures			Iron staining in fractures			
Notes on new photographs or analyses needed			Analysis of the grey versus brown mud may help answer questions related to alteration and biotite formation			
Other notes			The grey patches of rock appear to have their muddy matrix composed of muscovite and are located in areas of the rock which aren't exposed to fractures			
			The biotite? may then be caused by alteration from the original grey rock material			

	Thin section number		OD2016-D2-035		Rock type	Lithology: 1
	Overall texture of rock		Wisps of mud in a sandstone		Subarkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	Quartz suturing	
2	Biotite	Diagenetic?	15%	100	Rough looking grains and clusters of smaller clean grains. Sometimes altering to chlorite	
3	Muscovite	Detrital	Trace	200		
4	Muscovite	Diagenetic	5%		Fine grain matrix material	
5	Albite	Detrital	10%	120	Albite twins. Occasionally with perthite twinning. Outer edges are less altered and may be a diagenetic rim	
6	Iron nodules	Hydrothermal	trace	400		
7	Zircon	Detrital	trace	80		
8	Apatite		trace			
Notes on fractures						
Notes on new photographs or analyses needed			Photo showing mud wisp may be helpful for documentation			
Other notes		grain supported				

	Thin section number		OD2016-D2-036		Rock type	Lithology: 1
	Overall texture of rock		Sandstone with wisps of mud		Subarkosic Sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	Quartz suturing cements the rock	
2	Biotite	Diagenetic?	5%	80	Biotites often occur as patches of smaller grains. Some larger clean biotite	
3	Muscovite	Detrital	1%	200	Clean elongate muscovite grains sometimes bent	
4	Muscovite	Diagenetic	14%		Fine grain white mica as a matrix between grains	
5	Albite	Detrital/Diagenetic rims	10%	150	Often show clean diagenetic rims around altered centre	
6	Zircon	Detrital	trace	70		
7	Opaque minerals	Detrital?	trace			
Notes on fractures			No major fractures. Some small fractures around the muddy areas but no notable mineralization			
Notes on new photographs or analyses needed			Reasonable amount of zircon grains			
Other notes			Wispy patches of fine grained mud			

	Thin section number		OD2016-D2-037		Rock type	Lithology: 5
	Overall texture of rock		Depositional laminations		Subarkosic very fine sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz		50%	80	sub angular to sub rounded	
2	Biotite		5%	40	Altered to chlorite	

3	Muscovite	Diagenetic?	1%	100	Clean crystals sometimes bent
4	Albite		4%	60	
5	Iron nodules	Hydrothermal	trace	400	Often contacting iron stained fractures
6	Matrix		40%		Largely Muscovite
7	Mud		trace		Wisps of fine mud throughout the rock
8	Opaque minerals		Trace		
Notes on fractures			Fractures stained with iron		
Notes on new photographs or analyses needed					
Other notes			Large mica grains are often aligned		

	Thin section number		OD2016-D2-039		Rock type	Lithology: 4
	Overall texture of rock		Depositional laminations		Siltstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	15%	50	Some suturing in quartz rich layers	
2	Biotite	Detrital	1	70	Altering to chlorite	
3	Muscovite	Detrital	trace	100	Altering to chlorite	
4	Iron (hematite?)	Hydrothermal	42%			
5	Matrix	Diagenetic/Metamorphic?	40%		Primarily muscovite, metamorphic fabric present	
6	Opaque minerals	Detrital?	Trace			
7	Albite	Detrital	1%	50		
Notes on fractures			Huge fractures completely infilled with iron			
Notes on new photographs or analyses needed			Photo of pervasive iron, chlorite alteration, metamorphic zone			
Other notes			Iron staining follows fractures and invades from fractures to spaces with quartz grains			
			Blue 'mineral' present in some fractures is contaminant silicon carbide			
			Both biotite and muscovite are altering to chlorite, this may have to do with the iron			

	Thin section number		OD2016-D2-040		Rock type	Lithology: 10
	Overall texture of rock		Depositional laminations and alternating grain si		Subarkosic muddy sandstone	
			Rock shows a sheared fabric			
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital/metamorphic	50%	150	Some sigmoidal clasts in sheared areas of the rock. Quartz grains align with shear. Quartz suturing where quartz grains are in contact. Subangular to rounded quartz grains in muddy matrix	
2	Biotite	Diagenetic	5%	50	Biotite occurs as clusters of small grains. Clusters have a mean size of ~150 microns. Some grains highly altered to chlorite.	
3	Albite	Detrital/diagenetic rims	7%	150	Clean diagenetic rims surrounding altered cores	
4	Chlorite	Diagenetic?	1%	250	Complete chlorite grains assumed to be altered from biotite, but no evidence of original mineralogy. Their larger size relative to biotite may mean these were originally detrital	
5	Muscovite	Detrital	Trace	200	Large grains some grains appear clean others are bent or have their ends frayed	
6	Zircon	Detrital	trace			
7	Iron nodules	Hydrothermal?	trace	250		
8	Matrix	diagenetic	37%		Largely appears to be fine grained muscovite	
9	Lithic clasts?	Detrital	Trace	100	Quartz siltstone lithic clasts	
Notes on fractures			Fractures follow shearing. Little to no mineralization in fractures.			
Notes on new photographs or analyses needed			Photograph chlorite			
Other notes						

	Thin section number		OD2016-D2-041		Rock type	Lithology: 1
	Overall texture of rock		Weak planar bedding		Subarkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	70%	150	Quartz suturing	
2	Albite	Detrital	12%	150	Diagenetic rims	
3	Biotite	Diagenetic?	7%	100	Rough looking grains and clusters of small grains. Rare chlorite alteration	
4	Muscovite	Detrital	1%	250	Large clean grains	
5	Zircon	Detrital	Trace			
6	Opaque minerals	Detrital?	Trace			
7	Matrix	Diagenetic?	10%		Fine grain muscovite	
Notes on fractures						
Notes on new photographs or analyses needed			One 300 micron quartz grain with primary fluid inclusions should be photographed for documentation			
Other notes			Good amount of zircons			

	Thin section number		OD2016-D2-043-1		Rock type	Lithology: 4
	Overall texture of rock		Depositional laminations?		Wacke	
			Rock texture is poorly preserved			
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	60	Subangular to rounded	
2	Biotite	Detrital?	trace	200	Altering to chlorite	

3	Biotite	Diagenetic	10%	40	Rough looking biotite grains	
4	Muscovite	Detrital	Trace	80		
5	Zircon	Detrital		40	Very few zircons	
6	Matrix	Diagenetic	57%			
7	Albite	Detrital	3%	60		
8	Iron nodules	Hydrothermal	Trace	300		
Notes on fractures			Fractures infilled with iron staining			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-043-2		Rock type	Lithology: 4
	Overall texture of rock		Depositional laminations?		Wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	70	Subangular to rounded. Some quartz grains larger than present in 43-1	
2	Biotite	Detrital?	trace	200	Altering to chlorite	
3	Biotite	Diagenetic	10%	40	Rough looking biotite grains	
4	Muscovite	Detrital	Trace	80		
5	Matrix		57%			
6	Albite		3%	60		
7	Iron nodules		Trace	300		
Notes on fractures			Fractures infilled with iron staining			
Notes on new photographs or analyses needed						
Other notes			Trace fossils? Phycosiphon			

	Thin section number		OD2016-D2-044		Rock type	Lithology: 4
	Overall texture of rock		Depositional laminations		Wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	20%	40	subangular to subrounded	
2	Biotite	Detrital?	Trace	100	Altering to chlorite	
3	Biotite	Diagenetic	5%	40	Fine grained and disseminated in matrix	
4	Muscovite	Detrital	Trace	80	Elongate clean crystals	
5	Matrix	Diagenetic	72%		Primarily muscovite, some quartz	
6	Albite	Detrital	3%	40		
7	Iron nodules	Hydrothermal	Trace	250	attached to iron filled fractures	
Notes on fractures			80 degree fracture cleavage. Fractures filled with iron staining			
Notes on new photographs or analyses needed						
Other notes			Metamorphic fabric in matrix			

	Thin section number		OD2016-D2-045		Rock type	Lithology: 2
	Overall texture of rock		Depositional laminations. Mud drapes		Arkosic wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	40%	120	Quartz suturing	
2	Biotite	Diagenetic	9%	80	Clusters of small crystals	
3	Albite	Detrital/Diagenetic	5%	120	Diagenetic rims. Albite and carlsbad twinning	
4	Muscovite	Detrital	1%	200	Large euhedral crystals	
5	Lithic clasts	Detrital	Trace		Quartz siltstone	
7	Matrix	Metamorphic	45%		Fine grain muscovite showing metamorphic texture	
8	Zircon	Detrital	Trace	60		
Notes on fractures						
Notes on new photographs or analyses needed			Photo of metamorphic muscovite; Reasonable amount of zircons for dating			
Other notes			Alternating layers of mud and sand			

	Thin section number		OD2016-D2-047		Rock type	Lithology: 8
	Overall texture of rock		massive sandstone		Subarkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	65%	200	Quartz suturing	
2	Biotite	Diagenetic	15%	100	Occurs as rough looking grains and clusters of small grains	
3	Muscovite	Detrital	Trace	100	Clean tabular muscovite grains	
4	Zircon	Detrital	Trace			
5	Albite	Detrital	12%	150	Perthite twins, albite twins	
6	Lithic clast	Detrital	Trace		Rounded quartz siltstone	
7	Matrix		8%		Fine grain biotite and muscovite	

Notes on fractures			No notable fractures			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-049		Rock type	Lithology: 1
	Overall texture of rock		Massive		Arkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	67%	150	Quartz suturing	
2	Biotite	Diagenetic	5%	120	Rough grains and clusters of smaller grains. The rough looking grains fit the shape of the surrounding quartz grains	
3	Muscovite	Detrital	1%	250	Clean large grain	
4	Albite	Detrital	18%	150	Diagenetic rims	
5	Opaque minerals	Detrital?	Trace			
6	Zircon	Detrital	Trace			
7	Matrix		9%			
Notes on fractures			Fractures with iron staining			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-050-1		Rock type	Lithology: 5
	Overall texture of rock		Depositional laminations and graded beds		Quartz wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	40%	60	Quartz suturing in quartz rich layers	
2	Albite	Detrital	3%	60	Albite twins	
3	Muscovite	Detrital	2%	120	Large clean crystals. More present where quartz is coarser	
4	Biotite	Diagenetic?	5%	60	Grains showing cleavage that are altering to chlorite (not the fine grain biotite in the matrix)	
5	Zircon	Detrital	trace	30		
6	Iron nodules		1%	300		
7	Opaque minerals		Trace			
8	Matrix		40%		Fine grain muscovite and biotite	
Notes on fractures			Fractures filled with iron and iron invades into the matrix			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-050-2		Rock type	Lithology: 5
	Overall texture of rock		Depositional laminations and graded beds		Quartz wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	40%	60	Quartz suturing in quartz rich layers	
2	Albite	Detrital	3%	60	Albite twins	
3	Muscovite	Detrital	2%	120	Large clean crystals. More present where quartz is coarser	
4	Biotite	Diagenetic?	5%	60	Grains showing cleavage that are altering to chlorite (not the fine grain biotite in the matrix)	
5	Zircon	Detrital	trace	30		
6	Iron nodules		1%	300		
7	Opaque minerals		Trace			
8	Matrix		40%		Fine grain muscovite and biotite	
9	Tourmaline?	Detrital		60		
Notes on fractures			Fractures filled with iron and iron invades into the matrix			
Notes on new photographs or analyses needed			Single possible tourmaline grain marked on thin section			
Other notes						

	Thin section number		OD2016-D2-052		Rock type	Lithology: 2
	Overall texture of rock		Alternating sand and mud beds		Subarkosic muddy sandstone	
	Coarse grained, clast supported					
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	60%	300	Sub angular to well rounded grains. Quartz suturing where grains touch	
2	Albite	Detrital/Diagenetic	10%	200	Diagenetic rims	
3	Biotite	Diagenetic	8%	100	Occur as clusters of small crystals	
4	Muscovite	Detrital	2%	400	Clean grains sometimes bent	
5	Lithic clasts	Detrital	1%		Lithic clasts appear to be siltstones containing quartz and muscovite	
6	Matrix	Diagenetic?	19%		Muscovite matrix	
	Thin section number		OD2016-D2-052			
	Medium grained, matrix supported					
1	Quartz	Detrital	50%	150	Sub angular to well rounded grains	
2	Albite	Detrital/Diagenetic	8%	100	Diagenetic rims	

3	Biotite	Diagenetic	8%	80	Occur as clusters of small crystals
4	Muscovite	Detrital	1%	200	Clean grains sometimes bent
5	Lithic clasts	Detrital	trace	80	Lithic clasts appear to be siltstones containing quartz and muscovite
6	Matrix	Diagenetic?	33%		Muscovite matrix
7	Zircon	Detrital	trace		
8	Opaque minerals	Detrital?	trace		
	Thin section number		OD2016-D2-052		
	Fine grained, matrix supported, gradational from medium grained				
1	Quartz	Detrital	30%	60	Sub angular to well rounded grains
2	Albite	Detrital/Diagenetic	5%	60	Diagenetic rims
3	Biotite	Diagenetic	5%	40	Occur as clusters of small crystals
4	Muscovite	Detrital	1%	100	Clean grains sometimes bent
5	Matrix	Diagenetic?	59%		Muscovite matrix
6	Zircon	detrital	Trace		
	Thin section number		OD2016-D2-052		
	Dark mud layers				
1	Muscovite	Detrital	15%	40	Elongate crystals lying parallel to bedding
2	Quartz	Detrital	5%	30	
3	Dark mud		80%		Bent and wavy texture
4	Zircon	Detrital	Trace		
Notes on fractures			Fractures filled with iron		
Notes on new photographs or analyses needed			Enough zircons present to possibly get an age dating. May be worthwile given the rock texture is different from the rest		
Other notes					

	Thin section number		OD2016-D2-054		Rock type Lithology: 2
	Overall texture of rock		Alternating deformed sand and mud beds		Sub arkosic sandstone and silty mudstone
	Medium grained, grain supported				
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	69%	150	Quartz suturing at contacts
2	Albite	Detrital/diagenetic	12%	150	Albite twinning and diagenetic rims
3	Biotite	Diagenetic?	10%	60	Occurs as clusters of small crystals
4	Muscovite	Detrital	1%	250	Large clean crystals
5	Matrix	Diagenetic?	8%		Fine grained muscovite
6	Apatite	Detrital	Trace	80	
7	Zircon	Detrital	Trace		
8	Chlorite	Detrital?	trace	80	
	Thin section number		OD2016-D2-054		
	Fine grained, grain supported				
1	Quartz	Detrital	60%	100	Quartz suturing at contacts
2	Albite	Detrital/diagenetic	15%	100	Albite twinning and diagenetic rims
3	Biotite	Diagenetic?	8%	40	Occurs as clusters of small crystals
4	Muscovite	Detrital	2%	200	Large clean crystals
5	Matrix	Diagenetic?	15%		Fine grained muscovite
6	Chlorite	Detrital?	trace	80	
7	Zircon	Detrital	trace		
8	Apatite	Detrital	trace		
	Thin section number		OD2016-D2-054		
	Dark mud layers				
1	Quartz	Detrital	10%	40	
2	Albite	Detrital	3%	40	
3	Biotite	Diagenetic?	2%	30	small rough crystals
4	Muscovite	Detrital	3%	80	Clean crystals, long axis oriented parallel with bedding
5	Matrix		82%		
6	Chlorite	Detrital?	Trace		
Notes on fractures			Fractures filled with iron		
Notes on new photographs or analyses needed			Enough zircons present to possibly get an age dating. May be worthwile given the rock texture is different from the rest		
Other notes					

	Thin section number		OD2016-D2-60		Rock type Lithology: 2
	Overall texture of rock		Mud drapes and possible ripple structures		subarkosic sandstone and mudstone
Coarse grained, grain supported					
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz		50%	200	Quartz suturing at contacts
2	Albite	Detrital/Diagenetic	11%	200	Diagenetic rims
3	Biotite	Diagenetic?	8%	80	Occurs as clusters of small crystals. Sometimes altering to chlorite

4	Muscovite	Detrital	Trace	200	Large clean crystals
5	Matrix		30%		Fine grain muscovite
6	Lithic clasts		trace	150	well rounded quartz siltstone with some mica
7	Zircon		trace		Dozens of zircon grains in heavy mineral beds
8	Opqaue minerals		1%		highly abundant in heavy mineral beds
9	Tourmaline		Trace		Two well rounded grains which appear to be tourmaline
10	Apatite		Trace		
	Thin section number		OD2016-D2-60		
Silty mud					
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	10%	60	sub angular to sub rounded grains
2	Albite	Detrital	1%	60	
3	Biotite	Diagenetic	1%	40	Occurs as clusters of small crystals or rough singular crystals. Sometimes altering to chlorite
4	Muscovite	Detrital	1%	100	Aligned fine grain muscovite
5	Matrix	Diagenetic?	87%		
	Thin section number		OD2016-D2-60		
Mud					
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	8%	40	
2	Albite	Detrital	Trace	40	
3	Biotite	Diagenetic	Trace	40	Rough looking grains
4	Muscovite	Detrital	1%	40	
5	Matrix	Diagenetic?	91%		Aligned fine grain muscovite
Notes on fractures			Fractures with iron staining		
Notes on new photographs or analyses needed			High abundance of heavy minerals. Photo of heavy mineral bed abutting mud as it is an up indicator.		
			Photo of sheared quartz in mud.		
Other notes			Heavy mineral beds		
			The mud appears to have be squeezed into the coarser material		

	Thin section number		OD2016-D2-063		Rock type Lithology: 6
	Overall texture of rock		Massive		Mudstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	5%	40	subangular to subrounded
2	Albite	Detrital	1%	40	
3	Biotite	Diagenetic?	1%	40	Altering to chlorite. Rough looking grains or clusters of small grains
4	Muscovite	Detrital	1%	150	Clean skinny grains
5	Matrix	Diagenetic?	92%		Quartz and muscovite matrix. Aligned mica grains in the matrix
6	Iron nodules	Hydrothermal	Trace	200	
Notes on fractures			Fractures are mostly parallel and contain iron staining		
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-065		Rock type Lithology: 1
	Overall texture of rock		Massive sandstone with wisps of mud		Subarkose
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	70%	150	
2	Albite	Detrital/Diagenetic	15%	150	Diagenetic rims
3	Muscovite	Detrital	1%	250	
4	Biotite	Diagenetic	3%	80	Rough looking grains and clusters of smaller clean grains. Sometimes altering to chlorite
5	Matrix	Diagenetic?	10%		Fine grain white mica
6	Opaque minerals		1%	80	Present in heavy mineral beds
7	Zircon		Trace	60	Present in heavy mineral beds
Notes on fractures			One fracture observed, no mineralization		
Notes on new photographs or analyses needed			Thin beds of heavy minerals, good sample for zircons		
Other notes		Wisps of mud			

	Thin section number		OD2016-D2-066		Rock type Lithology: 4
	Overall texture of rock		depositional laminations		Laminated subarkosic wacke
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	Minor suturing
2	Albite	Detrital	1%	60	Altering to sericite
3	Biotite	Detrital?	Trace	120	Altering to chlorite
4	Biotite	Diagenetic	Trace	40	clusters of small crystals
5	Muscovite	Detrital	1%	150	Large clean crystals

6	Iron nodules	Hydrothermal	1%	700	occuring in coarser layers	
7	Matrix	Diagenetic?	67%		Fine grain muscovite and biotite	
Notes on fractures			30 degree fracture cleavage, fractures contain iron staining			
Notes on new photographs or analyses needed						
Other notes			Alternating beds of quartz-rich silt and mud			
			Graded bedding			

	Thin section number		OD2016-D2-068		Rock type	Lithology: 3
	Overall texture of rock		Wispy sand, angular fracturing, patches of grey		Arkosic wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	15%	60	Quartz grains occur as wisps of silt in the muddy matrix, where close together there is suturing. Some quartz grains in matrix subangular to subrounded.	
2	Chlorite	Detrital	trace	100	Large clean chlorite grain in grey matrix	
3	Brown muddy matrix		75%		Biotite for brown colouration?	
4	Grey muddy matrix		10%			
5	Muscovite	Detrital	trace	100	Clean muscovite crystals	
7	Biotite	Detrital	Trace	100	rough biotite grains altering to chlorite	
8	Lithic clasts	Detrital	Trace	200	Quartz silstone lithic clasts	
9	Albite		1%	60		
Notes on fractures			Iron staining in fractures			
Notes on new photographs or analyses needed						
Other notes			The grey patches of rock appear to have their muddy matrix composed of muscovite and are located in areas of the rock which aren't exposed to fractures			
			The brown colouration may be biotite or just some kind of brown staining of the muscovite matrix			
			Wisps of quartz sand with iron staining			

	Thin section number		OD2016-D2-069		Rock type	Lithology: 5
	Overall texture of rock		depositional laminations		Subarkosic Sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	50%	80	Quartz suturing	
2	Albite	Detrital	5%	80		
3	Biotite	Detrital	Trace	60	Altering to chlorite	
4	Muscovite	Detrital	1%	200	Large clean bent grains	
5	Iron nodules	Hydrothermal	1%	1000		
6	Matrix	Diagenetic	43%		Fine grain muscovite and biotite.	
Notes on fractures			Fractures filled with iron staining			
Notes on new photographs or analyses needed			Single euhedral mineral grain with octahedral shape, uniaxial and looking directly down c-axis			
Other notes			Holes in the side with a radial texture? No noteable mineralization in petrographic microscope. Potentially previously hosted iron nodules			

	Thin section number		OD2016-D2-072		Rock type	Lithology: 4
	Overall texture of rock		Rock texture is poorly preserved		Quartz Wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	30%	60	Angular to rounded	
2	Biotite	Detrital?		80	Altering to chlorite	
4	Muscovite	Detrital	trace	60	Clean stubby muscovite grains	
5	Matrix		63%		Muscovite and rough looking small biotite grains in the matrix	
6	Albite		3%			
7	Iron nodules		1%	300		
8	Lithic clast	Detrital	3%	200	Single large quartz siltstone lithic clast marked	
Notes on fractures			Fractures infilled with iron staining and at 0 degree angles			
Notes on new photographs or analyses needed			Single large quartz siltstone lithic clast marked			
Other notes			The area opposite of the thin section label has abundant potential lithic clasts			

	Thin section number		OD2016-D2-073		Rock type	Lithology: 4
	Overall texture of rock		depositional laminations		Laminated subarkosic wacke and mudrock	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	25%	40	Subangular to subrounded, suturing in quartz rich layers where grains contact	
2	Albite	Detrital	3%	50		
3	Biotite	Detrital?	Trace	150	Altering to chlorite	
4	Muscovite	Detrital	Trace	100	Long clean grains	
5	Iron nodules	Hydrothermal	1%	600		
6	Matrix	Diagenetic	71%		Fine grain rough-looking biotite grains in matrix	
7	Lithic clasts	Detrital	Trace	120	Quartz siltstone	
Notes on fractures			Fractures contain iron staining, 50 degree angle fracture cleavage			
Notes on new photographs or analyses needed						

	Thin section number		OD2016-D2-076		Rock type Lithology: 1
	Overall texture of rock		Massive sandstone with wisps of mud		Sub arkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	80%	150	Quartz suturing
2	Albite	Detrital/Diagenetic	7%	150	Altering to sericite, albite twinning,
3	Muscovite	Detrital	Trace	200	Large clean crystals
4	Biotite	Diagenetic	5%	100	Occur as clusters of biotite grains
5	Matrix	Diagenetic?	8%		Fine grain muscovite
6	Opaque minerals	Diagenetic?	Trace	60	In one location occur as clusters
7	Zircon	Detrital	Trace		
Notes on fractures		thin fractures with iron staining			
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-077		Rock type Lithology: 2
	Overall texture of rock		Depositional laminations		Arkose
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	75%	200	Quartz suturing
2	Albite	Detrital/Diagenetic	8%	200	Albite twins, diagenetic rims
3	Biotite	Diagenetic	10%	100	Clusters of small crystals
4	Muscovite	Detrital	2%	300	Largue euhedral crystals
5	Matrix		5%		Fine grain muscovite
7	Apatite	Detrital?	Trace		
8	Zircon	Detrital	Trace		
9	Iron nodule	Hydrothermal	Trace	2500	A single large iron nodule which appears to be replacing matrix and filling pore space
Notes on fractures			Single fracture with quartz vein		
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-080		Rock type Lithology: 4
	Overall texture of rock		depositional laminations		subarkosic wacke
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	50%	80	suturing where grains touch
2	Albite	Detrital	3%	60	Albite twins
3	Biotite	Diagenetic	2%	40	Clusters of small grains
4	Muscovite	Detrital	1%	200	Large clean grains
5	Iron nodules	Hydrothermal	Trace	500	
6	Matrix	Diagenetic?	44%		Fine grain muscovite
7	Biotite	Detrital?	trace	80	Large single biotite grains altering to chlorite
Notes on fractures			No mineralization along the fractures observed		
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-081-1		Rock type Lithology: 1
	Overall texture of rock		Fractured massive sandstone		Subarkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	70%	120	Quartz suturing
2	Albite	Detrital/Diagenetic	8%	120	perthite and albite twins. Diagenetic rims
3	Biotite	Diagenetic	5%	50	Clusters of small biotite crystals. Altering to chlorite
4	Muscovite	Detrital	2%	200	Clean and sometimes bent large crystals
5	Zircon	Detrital	Trace	60	
6	Matrix	Diagenetic	15%		
7	Opaque minerals		Trace	40	
Notes on fractures			Some iron staining in fractures. Many fragments of broken off quartz grains present in fractures		
Notes on new photographs or analyses needed					
Other notes		Grain supported			

	Thin section number		OD2016-D2-081-2		Rock type Lithology: 1
	Overall texture of rock		Fractured massive sandstone		Subarkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	65%	100	Quartz suturing

2	Albite	Detrital/Diagenetic	8%	100	perthite and albite twins. Diagenetic rims	
3	Biotite	Diagenetic	5%	50	Clusters of small biotite crystals. Altering to chlorite	
4	Muscovite	Detrital	2%	200	Clean and sometimes bent large crystals	
5	Zircon	Detrital	Trace	60		
6	Matrix	Diagenetic	20%			
7	Opaque minerals	?	Trace	40		
Notes on fractures			Some iron staining in fractures. Many fragments of broken off quartz grains present in fractures			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-085		Rock type	Lithology: 4
	Overall texture of rock		depositional laminations		Subarkosic mudrock	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	20%	40	subangular to rounded	
2	Albite	Detrital	2%	40		
3	Biotite	Detrital?	trace	100	Altering to chlorite	
4	Muscovite	Detrital	1%	150	Large clean crystals	
5	Iron nodules	Hydrothermal	1%	400		
6	Matrix	Diagenetic?	76%		Biotite and muscovite matrix	
Notes on fractures			30 degree fracture cleavage, fractures contain iron staining			
Notes on new photographs or analyses needed			Well rounded quartz grain in matrix			
Other notes						

	Thin section number		OD2016-D2-086		Rock type	Lithology: 4
	Overall texture of rock		depositional laminations		Subarkosic wacke	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	40%	40	subangular to rounded	
2	Albite	Detrital	1%	40		
3	Biotite	Detrital?	Trace	100	Altering to chlorite	
4	Muscovite	Detrital	1%	150	Large clean crystals	
5	Iron nodules	Hydrothermal	1%	300		
6	Matrix	Diagenetic?	57%		Biotite and muscovite matrix	
Notes on fractures			fractures contain iron staining			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-103		Rock type	Lithology: 5
	Overall texture of rock		depositional laminations		Subarkosic very fine sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	60%	80	Minor suturing	
2	Albite	Detrital/diagenetic rims	3%	80	Diagenetic rims	
3	Biotite	Diagenetic	5%	40	clusters of small crystals	
4	Muscovite	Detrital	1%	120		
5	Iron nodules	Hydrothermal		300		
6	Matrix	Diagenetic?	31%		Muscovite	
Notes on fractures			None observed			
Notes on new photographs or analyses needed						
Other notes						

	Thin section number		OD2016-D2-109		Rock type	Lithology: 1
	Overall texture of rock		Massive		Subarkosic sandstone	
Minerals		Type	how much	mean size (mm)	any texture	
1	Quartz	Detrital	65%	150	Quartz suturing	
2	Albite	Detrital/Diagenetic	5%	150	Diagenetic rims	
3	K-feldspar	Detrital	2%	100	Microcline twinning	
4	Biotite	Diagenetic	3%	80	Clusters of small crystals, rarely altering to chlorite	
5	Muscovite	Detrital	trace	200	Large clean crystals	
6	Opaque minerals	Detrital?	Trace	100		
7	Matrix	Diagenetic	2%	20	Fine grain muscovite between quartz grains	
8	Zircon	Detrital	Trace	60		
Notes on fractures			None observed			
Notes on new photographs or analyses needed			photograph of microcline twinning			

Other notes				

	Thin section number		OD2016-D2-137		Rock type Lithology: 4
	Overall texture of rock		Depositional laminations		Subarkosic siltstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	40%	80	subangular to subrounded. Some suturing
2	Albite	Detrital/diagenetic	3%	80	diagenetic rims
3	Biotite	Detrital?	5%	40	Clusters of small crystals or disseminated in matrix. Sometimes altering to chlorite
4	Muscovite	Detrital	Trace	100	Large clean crystals
5	Iron nodules	Hydrothermal	Trace	300	
6	Matrix	Diagenetic?	52%		Biotite and muscovite matrix
Notes on fractures					
Notes on new photographs or analyses needed					
Other notes			Graded bedding; Sharp contacts		

	Thin section number		OD2016-D2-138		Rock type Lithology: 4
	Overall texture of rock		depositional laminations		Subarkosic siltstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	30%	60	subangular to rounded
2	Albite	Detrital	2%	60	Albite twinning, diagenetic rims
3	Biotite	Detrital	Trace	100	Altering to chlorite
4	Biotite	Diagenetic	5%	50	Clusters or disseminated small grains
5	Muscovite	Detrital	Trace	150	Large clean crystals
6	Iron nodules	Hydrothermal	Trace	600	
7	Matrix	Diagenetic?	63%		Biotite and muscovite matrix
Notes on fractures			Fractures filled with iron		
Notes on new photographs or analyses needed					
Other notes					

	Thin section number		OD2016-D2-140		Rock type Lithology: 9
	Overall texture of rock		depositional laminations		Subarkosic sandstone
Minerals		Type	how much	mean size (mm)	any texture
1	Quartz	Detrital	65%	80	Quartz suturing between grains
2	Albite	Detrital	3%	80	Diagenetic rims
3	Biotite	Diagenetic	6%	30	Fine grain biotite occuring as small clusters or disseminated in matrix
4	Muscovite	Detrital	1%	150	Large clean crystals
5	Iron nodules	Hydrothermal	Trace	500	
6	Matrix	Diagenetic?	25%		
7	Zircon	Detrital	Trace		
Notes on fractures					
Notes on new photographs or analyses needed					
Other notes					

Appendix 5: OD2016-D2 detrital zircon U-Pb data.

Lab number	Sample
12146	OD2016-D2-016
12151	OD2016-D2-018
12152	OD2016-D2-019
12147	OD2016-D2-022
12148	OD2016-D2-023
12149	OD2016-D2-030
12153	OD2016-D2-037
12150	OD2016-D2-047
12154	OD2016-D2-066
12155	OD2016-D2-069

Appendix 5. 2016ODEN U-Pb zircon data.

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coeffi cient	204 corr 207*/206 *	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206 * Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12146-020.1	161	73	0.47	0.38	261	10	10241	292	8.6E-5	32	0.15	23.7	0.137	2.7	1.719	1.5	0.1706	1.2	0.796	0.0731	0.9	1016	11	1015	18	-0	1015.47	18.92	0.00	0.99	17.33	0.895	2.14
Y	12146-079.1	387	154	0.41	0.27	381	13	10543	301	3.6E-5	32	0.06	56.8	0.128	1.8	1.729	1.2	0.1707	1.1	0.912	0.0735	0.5	1016	11	1027	10	+1	1021.53	15.02	0.57	0.45	17.33	0.895	2.14
Y	12146-070.1	46	71	1.58	0.43	251	11	6370	220	4.0E-4	27	0.69	7.2	0.485	2.7	1.727	3.0	0.1800	1.4	0.458	0.0696	2.6	1067	13	916	54	-18	1056.11	25.51	7.80	0.01	17.33	0.895	2.14
Y	12146-055.1	503	38	0.08	0.53	746	51	13586	388	2.4E-5	33	0.04	80.8	0.023	4.0	1.955	1.2	0.1869	1.2	0.939	0.0758	0.4	1105	12	1091	8	-1	1095.79	14.06	0.91	0.34	17.33	0.895	2.14
Y	12146-122.1	154	57	0.38	0.43	214	7	10352	296	4.8E-5	41	0.08	25.2	0.115	2.9	2.009	1.4	0.1897	1.2	0.836	0.0768	0.8	1120	12	1117	15	-0	1118.57	19.06	0.02	0.89	17.33	0.895	2.14
Y	12146-083.1	101	33	0.34	0.56	378	16	10970	313	1.3E-4	32	0.22	16.7	0.105	4.0	2.030	1.7	0.1935	1.2	0.730	0.0761	1.1	1140	13	1097	23	-4	1129.80	22.04	2.69	0.10	17.33	0.895	2.14
Y	12146-064.1	155	29	0.19	0.58	147	5	11182	319	8.9E-5	29	0.15	26.7	0.053	4.4	2.164	1.4	0.2000	1.2	0.826	0.0785	0.8	1176	13	1159	16	-2	1169.07	19.72	0.68	0.41	17.33	0.895	2.14
Y	12146-037.1	95	41	0.45	0.51	153	5	10833	309	1.7E-4	27	0.30	16.6	0.139	3.4	2.230	1.7	0.2041	1.2	0.719	0.0792	1.2	1197	13	1178	23	-2	1192.53	23.02	0.50	0.48	17.33	0.895	2.14
Y	12146-007.1	155	50	0.33	0.48	150	5	7673	263	6.4E-5	33	0.11	26.7	0.106	6.6	2.241	1.4	0.2015	1.2	0.844	0.0807	0.7	1183	13	1213	15	+3	1195.75	19.31	2.38	0.12	17.33	0.895	2.14
Y	12146-067.1	137	38	0.28	0.51	175	8	9635	275	9.1E-5	30	0.16	24.2	0.085	3.6	2.280	1.4	0.2057	1.2	0.816	0.0804	0.8	1206	13	1207	16	+0	1206.18	20.44	0.00	0.96	17.33	0.895	2.14
Y	12146-086.1	108	54	0.51	0.45	148	6	9759	279	1.1E-4	32	0.19	19.1	0.162	2.9	2.281	1.6	0.2062	1.2	0.770	0.0802	1.0	1208	13	1203	20	-1	1206.61	22.03	0.05	0.82	17.33	0.895	2.14
Y	12146-114.1	294	212	0.75	0.24	319	11	10597	303	2.3E-5	41	0.04	52.6	0.230	1.4	2.307	1.9	0.2084	1.8	0.966	0.0803	0.5	1220	20	1204	10	-1	1207.56	17.98	0.48	0.49	17.33	0.895	2.14
Y	12146-084.1	177	67	0.39	0.40	152	5	9758	279	7.9E-5	29	0.14	31.5	0.119	4.1	2.293	1.4	0.2073	1.2	0.847	0.0802	0.7	1214	13	1202	14	-1	1209.09	19.29	0.38	0.54	17.33	0.895	2.14
Y	12146-034.1	264	135	0.53	0.28	617	21	9048	258	3.7E-5	33	0.06	47.8	0.159	1.7	2.361	1.3	0.2107	1.1	0.907	0.0813	0.5	1233	13	1228	10	-0	1229.68	16.37	0.09	0.77	17.33	0.895	2.14
Y	12146-088.1	408	120	0.30	0.30	568	19	9596	274	2.3E-14	9999	0.00	73.6	0.094	1.8	2.363	1.2	0.2099	1.1	0.944	0.0816	0.4	1228	13	1237	8	+1	1234.14	13.64	0.29	0.59	17.33	0.895	2.14
Y	12146-078.1	198	64	0.33	0.40	433	18	8818	319	8.4E-5	26	0.15	36.4	0.101	2.6	2.385	1.3	0.2135	1.2	0.863	0.0810	0.7	1247	13	1222	13	-2	1235.05	18.74	1.75	0.19	17.33	0.895	2.14
Y	12146-089.1	173	69	0.41	0.39	348	12	9380	268	3.2E-5	45	0.06	31.3	0.119	2.5	2.374	2.3	0.2107	2.2	0.960	0.0817	0.6	1233	25	1239	13	+1	1237.66	22.80	0.05	0.82	17.33	0.895	2.14
Y	12146-039.1	104	24	0.24	0.63	310	10	7116	203	2.2E-4	22	0.37	19.2	0.064	5.2	2.441	1.6	0.2154	1.2	0.734	0.0822	1.1	1258	14	1250	22	-1	1255.50	23.24	0.09	0.77	17.33	0.895	2.14
Y	12146-029.1	154	57	0.39	0.43	356	12	10549	301	5.5E-4	13	0.95	28.2	0.116	3.5	2.478	1.8	0.2137	1.2	0.659	0.0841	1.3	1249	13	1295	26	+4	1257.69	24.00	2.42	0.12	17.33	0.895	2.14
Y	12146-023.1	32	13	0.44	0.87	130	4	9517	272	4.0E-4	29	0.69	6.0	0.118	6.8	2.413	2.9	0.2212	1.4	0.489	0.0791	2.5	1288	16	1175	50	-11	1275.32	30.81	4.86	0.03	17.33	0.895	2.14
Y	12146-030.1	316	322	1.05	0.20	329	11	6758	193	2.0E-5	41	0.03	60.6	0.327	1.1	2.609	1.2	0.2234	1.1	0.932	0.0847	0.4	1300	13	1309	9	+1	1306.01	14.80	0.30	0.58	17.33	0.895	2.14
Y	12146-081.1	195	68	0.36	0.40	222	8	10843	310	1.1E-4	22	0.19	38.8	0.102	2.6	2.665	1.3	0.2317	1.2	0.861	0.0834	0.7	1344	14	1279	13	-6	1310.03	19.43	10.67	0.00	17.33	0.895	2.14
Y	12146-054.1	47	13	0.30	0.90	108	4	7722	221	7.3E-5	58	0.13	9.2	0.088	5.8	2.644	1.9	0.2303	1.3	0.702	0.0833	1.3	1336	16	1275	26	-5	1319.10	27.05	3.92	0.05	17.33	0.895	2.14
Y	12146-003.1	161	39	0.25	0.50	217	7	11159	319	4.3E-5	38	0.08	31.6	0.072	3.2	2.709	1.3	0.2282	1.2	0.879	0.0861	0.6	1325	14	1340	12	+1	1333.39	18.55	0.64	0.43	17.33	0.895	2.14
Y	12146-085.1	244	87	0.37	0.35	437	15	10025	286	3.2E-5	35	0.06	51.6	0.108	2.1	3.039	1.2	0.2459	1.1	0.921	0.0896	0.5	1417	15	1418	9	+0	1417.62	16.02	0.00	0.99	17.33	0.895	2.14
Y	12146-043.1	115	69	0.62	0.40	436	15	7981	228	1.1E-4	27	0.20	24.7	0.182	2.3	3.084	1.5	0.2496	1.2	0.809	0.0896	0.9	1436	15	1418	16	-1	1427.67	22.46	0.68	0.41	17.33	0.895	2.14
Y	12146-118.1	79	107	1.40	0.35	393	17	8888	408	2.0E-4	24	0.35	17.6	0.412	1.9	3.278	1.6	0.2593	1.2	0.752	0.0917	1.1	1486	16	1460	20	-2	1476.32	25.37	0.98	0.32	17.33	0.895	2.14
Y	12146-047.1	78	34	0.45	0.56	276	18	9800	280	1.1E-4	33	0.19	17.5	0.133	3.3	3.295	1.5	0.2608	1.2	0.790	0.0916	0.9	1494	16	1459	18	-3	1478.49	24.16	2.00	0.16	17.33	0.895	2.14
Y	12146-011.1	121	63	0.54	0.41	280	10	10684	425	1.2E-4	25	0.20	27.0	0.152	2.4	3.309	1.4	0.2603	1.2	0.843	0.0922	0.8	1492	16	1471	14	-2	1480.52	21.27	0.92	0.34	17.33	0.895	2.14
Y	12146-044.1	122	86	0.73	0.36	280	9	10096	352	5.3E-5	38	0.09	26.8	0.225	3.2	3.289	1.4	0.2557	1.2	0.866	0.0933	0.7	1468	15	1494	13	+2	1483.06	20.05	1.73	0.19	17.33	0.895	2.14
Y	12146-060.1	17	26	1.55	0.72	418	14	9656	395	6.5E-4	29	1.13	3.9	0.466	4.0	3.165	3.9	0.2623	1.6	0.416	0.0875	3.5	1501	22	1372	68	-11	1487.45	40.91	3.41	0.06	17.33	0.895	2.14
Y	12146-091.1	104	51	0.51	0.46	276	9	10950	313	9.6E-5	30	0.17	23.4	0.145	2.7	3.365	1.4	0.2630	1.2	0.834	0.0928	0.8	1505	16	1484	15	-2	1493.77	21.97	0.92	0.34	17.33	0.895	2.14
Y	12146-027.1	55	66	1.24	2.81	234	11	9837	281	1.3E-4	35	0.22	12.5	0.371	8.2	3.368	1.7	0.2660	1.3	0.743	0.0919	1.1	1520	17	1464	22	-4	1498.50	26.73	4.01	0.05	17.33	0.895	2.14
Y	12146-059.1	312	137	0.45	0.30	303	14	10847	310	6.6E-6	71	0.01	70.1	0.139	1.6	3.396	1.2	0.2612	1.1	0.941	0.0943	0.4	1496	15	1515	8	+1	1510.32	14.28	1.18	0.28	17.33	0.895	2.14
Y	12146-096.1	366	72	0.20	0.42	594	20	12088	345	2.5E-6	100	0.00	83.1	0.060	2.2	3.465	1.2	0.2646	1.1	0.954	0.0950	0.4	1513	15	1528	7	+1	1524.96	12.89	0.72	0.39	17.33	0.895	2.14
Y	12146-073.1	114	41	0.37	0.51	180	8	9472	339	4.9E-5	41	0.08	26.1	0.112	2.9	3.502	1.4	0.2660	1.2	0.864	0.0955	0.7	1521	16	1538	13	+1	1530.65	20.49	0.67	0.41	17.33	0.895	2.14
Y	12146-117.1	111	77	0.72	0.39	290	12	9215	263	7.3E-5	33	0.13	25.9	0.212	2.1	3.578	1.4	0.2727	1.2	0.854	0.0952	0.7	1554	16	1531	14	-2	1540.83	21.13	1.16	0.28	17.33	0.895	2.14
Y	12146-022.1	132	62	0.48	0.42	245	11	9992	285	8.7E-5	28	0.15	30.6	0.139	5.9	3.564	1.4	0.2703	1.2	0.865	0.0956	0.7	1543	16	1540	13	-0	1541.02	20.28	0.01	0.91	17.33	0.895	2.14
Y	12146-025.1	93	99	1.10	0.34	299	10	9316	266	1.5E-4	25	0.26	21.4	0.334	1.8	3.560	1.5	0.2681	1.2	0.813	0.0963	0.9	1531	16	1554	16	+2	1542.42	23.15	0.99	0.32	17.33	0.895	2.14
Y	12146-120.1	317	147	0.48	0.27	537	18	9318	266	3.3E-5	29	0.06	74.2	0.143	1.5	3.600	1.2	0.2727	1.1	0.945	0.0957	0.4	1555	16	1543	7	-1	1545.02	14.00	0.47	0.49	17.33	0.895	2.14
Y	12146-052.1	144	86	0.62	0.36	320	11	8893	254	3.1E-5	45	0.05	33.5	0.183	2.0	3.584	1.3	0.2700	1.2	0.894	0.0963	0.6	1541	16	1553	11	+1	1548.94	18.43	0.39	0.53	17.33	0.895	2.14
Y	12146-057.1	236	74	0.32	2.39	436	17	11440	472	4.5E-5	30	0.08	55.1	0.098	2.2	3.606	1.2	0.2725	1.1	0.920	0.0960	0.5	1553	16	1547	9	-0	1548.97	16.32	0.11	0.74	17.33	0.895	2.14
Y	12146-053.1	76	102	1.38	0.36	279	9	11130	318	1.1E-4	33	0.19	18.0	0.410	1.8	3.610	1.5	0.2747	1.2	0.798	0.0953	0.9	1565	17	1534	17	-2	1549.84	24.43	1.56	0.21	17.33	0.895	2.14
Y	12146-002.1	115	78	0.70	0.38	278	9	9613	368	1.4E-4	23	0.25	27.0	0.215	2.3	3.635	1.4	0.2724	1.2	0.837	0.0968	0.8	1553	16	1563	15	+1	1558.54	21.90	0.21	0.64	17.33	0.895	2.14
Y	12146-013.1	134	66	0.51	0.40	245	11	8731	249	4.4E-5	38	0.08	31.3	0.156	3.7	3.644	1.3	0.2718	1.2	0.890	0.0972	0.6	1550	16	1572	11	+2	1564.44	18.72	1.22	0.27	17.33	0.895	2.14
Y	12146-028.1	272	121	0.46	0.29	210	7	10973	313	2.4E-5	35	0.04	65.1	0.137	1.6	3.784	1.2	0.2791	1.1	0.945	0.0983	0.4	1587	16	1592	7	+0	1591.38	14.01	0.10	0.75	17.33	0.895	2.14
Y	12146-009.1	116	82	0.73	0.36	330	11	9865	282	4.2E-5	41	0.07	27.8	0.214	4.0	3.785	1.3	0.2784	1.2	0.881	0.0986	0.6	1583	17	1598	12	+1	1592.71	19.52	0.48	0.49	17.33	0.895	2.14
Y	12146-066.1	115	52	0.47	0.45	262	9	11388	349	5.9E-5	35	0.10	27.5	0.140	2.5	3.794	1.4	0.2791	1.2	0.874	0.0986	0.7	1587	17	1597	12	+1	1593.59	20.00	0.26	0.61	17.33	0.895	2.14
Y	12146-018.1	130	47	0.38	0.46	212	7	10228	292	5.1E-5	35	0.09	31.3	0.111	2.6	3.817	1.3	0.2815	1.2	0.887	0.0984	0.6	1599	17	1593	11	-0	1595.09	19.08	0.07	0.79	17.33	0.895	2.14
Y	12146-075.1	119	61	0.53	0.42	279	9	9762	279	6.4E-5	33	0.11	28.6	0.158	2.3	3.819	1.3	0.2802	1.2	0.874	0.0989	0.7	1592	17	1603	12	+1	1598.86	19.95	0.25	0.62	17.33	0.895	2.14
Y	12146-040.1	172	84	0.51	0.36	413	18	9662	321	3.9E-5	35	0.07	41.1	0.145	2.0	3.821	1.3	0.2788	1.2	0.913	0.0994	0.5	1585	16	1613	10	+2	1605.22	16.92	2.04	0.15	17.33	0.895	2.14
Y	12146-069.1	149	126	0.87	0.33	420	14	10104	289	5.7E-5	32	0.10	36.5	0.270	1.6	3.908	1.3	0.2859	1.2	0.897	0.0992	0.6	1621	17	1608	11	-1	1612.19	18.39	0.39	0.53	17.33	0.895	2.14
Y	12146-107.1	123	108	0.90	0.33	207	7	9100	260	9.3E-5	27	0.16	30.5	0.265	1.7	3.954	1.3	0.2887	1.2	0.872	0.0993	0.7	1635	17	1612	12	-2	1619.95	20.16	1.22	0.27	17.33	0.895	2.14
Y	12146-099.1	418	105	0.26	0.34	270	15	12212	349	1.4E-5	38	0.02	105.5	0.076	1.7	4.115	1.2	0.2940	1.1	0.965	0.1015	0.3	1662	16	1652	6	-1	1653.27	11.80	0.29	0.59	17.33	0.895	2.14
Y	12146-063.1	254	238	0.97	0.23	648	26	7330	233	2.5E-4	12	0.44	63.8	0.299	1.2	4.106	1.3	0.2930	1.1	0.890	0.1017	0.6	1656	17	1654	11	-0	1655.08	18.51	0.01	0.92	17.33	0.895	2.14
Y	12146-095.1	304	103	0.35	0.32	446	15	11900	432	2.4E-5	33	0.04	76.5	0.105	1.7	4.117	1.2	0.2929	1.1	0.951	0.1020	0.4	1656	17	1660	7	+0	1659.31	13.43	0.05	0.82	17.33	0.895	2.14
Y	12146-024.1	377	197	0.54	0.24	401	14	8220	235	2.4E-5	29	0.04	99.6	0.165	1.2	4.488	1.2	0.3074	1.1	0.963	0.1059	0.3	1728	17	1730	6	+0	1729.36	12.00	0.01	0.94	17.33	0.895	2.14
Y	12146-110.1	119	104	0.90	0.34	284	10	9564	273	9.8E-5	26	0.17	31.9	0.259	1.7	4.579	1.3	0.3133	1.2	0.880	0.1060	0.6	1757	18	1731	12	-2	1739.30	19.95	1.38	0.24	17.33	0.895	2.14
Y	12146-012.1	321	187	0.60	2.07	307	10	9672	276	1.6E-5	38	0.03	85.2	0.182	1.2	4.558	1.3	0.3092	1.1	0.891	0.1069	0.6	1737	17	1748	11	+1	1744.49	18.37	0.28	0.59	17.33	0.895	2.14
Y	12146-108.1	294	168	0.59	0.26	346	12	11181	435	3.7E-5	27	0.06	78.3	0.180	1.3	4.564	1.2	0.3097	1.1	0.951	0.1069	0.4	1739	17	1747	7	+1	1745.82	13.39	0.17	0.68	17.33	0.895	2.14
Y	12146-014.1	392	233	0.61	0.22	356	12	11218	375	1.7E-5	33	0.03	104.5	0.185	1.1	4.592	1.2	0.3106	1.1	0.966	0.1072	0.3	1744	17	1753	5	+1	1751.77	11.55	0.25	0.61	17.33	0.895	2.14
Y	12146-119.1	145	126	0.90	0.30	307	10	9601	322	3.7E-5	38	0.06	38.4	0.265	1.5	4.581	1.3	0.3079	1.2	0.915	0.1079	0.5	1730	18	1765	9	+2	1756.63	16.95	2.93	0.09	17.33	0.895	2.14
Y	12146-068.1	230	151	0.68	0.27	407	18	10007	327	2.9E-5	33	0.05	61.0	0.204	1.3	4.591	1.2	0.3085	1.1	0.944	0.1079	0.4	1734	17	1765	7	+2	1759.38	14.10	2.68	0.10	17.33	0.895	2.14
Y	12146-111.1	100	47	0.49	0.47	198	7	10608	382	4.4E-5	41	0.08	27.8	0.145	2.4	5.044	1.3	0.3243	1.2	0.893	0.1128	0.6	1811	19	1845	11	+2	1836.13	19.09	2.52	0.11	17.33	0.895	2.14
Y	12146-104.1	599	60	0.10	24.70	538	66	12600	539	2.2E-5	23	0.04	176.4	0.027	12.1	5.466	5.3	0.3427	5.3	0.993	0.1157	0.6	1899	87	1891	11	-1	1890.77	23.46	0.01	0.92	17.33	0.895	2.14
Y	12146-103.1	85	40	0.49	0.51	188	6	9339	267	1.1E-4	27	0.19	25.5	0.143	2.6	5.789	1.4	0.3478	1.2	0.877	0.1207	0.7	1924	20	1967	12	+2	1955.41	20.50	3.35	0.07	17.33	0.895	2.14
Y	12146-087.1	264	173	0.68	0.26	229	8	10351	296	3.3E-5	28	0.06	81.3	0.198	1.2	6.035	1.2	0.3586	1.1	0.960	0.1220	0.3	1976	19	1986	6	+1	1985.22	12.51	0.27	0.61	17.33	0.895	2.14
Y	12146-065.1	307	276	0.93	6.20	192	16	9986	285	1.3E-5	41	0.02	95.1	0.272	1.7	6.093	1.2	0.3607	1.1	0.966	0.1225	0.3	1986	19	1993	5	+0	1992.23	11.61	0.13	0.72	17.33	0.895	2.14
Y	12146-016.1	337	174	0.53	0.25	161	5	12497	424	1.5E-5	35	0.03	108.2	0.157	1.1	6.535	1.2	0.3740	1.1	0.967	0.1267	0.3	2048	20	2053	5	+0	2052.72	11.71	0.05	0.82	17.33	0.895	2.14
Y	12146-121.1	111	67	0.62	0.40	190	6	9122	260	2.8E-5	45	0.05	36.2	0.180	1.9	6.794	1.4	0.3799	1.2	0.838	0.1297	0.8	2076	21	2094	13	+1	2088.43	22.91	0.53	0.47	17.33	0.895	2.14

Appendix 5. 2016ODEN U-Pb zircon data.

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	*Yb ppm*	*1σ abs err*	*Hf ppm*	*1σ abs err*	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206* Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12146-113.1	64	47	0.76	0.49	170	6	10132	289	7.9E-5	32	0.14	26.6	0.215	2.1	11.317	1.3	0.4846	1.2	0.915	0.1694	0.5	2547	26	2551	9	+0	2550.85	17.87	0.02	0.88	17.33	0.895	2.14
Y	12146-125.1	126	135	1.11	0.34	325	33	8972	256	5.6E-5	26	0.10	54.4	0.322	1.2	12.409	1.4	0.5037	1.2	0.822	0.1787	0.8	2629	25	2641	14	+1	2638.11	24.36	0.15	0.70	17.33	0.895	2.14
Y	12147-013.1	58	19	0.34	1.88	125	5	9882	142	1.4E-3	35	2.36	8.1	0.081	41.0	1.575	12.8	0.1626	2.6	0.204	0.0703	12.5	971	24	937	257	-4	970.70	46.81	0.02	0.89	17.33	0.895	2.14
Y	12147-090.1	69	33	0.49	1.57	195	7	9489	135	1.4E-3	30	2.51	9.8	0.105	21.2	1.302	12.1	0.1653	2.4	0.200	0.0571	11.8	986	22	497	260	-106	978.44	43.61	4.72	0.03	17.33	0.895	2.14
Y	12147-079.1	121	69	0.59	0.99	255	10	10484	149	1.6E-4	71	0.27	17.5	0.192	7.1	1.746	3.4	0.1682	2.0	0.592	0.0753	2.7	1002	19	1075	55	+7	1006.02	35.51	1.59	0.21	17.33	0.895	2.14
Y	12147-009.1	268	100	0.38	0.86	335	12	11470	166	3.1E-4	35	0.53	39.4	0.106	13.1	1.696	3.1	0.1711	1.8	0.574	0.0719	2.5	1018	17	983	51	-4	1014.67	31.34	0.44	0.51	17.33	0.895	2.14
Y	12147-005.1	679	349	0.53	0.82	720	26	10278	152	6.6E-5	50	0.11	101.1	0.164	3.4	1.772	2.2	0.1733	1.9	0.885	0.0742	1.0	1030	19	1046	21	+2	1037.33	27.70	0.33	0.57	17.33	0.895	2.14
Y	12147-020.1	567	71	0.13	1.01	654	24	13215	193	4.4E-4	20	0.76	89.5	0.031	14.5	1.970	2.6	0.1839	1.8	0.704	0.0777	1.8	1088	18	1139	36	+5	1097.69	32.85	1.57	0.21	17.33	0.895	2.14
Y	12147-010.1	54	23	0.43	1.77	246	9	8810	129	1.3E-3	35	2.18	8.9	0.088	26.3	1.888	10.6	0.1908	2.6	0.247	0.0718	10.3	1126	27	979	209	-16	1122.67	53.45	0.53	0.47	17.33	0.895	2.14
Y	12147-102.1	230	86	0.38	0.85	477	17	9996	142	1.4E-4	50	0.23	37.4	0.106	6.5	2.068	2.9	0.1894	1.7	0.591	0.0792	2.4	1118	18	1177	47	+5	1124.93	33.59	1.34	0.25	17.33	0.895	2.14
Y	12147-091.1	117	27	0.24	1.48	239	9	11437	163	2.6E-4	50	0.45	19.2	0.081	12.1	2.035	3.5	0.1914	2.0	0.563	0.0771	2.9	1129	20	1124	58	-1	1128.34	38.41	0.01	0.93	17.33	0.895	2.14
Y	12147-022.1	174	55	0.33	1.10	231	9	10402	149	2.4E-4	45	0.42	28.6	0.085	9.6	2.045	3.1	0.1911	1.8	0.604	0.0776	2.4	1127	19	1137	48	+1	1128.62	35.55	0.04	0.85	17.33	0.895	2.14
Y	12147-019.1	274	96	0.36	0.85	281	10	10452	150	6.9E-4	21	1.19	45.4	0.093	8.9	1.981	3.8	0.1931	1.7	0.456	0.0744	3.4	1138	18	1053	68	-9	1131.71	34.81	1.51	0.22	17.33	0.895	2.14
Y	12147-040.1	168	87	0.54	0.94	323	12	9497	138	3.3E-4	41	0.57	27.7	0.156	7.1	2.038	3.5	0.1923	1.9	0.549	0.0769	2.9	1134	20	1118	58	-2	1132.09	37.30	0.06	0.80	17.33	0.895	2.14
Y	12147-063.1	217	107	0.51	0.81	266	10	9397	135	5.4E-4	27	0.94	36.1	0.146	6.8	1.995	3.6	0.1938	1.8	0.502	0.0746	3.1	1142	19	1059	62	-9	1134.25	35.48	1.72	0.19	17.33	0.895	2.14
Y	12147-044.1	269	105	0.40	0.80	343	12	10462	150	-8.4E-21	9999	0.00	44.7	0.126	5.3	2.135	2.0	0.1935	1.7	0.848	0.0800	1.1	1140	18	1197	21	+5	1163.71	27.80	4.20	0.04	17.33	0.895	2.14
Y	12147-032.1	508	203	0.41	0.58	238	9	12708	181	4.8E-5	58	0.08	86.7	0.124	3.9	2.156	1.8	0.1988	1.6	0.868	0.0786	0.9	1169	17	1163	18	-1	1166.22	25.02	0.06	0.80	17.33	0.895	2.14
Y	12147-036.1	140	60	0.44	1.08	439	16	8563	124	3.5E-4	41	0.61	23.9	0.127	8.8	2.141	3.6	0.1987	1.9	0.535	0.0781	3.0	1169	21	1150	60	-2	1166.58	38.97	0.08	0.77	17.33	0.895	2.14
Y	12147-062.1	66	17	0.27	1.90	176	7	10604	150	4.7E-4	50	0.81	11.5	0.102	14.7	2.131	5.4	0.2017	2.3	0.428	0.0766	4.9	1184	25	1112	98	-7	1179.27	48.33	0.53	0.47	17.33	0.895	2.14
Y	12147-047.1	82	37	0.47	1.35	215	8	10220	146	-2.2E-20	9999	0.00	14.2	0.131	9.5	2.236	3.0	0.2015	2.2	0.723	0.0805	2.1	1184	23	1209	41	+2	1189.62	40.77	0.28	0.60	17.33	0.895	2.14
Y	12147-083.1	410	75	0.19	0.92	170	6	14273	204	1.5E-4	35	0.26	71.7	0.052	7.8	2.227	2.1	0.2038	1.6	0.786	0.0792	1.3	1196	18	1178	25	-2	1189.88	29.10	0.33	0.56	17.33	0.895	2.14
Y	12147-038.1	46	42	0.94	1.38	412	15	9416	136	1.0E-3	41	1.79	8.2	0.279	10.2	2.317	9.0	0.2055	2.7	0.303	0.0818	8.6	1205	30	1240	169	+3	1205.76	59.37	0.04	0.84	17.33	0.895	2.14
Y	12147-052.1	86	40	0.48	1.30	168	6	10048	143	1.0E-32	100	0.00	15.1	0.125	9.0	2.332	2.8	0.2048	2.1	0.762	0.0826	1.8	1201	23	1260	35	+5	1218.05	39.62	1.92	0.17	17.33	0.895	2.14
Y	12147-003.1	572	236	0.43	0.58	639	23	9344	138	4.6E-5	58	0.08	104.2	0.130	3.7	2.366	1.8	0.2120	1.6	0.877	0.0810	0.9	1240	18	1220	17	-2	1229.55	25.06	0.58	0.45	17.33	0.895	2.14
Y	12147-001.1	536	142	0.27	0.71	292	11	8164	120	4.7E-5	58	0.08	97.0	0.081	4.9	2.451	2.1	0.2109	1.6	0.762	0.0843	1.4	1234	18	1299	27	+6	1253.45	30.30	4.18	0.04	17.33	0.895	2.14
Y	12147-122.1	127	139	1.12	0.75	363	13	11008	157	2.4E-4	50	0.41	24.0	0.361	4.4	2.554	3.6	0.2194	2.0	0.538	0.0844	3.1	1278	23	1303	59	+2	1281.49	42.45	0.15	0.70	17.33	0.895	2.14
Y	12147-050.1	230	49	0.22	1.19	791	28	12764	184	-3.4E-5	100	-0.06	44.8	0.067	7.8	2.688	2.1	0.2261	1.8	0.823	0.0862	1.2	1314	21	1343	24	+2	1326.77	31.54	0.86	0.36	17.33	0.895	2.14
Y	12147-074.1	153	61	0.41	1.03	289	16	10635	152	1.3E-4	58	0.23	30.3	0.123	6.8	2.715	2.6	0.2304	1.8	0.723	0.0855	1.8	1336	22	1326	34	-1	1333.31	37.32	0.06	0.80	17.33	0.895	2.14
Y	12147-092.1	1040	1375	1.37	1.62	956	34	9559	137	3.0E-5	45	0.05	223.8	0.408	2.7	2.964	1.8	0.2505	1.7	0.959	0.0858	0.5	1441	22	1334	10	-9	1354.27	18.90	18.70	0.00	17.33	0.895	2.14
Y	12147-008.1	317	156	0.51	0.70	369	13	10037	146	1.4E-4	41	0.25	63.5	0.142	4.7	2.796	2.1	0.2329	1.7	0.791	0.0870	1.3	1350	21	1362	25	+1	1354.46	32.01	0.13	0.72	17.33	0.895	2.14
Y	12147-034.1	340	161	0.49	0.68	312	11	11202	162	1.3E-4	41	0.23	68.5	0.154	4.2	2.856	2.1	0.2343	1.7	0.808	0.0884	1.2	1357	20	1391	23	+3	1371.60	30.99	1.20	0.27	17.33	0.895	2.14
Y	12147-082.1	564	109	0.20	0.77	229	8	12711	182	8.0E-5	38	0.14	118.9	0.056	5.3	3.046	1.8	0.2453	1.6	0.898	0.0901	0.8	1414	20	1427	15	+1	1422.27	24.01	0.26	0.61	17.33	0.895	2.14
Y	12147-007.1	69	38	0.57	1.45	198	7	10233	149	1.1E-3	32	1.84	14.7	0.136	13.9	2.947	7.1	0.2500	2.4	0.338	0.0855	6.7	1439	31	1327	130	-9	1431.50	59.80	0.75	0.39	17.33	0.895	2.14
Y	12147-011.1	122	46	0.39	1.30	447	16	12283	180	4.1E-4	38	0.72	26.1	0.102	10.2	3.124	3.5	0.2490	2.0	0.584	0.0910	2.8	1433	26	1447	53	+1	1435.91	46.90	0.05	0.83	17.33	0.895	2.14
Y	12147-006.1	132	41	0.32	1.32	257	9	10253	149	4.1E-4	35	0.71	28.3	0.080	19.6	3.130	3.2	0.2491	1.9	0.600	0.0911	2.6	1434	25	1450	49	+1	1436.95	44.84	0.08	0.78	17.33	0.895	2.14
Y	12147-045.1	41	22	0.56	6.38	146	5	8737	124	1.3E-3	33	2.33	9.1	0.107	30.0	2.778	11.6	0.2593	2.7	0.236	0.0777	11.2	1486	36	1139	224	-34	1471.54	70.66	2.85	0.09	17.33	0.895	2.14
Y	12147-057.1	159	100	0.65	1.35	343	12	10296	146	1.7E-4	50	0.29	34.4	0.171	5.6	3.291	2.5	0.2521	1.8	0.736	0.0947	1.7	1449	24	1522	32	+5	1474.27	38.79	3.31	0.07	17.33	0.895	2.14
Y	12147-056.1	268	149	0.57	0.67	462	17	10710	153	1.6E-4	38	0.28	59.1	0.179	4.0	3.281	2.1	0.2564	1.7	0.802	0.0928	1.3	1471	22	1484	24	+1	1477.23	32.73	0.16	0.69	17.33	0.895	2.14
Y	12147-088.1	188	61	0.33	1.04	352	13	11452	336	9.8E-5	58	0.17	41.8	0.100	6.5	3.290	2.2	0.2584	1.8	0.797	0.0923	1.4	1481	24	1475	26	-1	1478.31	34.72	0.04	0.84	17.33	0.895	2.14
Y	12147-087.1	173	33	0.20	1.36	195	7	11086	158	2.7E-4	35	0.48	38.3	0.059	10.7	3.308	2.6	0.2572	1.8	0.691	0.0933	1.9	1476	24	1493	36	+1	1480.99	39.65	0.17	0.68	17.33	0.895	2.14
Y	12147-015.1	127	41	0.33	1.33	223	8	10460	152	3.2E-4	41	0.55	28.0	0.101	9.4	3.350	3.0	0.2563	2.0	0.643	0.0948	2.3	1471	26	1524	44	+4	1483.96	44.95	1.08	0.30	17.33	0.895	2.14
Y	12147-121.1	462	201	0.45	0.56	294	11	11654	166	7.3E-5	41	0.13	103.1	0.133	3.3	3.324	2.0	0.2599	1.8	0.919	0.0928	0.8	1489	24	1483	15	-0	1484.90	25.28	0.04	0.83	17.33	0.895	2.14
Y	12147-026.1	361	235	0.67	0.55	475	17	10473	151	6.9E-4	17	1.20	80.2	0.177	4.2	3.404	2.5	0.2585	1.7	0.655	0.0955	1.9	1482	22	1538	36	+4	1496.57	37.77	1.78	0.18	17.33	0.895	2.14
Y	12147-053.1	215	70	0.34	0.95	183	7	11262	160	1.1E-4	50	0.19	48.8	0.094	6.2	3.378	2.2	0.2640	1.7	0.809	0.0928	1.3	1510	23	1484	24	-2	1497.37	33.46	0.60	0.44	17.33	0.895	2.14
Y	12147-066.1	103	158	1.59	0.76	240	9	10784	155	7.3E-4	30	1.27	24.1	0.452	7.1	3.237	5.0	0.2724	2.1	0.414	0.0862	4.6	1553	29	1343	88	-18	1527.29	53.36	5.57	0.02	17.33	0.895	2.14
Y	12147-068.1	183	89	0.50	0.88	303	11	11337	162	2.0E-4	41	0.35	41.6	0.138	5.7	3.523	2.4	0.2645	1.8	0.753	0.0966	1.6	1513	24	1559	29	+3	1531.37	37.71	1.49	0.22	17.33	0.895	2.14
Y	12147-075.1	183	99	0.56	0.85	332	12	10680	153	3.6E-21	9999	0.00	41.0	0.164	4.9	3.506	2.1	0.2604	1.8	0.867	0.0976	1.0	1492	24	1580	19	+6	1544.81	30.32	8.23	0.00	17.33	0.895	2.14
Y	12147-093.1	152	85	0.58	0.90	261	10	10833	155	2.3E-4	41	0.39	35.0	0.166	5.6	3.628	2.8	0.2677	1.9	0.652	0.0983	2.2	1529	25	1591	40	+4	1546.08	43.30	1.70	0.19	17.33	0.895	2.14
Y	12147-086.1	228	39	0.18	1.31	1043	37	13298	191	3.4E-4	28	0.60	53.7	0.049	11.4	3.616	2.4	0.2746	1.7	0.720	0.0955	1.7	1564	24	1538	32	-2	1554.39	38.29	0.41	0.52	17.33	0.895	2.14
Y	12147-024.1	70	58	0.85	1.12	181	7	9647	138	3.3E-4	50	0.57	16.4	0.212	7.2	3.645	4.9	0.2724	2.2	0.455	0.0971	4.3	1553	30	1569	81	+1	1554.74	57.19	0.03	0.86	17.33	0.895	2.14
Y	12147-067.1	83	101	1.26	0.85	409	15	8249	118	6.4E-4	32	1.10	19.6	0.356	5.0	3.694	4.3	0.2741	2.1	0.484	0.0977	3.8	1562	29	1581	71	+1	1564.41	53.84	0.07	0.80	17.33	0.895	2.14
Y	12147-048.1	100	53	0.54	1.18	433	16	9136	132	1.9E-4	58	0.33	23.2	0.163	7.2	3.813	3.0	0.2688	2.2	0.728	0.1029	2.0	1535	30	1677	38	+9	1585.61	47.78	8.87	0.00	17.33	0.895	2.14
Y	12147-095.1	148	83	0.58	0.88	352	13	10244	146	3.9E-4	30	0.68	36.0	0.151	6.0	3.750	2.7	0.2834	1.8	0.670	0.0960	2.0	1608	26	1547	38	-4	1588.31	42.66	1.72	0.19	17.33	0.895	2.14
Y	12147-108.1	144	98	0.71	0.83	359	13	10888	155	2.6E-4	38	0.44	34.8	0.193	5.0	3.803	2.5	0.2813	1.8	0.726	0.0981	1.7	1598	26	1587	33	-1	1593.75	40.72	0.06	0.80	17.33	0.895	2.14
Y	12147-094.1	118	66	0.58	1.07	345	13	9358	146	1.1E-4	71	0.19	28.0	0.167	6.4	3.806	2.6	0.2770	2.0	0.763	0.0996	1.7	1576	28	1617	31	+3	1594.11	41.86	0.95	0.33	17.33	0.895	2.14
Y	12147-014.1	138	70	0.52	1.02	639	23	12773	189	3.5E-4	35	0.61	33.4	0.161	6.5	3.834	2.9	0.2818	1.9	0.659	0.0987	2.2	1600	27	1599	41	-0	1600.08	45.32	0.00	0.99	17.33	0.895	2.14
Y	12147-049.1	91	60	0.68	1.04	243	9	10760	152	1.2E-20	9999	0.00	21.5	0.218	5.5	3.855	2.4	0.2769	2.0	0.838	0.1010	1.3	1576	28	1642	24	+5	1613.34	36.97	3.24	0.07	17.33	0.895	2.14
Y	12147-031.1	319	169	0.55	0.63	529	19	7683	111	3.5E-5	71	0.06	76.7	0.158	3.6	3.856	2.2	0.2799	2.1	0.933	0.0999	0.8	1591	29	1623	15	+2	1615.93	26.80	0.93	0.33	17.33	0.895	2.14
Y	12147-097.1	620	60	0.10	1.02	600	22	13293	191	4.4E-5	45	0.08	154.5	0.027	6.7	3.990	1.7	0.2902	1.6	0.937	0.0997	0.6	1642	23	1619	11	-2	1623.57	20.22	0.86	0.36	17.33	0.895	2.14
Y	12147-058.1	162	149	0.95	0.71	291	11	10274	147	1.1E-4	58	0.18	39.4	0.253	4.0	3.961	2.3	0.2836	1.8	0.806	0.1013	1.3	1610	26	1648	25	+3	1629.43	36.13	1.15	0.28	17.33	0.895	2.14
Y	12147-072.1	239	183	0.79	0.64	722	26	11467	164	9.5E-5	50	0.16	59.3	0.228	3.5	4.018	2.0	0.2891	1.7	0.849	0.1008	1.1	1637	25	1639	20	+0	1638.28	31.23	0.00	0.95	17.33	0.895	2.14
Y	12147-016.1	270	192	0.73	0.63	567	20	10138	147	1.5E-4	38	0.26	66.9	0.228	3.4	4.055	2.3	0.2884	2.0	0.876	0.1020	1.1	1634	29	1660	21	+2	1651.28	34.11	0.54	0.46	17.33	0.895	2.14
Y	12147-061.1	213	112	0.54	0.78	472	24	11772	350	7.7E-5	58	0.13	54.9	0.154	4.4	4.200	2.0	0.2994	1.7	0.853	0.1017	1.1	1689	26	1656	20	-2	1668.06	31.49	1.00	0.32	17.33	0.895	2.14
Y	12147-077.1	85	40	0.49	1.31	290	11	8690	125	4.5E-4	38	0.77	21.9	0.125	9.3	4.183	3.4	0.2997	2.1	0.612	0.1012	2.7	1690	31	1647	50	-3	1677.45	52.72	0.52	0.47	17.33	0.895	2.14
Y	12147-030.1	259	146	0.58	0.70	355	13	11115	160	1.6E-4	35	0.28	68.6	0.169	3.9	4.375	2.0	0.3085	1.7	0.837	0.1029	1.1	1733	26	1676	20	-4	1698.60	32.17	2.89	0.09	17.33	0.895	2.14
Y	12147-012.1	54	31	0.60	1.59	197	7	9035	132	9.5E-4	33	1.64	14.4	0.173	11.2	4.523	5.9	0.3092	2.5	0.427	0.1061	5.3	1737	38	1734	97	-0	1736.22	71.12	0.00	0.98	17.33	0.895	2.14
Y	12147-028.1	267	140	0.54	0.74	353	13	11655	171	1.5E-4	38	0.26	70.3	0.158	4.2	4.525	2.0	0.3065	1.7	0.846	0.1071	1.1	1724	26	1750	20	+2	1740.11	31.66	0.64	0.42	17.33	0.895	2.14
Y	12147-041.1	82	49	0.62	1.20	160	6	10098	144	2.6E-4	50	0.45	21.9	0.184	6.9	4.655	3.0	0.3104	2.1	0.702	0.1088	2.2	1743	32	1779	39	+2	1757.19	50.33	0.49	0.48	17.33	0.895	2.14
Y	12147-039.1	354	90	0.26	0.87	222	8	11799	170	1.4E-4	32	0.24	105.6	0.071	5.3	5.456	1.8	0.3473	1.6	0.896	0.1139	0.8	1922	27	1863	15	-4	1876.67	26.40	3.55	0.06	17.33	0.895	2.14
Y	12147-046.1	124	48	0.40	1.21	405	15	11155	162	8.0E-5	71	0.14	36.1	0.110	6.7	5.399	2.3	0.3397	1.9	0.839	0.1153	1.2	1885	31	1884	22	-0	1884.49	36.65	0.00	0.98	17.33	0.895	2.14

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	%com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	abs. err.	204 corr 207*/206* Age	abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12147-100.1	896	681	0.79	2.06	1641	60	11219	165	5.8E-4	13	1.00	229.8	0.142	3.4	6.016	1.8	0.2987	1.6	0.885	0.1461	0.8	1685	24	2301	14	+30	2153.97	22.86	581.74	0.00	17.33	0.895	2.14
Y	12148-130.1	306	93	0.31	1.31	249	9	11333	331	4.2E-4	24	0.73	43.4	0.086	7.4	1.617	2.7	0.1649	1.4	0.525	0.0711	2.3	984	13	961	47	-3	982.28	24.99	0.23	0.63	17.33	0.895	2.14
Y	12148-012.1	164	58	0.37	0.89	285	10	9274	270	3.2E-4	35	0.56	25.2	0.121	11.7	1.899	2.9	0.1789	1.5	0.528	0.0770	2.5	1061	15	1120	49	+6	1065.80	28.79	1.29	0.26	17.33	0.895	2.14
Y	12148-039.1	370	183	0.51	0.53	838	29	7642	223	1.3E-4	38	0.23	56.8	0.146	4.1	1.884	2.2	0.1789	1.4	0.635	0.0764	1.7	1061	13	1105	34	+4	1066.67	25.24	1.44	0.23	17.33	0.895	2.14
Y	12148-123.1	230	33	0.15	1.21	439	15	12515	365	1.5E-4	45	0.26	36.4	0.044	10.7	1.965	2.2	0.1845	1.5	0.667	0.0772	1.6	1092	15	1127	32	+3	1097.40	26.88	0.95	0.33	17.33	0.895	2.14
Y	12148-015.1	407	271	0.69	2.37	1257	44	10997	320	2.6E-4	24	0.44	66.3	0.210	3.0	1.996	1.9	0.1896	1.4	0.699	0.0764	1.4	1119	14	1105	28	-1	1116.10	24.87	0.21	0.65	17.33	0.895	2.14
Y	12148-060.1	122	52	0.44	0.99	189	7	8606	251	7.6E-4	27	1.32	19.9	0.116	10.4	1.913	4.6	0.1900	1.7	0.358	0.0730	4.3	1121	17	1015	88	-11	1116.53	33.37	1.50	0.22	17.33	0.895	2.14
Y	12148-078.1	52	20	0.40	2.80	182	10	9657	412	9.2E-4	38	1.59	8.5	0.131	16.3	2.035	8.1	0.1894	2.1	0.263	0.0779	7.8	1118	22	1145	155	+3	1118.55	43.24	0.03	0.87	17.33	0.895	2.14
Y	12148-071.1	93	50	0.56	2.65	334	12	10819	316	6.5E-4	33	1.12	15.2	0.160	9.1	1.938	5.0	0.1906	1.8	0.354	0.0737	4.7	1125	18	1034	94	-10	1120.99	35.49	0.93	0.33	17.33	0.895	2.14
Y	12148-108.1	242	40	0.17	1.09	665	23	12359	360	2.9E-4	30	0.51	39.9	0.047	11.3	1.996	2.4	0.1916	1.4	0.592	0.0756	2.0	1130	15	1084	39	-5	1123.77	27.85	1.22	0.27	17.33	0.895	2.14
Y	12148-085.1	57	15	0.27	1.82	110	4	9740	284	9.0E-4	35	1.56	9.3	0.064	25.3	2.210	8.1	0.1917	2.0	0.252	0.0836	7.8	1131	21	1284	153	+13	1132.75	42.17	0.90	0.34	17.33	0.895	2.14
Y	12148-116.1	268	64	0.25	1.69	141	5	10975	320	2.9E-4	29	0.51	45.2	0.074	7.7	2.073	2.3	0.1967	1.4	0.610	0.0764	1.9	1158	15	1106	37	-5	1150.03	27.87	1.65	0.20	17.33	0.895	2.14
Y	12148-121.1	463	133	0.30	0.62	605	21	8170	238	1.1E-4	35	0.20	77.6	0.081	4.9	2.120	1.7	0.1950	1.4	0.796	0.0789	1.0	1148	14	1169	20	+2	1154.91	23.48	0.69	0.41	17.33	0.895	2.14
Y	12148-126.1	84	39	0.48	1.13	342	12	8951	261	9.7E-4	28	1.67	14.2	0.106	20.1	1.936	6.6	0.1978	1.8	0.273	0.0710	6.4	1163	19	957	130	-24	1157.29	37.81	2.77	0.10	17.33	0.895	2.14
Y	12148-125.1	161	141	0.91	0.66	789	28	8284	242	4.3E-4	32	0.74	27.6	0.257	4.8	2.068	3.7	0.1997	1.6	0.427	0.0751	3.3	1174	17	1072	67	-10	1166.72	32.42	2.30	0.13	17.33	0.895	2.14
Y	12148-056.1	138	51	0.38	0.98	280	10	8504	248	5.3E-4	29	0.92	24.2	0.108	13.0	2.138	3.9	0.2037	1.6	0.405	0.0762	3.6	1195	17	1099	72	-10	1188.80	33.45	1.76	0.18	17.33	0.895	2.14
Y	12148-128.1	268	87	0.33	0.77	375	13	9143	267	3.3E-4	27	0.57	46.9	0.086	7.0	2.249	2.3	0.2040	1.4	0.617	0.0800	1.8	1197	16	1196	36	-0	1196.55	28.72	0.00	0.98	17.33	0.895	2.14
Y	12148-034.1	155	90	0.60	0.74	335	12	10549	307	2.6E-4	38	0.45	27.2	0.176	5.3	2.250	2.6	0.2044	1.5	0.586	0.0798	2.1	1199	17	1193	42	-1	1198.08	30.99	0.02	0.90	17.33	0.895	2.14
Y	12148-037.1	254	169	0.69	0.58	450	16	9511	277	1.6E-3	14	2.70	44.8	0.253	6.9	2.521	7.5	0.2053	1.7	0.230	0.0891	7.3	1204	19	1406	139	+16	1206.08	37.60	1.84	0.18	17.33	0.895	2.14
Y	12148-035.1	160	48	0.31	0.97	187	7	9001	262	4.5E-4	28	0.78	28.7	0.074	19.6	2.242	3.6	0.2090	1.5	0.417	0.0778	3.3	1223	17	1142	66	-8	1217.65	32.59	1.49	0.22	17.33	0.895	2.14
Y	12148-049.1	77	26	0.34	1.31	246	9	10011	291	5.4E-4	35	0.93	14.4	0.095	12.2	2.495	4.6	0.2175	1.8	0.379	0.0832	4.3	1269	20	1274	84	+0	1268.94	39.35	0.00	0.95	17.33	0.895	2.14
Y	12148-117.1	121	28	0.24	1.32	154	6	9611	280	4.3E-4	33	0.75	23.2	0.051	15.6	2.613	3.2	0.2230	1.7	0.519	0.0850	2.7	1297	20	1316	53	+2	1299.58	36.80	0.10	0.75	17.33	0.895	2.14
Y	12148-052.1	152	100	0.68	0.71	277	10	10290	300	4.7E-4	26	0.82	31.8	0.191	4.9	2.996	2.7	0.2439	1.5	0.567	0.0891	2.2	1407	19	1406	42	-0	1406.65	35.08	0.00	0.99	17.33	0.895	2.14
Y	12148-120.1	46	41	0.94	1.17	229	8	10225	298	1.9E-3	24	3.22	9.7	0.227	11.3	2.624	9.2	0.2469	2.2	0.238	0.0771	8.9	1423	28	1123	178	-30	1411.47	54.59	3.28	0.07	17.33	0.895	2.14
Y	12148-111.1	140	87	0.64	0.78	195	7	11533	336	4.6E-4	28	0.80	29.8	0.194	5.3	3.099	2.8	0.2481	1.6	0.565	0.0906	2.3	1429	20	1437	43	+1	1430.36	36.31	0.03	0.86	17.33	0.895	2.14
Y	12148-004.1	190	74	0.40	1.40	219	8	11985	349	3.1E-4	27	0.54	40.5	0.095	6.4	3.121	2.1	0.2479	1.4	0.681	0.0913	1.6	1428	19	1453	30	+2	1434.61	31.57	0.54	0.46	17.33	0.895	2.14
Y	12148-023.1	156	103	0.69	0.72	447	16	8454	246	2.6E-4	35	0.45	33.1	0.199	4.7	3.145	2.3	0.2476	1.5	0.659	0.0921	1.7	1426	19	1470	33	+3	1437.03	33.82	1.34	0.25	17.33	0.895	2.14
Y	12148-094.1	24	17	0.71	1.85	261	9	9173	272	1.9E-3	33	3.23	5.2	0.255	14.1	3.381	10.9	0.2499	2.8	0.256	0.0981	10.5	1438	36	1589	197	+11	1441.49	71.14	0.52	0.47	17.33	0.895	2.14
Y	12148-090.1	167	87	0.54	0.76	280	10	11404	332	5.5E-4	23	0.96	36.1	0.154	5.7	3.158	2.7	0.2524	1.5	0.562	0.0907	2.2	1451	20	1441	42	-1	1449.00	35.52	0.04	0.84	17.33	0.895	2.14
Y	12148-027.1	92	63	0.71	0.92	243	9	9578	279	9.9E-4	23	1.71	20.2	0.205	6.9	3.005	4.5	0.2572	1.7	0.386	0.0847	4.1	1476	23	1309	80	-14	1460.19	42.94	4.33	0.04	17.33	0.895	2.14
Y	12148-067.1	146	58	0.41	0.89	184	7	11088	323	2.5E-4	35	0.44	31.4	0.112	6.4	3.252	2.3	0.2510	1.5	0.670	0.0939	1.7	1444	20	1507	32	+5	1460.45	33.75	2.85	0.09	17.33	0.895	2.14
Y	12148-059.1	67	30	0.47	1.23	185	7	9547	278	6.4E-4	32	1.11	14.7	0.149	9.0	3.310	3.9	0.2558	1.8	0.466	0.0938	3.4	1468	24	1505	64	+3	1472.57	44.56	0.28	0.60	17.33	0.895	2.14
Y	12148-138.1	148	56	0.39	0.99	270	10	9755	285	3.6E-4	32	0.62	33.1	0.108	7.5	3.235	2.6	0.2598	1.6	0.598	0.0903	2.1	1489	21	1432	40	-4	1476.23	36.33	1.63	0.20	17.33	0.895	2.14
Y	12148-075.1	87	27	0.32	1.38	180	6	11953	349	8.6E-4	26	1.49	19.3	0.072	16.3	3.385	4.1	0.2595	1.8	0.430	0.0946	3.7	1487	23	1520	70	+2	1490.52	44.35	0.20	0.65	17.33	0.895	2.14
Y	12148-140.1	190	63	0.34	0.90	450	16	11593	338	2.1E-4	35	0.37	42.4	0.101	6.2	3.344	2.1	0.2597	1.5	0.710	0.0934	1.5	1488	20	1496	28	+1	1490.78	32.13	0.05	0.82	17.33	0.895	2.14
Y	12148-046.1	82	100	1.26	0.83	395	14	9016	263	5.6E-5	100	0.10	18.1	0.313	4.5	3.364	2.3	0.2580	1.7	0.734	0.0946	1.6	1480	23	1519	30	+3	1493.80	36.19	1.13	0.29	17.33	0.895	2.14
Y	12148-073.1	218	185	0.88	0.55	465	16	9774	285	2.6E-4	29	0.45	49.3	0.256	3.3	3.352	2.0	0.2632	1.4	0.710	0.0924	1.4	1506	19	1475	27	-2	1495.57	31.44	0.83	0.36	17.33	0.895	2.14
Y	12148-080.1	564	278	0.51	0.44	861	41	9791	286	8.4E-5	32	0.15	127.1	0.153	2.5	3.390	1.5	0.2626	1.3	0.897	0.0936	0.7	1503	18	1501	12	-0	1501.59	20.53	0.01	0.93	17.33	0.895	2.14
Y	12148-069.1	45	45	1.04	1.13	106	4	8280	242	9.6E-4	33	1.66	10.0	0.306	7.5	3.574	5.4	0.2606	2.1	0.396	0.0995	4.9	1493	28	1614	92	+8	1501.84	54.60	1.51	0.22	17.33	0.895	2.14
Y	12148-053.1	246	133	0.56	0.63	353	12	11447	334	2.5E-4	28	0.44	55.1	0.149	4.3	3.404	1.9	0.2605	1.4	0.735	0.0948	1.3	1492	19	1523	25	+2	1503.62	30.37	0.97	0.33	17.33	0.895	2.14
Y	12148-118.1	194	155	0.83	0.60	638	22	9087	265	2.8E-4	30	0.48	44.0	0.239	3.7	3.482	2.6	0.2641	1.5	0.569	0.0956	2.1	1511	20	1540	40	+2	1516.44	35.62	0.42	0.51	17.33	0.895	2.14
Y	12148-002.1	107	57	0.55	0.88	190	7	12013	349	4.2E-4	30	0.73	24.3	0.131	7.1	3.513	2.7	0.2646	1.6	0.590	0.0963	2.2	1513	21	1554	41	+3	1521.60	38.11	0.76	0.38	17.33	0.895	2.14
Y	12148-099.1	140	144	1.06	0.66	331	12	10493	306	3.1E-4	34	0.53	32.1	0.315	3.8	3.604	2.4	0.2680	1.6	0.646	0.0975	1.9	1531	21	1578	35	+3	1543.13	36.72	1.32	0.25	17.33	0.895	2.14
Y	12148-028.1	139	119	0.89	1.07	224	8	9340	272	2.8E-4	33	0.48	32.6	0.260	3.9	3.591	2.3	0.2732	1.5	0.672	0.0953	1.7	1557	21	1534	32	-2	1550.05	34.88	0.36	0.55	17.33	0.895	2.14
Y	12148-119.1	285	251	0.91	0.48	343	12	10658	311	1.1E-4	38	0.20	65.9	0.268	2.7	3.601	1.7	0.2689	1.4	0.828	0.0971	0.9	1535	19	1570	18	+2	1553.59	26.14	1.79	0.18	17.33	0.895	2.14
Y	12148-087.1	146	119	0.84	0.68	338	12	10703	312	2.9E-4	33	0.49	33.9	0.240	4.1	3.658	2.3	0.2708	1.5	0.672	0.0980	1.7	1545	21	1586	32	+3	1557.20	35.31	1.14	0.29	17.33	0.895	2.14
Y	12148-132.1	218	124	0.59	0.67	386	14	8064	236	2.8E-4	28	0.49	51.2	0.162	4.3	3.661	2.0	0.2738	1.4	0.720	0.0970	1.4	1560	20	1566	26	+0	1562.56	31.92	0.03	0.85	17.33	0.895	2.14
Y	12148-114.1	180	111	0.64	0.69	326	16	9248	270	2.8E-4	30	0.49	42.1	0.170	4.5	3.675	2.1	0.2728	1.5	0.700	0.0977	1.5	1555	20	1580	28	+2	1563.74	33.28	0.52	0.47	17.33	0.895	2.14
Y	12148-064.1	148	80	0.56	0.82	269	14	8942	261	2.8E-4	34	0.49	34.8	0.165	8.4	3.663	2.4	0.2747	1.5	0.654	0.0967	1.8	1565	21	1562	33	-0	1563.85	36.12	0.01	0.94	17.33	0.895	2.14
Y	12148-110.1	269	123	0.47	0.64	251	9	11251	328	2.5E-4	26	0.42	62.1	0.126	4.3	3.665	1.8	0.2690	1.4	0.774	0.0988	1.1	1536	19	1602	21	+5	1564.57	28.91	5.40	0.02	17.33	0.895	2.14
Y	12148-137.1	110	88	0.83	0.82	365	13	9060	265	4.9E-4	30	0.84	26.2	0.250	5.0	3.569	3.9	0.2765	1.6	0.424	0.0936	3.5	1574	23	1500	67	-6	1565.23	43.16	1.13	0.29	17.33	0.895	2.14
Y	12148-055.1	100	41	0.42	1.09	482	17	11534	336	5.9E-4	28	1.02	23.7	0.109	9.8	3.663	3.1	0.2766	1.6	0.523	0.0960	2.7	1574	23	1549	50	-2	1569.64	41.70	0.21	0.65	17.33	0.895	2.14
Y	12148-008.1	177	147	0.86	0.60	520	18	8622	251	2.7E-4	30	0.47	42.5	0.242	3.6	3.815	2.5	0.2795	1.5	0.592	0.0990	2.0	1589	21	1605	37	+1	1592.70	36.46	0.14	0.71	17.33	0.895	2.14
Y	12148-057.1	127	96	0.78	0.73	363	13	10131	295	2.3E-4	38	0.41	30.3	0.249	4.5	3.832	2.2	0.2775	1.5	0.695	0.1001	1.6	1579	22	1626	30	+3	1595.02	35.35	1.66	0.20	17.33	0.895	2.14
Y	12148-001.1	127	64	0.52	0.86	280	10	10125	295	1.6E-4	45	0.29	30.6	0.157	5.2	3.819	2.4	0.2799	1.9	0.801	0.0990	1.5	1591	27	1604	27	+1	1597.68	38.64	0.12	0.72	17.33	0.895	2.14
Y	12148-102.1	174	85	0.51	0.83	528	19	11910	348	2.3E-4	35	0.40	42.3	0.147	5.1	3.874	2.1	0.2829	1.5	0.715	0.0993	1.5	1606	21	1612	28	+0	1607.99	33.99	0.03	0.87	17.33	0.895	2.14
Y	12148-134.1	218	94	0.45	0.73	341	12	8884	259	1.2E-4	41	0.21	52.4	0.139	4.3	3.878	1.8	0.2801	1.4	0.809	0.1004	1.0	1592	20	1632	19	+3	1612.47	28.25	2.07	0.15	17.33	0.895	2.14
Y	12148-020.1	207	135	0.67	0.60	417	15	10868	316	2.3E-4	29	0.40	50.5	0.182	3.7	3.933	1.9	0.2836	1.4	0.765	0.1006	1.2	1609	20	1635	22	+2	1620.85	30.26	0.74	0.39	17.33	0.895	2.14
Y	12148-018.1	348	298	0.89	0.41	884	31	8932	260	6.6E-5	41	0.11	84.7	0.271	2.2	3.913	1.8	0.2836	1.6	0.920	0.1001	0.7	1609	23	1626	13	+1	1621.63	22.68	0.37	0.54	17.33	0.895	2.14
Y	12148-045.1	204	154	0.78	0.59	213	8	9790	285	1.9E-4	33	0.32	51.0	0.250	3.2	4.069	1.9	0.2914	1.4	0.777	0.1013	1.2	1648	21	1648	22	-0	1648.15	30.19	0.00	0.99	17.33	0.895	2.14
Y	12148-021.1	129	77	0.62	0.78	234	12	10342	301	3.3E-4	30	0.57	33.1	0.180	4.9	4.229	2.2	0.2988	1.5	0.680	0.1026	1.6	1686	23	1672	30	-1	1680.80	36.28	0.12	0.73	17.33	0.895	2.14
Y	12148-077.1	253	167	0.68	0.61	276	10	9035	264	1.9E-4	32	0.34	63.7	0.202	3.5	4.245	1.8	0.2931	1.4	0.790	0.1050	1.1	1657	21	1715	20	+4	1686.25	29.60	3.93	0.05	17.33	0.895	2.14
Y	12148-058.1	96	64	0.69	0.86	459	16	8259	240	1.1E-4	58	0.20	24.7	0.199	4.8	4.347	2.1	0.3014	1.6	0.759	0.1046	1.4	1698	24	1708	25	+1	1702.61	34.82	0.07	0.79	17.33	0.895	2.14
Y	12148-063.1	59	35	0.62	1.23	189	7	10058	293	5.0E-4	38	0.87	15.6	0.165	13.8	4.702	3.9	0.3070	1.9	0.491	0.1111	3.4	1726	29	1817	61	+6	1740.87	52.82	1.79	0.18	17.33	0.895	2.14
Y	12148-113.1	138	38	0.29	1.13	203	7	8178	238	3.0E-4	32	0.51	36.5	0.066	9.2	4.598	2.2	0.3086	1.5	0.711	0.1080	1.5	1734	23	1767	28	+2	1747.34	35.94	0.81	0.37	17.33	0.895	2.14
Y	12148-092.1	150	103	0.71	0.73	233	8	10377	303	1.4E-4	45	0.24	39.5	0.205	4.1	4.691	1.9	0.3060	1.5	0.789	0.1112	1.2	1721	23	1819	21	+6	1772.31	31.74	9.82	0.00	17.33	0.895	2.14
Y	12148-047.1	247	139	0.58	0.60	319	11	10552	307	6.5E-5	50	0.11	65.0	0.150	3.6	4.660	1.6	0.3067	1.4	0.871	0.1102	0.8	1724	21	1803	14	+5	1777.68	23.99	9.41	0.00	17.33	0.895	2.14
Y	12148-079.1	303	62	0.21	0.92	388	14	12323	360	2.1E-4	26	0.37	82.7	0.052	7.1	4.766	2.0	0.3178	1.4	0.705	0.1088	1.4	1779	22	1779	26	-0	1778.92	33.09	0.00	0.99	17.33	0.895	2.14
Y	12148-141.1	445	204	0.47	0.52	590	21	9146	267	5.7E-5	41	0.10	120.4	0.143	4.9	4.807	1.5	0.3152	1.3	0.913	0.1106	0.6	1766	21	1810	11	+3	1799.85	19.58	3.40	0.07	17.33	0.895	2.14
Y	12148-038.1	335	58	0.18	0.87	559	20	12427	362	9.3E-5	33	0.16	91.1	0.050	5.4	4.863	1.5	0.3168	1.4	0.898	0.1113	0.7	1774	21	1821	12	+3	1809.25	21.14	3.78	0.05	17.33	0.895	2.14

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	%com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coeffi cient	204 corr 207*/206 *	%err	204 corr 206*/238 Age	abs. err.	204 corr 207*/206 * Age	abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12148-136.1	108	103	0.98	0.74	206	7	8798	257	2.2E-4	38	0.37	34.3	0.296	3.5	6.626	2.0	0.3685	1.6	0.793	0.1304	1.2	2022	27	2104	21	+4	2072.46	33.93	5.52	0.02	17.33	0.895	2.14
Y	12148-022.1	125	71	0.59	0.80	116	4	11060	322	2.5E-4	27	0.43	54.7	0.144	4.4	12.920	1.7	0.5095	1.5	0.894	0.1839	0.7	2654	32	2688	12	+2	2683.95	23.54	0.96	0.33	17.33	0.895	2.14
Y	12149-042.1	472	99	0.22	0.46	504	18	14730	306	4.0E-5	38	0.07	70.5	0.068	3.2	1.766	1.1	0.1738	0.9	0.817	0.0737	0.6	1033	8	1033	13	+0	1033.17	14.12	0.00	0.99	17.33	0.895	2.14
Y	12149-008.1	237	22	0.09	1.12	230	15	13070	657	3.3E-4	20	0.56	39.0	0.022	15.0	1.996	1.9	0.1913	1.0	0.544	0.0757	1.6	1128	11	1086	32	-4	1123.87	20.01	1.63	0.20	17.33	0.895	2.14
Y	12149-011.1	317	93	0.30	0.55	315	7	10693	224	9.1E-5	33	0.16	52.5	0.095	3.7	2.043	1.3	0.1929	0.9	0.721	0.0768	0.9	1137	10	1117	18	-2	1132.26	17.31	0.90	0.34	17.33	0.895	2.14
Y	12149-024.1	180	76	0.43	5.43	563	13	11484	325	2.3E-4	27	0.39	31.9	0.129	4.2	2.212	2.6	0.2061	1.1	0.397	0.0779	2.4	1208	12	1143	48	-6	1203.91	22.48	1.74	0.19	17.33	0.895	2.14
Y	12149-005.1	150	51	0.36	0.73	207	5	9776	205	1.6E-4	35	0.27	26.6	0.107	5.0	2.259	1.8	0.2070	1.0	0.593	0.0791	1.4	1213	12	1176	28	-3	1207.25	21.36	1.50	0.22	17.33	0.895	2.14
Y	12149-030.1	434	180	0.43	0.40	432	23	9577	201	4.1E-5	41	0.07	76.6	0.135	2.4	2.310	1.1	0.2056	0.9	0.816	0.0815	0.6	1206	10	1233	13	+2	1215.73	15.82	2.82	0.09	17.33	0.895	2.14
Y	12149-007.1	274	78	0.29	0.56	223	13	10391	427	4.7E-5	45	0.08	49.8	0.091	3.5	2.349	1.2	0.2119	0.9	0.766	0.0804	0.8	1239	10	1207	15	-3	1228.64	17.17	2.85	0.09	17.33	0.895	2.14
Y	12149-001.1	490	555	1.17	0.29	551	101	5562	685	6.8E-4	11	1.18	87.1	0.427	3.0	2.895	1.5	0.2068	0.9	0.604	0.1015	1.2	1211	10	1653	22	+29	1246.90	19.30	290.71	0.00	17.33	0.895	2.14
Y	12149-022.1	422	255	0.62	3.19	1039	123	7973	167	5.0E-5	38	0.09	78.2	0.197	2.0	2.477	4.1	0.2155	4.1	0.987	0.0834	0.7	1258	47	1278	13	+2	1276.16	25.19	0.16	0.69	17.33	0.895	2.14
Y	12149-056.1	81	39	0.50	0.84	318	7	8376	176	1.3E-4	50	0.22	15.7	0.140	5.5	2.665	2.0	0.2246	1.2	0.587	0.0861	1.6	1306	14	1340	32	+3	1311.50	25.84	0.91	0.34	17.33	0.895	2.14
Y	12149-018.1	425	72	0.18	0.60	331	8	11323	382	5.5E-4	11	0.95	82.8	0.049	6.3	2.758	3.0	0.2265	2.8	0.927	0.0883	1.1	1316	33	1390	22	+6	1368.01	35.95	3.58	0.06	17.33	0.895	2.14
Y	12149-038.1	61	41	0.70	0.84	188	4	9677	202	4.1E-4	32	0.71	12.8	0.199	5.5	3.015	2.8	0.2466	1.3	0.458	0.0887	2.5	1421	16	1397	48	-2	1418.25	31.11	0.21	0.64	17.33	0.895	2.14
Y	12149-026.1	686	432	0.65	0.38	756	17	9441	451	3.6E-5	29	0.06	150.2	0.195	2.9	3.193	1.1	0.2549	0.8	0.781	0.0909	0.7	1464	11	1444	13	-2	1455.23	16.92	1.33	0.25	17.33	0.895	2.14
Y	12149-036.1	206	47	0.23	0.76	91	2	12378	405	2.4E-5	71	0.04	44.9	0.066	4.7	3.200	3.2	0.2534	3.1	0.970	0.0916	0.8	1456	41	1459	15	+0	1458.47	28.21	0.00	0.95	17.33	0.895	2.14
Y	12149-041.1	135	111	0.85	0.53	315	13	9126	191	5.4E-5	58	0.09	29.6	0.268	2.8	3.302	1.4	0.2547	1.0	0.721	0.0940	1.0	1463	14	1508	19	+3	1477.89	22.39	3.79	0.05	17.33	0.895	2.14
Y	12149-044.1	318	69	0.23	0.63	400	9	8678	182	-1.2E-13	9999	0.00	70.5	0.072	3.4	3.349	2.6	0.2582	2.5	0.975	0.0941	0.6	1480	34	1510	11	+2	1506.95	20.90	0.69	0.40	17.33	0.895	2.14
Y	12149-012.1	158	90	0.59	0.56	312	7	11146	440	1.4E-4	32	0.24	36.0	0.174	3.1	3.435	1.4	0.2645	1.0	0.701	0.0942	1.0	1513	14	1512	19	-0	1512.49	22.21	0.00	0.99	17.33	0.895	2.14
Y	12149-039.1	99	42	0.44	0.71	173	10	11756	245	2.1E-4	29	0.36	22.8	0.121	7.8	3.495	1.6	0.2667	1.0	0.639	0.0951	1.3	1524	14	1529	24	+0	1525.24	24.38	0.04	0.85	17.33	0.895	2.14
Y	12149-032.1	176	137	0.80	3.07	509	12	9108	191	8.6E-5	38	0.15	40.5	0.234	2.5	3.517	1.6	0.2677	1.0	0.599	0.0953	1.3	1529	13	1534	25	+0	1530.17	23.41	0.03	0.87	17.33	0.895	2.14
Y	12149-017.1	351	231	0.68	3.00	560	13	9712	204	6.2E-5	32	0.11	81.7	0.209	1.9	3.597	1.1	0.2708	0.9	0.832	0.0964	0.6	1545	12	1555	11	+1	1549.96	16.82	0.35	0.56	17.33	0.895	2.14
Y	12149-037.1	744	37	0.05	6.42	489	11	14409	609	1.4E-4	17	0.23	168.2	0.002	67.1	3.546	1.0	0.2631	0.9	0.863	0.0978	0.5	1506	11	1582	9	+5	1549.99	14.85	25.90	0.00	17.33	0.895	2.14
Y	12149-052.1	411	185	0.47	0.37	595	14	11910	570	7.6E-5	24	0.13	97.8	0.141	1.9	3.688	2.2	0.2771	2.1	0.972	0.0965	0.5	1577	30	1558	10	-1	1560.01	19.08	0.36	0.55	17.33	0.895	2.14
Y	12149-043.1	300	162	0.56	2.59	287	7	11206	235	3.6E-5	45	0.06	70.8	0.166	2.2	3.685	1.1	0.2743	0.9	0.836	0.0974	0.6	1563	13	1575	11	+1	1569.58	17.01	0.57	0.45	17.33	0.895	2.14
Y	12149-061.1	640	331	0.53	0.29	620	31	9552	396	6.1E-6	71	0.01	155.2	0.163	1.4	3.763	0.9	0.2821	0.9	0.919	0.0967	0.4	1602	12	1562	7	-3	1573.20	12.57	7.62	0.01	17.33	0.895	2.14
Y	12149-002.1	333	163	0.50	0.44	538	12	11822	399	1.5E-4	22	0.25	79.5	0.156	2.4	3.724	1.2	0.2783	0.9	0.780	0.0971	0.7	1583	13	1569	14	-1	1576.20	18.88	0.54	0.46	17.33	0.895	2.14
Y	12149-048.1	132	99	0.78	0.50	498	11	10757	428	2.7E-5	71	0.05	30.9	0.236	2.6	3.743	1.3	0.2733	1.0	0.779	0.0993	0.8	1558	14	1611	15	+4	1581.67	20.68	6.79	0.01	17.33	0.895	2.14
Y	12149-055.1	119	83	0.72	0.60	283	7	9476	317	7.4E-5	50	0.13	28.2	0.222	3.2	3.772	1.5	0.2773	1.1	0.716	0.0987	1.0	1578	15	1599	19	+1	1585.50	23.63	0.76	0.38	17.33	0.895	2.14
Y	12149-003.1	98	58	0.61	0.71	403	9	10527	221	1.8E-4	35	0.31	23.5	0.193	3.8	3.766	1.8	0.2798	1.2	0.661	0.0976	1.3	1590	17	1579	25	-1	1586.91	27.81	0.13	0.72	17.33	0.895	2.14
Y	12149-019.1	90	54	0.62	0.73	219	5	10968	229	2.0E-4	35	0.34	21.9	0.182	4.2	3.716	1.9	0.2832	1.1	0.611	0.0952	1.5	1607	16	1532	28	-6	1587.22	27.55	5.57	0.02	17.33	0.895	2.14
Y	12149-028.1	123	77	0.65	0.61	238	6	10675	223	5.2E-5	58	0.09	29.4	0.206	3.1	3.801	1.4	0.2786	1.0	0.739	0.0990	1.0	1584	15	1605	18	+1	1592.37	22.78	0.80	0.37	17.33	0.895	2.14
Y	12149-020.1	78	28	0.37	0.99	195	11	10730	225	5.6E-5	71	0.10	18.7	0.121	5.2	3.817	1.7	0.2794	1.2	0.690	0.0991	1.2	1588	16	1607	23	+1	1594.65	26.72	0.43	0.51	17.33	0.895	2.14
Y	12149-014.1	272	202	0.76	0.39	496	18	9166	191	8.0E-6	100	0.01	64.9	0.231	2.0	3.803	1.1	0.2774	0.9	0.844	0.0994	0.6	1578	13	1614	11	+2	1598.39	16.95	4.32	0.04	17.33	0.895	2.14
Y	12149-049.1	106	66	0.64	0.58	240	6	10111	292	1.4E-4	33	0.24	25.9	0.184	5.3	3.836	1.4	0.2837	1.0	0.703	0.0981	1.0	1610	14	1588	19	-2	1601.95	23.13	0.82	0.37	17.33	0.895	2.14
Y	12149-015.1	285	242	0.88	0.36	648	15	8679	181	1.1E-4	26	0.18	71.7	0.256	3.0	4.065	1.1	0.2925	0.9	0.808	0.1008	0.7	1654	13	1639	12	-1	1646.06	18.28	0.69	0.41	17.33	0.895	2.14
Y	12149-033.1	375	447	1.23	0.25	408	9	8973	187	4.3E-5	32	0.07	92.2	0.365	1.9	4.022	1.0	0.2862	0.9	0.884	0.1019	0.5	1623	12	1659	9	+3	1646.82	14.49	5.72	0.02	17.33	0.895	2.14
Y	12149-050.1	196	167	0.88	0.44	436	16	9029	273	5.4E-5	45	0.09	49.3	0.269	2.1	4.071	1.2	0.2922	1.0	0.791	0.1010	0.7	1652	14	1643	14	-1	1647.96	19.91	0.20	0.65	17.33	0.895	2.14
Y	12149-009.1	160	135	0.87	0.51	385	24	9409	197	1.7E-4	28	0.30	40.0	0.262	5.2	4.074	1.4	0.2907	1.0	0.713	0.1016	1.0	1645	14	1654	18	+1	1648.57	22.74	0.14	0.70	17.33	0.895	2.14
Y	12149-045.1	173	128	0.76	0.44	241	6	10200	213	5.9E-5	41	0.10	43.2	0.230	2.2	4.084	1.2	0.2901	1.0	0.800	0.1021	0.7	1642	14	1663	13	+1	1652.68	19.28	1.19	0.27	17.33	0.895	2.14
Y	12149-006.1	218	182	0.86	2.30	515	24	8492	329	6.8E-23	9999	0.00	54.3	0.255	2.1	4.090	1.1	0.2903	0.9	0.835	0.1022	0.6	1643	14	1665	12	+1	1655.27	18.01	1.42	0.23	17.33	0.895	2.14
Y	12149-027.1	346	126	0.38	0.46	513	12	7945	295	5.8E-5	32	0.10	87.0	0.113	2.5	4.125	1.0	0.2927	0.9	0.852	0.1022	0.5	1655	13	1665	10	+1	1660.85	16.37	0.31	0.58	17.33	0.895	2.14
Y	12149-034.1	292	128	0.45	0.47	509	12	11426	239	6.2E-5	33	0.11	74.4	0.135	2.5	4.228	1.1	0.2965	0.9	0.837	0.1034	0.6	1674	13	1686	11	+1	1681.11	17.29	0.47	0.49	17.33	0.895	2.14
Y	12149-029.1	118	54	0.47	0.72	321	7	11337	432	3.4E-5	71	0.06	30.8	0.155	3.6	4.473	1.4	0.3052	1.1	0.768	0.1063	0.9	1717	16	1737	16	+1	1726.70	22.77	0.75	0.39	17.33	0.895	2.14
Y	12149-053.1	117	74	0.66	0.62	293	7	8538	179	1.1E-4	38	0.20	30.8	0.190	3.3	4.540	1.4	0.3078	1.0	0.729	0.1070	1.0	1730	16	1749	18	+1	1737.94	23.93	0.61	0.43	17.33	0.895	2.14
Y	12149-040.1	198	177	0.93	0.43	301	7	9899	395	6.0E-5	41	0.10	54.1	0.273	2.1	4.818	1.2	0.3187	1.0	0.811	0.1096	0.7	1783	15	1793	13	+1	1789.14	19.49	0.26	0.61	17.33	0.895	2.14
Y	12149-004.1	235	101	0.44	0.52	480	20	12824	596	8.9E-5	29	0.15	66.8	0.130	2.6	5.046	1.1	0.3311	0.9	0.829	0.1105	0.6	1844	15	1808	11	-2	1821.74	18.26	3.49	0.06	17.33	0.895	2.14
Y	12149-023.1	61	78	1.33	0.63	172	4	10868	228	8.6E-5	58	0.15	16.9	0.417	3.2	5.066	1.7	0.3242	1.2	0.705	0.1134	1.2	1810	19	1854	22	+3	1828.49	28.99	2.27	0.13	17.33	0.895	2.14
Y	12149-025.1	202	74	0.38	0.60	256	17	9871	206	8.7E-5	32	0.15	57.4	0.115	3.1	5.145	1.2	0.3300	0.9	0.817	0.1131	0.7	1838	15	1850	12	+1	1845.05	19.16	0.35	0.56	17.33	0.895	2.14
Y	12149-059.1	455	147	0.33	0.44	248	6	11900	250	2.4E-5	41	0.04	128.9	0.099	2.2	5.147	1.0	0.3301	0.9	0.904	0.1131	0.4	1839	14	1849	7	+1	1846.84	13.82	0.43	0.51	17.33	0.895	2.14
Y	12149-060.1	804	28	0.04	0.87	534	24	14810	309	1.1E-5	41	0.02	228.2	0.011	4.8	5.169	1.0	0.3302	0.8	0.829	0.1135	0.6	1840	13	1857	10	+1	1850.00	16.58	0.98	0.32	17.33	0.895	2.14
Y	12149-046.1	230	126	0.57	0.49	348	8	9851	206	4.9E-5	41	0.08	66.9	0.172	2.3	5.337	1.2	0.3392	1.1	0.868	0.1141	0.6	1883	17	1866	11	-1	1871.14	18.76	0.66	0.42	17.33	0.895	2.14
Y	12149-031.1	123	64	0.54	0.69	145	3	10994	389	3.9E-5	58	0.07	42.6	0.155	3.1	7.582	1.3	0.4027	1.1	0.841	0.1365	0.7	2182	20	2184	12	+0	2183.21	21.17	0.01	0.93	17.33	0.895	2.14
Y	12149-054.1	475	24	0.05	0.92	193	5	13052	272	1.9E-5	32	0.03	215.8	0.015	4.2	15.988	0.9	0.5291	0.8	0.968	0.2192	0.2	2738	19	2974	4	+10	2958.54	9.34	150.35	0.00	17.33	0.895	2.14
Y	12150-013.1	50	30	0.62	1.31	191	7	9554	132	1.5E-3	30	2.62	7.3	0.165	15.1	1.642	14.2	0.1691	2.5	0.173	0.0704	14.0	1007	23	941	286	-8	992.86	166.15	0.02	0.89	17.33	0.895	2.14
Y	12150-036.1	85	29	0.36	2.18	222	8	9234	268	6.6E-4	32	1.14	12.4	0.093	12.9	1.582	5.1	0.1710	1.7	0.332	0.0671	4.9	1018	16	841	101	-23	1007.63	92.55	0.49	0.48	17.33	0.895	2.14
Y	12150-093.1	288	113	0.41	0.66	370	13	10448	304	7.4E-5	58	0.13	42.2	0.126	4.8	1.743	1.9	0.1707	1.4	0.742	0.0741	1.3	1016	13	1044	26	+3	1014.07	34.87	0.17	0.68	17.33	0.895	2.14
Y	12150-006.1	168	71	0.43	1.29	261	9	10616	146	-3.9E-5	100	-0.07	24.8	0.138	5.7	1.775	2.3	0.1714	1.8	0.778	0.0751	1.4	1020	17	1072	29	+5	1014.98	40.47	0.46	0.50	17.33	0.895	2.14
Y	12150-028.1	160	51	0.33	0.98	211	8	10522	145	8.6E-5	71	0.15	24.0	0.100	7.4	1.725	2.5	0.1738	1.8	0.705	0.0720	1.8	1033	17	985	36	-5	1035.91	46.63	0.20	0.66	17.33	0.895	2.14
Y	12150-124.1	264	65	0.26	0.85	694	24	12267	357	3.0E-4	29	0.52	42.7	0.070	8.1	1.957	2.6	0.1883	1.7	0.672	0.0754	1.9	1112	18	1079	38	-3	1113.70	51.40	0.07	0.78	17.33	0.895	2.14
Y	12150-122.1	143	119	0.86	0.68	434	15	8852	258	2.3E-4	45	0.40	23.6	0.245	4.9	2.018	2.8	0.1925	1.6	0.558	0.0760	2.3	1135	16	1096	47	-4	1129.83	54.35	0.20	0.65	17.33	0.895	2.14
Y	12150-061.1	491	249	0.52	3.21	385	14	11248	155	9.5E-4	11	1.64	83.3	0.109	5.2	2.669	2.3	0.1975	1.6	0.688	0.0980	1.7	1162	17	1586	31	+29	1135.56	47.78	26.22	0.00	17.33	0.895	2.14
Y	12150-004.1	339	166	0.51	0.99	319	18	9327	132	1.0E-3	15	1.74	55.1	0.130	6.2	2.217	3.5	0.1895	1.7	0.474	0.0848	3.1	1119	17	1312	60	+16	1137.70	67.58	2.60	0.11	17.33	0.895	2.14
Y	12150-048.1	87	30	0.36	1.15	200	7	10156	295	2.4E-4	50	0.42	14.6	0.107	9.5	2.075	4.4	0.1952	1.7	0.376	0.0771	4.1	1149	18	1124	82	-2	1146.96	87.52	0.02	0.89	17.33	0.895	2.14
Y	12150-051.1	93	48	0.54	0.96	250	14	8341	242	5.3E-4	33	0.92	15.7	0.144	8.4	2.025	4.1	0.1980	1.7	0.405	0.0742	3.8	1165	18	1046	77	-12	1151.85	81.36	0.53	0.46	17.33	0.895	2.14
Y	12150-027.1	103	46	0.46	1.03	167	6	10086	139	1.2E-20	9999	0.00	17.9	0.126	7.0	2.350	2.3	0.2022	1.9	0.806	0.0843	1.4	1187	21	1299	27	+9	1172.95	44.97	1.40	0.24	17.33	0.895	2.14
Y	12150-090.1	157	67	0.44	0.84	268	9	9431	275	1.1E-4	58	0.20	27.0	0.128	6.1	2.253	2.7	0.2007	1.5	0.569	0.0814	2.2	1179	16	1231	43	+5	1180.98	57.53	0.26	0.61	17.33	0.895	2.14
Y	12150-007.1	164	127	0.80	0.70	214	8	9600	135	8.3E-5	71	0.14	28.4	0.241	4.4	2.292	2.4	0.2014	1.8	0.753	0.0825	1.6	1183	19	1258	31	+7	1185.52	51.51	1.61	0.20	17.33	0.895	2.14
Y	12150-076.1	78	42	0.55	1.01	314	11	7859	228	5.3E-4	35	0.92	13.7	0.166	8.0	2.145	4.3	0.2047	1.7	0.405	0.0760	3.9	1200	19	1096	78	-10	1186.60	83.98	0.43	0.51	17.33	0.895	2.14
Y	12150-009.1	88	64	0.75	0.90	248	9	9802	135	8.1E-4	28	1.40	16.1	0.210	7.2	2.261	4.9	0.2133	2.0	0.403	0.0769	4.5	1246	23	1118	90	-13	1218.74	87.82	0.64	0.43	17.33	0.895	2.14

Appendix 5. 2016ODEN U-Pb zircon data.

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	*Yb ppm*	*1 σ abs err*	*Hf ppm*	*1 σ abs err*	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206 *	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206 * Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12150-057.1	260	204	0.81	1.14	723	25	7808	228	4.2E-4	24	0.73	48.4	0.236	3.8	2.356	2.5	0.2166	1.4	0.569	0.0789	2.1	1264	17	1170	41	-9	1243.07	49.22	1.74	0.19	17.33	0.895	2.14
Y	12150-030.1	41	29	0.72	1.33	245	9	8606	118	5.1E-4	50	0.88	8.1	0.199	9.9	2.631	6.2	0.2275	2.4	0.389	0.0839	5.7	1321	29	1290	111	-3	1315.16	121.72	0.02	0.88	17.33	0.895	2.14
Y	12150-072.1	76	73	1.00	0.82	240	8	10417	303	1.9E-4	58	0.33	14.8	0.268	5.4	2.689	3.8	0.2282	1.7	0.461	0.0855	3.3	1325	21	1326	65	+0	1325.27	71.77	0.00	0.99	17.33	0.895	2.14
Y	12150-017.1	166	38	0.24	1.12	421	24	11260	338	5.2E-4	24	0.91	32.7	0.052	13.0	2.532	3.1	0.2295	1.8	0.572	0.0800	2.5	1332	21	1198	50	-12	1336.32	72.63	0.43	0.51	17.33	0.895	2.14
Y	12150-053.1	177	115	0.67	0.64	281	10	10566	307	2.9E-4	30	0.51	36.1	0.191	4.4	2.911	2.3	0.2374	1.5	0.642	0.0889	1.8	1373	18	1403	34	+2	1376.47	54.59	0.19	0.66	17.33	0.895	2.14
Y	12150-049.1	41	70	1.75	0.90	104	4	9698	420	6.4E-4	41	1.12	8.9	0.501	5.4	3.061	5.2	0.2519	2.1	0.394	0.0881	4.8	1448	27	1385	92	-5	1426.54	79.85	0.16	0.69	17.33	0.895	2.14
Y	12150-069.1	217	195	0.93	0.49	398	14	9974	290	1.5E-4	35	0.27	47.0	0.262	2.9	3.127	2.1	0.2526	1.7	0.824	0.0898	1.2	1452	22	1421	22	-2	1439.85	45.15	0.64	0.42	17.33	0.895	2.14
Y	12150-078.1	46	21	0.48	1.46	137	5	8782	256	3.9E-13	9999	0.00	10.1	0.139	8.9	3.490	2.6	0.2544	1.9	0.752	0.0995	1.7	1461	25	1615	32	+11	1443.98	61.64	1.49	0.22	17.33	0.895	2.14
Y	12150-015.1	1039	409	0.41	0.83	741	26	13549	189	7.6E-4	9	1.32	226.1	0.109	5.1	3.210	2.5	0.2533	2.0	0.792	0.0919	1.5	1455	26	1466	29	+1	1455.64	65.47	0.03	0.85	17.33	0.895	2.14
Y	12150-077.1	37	30	0.82	1.25	375	13	9244	269	3.5E-4	58	0.60	8.0	0.249	7.8	3.255	5.3	0.2506	2.1	0.395	0.0942	4.9	1442	27	1512	92	+5	1458.38	107.80	0.16	0.69	17.33	0.895	2.14
Y	12150-081.1	32	15	0.48	1.72	225	8	9403	273	1.3E-3	32	2.31	7.0	0.077	27.2	3.021	8.4	0.2558	2.3	0.274	0.0856	8.0	1469	30	1330	156	-12	1460.00	211.16	0.08	0.78	17.33	0.895	2.14
Y	12150-086.1	267	147	0.57	0.60	328	12	11269	328	1.1E-4	41	0.20	58.4	0.161	3.8	3.254	2.0	0.2544	1.4	0.700	0.0928	1.4	1461	18	1483	27	+2	1463.85	50.88	0.16	0.68	17.33	0.895	2.14
Y	12150-041.1	93	64	0.71	1.66	227	8	9904	287	4.7E-21	9999	0.00	20.5	0.229	4.7	3.373	2.0	0.2567	1.6	0.804	0.0953	1.2	1473	21	1534	22	+4	1467.55	51.83	1.24	0.27	17.33	0.895	2.14
Y	12150-055.1	191	64	0.34	2.44	464	17	8927	125	8.4E-5	58	0.15	42.2	0.112	5.6	3.392	2.5	0.2570	1.7	0.703	0.0957	1.7	1475	23	1542	33	+5	1475.26	64.83	0.78	0.38	17.33	0.895	2.14
Y	12150-011.1	76	88	1.19	0.78	188	7	10106	140	3.8E-4	38	0.65	17.0	0.344	4.4	3.280	3.3	0.2617	2.0	0.608	0.0909	2.6	1499	27	1444	49	-4	1481.01	67.16	0.40	0.53	17.33	0.895	2.14
Y	12150-044.1	88	29	0.34	1.18	178	6	9671	281	7.7E-4	24	1.33	19.5	0.076	13.2	3.314	3.5	0.2585	1.6	0.468	0.0930	3.1	1482	22	1487	59	+0	1482.25	93.34	0.00	0.98	17.33	0.895	2.14
Y	12150-074.1	124	46	0.38	0.97	227	8	10583	307	3.5E-4	32	0.60	27.7	0.087	8.6	3.196	2.8	0.2589	1.9	0.682	0.0895	2.1	1484	25	1416	39	-5	1487.13	73.70	0.33	0.56	17.33	0.895	2.14
Y	12150-066.1	416	141	0.35	0.53	303	11	10764	312	7.4E-5	35	0.13	94.2	0.104	3.3	3.429	1.5	0.2634	1.3	0.894	0.0944	0.7	1507	18	1516	13	+1	1505.69	38.51	0.10	0.76	17.33	0.895	2.14
Y	12150-082.1	56	26	0.49	1.32	165	6	7809	227	2.3E-4	58	0.41	12.6	0.150	8.6	3.513	3.8	0.2637	1.9	0.496	0.0966	3.3	1509	25	1560	61	+4	1513.44	97.74	0.12	0.73	17.33	0.895	2.14
Y	12150-063.1	120	94	0.81	0.77	331	12	9722	136	2.3E-4	41	0.40	27.4	0.234	7.1	3.431	2.6	0.2656	1.8	0.712	0.0937	1.8	1518	25	1502	34	-1	1519.01	69.57	0.03	0.86	17.33	0.895	2.14
Y	12150-085.1	190	212	1.15	0.51	548	19	9639	280	-8.5E-21	9999	0.00	44.1	0.337	6.1	3.744	1.7	0.2696	1.4	0.868	0.1007	0.8	1539	20	1637	15	+7	1520.02	34.58	1.62	0.20	17.33	0.895	2.14
Y	12150-084.1	338	192	0.59	0.51	324	12	11271	156	2.5E-4	22	0.43	77.3	0.169	3.1	3.476	2.2	0.2666	1.6	0.731	0.0946	1.5	1524	22	1519	28	-0	1522.06	48.56	0.01	0.93	17.33	0.895	2.14
Y	12150-120.1	92	51	0.57	0.99	202	7	10780	314	3.4E-4	38	0.59	21.2	0.142	7.2	3.505	2.8	0.2676	1.7	0.591	0.0950	2.3	1529	23	1528	43	-0	1528.58	76.37	0.00	0.99	17.33	0.895	2.14
Y	12150-040.1	82	41	0.52	1.00	287	10	8874	258	4.6E-5	100	0.08	19.0	0.154	6.1	3.584	2.1	0.2692	1.6	0.764	0.0966	1.4	1537	22	1559	26	+2	1534.79	56.48	0.08	0.78	17.33	0.895	2.14
Y	12150-034.1	115	51	0.45	0.91	177	6	11199	325	3.5E-4	32	0.60	26.8	0.119	6.8	3.396	2.5	0.2720	1.5	0.609	0.0905	2.0	1551	21	1437	38	-9	1547.39	69.90	1.30	0.25	17.33	0.895	2.14
Y	12150-129.1	104	51	0.50	0.96	302	11	9331	271	4.1E-4	32	0.71	24.3	0.128	7.5	3.606	3.2	0.2714	1.6	0.501	0.0963	2.8	1548	22	1555	52	+0	1548.61	85.21	0.00	0.96	17.33	0.895	2.14
Y	12150-095.1	114	80	0.72	0.81	256	9	10548	307	4.0E-4	32	0.69	26.7	0.208	5.2	3.736	2.6	0.2725	1.6	0.607	0.0994	2.1	1553	22	1614	39	+4	1561.34	69.25	0.54	0.46	17.33	0.895	2.14
Y	12150-065.1	165	130	0.81	0.57	318	11	8612	250	8.7E-5	50	0.15	38.9	0.260	5.6	3.572	1.8	0.2735	1.4	0.809	0.0947	1.0	1558	20	1523	20	-3	1563.44	45.45	0.28	0.60	17.33	0.895	2.14
Y	12150-128.1	276	113	0.42	1.08	467	16	11943	348	2.5E-4	25	0.43	65.2	0.113	7.0	3.680	1.8	0.2750	1.4	0.777	0.0971	1.1	1566	19	1568	21	+0	1565.87	44.00	0.00	0.98	17.33	0.895	2.14
Y	12150-003.1	133	90	0.70	0.84	281	10	10463	148	2.7E-4	38	0.48	31.1	0.207	5.0	3.758	2.6	0.2737	1.9	0.713	0.0996	1.8	1559	26	1616	34	+4	1566.30	70.15	0.69	0.41	17.33	0.895	2.14
Y	12150-070.1	66	49	0.76	0.98	141	5	9858	286	6.0E-4	32	1.04	16.1	0.198	6.9	3.584	3.8	0.2815	1.8	0.470	0.0923	3.3	1599	25	1474	63	-10	1572.96	91.83	0.91	0.34	17.33	0.895	2.14
Y	12150-016.1	249	112	0.47	0.65	290	14	11366	157	4.9E-5	58	0.08	59.5	0.136	3.7	3.783	1.8	0.2778	1.6	0.897	0.0988	0.8	1580	23	1601	15	+1	1578.84	51.01	0.43	0.51	17.33	0.895	2.14
Y	12150-018.1	119	47	0.41	1.01	224	8	11717	162	6.7E-5	71	0.12	28.5	0.115	6.0	3.860	2.2	0.2792	1.8	0.832	0.1003	1.2	1587	25	1630	22	+3	1580.19	57.29	0.40	0.53	17.33	0.895	2.14
Y	12150-005.1	123	50	0.42	1.14	219	8	11436	162	3.1E-4	38	0.54	29.4	0.121	11.6	3.670	2.8	0.2774	1.9	0.673	0.0959	2.1	1578	27	1547	39	-2	1580.67	75.57	0.04	0.85	17.33	0.895	2.14
Y	12150-052.1	192	102	0.55	0.67	262	9	11881	345	1.2E-4	41	0.21	46.1	0.155	4.0	3.769	1.8	0.2788	1.4	0.800	0.0981	1.1	1585	20	1588	20	+0	1585.12	50.33	0.00	0.96	17.33	0.895	2.14
Y	12150-032.1	110	59	0.56	0.91	225	8	10487	144	3.0E-4	35	0.53	26.7	0.158	5.8	3.807	2.6	0.2820	1.8	0.698	0.0979	1.9	1601	26	1585	35	-1	1600.07	74.04	0.04	0.84	17.33	0.895	2.14
Y	12150-026.1	161	135	0.87	0.63	442	16	9490	131	1.5E-4	41	0.27	39.0	0.235	3.6	3.856	2.1	0.2826	1.7	0.811	0.0990	1.3	1604	25	1605	23	+0	1604.49	56.31	0.00	0.99	17.33	0.895	2.14
Y	12150-038.1	137	79	0.60	0.72	332	12	9408	273	2.8E-4	30	0.49	33.8	0.165	4.6	3.864	2.4	0.2866	1.8	0.765	0.0978	1.5	1624	26	1583	28	-3	1618.65	65.85	0.54	0.46	17.33	0.895	2.14
Y	12150-037.1	164	162	1.02	0.54	519	18	9228	268	6.6E-5	58	0.11	40.7	0.302	2.9	3.957	1.7	0.2887	1.5	0.830	0.0994	1.0	1635	21	1613	18	-2	1628.11	46.33	0.43	0.51	17.33	0.895	2.14
Y	12150-091.1	150	139	0.95	0.61	433	15	8895	259	7.8E-5	58	0.14	37.3	0.289	3.3	4.045	1.8	0.2895	1.5	0.809	0.1013	1.1	1639	22	1648	20	+1	1641.25	50.63	0.06	0.81	17.33	0.895	2.14
Y	12150-058.1	63	29	0.47	1.37	257	9	8130	237	7.4E-4	32	1.29	15.9	0.110	19.3	3.739	4.4	0.2938	1.9	0.433	0.0923	4.0	1661	28	1473	75	-14	1659.97	128.61	0.37	0.55	17.33	0.895	2.14
Y	12150-060.1	371	58	0.16	29.94	151	6	11543	344	3.4E-4	27	0.59	99.8	0.036	14.6	4.340	35.3	0.3127	35.2	0.999	0.1006	1.6	1754	541	1636	30	-8	1685.68	14.50	0.02	0.90	17.33	0.895	2.14
Y	12150-064.1	244	156	0.66	0.60	563	20	9821	390	1.5E-4	35	0.27	62.8	0.183	3.6	4.178	1.8	0.3002	1.4	0.801	0.1009	1.1	1692	21	1642	20	-4	1685.87	52.11	1.60	0.21	17.33	0.895	2.14
Y	12150-088.1	207	87	0.43	0.75	178	6	10830	315	9.8E-5	45	0.17	53.7	0.122	4.4	4.427	2.1	0.3020	1.4	0.675	0.1063	1.6	1701	21	1737	29	+2	1705.79	61.55	0.32	0.57	17.33	0.895	2.14
Y	12150-033.1	282	192	0.70	0.47	576	20	8035	233	8.0E-5	38	0.14	73.7	0.205	2.6	4.397	1.5	0.3036	1.4	0.888	0.1050	0.7	1709	20	1715	13	+0	1711.36	42.40	0.05	0.82	17.33	0.895	2.14
Y	12150-019.1	394	264	0.69	0.46	357	13	11029	154	7.3E-5	38	0.13	103.6	0.210	2.4	4.452	1.7	0.3063	1.6	0.924	0.1054	0.7	1722	24	1722	12	-0	1721.93	36.89	0.00	0.98	17.33	0.895	2.14
Y	12150-080.1	177	131	0.77	0.61	265	9	9976	290	1.3E-4	41	0.22	46.6	0.229	3.3	4.542	1.8	0.3064	1.4	0.817	0.1075	1.0	1723	22	1758	19	+2	1729.81	51.70	0.90	0.34	17.33	0.895	2.14
Y	12150-022.1	87	43	0.50	1.08	180	7	10731	149	4.7E-4	30	0.82	23.1	0.136	7.3	4.563	2.9	0.3080	1.9	0.667	0.1074	2.2	1731	29	1756	40	+2	1731.80	87.92	0.06	0.80	17.33	0.895	2.14
Y	12150-094.1	168	155	0.95	0.64	348	12	10723	314	2.5E-4	32	0.43	44.7	0.287	3.4	4.623	2.5	0.3103	1.5	0.616	0.1081	1.9	1742	23	1767	35	+2	1751.44	56.16	0.14	0.71	17.33	0.895	2.14
Y	12150-123.1	217	43	0.21	1.01	131	5	12129	353	1.0E-4	41	0.18	59.3	0.052	7.1	4.997	1.7	0.3174	1.4	0.857	0.1142	0.9	1777	22	1867	15	+6	1760.00	38.89	1.01	0.31	17.33	0.895	2.14
Y	12150-014.1	122	110	0.93	0.69	294	11	9591	132	1.5E-4	45	0.26	32.7	0.282	3.5	4.708	2.2	0.3126	1.8	0.823	0.1092	1.2	1753	28	1787	23	+2	1766.12	58.73	0.64	0.42	17.33	0.895	2.14
Y	12150-062.1	454	130	0.30	0.61	257	9	11077	153	1.1E-4	28	0.18	125.4	0.086	5.5	5.116	1.7	0.3219	1.6	0.936	0.1153	0.6	1799	25	1884	11	+5	1768.60	34.41	2.35	0.13	17.33	0.895	2.14
Y	12150-008.1	148	54	0.38	1.05	415	21	11626	165	1.5E-4	45	0.26	40.6	0.098	6.5	4.960	2.5	0.3196	1.8	0.732	0.1125	1.7	1788	28	1841	30	+3	1786.28	76.97	0.42	0.52	17.33	0.895	2.14
Y	12150-054.1	361	200	0.57	0.50	280	10	11136	324	1.3E-4	28	0.23	101.4	0.166	2.7	4.914	1.5	0.3267	1.3	0.885	0.1091	0.7	1823	21	1784	13	-2	1809.83	45.68	2.38	0.12	17.33	0.895	2.14
Y	12150-039.1	193	57	0.31	2.16	152	5	10391	302	3.3E-5	71	0.06	54.1	0.086	4.7	5.046	1.9	0.3258	1.7	0.919	0.1123	0.7	1818	27	1838	13	+1	1811.05	52.48	0.27	0.61	17.33	0.895	2.14
Y	12150-002.1	50	17	0.35	1.85	71	3	9504	134	5.3E-4	41	0.92	14.1	0.091	14.5	4.868	5.5	0.3270	2.3	0.427	0.1080	5.0	1824	37	1766	91	-4	1817.12	165.89	0.05	0.82	17.33	0.895	2.14
Y	12150-083.1	319	151	0.49	0.57	245	9	11040	413	1.1E-4	32	0.20	89.4	0.150	3.1	5.152	1.5	0.3264	1.4	0.888	0.1145	0.7	1821	22	1872	13	+3	1823.31	48.72	3.74	0.05	17.33	0.895	2.14
Y	12150-024.1	178	51	0.29	0.99	247	9	8671	121	7.9E-5	50	0.14	50.6	0.077	5.9	5.167	1.9	0.3300	1.7	0.887	0.1135	0.9	1839	27	1857	16	+1	1833.59	52.80	0.10	0.75	17.33	0.895	2.14
Y	12150-089.1	354	80	0.23	0.75	163	6	11052	322	6.0E-5	41	0.10	101.0	0.061	4.6	5.104	1.7	0.3320	1.6	0.934	0.1115	0.6	1848	26	1824	11	-2	1857.86	46.96	0.49	0.48	17.33	0.895	2.14
Y	12150-010.1	295	179	0.62	0.54	331	12	9140	127	1.3E-4	29	0.23	91.3	0.178	2.8	6.077	1.8	0.3599	1.6	0.919	0.1225	0.7	1982	27	1992	12	+1	1989.51	46.78	0.17	0.68	17.33	0.895	2.14
Y	12150-050.1	158	48	0.31	0.94	250	9	9928	288	7.3E-5	50	0.13	50.0	0.081	5.6	6.337	1.7	0.3687	1.4	0.878	0.1247	0.8	2023	25	2024	14	+0	2023.14	49.09	0.00	0.99	17.33	0.895	2.14
Y	12150-046.1	239	183	0.79	0.51	396	14	10092	293	8.9E-5	38	0.15	76.0	0.231	2.5	6.358	1.5	0.3697	1.4	0.899	0.1247	0.7	2028	24	2025	12	-0	2026.09	43.94	0.01	0.91	17.33	0.895	2.14
Y	12151-002.1	242	87	0.37	0.57	187	4	11147	233	1.1E-21	9999	0.00	16.5	0.116	5.5	0.632	1.8	0.0794	1.1	0.605	0.0577	1.4	493	5	520	31	+5	493.24	10.20	0.70	0.40	17.33	0.895	2.14
Y	12151-010.1	841	291	0.36	3.91	1321	52	8910	421	4.2E-4	10	0.73	124.0	0.114	2.5	2.253	1.2	0.1716	0.9	0.741	0.0952	0.8	1021	8	1533	15	+36	1054.56	16.05	825.48	0.00	17.33	0.895	2.14
Y	12151-088.1	90	28	0.32	0.92	141	8	10055	210	9.7E-5	58	0.17	14.5	0.102	6.4	2.036	2.0	0.1873	1.2	0.581	0.0788	1.6	1107	12	1167	32	+6	1113.49	22.42	3.00	0.08	17.33	0.895	2.14
Y	12151-069.1	416	148	0.37	0.38	273	6	11226	234	-7.0E-14	9999	0.00	67.6	0.108	2.4	2.001	1.0	0.1891	0.9	0.849	0.0768	0.5	1116	9	1115	11	-0	1115.87	13.97	0.01	0.92	17.33	0.895	2.14
Y	12151-064.1	670	245	0.38	0.32	443	10	12926	601	3.5E-5	32	0.06	112.9	0.114	4.1	2.081	1.7	0.1961	1.6	0.960	0.0770	0.5	1154	17	1120	9	-3	1128.53	17.13	2.91	0.09	17.33	0.895	2.14
Y	12151-092.1	46	19	0.41	1.14	296	7	10119	211	1.8E-4	58	0.31	7.6	0.119	8.4	2.032	3.0	0.1921	1.4	0.475	0.0767	2.6	1133	15	1114	52	-2	1131.40	28.09	0.12	0.72	17.33	0.895	2.14
Y	12151-053.1	193	128	0.69	0.47	257	6	10376	216	1.2E-4	35	0.21	33.2	0.214	2.9	2.124	4.8	0.2000	4.6	0.969	0.0770	1.2	1175	50	1122	24	-5	1132.07	43.89	0.93	0.33	17.33	0.895	2.14
Y	12151-072.1	455	209	0.47	0.40	508	44	10612	222	1.3E-5	71	0.02	77.6	0.144	2.3	2.141	4.1	0.1985	4.0	0.989	0.0782	0.6	1167	43	1153	12	-1	1153.75	23.53	0.11	0.74	17.33	0.895	2.14

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	abs. err.	204 corr 207*/206 * Age	abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12151-038.1	452	292	0.67	2.51	691	55	9266	194	3.5E-4	15	0.61	73.1	0.256	5.6	2.550	1.3	0.1882	1.0	0.731	0.0983	0.9	1112	10	1592	17	+33	1171.14	19.17	548.51	0.00	17.33	0.895	2.14
Y	12151-043.1	386	186	0.50	0.49	203	22	6615	877	4.8E-4	18	0.84	67.5	0.139	4.4	2.243	5.4	0.2037	5.1	0.941	0.0799	1.8	1195	55	1194	36	-0	1193.99	60.32	0.00	0.98	17.33	0.895	2.14
Y	12151-089.1	379	95	0.26	0.49	213	9	10694	223	2.0E-5	58	0.03	68.9	0.079	3.1	2.376	1.1	0.2119	0.9	0.832	0.0813	0.6	1239	10	1229	12	-1	1234.93	15.31	0.39	0.53	17.33	0.895	2.14
Y	12151-020.1	620	273	0.45	0.34	391	9	10178	214	7.9E-5	25	0.14	112.9	0.135	2.1	2.395	1.1	0.2120	0.9	0.824	0.0819	0.6	1240	10	1244	12	+0	1241.42	15.20	0.09	0.77	17.33	0.895	2.14
Y	12151-068.1	390	157	0.41	0.41	275	6	11201	234	4.7E-5	38	0.08	71.9	0.131	2.4	2.439	1.1	0.2145	0.9	0.810	0.0825	0.6	1253	10	1256	13	+0	1254.19	15.98	0.05	0.83	17.33	0.895	2.14
Y	12151-080.1	127	36	0.29	0.83	256	6	11665	244	1.4E-4	38	0.24	24.9	0.078	5.9	2.628	1.7	0.2282	1.1	0.627	0.0835	1.3	1325	13	1281	25	-4	1316.13	22.43	2.35	0.12	17.33	0.895	2.14
Y	12151-039.1	246	179	0.75	0.42	387	9	9407	197	5.5E-5	45	0.10	48.5	0.231	2.3	2.681	1.3	0.2291	1.0	0.753	0.0849	0.8	1330	11	1313	16	-1	1324.18	18.66	0.73	0.39	17.33	0.895	2.14
Y	12151-060.1	9	5	0.53	2.38	78	2	8547	179	-1.2E-12	9999	0.00	1.6	0.135	16.0	2.563	13.3	0.2150	12.7	0.958	0.0864	3.8	1256	145	1348	73	+8	1330.56	126.68	0.33	0.56	17.33	0.895	2.14
Y	12151-050.1	175	101	0.60	0.54	329	13	11156	234	4.6E-5	58	0.08	35.0	0.184	3.1	2.764	1.4	0.2331	1.0	0.726	0.0860	0.9	1351	12	1338	18	-1	1346.84	20.31	0.30	0.59	17.33	0.895	2.14
Y	12151-107.1	368	151	0.42	0.41	442	16	8644	300	2.4E-5	50	0.04	75.8	0.124	2.4	2.903	1.0	0.2398	0.9	0.846	0.0878	0.6	1386	11	1378	11	-1	1381.72	15.61	0.25	0.62	17.33	0.895	2.14
Y	12151-105.1	337	54	0.16	0.70	1147	56	12071	439	7.0E-5	32	0.12	70.8	0.049	4.4	3.038	1.1	0.2448	0.9	0.808	0.0900	0.7	1412	11	1426	13	+1	1417.92	17.10	0.66	0.42	17.33	0.895	2.14
Y	12151-024.1	53	35	0.67	0.95	201	5	10153	213	-1.9E-20	9999	0.00	11.8	0.210	5.1	3.224	2.0	0.2568	1.3	0.673	0.0911	1.5	1474	18	1448	28	-2	1466.18	29.91	0.59	0.44	17.33	0.895	2.14
Y	12151-059.1	392	136	0.36	0.40	364	8	11494	239	3.6E-5	35	0.06	87.9	0.112	2.2	3.355	1.0	0.2612	0.9	0.877	0.0931	0.5	1496	12	1491	9	-0	1492.91	14.70	0.11	0.74	17.33	0.895	2.14
Y	12151-049.1	195	99	0.52	0.51	224	5	9120	348	3.3E-5	58	0.06	43.0	0.169	2.7	3.346	1.2	0.2563	1.0	0.792	0.0947	0.7	1471	13	1522	14	+4	1493.10	18.92	7.23	0.01	17.33	0.895	2.14
Y	12151-111.1	427	211	0.51	0.35	655	24	10650	428	2.4E-5	45	0.04	96.6	0.150	1.9	3.370	1.0	0.2632	0.9	0.875	0.0929	0.5	1506	12	1485	9	-2	1493.63	14.78	1.81	0.18	17.33	0.895	2.14
Y	12151-054.1	269	215	0.82	0.38	847	30	7044	148	5.9E-5	38	0.10	60.3	0.247	2.0	3.356	1.2	0.2610	0.9	0.801	0.0932	0.7	1495	12	1493	13	-0	1494.09	18.09	0.02	0.89	17.33	0.895	2.14
Y	12151-008.1	78	66	0.88	0.68	267	6	9988	209	2.1E-4	38	0.36	17.6	0.276	3.7	3.322	2.1	0.2629	1.2	0.577	0.0916	1.7	1505	16	1460	32	-3	1495.55	28.30	1.59	0.21	17.33	0.895	2.14
Y	12151-007.1	279	63	0.23	0.66	703	69	12310	258	4.3E-5	45	0.07	63.4	0.074	3.7	3.388	1.1	0.2646	0.9	0.808	0.0929	0.7	1513	12	1485	13	-2	1499.73	17.92	2.39	0.12	17.33	0.895	2.14
Y	12151-082.1	676	301	0.46	0.31	1214	27	8496	178	1.6E-5	45	0.03	153.6	0.138	1.6	3.401	0.9	0.2644	0.9	0.910	0.0933	0.4	1513	11	1494	7	-1	1499.73	12.90	1.80	0.18	17.33	0.895	2.14
Y	12151-100.1	272	115	0.44	0.43	462	10	10138	377	5.8E-5	33	0.10	61.9	0.136	4.3	3.416	1.1	0.2650	0.9	0.828	0.0935	0.6	1515	12	1498	11	-1	1506.50	16.83	0.98	0.32	17.33	0.895	2.14
Y	12151-047.1	575	196	0.35	0.40	354	8	11216	236	1.3E-5	58	0.02	129.7	0.114	2.1	3.407	1.0	0.2627	0.9	0.891	0.0941	0.4	1504	12	1510	8	+0	1507.42	14.16	0.17	0.68	17.33	0.895	2.14
Y	12151-108.1	312	160	0.53	0.39	516	12	10397	217	4.5E-5	38	0.08	69.3	0.161	2.1	3.357	2.8	0.2587	2.8	0.978	0.0941	0.6	1483	37	1510	11	+2	1507.59	21.36	0.48	0.49	17.33	0.895	2.14
Y	12151-073.1	320	189	0.61	0.39	524	26	10393	491	5.3E-5	35	0.09	73.5	0.186	2.1	3.460	1.1	0.2670	0.9	0.824	0.0940	0.6	1526	12	1508	12	-1	1516.49	17.09	1.05	0.30	17.33	0.895	2.14
Y	12151-009.1	516	270	0.54	0.34	352	18	11721	246	2.3E-5	45	0.04	118.6	0.162	1.8	3.507	1.0	0.2674	0.9	0.881	0.0951	0.5	1528	12	1530	9	+0	1529.18	14.54	0.02	0.89	17.33	0.895	2.14
Y	12151-090.1	203	97	0.50	0.50	431	10	9838	205	9.6E-6	100	0.02	46.1	0.148	2.7	3.517	1.1	0.2648	0.9	0.818	0.0963	0.7	1514	13	1554	12	+3	1534.05	18.02	4.91	0.03	17.33	0.895	2.14
Y	12151-044.1	213	54	0.26	0.61	272	6	9853	205	3.1E-5	50	0.05	50.1	0.085	3.3	3.619	1.1	0.2737	0.9	0.827	0.0959	0.6	1560	13	1546	12	-1	1552.27	17.43	0.61	0.44	17.33	0.895	2.14
Y	12151-001.1	290	165	0.59	0.42	306	7	10670	387	1.4E-5	71	0.03	69.1	0.182	2.1	3.659	1.1	0.2775	0.9	0.853	0.0957	0.6	1579	13	1541	11	-3	1556.64	16.99	4.61	0.03	17.33	0.895	2.14
Y	12151-035.1	582	522	0.93	0.23	684	28	11032	229	5.2E-5	24	0.09	139.0	0.284	1.1	3.703	0.9	0.2782	0.8	0.907	0.0965	0.4	1582	12	1558	7	-2	1565.67	13.10	2.76	0.10	17.33	0.895	2.14
Y	12151-004.1	223	203	0.94	0.40	393	23	9328	196	3.0E-5	58	0.05	52.8	0.297	4.1	3.716	1.2	0.2761	0.9	0.806	0.0976	0.7	1572	13	1579	13	+0	1575.28	18.77	0.13	0.72	17.33	0.895	2.14
Y	12151-052.1	206	74	0.37	0.60	248	6	11793	247	3.1E-5	58	0.05	49.0	0.109	3.3	3.725	1.2	0.2772	1.0	0.805	0.0974	0.7	1577	13	1576	13	-0	1576.56	18.89	0.01	0.94	17.33	0.895	2.14
Y	12151-070.1	235	198	0.87	0.38	337	18	9666	202	5.0E-5	41	0.09	56.0	0.263	1.9	3.745	1.1	0.2770	0.9	0.817	0.0981	0.7	1576	13	1588	12	+1	1581.99	18.01	0.40	0.53	17.33	0.895	2.14
Y	12151-085.1	194	97	0.52	0.53	317	7	10565	220	6.4E-5	41	0.11	45.8	0.152	2.9	3.746	1.2	0.2756	1.0	0.786	0.0986	0.8	1569	14	1598	14	+2	1582.23	19.89	2.07	0.15	17.33	0.895	2.14
Y	12151-027.1	137	126	0.95	0.43	206	5	9627	200	1.4E-4	29	0.24	32.6	0.292	2.2	3.772	1.3	0.2766	1.0	0.735	0.0989	0.9	1574	14	1603	17	+2	1585.55	21.31	1.74	0.19	17.33	0.895	2.14
Y	12151-040.1	151	106	0.73	2.54	309	17	10531	451	7.9E-5	41	0.14	35.7	0.218	2.6	3.778	1.3	0.2756	1.0	0.752	0.0994	0.9	1569	14	1613	16	+3	1587.32	21.28	4.20	0.04	17.33	0.895	2.14
Y	12151-062.1	120	39	0.34	0.79	323	15	9315	195	1.1E-4	38	0.19	29.0	0.096	4.7	3.769	1.5	0.2817	1.0	0.707	0.0970	1.0	1600	15	1568	19	-2	1588.32	23.18	1.72	0.19	17.33	0.895	2.14
Y	12151-101.1	232	148	0.66	0.43	328	7	11230	233	6.6E-5	33	0.11	55.4	0.198	2.1	3.775	1.1	0.2785	0.9	0.821	0.0983	0.6	1584	13	1592	12	+1	1588.34	17.62	0.23	0.63	17.33	0.895	2.14
Y	12151-005.1	156	97	0.64	0.54	298	7	10281	215	1.1E-4	35	0.19	37.5	0.188	4.8	3.780	1.4	0.2795	1.0	0.706	0.0981	1.0	1589	14	1588	19	-0	1588.68	22.52	0.00	0.97	17.33	0.895	2.14
Y	12151-094.1	183	107	0.61	0.51	522	20	8953	187	8.0E-5	35	0.14	43.6	0.186	2.6	3.857	1.8	0.2773	1.0	0.567	0.1009	1.5	1578	14	1640	27	+4	1590.21	25.17	4.15	0.04	17.33	0.895	2.14
Y	12151-012.1	225	123	0.57	0.48	300	7	10445	219	8.6E-5	33	0.15	53.7	0.177	2.6	3.788	1.2	0.2785	0.9	0.781	0.0987	0.8	1584	13	1599	14	+1	1590.65	19.46	0.61	0.43	17.33	0.895	2.14
Y	12151-103.1	323	174	0.56	0.38	551	19	9516	346	4.5E-5	35	0.08	78.4	0.170	4.6	3.833	1.0	0.2825	0.9	0.857	0.0984	0.5	1604	13	1594	10	-1	1598.13	15.94	0.36	0.55	17.33	0.895	2.14
Y	12151-091.1	155	74	0.49	0.57	229	5	9723	203	1.2E-5	100	0.02	37.4	0.155	3.0	3.828	1.2	0.2798	1.0	0.799	0.0992	0.7	1590	14	1609	14	+1	1599.76	19.58	0.95	0.33	17.33	0.895	2.14
Y	12151-087.1	138	46	0.34	0.75	549	12	10836	227	7.3E-5	45	0.13	33.6	0.114	4.0	3.845	1.4	0.2833	1.0	0.743	0.0984	0.9	1608	14	1595	17	-1	1602.50	22.02	0.33	0.57	17.33	0.895	2.14
Y	12151-041.1	371	169	0.47	0.40	569	13	10528	220	1.7E-5	58	0.03	88.6	0.144	2.1	3.823	1.0	0.2780	0.9	0.872	0.0997	0.5	1581	12	1619	9	+3	1604.88	15.21	5.72	0.02	17.33	0.895	2.14
Y	12151-110.1	284	174	0.63	0.38	355	14	9694	202	2.0E-5	58	0.03	68.6	0.184	2.0	3.845	1.1	0.2806	0.9	0.855	0.0994	0.5	1594	13	1613	10	+1	1605.29	16.23	1.28	0.26	17.33	0.895	2.14
Y	12151-074.1	454	149	0.34	18.90	477	11	11721	244	2.0E-5	45	0.04	111.9	0.101	15.2	3.927	1.0	0.2868	0.9	0.892	0.0993	0.4	1626	13	1611	8	-1	1615.82	14.32	0.86	0.35	17.33	0.895	2.14
Y	12151-097.1	149	54	0.38	0.63	784	18	12038	251	7.7E-5	38	0.13	36.8	0.108	3.6	3.935	1.2	0.2873	1.0	0.772	0.0993	0.8	1628	14	1612	15	-1	1620.55	20.33	0.65	0.42	17.33	0.895	2.14
Y	12151-051.1	200	62	0.32	0.71	611	14	11385	239	7.7E-5	38	0.13	49.4	0.095	8.5	3.967	1.3	0.2870	1.0	0.765	0.1003	0.8	1627	14	1629	15	+0	1627.59	20.58	0.01	0.91	17.33	0.895	2.14
Y	12151-098.1	101	87	0.89	0.57	299	14	9482	198	9.7E-5	45	0.17	24.9	0.268	2.9	3.972	1.5	0.2867	1.1	0.704	0.1005	1.1	1625	15	1633	20	+1	1627.91	24.56	0.11	0.74	17.33	0.895	2.14
Y	12151-058.1	348	287	0.85	0.30	684	15	9836	205	3.3E-5	38	0.06	85.7	0.251	3.4	3.972	1.0	0.2871	0.9	0.879	0.1003	0.5	1627	13	1630	9	+0	1629.14	14.87	0.04	0.84	17.33	0.895	2.14
Y	12151-046.1	43	29	0.71	1.01	222	5	9340	196	2.0E-4	50	0.35	10.6	0.211	5.5	3.927	2.5	0.2910	1.4	0.564	0.0979	2.1	1646	20	1584	38	-4	1632.02	35.71	2.06	0.15	17.33	0.895	2.14
Y	12151-096.1	145	123	0.88	0.47	315	7	10367	335	6.6E-5	45	0.11	35.9	0.262	2.4	4.006	1.3	0.2889	1.0	0.761	0.1006	0.8	1636	14	1635	16	-0	1635.49	21.28	0.00	0.97	17.33	0.895	2.14
Y	12151-026.1	113	67	0.61	0.58	239	8	10282	279	8.8E-5	41	0.15	28.1	0.176	3.2	4.013	1.4	0.2890	1.0	0.737	0.1007	0.9	1636	15	1637	17	+0	1636.82	22.38	0.00	0.96	17.33	0.895	2.14
Y	12151-016.1	803	898	1.16	0.42	3061	485	11200	368	1.8E-4	18	0.31	180.7	0.312	1.5	3.945	1.1	0.2621	0.9	0.825	0.1092	0.6	1500	12	1786	11	+18	1645.40	17.61	298.67	0.00	17.33	0.895	2.14
Y	12151-023.1	248	175	0.73	0.42	589	14	10021	301	8.3E-5	32	0.14	60.8	0.222	5.7	4.040	1.2	0.2850	1.0	0.800	0.1028	0.7	1616	14	1676	13	+4	1646.19	19.32	9.63	0.00	17.33	0.895	2.14
Y	12151-079.1	404	228	0.58	2.08	427	10	9552	199	3.2E-5	38	0.06	101.0	0.180	1.7	4.084	1.0	0.2913	0.9	0.882	0.1017	0.5	1648	13	1655	9	+0	1652.49	14.77	0.17	0.68	17.33	0.895	2.14
Y	12151-086.1	266	121	0.47	0.70	519	18	10838	226	5.5E-5	35	0.10	67.4	0.143	2.4	4.170	1.4	0.2951	0.9	0.669	0.1025	1.0	1667	14	1669	19	+0	1667.85	22.06	0.01	0.92	17.33	0.895	2.14
Y	12151-029.1	125	45	0.37	0.80	117	3	10935	229	5.0E-5	58	0.09	33.0	0.107	4.3	4.438	1.4	0.3064	1.0	0.758	0.1051	0.9	1723	16	1715	17	-1	1719.36	22.92	0.11	0.74	17.33	0.895	2.14
Y	12151-025.1	329	136	0.43	0.46	302	7	10787	393	3.0E-5	45	0.05	87.3	0.127	2.3	4.562	1.0	0.3092	0.9	0.868	0.1070	0.5	1737	14	1749	9	+1	1745.00	15.95	0.55	0.46	17.33	0.895	2.14
Y	12151-104.1	170	61	0.37	0.63	297	7	8363	369	8.9E-5	33	0.15	45.9	0.104	3.4	4.718	1.5	0.3139	1.0	0.635	0.1090	1.2	1760	15	1783	21	+1	1767.34	24.37	0.78	0.38	17.33	0.895	2.14
Y	12151-056.1	226	115	0.52	0.49	382	9	11389	238	7.3E-5	33	0.13	61.9	0.158	7.5	4.808	1.1	0.3181	0.9	0.825	0.1096	0.6	1780	15	1793	12	+1	1788.08	18.48	0.47	0.49	17.33	0.895	2.14
Y	12151-106.1	132	138	1.08	0.45	287	20	10263	214	-6.2E-21	9999	0.00	35.9	0.322	2.1	4.891	1.2	0.3176	1.0	0.820	0.1117	0.7	1778	15	1827	13	+3	1806.87	19.81	6.05	0.01	17.33	0.895	2.14
Y	12151-048.1	85	71	0.87	0.65	189	4	8186	314	4.4E-5	71	0.08	23.5	0.254	3.2	4.951	1.5	0.3214	1.1	0.748	0.1117	1.0	1796	17	1828	18	+2	1811.52	25.26	1.56	0.21	17.33	0.895	2.14
Y	12151-057.1	137	67	0.51	0.61	244	13	9004	188	3.6E-5	58	0.06	38.0	0.155	3.0	5.193	2.5	0.3239	1.0	0.397	0.1163	2.3	1809	16	1900	41	+5	1819.15	29.39	4.13	0.04	17.33	0.895	2.14
Y	12151-014.1	167	88	0.55	0.58	266	6	9210	193	1.1E-5	100	0.02	48.7	0.171	2.7	5.441	1.2	0.3404	1.0	0.831	0.1159	0.7	1888	16	1895	12	+0	1892.34	19.28	0.10	0.76	17.33	0.895	2.14
Y	12151-109.1	175	94	0.55	0.50	315	7	10488	414	4.0E-5	45	0.07	51.2	0.165	2.4	5.645	1.1	0.3402	1.0	0.862	0.1203	0.6	1888	16	1961	10	+4	1938.75	17.62	14.86	0.00	17.33	0.895	2.14
Y	12151-078.1	223	87	0.40	0.54	367	8	11263	235	-2.8E-14	9999	0.00	66.6	0.130	4.8	5.834	1.1	0.3476	0.9	0.880	0.1217	0.5	1923	16	1982	9	+3	1965.93	16.03	10.39	0.00	17.33	0.895	2.14
Y	12151-017.1	74	82	1.14	0.63	114	3	10402	331	4.4E-5	71	0.08	24.5	0.329	2.8	7.087	1.5	0.3864	1.2	0.785	0.1330	0.9	2106	21	2138	16	+2	2126.06	25.92	1.44	0.23	17.33	0.895	2.14
Y	12152-060.1	192	83	0.44	0.81	290	10	10326	301	1.3E-4	58	0.23	27.0	0.130	6.6	1.619	2.5	0.1631	1.5	0.603	0.0720	2.0	974	14	986	41	+1	975.13	26.30	0.07	0.79	17.33	0.895	2.14
Y	12152-142.1	174	56	0.33	1.05	207	7	10638	312	2.5E-4	45	0.44	25.6	0.094	9.1	1.737	3.1	0.1715	1.6	0.518	0.0735	2.6	1020	15	1027	53	+1	1020.77	29.01	0.02	0.90	17.33	0.895	2.14
Y	12152-018.1	330	100	0.31	0.77	261	9	11148	326	2.8E-4	30	0.48	51.4	0.092	6.7	1.850	2.8	0.1815	1.4	0.510	0.0739	2.4	1075	14	1039	49	-4	1072.29	27.11	0.52	0.47	17.33	0.895	2.14

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	%com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coeffi cient	204 corr 207*/206 *	%err	204 corr 206*/238 Age	abs. err.	204 corr 207*/206 * Age	abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12152-043.1	79	31	0.40	1.35	196	7	9726	284	3.9E-4	50	0.67	12.5	0.120	11.6	1.881	5.6	0.1832	2.0	0.357	0.0745	5.2	1084	20	1054	105	-3	1083.28	39.03	0.08	0.77	17.33	0.895	2.14
Y	12152-179.1	64	26	0.42	1.53	227	8	9202	270	3.8E-4	58	0.67	10.3	0.120	13.8	1.972	5.2	0.1878	2.0	0.396	0.0762	4.8	1109	21	1099	95	-1	1108.79	40.79	0.01	0.92	17.33	0.895	2.14
Y	12152-046.1	215	111	0.54	0.72	354	13	10290	301	3.0E-4	33	0.52	34.7	0.160	5.5	1.966	2.7	0.1882	1.5	0.557	0.0757	2.2	1112	15	1088	45	-2	1109.27	28.83	0.25	0.61	17.33	0.895	2.14
Y	12152-170.1	146	46	0.33	1.19	226	8	10229	301	4.8E-4	35	0.82	23.9	0.066	14.6	1.946	4.0	0.1904	1.7	0.420	0.0741	3.6	1124	17	1044	73	-8	1118.93	33.50	1.15	0.28	17.33	0.895	2.14
Y	12152-049.1	106	46	0.45	1.08	370	13	10038	293	3.9E-4	41	0.68	17.3	0.093	11.3	1.989	3.9	0.1902	1.7	0.437	0.0758	3.5	1123	18	1090	71	-3	1120.70	34.08	0.21	0.65	17.33	0.895	2.14
Y	12152-189.1	100	43	0.44	1.14	273	10	9952	291	5.2E-4	38	0.90	16.5	0.112	11.4	1.965	4.6	0.1912	1.8	0.391	0.0745	4.2	1128	18	1056	84	-7	1124.22	35.80	0.72	0.40	17.33	0.895	2.14
Y	12152-076.1	244	114	0.48	0.71	316	11	8939	261	6.1E-5	71	0.11	39.7	0.141	5.1	2.076	2.0	0.1896	1.5	0.723	0.0794	1.4	1119	15	1183	28	+6	1132.75	26.79	4.11	0.04	17.33	0.895	2.14
Y	12152-159.1	280	62	0.23	0.95	267	10	11015	322	1.4E-4	45	0.24	46.6	0.063	8.0	2.085	2.1	0.1937	1.4	0.692	0.0781	1.5	1141	15	1149	30	+1	1142.73	27.13	0.05	0.82	17.33	0.895	2.14
Y	12152-188.1	197	68	0.36	0.91	365	13	8892	260	-3.8E-5	100	-0.07	32.7	0.115	6.1	2.110	2.1	0.1939	1.5	0.748	0.0789	1.4	1142	16	1170	27	+3	1149.51	27.84	0.80	0.37	17.33	0.895	2.14
Y	12152-151.1	74	20	0.28	1.68	169	6	7968	234	6.0E-4	41	1.05	12.5	0.065	20.7	2.165	6.3	0.1965	1.9	0.307	0.0799	6.0	1156	20	1195	118	+4	1157.39	40.46	0.10	0.75	17.33	0.895	2.14
Y	12152-056.1	704	174	0.25	0.88	208	7	13604	397	5.3E-5	45	0.09	117.9	0.083	3.9	2.137	1.5	0.1948	1.3	0.870	0.0796	0.8	1147	14	1186	15	+4	1165.05	20.55	3.56	0.06	17.33	0.895	2.14
Y	12152-092.1	160	48	0.31	1.76	236	8	10753	314	2.6E-4	41	0.46	27.7	0.091	8.7	2.153	2.9	0.2016	1.6	0.550	0.0775	2.4	1184	17	1133	48	-5	1177.75	31.77	1.03	0.31	17.33	0.895	2.14
Y	12152-072.1	84	28	0.35	1.37	167	6	11203	327	7.7E-4	32	1.33	14.5	0.070	18.7	2.033	5.5	0.2020	1.8	0.332	0.0730	5.2	1186	20	1013	105	-19	1178.43	38.41	2.88	0.09	17.33	0.895	2.14
Y	12152-057.1	407	125	0.32	0.68	470	17	10003	397	8.8E-5	45	0.15	70.5	0.091	9.0	2.205	1.8	0.2019	1.4	0.788	0.0792	1.1	1185	15	1178	21	-1	1182.84	24.49	0.09	0.77	17.33	0.895	2.14
Y	12152-167.1	172	47	0.28	1.16	157	6	10800	432	4.1E-4	33	0.71	30.0	0.064	13.0	2.146	3.3	0.2033	1.6	0.483	0.0766	2.9	1193	17	1110	58	-8	1185.09	33.13	1.91	0.17	17.33	0.895	2.14
Y	12152-003.1	251	155	0.64	0.59	413	15	9837	287	1.9E-4	35	0.34	43.8	0.183	4.2	2.251	2.2	0.2031	1.4	0.667	0.0804	1.6	1192	16	1206	32	+1	1194.90	28.11	0.16	0.69	17.33	0.895	2.14
Y	12152-141.1	53	32	0.63	1.44	189	7	9944	291	9.7E-4	38	1.68	9.8	0.135	15.5	2.208	7.9	0.2148	2.2	0.280	0.0746	7.5	1254	25	1057	152	-21	1246.91	49.15	1.84	0.18	17.33	0.895	2.14
Y	12152-147.1	213	226	1.10	0.56	372	13	10594	310	2.6E-4	35	0.45	39.3	0.309	5.9	2.436	2.4	0.2146	1.5	0.620	0.0823	1.9	1253	17	1254	37	+0	1253.30	31.17	0.00	0.99	17.33	0.895	2.14
Y	12152-027.1	316	94	0.31	0.81	322	12	9878	290	3.9E-4	24	0.68	58.2	0.081	7.3	2.461	2.3	0.2141	1.4	0.618	0.0834	1.8	1251	16	1278	35	+2	1255.23	29.72	0.49	0.48	17.33	0.895	2.14
Y	12152-154.1	227	77	0.35	0.88	260	9	11163	327	6.4E-5	71	0.11	40.9	0.115	5.8	2.480	2.0	0.2099	1.5	0.757	0.0857	1.3	1228	17	1332	25	+9	1258.00	28.30	12.07	0.00	17.33	0.895	2.14
Y	12152-162.1	143	70	0.51	0.91	432	15	9269	271	2.3E-4	45	0.40	26.4	0.132	7.1	2.488	3.1	0.2149	2.2	0.716	0.0840	2.2	1255	25	1292	42	+3	1264.34	44.04	0.56	0.45	17.33	0.895	2.14
Y	12152-005.1	205	81	0.41	0.81	635	22	11119	325	4.6E-4	25	0.80	38.2	0.120	6.5	2.501	2.7	0.2169	1.5	0.554	0.0836	2.2	1265	17	1284	43	+2	1267.75	31.80	0.17	0.68	17.33	0.895	2.14
Y	12152-093.1	224	52	0.24	1.08	595	21	12818	376	2.2E-4	38	0.39	41.5	0.056	10.1	2.575	2.3	0.2154	1.5	0.653	0.0867	1.7	1257	17	1354	34	+8	1275.56	31.09	6.41	0.01	17.33	0.895	2.14
Y	12152-094.1	140	82	0.60	0.84	410	14	10689	312	3.2E-4	38	0.55	26.4	0.192	5.7	2.533	3.6	0.2199	1.6	0.443	0.0835	3.2	1281	19	1282	63	+0	1281.38	35.67	0.00	0.99	17.33	0.895	2.14
Y	12152-178.1	156	134	0.89	0.71	291	10	10212	299	1.8E-4	50	0.30	29.9	0.278	4.3	2.557	2.5	0.2232	1.6	0.631	0.0831	1.9	1299	19	1271	38	-2	1293.38	33.33	0.42	0.52	17.33	0.895	2.14
Y	12152-095.1	18	27	1.56	1.59	139	5	9143	268	2.9E-3	33	5.01	3.4	0.346	15.8	1.898	26.3	0.2251	3.5	0.133	0.0612	26.1	1309	41	645	560	-114	1299.04	81.68	2.13	0.14	17.33	0.895	2.14
Y	12152-182.1	310	180	0.60	0.59	803	28	8545	250	1.2E-4	41	0.21	59.3	0.190	3.7	2.642	2.2	0.2228	1.4	0.648	0.0860	1.7	1297	17	1338	32	+3	1305.13	29.81	1.30	0.25	17.33	0.895	2.14
Y	12152-160.1	248	111	0.46	0.74	990	35	5021	147	1.9E-4	38	0.32	47.9	0.147	4.9	2.609	2.1	0.2252	1.5	0.690	0.0840	1.5	1310	17	1292	30	-1	1305.17	29.85	0.25	0.62	17.33	0.895	2.14
Y	12152-169.1	99	35	0.36	1.42	215	8	10338	304	4.8E-4	41	0.83	19.2	0.106	11.9	2.583	4.2	0.2263	1.8	0.434	0.0828	3.8	1315	22	1264	74	-4	1310.74	41.71	0.45	0.50	17.33	0.895	2.14
Y	12152-175.1	97	55	0.58	1.03	271	10	10692	313	1.0E-3	24	1.73	20.1	0.155	9.4	2.719	4.9	0.2407	1.8	0.362	0.0819	4.5	1390	22	1244	89	-13	1379.92	42.22	2.74	0.10	17.33	0.895	2.14
Y	12152-052.1	67	80	1.23	0.93	305	11	9386	275	8.8E-4	32	1.52	14.0	0.342	6.3	2.912	5.3	0.2421	2.0	0.370	0.0872	4.9	1398	25	1366	95	-3	1395.63	47.53	0.11	0.74	17.33	0.895	2.14
Y	12152-145.1	106	32	0.31	1.38	218	8	10939	321	6.2E-4	30	1.08	22.7	0.064	16.0	3.076	4.5	0.2491	1.7	0.387	0.0896	4.1	1434	22	1416	79	-1	1432.46	42.99	0.05	0.83	17.33	0.895	2.14
Y	12152-173.1	113	46	0.41	1.18	265	10	8580	252	3.4E-4	41	0.59	24.2	0.113	9.1	3.183	3.0	0.2479	1.7	0.563	0.0931	2.5	1428	22	1490	47	+5	1438.11	39.96	1.41	0.23	17.33	0.895	2.14
Y	12152-174.1	51	23	0.48	1.63	373	13	7923	232	1.4E-3	29	2.44	11.1	0.092	22.1	2.637	8.6	0.2546	2.2	0.254	0.0751	8.4	1462	29	1072	168	-41	1442.96	55.70	6.51	0.01	17.33	0.895	2.14
Y	12152-036.1	121	89	0.75	0.83	268	10	10669	312	1.9E-4	50	0.33	25.7	0.227	5.0	3.211	2.5	0.2465	1.6	0.654	0.0945	1.9	1420	21	1518	35	+7	1443.25	36.54	5.55	0.02	17.33	0.895	2.14
Y	12152-075.1	103	69	0.69	0.95	287	10	8421	246	3.6E-4	41	0.62	21.9	0.174	7.0	3.284	3.1	0.2480	1.7	0.560	0.0961	2.5	1428	22	1549	48	+9	1446.49	40.71	5.14	0.02	17.33	0.895	2.14
Y	12152-084.1	201	127	0.65	0.69	197	11	11954	356	5.7E-5	71	0.10	43.4	0.195	4.1	3.174	1.9	0.2506	1.5	0.793	0.0919	1.1	1441	19	1465	22	+2	1451.42	28.92	0.64	0.42	17.33	0.895	2.14
Y	12152-096.1	291	90	0.32	0.79	191	7	12176	356	2.0E-4	32	0.34	61.6	0.083	6.1	3.207	1.9	0.2469	1.4	0.758	0.0942	1.2	1423	18	1512	23	+7	1455.51	28.99	9.41	0.00	17.33	0.895	2.14
Y	12152-032.1	167	77	0.48	0.87	316	11	11493	336	1.4E-4	50	0.24	36.0	0.129	5.8	3.211	2.1	0.2505	1.5	0.721	0.0930	1.5	1441	20	1487	28	+3	1456.04	32.67	1.81	0.18	17.33	0.895	2.14
Y	12152-012.1	156	81	0.54	0.82	365	13	9502	277	1.7E-4	45	0.29	34.2	0.152	5.3	3.220	2.7	0.2560	1.5	0.567	0.0912	2.2	1469	20	1452	42	-1	1465.92	36.18	0.14	0.70	17.33	0.895	2.14
Y	12152-181.1	188	123	0.68	0.71	366	13	9918	456	9.3E-5	58	0.16	41.1	0.197	4.3	3.241	2.0	0.2549	1.5	0.757	0.0922	1.3	1464	20	1472	25	+1	1466.94	30.91	0.08	0.78	17.33	0.895	2.14
Y	12152-058.1	134	61	0.47	1.00	202	7	10985	321	2.7E-4	41	0.47	29.2	0.128	7.3	3.309	2.6	0.2529	1.6	0.622	0.0949	2.0	1453	21	1526	38	+5	1469.14	37.42	2.72	0.10	17.33	0.895	2.14
Y	12152-042.1	144	56	0.40	1.02	424	15	10934	320	4.6E-4	29	0.80	31.8	0.103	8.3	3.229	2.8	0.2568	1.6	0.558	0.0912	2.4	1473	21	1451	45	-2	1469.36	37.64	0.21	0.65	17.33	0.895	2.14
Y	12152-066.1	344	61	0.18	0.89	152	6	10200	298	1.4E-4	33	0.24	73.6	0.050	13.2	3.242	1.7	0.2494	1.4	0.817	0.0943	1.0	1435	18	1514	18	+6	1472.39	25.90	9.61	0.00	17.33	0.895	2.14
Y	12152-040.1	138	49	0.37	1.09	241	9	10097	295	8.7E-5	71	0.15	30.1	0.096	7.8	3.283	2.2	0.2543	1.6	0.731	0.0936	1.5	1461	21	1500	28	+3	1474.46	33.85	1.26	0.26	17.33	0.895	2.14
Y	12152-180.1	361	111	0.32	0.72	291	10	12658	370	7.9E-5	45	0.14	78.9	0.099	4.4	3.274	1.6	0.2541	1.4	0.842	0.0934	0.9	1460	18	1497	17	+3	1479.38	24.85	2.24	0.13	17.33	0.895	2.14
Y	12152-087.1	144	83	0.60	0.86	387	23	8527	250	1.6E-4	50	0.28	31.3	0.193	5.2	3.431	2.3	0.2523	1.6	0.702	0.0986	1.6	1450	21	1599	30	+10	1493.45	34.97	16.68	0.00	17.33	0.895	2.14
Y	12152-017.1	276	120	0.45	0.74	533	19	10505	309	2.7E-4	26	0.47	62.2	0.124	4.9	3.339	3.1	0.2617	1.9	0.615	0.0925	2.5	1499	26	1478	47	-2	1493.83	44.82	0.15	0.70	17.33	0.895	2.14
Y	12152-062.1	348	166	0.49	0.56	310	11	11286	329	4.2E-5	58	0.07	76.4	0.144	3.4	3.327	1.6	0.2557	1.4	0.873	0.0944	0.8	1468	18	1515	14	+3	1496.41	22.76	4.20	0.04	17.33	0.895	2.14
Y	12152-050.1	134	65	0.51	0.92	261	9	10489	306	8.1E-5	71	0.14	29.6	0.145	5.8	3.376	2.1	0.2580	1.6	0.745	0.0949	1.4	1479	21	1526	27	+3	1496.82	33.27	1.90	0.17	17.33	0.895	2.14
Y	12152-067.1	101	74	0.76	0.89	201	7	10485	306	1.1E-4	71	0.19	22.3	0.236	5.2	3.402	2.4	0.2571	1.7	0.700	0.0960	1.7	1475	22	1547	32	+5	1497.24	36.92	3.46	0.06	17.33	0.895	2.14
Y	12152-063.1	155	55	0.37	1.01	206	7	10451	305	2.5E-4	38	0.43	34.9	0.099	7.5	3.468	2.3	0.2623	1.6	0.664	0.0959	1.7	1502	21	1545	33	+3	1513.84	35.52	1.23	0.27	17.33	0.895	2.14
Y	12152-078.1	52	44	0.87	1.18	384	14	11410	333	5.9E-4	41	1.03	12.0	0.248	7.8	3.457	4.6	0.2700	2.0	0.443	0.0928	4.1	1541	28	1485	78	-4	1534.13	52.25	0.47	0.49	17.33	0.895	2.14
Y	12152-054.1	116	46	0.41	1.10	219	13	10249	299	1.8E-4	50	0.32	26.7	0.122	7.0	3.634	2.9	0.2665	1.6	0.569	0.0989	2.4	1523	22	1604	44	+6	1537.95	40.30	2.62	0.11	17.33	0.895	2.14
Y	12152-070.1	134	228	1.75	0.57	488	17	9573	280	4.1E-5	100	0.07	30.5	0.530	3.0	3.547	2.0	0.2642	1.6	0.780	0.0974	1.3	1512	21	1574	24	+4	1538.96	32.29	3.84	0.05	17.33	0.895	2.14
Y	12152-088.1	187	125	0.69	0.71	326	12	9757	285	2.4E-4	35	0.42	42.6	0.198	8.3	3.583	2.2	0.2661	1.5	0.697	0.0977	1.6	1521	20	1580	29	+4	1539.65	33.88	2.77	0.10	17.33	0.895	2.14
Y	12152-085.1	176	82	0.48	0.85	340	12	11842	346	1.8E-4	41	0.32	41.2	0.143	5.3	3.622	2.1	0.2720	1.5	0.718	0.0966	1.5	1551	21	1559	28	+1	1553.86	33.46	0.06	0.80	17.33	0.895	2.14
Y	12152-144.1	331	52	0.16	1.08	874	31	12595	369	1.4E-4	35	0.24	79.0	0.043	8.3	3.655	1.7	0.2779	1.4	0.806	0.0954	1.0	1581	20	1536	19	-3	1557.93	27.65	2.58	0.11	17.33	0.895	2.14
Y	12152-183.1	180	88	0.51	0.80	235	8	10536	308	1.1E-4	50	0.20	41.9	0.158	4.7	3.670	1.9	0.2709	1.5	0.771	0.0982	1.2	1546	21	1591	23	+3	1565.20	31.10	2.13	0.14	17.33	0.895	2.14
Y	12152-029.1	83	48	0.59	1.19	217	12	9410	276	2.9E-4	50	0.50	19.4	0.158	8.1	3.720	3.1	0.2729	1.8	0.589	0.0989	2.5	1556	25	1603	47	+3	1565.82	45.13	0.78	0.38	17.33	0.895	2.14
Y	12152-166.1	107	73	0.70	0.88	242	9	10009	292	9.3E-5	71	0.16	24.8	0.179	5.6	3.693	2.2	0.2696	1.6	0.736	0.0993	1.5	1539	22	1612	28	+5	1566.35	35.55	4.11	0.04	17.33	0.895	2.14
Y	12152-019.1	305	49	0.17	1.01	171	6	11851	446	4.7E-5	58	0.08	72.0	0.046	6.7	3.680	1.9	0.2750	1.4	0.723	0.0971	1.3	1566	19	1569	25	+0	1566.98	30.59	0.01	0.94	17.33	0.895	2.14
Y	12152-176.1	247	100	0.42	0.78	257	9	10187	298	2.9E-4	28	0.50	58.8	0.113	5.5	3.687	2.1	0.2774	1.4	0.699	0.0964	1.5	1578	20	1555	28	-2	1570.34	32.66	0.46	0.50	17.33	0.895	2.14
Y	12152-074.1	202	58	0.29	0.94	182	7	12364	361	1.7E-4	38	0.29	47.8	0.073	6.9	3.704	1.9	0.2751	1.5	0.761	0.0977	1.2	1567	20	1580	23	+1	1572.22	30.74	0.18	0.67	17.33	0.895	2.14
Y	12152-068.1	105	78	0.77	0.88	177	6	9174	268	2.5E-4	45	0.43	24.9	0.208	5.6	3.757	2.6	0.2752	1.7	0.638	0.0990	2.0	1567	23	1605	38	+3	1577.59	39.80	0.74	0.39	17.33	0.895	2.14
Y	12152-161.1	93	45	0.50	1.13	319	11	8696	254	1.7E-4	58	0.29	22.2	0.152	7.0	3.866	2.5	0.2766	1.7	0.679	0.1014	1.8	1574	24	1649	34	+5	1597.77	39.79	3.17	0.07	17.33	0.895	2.14
Y	12152-038.1	144	58	0.41	1.00	153	6	9692	284	2.2E-4	41	0.39	34.0	0.118	6.6	3.895	2.3	0.2754	1.6	0.694	0.1026	1.6	1568	22	1671	30	+7	1601.75	36.18	7.58	0.01	17.33	0.895	2.14
Y	12152-065.1	512	395	0.80	0.41	794	28	9554	280	2.1E-5	71	0.04	117.9	0.219	2.3	3.705	1.5	0.2678	1.3	0.912	0.1004	0.6	1529	18	1631	11	+7	1602.66	19.27	22.50	0.00	17.33	0.895	2.14
Y	12152-083.1	496	112	0.23	0.71	287	10	12231	358	7.4E-5	38	0.13	118.8	0.069	4.5	3.826	1.5	0.2789	1.3	0.890	0.0995	0.7	1586	19	1615	13	+2	1605.28	21.51	1.60	0.21	17.33	0.895	2.14
Y	12152-008.1	254	126	0.51	0.66	377	13	8371	244	1.1E-4	41	0.19	62.9	0.143	4.0	3.930	1.7	0.2884	1.5	0.831	0.0988	1.0	1634	21	1602	18	-2	1615.88	27.52	1.24	0.27	17.33	0.895	2.14

Appendix 5. 2016ODEN U-Pb zircon data.

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	*Yb ppm*	*1σ abs err*	*Hf ppm*	*1σ abs err*	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206 *	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206 * Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12152-044.1	85	44	0.53	1.23	182	7	9377	276	5.5E-4	35	0.96	21.1	0.132	9.8	3.812	3.7	0.2876	1.8	0.492	0.0961	3.3	1630	26	1550	61	-6	1616.06	48.01	1.46	0.23	17.33	0.895	2.14
Y	12152-187.1	145	95	0.67	0.78	242	9	10905	319	1.7E-4	45	0.30	35.1	0.215	4.4	3.950	2.1	0.2811	1.5	0.728	0.1019	1.5	1597	22	1659	27	+4	1620.99	34.46	3.24	0.07	17.33	0.895	2.14
Y	12152-082.1	188	122	0.67	0.69	396	14	9646	282	2.0E-4	35	0.34	46.2	0.203	4.3	4.015	2.0	0.2861	1.5	0.752	0.1018	1.3	1622	21	1657	24	+2	1636.93	32.07	1.17	0.28	17.33	0.895	2.14
Y	12152-079.1	109	68	0.64	0.95	215	8	10126	296	4.6E-4	32	0.79	26.9	0.179	6.4	4.114	2.8	0.2871	1.7	0.592	0.1039	2.3	1627	24	1695	42	+5	1643.05	42.08	1.98	0.16	17.33	0.895	2.14
Y	12152-053.1	304	177	0.60	1.03	337	12	10753	314	1.1E-4	38	0.19	73.1	0.175	3.4	3.991	1.7	0.2799	1.4	0.843	0.1034	0.9	1591	20	1686	16	+6	1646.37	25.56	13.99	0.00	17.33	0.895	2.14
Y	12152-184.1	407	260	0.66	0.49	522	27	11502	336	1.4E-4	29	0.24	103.1	0.199	4.8	4.256	1.6	0.2950	1.4	0.865	0.1046	0.8	1666	20	1708	15	+3	1693.31	23.74	2.85	0.09	17.33	0.895	2.14
Y	12152-185.1	275	146	0.55	0.64	545	19	10659	312	1.2E-4	38	0.21	70.4	0.162	3.6	4.311	1.7	0.2976	1.4	0.836	0.1051	0.9	1679	21	1716	17	+2	1700.83	26.71	1.80	0.18	17.33	0.895	2.14
Y	12152-186.1	166	79	0.49	0.85	267	10	8200	240	2.3E-4	35	0.40	43.1	0.148	5.1	4.404	2.1	0.3027	1.5	0.735	0.1055	1.4	1705	23	1724	26	+1	1712.84	34.19	0.30	0.58	17.33	0.895	2.14
Y	12152-055.1	66	51	0.80	1.07	236	8	8871	259	4.6E-4	38	0.79	17.7	0.211	6.8	4.365	3.3	0.3111	1.8	0.553	0.1018	2.8	1746	28	1656	51	-6	1724.03	48.70	2.37	0.12	17.33	0.895	2.14
Y	12152-069.1	485	108	0.23	0.72	233	8	10618	311	1.0E-5	100	0.02	124.1	0.069	4.0	4.384	1.5	0.2981	1.3	0.925	0.1066	0.6	1682	20	1743	10	+4	1729.81	18.32	7.38	0.01	17.33	0.895	2.14
Y	12152-034.1	121	71	0.60	0.94	241	14	11524	337	1.3E-4	58	0.22	31.0	0.175	5.6	4.541	2.2	0.2977	1.6	0.747	0.1106	1.4	1680	24	1810	26	+8	1737.00	36.36	13.37	0.00	17.33	0.895	2.14
Y	12152-081.1	533	242	0.47	0.52	357	13	10211	299	1.0E-5	100	0.02	133.3	0.141	2.8	4.363	1.5	0.2912	1.3	0.924	0.1087	0.6	1648	20	1777	10	+8	1749.20	18.02	35.09	0.00	17.33	0.895	2.14
Y	12152-168.1	135	60	0.46	1.03	462	16	10827	317	3.0E-4	35	0.51	36.2	0.114	10.8	4.681	2.6	0.3109	1.6	0.604	0.1092	2.1	1745	24	1786	38	+3	1756.53	41.58	0.83	0.36	17.33	0.895	2.14
Y	12152-014.1	349	153	0.45	0.85	343	23	10258	309	6.6E-4	42	1.15	94.5	0.118	10.0	5.008	4.5	0.3153	1.6	0.348	0.1152	4.2	1767	24	1883	76	+7	1775.81	46.37	2.04	0.15	17.33	0.895	2.14
Y	12152-165.1	217	25	0.12	1.65	504	18	12649	372	4.8E-5	71	0.08	60.0	0.035	10.1	4.979	1.8	0.3224	1.5	0.845	0.1120	0.9	1801	23	1832	17	+2	1821.30	27.92	1.12	0.29	17.33	0.895	2.14
Y	12152-051.1	223	127	0.59	0.69	491	17	9884	366	5.9E-5	58	0.10	62.6	0.167	3.7	5.096	1.7	0.3263	1.4	0.864	0.1133	0.8	1820	23	1853	15	+2	1842.49	25.67	1.37	0.24	17.33	0.895	2.14
Y	12153-015.1	77	34	0.45	0.85	79	2	9965	208	-3.8E-5	100	-0.07	12.2	0.141	5.6	1.981	1.9	0.1841	1.2	0.618	0.0781	1.5	1089	12	1148	30	+6	1096.85	22.65	3.15	0.08	17.33	0.895	2.14
Y	12153-040.1	685	99	0.15	0.48	60	2	9936	207	4.1E-6	100	0.01	108.1	0.047	3.1	1.933	2.0	0.1837	2.0	0.974	0.0763	0.5	1087	20	1104	9	+2	1100.65	17.09	0.56	0.45	17.33	0.895	2.14
Y	12153-002.1	156	50	0.33	0.72	286	7	11124	233	9.3E-5	45	0.16	26.3	0.097	5.0	2.094	1.6	0.1967	1.0	0.638	0.0772	1.2	1158	11	1127	25	-3	1152.50	19.91	1.29	0.26	17.33	0.895	2.14
Y	12153-021.1	561	804	1.48	0.21	589	22	7771	162	2.2E-5	45	0.04	98.2	0.455	1.1	2.236	1.0	0.2037	0.9	0.870	0.0796	0.5	1195	10	1187	10	-1	1191.28	13.96	0.38	0.54	17.33	0.895	2.14
Y	12153-004.1	225	75	0.34	0.57	244	6	10576	221	2.2E-5	71	0.04	41.0	0.107	3.4	2.400	3.0	0.2123	2.9	0.965	0.0820	0.8	1241	32	1245	15	+0	1244.63	27.79	0.02	0.90	17.33	0.895	2.14
Y	12153-070.1	373	93	0.26	0.49	329	8	10701	528	3.1E-5	45	0.05	68.6	0.076	3.1	2.444	1.1	0.2143	0.9	0.830	0.0827	0.6	1252	10	1262	12	+1	1256.16	15.41	0.45	0.50	17.33	0.895	2.14
Y	12153-018.1	149	48	0.34	0.70	370	15	10913	228	1.3E-4	35	0.22	28.2	0.103	4.6	2.568	1.5	0.2210	1.0	0.658	0.0843	1.2	1287	12	1299	22	+1	1289.53	20.89	0.23	0.63	17.33	0.895	2.14
Y	12153-054.1	103	56	0.56	0.65	169	4	10090	476	1.3E-4	41	0.22	19.9	0.166	4.0	2.601	1.7	0.2257	1.1	0.626	0.0836	1.3	1312	13	1283	26	-2	1306.03	22.79	0.99	0.32	17.33	0.895	2.14
Y	12153-027.1	329	90	0.28	0.50	297	19	11866	484	5.3E-5	35	0.09	63.7	0.087	3.1	2.644	1.1	0.2255	0.9	0.817	0.0850	0.6	1311	11	1316	12	+0	1313.22	16.38	0.10	0.75	17.33	0.895	2.14
Y	12153-024.1	70	49	0.72	0.86	217	10	8152	170	7.7E-4	26	1.34	13.5	0.163	7.9	2.879	3.7	0.2262	1.4	0.373	0.0923	3.5	1315	17	1474	66	+12	1321.94	32.58	5.03	0.02	17.33	0.895	2.14
Y	12153-052.1	126	94	0.77	0.48	207	5	9386	198	3.1E-5	71	0.05	25.2	0.243	2.7	2.812	1.3	0.2332	1.0	0.740	0.0874	0.9	1351	12	1370	17	+2	1357.38	20.12	0.76	0.38	17.33	0.895	2.14
Y	12153-006.1	179	94	0.54	4.41	424	10	9471	198	1.2E-5	100	0.02	37.5	0.181	2.8	2.986	1.2	0.2439	1.0	0.782	0.0888	0.8	1407	12	1399	15	-1	1404.08	18.90	0.16	0.69	17.33	0.895	2.14
Y	12153-034.1	234	90	0.40	4.73	293	13	10768	225	1.4E-4	25	0.25	48.6	0.113	3.2	3.008	1.3	0.2421	0.9	0.737	0.0901	0.8	1397	12	1428	16	+2	1407.68	19.11	2.36	0.12	17.33	0.895	2.14
Y	12153-013.1	129	40	0.32	0.77	198	5	10914	290	8.1E-5	45	0.14	28.4	0.095	4.8	3.299	1.4	0.2562	1.0	0.713	0.0934	1.0	1471	13	1495	19	+2	1478.62	22.07	1.11	0.29	17.33	0.895	2.14
Y	12153-059.1	91	55	0.62	0.74	273	6	10890	228	1.6E-4	41	0.28	20.3	0.182	4.3	3.307	1.9	0.2593	1.1	0.611	0.0925	1.5	1486	15	1478	28	-1	1484.20	26.72	0.07	0.79	17.33	0.895	2.14
Y	12153-035.1	127	54	0.44	0.68	528	12	7382	256	7.8E-5	45	0.14	28.6	0.137	3.8	3.378	1.4	0.2619	1.0	0.719	0.0936	1.0	1499	14	1499	19	-0	1499.39	22.20	0.00	1.00	17.33	0.895	2.14
Y	12153-081.1	122	21	0.17	0.99	149	3	10501	322	2.9E-5	71	0.05	27.8	0.055	5.7	3.400	1.3	0.2650	1.0	0.761	0.0930	0.9	1515	14	1489	16	-2	1504.51	20.74	1.56	0.21	17.33	0.895	2.14
Y	12153-058.1	479	209	0.45	0.34	388	9	11339	590	1.6E-5	50	0.03	108.3	0.135	1.8	3.408	1.0	0.2633	0.9	0.894	0.0939	0.4	1507	12	1506	8	-0	1505.95	13.78	0.00	0.95	17.33	0.895	2.14
Y	12153-085.1	671	252	0.39	0.30	364	8	12182	254	3.2E-5	29	0.06	152.4	0.117	2.7	3.425	0.9	0.2642	0.8	0.916	0.0940	0.4	1511	11	1509	7	-0	1509.43	12.45	0.04	0.85	17.33	0.895	2.14
Y	12153-074.1	469	137	0.30	0.40	314	7	12172	253	2.7E-5	38	0.05	106.8	0.088	2.2	3.479	1.0	0.2652	0.9	0.893	0.0952	0.4	1516	12	1531	8	+1	1525.82	13.79	1.04	0.31	17.33	0.895	2.14
Y	12153-063.1	199	144	0.75	0.41	527	17	8719	319	2.7E-5	58	0.05	46.1	0.217	2.2	3.529	1.1	0.2698	0.9	0.815	0.0949	0.7	1540	13	1526	13	-1	1532.65	18.04	0.57	0.45	17.33	0.895	2.14
Y	12153-057.1	71	31	0.46	0.84	199	5	8450	176	1.2E-4	45	0.22	16.5	0.137	4.9	3.582	1.7	0.2700	1.1	0.648	0.0962	1.3	1541	15	1552	25	+1	1543.96	26.36	0.13	0.72	17.33	0.895	2.14
Y	12153-053.1	137	131	0.99	0.48	411	9	9211	192	1.5E-4	30	0.26	32.4	0.278	2.8	3.586	2.4	0.2765	1.1	0.475	0.0941	2.1	1574	16	1510	40	-5	1564.24	29.55	2.23	0.14	17.33	0.895	2.14
Y	12153-016.1	127	90	0.73	0.55	276	19	8466	177	1.1E-4	38	0.18	30.7	0.212	2.9	3.689	1.4	0.2813	1.0	0.710	0.0951	1.0	1598	14	1531	19	-5	1572.86	22.80	7.66	0.01	17.33	0.895	2.14
Y	12153-017.1	167	105	0.65	0.77	370	8	9049	602	6.2E-5	45	0.11	38.9	0.221	2.6	3.673	4.2	0.2717	4.1	0.969	0.0981	1.0	1549	56	1588	19	+3	1583.54	36.43	0.42	0.51	17.33	0.895	2.14
Y	12153-069.1	385	267	0.72	0.31	492	15	10343	476	4.5E-5	32	0.08	93.6	0.216	3.3	3.790	1.0	0.2828	0.9	0.876	0.0972	0.5	1606	12	1571	9	-2	1583.69	14.94	4.85	0.03	17.33	0.895	2.14
Y	12153-060.1	129	47	0.37	0.69	209	8	11167	313	8.1E-5	41	0.14	31.2	0.110	3.9	3.786	1.3	0.2804	1.0	0.746	0.0979	0.9	1593	14	1585	17	-1	1589.88	21.49	0.15	0.69	17.33	0.895	2.14
Y	12153-083.1	91	43	0.49	0.72	248	6	10362	315	1.8E-5	100	0.03	21.9	0.143	6.2	3.792	1.4	0.2813	1.1	0.753	0.0978	0.9	1598	15	1582	17	-1	1591.20	22.61	0.45	0.50	17.33	0.895	2.14
Y	12153-028.1	134	52	0.41	0.66	481	11	8550	178	1.3E-4	32	0.23	32.4	0.122	3.8	3.789	1.4	0.2821	1.0	0.715	0.0974	1.0	1602	14	1575	18	-2	1591.91	22.27	1.31	0.25	17.33	0.895	2.14
Y	12153-077.1	145	63	0.45	0.60	250	6	9498	198	9.7E-5	35	0.17	34.6	0.123	3.5	3.798	1.3	0.2782	1.0	0.753	0.0990	0.9	1582	14	1606	16	+2	1592.07	21.42	1.15	0.28	17.33	0.895	2.14
Y	12153-008.1	20	19	1.00	1.15	109	3	7364	228	8.0E-4	33	1.39	4.9	0.262	7.4	3.621	4.9	0.2846	1.8	0.357	0.0923	4.6	1614	25	1473	88	-11	1601.36	47.87	2.55	0.11	17.33	0.895	2.14
Y	12153-042.1	195	187	0.99	0.38	490	11	9826	401	3.8E-5	50	0.07	47.7	0.298	1.9	3.901	1.2	0.2850	0.9	0.811	0.0992	0.7	1617	13	1610	13	-0	1613.22	18.63	0.12	0.72	17.33	0.895	2.14
Y	12153-009.1	143	77	0.56	0.56	143	7	11193	516	1.4E-4	30	0.24	35.1	0.169	3.1	3.899	1.4	0.2861	1.0	0.727	0.0988	0.9	1622	14	1602	17	-1	1614.33	21.88	0.76	0.38	17.33	0.895	2.14
Y	12153-067.1	72	31	0.44	0.83	129	3	10391	216	1.1E-4	45	0.20	17.9	0.132	4.6	3.903	1.6	0.2883	1.1	0.675	0.0982	1.2	1633	16	1590	23	-3	1618.45	25.91	2.38	0.12	17.33	0.895	2.14
Y	12153-014.1	97	50	0.53	0.71	306	7	8559	179	9.6E-5	45	0.17	24.0	0.157	3.8	3.965	1.5	0.2873	1.1	0.705	0.1001	1.1	1628	15	1625	20	-0	1627.22	24.46	0.01	0.91	17.33	0.895	2.14
Y	12153-011.1	316	123	0.40	0.46	343	8	11199	234	4.3E-5	38	0.08	78.7	0.120	2.5	3.995	1.1	0.2902	0.9	0.847	0.0998	0.6	1643	13	1621	10	-2	1629.96	16.58	1.59	0.21	17.33	0.895	2.14
Y	12153-061.1	83	13	0.16	1.25	45	1	11173	232	4.2E-5	71	0.07	20.2	0.057	6.9	3.991	1.5	0.2834	1.1	0.734	0.1022	1.0	1608	15	1664	19	+4	1630.30	24.04	5.22	0.02	17.33	0.895	2.14
Y	12153-036.1	418	347	0.86	0.28	417	20	10465	218	2.6E-5	41	0.05	102.7	0.250	1.4	4.030	1.0	0.2862	0.9	0.891	0.1021	0.4	1623	12	1663	8	+3	1649.95	14.18	7.04	0.01	17.33	0.895	2.14
Y	12153-010.1	178	117	0.68	0.48	358	8	9040	284	4.1E-5	50	0.07	44.7	0.198	2.5	4.118	1.2	0.2925	1.0	0.804	0.1021	0.7	1654	14	1663	13	+1	1658.70	19.28	0.23	0.63	17.33	0.895	2.14
Y	12153-087.1	308	173	0.58	0.38	1492	33	10563	220	4.8E-5	33	0.08	80.6	0.181	1.8	4.270	1.0	0.3048	0.9	0.863	0.1016	0.5	1715	13	1653	10	-4	1675.70	16.03	13.25	0.00	17.33	0.895	2.14
Y	12153-076.1	379	217	0.59	0.33	381	9	11427	238	5.5E-5	28	0.10	95.7	0.176	1.7	4.203	1.0	0.2939	0.9	0.882	0.1037	0.5	1661	13	1692	9	+2	1681.43	14.67	3.78	0.05	17.33	0.895	2.14
Y	12153-078.1	154	74	0.50	0.59	225	5	11000	298	-8.4E-14	9999	0.00	39.8	0.140	2.9	4.290	1.2	0.3001	1.0	0.828	0.1037	0.6	1692	14	1691	12	-0	1691.24	18.54	0.00	0.95	17.33	0.895	2.14
Y	12153-020.1	191	231	1.25	0.38	446	19	8143	170	4.3E-5	50	0.07	49.3	0.364	1.9	4.410	1.2	0.3010	1.0	0.818	0.1063	0.7	1696	15	1736	13	+3	1718.73	20.02	3.94	0.05	17.33	0.895	2.14
Y	12153-075.1	287	269	0.97	0.46	515	33	10528	219	2.2E-5	50	0.04	75.5	0.283	1.5	4.489	1.1	0.3064	1.0	0.894	0.1063	0.5	1723	15	1736	9	+1	1732.31	15.71	0.57	0.45	17.33	0.895	2.14
Y	12153-029.1	69	41	0.61	0.79	183	13	9883	466	7.6E-5	58	0.13	18.2	0.185	4.0	4.541	1.6	0.3095	1.2	0.707	0.1064	1.2	1738	18	1739	21	+0	1738.47	27.06	0.00	0.98	17.33	0.895	2.14
Y	12153-045.1	109	77	0.74	0.55	219	5	9670	201	1.5E-4	30	0.27	29.5	0.222	2.8	4.739	1.4	0.3158	1.0	0.730	0.1088	0.9	1769	16	1780	17	+1	1774.03	23.41	0.20	0.65	17.33	0.895	2.14
Y	12153-038.1	248	66	0.28	0.60	217	5	13743	385	1.3E-5	71	0.02	69.4	0.082	3.0	5.001	1.0	0.3255	0.9	0.872	0.1114	0.5	1817	14	1823	9	+0	1820.73	16.01	0.11	0.74	17.33	0.895	2.14
Y	12153-051.1	530	48	0.09	1.02	779	18	12629	593	2.9E-6	100	0.00	148.7	0.029	3.4	5.067	1.4	0.3264	0.9	0.607	0.1126	1.1	1821	14	1842	20	+1	1827.26	22.79	0.71	0.40	17.33	0.895	2.14
Y	12153-088.1	144	50	0.36	0.66	226	5	11715	244	1.1E-4	30	0.19	40.8	0.099	3.7	5.063	1.2	0.3291	1.0	0.784	0.1116	0.8	1834	15	1825	14	-1	1829.31	20.74	0.17	0.68	17.33	0.895	2.14
Y	12153-048.1	74	16	0.23	1.13	91	2	8605	373	1.2E-4	41	0.20	20.7	0.066	6.5	5.120	1.5	0.3266	1.1	0.724	0.1137	1.0	1822	17	1859	19	+2	1838.71	25.69	2.13	0.14	17.33	0.895	2.14
Y	12153-023.1	168	147	0.90	0.41	377	9	10022	209	6.8E-5	35	0.12	48.6	0.263	1.9	5.291	1.1	0.3363	0.9	0.829	0.1141	0.6	1869	15	1866	11	-0	1866.93	18.61	0.02	0.88	17.33	0.895	2.14
Y	12153-082.1	214	431	2.08	0.27	389	17	10034	209	2.0E-5	58	0.03	62.3	0.620	1.1	5.388	1.0	0.3394	0.9	0.871	0.1152	0.5	1884	15	1882	9	-0	1882.64	16.21	0.01	0.94	17.33	0.895	2.14
Y	12153-064.1	25	18	0.76	1.12	224	5	10480	218	1.7E-4	58	0.29	7.5	0.199	6.0	5.760	2.4	0.3500	1.5	0.636	0.1194	1.8	1934	25	1947	32	+1	1939.05	39.76	0.09	0.76	17.33	0.895	2.14
Y	12153-079.1	62	51	0.85	0.69	261	23	8978	394	7.9E-5	50	0.14	21.4	0.233	3.1	7.382	1.4	0.4056	1.1	0.773	0.1320	0.9	2195	21	2125	16	-4	2151.51	25.55	6.80	0.01	17.33	0.895	2.14

P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206* Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12153-041.1	184	152	0.85	0.41	182	4	9533	199	-5.4E-6	100	-0.01	79.9	0.241	1.6	12.746	1.0	0.5051	0.9	0.921	0.1830	0.4	2636	20	2680	6	+2	2675.10	13.45	4.52	0.03	17.33	0.895	2.14
Y	12154-122.1	116	50	0.44	0.46	242	9	9857	327	6.7E-5	41	0.12	18.0	0.143	3.0	1.846	1.5	0.1797	1.2	0.779	0.0745	1.0	1065	12	1056	19	-1	1062.70	20.16	0.16	0.69	17.33	0.895	2.14
Y	12154-064.1	84	29	0.36	0.54	304	12	9022	347	1.7E-4	27	0.29	14.3	0.101	4.1	2.092	3.9	0.1978	3.5	0.888	0.0767	1.8	1164	37	1114	36	-5	1137.87	51.73	0.91	0.34	17.33	0.895	2.14
Y	12154-129.1	270	98	0.38	0.33	387	13	10831	309	5.8E-5	28	0.10	45.4	0.115	2.1	2.100	1.3	0.1961	1.1	0.890	0.0777	0.6	1154	12	1139	12	-2	1146.28	16.88	0.84	0.36	17.33	0.895	2.14
Y	12154-012.1	301	207	0.71	0.24	464	19	9385	268	2.0E-5	45	0.04	50.7	0.216	1.4	2.102	1.2	0.1961	1.1	0.914	0.0778	0.5	1154	12	1141	10	-1	1146.41	15.68	0.73	0.39	17.33	0.895	2.14
Y	12154-074.1	88	17	0.20	1.06	155	5	12401	446	1.5E-4	28	0.25	15.1	0.055	6.2	2.107	1.7	0.1997	1.2	0.732	0.0765	1.1	1174	13	1108	22	-6	1156.73	22.20	6.26	0.01	17.33	0.895	2.14
Y	12154-103.1	71	22	0.32	0.62	159	9	7373	321	2.1E-4	26	0.37	12.1	0.100	4.6	2.128	1.8	0.1991	1.2	0.670	0.0775	1.4	1170	13	1134	27	-3	1163.33	23.69	1.41	0.23	17.33	0.895	2.14
Y	12154-126.1	304	148	0.50	0.27	174	6	11066	316	1.1E-5	58	0.02	52.5	0.163	1.6	2.194	1.2	0.2006	1.1	0.924	0.0793	0.5	1179	12	1180	9	+0	1179.57	15.10	0.01	0.93	17.33	0.895	2.14
Y	12154-077.1	679	239	0.36	0.22	423	21	12681	362	2.3E-5	28	0.04	118.0	0.114	2.3	2.222	1.2	0.2024	1.1	0.958	0.0796	0.3	1188	12	1188	7	-0	1187.83	12.16	0.00	0.97	17.33	0.895	2.14
Y	12154-011.1	289	162	0.58	0.40	359	24	9785	279	9.0E-5	28	0.16	51.1	0.174	6.8	2.232	1.4	0.2054	1.1	0.847	0.0788	0.7	1204	13	1167	14	-4	1188.21	18.89	3.70	0.05	17.33	0.895	2.14
Y	12154-109.1	473	208	0.46	0.24	386	13	11045	315	3.3E-5	28	0.06	83.0	0.138	1.5	2.241	1.2	0.2045	1.1	0.939	0.0795	0.4	1199	12	1185	8	-1	1189.41	14.03	0.96	0.33	17.33	0.895	2.14
Y	12154-140.1	499	125	0.26	0.28	349	12	9800	280	1.6E-5	38	0.03	85.6	0.078	1.8	2.203	1.2	0.1999	1.1	0.951	0.0799	0.4	1175	12	1195	7	+2	1189.47	12.86	2.08	0.15	17.33	0.895	2.14
Y	12154-056.1	688	113	0.17	0.28	346	13	12354	418	1.3E-5	33	0.02	118.2	0.053	1.8	2.204	1.2	0.2001	1.1	0.967	0.0799	0.3	1176	12	1195	6	+2	1190.53	11.12	1.96	0.16	17.33	0.895	2.14
Y	12154-116.1	169	55	0.34	0.47	303	28	10057	339	1.1E-4	24	0.19	29.4	0.098	3.0	2.278	1.4	0.2033	1.2	0.835	0.0813	0.8	1193	13	1228	15	+3	1207.20	20.01	3.04	0.08	17.33	0.895	2.14
Y	12154-081.1	143	43	0.31	0.49	309	12	8578	280	4.8E-5	41	0.08	25.6	0.091	3.2	2.311	1.4	0.2075	1.2	0.844	0.0808	0.7	1216	13	1216	15	+0	1215.76	19.63	0.00	0.99	17.33	0.895	2.14
Y	12154-002.1	133	55	0.42	0.47	249	8	9344	267	3.3E-4	18	0.57	22.6	0.133	3.4	2.519	1.7	0.1977	1.2	0.719	0.0924	1.2	1163	13	1475	22	+23	1218.29	23.68	144.55	0.00	17.33	0.895	2.14
Y	12154-082.1	253	84	0.34	0.32	416	14	11458	327	-3.7E-6	100	-0.01	45.4	0.111	1.9	2.338	1.2	0.2088	1.1	0.928	0.0812	0.5	1222	13	1227	9	+0	1225.16	14.94	0.09	0.77	17.33	0.895	2.14
Y	12154-132.1	223	42	0.20	0.49	231	8	11704	413	3.1E-5	41	0.05	39.9	0.059	3.2	2.336	1.3	0.2083	1.1	0.895	0.0813	0.6	1220	13	1230	11	+1	1225.20	17.12	0.36	0.55	17.33	0.895	2.14
Y	12154-066.1	22	13	0.59	0.82	105	4	8553	261	2.4E-4	41	0.42	4.1	0.171	5.6	2.499	2.7	0.2156	1.5	0.544	0.0841	2.2	1259	17	1294	44	+3	1262.84	31.25	0.57	0.45	17.33	0.895	2.14
Y	12154-096.1	384	105	0.28	0.33	300	10	11366	326	3.5E-4	10	0.60	71.1	0.084	7.8	2.600	1.5	0.2158	1.1	0.754	0.0874	1.0	1260	13	1369	19	+9	1291.93	22.00	22.50	0.00	17.33	0.895	2.14
Y	12154-094.1	219	98	0.46	0.34	462	22	9780	279	5.5E-5	30	0.10	42.6	0.140	2.0	2.630	1.3	0.2258	1.2	0.891	0.0845	0.6	1313	14	1303	11	-1	1307.07	17.71	0.28	0.59	17.33	0.895	2.14
Y	12154-021.1	291	110	0.39	0.31	403	14	9911	283	5.3E-5	26	0.09	58.2	0.116	1.9	2.750	1.2	0.2331	1.1	0.919	0.0856	0.5	1351	14	1328	9	-2	1335.96	15.95	1.72	0.19	17.33	0.895	2.14
Y	12154-032.1	133	63	0.49	0.42	217	7	10363	296	1.1E-4	27	0.19	26.3	0.159	2.5	2.763	2.5	0.2305	2.4	0.949	0.0869	0.8	1337	29	1359	15	+2	1354.14	27.39	0.44	0.51	17.33	0.895	2.14
Y	12154-098.1	109	32	0.31	0.57	203	7	10086	288	2.8E-5	58	0.05	21.9	0.102	3.2	2.955	1.4	0.2350	1.2	0.856	0.0912	0.7	1360	15	1451	14	+7	1407.64	20.44	20.43	0.00	17.33	0.895	2.14
Y	12154-136.1	306	172	0.58	0.37	237	8	12341	352	4.5E-5	26	0.08	65.3	0.179	1.4	3.140	1.2	0.2483	1.1	0.937	0.0917	0.4	1430	15	1462	8	+2	1453.51	14.52	3.57	0.06	17.33	0.895	2.14
Y	12154-078.1	107	54	0.52	0.40	242	11	8535	307	3.6E-5	45	0.06	23.5	0.147	2.5	3.278	1.3	0.2542	1.2	0.877	0.0935	0.6	1460	15	1499	12	+3	1483.39	19.37	3.80	0.05	17.33	0.895	2.14
Y	12154-127.1	322	60	0.19	0.38	550	19	12705	362	2.9E-5	29	0.05	71.8	0.054	2.3	3.317	1.2	0.2590	1.1	0.952	0.0929	0.4	1485	15	1485	7	+0	1485.29	13.22	0.00	0.98	17.33	0.895	2.14
Y	12154-028.1	69	39	0.58	0.53	240	8	10465	299	1.2E-4	33	0.21	15.6	0.173	3.1	3.324	1.6	0.2621	1.2	0.771	0.0920	1.0	1500	17	1467	19	-3	1486.34	25.14	1.69	0.19	17.33	0.895	2.14
Y	12154-105.1	55	31	0.59	0.59	260	9	9067	312	1.8E-4	30	0.32	12.4	0.175	3.5	3.311	1.8	0.2631	1.3	0.710	0.0913	1.3	1506	17	1452	24	-4	1487.36	27.61	3.31	0.07	17.33	0.895	2.14
Y	12154-026.1	99	53	0.55	0.45	267	14	10591	302	7.5E-5	35	0.13	22.3	0.164	2.6	3.347	1.4	0.2609	1.2	0.834	0.0930	0.8	1495	16	1489	15	-0	1491.57	22.02	0.06	0.80	17.33	0.895	2.14
Y	12154-034.1	667	161	0.25	0.26	243	12	12249	351	4.7E-5	18	0.08	141.4	0.074	1.6	3.178	2.9	0.2470	2.9	0.994	0.0933	0.3	1423	37	1494	6	+5	1492.09	12.24	3.73	0.05	17.33	0.895	2.14
Y	12154-007.1	121	85	0.73	1.93	370	15	10177	291	8.1E-5	32	0.14	26.8	0.218	2.1	3.346	1.4	0.2591	1.2	0.846	0.0936	0.7	1485	16	1501	14	+1	1493.85	21.20	0.56	0.46	17.33	0.895	2.14
Y	12154-052.1	142	133	0.97	0.30	433	18	8903	254	6.3E-5	32	0.11	32.0	0.291	1.6	3.368	1.3	0.2624	1.2	0.880	0.0931	0.6	1502	16	1490	12	-1	1494.42	19.22	0.37	0.54	17.33	0.895	2.14
Y	12154-101.1	167	368	2.27	0.21	441	22	10196	320	3.9E-5	38	0.07	38.3	0.683	1.0	3.409	1.3	0.2664	1.2	0.897	0.0928	0.6	1523	16	1484	11	-3	1496.85	18.17	3.96	0.05	17.33	0.895	2.14
Y	12154-025.1	360	293	0.84	0.21	605	20	10288	294	2.6E-5	32	0.04	81.2	0.256	1.1	3.380	1.2	0.2624	1.1	0.948	0.0934	0.4	1502	15	1496	7	-0	1497.56	13.61	0.12	0.72	17.33	0.895	2.14
Y	12154-042.1	81	52	0.66	0.46	280	9	8262	363	4.5E-5	50	0.08	18.3	0.198	2.6	3.381	1.6	0.2620	1.3	0.852	0.0936	0.8	1500	18	1500	15	-0	1499.91	23.35	0.00	1.00	17.33	0.895	2.14
Y	12154-063.1	112	36	0.33	0.55	269	12	10048	422	5.1E-5	41	0.09	24.9	0.096	3.3	3.365	1.4	0.2582	1.2	0.856	0.0945	0.7	1480	16	1519	14	+3	1502.26	20.79	3.43	0.06	17.33	0.895	2.14
Y	12154-008.1	289	86	0.31	0.35	330	11	10041	287	3.2E-5	32	0.06	64.6	0.094	3.5	3.372	1.2	0.2604	1.1	0.937	0.0939	0.4	1492	15	1506	8	+1	1502.83	14.62	0.66	0.42	17.33	0.895	2.14
Y	12154-062.1	390	85	0.22	0.35	236	8	14164	405	1.2E-5	45	0.02	88.5	0.069	1.9	3.417	1.2	0.2643	1.1	0.957	0.0938	0.3	1512	15	1503	7	-1	1504.90	12.83	0.24	0.62	17.33	0.895	2.14
Y	12154-089.1	70	42	0.61	0.51	367	12	8578	245	6.4E-5	45	0.11	16.1	0.180	2.9	3.424	1.5	0.2682	1.2	0.807	0.0926	0.9	1532	17	1480	17	-4	1506.26	23.95	4.51	0.03	17.33	0.895	2.14
Y	12154-017.1	17	8	0.50	1.11	193	7	8067	230	4.7E-4	33	0.81	4.0	0.141	7.8	3.208	4.1	0.2674	1.6	0.385	0.0870	3.8	1528	22	1361	73	-14	1511.13	40.85	5.11	0.02	17.33	0.895	2.14
Y	12154-100.1	125	77	0.63	15.08	150	5	10845	310	9.4E-5	27	0.16	30.1	0.186	5.6	3.715	5.1	0.2803	5.0	0.967	0.0961	1.3	1593	70	1550	25	-3	1555.29	47.52	0.32	0.57	17.33	0.895	2.14
Y	12154-020.1	97	38	0.41	0.52	176	6	10949	381	9.7E-5	30	0.17	23.0	0.113	3.1	3.680	3.1	0.2758	3.0	0.969	0.0968	0.8	1570	42	1563	15	-1	1563.65	28.07	0.03	0.87	17.33	0.895	2.14
Y	12154-031.1	249	92	0.38	0.34	394	21	9673	276	1.8E-5	45	0.03	58.4	0.119	1.8	3.658	1.2	0.2733	1.1	0.937	0.0971	0.4	1558	16	1569	8	+1	1566.18	14.81	0.38	0.54	17.33	0.895	2.14
Y	12154-045.1	358	155	0.45	0.28	381	13	10997	314	1.4E-4	16	0.24	84.4	0.135	3.4	3.733	1.4	0.2741	1.1	0.800	0.0988	0.8	1561	16	1601	16	+3	1580.74	22.53	3.15	0.08	17.33	0.895	2.14
Y	12154-139.1	222	126	0.59	0.30	325	11	10660	304	4.3E-5	30	0.07	53.2	0.176	1.6	3.757	1.2	0.2789	1.1	0.925	0.0977	0.5	1586	16	1581	9	-0	1582.07	15.93	0.07	0.79	17.33	0.895	2.14
Y	12154-029.1	96	52	0.56	0.45	270	9	9042	258	4.3E-5	45	0.08	23.1	0.168	2.5	3.795	1.4	0.2803	1.2	0.865	0.0982	0.7	1593	17	1590	13	-0	1591.13	20.81	0.02	0.88	17.33	0.895	2.14
Y	12154-038.1	254	174	0.71	0.26	441	17	9825	317	4.7E-4	26	0.81	61.7	0.198	4.0	3.879	2.1	0.2824	1.2	0.543	0.0996	1.8	1604	16	1617	33	+1	1606.15	29.59	0.12	0.73	17.33	0.895	2.14
Y	12154-040.1	62	62	1.02	0.44	231	8	8918	255	9.4E-5	38	0.16	15.4	0.299	2.3	3.963	1.6	0.2892	1.2	0.797	0.0994	0.9	1638	18	1613	18	-2	1624.92	25.23	0.95	0.33	17.33	0.895	2.14
Y	12154-044.1	143	118	0.85	0.32	287	10	12245	463	4.1E-5	38	0.07	36.0	0.252	1.6	4.057	1.3	0.2922	1.2	0.902	0.1007	0.6	1652	17	1637	10	-1	1641.60	18.14	0.56	0.46	17.33	0.895	2.14
Y	12154-084.1	139	77	0.57	2.94	522	37	8398	240	4.8E-5	35	0.08	35.0	0.173	5.4	4.062	1.3	0.2925	1.2	0.897	0.1007	0.6	1654	17	1637	11	-1	1642.38	18.53	0.67	0.41	17.33	0.895	2.14
Y	12154-087.1	260	112	0.45	2.20	401	14	10089	288	3.8E-5	28	0.07	65.4	0.133	1.6	4.073	1.2	0.2928	1.1	0.944	0.1009	0.4	1656	17	1641	7	-1	1643.37	14.36	0.65	0.42	17.33	0.895	2.14
Y	12154-036.1	333	198	0.61	0.24	644	34	9084	361	7.3E-5	19	0.13	80.6	0.179	1.3	3.943	1.2	0.2815	1.1	0.946	0.1016	0.4	1599	16	1654	7	+4	1643.54	13.66	9.69	0.00	17.33	0.895	2.14
Y	12154-054.1	115	65	0.58	0.41	220	7	9543	361	2.8E-5	50	0.05	28.4	0.179	2.1	4.025	1.3	0.2869	1.2	0.891	0.1018	0.6	1626	17	1657	11	+2	1646.96	18.91	2.25	0.13	17.33	0.895	2.14
Y	12154-120.1	109	49	0.47	0.46	281	10	8357	239	7.4E-5	32	0.13	27.5	0.147	2.4	4.156	3.0	0.2947	2.9	0.975	0.1023	0.7	1665	42	1666	12	+0	1666.04	24.04	0.00	0.98	17.33	0.895	2.14
Y	12154-041.1	191	130	0.70	0.27	450	42	10261	363	4.0E-5	30	0.07	48.7	0.213	1.4	4.212	1.3	0.2968	1.2	0.937	0.1029	0.4	1675	17	1677	8	+0	1677.04	15.32	0.01	0.91	17.33	0.895	2.14
Y	12154-050.1	68	35	0.53	0.54	153	5	9325	266	3.8E-5	50	0.07	17.4	0.164	5.3	4.446	1.4	0.3000	1.2	0.868	0.1075	0.7	1691	18	1757	13	+4	1734.73	20.95	8.95	0.00	17.33	0.895	2.14
Y	12154-092.1	159	97	0.63	0.34	204	7	10230	292	3.9E-5	35	0.07	42.1	0.185	1.7	4.529	1.3	0.3091	1.2	0.918	0.1063	0.5	1736	18	1736	9	+0	1736.35	16.78	0.00	0.99	17.33	0.895	2.14
Y	12154-070.1	140	87	0.64	0.36	216	7	10719	306	7.2E-5	28	0.13	37.4	0.192	1.8	4.600	1.3	0.3124	1.2	0.901	0.1068	0.6	1753	18	1745	10	-0	1747.13	18.25	0.12	0.72	17.33	0.895	2.14
Y	12154-107.1	226	87	0.40	0.35	184	6	11353	324	-3.3E-6	100	-0.01	61.4	0.122	1.7	4.666	1.2	0.3159	1.1	0.947	0.1071	0.4	1770	18	1751	7	-1	1753.83	13.99	0.97	0.33	17.33	0.895	2.14
Y	12154-108.1	149	55	0.38	0.44	180	6	10878	311	6.0E-5	29	0.10	40.7	0.116	2.3	4.751	1.3	0.3186	1.2	0.913	0.1082	0.5	1783	18	1769	9	-1	1772.03	17.35	0.46	0.50	17.33	0.895	2.14
Y	12154-119.1	271	98	0.37	0.33	79	3	9479	271	1.0E-4	18	0.18	73.6	0.113	1.8	4.755	1.2	0.3156	1.1	0.937	0.1093	0.4	1768	18	1787	8	+1	1783.65	14.73	0.92	0.34	17.33	0.895	2.14
Y	12154-065.1	136	97	0.73	0.35	371	13	8641	247	6.1E-5	30	0.11	38.0	0.214	2.9	4.879	1.3	0.3244	1.2	0.906	0.1091	0.5	1811	18	1784	10	-2	1790.78	18.04	1.59	0.21	17.33	0.895	2.14
Y	12154-128.1	377	212	0.58	4.93	401	14	9516	271	2.3E-5	26	0.04	101.3	0.172	5.3	4.738	1.1	0.3125	1.1	0.972	0.1100	0.3	1753	17	1799	5	+3	1794.40	10.61	6.53	0.01	17.33	0.895	2.14
Y	12154-141.1	181	99	0.56	0.33	399	20	9241	264	8.1E-6	71	0.01	50.4	0.167	1.6	4.929	1.4	0.3238	1.1	0.847	0.1104	0.7	1808	18	1806	13	-0	1806.68	21.53	0.02	0.90	17.33	0.895	2.14
Y	12154-053.1	160	71	0.46	0.38	357	12	11222	320	6.2E-5	27	0.11	45.7	0.134	2.0	5.103	1.2	0.3317	1.2	0.923	0.1116	0.5	1846	19	1826	9	-1	1829.72	16.45	1.00	0.32	17.33	0.895	2.14
Y	12154-068.1	268	88	0.34	0.35	585	20	12094	345	2.0E-5	38	0.03	76.0	0.099	1.8	5.112	1.2	0.3305	1.1	0.954	0.1122	0.4	1841	18	1835	6	-0	1835.76	13.20	0.09	0.77	17.33	0.895	2.14
Y	12154-118.1	160	81	0.53	0.37	373	13	10936	312	-4.6E-6	100	-0.01	45.6	0.154	1.8	5.163	1.2	0.3317	1.2	0.933	0.1129	0.4	1847	19	1846	8	-0	1846.40	15.52	0.00	0.99	17.33	0.895	2.14
Y	12154-137.1	181	45	0.26	0.47	132	4	9099	325	4.3E-5	30	0.07	51.8	0.078	2.5	5.266	1.2	0.3332	1.1	0.934	0.1146	0.4	1854	18	1874	8	+1	1870.83	15.19	1.04	0.31	17.33	0.895	2.14
Y	12154-095.1	151	69	0.47	2.17	130	4	11696	708	2.1E-5	45	0.04	45.7	0.128	2.0	5.913	1.2	0.3523	1.2	0.938	0.1217	0.4	1946	19	1981	8	+2	1976.13	14.87	2.89	0.09	17.33	0.895	2.14

Appendix 5. 2016ODEN U-Pb zircon data.

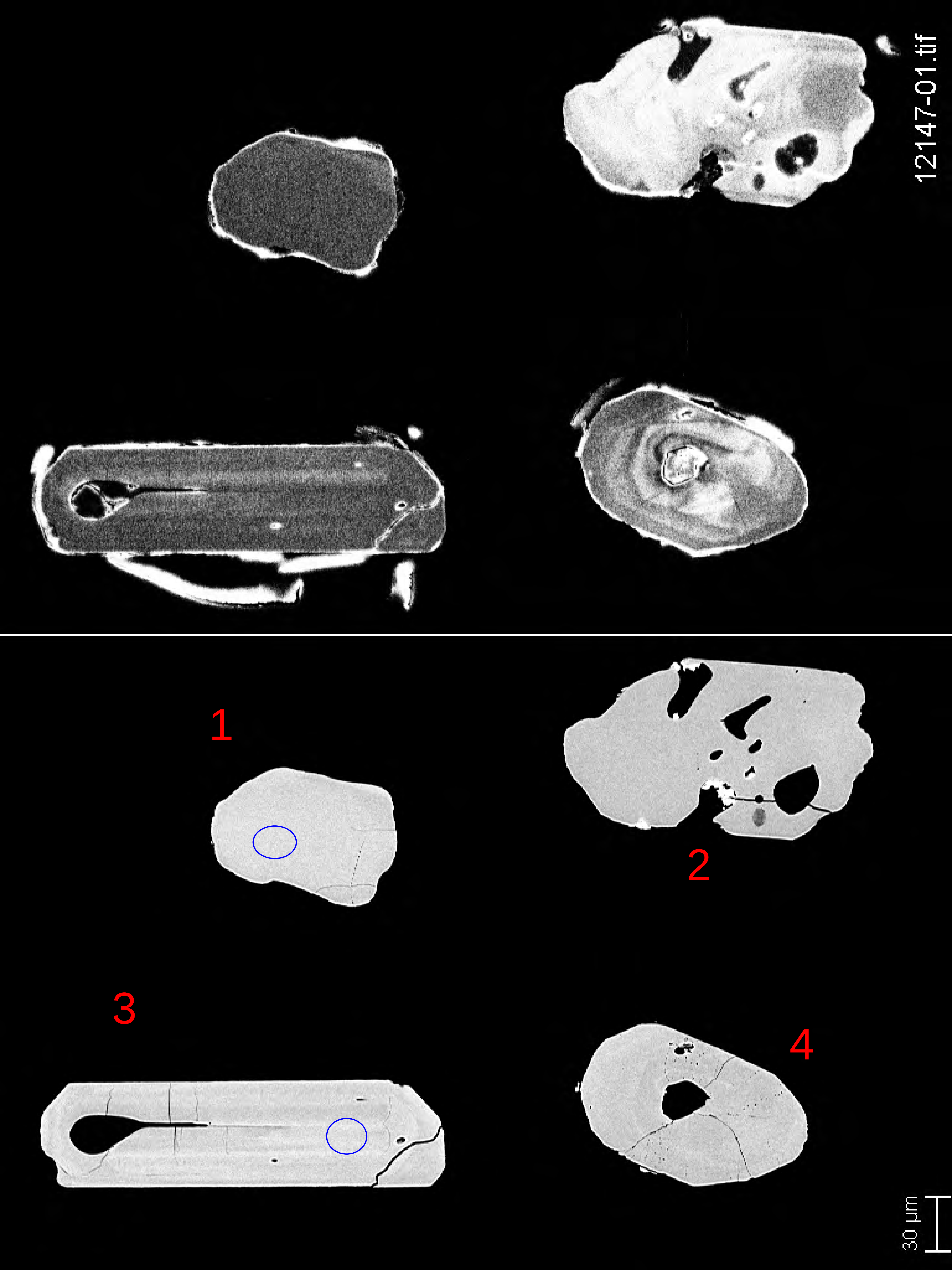
P	Spot Name	ppm U	ppm Th	232Th /238U	% err	Yb ppm	1σ abs err	Hf ppm	1σ abs err	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	abs. err.	204 corr 207*/206 * Age	abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
Y	12154-125.1	180	36	0.21	0.72	205	25	10216	373	2.1E-5	38	0.04	56.8	0.063	2.3	6.448	1.2	0.3682	1.1	0.956	0.1270	0.4	2021	20	2057	6	+2	2052.97	12.84	2.95	0.09	17.33	0.895	2.14
Y	12154-083.1	93	29	0.32	0.54	74	3	11257	468	2.1E-5	45	0.04	41.5	0.090	2.3	13.326	1.2	0.5196	1.2	0.956	0.1860	0.4	2697	26	2707	6	+0	2706.56	13.07	0.13	0.71	17.33	0.895	2.14
Y	12154-080.1	55	59	1.12	0.46	258	15	9357	267	5.9E-5	38	0.10	25.0	0.310	1.8	13.995	1.3	0.5326	1.2	0.922	0.1906	0.5	2753	28	2747	8	-0	2747.59	17.34	0.04	0.85	17.33	0.895	2.14
Y	12155-098.1	243	163	0.69	0.25	644	28	7887	225	4.9E-5	32	0.08	38.2	0.212	1.6	1.941	1.3	0.1829	1.1	0.885	0.0770	0.6	1083	11	1120	12	+4	1100.20	16.77	4.92	0.03	17.33	0.895	2.14
Y	12155-018.1	109	56	0.53	0.42	315	16	9516	417	1.4E-4	27	0.25	18.2	0.164	2.8	2.003	1.6	0.1942	1.2	0.744	0.0748	1.1	1144	13	1063	22	-8	1122.79	21.38	10.38	0.00	17.33	0.895	2.14
Y	12155-070.1	205	101	0.51	0.31	220	11	10229	292	4.9E-5	33	0.08	34.1	0.152	2.0	2.049	1.4	0.1934	1.2	0.868	0.0768	0.7	1140	13	1117	14	-2	1129.72	18.55	1.44	0.23	17.33	0.895	2.14
Y	12155-004.1	56	24	0.45	0.65	221	10	9832	281	7.0E-4	20	1.21	9.3	0.130	6.0	1.991	3.2	0.1925	1.3	0.410	0.0750	2.9	1135	14	1068	59	-7	1131.17	26.43	1.26	0.26	17.33	0.895	2.14
Y	12155-095.1	129	61	0.48	0.39	263	9	9671	384	6.0E-5	38	0.10	21.2	0.143	2.7	2.050	1.4	0.1908	1.2	0.824	0.0779	0.8	1126	12	1145	16	+2	1132.64	19.56	0.91	0.34	17.33	0.895	2.14
Y	12155-066.1	97	54	0.58	0.52	169	6	10278	293	4.7E-4	19	0.82	15.6	0.194	3.6	2.038	5.0	0.1885	4.4	0.882	0.0784	2.3	1113	45	1157	46	+4	1134.19	64.80	0.46	0.50	17.33	0.895	2.14
Y	12155-124.1	58	24	0.42	0.61	116	5	10874	310	5.5E-5	58	0.09	9.6	0.127	4.1	2.061	1.7	0.1919	1.3	0.733	0.0779	1.2	1132	13	1144	23	+1	1134.76	22.94	0.21	0.64	17.33	0.895	2.14
Y	12155-071.1	407	112	0.28	0.29	313	11	12972	370	2.3E-5	35	0.04	67.5	0.084	2.0	2.078	1.2	0.1932	1.1	0.935	0.0780	0.4	1139	12	1147	8	+1	1144.25	14.09	0.35	0.56	17.33	0.895	2.14
Y	12155-086.1	206	34	0.17	0.50	245	8	15369	438	6.9E-5	28	0.12	33.6	0.052	3.7	2.068	1.3	0.1892	1.1	0.871	0.0793	0.6	1117	12	1179	13	+6	1144.59	17.65	12.37	0.00	17.33	0.895	2.14
Y	12155-096.1.1	134	53	0.41	0.41	216	7	9845	281	3.1E-5	50	0.05	22.3	0.122	2.7	2.089	1.4	0.1941	1.2	0.848	0.0780	0.7	1144	12	1148	15	+0	1145.43	18.87	0.06	0.81	17.33	0.895	2.14
Y	12155-022.1	172	79	0.47	0.36	302	15	10745	307	4.7E-5	38	0.08	28.9	0.147	2.3	2.109	1.4	0.1953	1.2	0.858	0.0783	0.7	1150	12	1155	14	+0	1152.12	18.43	0.06	0.81	17.33	0.895	2.14
Y	12155-102.1	117	33	0.29	0.52	170	6	10790	308	8.3E-5	33	0.14	19.8	0.087	3.7	2.112	1.5	0.1966	1.2	0.798	0.0779	0.9	1157	13	1144	18	-1	1152.82	20.56	0.32	0.57	17.33	0.895	2.14
Y	12155-045.1	222	94	0.44	0.33	634	24	9435	269	4.6E-5	33	0.08	37.5	0.132	2.1	2.119	1.3	0.1967	1.1	0.884	0.0781	0.6	1158	12	1150	12	-1	1153.77	17.29	0.20	0.66	17.33	0.895	2.14
Y	12155-062.1	76	26	0.35	0.60	299	10	8001	228	1.4E-4	33	0.24	12.9	0.115	4.2	2.105	1.8	0.1974	1.2	0.702	0.0773	1.3	1161	13	1130	25	-3	1154.41	23.19	1.22	0.27	17.33	0.895	2.14
Y	12155-026.1	270	52	0.20	0.43	356	12	8731	249	4.2E-5	32	0.07	45.9	0.058	3.0	2.137	1.3	0.1978	1.1	0.902	0.0784	0.5	1164	12	1156	11	-1	1159.34	16.35	0.23	0.64	17.33	0.895	2.14
Y	12155-088.1	356	123	0.36	0.28	500	17	8849	253	5.8E-5	23	0.10	61.2	0.106	1.8	2.164	2.3	0.1999	2.2	0.977	0.0785	0.5	1175	24	1159	10	-1	1161.75	18.29	0.36	0.55	17.33	0.895	2.14
Y	12155-078.1	166	56	0.35	0.38	327	11	8666	385	9.4E-5	25	0.16	28.4	0.096	2.8	2.145	1.4	0.1988	1.2	0.859	0.0782	0.7	1169	13	1153	14	-2	1161.82	19.25	0.68	0.41	17.33	0.895	2.14
Y	12155-073.1	398	105	0.27	0.29	270	11	11370	324	3.1E-5	29	0.05	67.3	0.083	4.1	2.136	2.0	0.1966	2.0	0.974	0.0788	0.5	1157	21	1167	9	+1	1165.60	16.90	0.20	0.65	17.33	0.895	2.14
Y	12155-020.1	531	253	0.49	0.21	592	29	10088	288	3.1E-5	26	0.05	91.3	0.155	1.2	2.170	1.2	0.1999	1.1	0.949	0.0787	0.4	1175	12	1165	7	-1	1167.86	13.05	0.50	0.48	17.33	0.895	2.14
Y	12155-044.1	744	54	0.07	0.41	87	3	13228	378	8.8E-6	41	0.02	128.2	0.023	2.7	2.184	1.2	0.2005	1.1	0.967	0.0790	0.3	1178	12	1173	6	-1	1173.71	11.19	0.16	0.69	17.33	0.895	2.14
Y	12155-126.1	239	55	0.24	0.39	243	8	11109	317	2.1E-5	45	0.04	41.3	0.074	2.6	2.197	1.3	0.2006	1.2	0.914	0.0794	0.5	1179	12	1182	10	+0	1180.85	15.94	0.06	0.81	17.33	0.895	2.14
Y	12155-089.1	284	167	0.61	0.25	297	12	13312	466	5.1E-5	28	0.09	48.4	0.180	1.6	2.202	1.3	0.1985	1.1	0.908	0.0804	0.5	1167	12	1208	10	+4	1190.29	16.03	6.43	0.01	17.33	0.895	2.14
Y	12155-103.1	344	123	0.37	0.28	228	8	11820	337	1.6E-5	45	0.03	59.1	0.116	1.8	2.207	1.2	0.1999	1.1	0.930	0.0801	0.4	1175	12	1199	9	+2	1190.29	14.58	2.50	0.11	17.33	0.895	2.14
Y	12155-053.1	128	73	0.59	0.39	460	20	8315	319	8.4E-5	33	0.15	22.3	0.180	2.5	2.242	1.5	0.2024	1.2	0.811	0.0804	0.9	1188	13	1206	17	+2	1194.52	21.09	0.67	0.41	17.33	0.895	2.14
Y	12155-050.1	138	46	0.34	0.46	194	7	10127	289	1.0E-4	28	0.17	24.8	0.102	3.1	2.300	1.4	0.2101	1.2	0.817	0.0794	0.8	1229	13	1182	16	-4	1210.67	20.43	4.91	0.03	17.33	0.895	2.14
Y	12155-057.1	370	93	0.26	0.32	247	8	8975	256	4.5E-5	25	0.08	65.5	0.081	2.0	2.310	1.2	0.2060	1.1	0.933	0.0813	0.4	1207	12	1230	9	+2	1222.10	14.43	2.11	0.15	17.33	0.895	2.14
Y	12155-029.1	77	18	0.24	0.70	167	6	9018	257	1.3E-4	32	0.23	13.9	0.078	4.9	2.328	1.7	0.2096	1.2	0.734	0.0805	1.1	1227	14	1210	22	-2	1222.30	23.28	0.40	0.53	17.33	0.895	2.14
Y	12155-090.1	178	58	0.34	0.39	221	7	10222	292	6.1E-5	30	0.11	31.5	0.101	2.6	2.322	1.3	0.2063	1.2	0.874	0.0816	0.6	1209	13	1237	13	+2	1222.69	18.11	2.39	0.12	17.33	0.895	2.14
Y	12155-010.1	301	82	0.28	0.34	264	9	11364	324	1.8E-5	45	0.03	53.7	0.086	2.2	2.322	1.2	0.2073	1.1	0.925	0.0812	0.5	1214	13	1227	9	+1	1222.71	15.12	0.69	0.41	17.33	0.895	2.14
Y	12155-043.1	298	123	0.43	0.28	359	12	11257	321	6.6E-6	71	0.01	55.3	0.134	3.5	2.451	1.2	0.2164	1.1	0.935	0.0822	0.4	1263	13	1249	8	-1	1253.65	14.59	0.71	0.40	17.33	0.895	2.14
Y	12155-040.1	197	55	0.29	0.42	243	10	10121	389	3.7E-5	38	0.06	36.1	0.086	2.7	2.433	1.3	0.2134	1.2	0.890	0.0827	0.6	1247	13	1262	12	+1	1255.33	17.51	0.80	0.37	17.33	0.895	2.14
Y	12155-023.1	182	120	0.68	0.30	213	9	11403	325	2.3E-5	50	0.04	33.5	0.207	1.8	2.443	1.3	0.2140	1.2	0.892	0.0828	0.6	1250	13	1264	11	+1	1258.07	17.46	0.62	0.43	17.33	0.895	2.14
Y	12155-067.1	174	78	0.46	0.36	356	15	9774	279	9.0E-5	26	0.16	32.1	0.144	2.3	2.489	1.4	0.2149	1.2	0.858	0.0840	0.7	1255	13	1292	13	+3	1272.99	19.12	3.86	0.05	17.33	0.895	2.14
Y	12155-012.1	152	80	0.54	0.39	274	9	9036	277	5.2E-5	35	0.09	29.8	0.168	3.8	2.681	1.3	0.2274	1.2	0.869	0.0855	0.7	1321	14	1327	13	+1	1324.26	19.05	0.11	0.74	17.33	0.895	2.14
Y	12155-061.1.2	233	74	0.33	0.38	287	10	11181	319	1.9E-5	50	0.03	44.9	0.102	2.3	2.657	1.3	0.2241	1.1	0.910	0.0860	0.5	1303	14	1338	10	+3	1325.13	16.50	4.08	0.04	17.33	0.895	2.14
Y	12155-099.1	84	48	0.59	0.44	165	6	9892	282	1.2E-4	30	0.21	16.1	0.167	3.1	2.704	1.5	0.2247	1.2	0.785	0.0873	1.0	1306	14	1367	18	+5	1328.58	22.91	6.79	0.01	17.33	0.895	2.14
Y	12155-084.1	369	180	0.51	5.33	327	33	11438	380	3.2E-5	27	0.06	74.1	0.158	4.4	2.816	1.2	0.2338	1.1	0.937	0.0873	0.4	1355	14	1368	8	+1	1364.22	14.40	0.67	0.41	17.33	0.895	2.14
Y	12155-025.1	248	127	0.53	0.29	264	12	11004	314	2.6E-5	38	0.05	51.1	0.167	1.6	2.899	1.2	0.2401	1.1	0.925	0.0876	0.5	1387	14	1373	9	-1	1377.39	15.63	0.66	0.42	17.33	0.895	2.14
Y	12155-027.1	84	58	0.72	0.41	269	9	9817	335	9.1E-5	33	0.16	18.0	0.201	2.7	3.141	1.5	0.2493	1.2	0.814	0.0914	0.9	1435	16	1454	16	+1	1443.88	22.71	0.72	0.40	17.33	0.895	2.14
Y	12155-048.1	43	54	1.30	0.47	102	3	9986	285	2.5E-4	29	0.43	9.5	0.393	2.5	3.117	2.0	0.2565	1.3	0.646	0.0881	1.5	1472	17	1385	30	-7	1448.91	29.34	6.32	0.01	17.33	0.895	2.14
Y	12155-127.1	69	36	0.54	2.63	232	12	9540	347	6.8E-5	41	0.12	15.0	0.174	2.8	3.191	1.5	0.2532	1.2	0.813	0.0914	0.9	1455	16	1455	17	+0	1454.89	23.01	0.00	1.00	17.33	0.895	2.14
Y	12155-100.1	129	68	0.54	0.37	212	7	11793	455	4.7E-5	38	0.08	27.0	0.164	2.2	3.176	1.3	0.2434	1.2	0.881	0.0946	0.6	1404	15	1521	12	+9	1474.05	18.80	38.42	0.00	17.33	0.895	2.14
Y	12155-056.1	73	39	0.55	0.49	249	8	9400	268	1.9E-4	24	0.32	16.3	0.160	3.0	3.302	3.7	0.2594	3.6	0.962	0.0923	1.0	1487	48	1474	19	-1	1475.78	36.16	0.06	0.81	17.33	0.895	2.14
Y	12155-041.1	153	74	0.50	0.36	206	9	11562	356	1.6E-5	58	0.03	33.7	0.151	2.0	3.307	1.5	0.2564	1.2	0.777	0.0936	0.9	1471	15	1499	18	+2	1482.88	23.29	1.40	0.24	17.33	0.895	2.14
Y	12155-036.1	154	85	0.57	0.34	454	15	8690	318	4.8E-5	33	0.08	34.6	0.174	1.9	3.341	1.3	0.2619	1.2	0.898	0.0925	0.6	1500	15	1478	11	-2	1485.26	18.02	1.27	0.26	17.33	0.895	2.14
Y	12155-094.1	154	72	0.48	0.36	252	11	11510	531	7.6E-5	27	0.13	33.1	0.145	2.1	3.251	1.3	0.2500	1.2	0.887	0.0943	0.6	1438	15	1514	11	+6	1485.62	18.39	16.45	0.00	17.33	0.895	2.14
Y	12155-060.1	151	84	0.58	0.33	86	3	11864	442	3.2E-5	41	0.05	33.3	0.172	1.9	3.299	3.6	0.2564	3.5	0.988	0.0933	0.5	1471	46	1494	10	+2	1493.27	20.42	0.24	0.63	17.33	0.895	2.14
Y	12155-076.1	209	70	0.34	0.39	314	11	11017	314	2.2E-5	41	0.04	47.0	0.107	2.0	3.363	1.2	0.2615	1.1	0.931	0.0933	0.4	1498	15	1493	8	-0	1494.36	15.32	0.06	0.81	17.33	0.895	2.14
Y	12155-035.1	143	64	0.46	0.39	241	8	10138	363	4.7E-5	35	0.08	31.7	0.145	2.2	3.350	1.3	0.2587	1.2	0.892	0.0939	0.6	1483	15	1507	11	+2	1498.22	18.32	1.50	0.22	17.33	0.895	2.14
Y	12155-003.1	277	352	1.31	0.20	800	27	9076	259	2.3E-5	38	0.04	61.8	0.394	1.0	3.365	1.2	0.2600	1.1	0.938	0.0939	0.4	1490	15	1506	8	+1	1501.98	14.57	0.85	0.36	17.33	0.895	2.14
Y	12155-037.1	121	36	0.31	0.49	214	7	10657	347	-2.0E-5	58	-0.03	27.1	0.095	2.8	3.381	1.3	0.2609	1.2	0.895	0.0940	0.6	1494	16	1508	11	+1	1503.09	18.29	0.47	0.49	17.33	0.895	2.14
Y	12155-052.1	94	33	0.37	0.54	167	6	10556	405	1.2E-4	28	0.20	21.7	0.106	5.3	3.498	1.5	0.2681	1.2	0.824	0.0946	0.8	1531	16	1521	15	-1	1525.83	22.57	0.21	0.65	17.33	0.895	2.14
Y	12155-085.1.2	49	42	0.88	0.48	273	9	8700	248	1.6E-5	100	0.03	11.2	0.269	2.6	3.536	1.6	0.2686	1.3	0.813	0.0955	0.9	1534	17	1538	17	+0	1535.72	24.33	0.03	0.86	17.33	0.895	2.14
Y	12155-077.1	167	77	0.47	0.37	377	13	9975	285	2.7E-5	41	0.05	38.7	0.145	1.9	3.553	1.3	0.2693	1.2	0.924	0.0957	0.5	1537	16	1541	9	+0	1540.45	16.70	0.04	0.83	17.33	0.895	2.14
Y	12155-024.1	275	83	0.31	0.35	378	13	11328	323	1.8E-5	41	0.03	64.7	0.094	1.9	3.633	1.2	0.2741	1.1	0.945	0.0961	0.4	1562	16	1550	7	-1	1552.67	14.09	0.40	0.53	17.33	0.895	2.14
Y	12155-064.1	177	113	0.66	0.30	273	9	11115	317	5.4E-5	29	0.09	42.0	0.203	1.6	3.672	1.3	0.2764	1.2	0.915	0.0964	0.5	1573	16	1555	10	-1	1560.06	17.08	0.87	0.35	17.33	0.895	2.14
Y	12155-097.1	174	125	0.75	0.28	213	7	10586	390	6.7E-5	26	0.12	39.8	0.225	1.5	3.624	1.3	0.2669	1.1	0.911	0.0985	0.5	1525	16	1596	10	+5	1575.11	16.80	14.70	0.00	17.33	0.895	2.14
Y	12155-051.1	70	43	0.63	0.49	300	12	10340	353	1.3E-4	30	0.22	16.7	0.194	2.7	3.724	1.5	0.2782	1.2	0.797	0.0971	0.9	1582	17	1569	17	-1	1575.85	24.49	0.27	0.61	17.33	0.895	2.14
Y	12155-007.1	185	94	0.53	0.34	375	15	11561	330	6.3E-5	27	0.11	44.7	0.156	1.8	3.786	1.3	0.2808	1.2	0.912	0.0978	0.5	1595	16	1583	10	-1	1586.12	17.12	0.45	0.50	17.33	0.895	2.14
Y	12155-075.1	239	85	0.37	0.32	134	5	11434	326	3.0E-5	32	0.05	57.0	0.110	1.8	3.769	1.2	0.2778	1.1	0.943	0.0984	0.4	1580	16	1594	7	+1	1591.41	14.17	0.62	0.43	17.33	0.895	2.14
Y	12155-101.1	92	28	0.32	0.56	127	4	10367	351	4.3E-5	45	0.07	21.2	0.094	3.3	3.712	1.4	0.2683	1.2	0.868	0.1003	0.7	1532	16	1631	13	+7	1592.44	20.29	22.93	0.00	17.33	0.895	2.14
Y	12155-046.1	241	123	0.53	0.29	358	12	11165	319	1.3E-5	50	0.02	57.9	0.160	1.5	3.803	1.2	0.2804	1.1	0.942	0.0984	0.4	1593	16	1593	8	+0	1593.35	14.37	0.00	0.99	17.33	0.895	2.14
Y	12155-009.1	248	186	0.77	0.25	459	16	9625	275	2.7E-5	35	0.05	59.0	0.228	1.3	3.774	4.1	0.2775	4.1	0.995	0.0986	0.4	1579	58	1599	8	+1	1598.21	16.47	0.12	0.73	17.33	0.895	2.14
Y	12155-093.1	351	314	0.92	0.18	359	16	8142	317	2.7E-5	28	0.05	84.4	0.277	0.9	3.806	1.2	0.2796	1.1	0.960	0.0987	0.3	1590	16	1600	6	+1	1598.55	12.26	0.38	0.54	17.33	0.895	2.14
Y	12155-030.1	127	62	0.51	0.40	166	6	11471	327	5.6E-5	33	0.10	30.3	0.149	2.2	3.806	1.3	0.2787	1.2	0.889	0.0990	0.6	1585	16	1606	11	+1	1598.97	18.83	1.09	0.30	17.33	0.895	2.14
Y	12155-130.1	147	80	0.56	0.34	282	10	11023	314	3.4E-5	38	0.06	35.7	0.170	1.8	3.841	1.3	0.2821	1.2	0.915	0.0987	0.5	1602	16	1601	9	-0	1600.95	16.89	0.01	0.94	17.33	0.895	2.14
Y	12155-038.1	265	136	0.53	0.27	357	12	10506	300	5.2E-5	24	0.09	64.1	0.159	1.4	3.854	1.2	0.2815	1.1	0.942	0.0993	0.4	1599	16	1611	8	+1	1608.44	14.26	0.42	0.52	17.33	0.895	2.14

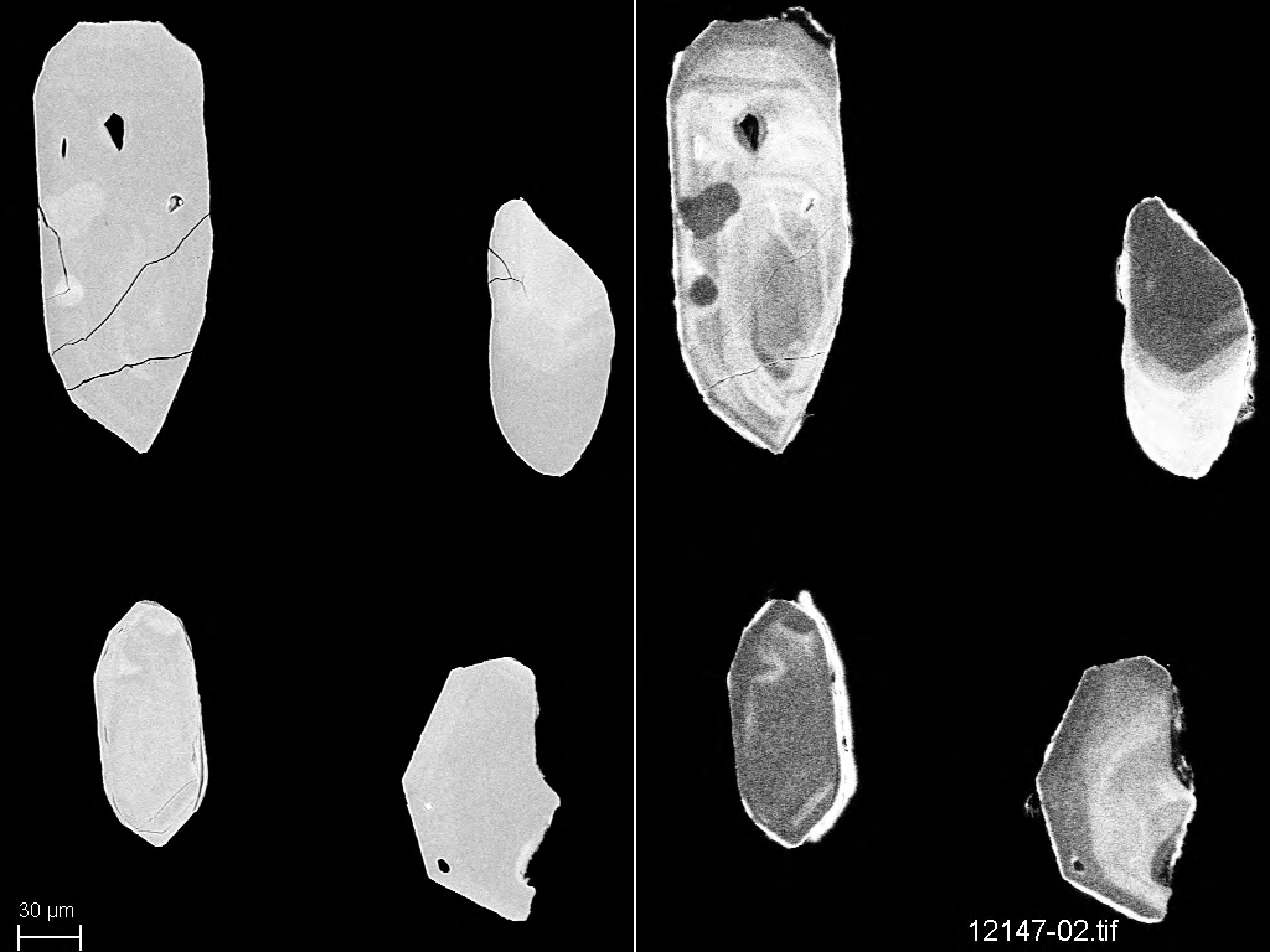
P	Spot Name	ppm U	ppm Th	232Th /238U	% err	*Yb ppm*	*1 σ abs err*	*Hf ppm*	*1 σ abs err*	204 /206	% err	4-corr %com 206	4-corr ppm 206*	4-corr 208Pb* /206Pb*	% err	204 corr 207*/235	% err	204 corr 206*/238	%err
Y	12155-074.1	103	90	0.90	3.67	319	28	9578	273	9.3E-5	28	0.16	25.2	0.266	3.5	3.911	1.4	0.2857	1.2
Y	12155-006.1	275	143	0.54	0.27	289	10	11493	328	9.1E-6	58	0.02	66.1	0.166	1.4	3.887	1.2	0.2797	1.1
Y	12155-031.1	34	43	1.31	0.51	279	9	7970	227	1.1E-4	45	0.19	8.6	0.385	2.6	4.130	1.8	0.2946	1.3
Y	12155-017.1	125	52	0.43	0.44	194	7	12027	406	4.2E-5	38	0.07	31.8	0.126	2.4	4.193	1.3	0.2956	1.2
Y	12155-069.1.1	109	74	0.70	0.37	176	7	8893	254	-2.6E-14	9999	0.00	28.4	0.203	1.9	4.442	1.3	0.3026	1.2
Y	12155-014.1	339	136	0.42	0.27	188	8	10895	373	1.6E-5	35	0.03	93.0	0.126	1.4	4.844	1.2	0.3197	1.1
Y	12155-028.1	125	61	0.51	0.40	344	12	11288	448	7.4E-5	27	0.13	35.2	0.151	2.0	5.043	1.3	0.3267	1.2
Y	12155-021.1	463	151	0.34	0.26	671	23	12197	348	2.7E-5	23	0.05	131.4	0.099	1.3	5.125	1.1	0.3307	1.1
Y	12155-068.1	113	54	0.49	0.43	311	11	9725	395	5.8E-5	33	0.10	30.9	0.141	2.3	5.010	1.3	0.3166	1.2
Y	12155-005.1	311	80	0.26	0.35	400	14	12529	456	2.6E-5	29	0.05	90.0	0.077	2.9	5.324	1.2	0.3374	1.1
Y	12155-039.1	227	122	0.55	0.29	302	10	10763	307	2.8E-5	32	0.05	68.1	0.161	1.4	5.755	1.2	0.3493	1.1
Y	12155-002.1	86	105	1.26	0.35	365	12	7899	300	9.3E-5	28	0.16	26.0	0.372	3.7	5.943	1.4	0.3519	1.2
Y	12155-092.1	303	156	0.53	0.25	252	11	12189	348	1.5E-5	35	0.03	95.1	0.156	1.1	6.164	1.2	0.3656	1.1
Y	12155-083.1	86	46	0.56	0.46	181	8	9515	422	1.2E-4	23	0.21	25.2	0.143	2.4	6.221	1.3	0.3426	1.2
Y	12155-072.1	313	61	0.20	0.38	347	14	13486	385	9.0E-6	45	0.02	101.9	0.058	1.9	6.705	1.2	0.3793	1.1
Y	12155-087.1.2	38	62	1.70	0.41	182	6	8356	238	1.0E-5	100	0.02	16.0	0.495	1.5	12.407	1.4	0.4941	1.3
Y	12155-049.1	288	128	0.46	0.28	135	5	10678	411	1.1E-5	38	0.02	124.9	0.131	1.1	12.782	1.2	0.5053	1.1

Spot Name	error coefficient	204 corr 207*/206*	%err	204 corr 206*/238 Age	Age abs. err.	204 corr 207*/206* Age	Age abs. err.	% Disc.	Concordia age	2sigma Err	MSWD	Probability	Common pb 206/204	Common pb 207/206	Common pb 208/206
12155-074.1	0.864	0.0993	0.7	1620	17	1610	13	-1	1614.01	20.61	0.21	0.64	17.33	0.895	2.14
12155-006.1	0.948	0.1008	0.4	1590	16	1639	7	+3	1630.02	13.47	7.77	0.01	17.33	0.895	2.14
12155-031.1	0.743	0.1017	1.2	1665	19	1655	22	-1	1660.40	29.28	0.10	0.75	17.33	0.895	2.14
12155-017.1	0.899	0.1029	0.6	1669	17	1677	11	+1	1674.70	18.32	0.14	0.71	17.33	0.895	2.14
12155-069.1.1	0.908	0.1065	0.5	1704	18	1740	10	+2	1730.70	17.70	3.04	0.08	17.33	0.895	2.14
12155-014.1	0.965	0.1099	0.3	1788	18	1798	6	+1	1796.47	11.71	0.24	0.62	17.33	0.895	2.14
12155-028.1	0.909	0.1119	0.5	1822	18	1831	10	+1	1829.22	17.59	0.18	0.67	17.33	0.895	2.14
12155-021.1	0.974	0.1124	0.3	1842	18	1839	5	-0	1839.03	10.51	0.02	0.88	17.33	0.895	2.14
12155-068.1	0.901	0.1148	0.6	1773	18	1876	10	+6	1850.79	18.05	24.52	0.00	17.33	0.895	2.14
12155-005.1	0.956	0.1144	0.3	1874	18	1871	6	-0	1871.53	12.89	0.02	0.88	17.33	0.895	2.14
12155-039.1	0.955	0.1195	0.4	1931	19	1949	6	+1	1946.68	12.92	0.75	0.39	17.33	0.895	2.14
12155-002.1	0.881	0.1225	0.6	1944	20	1993	11	+3	1980.14	20.22	4.41	0.04	17.33	0.895	2.14
12155-092.1	0.971	0.1223	0.3	2009	19	1989	5	-1	1991.06	11.06	0.91	0.34	17.33	0.895	2.14
12155-083.1	0.899	0.1317	0.6	1899	19	2121	10	+12	2073.23	17.80	105.81	0.00	17.33	0.895	2.14
12155-072.1	0.973	0.1282	0.3	2073	20	2074	5	+0	2073.54	10.70	0.00	0.98	17.33	0.895	2.14
12155-087.1.2	0.913	0.1821	0.6	2588	27	2672	9	+4	2662.36	18.18	8.68	0.00	17.33	0.895	2.14
12155-049.1	0.982	0.1835	0.2	2636	24	2684	4	+2	2682.46	9.57	3.68	0.06	17.33	0.895	2.14

Appendix 6: OD2016-D2 detrital zircon BSE-CL imagery.

Lab number	Sample
12146	OD2016-D2-016
12151	OD2016-D2-018
12152	OD2016-D2-019
12147	OD2016-D2-022
12148	OD2016-D2-023
12149	OD2016-D2-030
12153	OD2016-D2-037
12150	OD2016-D2-047
12154	OD2016-D2-066
12155	OD2016-D2-069


12147-01.tif
1
2
3
4
30 µm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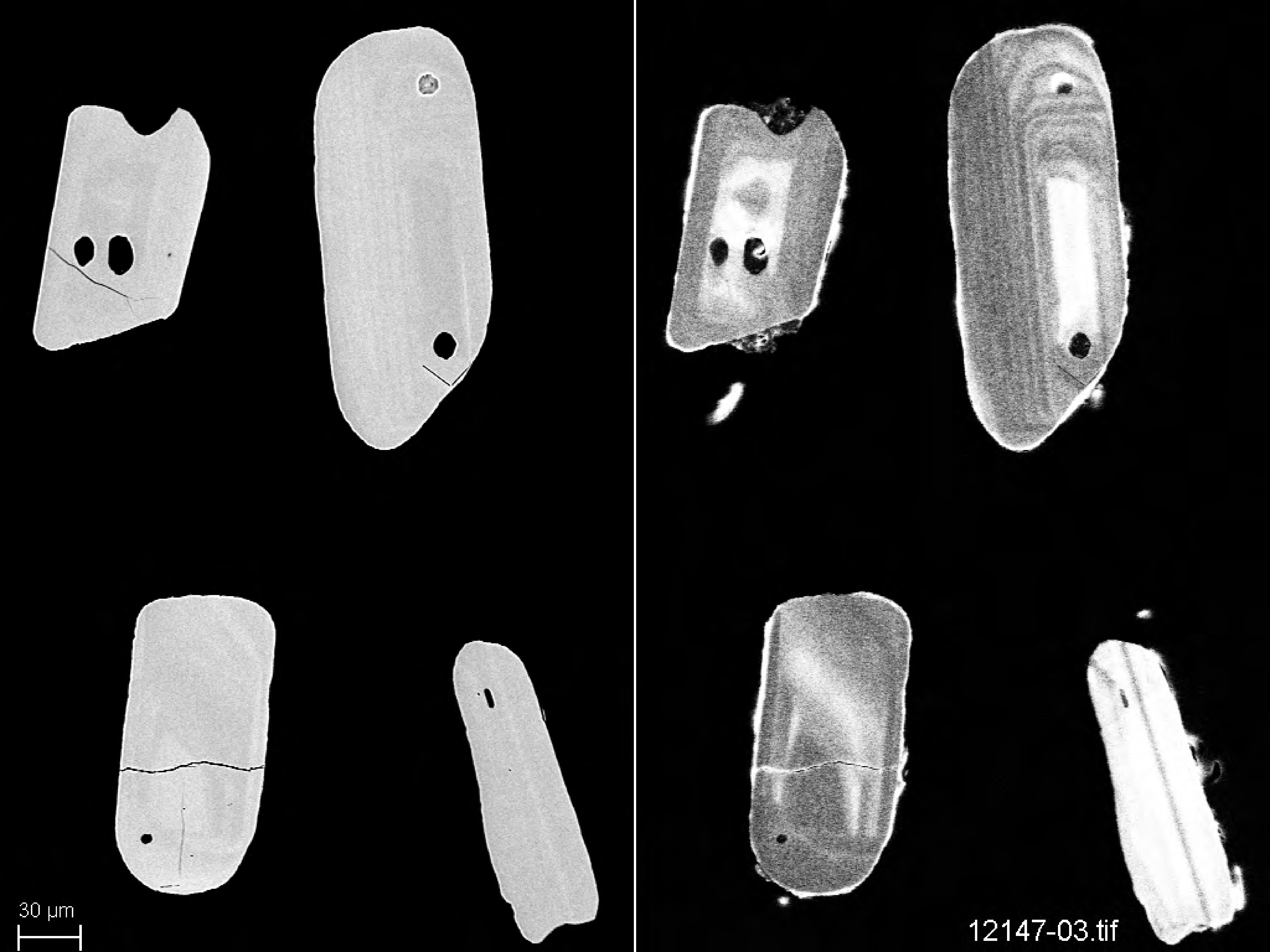
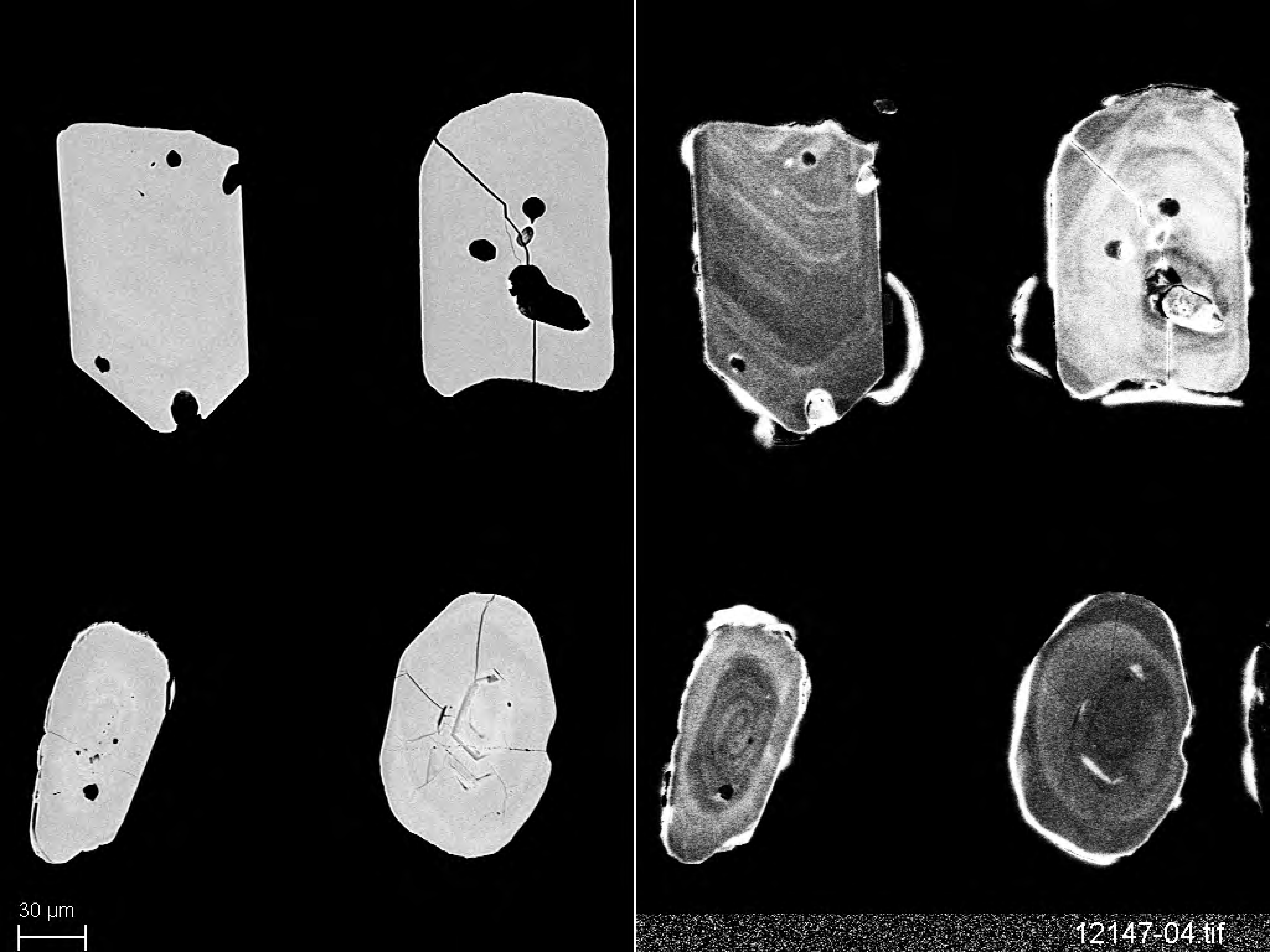

30 µm
12147-03.tif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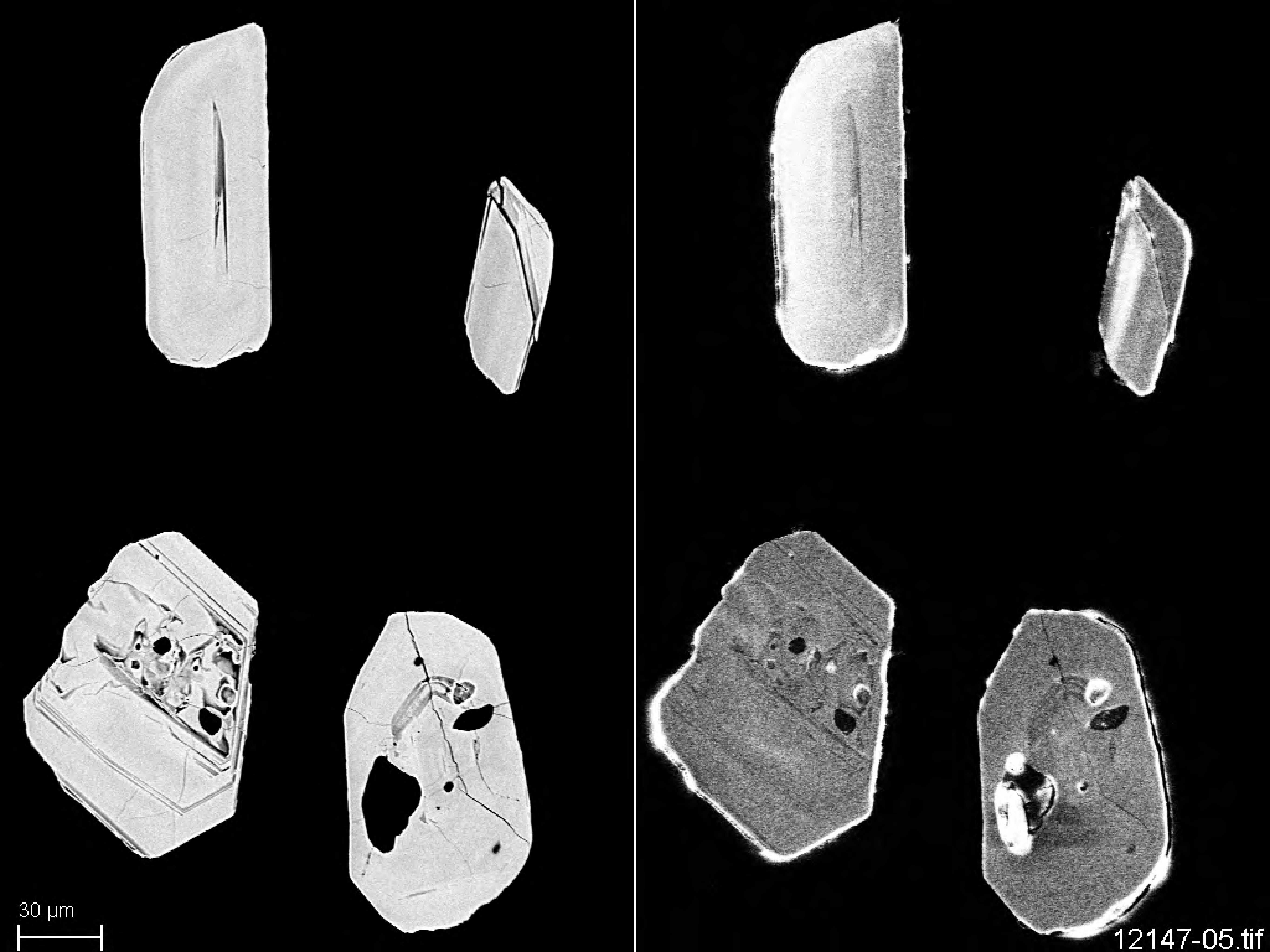
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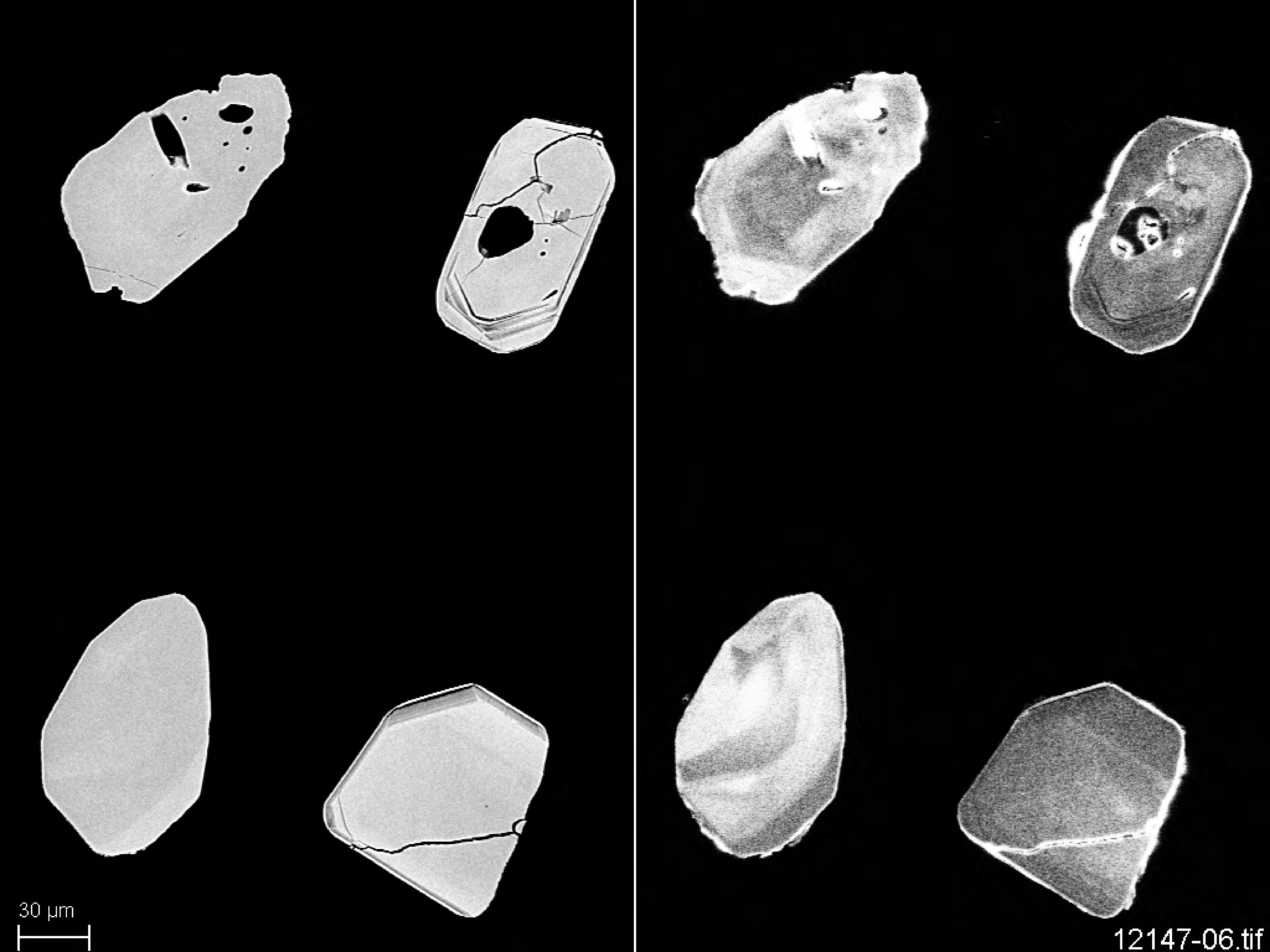
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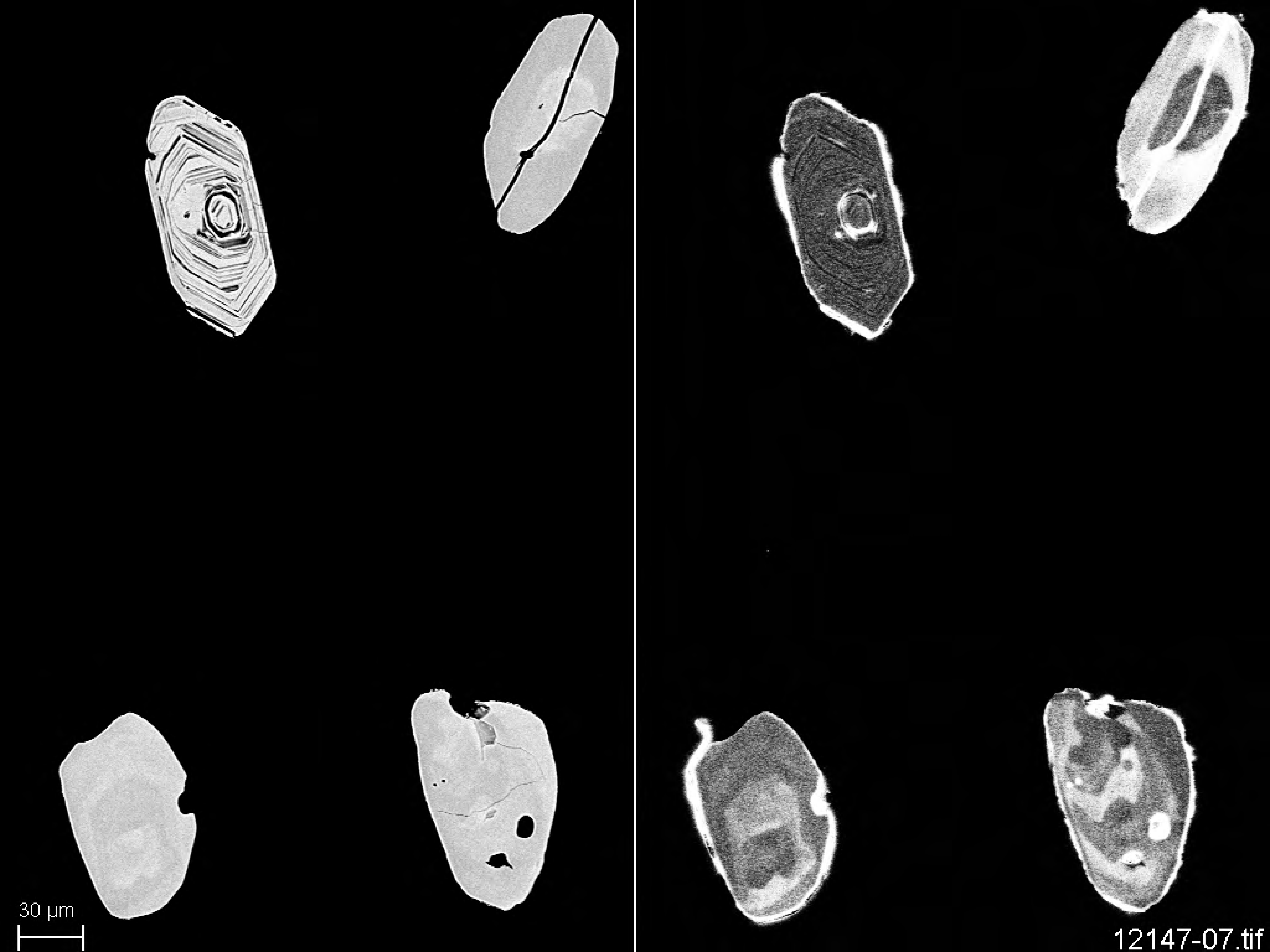
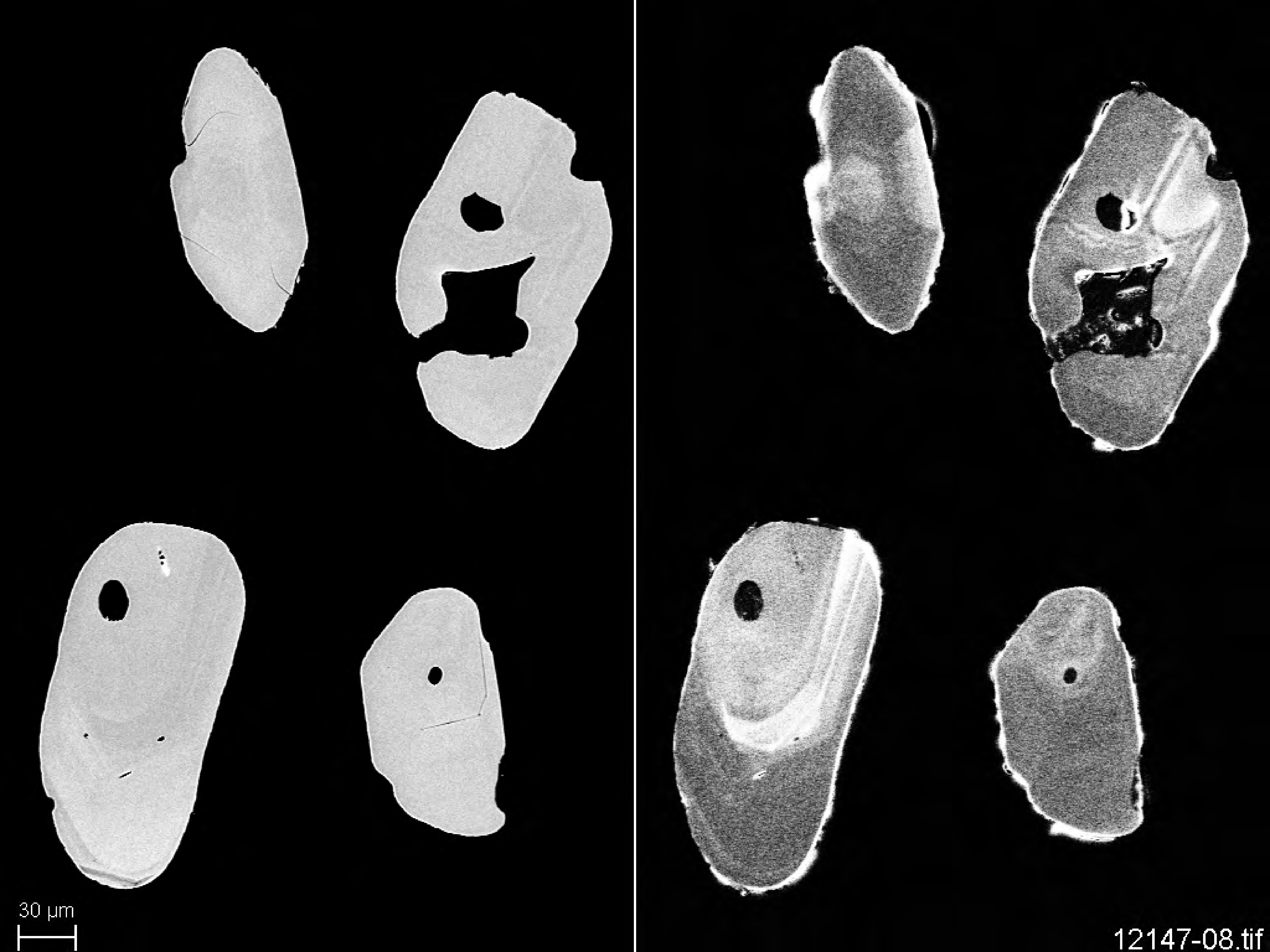

30 µm
12147-07.tif


30 µm
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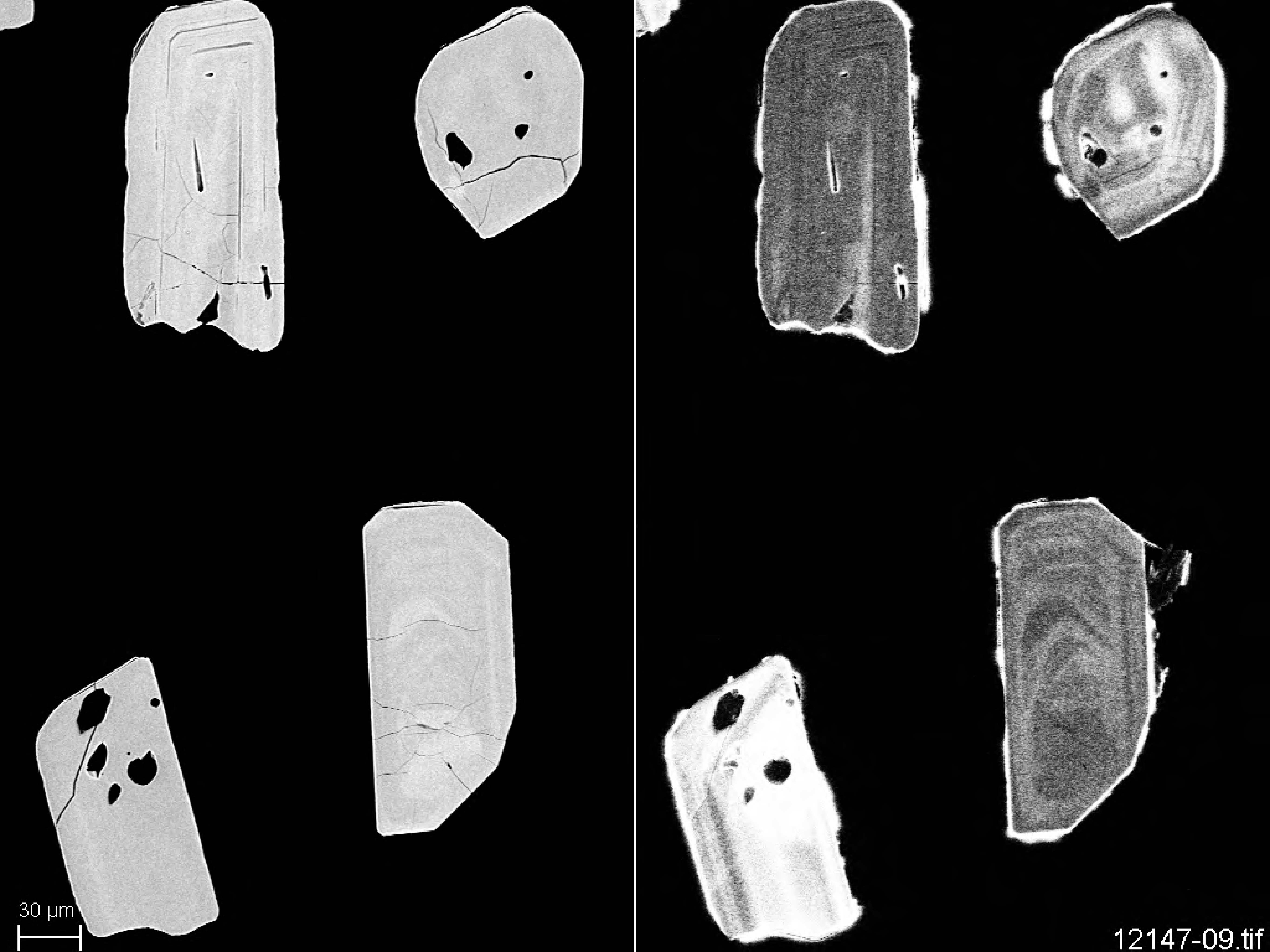
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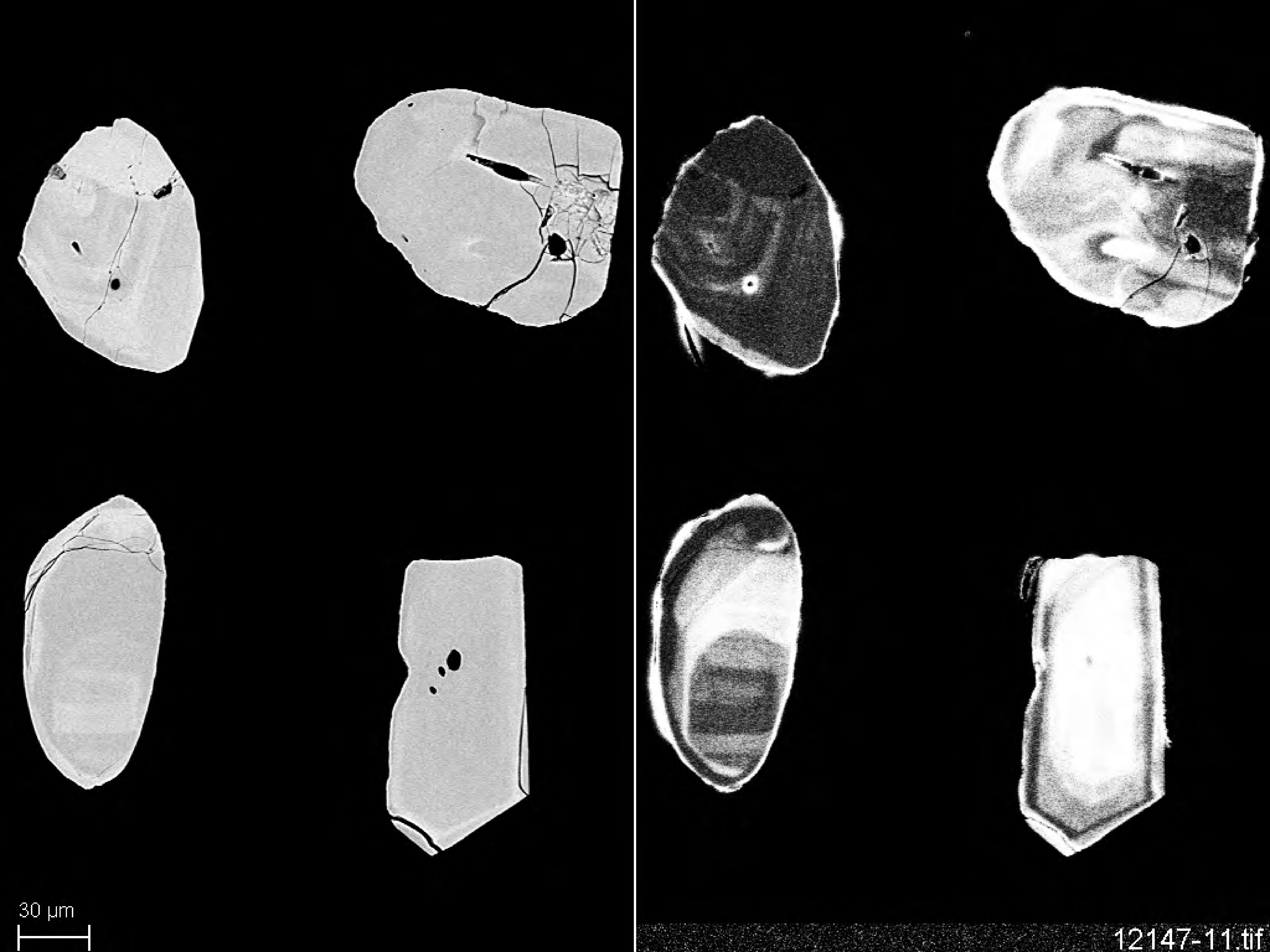
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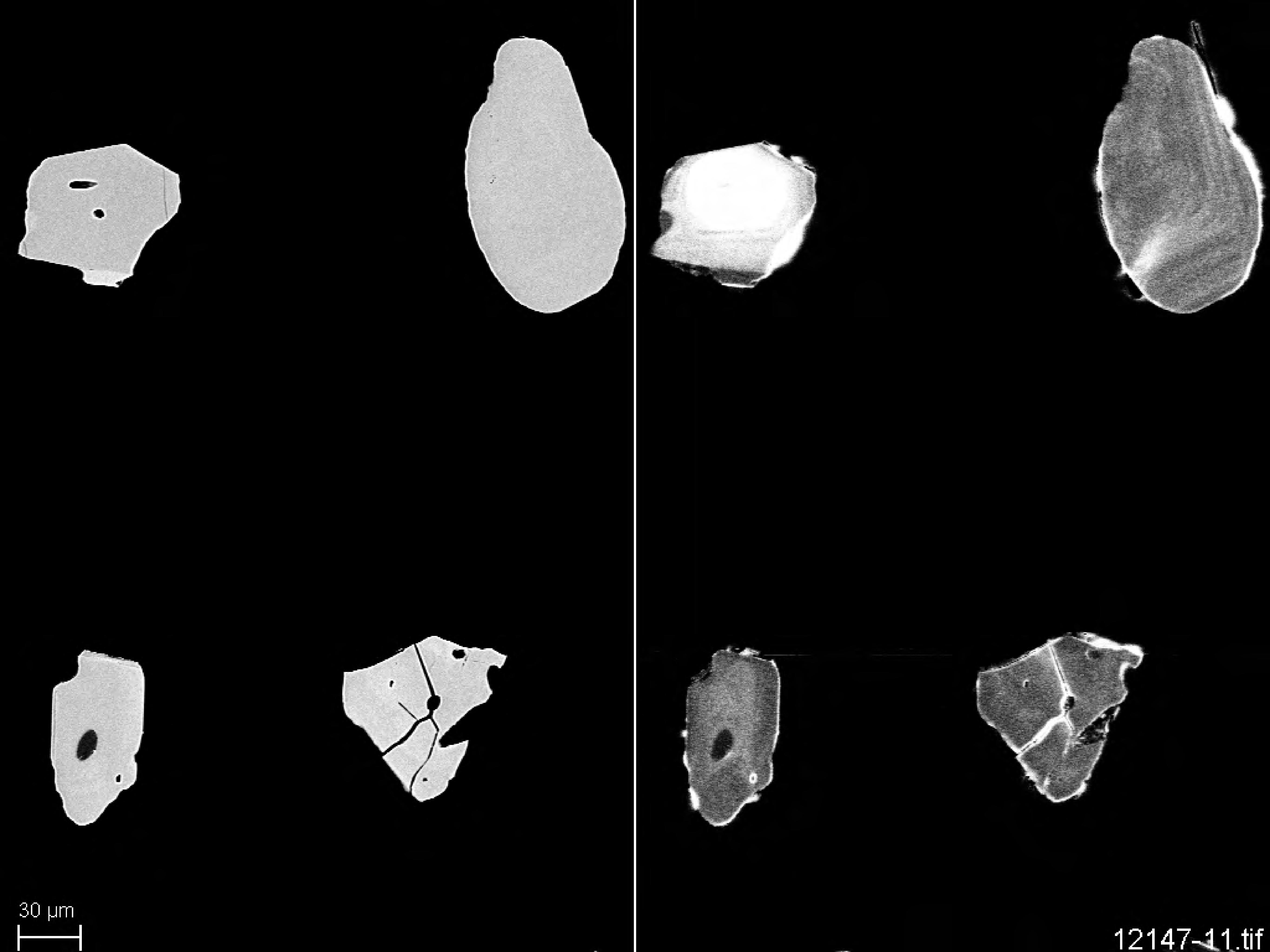
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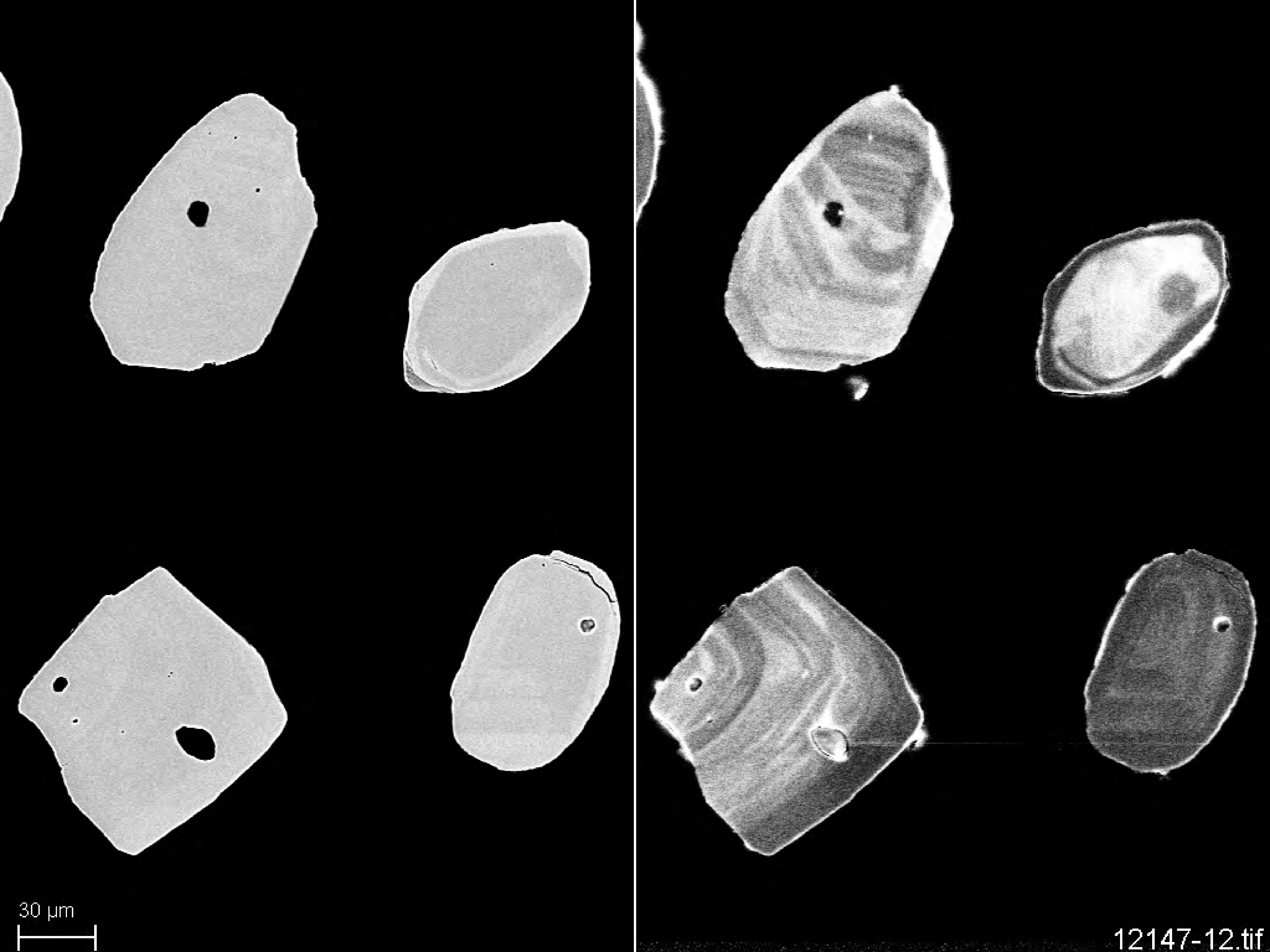
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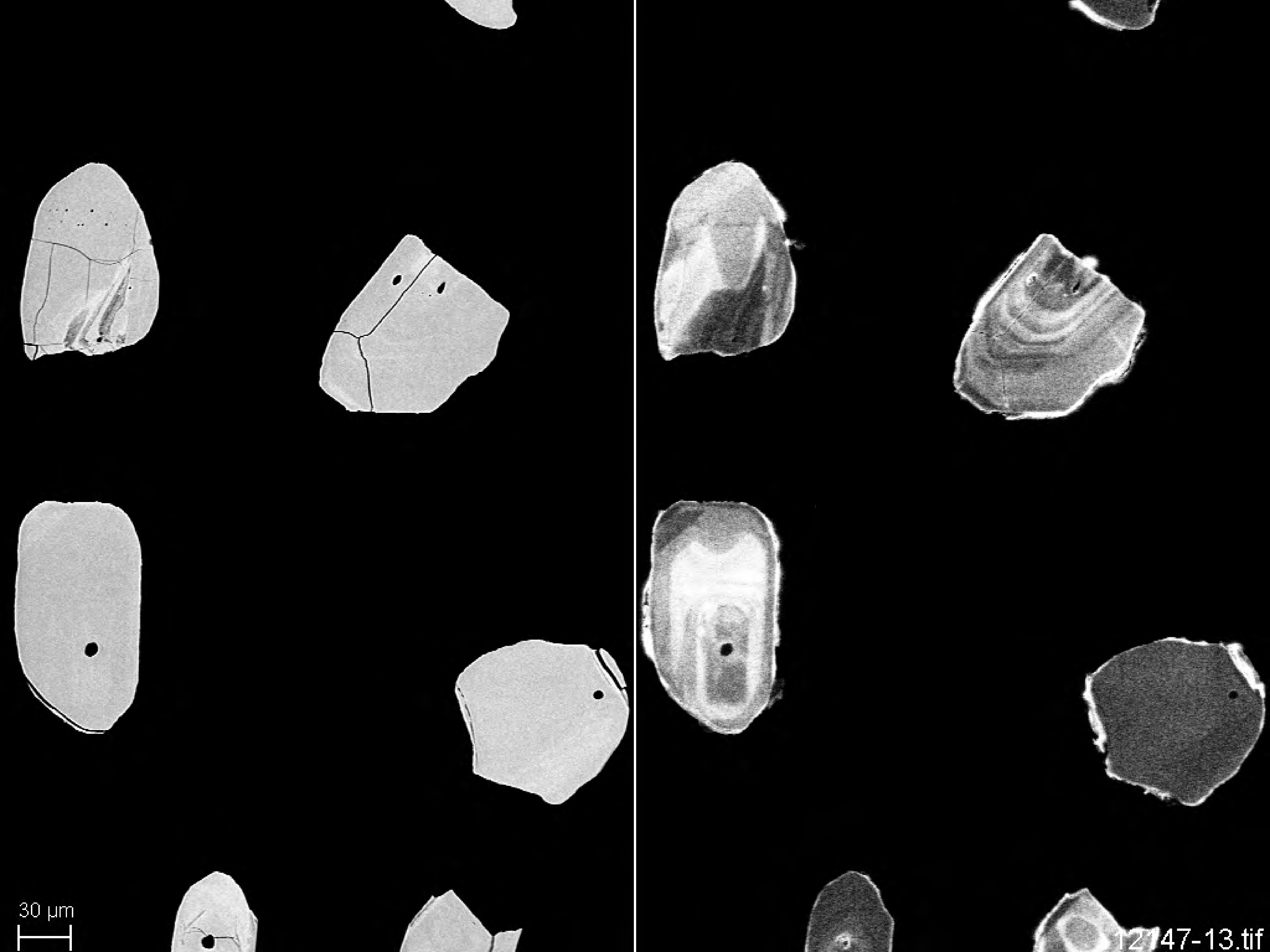
30 μm
12147-13.tif


30 µm
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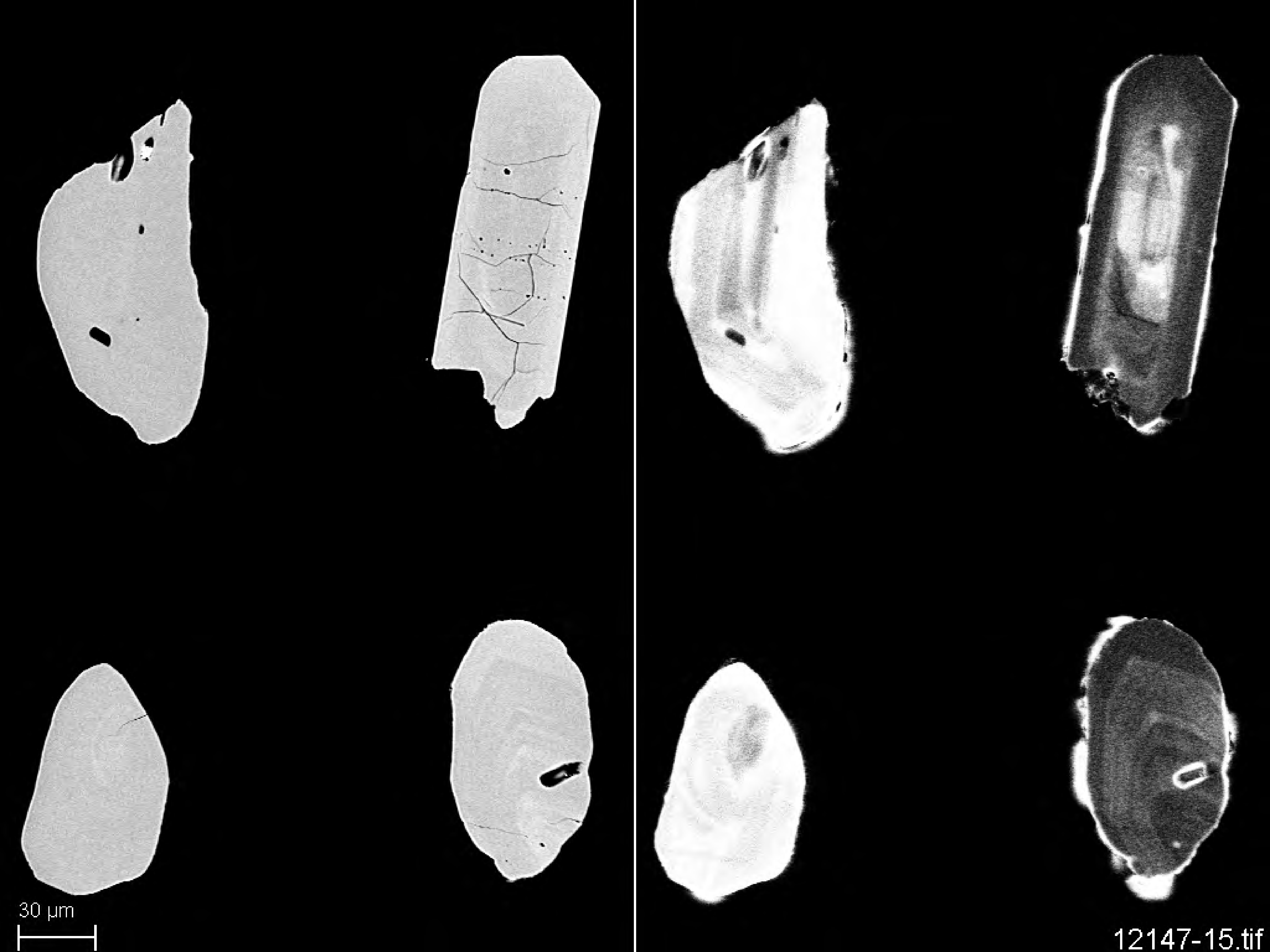
30 µm
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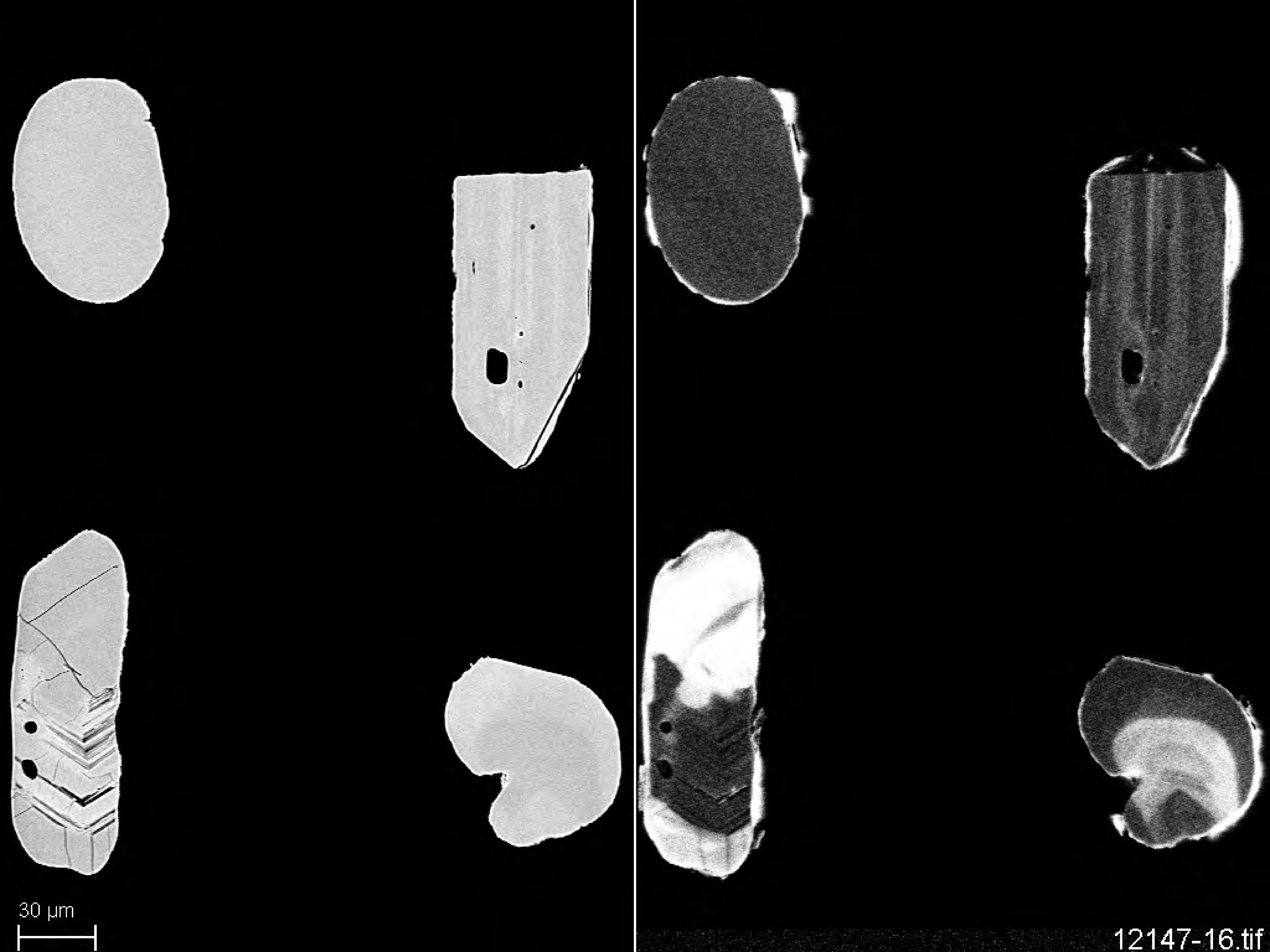
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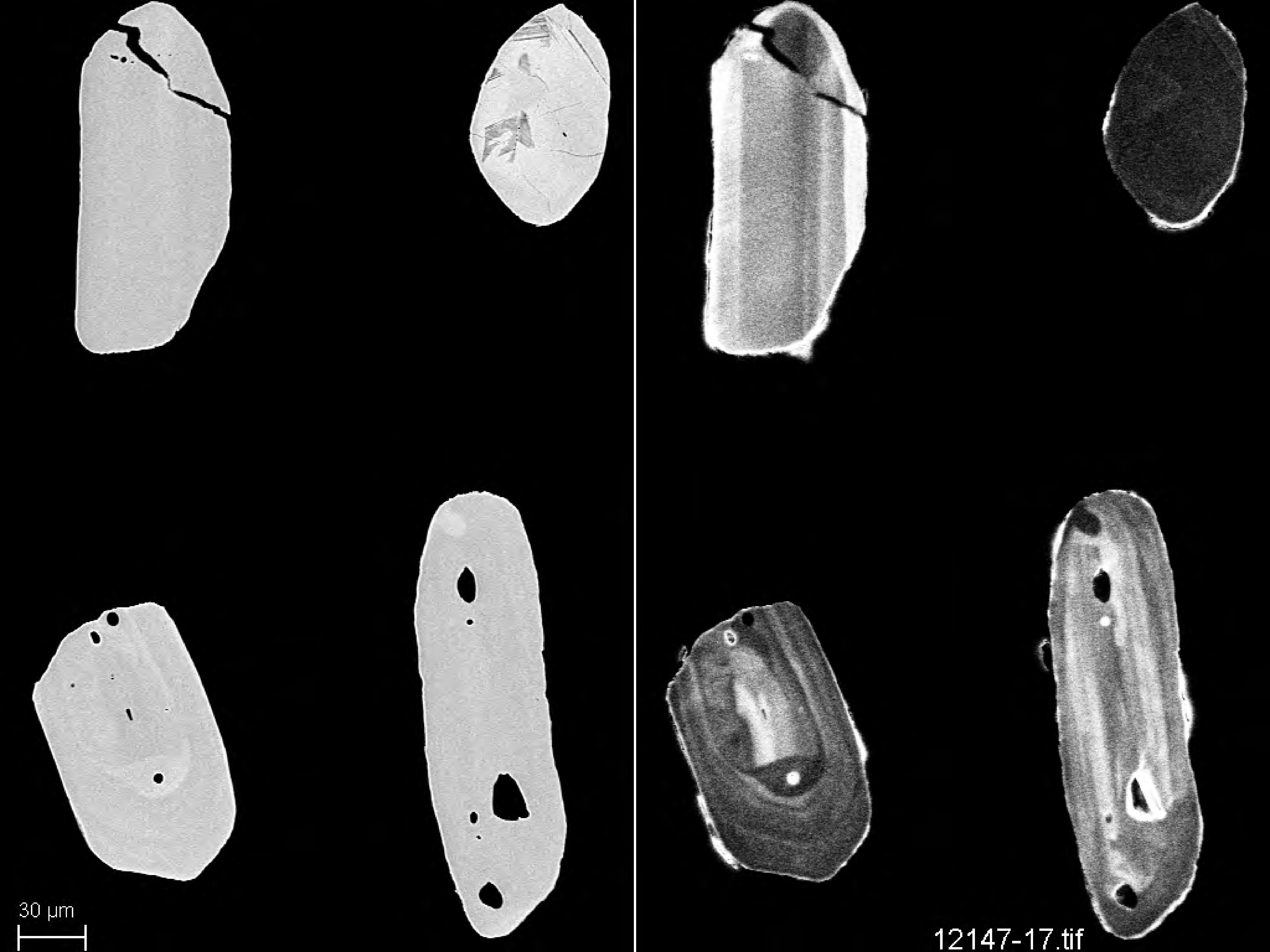
30 µm
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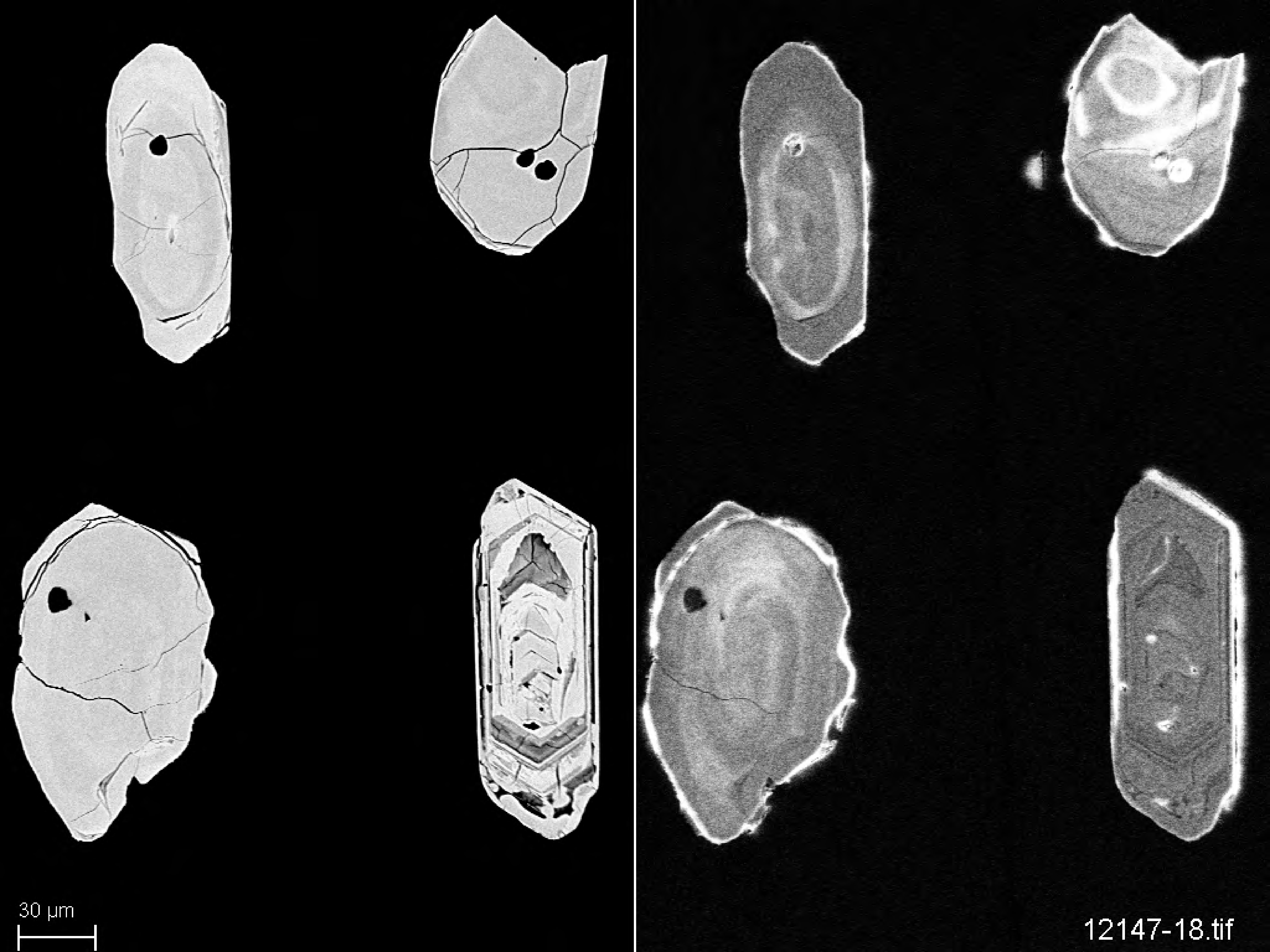
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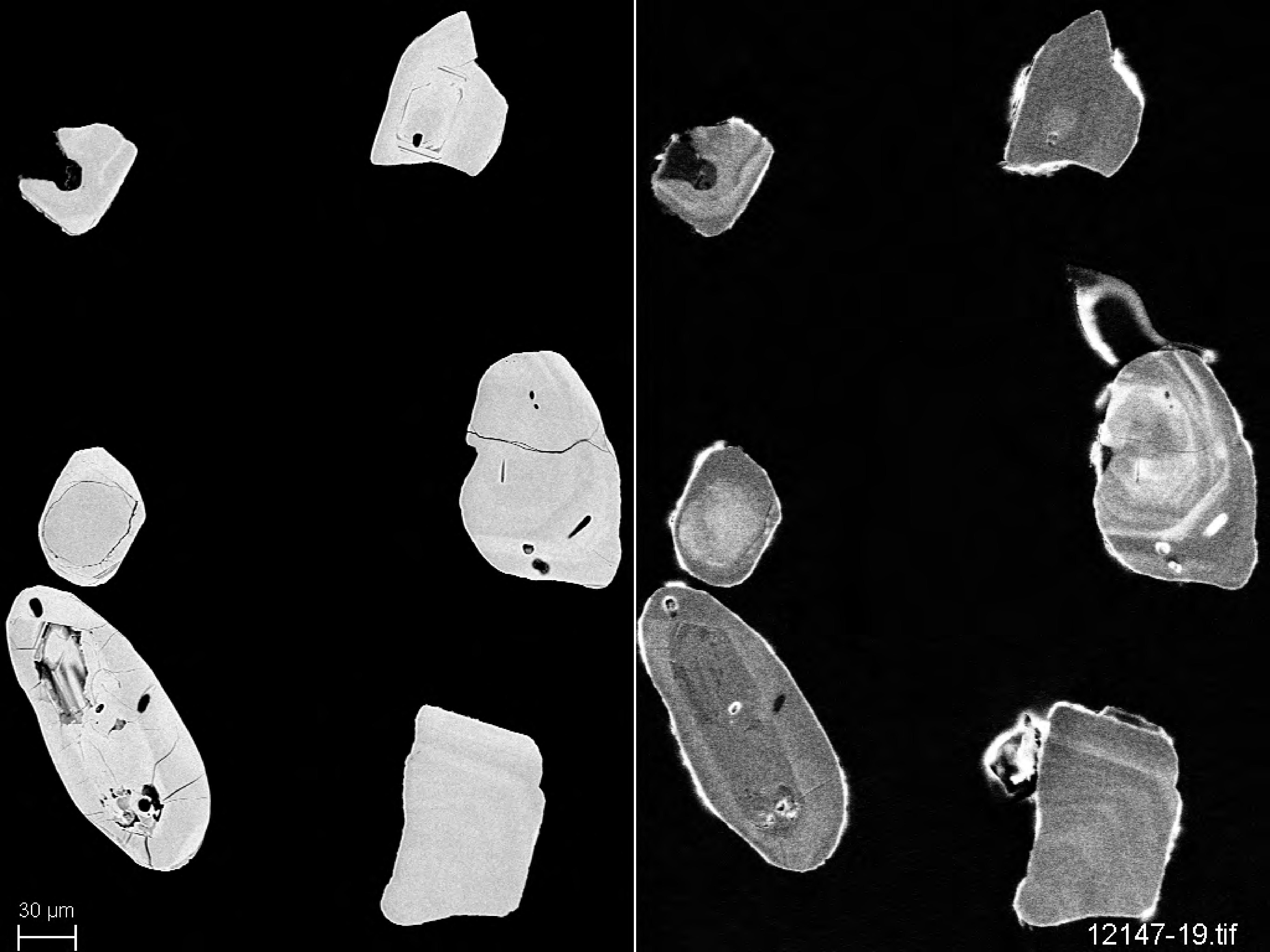
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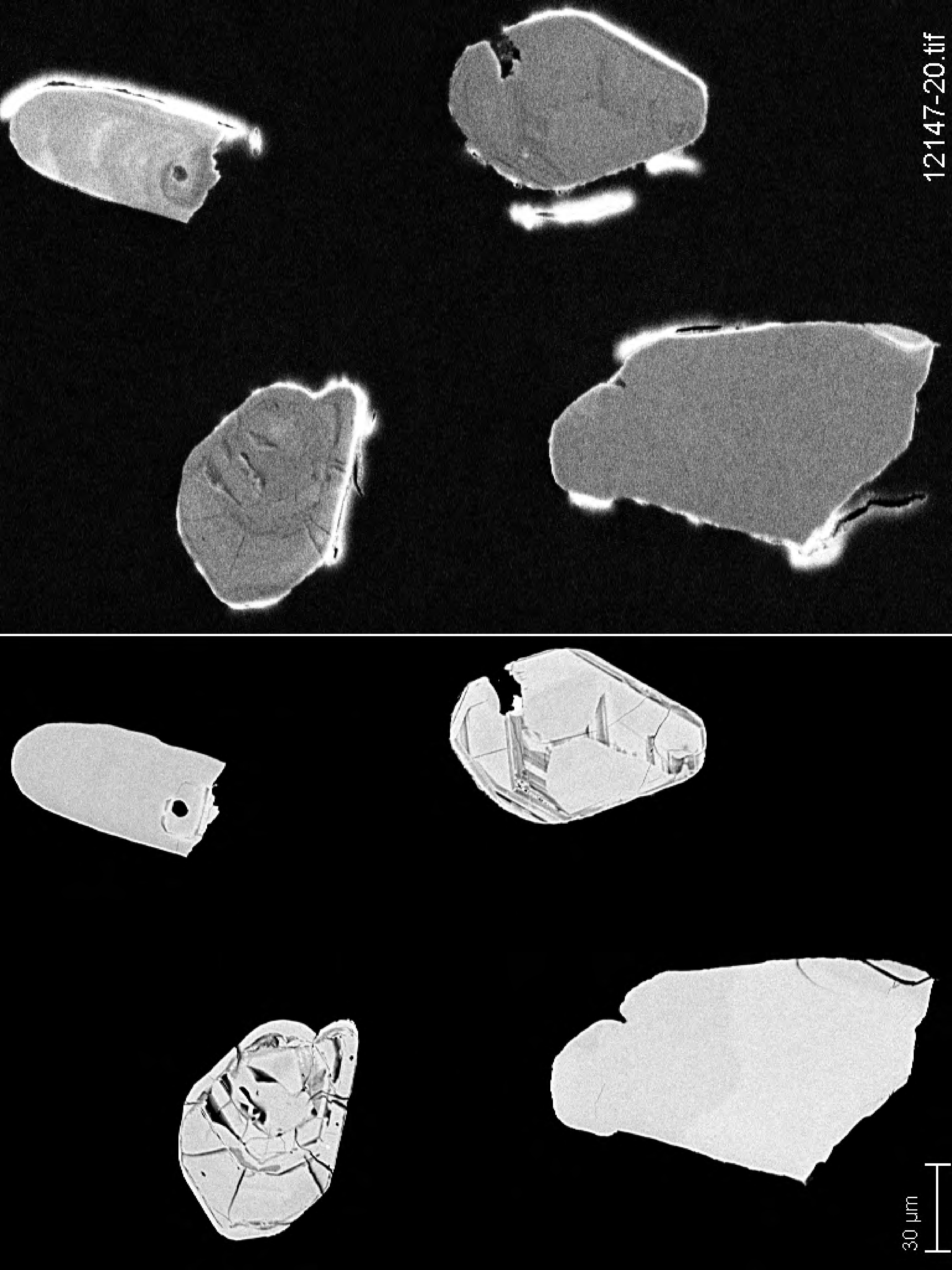
12147-20.tif
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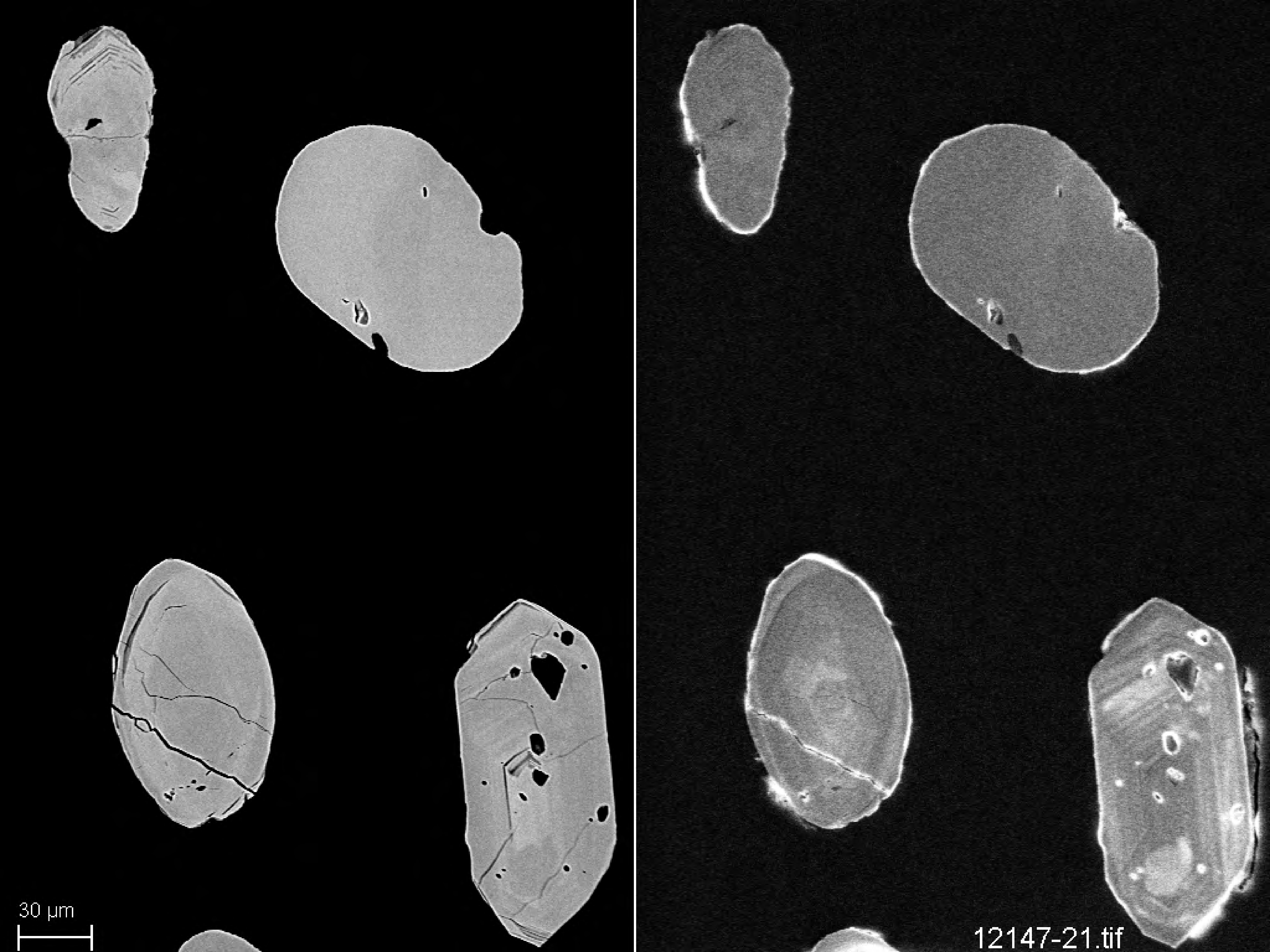
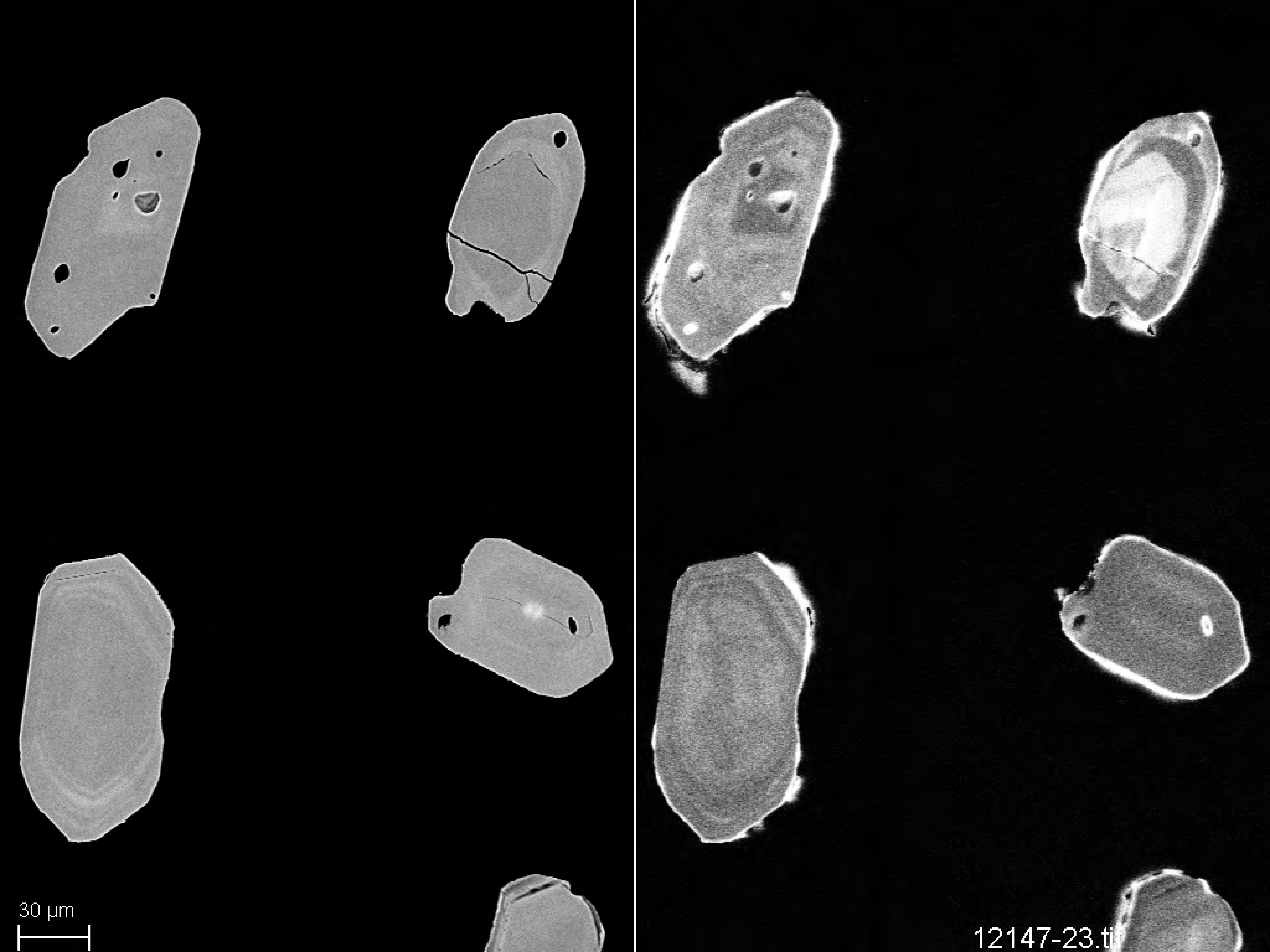

30 µm
12147-21.tif


30 µm
12147-22.tif


30 µm
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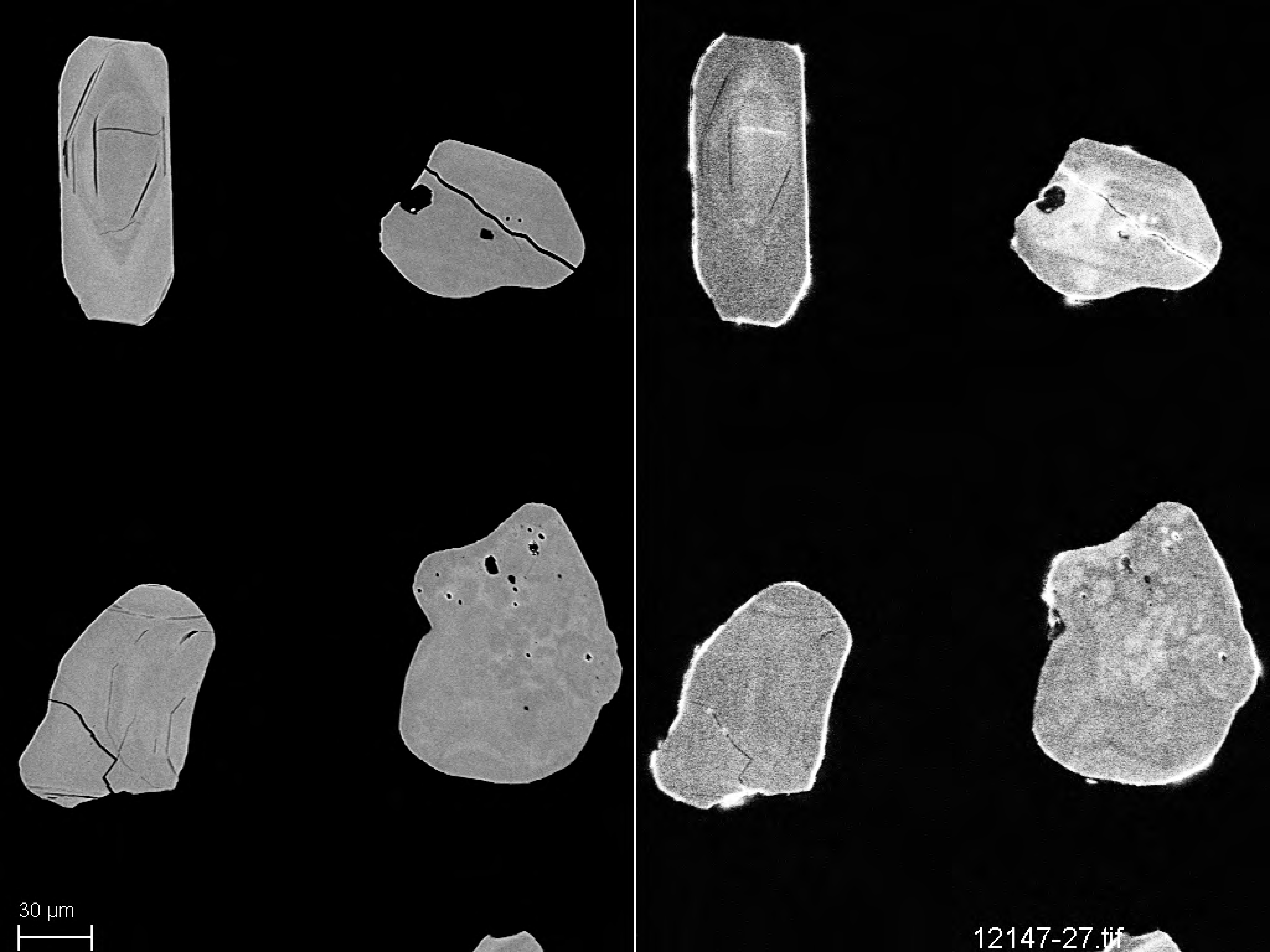
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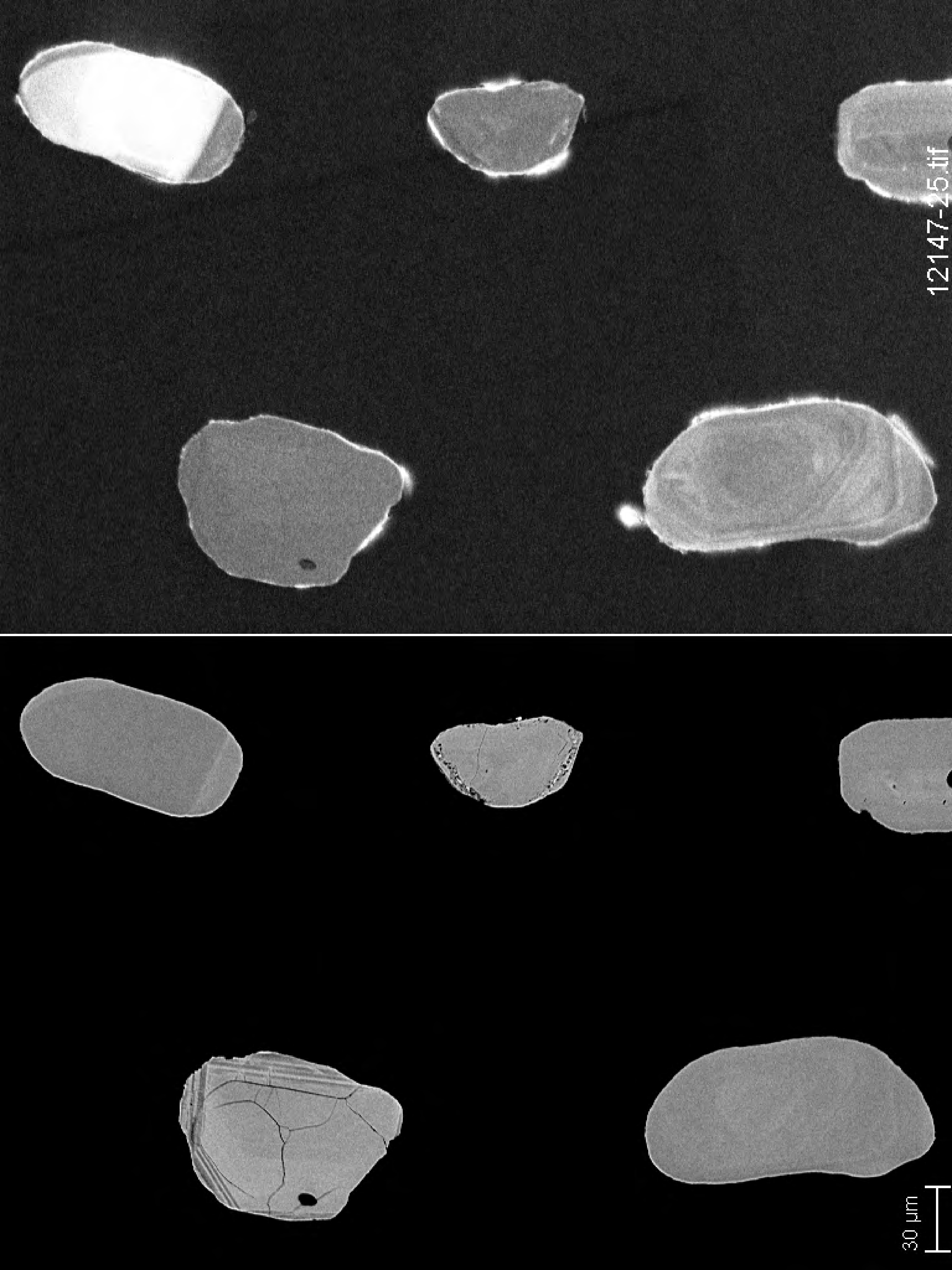
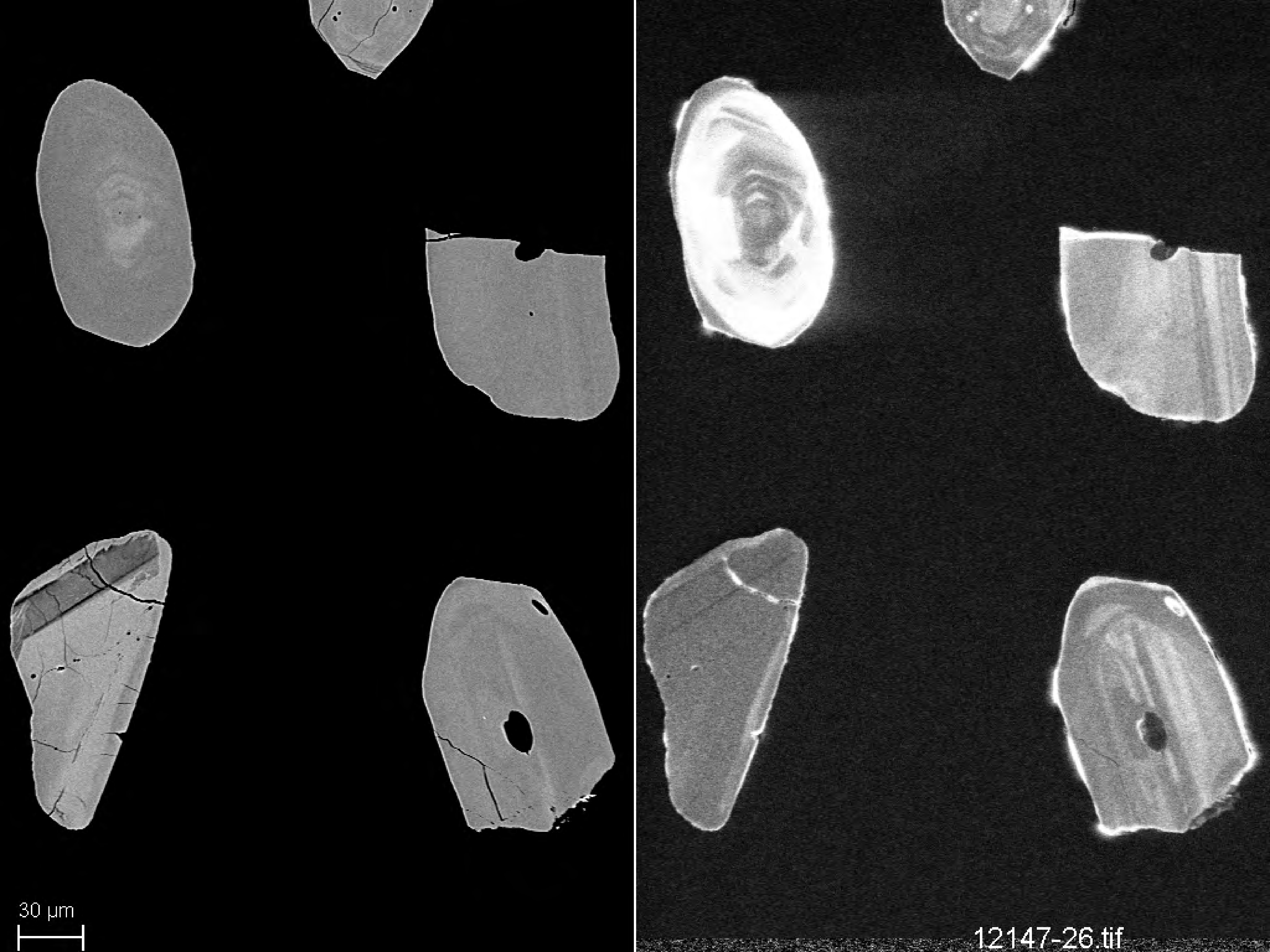

12147-25.tif
30 µm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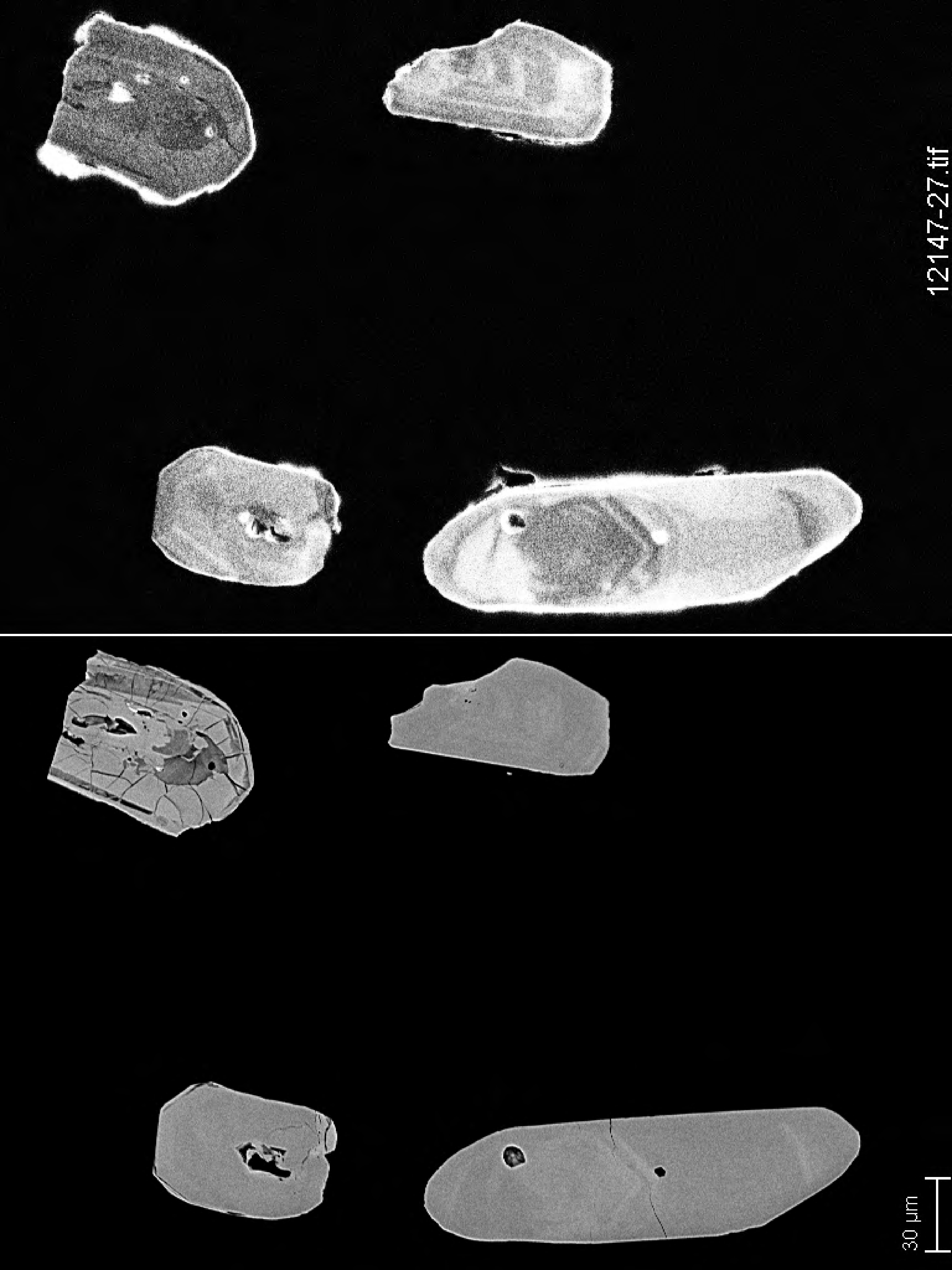
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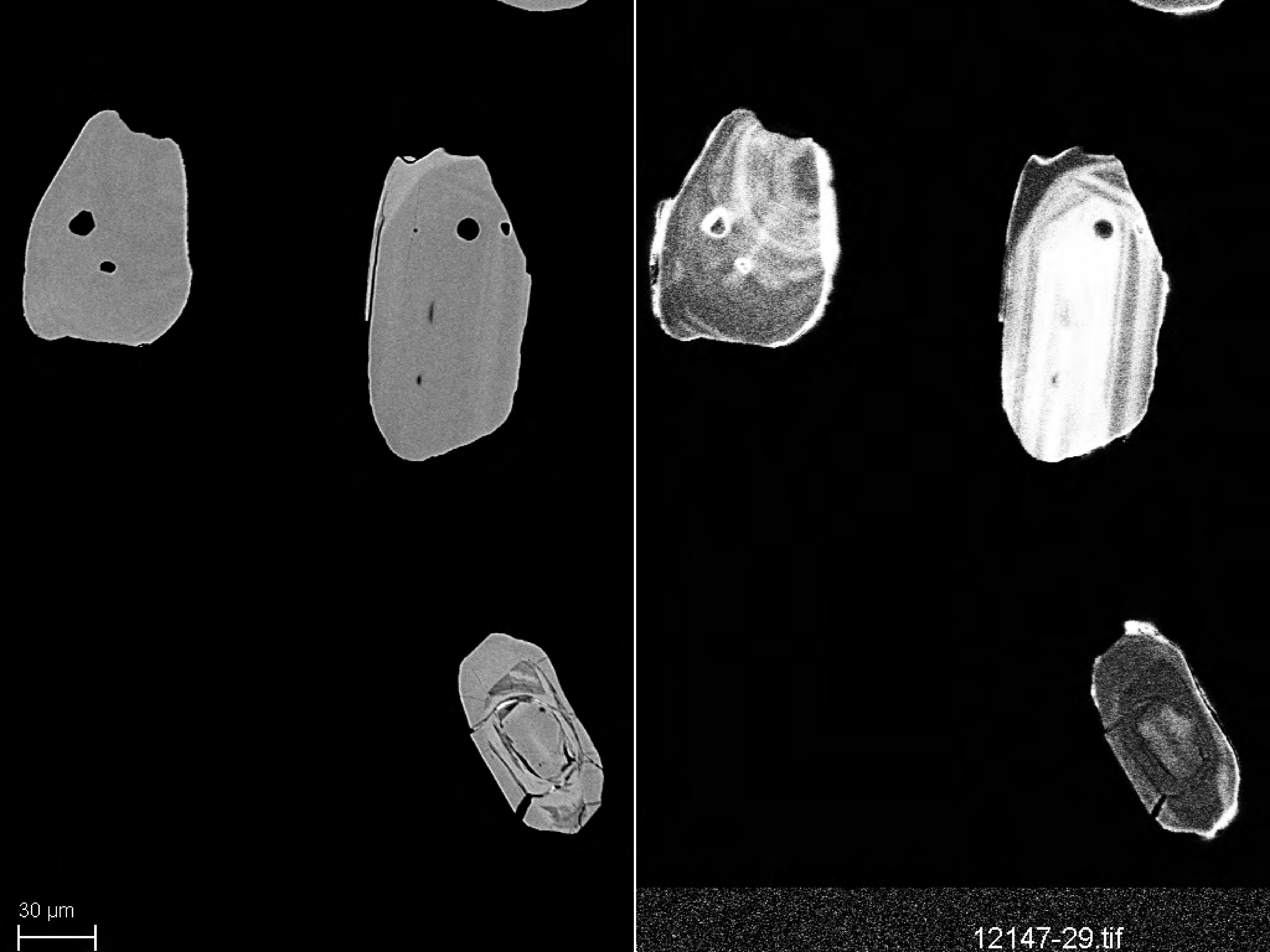
30 µm


30 µm
12147-28.tif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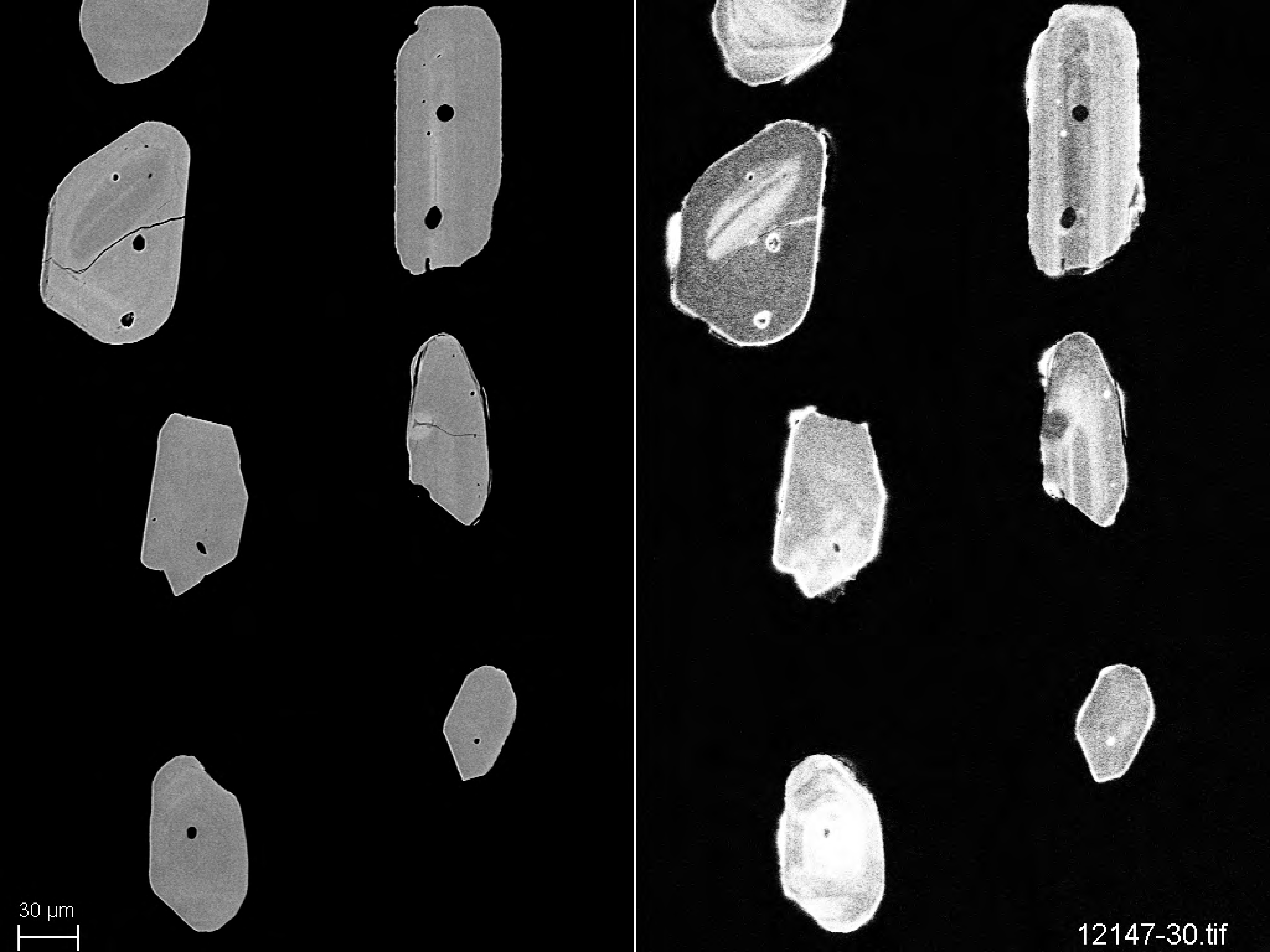
30 µm
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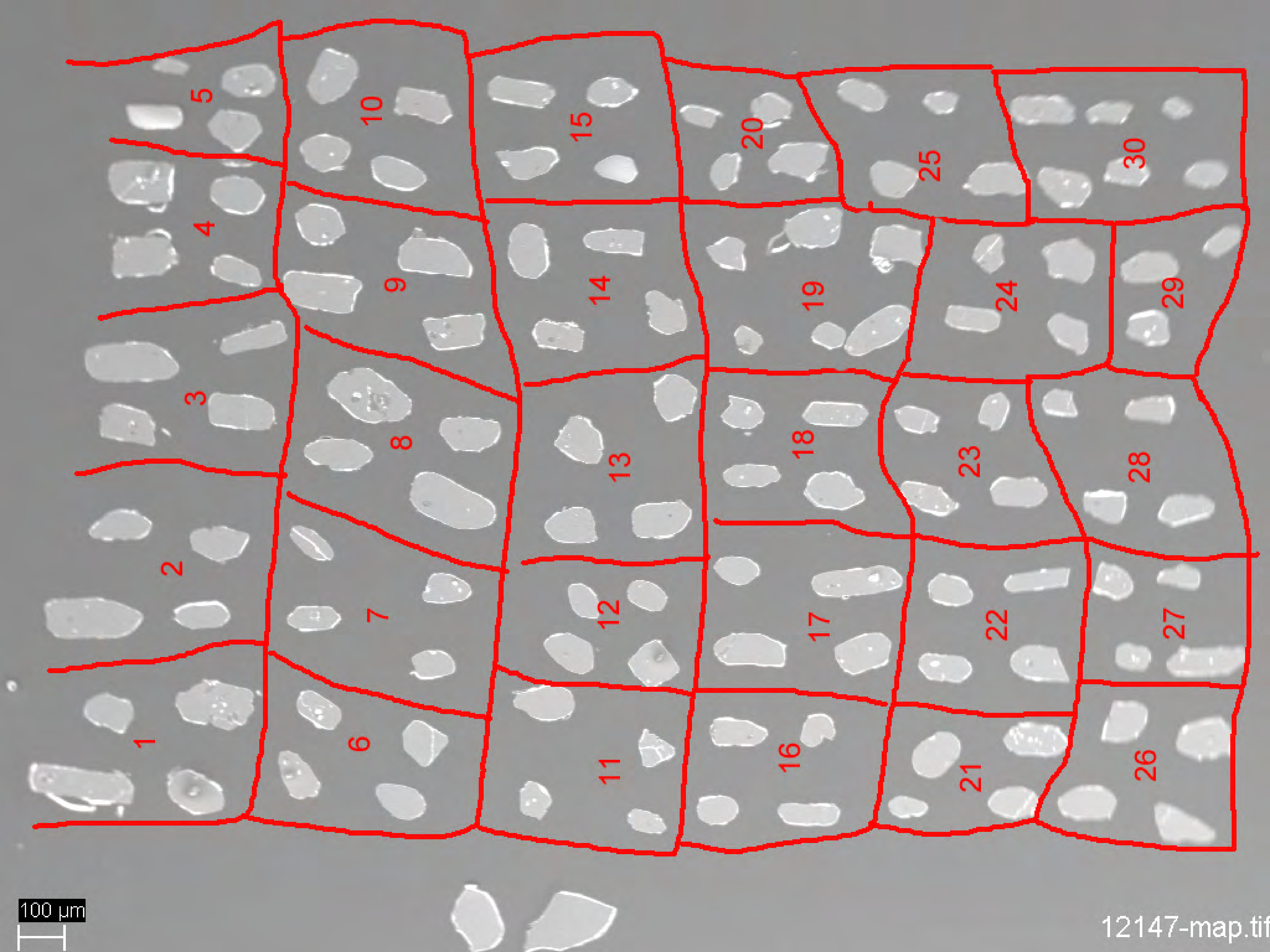
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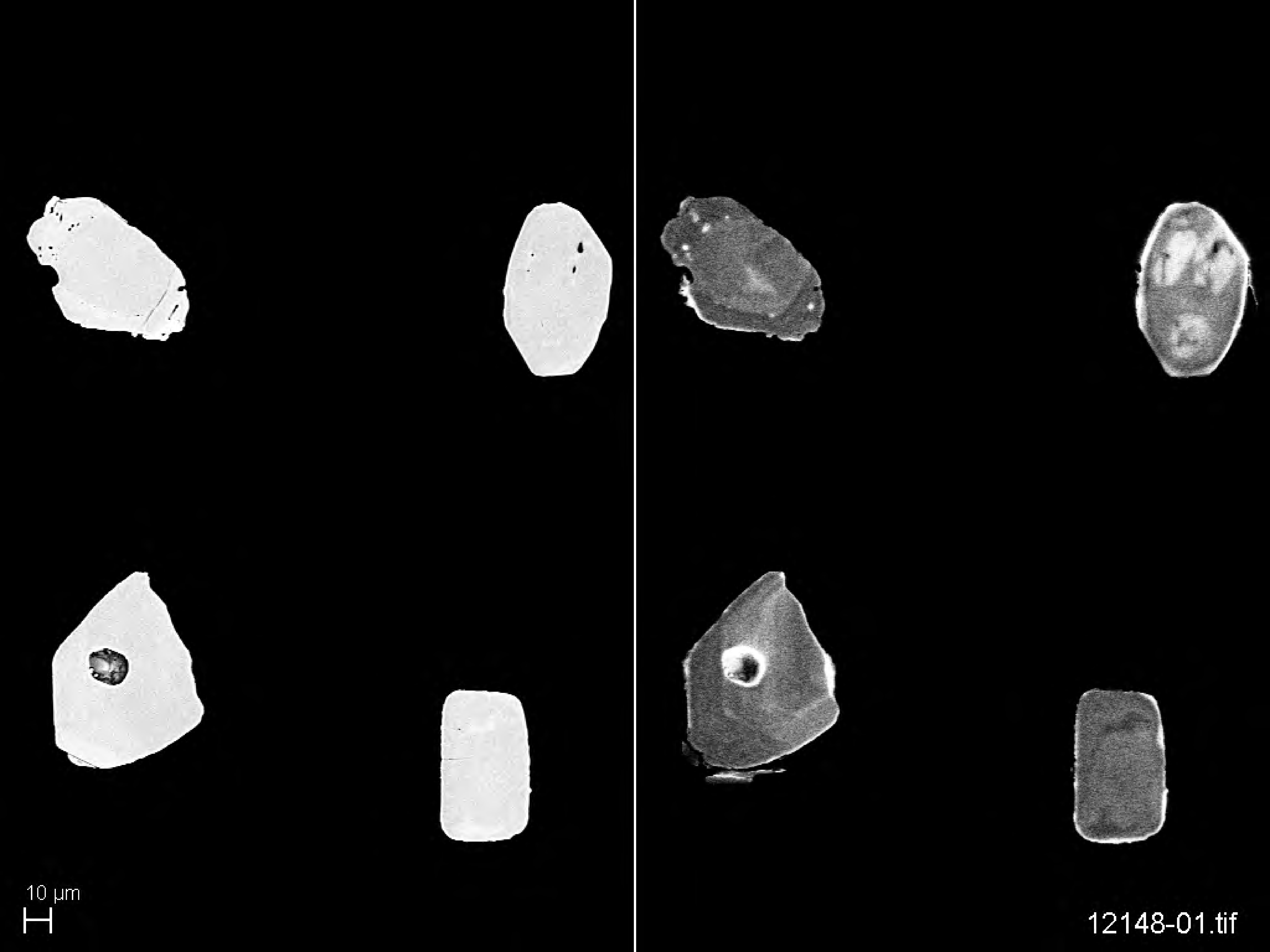
12147-map.tif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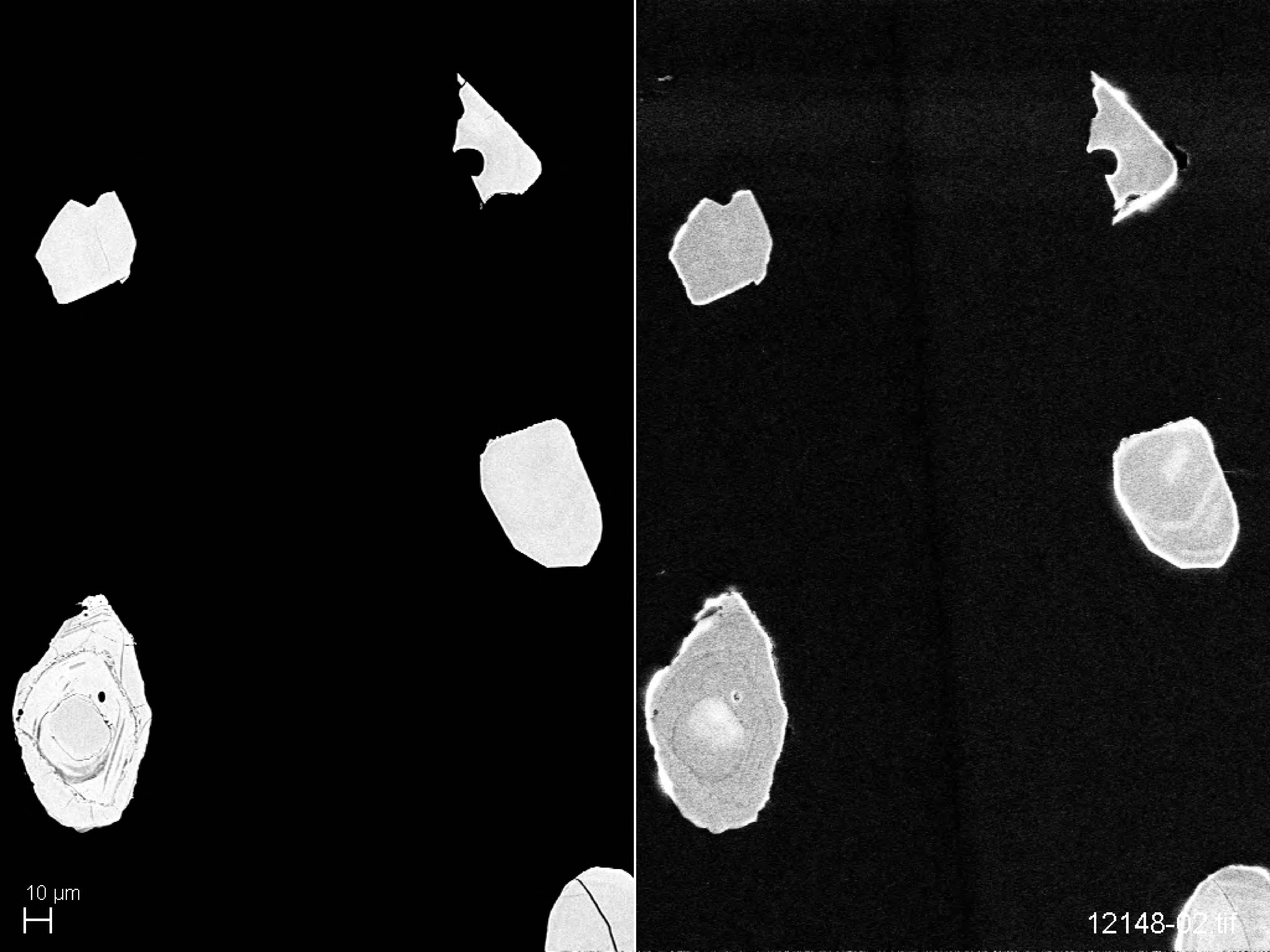
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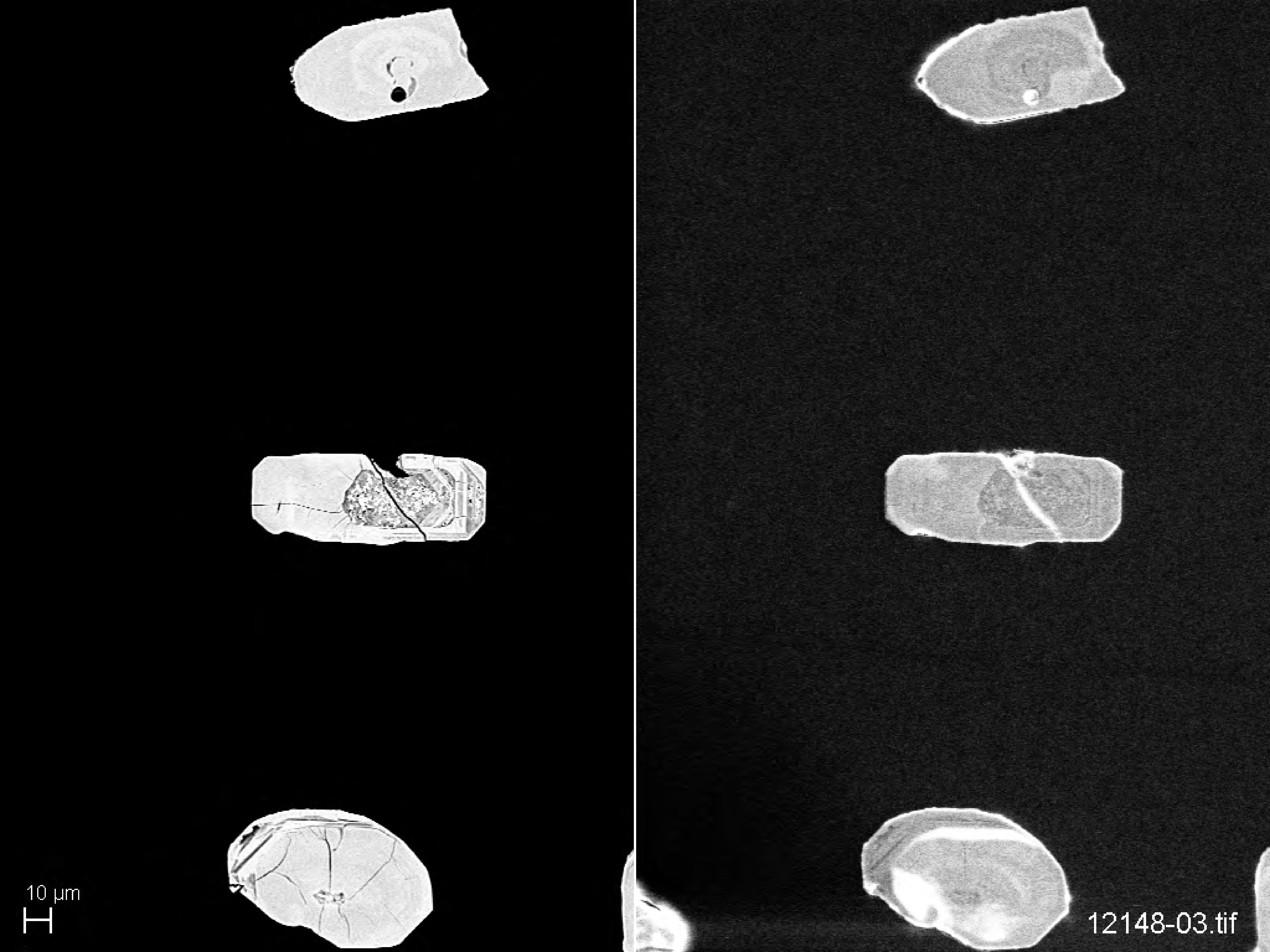
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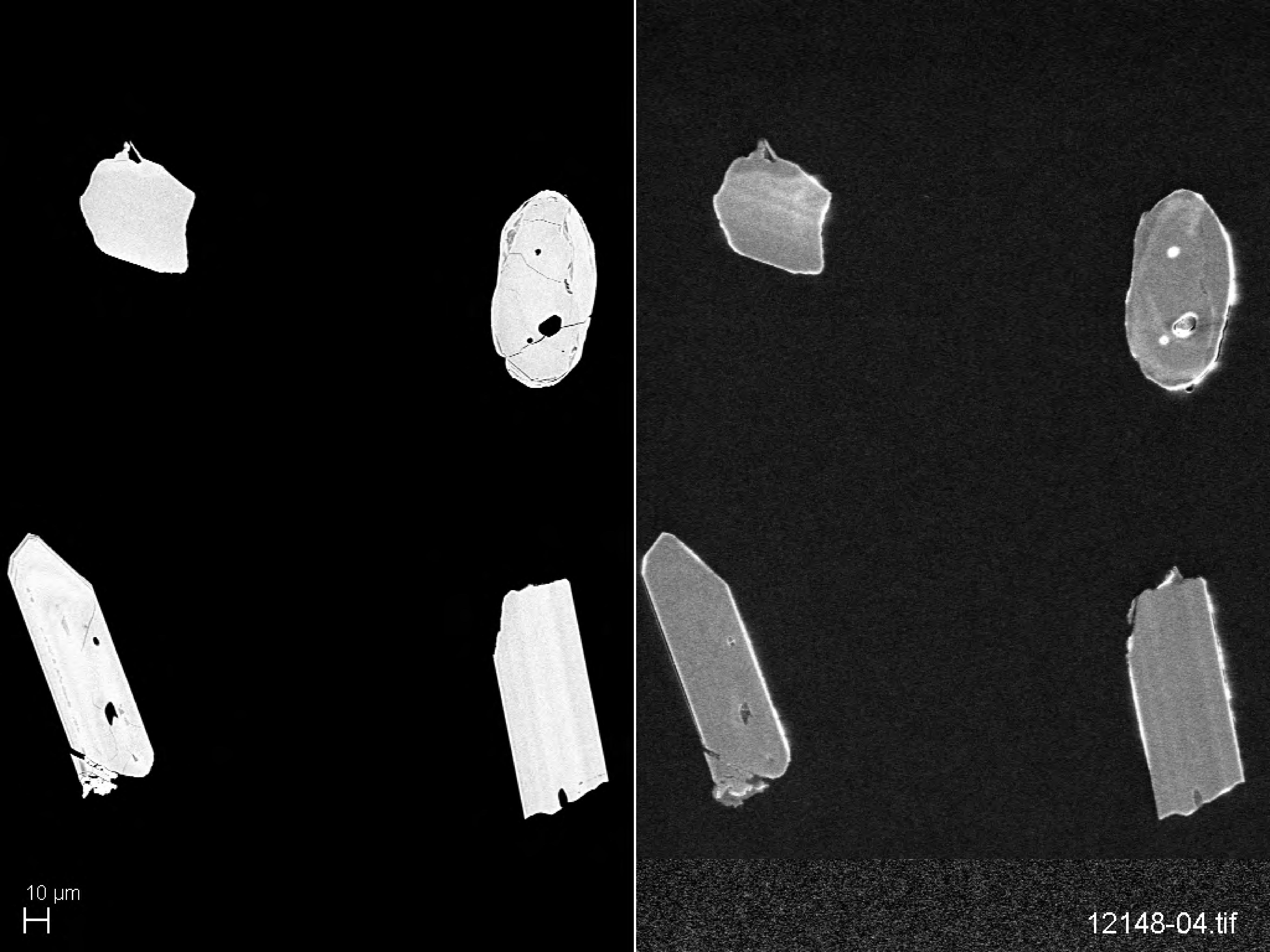
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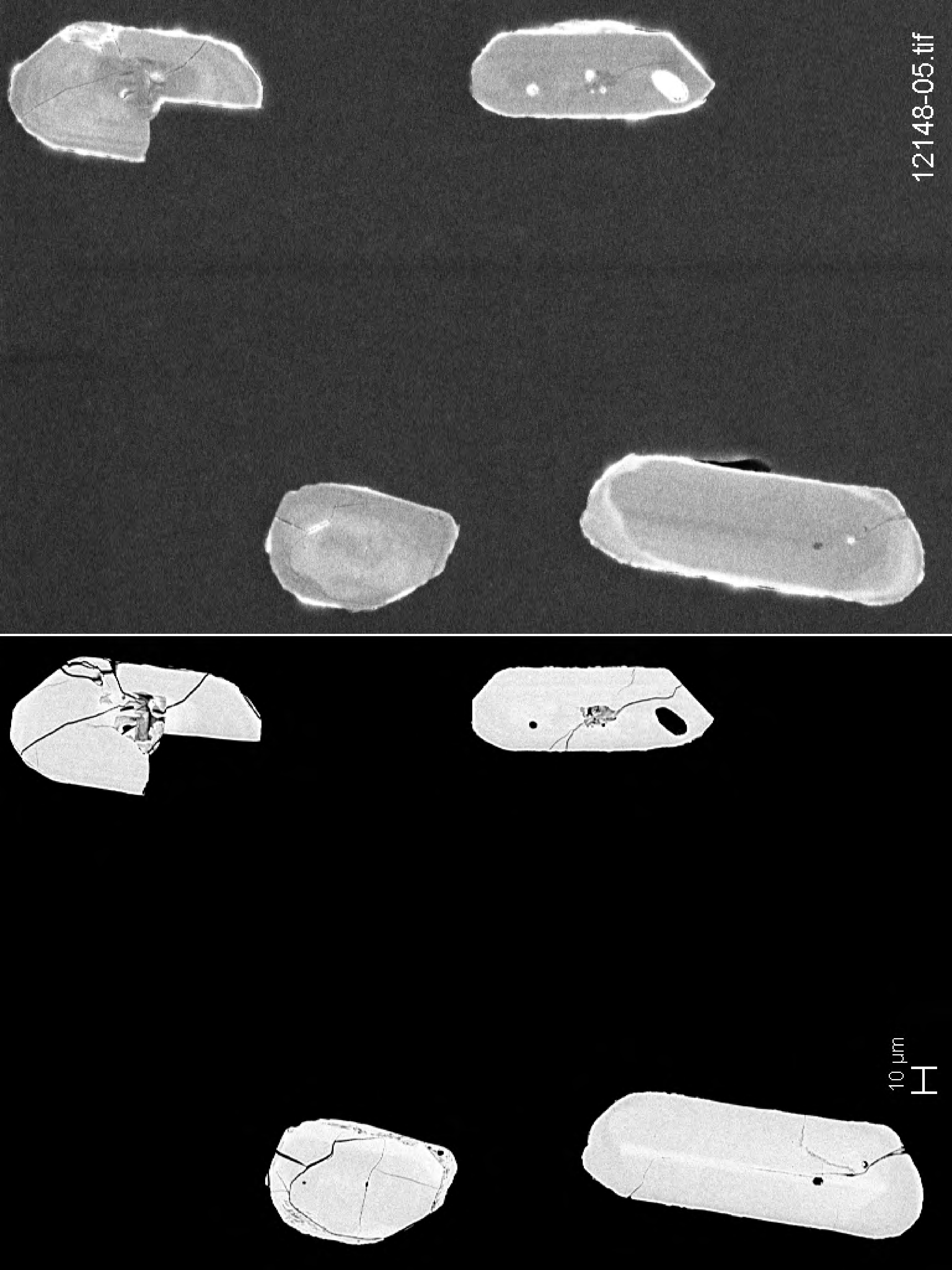
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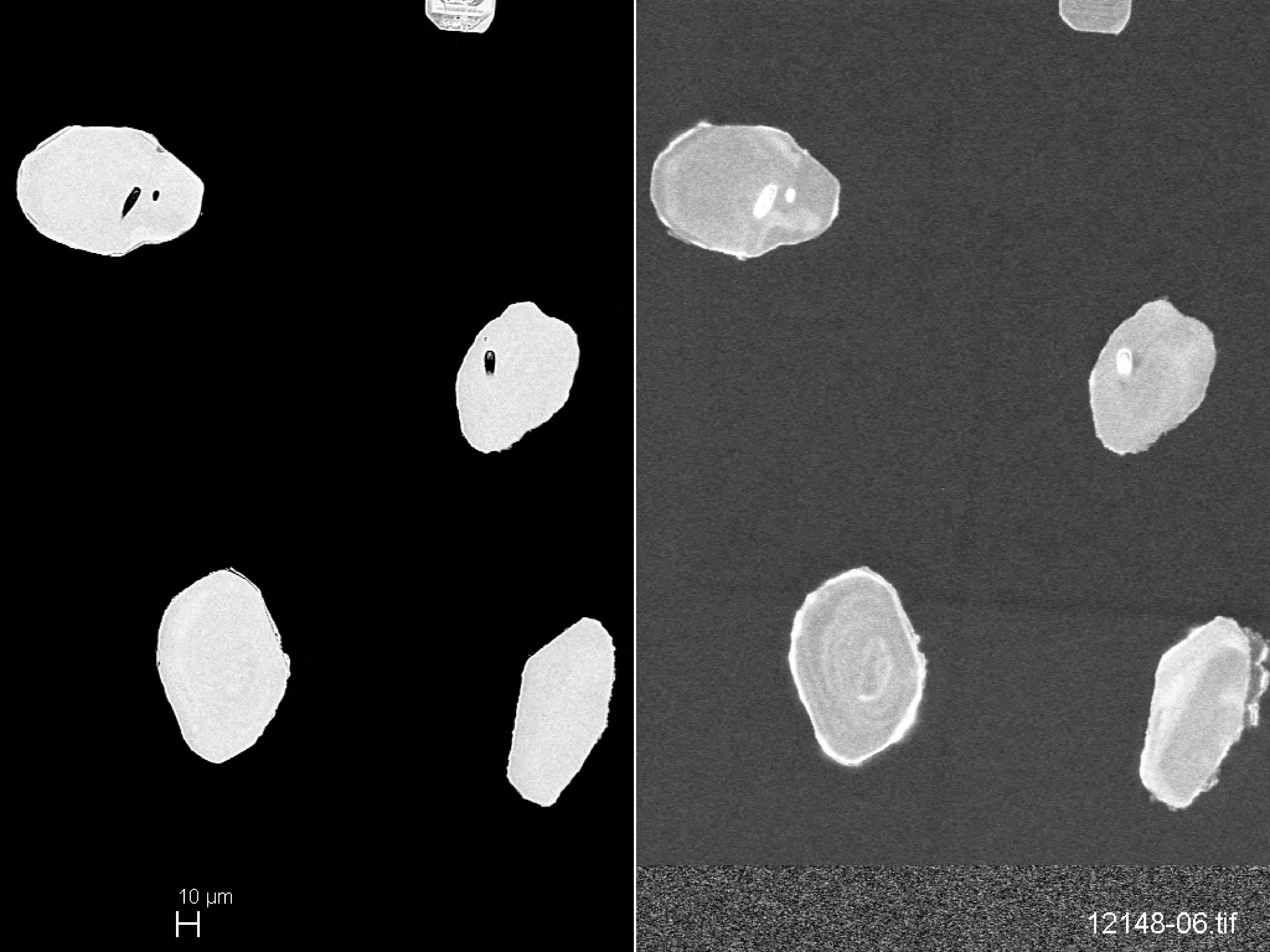
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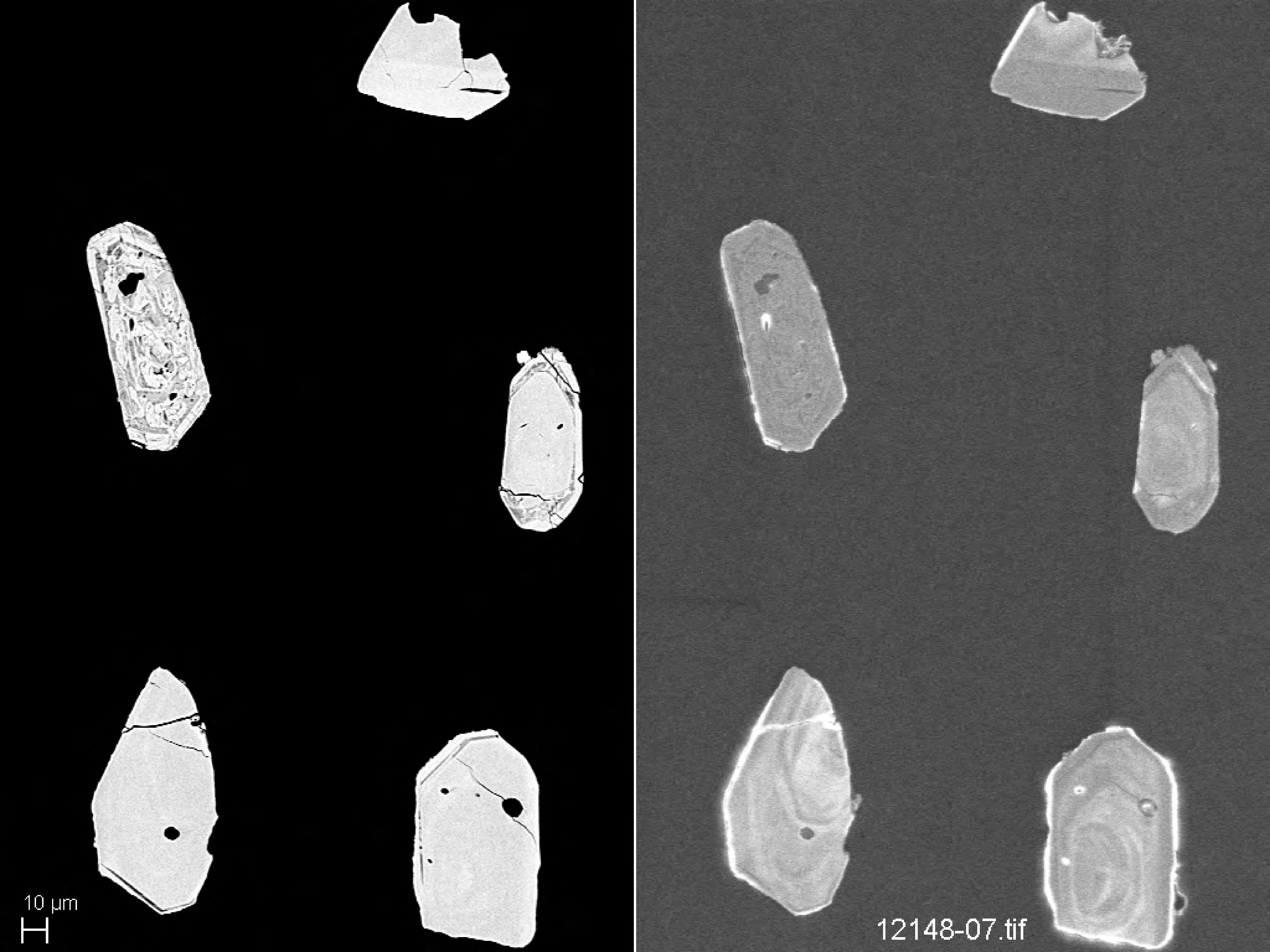
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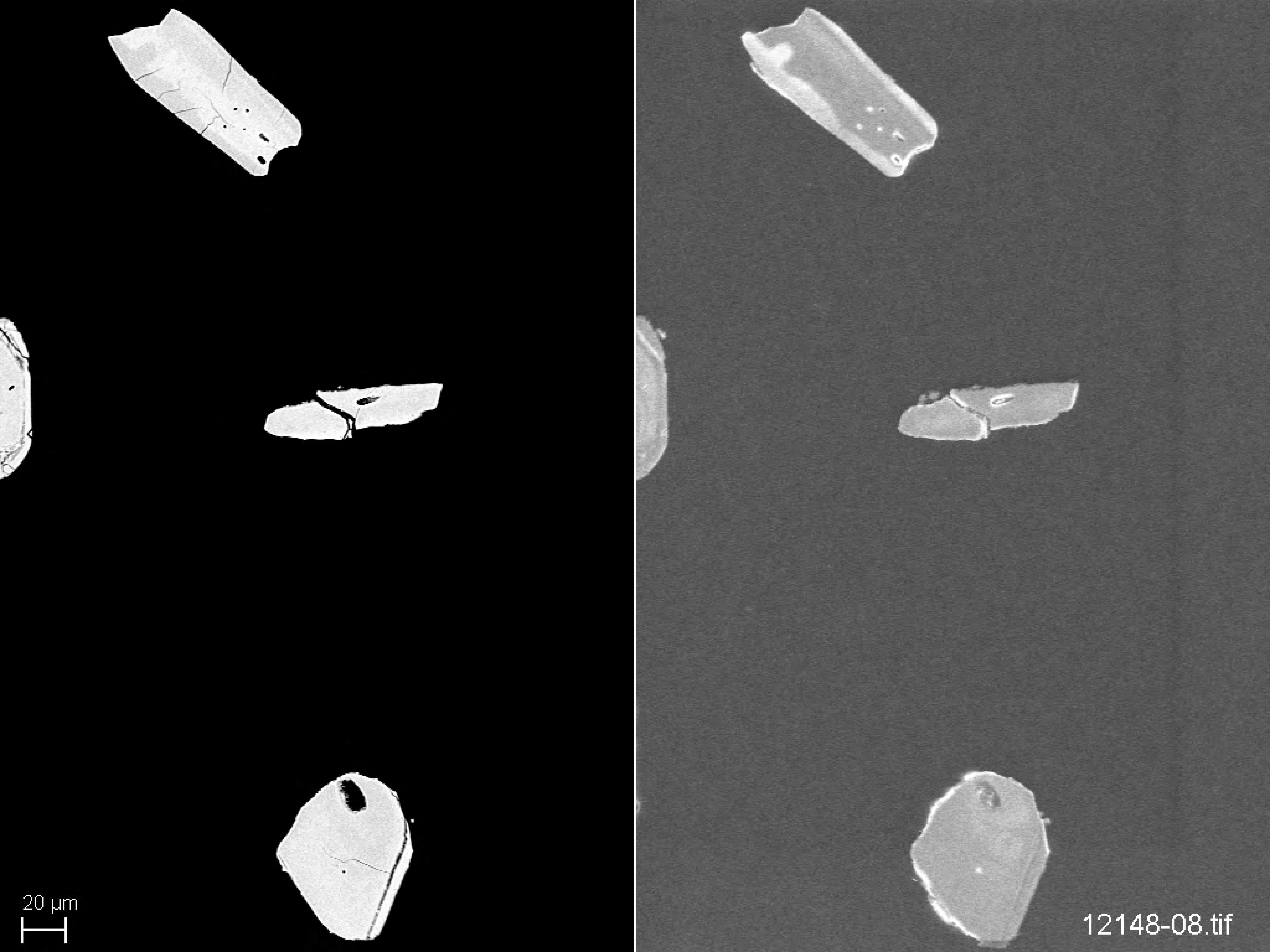
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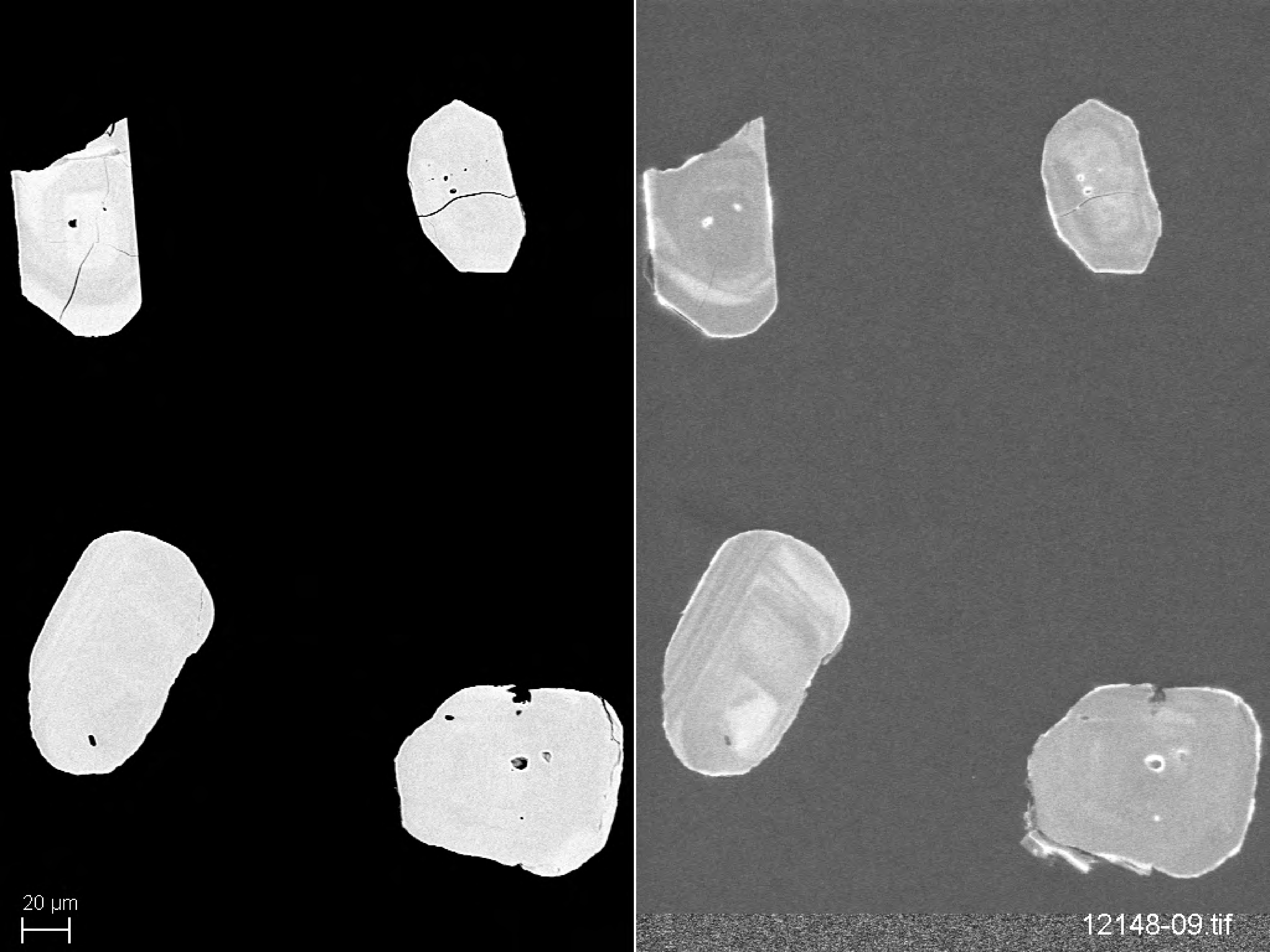
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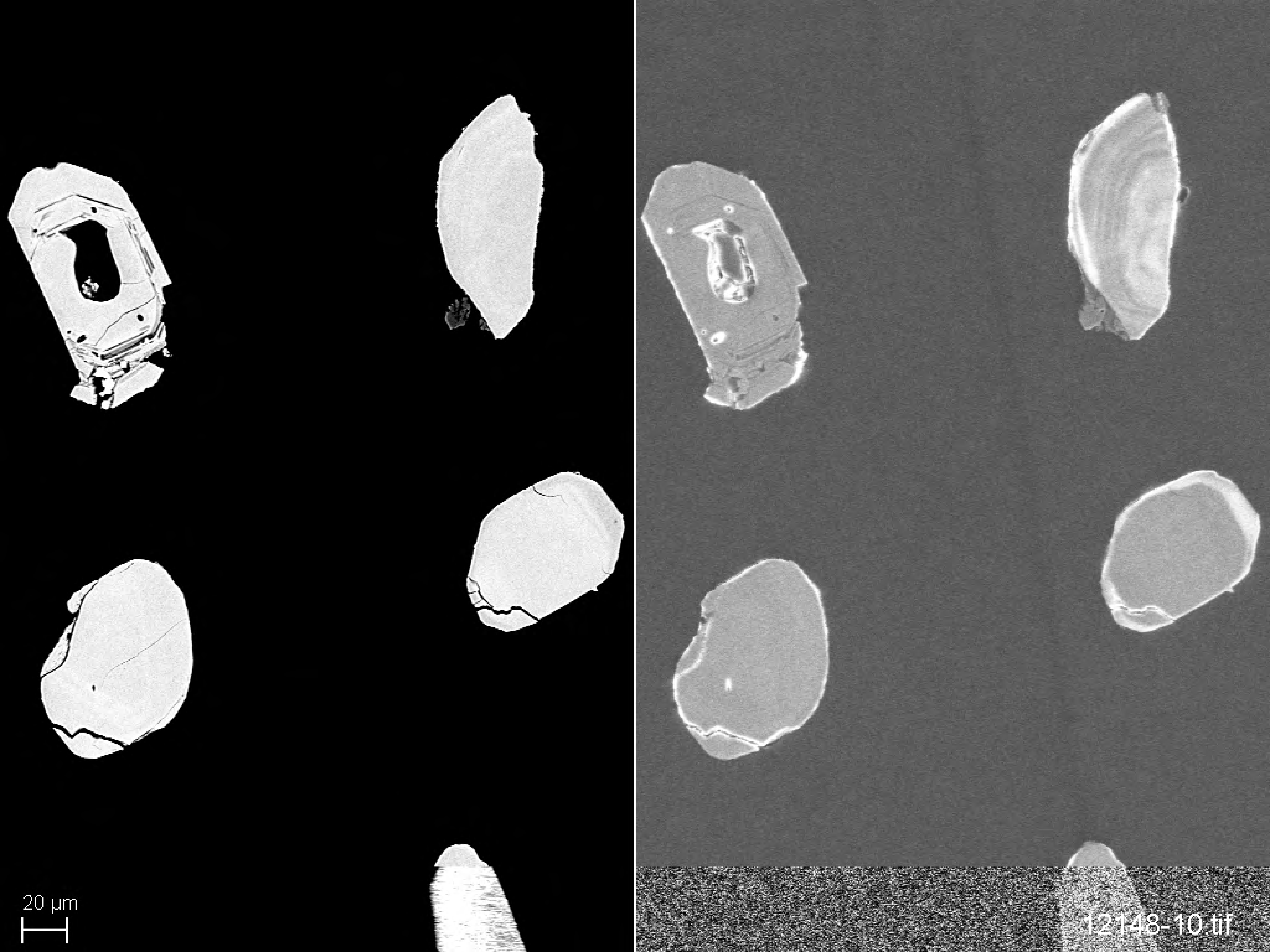
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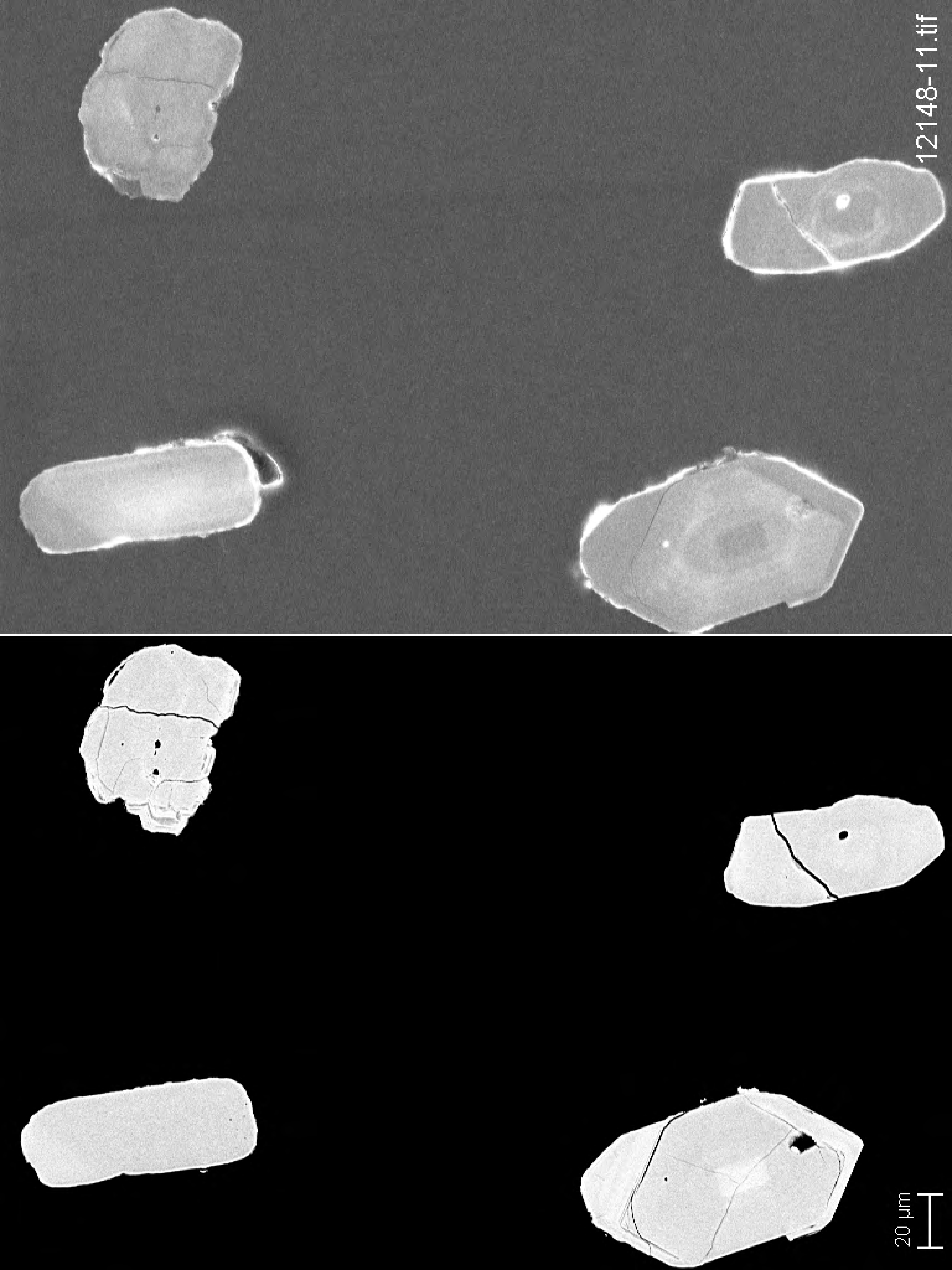
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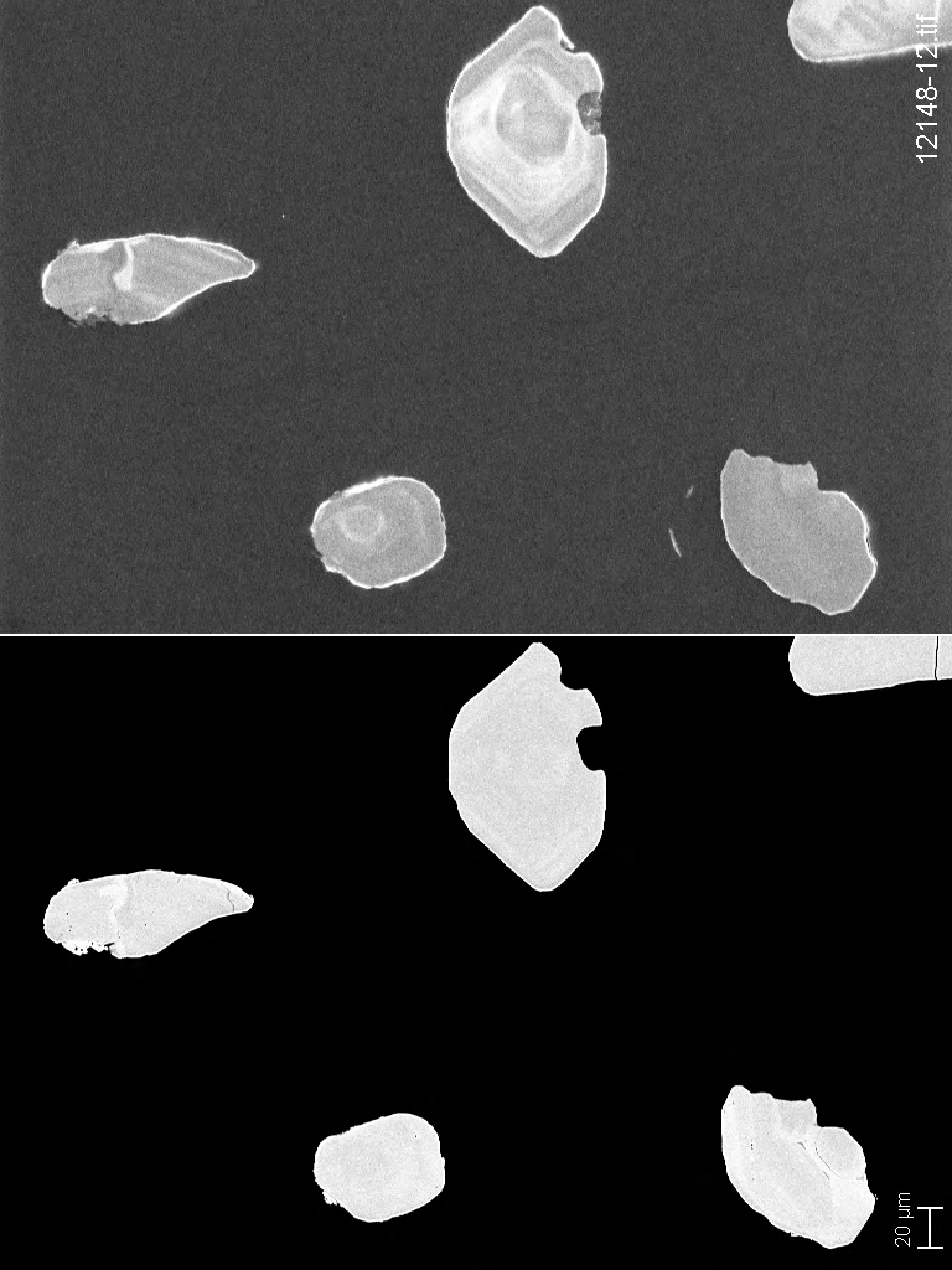
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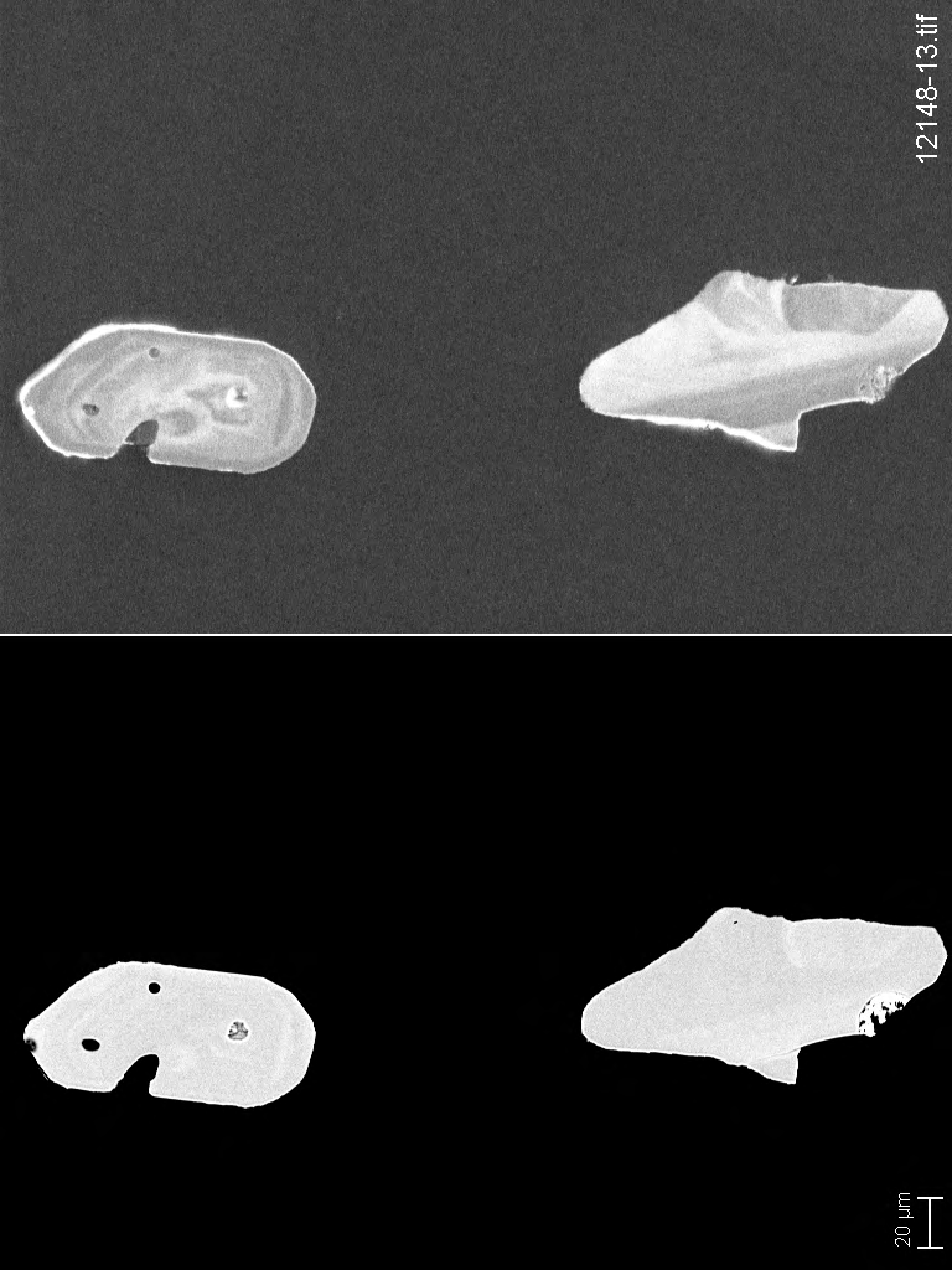
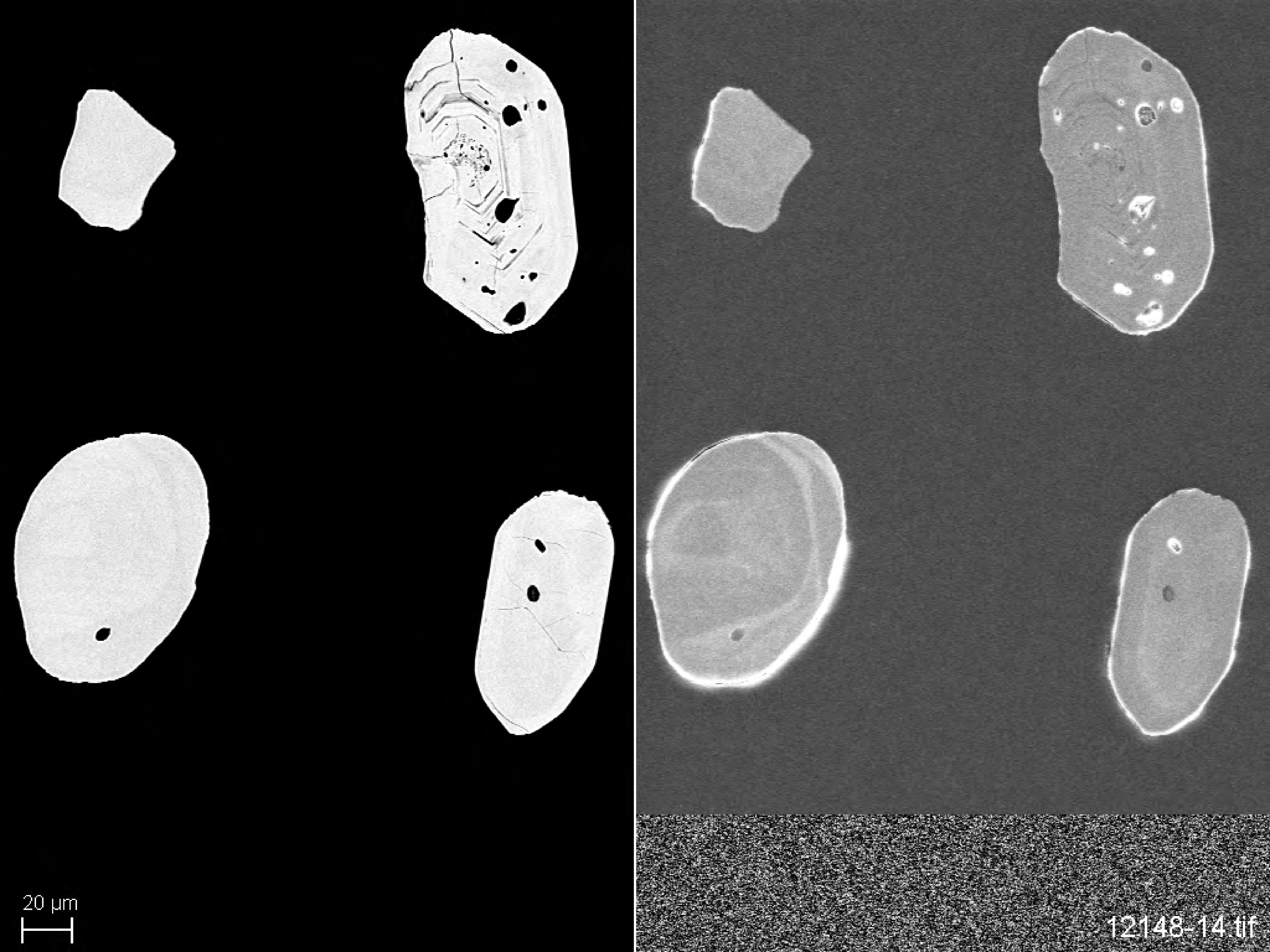
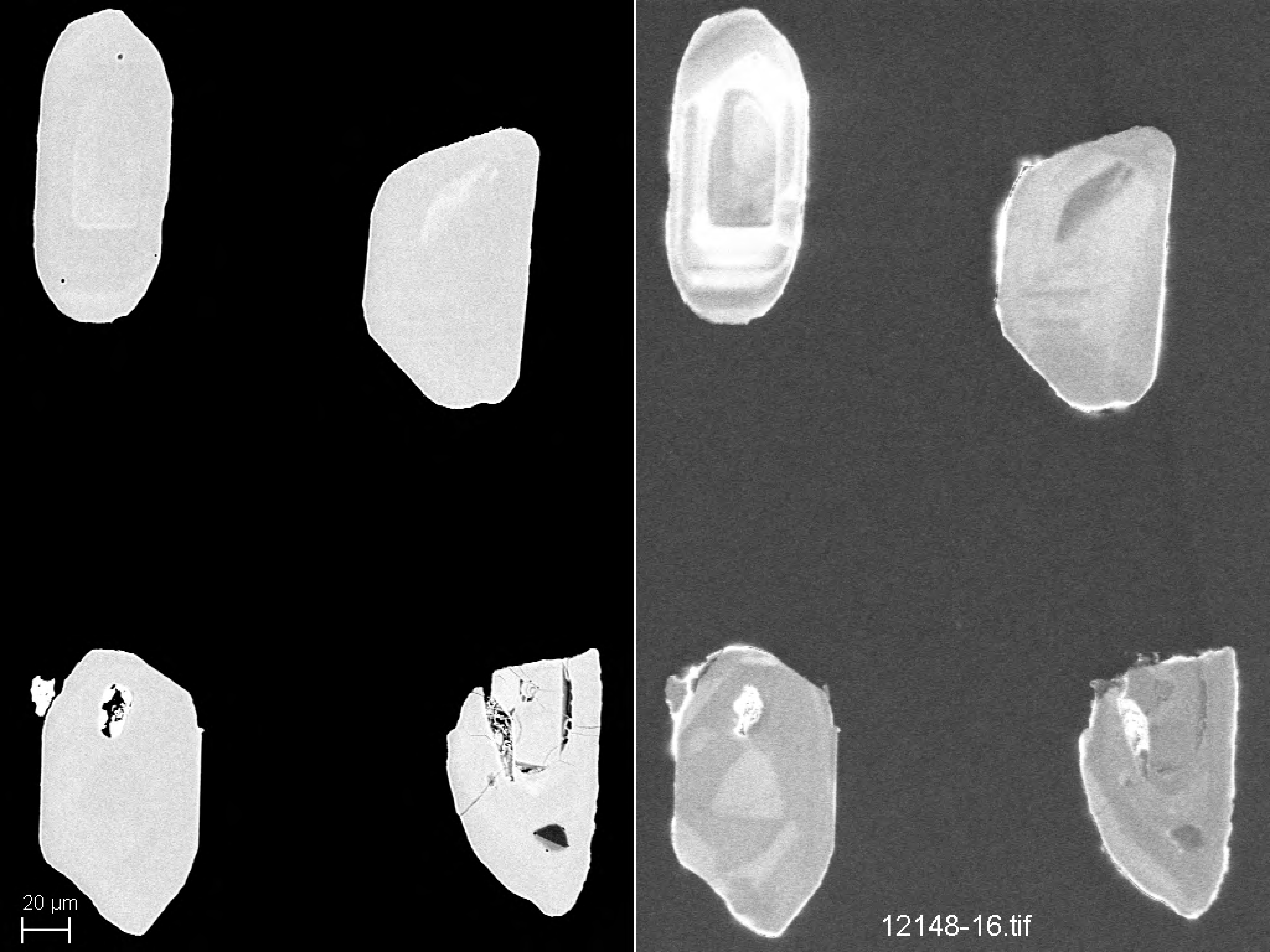
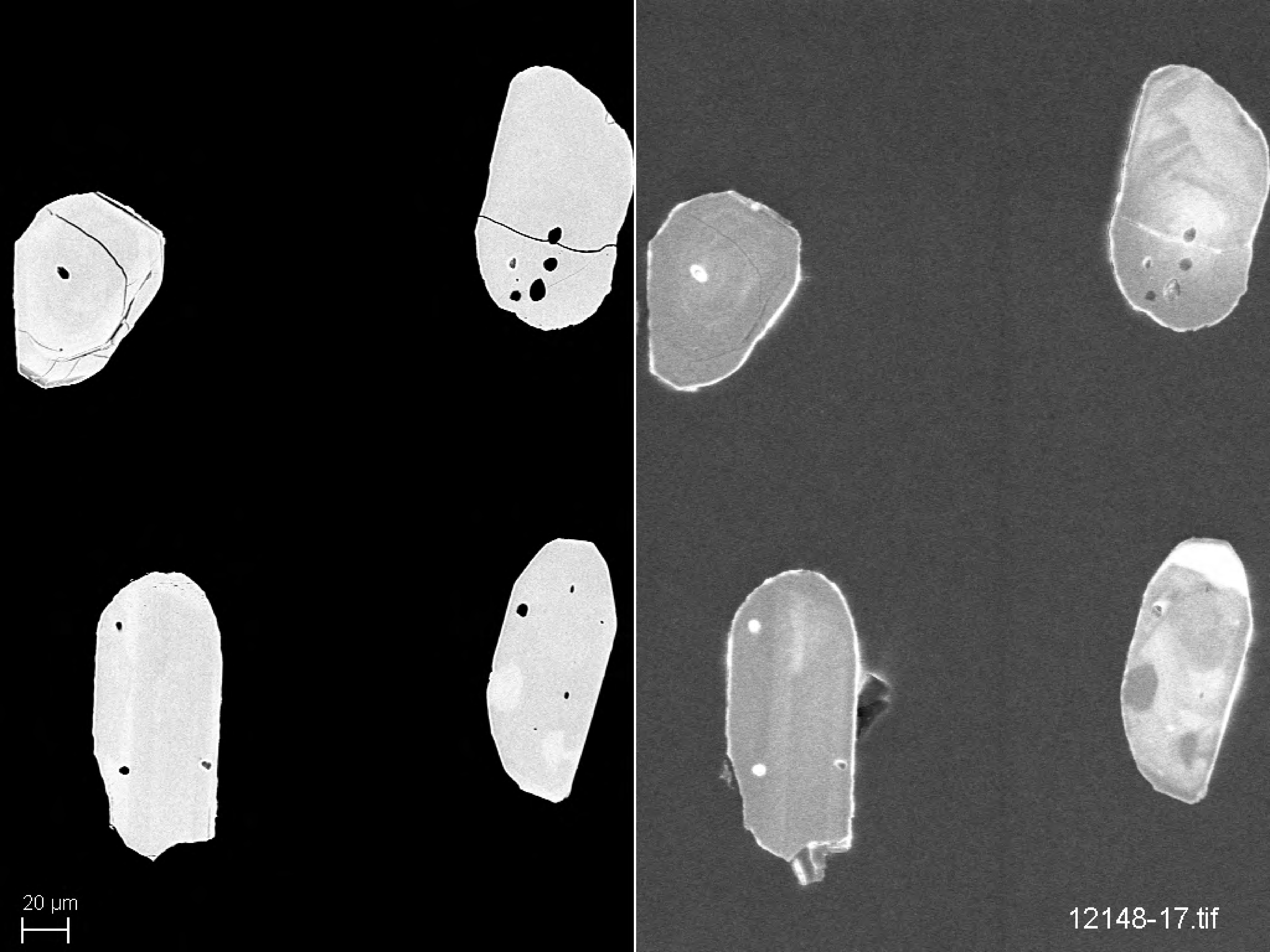

12148-13.tif
20 µm



20 µm
12148-14.tif


20 µm
12148-15.tif


20 µm
12148-16.tif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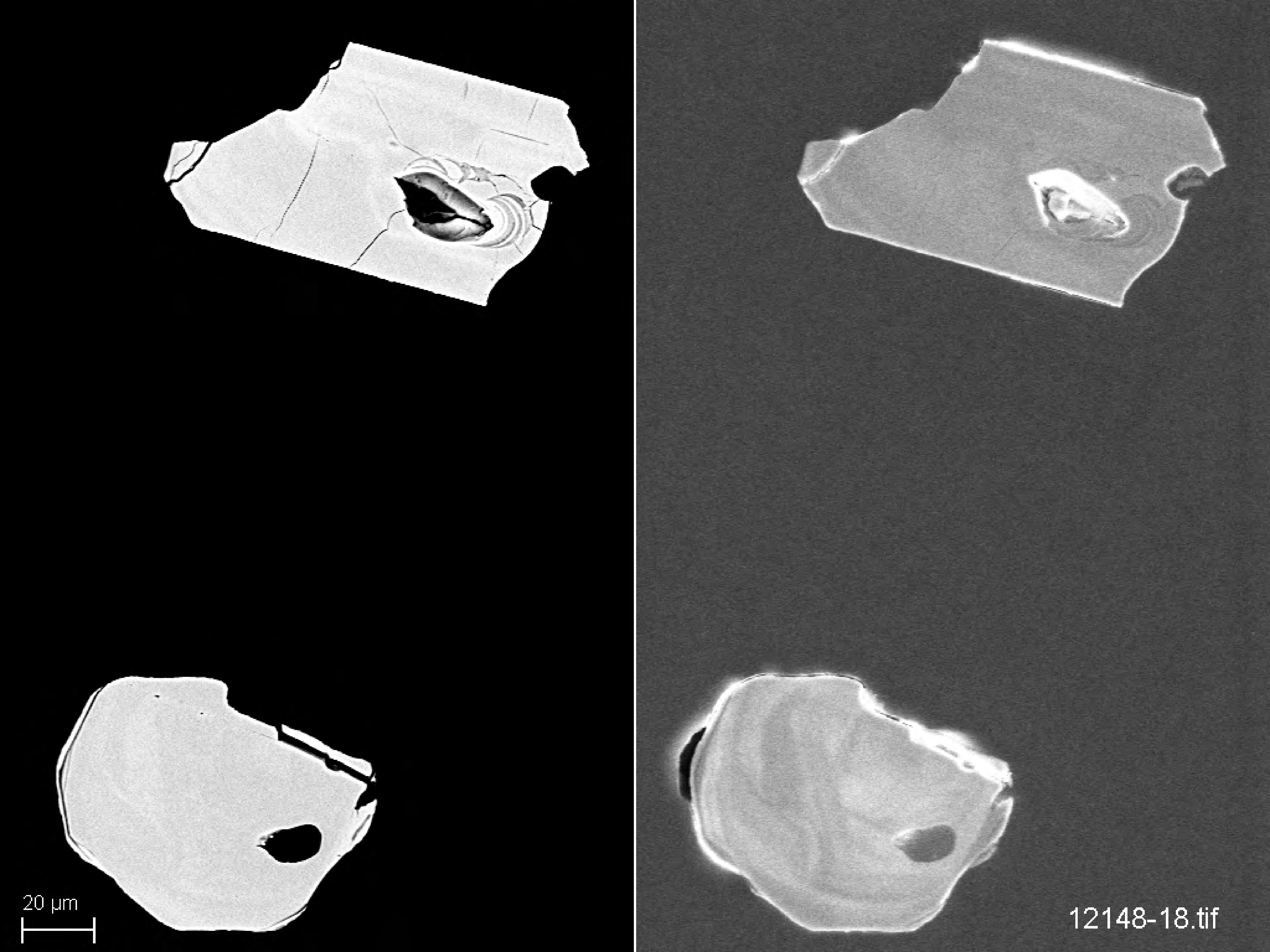
20 µm
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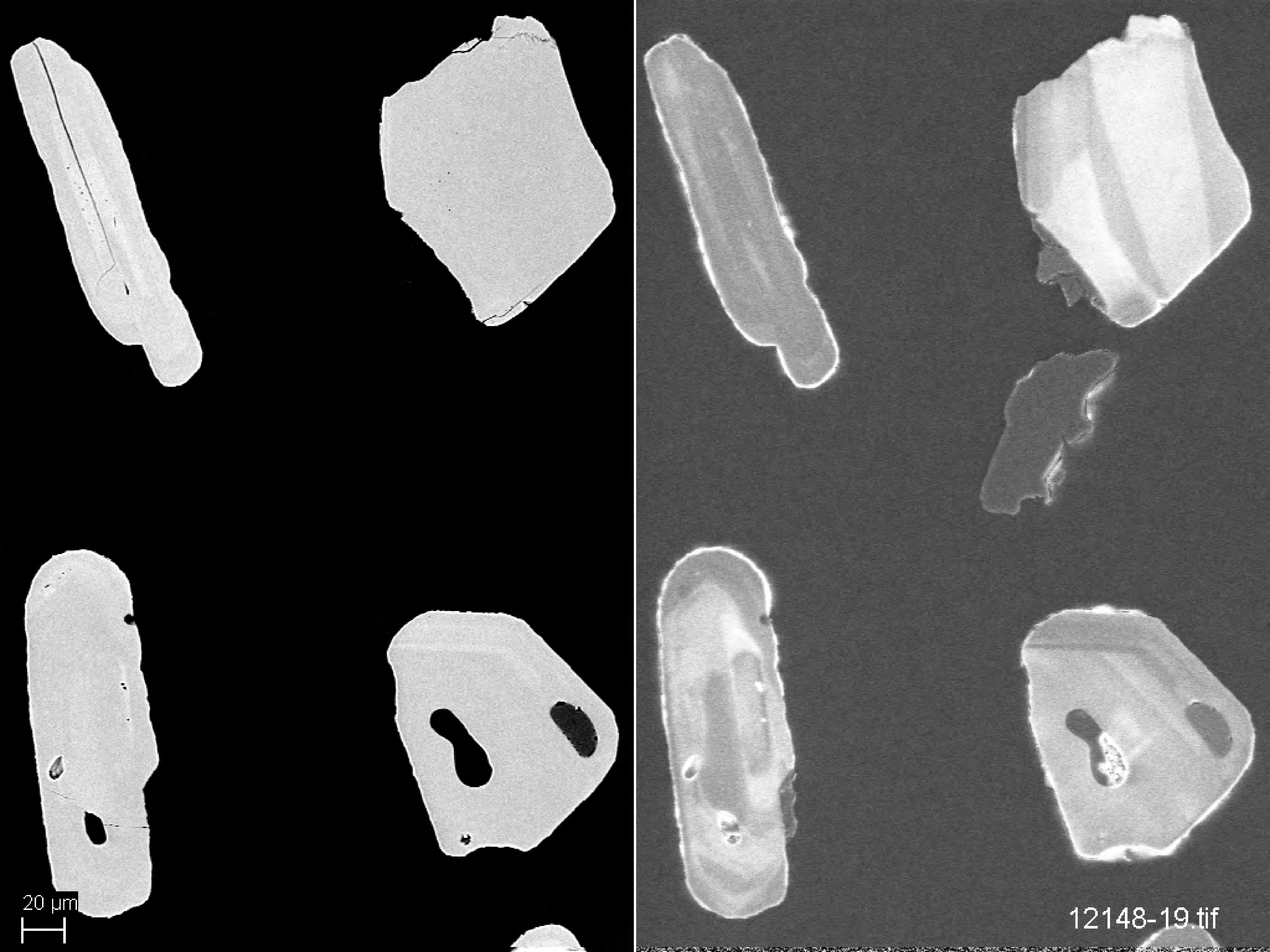
20 µm
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20 µm
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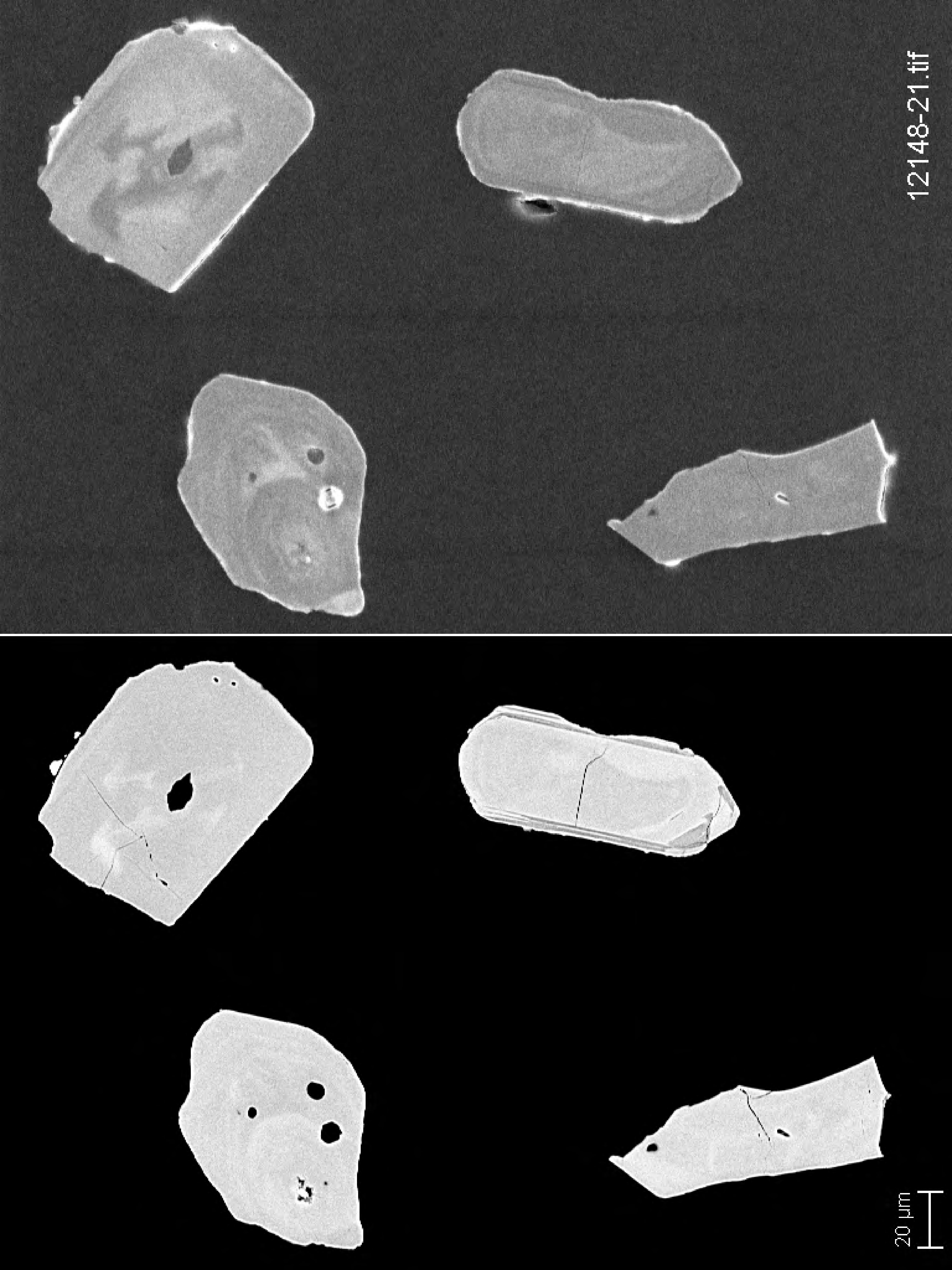
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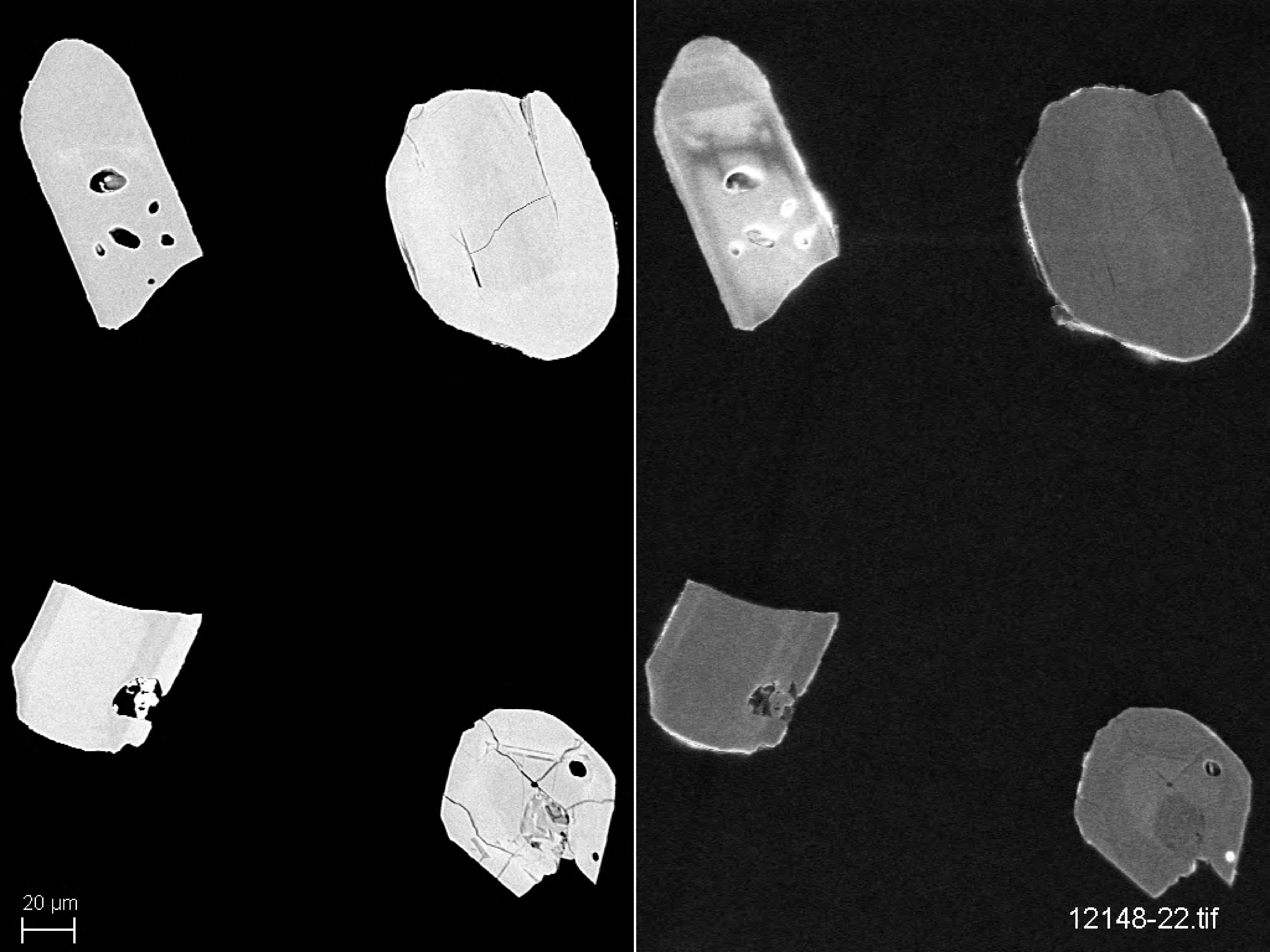
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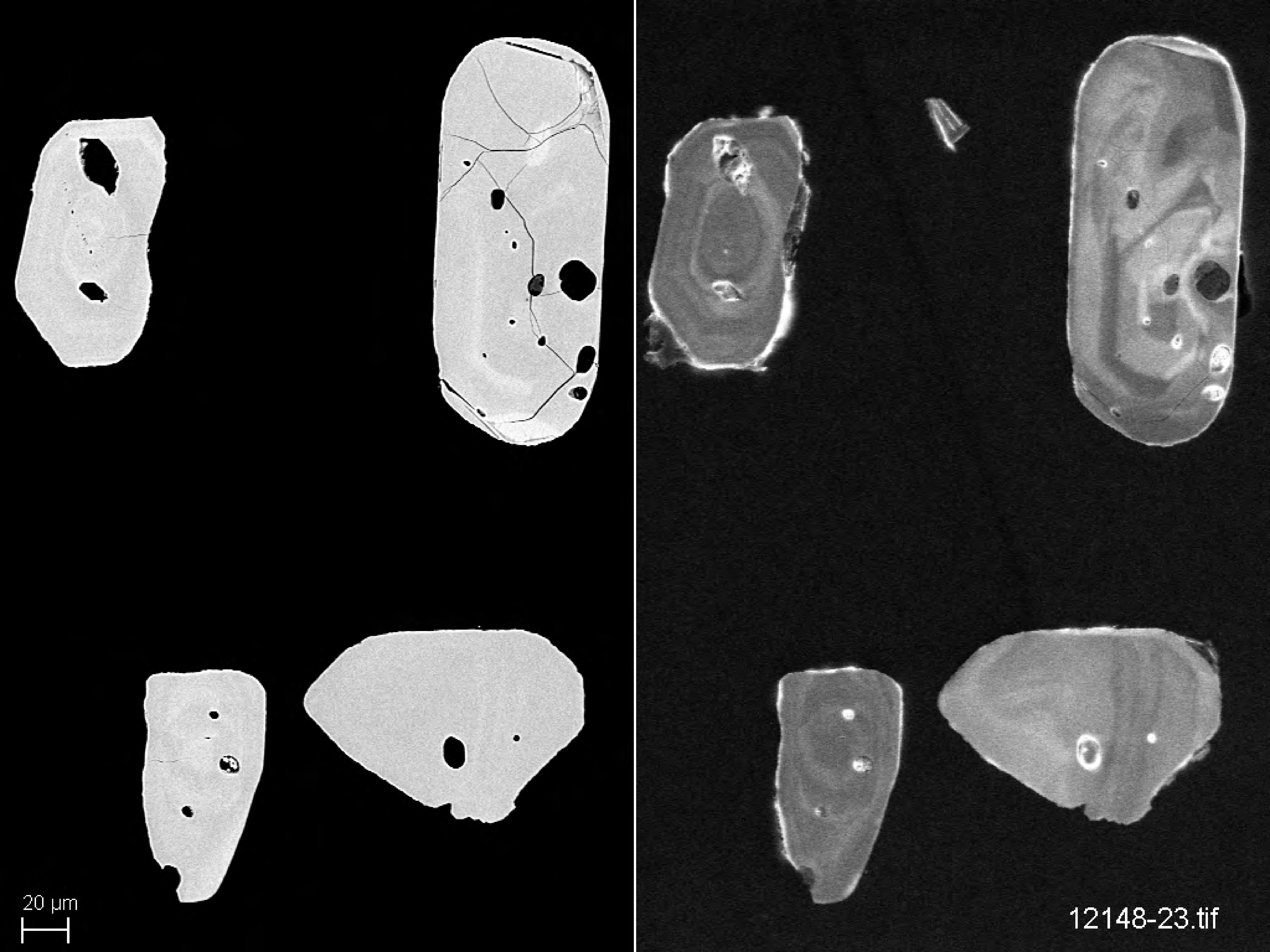
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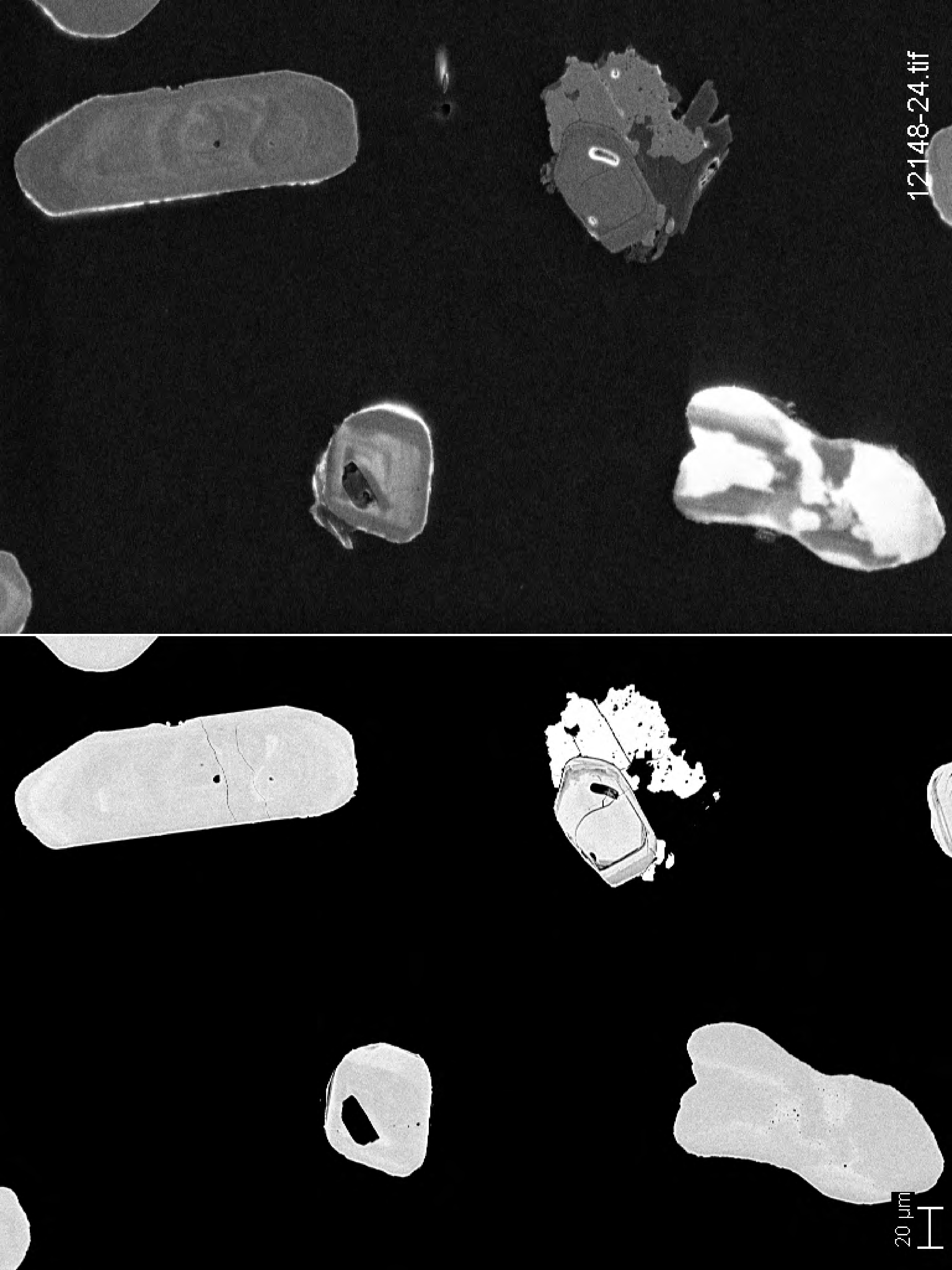
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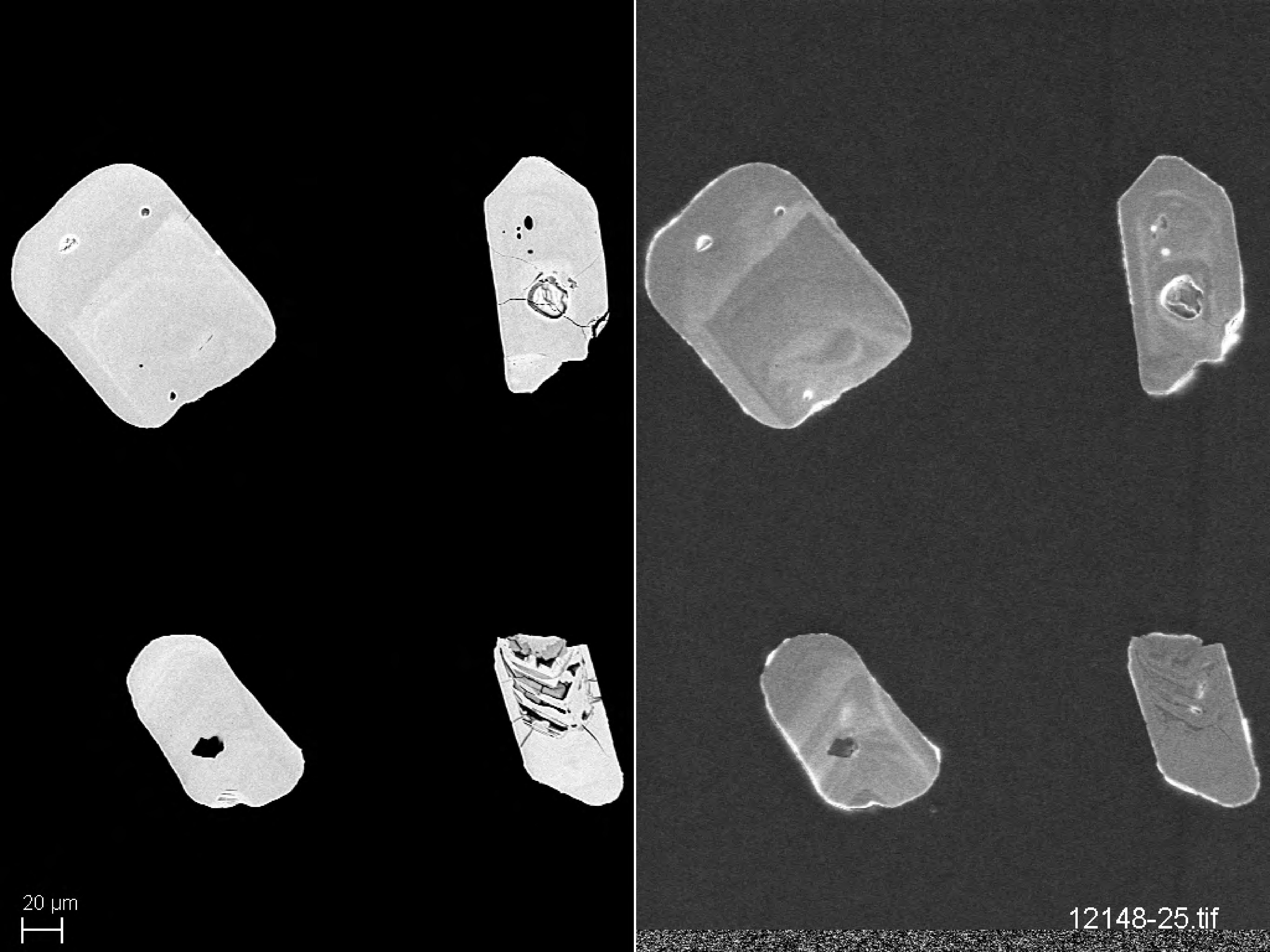
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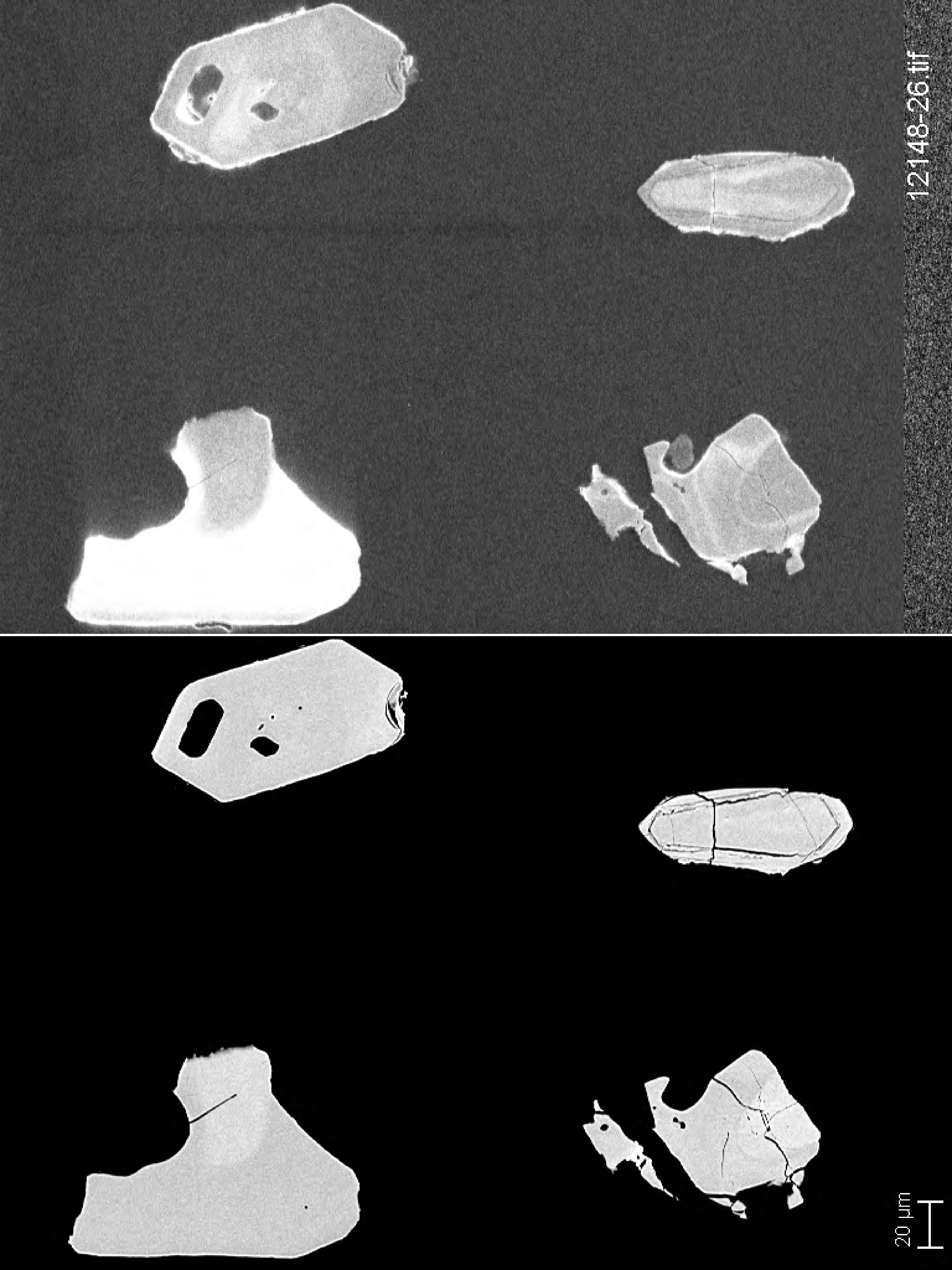
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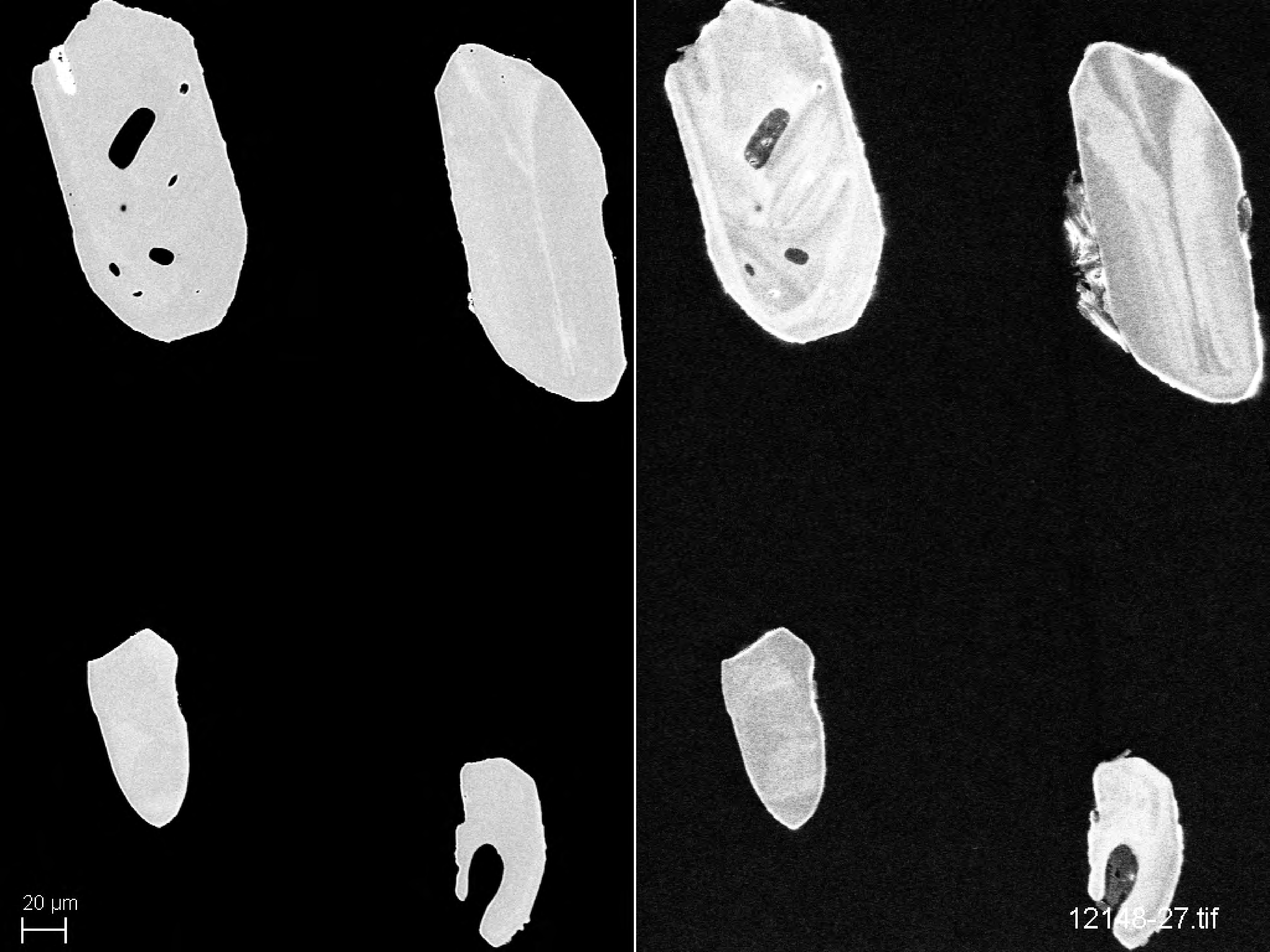
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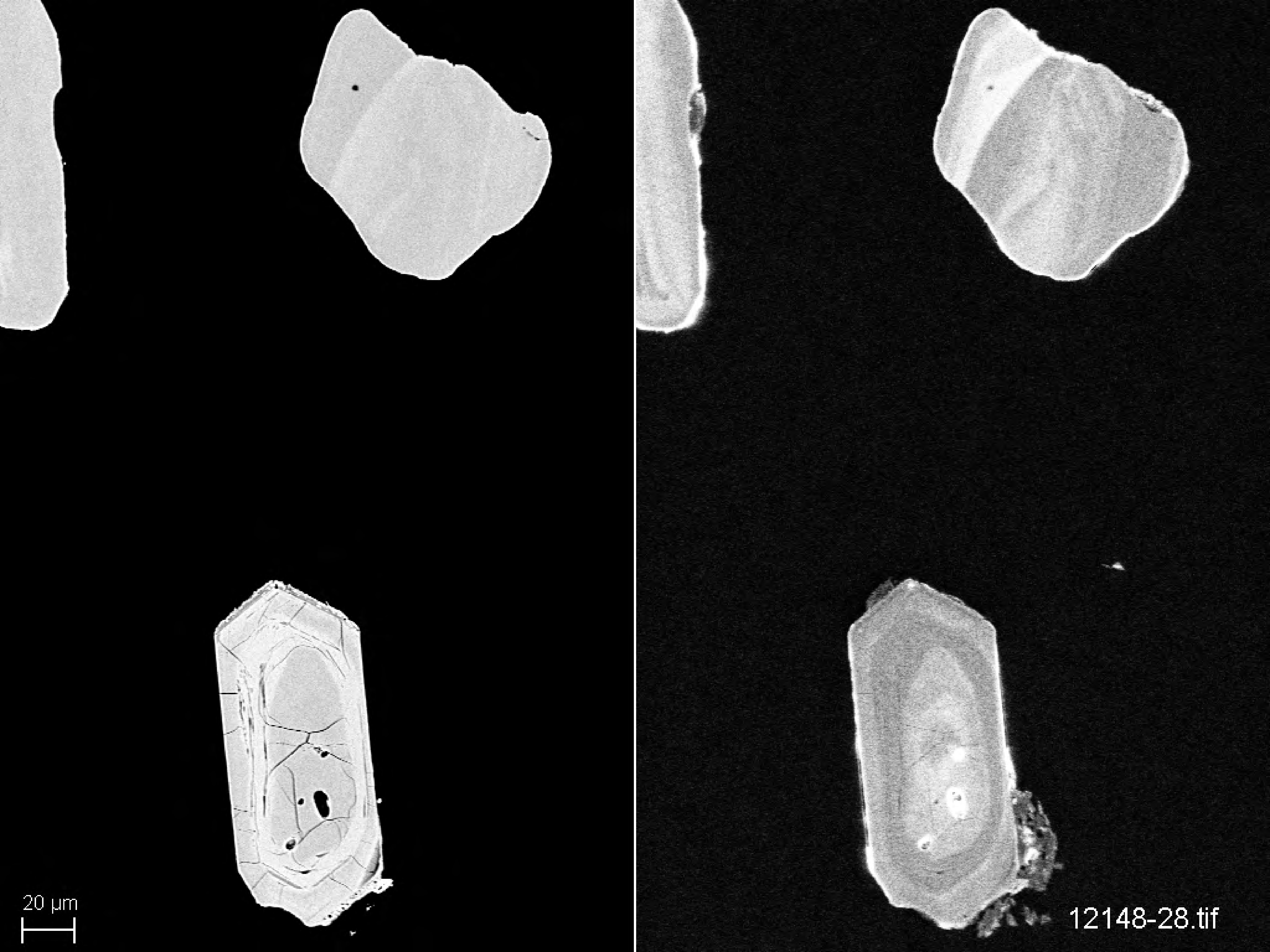
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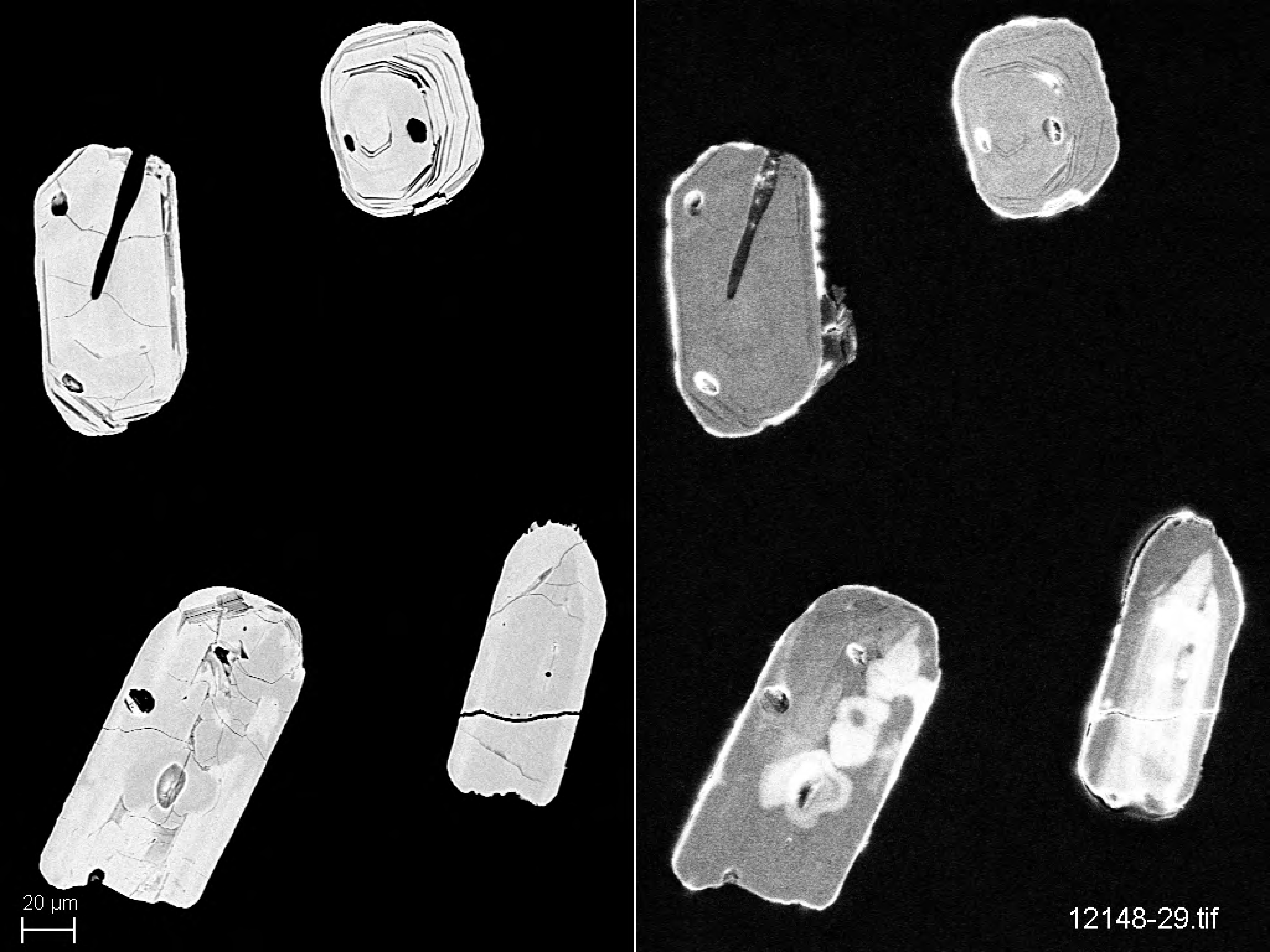
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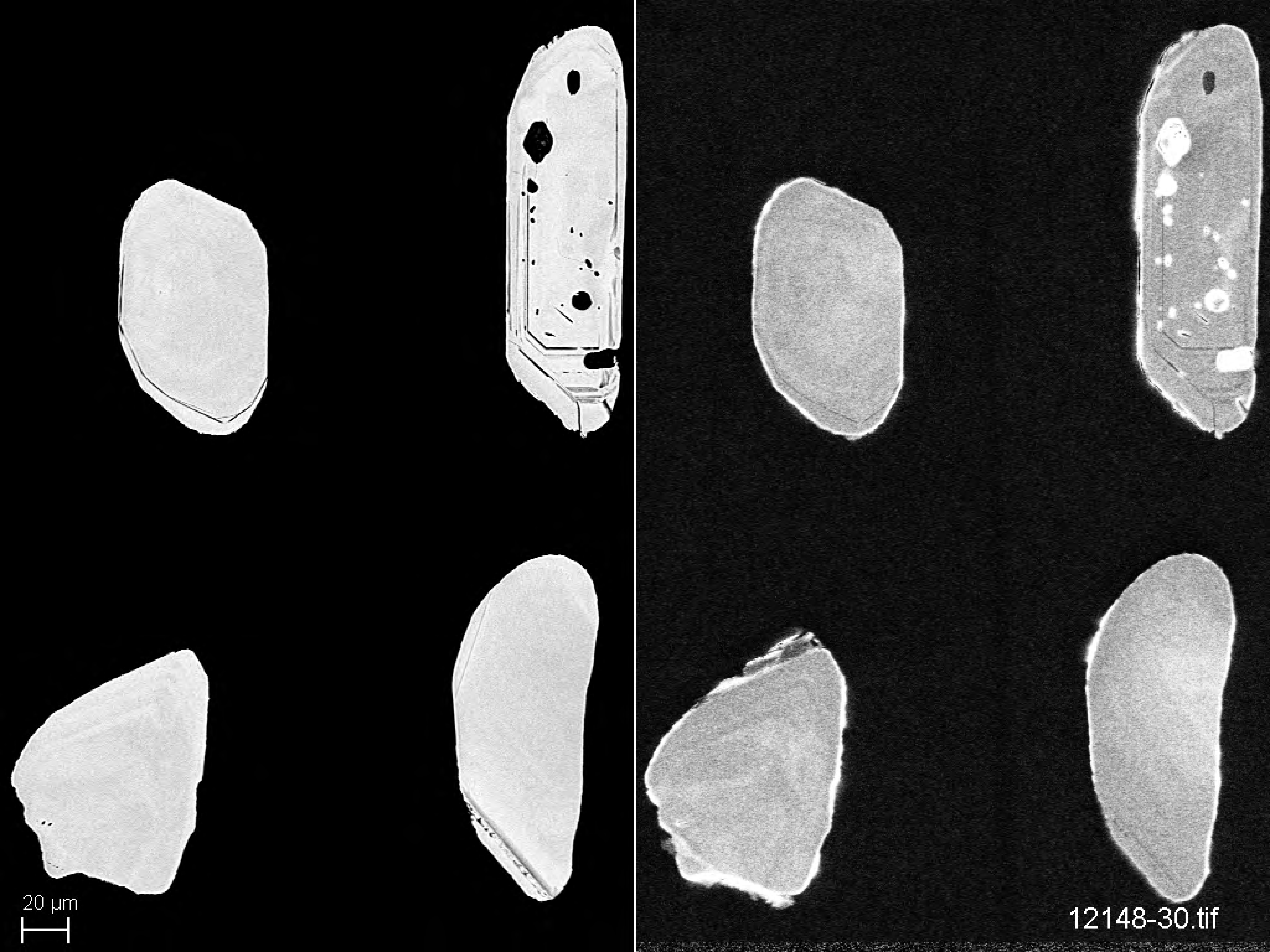

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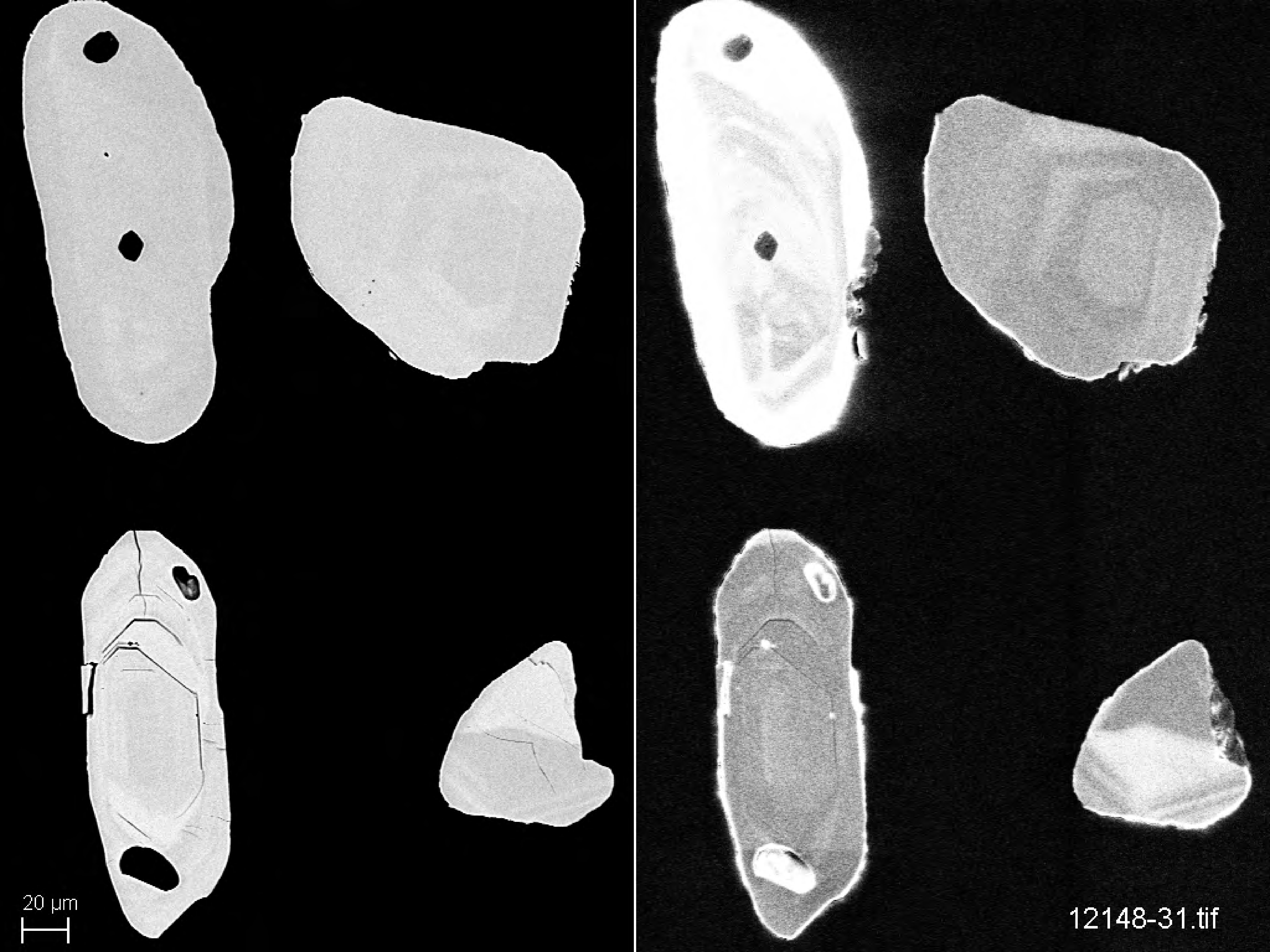
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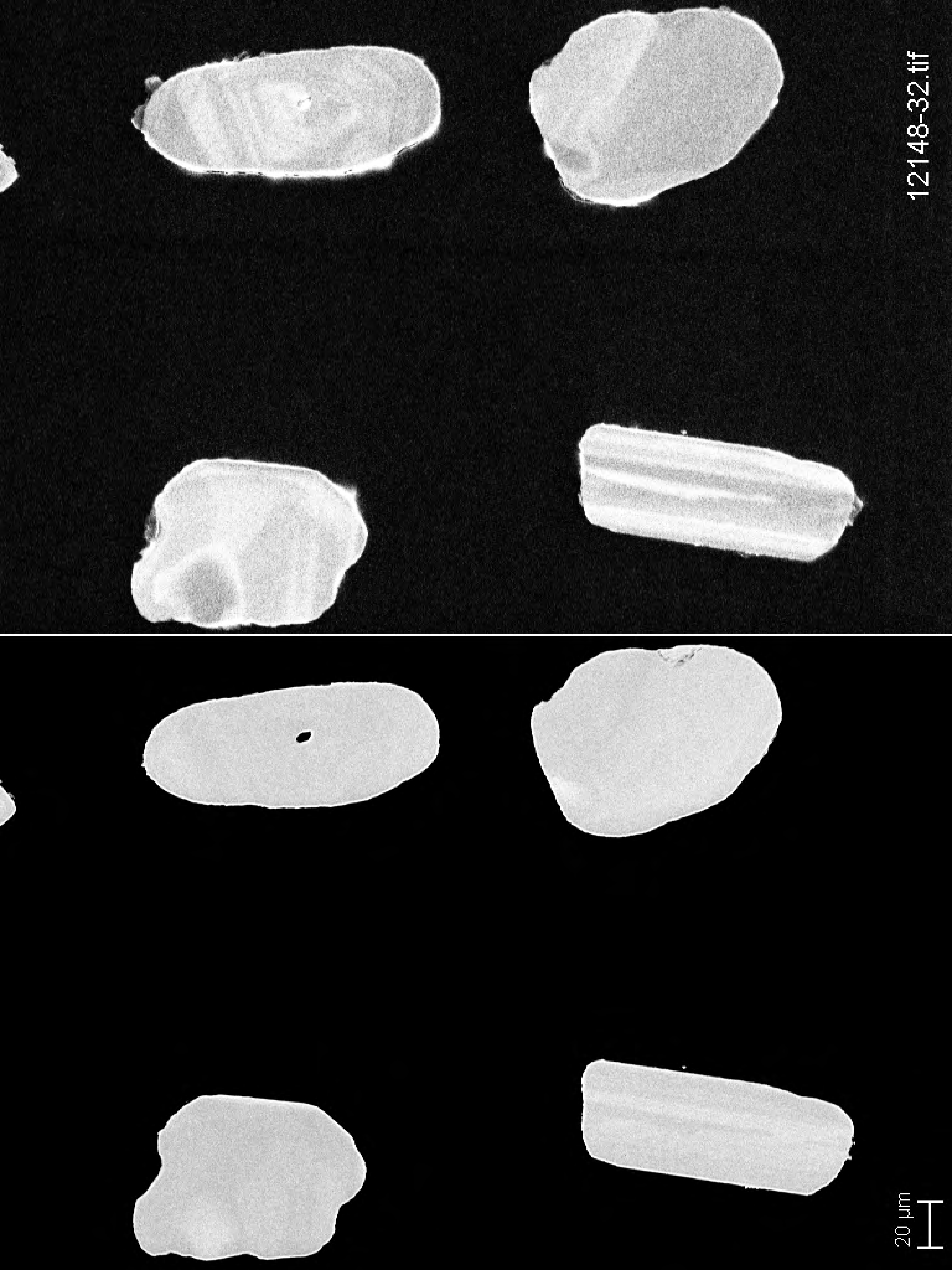
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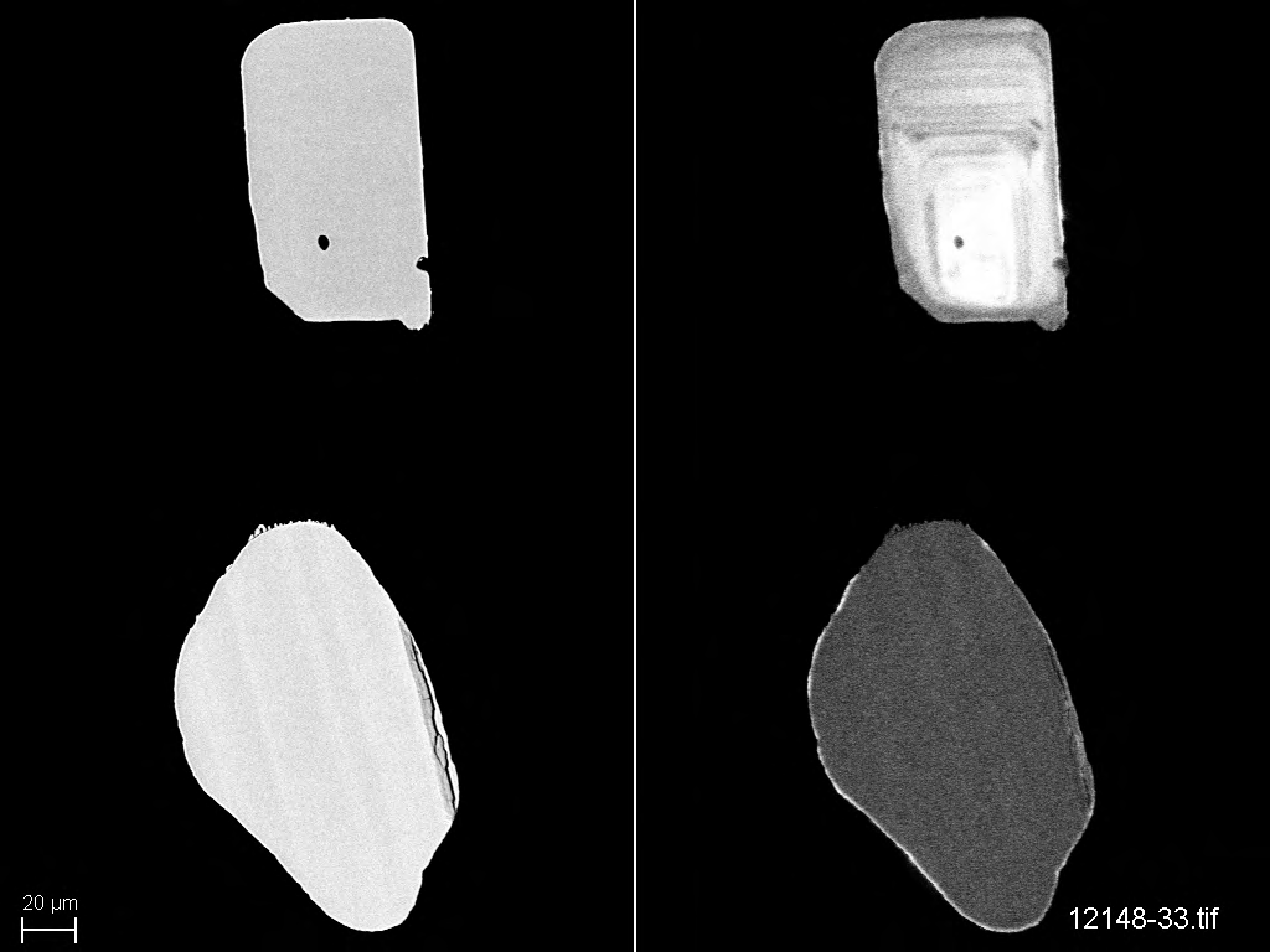
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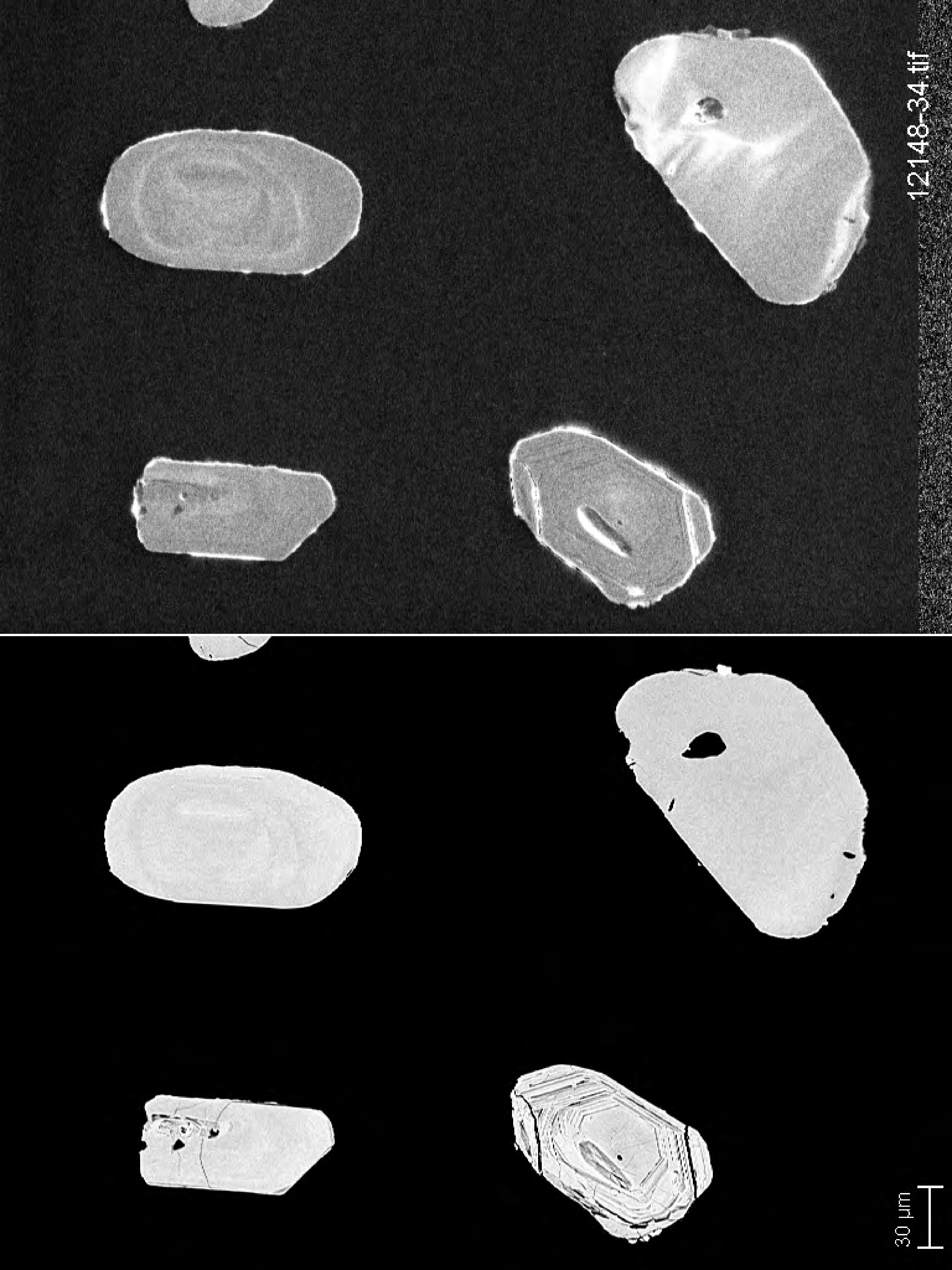
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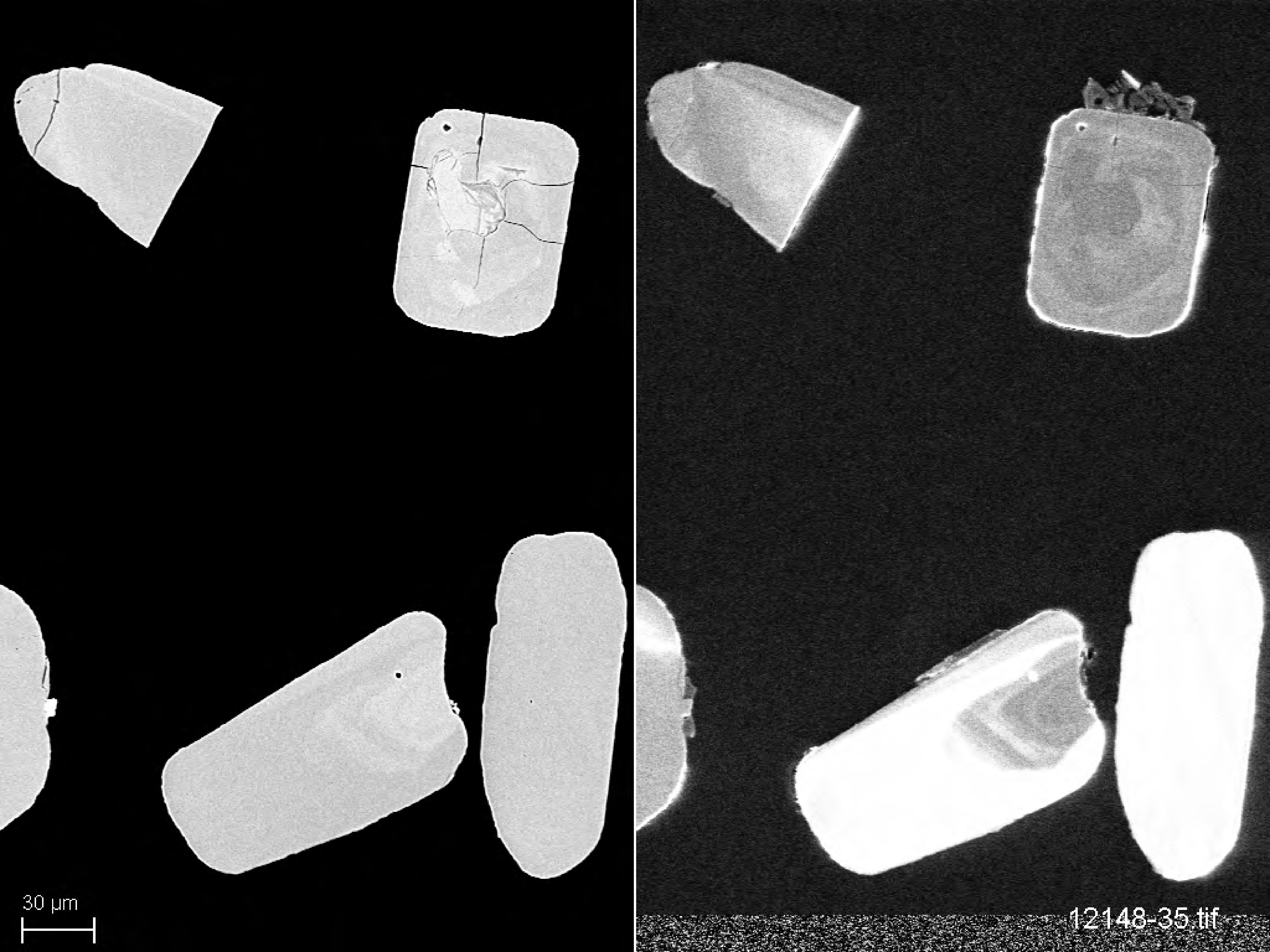
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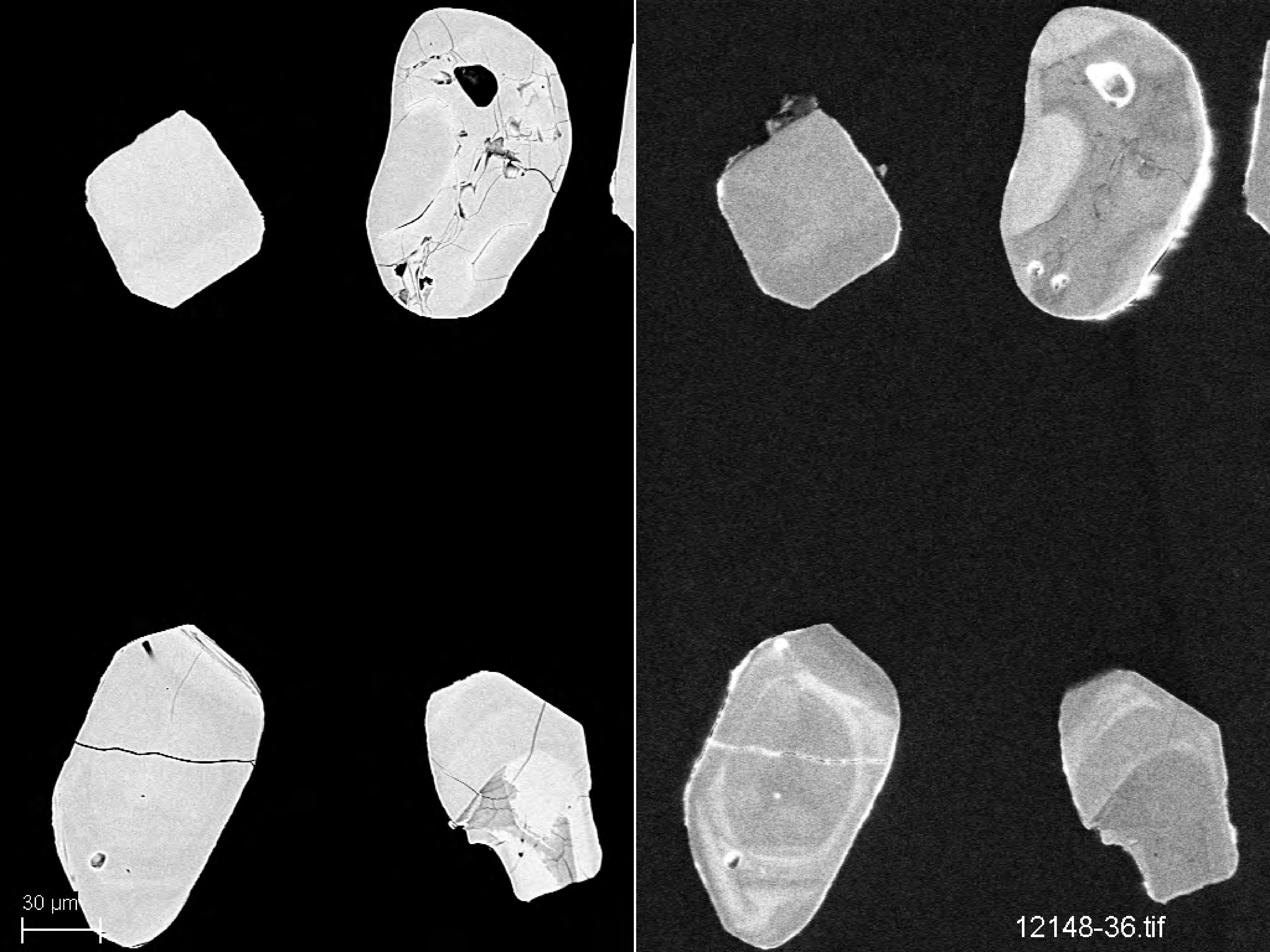
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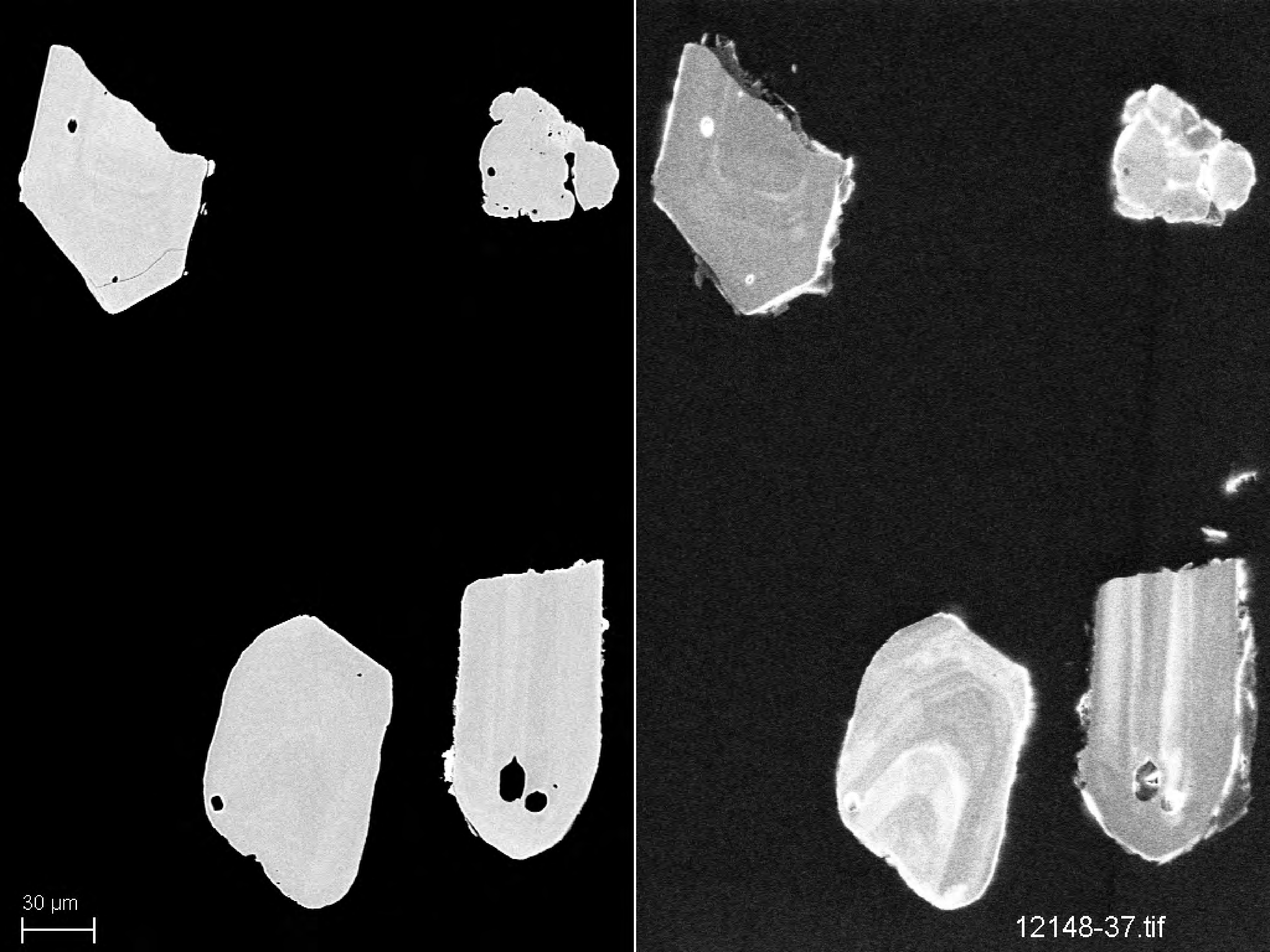
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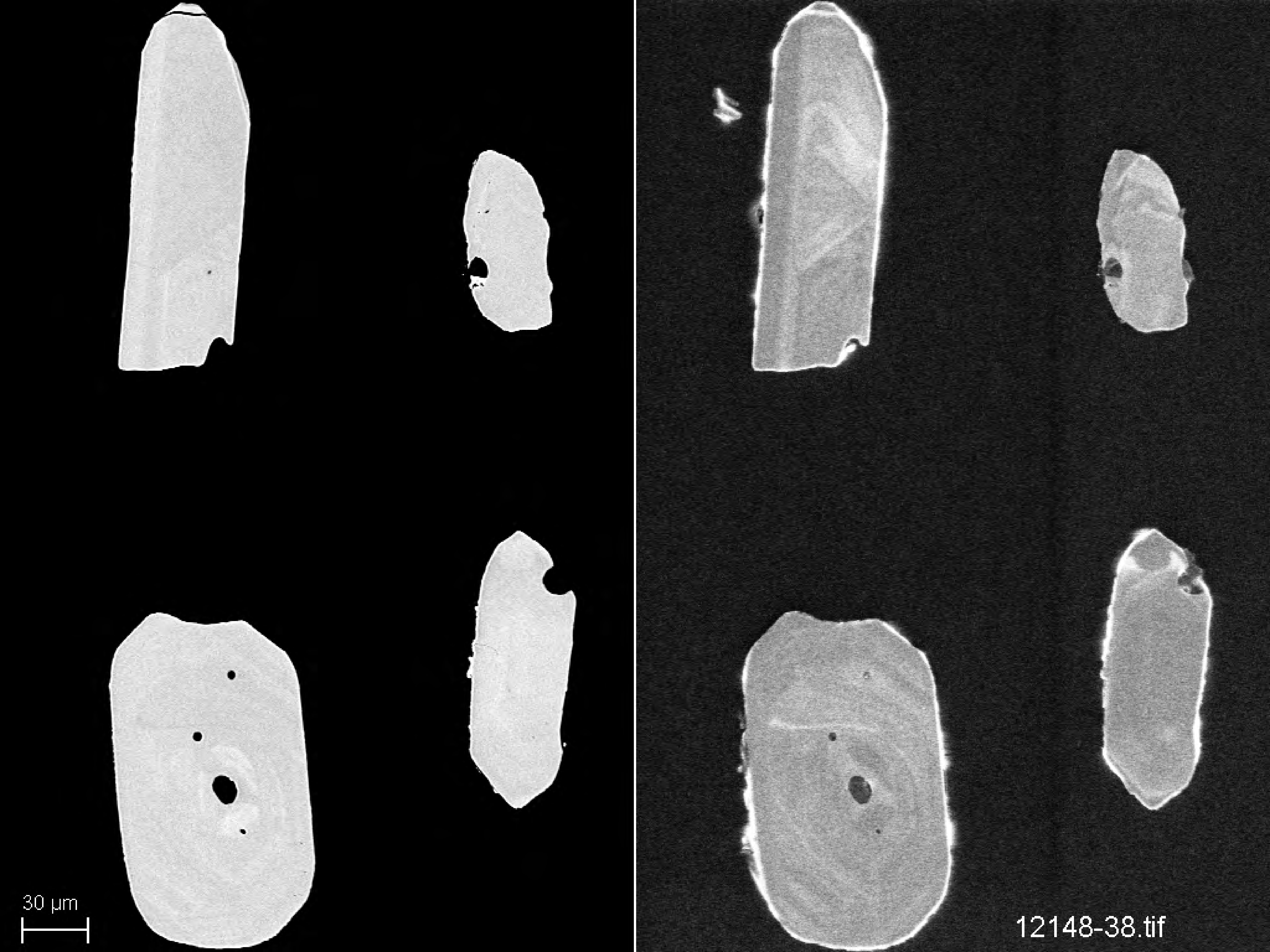
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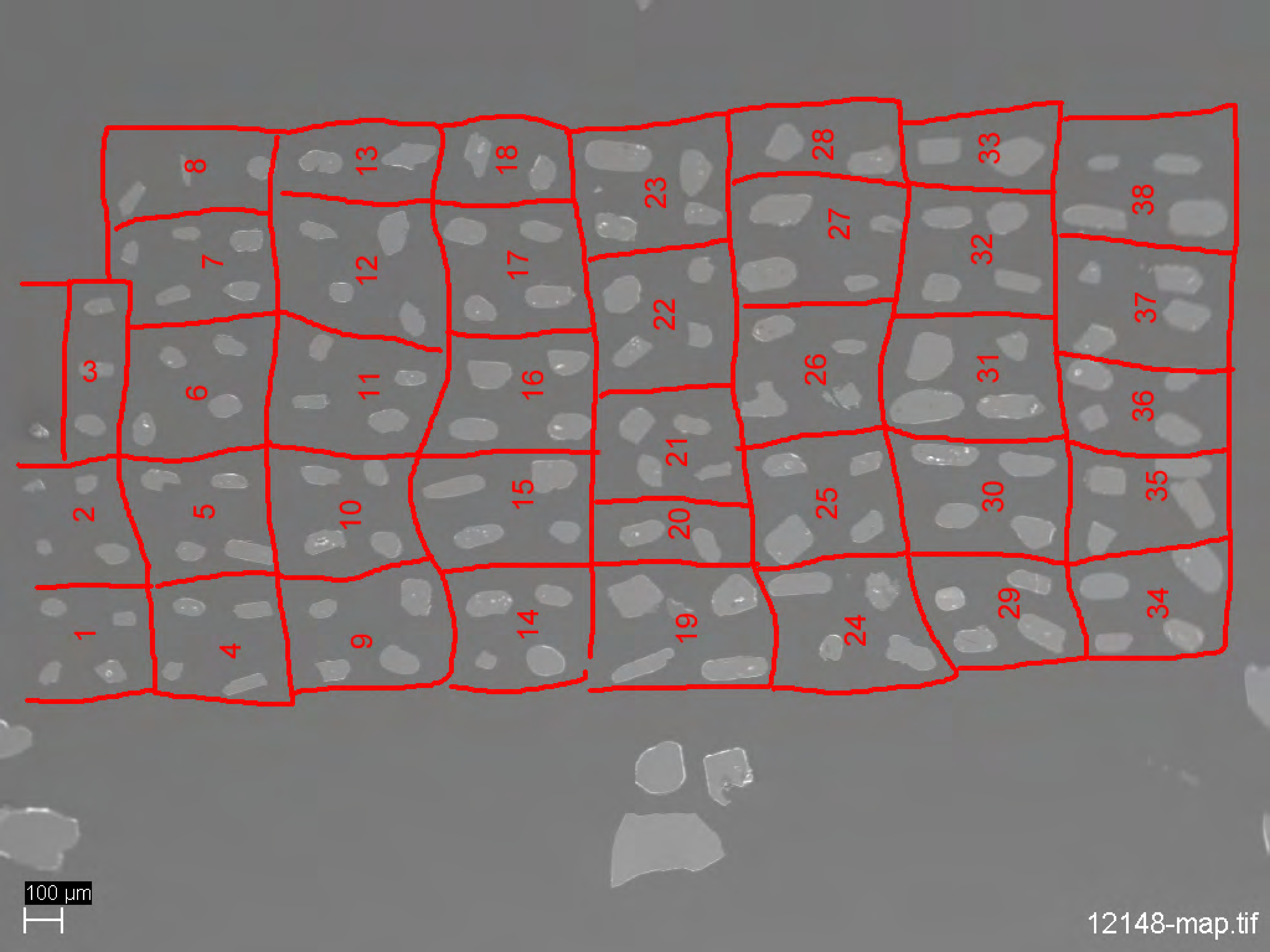

100 µm
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30 µm
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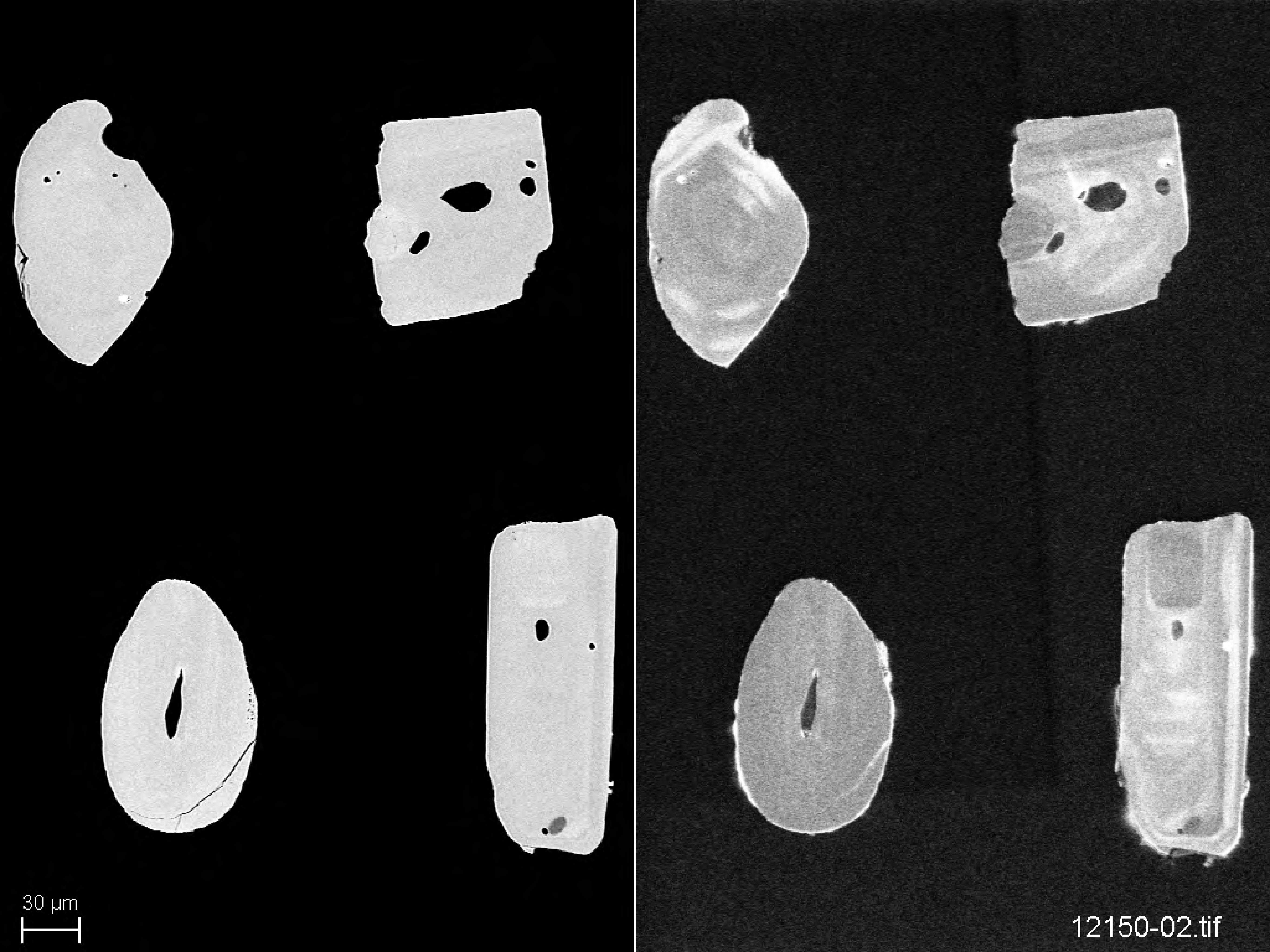
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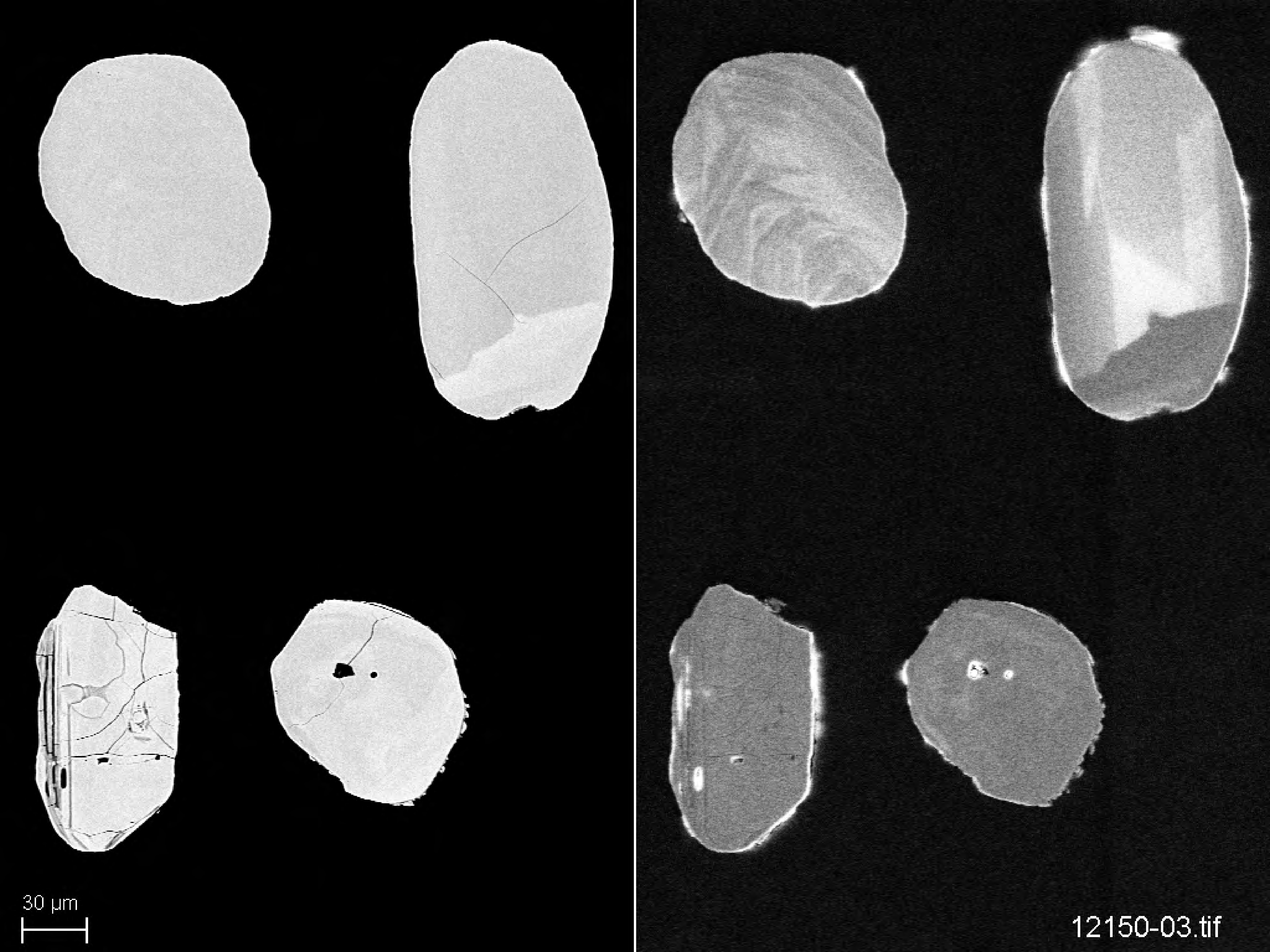

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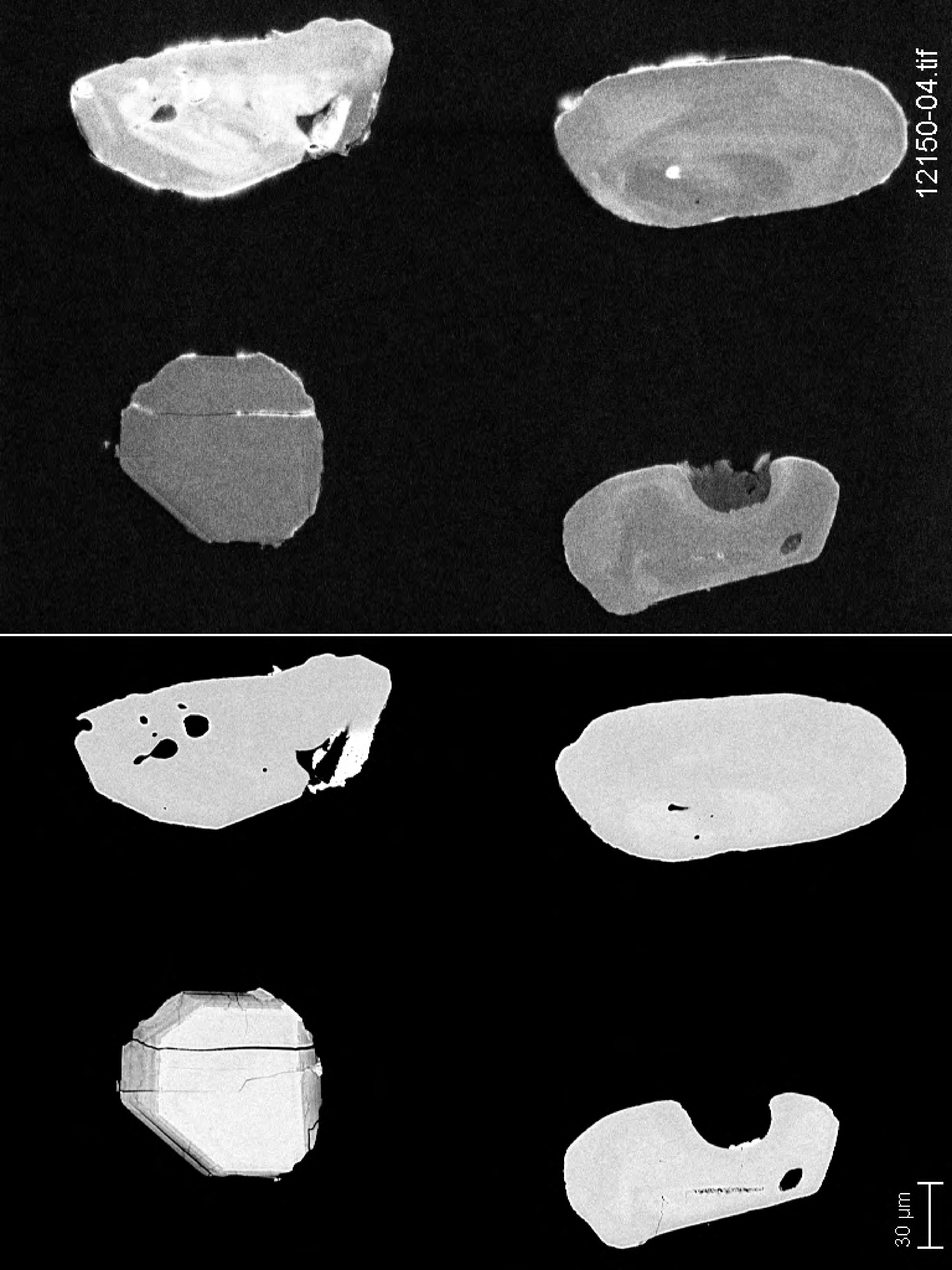
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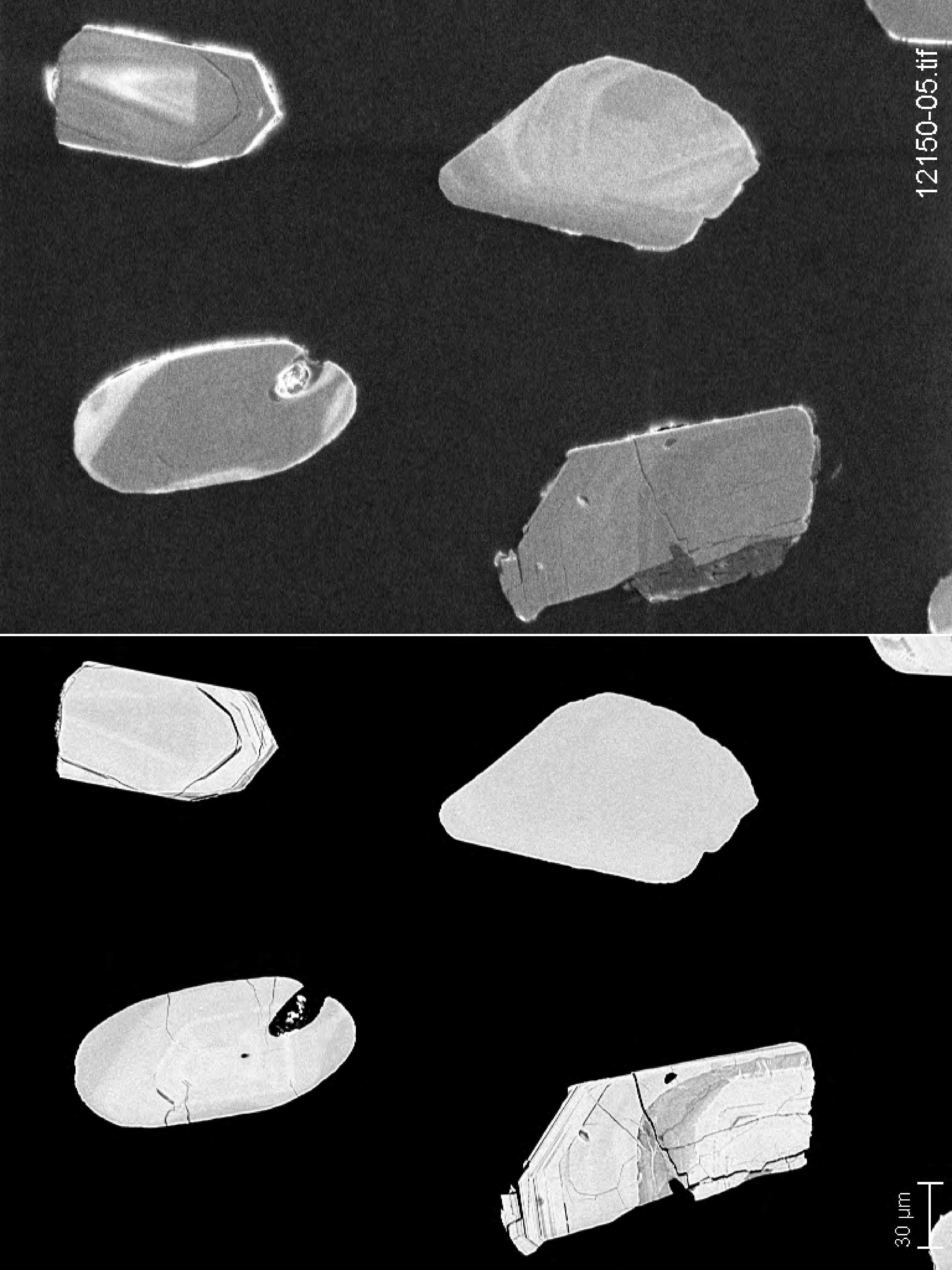
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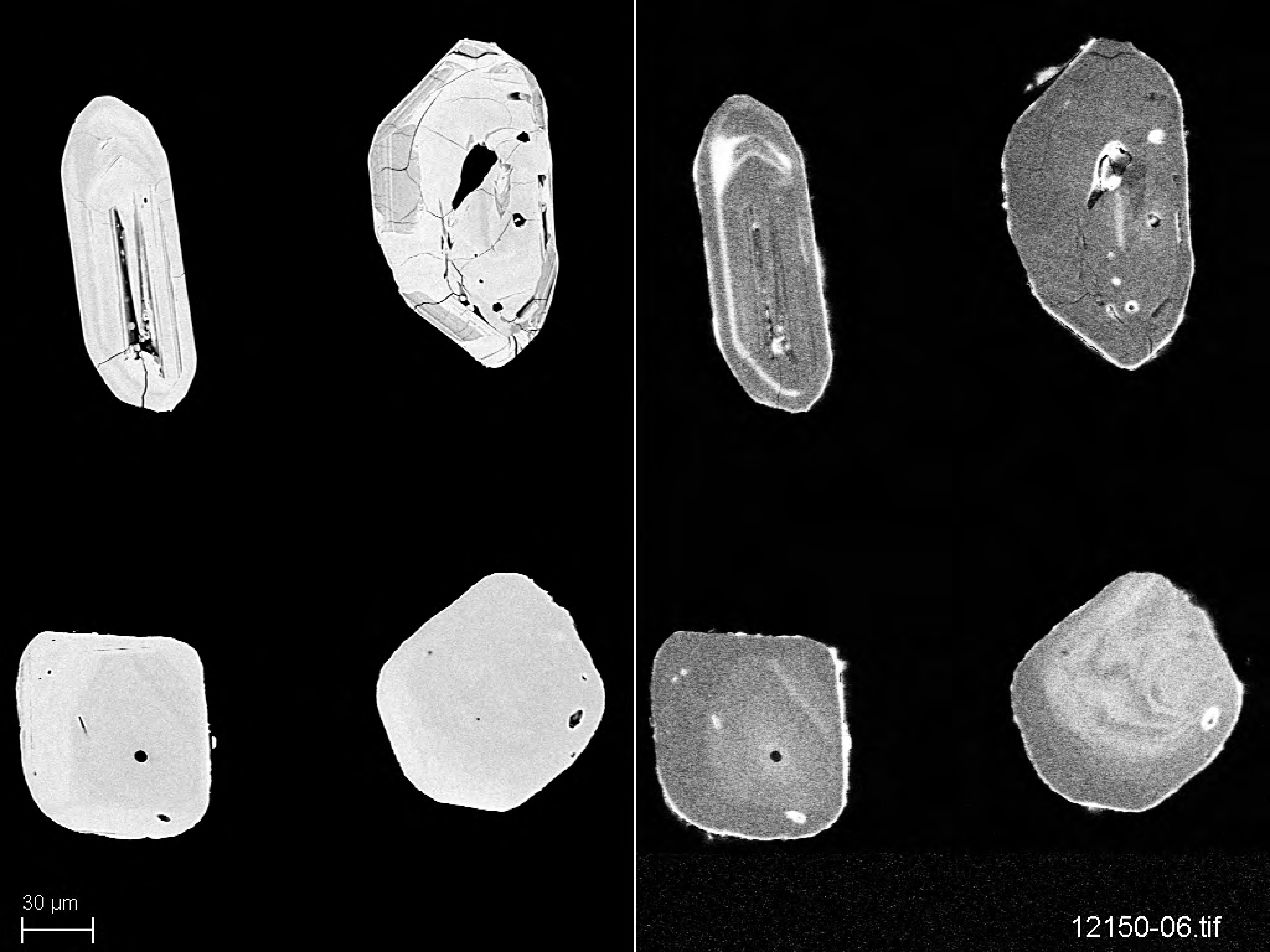
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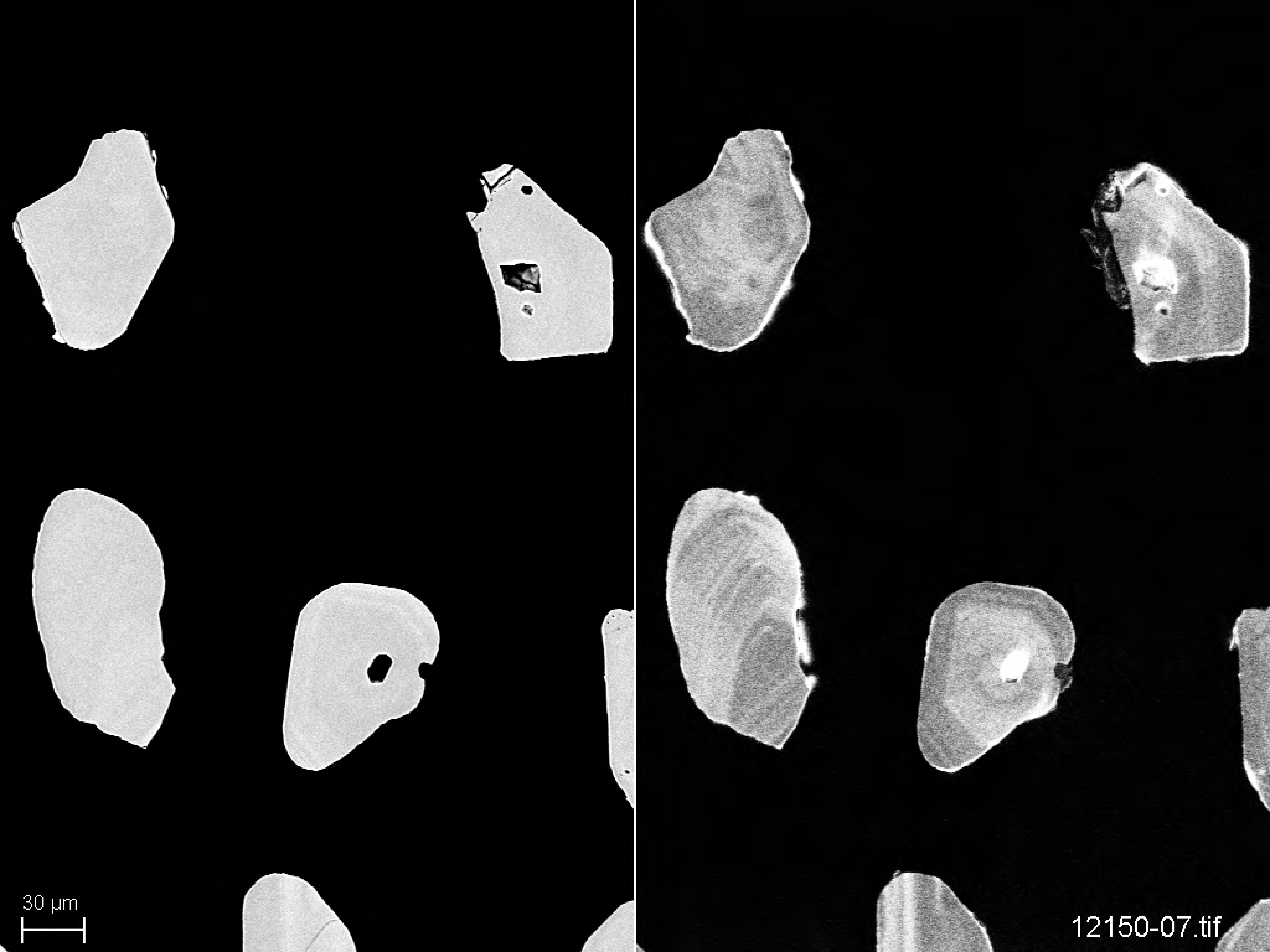

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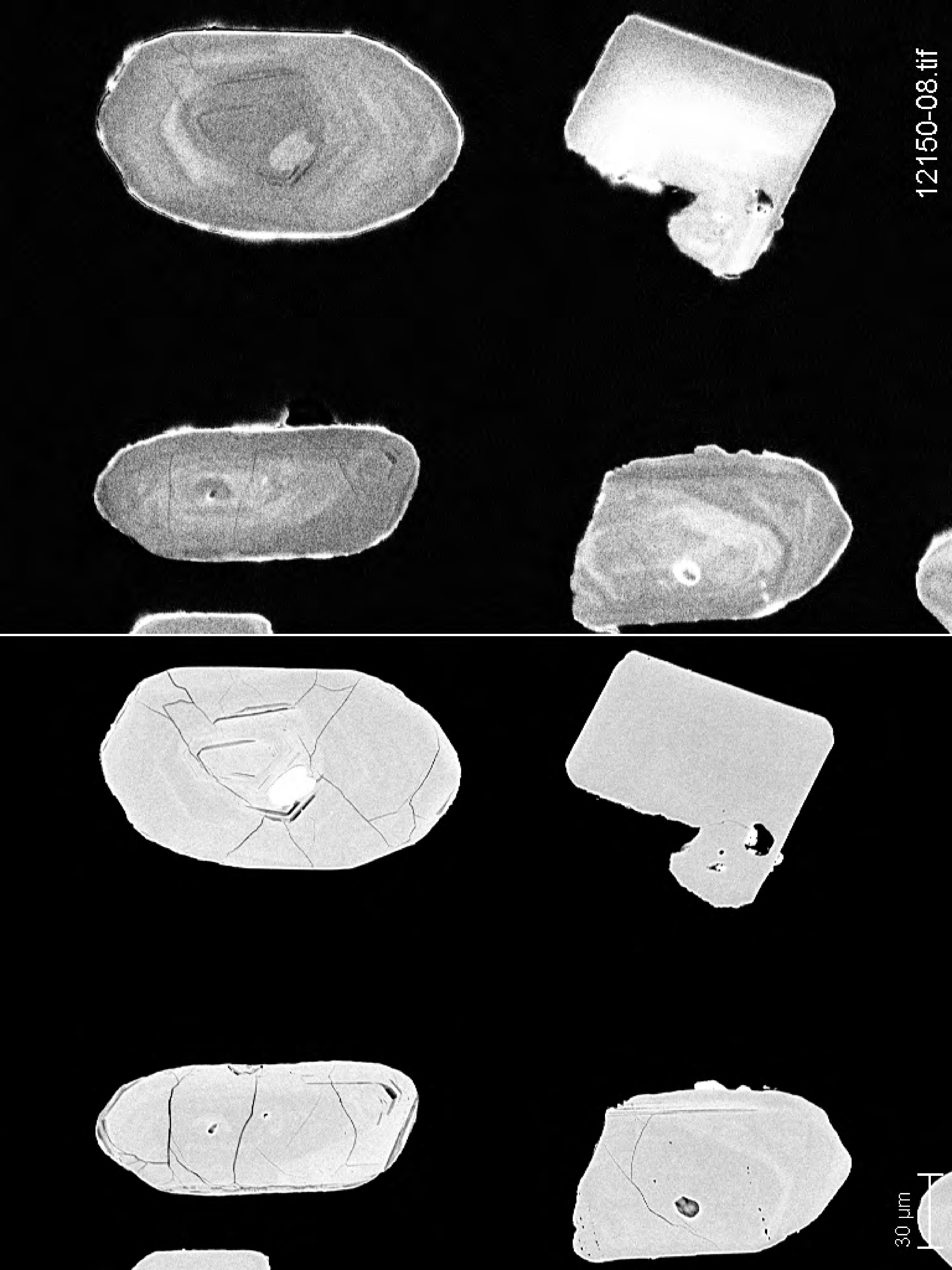
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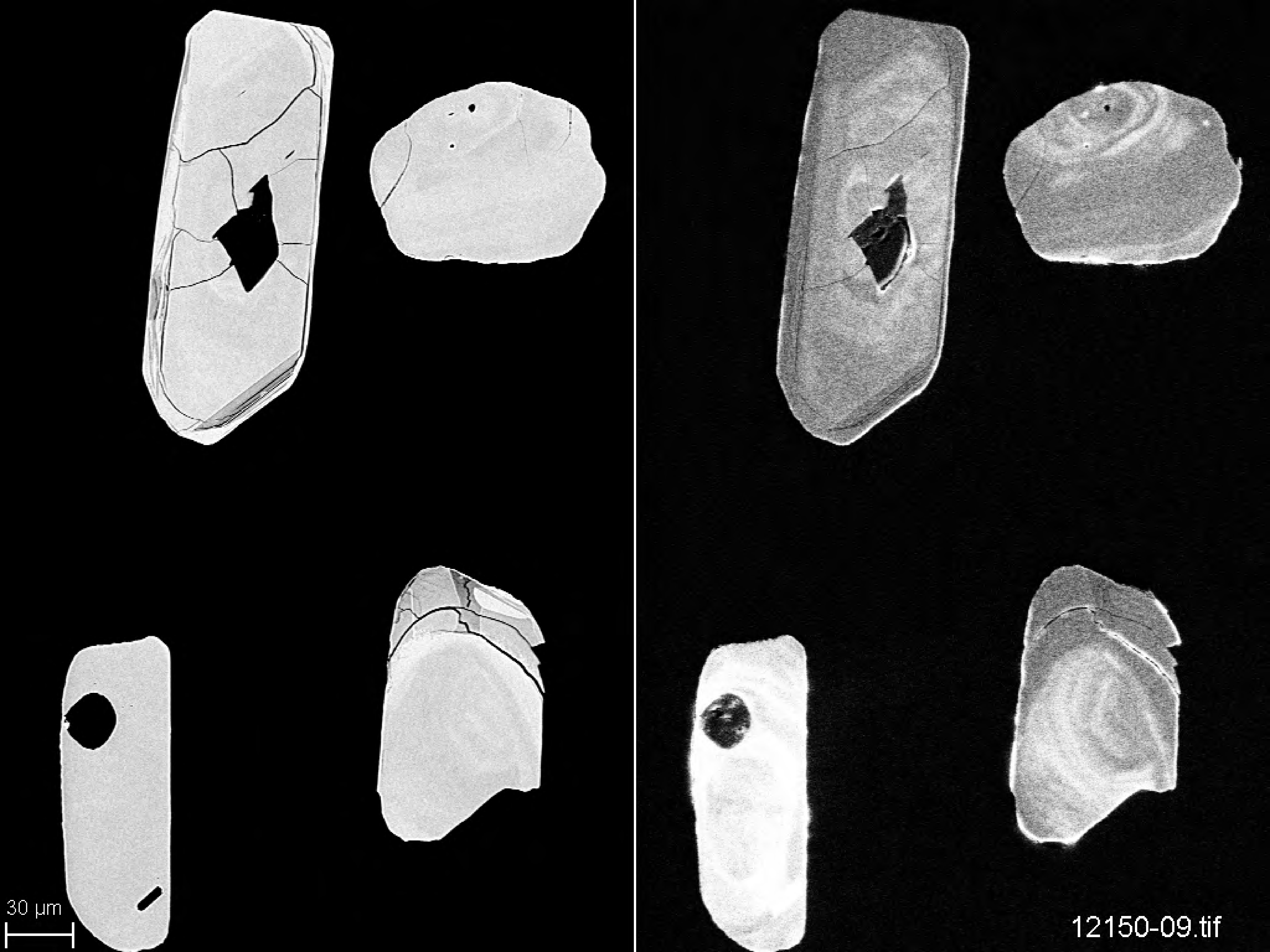
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12150-09.tif


30 µm
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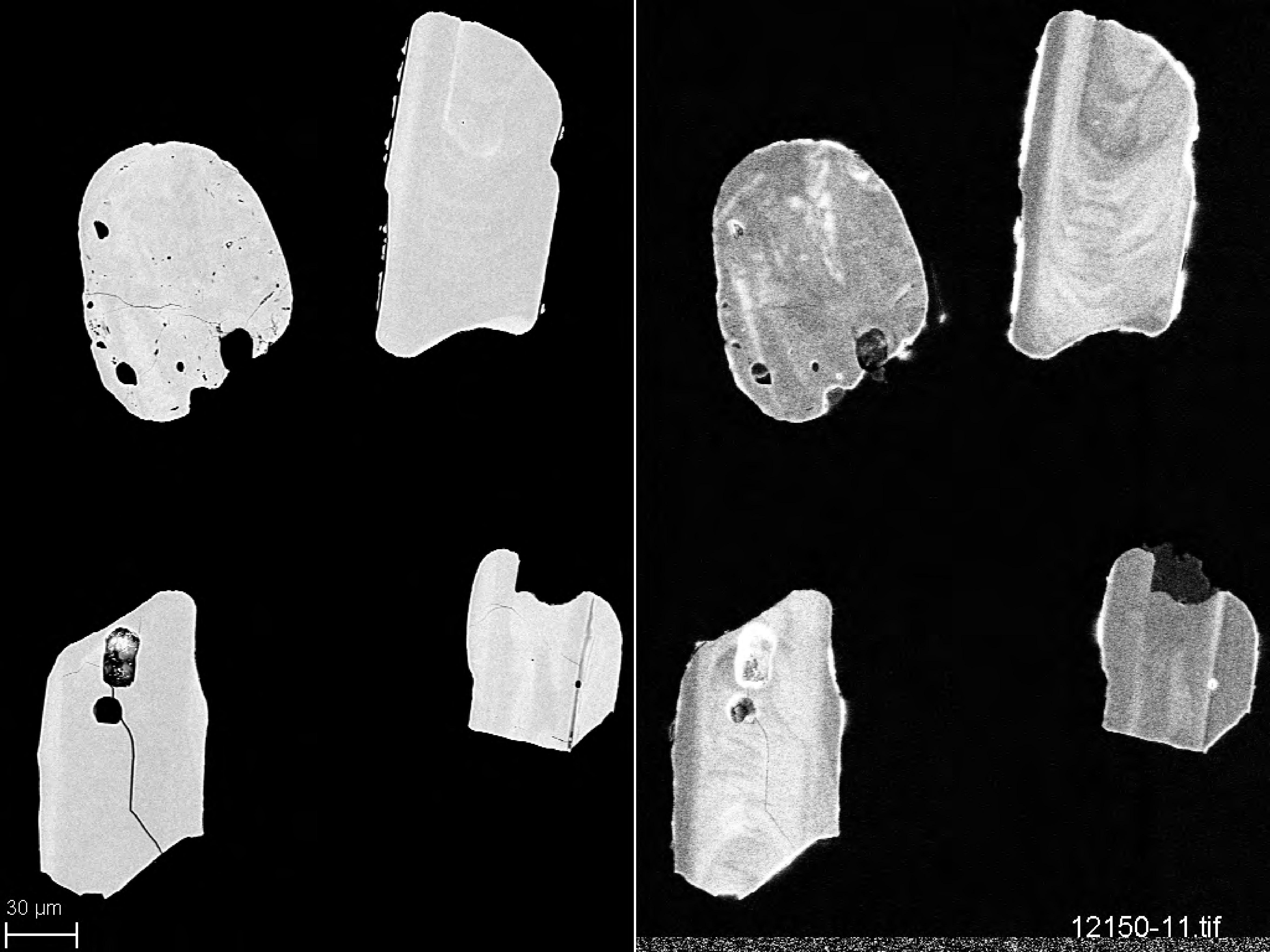
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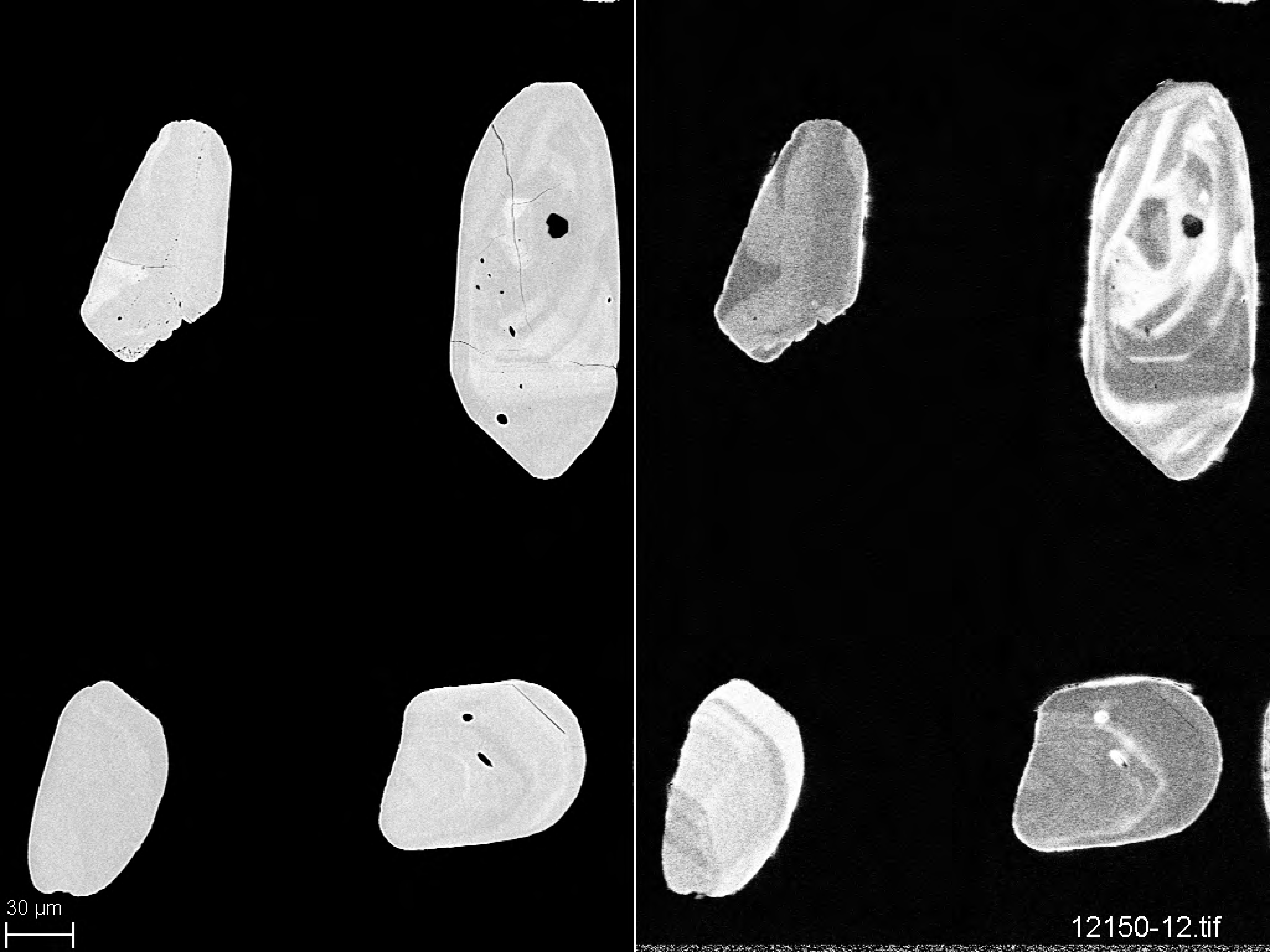
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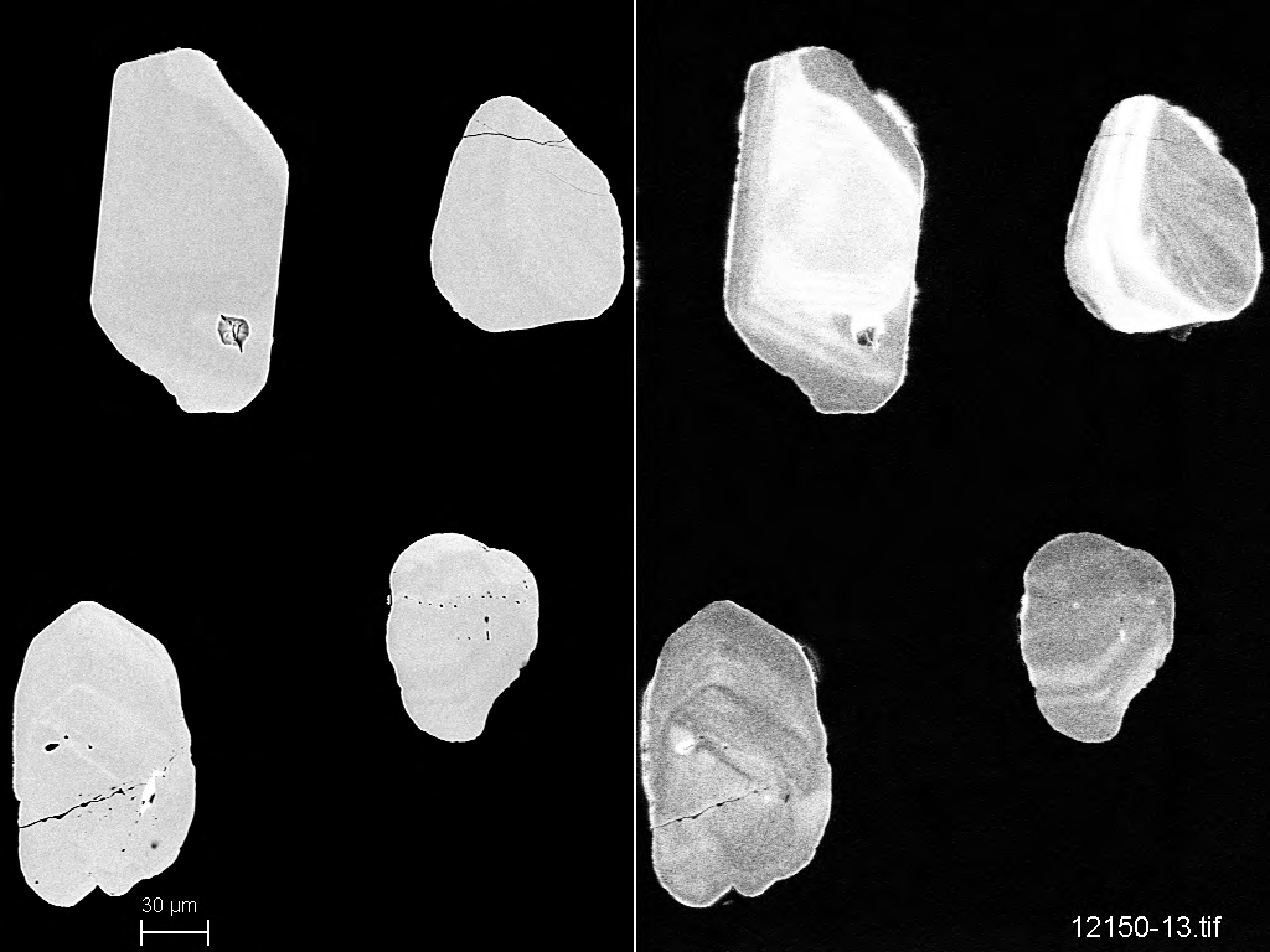
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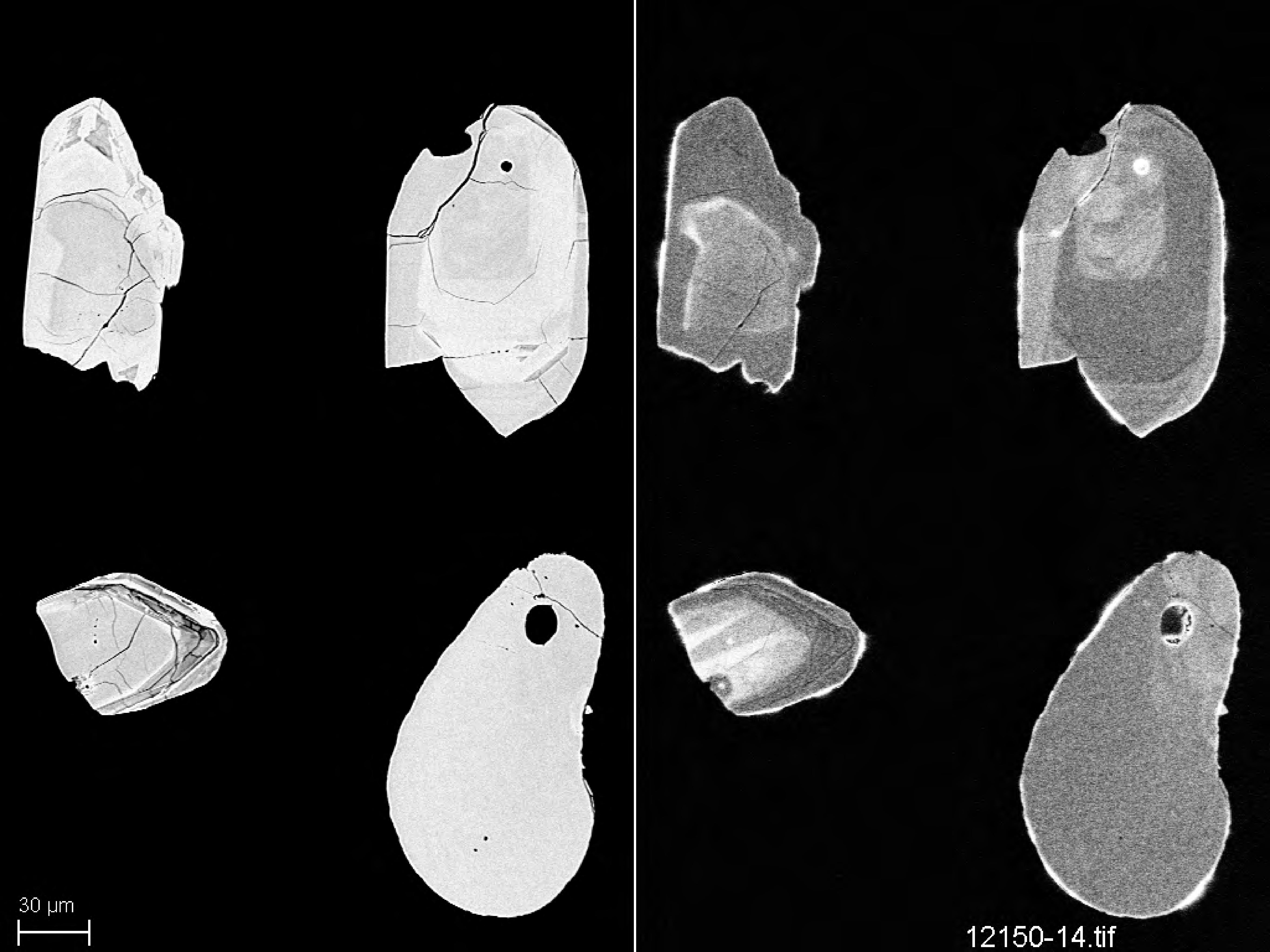
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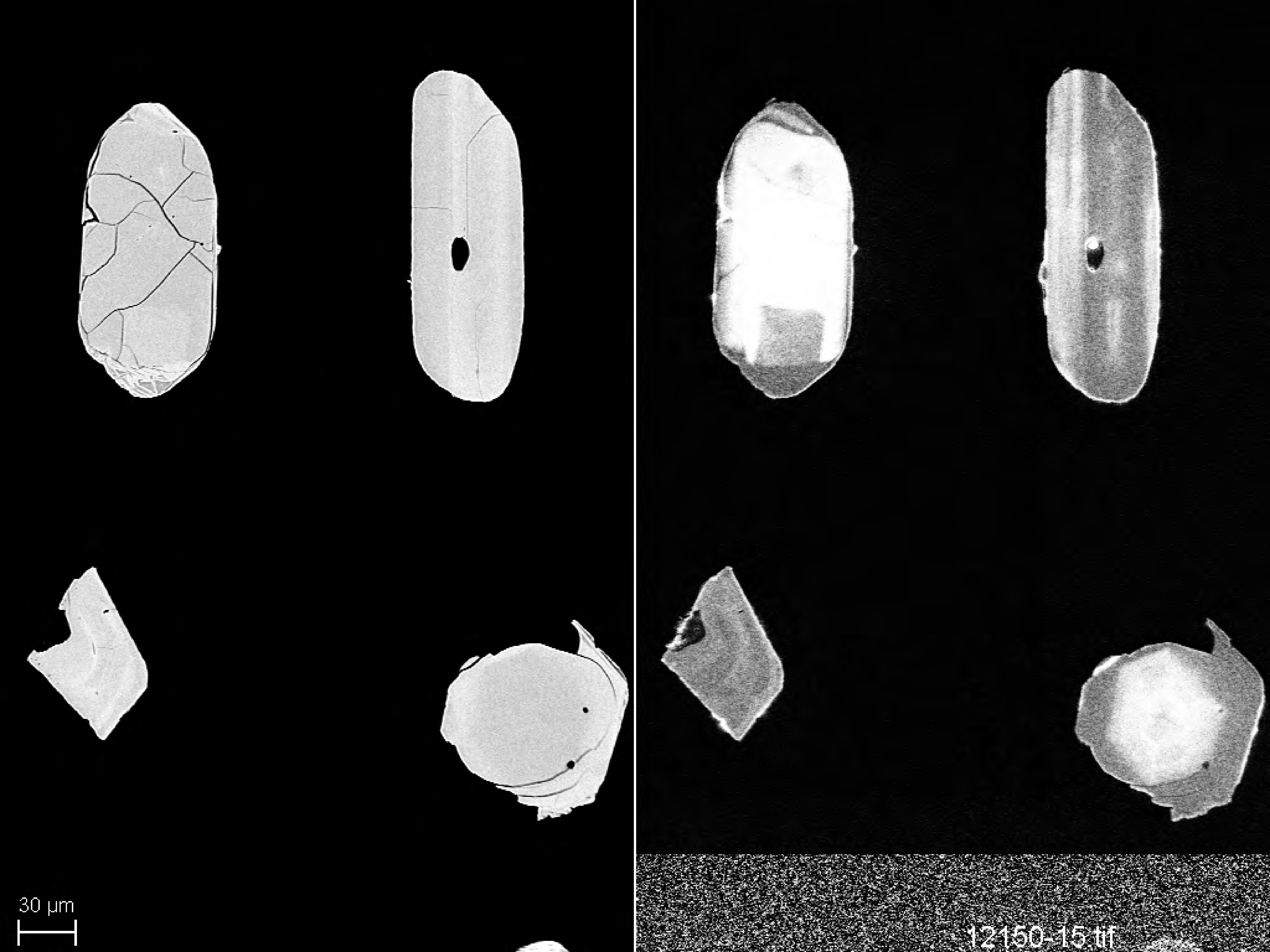

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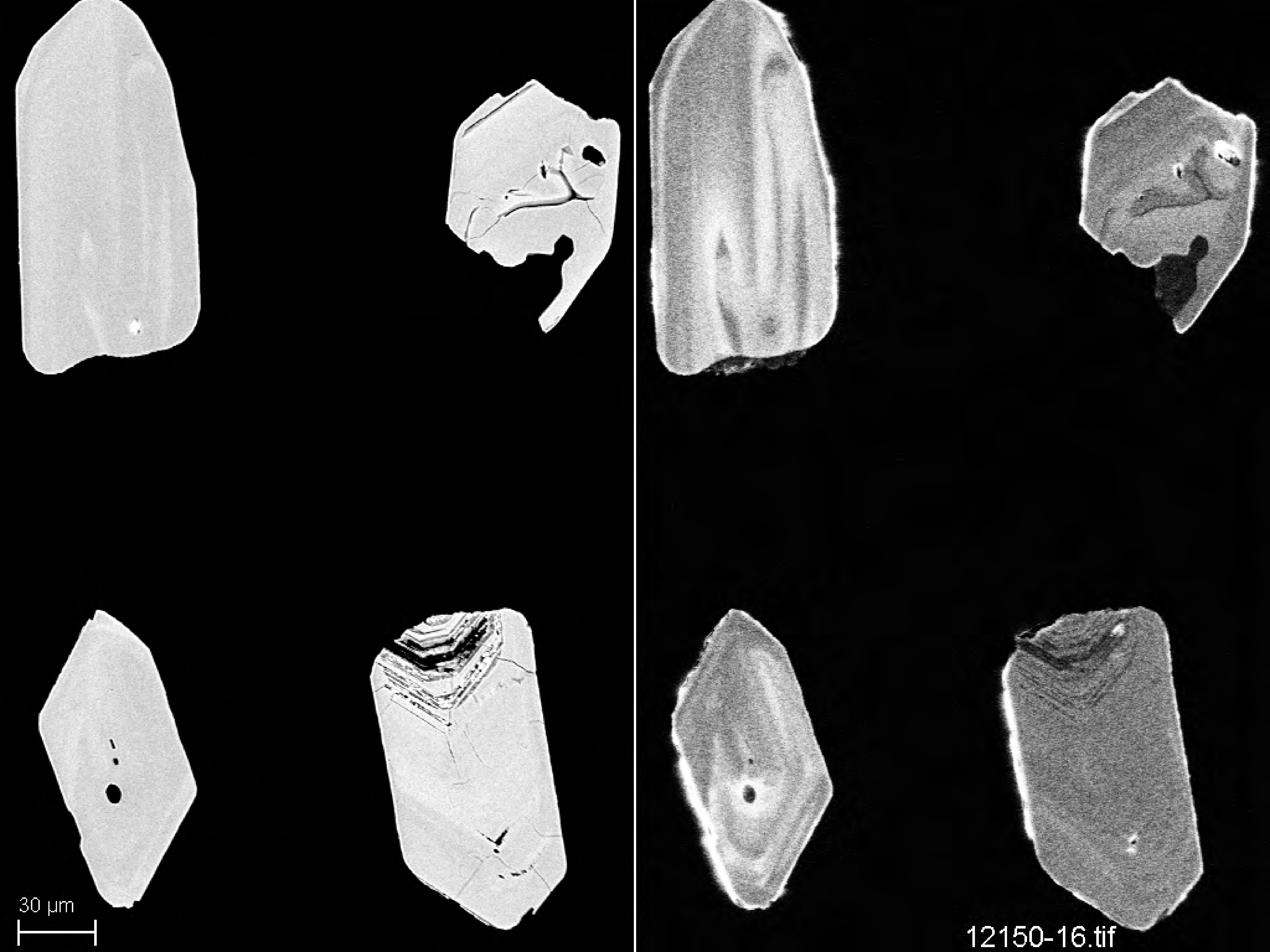
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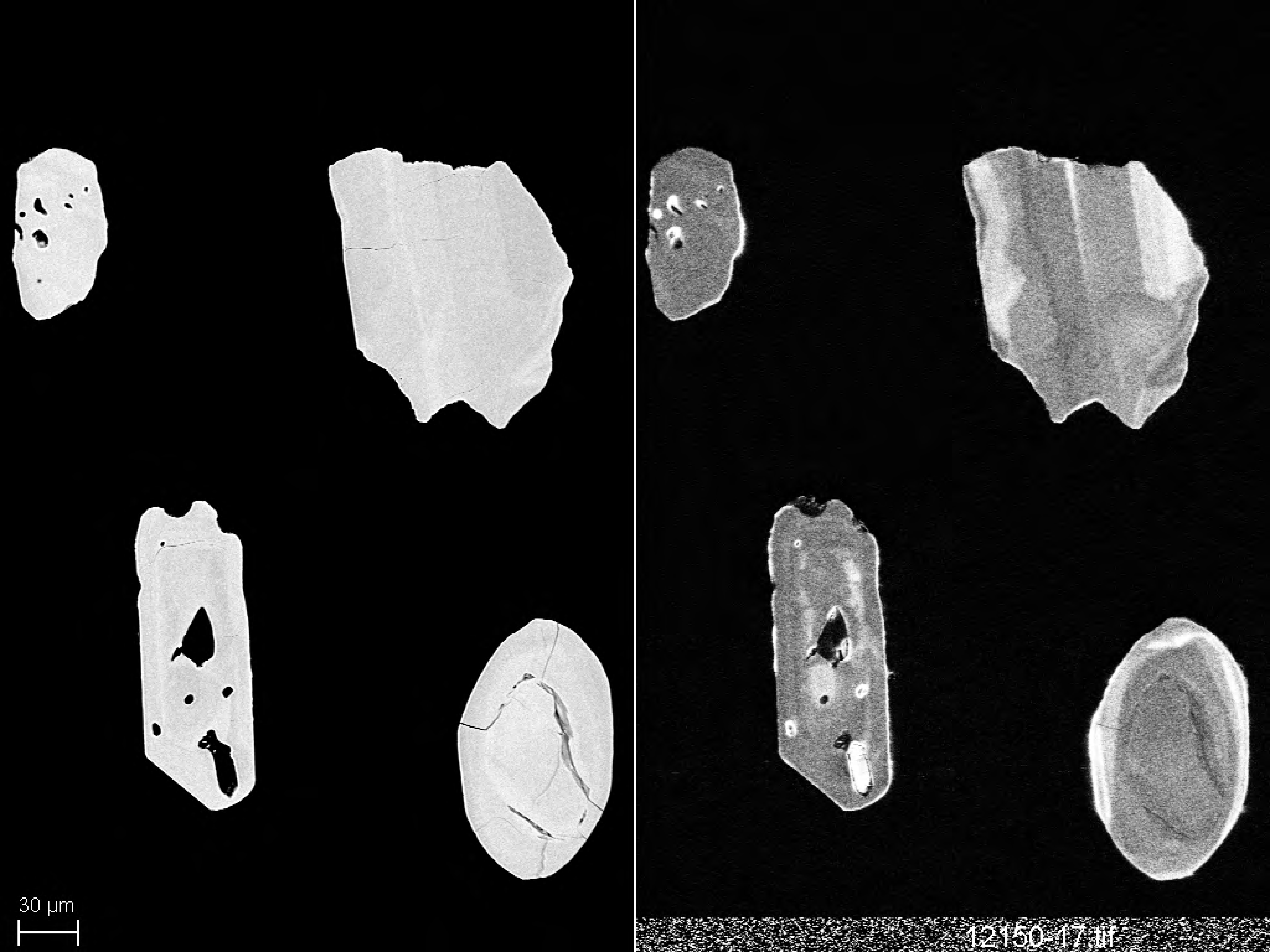
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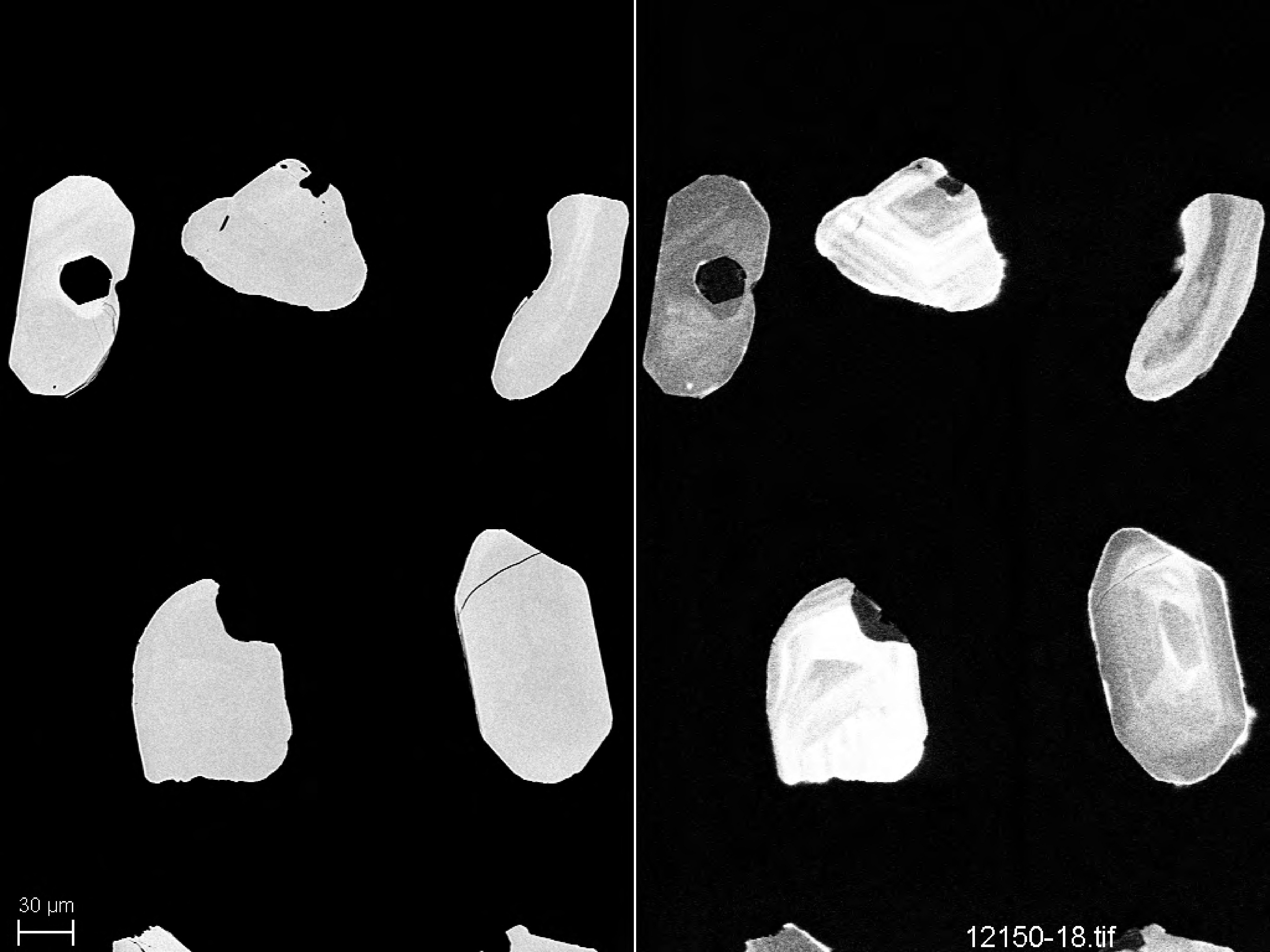

30 µm
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30 µm
12150-19.tif


30 µm
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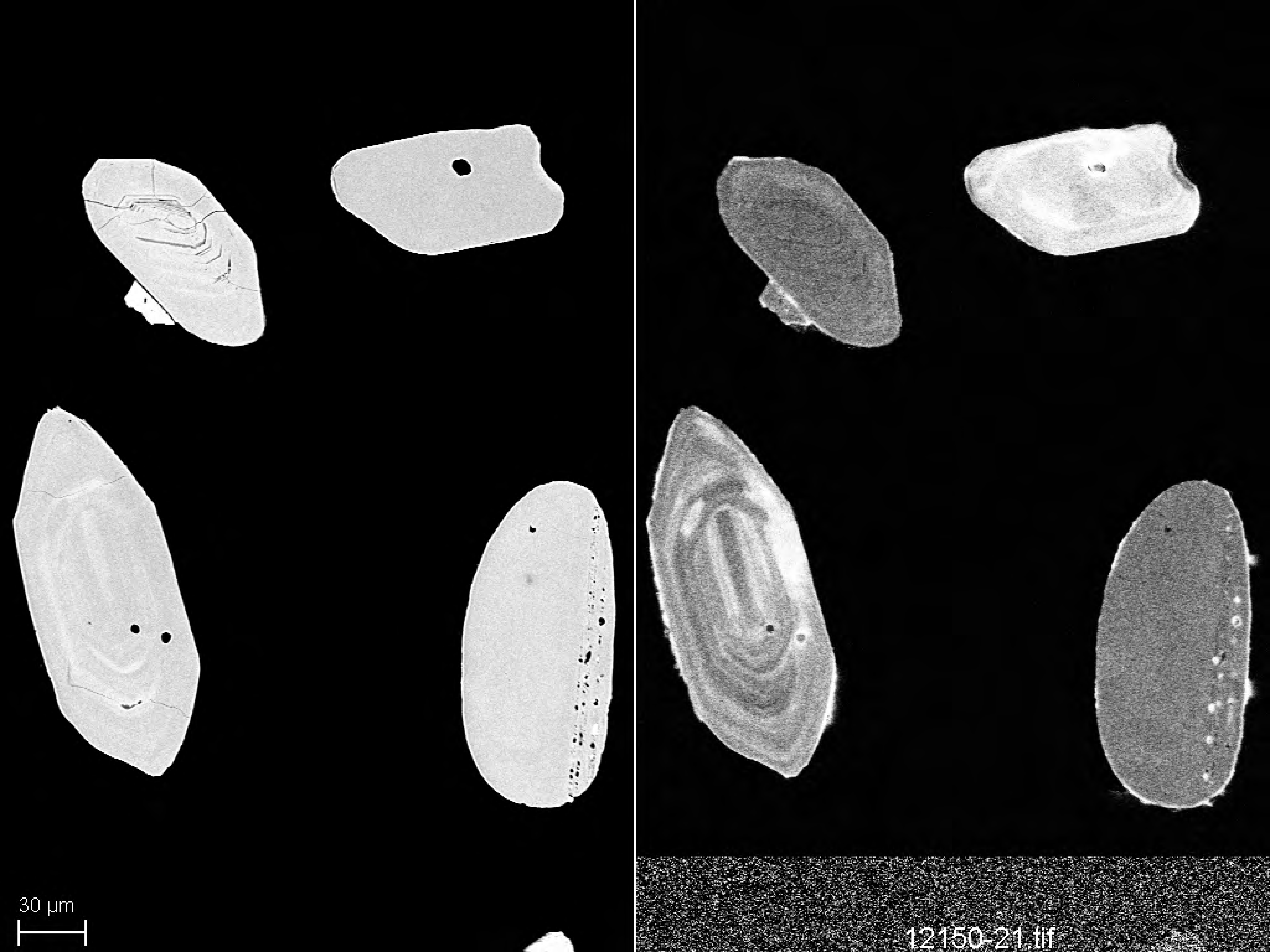
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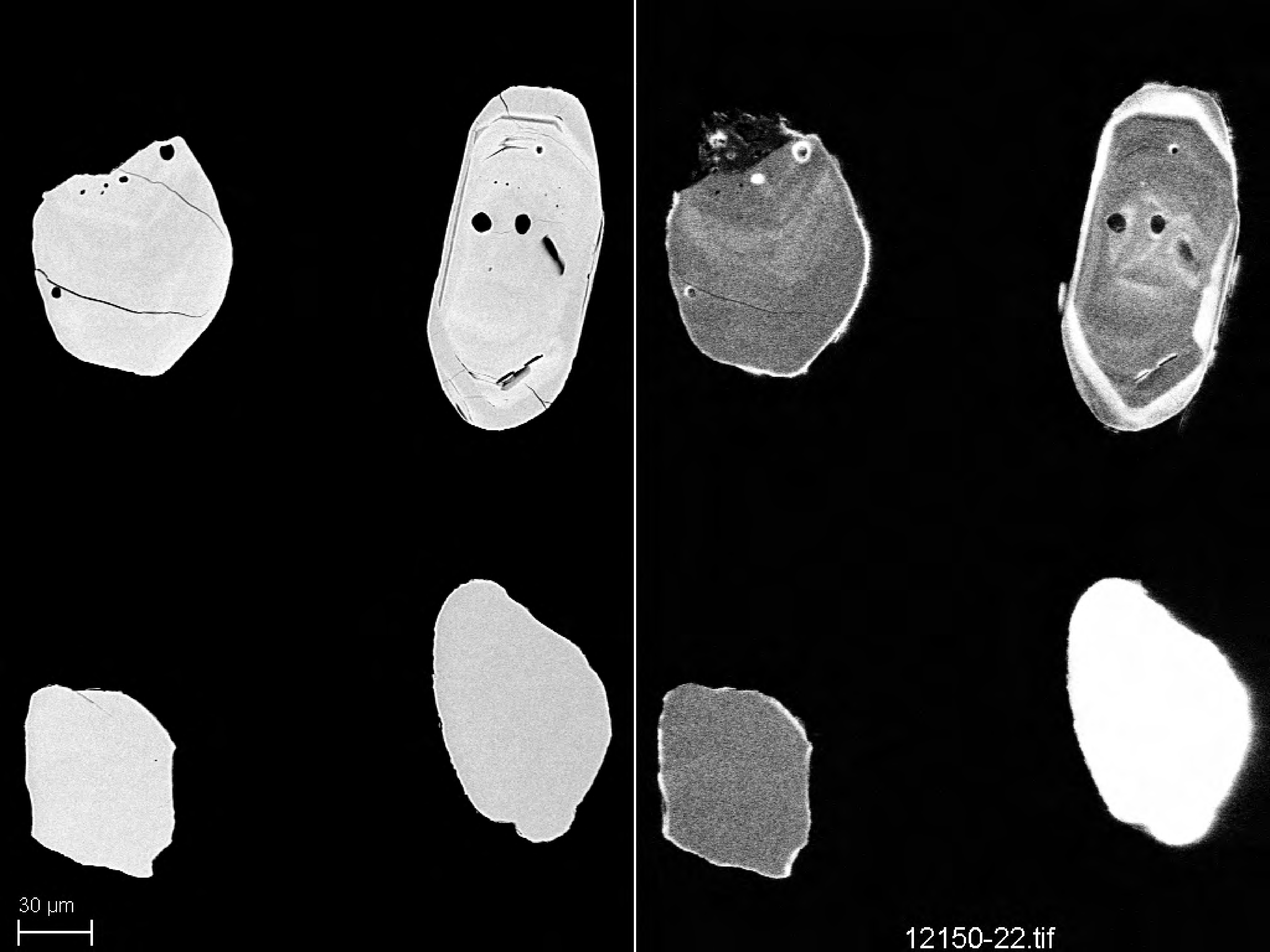
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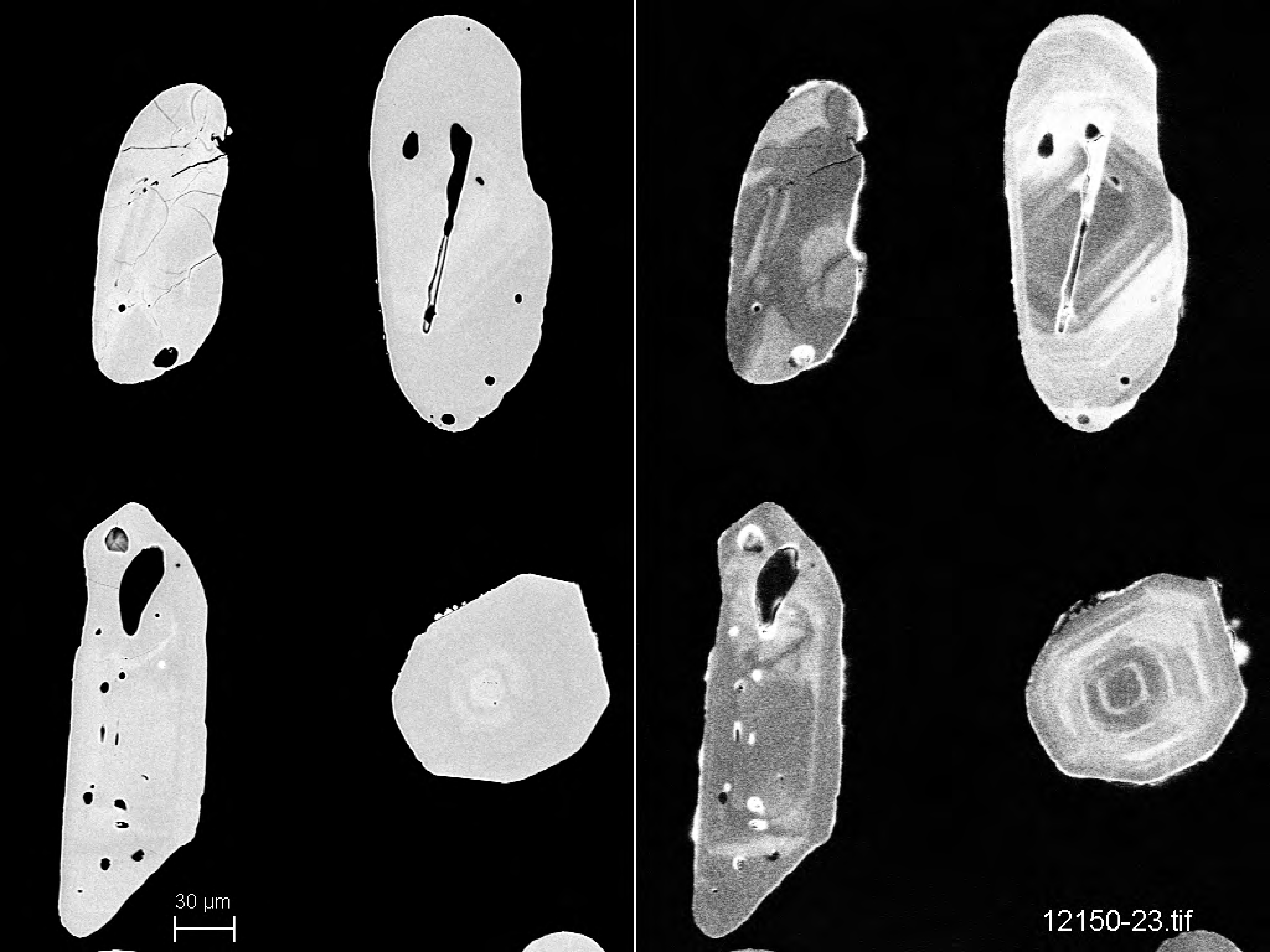
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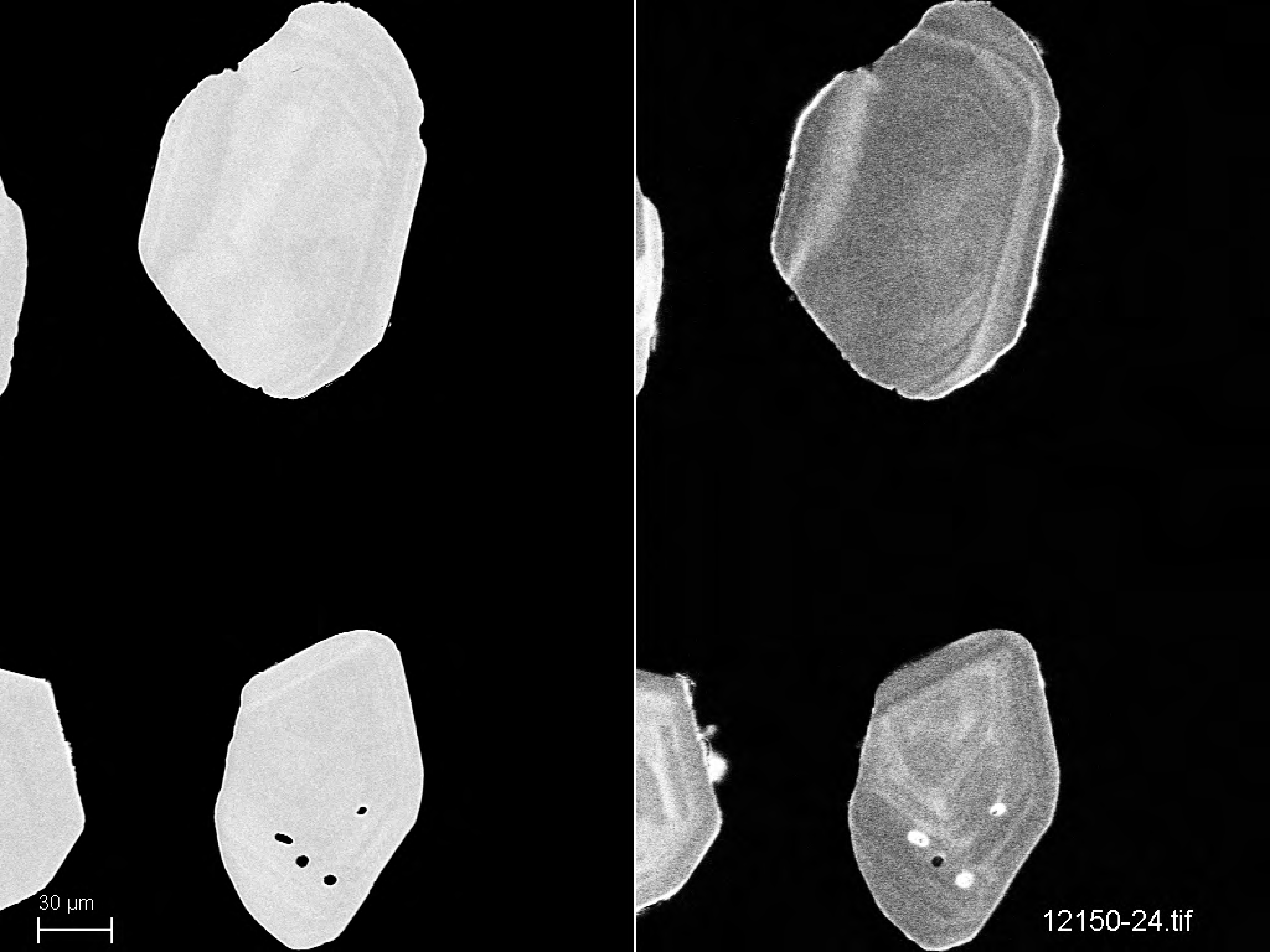
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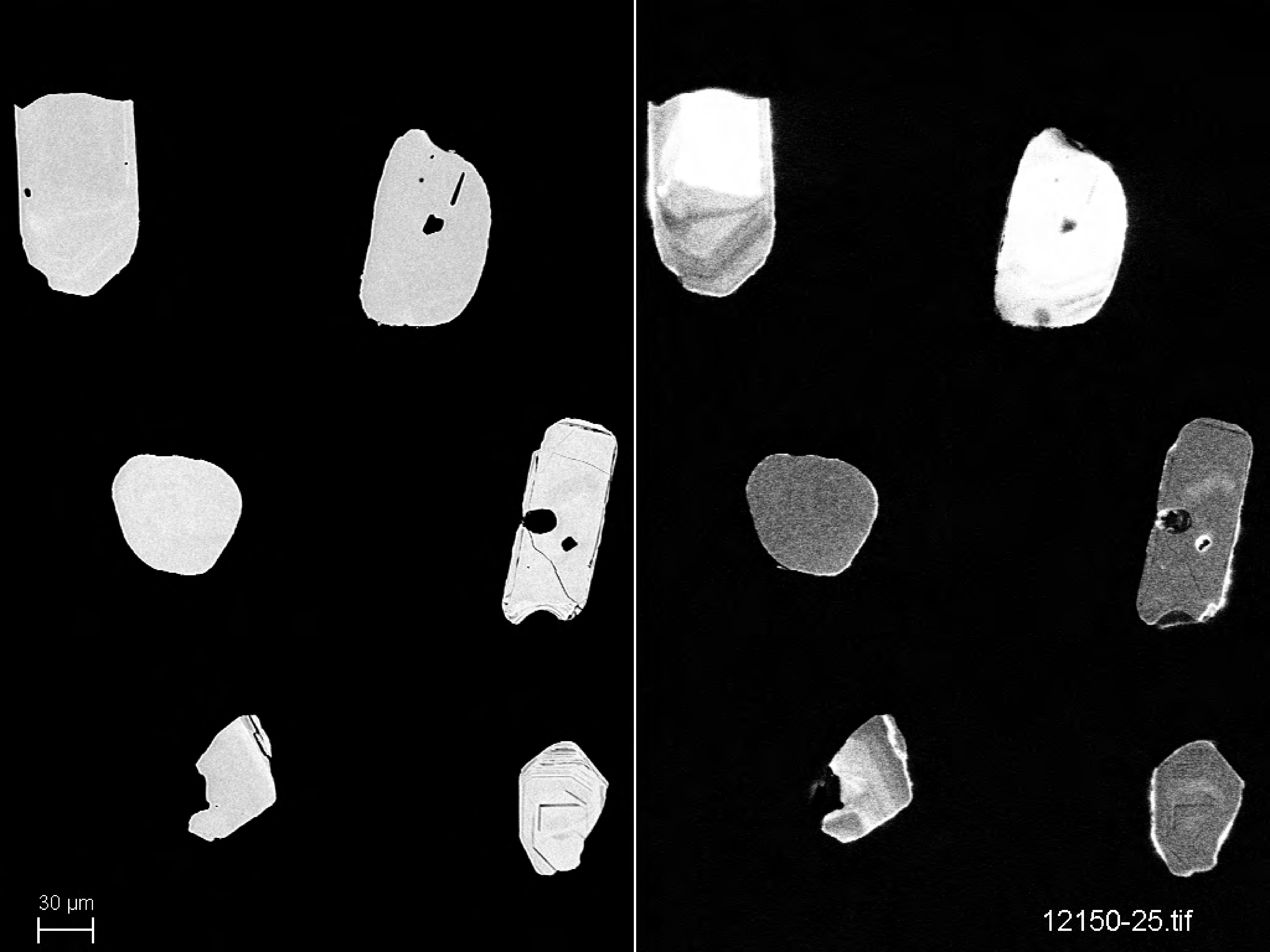
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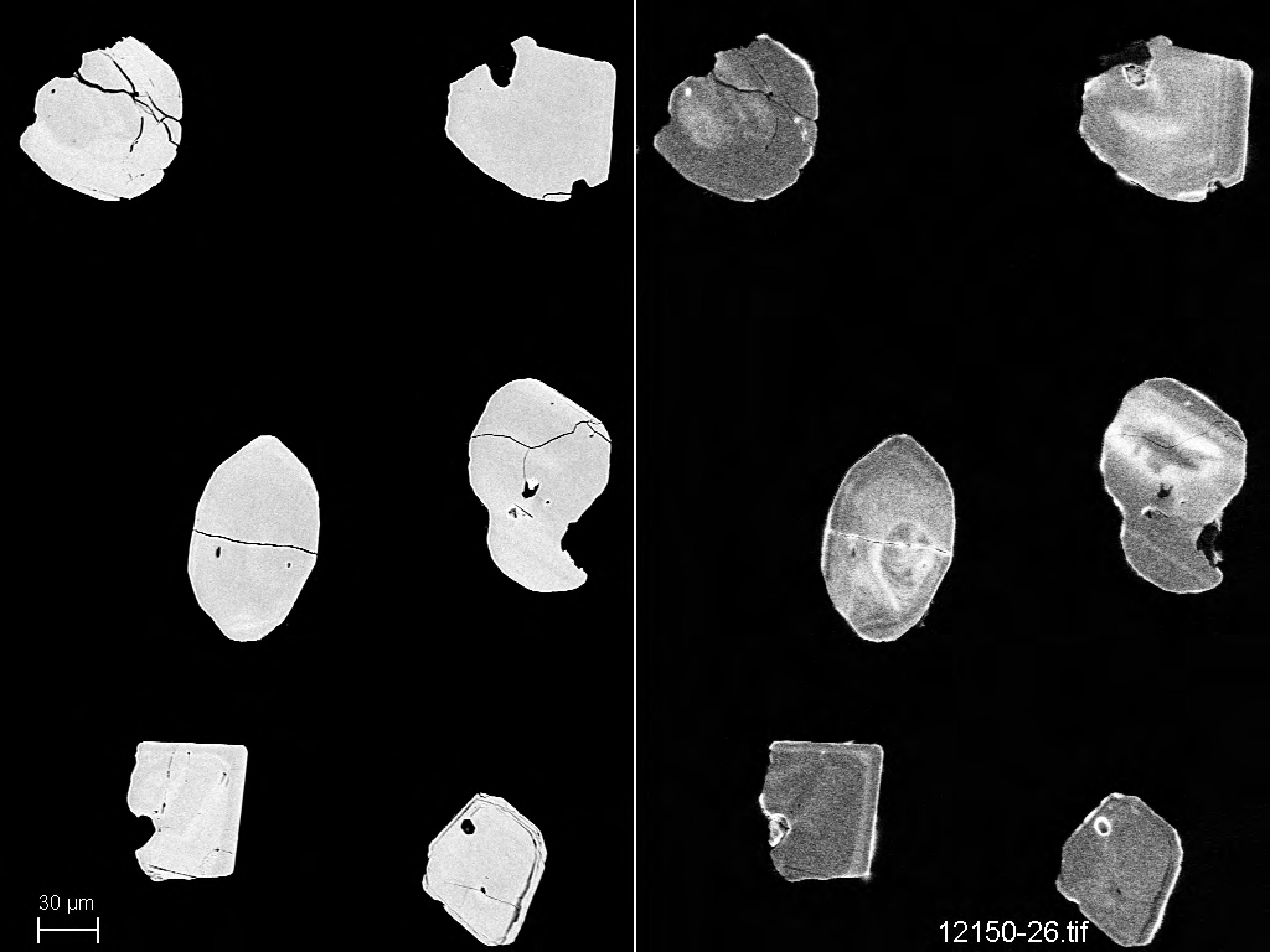
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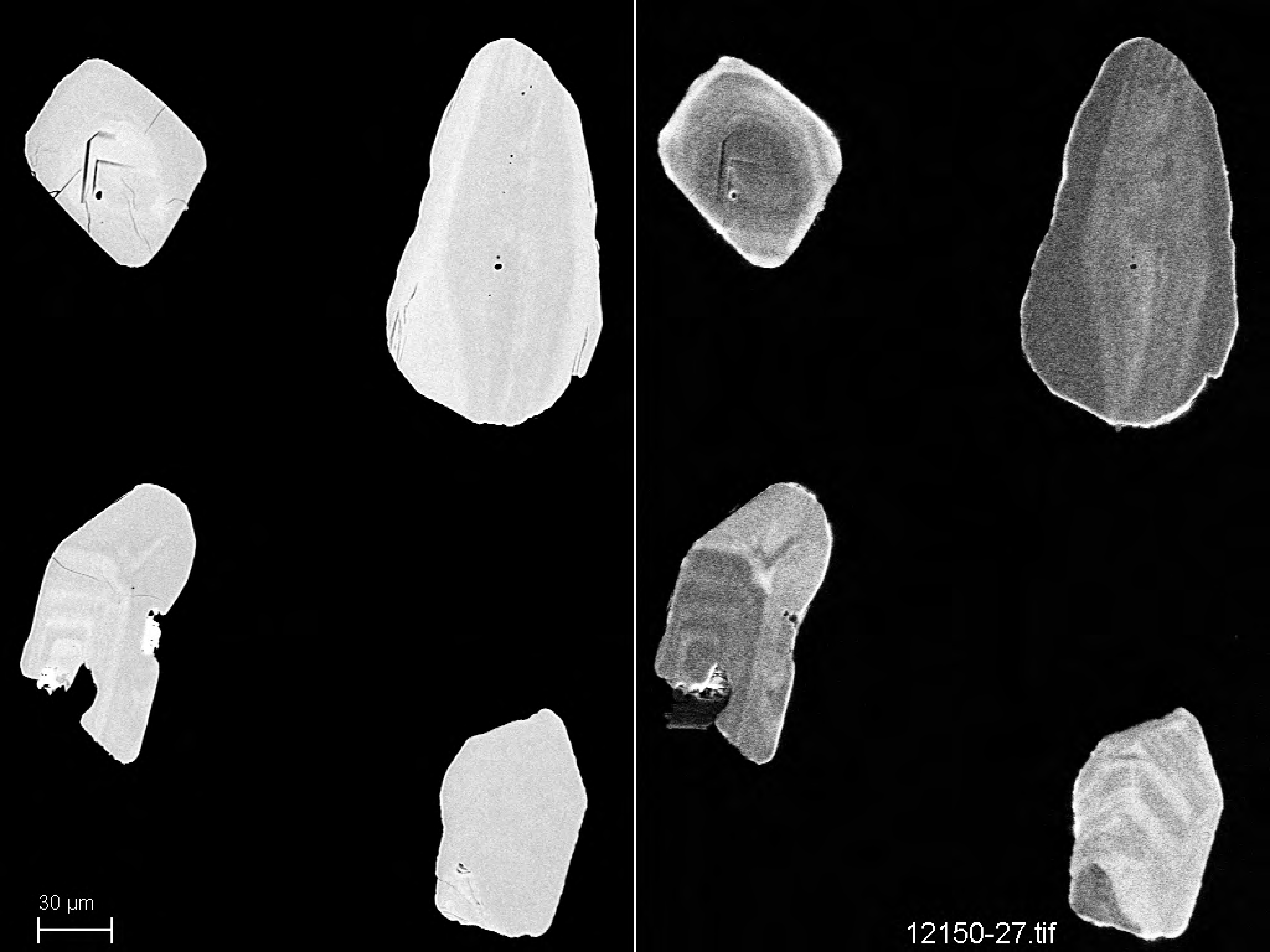
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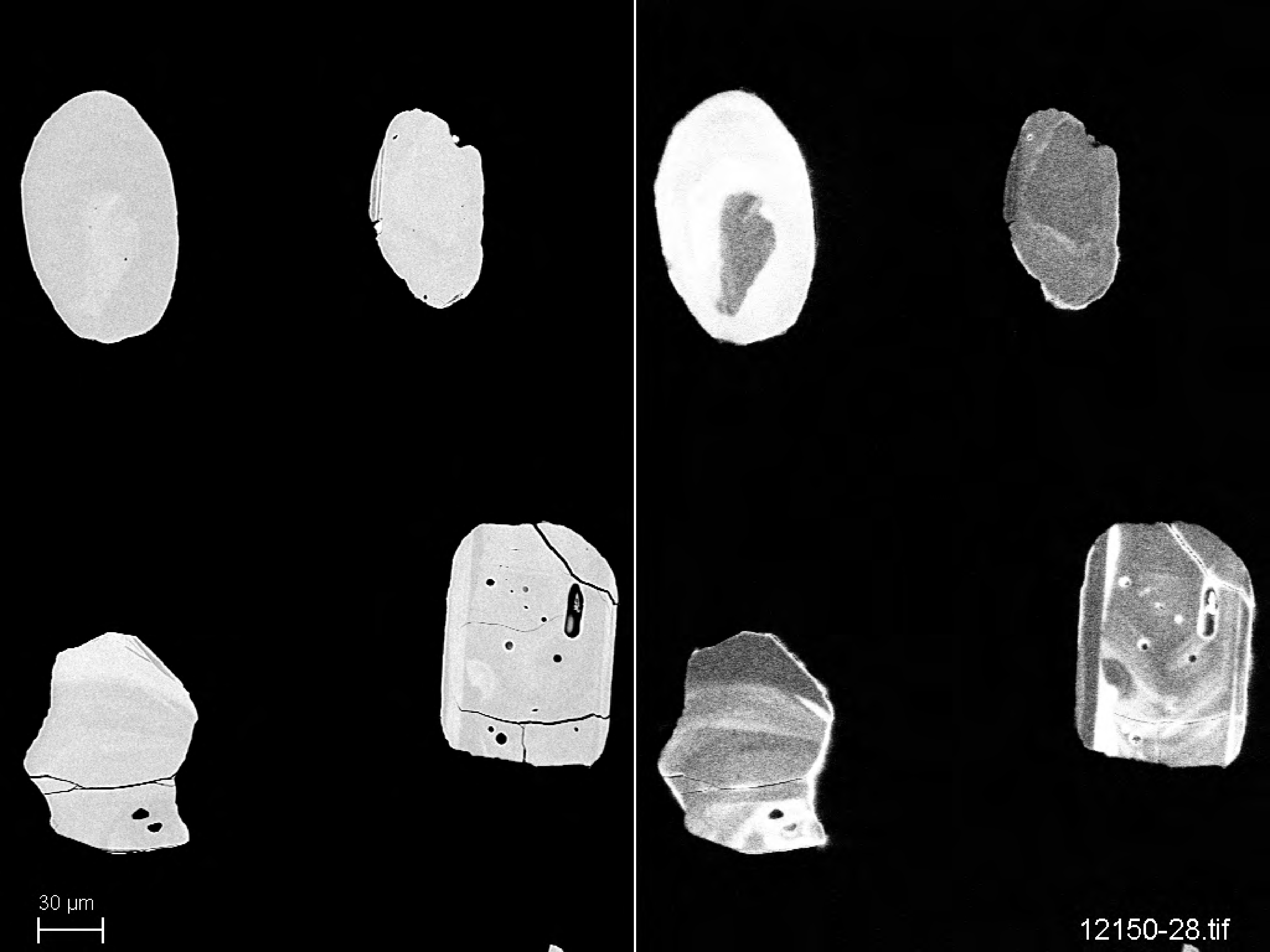
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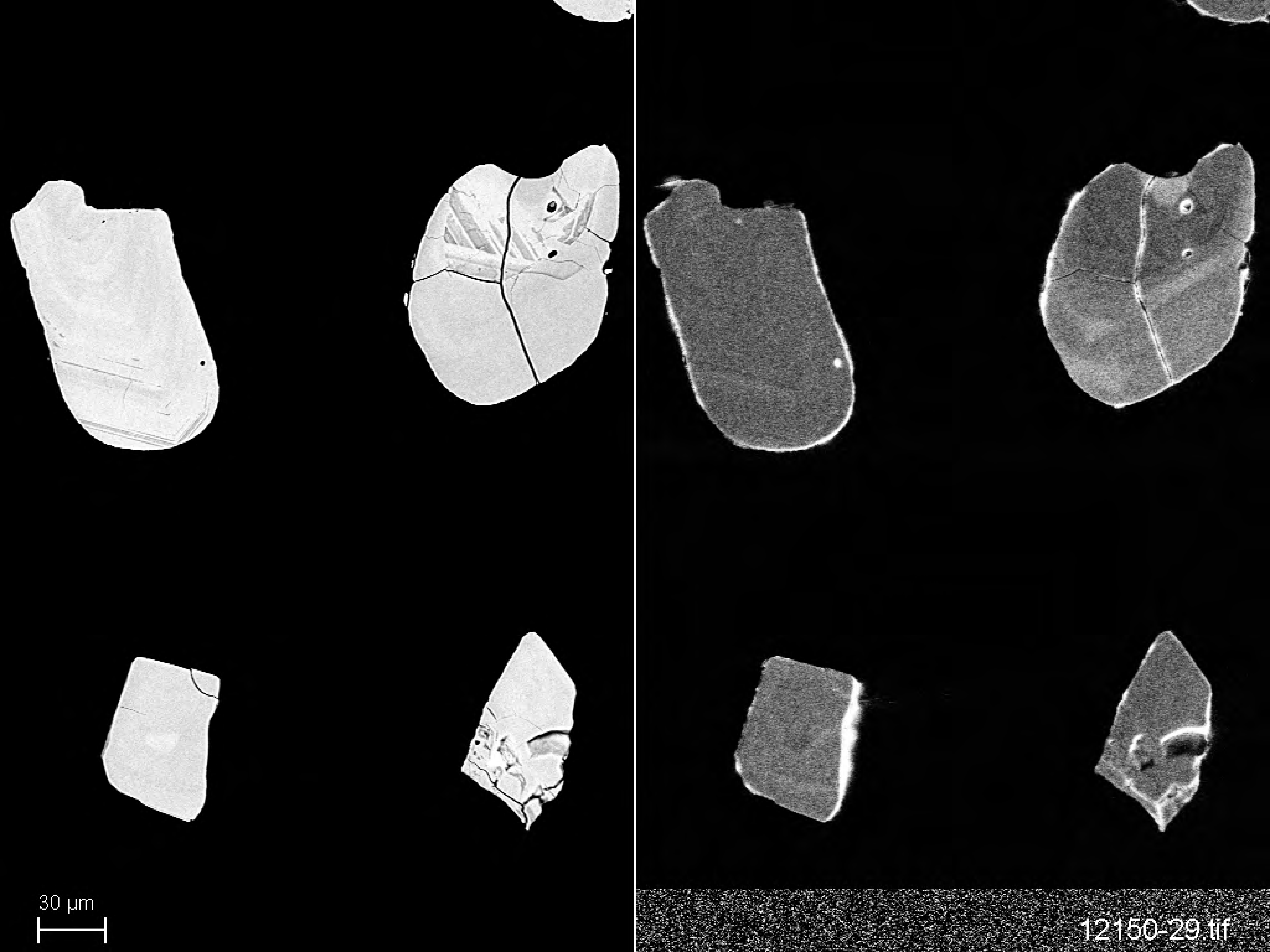
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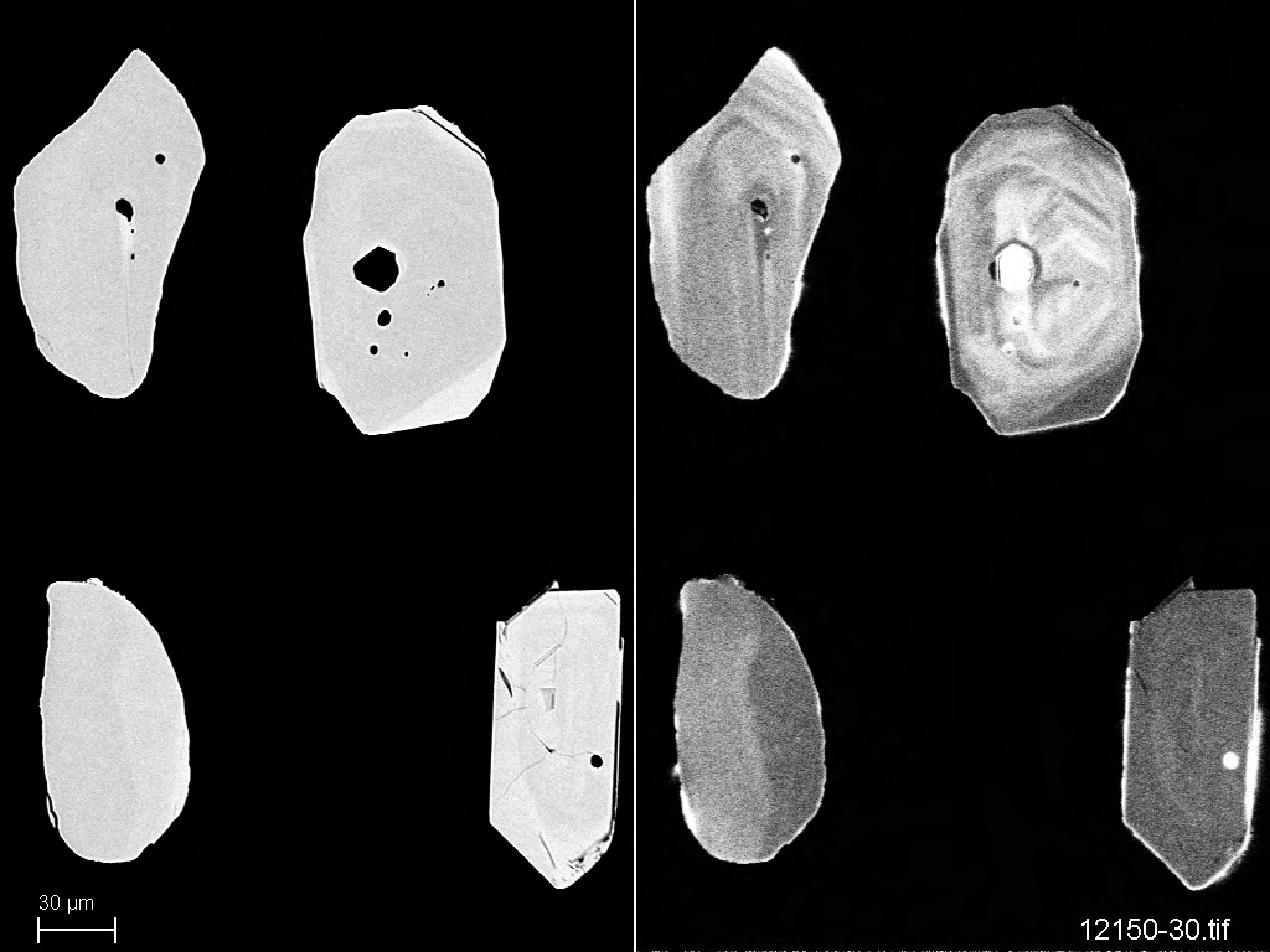
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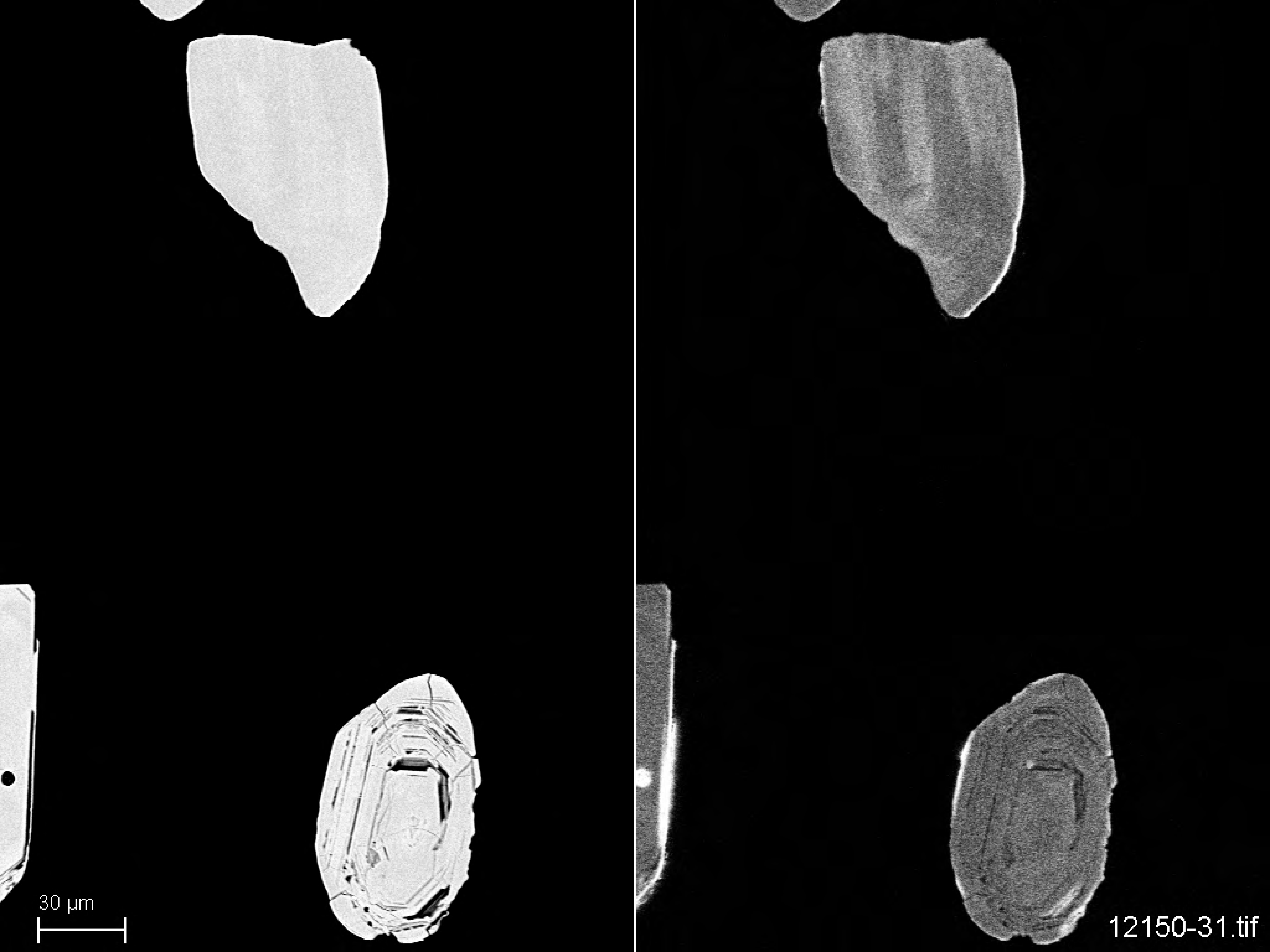
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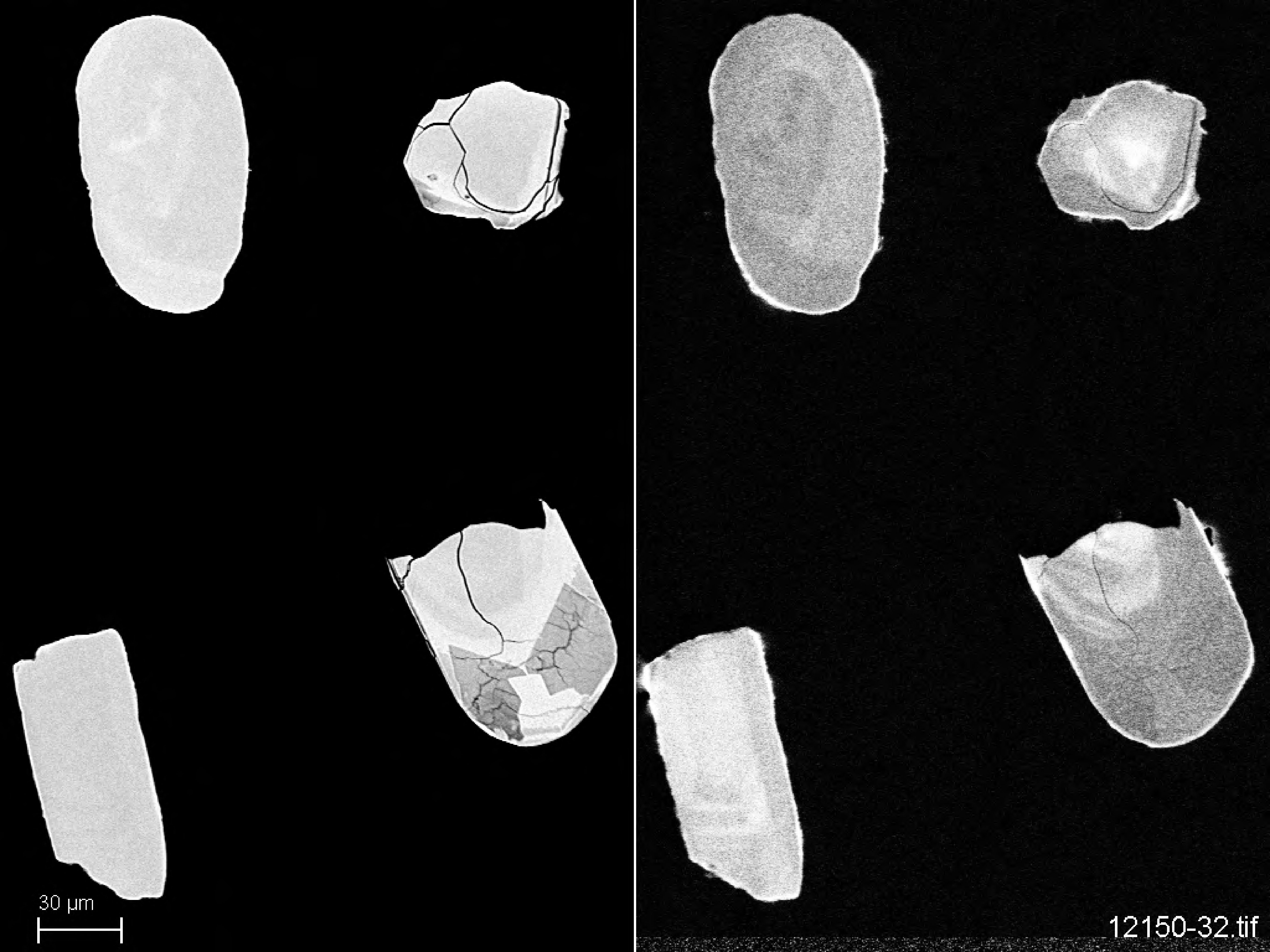
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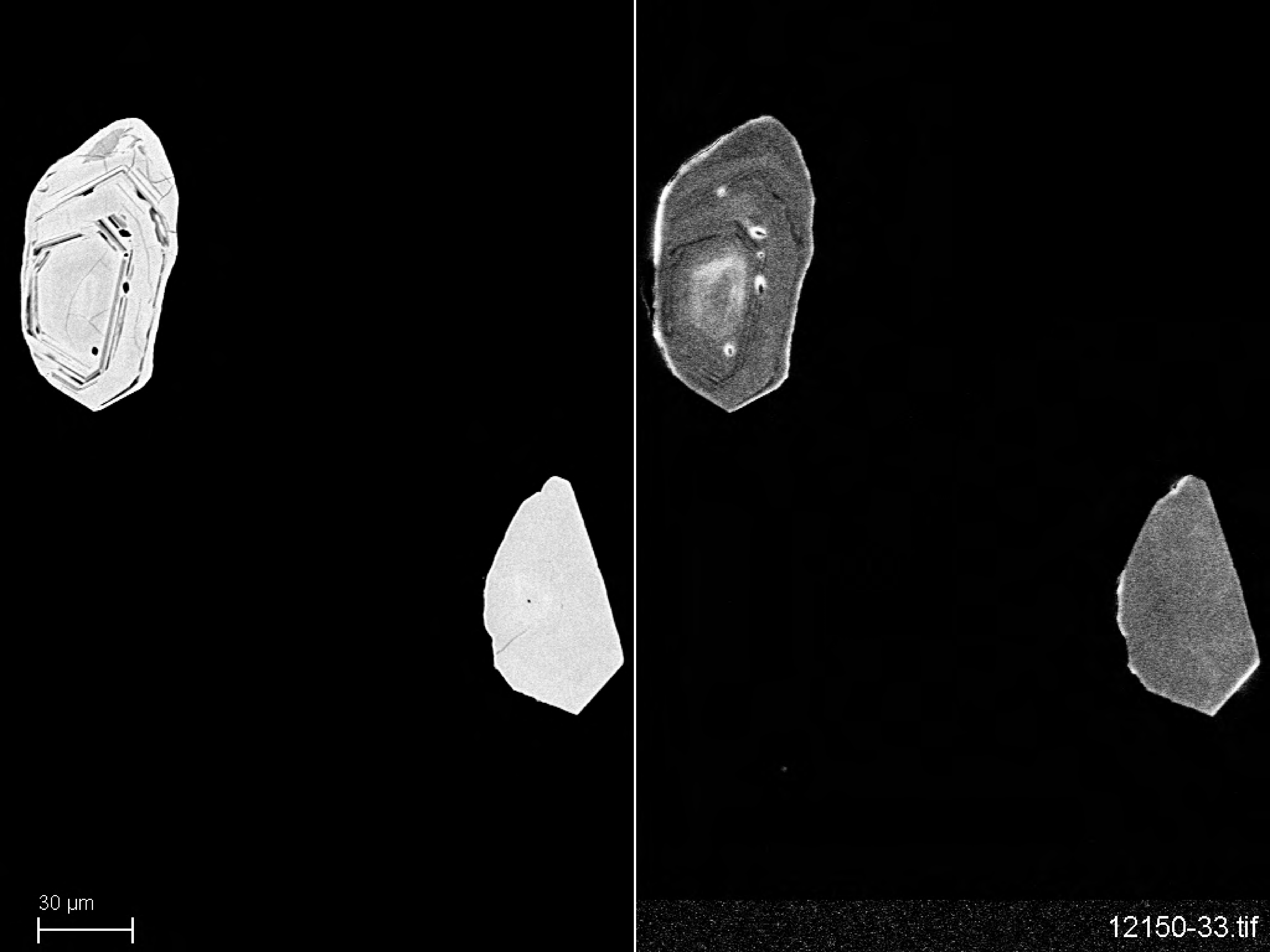
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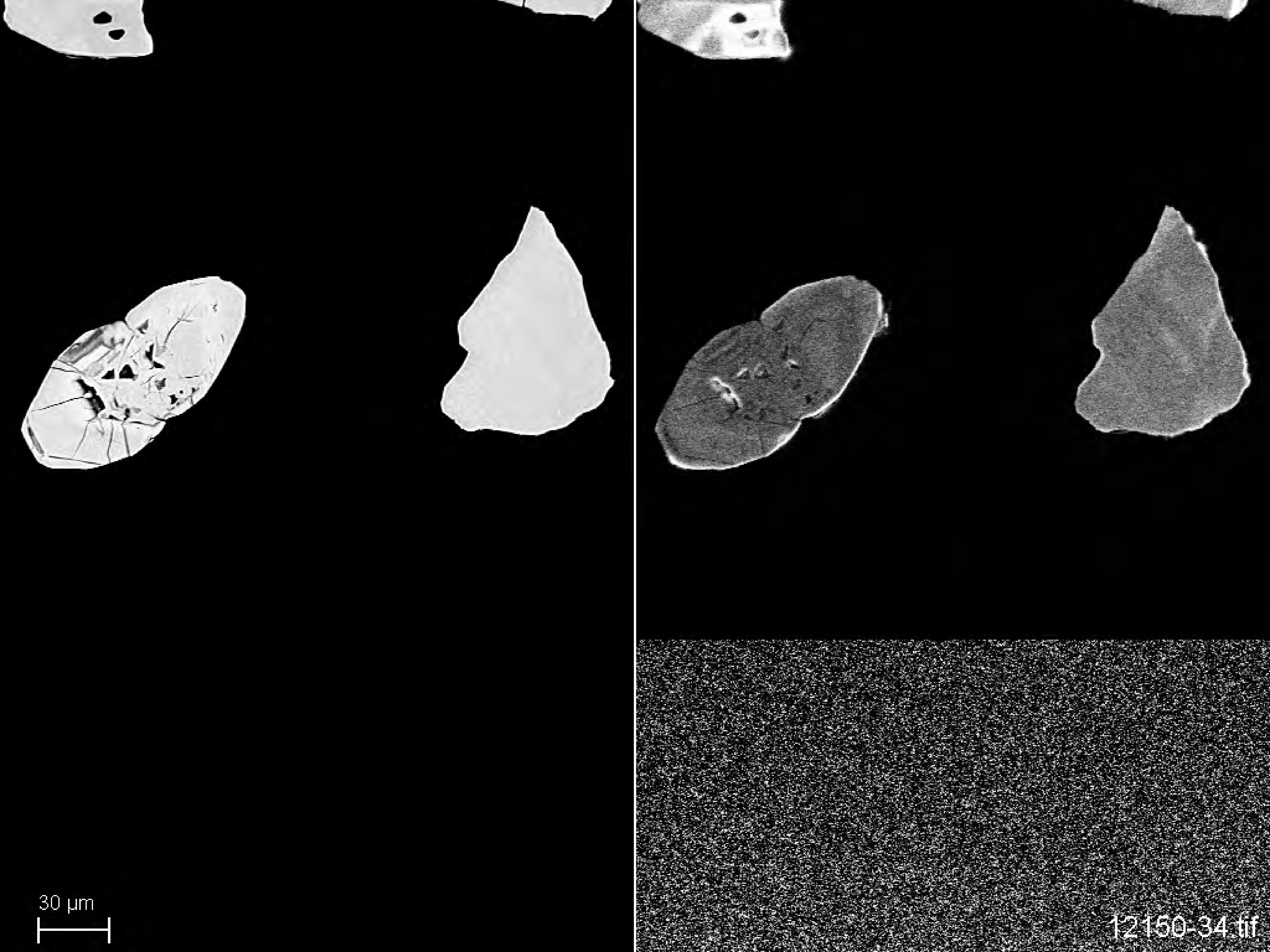
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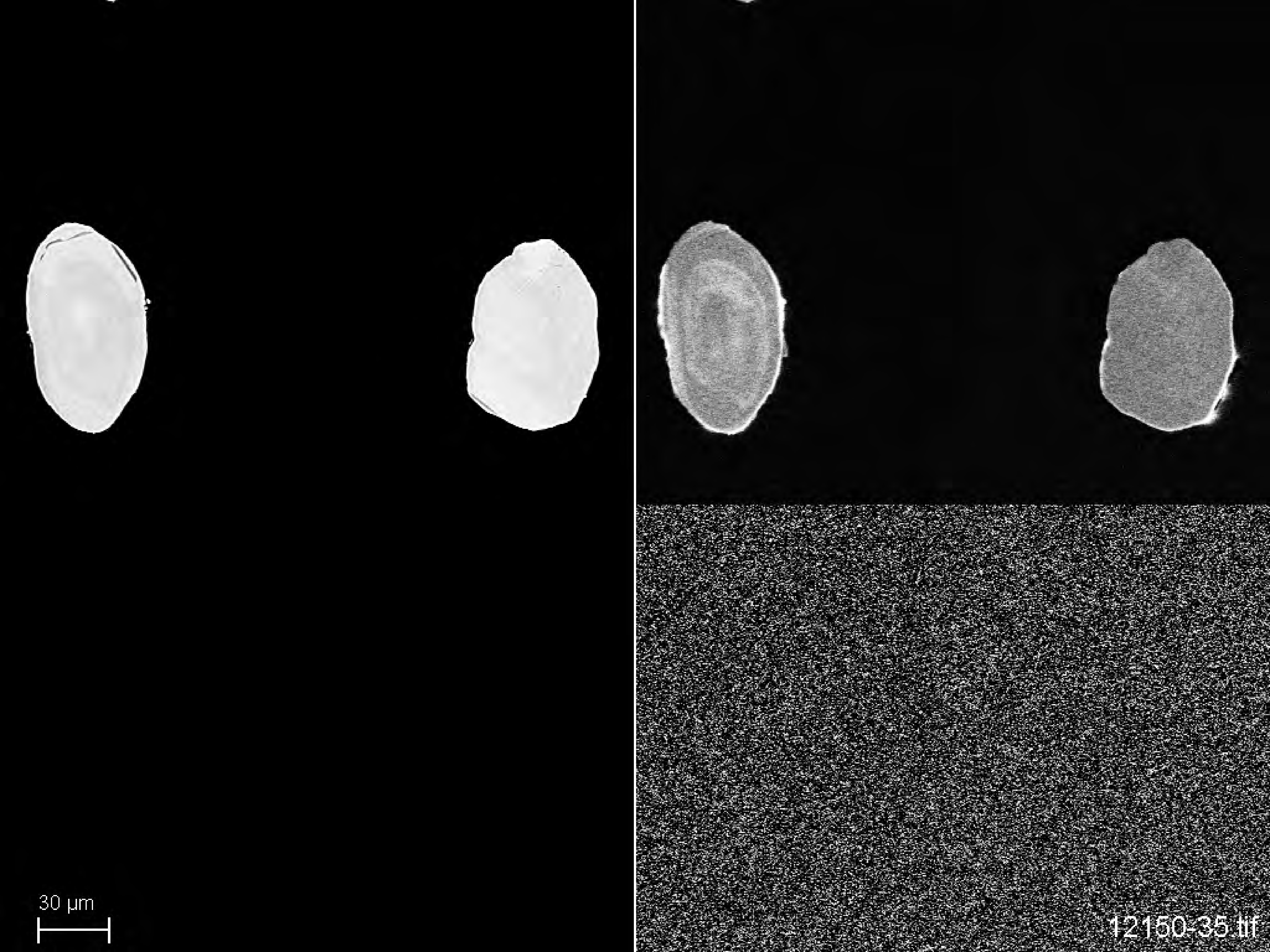
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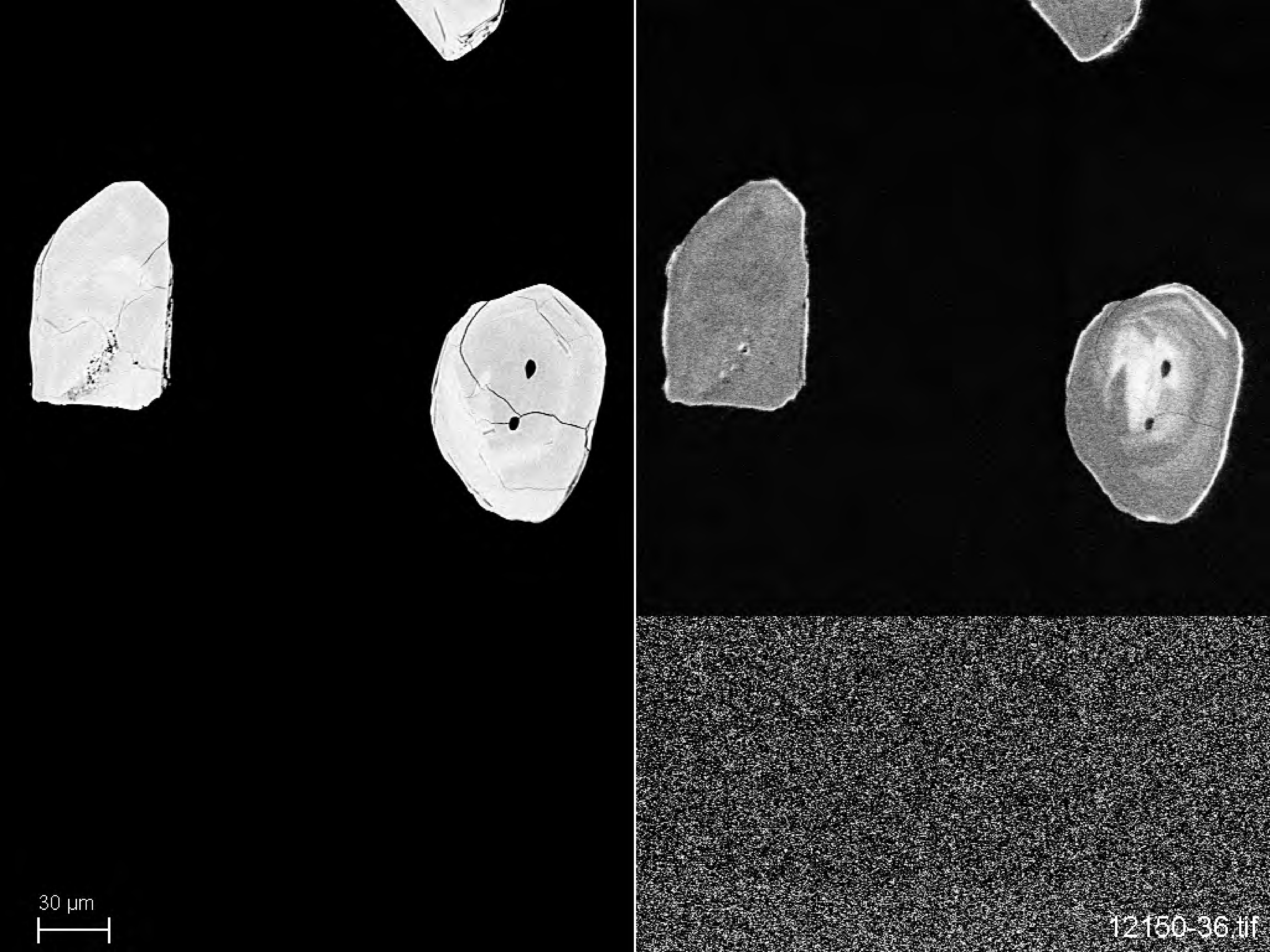
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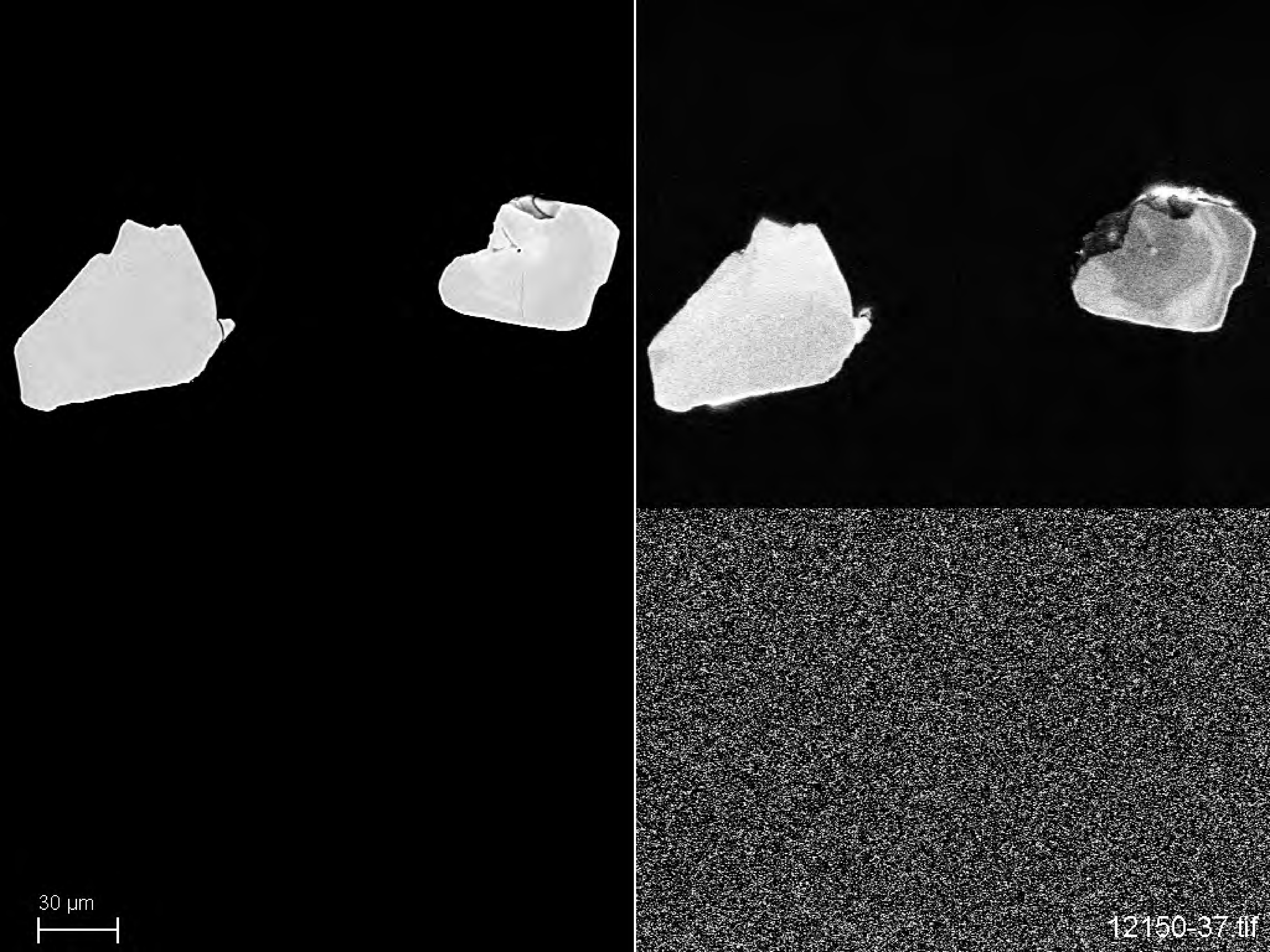
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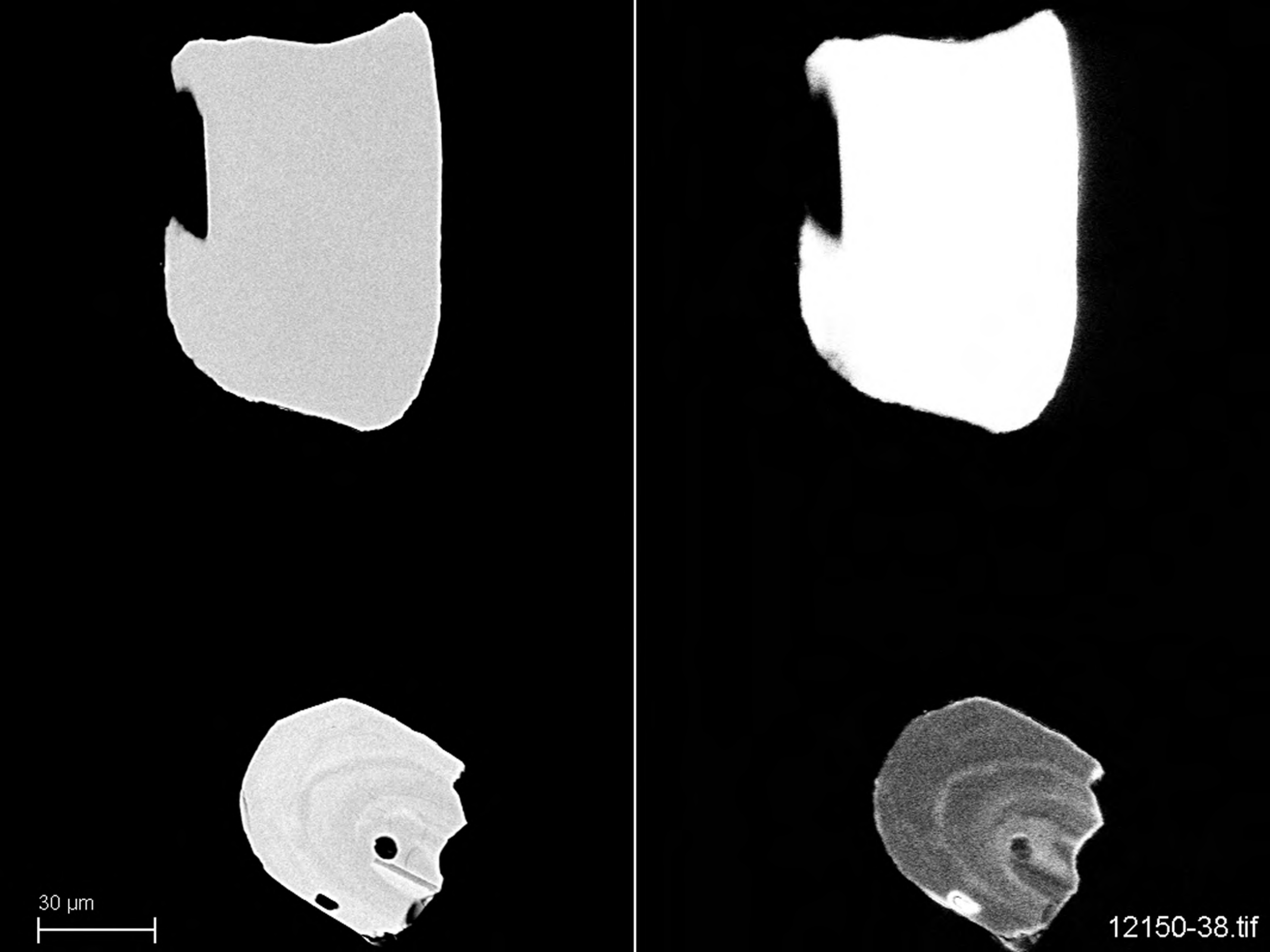
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100 µm
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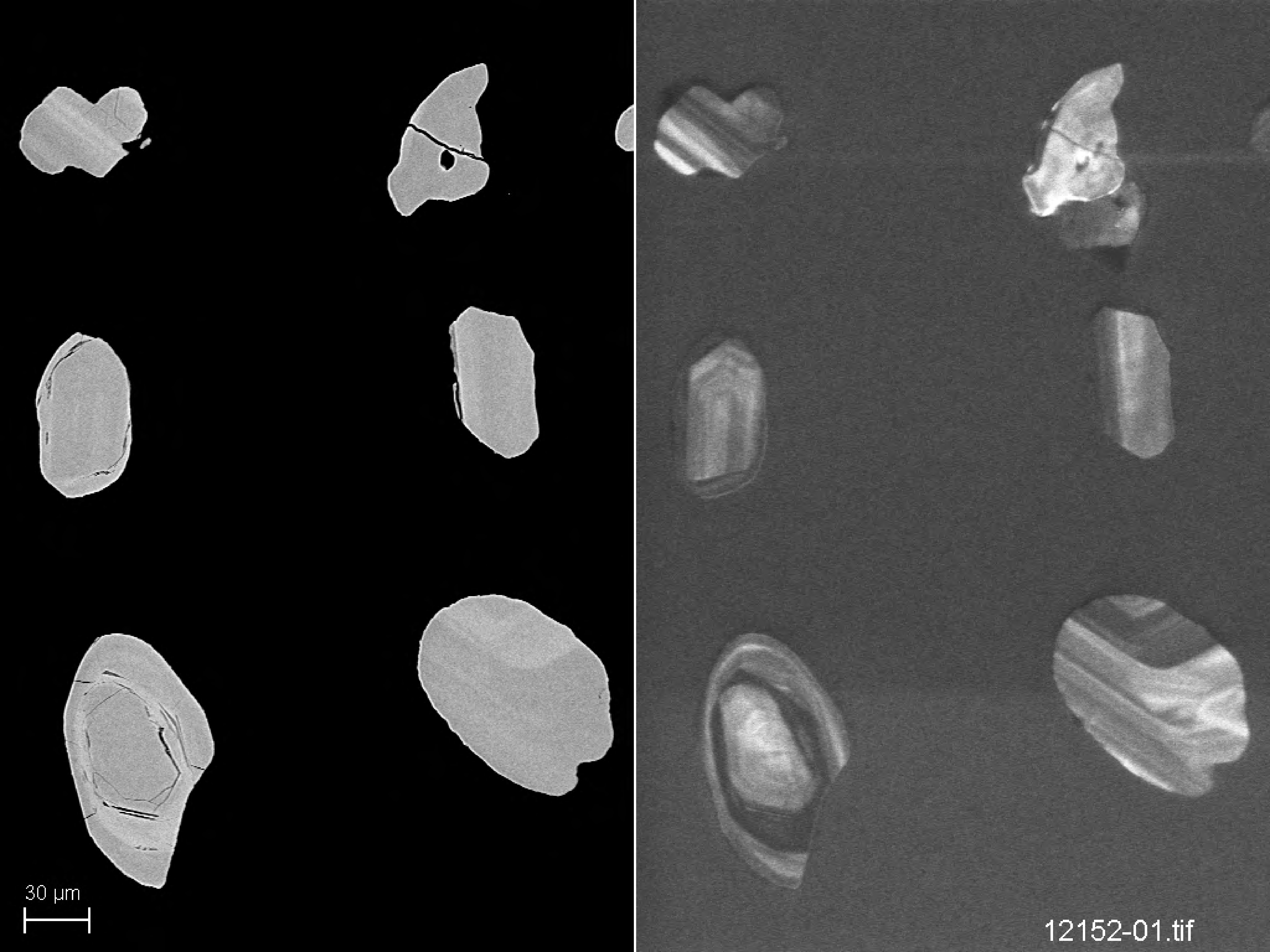
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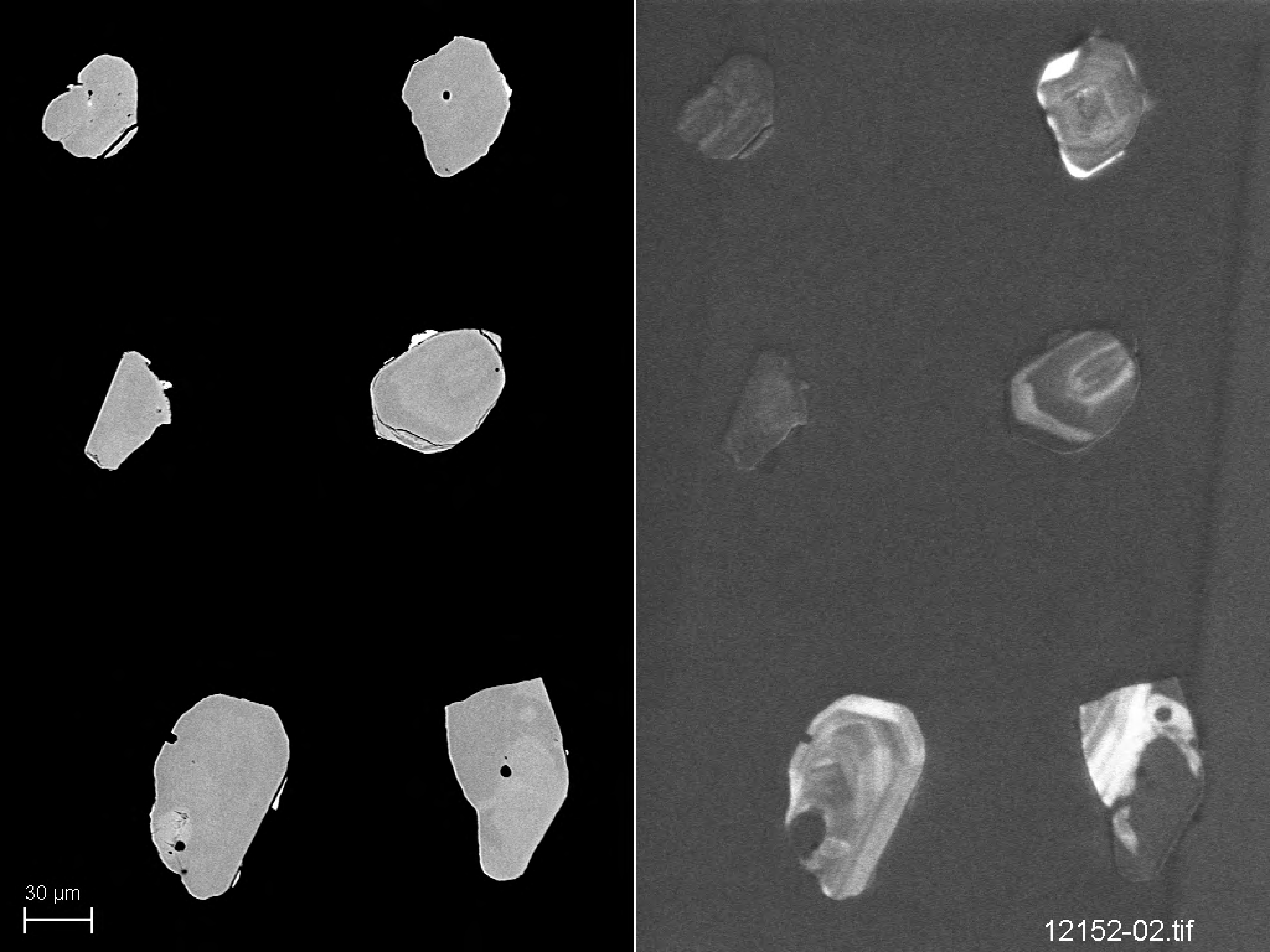
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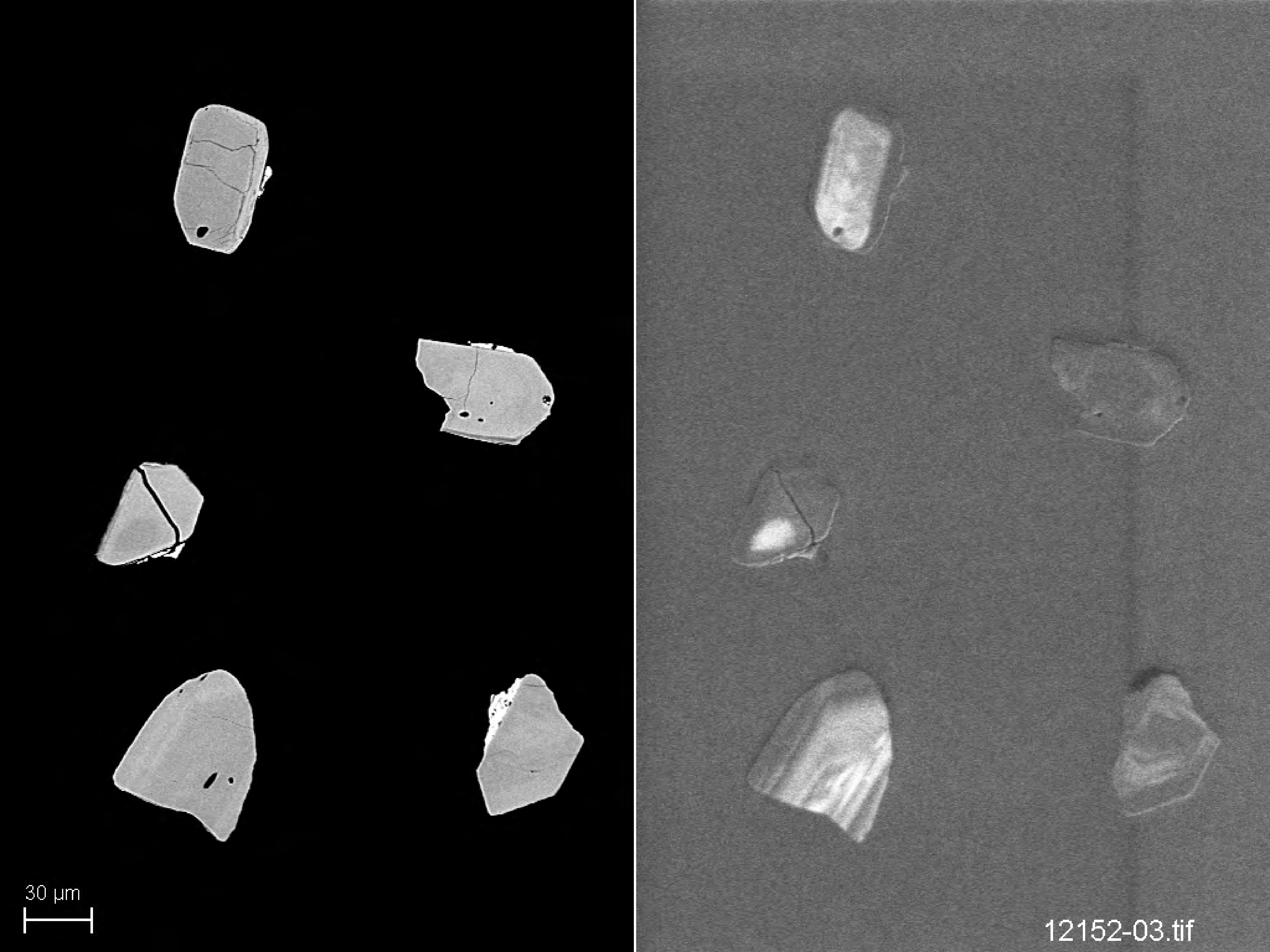
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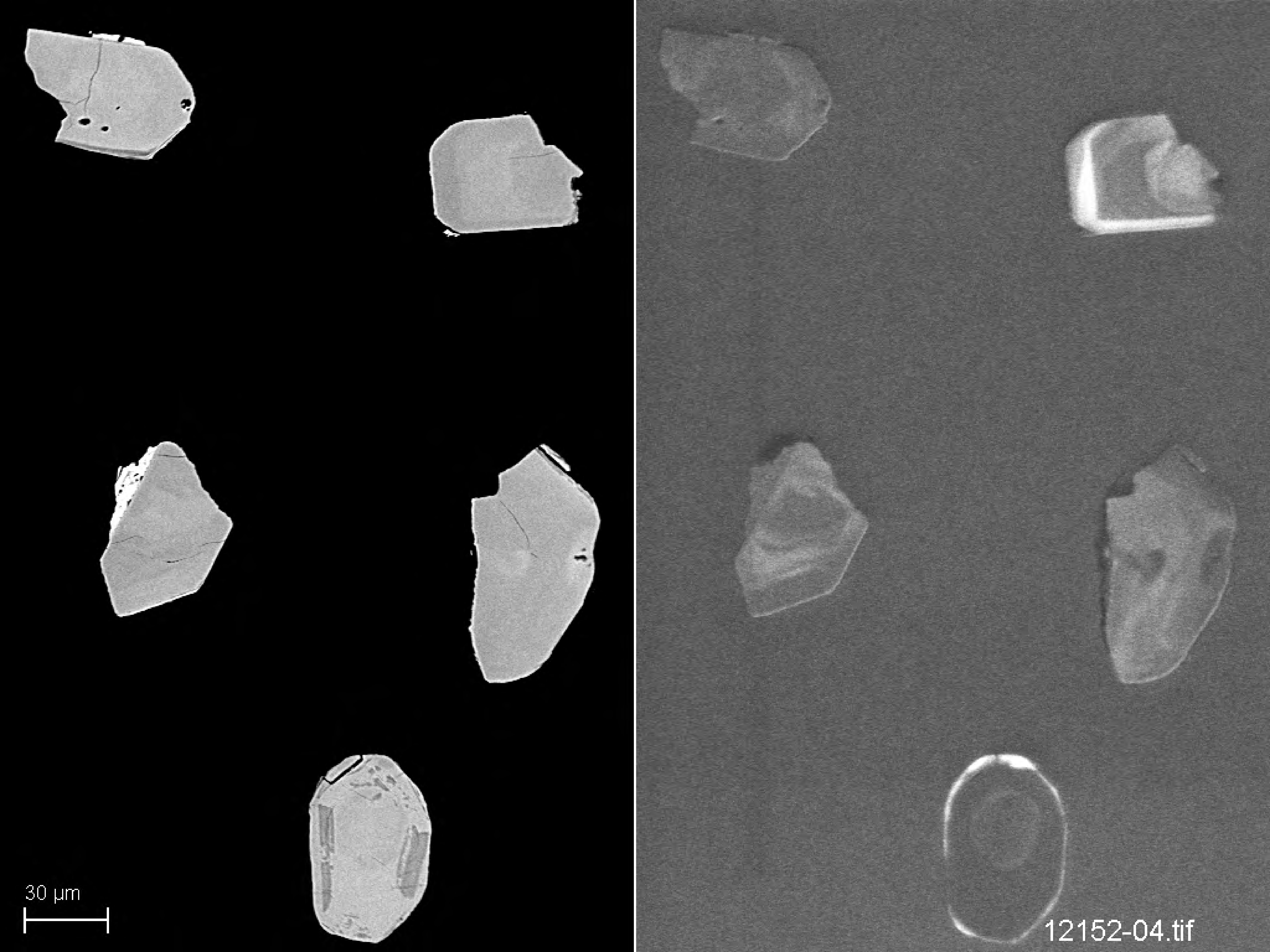
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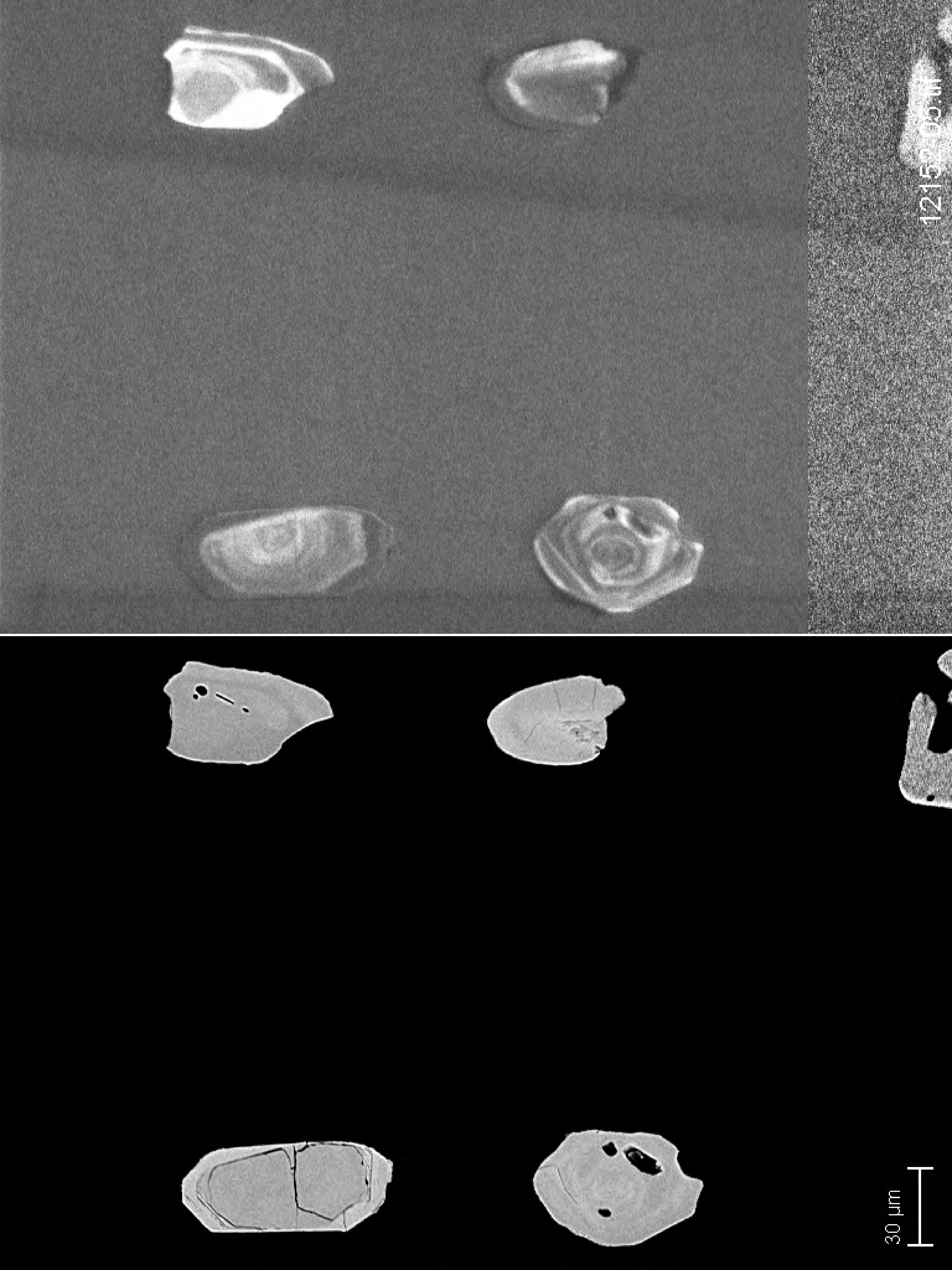
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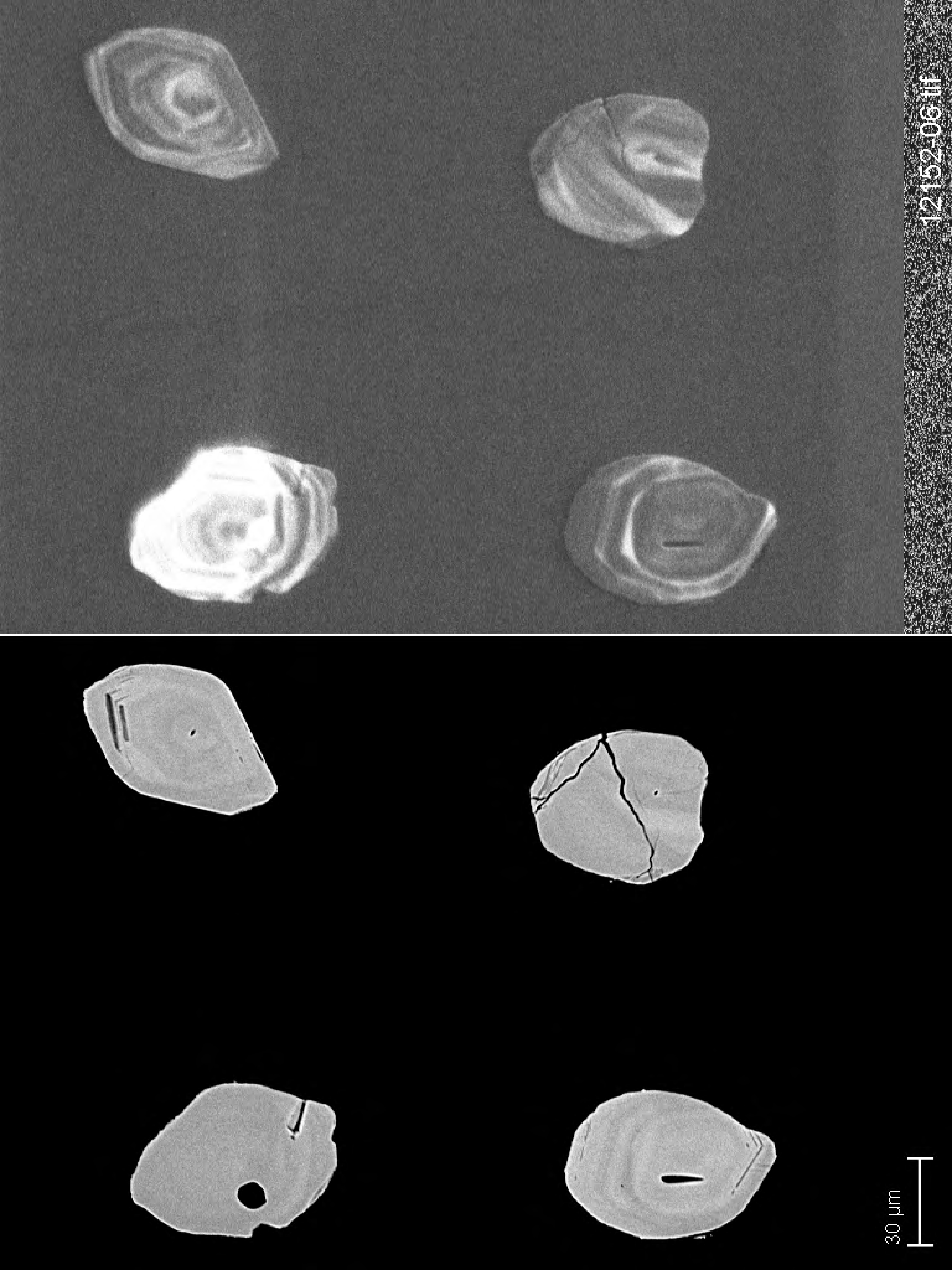

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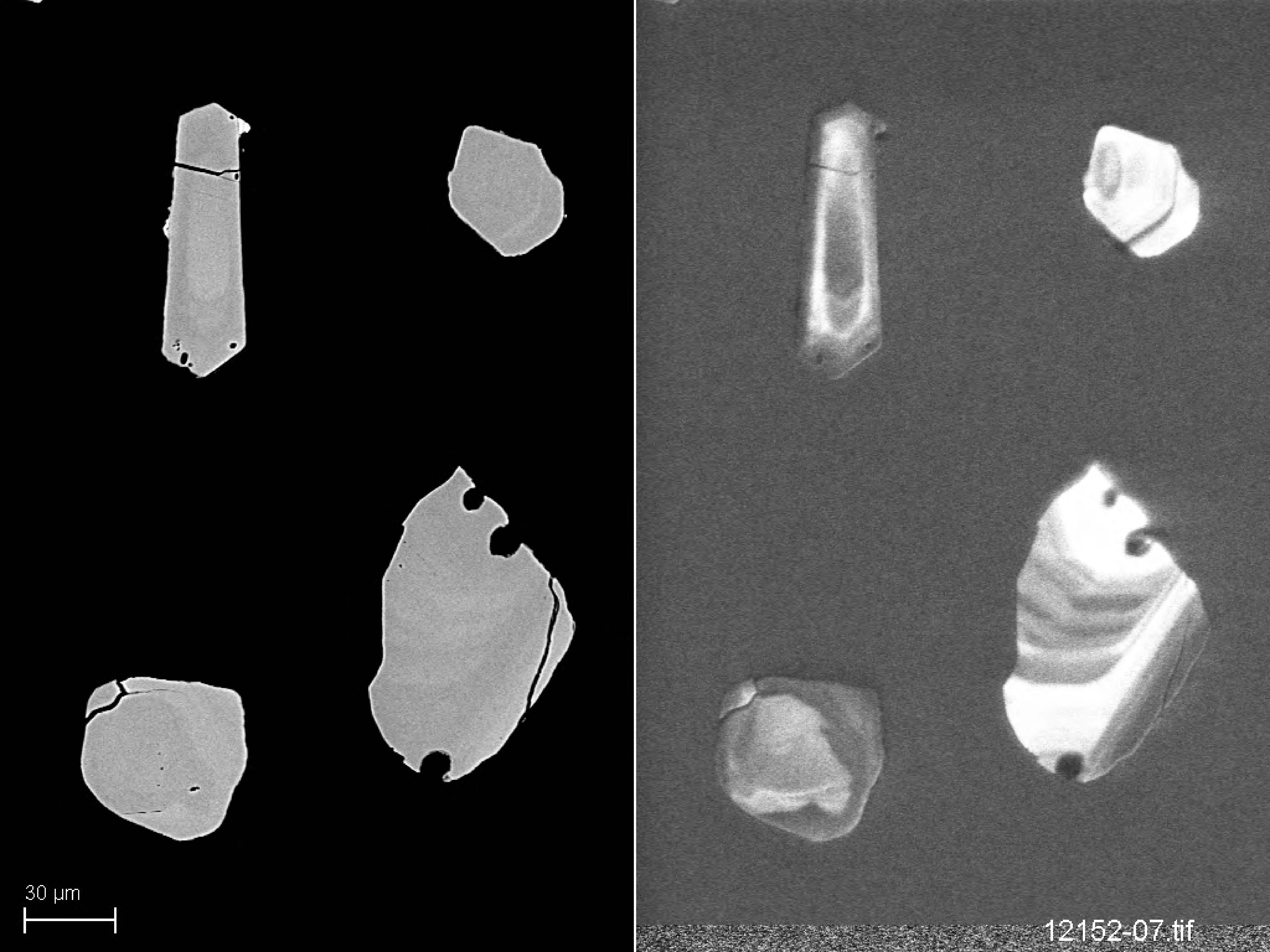

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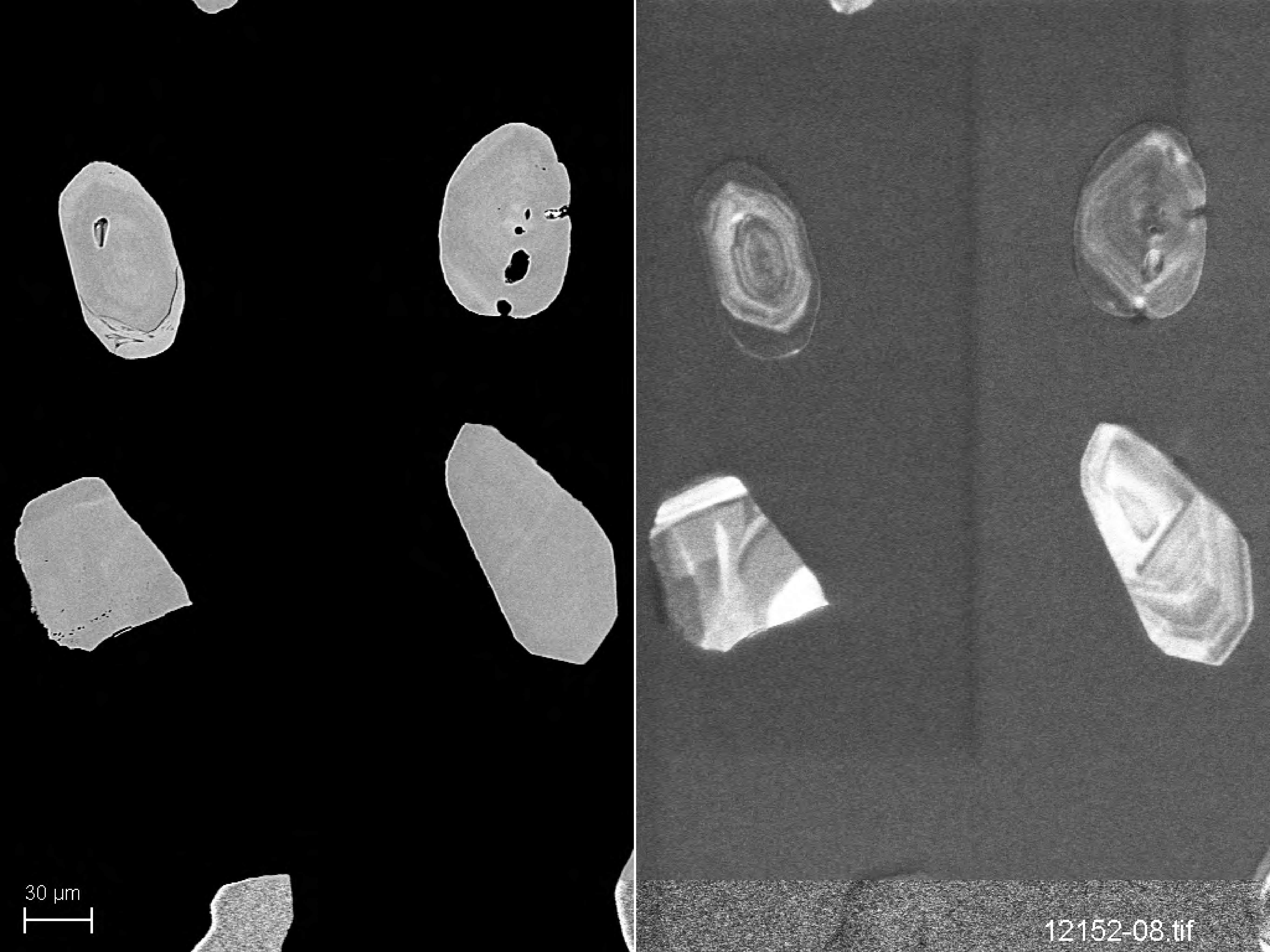
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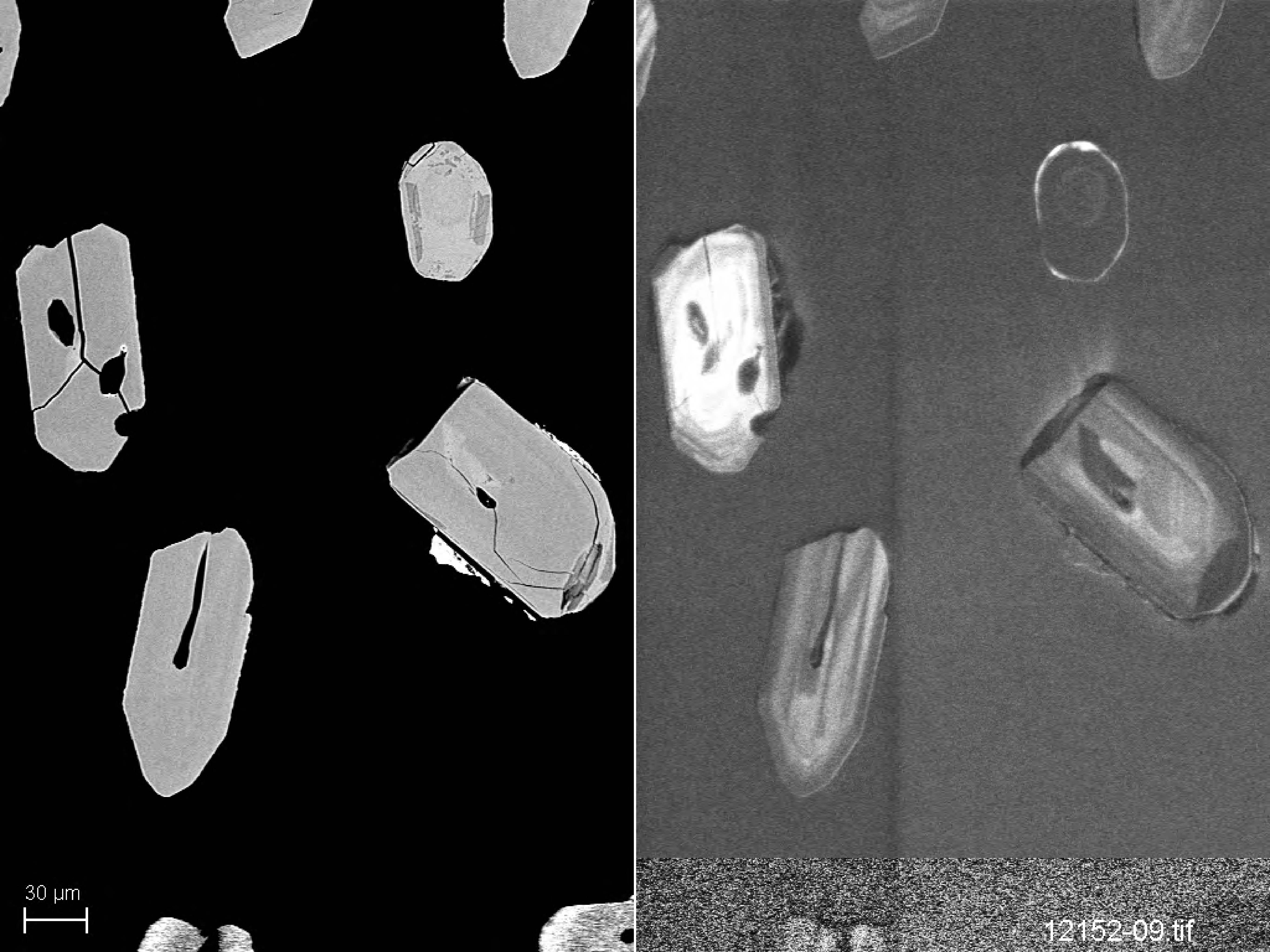
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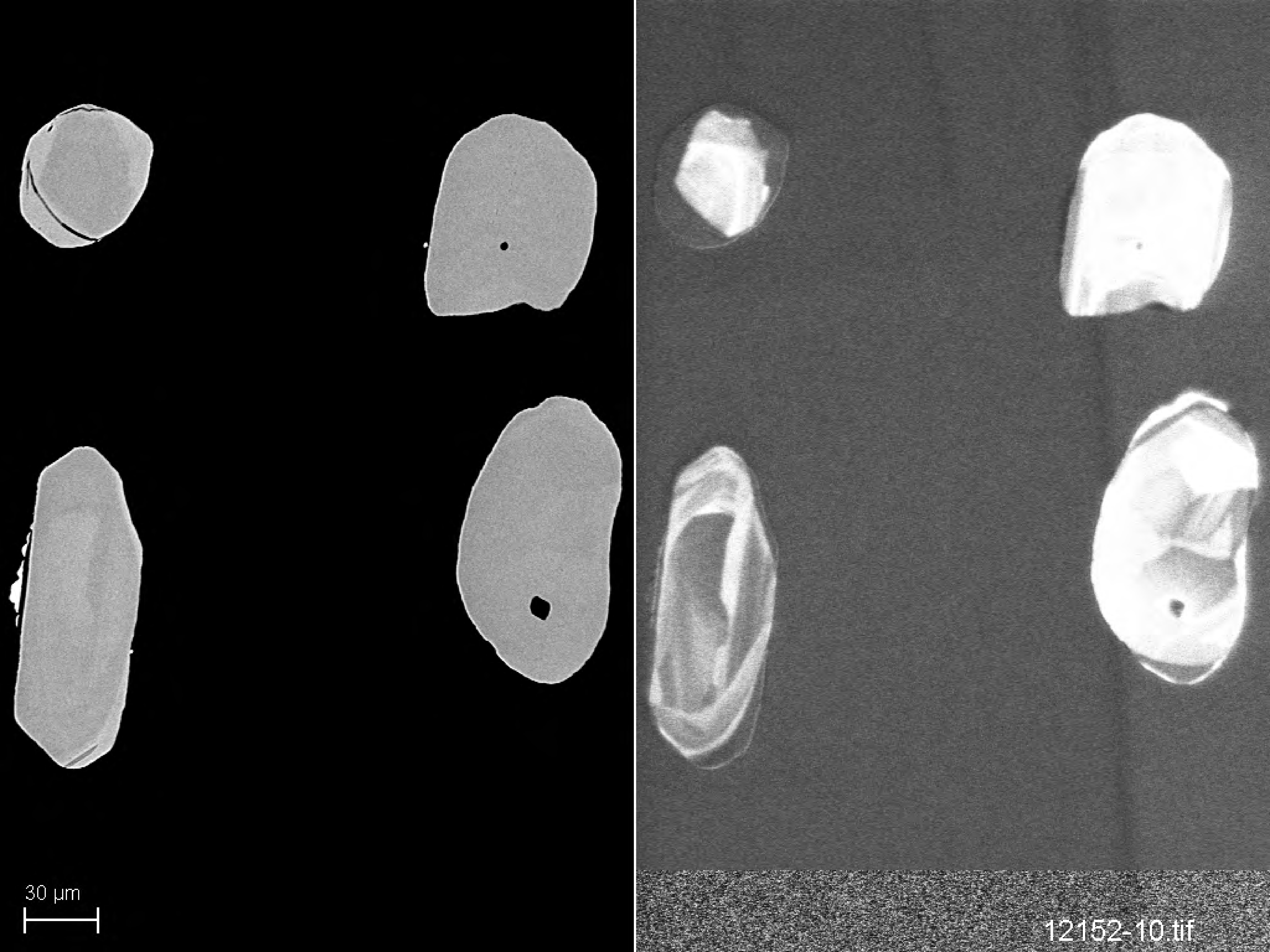

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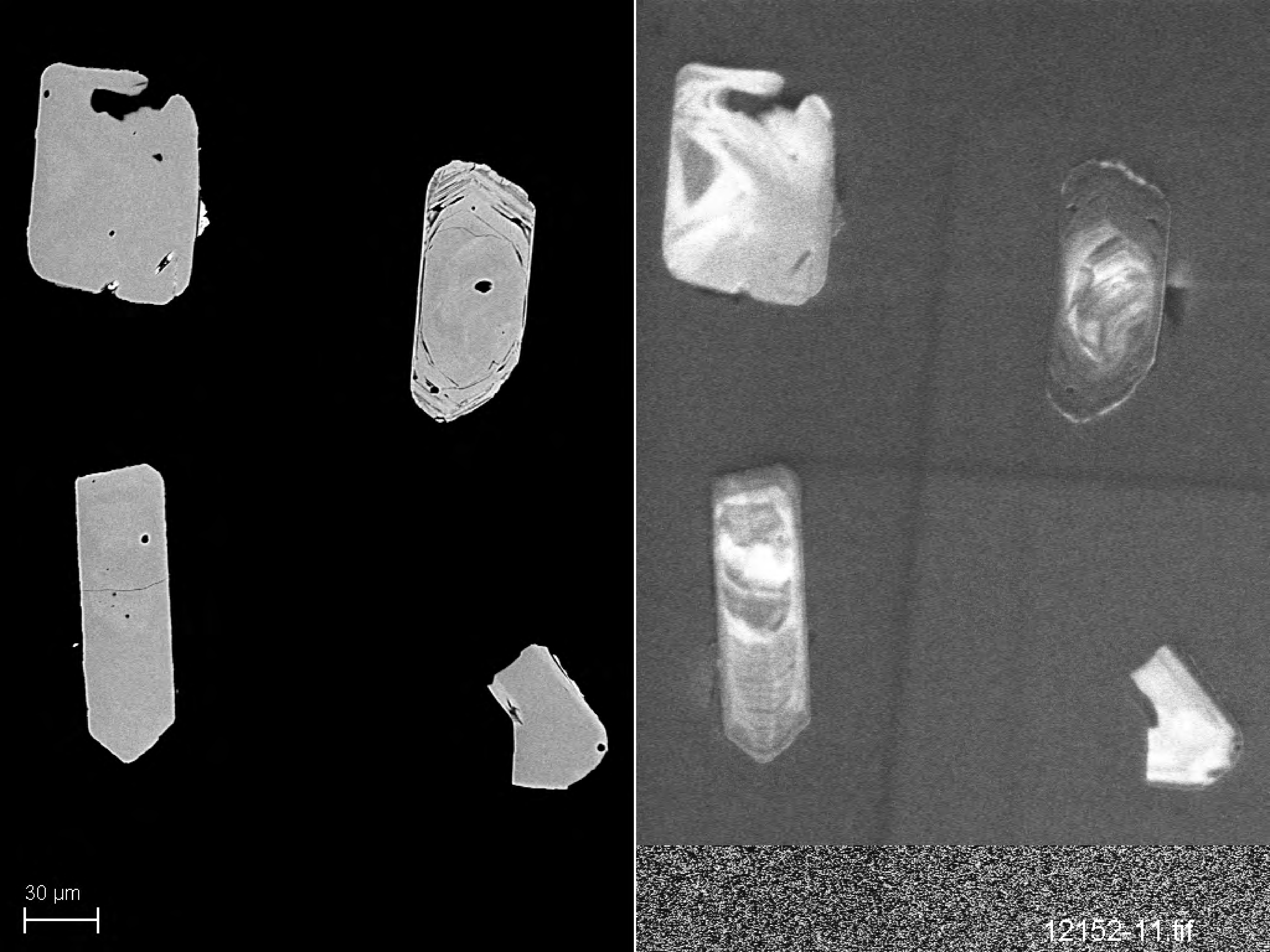
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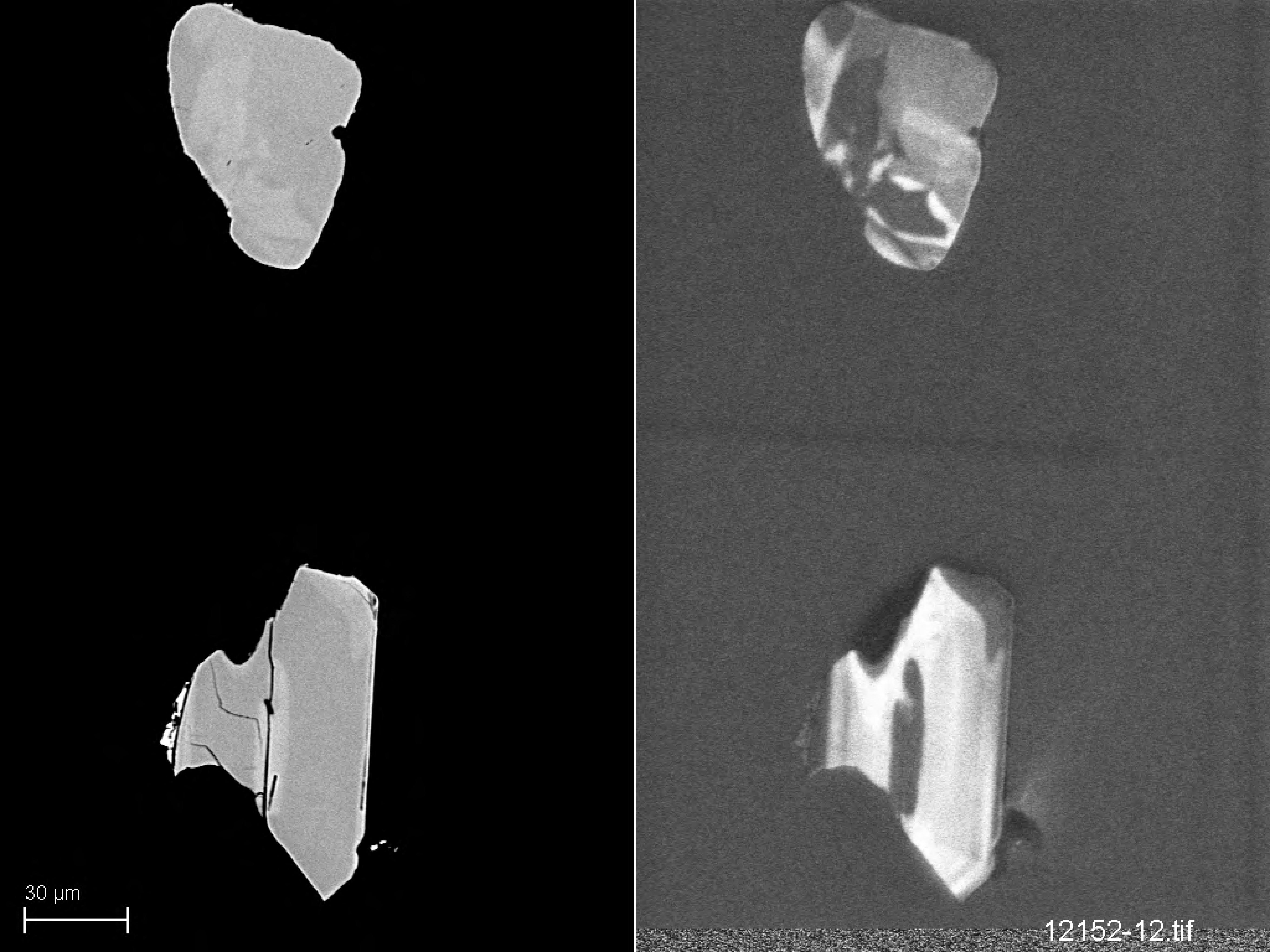
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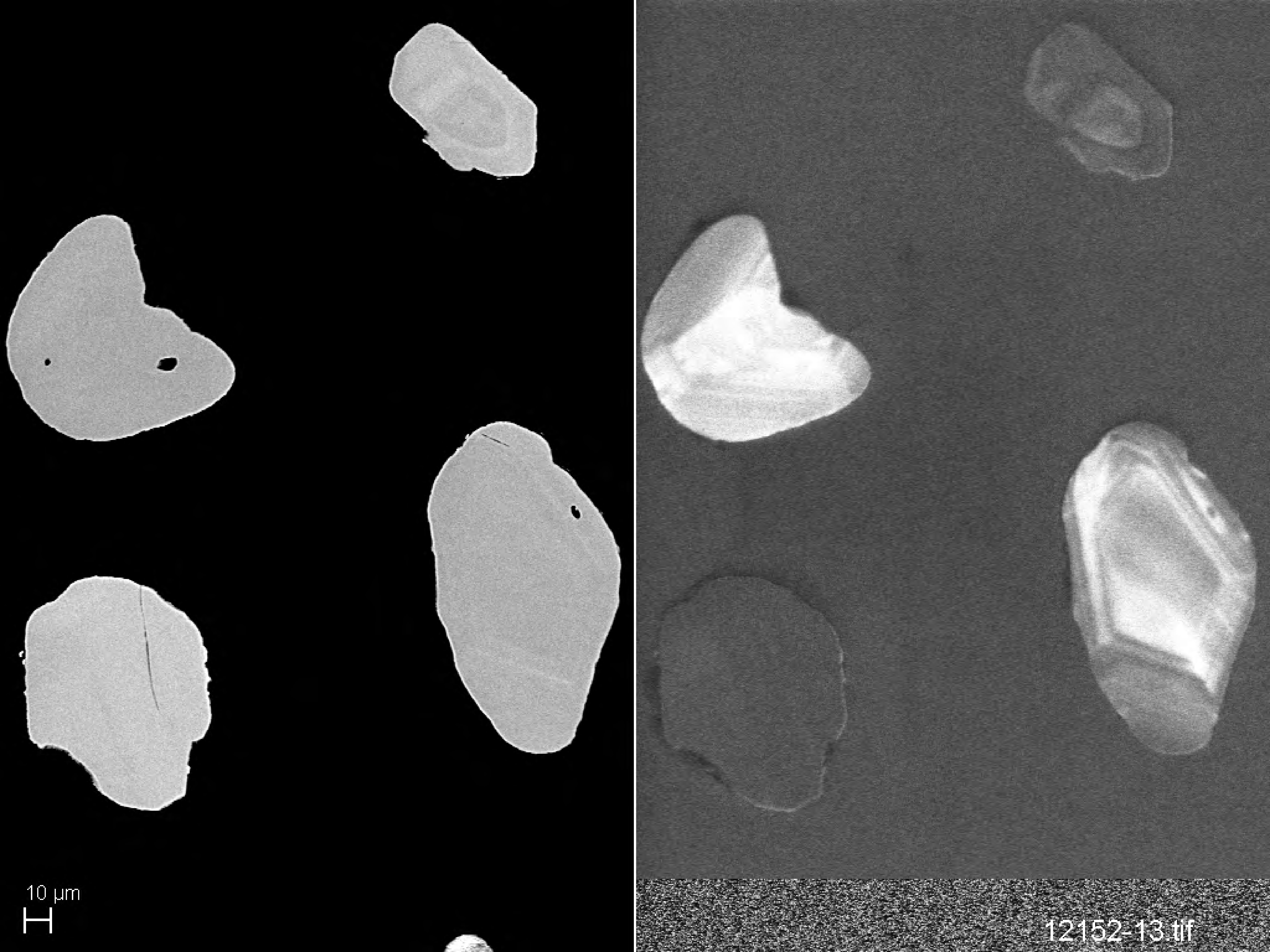
10 µm
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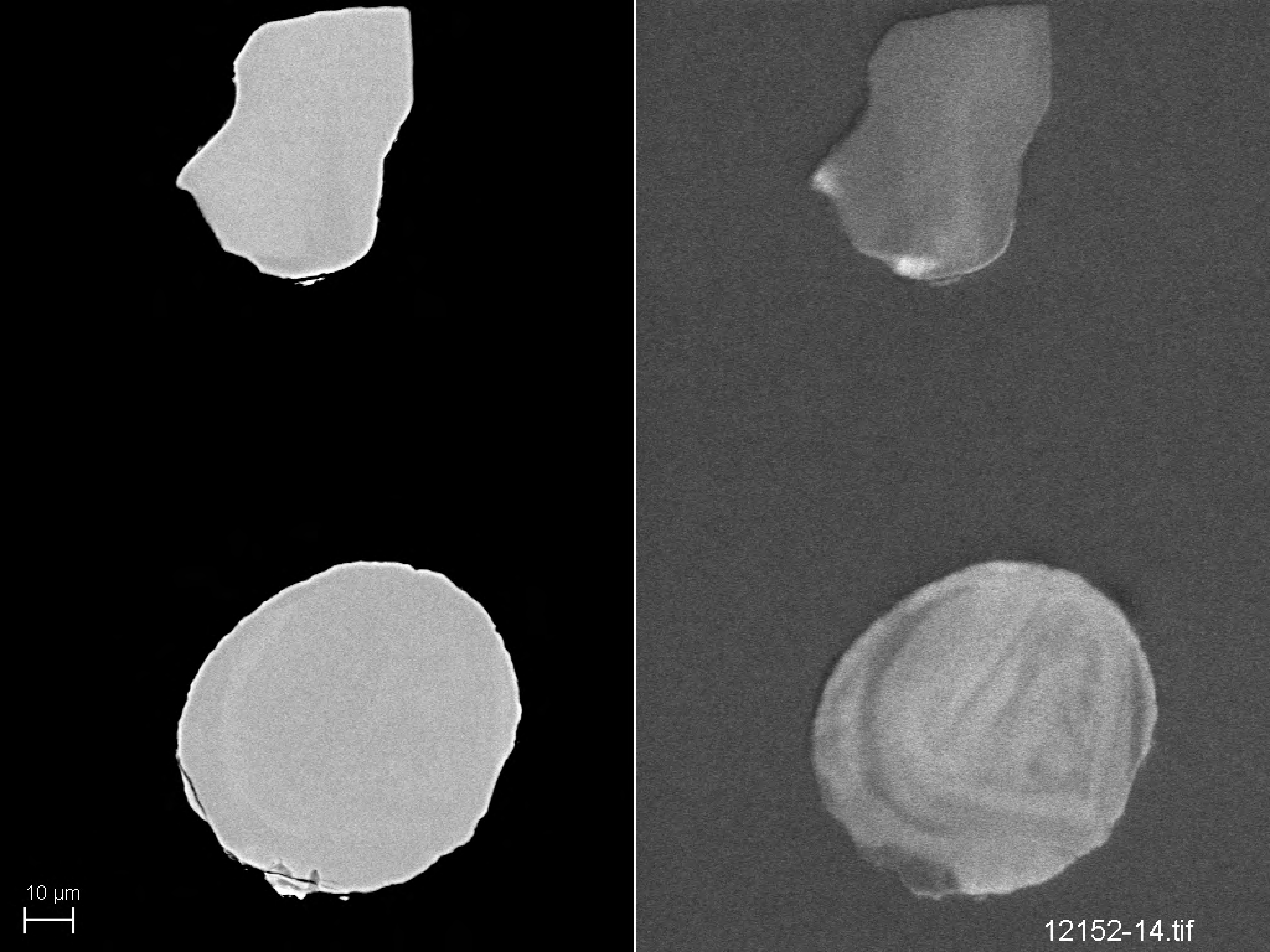
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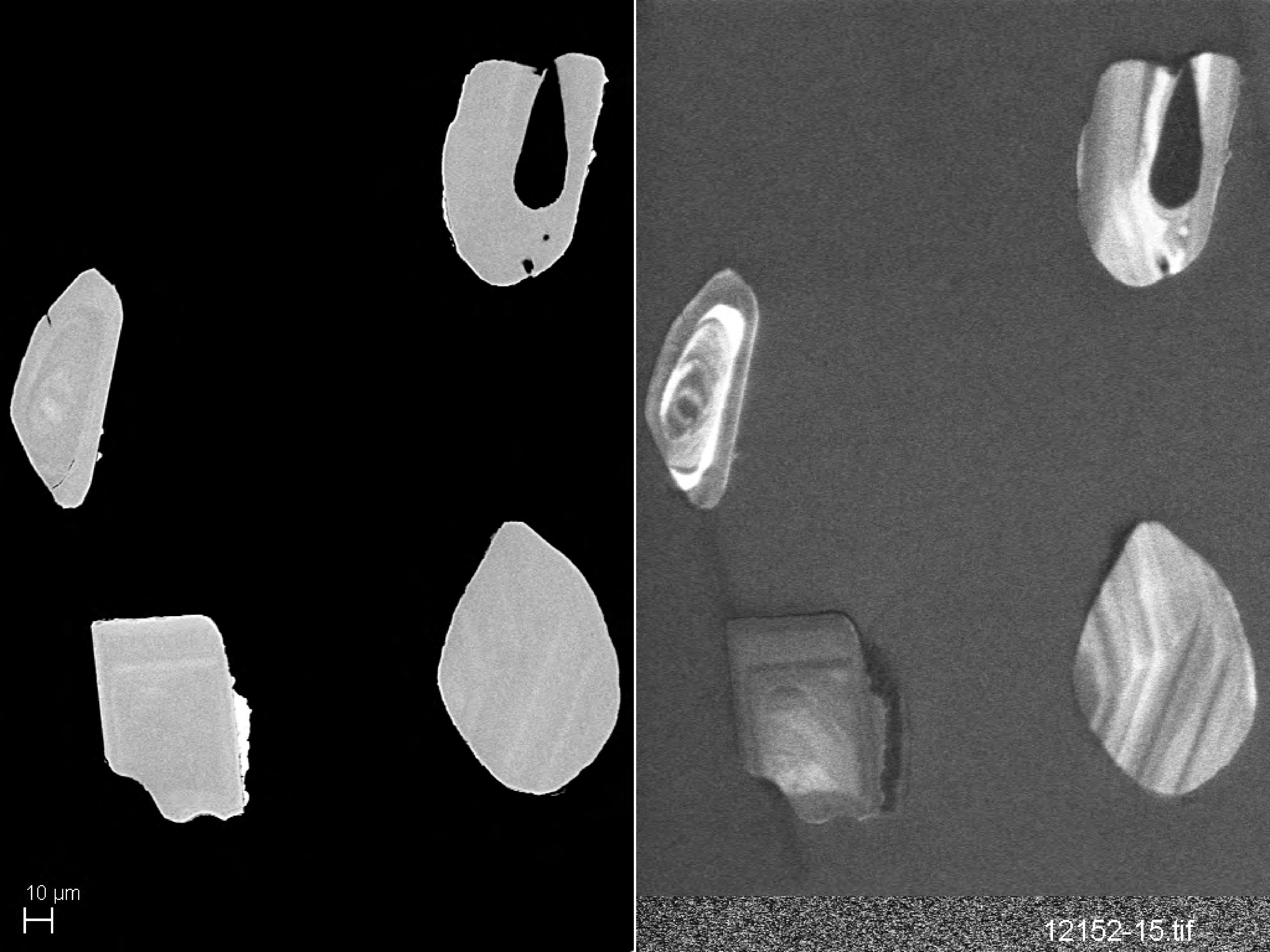

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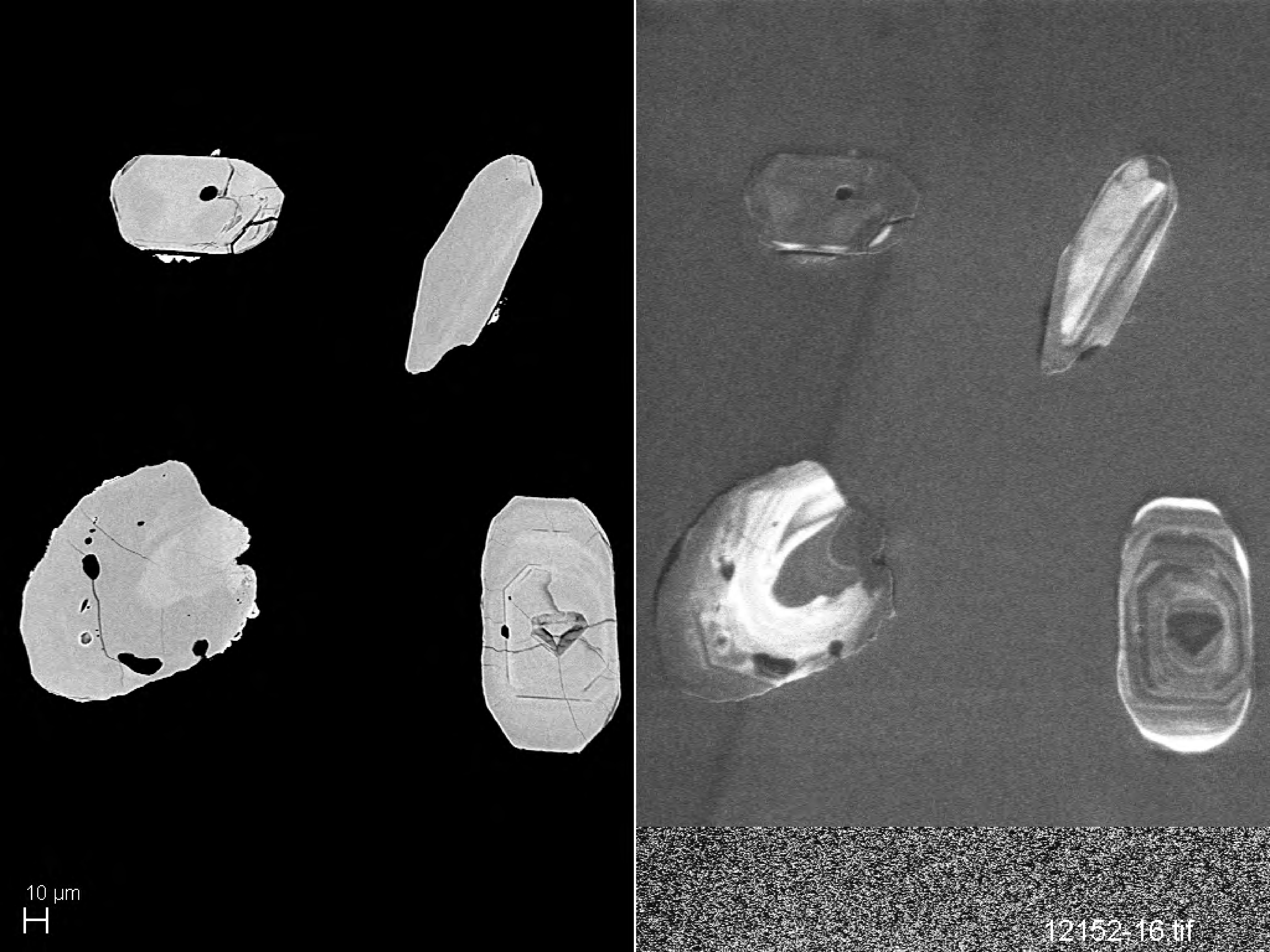
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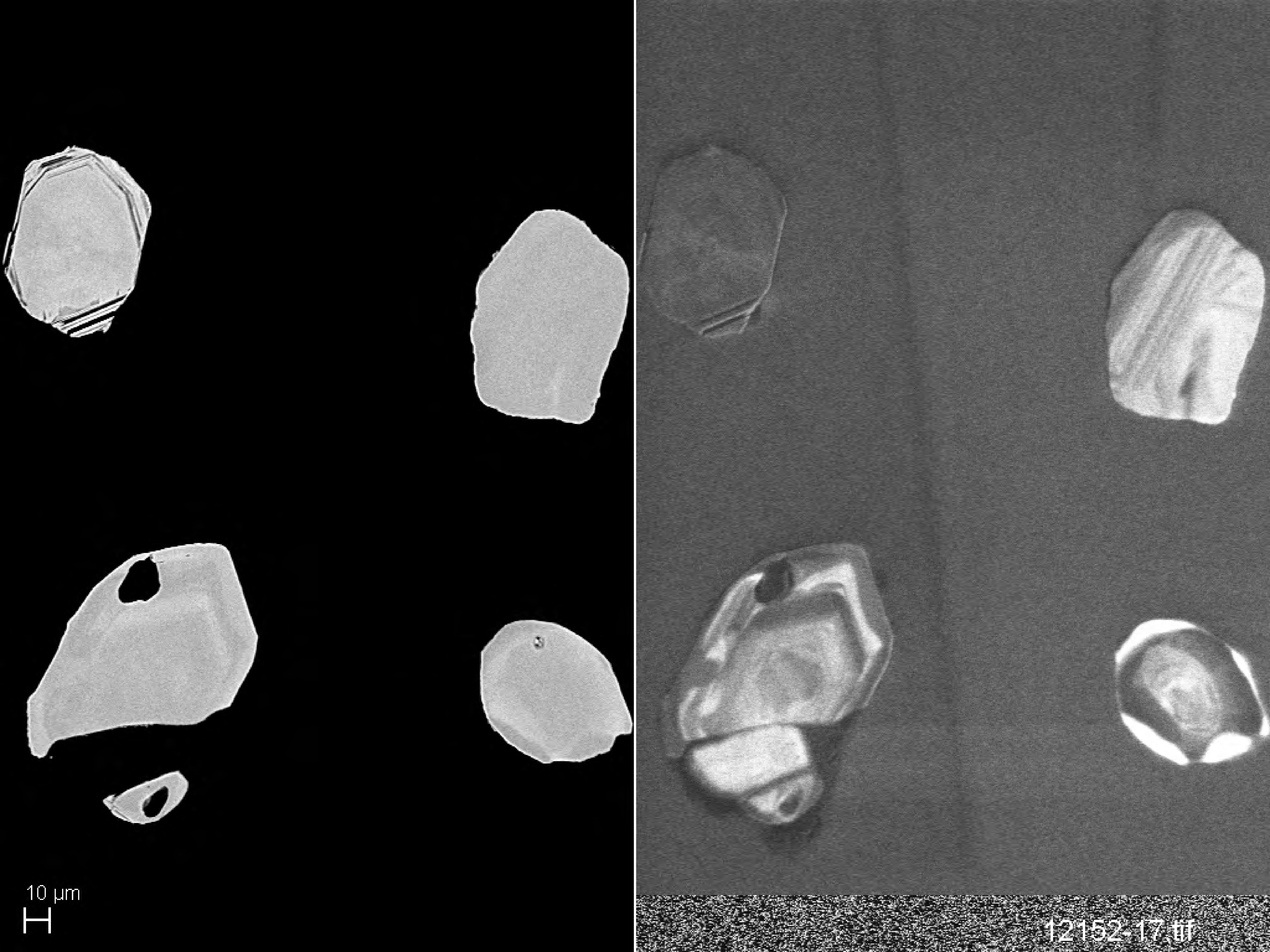
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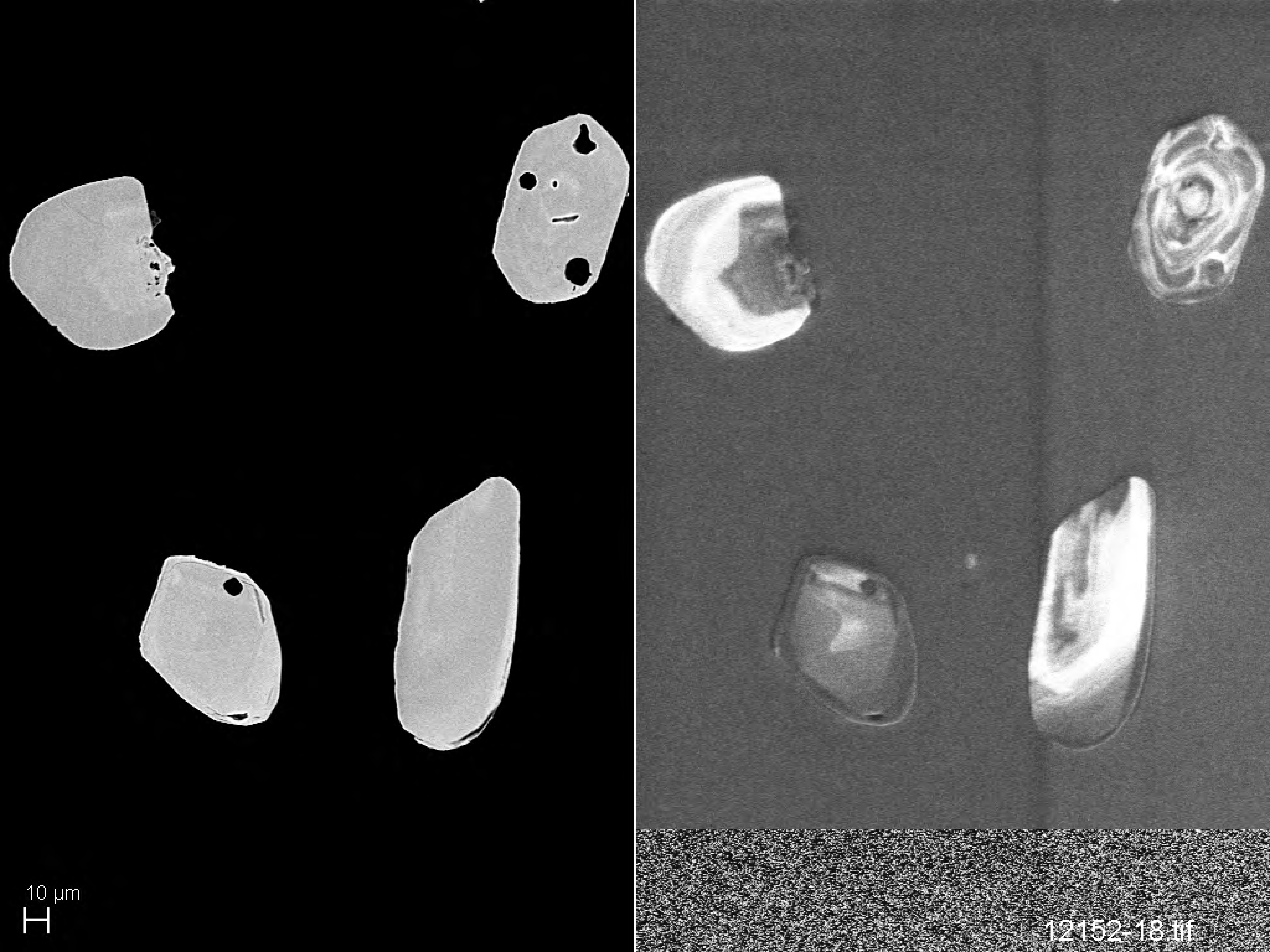
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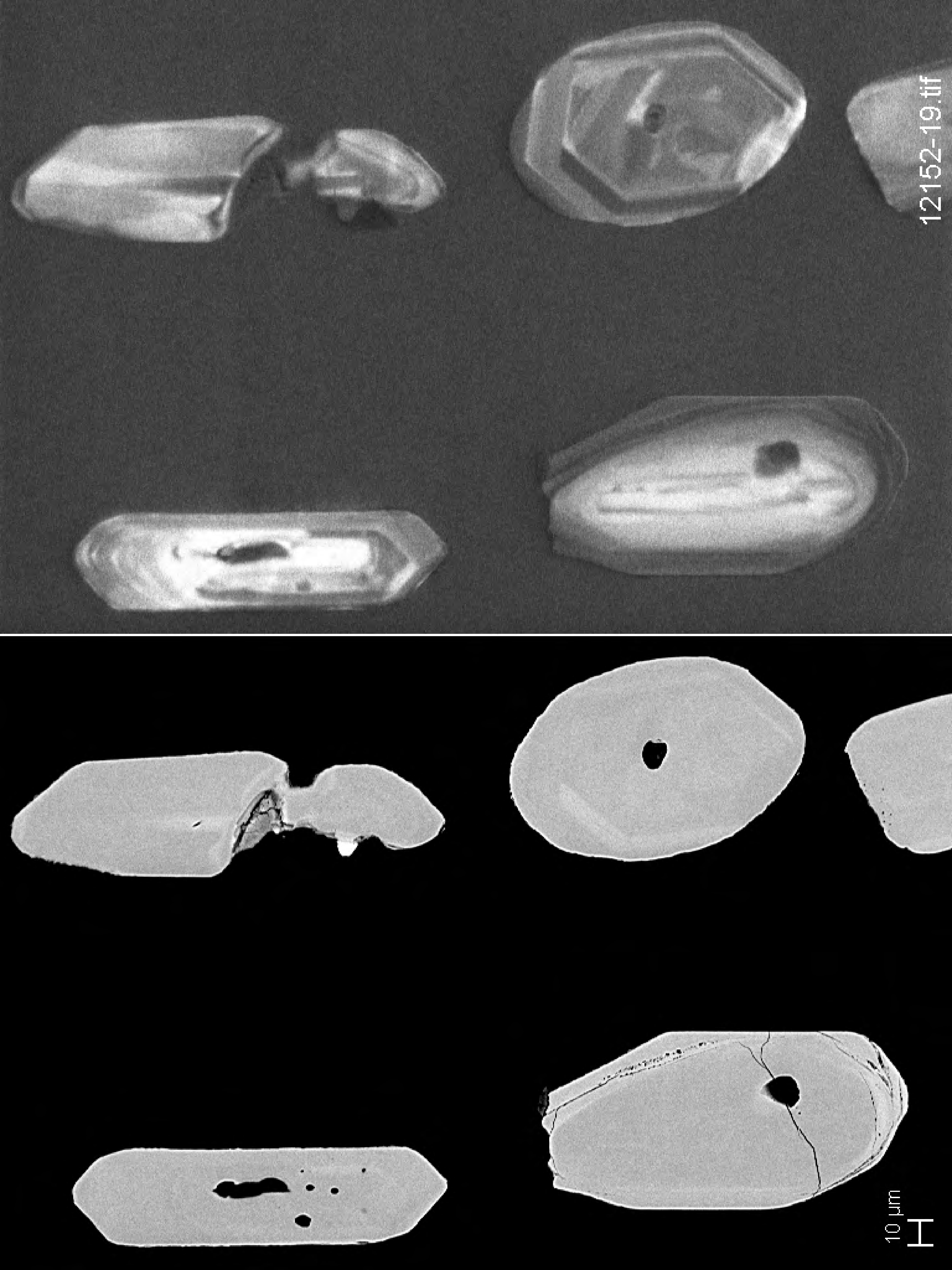
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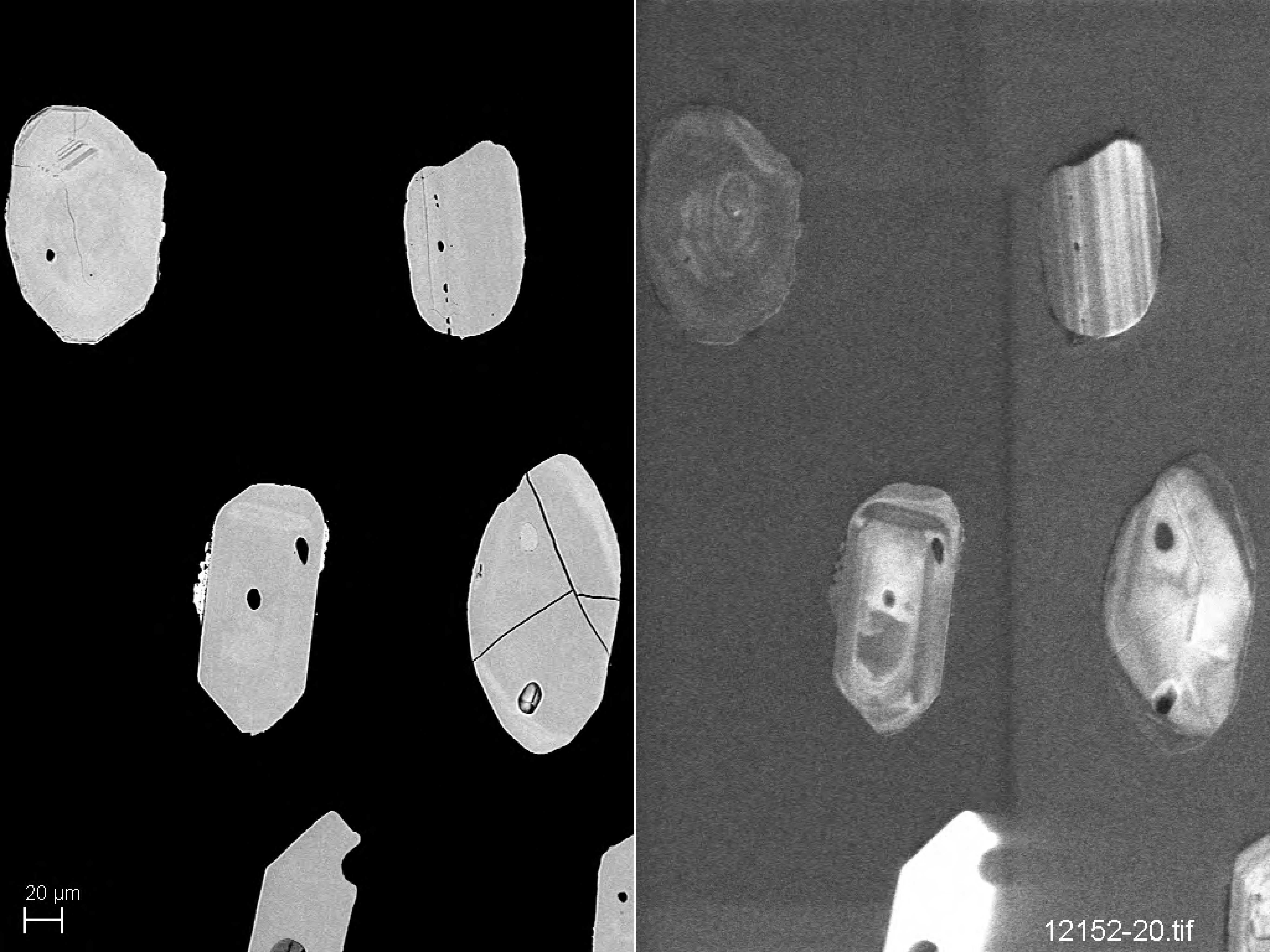
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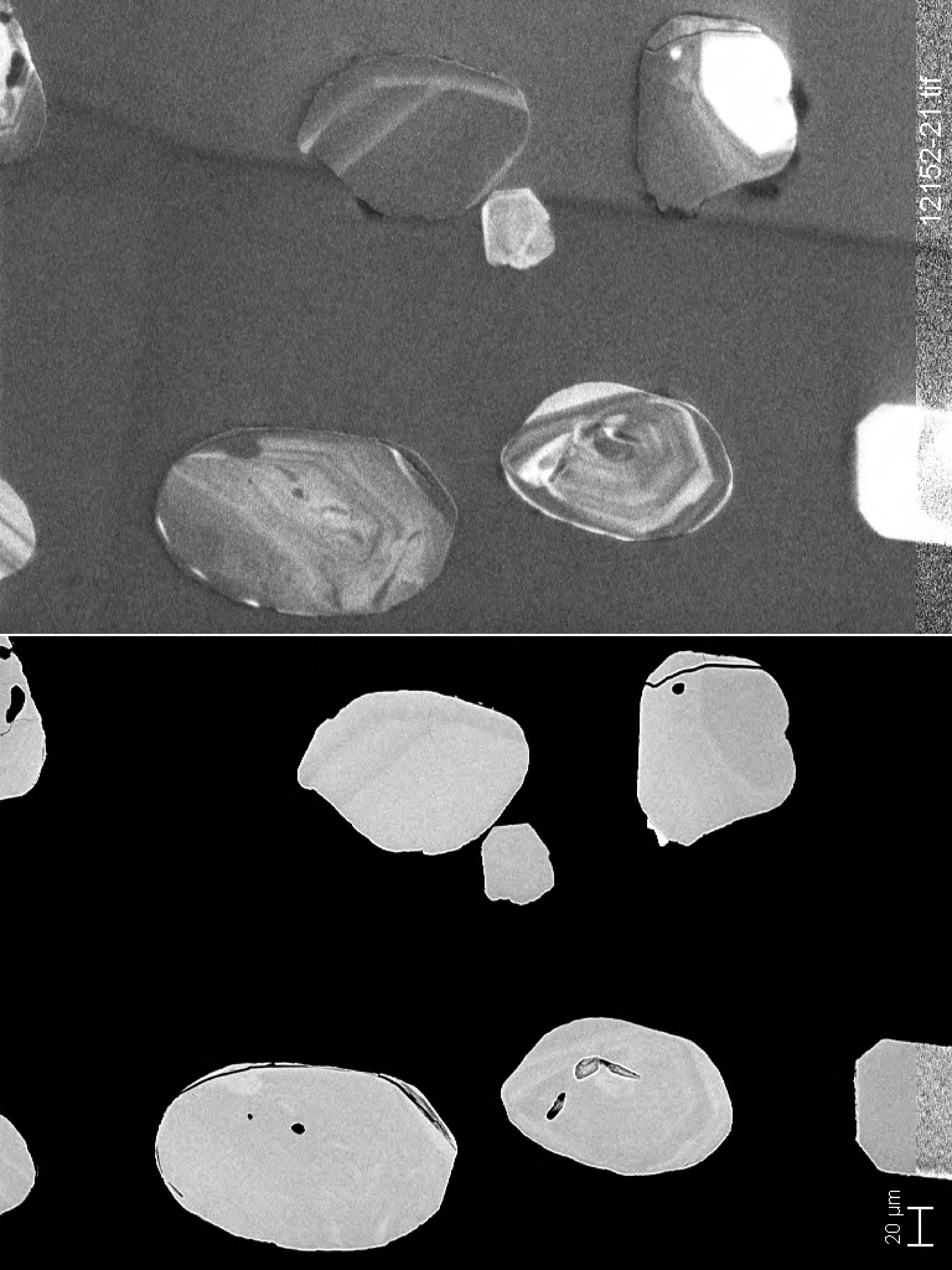
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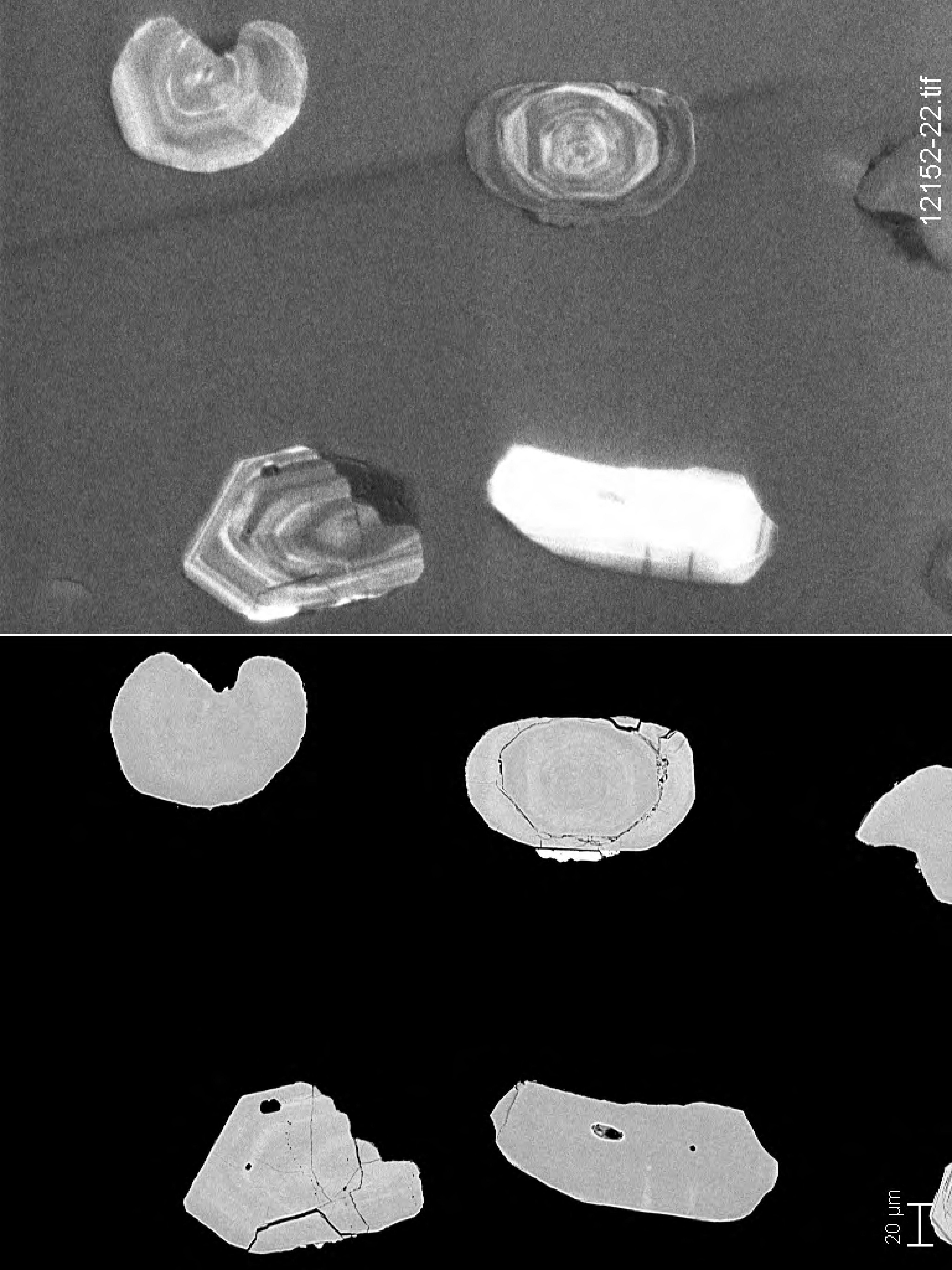
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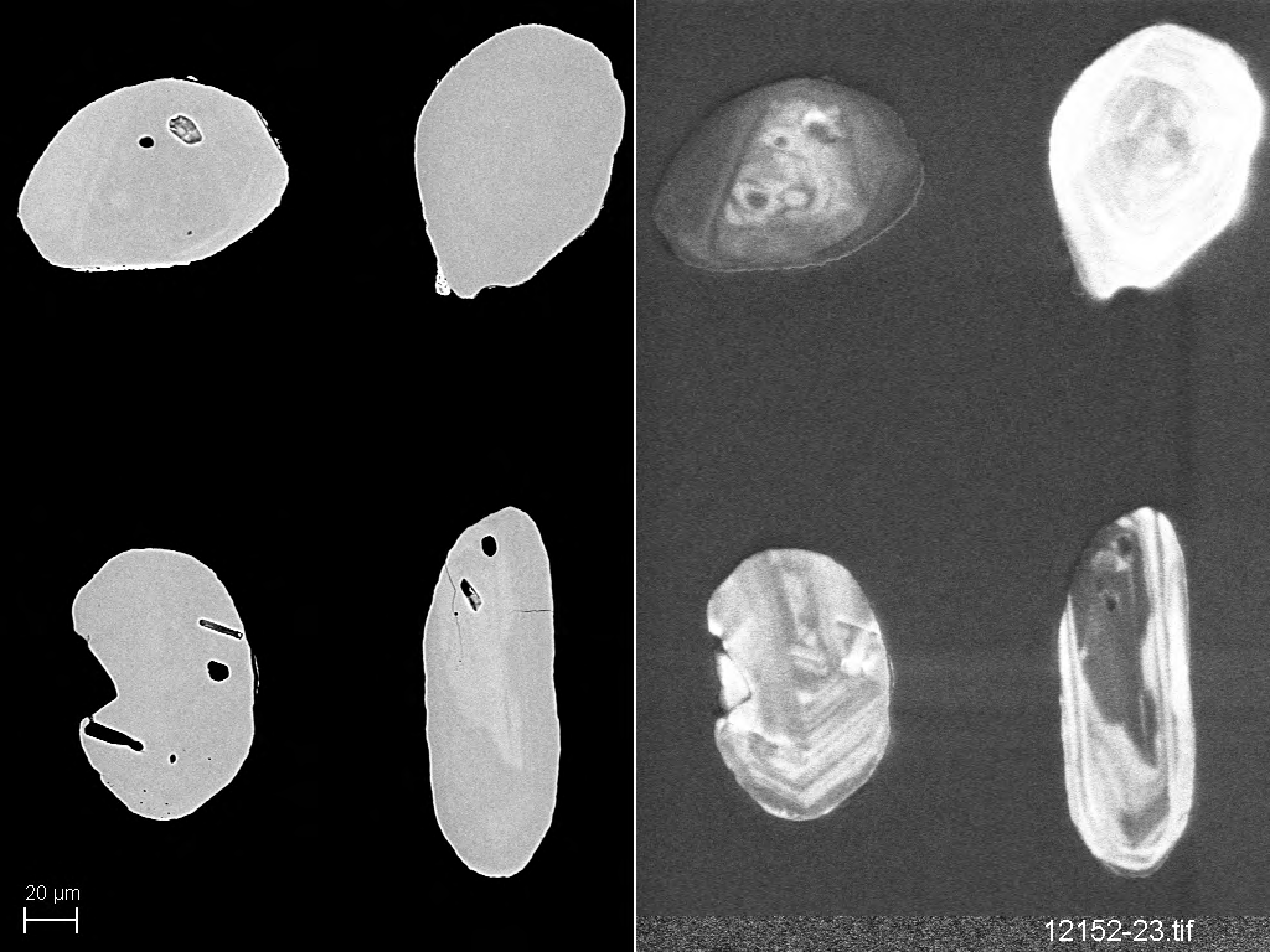
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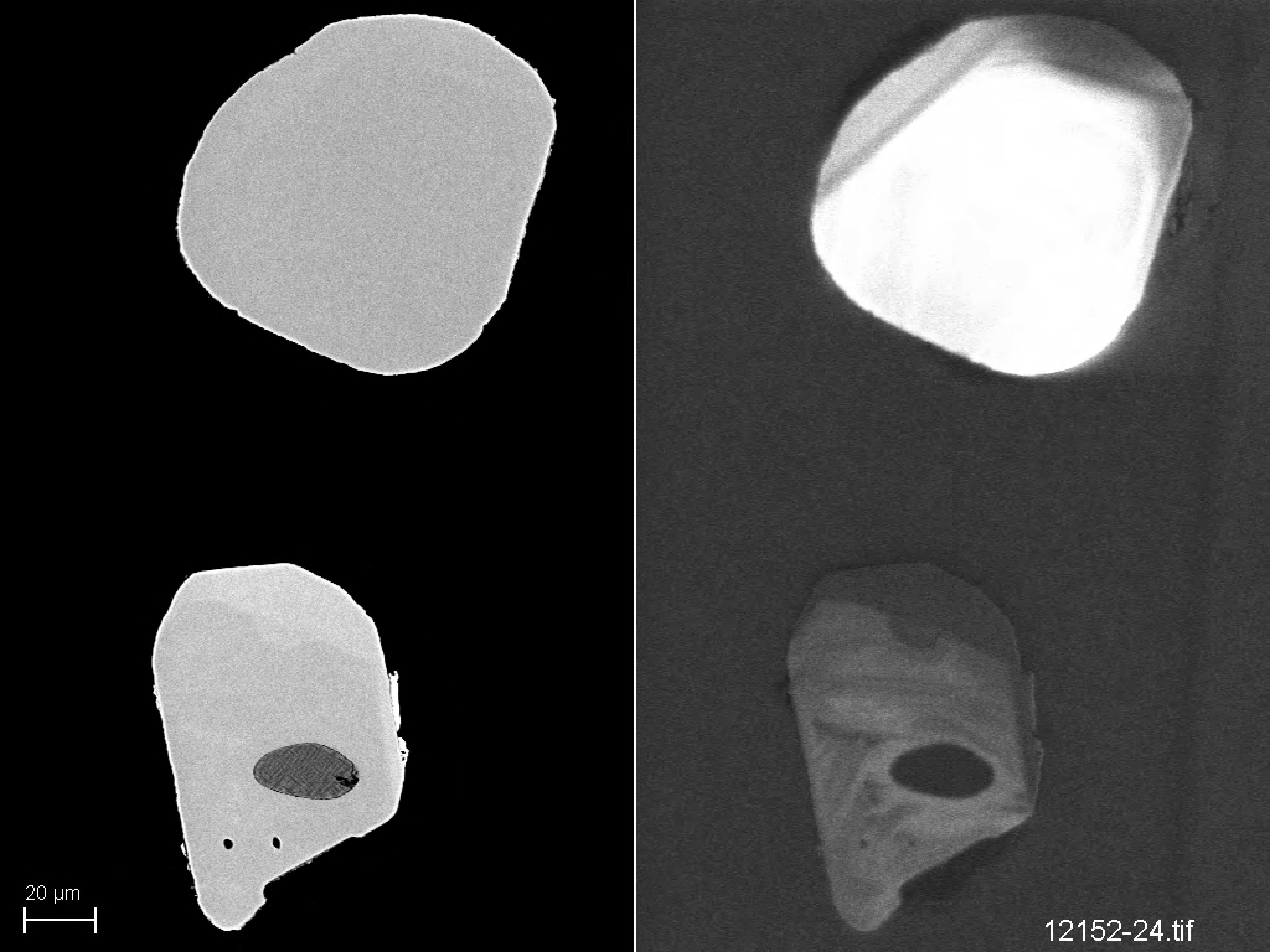
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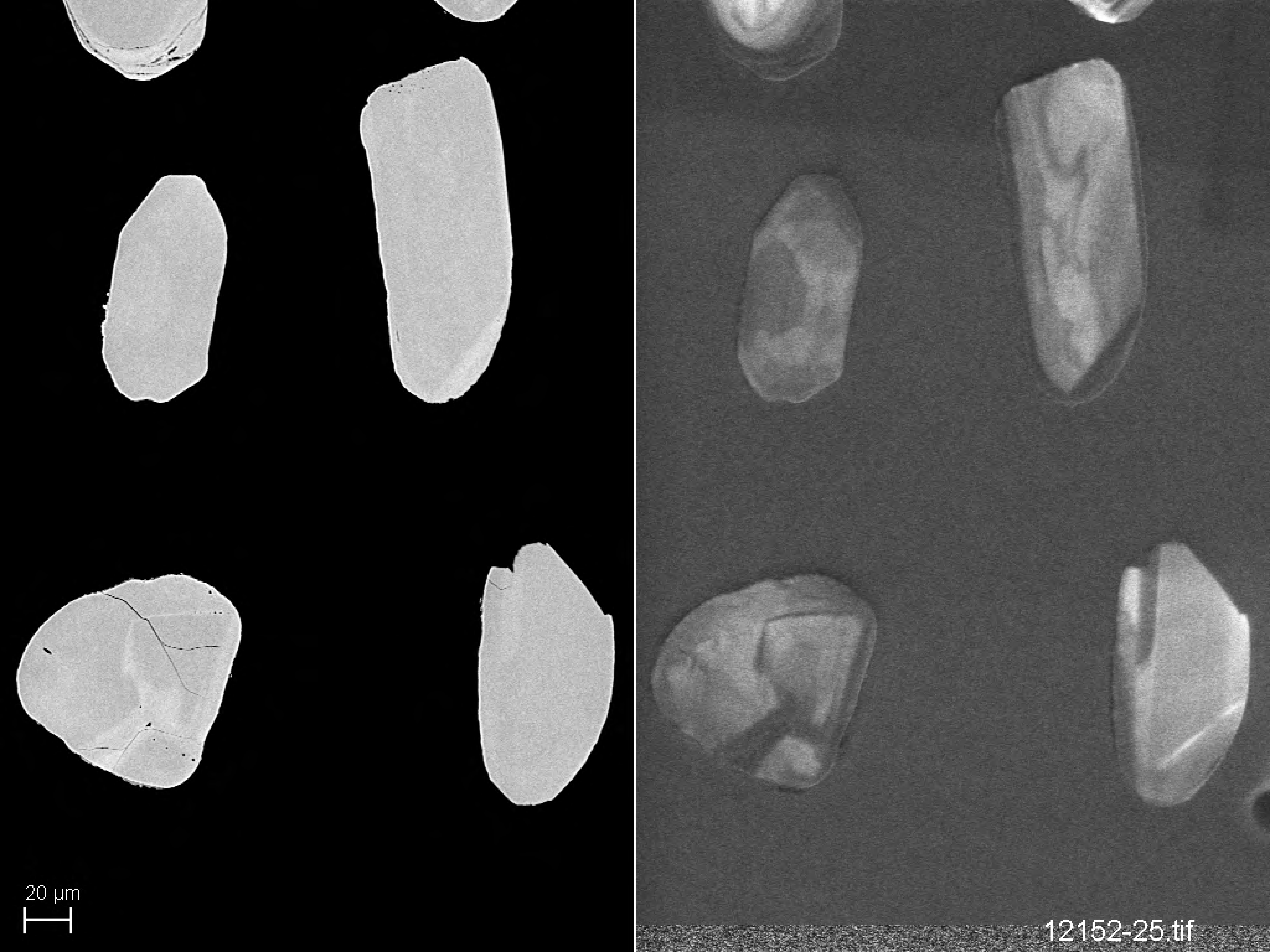
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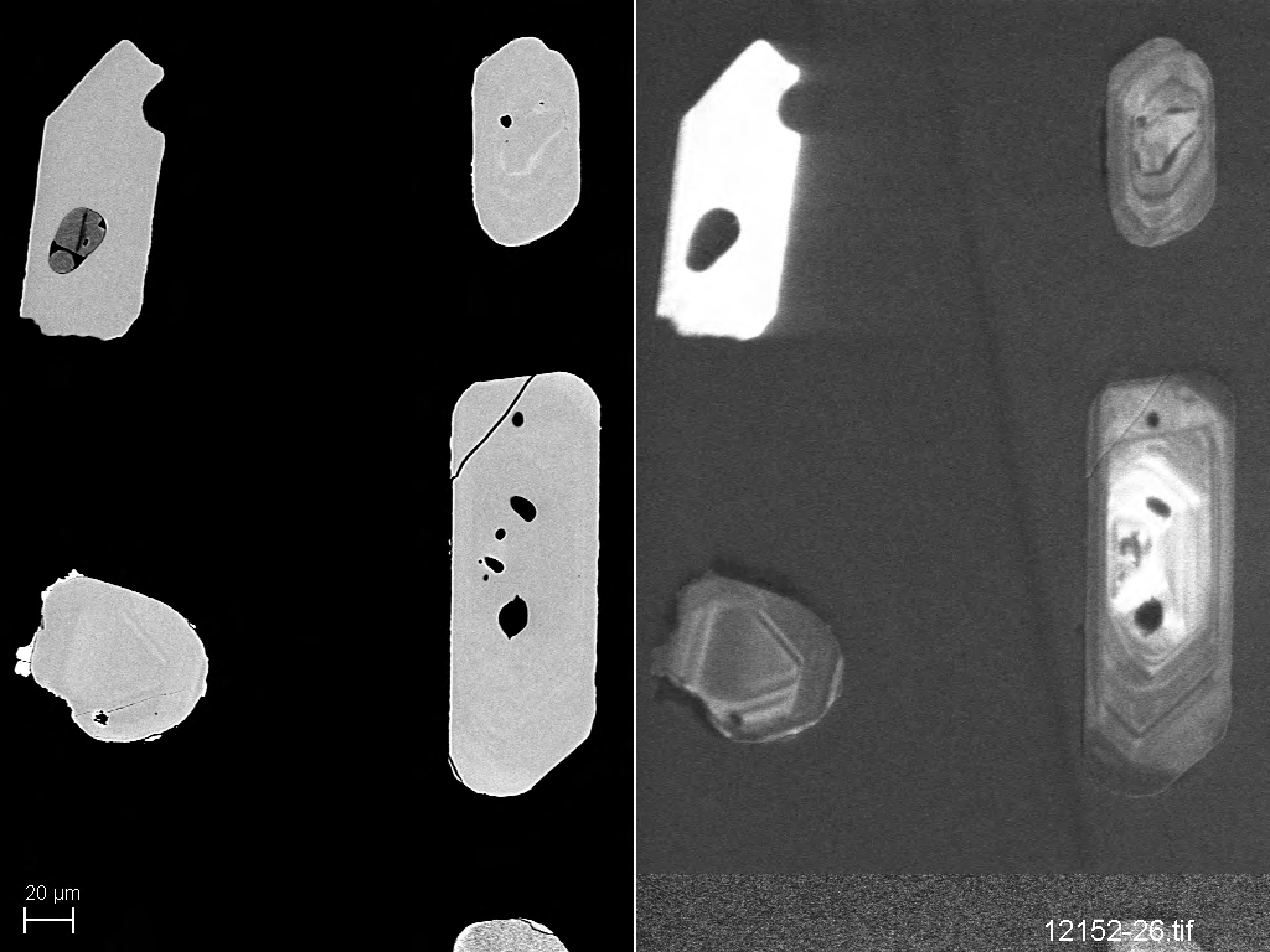
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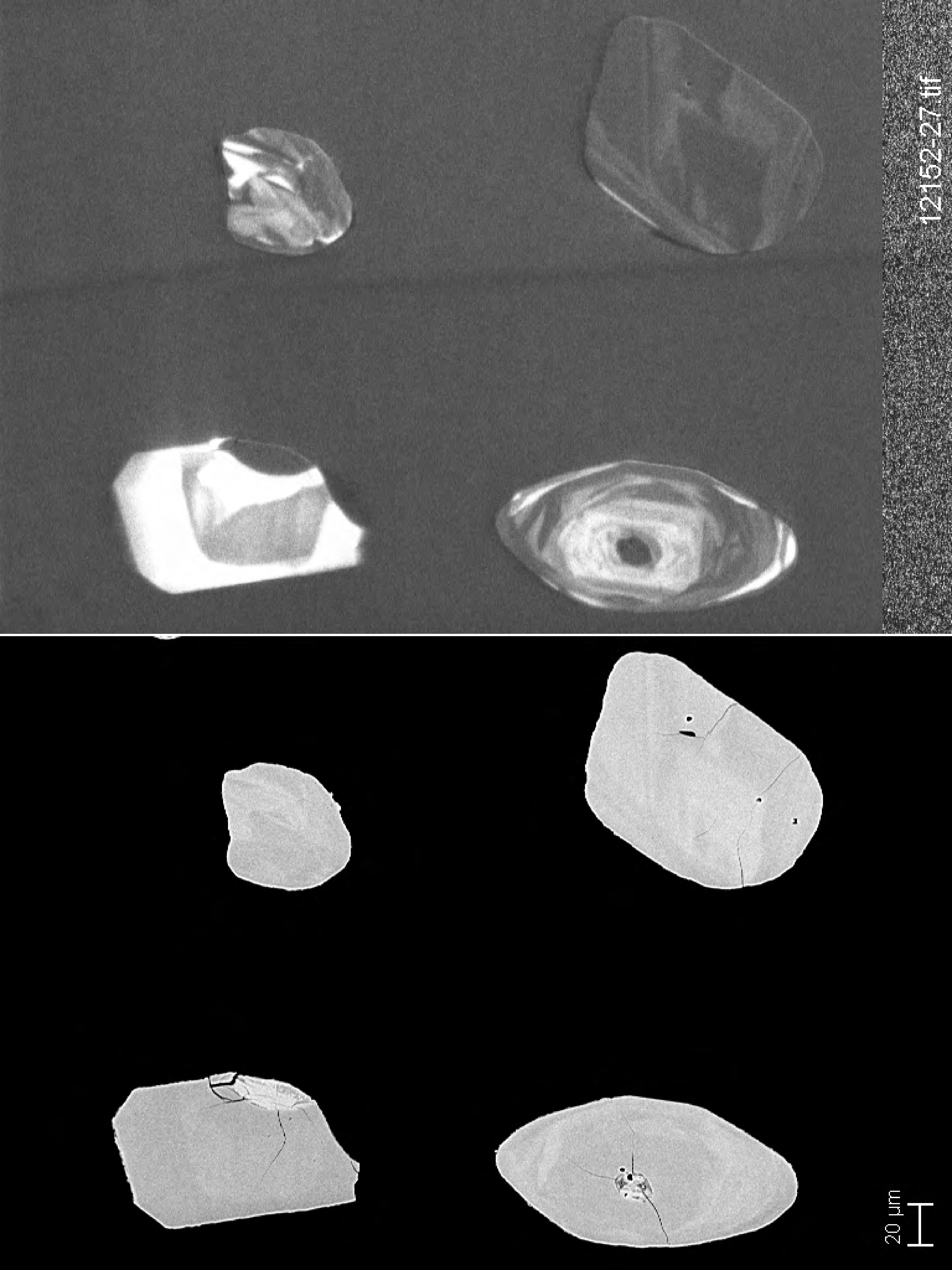
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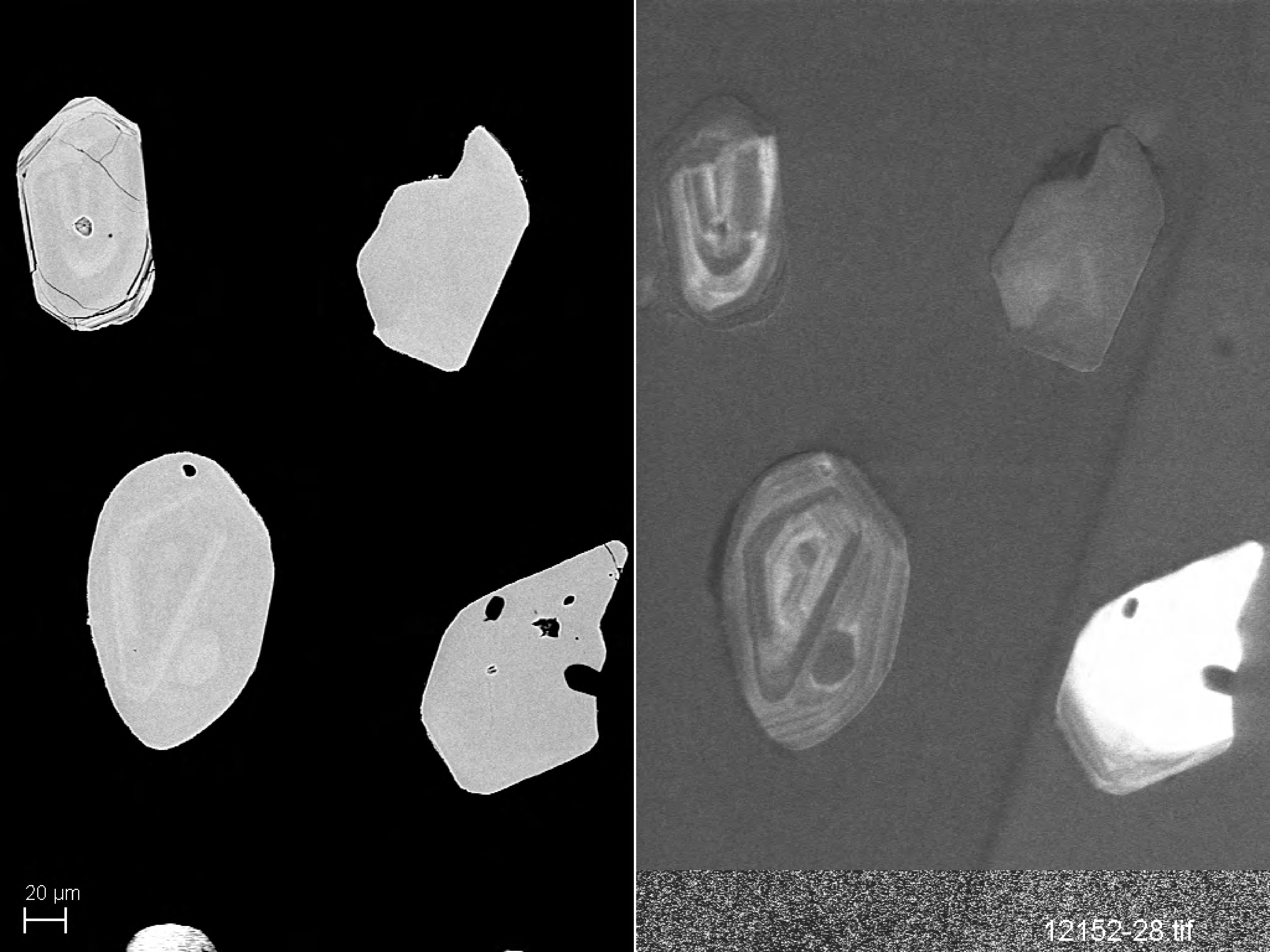
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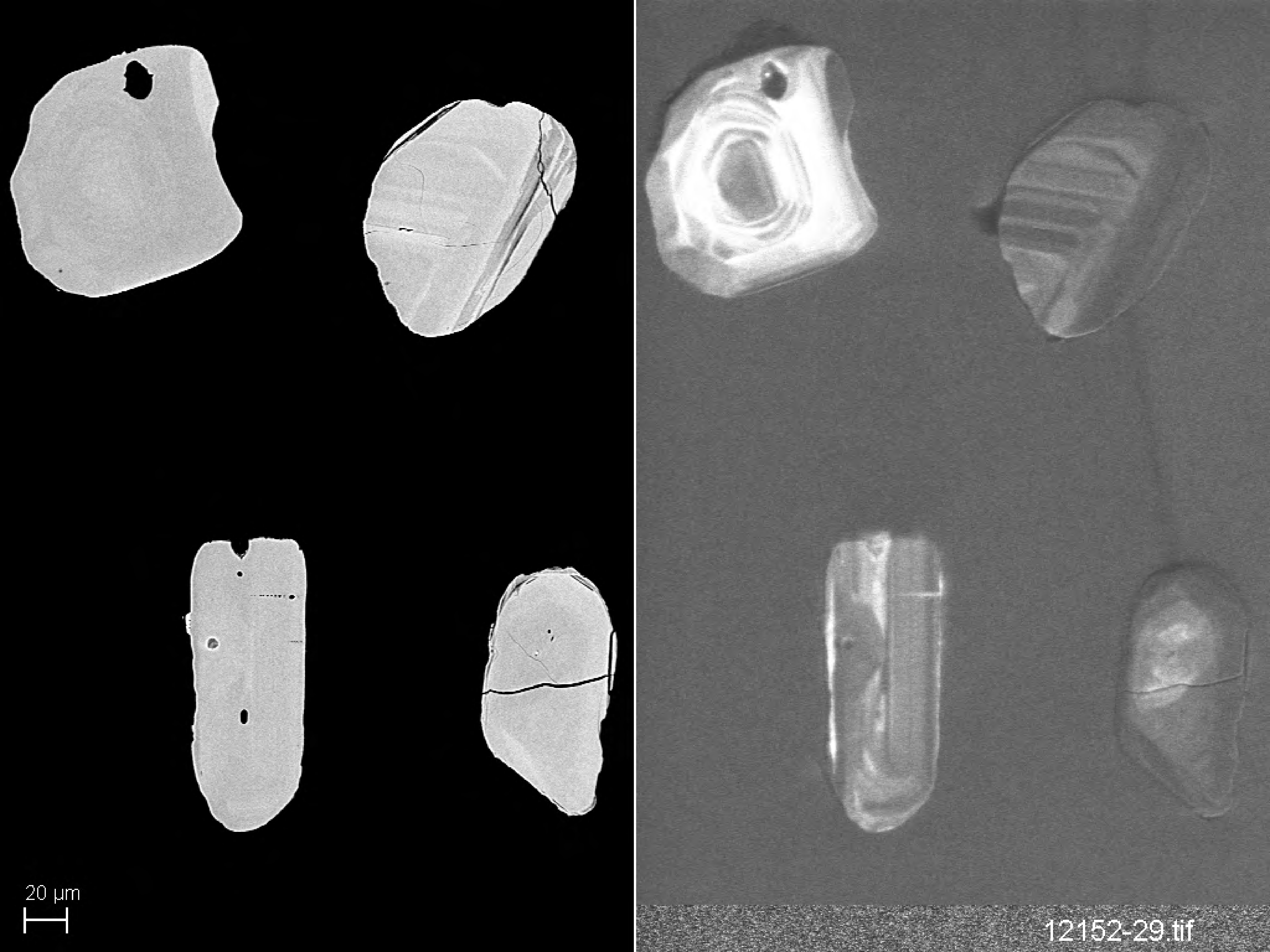
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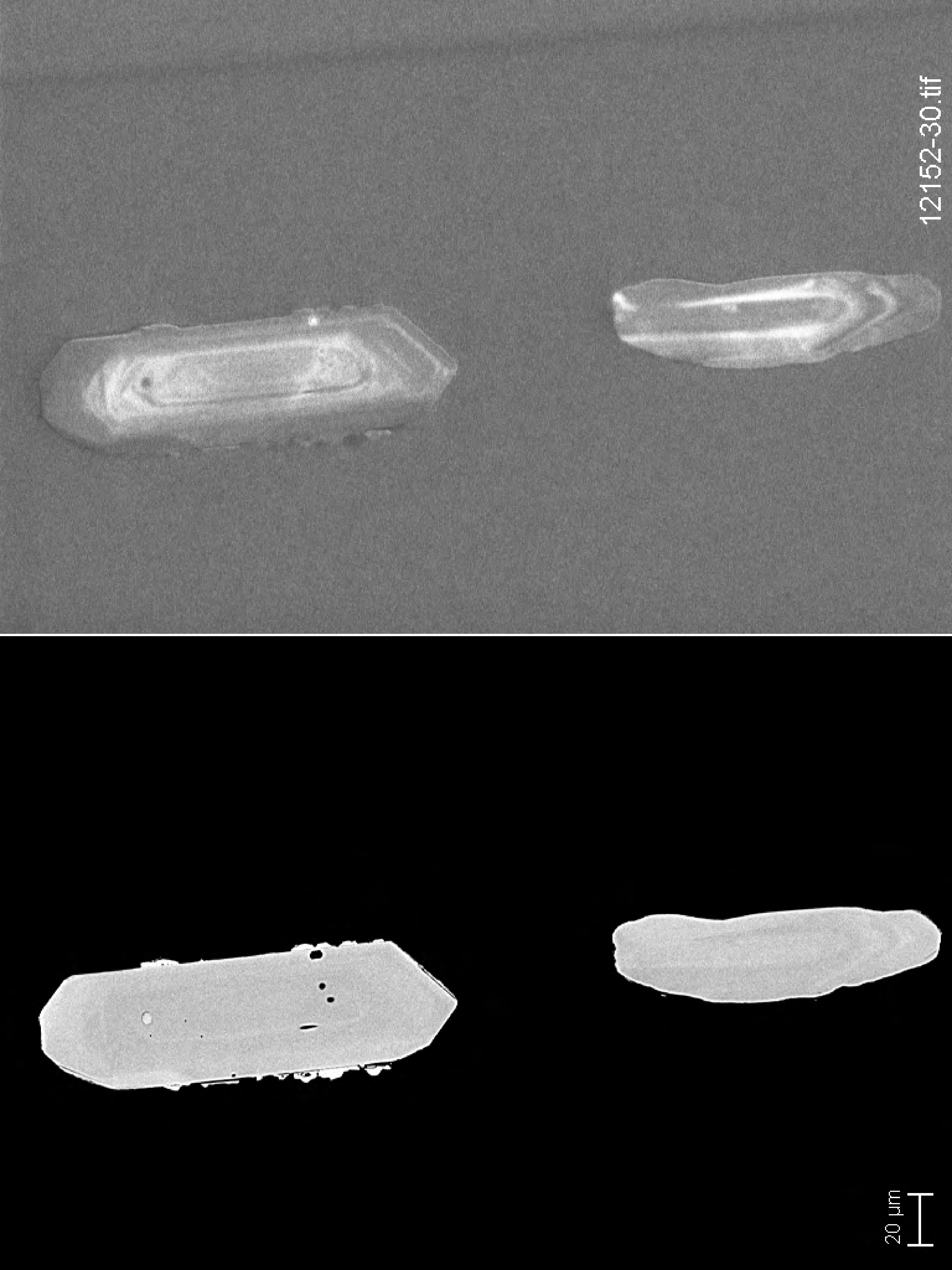
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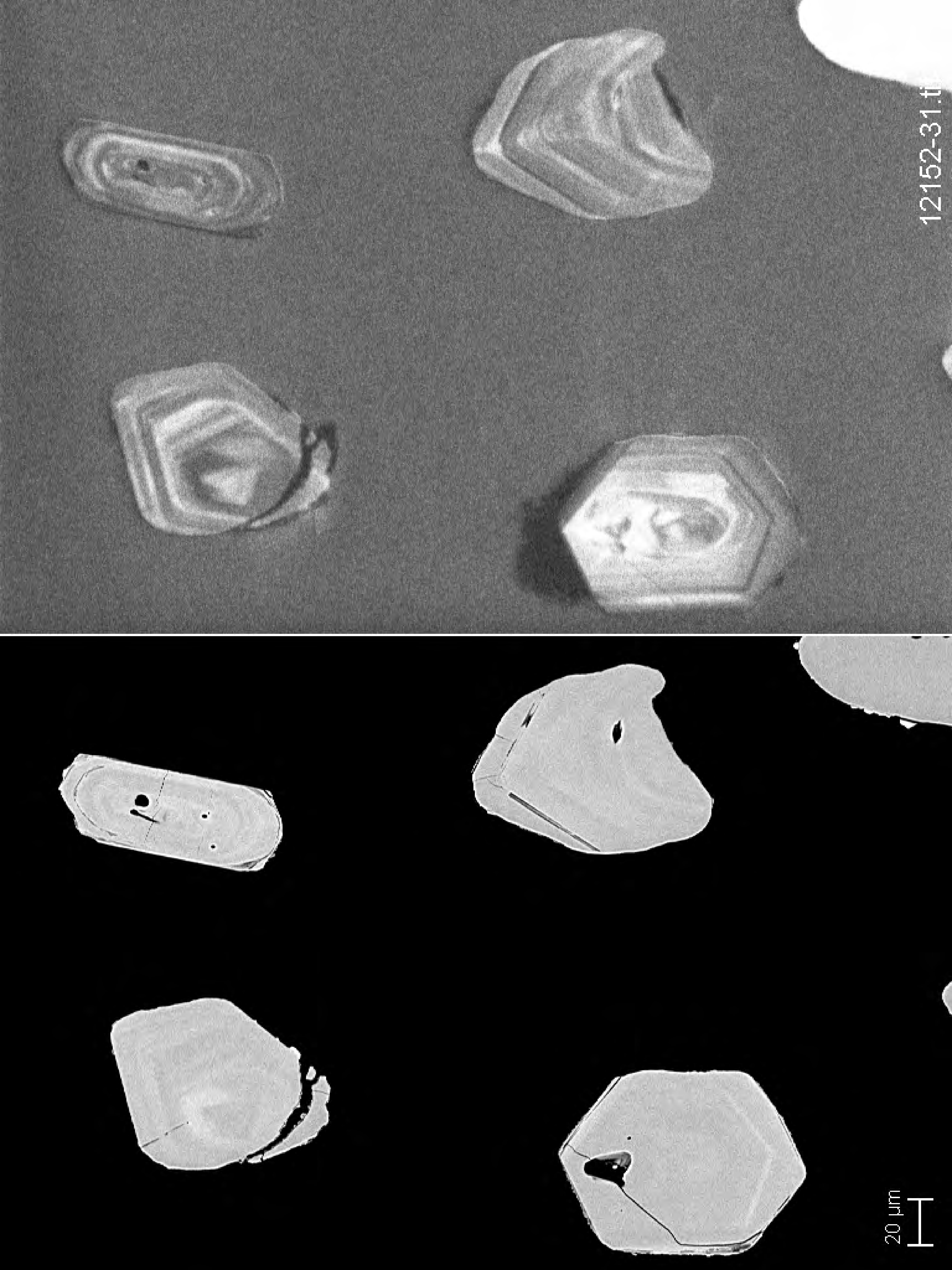
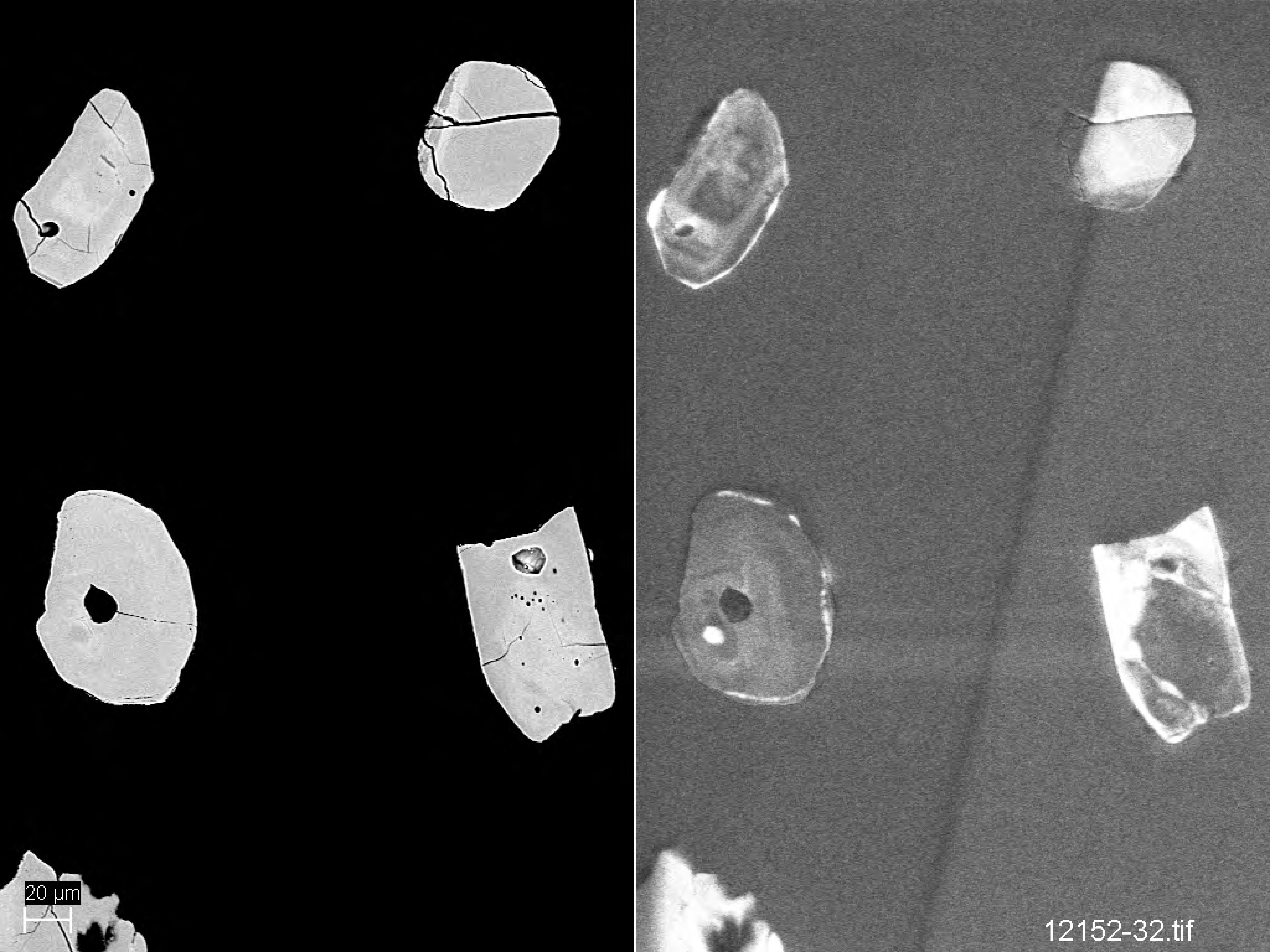


12152-31
20 µm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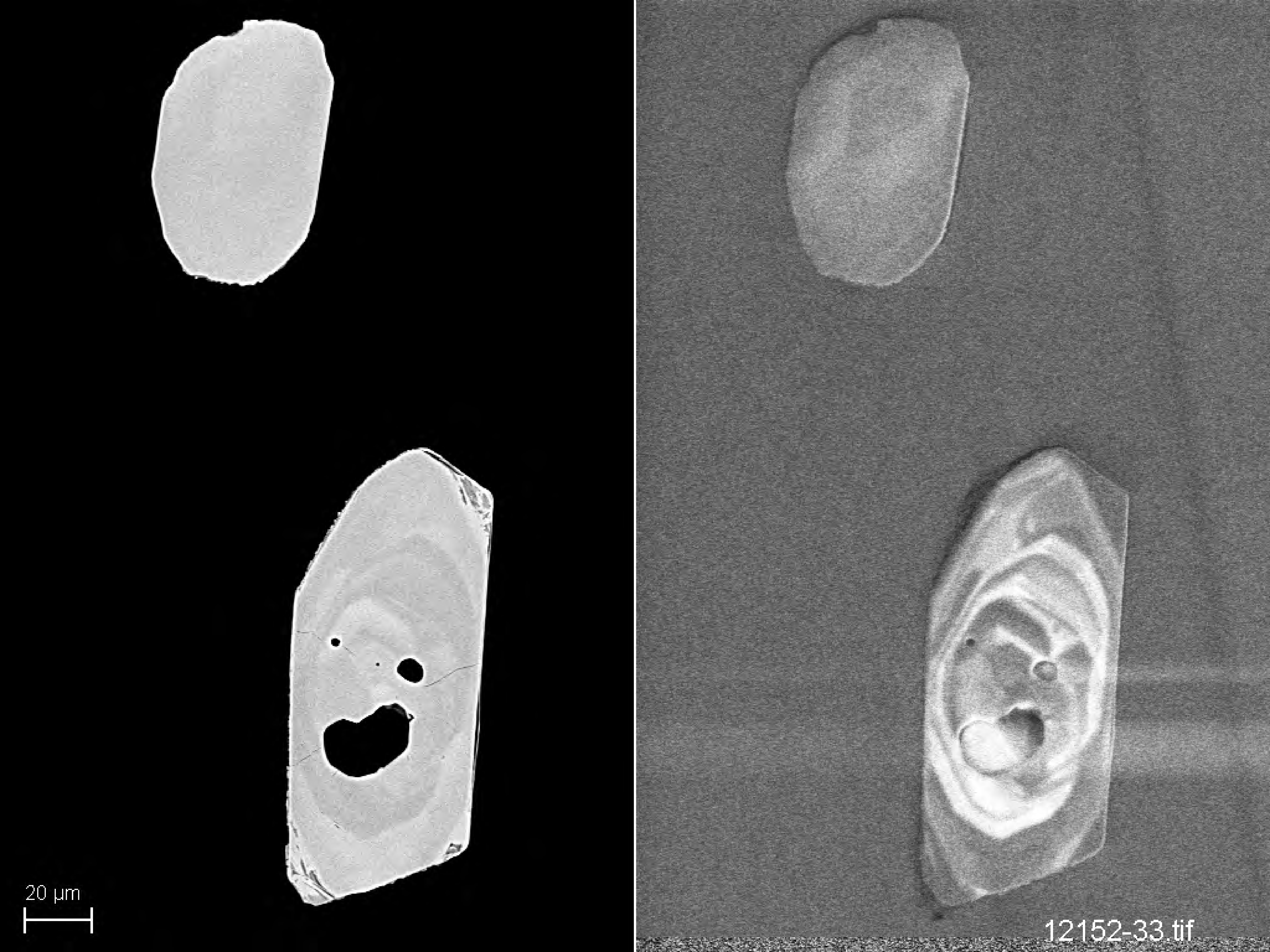
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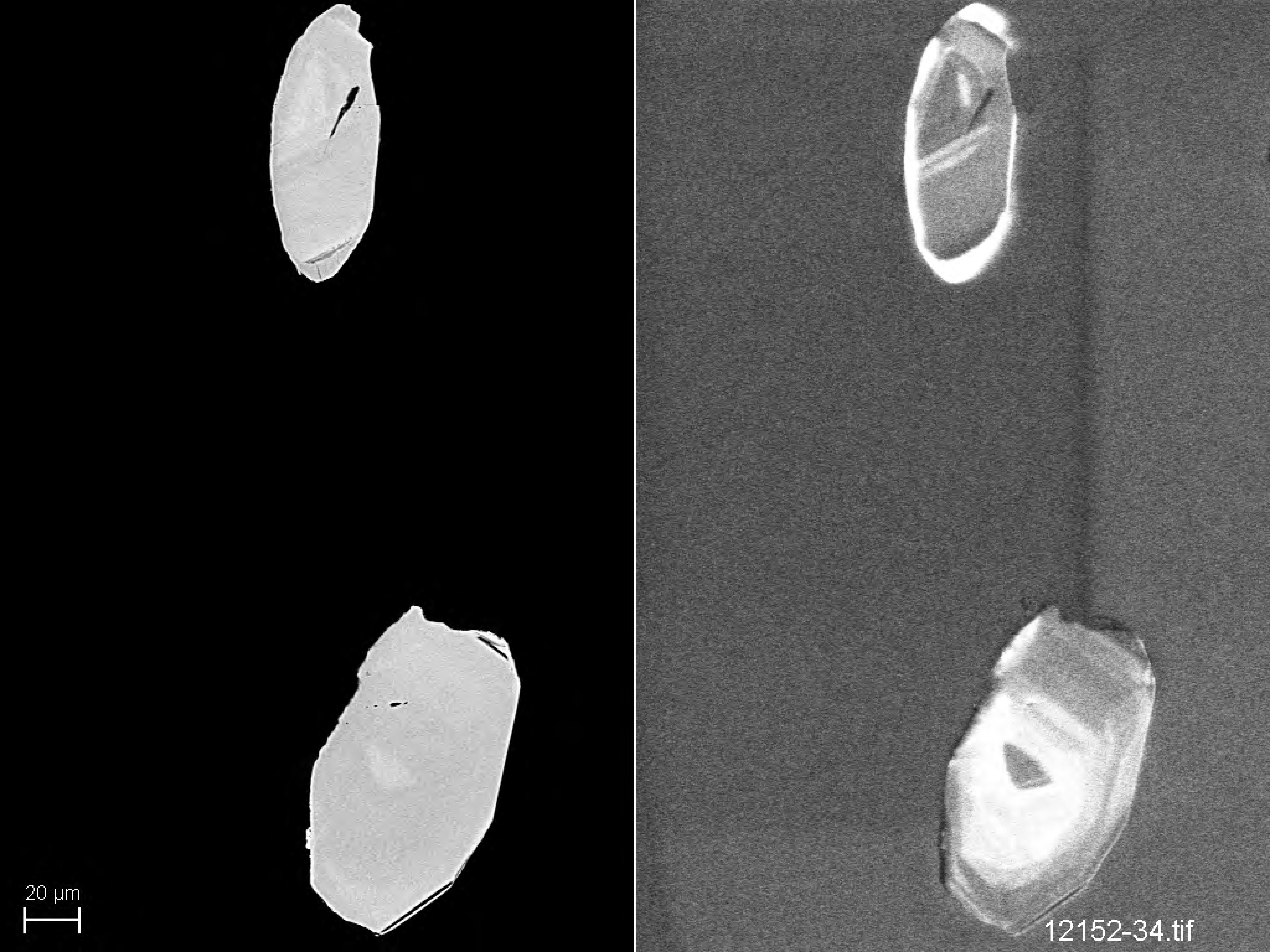
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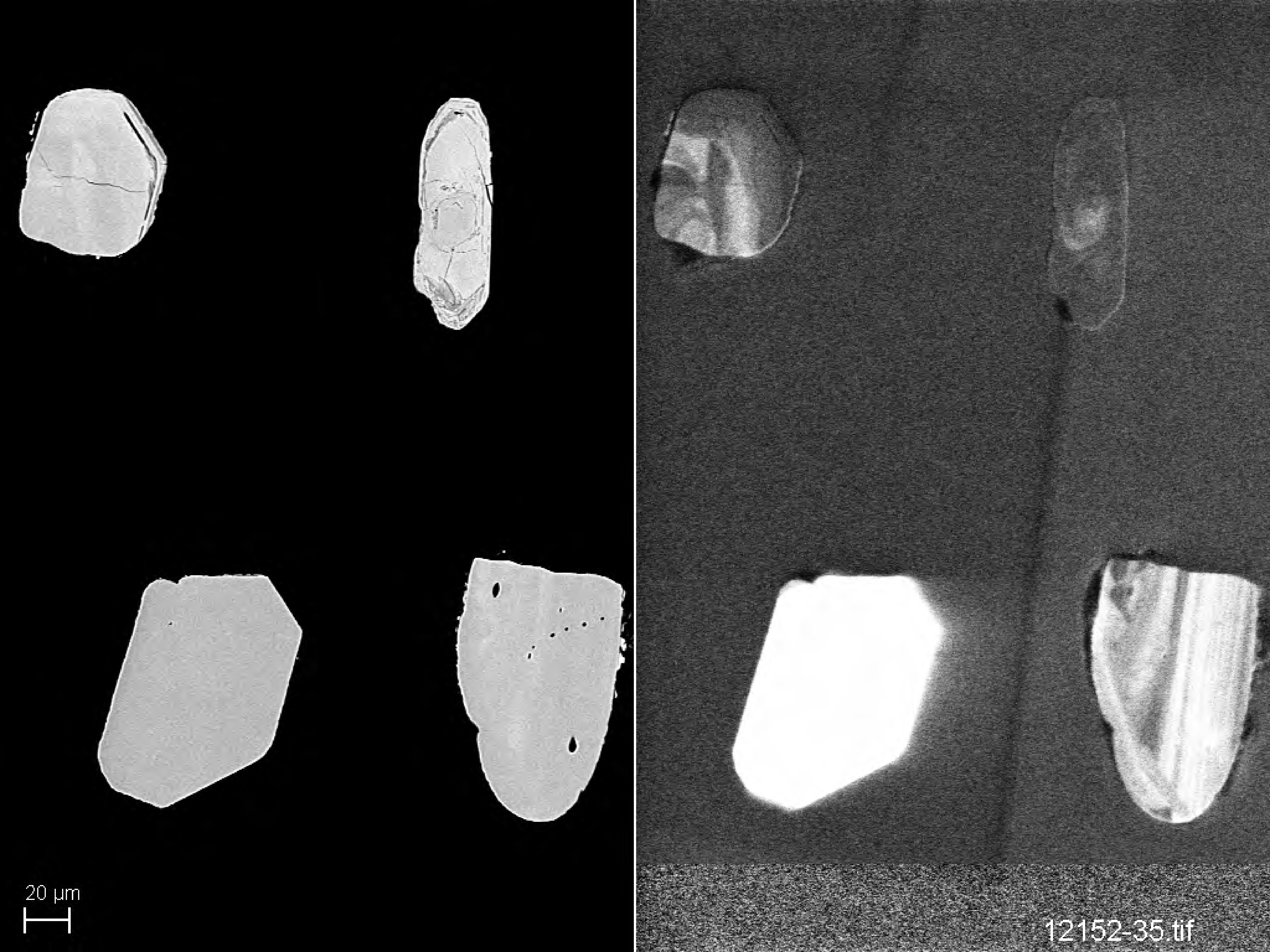
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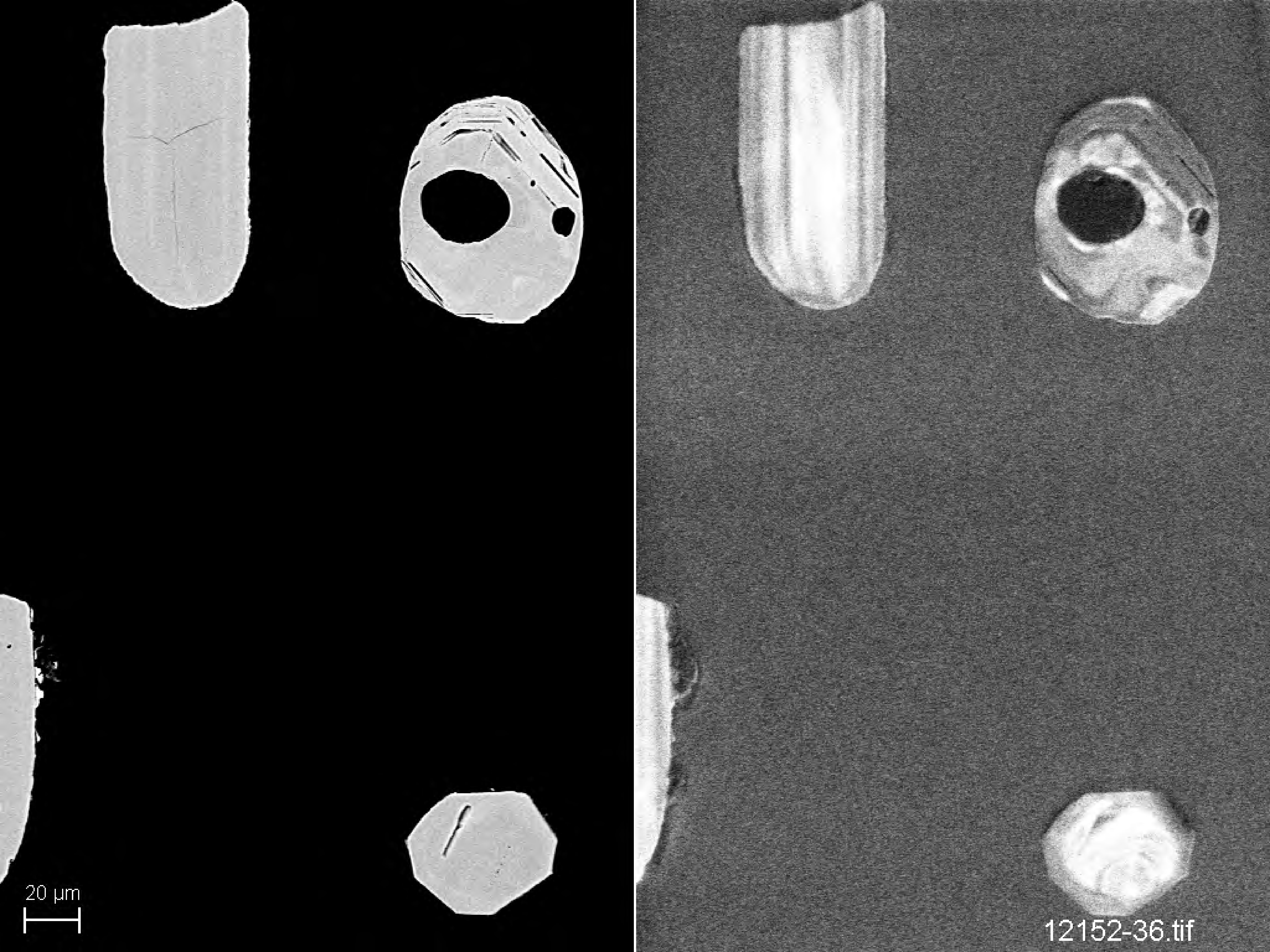
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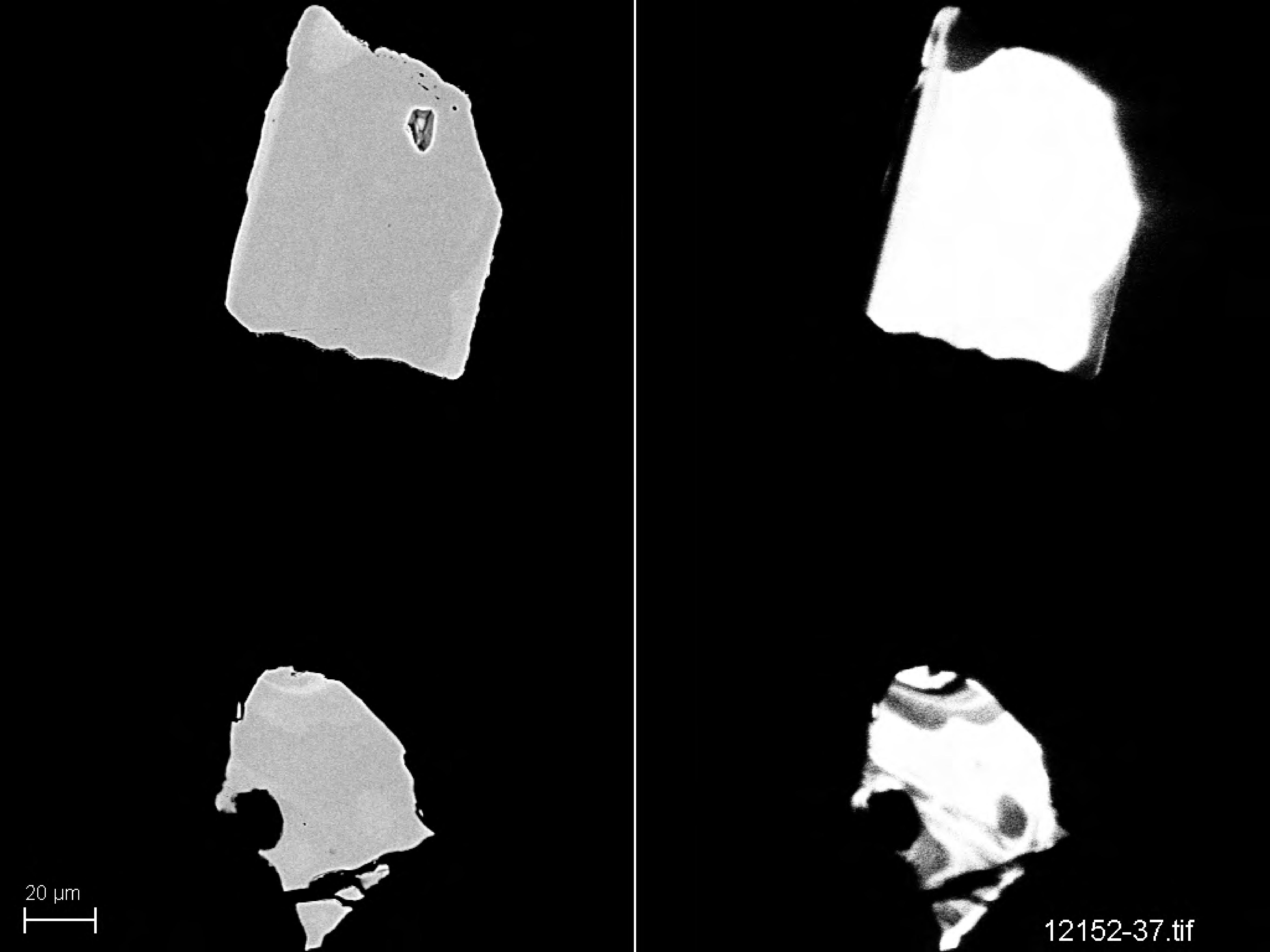
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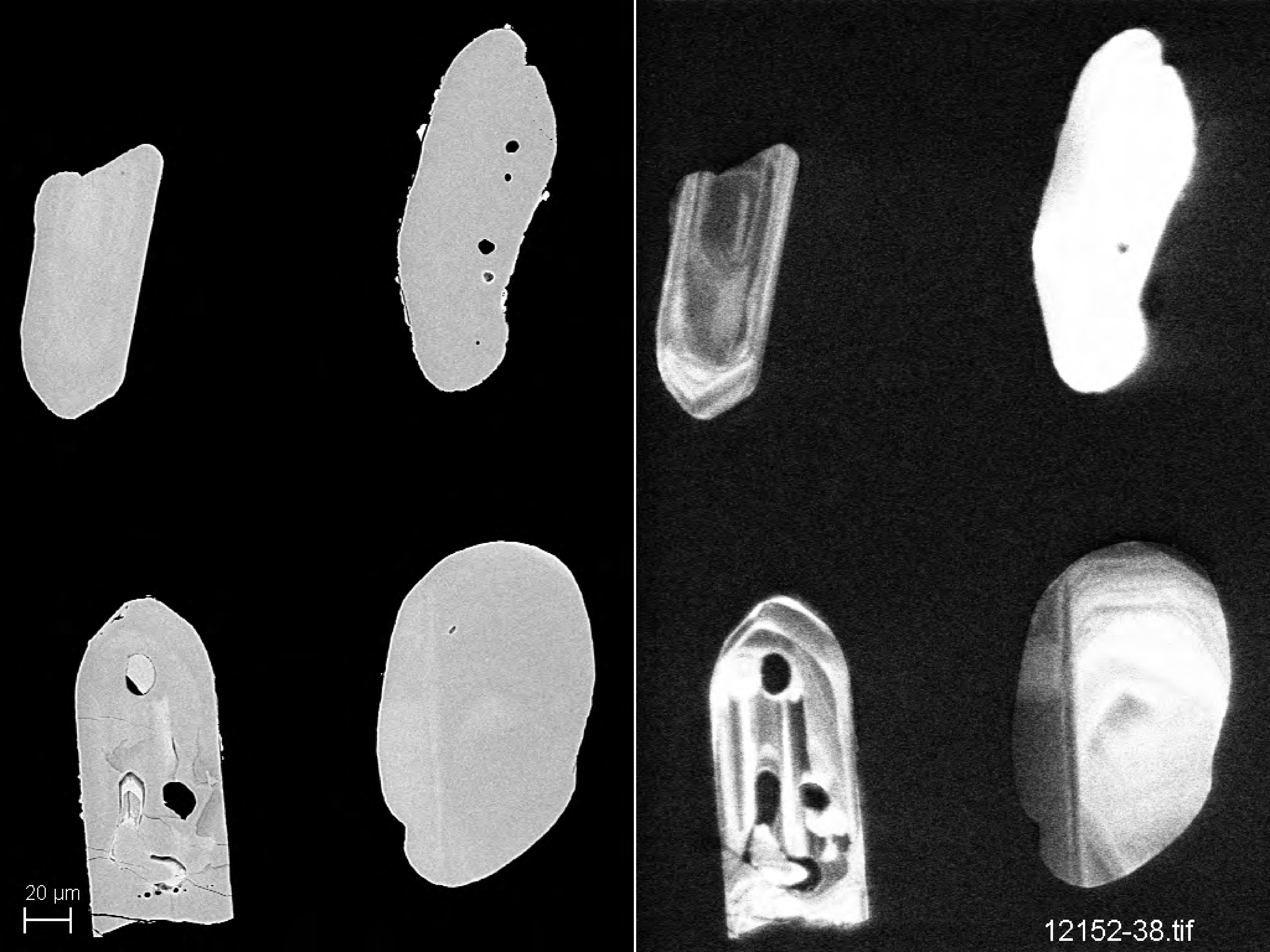
20 µm
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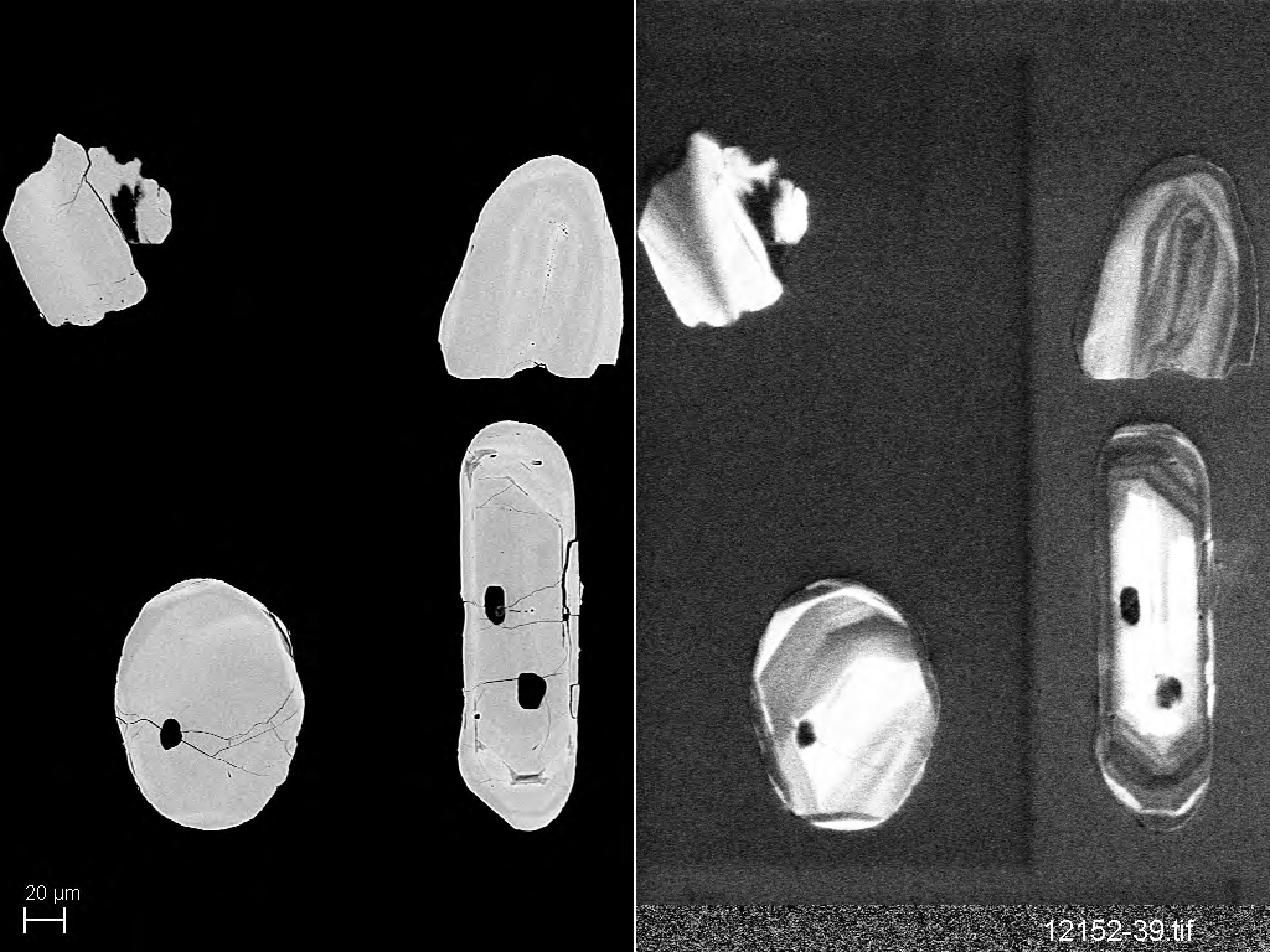
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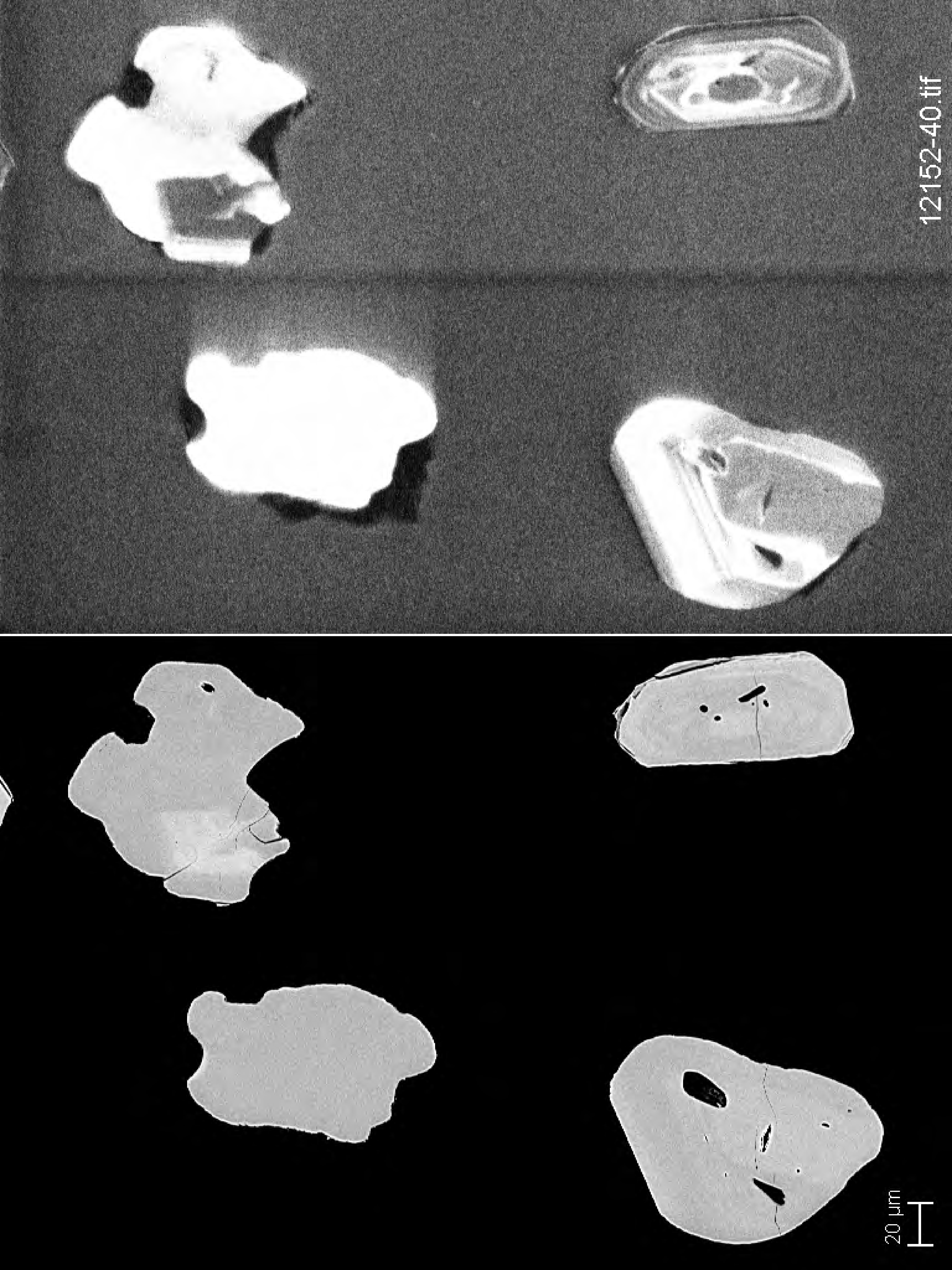
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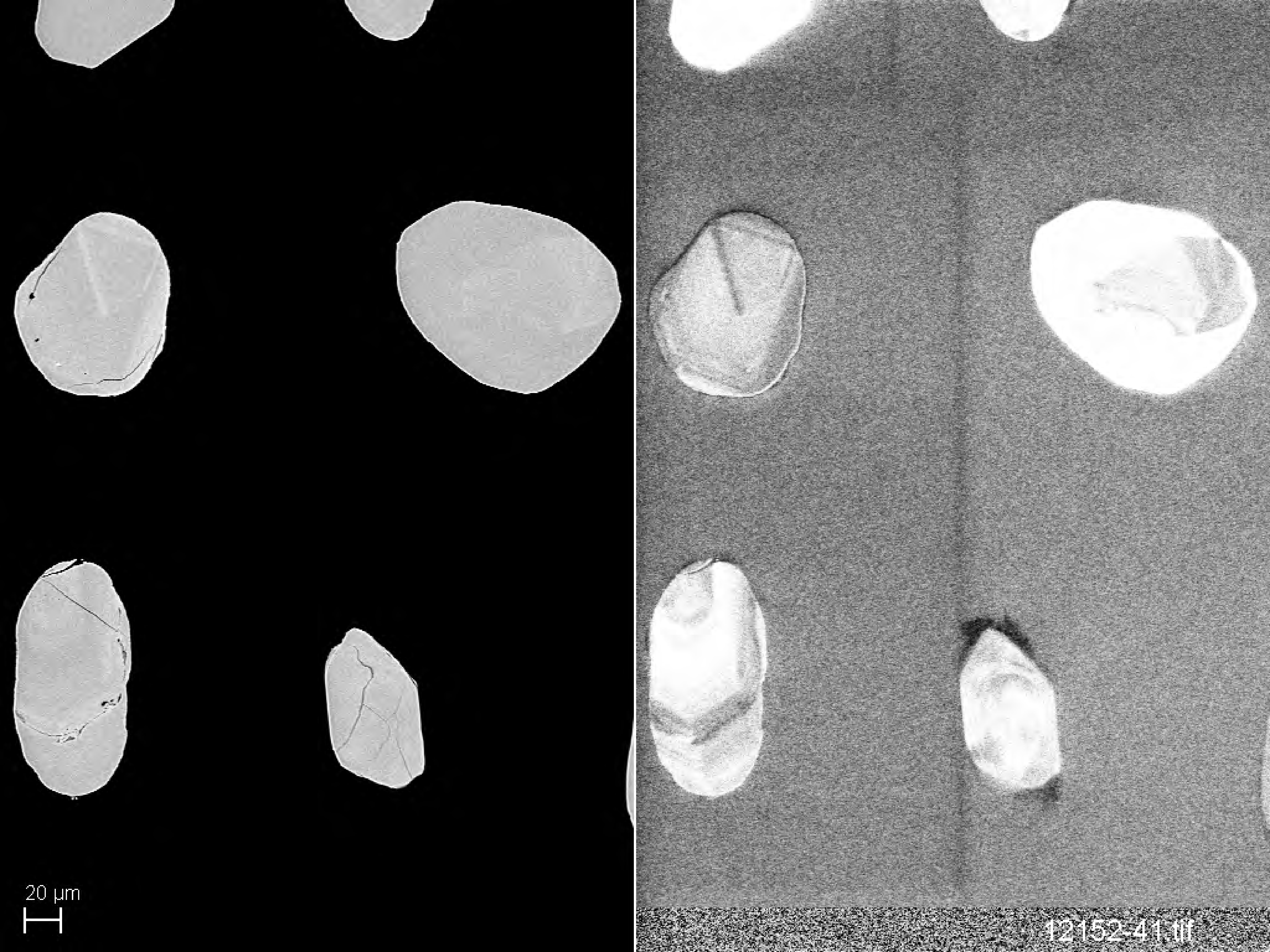
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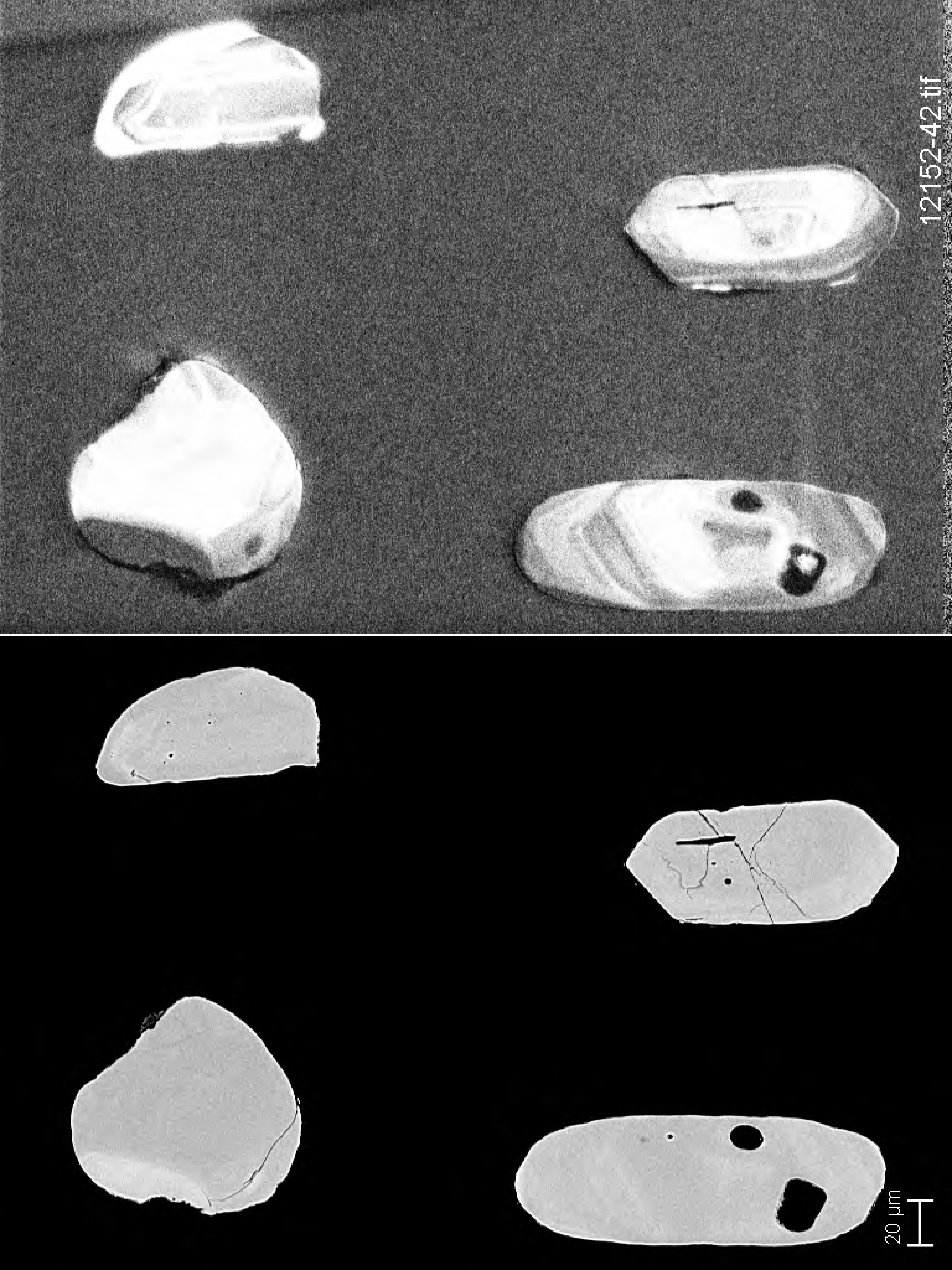
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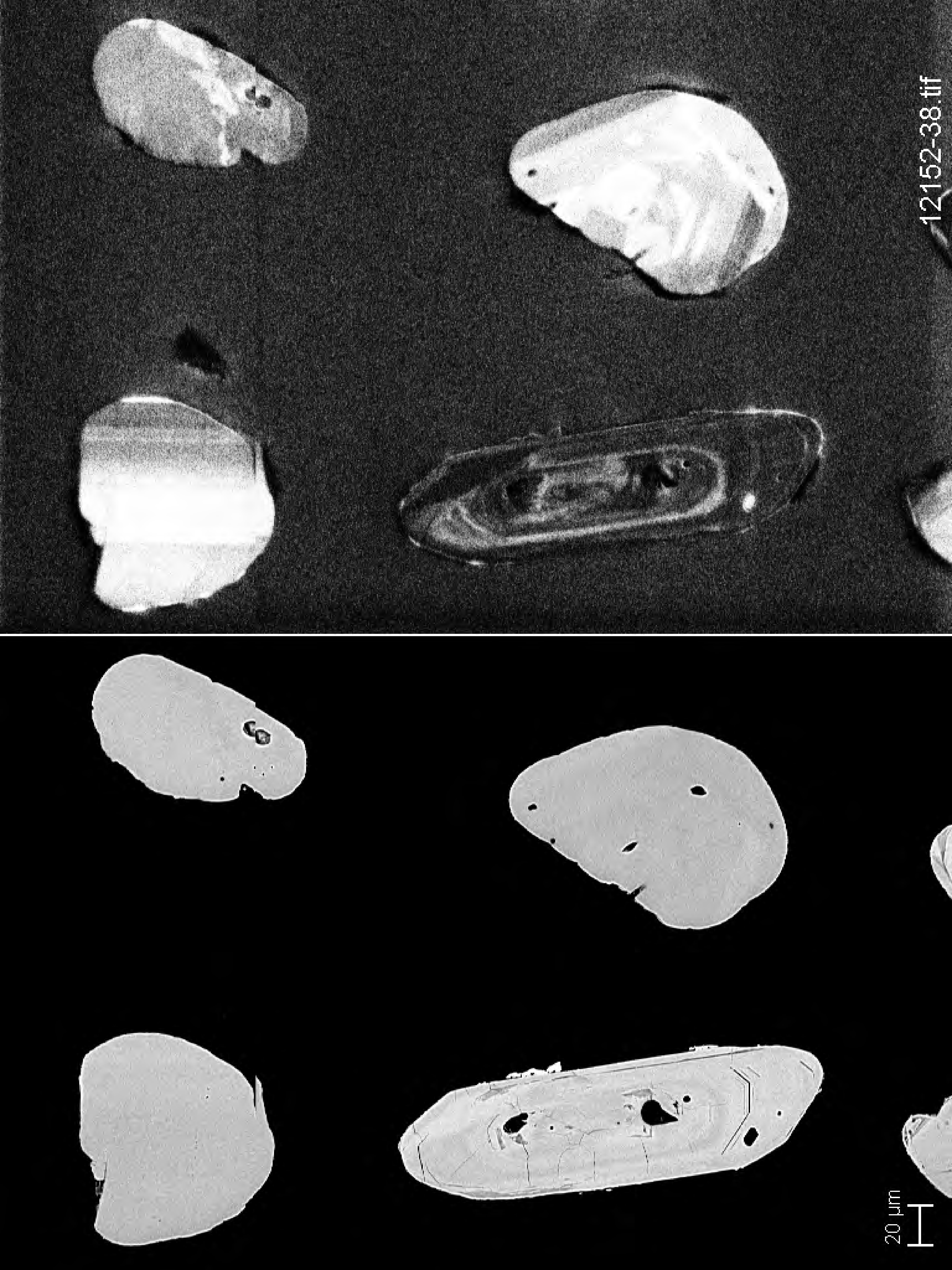
20 µm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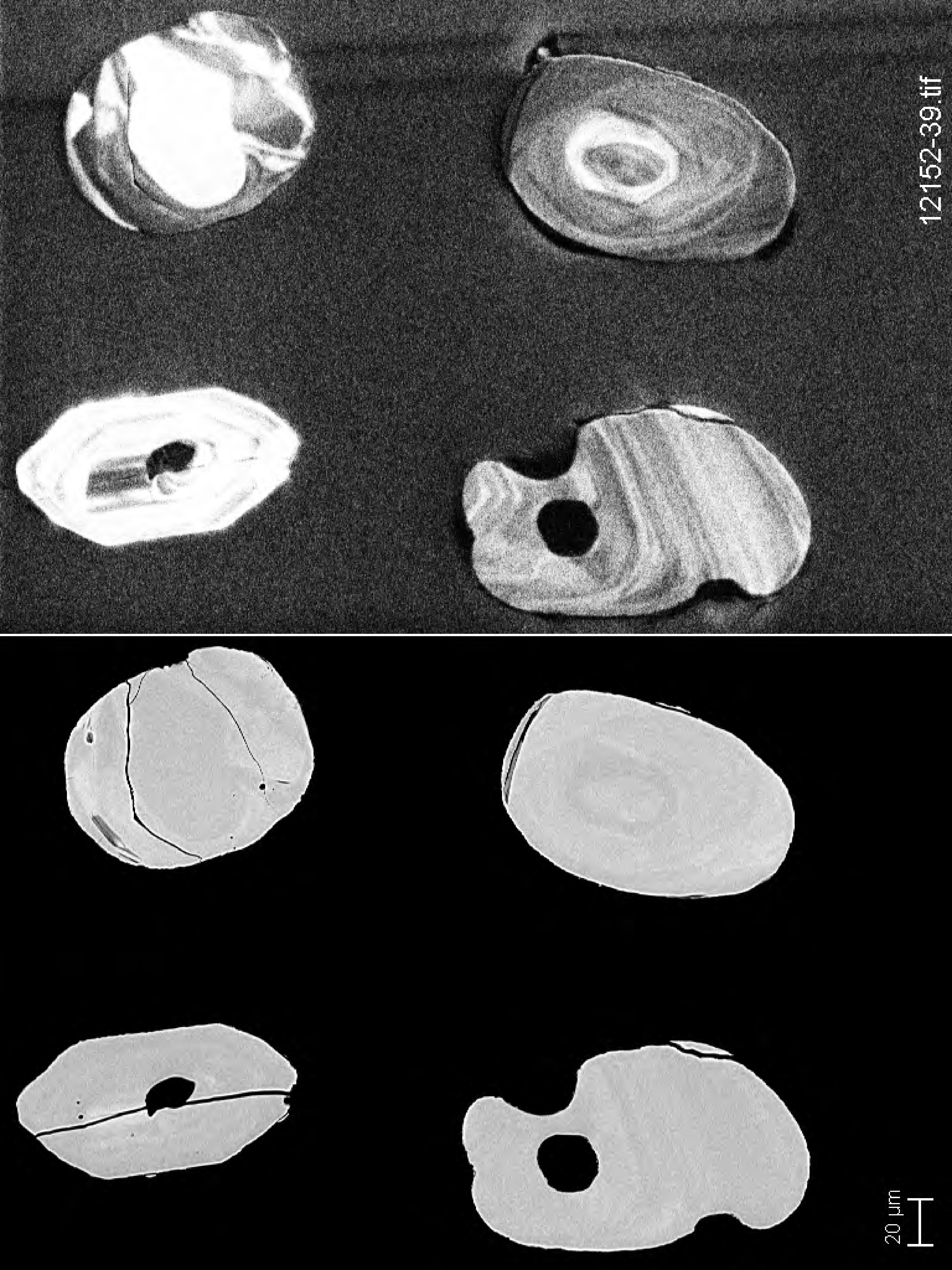
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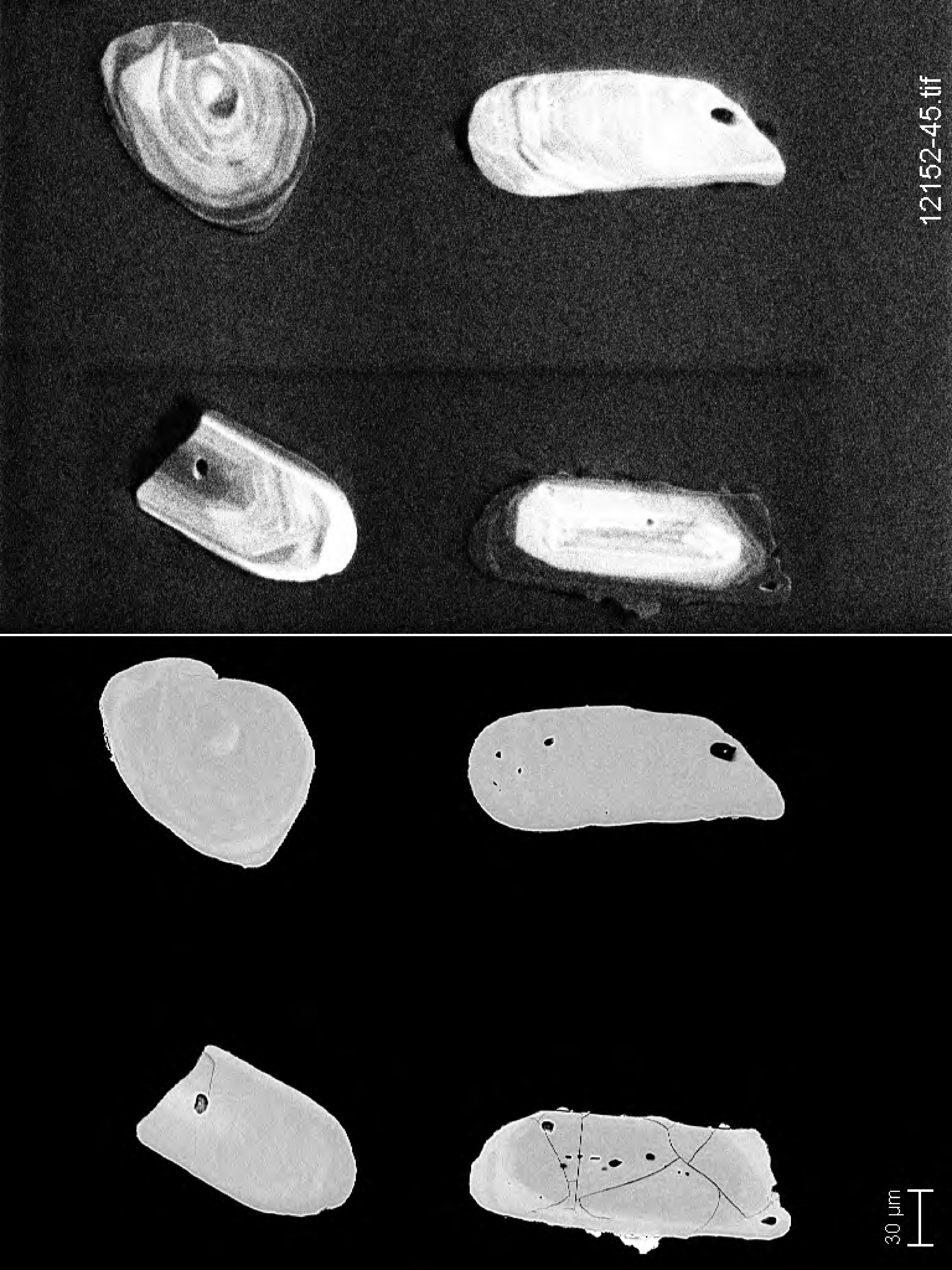
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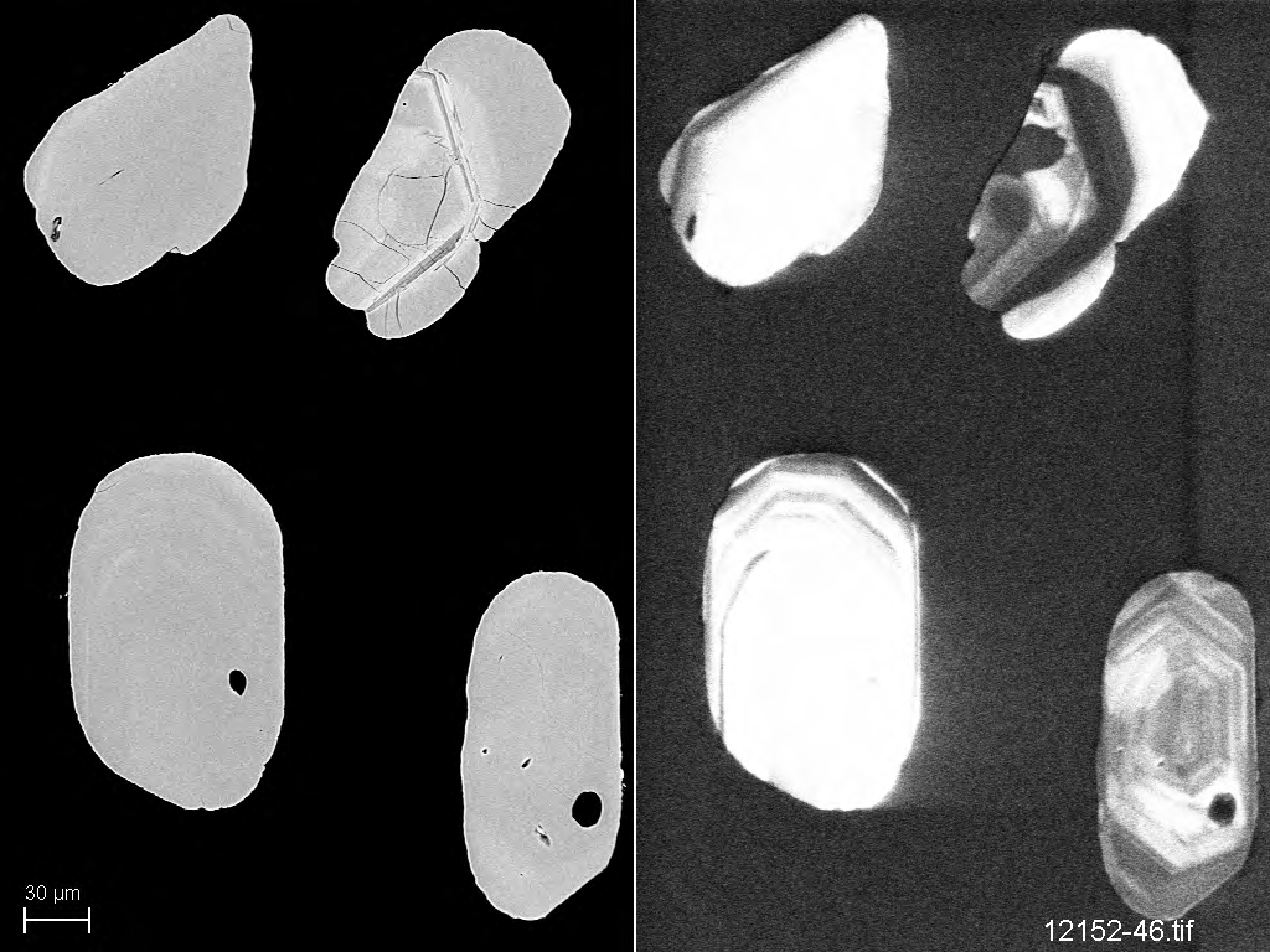
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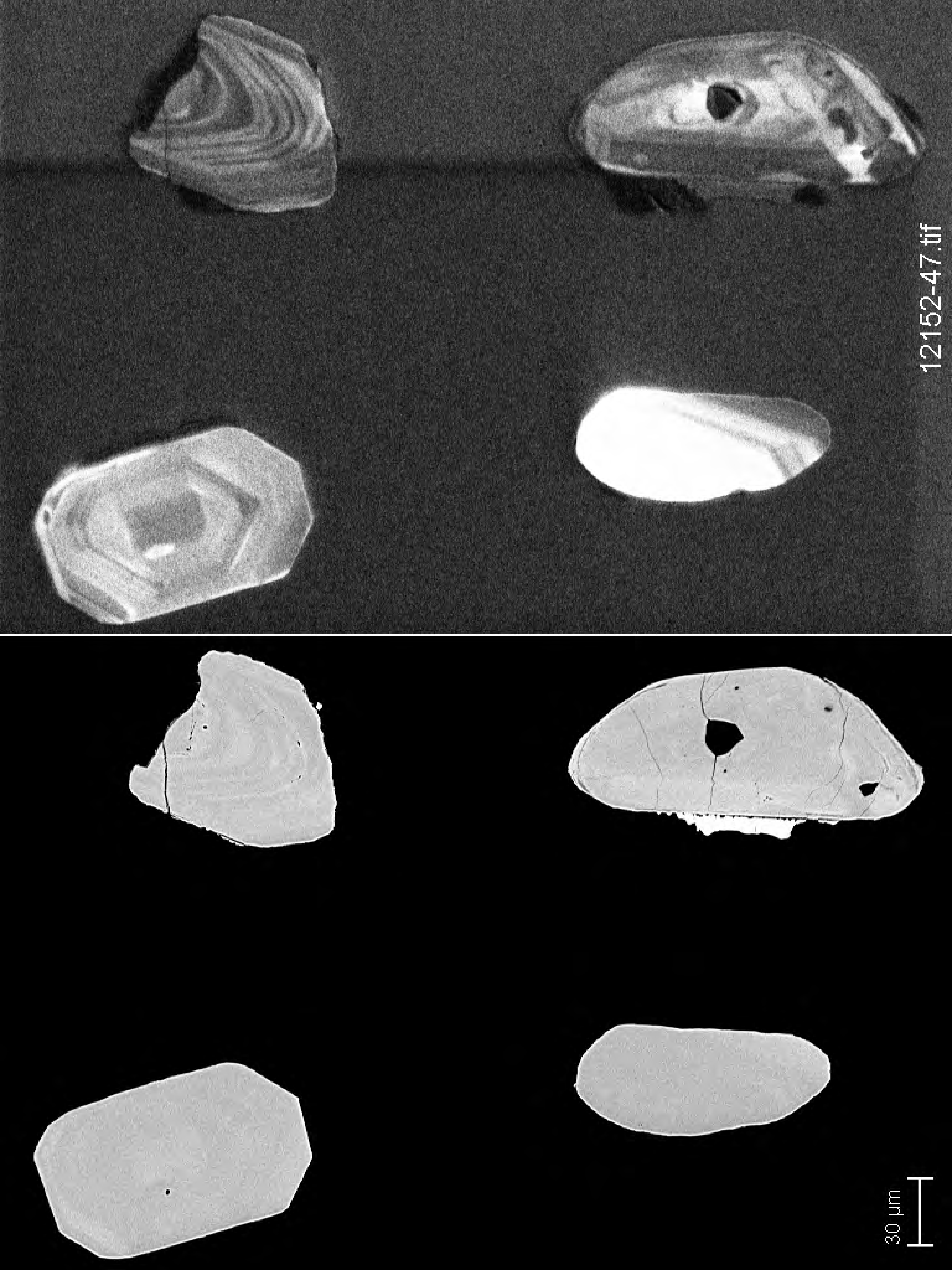
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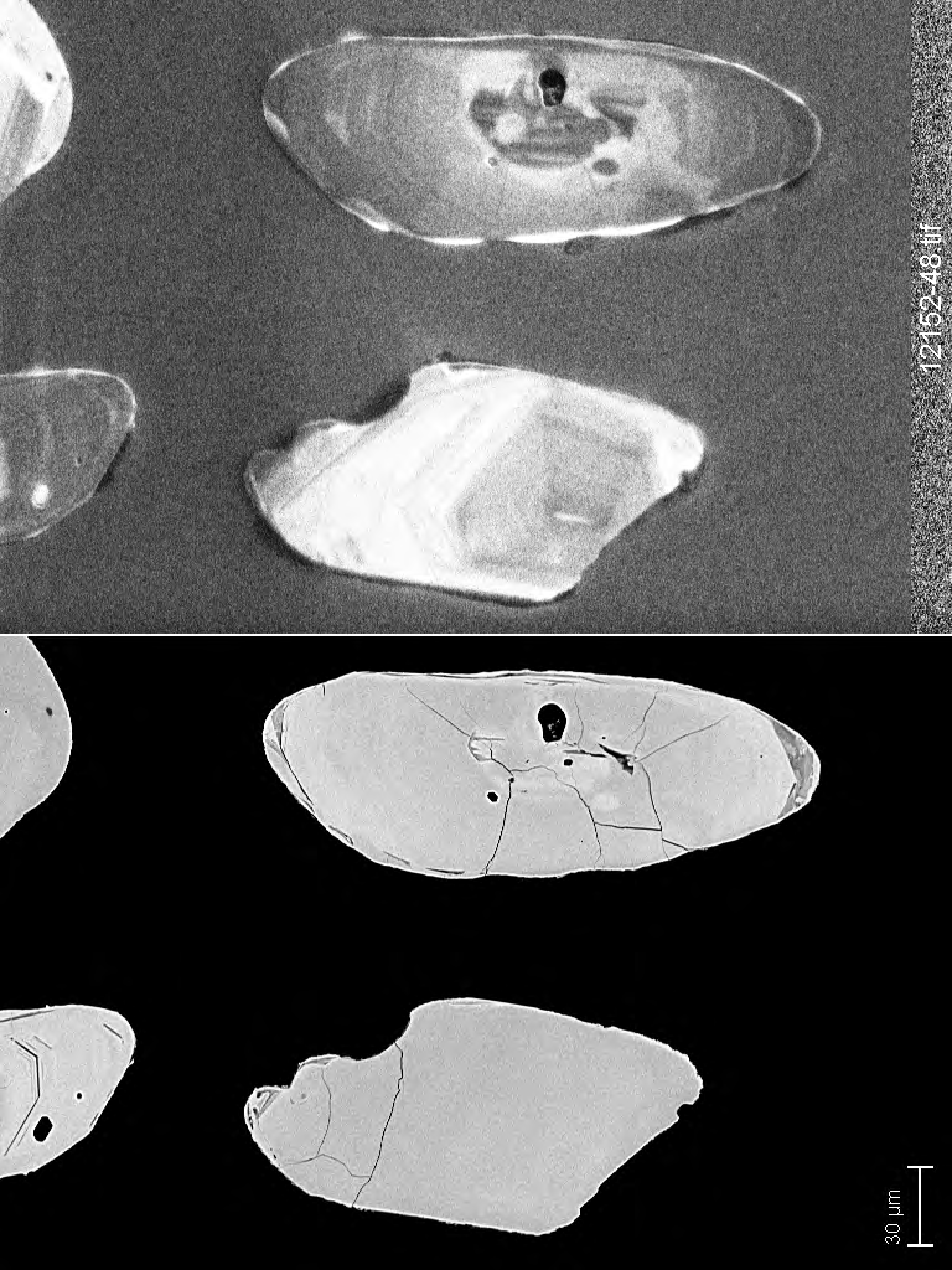
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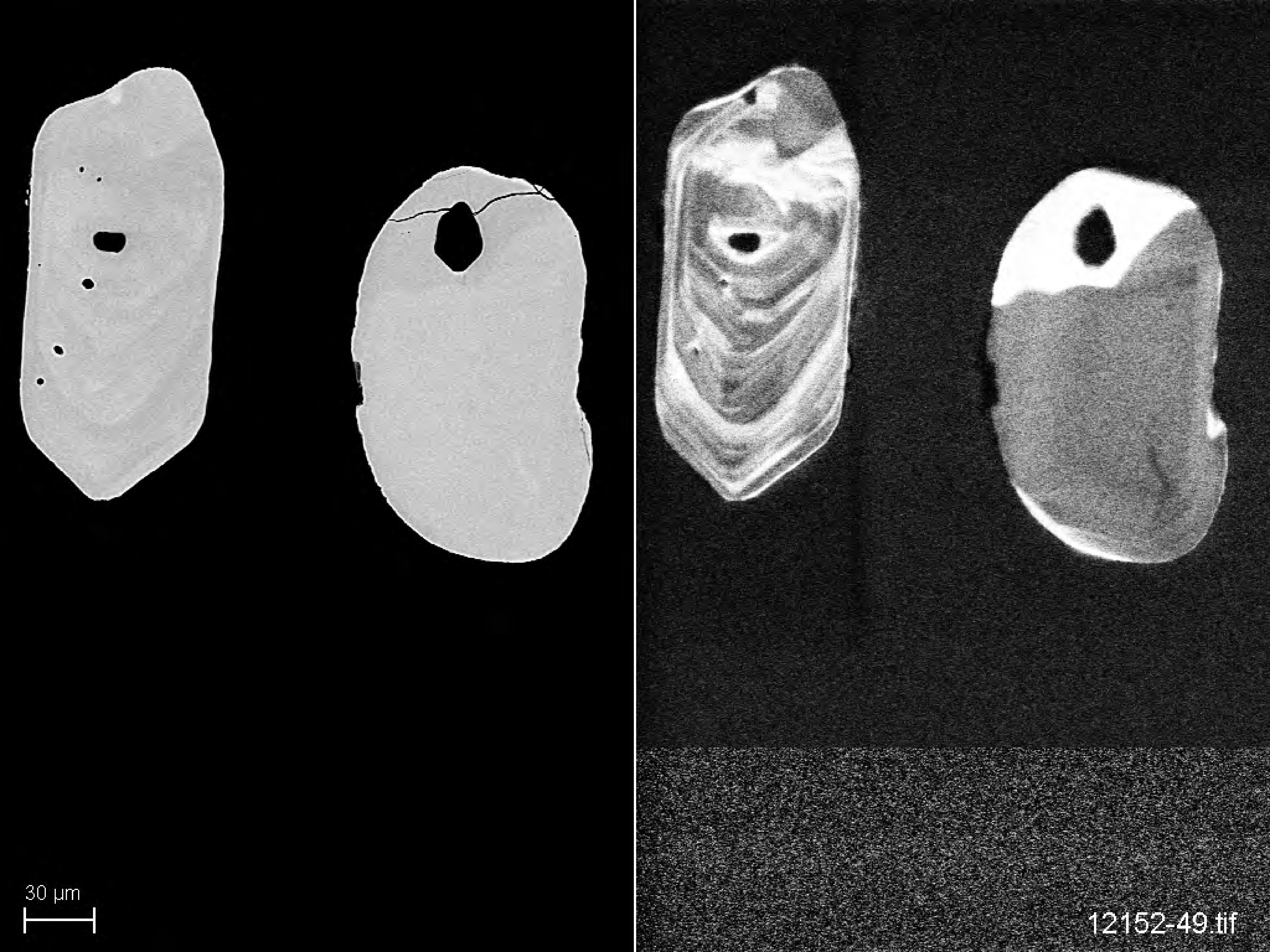
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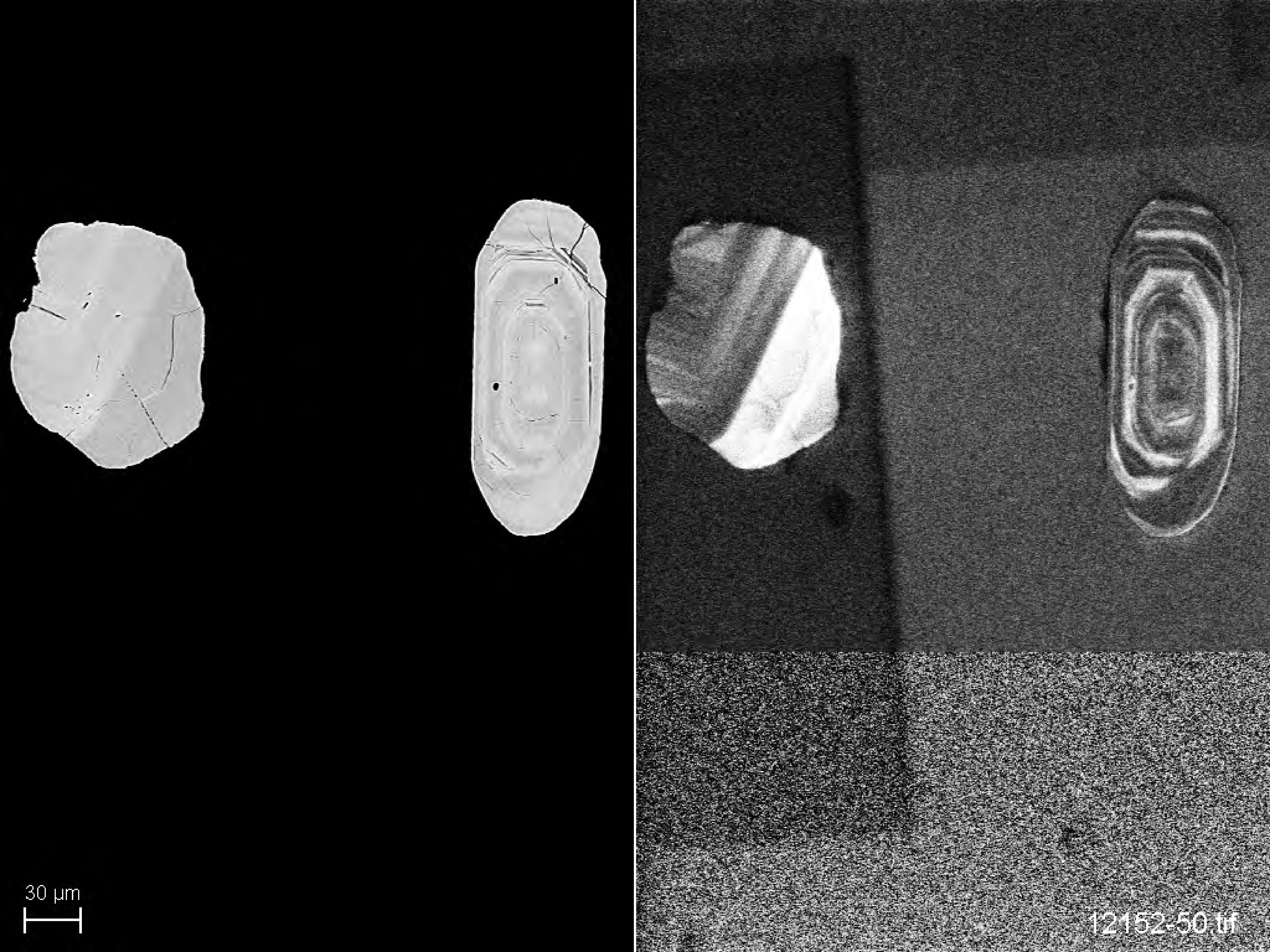

30 µm
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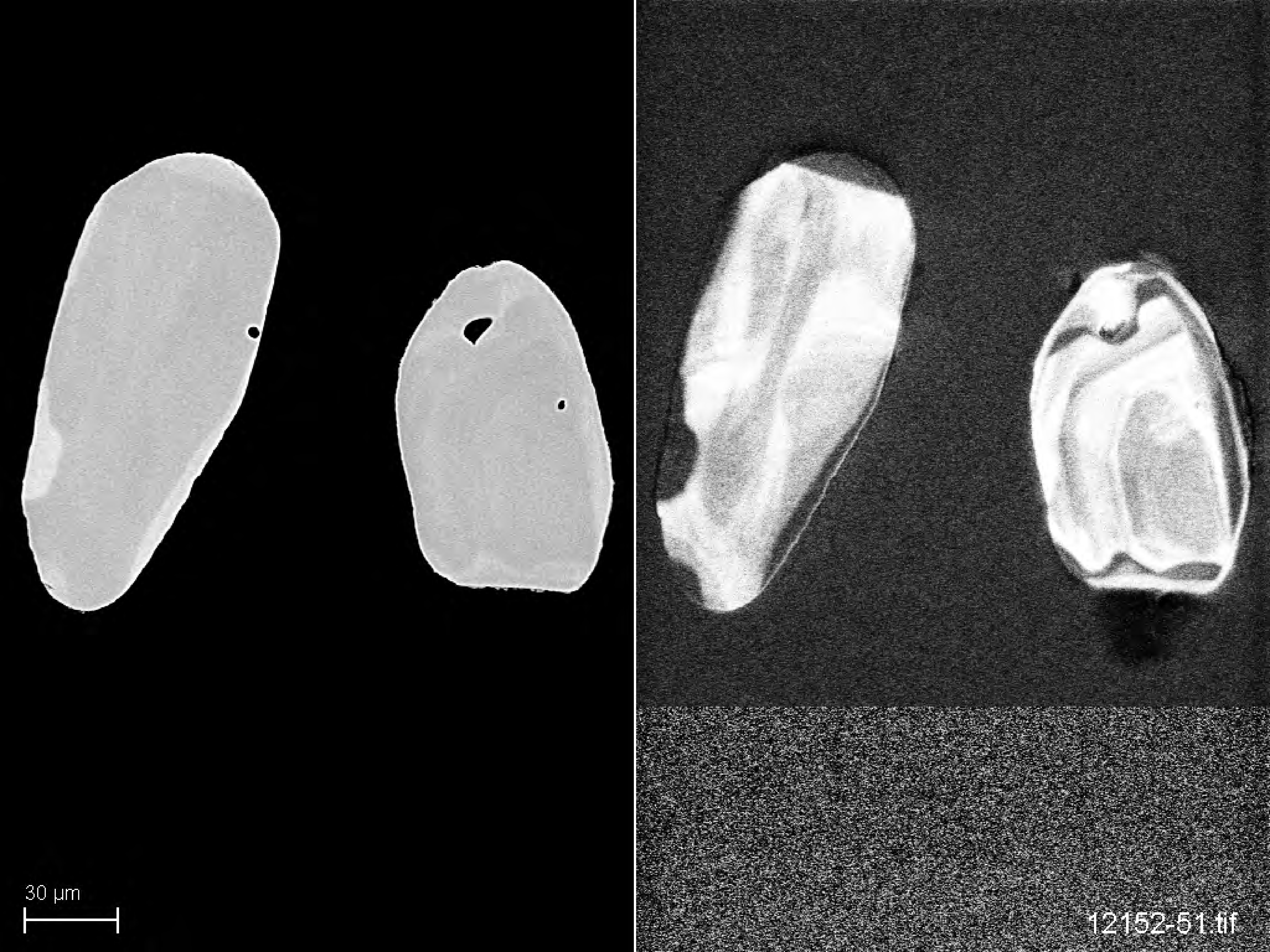
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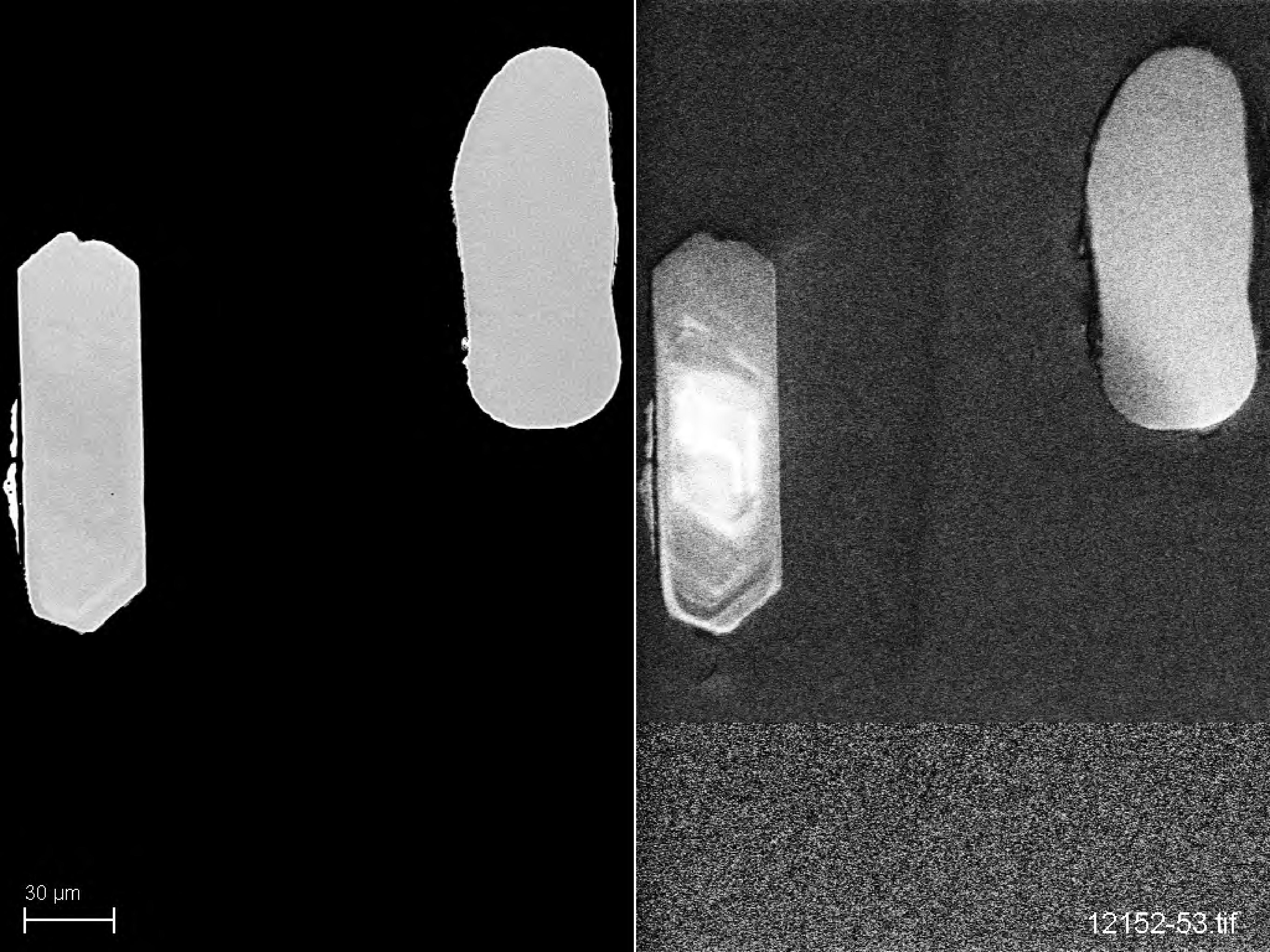
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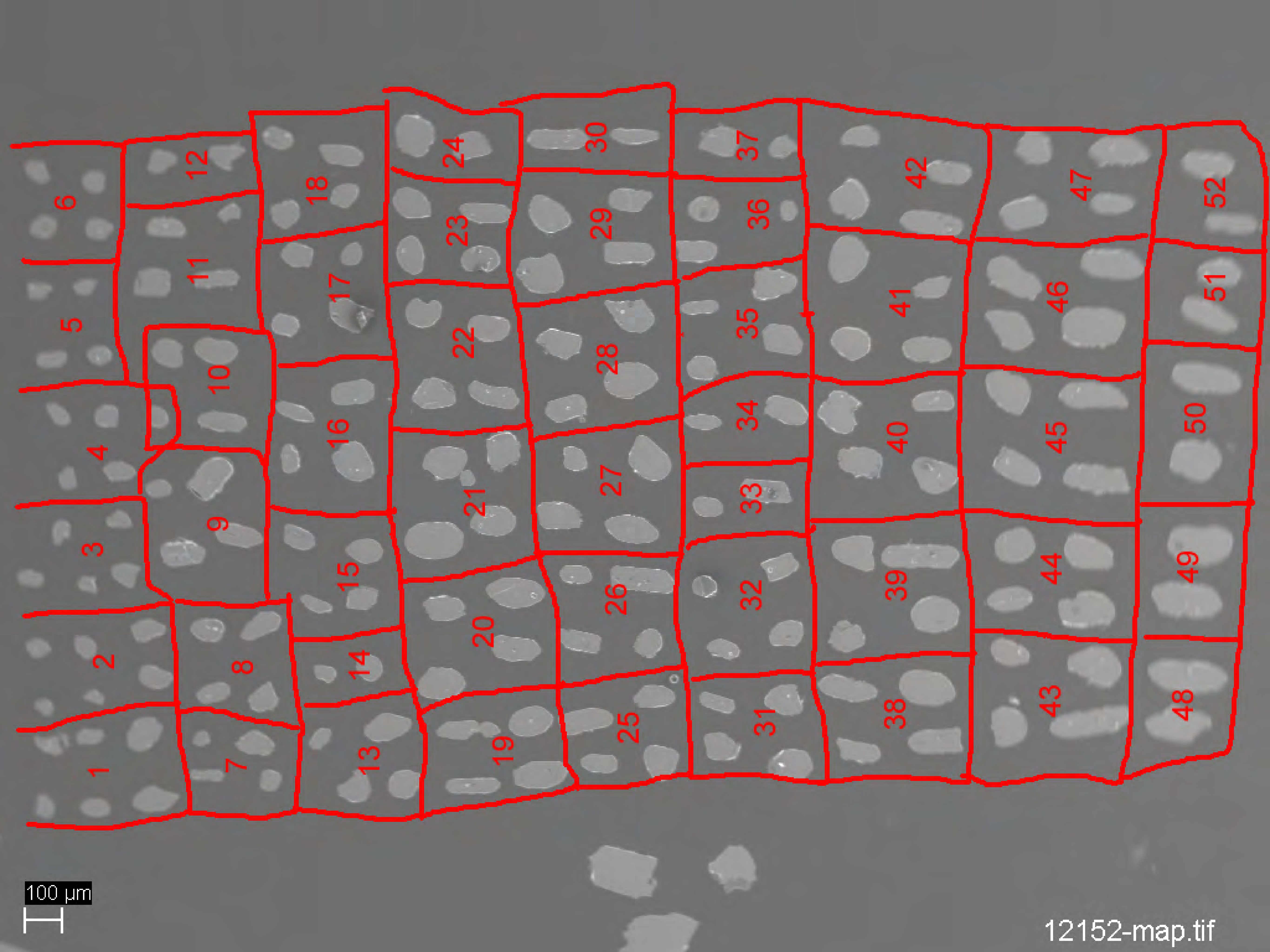

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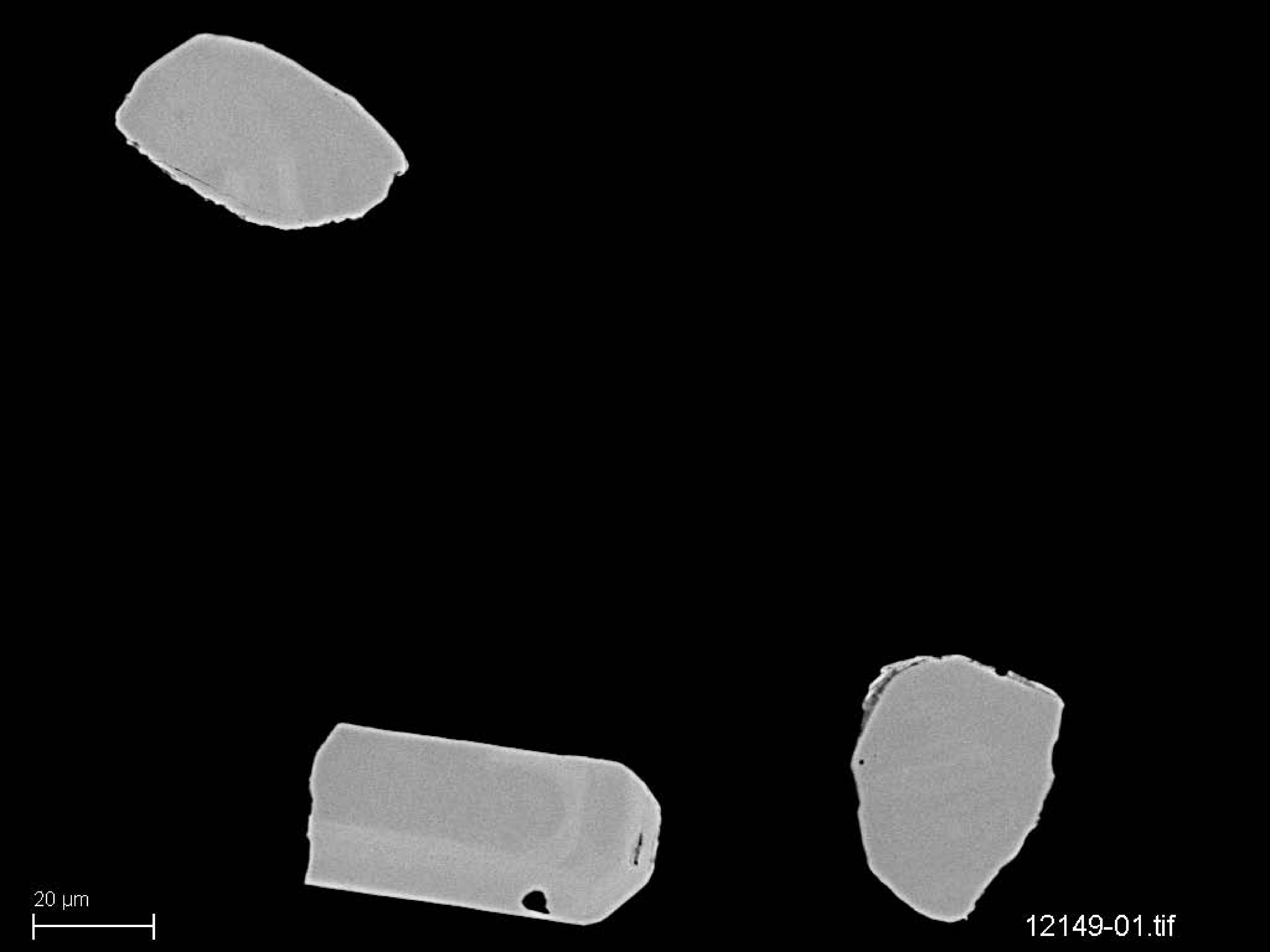
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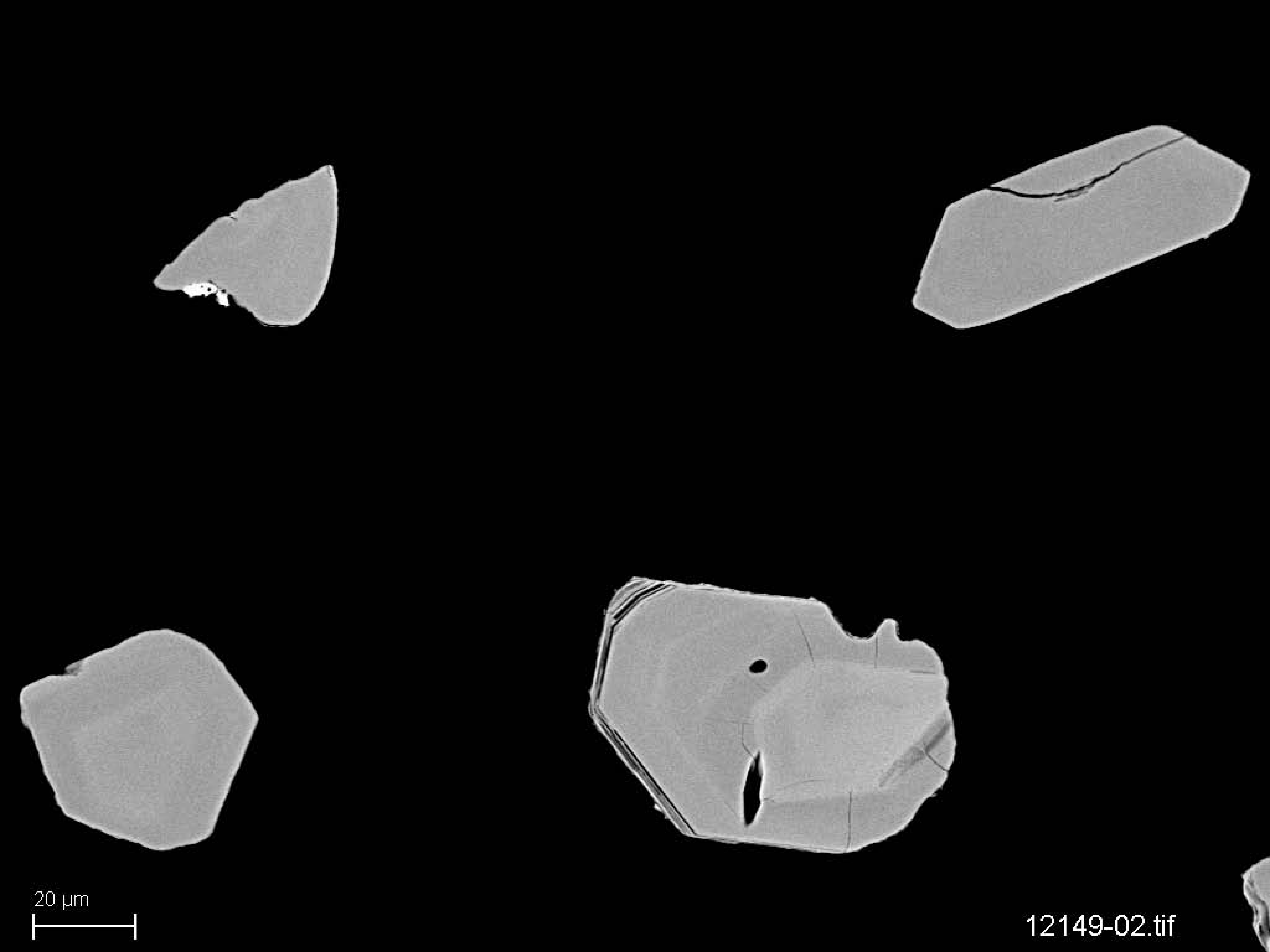

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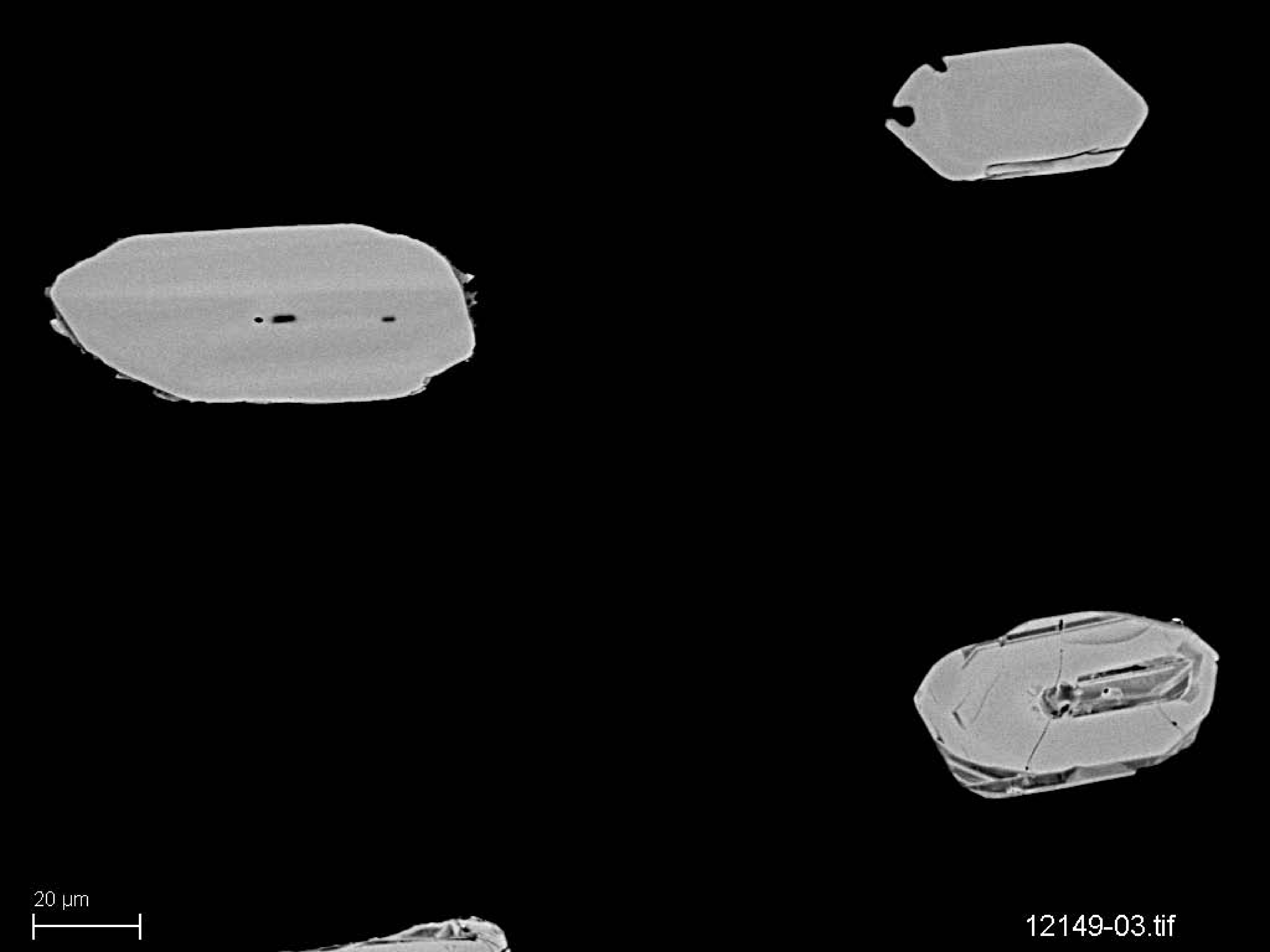
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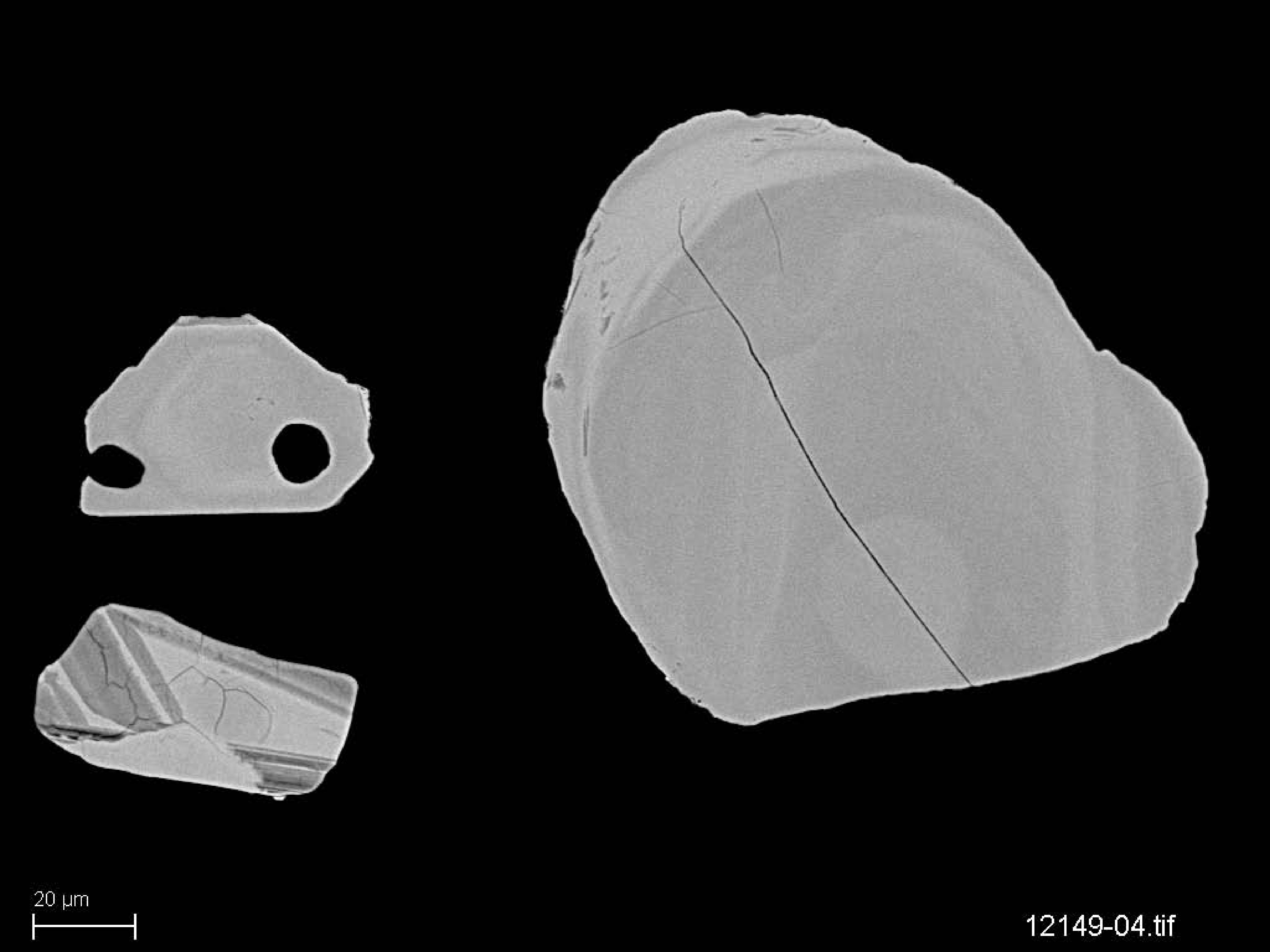
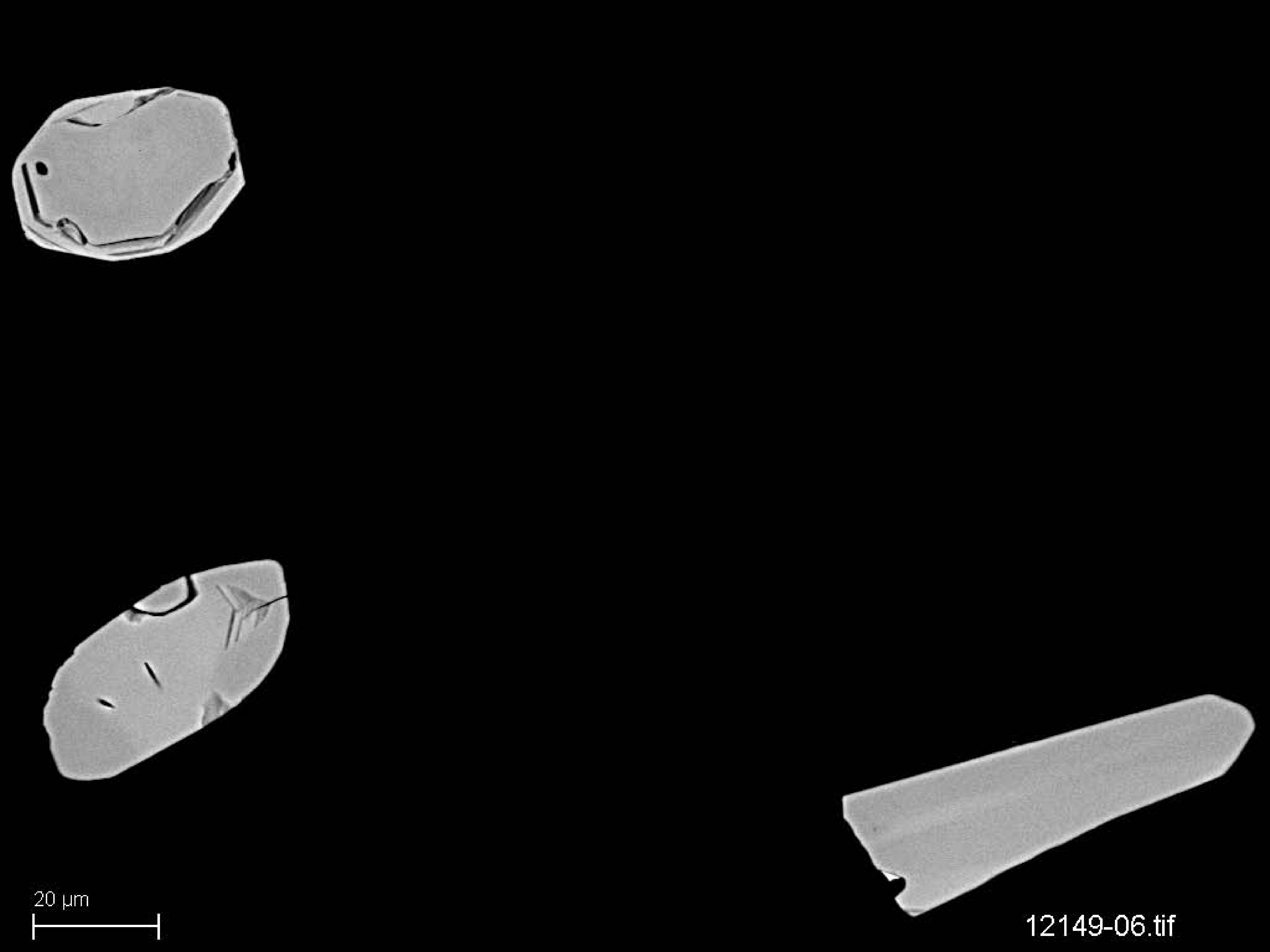

20 µm
12149-04.tif


10 µm
12149-05.tif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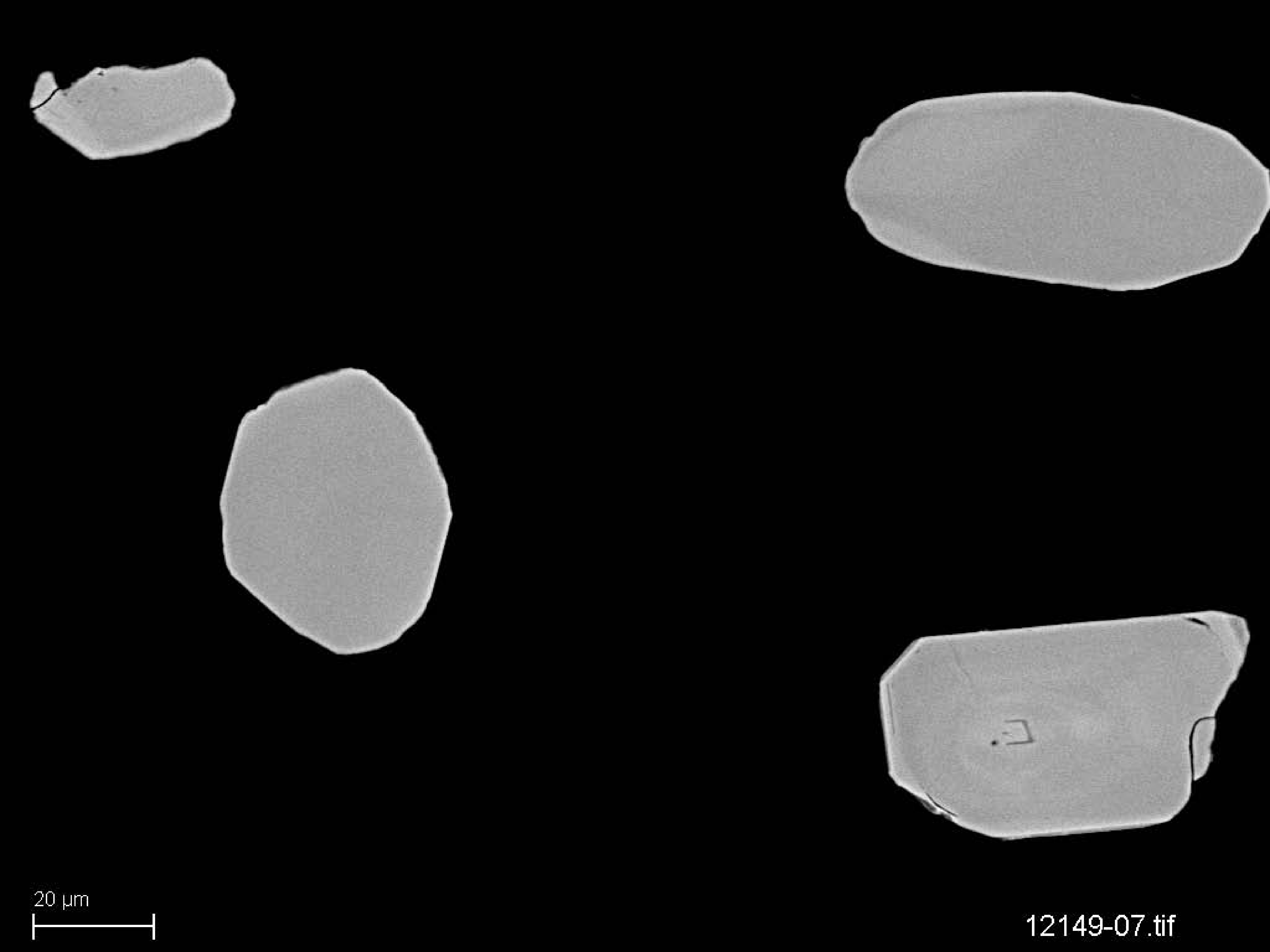
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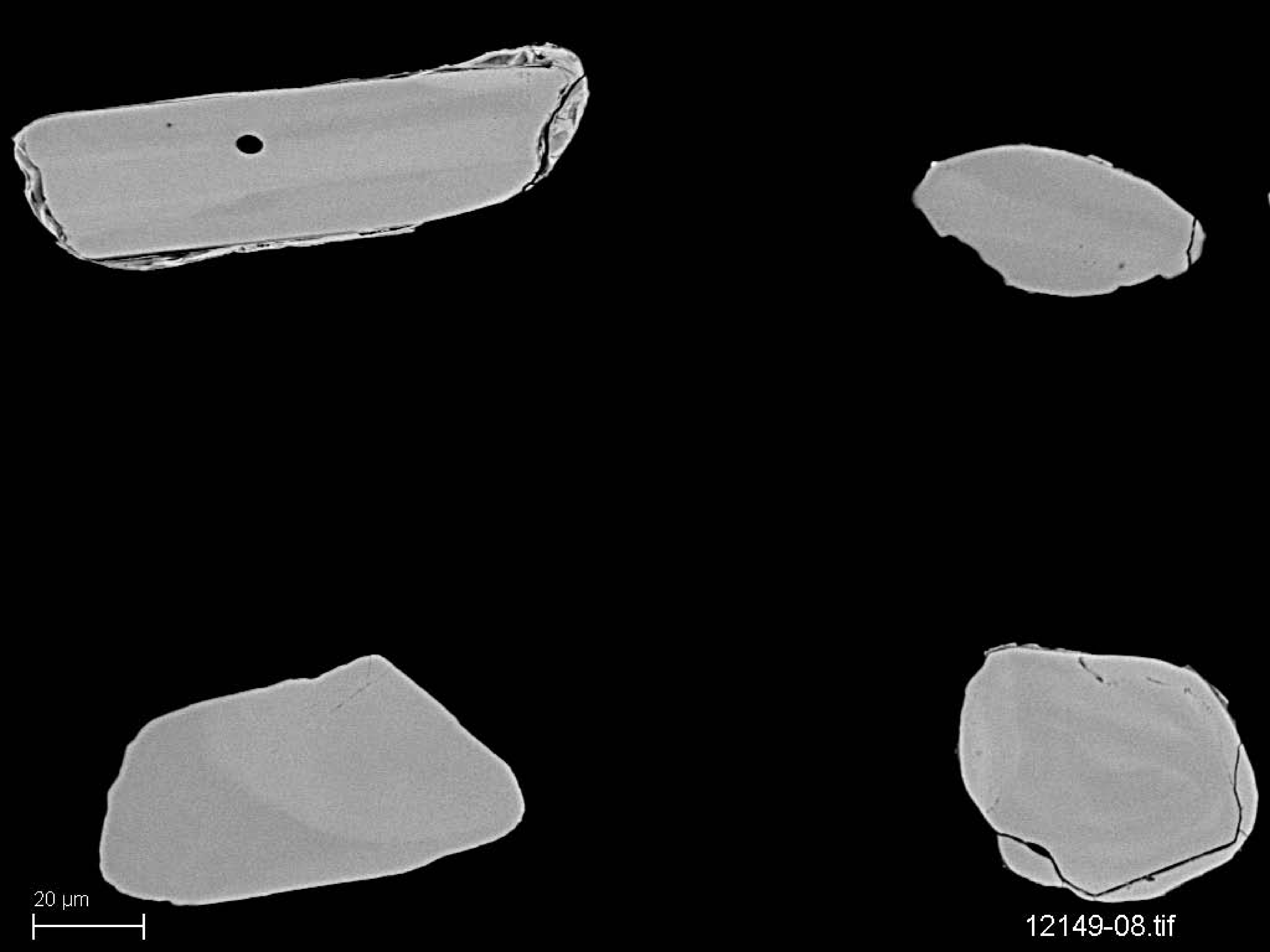
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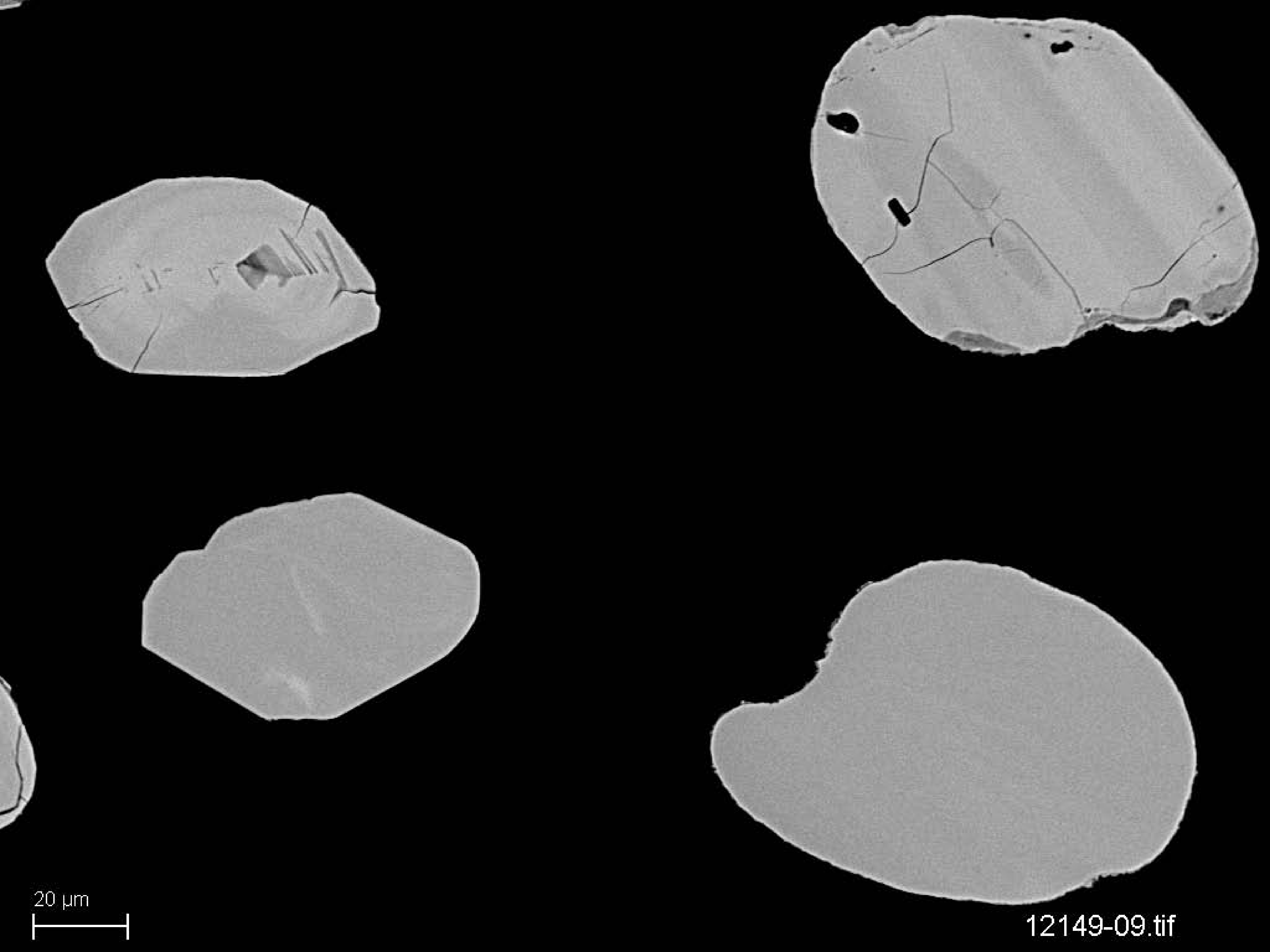

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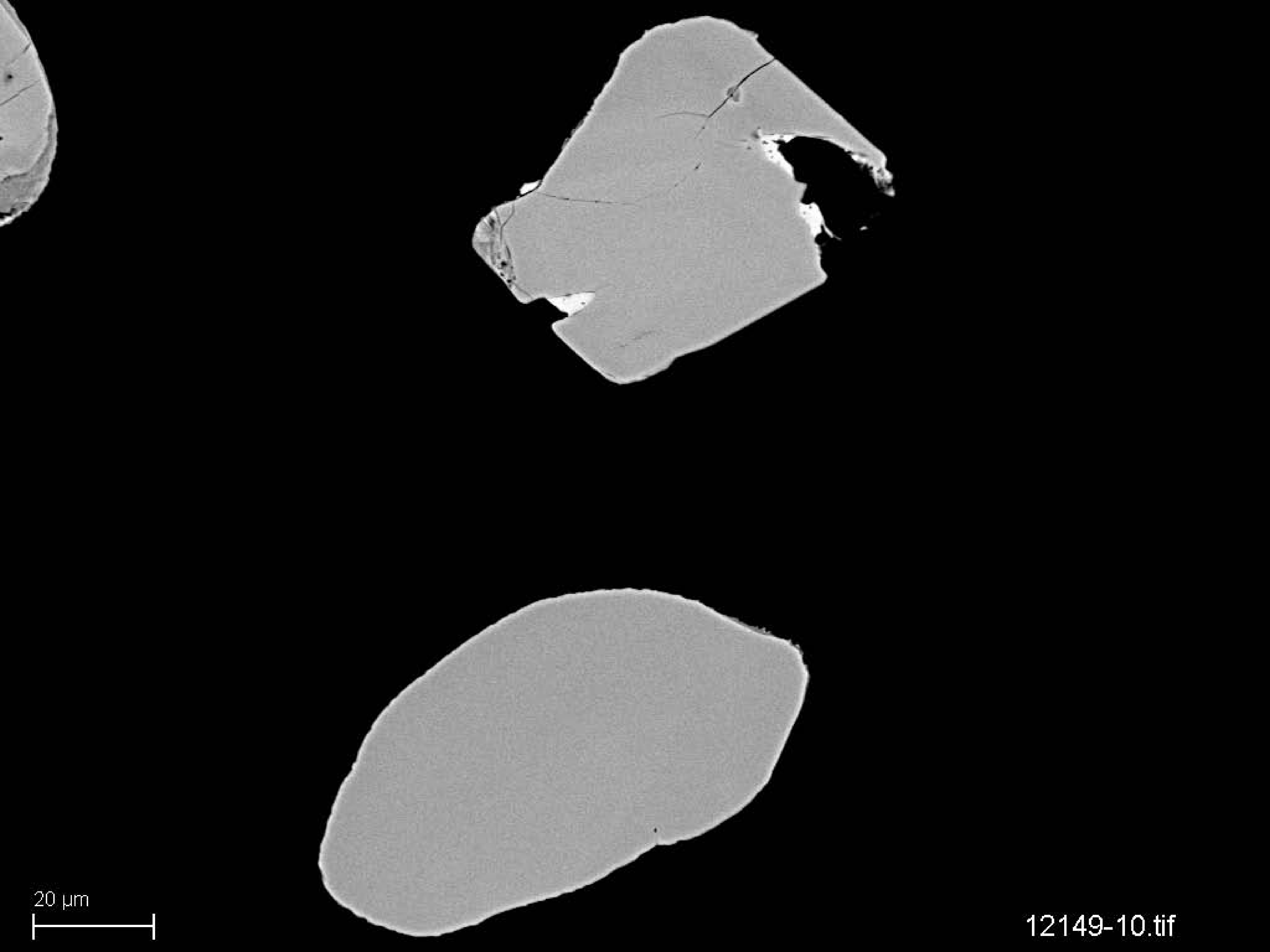
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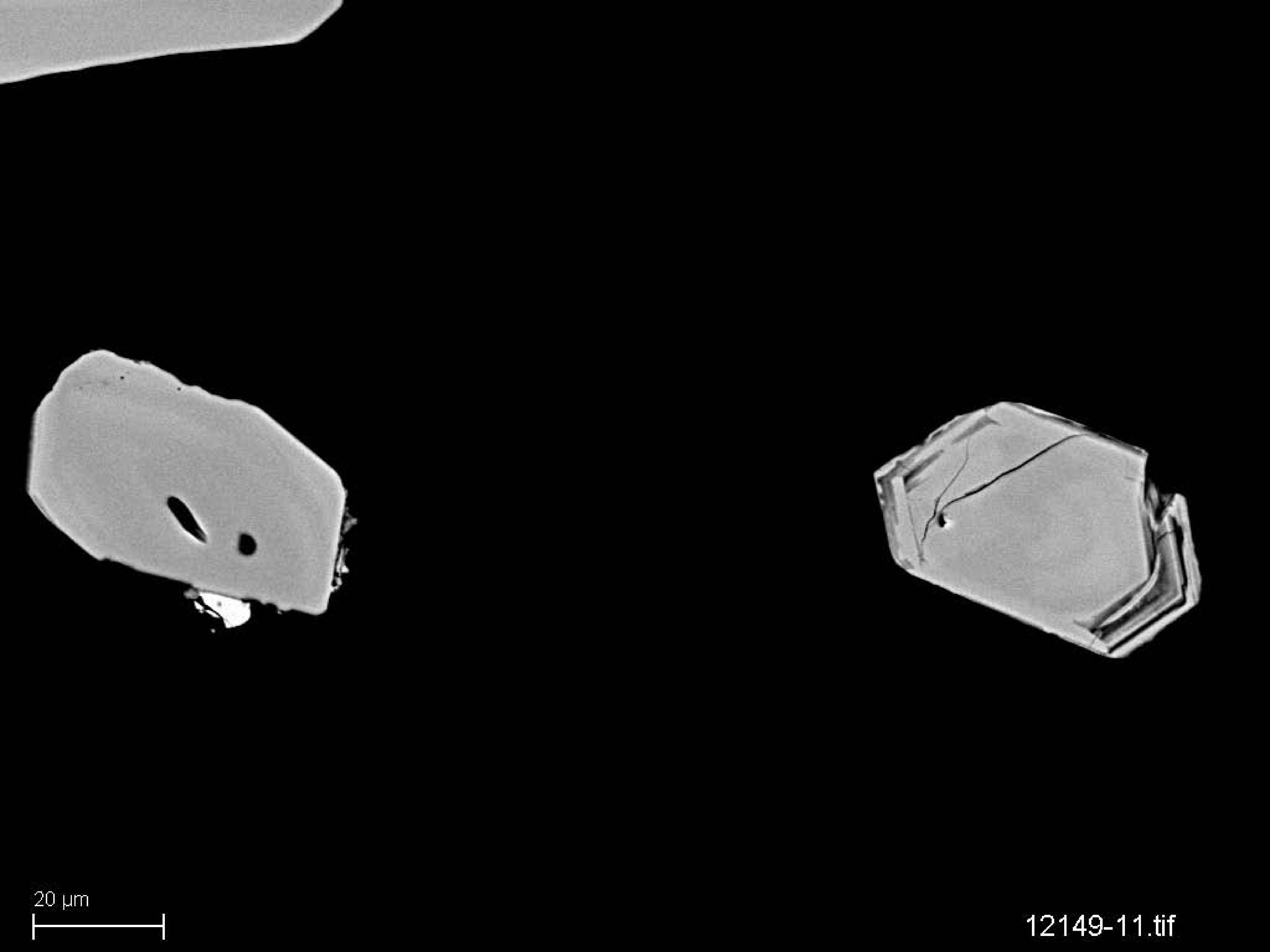
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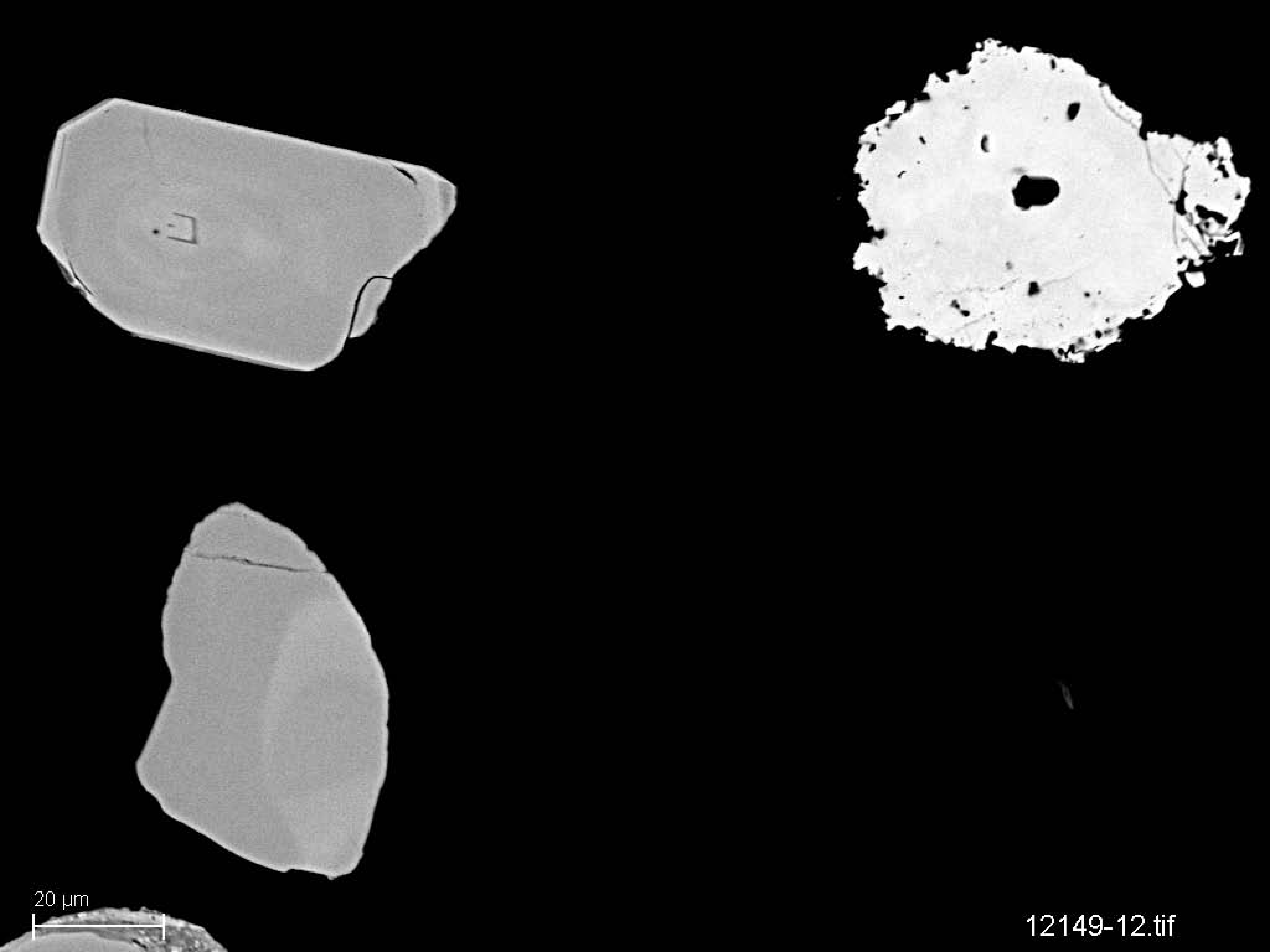
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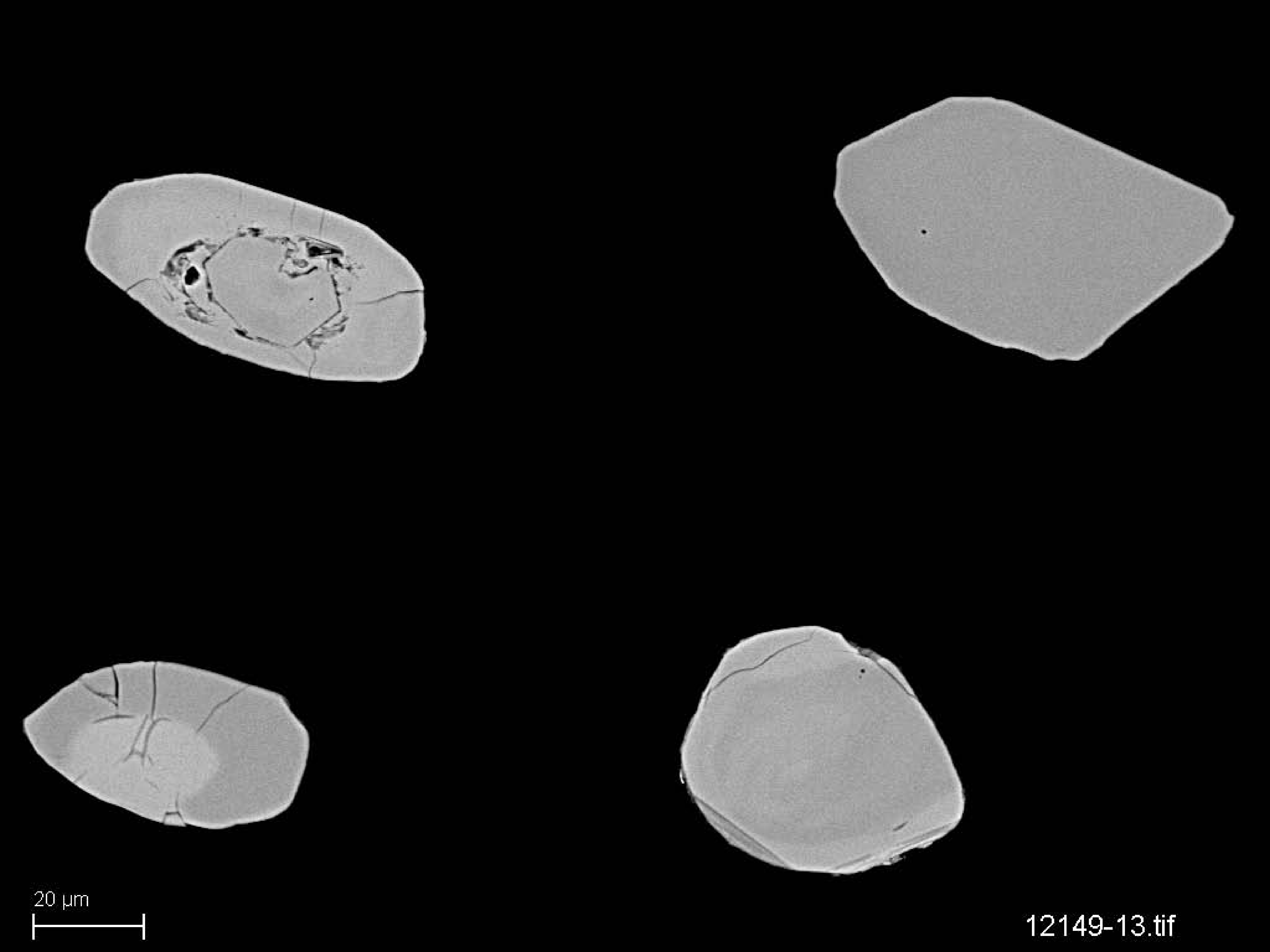
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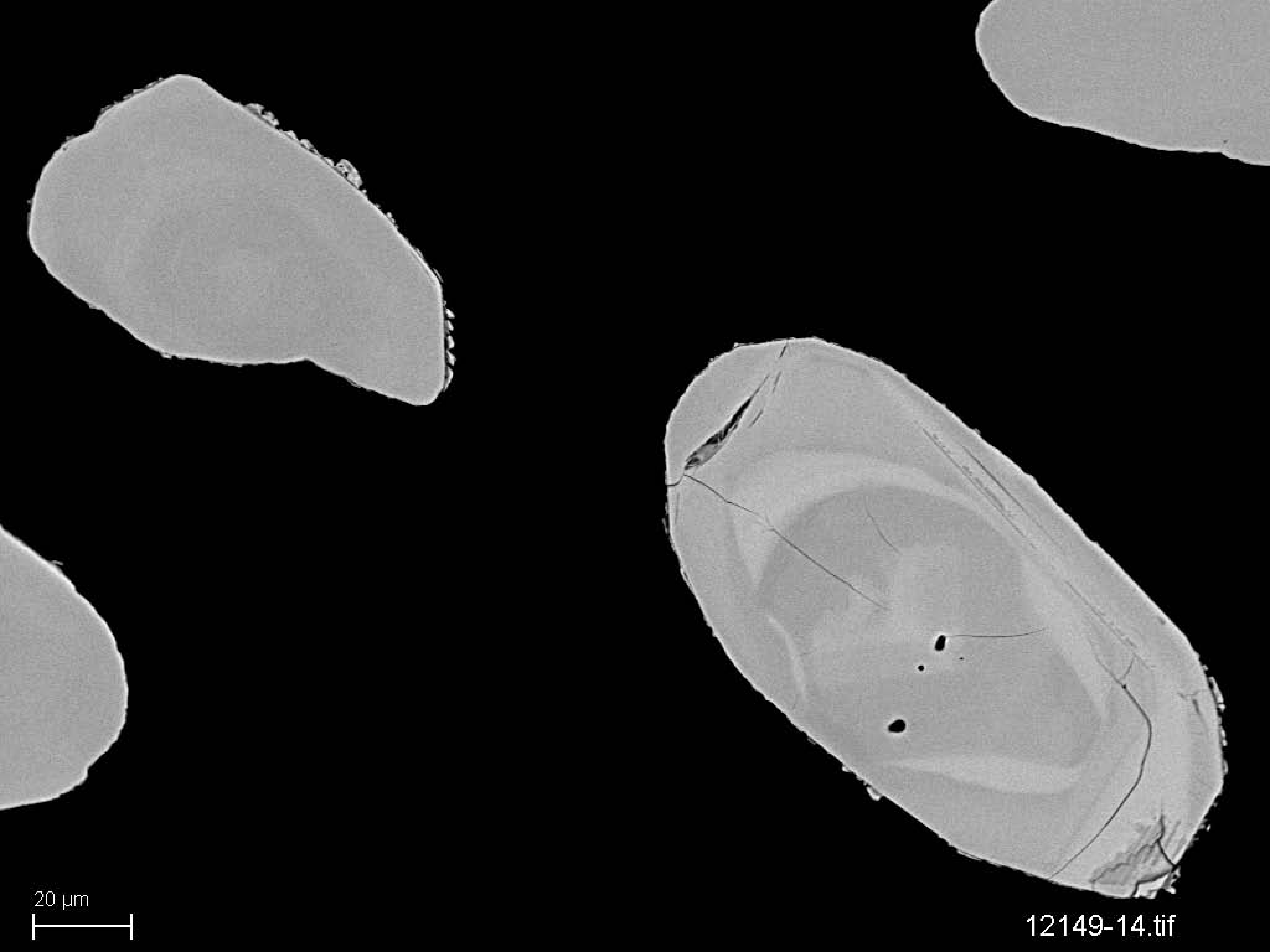
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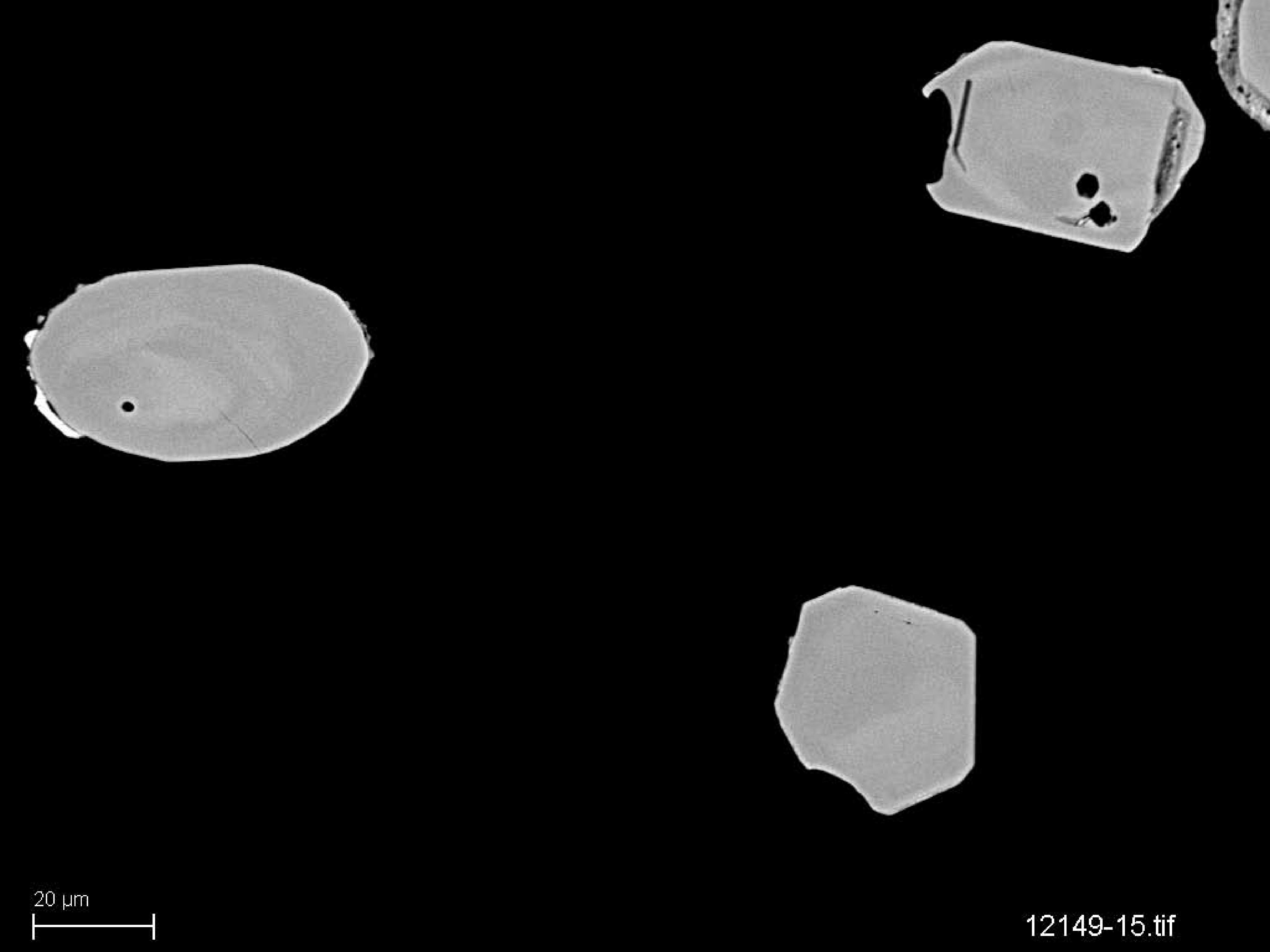
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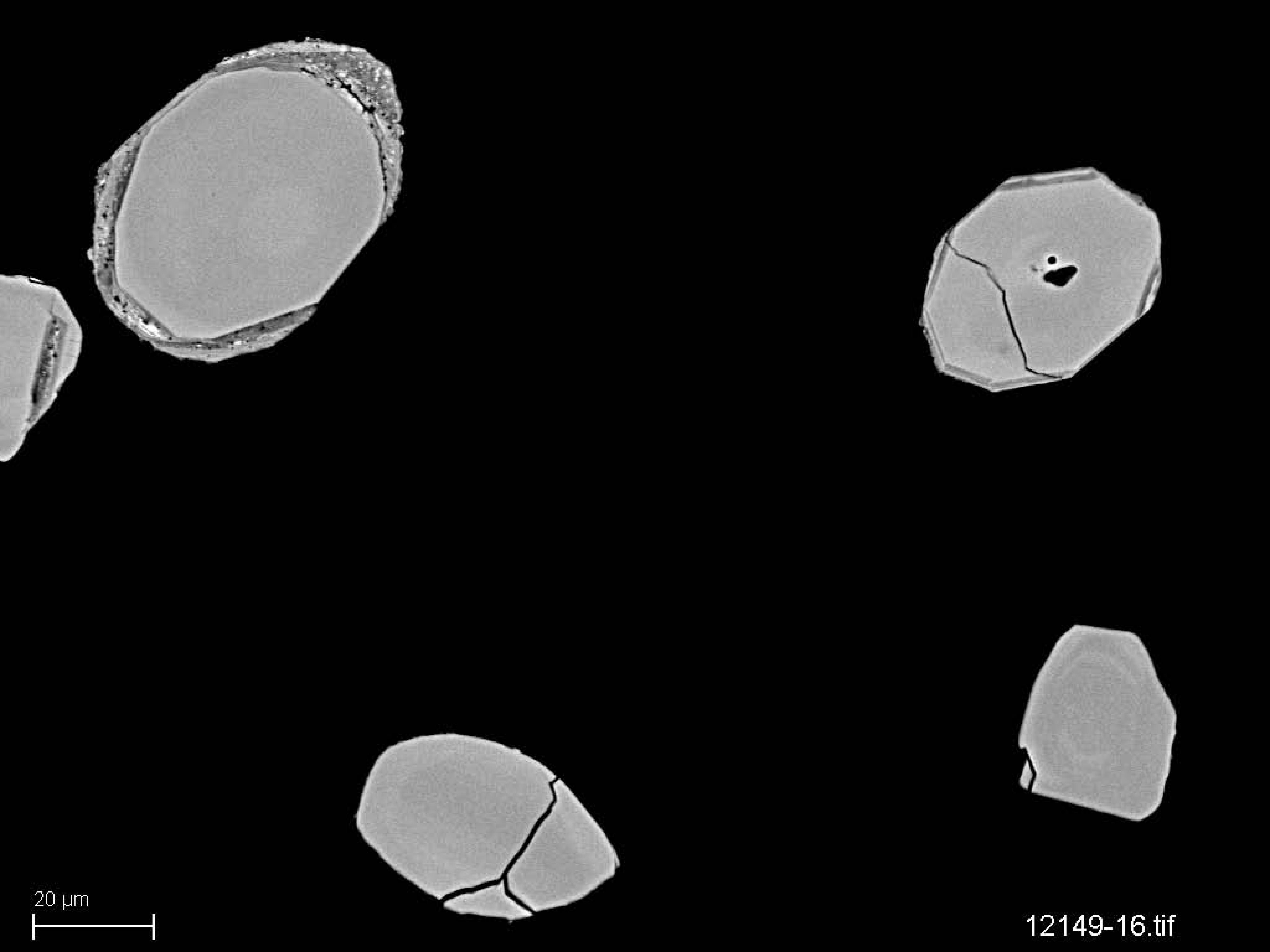
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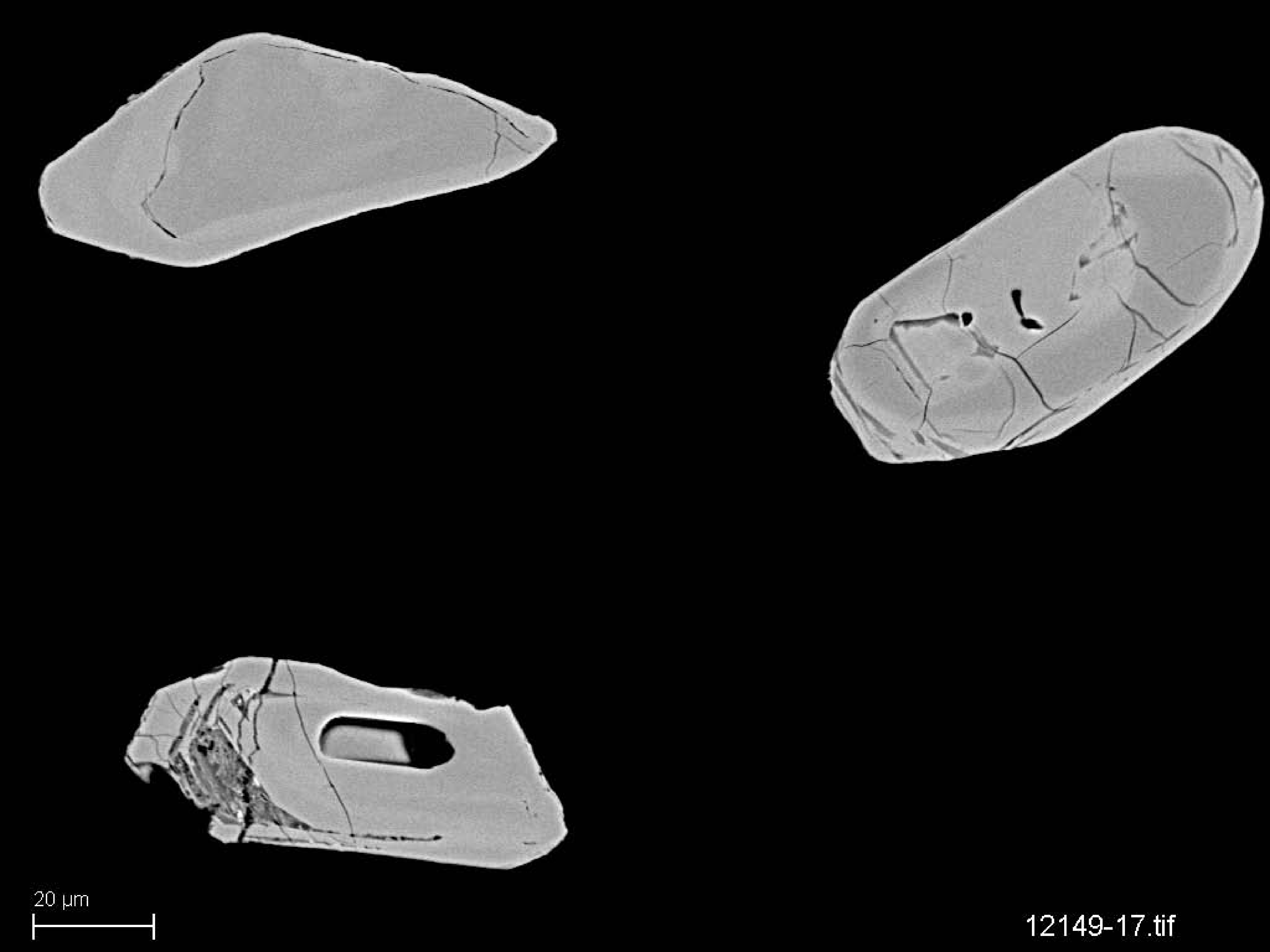
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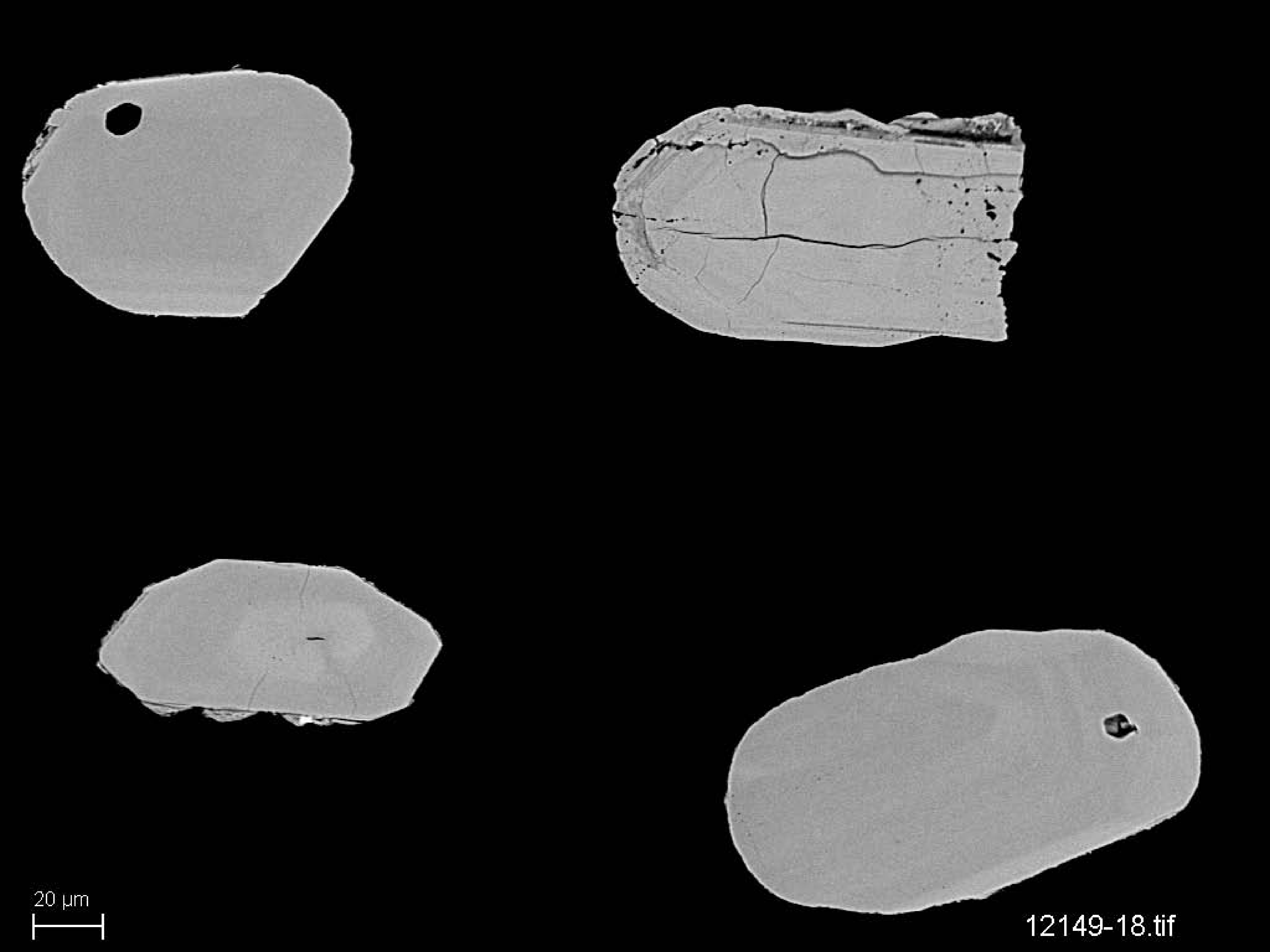
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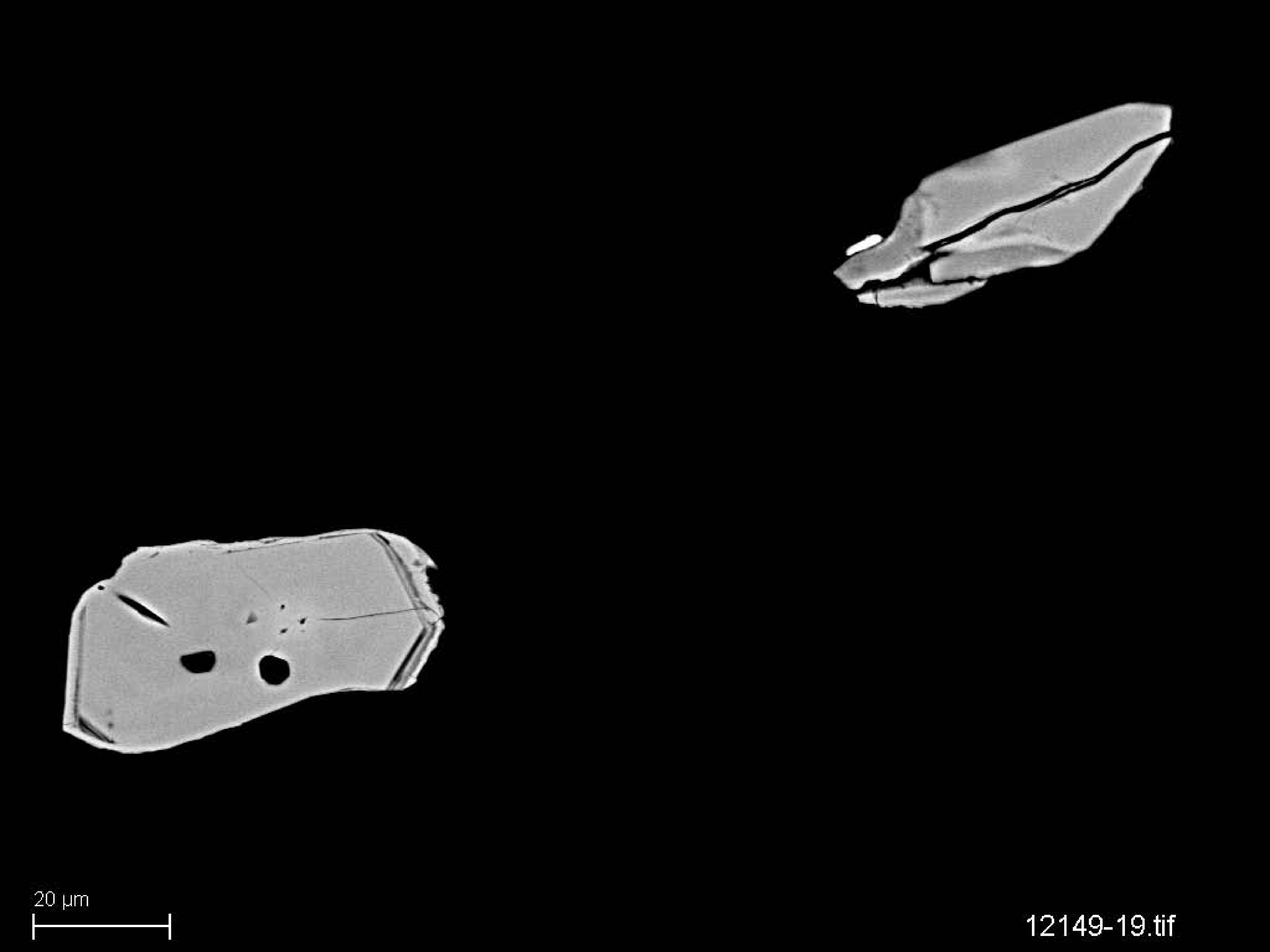
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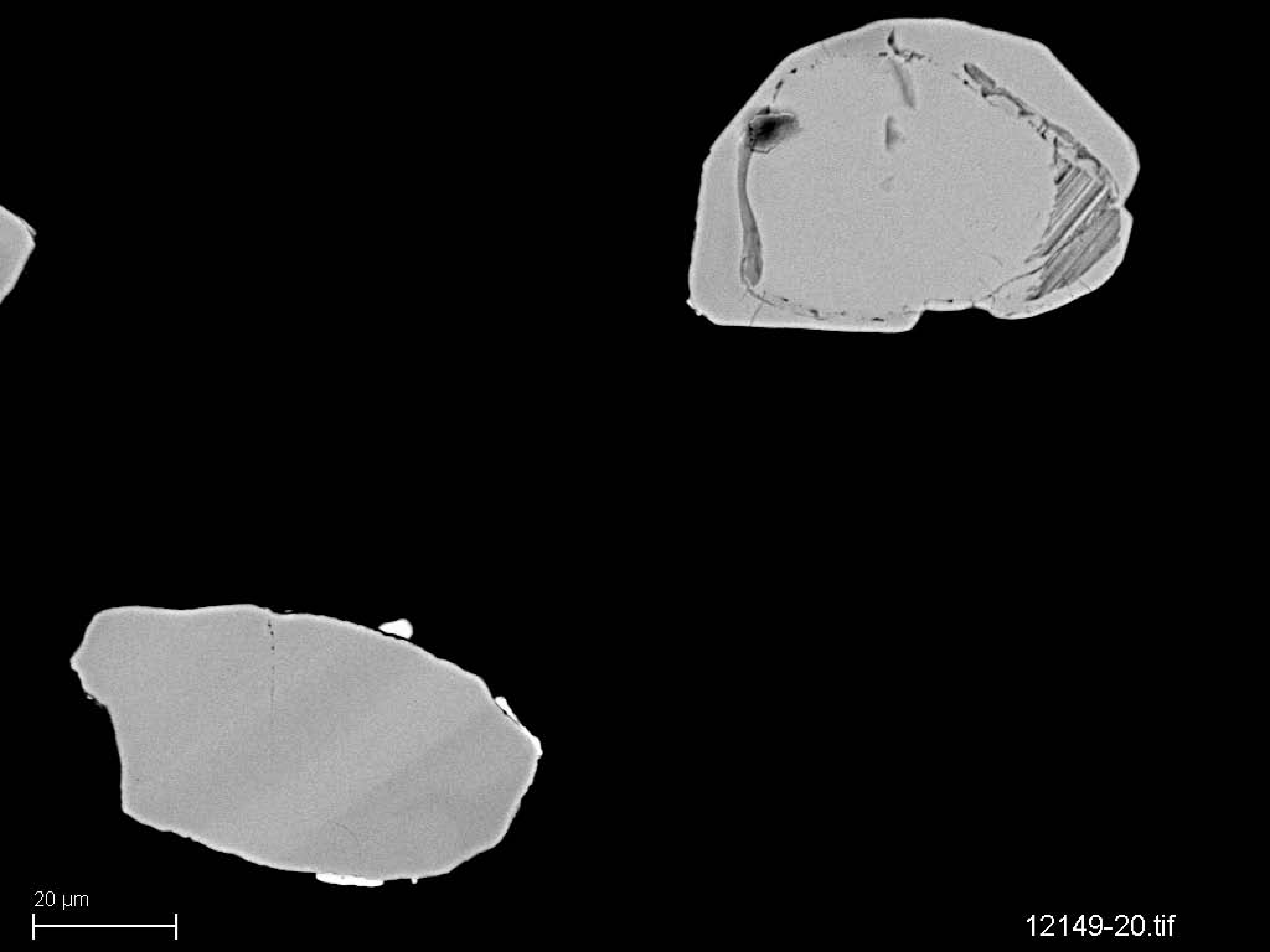
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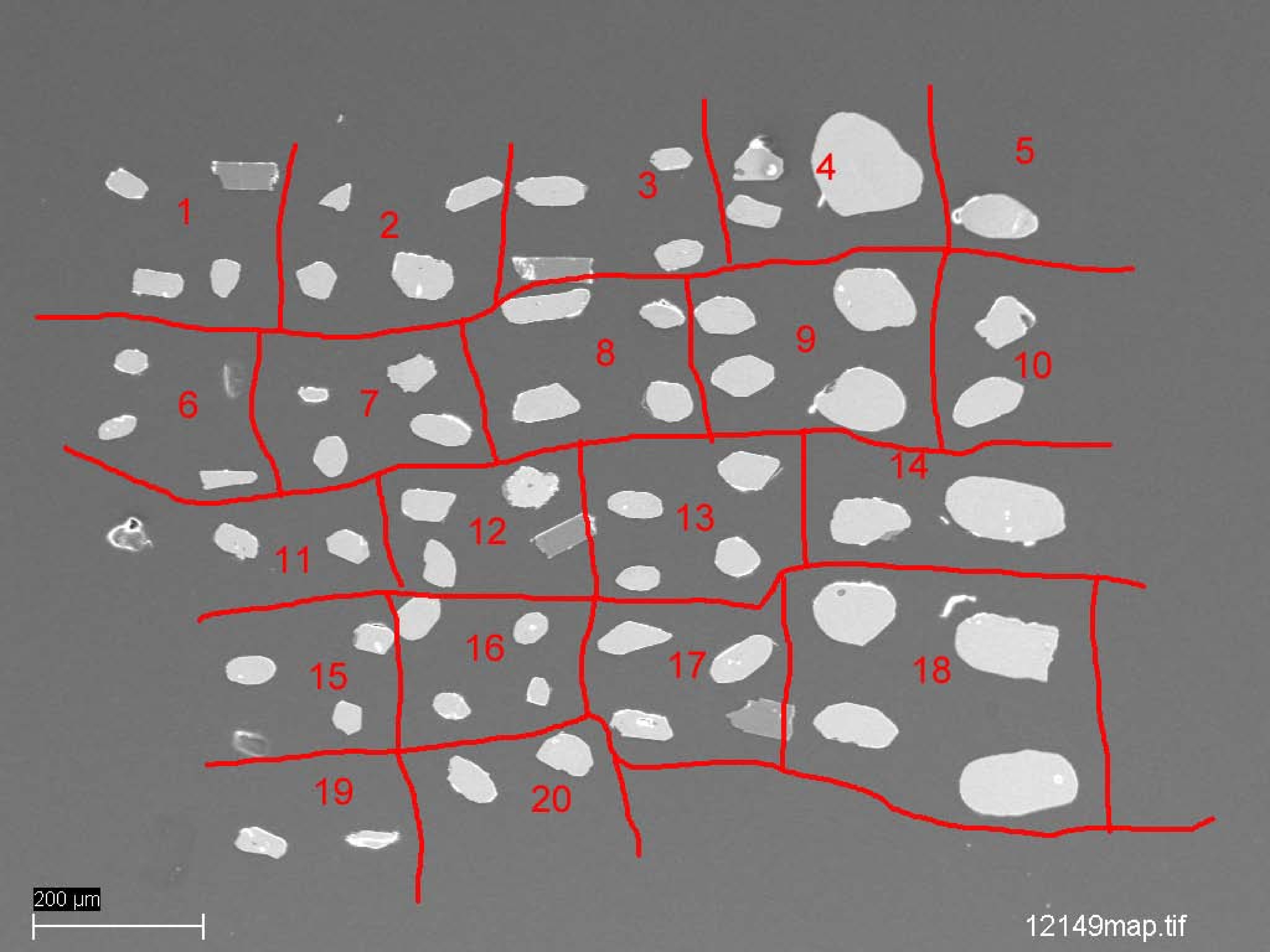

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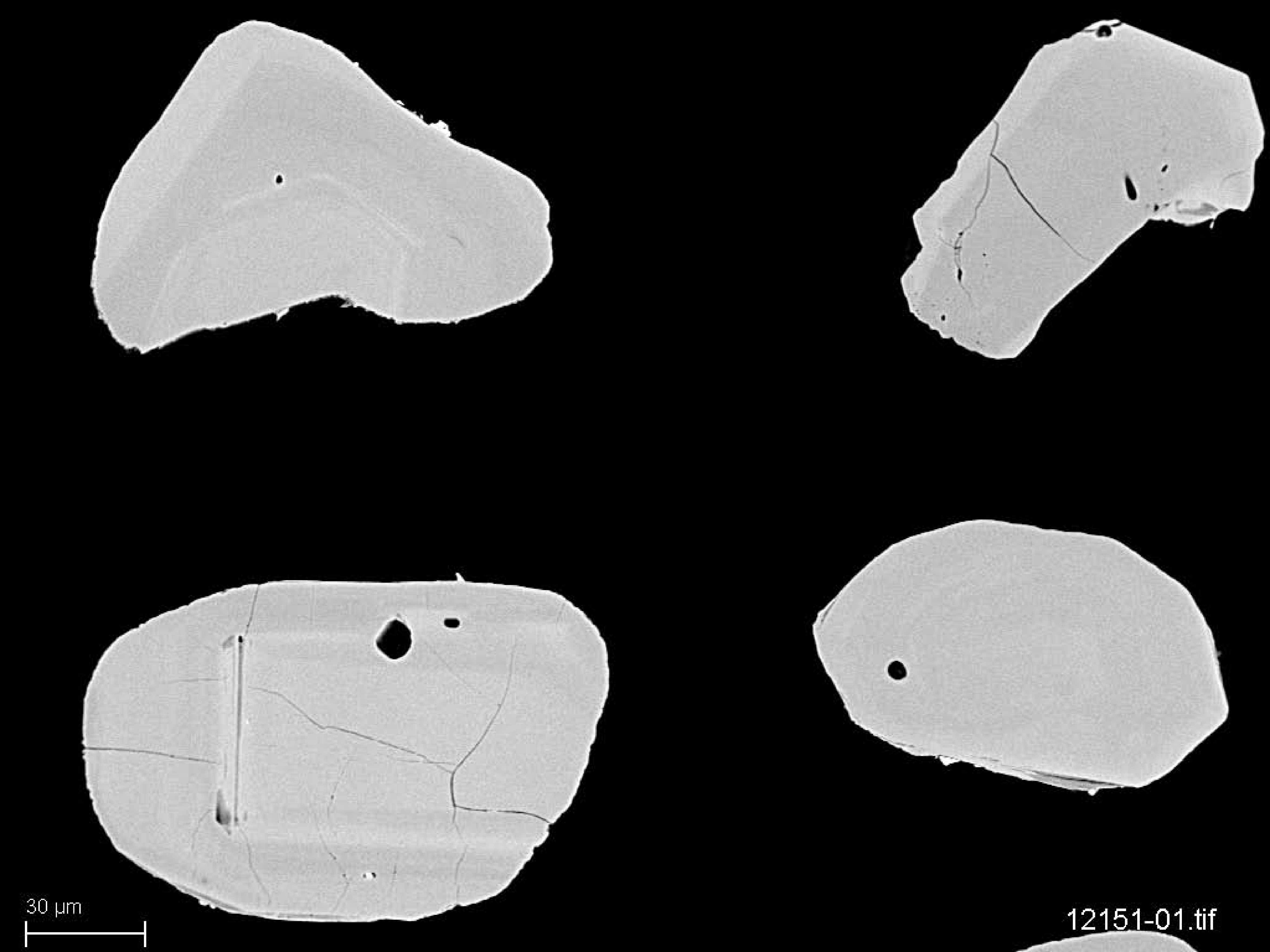
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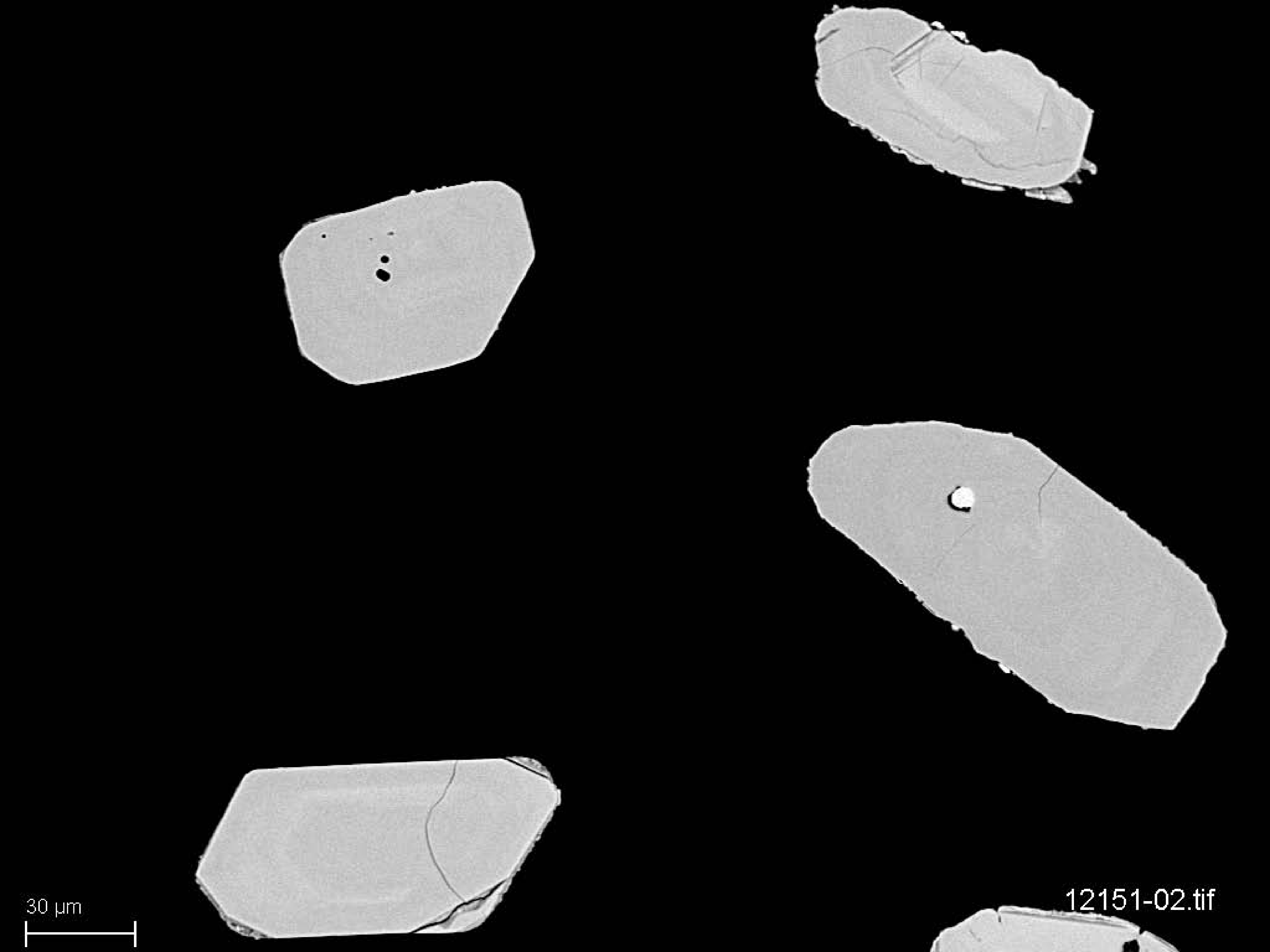

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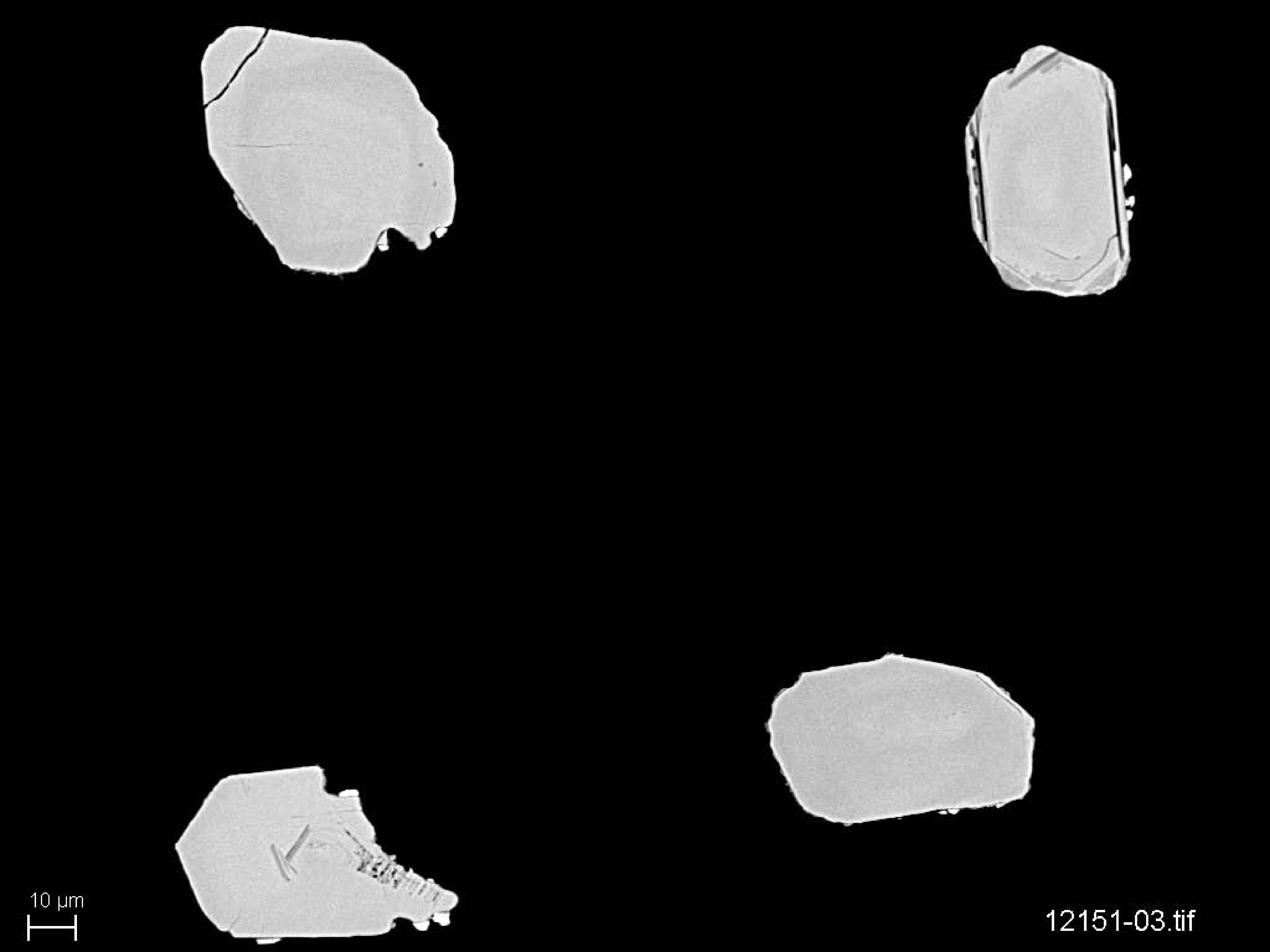
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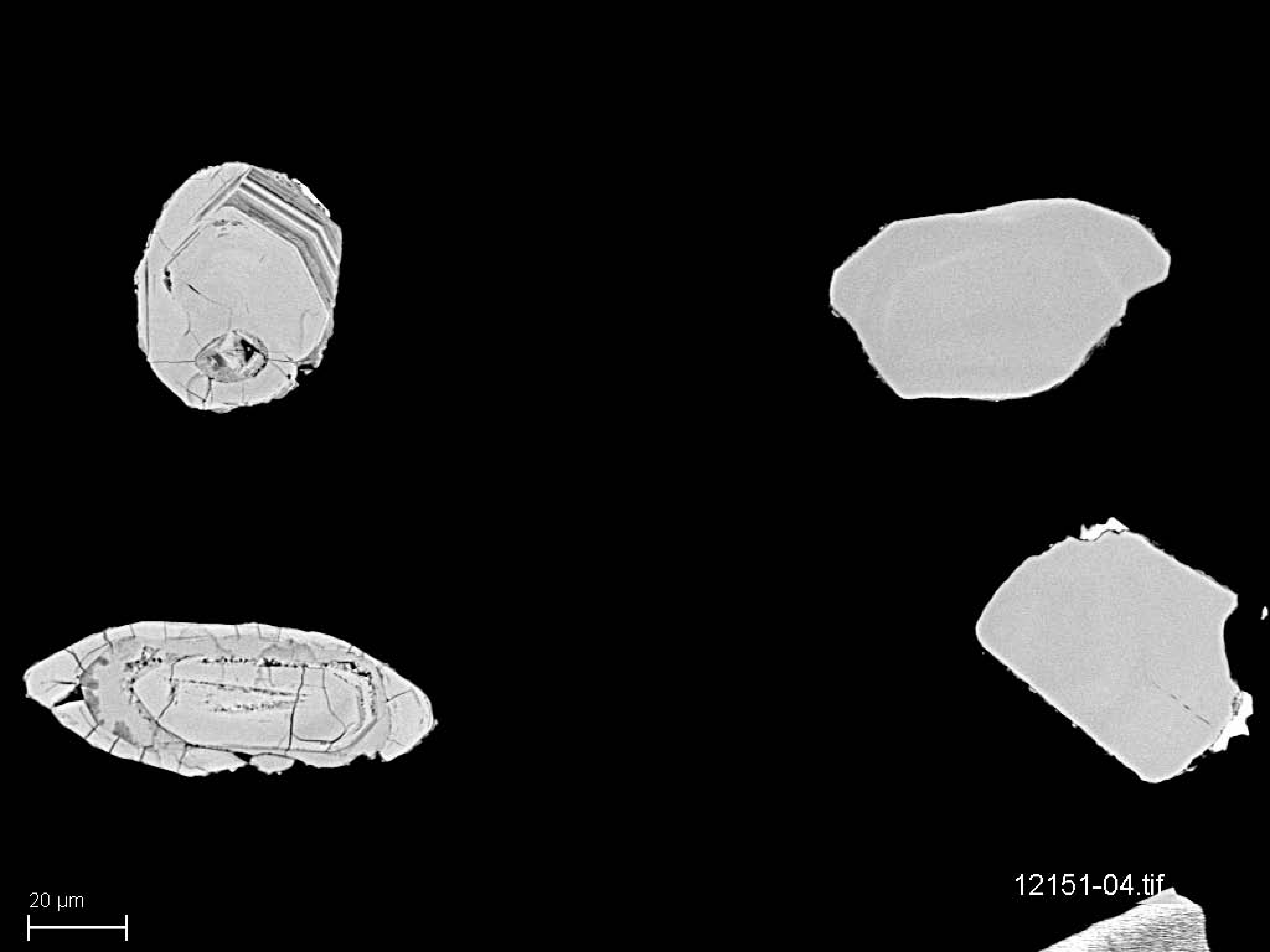
20 µm
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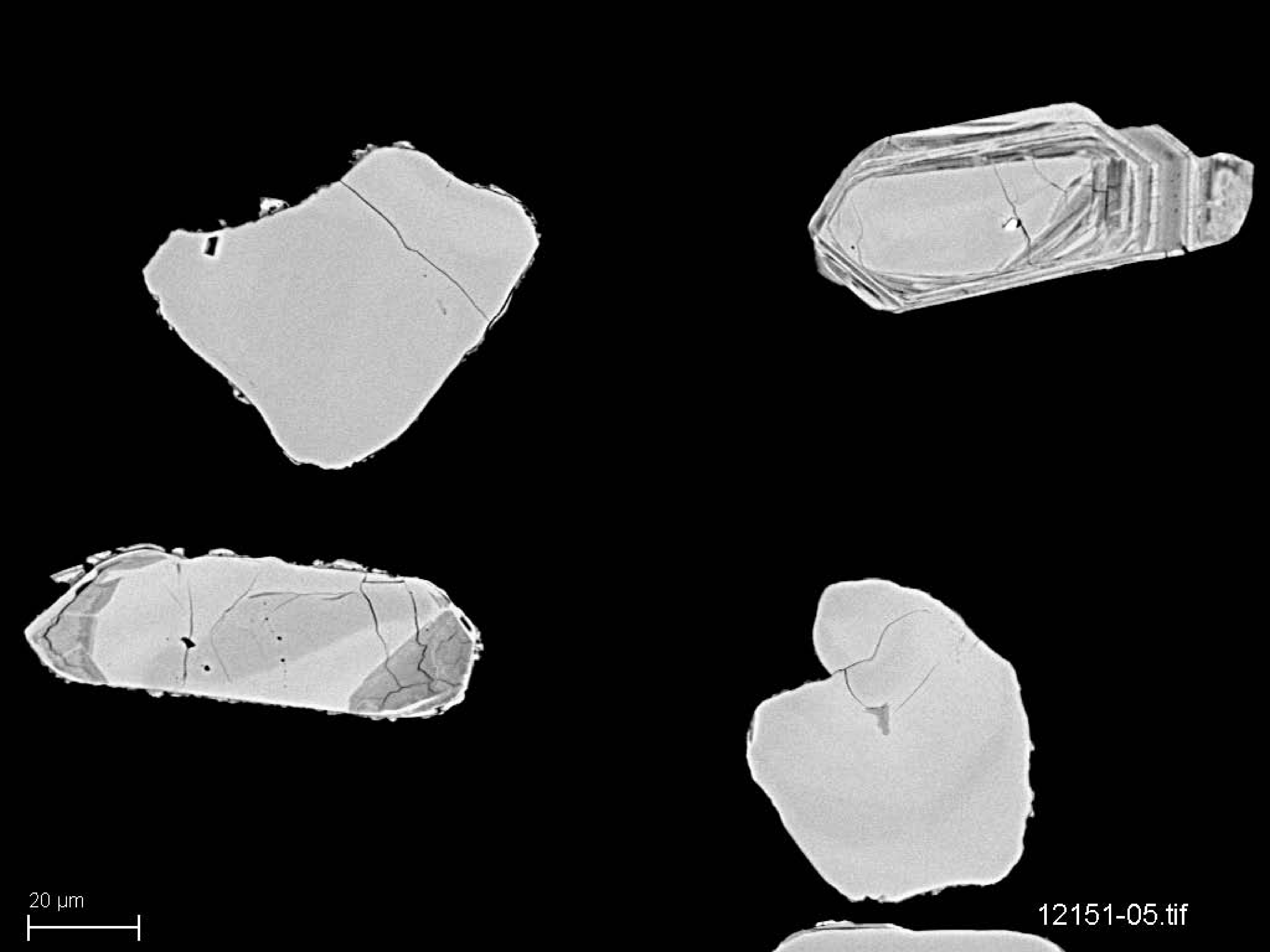
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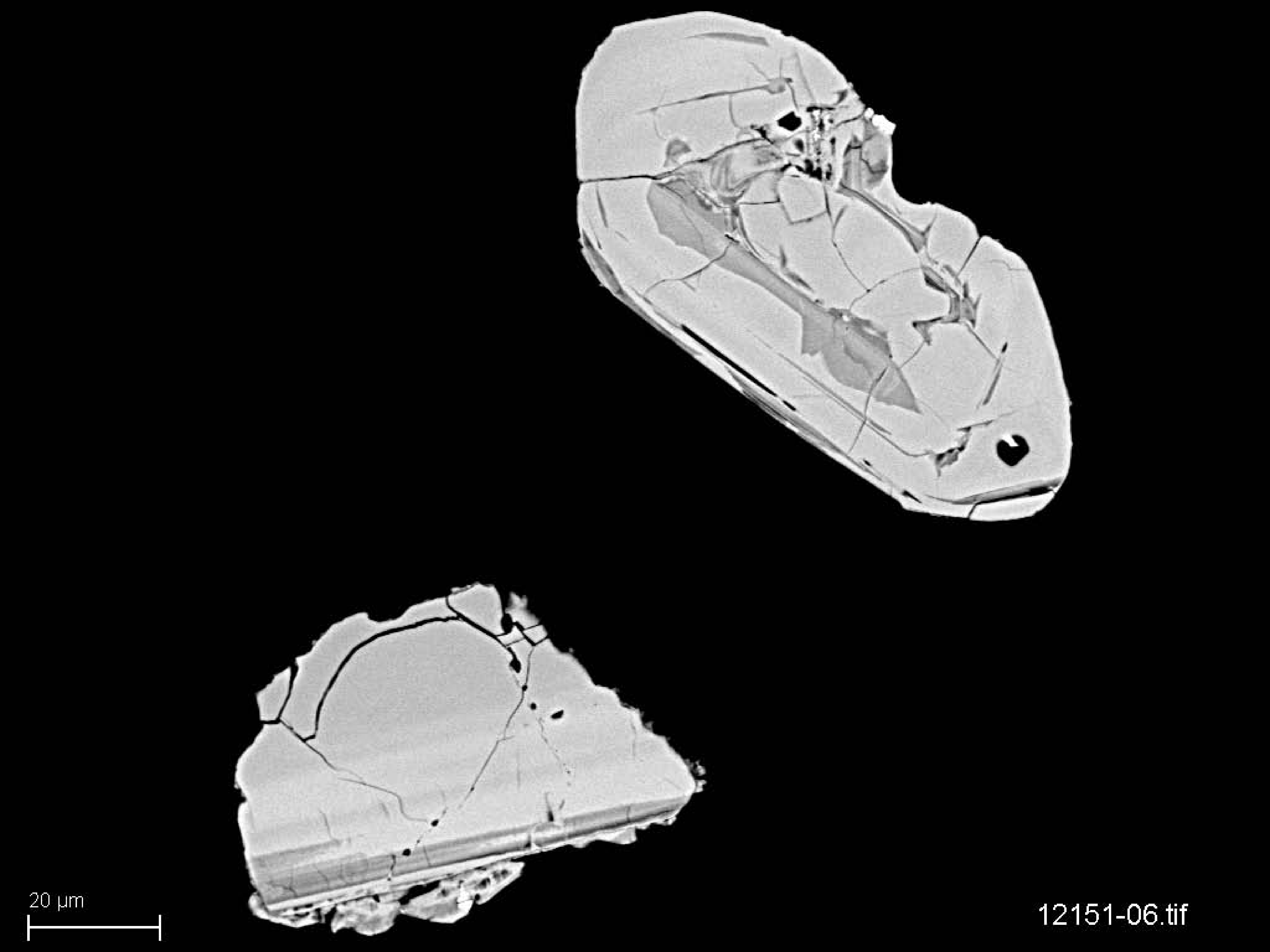
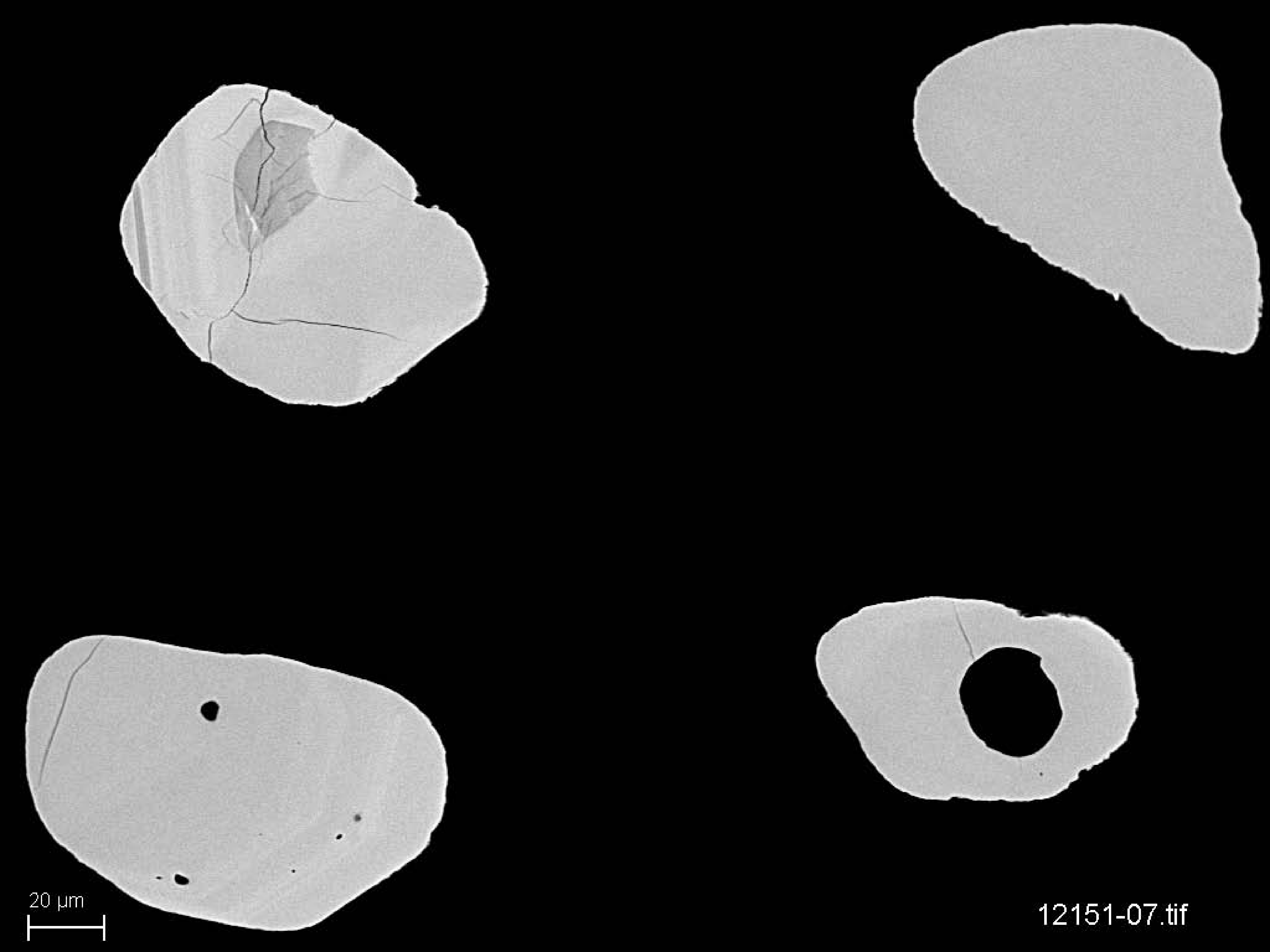
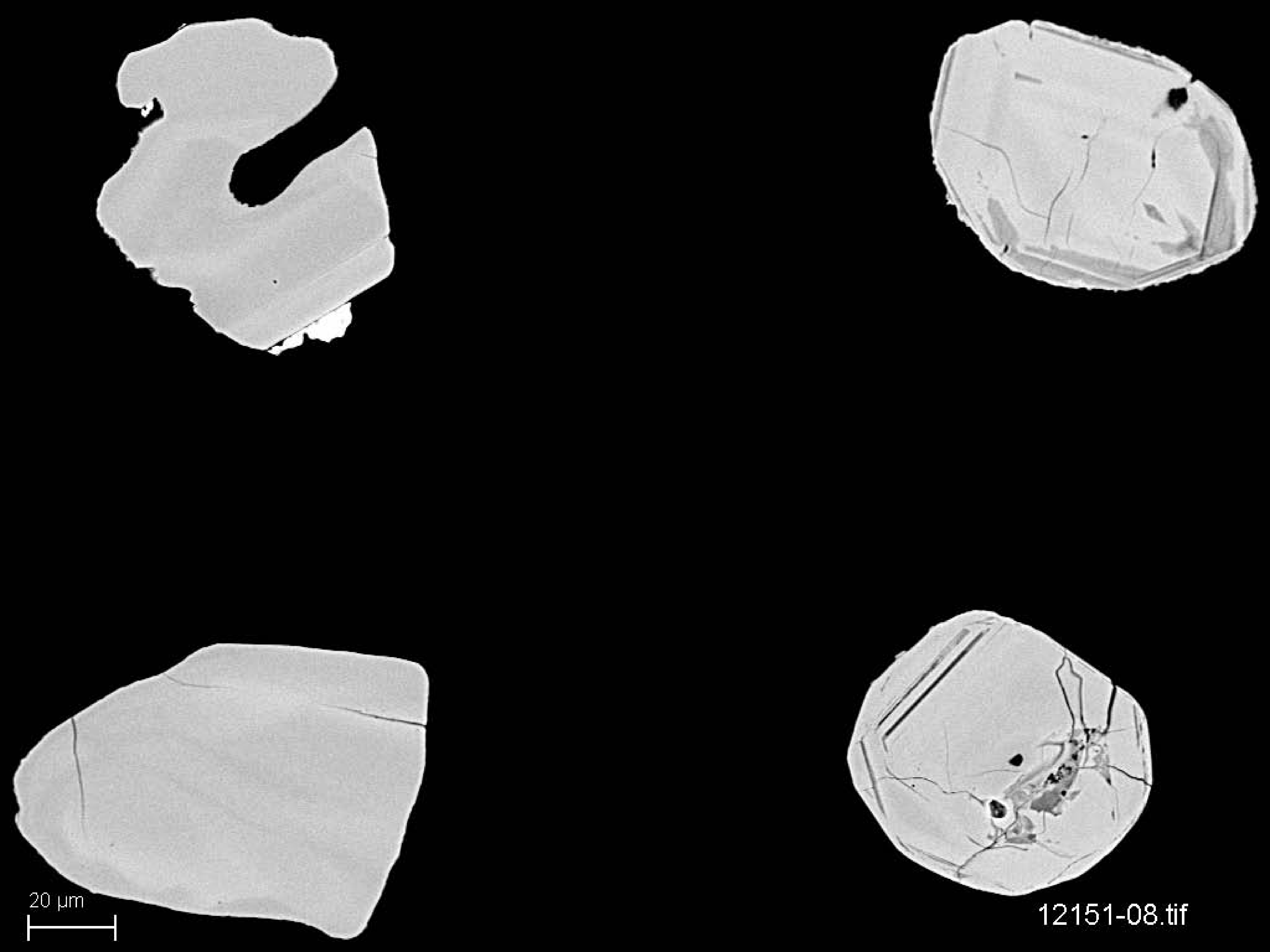
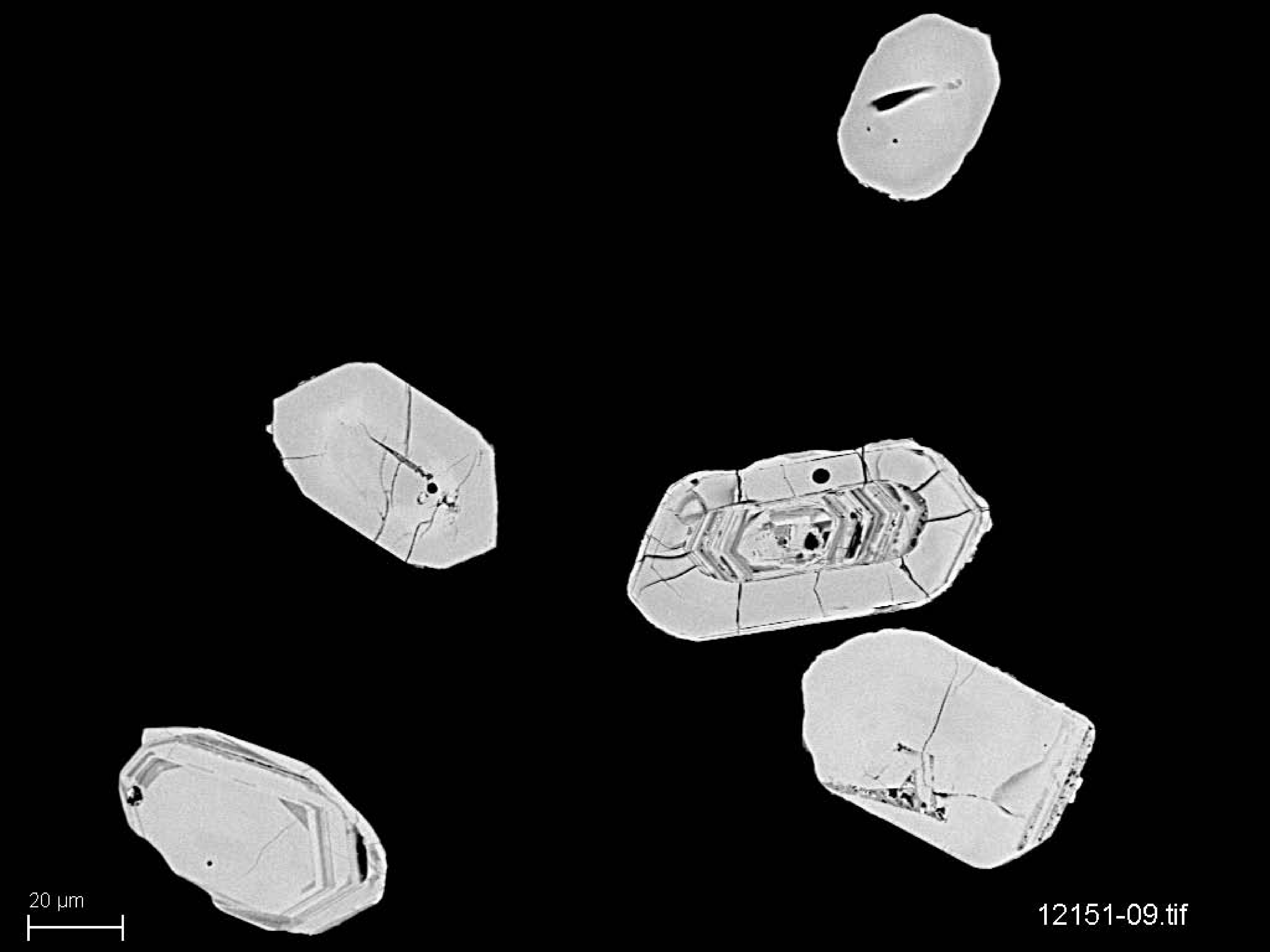
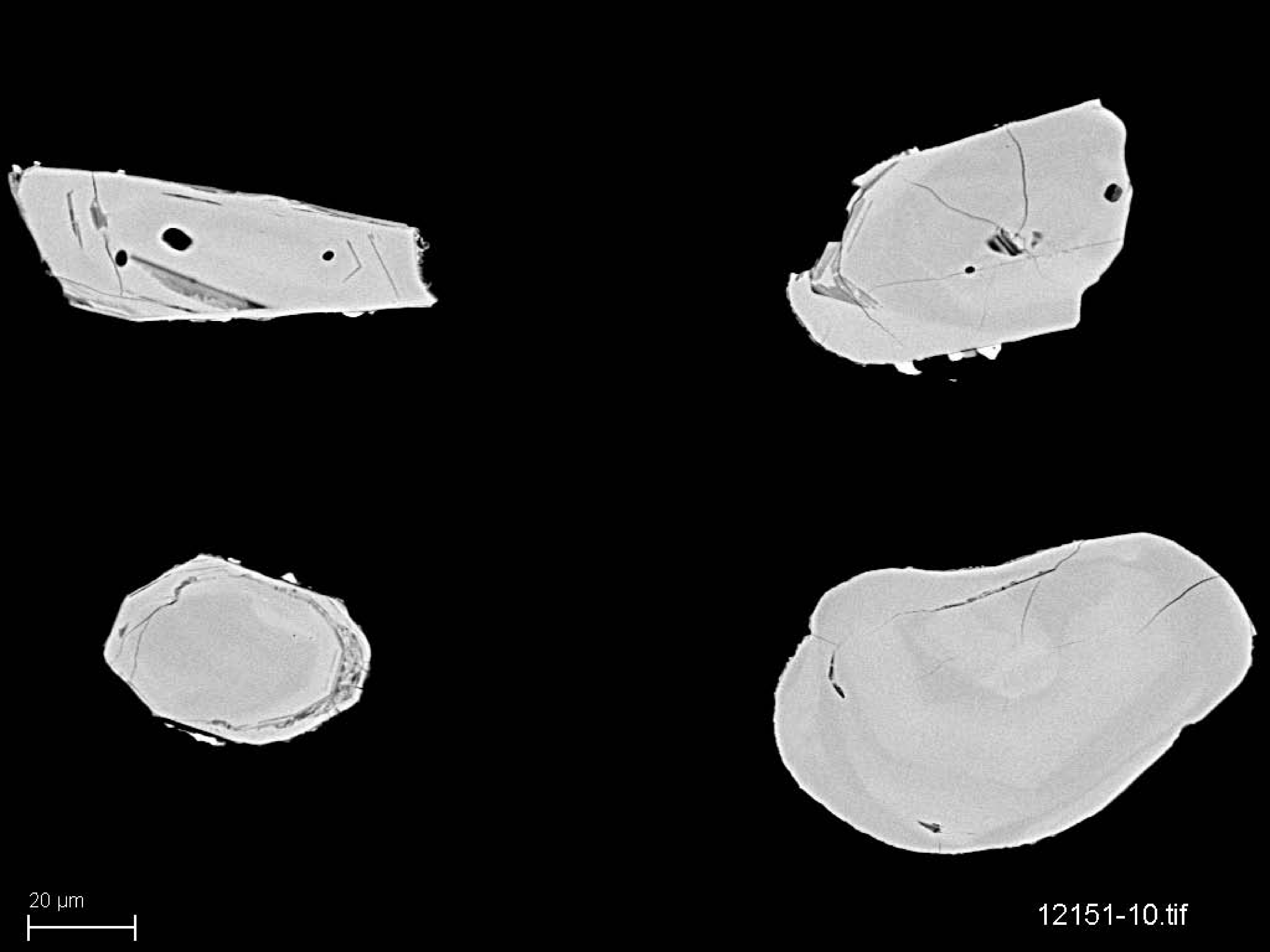
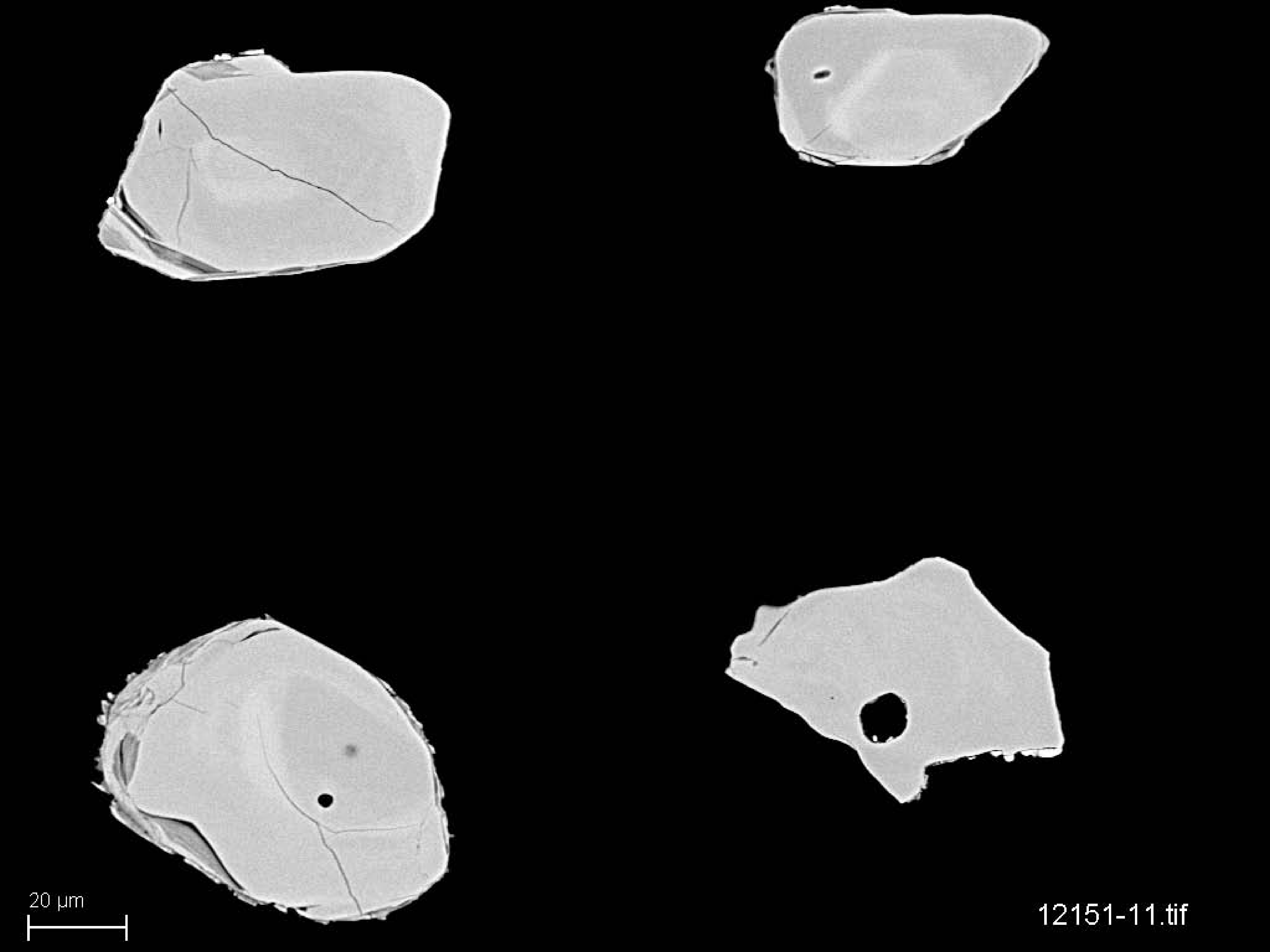

20 µm
12151-06.tif


20 µm
12151-07.tif

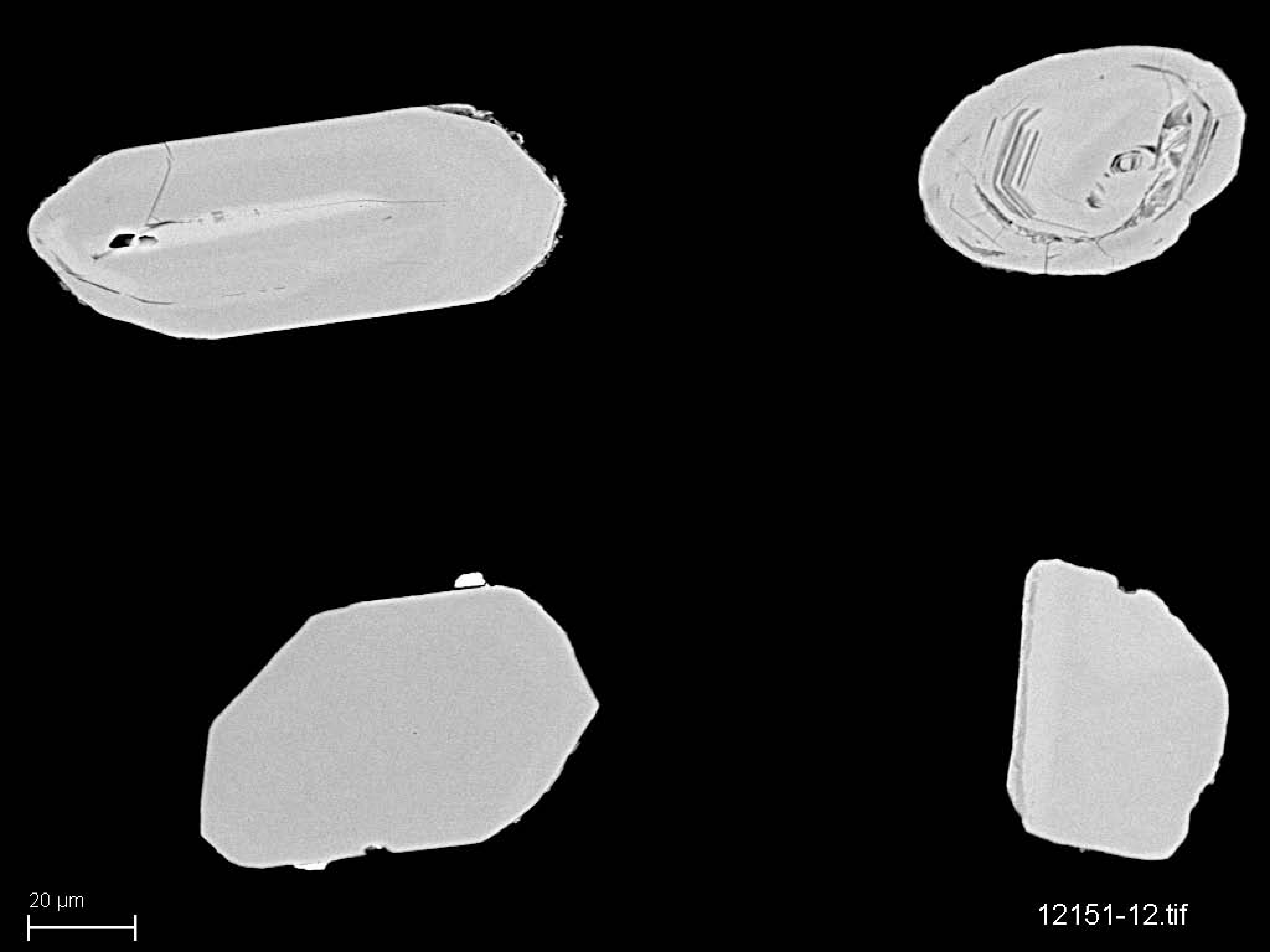

20 µm
12151-08.tif

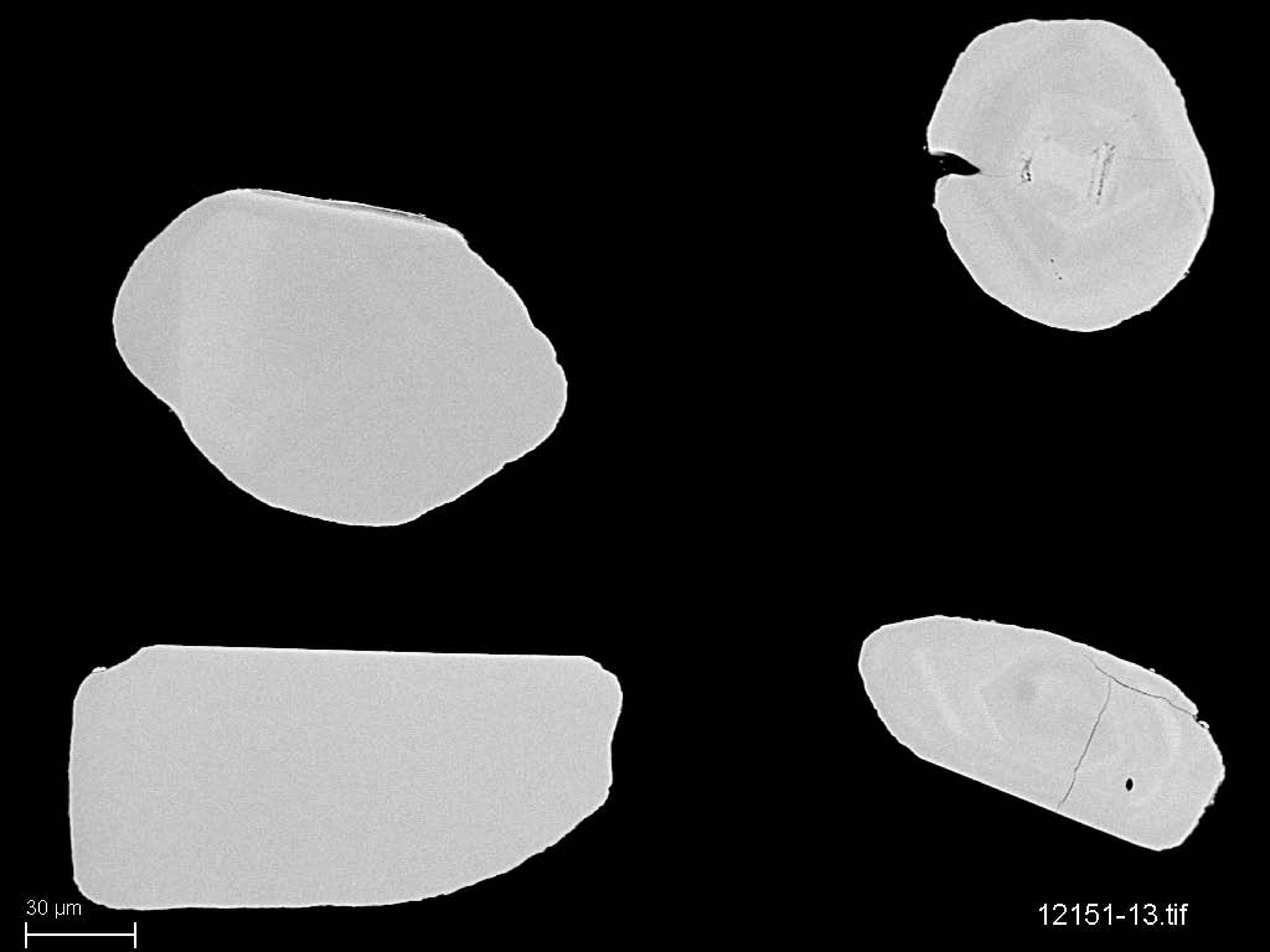

20 µm
12151-09.tif

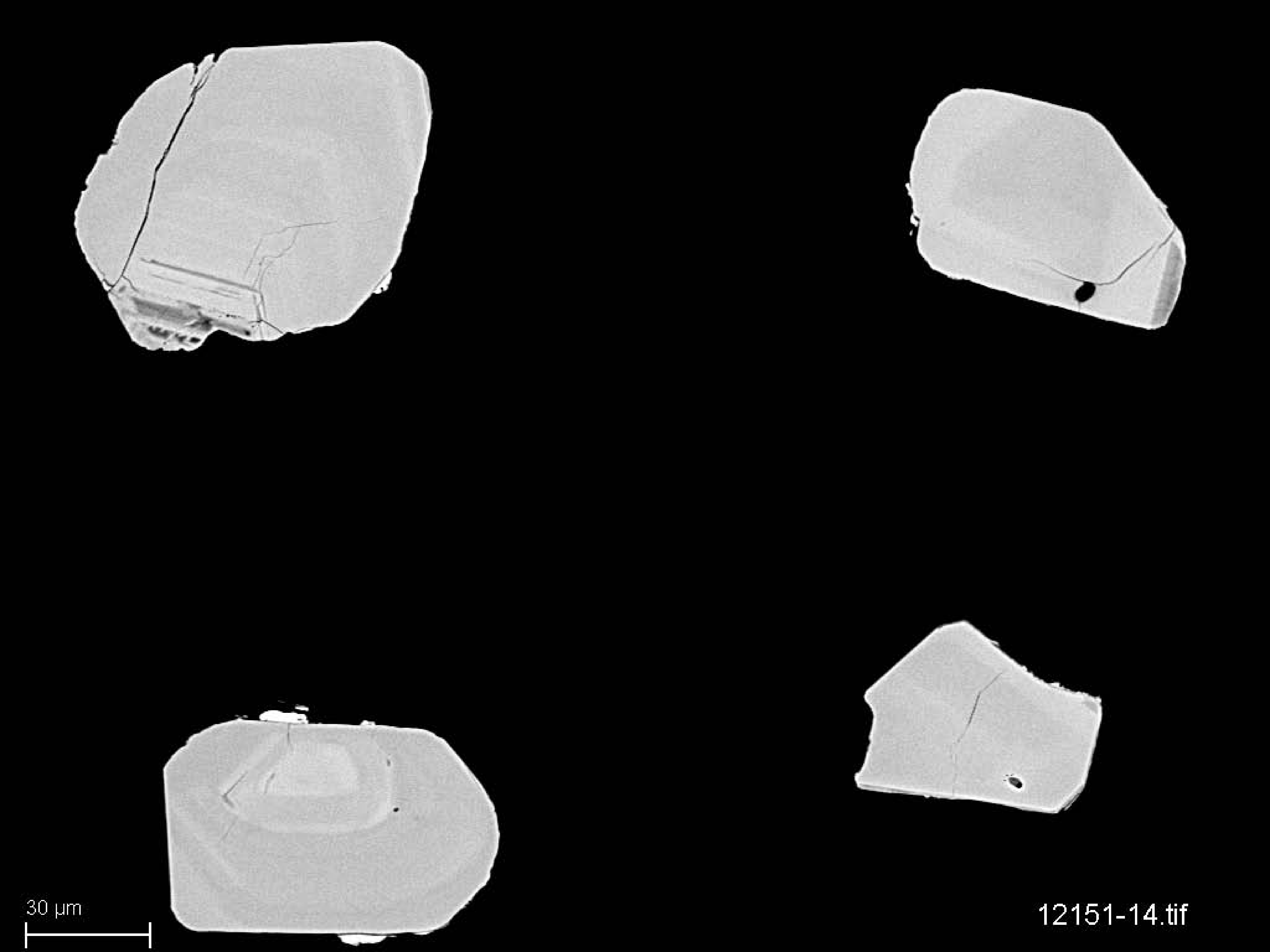

20 µm
12151-10.tif

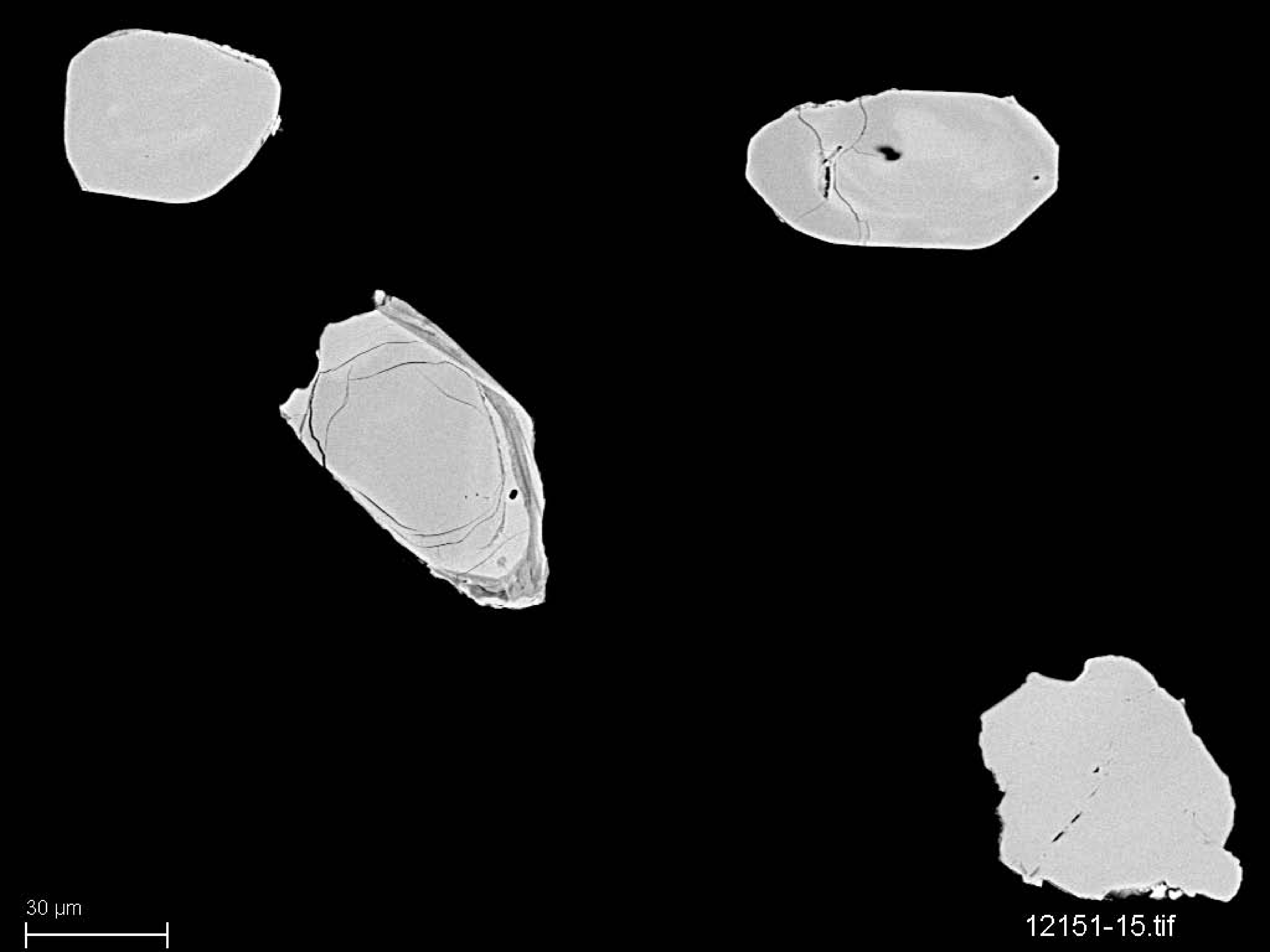


20 µm
12151-11.tif

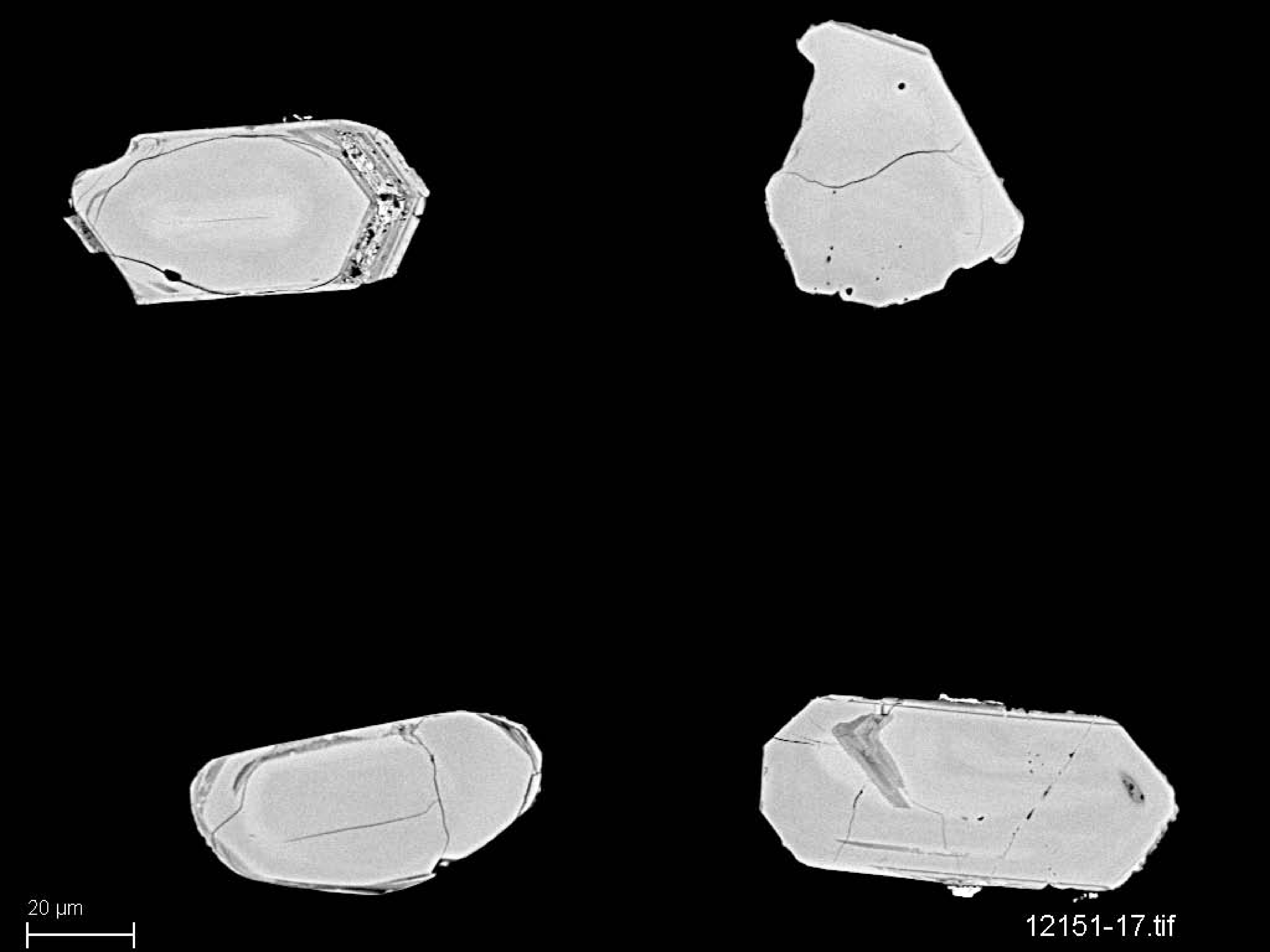

20 µm
12151-12.tif

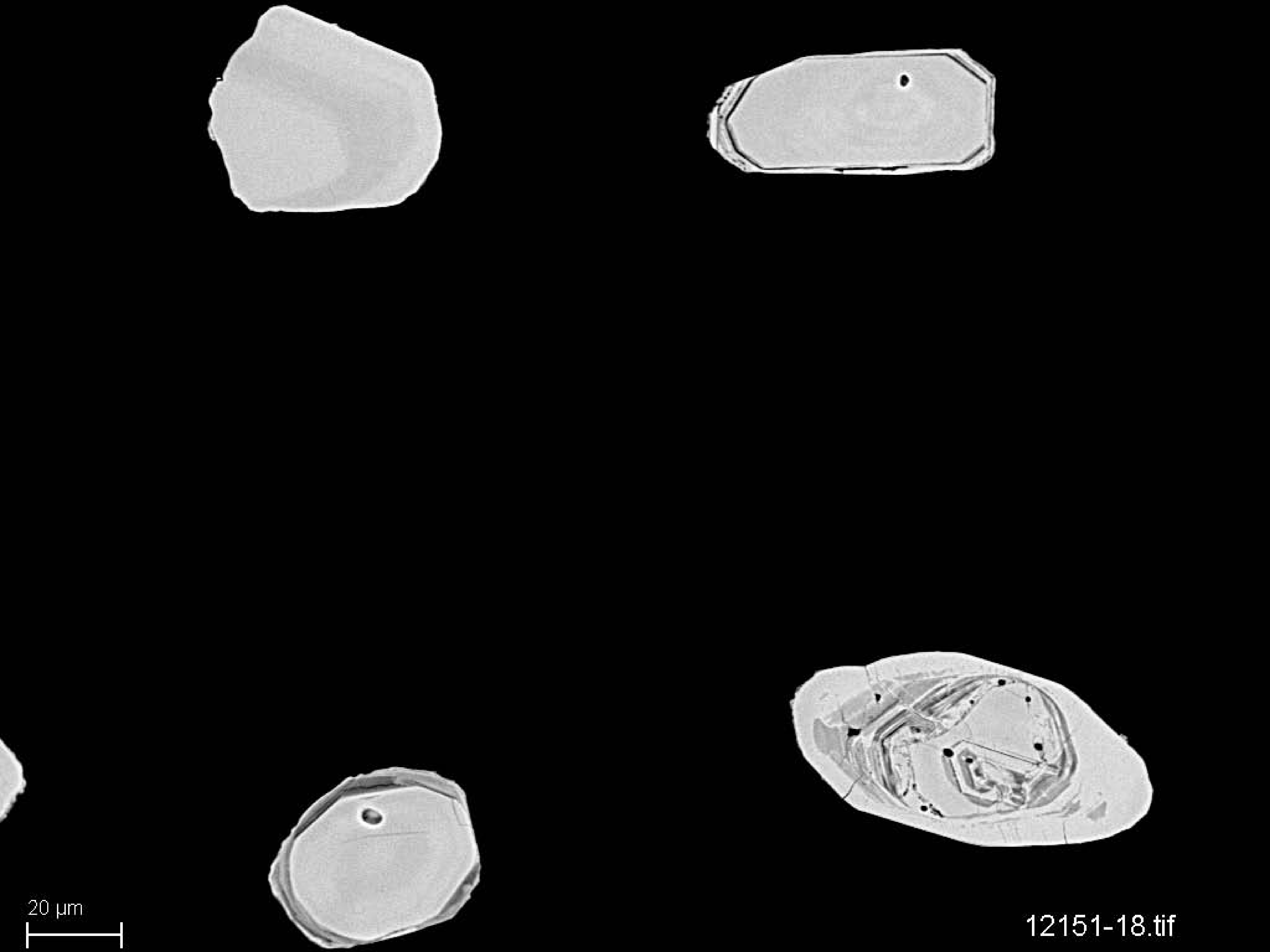

30 µm
12151-13.tif

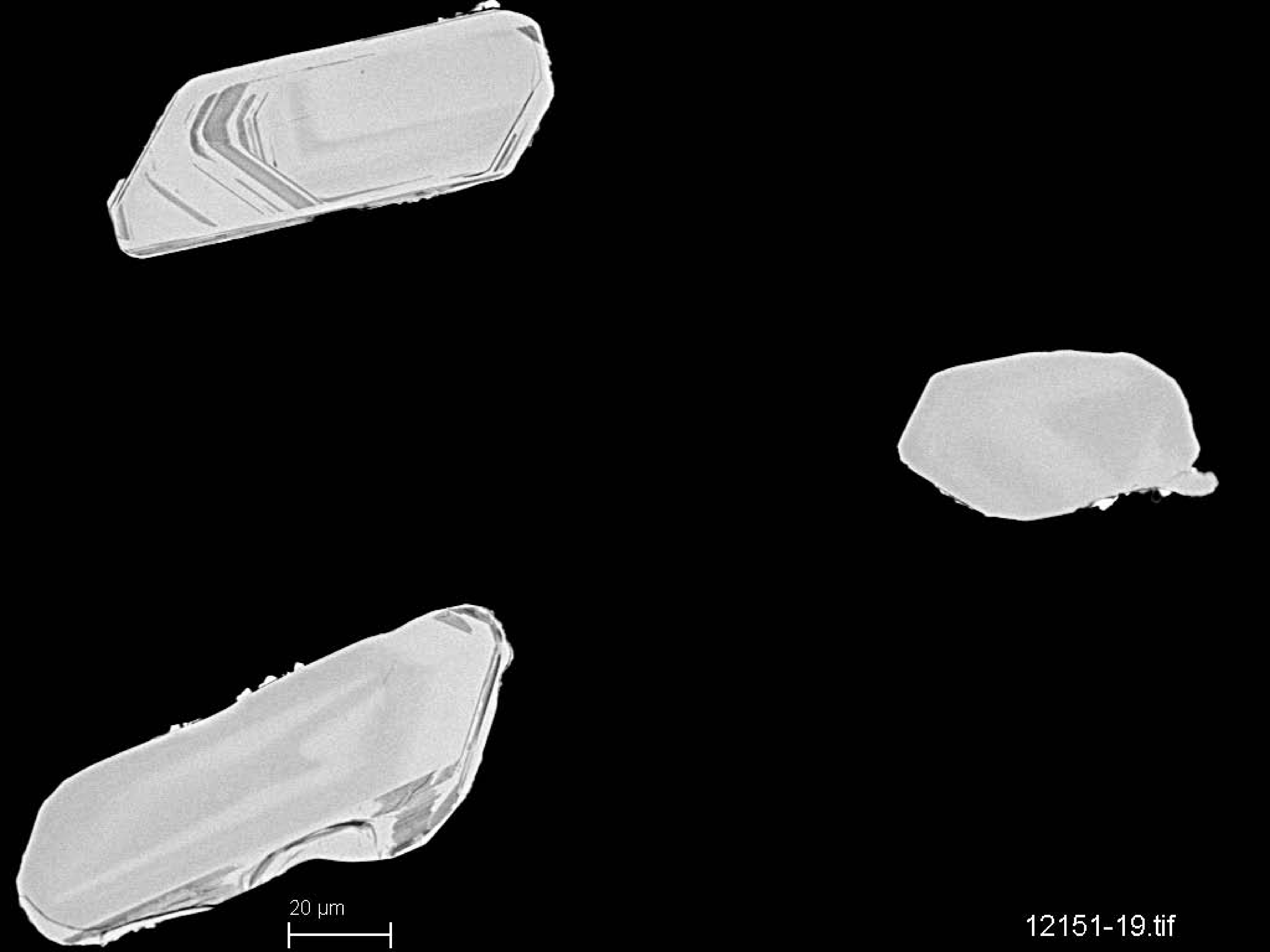

30 µm
12151-14.tif

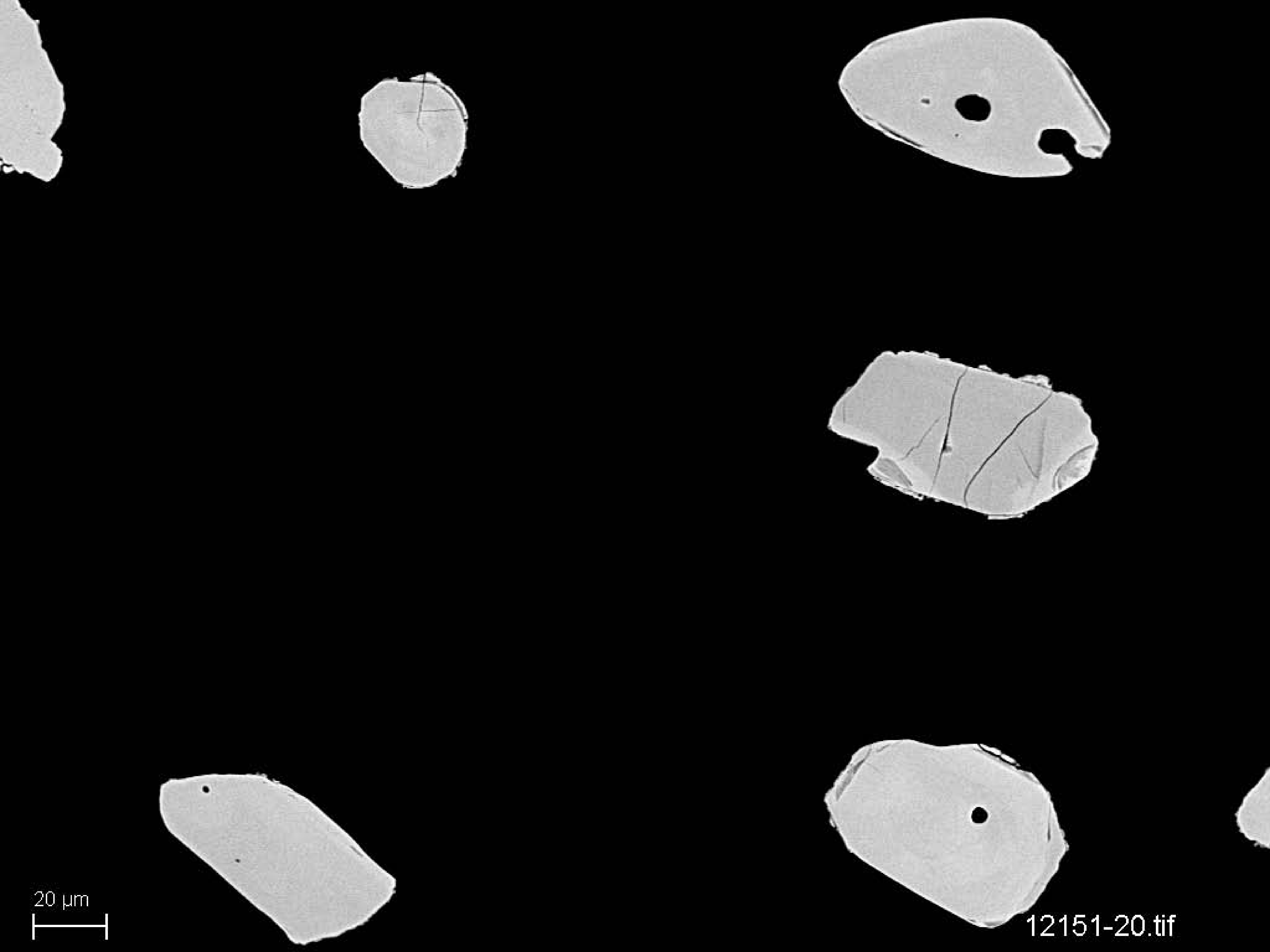

30 µm
12151-15.tif


10 μm
12151-16.tif

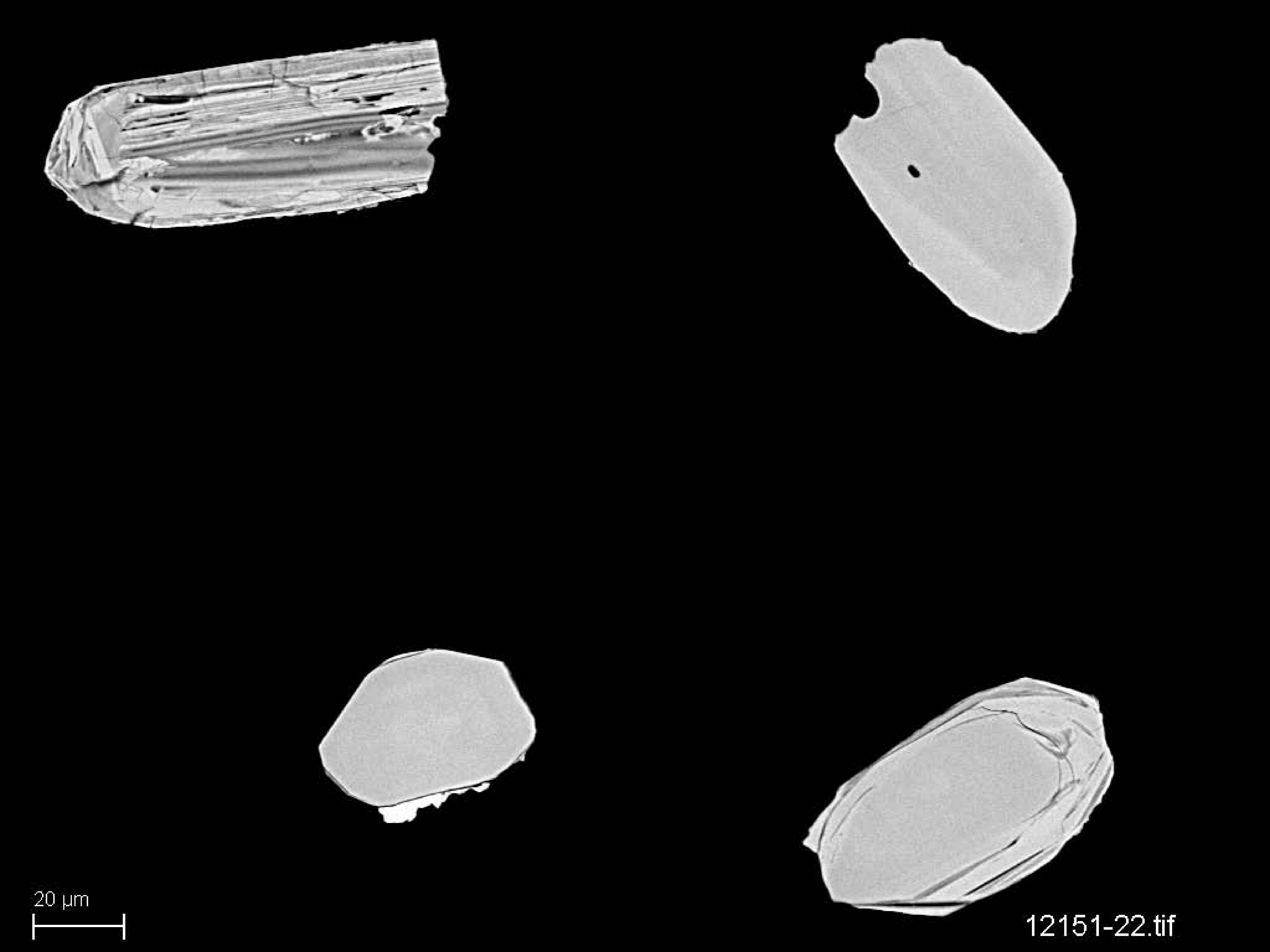

20 μm
12151-17.tif


20 µm
12151-18.tif

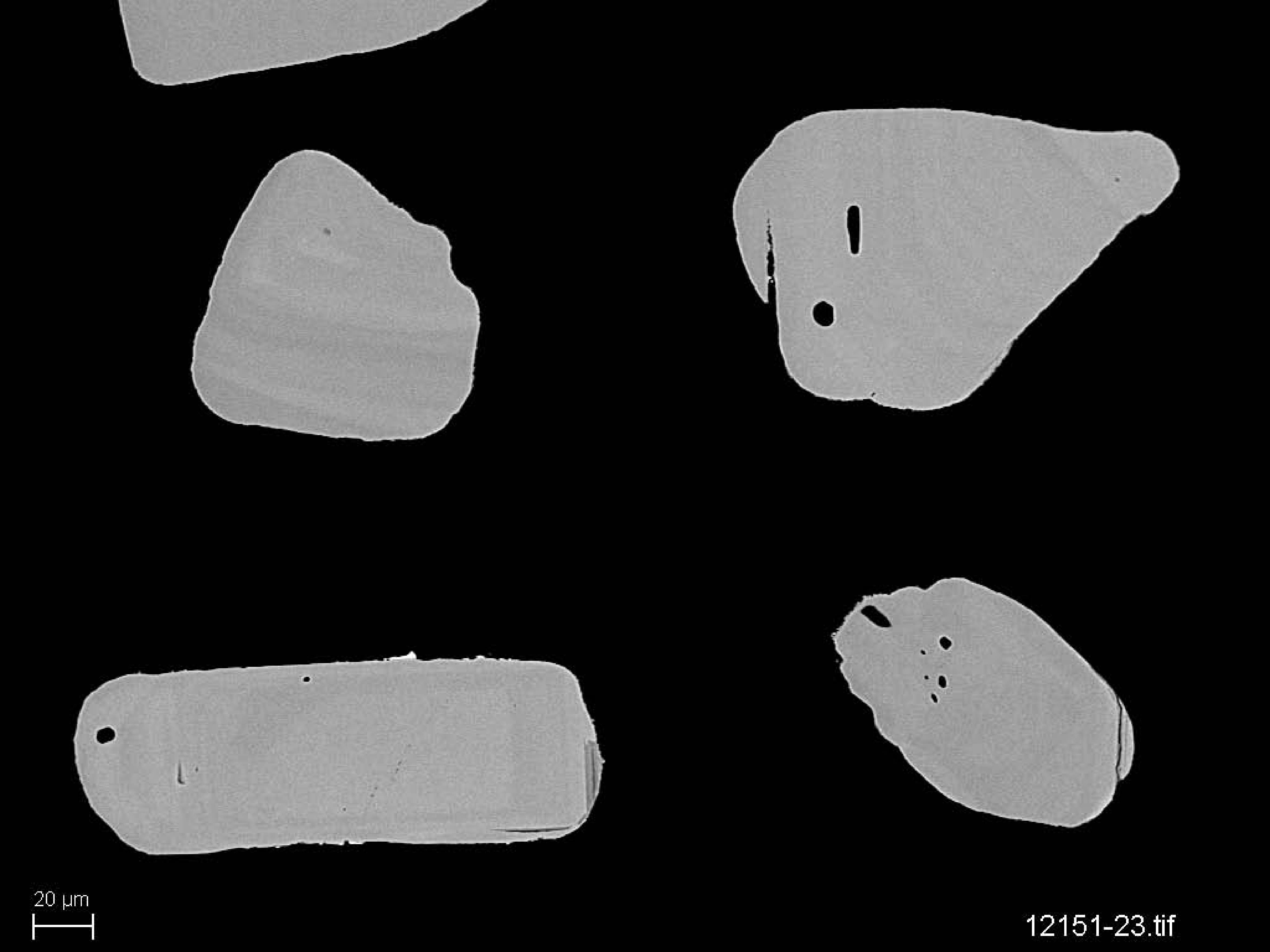

20 µm
12151-19.tif


20 µm
12151-20.tif

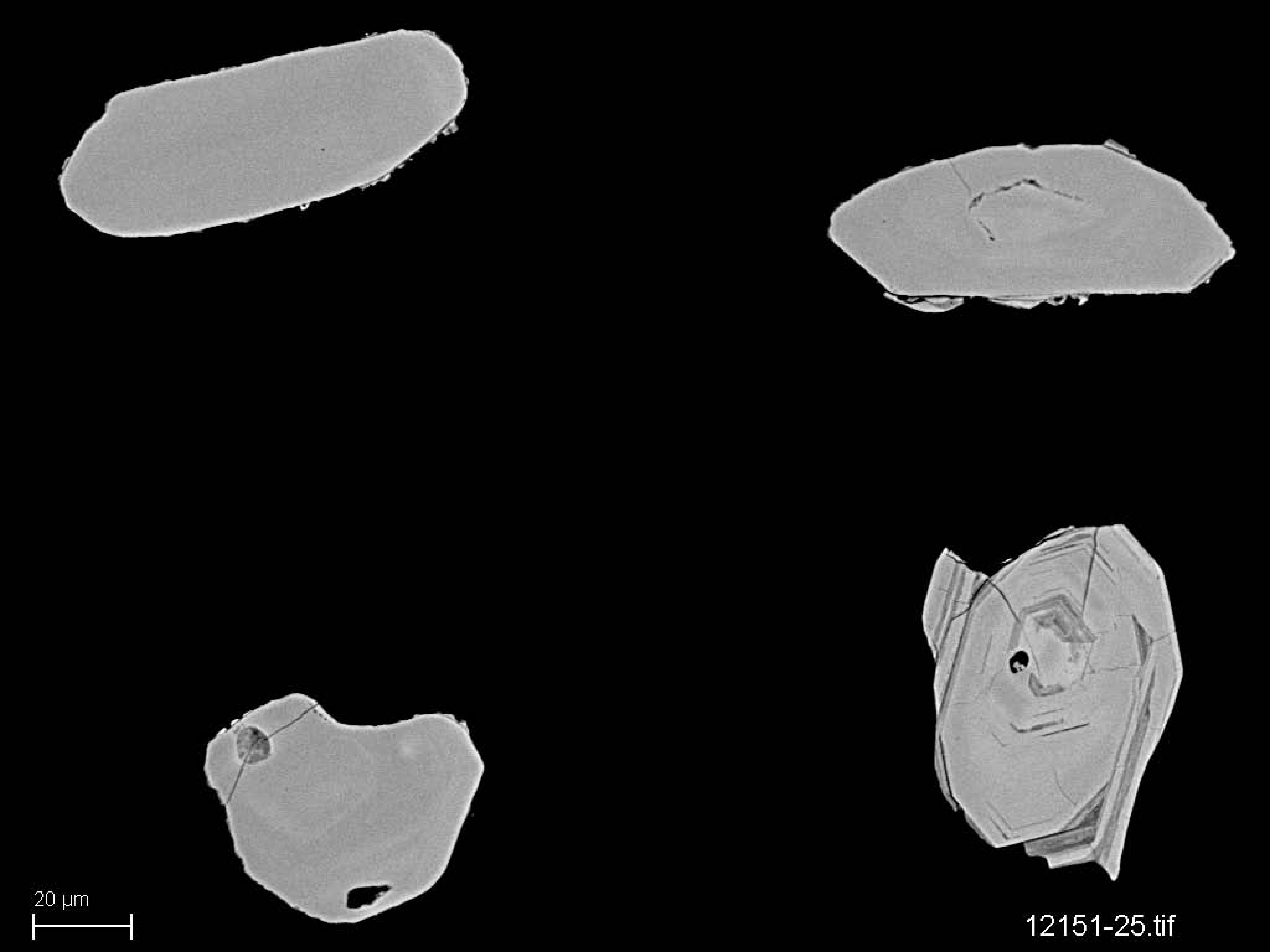

20 µm
12151-21.tif

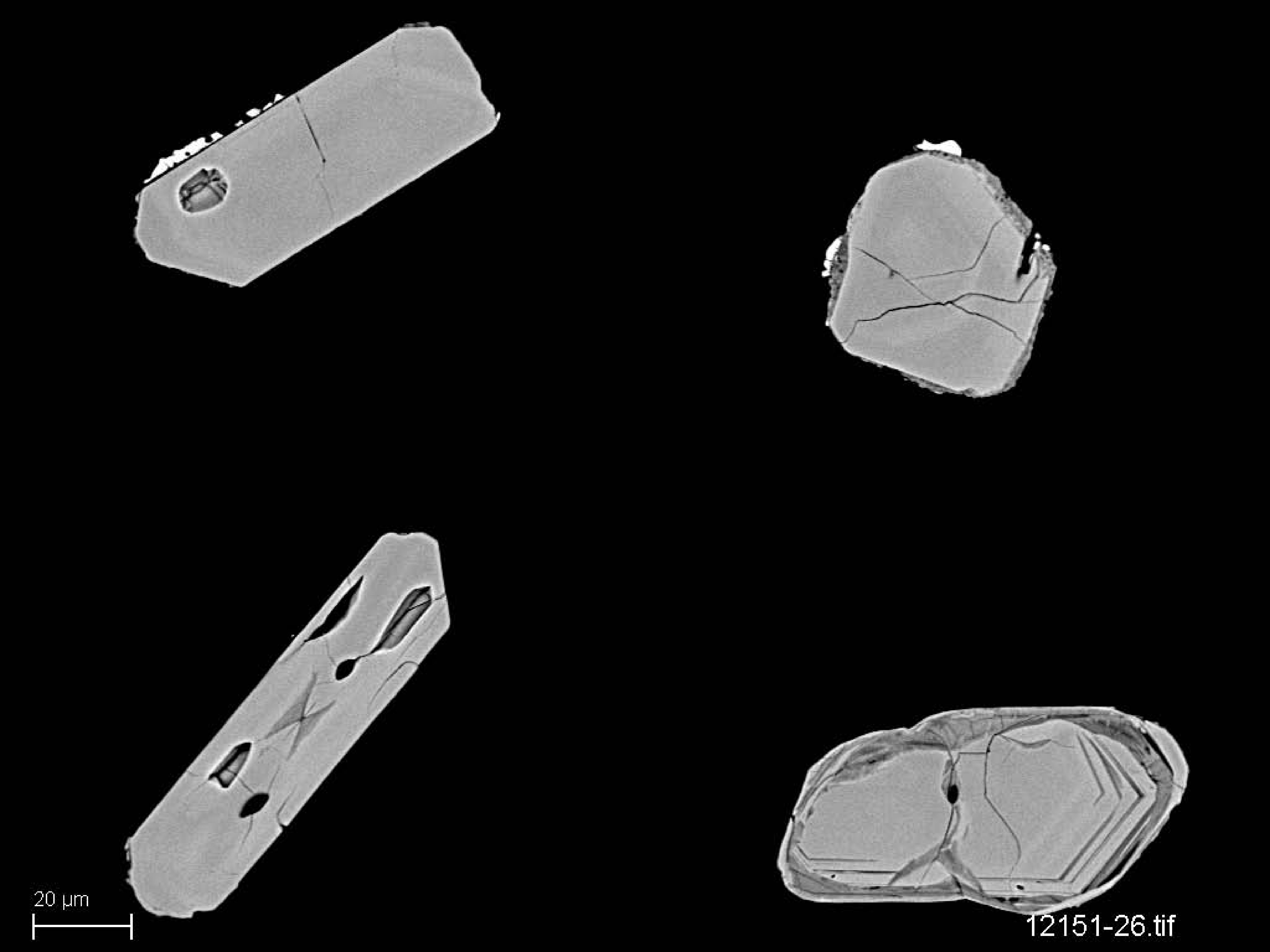


20 µm
12151-22.tif


20 µm
12151-23.tif

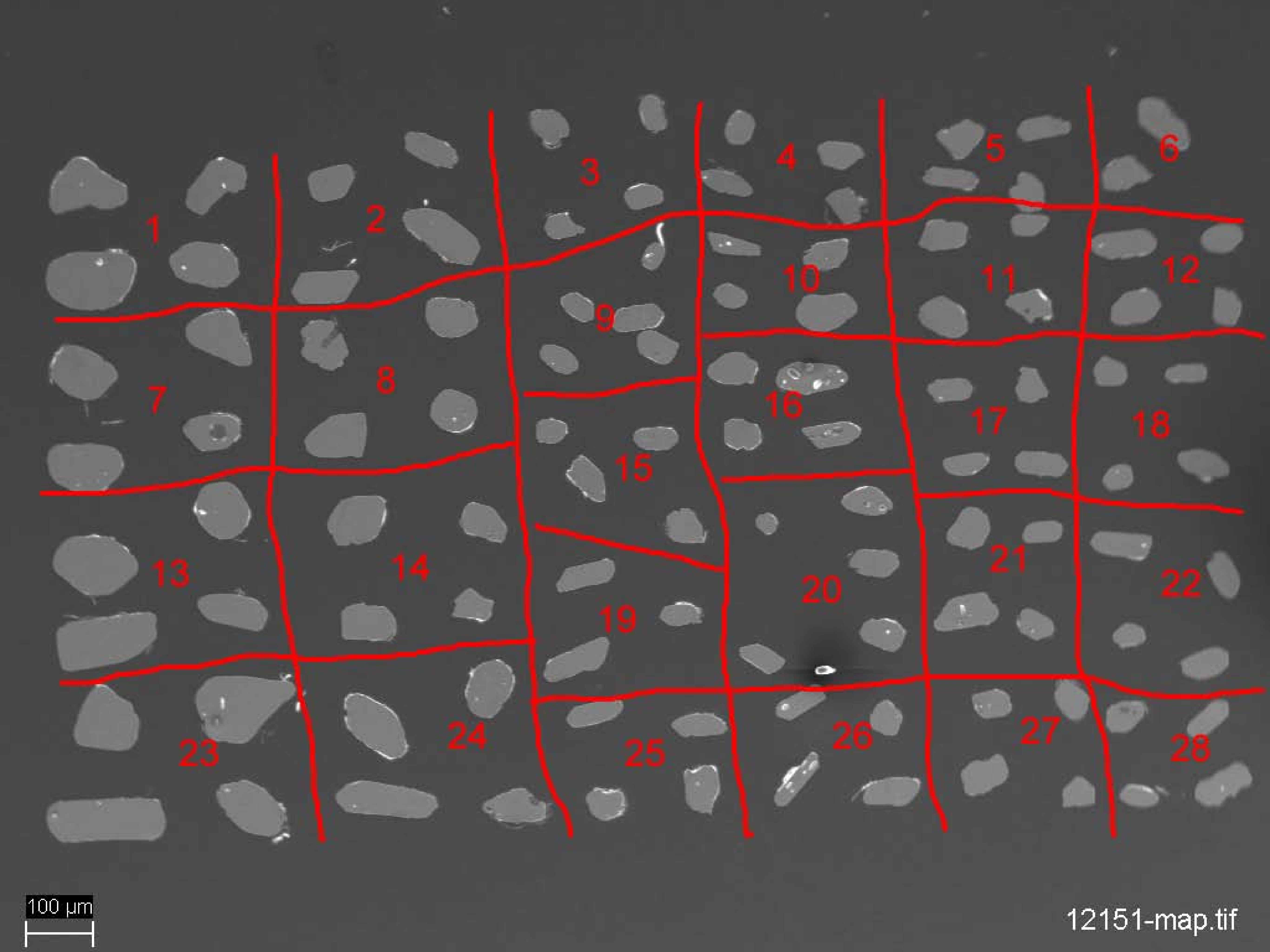

20 µm
12151-24.tif


20 µm
12151-25.tif


20 µm
12151-26.tif


20 µm
12151-27.tif


20 µm
12151-28.tif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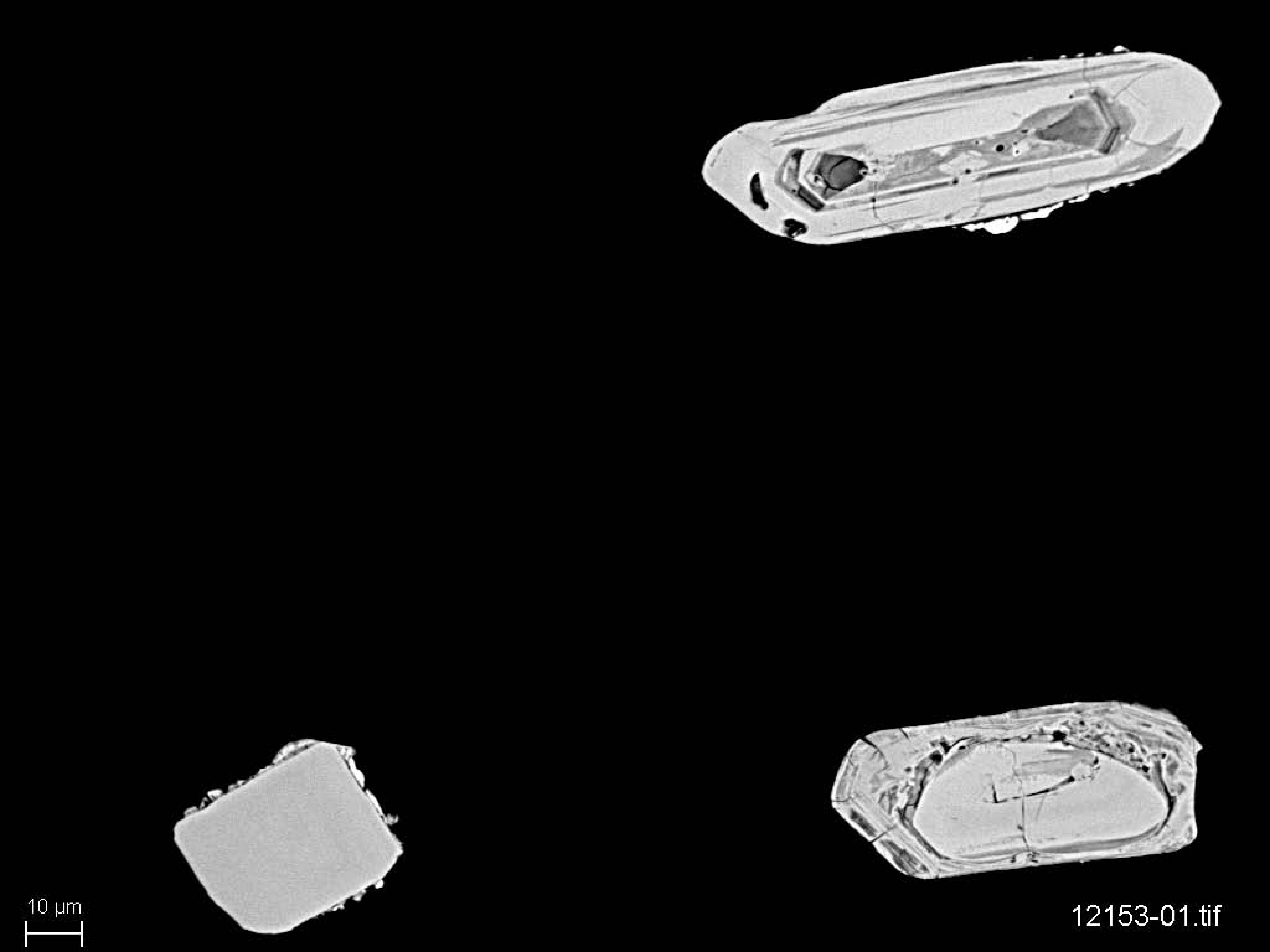
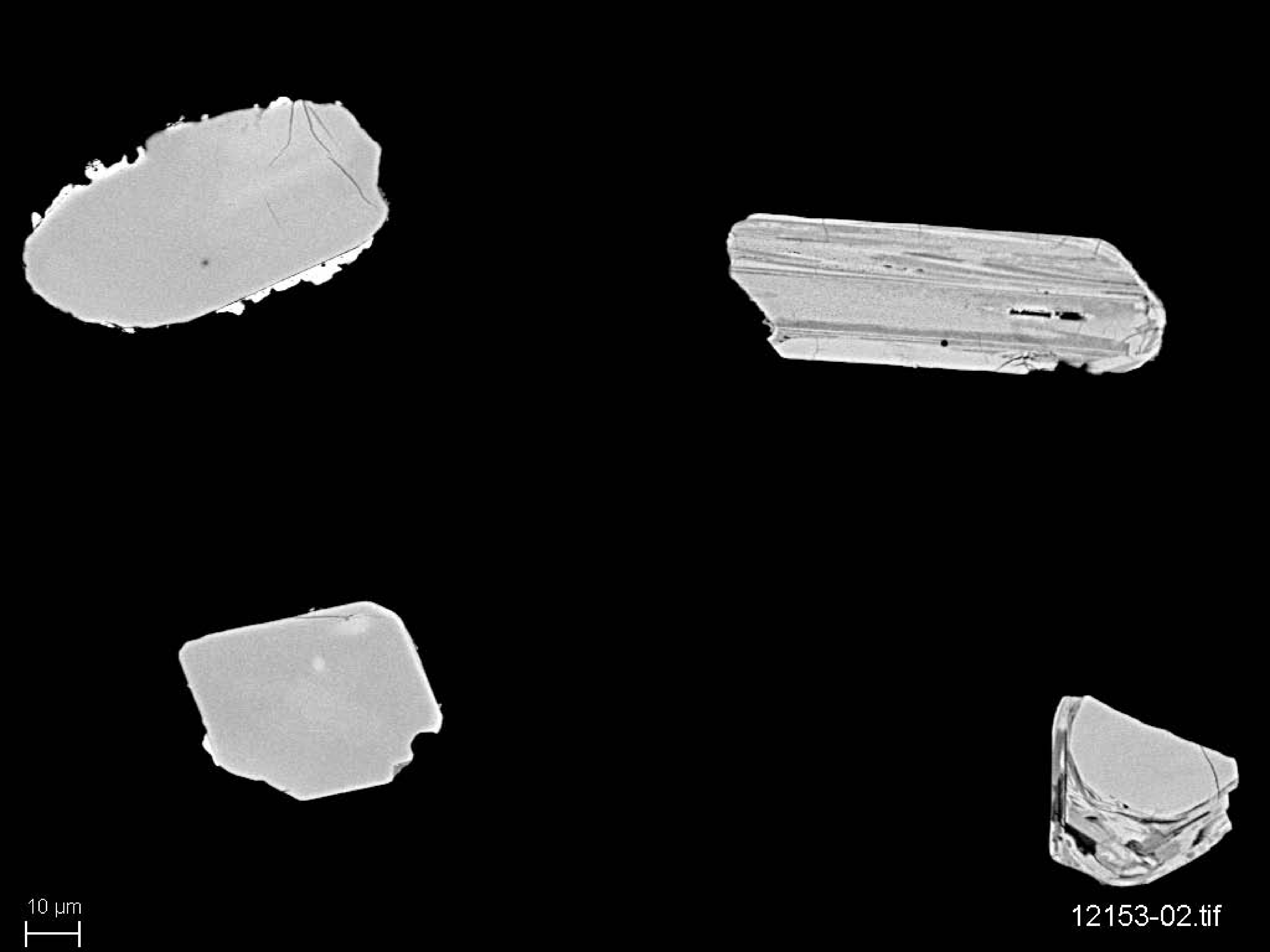
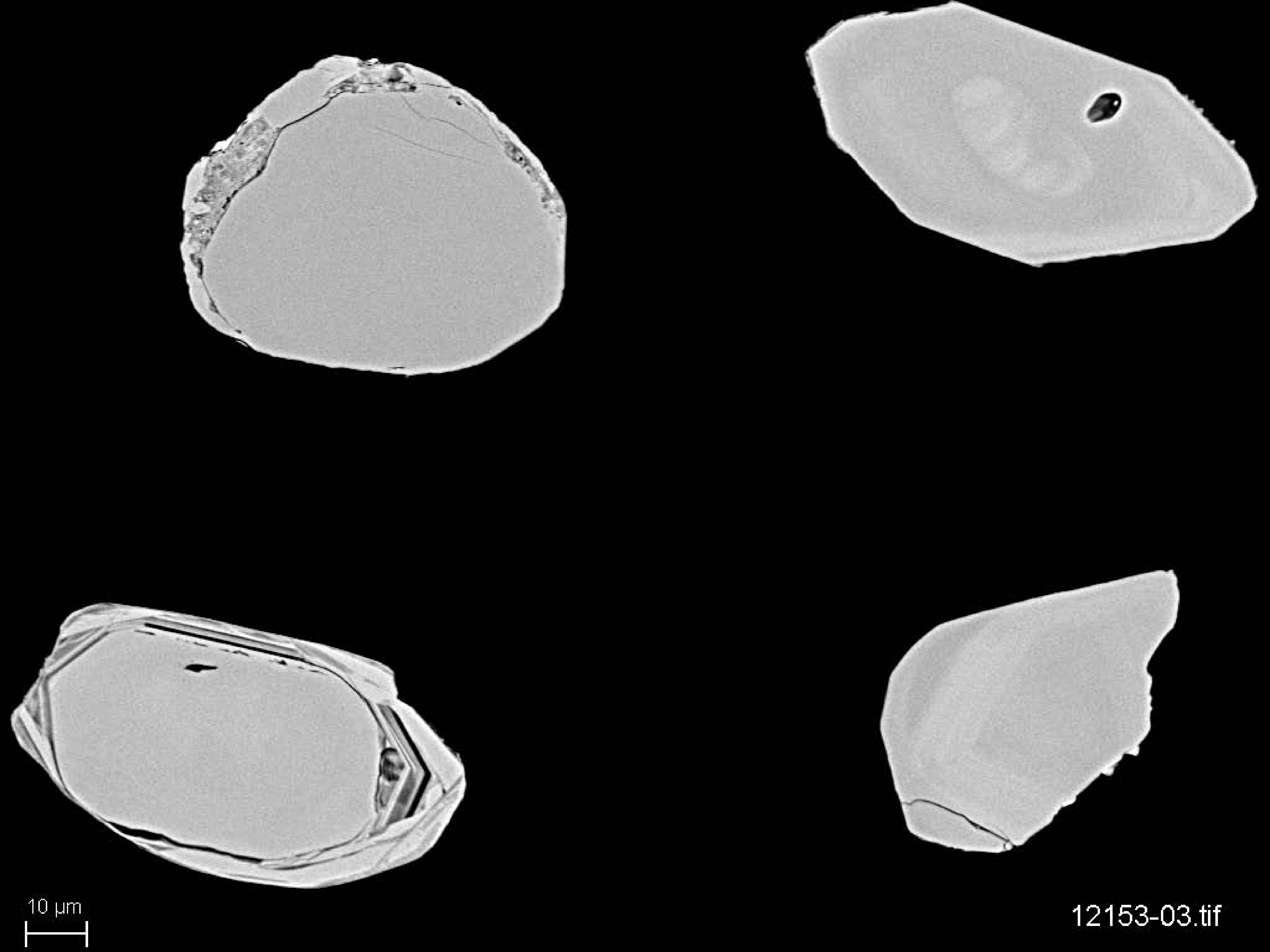
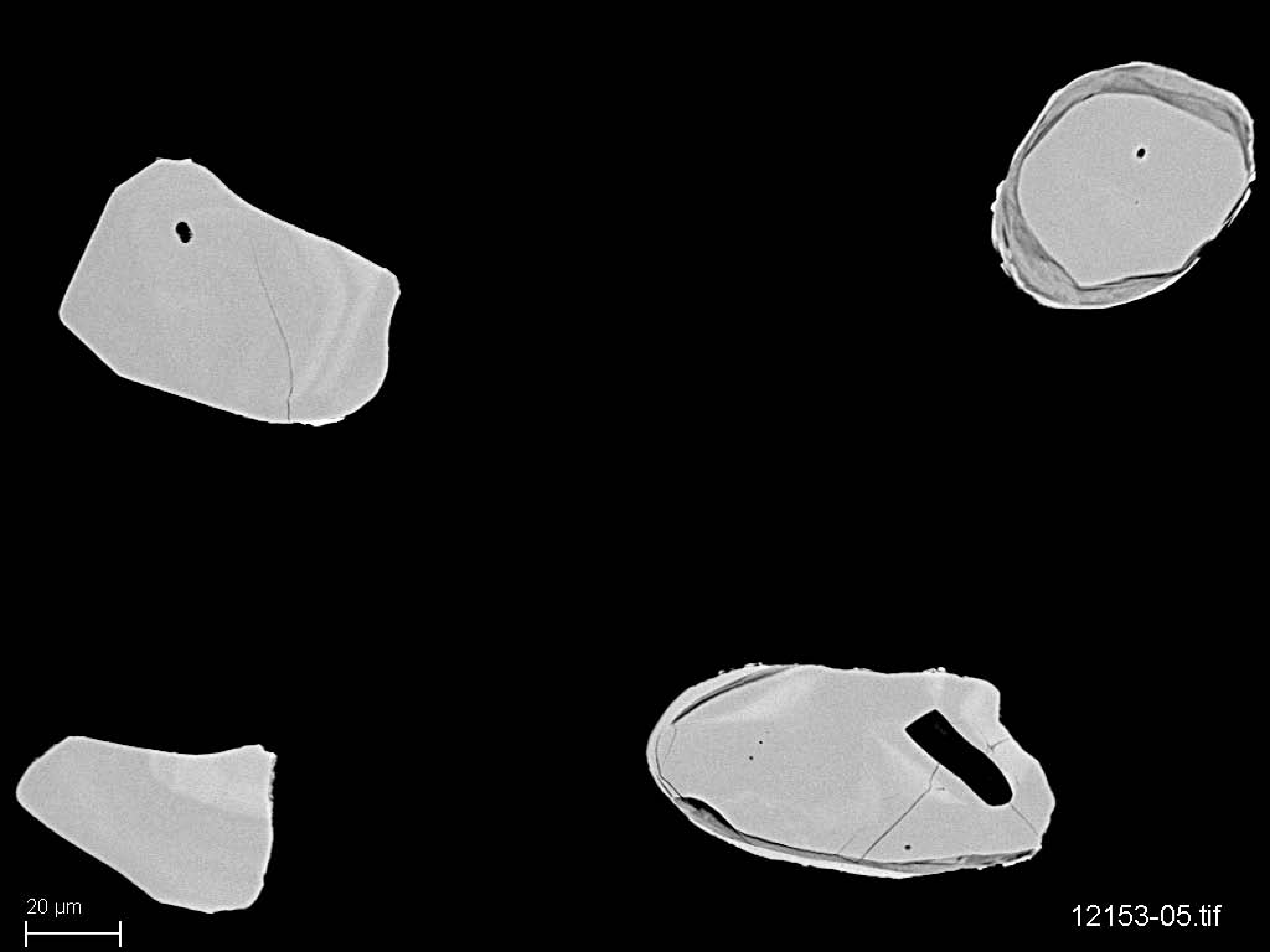
100 µm
12151-map.tif

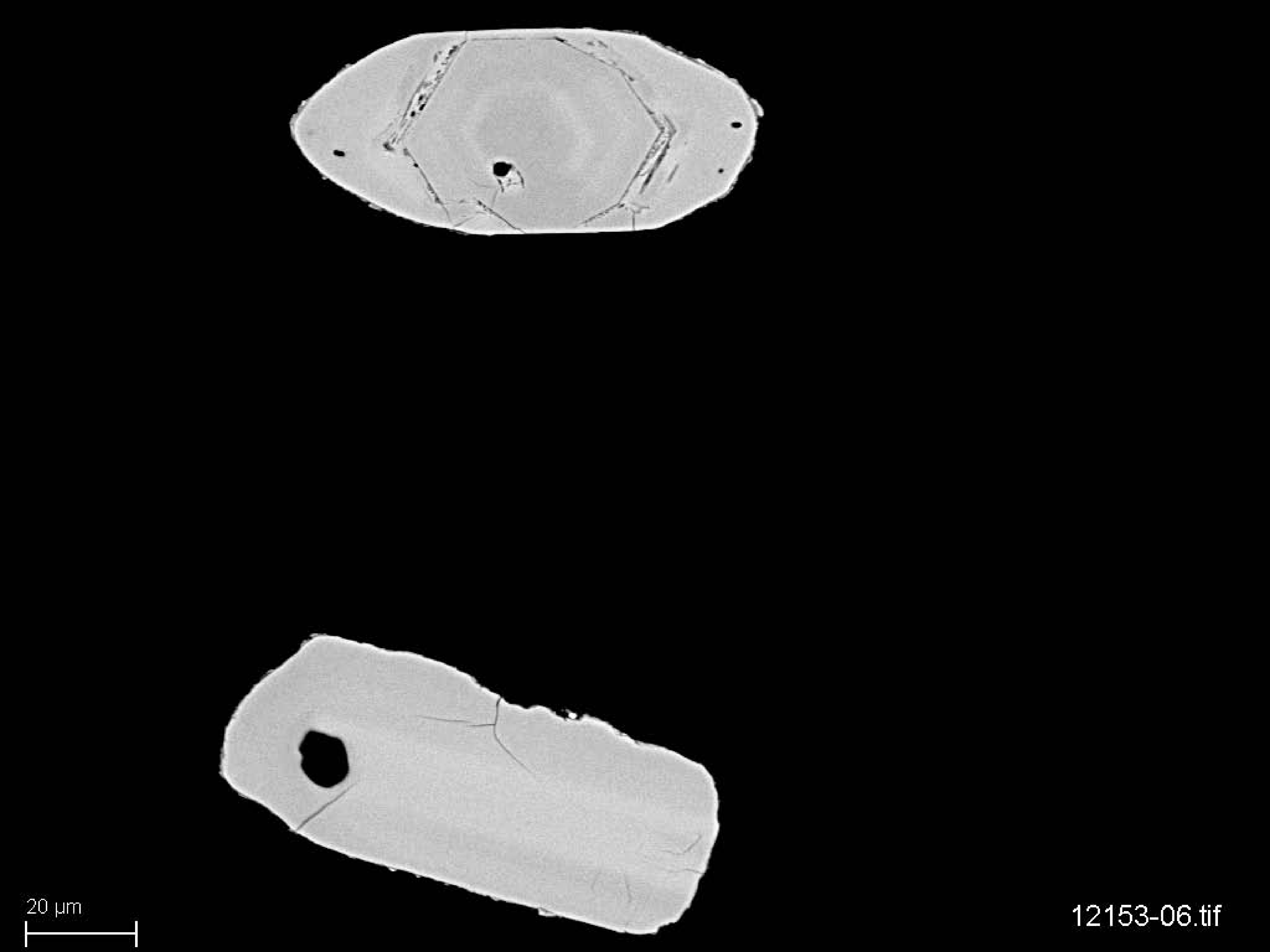

10 µm
12153-01.tif

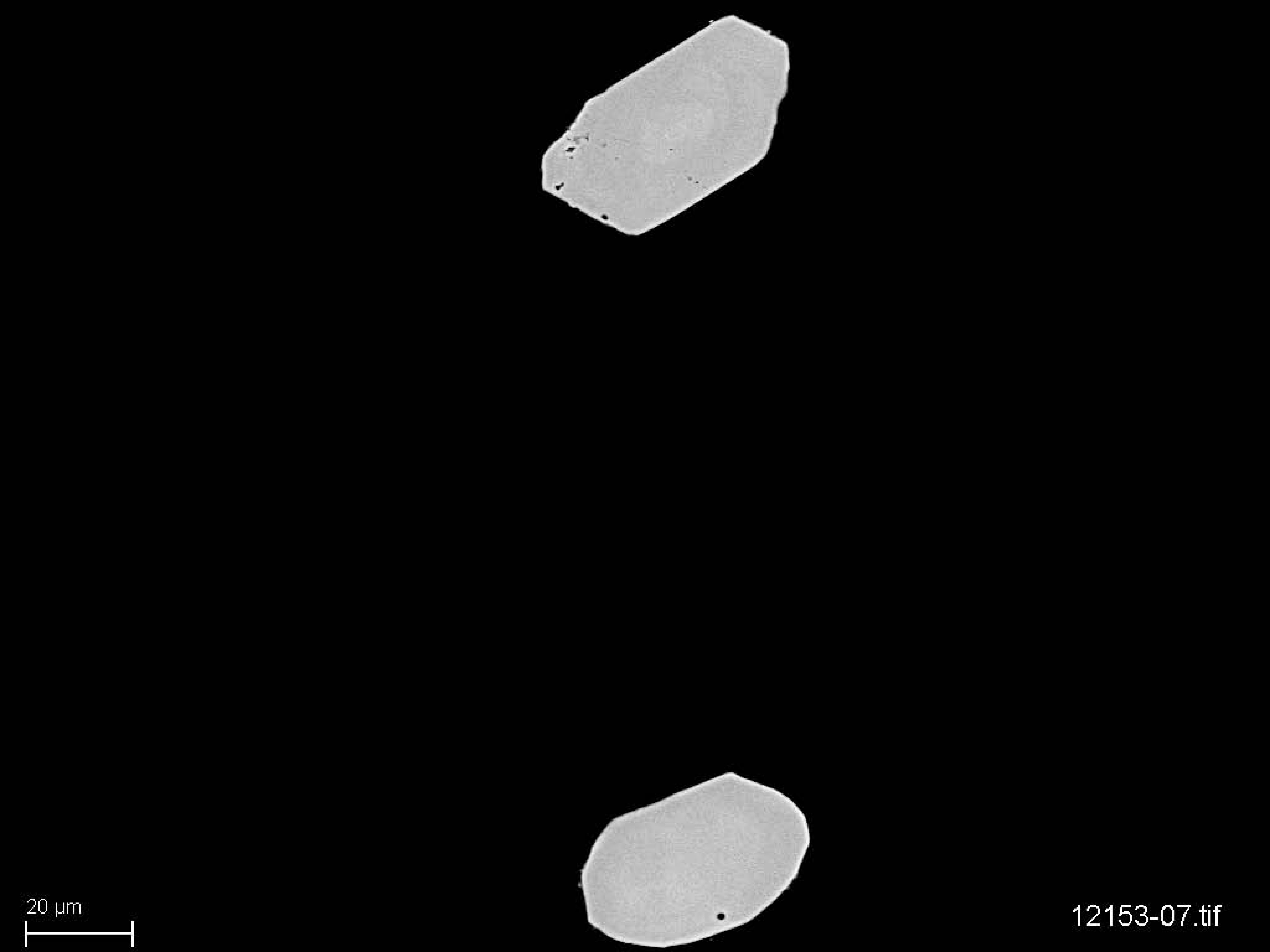

10 µm
12153-02.tif

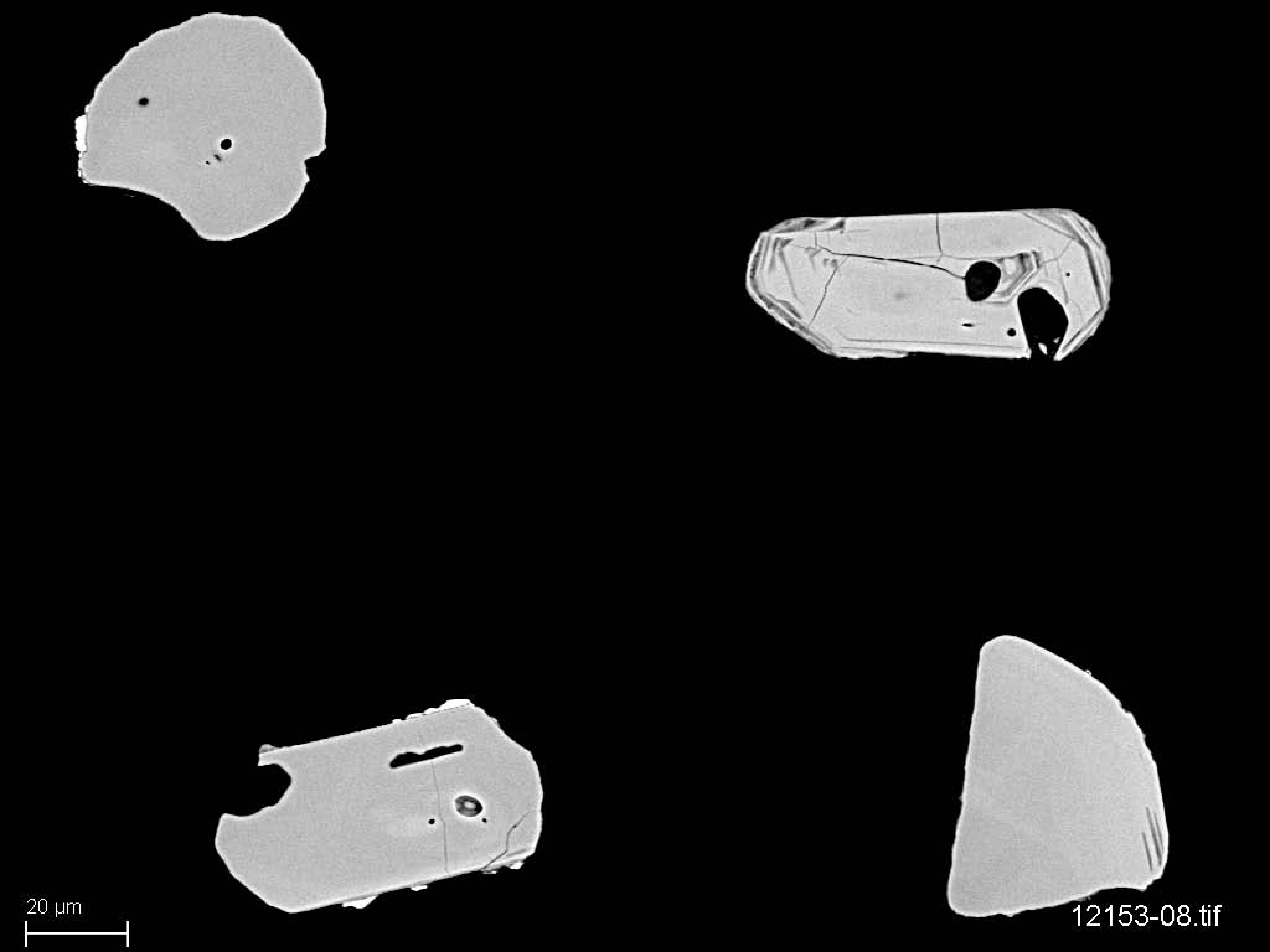

10 µm
12153-03.tif

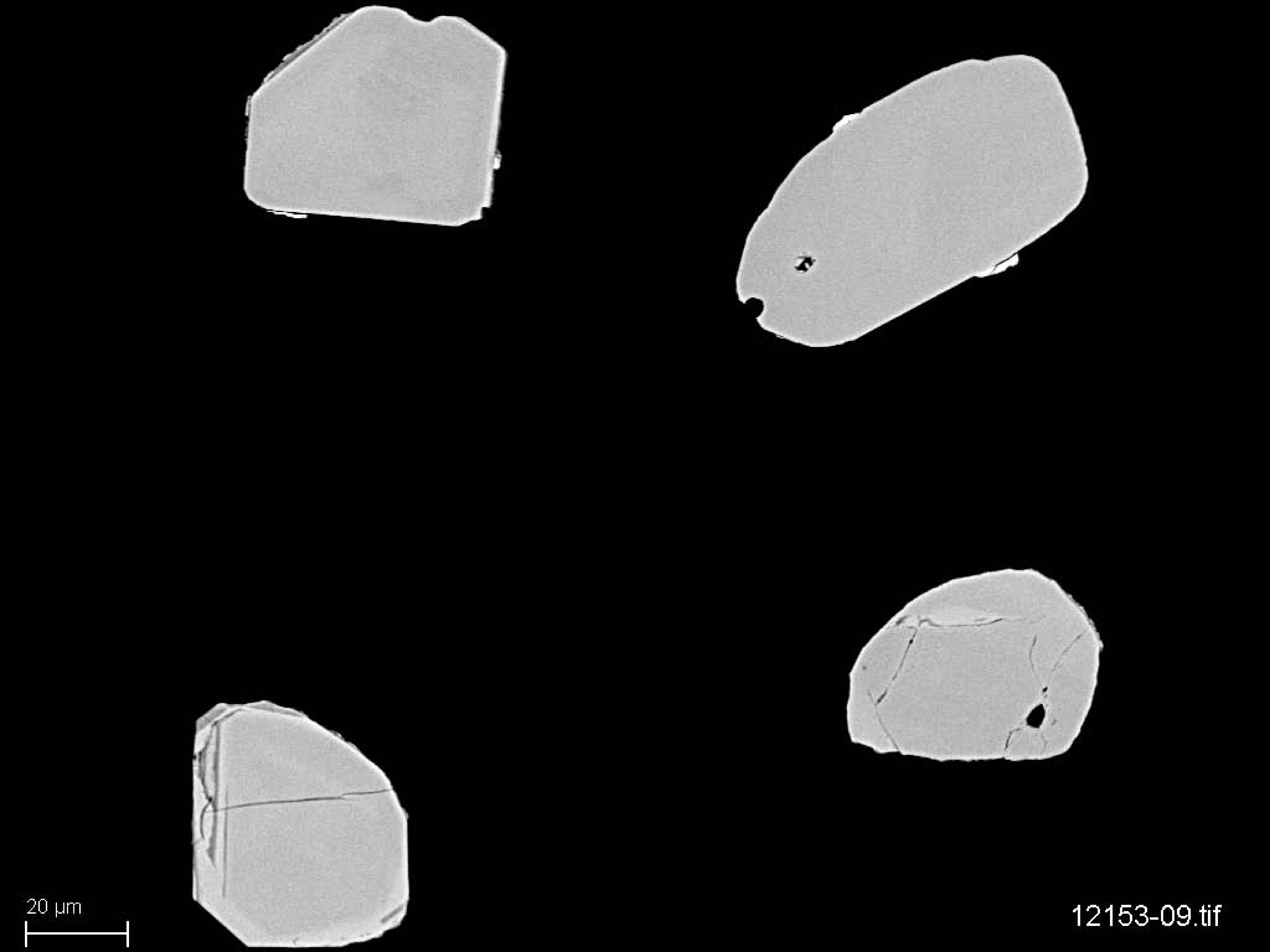

20 µm
12153-04.tif

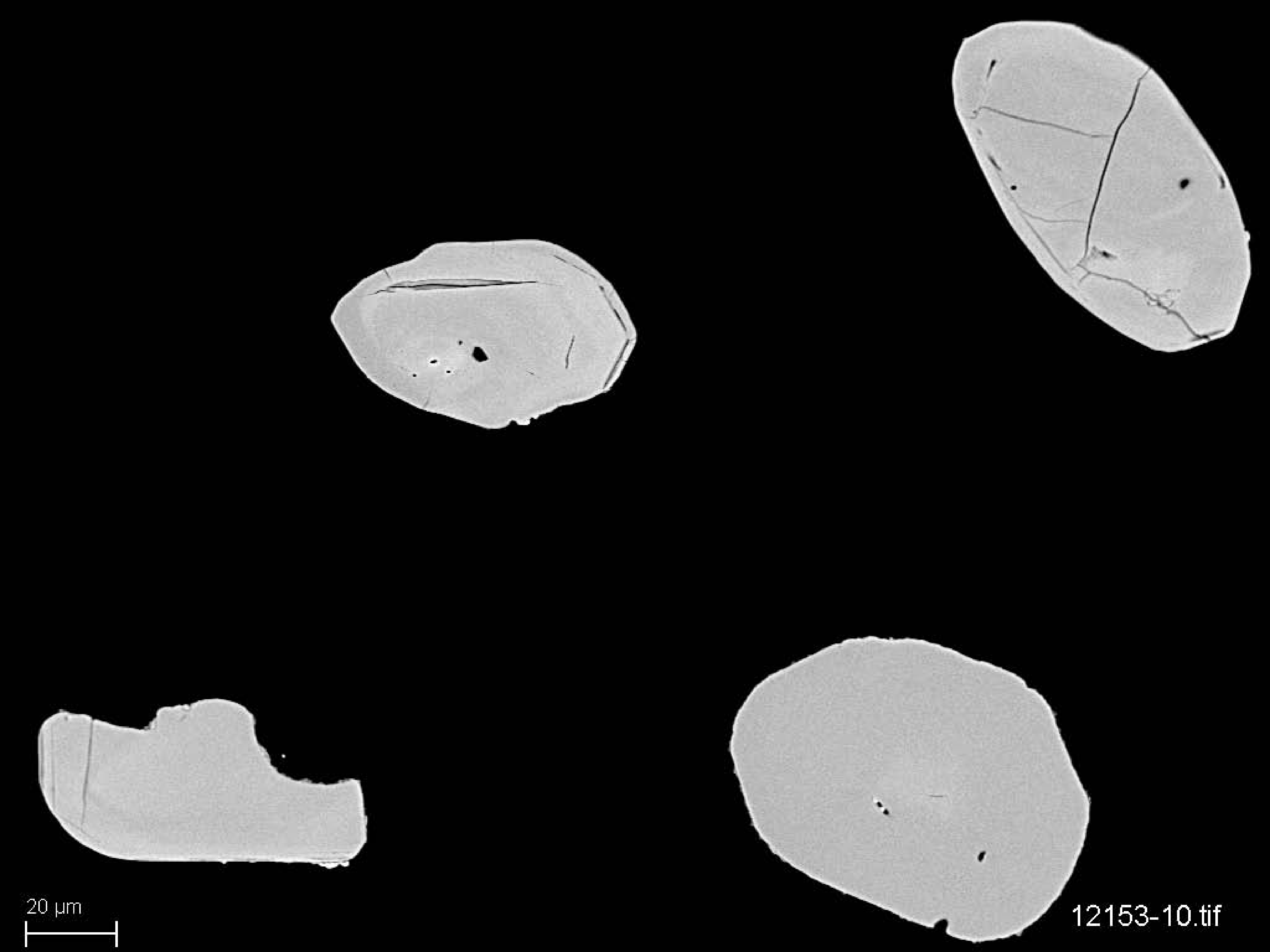

20 µm
12153-05.tif

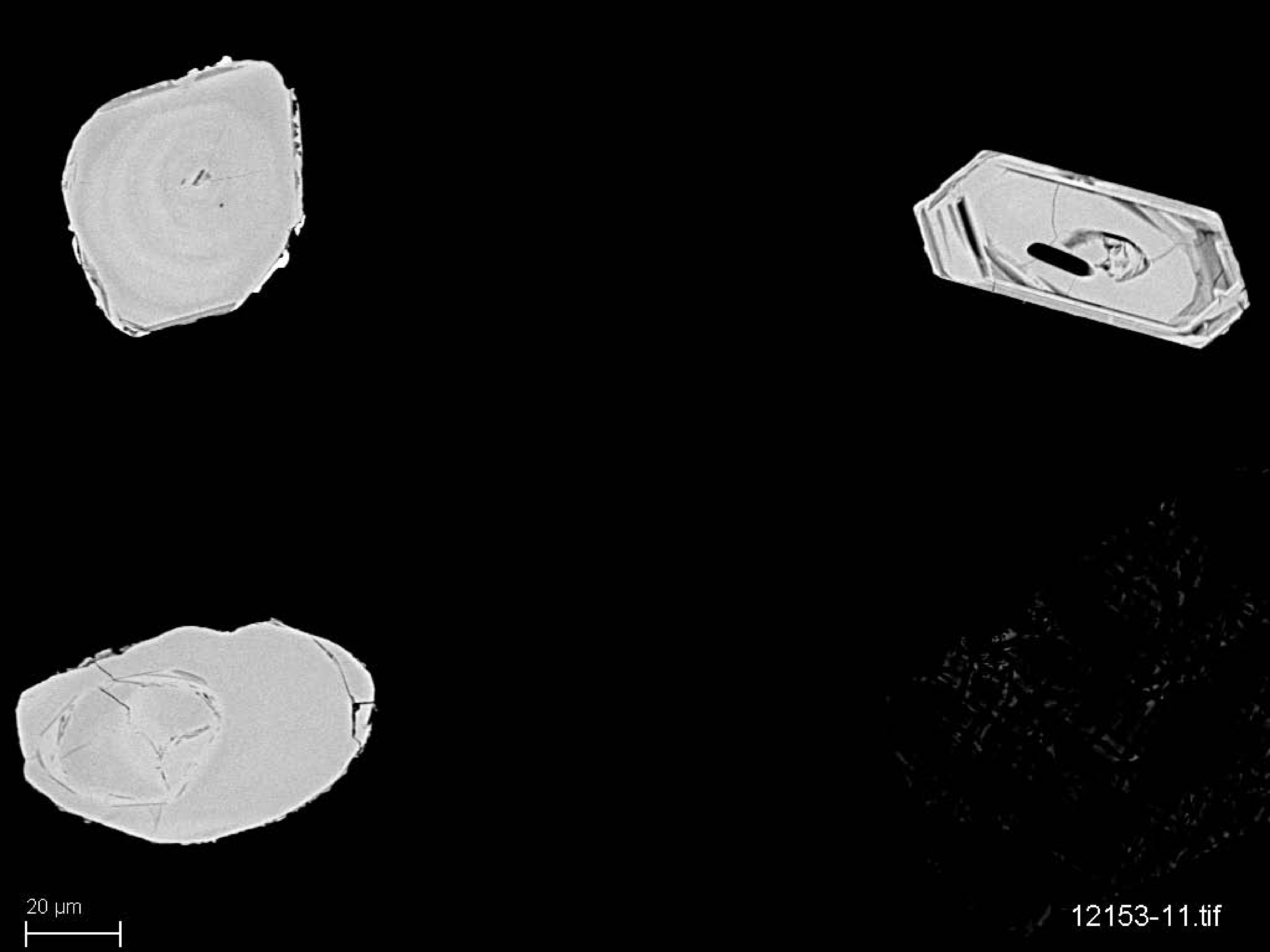

20 µm
12153-06.tif

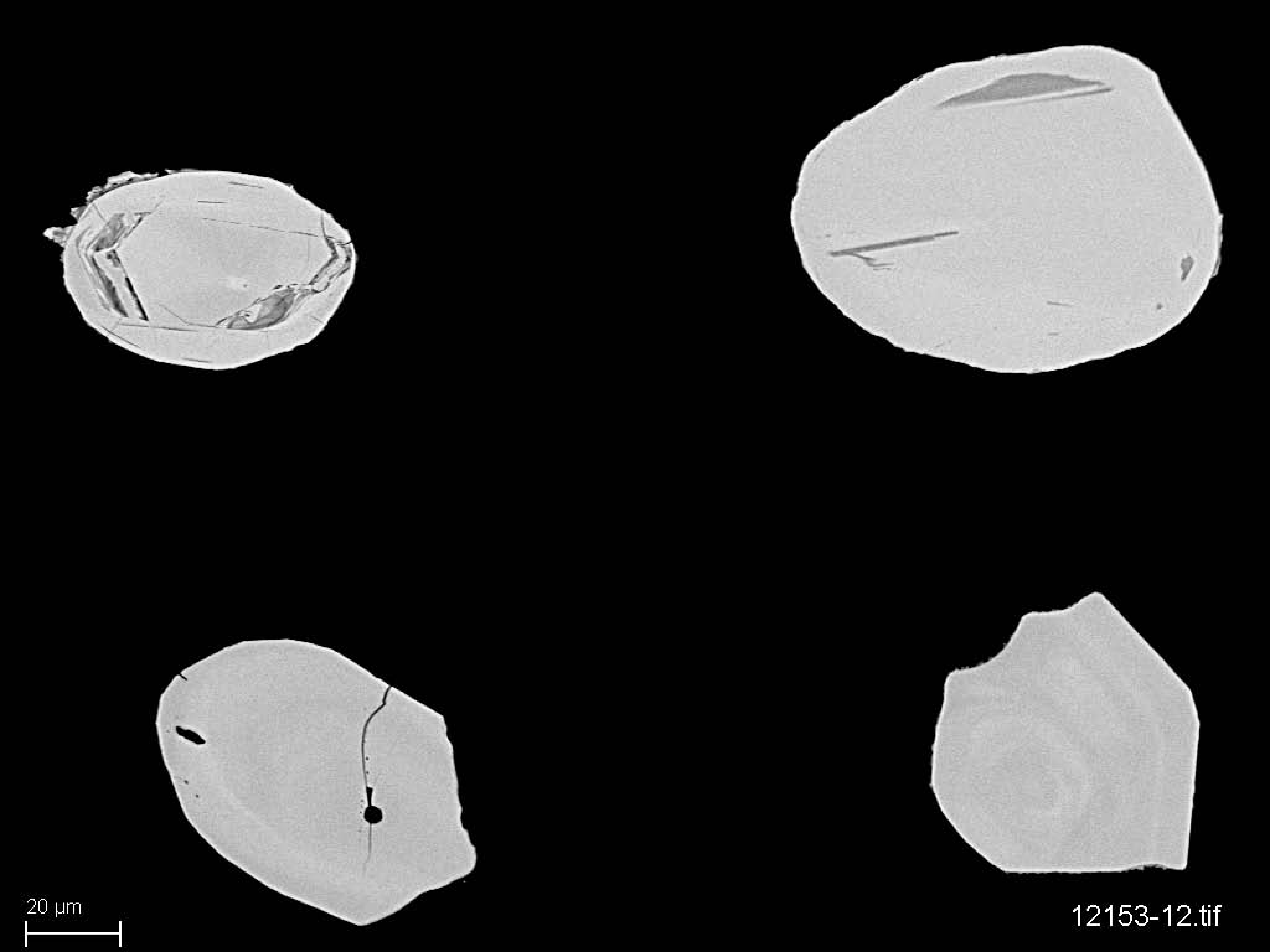

20 µm
12153-07.tif


20 µm
12153-08.tif


20 µm
12153-09.tif

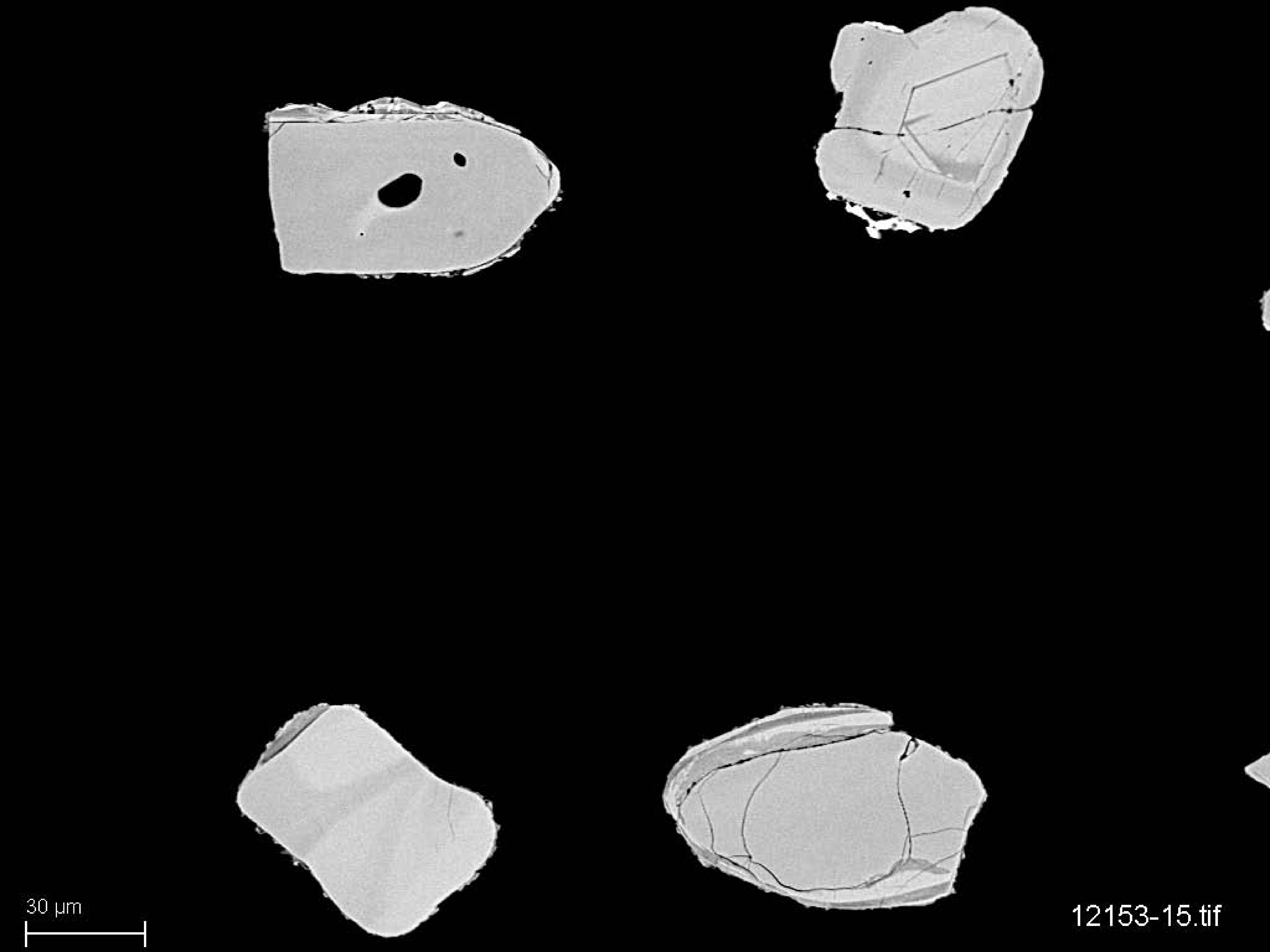

20 µm
12153-10.tif


20 µm
12153-11.tif

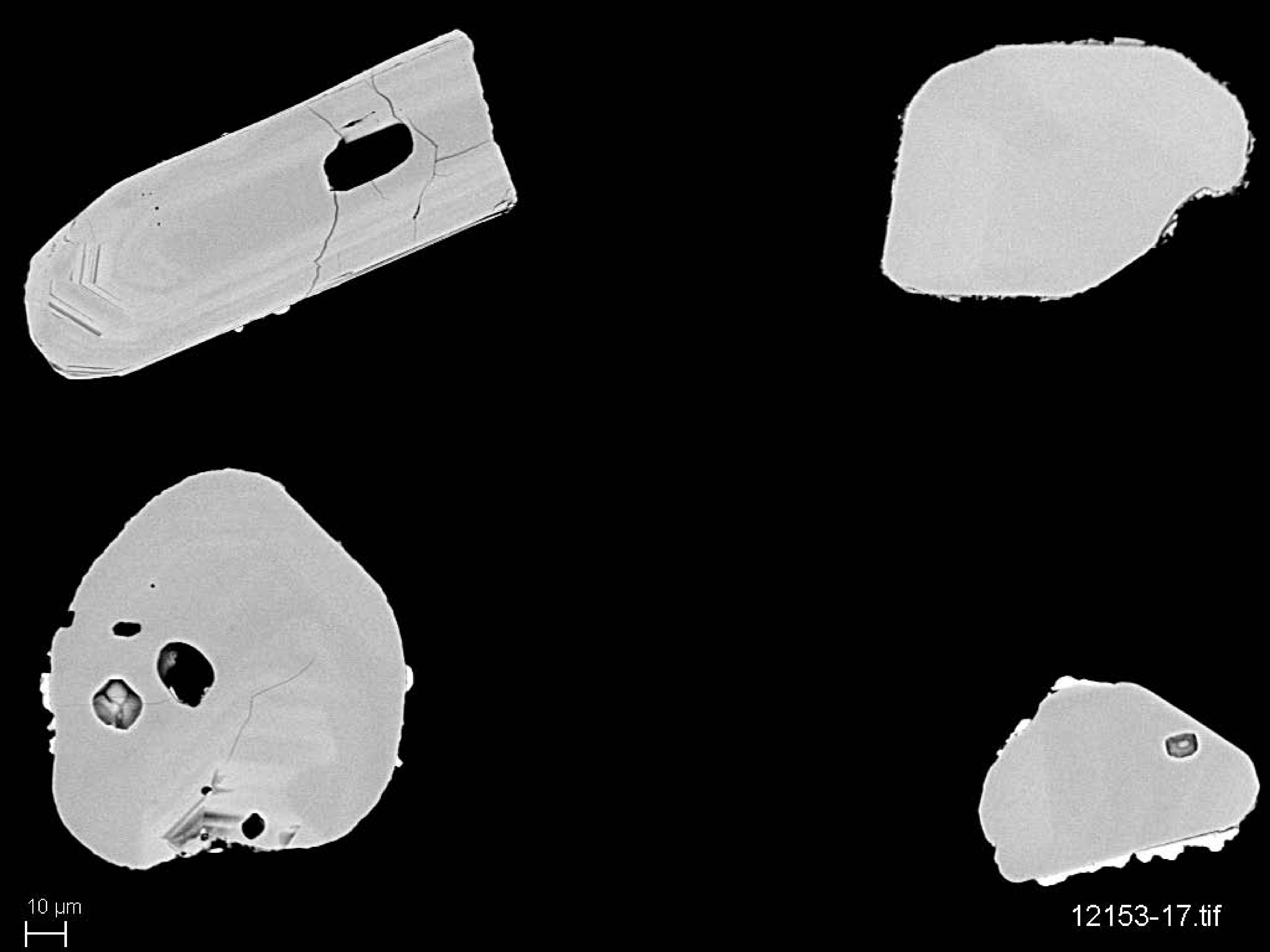

20 µm
12153-12.tif

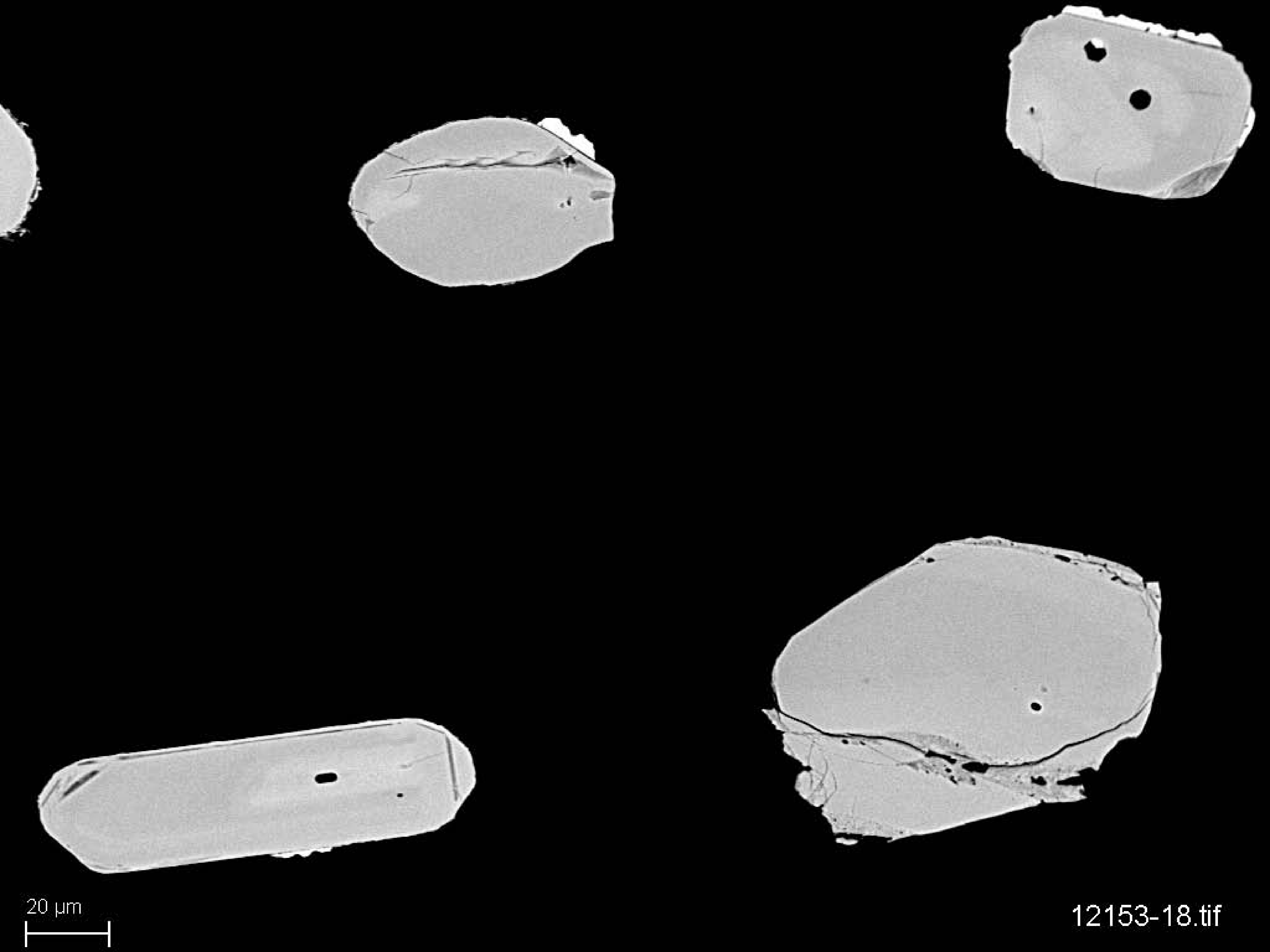

10 µm
12153-13.tif


10 µm
12153-14.tif


30 µm
12153-15.tif


10 µm
12153-16.tif


10 µm
12153-17.tif


20 µm
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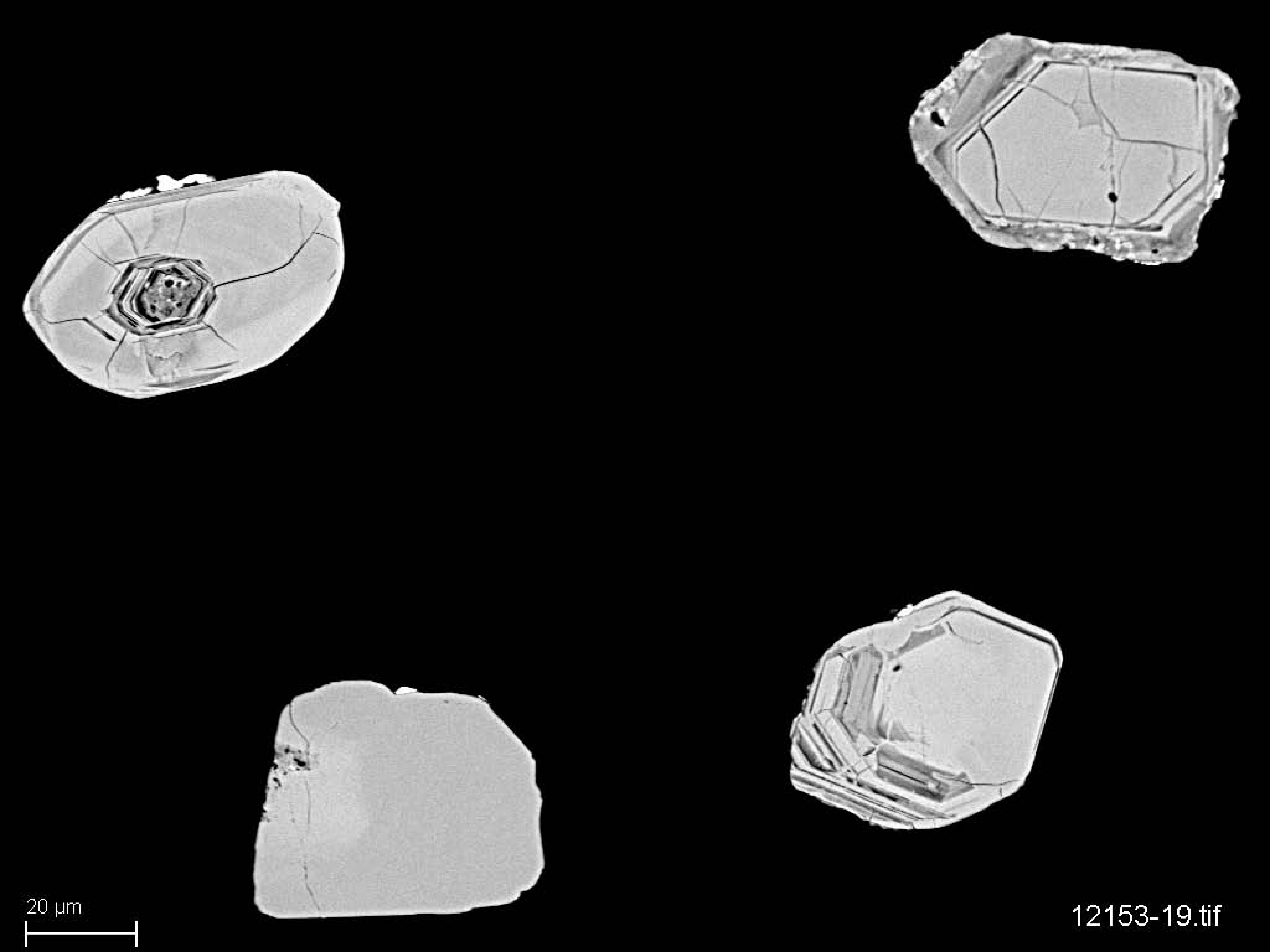
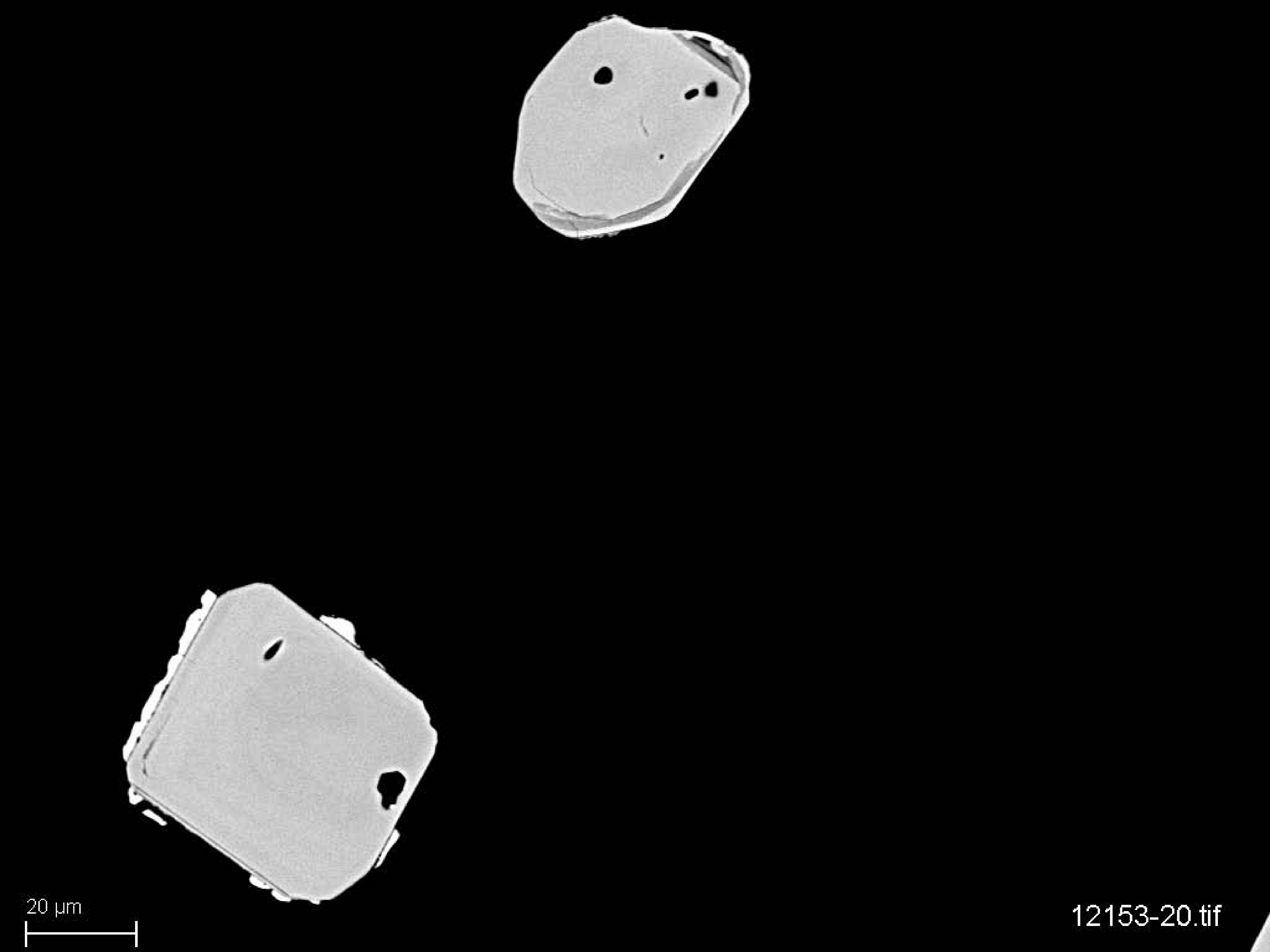
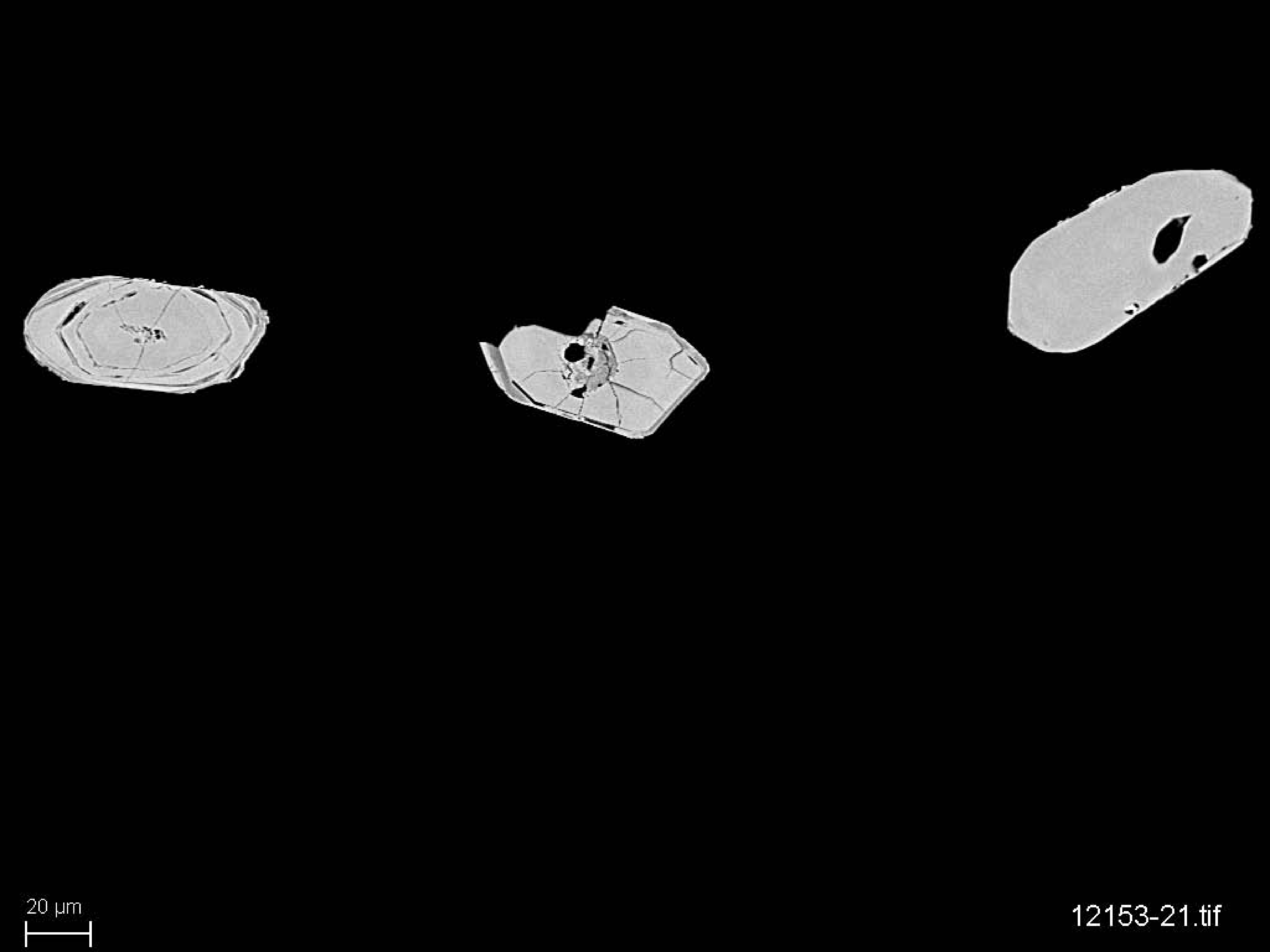
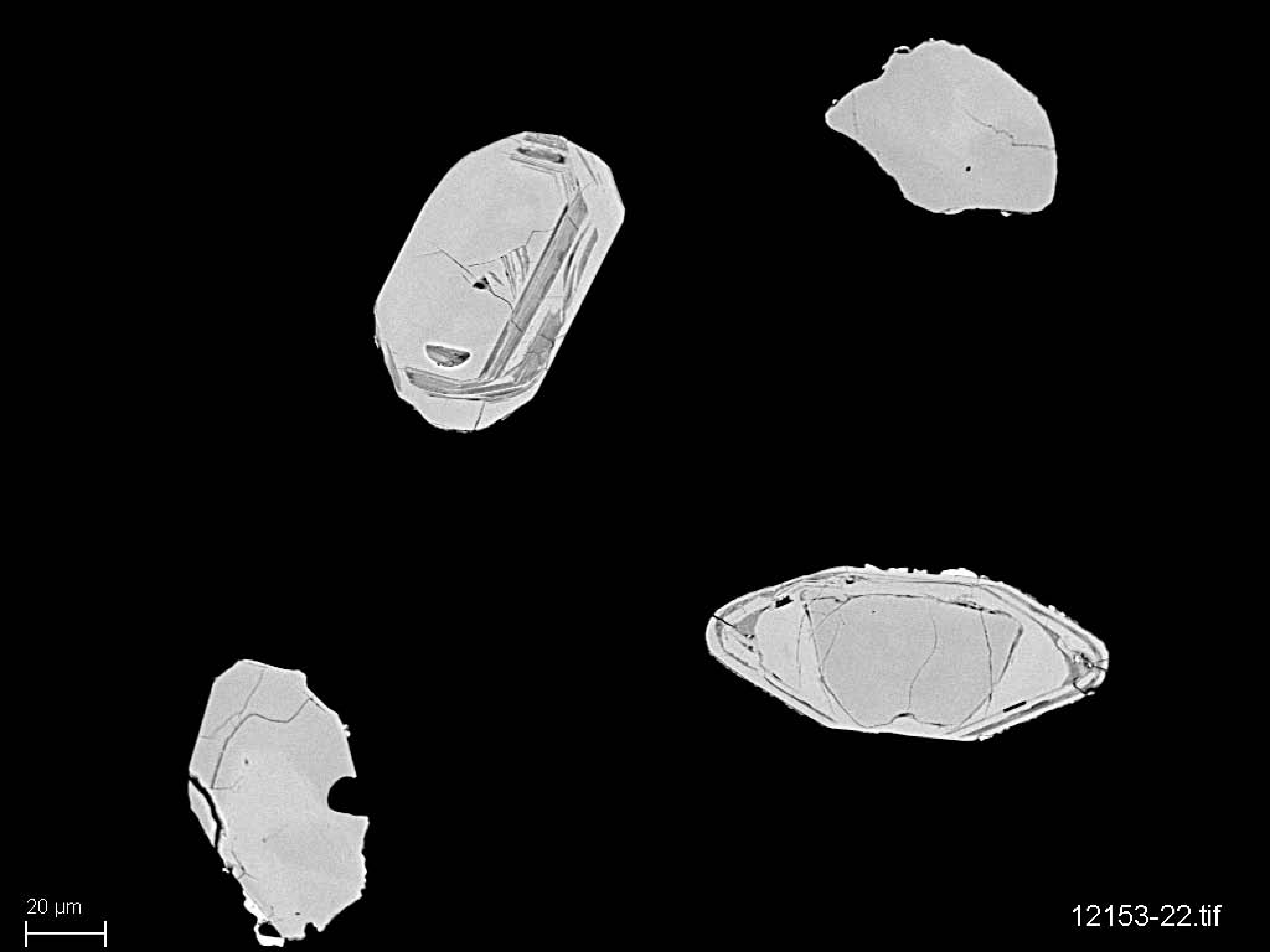
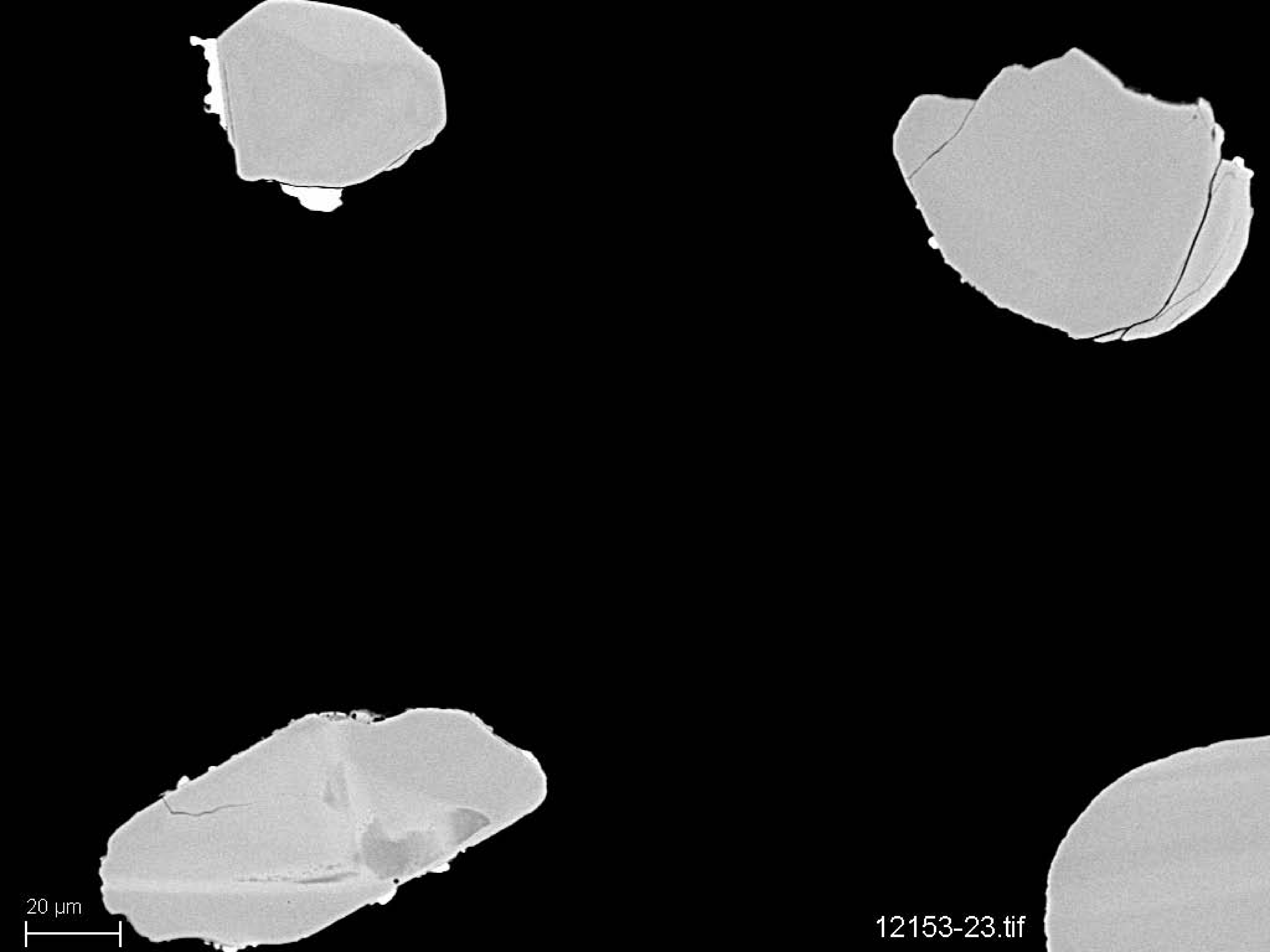

20 µm
12153-19.tif



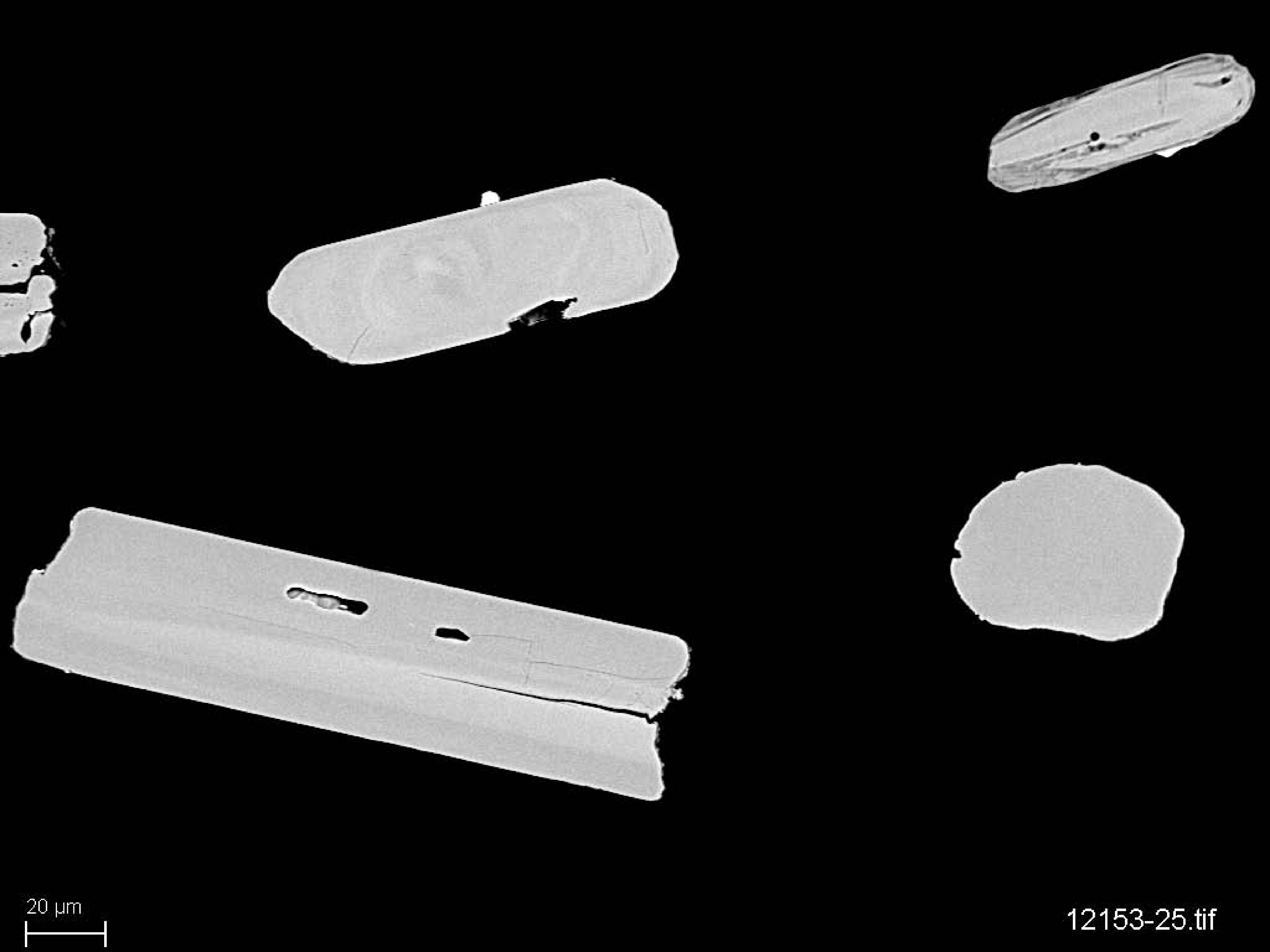
20 µm
12153-20.tif

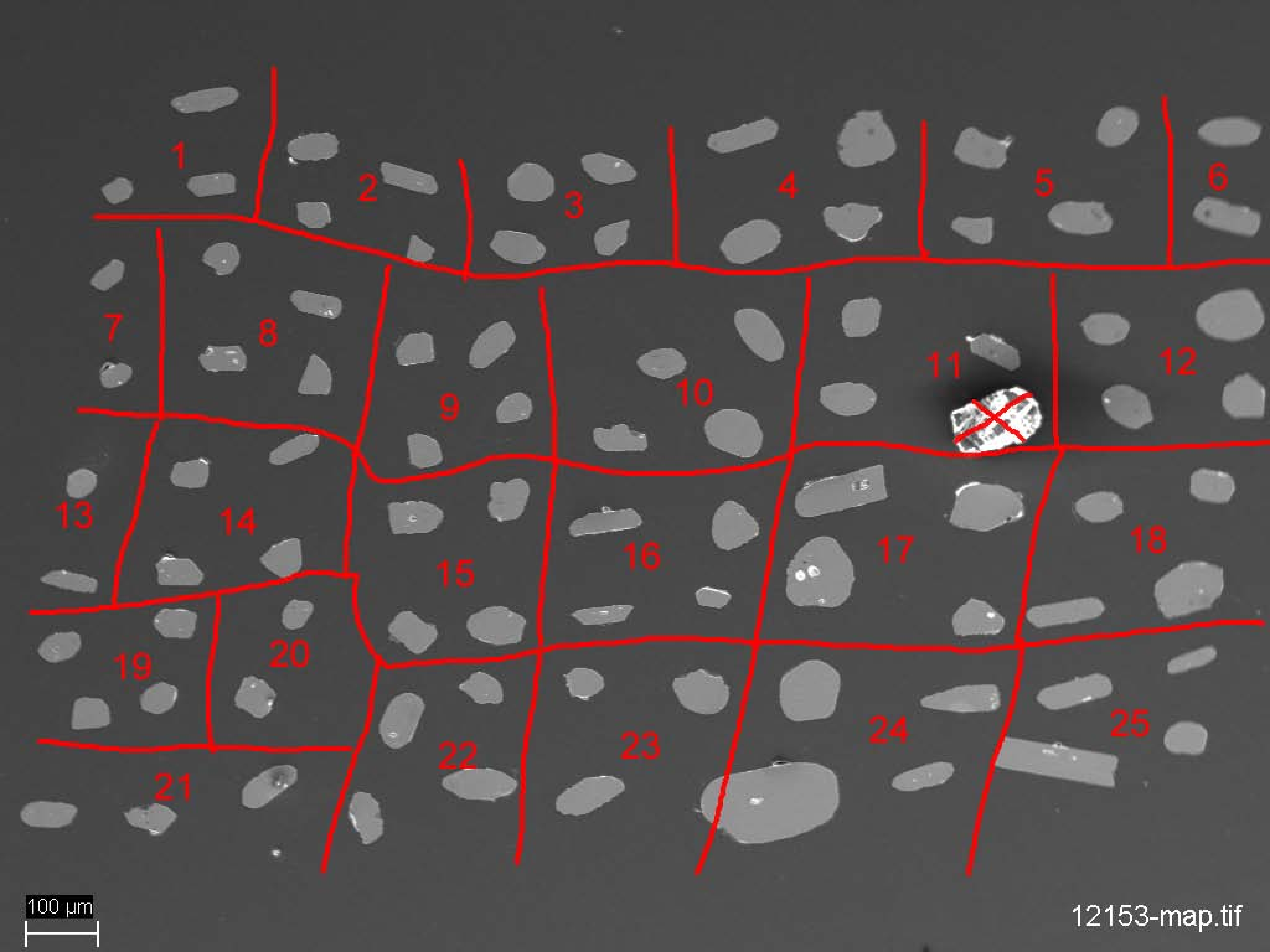

20 µm
12153-21.tif


20 µm
12153-22.tif


20 µm
12153-23.tif


20 µm
12153-24.tif


20 µm
12153-25.tif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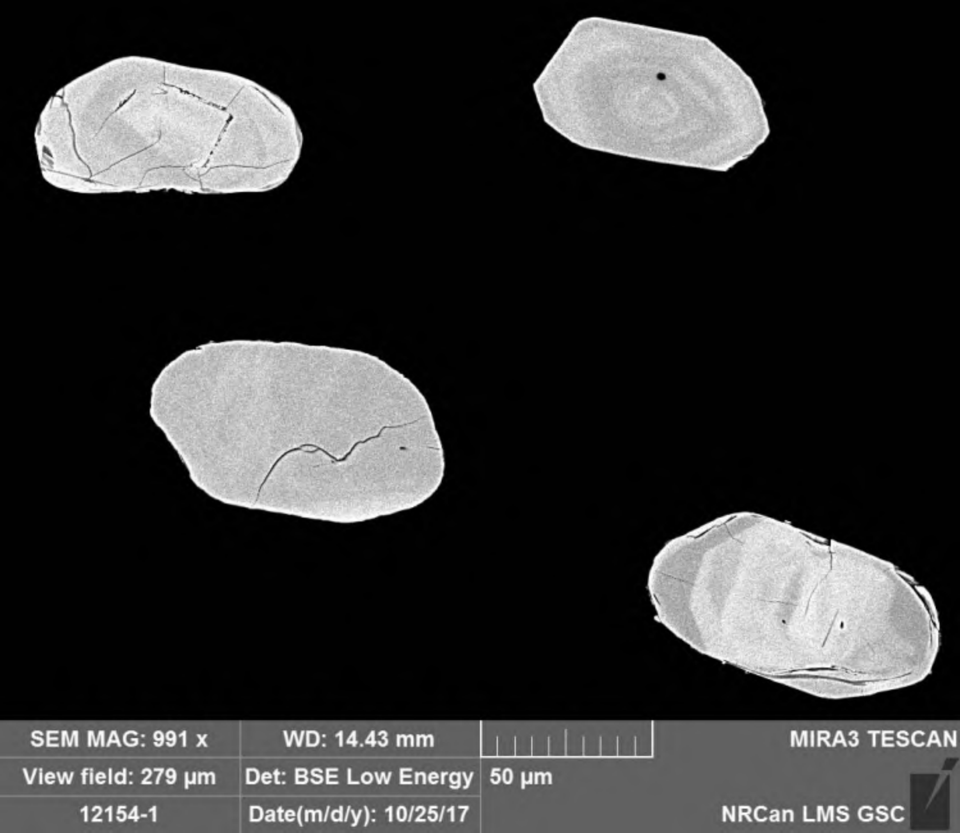
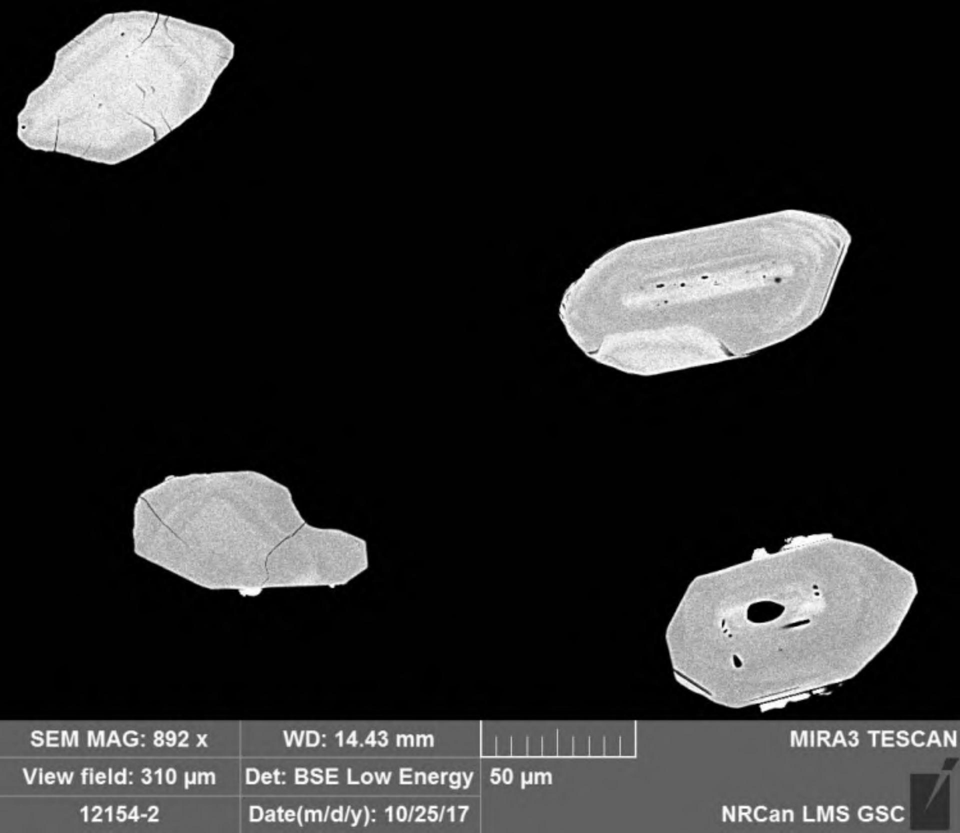
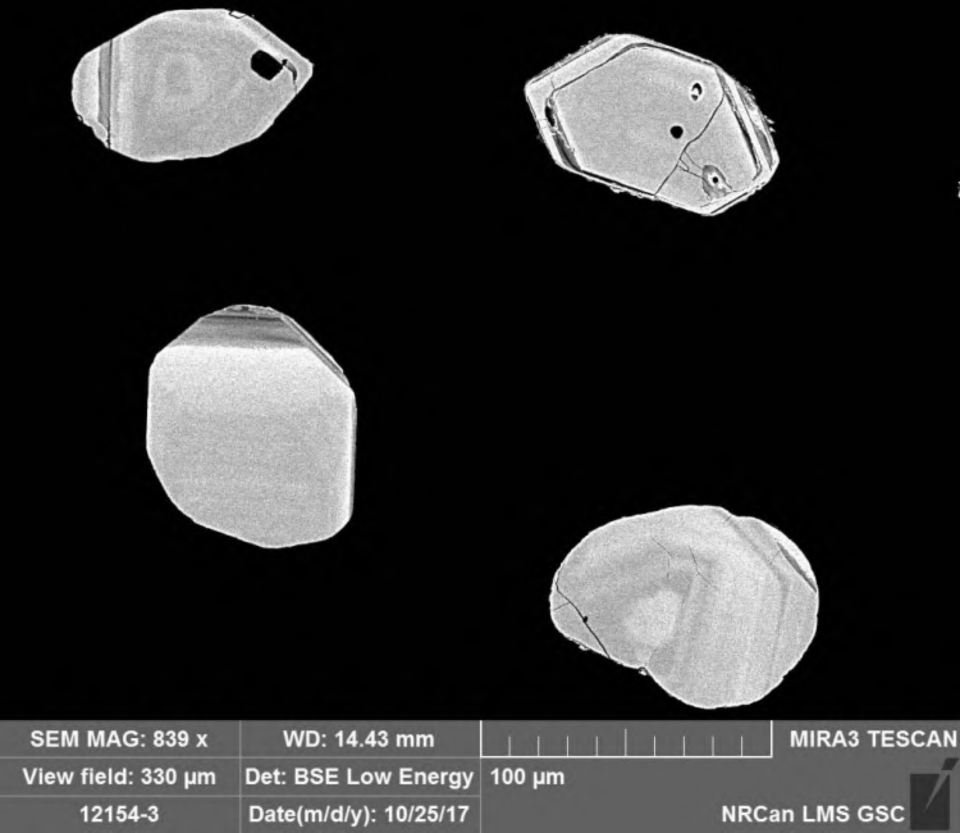
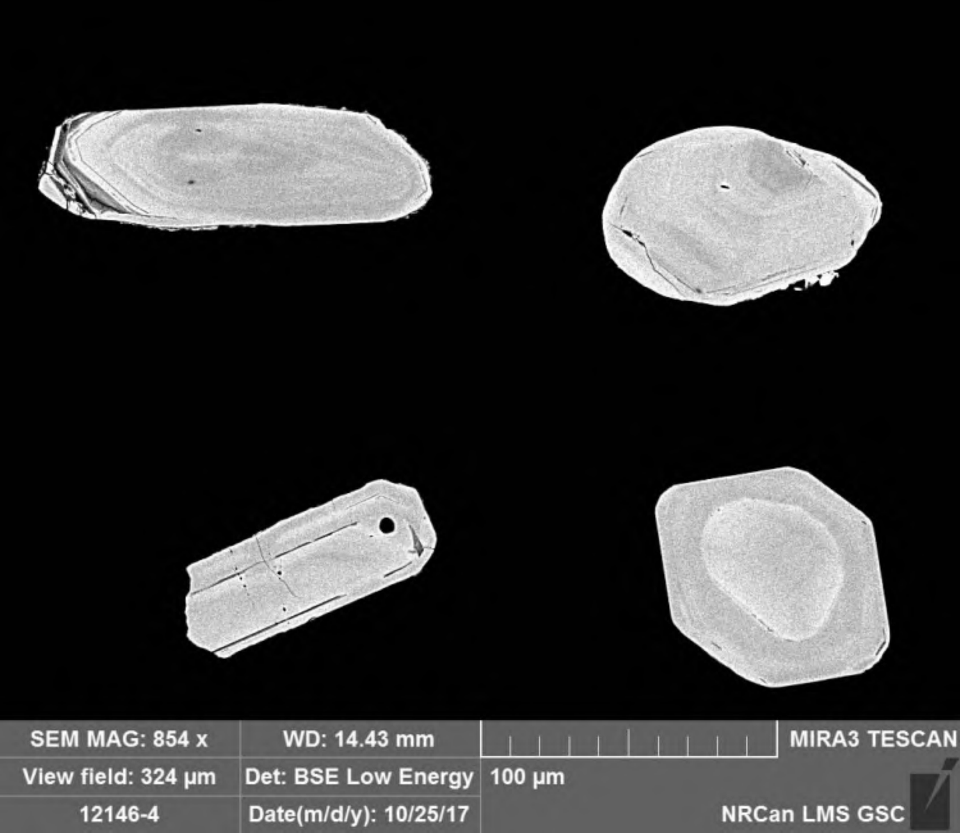
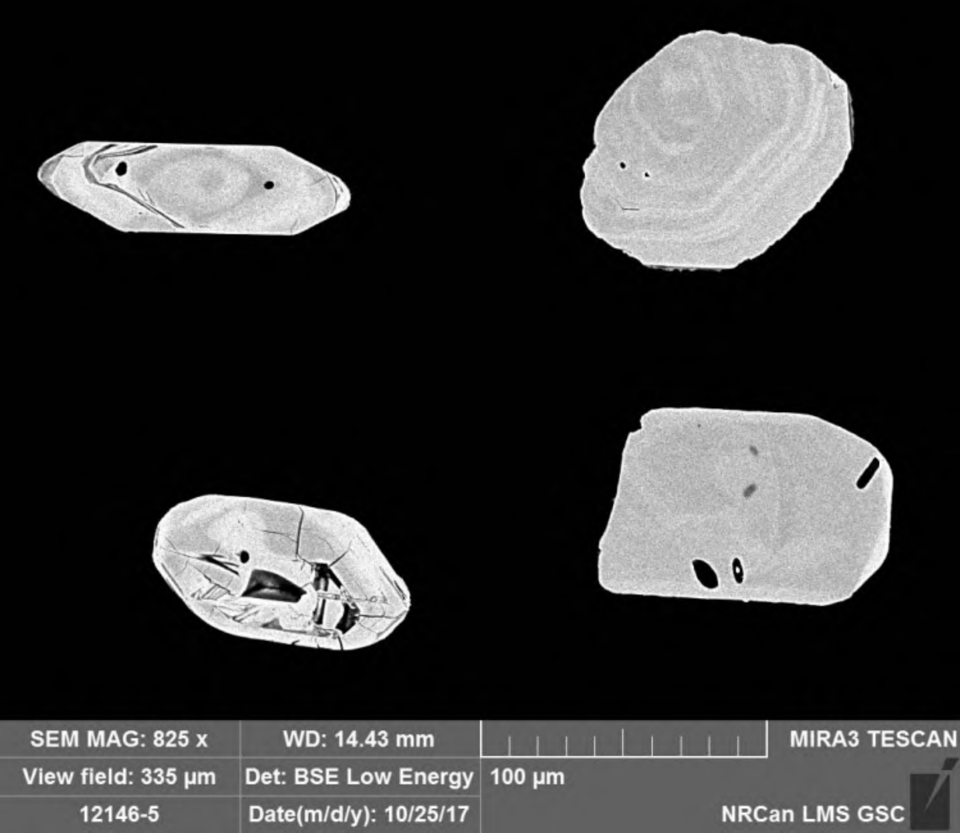
100 µm
12153-map.tif

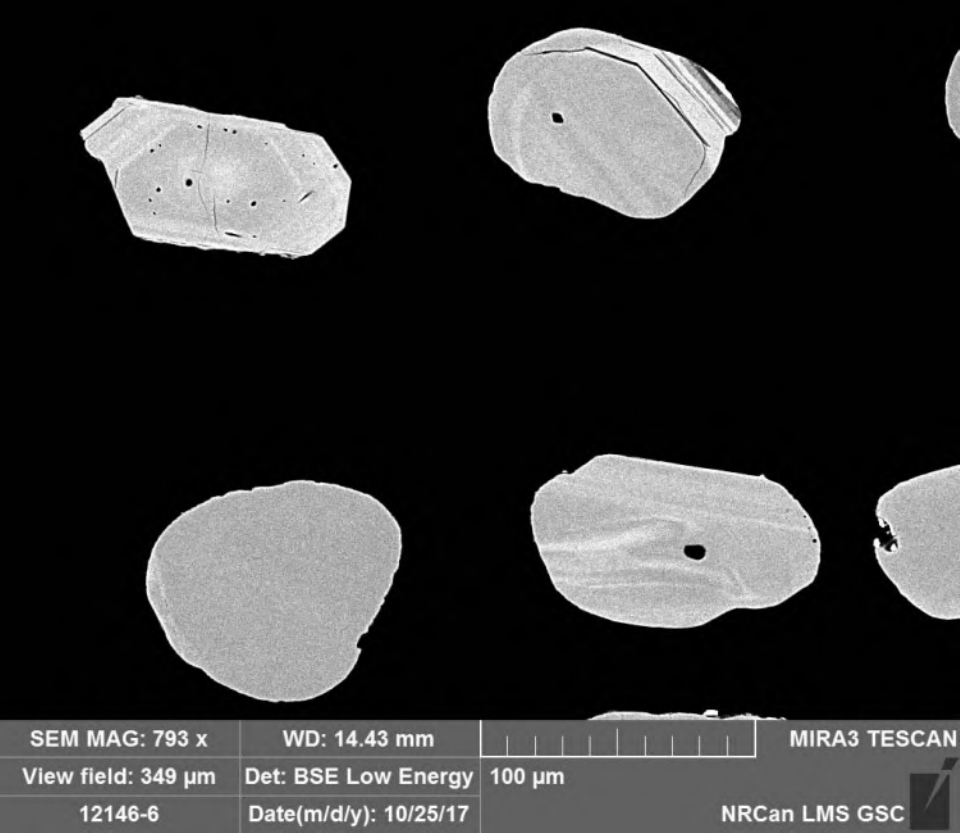

SEM MAG: 991 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 279 μm
Det: BSE Low Energy
50 μm
12154-1
Date(m/d/y): 10/25/17
NRCan LMS GSC

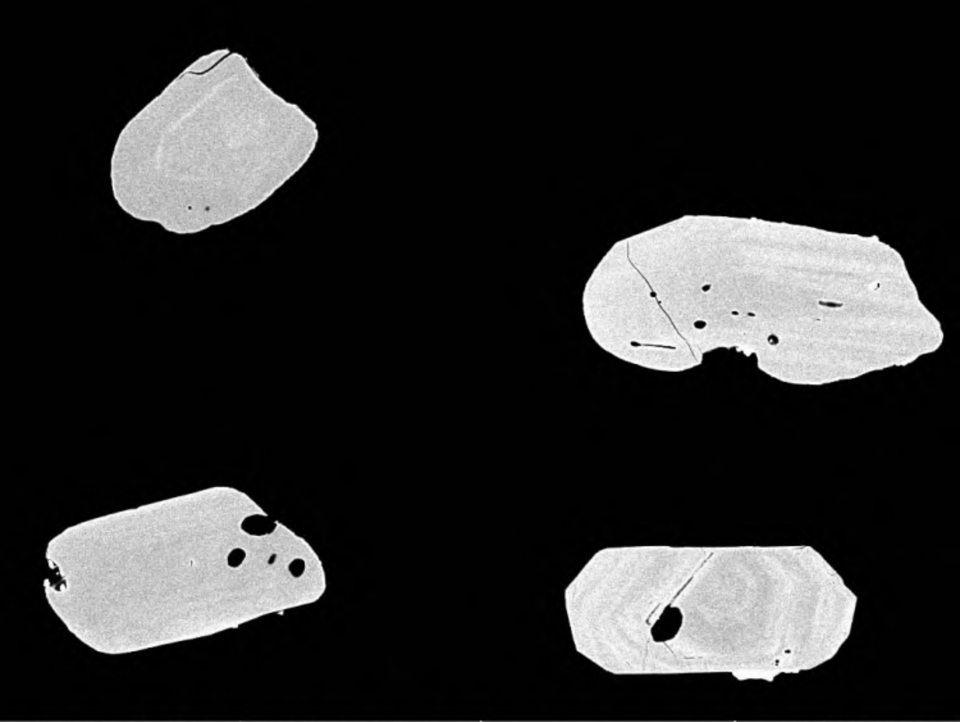

SEM MAG: 892 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 310 µm
Det: BSE Low Energy
50 µm
12154-2
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 839 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 330 µm
Det: BSE Low Energy
100 µm
12154-3
Date(m/d/y): 10/25/17
NRCan LMS GSC

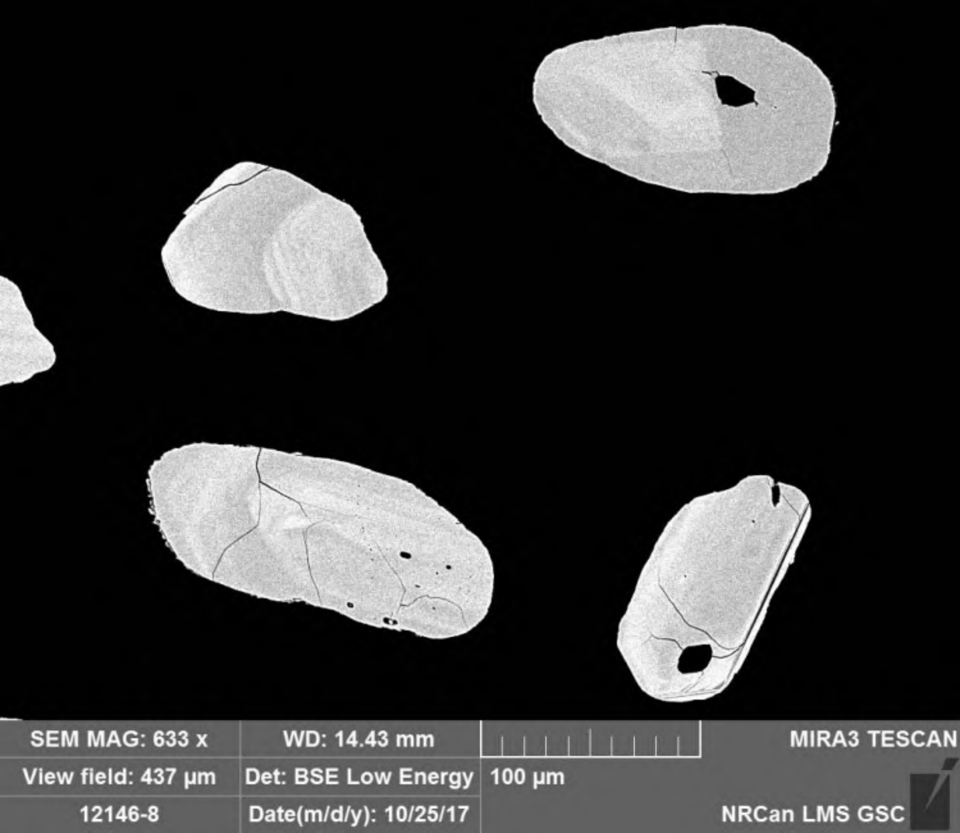

SEM MAG: 854 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 324 µm
Det: BSE Low Energy
100 µm
12146-4
Date(m/d/y): 10/25/17
NRCan LMS GSC

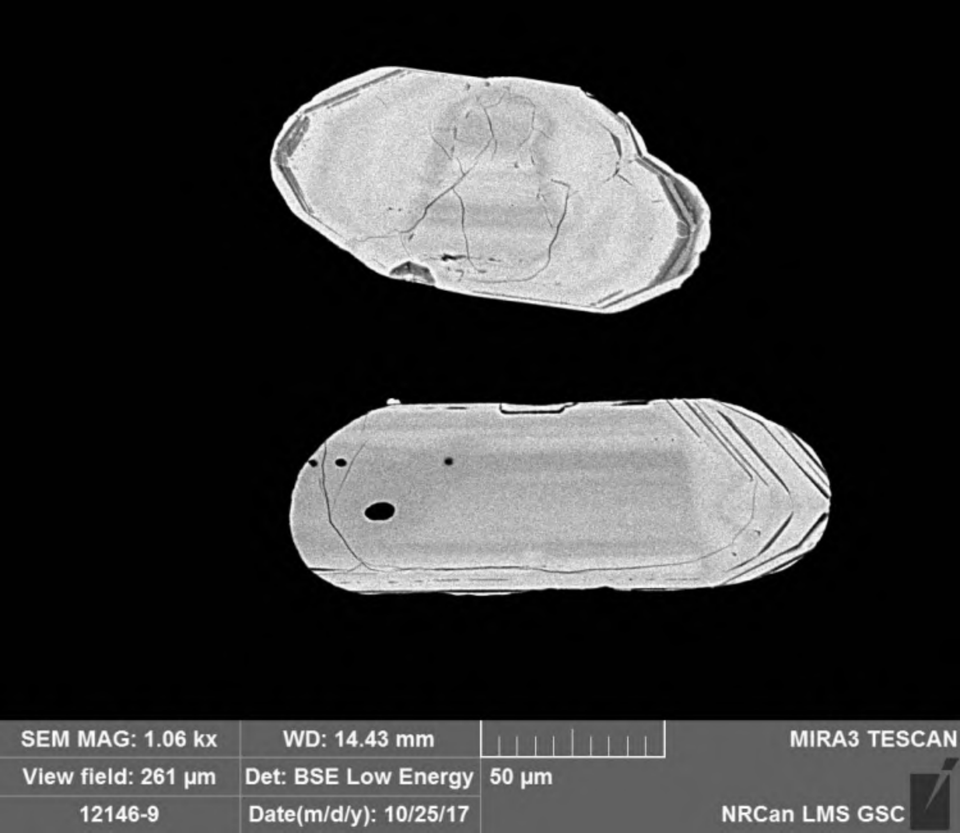

SEM MAG: 825 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 335 µm
Det: BSE Low Energy
100 µm
12146-5
Date(m/d/y): 10/25/17
NRCan LMS GSC

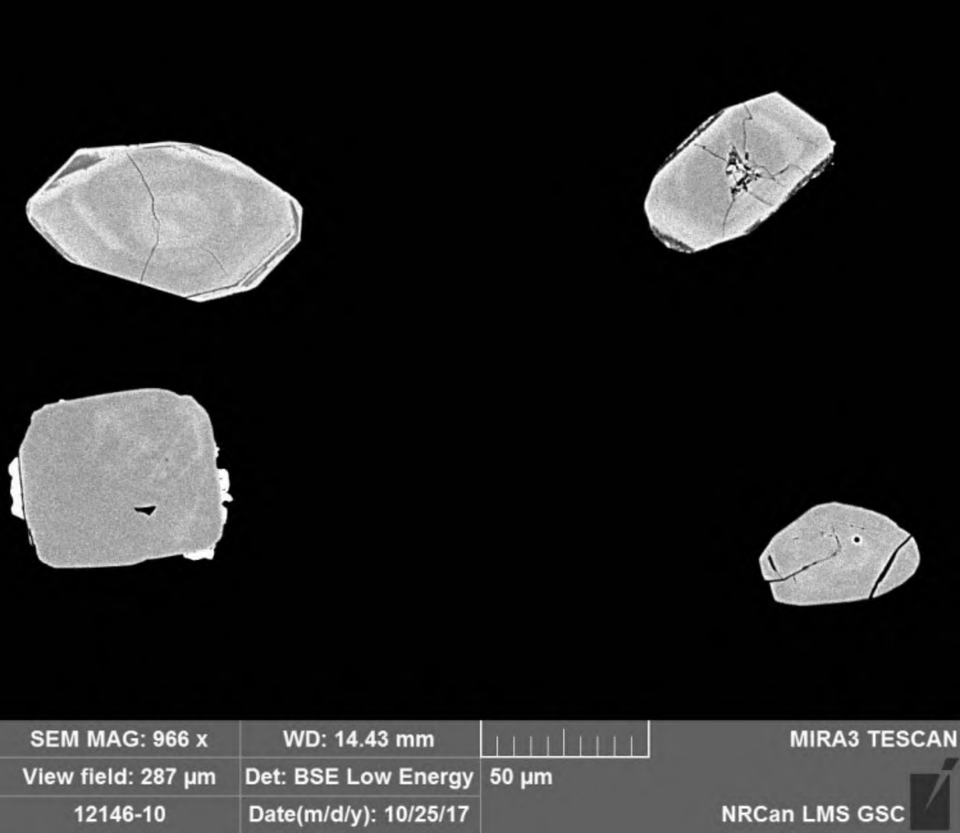

SEM MAG: 793 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 349 µm
Det: BSE Low Energy
100 µm
12146-6
Date(m/d/y): 10/25/17
NRCan LMS GSC

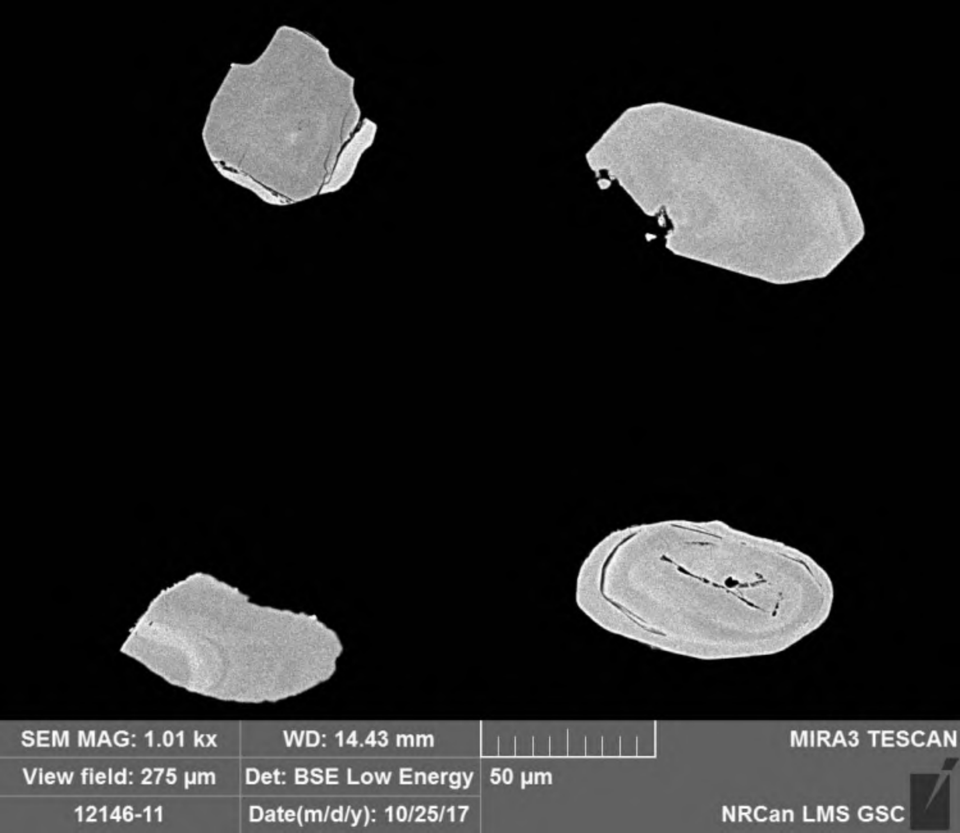


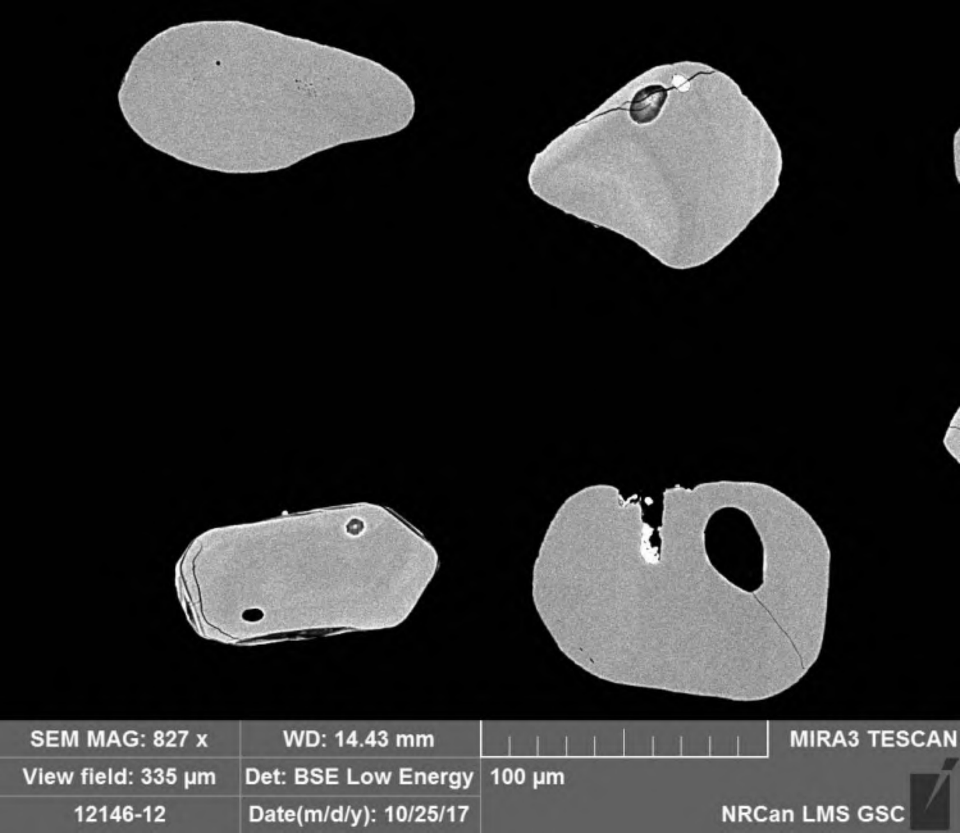
SEM MAG: 732 x	WD: 14.43 mm		MIRA3 TESCAN
View field: 378 µm	Det: BSE Low Energy	100 µm	
12146-7	Date(m/d/y): 10/25/17		NRCan LMS GSC

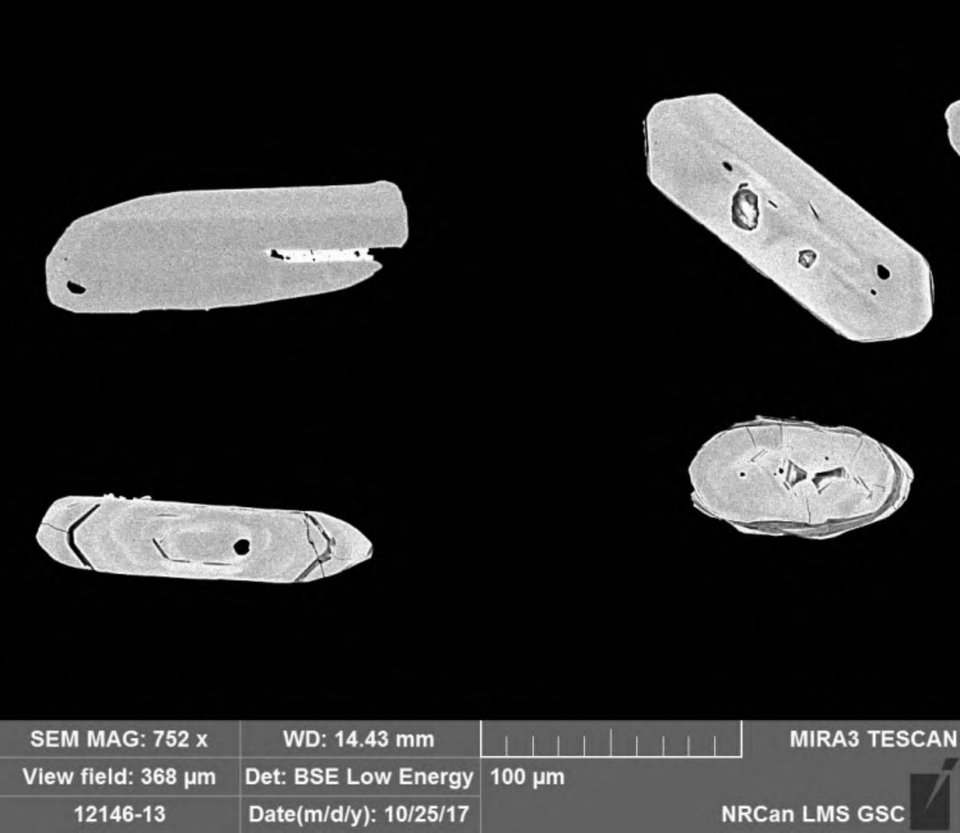

SEM MAG: 633 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 437 µm
Det: BSE Low Energy
100 µm
12146-8
Date(m/d/y): 10/25/17
NRCan LMS GSC

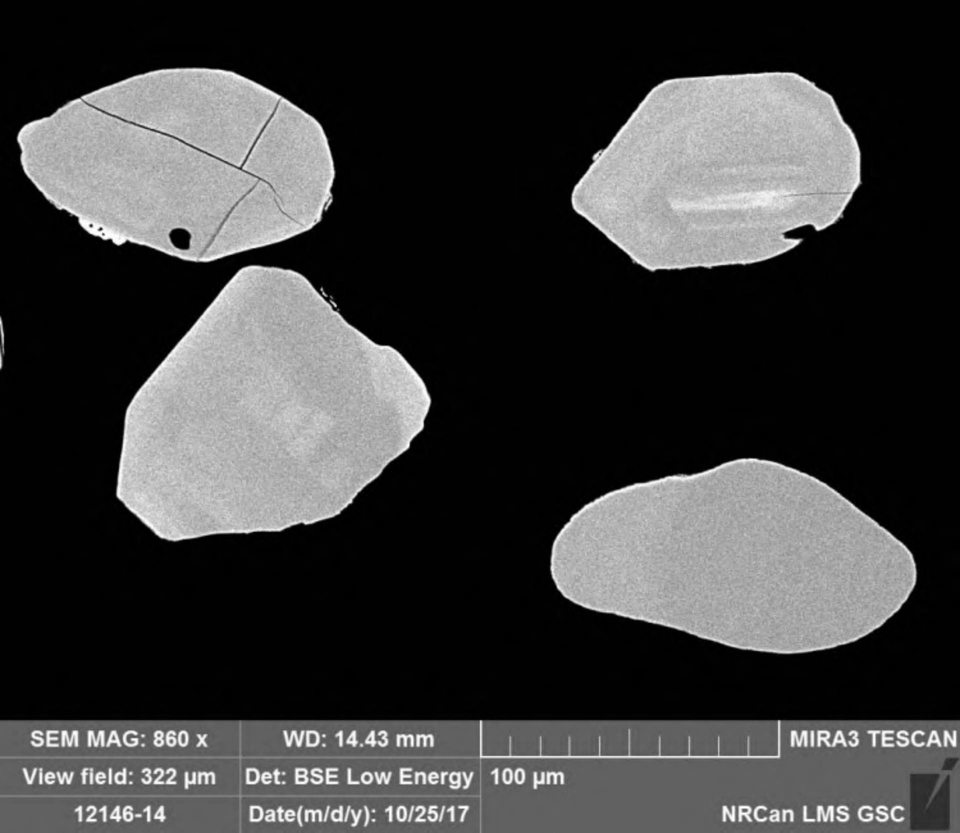

SEM MAG: 1.06 kx
WD: 14.43 mm
MIRA3 TESCAN
View field: 261 µm
Det: BSE Low Energy
50 µm
12146-9
Date(m/d/y): 10/25/17
NRCan LMS GSC

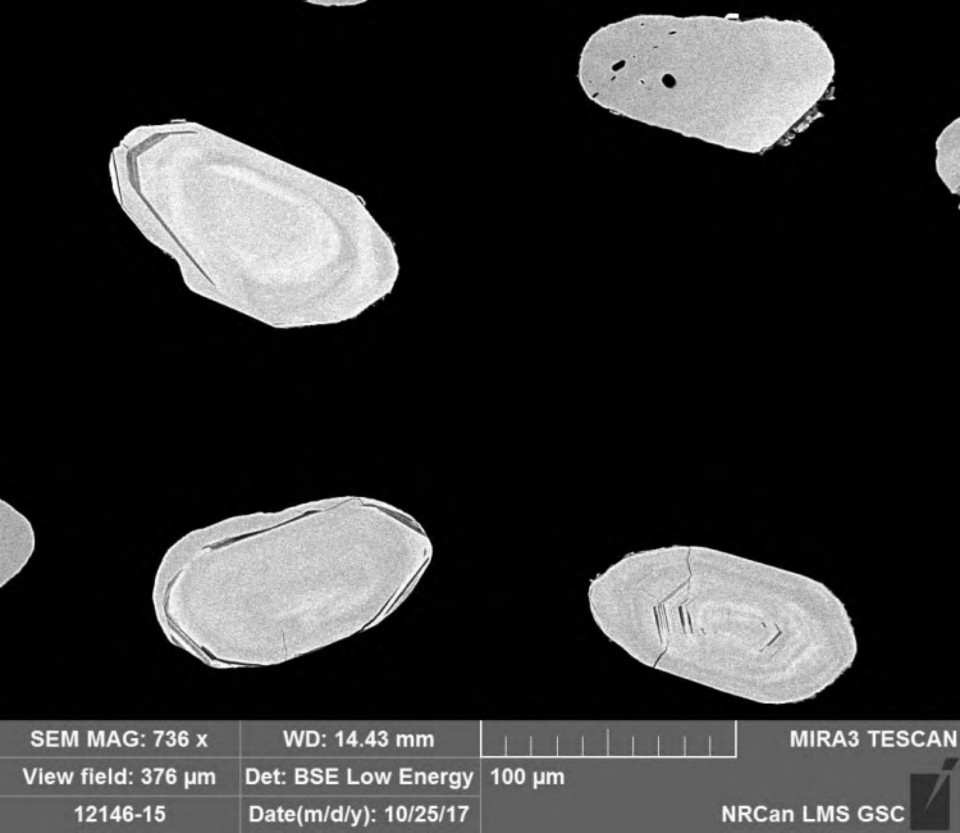

SEM MAG: 966 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 287 µm
Det: BSE Low Energy
50 µm
12146-10
Date(m/d/y): 10/25/17
NRCan LMS GSC

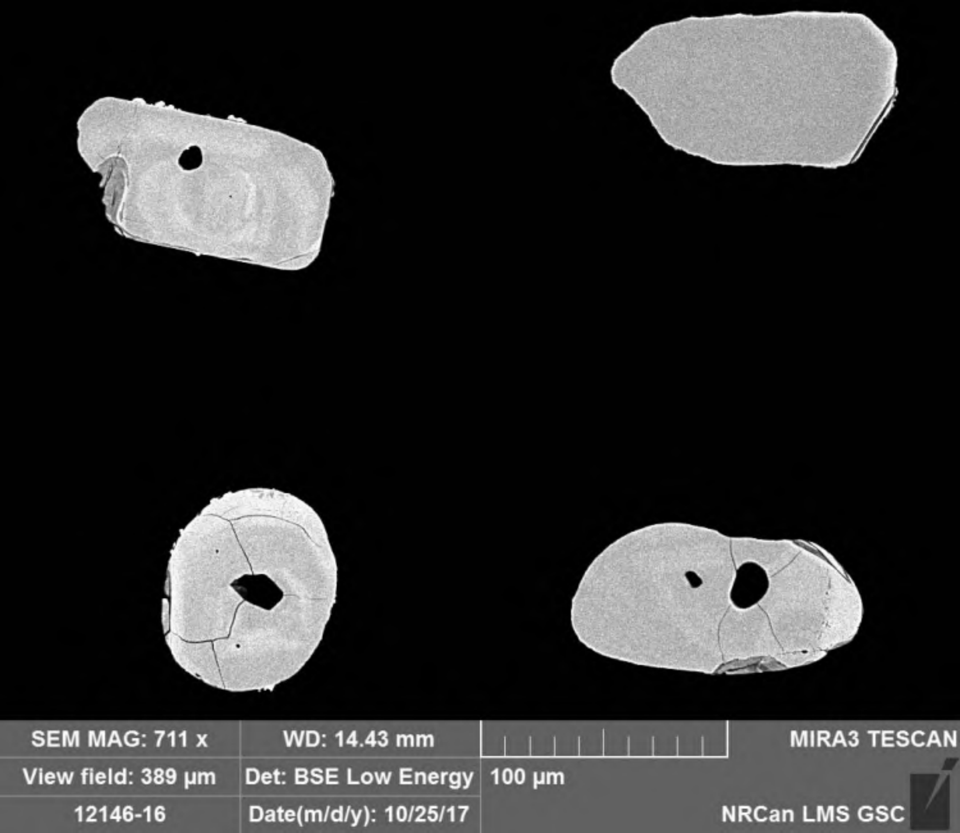

SEM MAG: 1.01 kx
WD: 14.43 mm
MIRA3 TESCAN
View field: 275 µm
Det: BSE Low Energy
50 µm
12146-11
Date(m/d/y): 10/25/17
NRCan LMS GSC

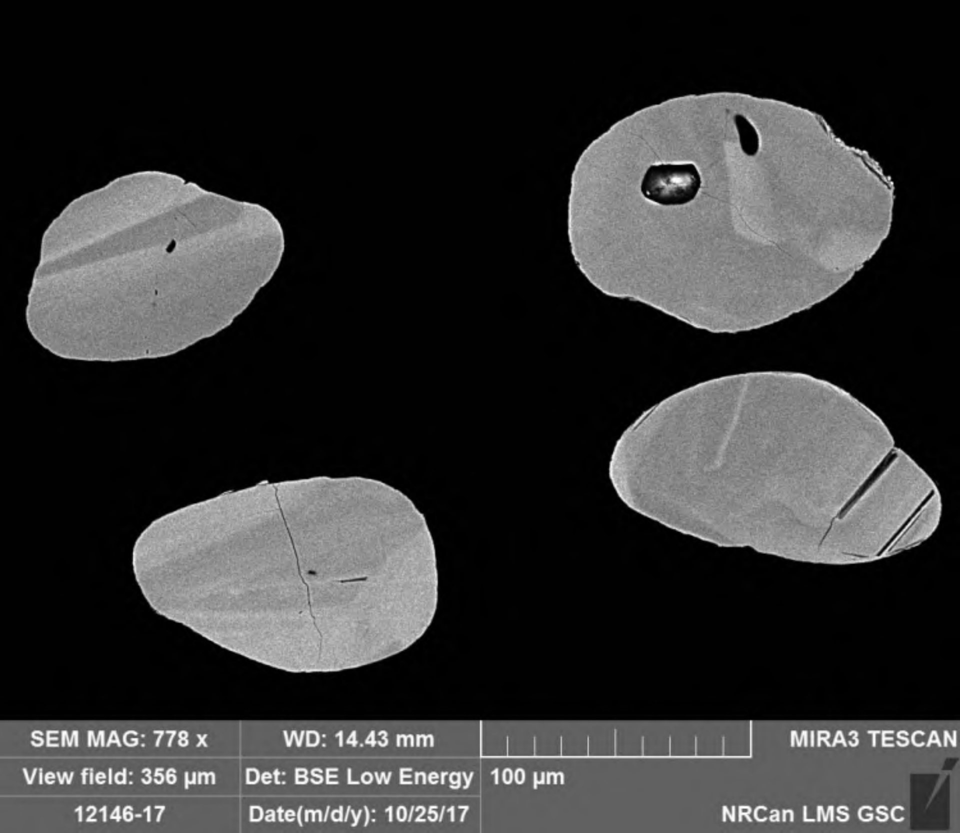

SEM MAG: 827 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 335 µm
Det: BSE Low Energy
100 µm
12146-12
Date(m/d/y): 10/25/17
NRCan LMS GSC

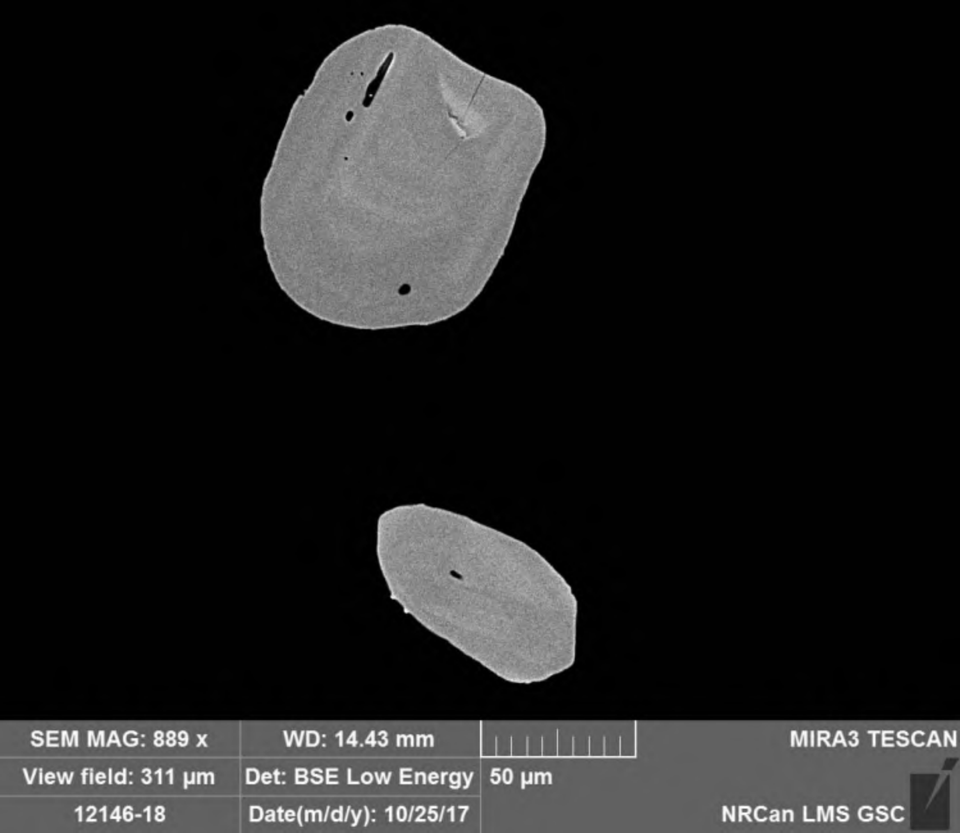

SEM MAG: 752 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 368 µm
Det: BSE Low Energy
100 µm
12146-13
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 860 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 322 µm
Det: BSE Low Energy
100 µm
12146-14
Date(m/d/y): 10/25/17
NRCan LMS GSC

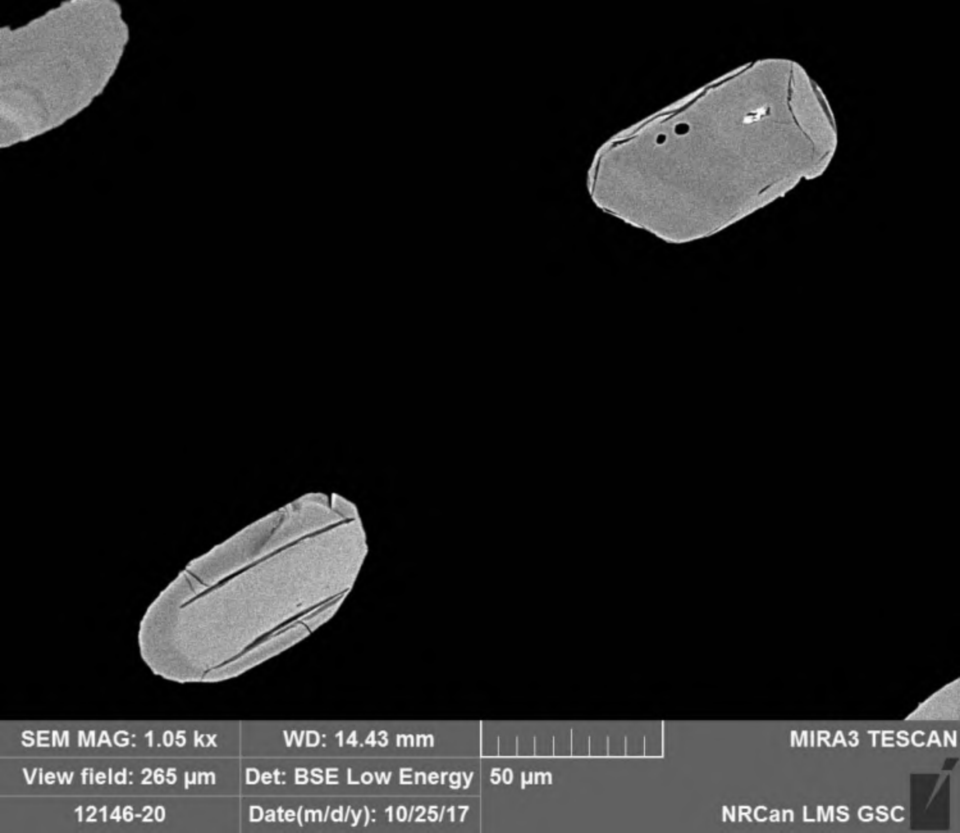

SEM MAG: 736 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 376 µm
Det: BSE Low Energy
100 µm
12146-15
Date(m/d/y): 10/25/17
NRCan LMS GSC

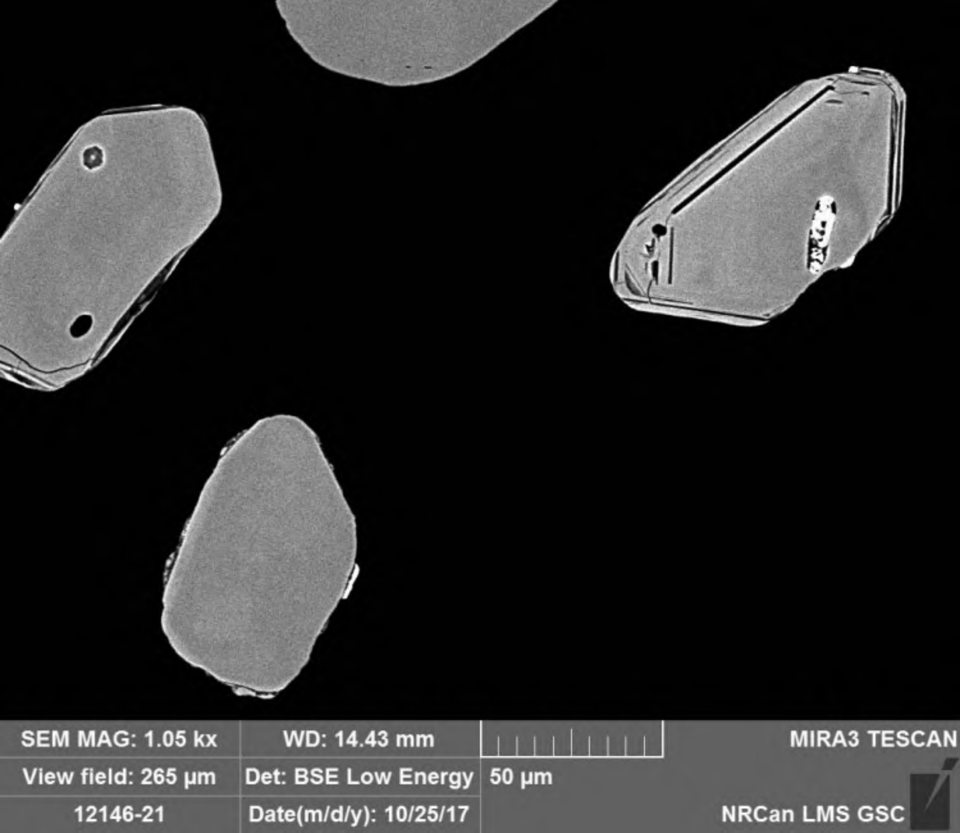

SEM MAG: 711 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 389 µm
Det: BSE Low Energy
100 µm
12146-16
Date(m/d/y): 10/25/17
NRCan LMS GSC

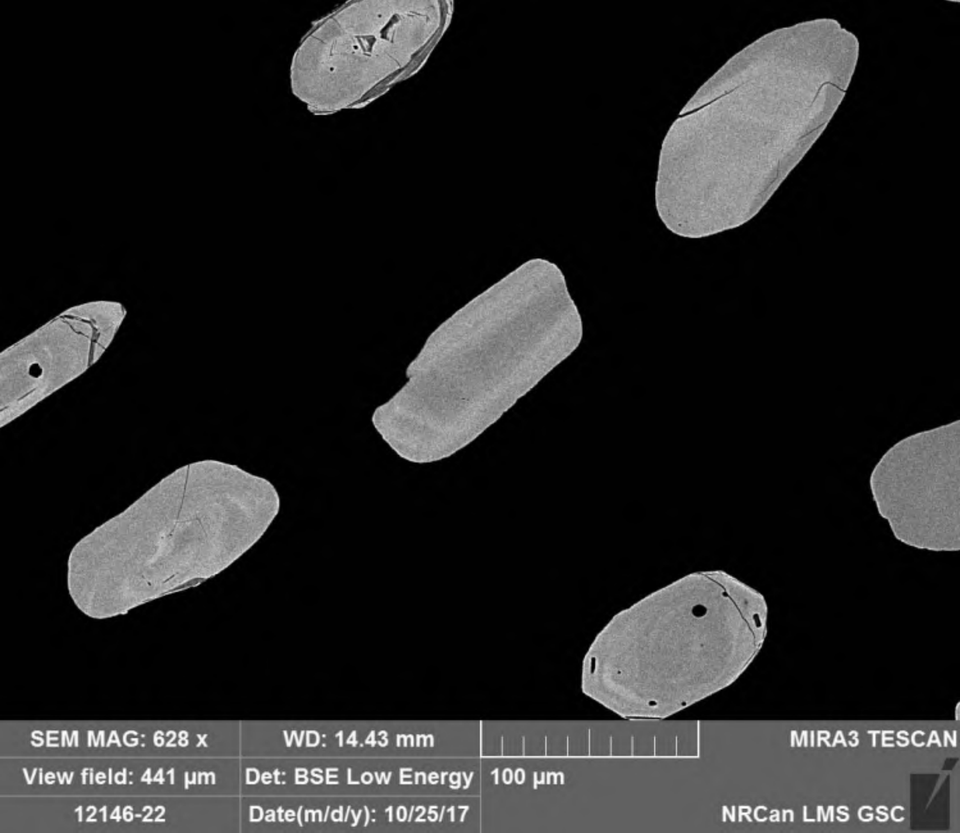

SEM MAG: 778 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 356 µm
Det: BSE Low Energy
100 µm
12146-17
Date(m/d/y): 10/25/17
NRCan LMS GSC

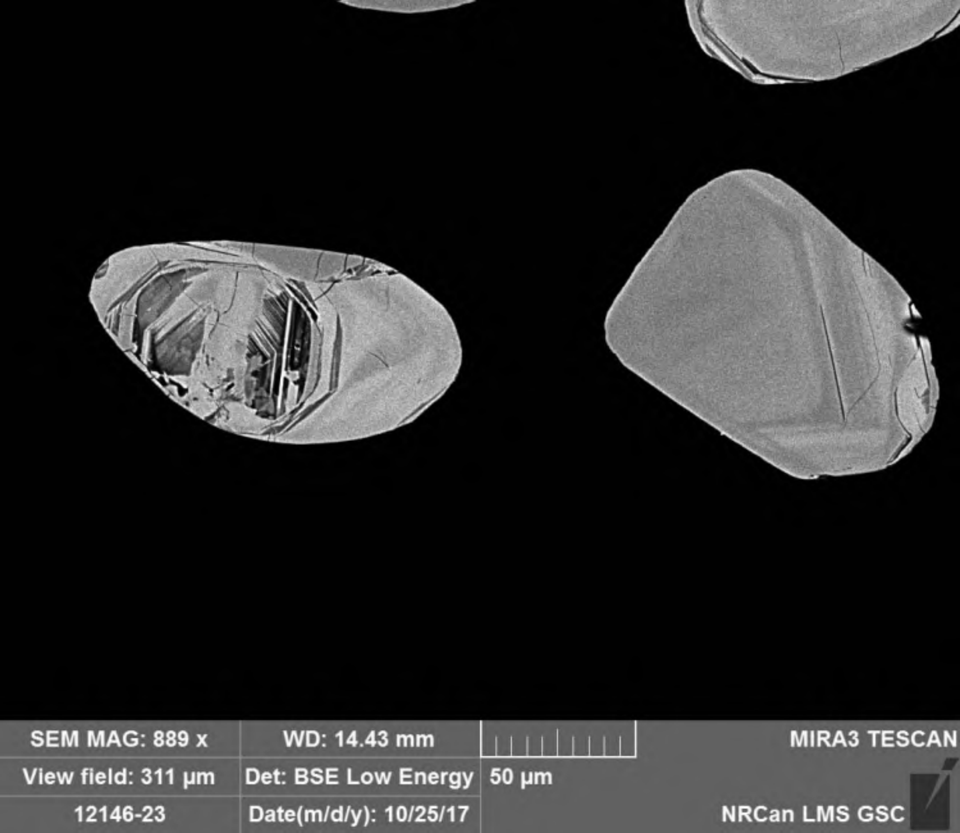

SEM MAG: 889 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 311 µm
Det: BSE Low Energy
50 µm
12146-18
Date(m/d/y): 10/25/17
NRCan LMS GSC

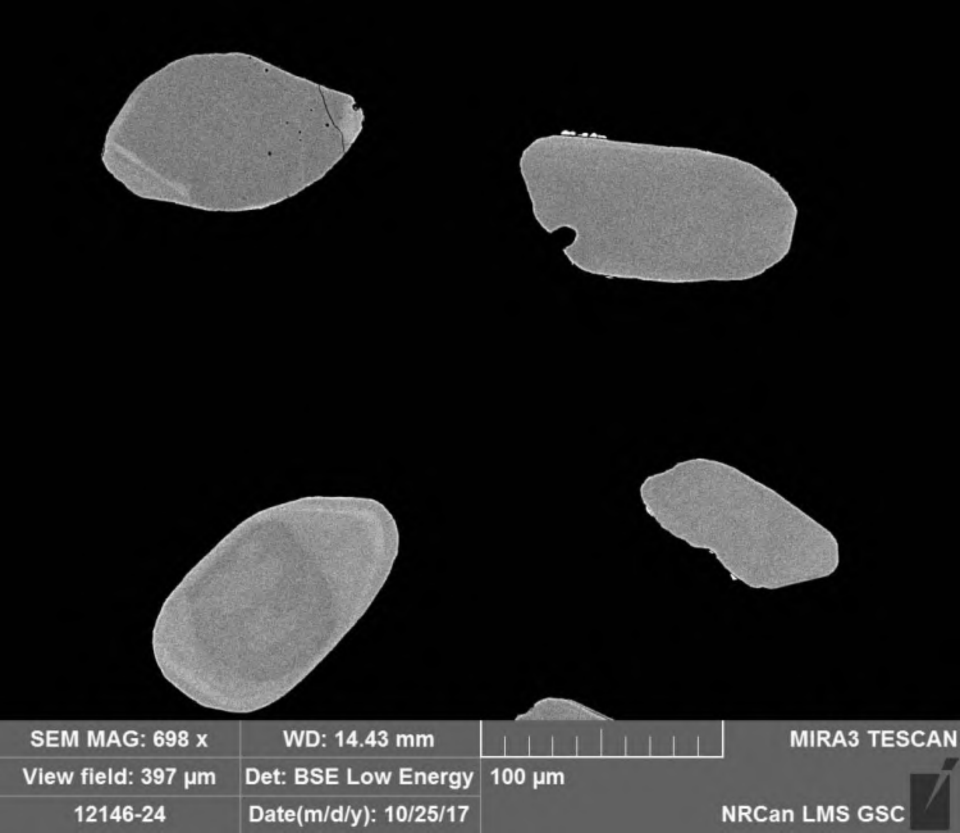

SEM MAG: 942 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 294 µm
Det: BSE Low Energy
50 µm
12146-19
Date(m/d/y): 10/25/17
NRCan LMS GSC

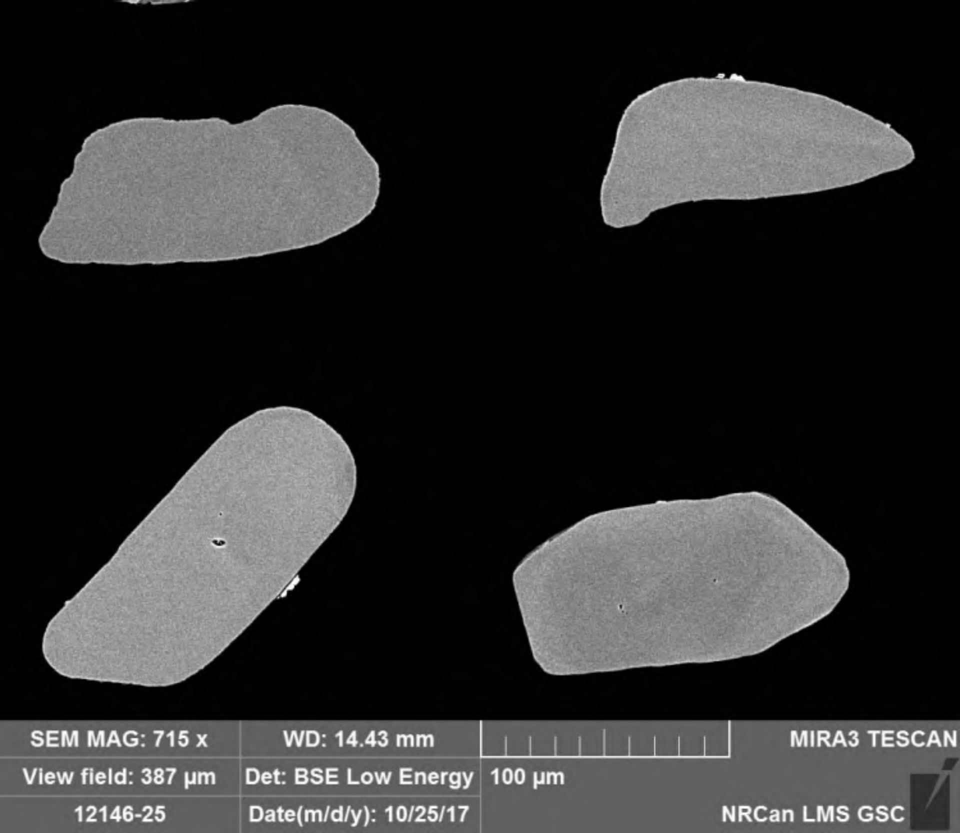

SEM MAG: 1.05 kx
WD: 14.43 mm
MIRA3 TESCAN
View field: 265 µm
Det: BSE Low Energy
50 µm
12146-20
Date(m/d/y): 10/25/17
NRCan LMS GSC

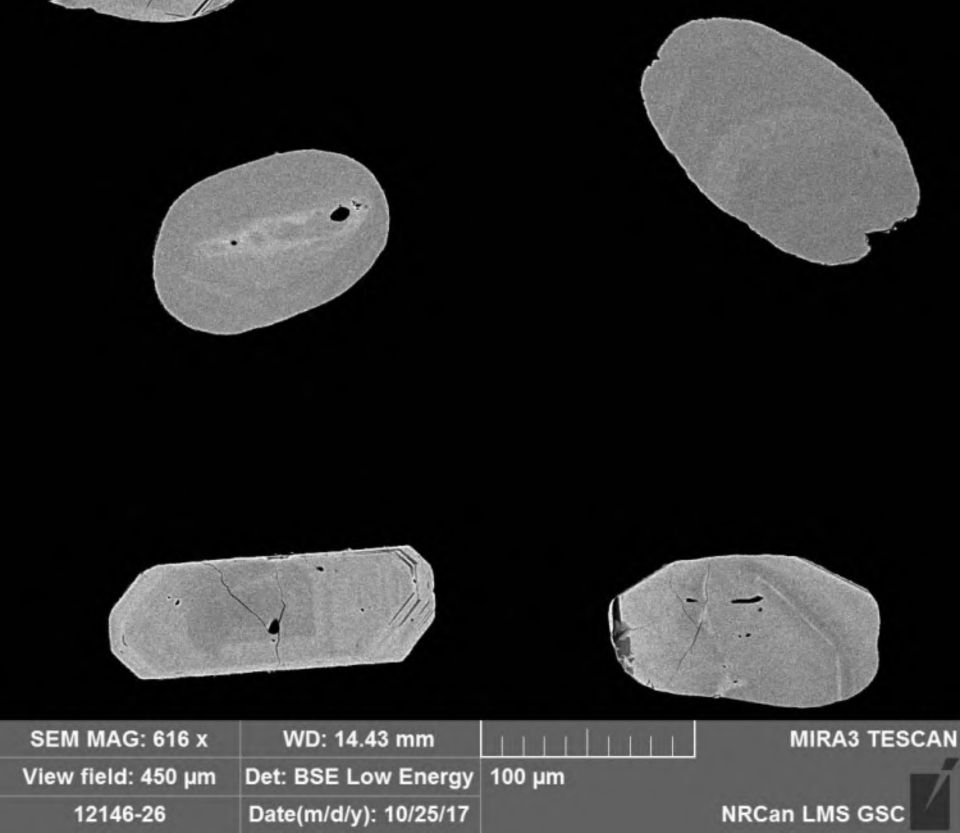

SEM MAG: 1.05 kx
WD: 14.43 mm
MIRA3 TESCAN
View field: 265 μm
Det: BSE Low Energy
50 μm
12146-21
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 628 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 441 μm
Det: BSE Low Energy
100 μm
12146-22
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 889 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 311 µm
Det: BSE Low Energy
50 µm
12146-23
Date(m/d/y): 10/25/17
NRCan LMS GSC

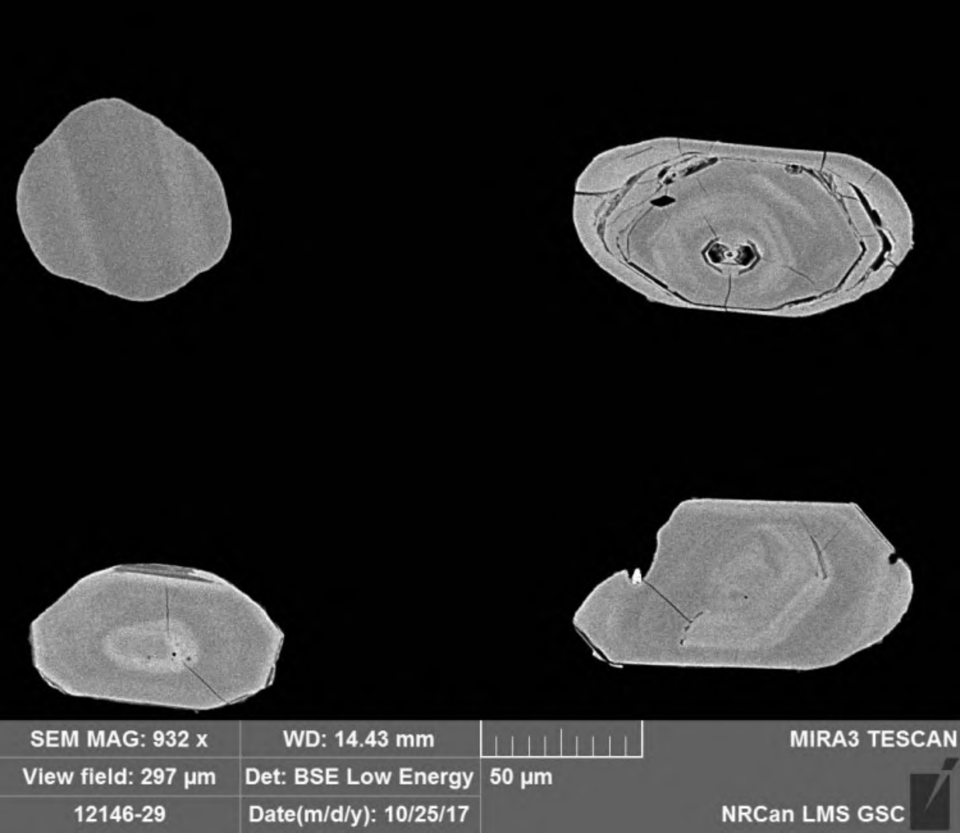

SEM MAG: 698 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 397 µm
Det: BSE Low Energy
100 µm
12146-24
Date(m/d/y): 10/25/17
NRCan LMS GSC

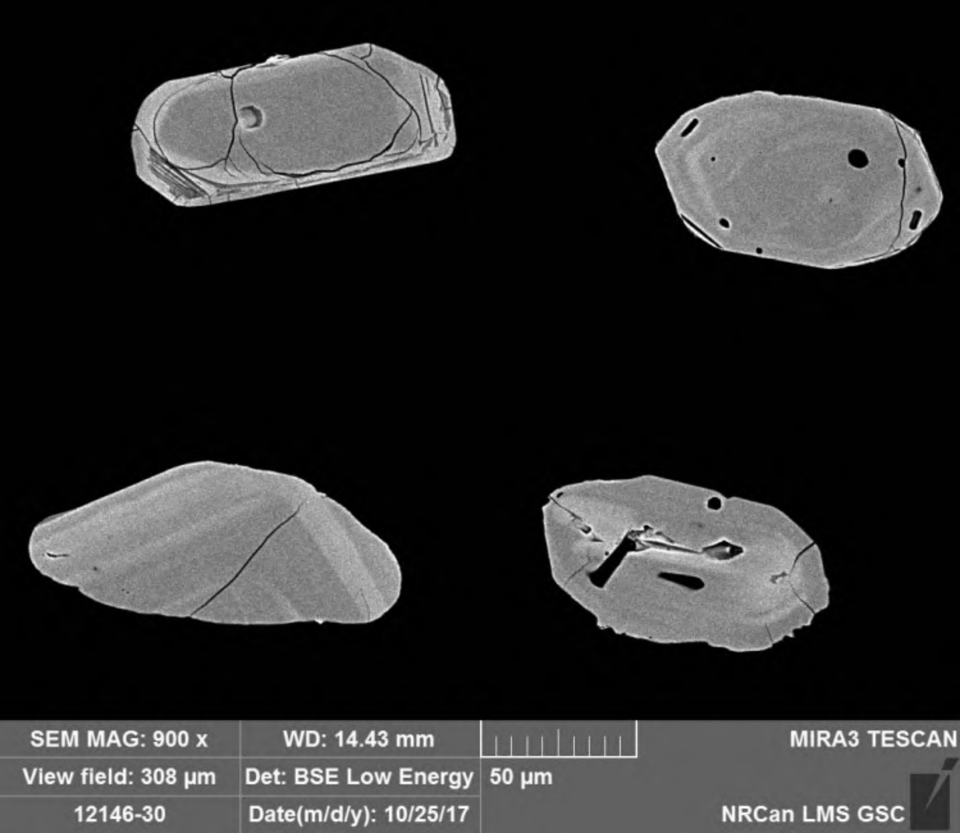

SEM MAG: 715 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 387 µm
Det: BSE Low Energy
100 µm
12146-25
Date(m/d/y): 10/25/17
NRCan LMS GSC

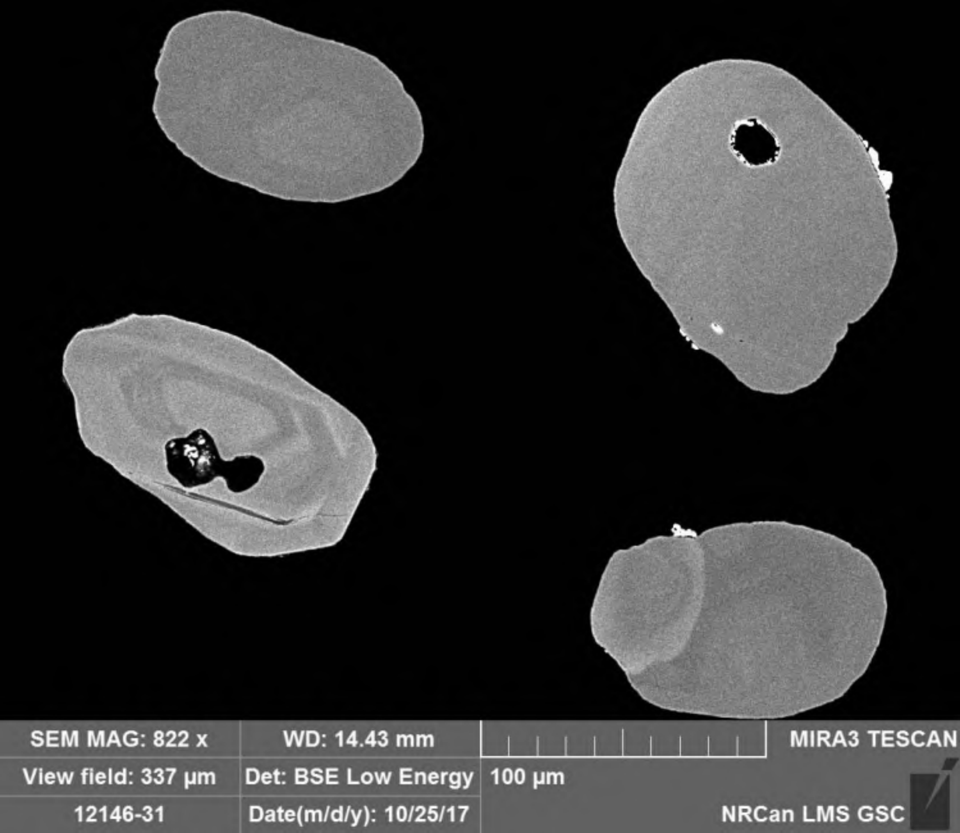

SEM MAG: 616 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 450 µm
Det: BSE Low Energy
100 µm
12146-26
Date(m/d/y): 10/25/17
NRCan LMS GSC

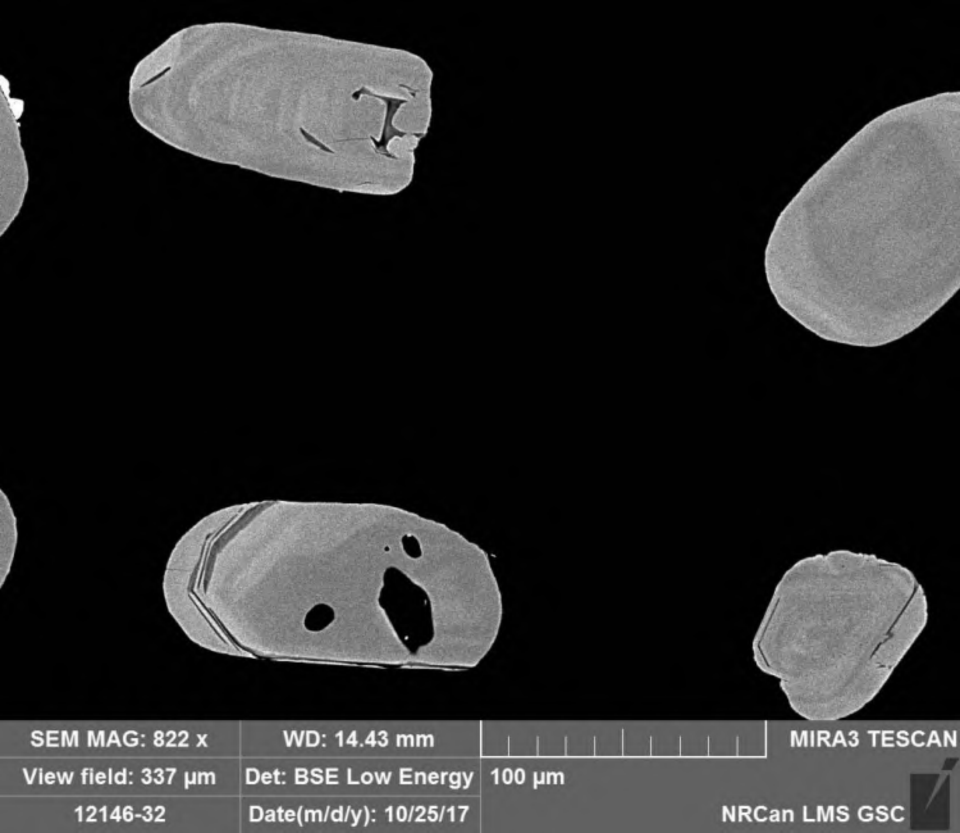

SEM MAG: 1.12 kx
WD: 14.43 mm
MIRA3 TESCAN
View field: 247 μm
Det: BSE Low Energy
50 μm
12146-27
Date(m/d/y): 10/25/17
NRCan LMS GSC

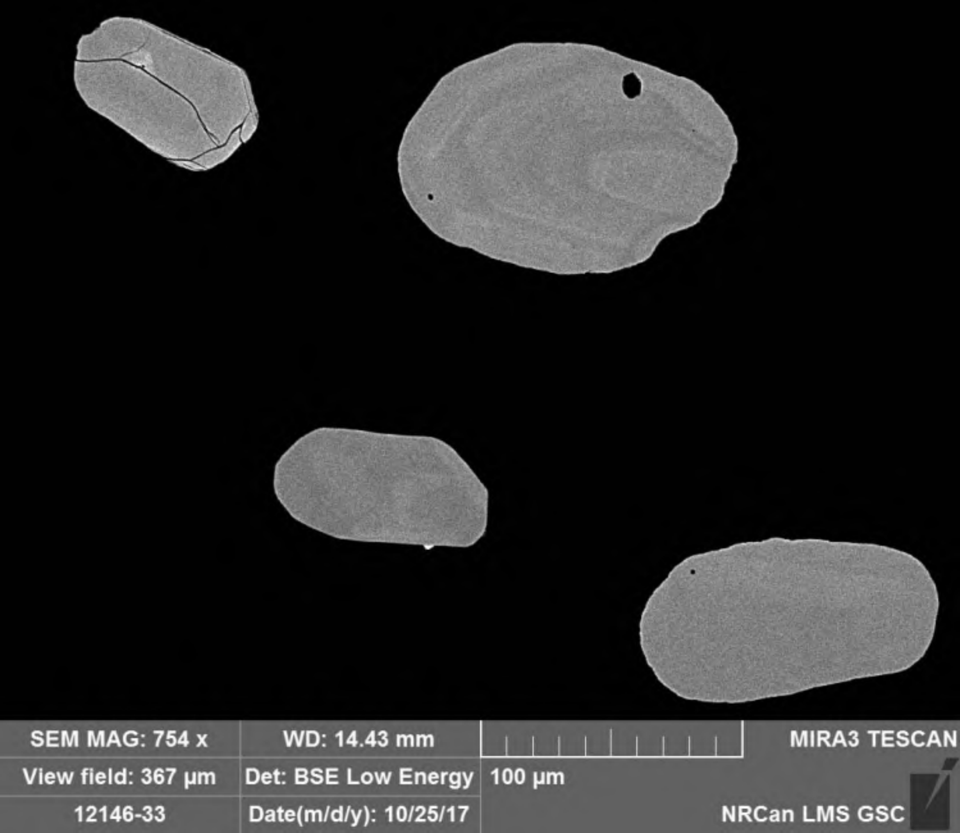

SEM MAG: 835 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 331 μm
Det: BSE Low Energy
100 μm
12146-28
Date(m/d/y): 10/25/17
NRCan LMS GSC

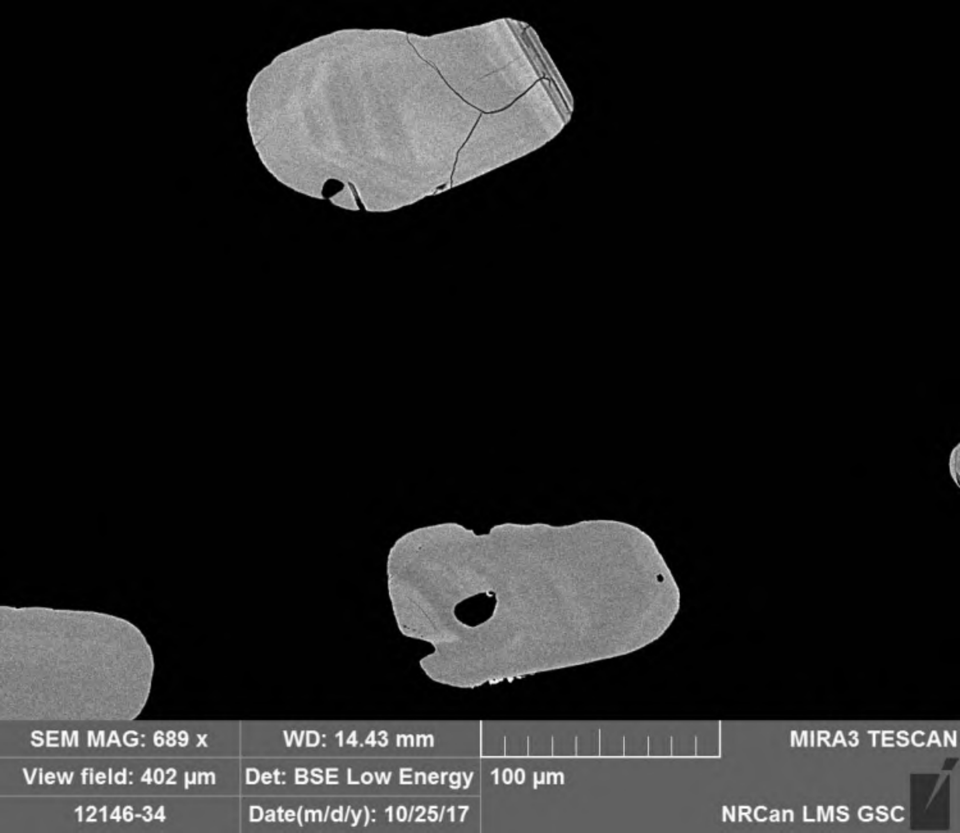

SEM MAG: 932 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 297 µm
Det: BSE Low Energy
50 µm
12146-29
Date(m/d/y): 10/25/17
NRCan LMS GSC

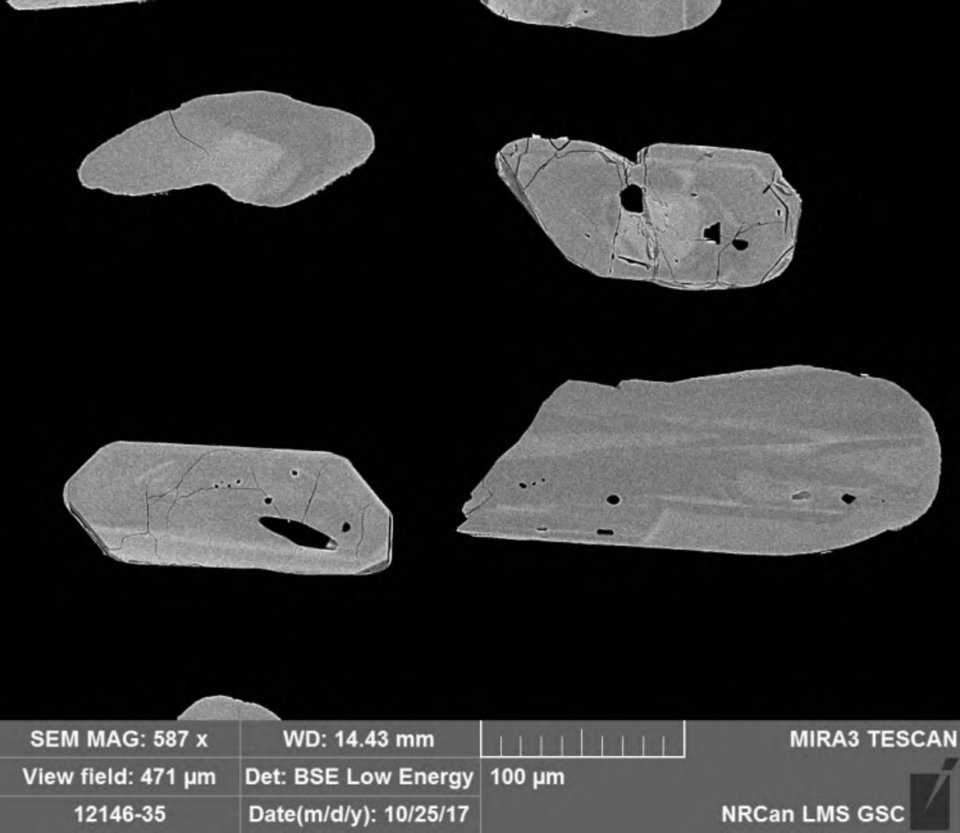

SEM MAG: 900 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 308 µm
Det: BSE Low Energy
50 µm
12146-30
Date(m/d/y): 10/25/17
NRCan LMS GSC

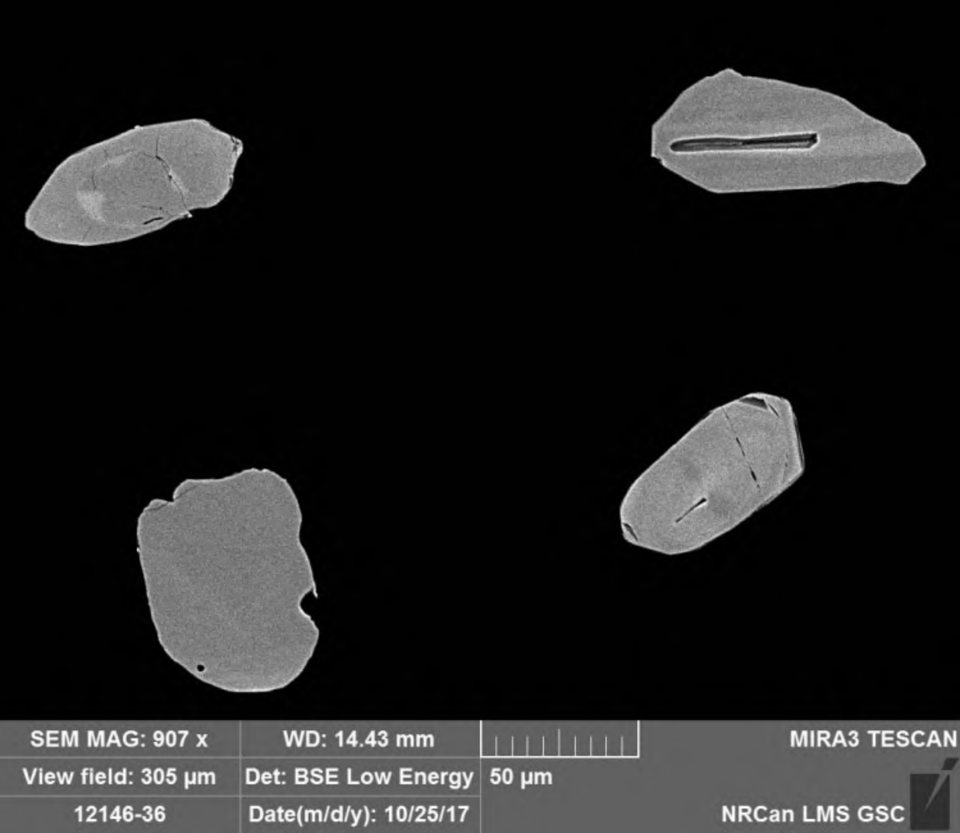

SEM MAG: 822 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 337 μm
Det: BSE Low Energy
100 μm
12146-31
Date(m/d/y): 10/25/17
NRCan LMS GSC

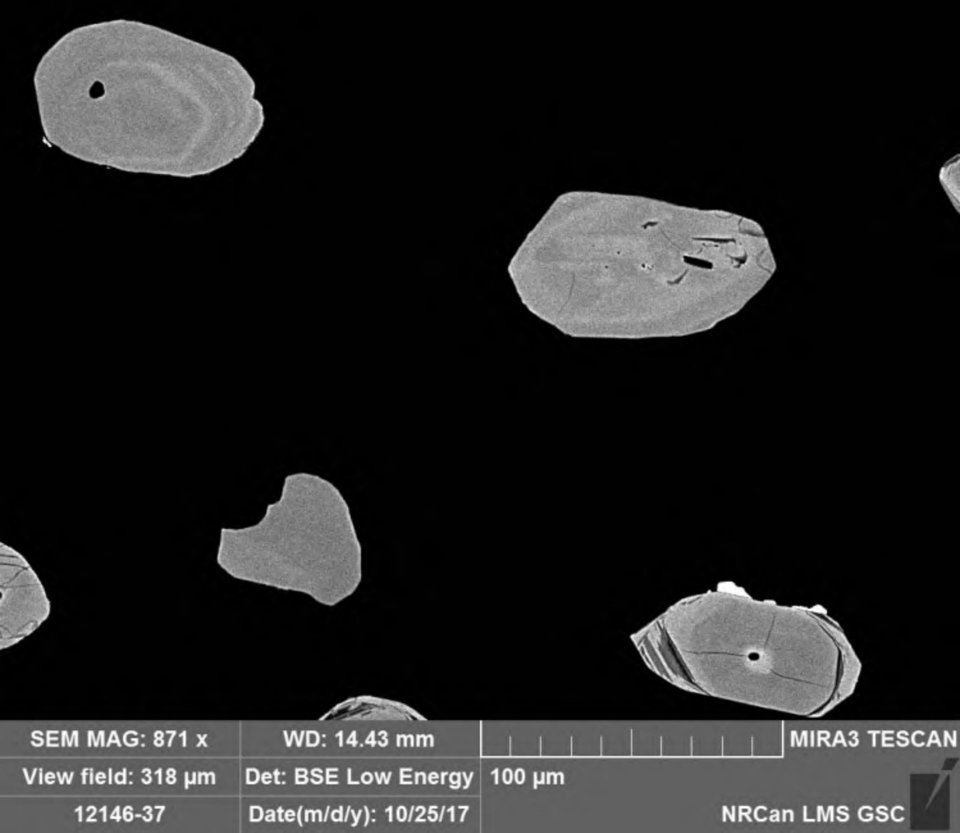

SEM MAG: 822 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 337 μm
Det: BSE Low Energy
100 μm
12146-32
Date(m/d/y): 10/25/17
NRCan LMS GSC

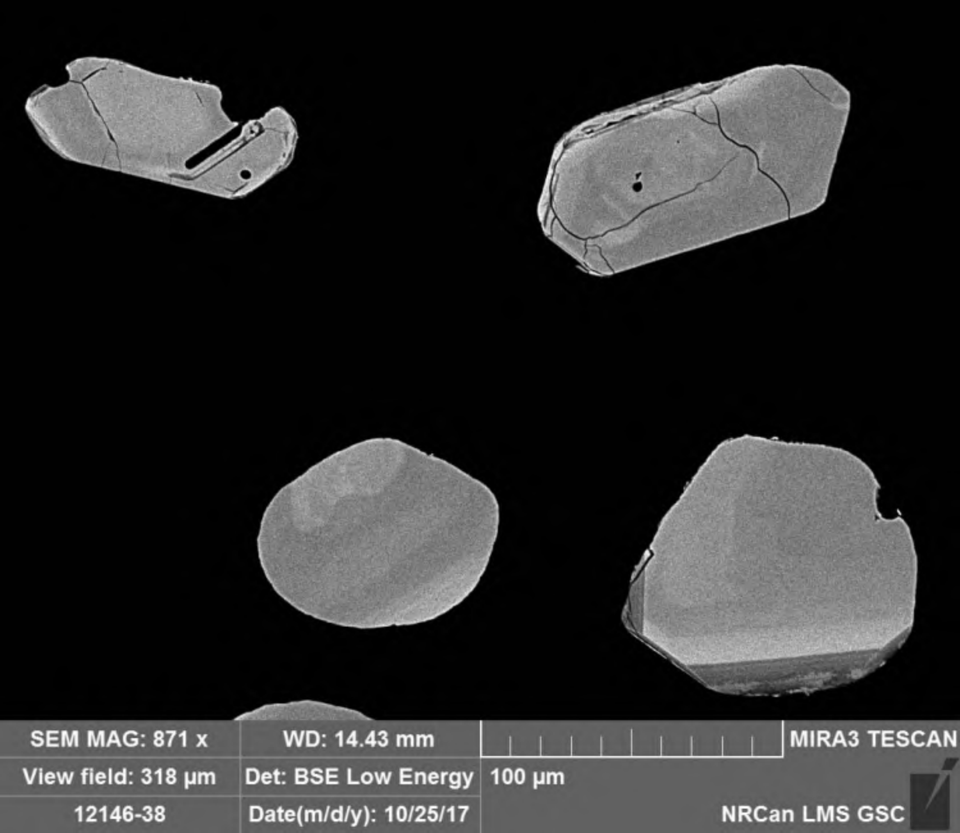

SEM MAG: 754 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 367 µm
Det: BSE Low Energy
100 µm
12146-33
Date(m/d/y): 10/25/17
NRCan LMS GSC

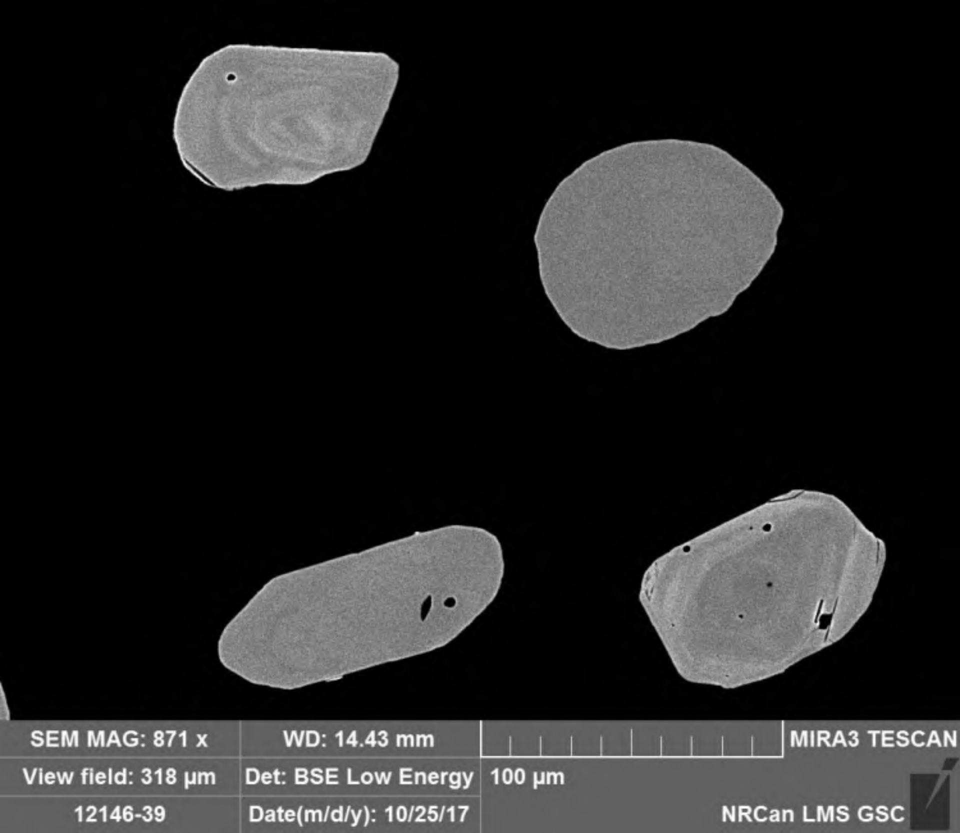

SEM MAG: 689 x
View field: 402 µm
12146-34
WD: 14.43 mm
Det: BSE Low Energy
Date(m/d/y): 10/25/17
100 µm
MIRA3 TESCAN
NRCan LMS GSC

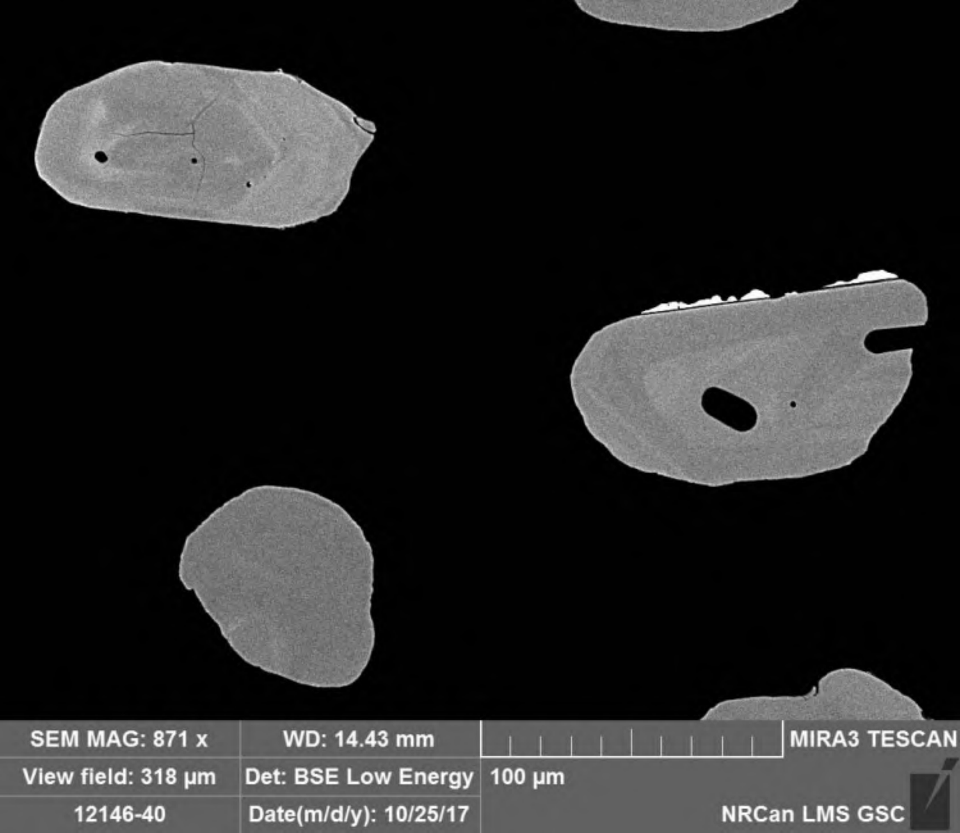

SEM MAG: 587 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 471 µm
Det: BSE Low Energy
100 µm
12146-35
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 907 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 305 µm
Det: BSE Low Energy
50 µm
12146-36
Date(m/d/y): 10/25/17
NRCan LMS GSC

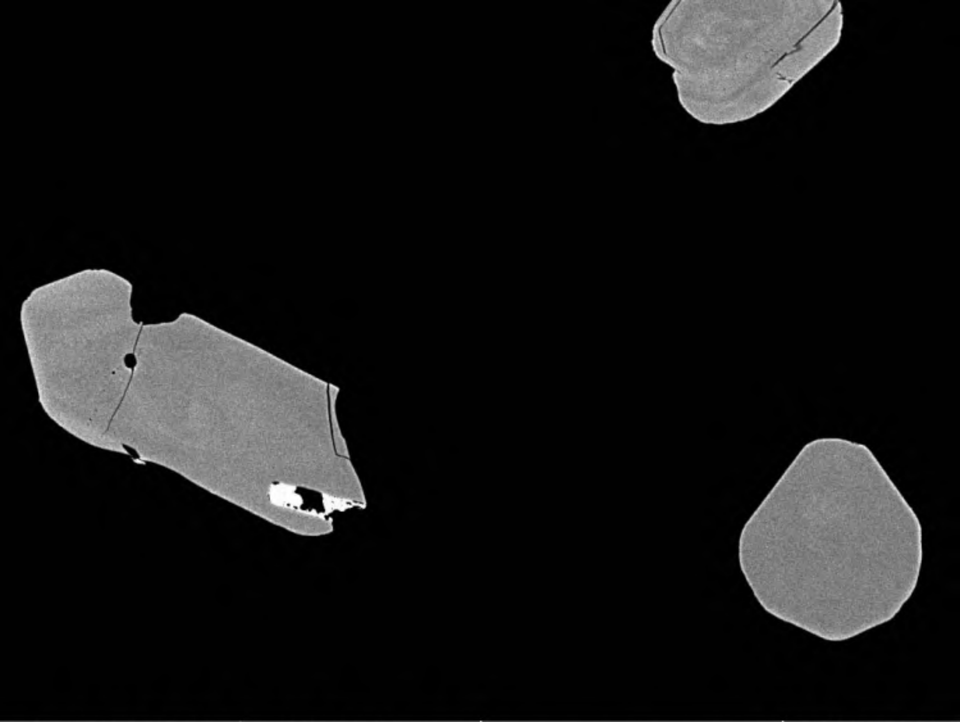

SEM MAG: 871 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 318 μm
Det: BSE Low Energy
100 μm
12146-37
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 871 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 318 µm
Det: BSE Low Energy
100 µm
12146-38
Date(m/d/y): 10/25/17
NRCan LMS GSC

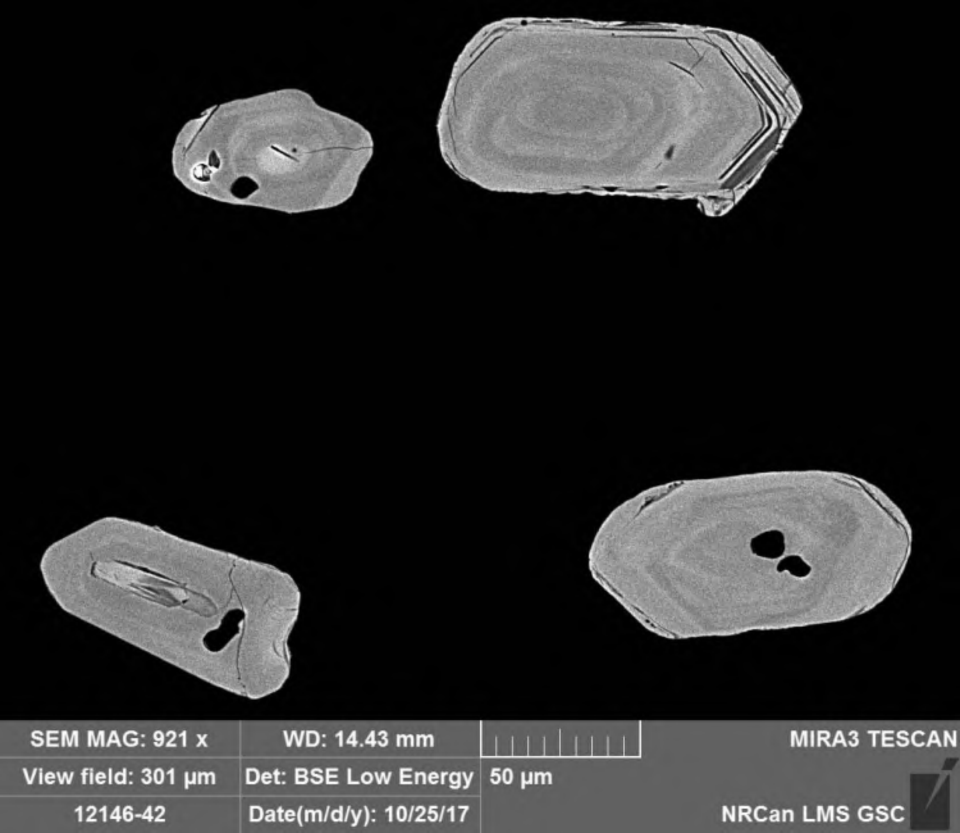

SEM MAG: 871 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 318 µm
Det: BSE Low Energy
100 µm
12146-39
Date(m/d/y): 10/25/17
NRCan LMS GSC

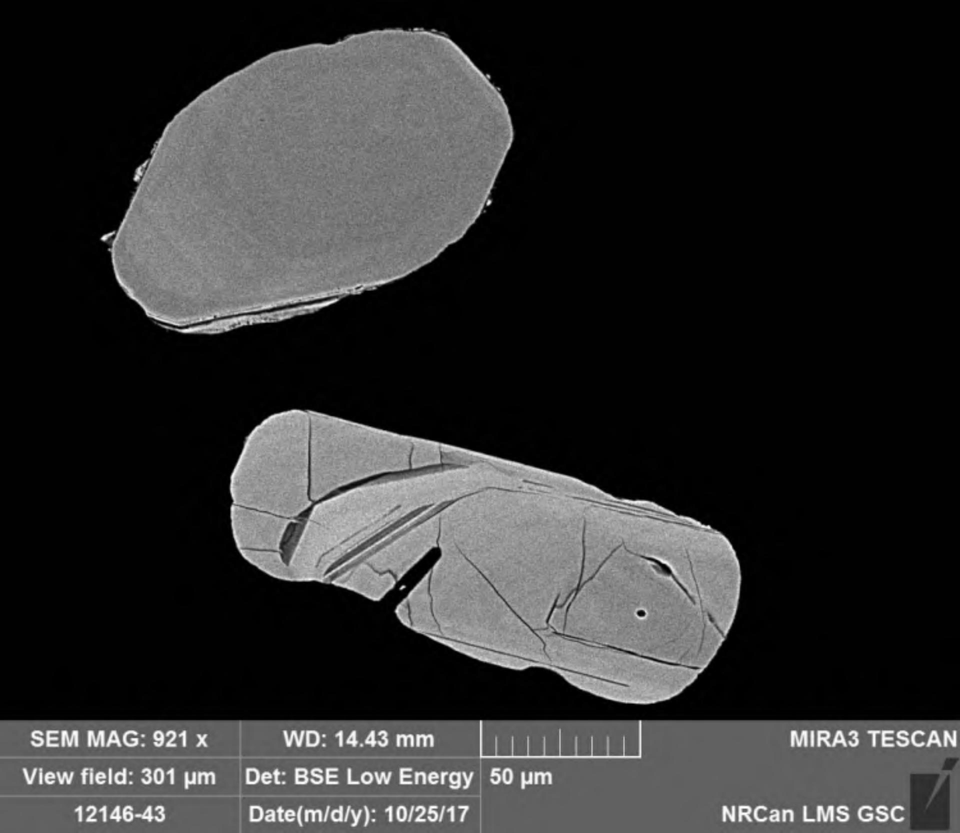


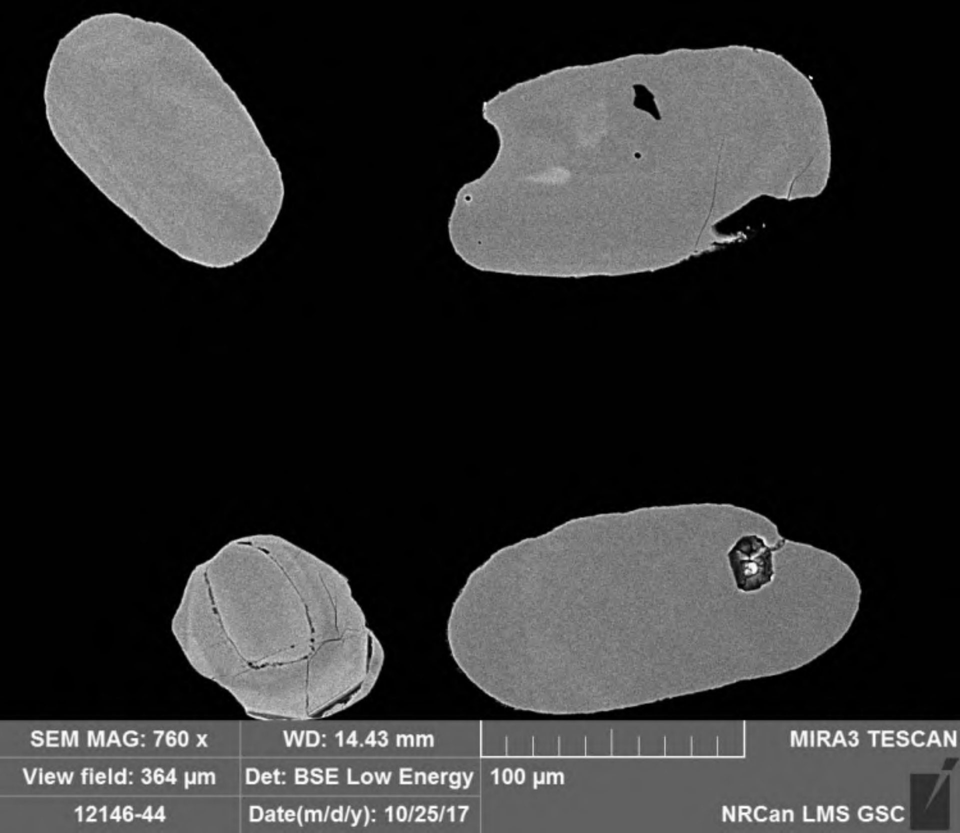
SEM MAG: 871 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 318 µm
Det: BSE Low Energy
100 µm
12146-40
Date(m/d/y): 10/25/17
NRCan LMS GSC

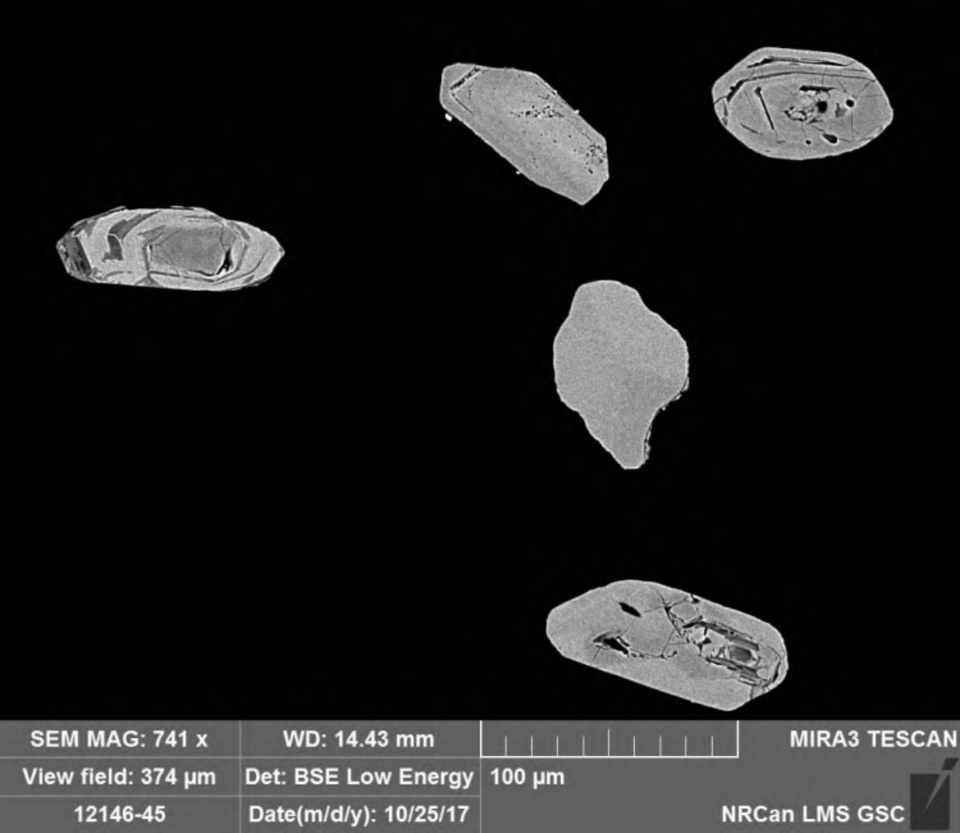


SEM MAG: 871 x	WD: 14.43 mm		MIRA3 TESCAN
View field: 318 µm	Det: BSE Low Energy	100 µm	
12146-41	Date(m/d/y): 10/25/17		NRCan LMS GSC

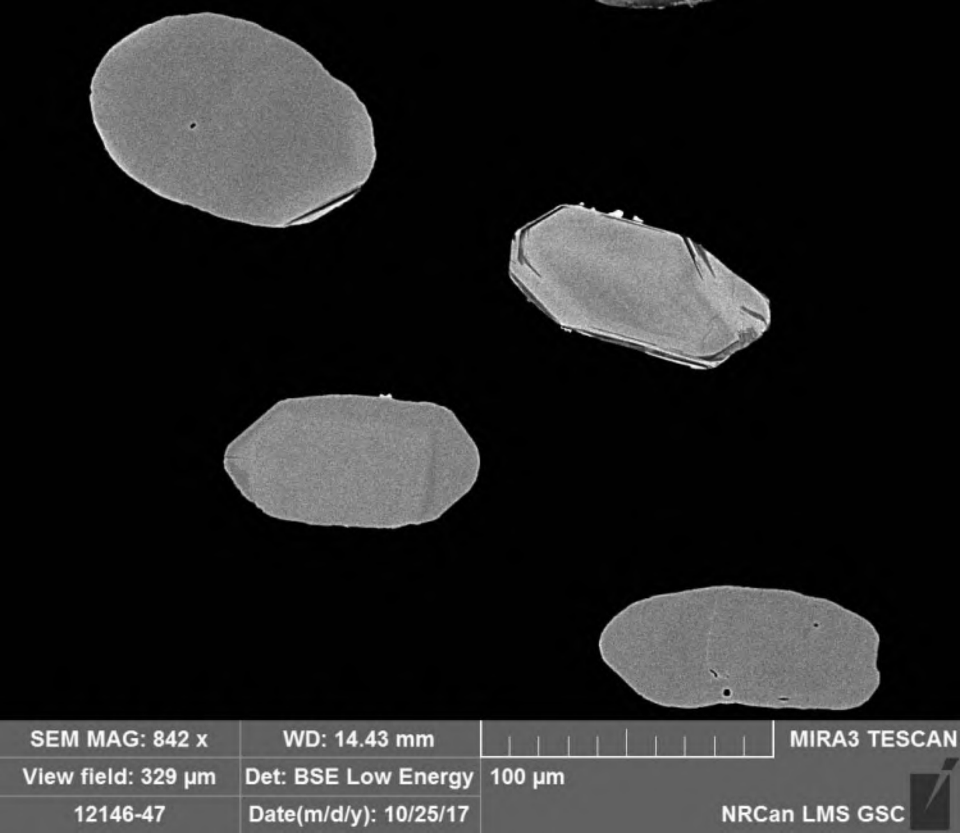

SEM MAG: 921 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 301 µm
Det: BSE Low Energy
50 µm
12146-42
Date(m/d/y): 10/25/17
NRCan LMS GSC

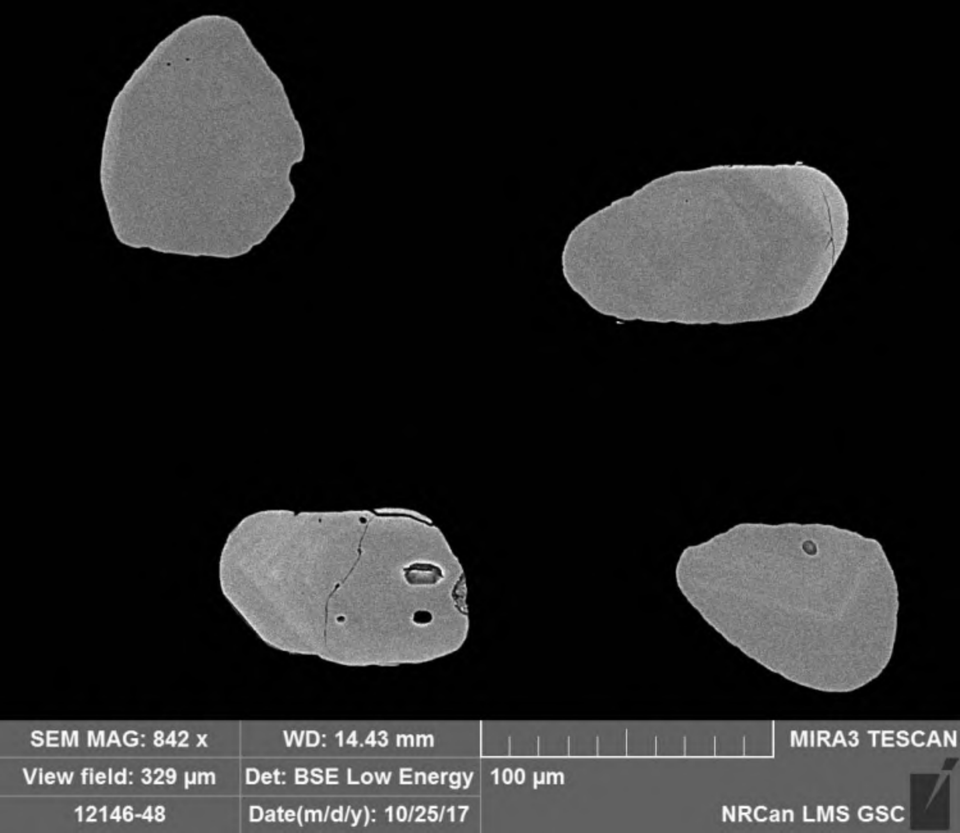

SEM MAG: 921 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 301 µm
Det: BSE Low Energy
50 µm
12146-43
Date(m/d/y): 10/25/17
NRCan LMS GSC

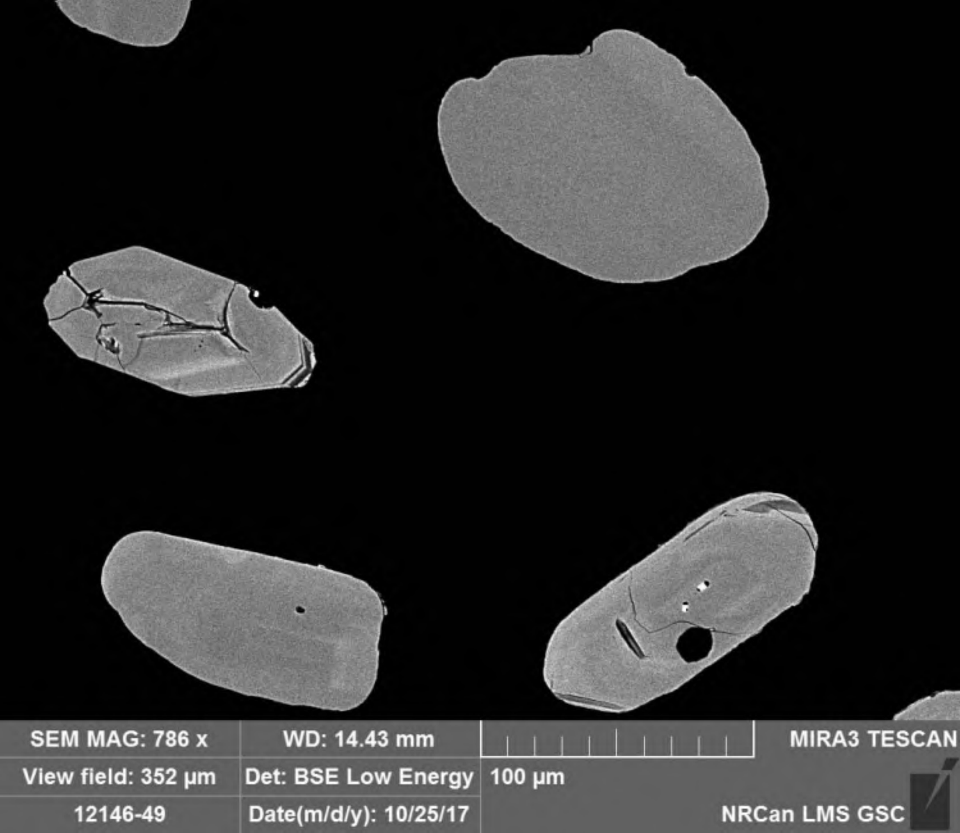

SEM MAG: 760 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 364 μm
Det: BSE Low Energy
100 μm
12146-44
Date(m/d/y): 10/25/17
NRCan LMS GSC

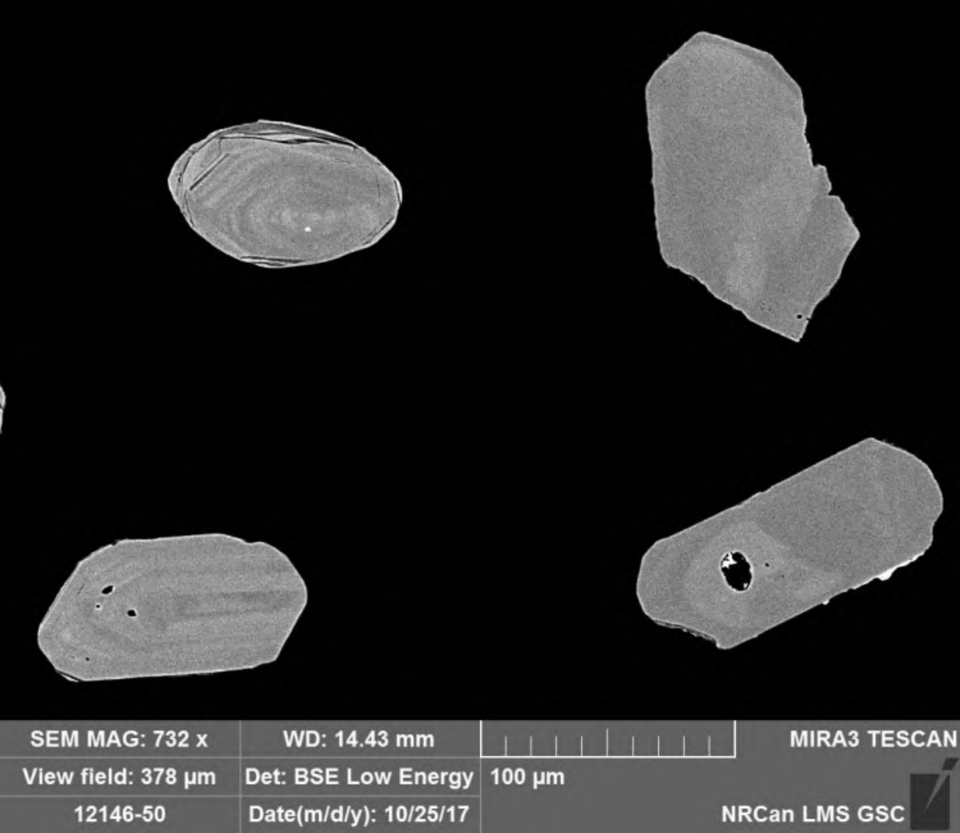

SEM MAG: 741 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 374 µm
Det: BSE Low Energy
100 µm
12146-45
Date(m/d/y): 10/25/17
NRCan LMS GSC

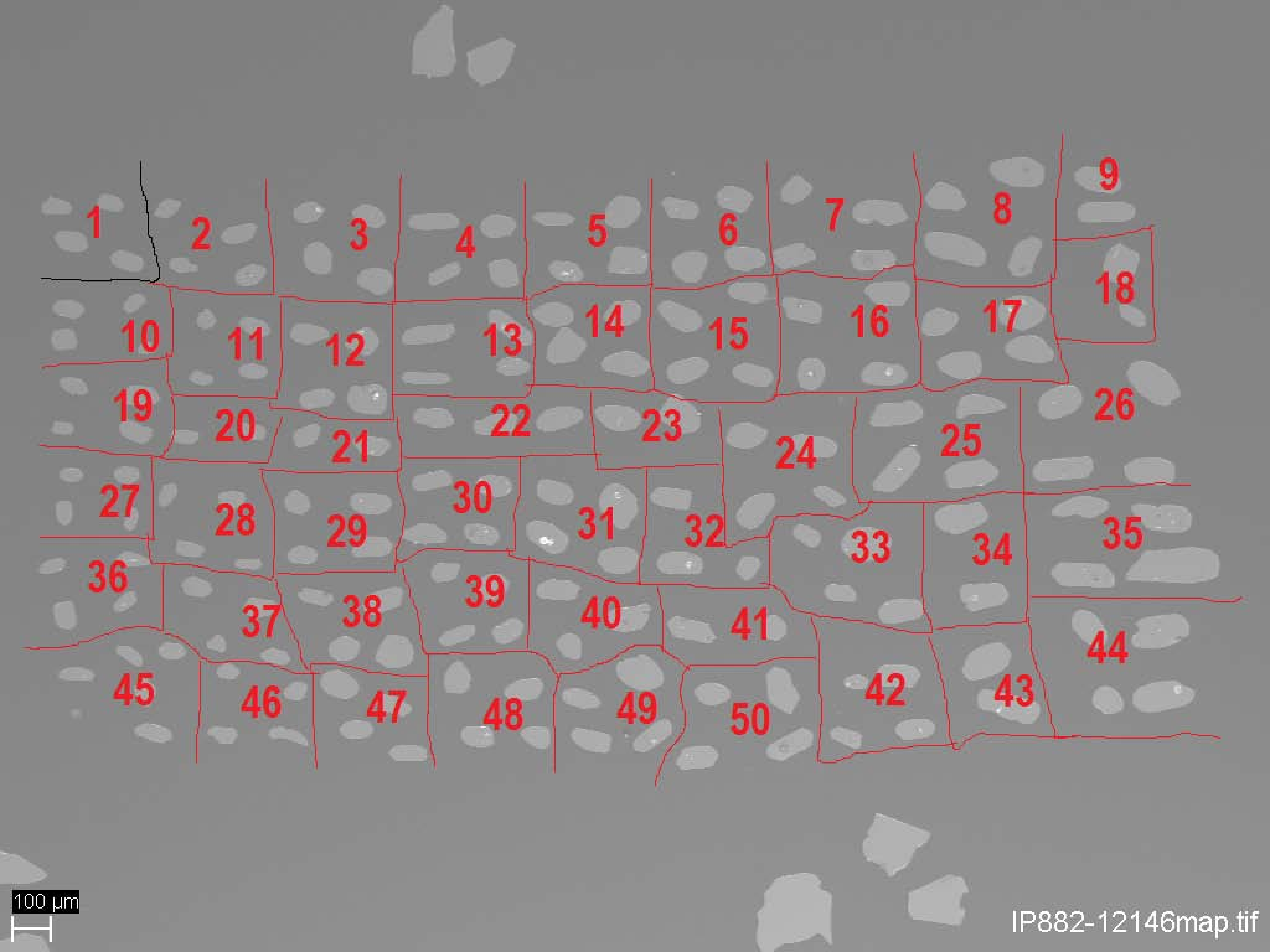

SEM MAG: 904 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 306 µm
Det: BSE Low Energy
50 µm
12146-46
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 842 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 329 μm
Det: BSE Low Energy
100 μm
12146-47
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 842 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 329 µm
Det: BSE Low Energy
100 µm
12146-48
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 786 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 352 μm
Det: BSE Low Energy
100 μm
12146-49
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 732 x
WD: 14.43 mm
MIRA3 TESCAN
View field: 378 µm
Det: BSE Low Energy
100 µm
12146-50
Date(m/d/y): 10/25/17
NRCan LMS GSC



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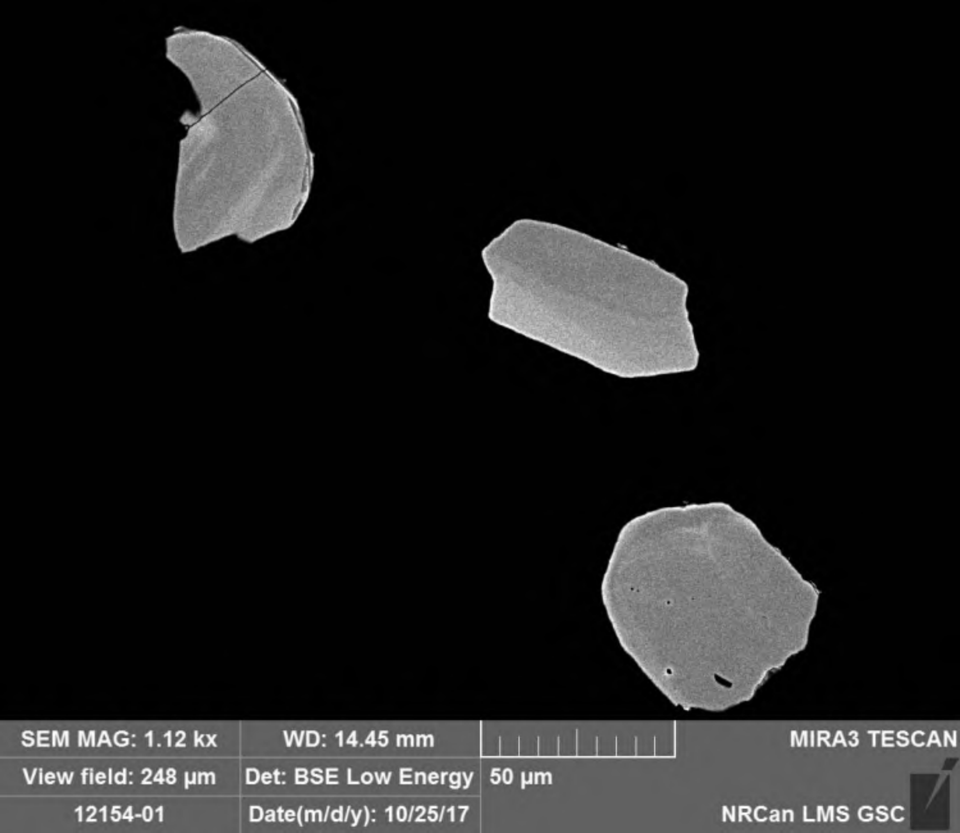
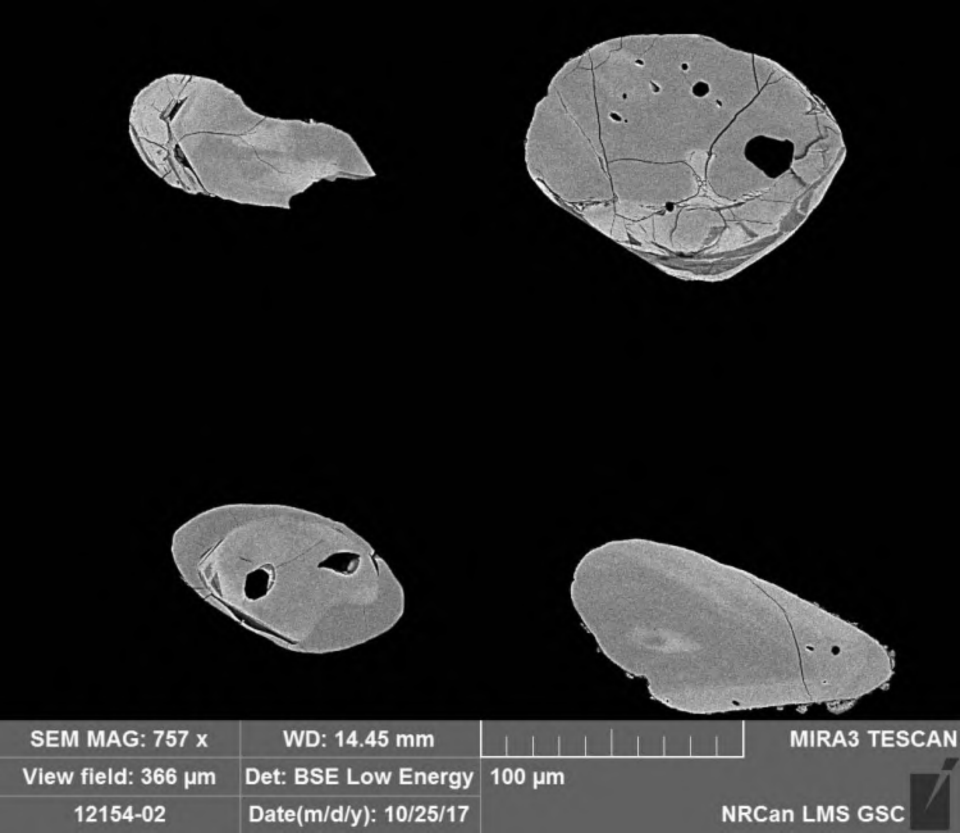
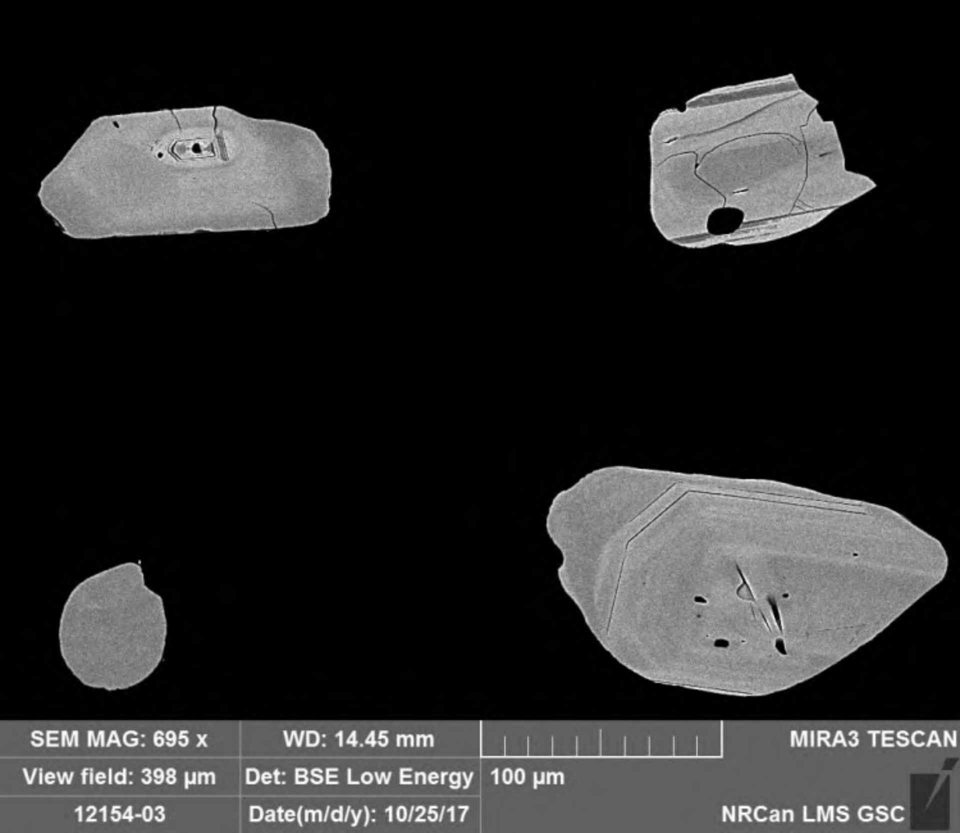
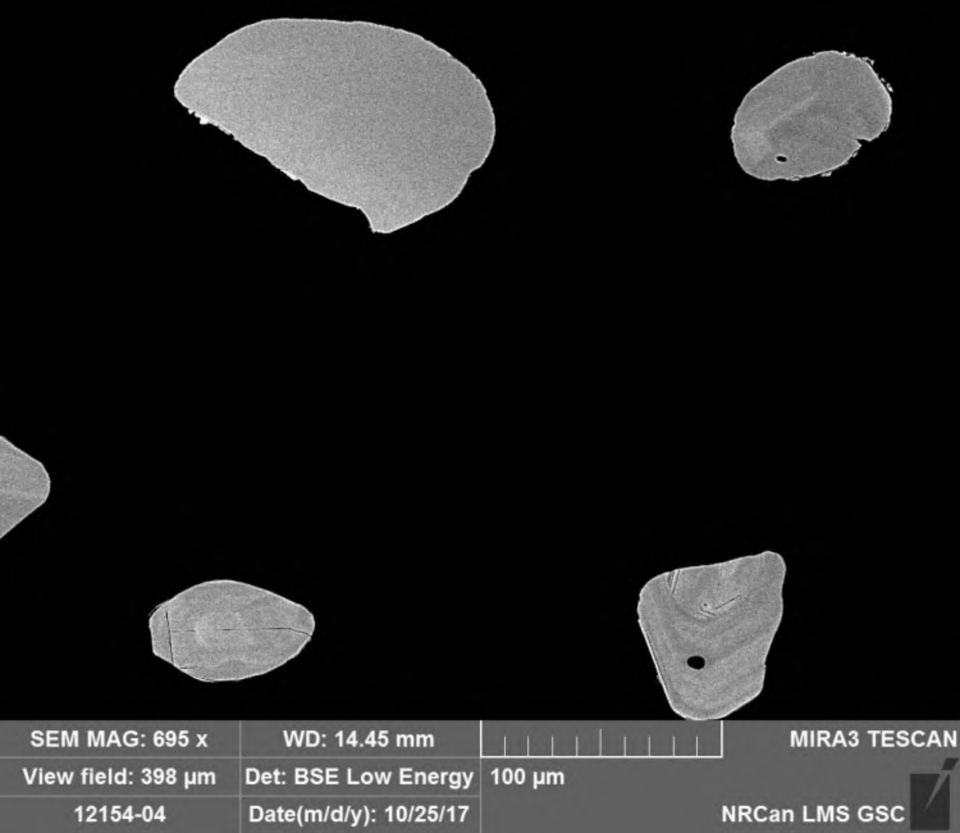
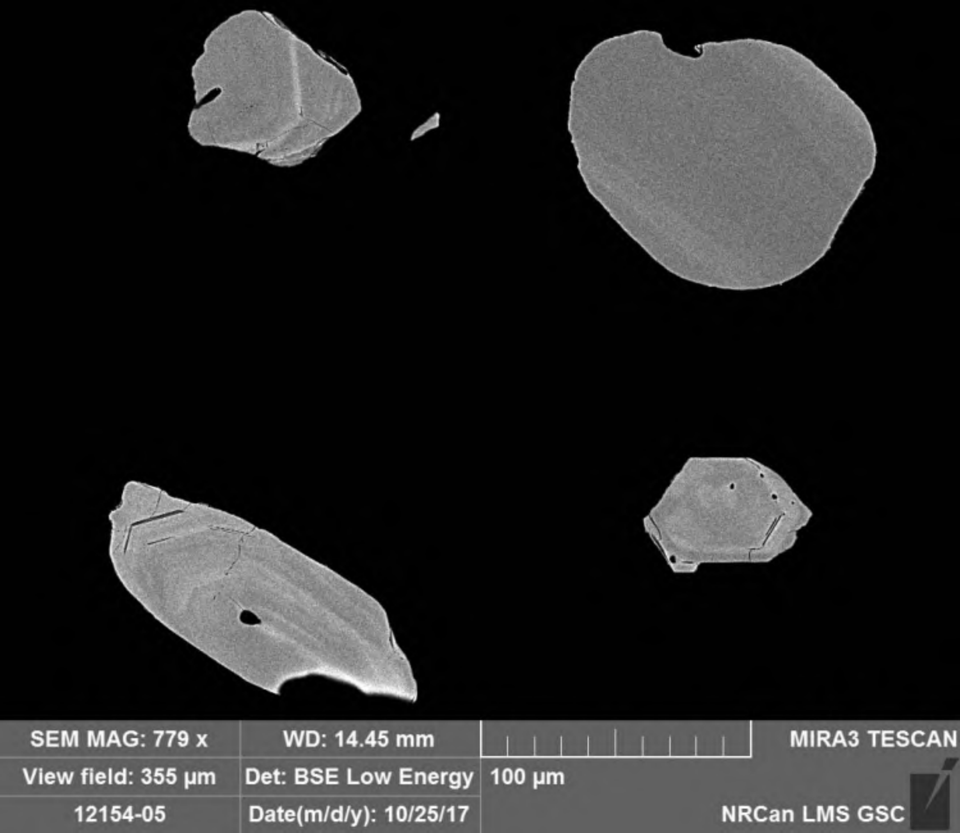
100 µm
IP882-12146map.tif

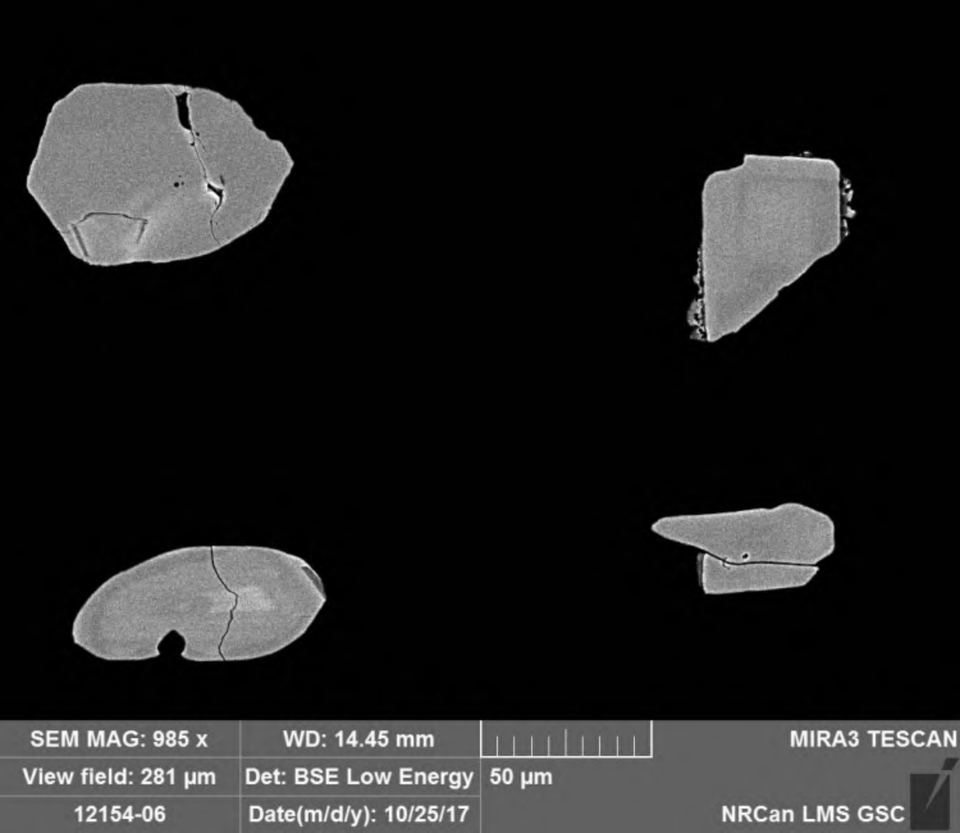

SEM MAG: 1.12 kx
WD: 14.45 mm
MIRA3 TESCAN
View field: 248 µm
Det: BSE Low Energy
50 µm
12154-01
Date(m/d/y): 10/25/17
NRCan LMS GSC

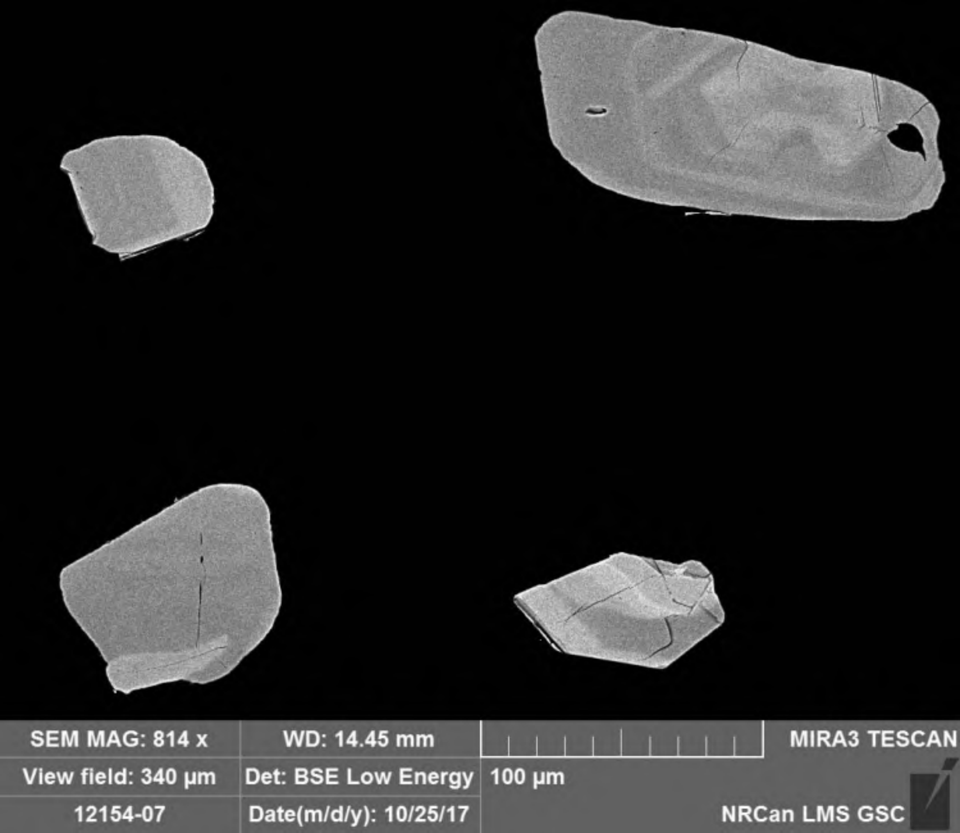

SEM MAG: 757 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 366 μm
Det: BSE Low Energy
100 μm
12154-02
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 695 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 398 µm
Det: BSE Low Energy
100 µm
12154-03
Date(m/d/y): 10/25/17
NRCan LMS GSC

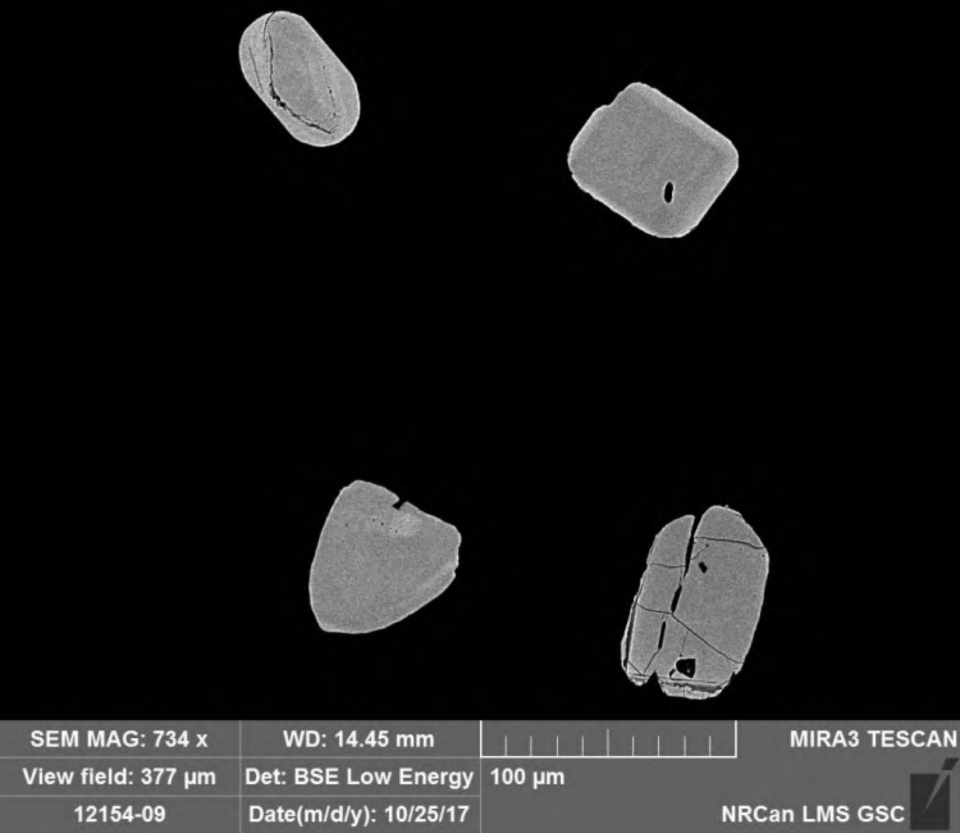

SEM MAG: 695 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 398 µm
Det: BSE Low Energy
100 µm
12154-04
Date(m/d/y): 10/25/17
NRCan LMS GSC

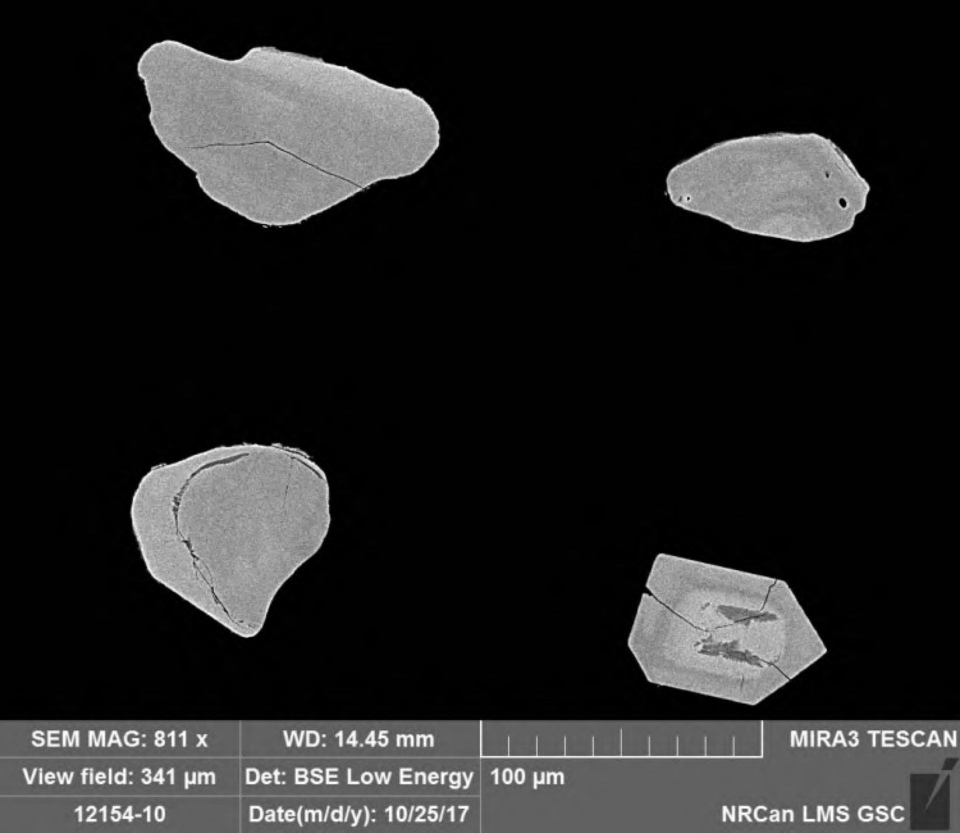

SEM MAG: 779 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 355 µm
Det: BSE Low Energy
100 µm
12154-05
Date(m/d/y): 10/25/17
NRCan LMS GSC

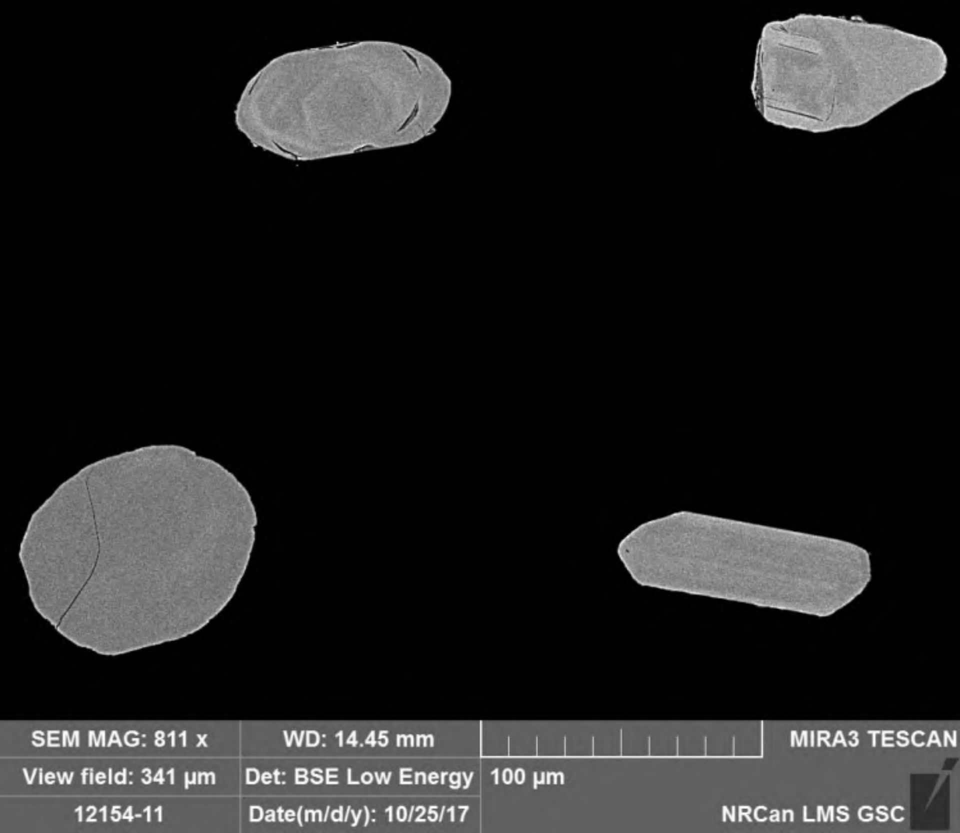

SEM MAG: 985 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 281 µm
Det: BSE Low Energy
50 µm
12154-06
Date(m/d/y): 10/25/17
NRCan LMS GSC

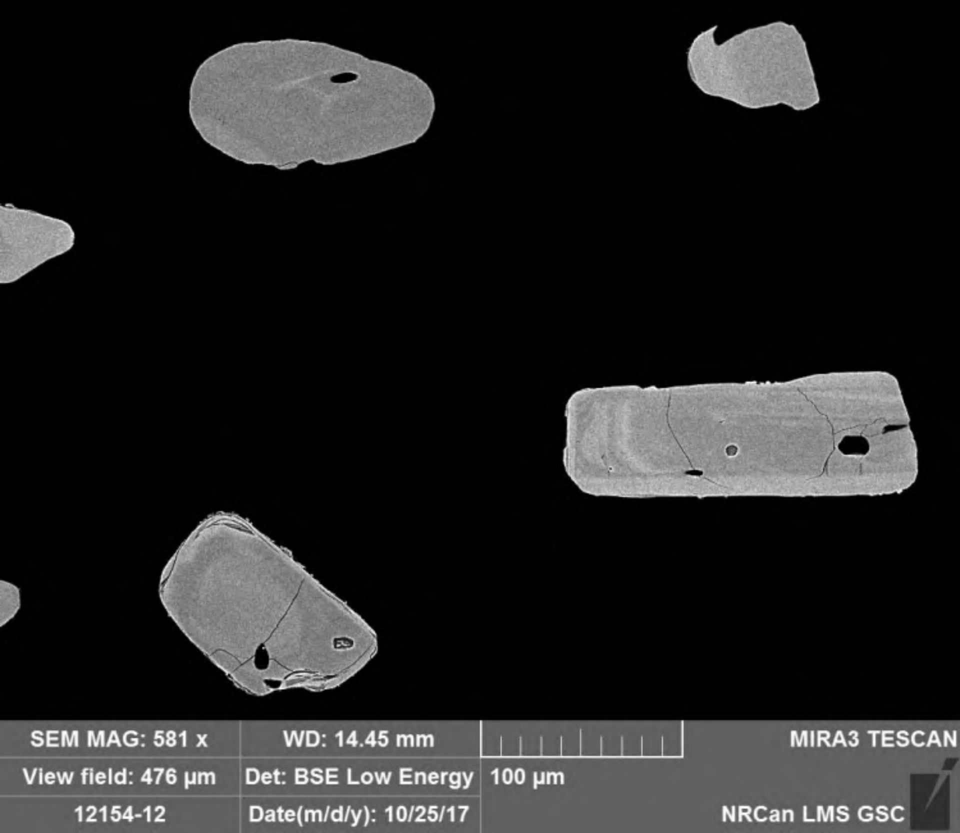

SEM MAG: 814 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 340 µm
Det: BSE Low Energy
100 µm
12154-07
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 1.04 kx
WD: 14.45 mm
MIRA3 TESCAN
View field: 265 µm
Det: BSE Low Energy
50 µm
12154-08
Date(m/d/y): 10/25/17
NRCan LMS GSC

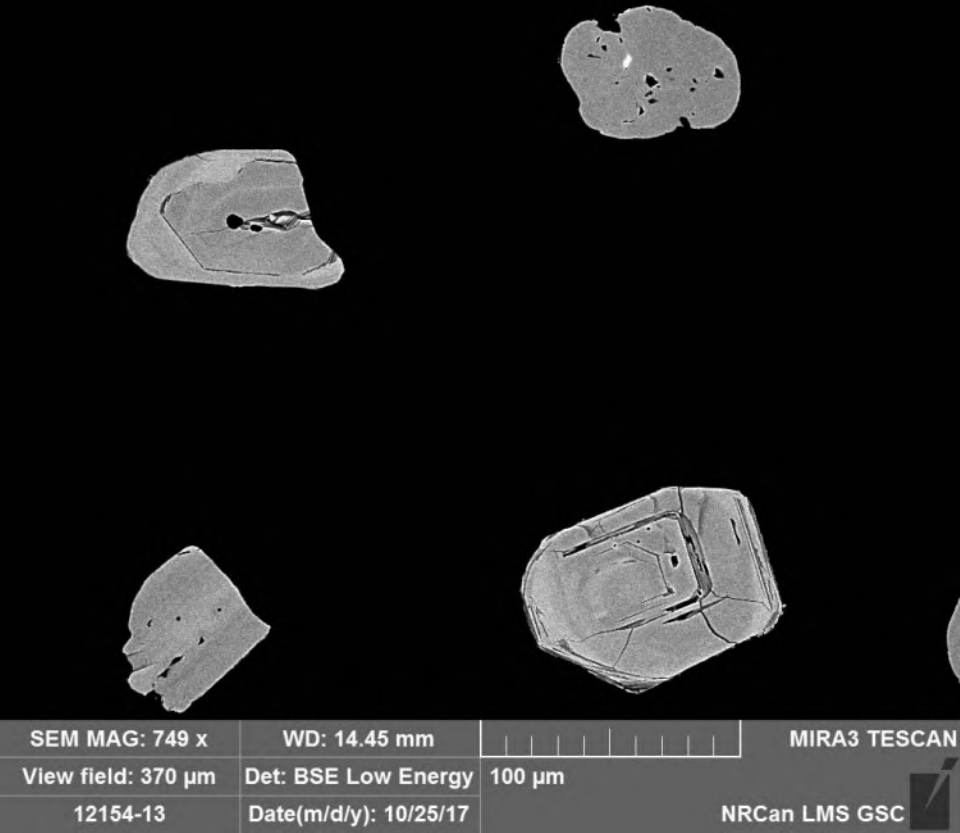

SEM MAG: 734 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 377 µm
Det: BSE Low Energy
100 µm
12154-09
Date(m/d/y): 10/25/17
NRCan LMS GSC

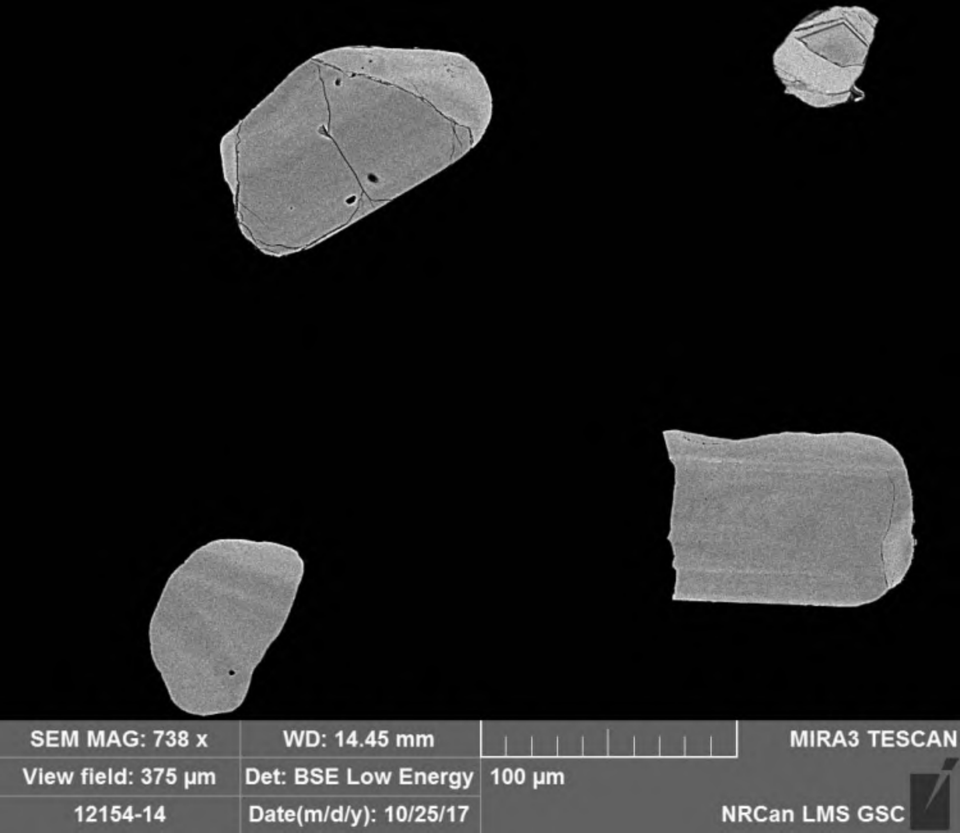

SEM MAG: 811 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 341 µm
Det: BSE Low Energy
100 µm
12154-10
Date(m/d/y): 10/25/17
NRCan LMS GSC

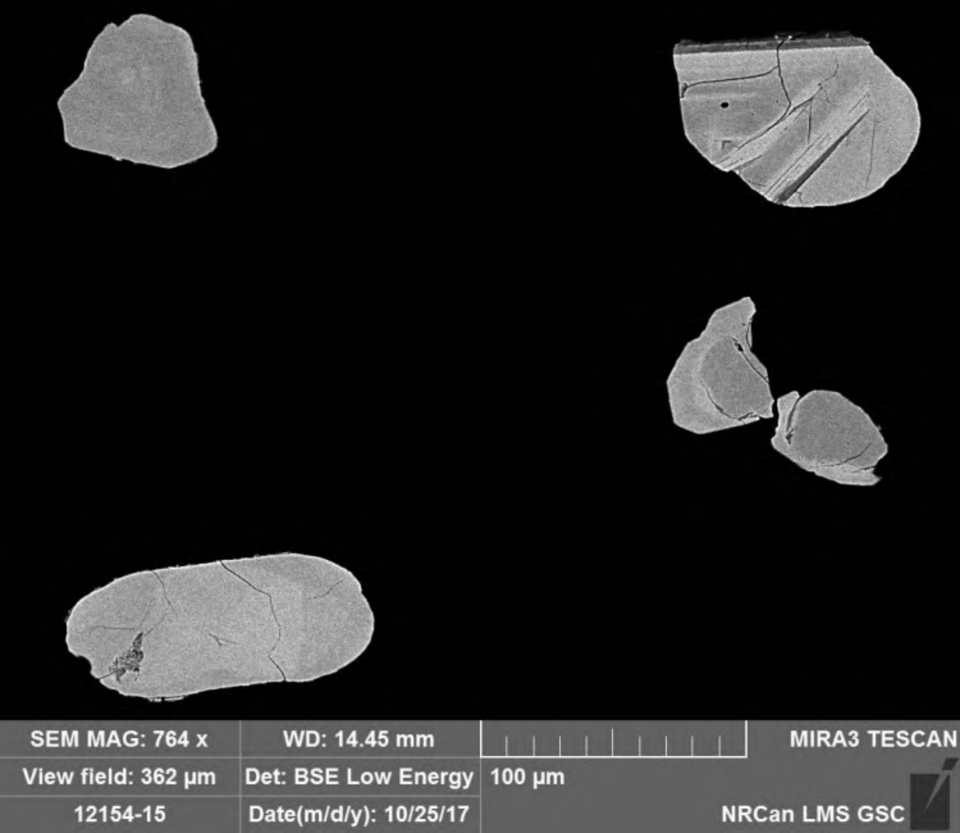

SEM MAG: 811 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 341 µm
Det: BSE Low Energy
100 µm
12154-11
Date(m/d/y): 10/25/17
NRCan LMS GSC

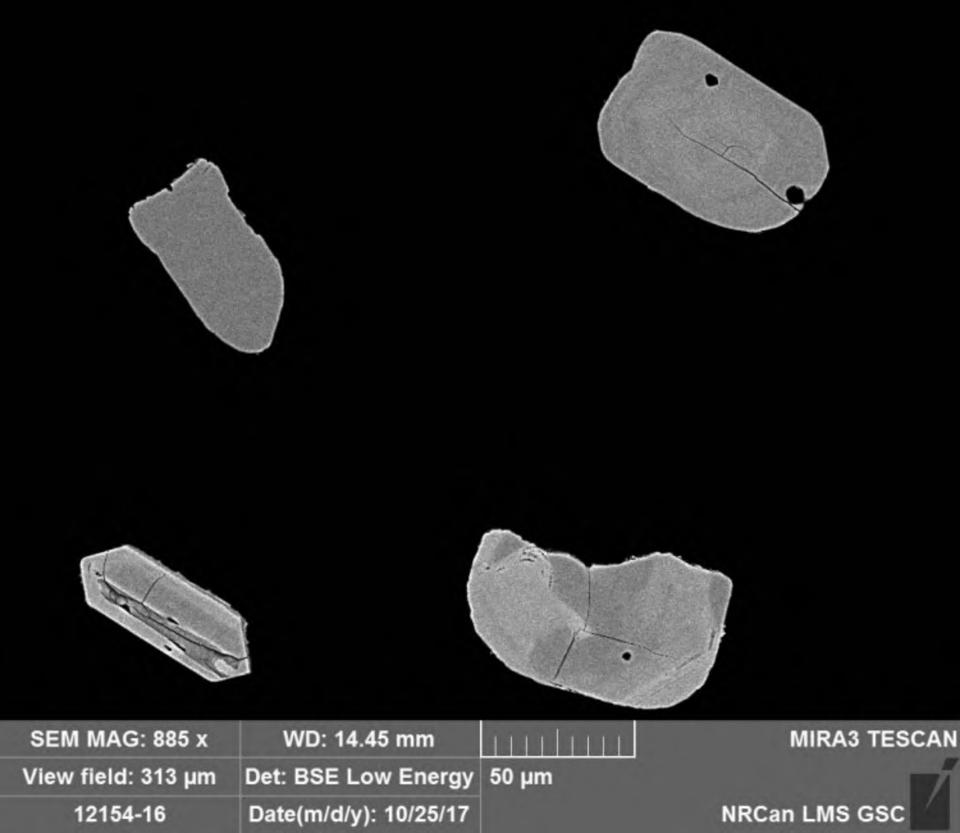


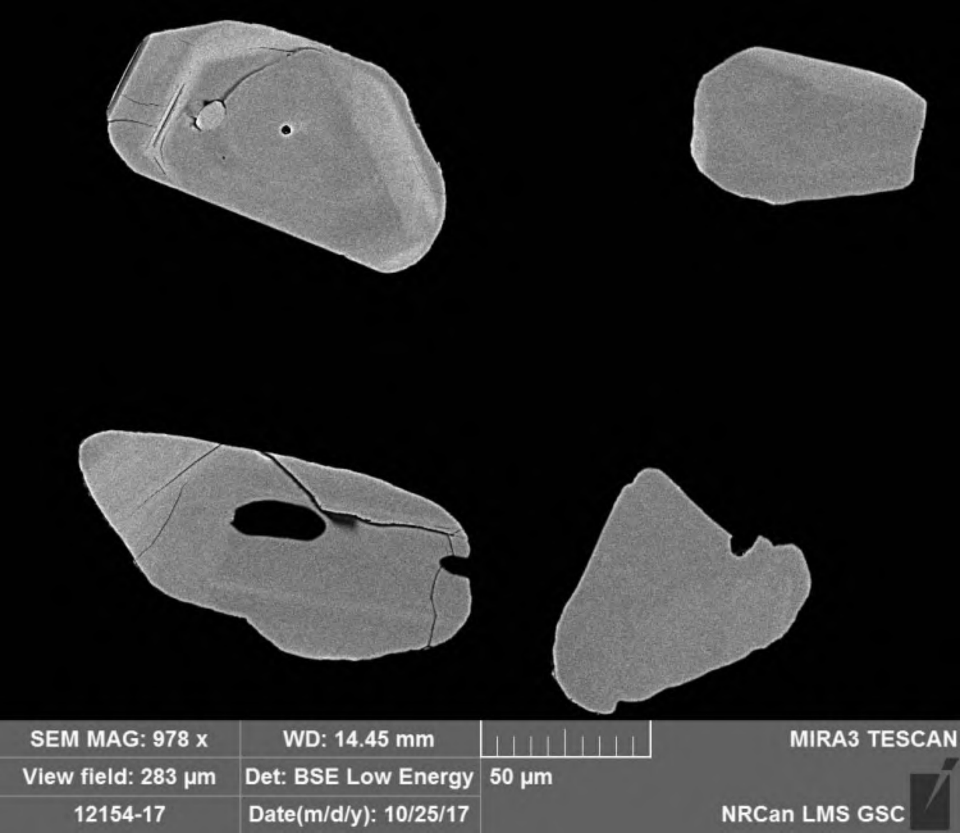
SEM MAG: 581 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 476 µm
Det: BSE Low Energy
100 µm
12154-12
Date(m/d/y): 10/25/17
NRCan LMS GSC

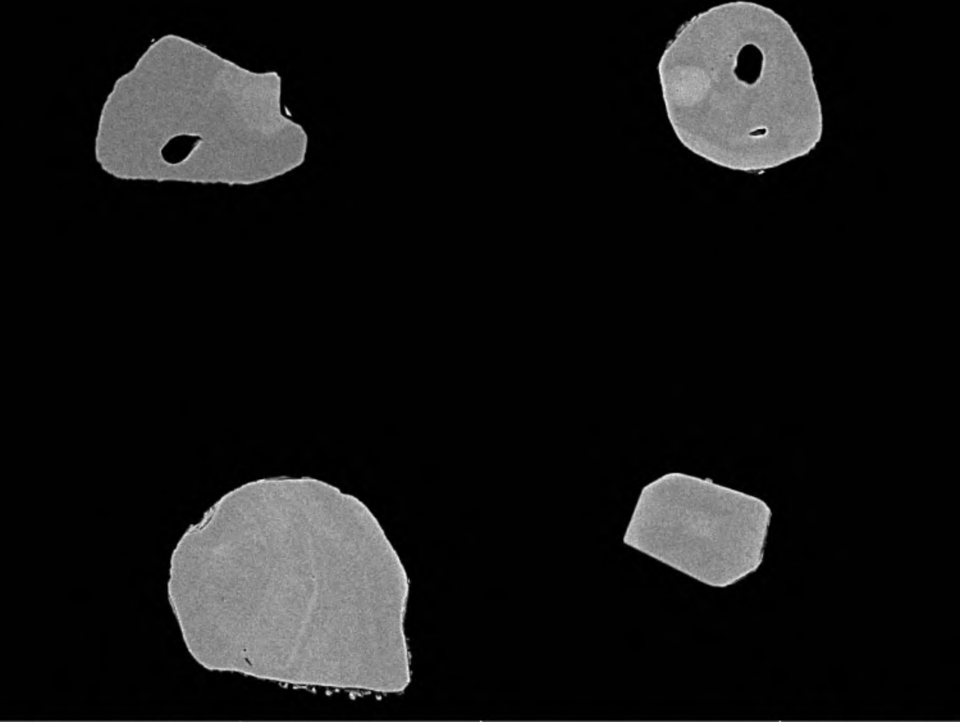

SEM MAG: 749 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 370 µm
Det: BSE Low Energy
100 µm
12154-13
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 738 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 375 µm
Det: BSE Low Energy
100 µm
12154-14
Date(m/d/y): 10/25/17
NRCan LMS GSC

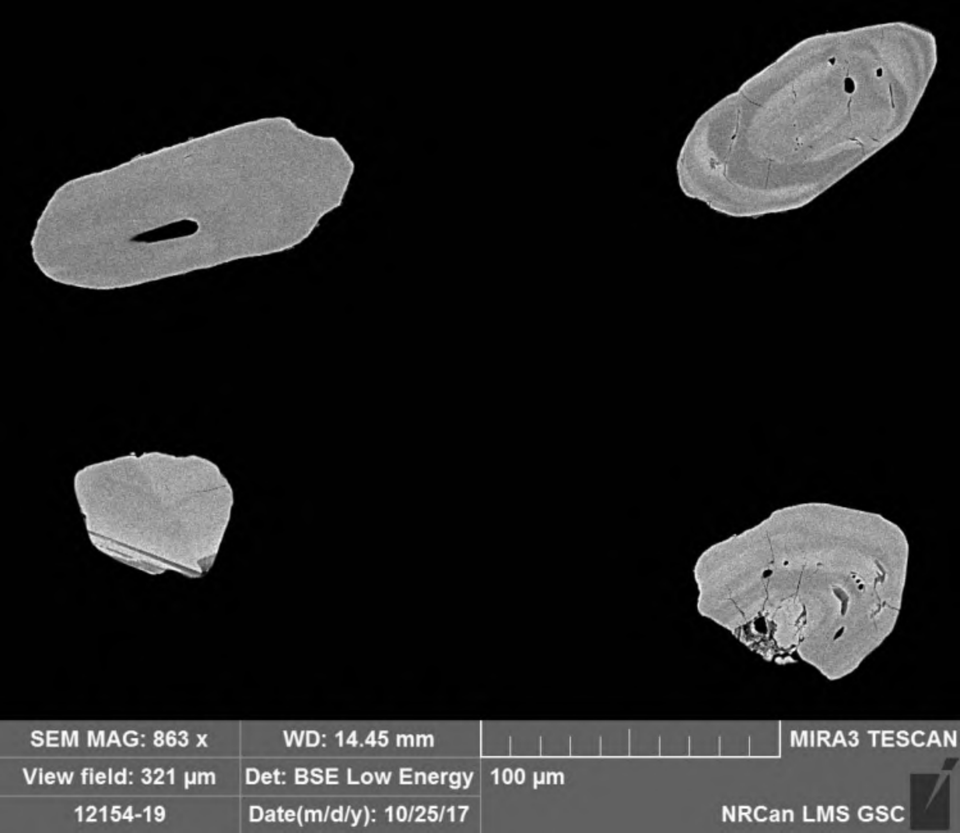

SEM MAG: 764 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 362 µm
Det: BSE Low Energy
100 µm
12154-15
Date(m/d/y): 10/25/17
NRCan LMS GSC

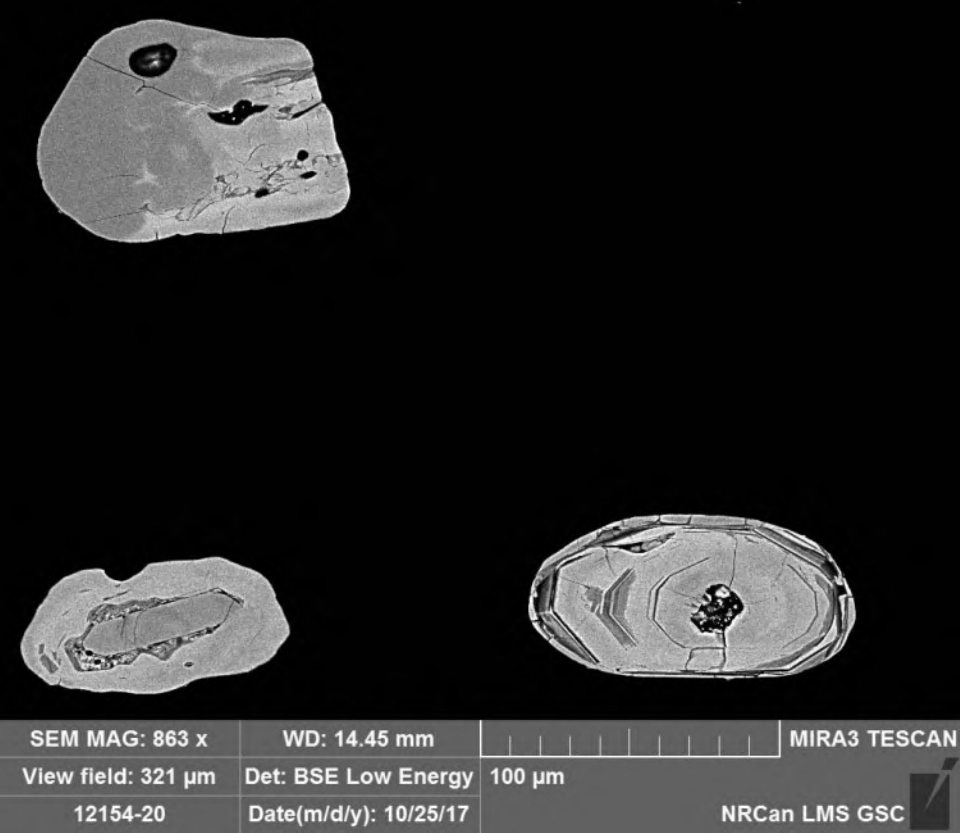

SEM MAG: 885 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 313 µm
Det: BSE Low Energy
50 µm
12154-16
Date(m/d/y): 10/25/17
NRCan LMS GSC

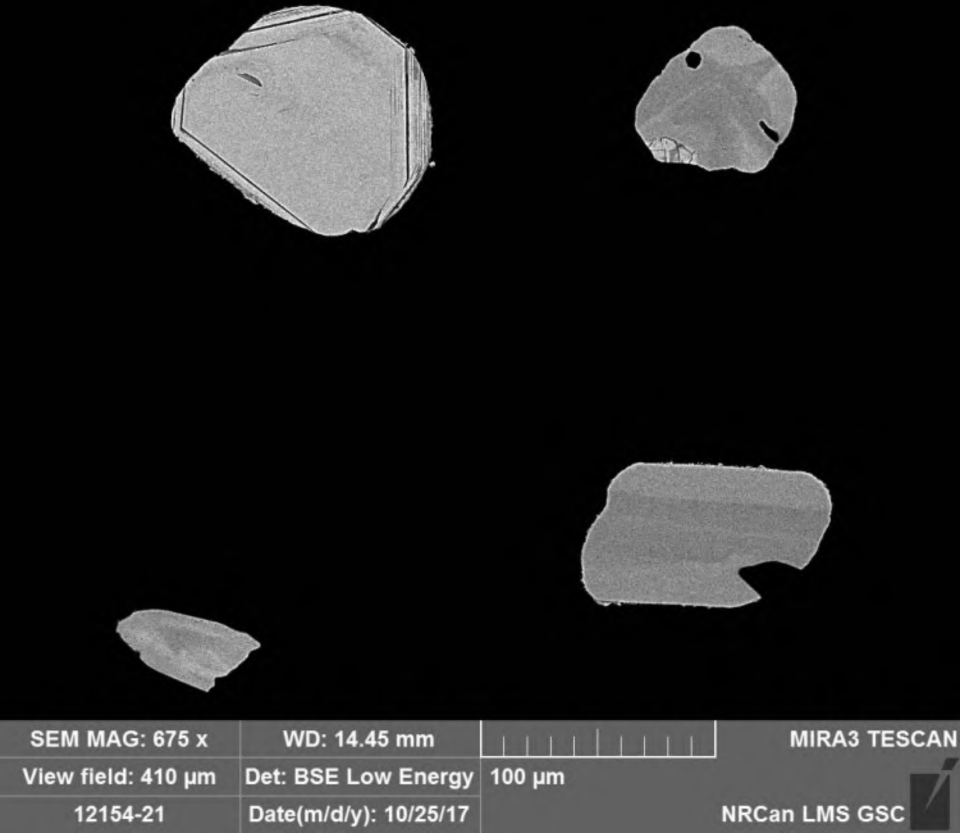

SEM MAG: 978 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 283 µm
Det: BSE Low Energy
50 µm
12154-17
Date(m/d/y): 10/25/17
NRCan LMS GSC

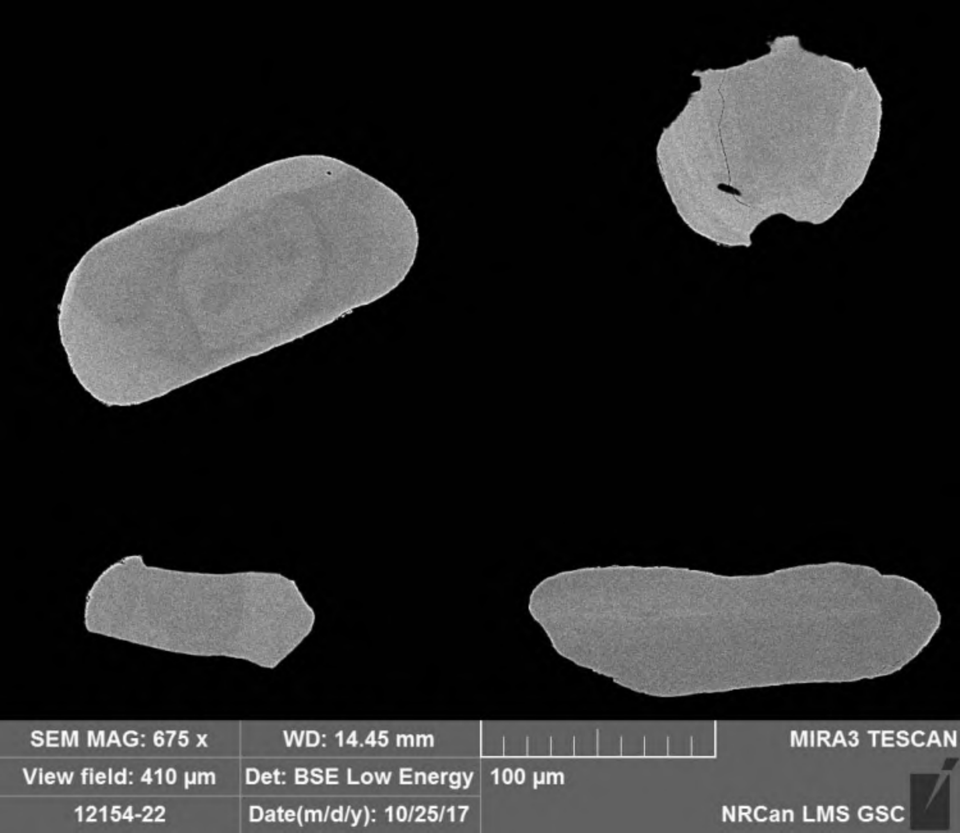


SEM MAG: 863 x	WD: 14.45 mm		MIRA3 TESCAN
View field: 321 µm	Det: BSE Low Energy	100 µm	
12154-18	Date(m/d/y): 10/25/17		NRCan LMS GSC

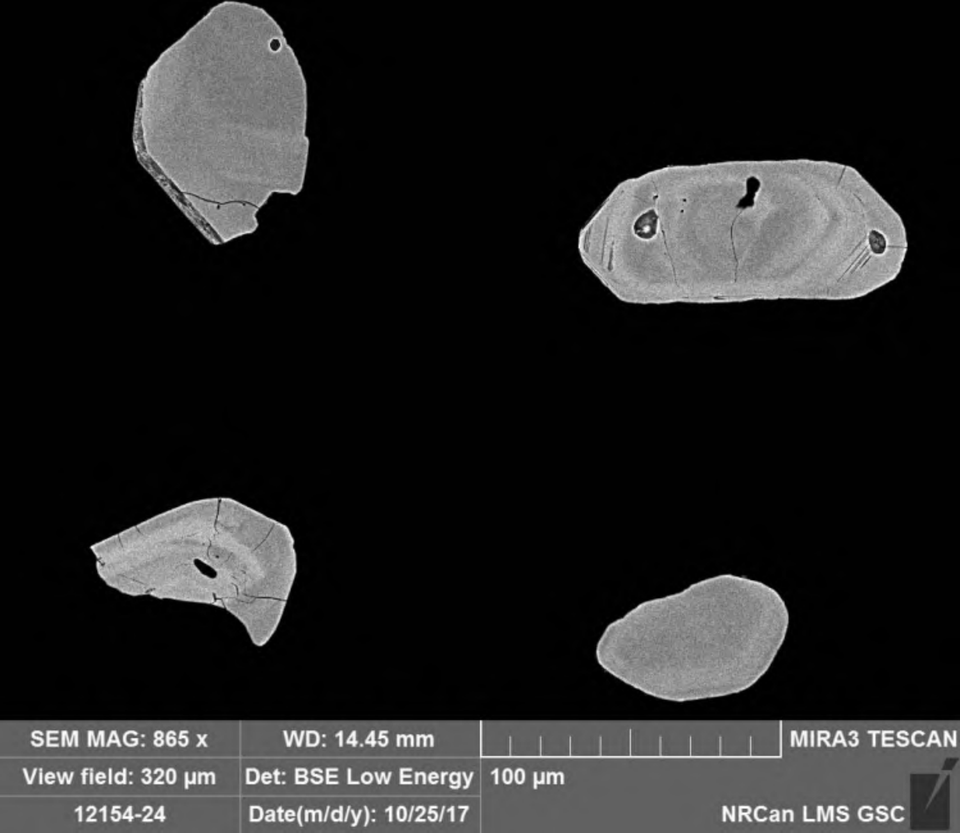

SEM MAG: 863 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 321 µm
Det: BSE Low Energy
100 µm
12154-19
Date(m/d/y): 10/25/17
NRCan LMS GSC

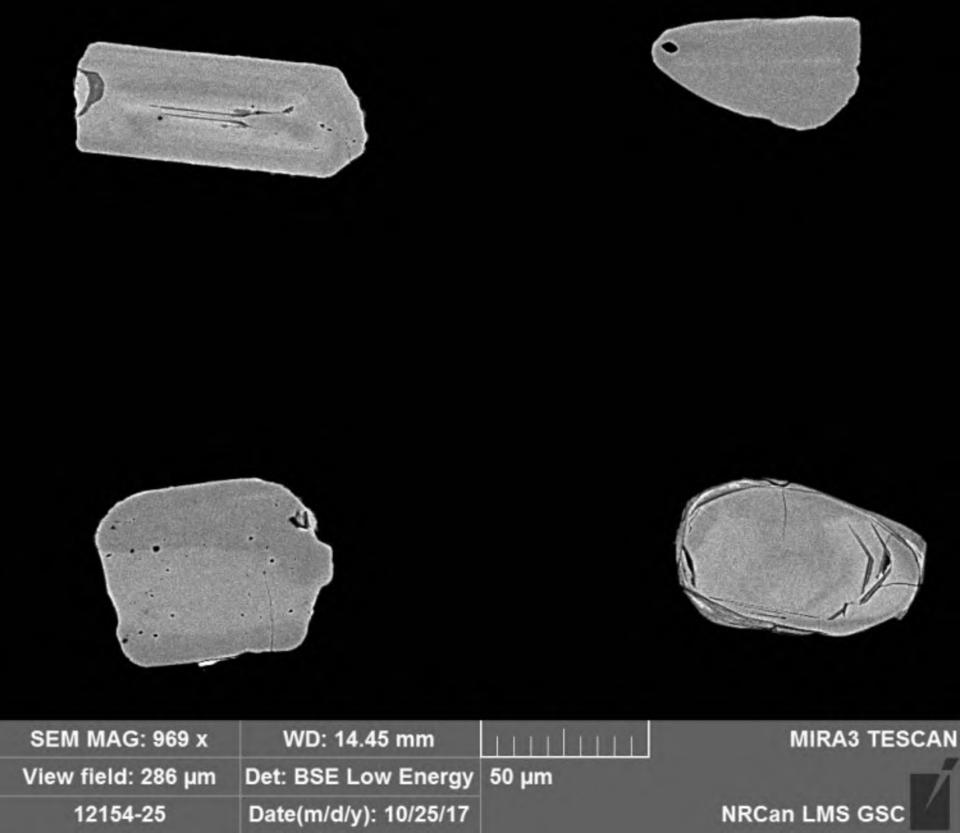

SEM MAG: 863 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 321 µm
Det: BSE Low Energy
100 µm
12154-20
Date(m/d/y): 10/25/17
NRCan LMS GSC

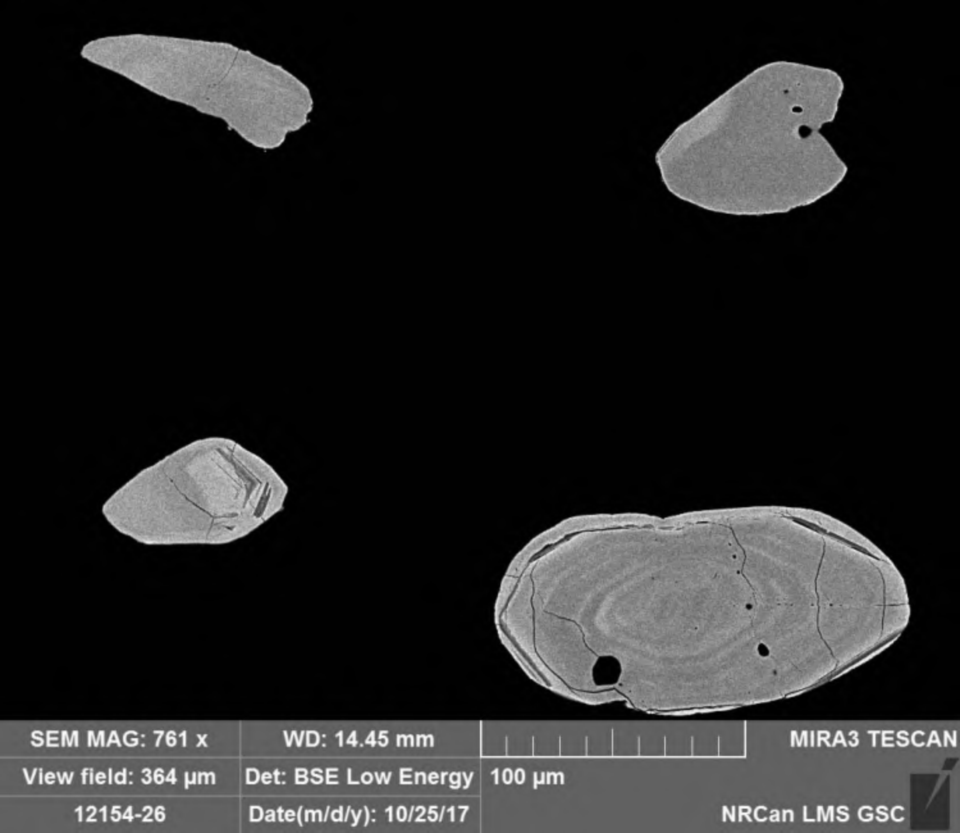

SEM MAG: 675 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 410 μm
Det: BSE Low Energy
100 μm
12154-21
Date(m/d/y): 10/25/17
NRCan LMS GSC

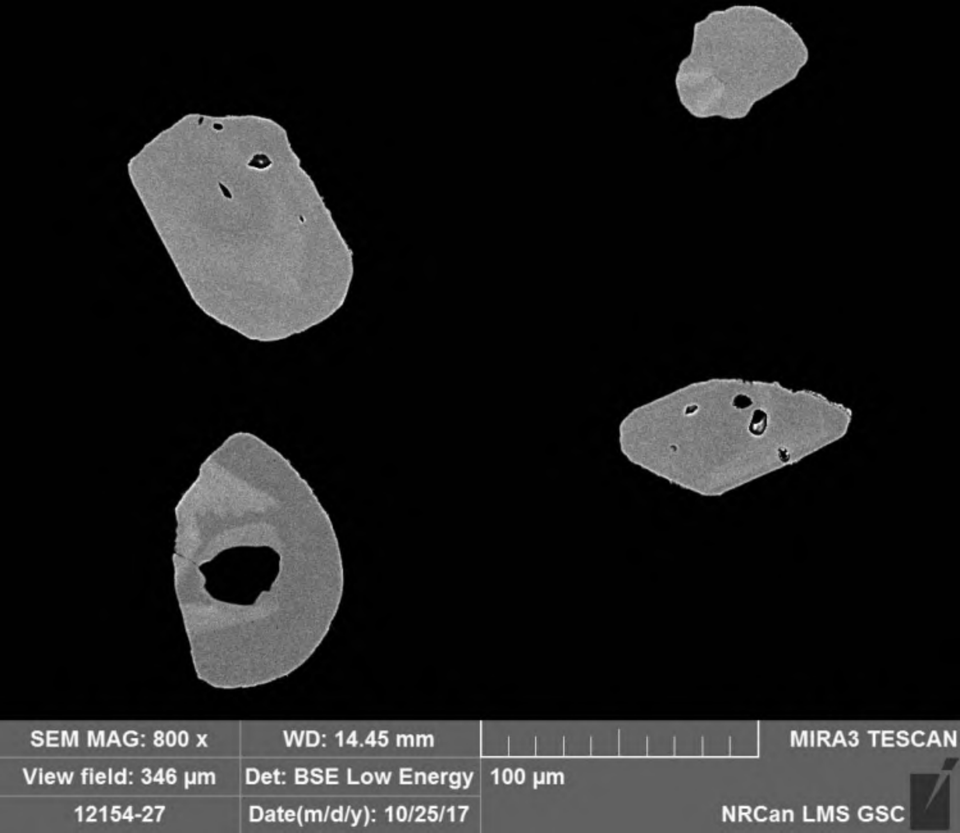

SEM MAG: 675 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 410 µm
Det: BSE Low Energy
100 µm
12154-22
Date(m/d/y): 10/25/17
NRCan LMS GSC

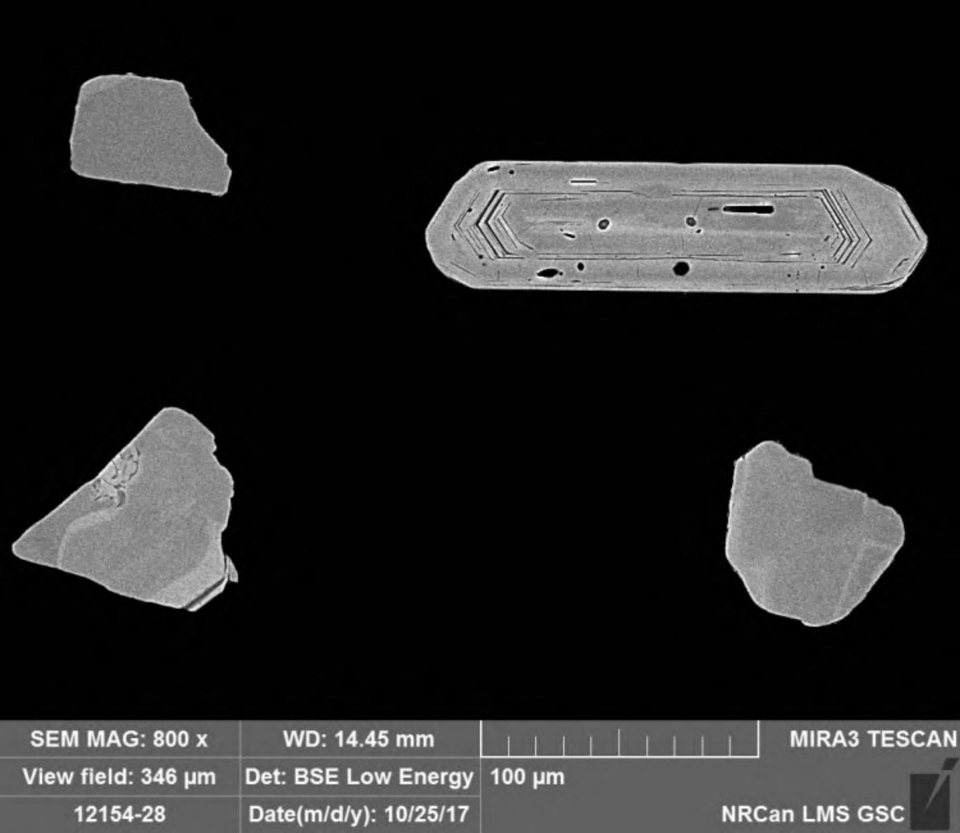

SEM MAG: 895 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 309 µm
Det: BSE Low Energy
50 µm
12154-23
Date(m/d/y): 10/25/17
NRCan LMS GSC

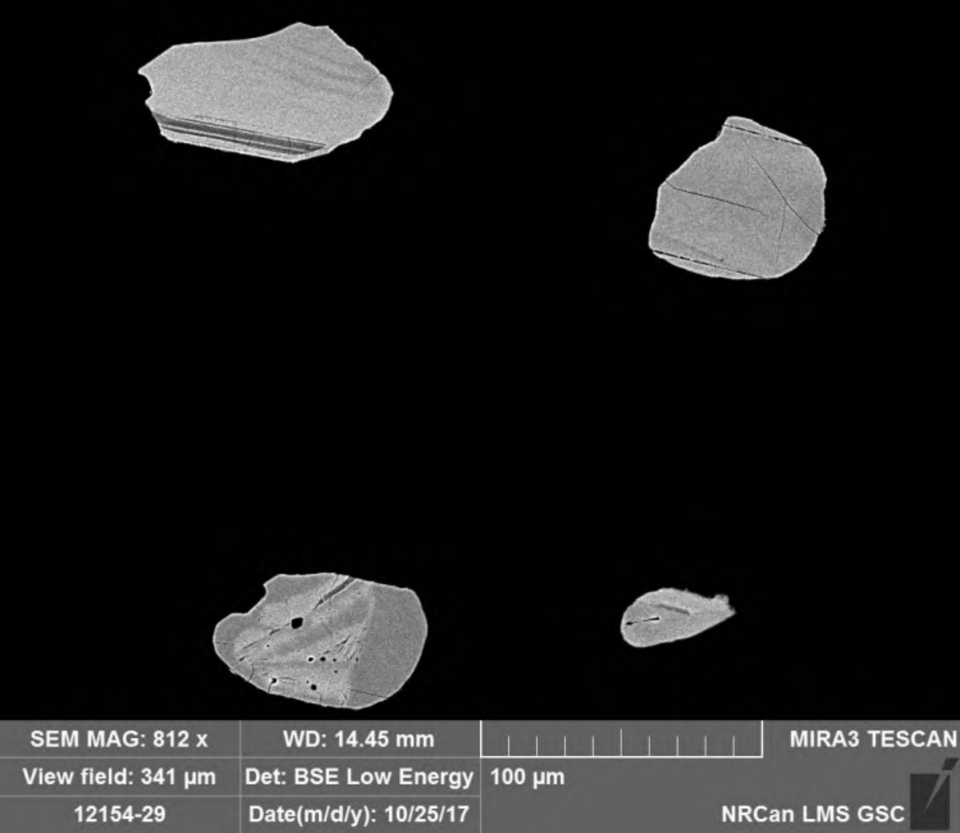

SEM MAG: 865 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 320 µm
Det: BSE Low Energy
100 µm
12154-24
Date(m/d/y): 10/25/17
NRCan LMS GSC

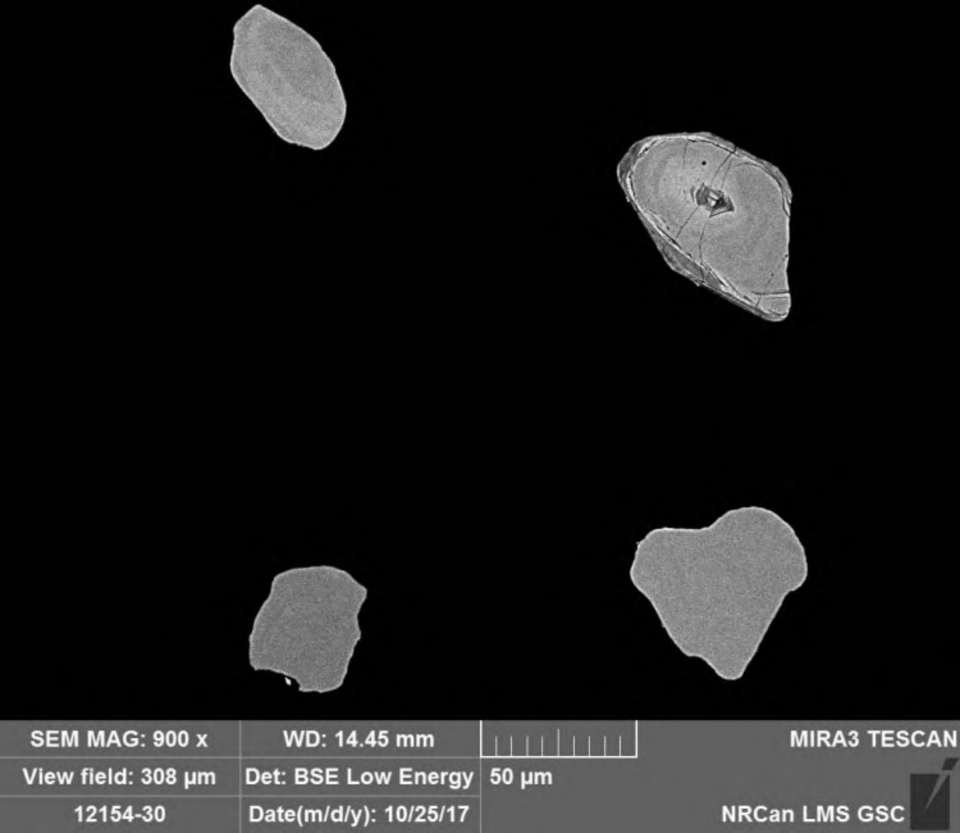

SEM MAG: 969 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 286 µm
Det: BSE Low Energy
50 µm
12154-25
Date(m/d/y): 10/25/17
NRCan LMS GSC

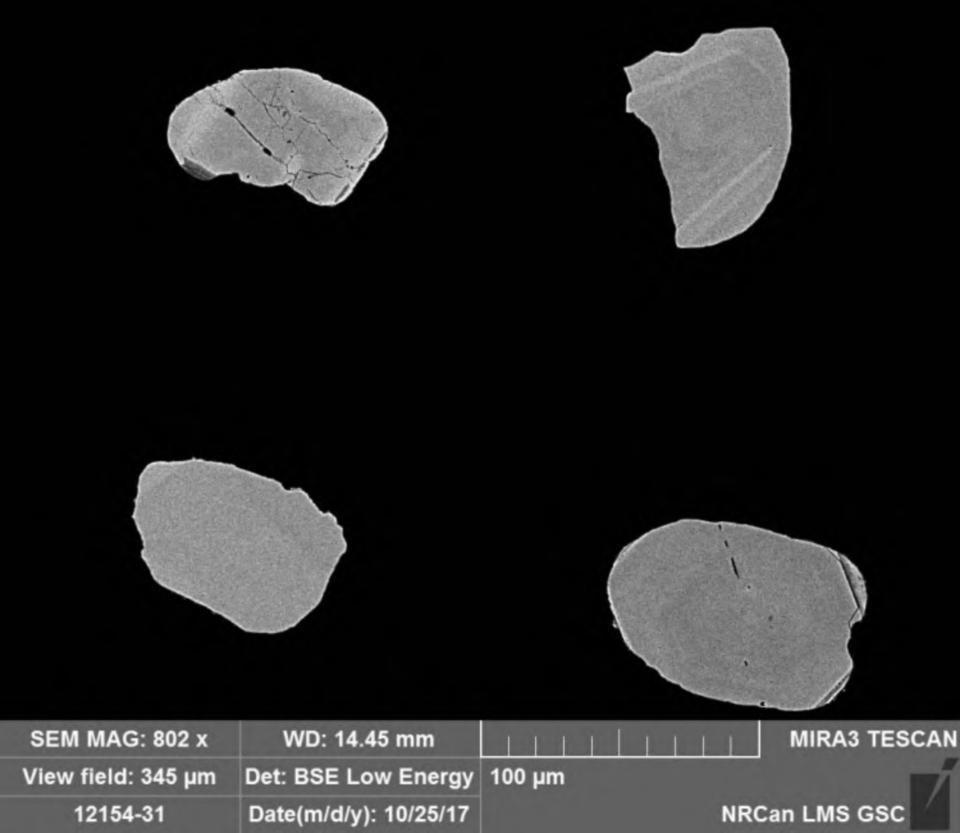

SEM MAG: 761 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 364 µm
Det: BSE Low Energy
100 µm
12154-26
Date(m/d/y): 10/25/17
NRCan LMS GSC

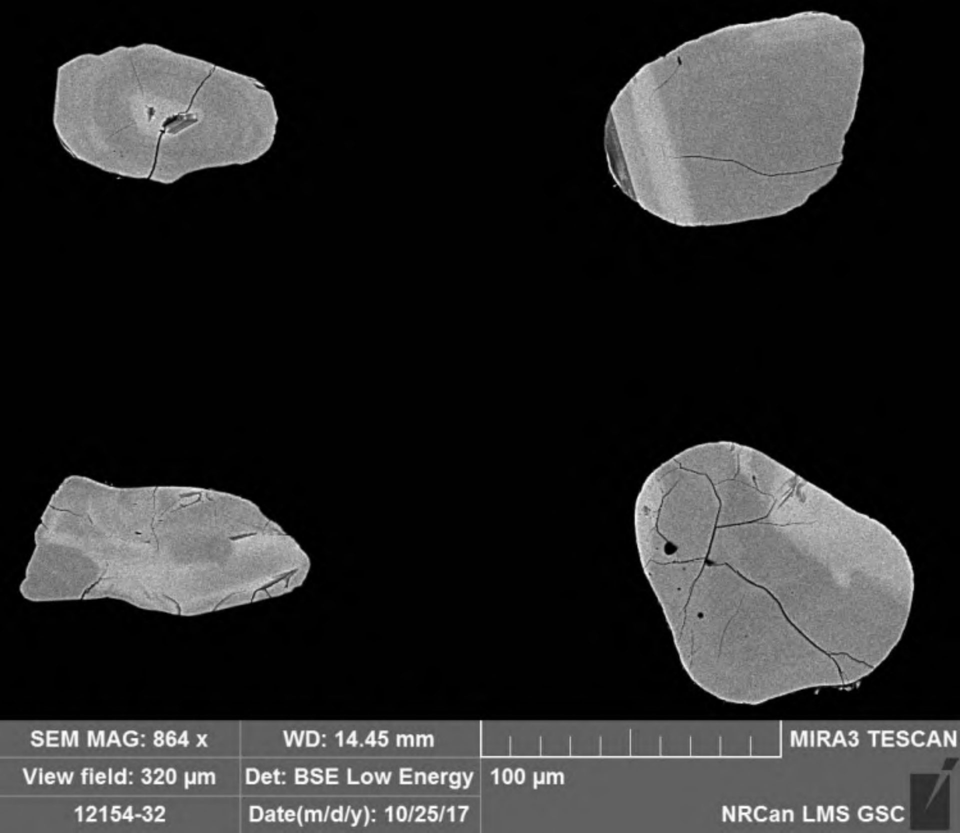

SEM MAG: 800 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 346 µm
Det: BSE Low Energy
100 µm
12154-27
Date(m/d/y): 10/25/17
NRCan LMS GSC

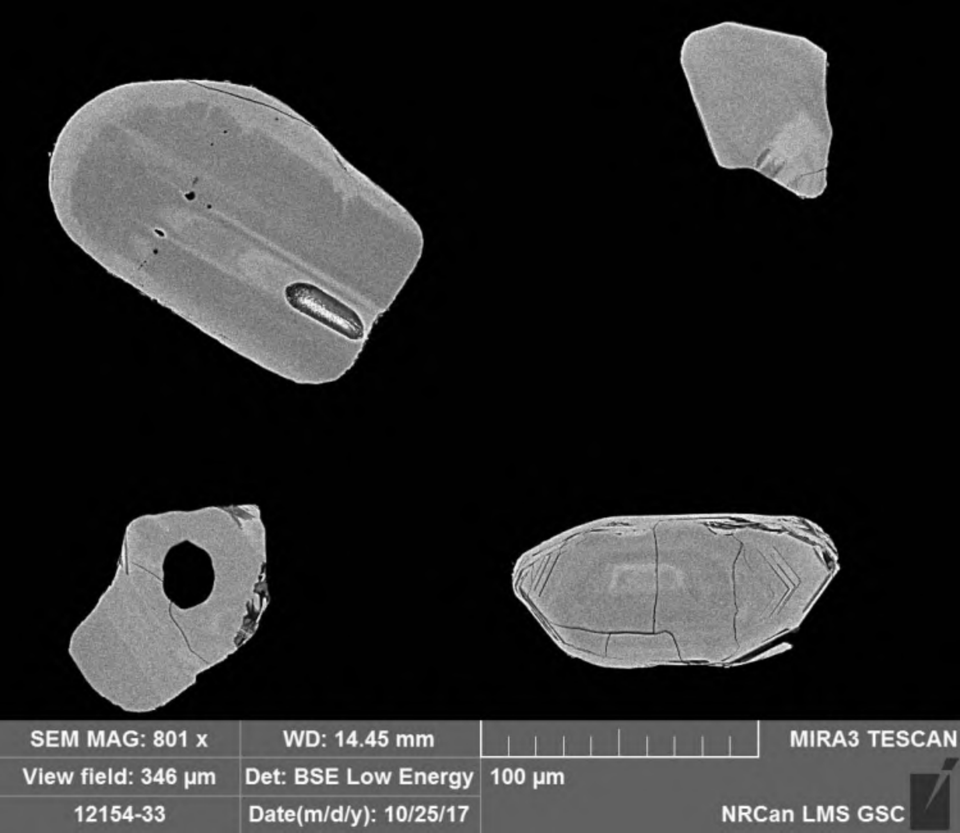

SEM MAG: 800 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 346 µm
Det: BSE Low Energy
100 µm
12154-28
Date(m/d/y): 10/25/17
NRCan LMS GSC

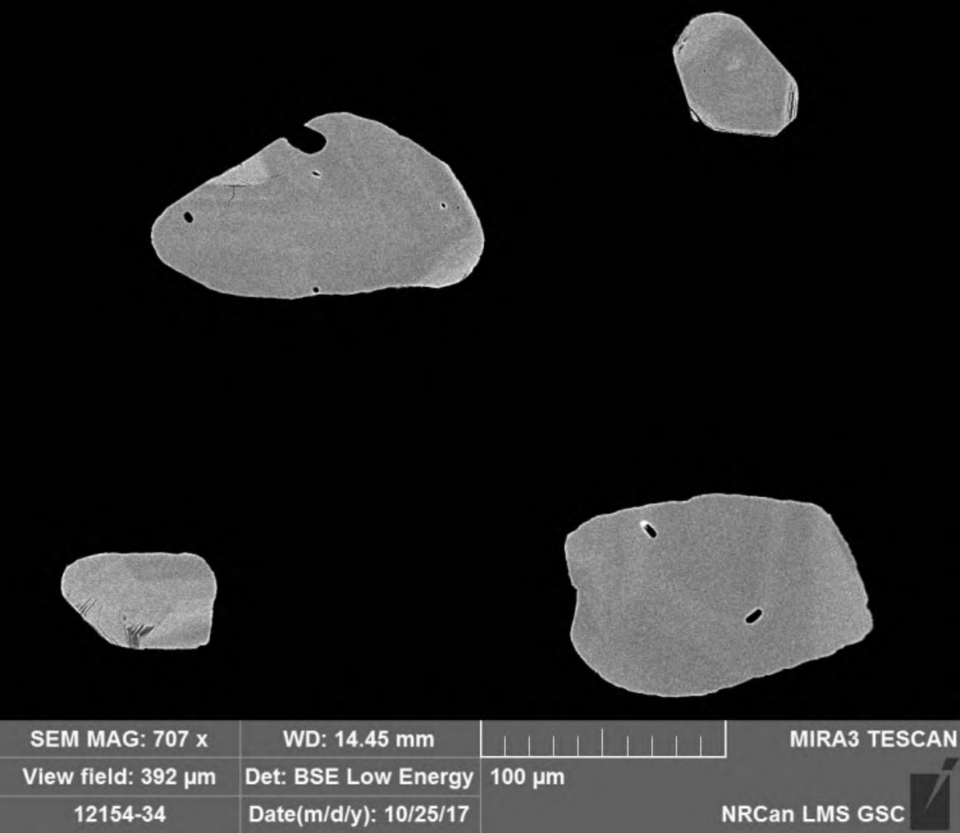

SEM MAG: 812 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 341 µm
Det: BSE Low Energy
100 µm
12154-29
Date(m/d/y): 10/25/17
NRCan LMS GSC

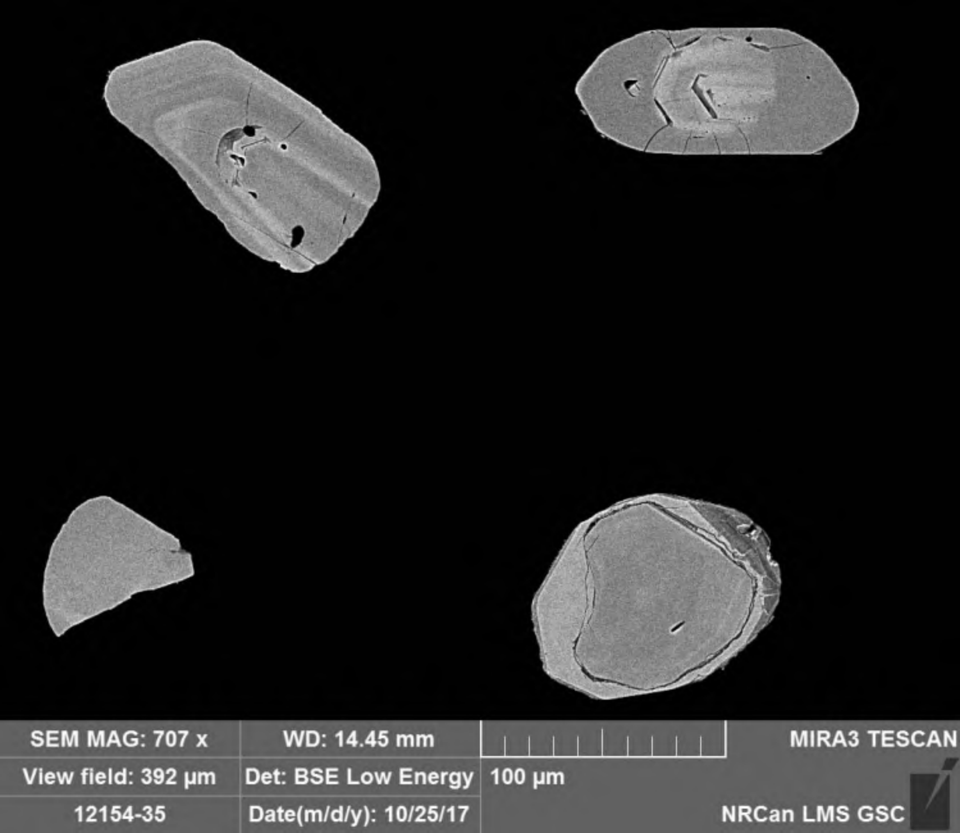

SEM MAG: 900 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 308 µm
Det: BSE Low Energy
50 µm
12154-30
Date(m/d/y): 10/25/17
NRCan LMS GSC

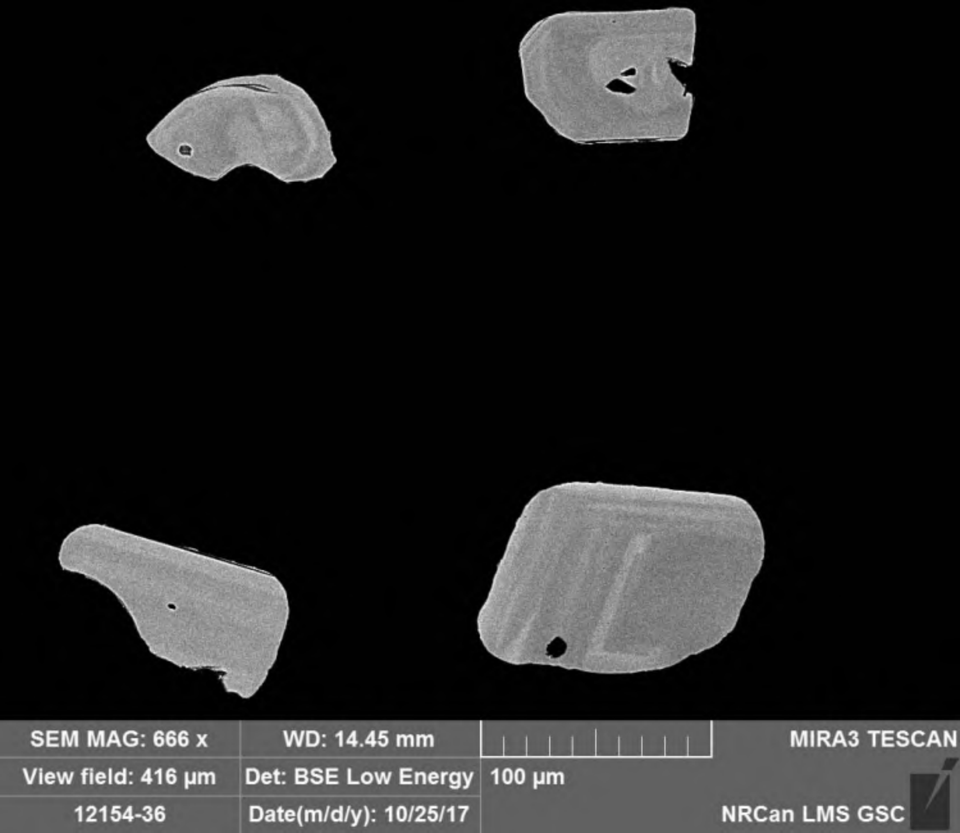

SEM MAG: 802 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 345 µm
Det: BSE Low Energy
100 µm
12154-31
Date(m/d/y): 10/25/17
NRCan LMS GSC

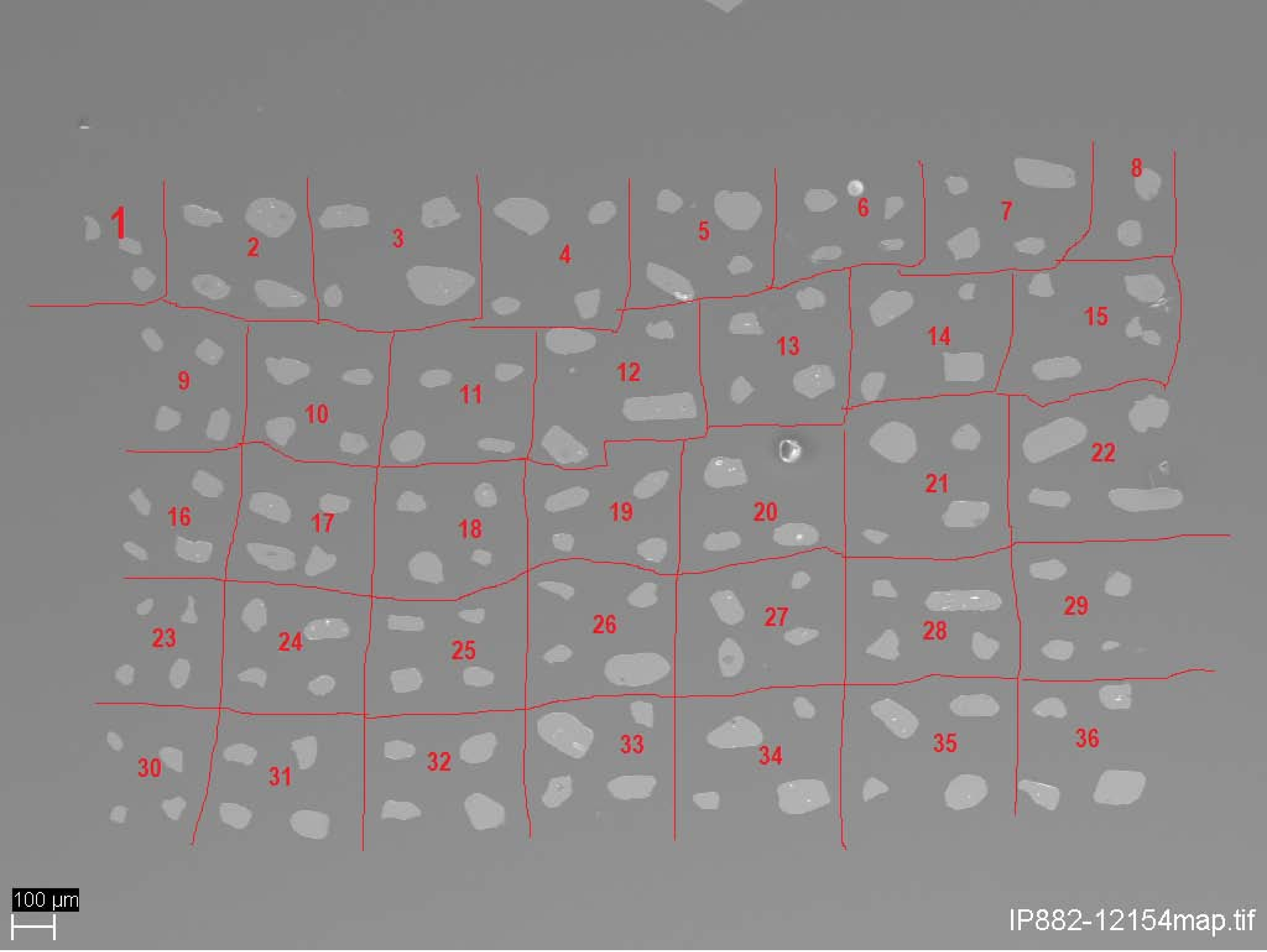

SEM MAG: 864 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 320 μm
Det: BSE Low Energy
100 μm
12154-32
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 801 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 346 µm
Det: BSE Low Energy
100 µm
12154-33
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 707 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 392 µm
Det: BSE Low Energy
100 µm
12154-34
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 707 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 392 μm
Det: BSE Low Energy
100 μm
12154-35
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 666 x
WD: 14.45 mm
MIRA3 TESCAN
View field: 416 µm
Det: BSE Low Energy
100 µm
12154-36
Date(m/d/y): 10/25/17
NRCan LMS GSC


1
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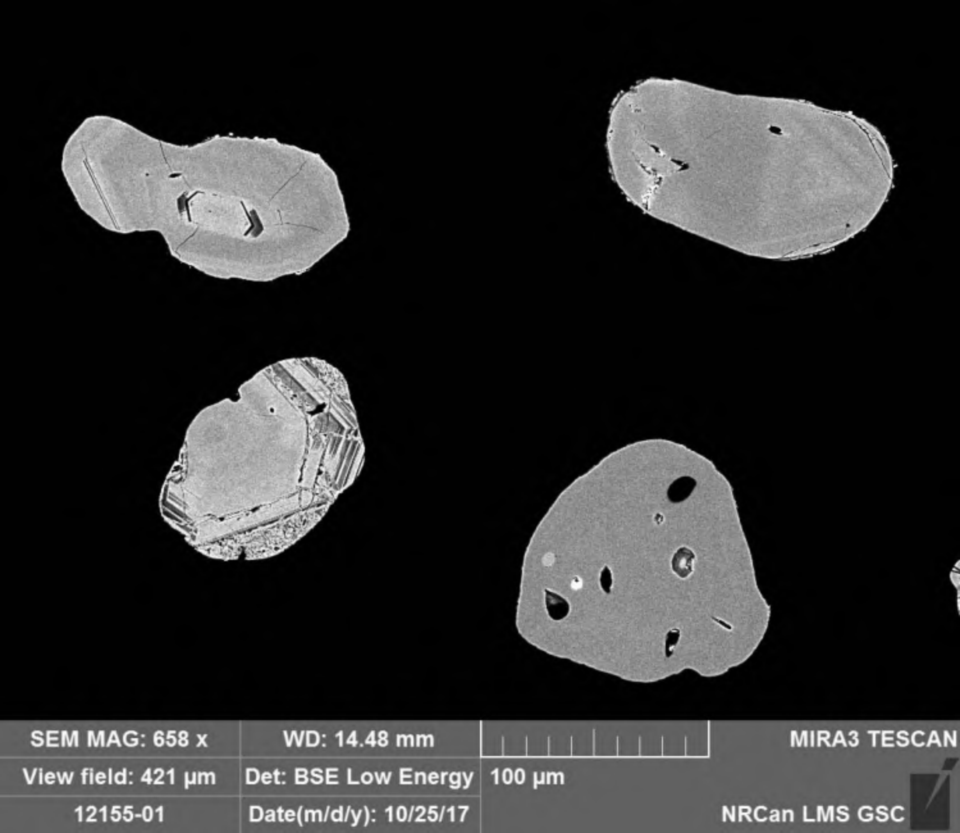
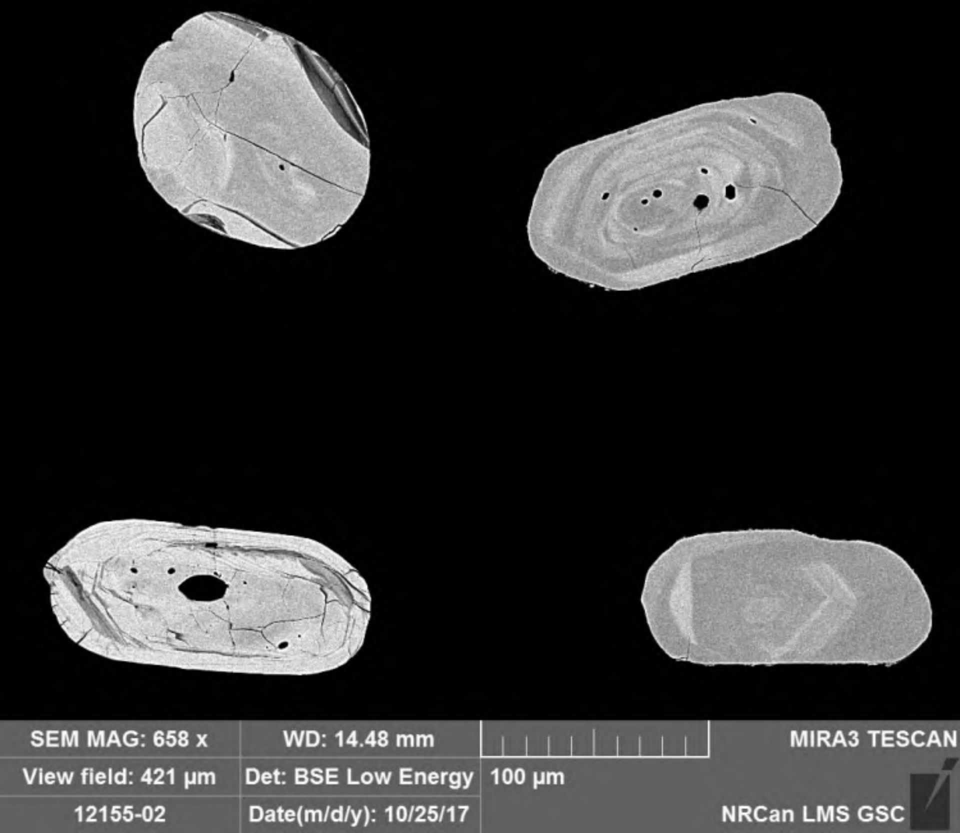
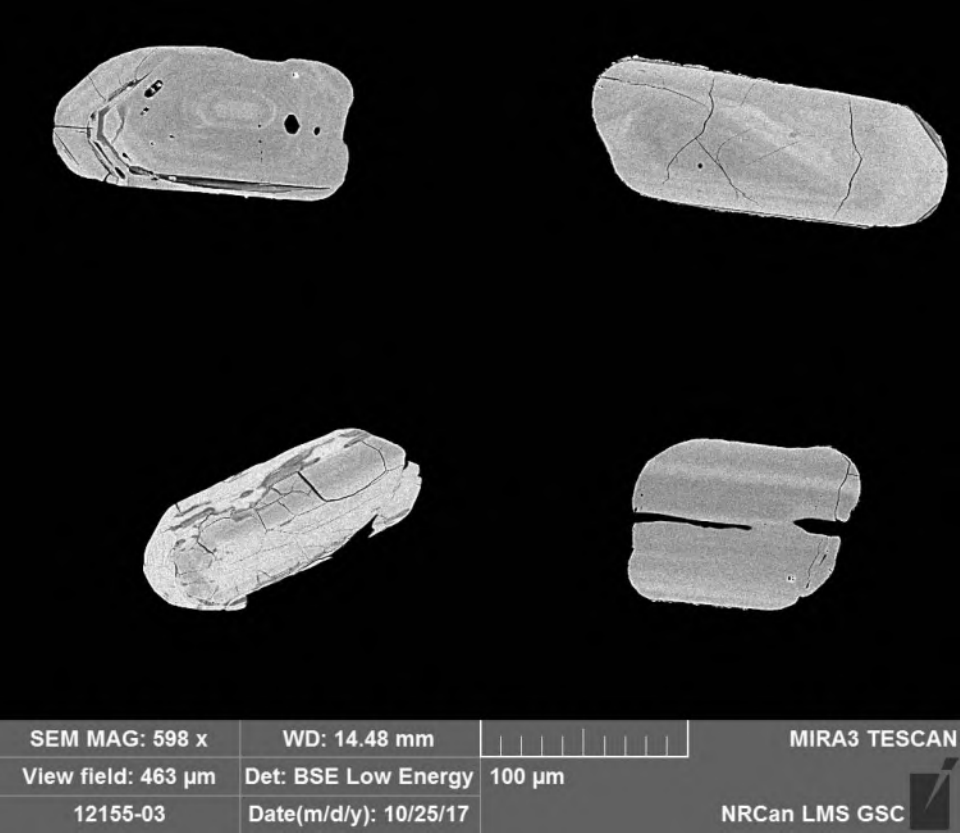
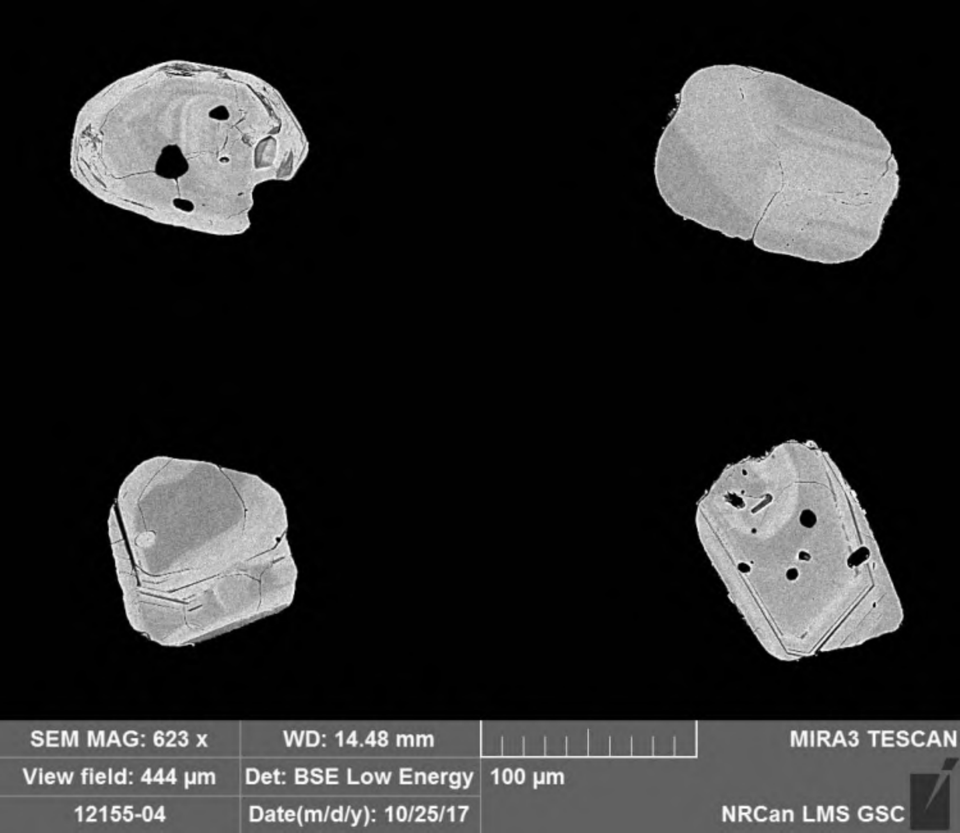
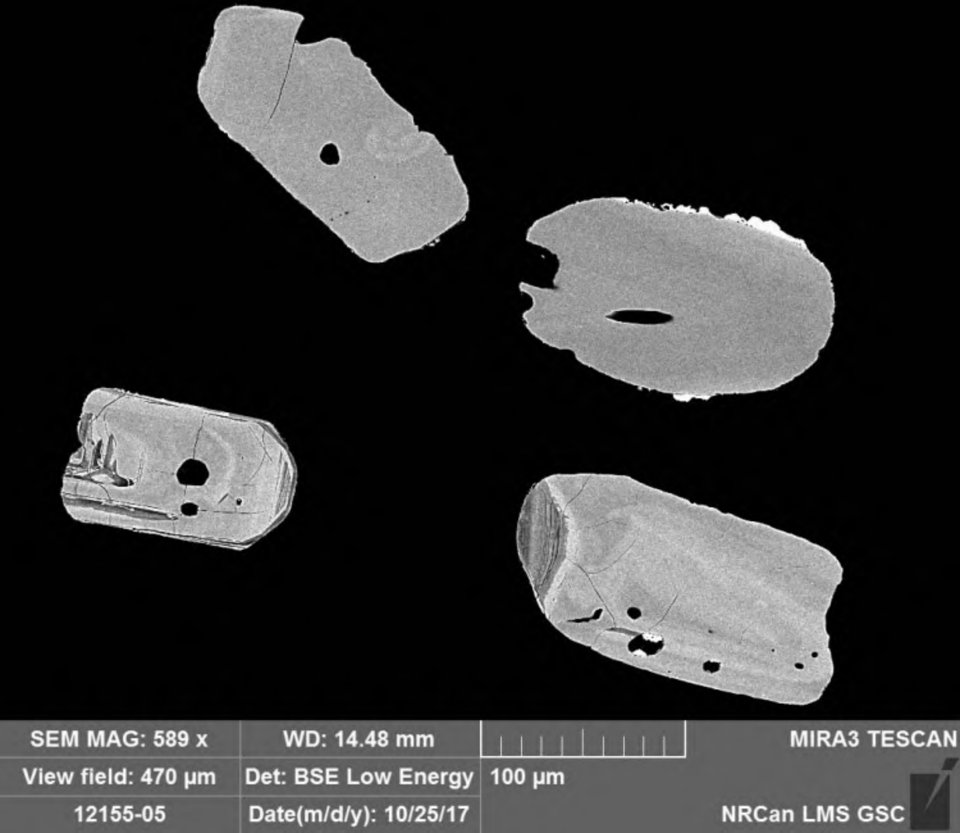
35
36
100 µm
IP882-12154map.tif


SEM MAG: 658 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 421 µm
Det: BSE Low Energy
100 µm
12155-01
Date(m/d/y): 10/25/17
NRCan LMS GSC

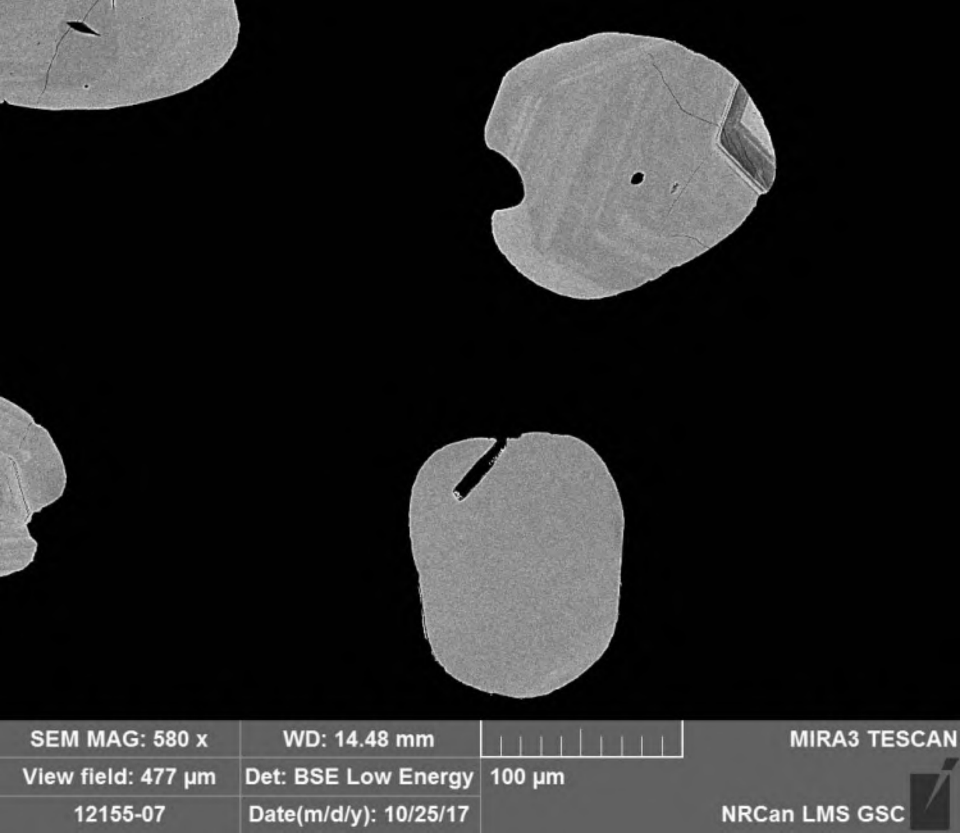

SEM MAG: 658 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 421 µm
Det: BSE Low Energy
100 µm
12155-02
Date(m/d/y): 10/25/17
NRCan LMS GSC

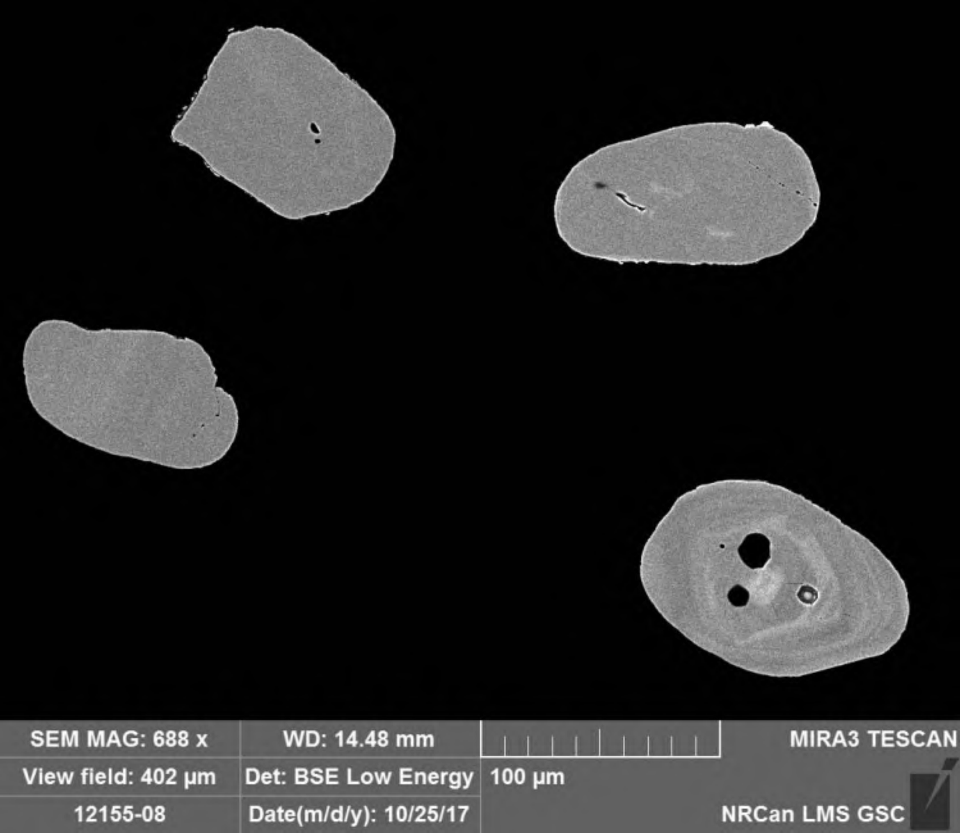

SEM MAG: 598 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 463 µm
Det: BSE Low Energy
100 µm
12155-03
Date(m/d/y): 10/25/17
NRCan LMS GSC

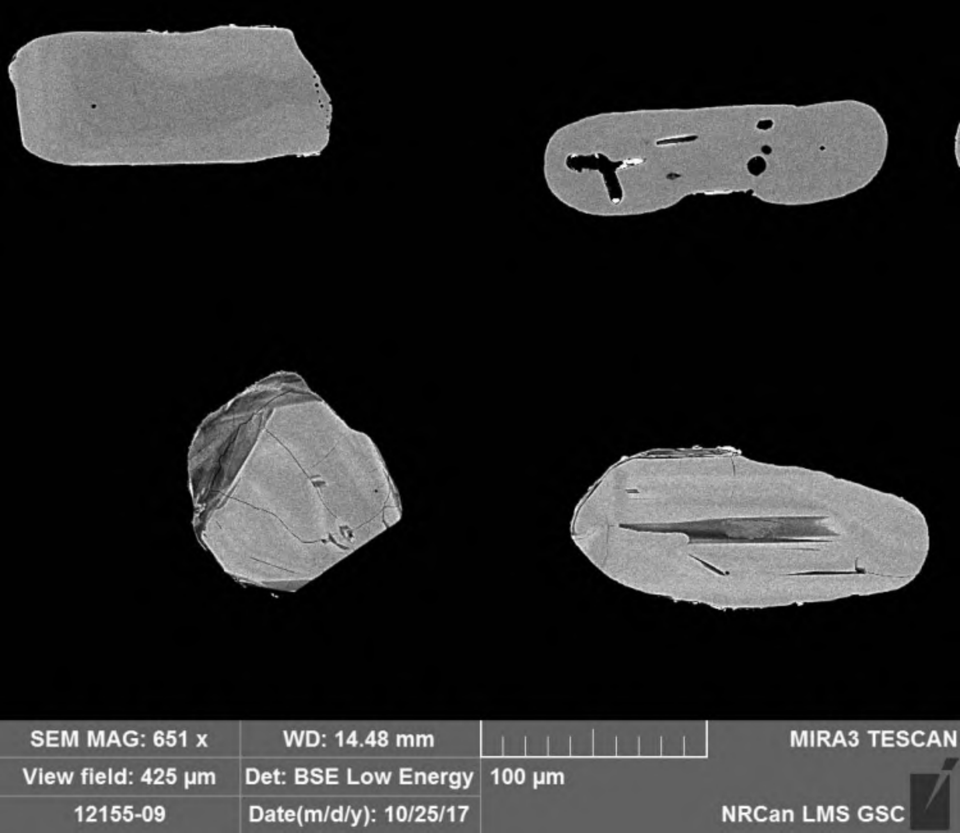

SEM MAG: 623 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 444 µm
Det: BSE Low Energy
100 µm
12155-04
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 589 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 470 µm
Det: BSE Low Energy
100 µm
12155-05
Date(m/d/y): 10/25/17
NRCan LMS GSC

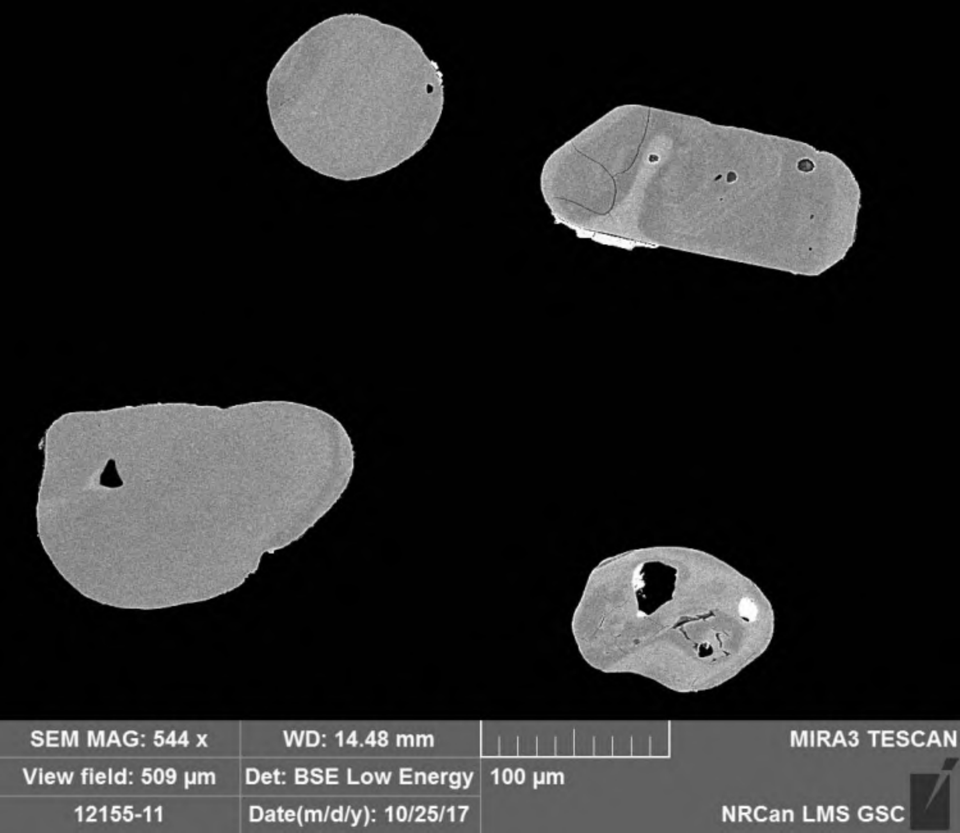

SEM MAG: 533 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 519 µm
Det: BSE Low Energy
100 µm
12155-06
Date(m/d/y): 10/25/17
NRCan LMS GSC

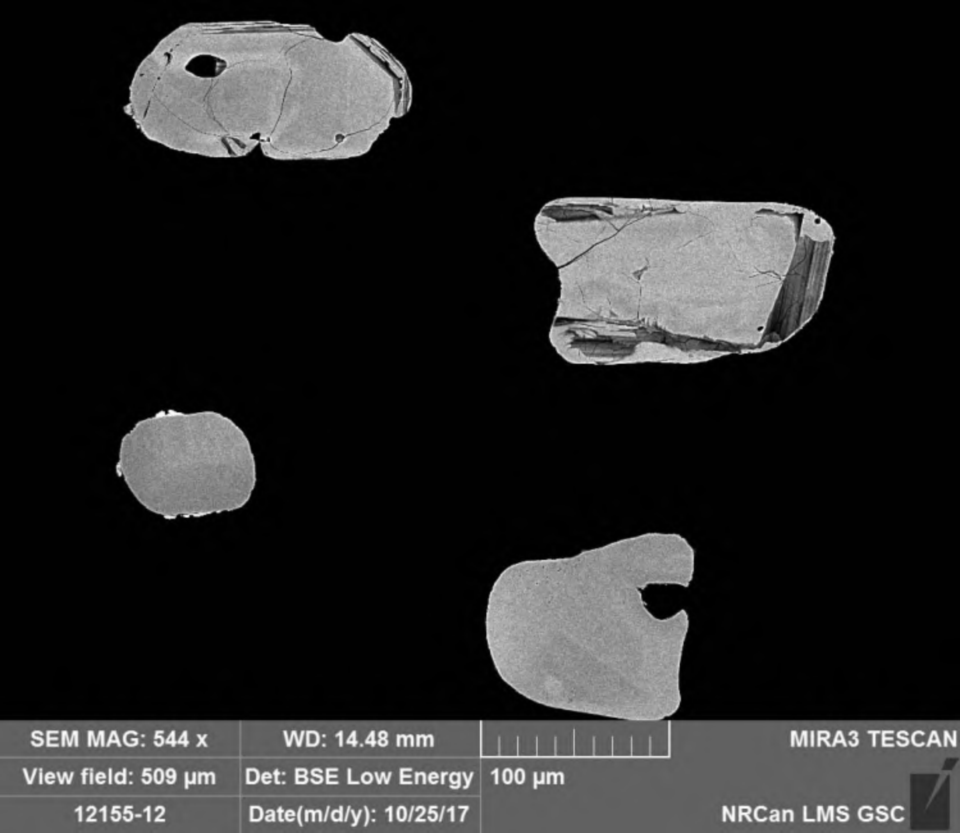

SEM MAG: 580 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 477 µm
Det: BSE Low Energy
100 µm
12155-07
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 688 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 402 µm
Det: BSE Low Energy
100 µm
12155-08
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 651 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 425 µm
Det: BSE Low Energy
100 µm
12155-09
Date(m/d/y): 10/25/17
NRCan LMS GSC

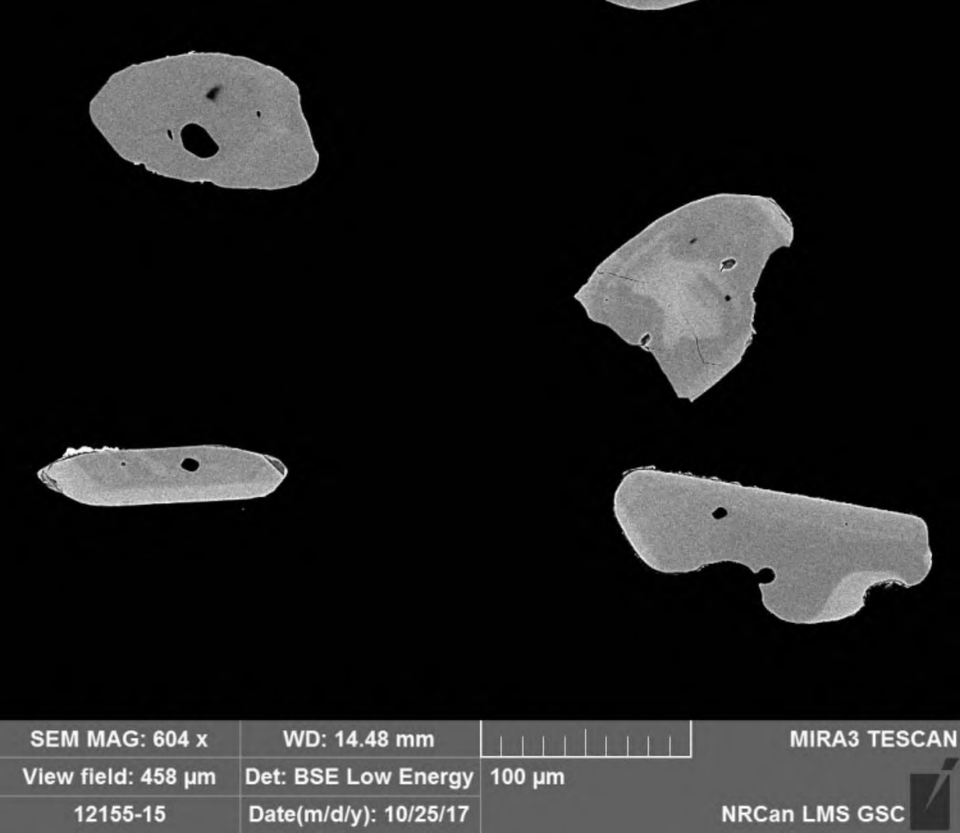

SEM MAG: 685 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 404 µm
Det: BSE Low Energy
100 µm
12155-10
Date(m/d/y): 10/25/17
NRCan LMS GSC

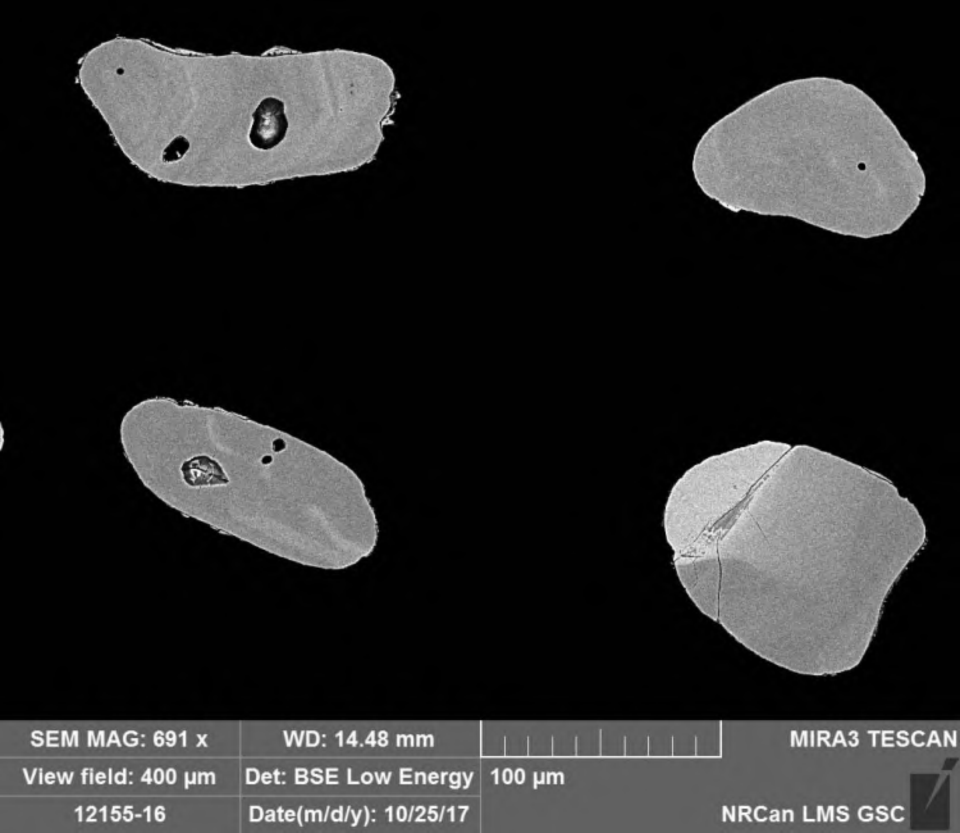

SEM MAG: 544 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 509 µm
Det: BSE Low Energy
100 µm
12155-11
Date(m/d/y): 10/25/17
NRCan LMS GSC

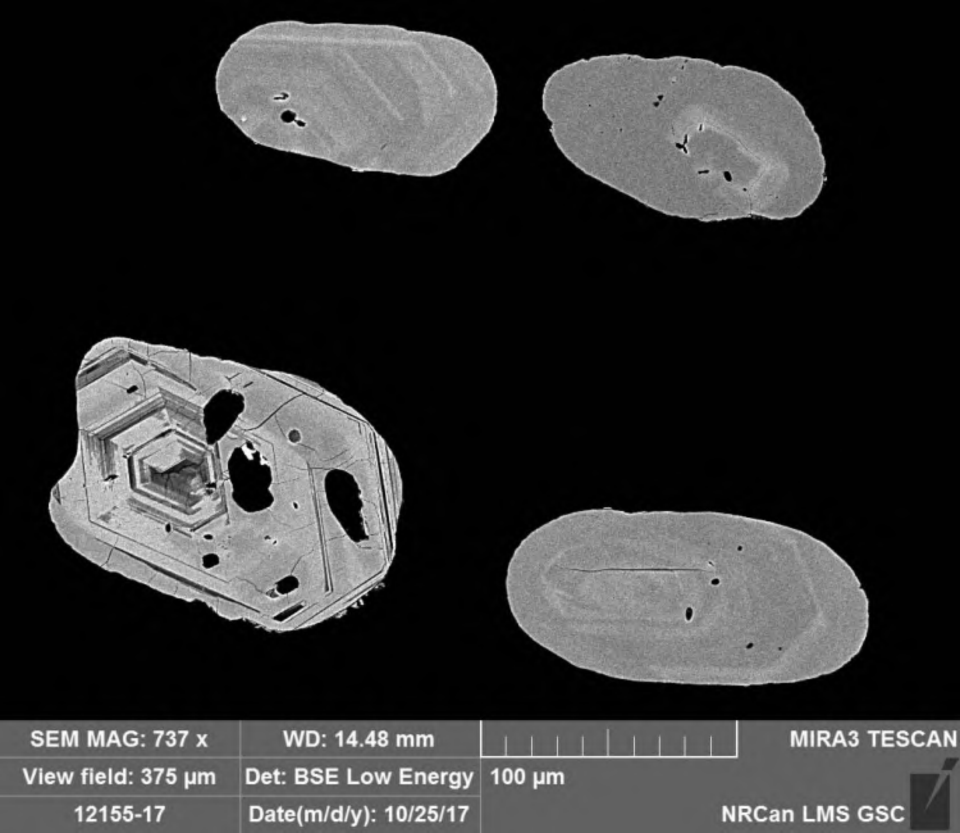

SEM MAG: 544 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 509 µm
Det: BSE Low Energy
100 µm
12155-12
Date(m/d/y): 10/25/17
NRCan LMS GSC

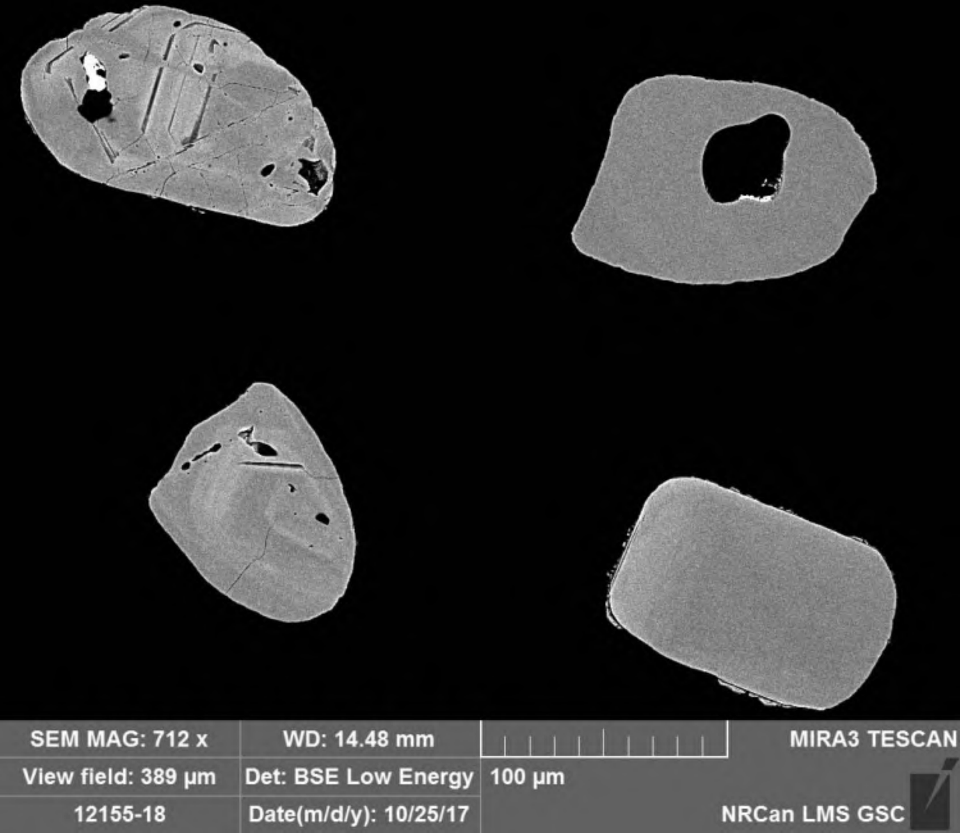

SEM MAG: 607 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 456 µm
Det: BSE Low Energy
100 µm
12155-13
Date(m/d/y): 10/25/17
NRCan LMS GSC

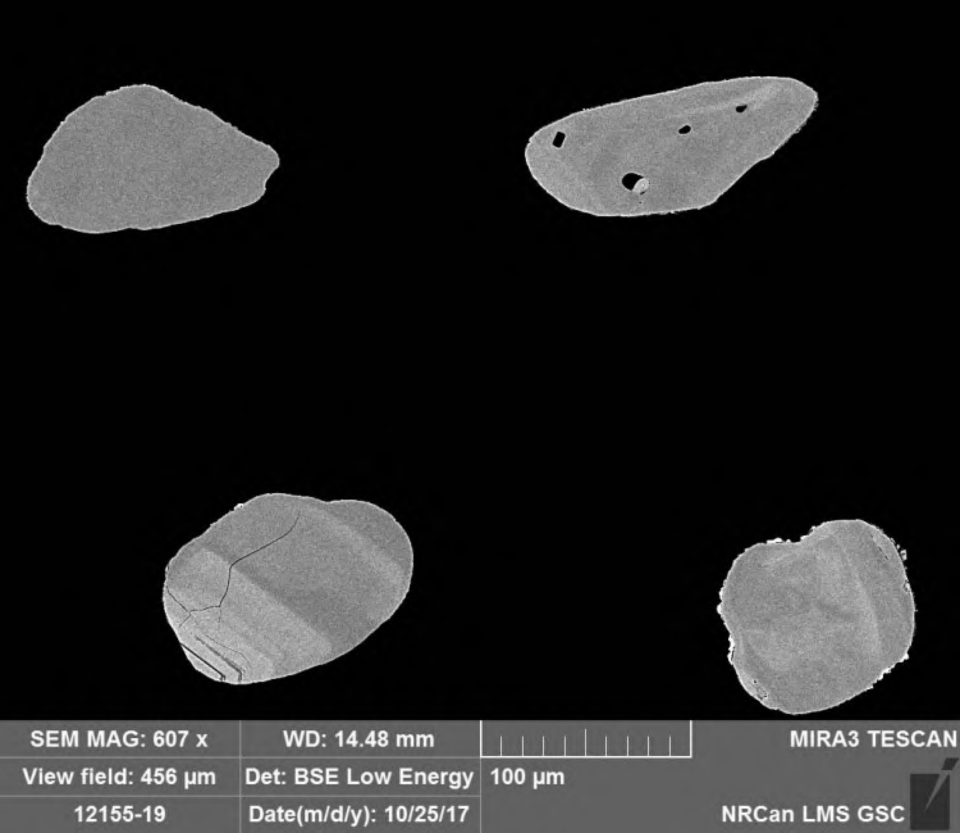

SEM MAG: 644 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 430 µm
Det: BSE Low Energy
100 µm
12155-14
Date(m/d/y): 10/25/17
NRCan LMS GSC

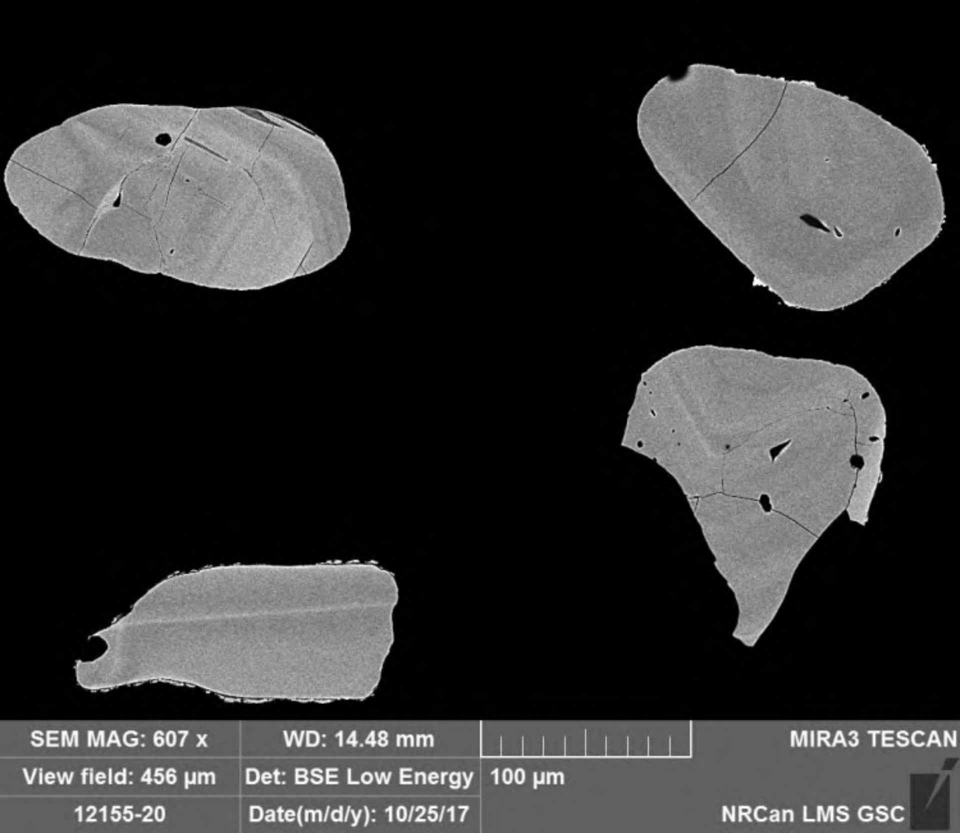

SEM MAG: 604 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 458 µm
Det: BSE Low Energy
100 µm
12155-15
Date(m/d/y): 10/25/17
NRCan LMS GSC

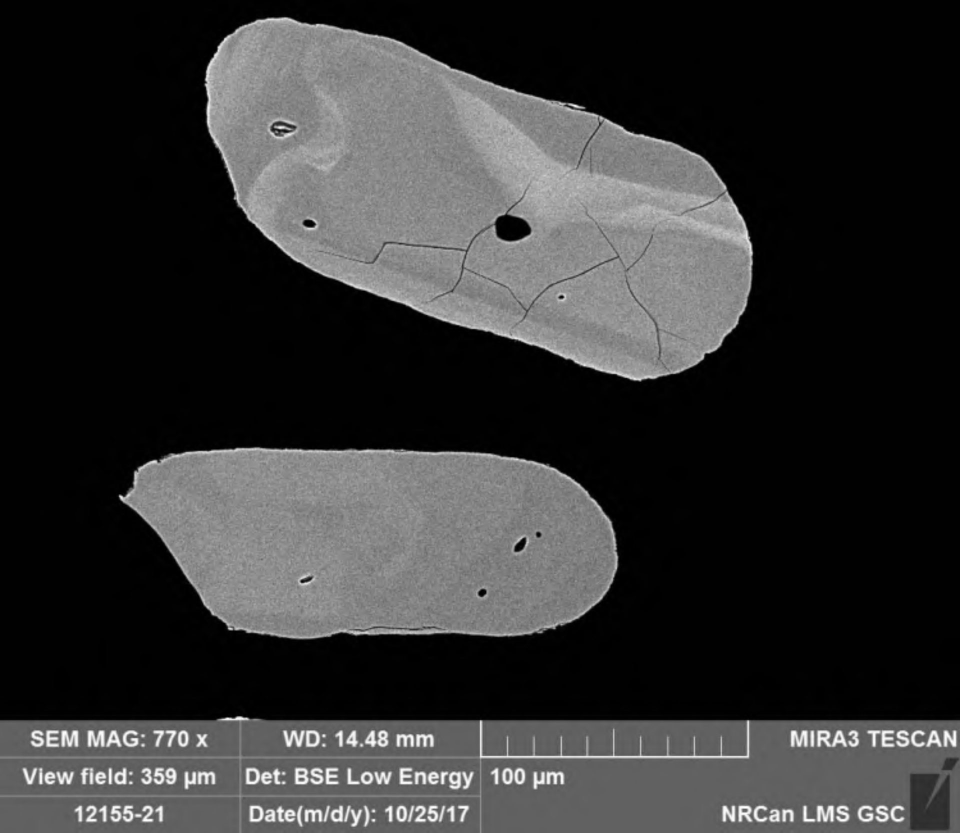

SEM MAG: 691 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 400 µm
Det: BSE Low Energy
100 µm
12155-16
Date(m/d/y): 10/25/17
NRCan LMS GSC

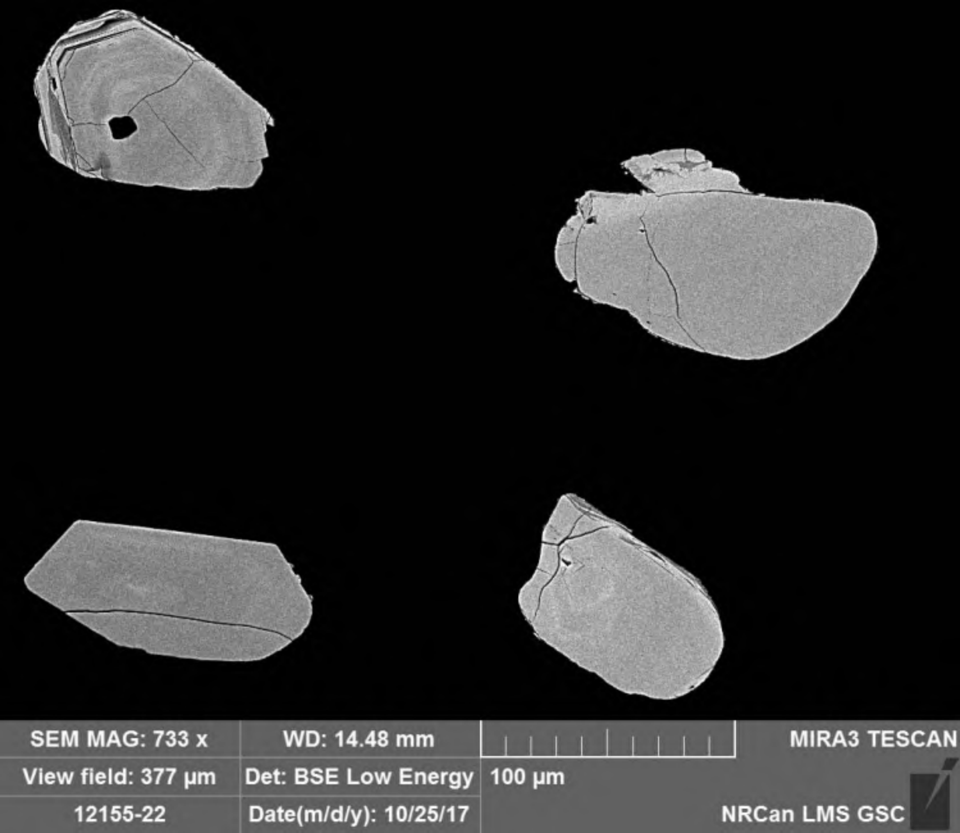

SEM MAG: 737 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 375 µm
Det: BSE Low Energy
100 µm
12155-17
Date(m/d/y): 10/25/17
NRCan LMS GSC

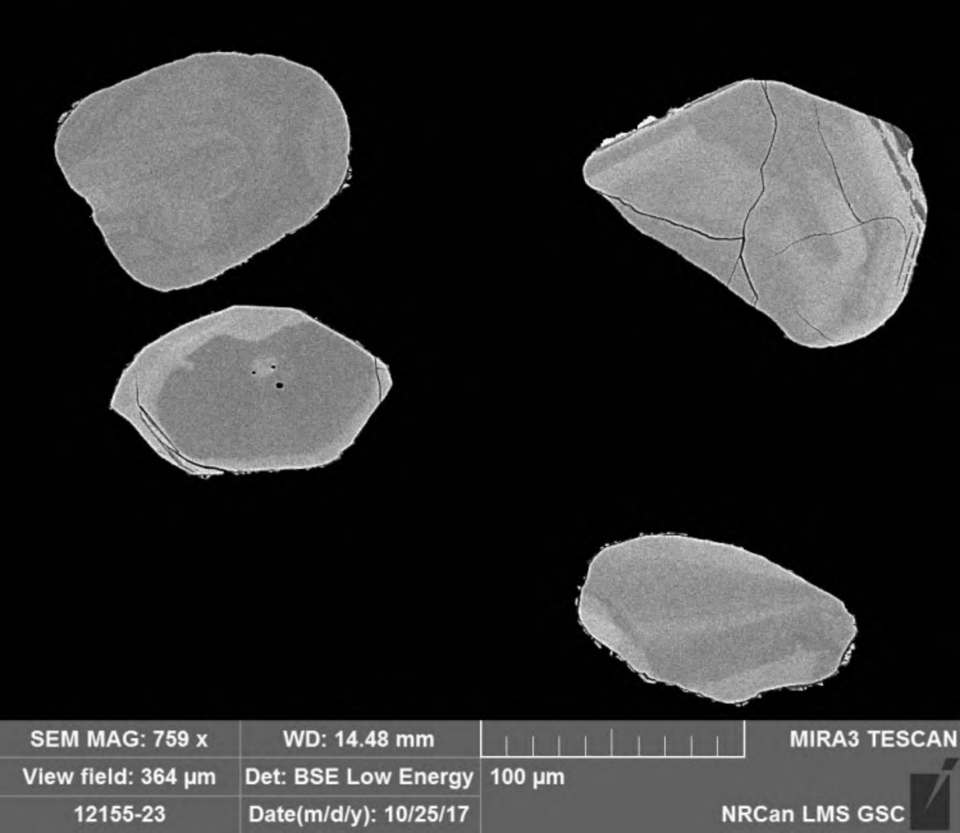

SEM MAG: 712 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 389 µm
Det: BSE Low Energy
100 µm
12155-18
Date(m/d/y): 10/25/17
NRCan LMS GSC

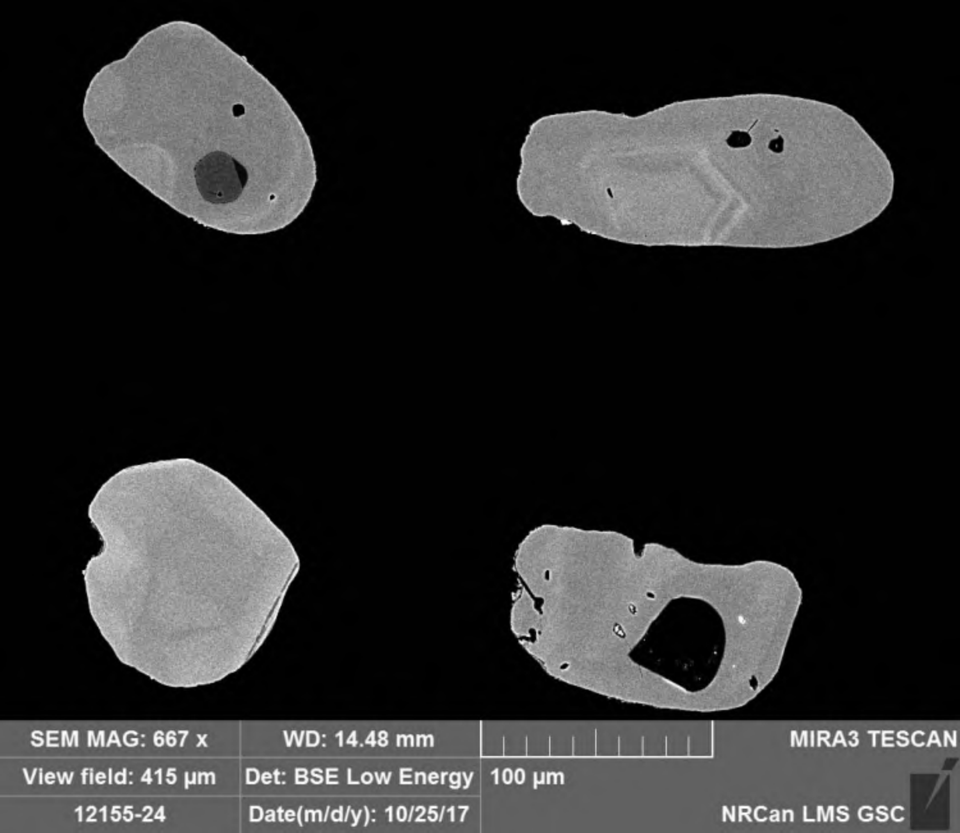

SEM MAG: 607 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 456 µm
Det: BSE Low Energy
100 µm
12155-19
Date(m/d/y): 10/25/17
NRCan LMS GSC

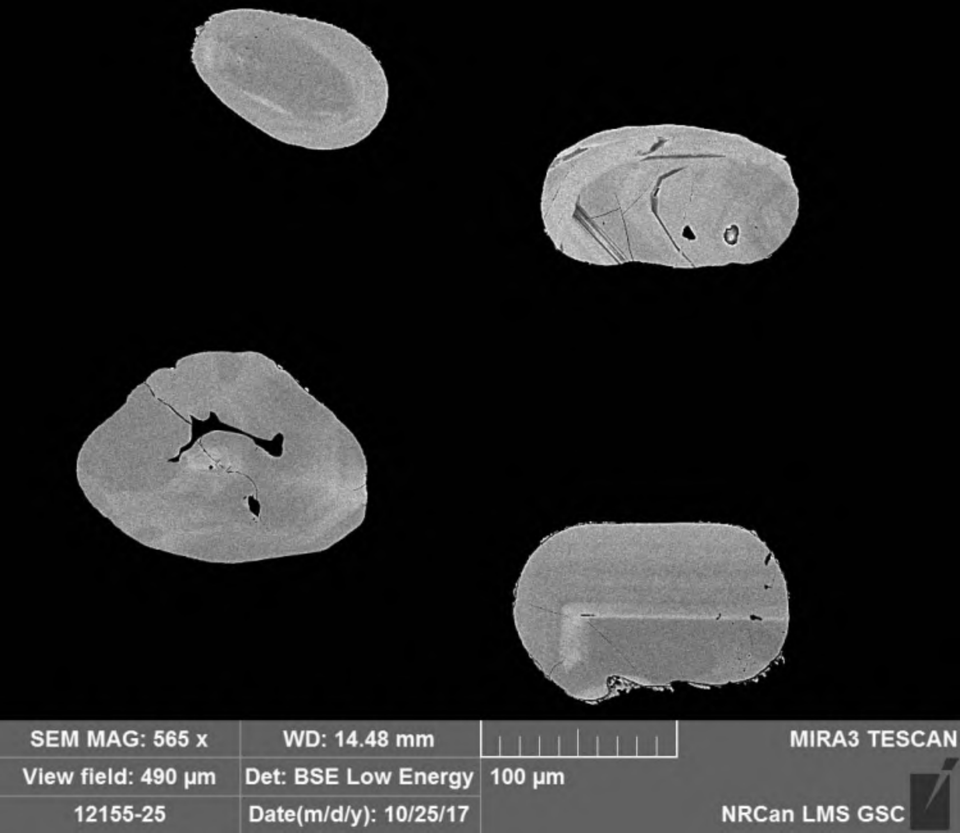

SEM MAG: 607 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 456 µm
Det: BSE Low Energy
100 µm
12155-20
Date(m/d/y): 10/25/17
NRCan LMS GSC

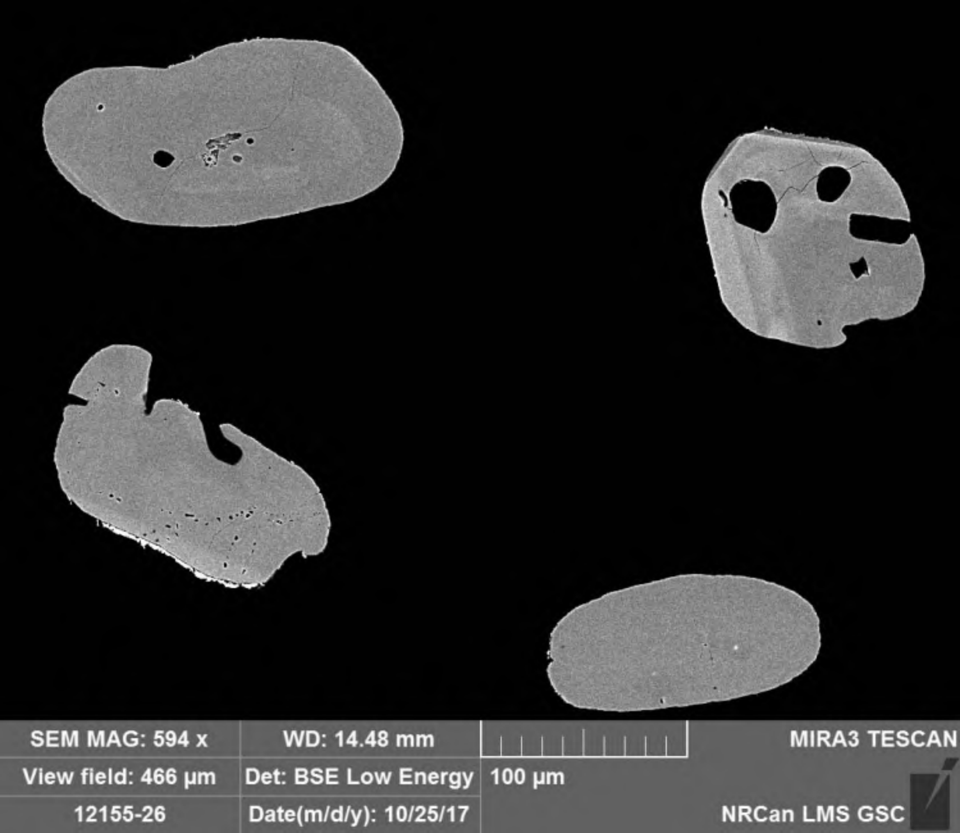

SEM MAG: 770 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 359 µm
Det: BSE Low Energy
100 µm
12155-21
Date(m/d/y): 10/25/17
NRCan LMS GSC

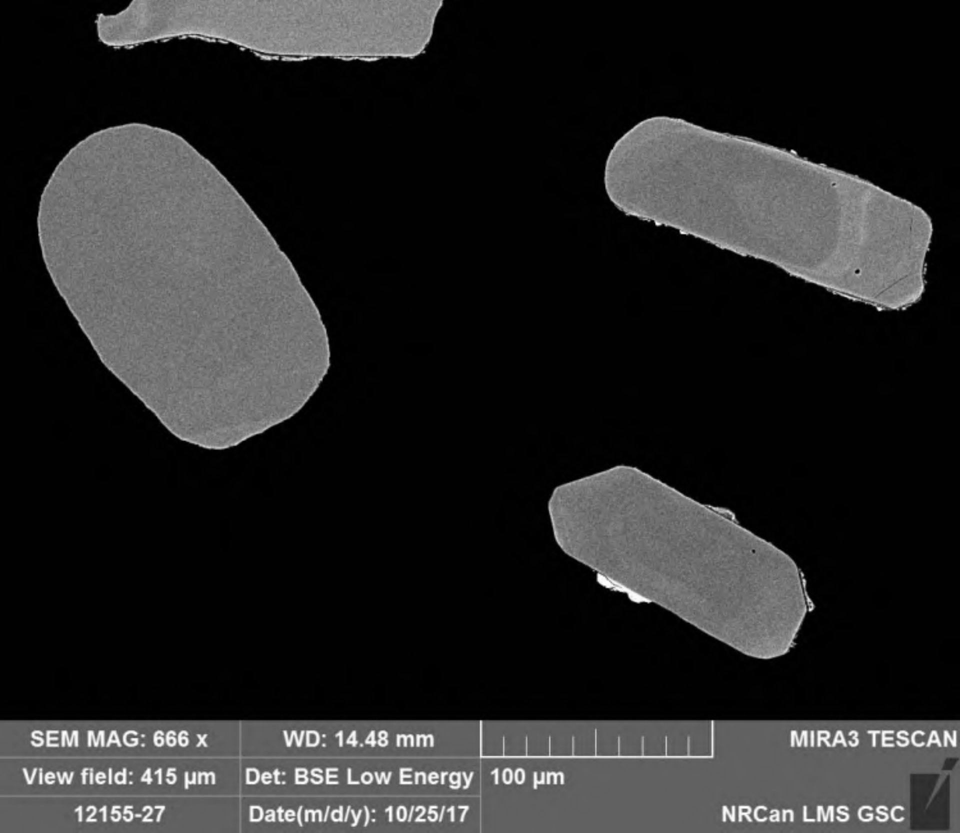

SEM MAG: 733 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 377 µm
Det: BSE Low Energy
100 µm
12155-22
Date(m/d/y): 10/25/17
NRCan LMS GSC

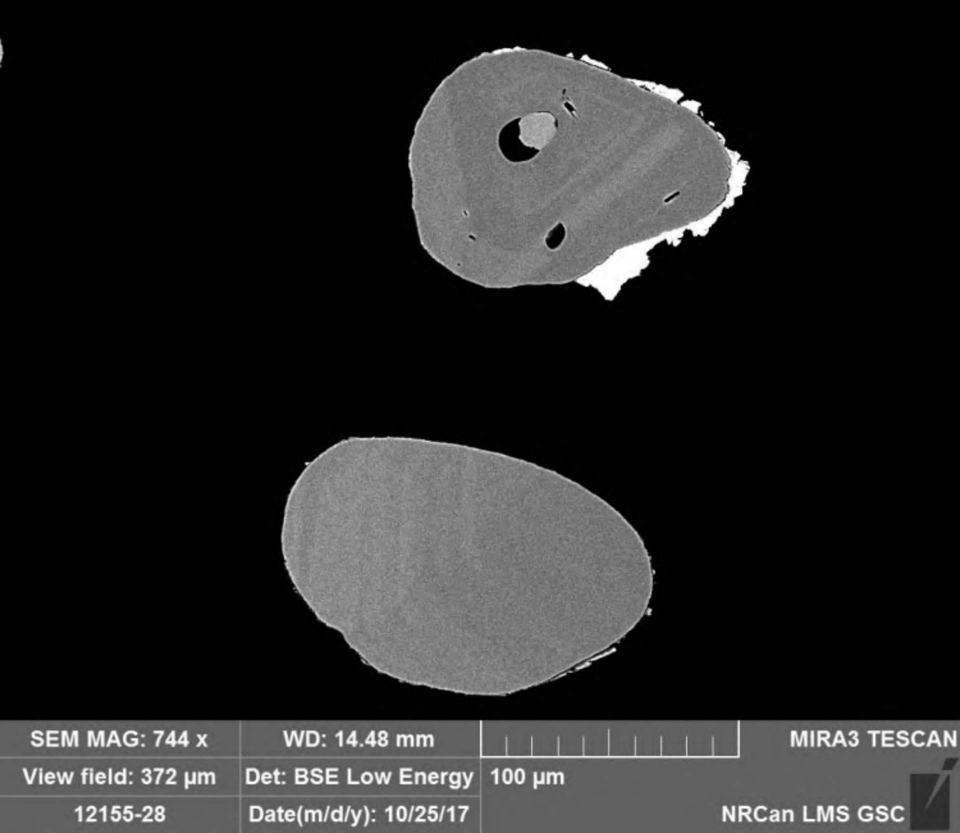

SEM MAG: 759 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 364 µm
Det: BSE Low Energy
100 µm
12155-23
Date(m/d/y): 10/25/17
NRCan LMS GSC

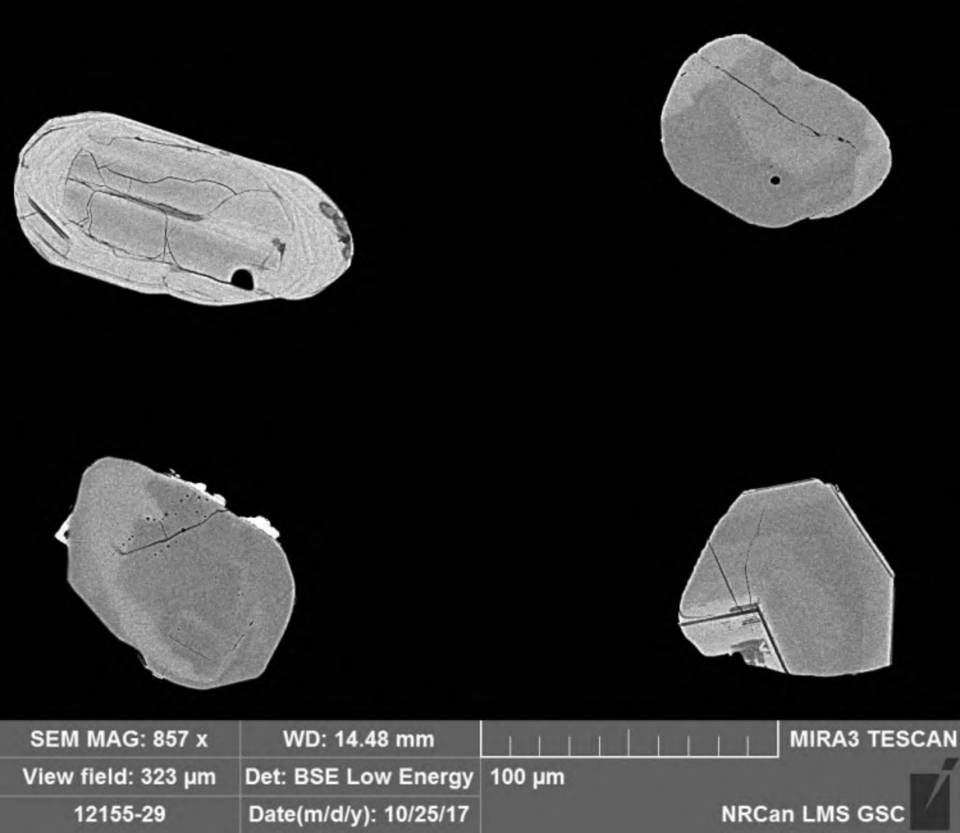

SEM MAG: 667 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 415 µm
Det: BSE Low Energy
100 µm
12155-24
Date(m/d/y): 10/25/17
NRCan LMS GSC

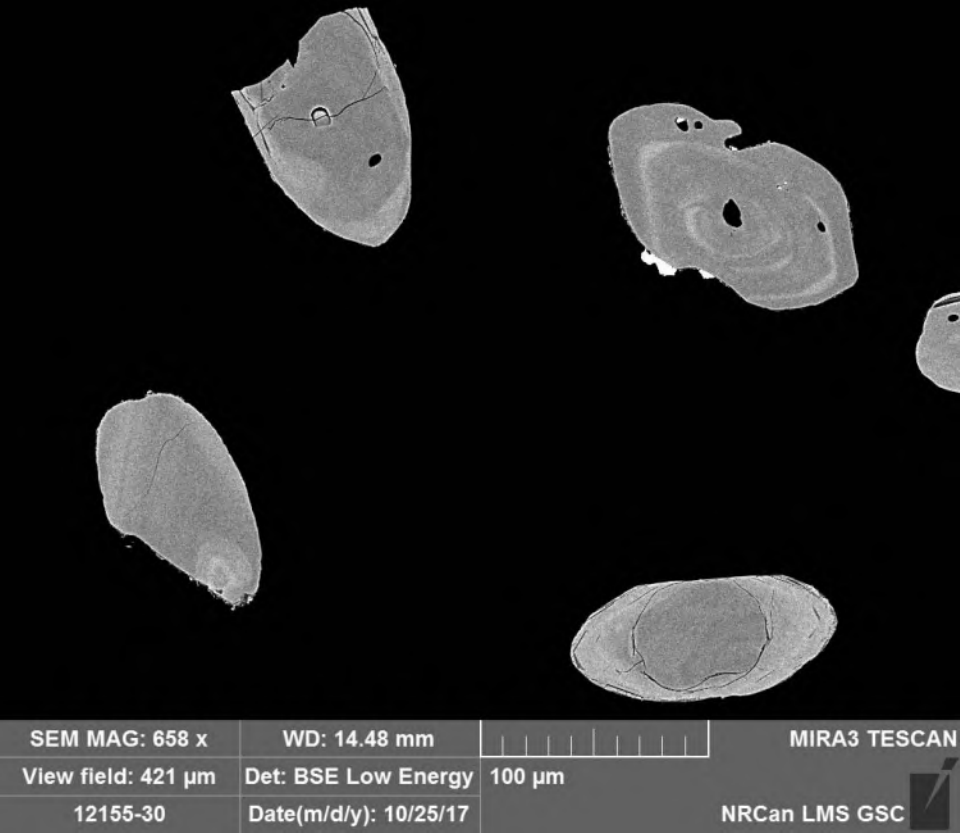

SEM MAG: 565 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 490 µm
Det: BSE Low Energy
100 µm
12155-25
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 594 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 466 µm
Det: BSE Low Energy
100 µm
12155-26
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 666 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 415 µm
Det: BSE Low Energy
100 µm
12155-27
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 744 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 372 µm
Det: BSE Low Energy
100 µm
12155-28
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 857 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 323 µm
Det: BSE Low Energy
100 µm
12155-29
Date(m/d/y): 10/25/17
NRCan LMS GSC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MIRA3 TESCAN
View field: 421 µm
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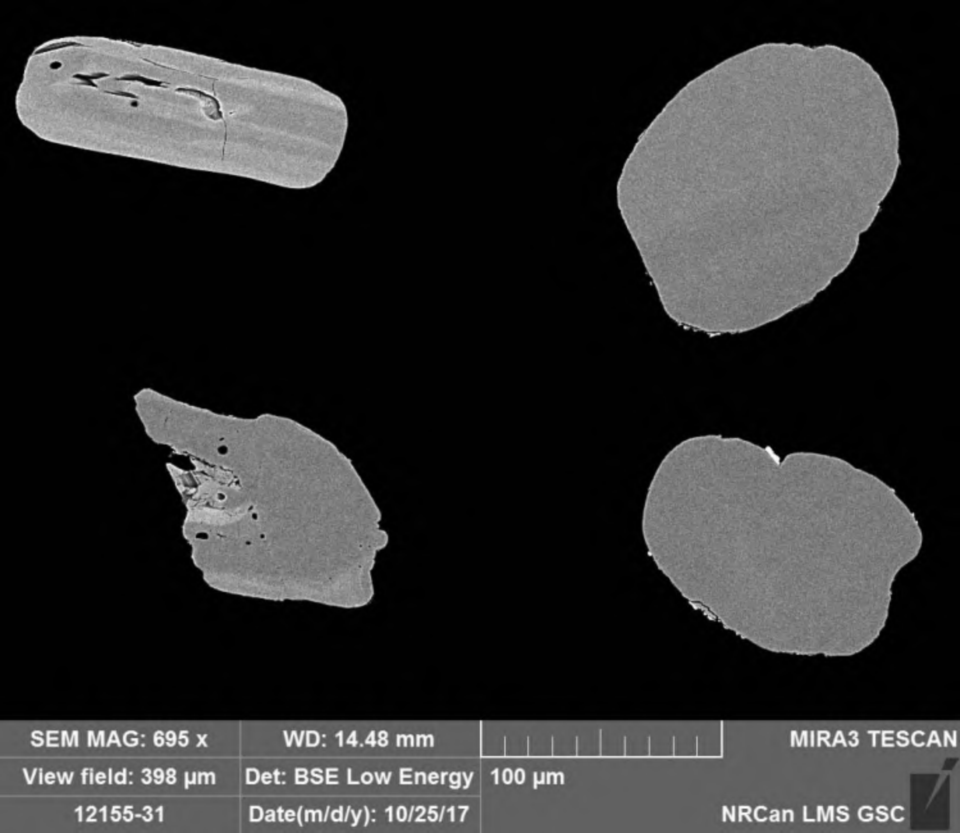
12155-30
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 695 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 398 µm
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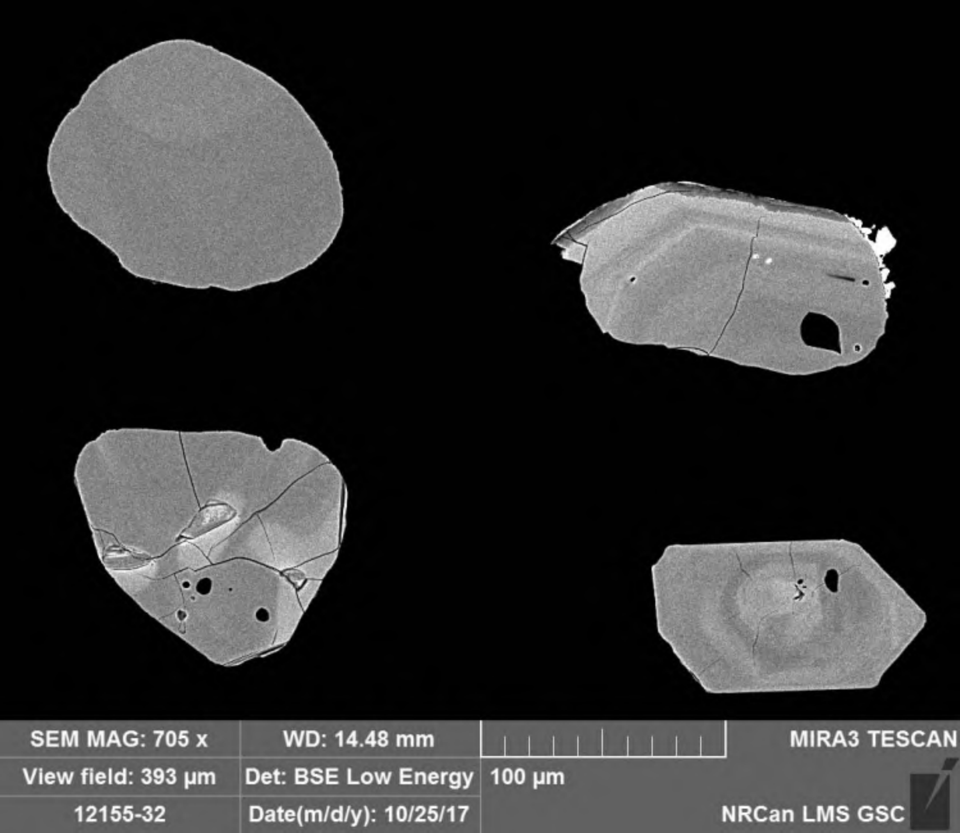
100 µm
12155-31
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 705 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 393 µm
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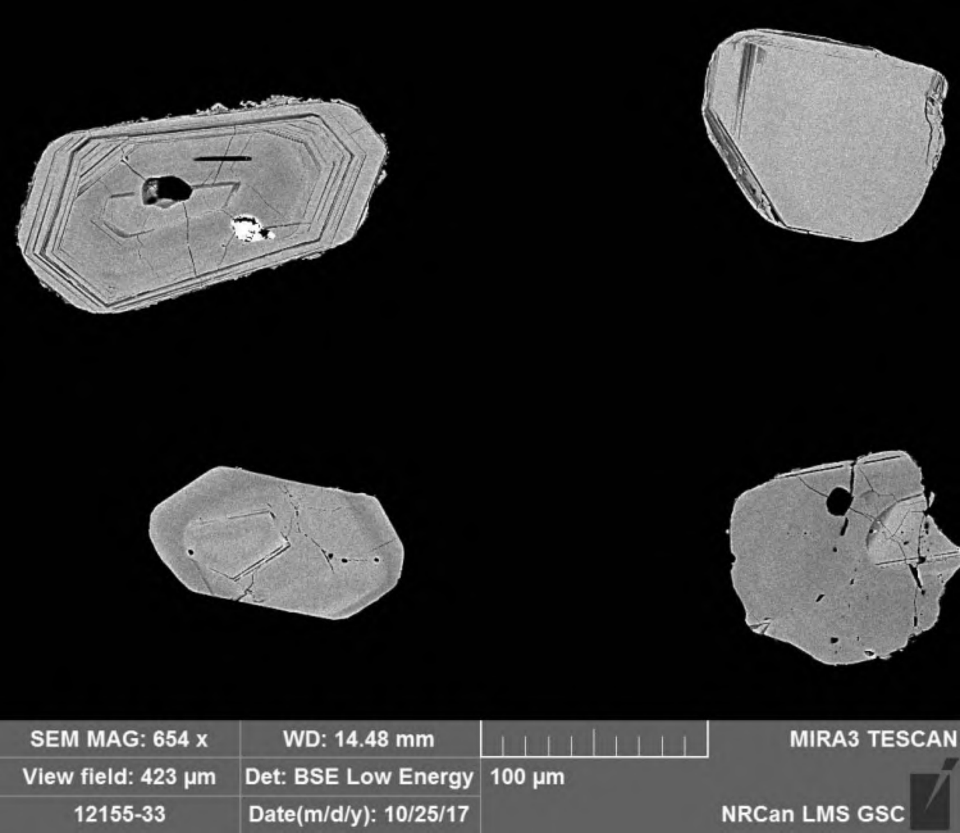
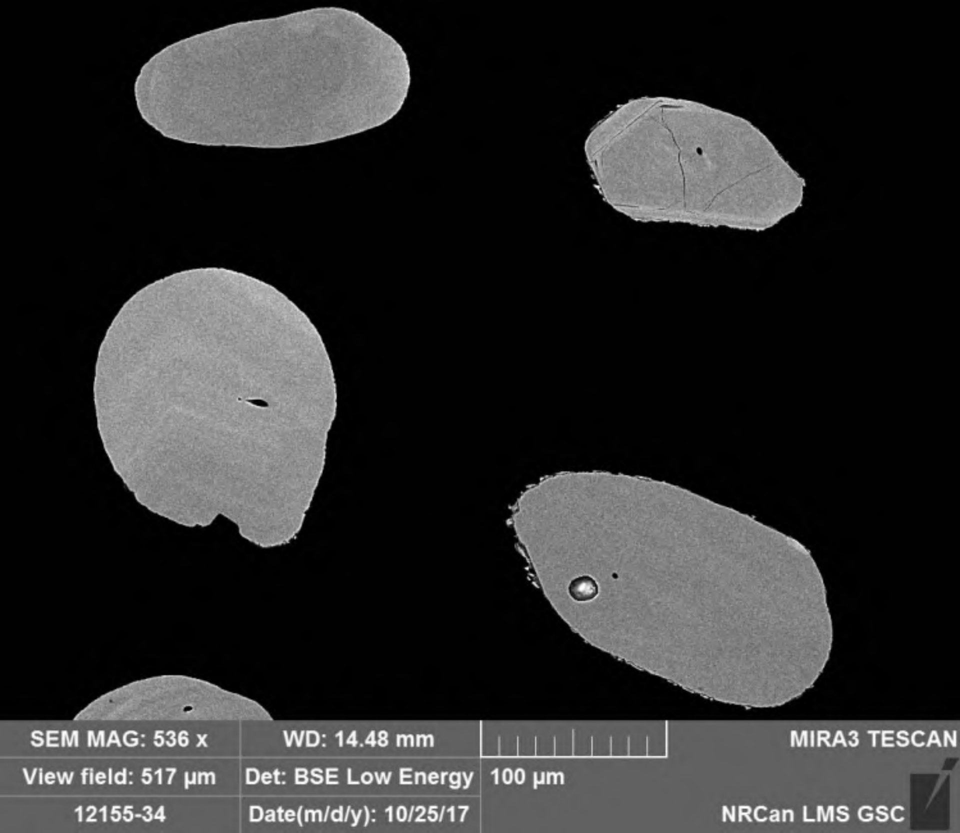
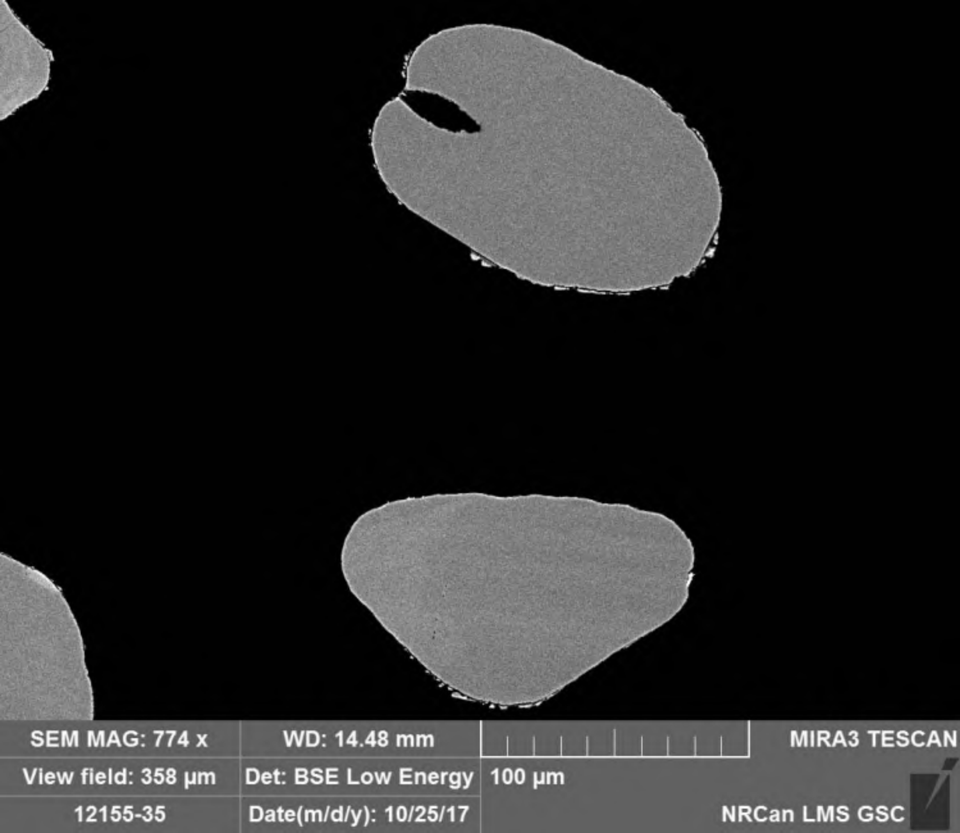
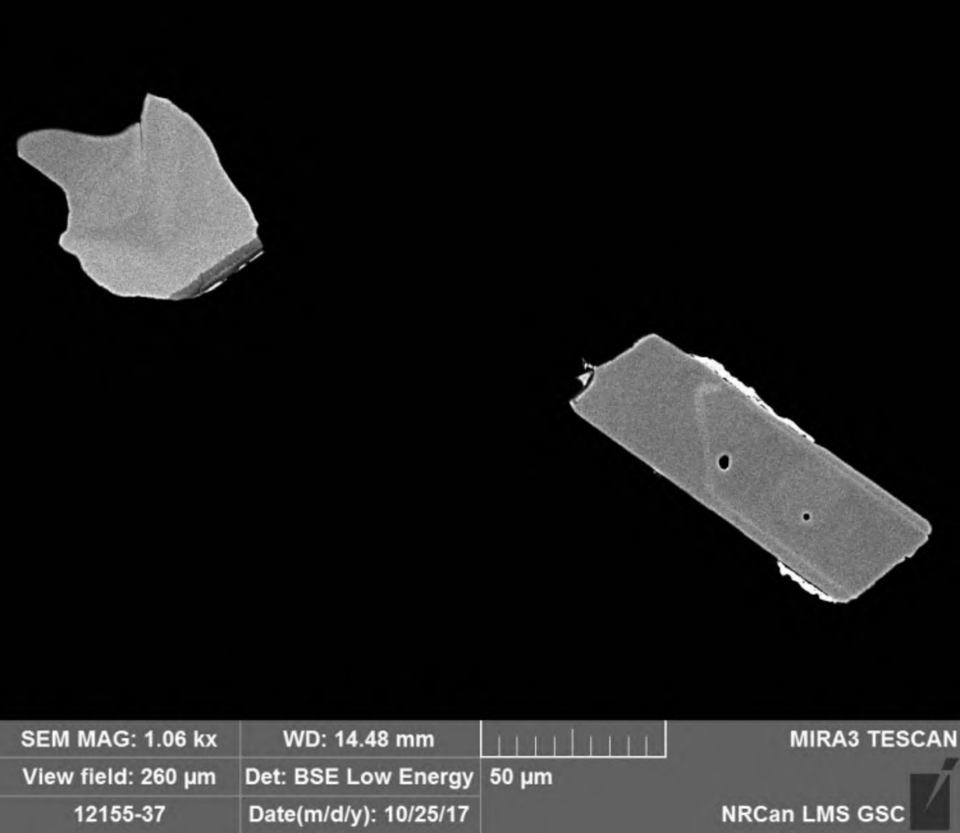
100 µm
12155-32
Date(m/d/y): 10/25/17
NRCan LMS GSC

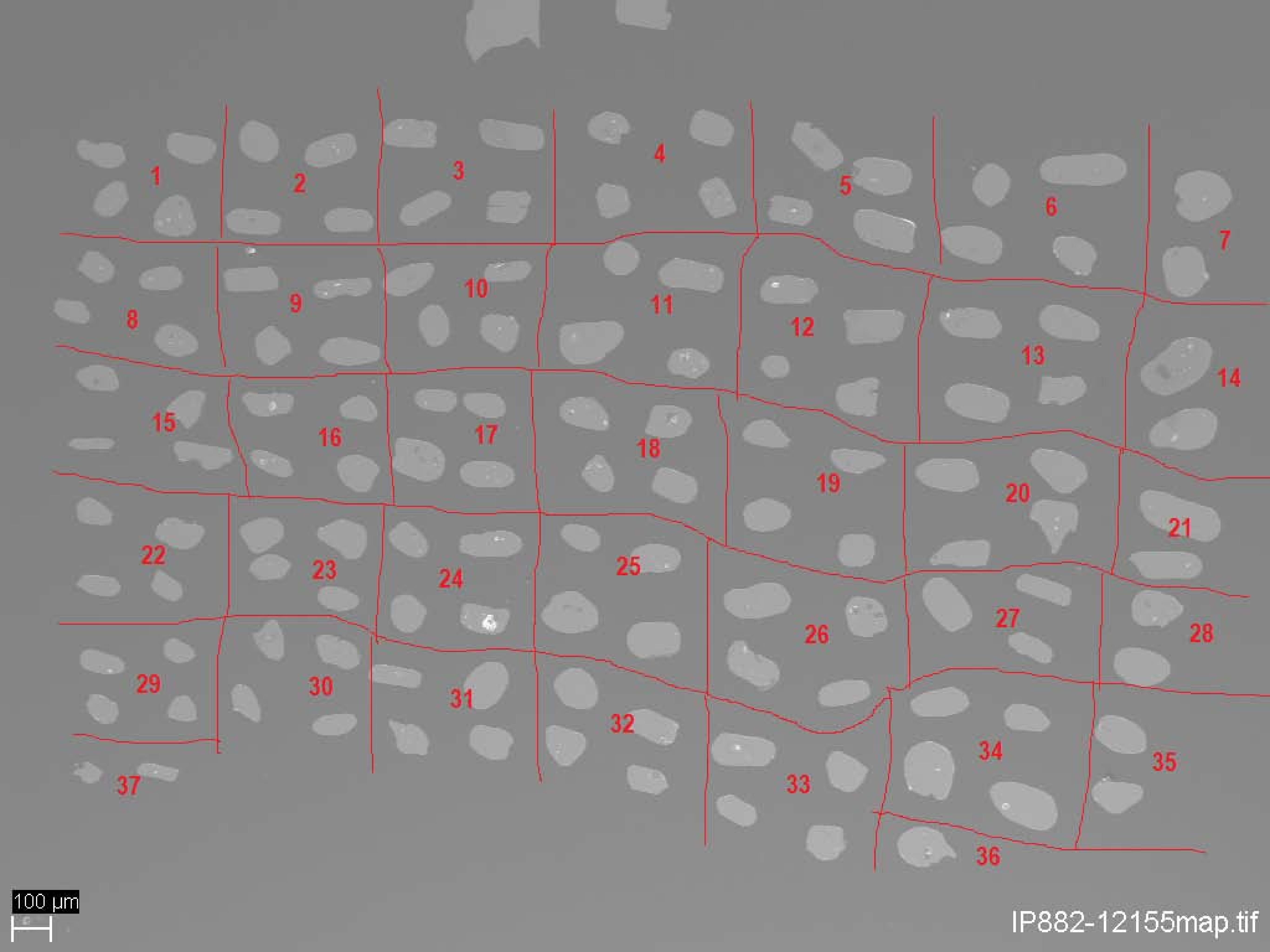

SEM MAG: 654 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 423 µm
Det: BSE Low Energy
100 µm
12155-33
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 536 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 517 µm
Det: BSE Low Energy
100 µm
12155-34
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 774 x
WD: 14.48 mm
MIRA3 TESCAN
View field: 358 µm
Det: BSE Low Energy
100 µm
12155-35
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 1.34 kx
WD: 14.48 mm
MIRA3 TESCAN
View field: 206 µm
Det: BSE Low Energy
50 µm
12155-36
Date(m/d/y): 10/25/17
NRCan LMS GSC


SEM MAG: 1.06 kx
WD: 14.48 mm
MIRA3 TESCAN
View field: 260 μm
Det: BSE Low Energy
50 μm
12155-37
Date(m/d/y): 10/25/17
NRCan LMS GSC



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100 µm
IP882-12155map.tif

Appendix 7: OD2016-D2 Hf-isotope data.

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12148-001.1-875	12148-001.1	1590.838569	27.37927158	1604	27	1.0	0.281937	0.000035	0.001139	0.000018	0.281903	0.000036	4.9	1.3	2006	1856		OK
12148-002.1-875	12148-002.1	1513.217744	21.35408725	1554	41	2.9	0.281932	0.000046	0.000744	0.000012	0.281910	0.000046	4.1	1.6	2022	1874		OK
12148-004.1-875	12148-004.1	1427.515761	18.50613709	1453	30	2.0	0.282018	0.000036	0.001020	0.000016	0.281990	0.000037	4.6	1.3	1912	1757		OK
12148-008.1-875	12148-008.1	1588.974599	20.77109202	1605	37	1.1	0.281931	0.000047	0.002431	0.000039	0.281857	0.000049	3.4	1.7	2106	1962		OK
12148-012.1-875	12148-012.1	1061.223506	14.94791782	1120	49	5.7	0.282297	0.000068	0.000905	0.000014	0.282278	0.000068	7.2	2.4	1491	1314		OK
12148-015.1-875	12148-015.1	1118.999044	13.94191921	1105	28	-1.4	0.282200	0.000054	0.000697	0.000011	0.282186	0.000054	3.6	1.9	1706	1540		OK
12148-018.1-875	12148-018.1	1609.458704	23.01155137	1626	13	1.1	0.281952	0.000051	0.002344	0.000037	0.281880	0.000053	4.6	1.9	2042	1894		OK
12148-020.1-875	12148-020.1	1609.217294	20.31962597	1635	22	1.8	0.281889	0.000034	0.001246	0.000020	0.281851	0.000035	3.8	1.2	2101	1956		OK
12148-021.1-875	12148-021.1	1685.552853	22.6407885	1672	30	-0.9	0.281672	0.000150	0.001051	0.000017	0.281639	0.000150	-2.9	5.3	2543	2423		OK
12148-022.1-875	12148-022.1	2654.436142	32.39028092	2688	12	1.5	0.281078	0.000036	0.000389	0.000006	0.281058	0.000036	0.1	1.3	3139	3052		OK
12148-023.1-875	12148-023.1	1425.901982	19.45673154	1470	33	3.4	0.282032	0.000035	0.001833	0.000029	0.281981	0.000037	4.7	1.3	1920	1766		OK
12148-027.1-875	12148-027.1	1475.599069	22.64862575	1309	80	-14.2	0.281969	0.000041	0.001607	0.000025	0.281930	0.000042	-0.9	1.5	2139	1997		OK
12148-028.1-875	12148-028.1	1557.112432	21.04069221	1534	32	-1.7	0.281915	0.000038	0.000737	0.000012	0.281894	0.000038	3.0	1.4	2071	1926		OK
12148-034.1-875	12148-034.1	1198.85244	16.69894055	1193	42	-0.5	0.282087	0.000040	0.001251	0.000020	0.282059	0.000041	1.1	1.4	1928	1775		OK
12148-035.1-875	12148-035.1	1223.369397	16.92933235	1142	66	-7.8	0.282099	0.000050	0.000876	0.000014	0.282081	0.000050	0.7	1.8	1914	1760		OK
12148-037.1-875	12148-037.1	1203.617208	18.88306243	1406	139	15.8	0.281941	0.000036	0.001567	0.000025	0.281900	0.000037	0.3	1.3	2142	2001		OK
12148-038.1-875	12148-038.1	1774.115562	20.96873805	1821	12	3.0	0.281589	0.000055	0.000534	0.000008	0.281571	0.000055	-1.8	2.0	2595	2478		OK
12148-039.1-875	12148-039.1	1060.917638	13.49678218	1105	34	4.3	0.282352	0.000038	0.003072	0.000049	0.282288	0.000042	7.2	1.5	1479	1301		OK
12148-045.1-875	12148-045.1	1648.316422	20.94527542	1648	22	0.0	0.281878	0.000038	0.000931	0.000009	0.281849	0.000038	4.1	1.4	2095	1951		OK
12148-046.1-875	12148-046.1	1479.602262	22.50884649	1519	30	2.9	0.281977	0.000033	0.001407	0.000014	0.281937	0.000033	4.2	1.2	1987	1836		OK
12148-047.1-875	12148-047.1	1724.311057	21.21581983	1803	14	5.0	0.281677	0.000031	0.001490	0.000015	0.281626	0.000032	-0.3	1.1	2485	2362		OK
12148-049.1-875	12148-049.1	1268.658371	20.22882896	1274	84	0.4	0.282064	0.000055	0.000822	0.000008	0.282045	0.000055	2.4	2.0	1908	1754		OK
12148-052.1-875	12148-052.1	1406.719184	19.24945814	1406	42	0.0	0.281903	0.000030	0.001231	0.000012	0.281871	0.000030	-0.7	1.1	2206	2068		OK
12148-053.1-875	12148-053.1	1492.436532	18.97905837	1523	25	2.3	0.281975	0.000050	0.001085	0.000011	0.281944	0.000050	4.6	1.8	1968	1816		OK
12148-055.1-875	12148-055.1	1574.12632	22.99676466	1549	50	-1.8	0.281898	0.000031	0.001809	0.000018	0.281845	0.000032	1.6	1.1	2169	2029		OK
12148-056.1-875	12148-056.1	1194.913204	17.32294349	1099	72	-9.6	0.282182	0.000033	0.001057	0.000011	0.282160	0.000033	2.6	1.2	1765	1603		OK
12148-058.1-875	12148-058.1	1698.244376	23.87055722	1708	25	0.6	0.281828	0.000033	0.001401	0.000014	0.281783	0.000033	3.1	1.2	2203	2064		OK
12148-060.1-875	12148-060.1	1121.175159	17.08878708	1015	88	-11.4	0.282124	0.000029	0.001109	0.000011	0.282103	0.000029	-1.4	1.0	1944	1793		OK
12148-063.1-875	12148-063.1	1725.788576	28.76462468	1817	61	5.7	0.281732	0.000045	0.000654	0.000007	0.281710	0.000045	3.0	1.6	2291	2157		OK
12148-064.1-875	12148-064.1	1564.724104	21.43891896	1562	33	-0.2	0.281886	0.000032	0.001047	0.000011	0.281855	0.000032	2.3	1.1	2139	1997		OK
12148-067.1-875	12148-067.1	1443.77796	19.5764801	1507	32	4.7	0.281949	0.000052	0.000530	0.000005	0.281934	0.000052	3.8	1.8	2000	1851		OK
12148-069.1-875	12148-069.1	1492.999074	28.25990571	1614	92	8.4	0.281831	0.000046	0.000350	0.000004	0.281821	0.000046	2.3	1.6	2181	2041		OK
12148-071.1-875	12148-071.1	1124.771749	18.15344602	1034	94	-9.5	0.282158	0.000036	0.001367	0.000014	0.282132	0.000036	0.1	1.3	1869	1713		OK
12148-073.1-875	12148-073.1	1506.022471	19.39823507	1475	27	-2.3	0.281975	0.000035	0.001664	0.000017	0.281929	0.000036	2.9	1.3	2033	1885		OK
12148-075.1-875	12148-075.1	1487.308797	23.2974191	1520	70	2.4	0.281893	0.000041	0.000642	0.000007	0.281875	0.000041	2.0	1.5	2123	1980		OK
12148-077.1-875	12148-077.1	1657.03476	20.92990146	1715	20	3.8	0.281799	0.000055	0.001004	0.000010	0.281767	0.000055	2.7	2.0	2234	2096		OK
12148-078.1-875	12148-078.1	1118.055829	21.80821321	1145	155	2.5	0.282150	0.000038	0.000536	0.000005	0.282139	0.000038	2.8	1.3	1784	1623		OK
12148-079.1-875	12148-079.1	1779.119883	21.63667813	1779	26	0.0	0.281712	0.000045	0.001571	0.000016	0.281659	0.000045	0.3	1.6	2428	2302		OK
12148-080.1-875	12148-080.1	1502.946309	17.72390387	1501	12	-0.2	0.282090	0.000058	0.001513	0.000015	0.282047	0.000058	7.7	2.1	1754	1590		OK
12148-085.1-875	12148-085.1	1130.613302	21.2050188	1284	153	13.0	0.282190	0.000076	0.000409	0.000004	0.282180	0.000076	7.5	2.7	1602	1430		OK
12148-087.1-875	12148-087.1	1545.051522	21.0243951	1586	32	2.9	0.281877	0.000028	0.000979	0.000010	0.281848	0.000028	2.6	1.0	2139	1997		OK
12148-090.1-875	12148-090.1	1450.66386	19.58660642	1441	42	-0.7	0.281937	0.000033	0.001052	0.000011	0.281909	0.000033	1.4	1.2	2100	1956		OK
12148-092.1-875	12148-092.1	1721.081815	22.89328406	1819	21	6.1	0.281681	0.000034	0.000812	0.000008	0.281653	0.000034	1.0	1.2	2415	2288		OK
12148-094.1-875	12148-094.1	1437.728946	35.96189542	1589	197	10.6	0.281962	0.000032	0.000838	0.000009	0.281937	0.000032	5.8	1.1	1940	1787		OK
12148-099.1-875	12148-099.1	1530.647684	21.35168493	1578	35	3.3	0.281889	0.000023	0.000755	0.000008	0.281867	0.000023	3.1	0.8	2103	1959		OK
12148-102.1-875	12148-102.1	1605.852276	21.4922037	1612	28	0.4	0.281876	0.000031	0.001335	0.000014	0.281836	0.000031	2.7	1.1	2150	2008		OK
12148-108.1-875	12148-108.1	1129.968738	14.99009704	1084	39	-4.7	0.282148	0.000036	0.001264	0.000013	0.282123	0.000036	0.9	1.3	1858	1702		OK
12148-110.1-875	12148-110.1	1535.594416	19.13747839	1602	21	4.7	0.281902	0.000030	0.000762	0.000008	0.281879	0.000030	4.1	1.1	2059	1913		OK
12148-111.1-875	12148-111.1	1428.883205	19.94523444	1437	43	0.7	0.281827	0.000035	0.000596	0.000006	0.281811	0.000035	-2.1	1.2	2316	2185		OK
12148-113.1-875	12148-113.1	1733.987826	23.3103902	1767	28	2.1	0.281772	0.000040	0.001426	0.000014	0.281725	0.000040	2.4	1.4	2292	2159		OK
12148-114.1-875	12148-114.1	1555.180569	20.4115138	1580	28	1.8	0.281887	0.000040	0.000898	0.000009	0.281860	0.000040	2.9	1.4	2115	1972		OK
12148-116.1-875	12148-116.1	1157.814759	15.16883081	1106	37	-5.1	0.282186	0.000033	0.001476	0.000015	0.282156	0.000033	2.5	1.2	1771	1610		OK

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12148-117.1-875	12148-117.1	1297.450305	19.55299067	1316	53	1.5	0.282069	0.000035	0.000841	0.000009	0.282048	0.000035	3.5	1.2	1873	1716		OK
12148-118.1-875	12148-118.1	1510.854635	19.76527294	1540	40	2.1	0.282079	0.000031	0.002326	0.000024	0.282012	0.000032	7.3	1.1	1808	1647		OK
12148-119.1-875	12148-119.1	1535.124526	19.02951206	1570	18	2.5	0.281974	0.000055	0.000696	0.000007	0.281954	0.000055	6.0	2.0	1916	1761		OK
12148-120.1-875	12148-120.1	1422.700312	27.93303834	1123	178	-29.8	0.281990	0.000048	0.000901	0.000009	0.281971	0.000048	-3.6	1.7	2165	2026		OK
12148-121.1-875	12148-121.1	1148.265629	14.21999797	1169	20	1.9	0.282312	0.000036	0.002812	0.000029	0.282250	0.000038	7.3	1.3	1522	1346		OK
12148-123.1-875	12148-123.1	1091.721211	14.64585757	1127	32	3.4	0.282136	0.000046	0.000912	0.000009	0.282117	0.000046	1.6	1.6	1843	1686		OK
12148-123.2-875	12148-123.1	1091.721211	14.64585757	1127	32	3.4	0.282144	0.000030	0.000819	0.000008	0.282127	0.000030	2.0	1.1	1821	1662		Duplicate
12148-125.1-875	12148-125.1	1173.850568	16.84973731	1072	67	-10.4	0.282353	0.000025	0.003503	0.000036	0.282283	0.000028	6.3	1.0	1513	1337		OK
12148-126.1-875	12148-126.1	1163.497886	19.24209899	957	130	-23.7	0.282121	0.000048	0.001441	0.000015	0.282095	0.000048	-3.0	1.7	1998	1849		OK
12148-128.1-875	12148-128.1	1196.703345	15.64588092	1196	36	-0.1	0.282182	0.000035	0.000993	0.000010	0.282160	0.000035	4.7	1.2	1704	1539		OK
12148-130.1-875	12148-130.1	983.9966221	12.98307331	961	47	-2.6	0.282194	0.000087	0.000866	0.000009	0.282179	0.000087	0.1	3.1	1813	1654		OK
12148-132.1-875	12148-132.1	1560.295501	20.05660888	1566	26	0.4	0.281951	0.000040	0.001688	0.000017	0.281901	0.000041	4.0	1.4	2034	1886		OK
12148-134.1-875	12148-134.1	1591.687007	20.22826746	1632	19	2.8	0.281946	0.000038	0.001296	0.000013	0.281906	0.000038	5.7	1.4	1980	1829		OK
12148-136.1-875	12148-136.1	2022.31783	27.38030883	2104	21	4.5	0.281504	0.000034	0.000919	0.000009	0.281468	0.000034	1.0	1.2	2635	2520		OK
12148-137.1-875	12148-137.1	1573.846163	23.00798753	1500	67	-5.6	0.281991	0.000035	0.001335	0.000014	0.281953	0.000035	4.4	1.3	1963	1811		OK
12148-138.1-875	12148-138.1	1488.942309	20.66812743	1432	40	-4.5	0.281987	0.000037	0.000836	0.000008	0.281965	0.000037	3.2	1.3	1982	1832		OK
12148-140.1-875	12148-140.1	1488.27303	19.62849562	1496	28	0.6	0.282023	0.000032	0.001508	0.000015	0.281981	0.000033	5.2	1.2	1905	1750		OK
12150-002.1	12150-002.1	1823.612267	37.29511424	1766	91	-3.8	0.281787	0.000029	0.000211	0.000002	0.281780	0.000029	4.3	1.0	2170	2029		OK
12150-003.1	12150-003.1	1559.350378	25.73156919	1616	34	4.0	0.281906	0.000028	0.000948	0.000010	0.281877	0.000028	4.3	1.0	2054	1907		OK
12150-004.1	12150-004.1	1118.537033	17.00736514	1312	60	16.1	0.282142	0.000026	0.000779	0.000008	0.282123	0.000026	6.1	0.9	1710	1545		OK
12150-005.1	12150-005.1	1578.383476	26.69010869	1547	39	-2.3	0.281876	0.000037	0.001096	0.000054	0.281844	0.000042	1.5	1.5	2173	2033		OK
12150-006.1	12150-006.1	1019.565624	16.56878622	1072	29	5.3	0.282206	0.000031	0.000803	0.000040	0.282190	0.000034	3.0	1.2	1717	1552		OK
12150-007.1	12150-007.1	1183.05443	19.44065977	1258	31	6.5	0.282042	0.000026	0.001447	0.000015	0.282008	0.000027	0.8	0.9	1999	1850		OK
12150-008.1	12150-008.1	1787.949955	28.22025193	1841	30	3.3	0.281631	0.000032	0.001415	0.000014	0.281582	0.000032	-1.0	1.2	2558	2439		OK
12150-009.1	12150-009.1	1246.499577	22.52675605	1118	90	-12.7	0.282121	0.000032	0.000667	0.000033	0.282107	0.000034	1.1	1.2	1870	1714		OK
12150-010.1	12150-010.1	1981.72973	27.49206264	1992	12	0.6	0.281649	0.000032	0.000936	0.000046	0.281614	0.000037	3.6	1.3	2386	2258		OK
12150-011.1	12150-011.1	1498.685255	26.52190511	1444	49	-4.2	0.281711	0.000038	0.000469	0.000023	0.281699	0.000039	-6.0	1.4	2559	2440		OK
12150-013.1	12150-013.1	1007.028905	22.92645189	941	286	-7.5	0.282247	0.000042	0.000692	0.000034	0.282235	0.000044	1.6	1.6	1701	1536		OK
12150-014.1	12150-014.1	1753.411266	27.52159452	1787	23	2.1	0.281765	0.000033	0.001195	0.000059	0.281725	0.000040	2.8	1.4	2279	2144		OK
12150-015.1	12150-015.1	1455.220819	25.97029697	1466	29	0.8	0.282078	0.000067	0.001239	0.000061	0.282044	0.000071	6.8	2.5	1784	1623		OK
12150-016.1	12150-016.1	1580.438371	22.9533761	1601	15	1.4	0.281894	0.000035	0.000931	0.000046	0.281866	0.000039	3.6	1.4	2089	1944		OK
12150-017.1	12150-017.1	1331.721789	21.15775941	1198	50	-12.4	0.282041	0.000029	0.001192	0.000059	0.282014	0.000037	-0.4	1.3	2024	1876		OK
12150-018.1	12150-018.1	1587.105886	25.48313921	1630	22	2.9	0.281861	0.000033	0.000827	0.000008	0.281836	0.000033	3.2	1.2	2137	1995		OK
12150-018.2	12150-018.1	1587.105886	25.48313921	1630	22	2.9	0.281863	0.000033	0.000826	0.000008	0.281838	0.000033	3.2	1.2	2133	1990		Duplicate
12150-019.1	12150-019.1	1722.298463	24.02305256	1722	12	0.0	0.281801	0.000041	0.001034	0.000051	0.281768	0.000045	2.8	1.6	2227	2090		OK
12150-022.1	12150-022.1	1731.052045	29.38136675	1756	40	1.6	0.281817	0.000028	0.001177	0.000058	0.281778	0.000036	4.0	1.3	2181	2041		OK
12150-026.1	12150-026.1	1604.412894	24.60853522	1605	23	0.0	0.281839	0.000036	0.001756	0.000087	0.281786	0.000049	0.8	1.7	2264	2128		OK
12150-027.1	12150-027.1	1187.252041	20.5238745	1299	27	9.4	0.282094	0.000031	0.000627	0.000031	0.282079	0.000033	4.2	1.2	1816	1657		OK
12150-028.1	12150-028.1	1033.213495	16.98488085	985	36	-5.3	0.282236	0.000030	0.000716	0.000035	0.282223	0.000033	2.2	1.2	1700	1534		OK
12150-030.1	12150-030.1	1321.345853	28.74426743	1290	111	-2.7	0.282061	0.000027	0.001398	0.000069	0.282027	0.000038	2.2	1.3	1936	1783		OK
12150-032.1	12150-032.1	1601.182288	26.12642819	1585	35	-1.1	0.281890	0.000029	0.001022	0.000051	0.281860	0.000035	3.0	1.2	2114	1970		OK
12150-033.1	12150-033.1	1709.338164	20.38937245	1715	13	0.4	0.281857	0.000037	0.002465	0.000122	0.281777	0.000059	3.0	2.1	2211	2072		OK
12150-034.1	12150-034.1	1551.162237	21.36007975	1437	38	-8.9	0.282012	0.000043	0.000805	0.000040	0.281990	0.000046	4.2	1.6	1922	1768		OK
12150-036.1	12150-036.1	1017.88422	16.06062032	841	101	-22.8	0.282184	0.000045	0.000764	0.000038	0.282172	0.000047	-2.9	1.7	1901	1748		OK
12150-037.1	12150-037.1	1634.797828	20.96145399	1613	18	-1.5	0.281877	0.000041	0.001479	0.000073	0.281832	0.000049	2.6	1.8	2156	2015		OK
12150-038.1	12150-038.1	1624.293627	25.81599248	1583	28	-3.0	0.281900	0.000035	0.001102	0.000054	0.281867	0.000041	3.2	1.4	2099	1954		OK
12150-039.1	12150-039.1	1817.850977	26.9566575	1838	13	1.2	0.281695	0.000033	0.000714	0.000035	0.281670	0.000036	2.1	1.3	2365	2235		OK
12150-040.1	12150-040.1	1536.851771	22.25903261	1559	26	1.6	0.282008	0.000035	0.000819	0.000040	0.281984	0.000038	6.8	1.4	1856	1698		OK
12150-041.1	12150-041.1	1472.940305	21.17407864	1534	22	4.5	0.281981	0.000043	0.000677	0.000033	0.281962	0.000045	5.4	1.6	1922	1768		OK
12150-046.1	12150-046.1	2027.892763	24.10467371	2025	12	-0.2	0.281546	0.000035	0.001164	0.000058	0.281502	0.000041	0.4	1.5	2613	2496		OK
12150-048.1	12150-048.1	1149.214931	17.59871059	1124	82	-2.4	0.282196	0.000034	0.000672	0.000033	0.282182	0.000036	3.9	1.3	1701	1536		OK
12150-049.1	12150-049.1	1448.478003	26.65799953	1385	92	-5.1	0.281701	0.000041	0.000494	0.000024	0.281688	0.000042	-7.7	1.5	2618	2503		OK

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12150-050.1	12150-050.1	2023.299882	25.17783444	2024	14	0.0	0.281714	0.000041	0.000950	0.000047	0.281678	0.000045	6.6	1.6	2223	2085		OK
12150-051.1	12150-051.1	1164.653778	17.89281909	1046	77	-12.4	0.282115	0.000049	0.000859	0.000042	0.282098	0.000052	-0.8	1.8	1935	1783		OK
12150-052.1	12150-052.1	1585.178642	20.12949402	1588	20	0.2	0.281866	0.000035	0.000770	0.000038	0.281843	0.000038	2.5	1.3	2149	2007		OK
12150-053.1	12150-053.1	1373.17212	18.18371256	1403	34	2.3	0.281967	0.000043	0.001012	0.000050	0.281941	0.000047	1.7	1.7	2055	1908		OK
12150-054.1	12150-054.1	1822.530324	21.42607183	1784	13	-2.5	0.281701	0.000031	0.000845	0.000042	0.281673	0.000035	0.9	1.2	2395	2267		OK
12150-055.1	12150-055.1	1474.562687	22.80078593	1542	33	4.9	0.282177	0.000031	0.001814	0.000090	0.282124	0.000046	11.4	1.6	1555	1380		OK
12150-057.1	12150-057.1	1263.969566	16.60105549	1170	41	-8.9	0.282221	0.000033	0.002784	0.000138	0.282160	0.000061	4.1	2.2	1721	1557		OK
12150-058.1	12150-058.1	1660.718088	27.86467053	1473	75	-14.4	0.281991	0.000032	0.001434	0.000071	0.281951	0.000042	3.7	1.5	1985	1834		OK
12150-061.1	12150-061.1	1162.117102	16.75507258	1586	31	29.2	0.281891	0.000035	0.000790	0.000039	0.281868	0.000038	3.3	1.3	2096	1951		OK
12150-062.1	12150-062.1	1799.182444	24.57797319	1884	11	5.1	0.281729	0.000027	0.002036	0.000101	0.281656	0.000047	2.6	1.7	2365	2235		OK
12150-063.1	12150-063.1	1518.342146	24.93115268	1502	34	-1.2	0.281924	0.000032	0.000928	0.000046	0.281898	0.000036	2.4	1.3	2084	1939		OK
12150-064.1	12150-064.1	1692.301888	21.22370933	1642	20	-3.5	0.281938	0.000031	0.001785	0.000088	0.281883	0.000046	5.1	1.6	2026	1877		OK
12150-065.1	12150-065.1	1558.418216	19.90970112	1523	20	-2.6	0.281938	0.000032	0.000941	0.000047	0.281911	0.000037	3.4	1.3	2041	1893		OK
12150-066.1	12150-066.1	1507.308364	17.82123683	1516	13	0.7	0.281984	0.000034	0.001250	0.000062	0.281948	0.000041	4.6	1.5	1963	1811		OK
12150-069.1	12150-069.1	1451.640539	22.19696326	1421	22	-2.4	0.281882	0.000042	0.000918	0.000045	0.281858	0.000045	-0.8	1.6	2225	2088		OK
12150-070.1	12150-070.1	1599.087791	25.00382549	1474	63	-9.6	0.281969	0.000033	0.000572	0.000028	0.281953	0.000035	3.8	1.2	1980	1829		OK
12150-072.1	12150-072.1	1325.074301	20.7179161	1326	65	0.1	0.281925	0.000031	0.000702	0.000035	0.281908	0.000034	-1.2	1.2	2176	2036		OK
12150-074.1	12150-074.1	1484.131349	25.37593144	1416	39	-5.4	0.282023	0.000028	0.001066	0.000053	0.281995	0.000034	3.9	1.2	1926	1773		OK
12150-076.1	12150-076.1	1200.333946	18.97792317	1096	78	-10.5	0.282106	0.000028	0.001515	0.000075	0.282075	0.000040	-0.6	1.4	1955	1804		OK
12150-077.1	12150-077.1	1441.572577	26.96895875	1512	92	5.2	0.281983	0.000028	0.001380	0.000068	0.281944	0.000038	4.3	1.4	1976	1825		OK
12150-078.1	12150-078.1	1461.221092	25.41792883	1615	32	10.6	0.281953	0.000040	0.000869	0.000043	0.281927	0.000043	6.0	1.5	1946	1793		OK
12150-080.1	12150-080.1	1723.041068	21.90579269	1758	19	2.2	0.281724	0.000030	0.000953	0.000047	0.281693	0.000035	1.0	1.2	2369	2239		OK
12150-081.1	12150-081.1	1468.504975	30.10418346	1330	156	-11.6	0.281866	0.000043	0.001097	0.000054	0.281839	0.000048	-3.6	1.7	2324	2193		OK
12150-082.1	12150-082.1	1508.667746	25.17806058	1560	61	3.7	0.281938	0.000037	0.001140	0.000056	0.281905	0.000043	4.0	1.5	2031	1883		OK
12150-083.1	12150-083.1	1820.882599	21.64942731	1872	13	3.1	0.281541	0.000033	0.000567	0.000028	0.281521	0.000035	-2.4	1.2	2671	2558		OK
12150-084.1	12150-084.1	1523.519354	21.71950862	1519	28	-0.3	0.281965	0.000070	0.001301	0.000064	0.281928	0.000074	3.9	2.6	2006	1857		OK
12150-085.1	12150-085.1	1539.00439	19.78590587	1637	15	6.7	0.281886	0.000030	0.001755	0.000087	0.281832	0.000045	3.2	1.6	2141	1999		OK
12150-086.1	12150-086.1	1461.223131	18.37495644	1483	27	1.6	0.281998	0.000035	0.001202	0.000059	0.281965	0.000042	4.4	1.5	1949	1796		OK
12150-088.1	12150-088.1	1701.453957	21.40236974	1737	29	2.3	0.281758	0.000027	0.000657	0.000032	0.281737	0.000030	2.1	1.1	2285	2151		OK
12150-089.1	12150-089.1	1848.099674	25.52439808	1824	11	-1.5	0.281651	0.000037	0.000525	0.000026	0.281633	0.000038	0.4	1.4	2456	2331		OK
12150-090.1	12150-090.1	1179.328661	16.46647544	1231	43	4.6	0.282089	0.000057	0.001019	0.000050	0.282066	0.000060	2.2	2.1	1889	1734		OK
12150-091.1	12150-091.1	1639.272605	21.55123482	1648	20	0.6	0.281845	0.000062	0.001614	0.000080	0.281795	0.000069	2.1	2.4	2215	2077		OK
12150-093.1	12150-093.1	1015.87873	13.33536742	1044	26	2.9	0.282258	0.000026	0.001140	0.000056	0.282236	0.000034	4.0	1.2	1634	1465		OK
12150-093.2	12150-093.1	1015.87873	13.33536742	1044	26	2.9	0.282261	0.000022	0.001183	0.000058	0.282238	0.000031	4.1	1.1	1629	1460		Duplicate
12150-094.1	12150-094.1	1742.091613	23.09947284	1767	35	1.6	0.281668	0.000027	0.001027	0.000051	0.281634	0.000033	-0.9	1.2	2492	2369		OK
12150-095.1	12150-095.1	1553.370394	22.04325933	1614	39	4.2	0.281863	0.000038	0.000837	0.000041	0.281838	0.000041	2.9	1.5	2143	2002		OK
12150-120.1	12150-120.1	1528.61564	22.66274219	1528	43	-0.1	0.281898	0.000032	0.000674	0.000033	0.281879	0.000034	2.3	1.2	2109	1965		OK
12150-122.1	12150-122.1	1134.795774	16.33121925	1096	47	-3.9	0.282194	0.000033	0.001932	0.000095	0.282154	0.000049	2.3	1.7	1781	1619		OK
12150-123.1	12150-123.1	1776.981341	22.01571547	1867	15	5.5	0.281594	0.000039	0.000504	0.000025	0.281576	0.000040	-0.6	1.4	2552	2433		OK
12150-124.1	12150-124.1	1112.017695	17.74917284	1079	38	-3.4	0.282115	0.000036	0.001941	0.000096	0.282076	0.000051	-0.9	1.8	1964	1813		OK
12150-128.1	12150-128.1	1566.127407	19.29076675	1568	21	0.1	0.281778	0.000027	0.001214	0.000060	0.281742	0.000035	-1.6	1.3	2383	2255		OK
12150-129.1	12150-129.1	1547.994469	22.12666681	1555	52	0.5	0.281963	0.000036	0.001240	0.000061	0.281927	0.000043	4.7	1.5	1985	1835		OK
12154-002.1	12154-002.1	1163.18917	12.76870972	1475	22	23.1	0.282006	0.000045	0.000872	0.000043	0.281982	0.000048	4.8	1.7	1916	1761		OK
12154-003.1	12154-003.1	1408.888729	15.41881635	1436	17	2.1	0.281951	0.000033	0.000696	0.000034	0.281932	0.000035	2.1	1.3	2051	1904		OK
12154-007.1	12154-007.1	1485.195211	15.71486522	1501	14	1.2	0.281951	0.000023	0.001323	0.000065	0.281914	0.000034	3.0	1.2	2050	1903		OK
12154-008.1	12154-008.1	1492.103198	15.10969475	1506	8	1.0	0.282031	0.000024	0.001721	0.000085	0.281982	0.000040	5.5	1.4	1895	1739		OK
12154-011.1	12154-011.1	1204.397337	12.61231817	1167	14	-3.5	0.282172	0.000027	0.001143	0.000056	0.282147	0.000034	3.6	1.2	1751	1588		OK
12154-012.1	12154-012.1	1154.237155	12.03219351	1141	10	-1.3	0.282210	0.000025	0.002223	0.000110	0.282163	0.000048	3.6	1.7	1734	1570		OK
12154-017.1	12154-017.1	1527.606744	21.6188789	1361	73	-13.8	0.282011	0.000024	0.001064	0.000053	0.281984	0.000031	2.3	1.1	1986	1836		OK
12154-020.1	12154-020.1	1570.254846	42.2870314	1563	15	-0.5	0.281827	0.000045	0.000785	0.000039	0.281804	0.000047	0.5	1.7	2251	2115		OK
12154-021.1	12154-021.1	1350.86417	13.83931893	1328	9	-1.9	0.282129	0.000048	0.001855	0.000092	0.282083	0.000059	5.0	2.1	1789	1628		OK
12154-025.1	12154-025.1	1502.338267	15.11398563	1496	7	-0.5	0.281930	0.000029	0.002603	0.000129	0.281857	0.000057	0.8	2.0	2179	2039		OK

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12154-026.1	12154-026.1	1494.509841	15.97726126	1489	15	-0.4	0.281935	0.000036	0.001066	0.000053	0.281905	0.000041	2.4	1.5	2076	1931		OK
12154-028.1	12154-028.1	1500.428642	16.56310868	1467	19	-2.6	0.281933	0.000039	0.000789	0.000039	0.281911	0.000042	2.1	1.5	2077	1931		OK
12154-029.1	12154-029.1	1593.059524	16.86359557	1590	13	-0.2	0.281978	0.000042	0.001269	0.000063	0.281940	0.000048	5.9	1.7	1933	1779		OK
12154-031.1	12154-031.1	1557.559931	15.7638387	1569	8	0.8	0.281925	0.000025	0.001258	0.000062	0.281888	0.000034	3.6	1.2	2062	1916		OK
12154-032.1	12154-032.1	1337.245586	29.01086177	1359	15	1.8	0.281950	0.000037	0.000765	0.000038	0.281931	0.000040	0.3	1.4	2104	1961		OK
12154-034.1	12154-034.1	1422.898127	36.54293266	1494	6	5.3	0.281973	0.000037	0.000568	0.000028	0.281957	0.000038	4.4	1.4	1958	1806		OK
12154-036.1	12154-036.1	1598.689289	15.97693187	1654	7	3.8	0.281894	0.000026	0.001733	0.000086	0.281840	0.000042	3.9	1.5	2112	1968		OK
12154-038.1	12154-038.1	1603.658019	16.44617963	1617	33	0.9	0.281835	0.000033	0.001583	0.000078	0.281787	0.000044	1.1	1.6	2254	2118		OK
12154-040.1	12154-040.1	1637.557302	18.03170989	1613	18	-1.7	0.281892	0.000029	0.001380	0.000068	0.281850	0.000039	3.3	1.4	2117	1973		OK
12154-042.1	12154-042.1	1499.973893	17.67330568	1500	15	0.0	0.281953	0.000029	0.001143	0.000056	0.281921	0.000036	3.2	1.3	2035	1887		OK
12154-044.1	12154-044.1	1652.341036	16.98590093	1637	10	-1.0	0.281845	0.000026	0.000796	0.000039	0.281821	0.000030	2.8	1.1	2166	2025		OK
12154-045.1	12154-045.1	1561.414487	15.67515932	1601	16	2.8	0.281930	0.000026	0.001324	0.000065	0.281890	0.000036	4.4	1.3	2036	1888		OK
12154-050.1	12154-050.1	1691.279386	17.95646482	1757	13	4.3	0.281769	0.000029	0.000948	0.000047	0.281738	0.000034	2.6	1.2	2270	2135		OK
12154-052.1	12154-052.1	1501.958498	15.64202763	1490	12	-0.9	0.281864	0.000035	0.001873	0.000093	0.281812	0.000050	-0.9	1.8	2282	2148		OK
12154-053.1	12154-053.1	1846.391279	18.50787748	1826	9	-1.3	0.281671	0.000028	0.000931	0.000046	0.281639	0.000033	0.7	1.2	2442	2316		OK
12154-054.1	12154-054.1	1625.936356	16.9213004	1657	11	2.1	0.281757	0.000056	0.001148	0.000057	0.281721	0.000060	-0.3	2.1	2372	2243		OK
12154-056.1	12154-056.1	1175.669936	11.96815528	1195	6	1.7	0.282156	0.000029	0.000979	0.000048	0.282134	0.000034	3.8	1.2	1762	1599		OK
12154-062.1	12154-062.1	1511.709699	15.28556627	1503	7	-0.6	0.281990	0.000024	0.001308	0.000065	0.281953	0.000034	4.4	1.2	1961	1809		OK
12154-063.1	12154-063.1	1480.404177	15.74526845	1519	14	2.8	0.281991	0.000057	0.000913	0.000045	0.281965	0.000060	5.2	2.1	1924	1770		OK
12154-064.1	12154-064.1	1163.60723	37.28360536	1114	36	-4.9	0.282281	0.000031	0.001362	0.000042	0.282253	0.000035	6.2	1.2	1552	1378		OK
12154-065.1	12154-065.1	1811.08561	18.40297613	1784	10	-1.7	0.281775	0.000029	0.001504	0.000047	0.281724	0.000034	2.8	1.2	2281	2147		OK
12154-066.1	12154-066.1	1258.517826	16.63186533	1294	44	3.0	0.282015	0.000057	0.000378	0.000012	0.282006	0.000057	1.5	2.0	1980	1830		OK
12154-068.1	12154-068.1	1840.744114	18.15731547	1835	6	-0.4	0.281639	0.000023	0.001507	0.000047	0.281587	0.000029	-1.0	1.0	2551	2431		OK
12154-070.1	12154-070.1	1752.55162	17.87381591	1745	10	-0.5	0.281719	0.000043	0.001186	0.000037	0.281680	0.000045	0.3	1.6	2405	2277		OK
12154-077.1	12154-077.1	1188.209713	12.12286145	1188	7	0.0	0.282218	0.000024	0.001851	0.000058	0.282177	0.000032	5.2	1.1	1672	1505		OK
12154-078.1	12154-078.1	1460.186298	15.36175795	1499	12	2.9	0.281925	0.000039	0.001163	0.000036	0.281892	0.000041	2.2	1.5	2098	1954		OK
12154-080.1	12154-080.1	2752.505157	27.55092339	2747	8	-0.2	0.281046	0.000023	0.000753	0.000023	0.281007	0.000025	-0.4	0.9	3213	3130		OK
12154-081.1	12154-081.1	1215.645749	13.04285856	1216	15	0.0	0.282191	0.000022	0.001417	0.000044	0.282159	0.000028	5.2	1.0	1694	1527		OK
12154-082.1	12154-082.1	1222.16517	12.64503078	1227	9	0.4	0.282018	0.000030	0.001733	0.000054	0.281978	0.000036	-1.0	1.3	2084	1940		OK
12154-083.1	12154-083.1	2697.470454	25.6306936	2707	6	0.4	0.280943	0.000043	0.000592	0.000018	0.280913	0.000044	-4.6	1.6	3448	3377		OK
12154-084.1	12154-084.1	1654.087759	17.01390848	1637	11	-1.2	0.281815	0.000021	0.001029	0.000032	0.281783	0.000024	1.5	0.9	2248	2112		OK
12154-087.1	12154-087.1	1655.617988	16.71260721	1641	7	-1.0	0.281844	0.000031	0.001521	0.000047	0.281797	0.000036	2.0	1.3	2216	2078		OK
12154-089.1	12154-089.1	1531.546225	16.82562964	1480	17	-3.9	0.282010	0.000028	0.001047	0.000033	0.281981	0.000031	4.9	1.1	1915	1760		OK
12154-092.1	12154-092.1	1736.185558	17.60662054	1736	9	0.0	0.281730	0.000046	0.000871	0.000027	0.281702	0.000047	0.8	1.7	2363	2233		OK
12154-094.1	12154-094.1	1312.632348	13.66874875	1303	11	-0.8	0.282057	0.000045	0.001753	0.000055	0.282014	0.000049	2.0	1.8	1957	1805		OK
12154-095.1	12154-095.1	1945.758971	19.37084427	1981	8	2.1	0.281481	0.000029	0.000336	0.000010	0.281469	0.000029	-1.8	1.0	2714	2603		OK
12154-098.1	12154-098.1	1360.447359	14.65960679	1451	14	6.9	0.282004	0.000025	0.000870	0.000027	0.281980	0.000027	4.2	1.0	1935	1781		OK
12154-100.1	12154-100.1	1592.650087	70.17585137	1550	25	-3.1	0.281969	0.000026	0.000588	0.000018	0.281952	0.000027	5.5	1.0	1932	1779		OK
12154-101.1	12154-101.1	1522.519635	15.71912992	1484	11	-2.9	0.281742	0.000024	0.001079	0.000034	0.281712	0.000027	-4.6	1.0	2504	2382		OK
12154-101.1	12154-101.1	1522.519635	15.71912992	1484	11	-2.9	0.281880	0.000025	0.000841	0.000026	0.281857	0.000027	0.6	1.0	2186	2047		OK
12154-105.1	12154-105.1	1505.861293	17.09560245	1452	24	-4.2	0.281960	0.000048	0.000989	0.000031	0.281933	0.000049	2.5	1.8	2039	1891		OK
12154-107.1	12154-107.1	1769.801611	17.63500752	1751	7	-1.2	0.281746	0.000034	0.000623	0.000019	0.281726	0.000035	2.0	1.2	2300	2167		OK
12154-108.1	12154-108.1	1782.769417	18.05737671	1769	9	-0.9	0.281732	0.000034	0.001271	0.000040	0.281690	0.000037	1.2	1.3	2368	2238		OK
12154-109.1	12154-109.1	1199.363984	12.31311818	1185	8	-1.4	0.282080	0.000034	0.001227	0.000038	0.282053	0.000037	0.7	1.3	1947	1795		OK
12154-116.1	12154-116.1	1192.903348	12.93559627	1228	15	3.1	0.282141	0.000032	0.001131	0.000035	0.282115	0.000035	3.9	1.2	1782	1621		OK
12154-118.1	12154-118.1	1846.682236	18.55485362	1846	8	0.0	0.281678	0.000026	0.001263	0.000039	0.281634	0.000030	1.0	1.1	2439	2314		OK
12154-119.1	12154-119.1	1768.370526	17.51656609	1787	8	1.2	0.281463	0.000030	0.000298	0.000009	0.281453	0.000030	-6.8	1.1	2875	2773		OK
12154-120.1	12154-120.1	1664.777119	42.32238722	1666	12	0.1	0.281900	0.000021	0.001577	0.000049	0.281851	0.000028	4.5	1.0	2081	1935		OK
12154-122.1	12154-122.1	1065.14143	11.79060638	1056	19	-0.9	0.282129	0.000035	0.000850	0.000026	0.282112	0.000036	-0.1	1.3	1898	1744		OK
12154-125.1	12154-125.1	2020.962894	19.74180947	2057	6	2.0	0.281602	0.000027	0.000570	0.000018	0.281580	0.000028	3.9	1.0	2418	2291		OK
12154-126.1	12154-126.1	1178.710659	12.23868505	1180	9	0.1	0.282113	0.000034	0.000710	0.000022	0.282098	0.000035	2.2	1.2	1852	1695		OK
12154-127.1	12154-127.1	1484.900155	14.92324064	1485	7	0.0	0.281919	0.000028	0.001673	0.000052	0.281872	0.000034	1.1	1.2	2151	2010		OK

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12154-128.1	12154-128.1	1752.802246	17.14980138	1799	5	2.9	0.281734	0.000023	0.001187	0.000037	0.281694	0.000027	2.0	1.0	2339	2208		OK
12154-129.1	12154-129.1	1154.238509	12.07542057	1139	12	-1.5	0.282284	0.000025	0.001143	0.000036	0.282260	0.000028	7.0	1.0	1520	1344		OK
12154-132.1	12154-132.1	1219.504104	12.77221152	1230	11	0.9	0.282071	0.000038	0.000885	0.000028	0.282051	0.000039	1.6	1.4	1923	1769		OK
12154-136.1	12154-136.1	1429.807172	14.50793321	1462	8	2.4	0.281804	0.000034	0.000685	0.000021	0.281785	0.000035	-2.5	1.2	2358	2228		OK
12154-137.1	12154-137.1	1853.636952	18.46744863	1874	8	1.3	0.281723	0.000026	0.000653	0.000020	0.281700	0.000027	4.0	1.0	2275	2140		OK
12154-139.1	12154-139.1	1585.879845	16.0784943	1581	9	-0.4	0.281895	0.000033	0.000994	0.000031	0.281866	0.000035	3.1	1.2	2104	1960		OK
12154-140.1	12154-140.1	1174.763406	12.04522805	1195	7	1.9	0.282205	0.000028	0.001048	0.000033	0.282182	0.000031	5.5	1.1	1656	1488		OK
12154-141.1	12154-141.1	1808.493123	18.10223984	1806	13	-0.2	0.281755	0.000026	0.001276	0.000040	0.281712	0.000030	2.8	1.1	2295	2161		OK
12155-002.1	12155-002.1	1943.748158	20.10183175	1993	11	2.8	0.281598	0.000053	0.002258	0.000070	0.281513	0.000059	0.0	2.1	2610	2493		OK
12155-003.1	12155-003.1	1489.802812	15.0951691	1506	8	1.2	0.282012	0.000029	0.002962	0.000092	0.281928	0.000045	3.6	1.6	2015	1866		OK
12155-004.1	12155-004.1	1134.97966	13.62164862	1068	59	-6.8	0.282131	0.000045	0.000911	0.000028	0.282113	0.000046	0.2	1.6	1889	1734		OK
12155-005.1	12155-005.1	1874.045236	18.39423635	1871	6	-0.2	0.281716	0.000032	0.001196	0.000037	0.281674	0.000035	3.0	1.2	2335	2203		OK
12155-006.1	12155-006.1	1589.750184	15.96603031	1639	7	3.4	0.281873	0.000026	0.001012	0.000031	0.281842	0.000029	3.6	1.0	2118	1974		OK
12155-007.1	12155-007.1	1595.438917	16.25589277	1583	10	-0.9	0.281885	0.000026	0.001464	0.000046	0.281841	0.000031	2.3	1.1	2156	2015		OK
12155-009.1	12155-009.1	1578.842129	57.54157754	1599	8	1.4	0.281890	0.000031	0.001205	0.000037	0.281854	0.000034	3.1	1.2	2118	1974		OK
12155-010.1	12155-010.1	1214.374519	12.55732689	1227	9	1.2	0.282163	0.000030	0.000761	0.000024	0.282146	0.000031	5.0	1.1	1715	1550		OK
12155-012.1	12155-012.1	1320.840085	13.92324156	1327	13	0.5	0.282118	0.000035	0.001712	0.000053	0.282075	0.000040	4.7	1.4	1806	1646		OK
12155-014.1	12155-014.1	1788.345351	17.55758411	1798	6	0.6	0.281672	0.000024	0.000638	0.000020	0.281651	0.000025	0.4	0.9	2435	2309		OK
12155-017.1	12155-017.1	1669.238071	17.17347024	1677	11	0.5	0.281817	0.000032	0.001627	0.000051	0.281766	0.000037	1.7	1.3	2261	2126		OK
12155-018.1	12155-018.1	1144.285075	12.55450639	1063	22	-8.3	0.282155	0.000026	0.000829	0.000026	0.282139	0.000028	1.0	1.0	1836	1678		OK
12155-020.1	12155-020.1	1175.019896	12.02818672	1165	7	-1.0	0.282124	0.000028	0.001176	0.000037	0.282099	0.000031	1.9	1.1	1860	1703		OK
12155-021.1	12155-021.1	1841.64319	17.89521571	1839	5	-0.2	0.281695	0.000026	0.001357	0.000042	0.281648	0.000031	1.3	1.1	2414	2286		OK
12155-022.1	12155-022.1	1150.15807	12.24247191	1155	14	0.4	0.282128	0.000032	0.000924	0.000029	0.282108	0.000034	2.0	1.2	1845	1687		OK
12155-023.1	12155-023.1	1250.331191	13.12782951	1264	11	1.2	0.281988	0.000031	0.000691	0.000022	0.281972	0.000032	-0.4	1.1	2075	1930		OK
12155-024.1	12155-024.1	1561.613393	15.71730088	1550	7	-0.8	0.281982	0.000028	0.001169	0.000036	0.281948	0.000031	5.3	1.1	1941	1788		OK
12155-025.1	12155-025.1	1387.082774	14.21033744	1373	9	-1.1	0.282009	0.000031	0.000648	0.000020	0.281993	0.000032	2.8	1.1	1959	1807		OK
12155-026.1	12155-026.1	1163.613091	12.13709127	1156	11	-0.7	0.282270	0.000028	0.001212	0.000038	0.282244	0.000031	6.8	1.1	1544	1370		OK
12155-027.1	12155-027.1	1434.895137	15.52432718	1454	16	1.5	0.281901	0.000037	0.001368	0.000043	0.281864	0.000040	0.1	1.4	2190	2051		OK
12155-028.1	12155-028.1	1822.298635	18.4509246	1831	10	0.6	0.281581	0.000029	0.001038	0.000032	0.281545	0.000032	-2.5	1.1	2645	2530		OK
12155-029.1	12155-029.1	1226.852795	13.68370542	1210	22	-1.5	0.282163	0.000034	0.000798	0.000025	0.282145	0.000035	4.5	1.2	1728	1563		OK
12155-030.1	12155-030.1	1584.928383	16.41458359	1606	11	1.5	0.281816	0.000041	0.000625	0.000019	0.281797	0.000042	1.2	1.5	2238	2101		OK
12155-031.1	12155-031.1	1664.534624	19.46648952	1655	22	-0.7	0.281809	0.000025	0.001158	0.000036	0.281773	0.000028	1.5	1.0	2259	2124		OK
12155-035.1	12155-035.1	1483.08962	15.38853199	1507	11	1.7	0.282008	0.000030	0.000778	0.000024	0.281986	0.000031	5.7	1.1	1886	1730		OK
12155-036.1	12155-036.1	1499.530293	15.48168186	1478	11	-1.6	0.282037	0.000029	0.001857	0.000058	0.281985	0.000036	5.0	1.3	1906	1751		OK
12155-037.1	12155-037.1	1494.441744	15.59270078	1508	11	1.0	0.282033	0.000023	0.001307	0.000041	0.281996	0.000028	6.0	1.0	1863	1706		OK
12155-038.1	12155-038.1	1599.087525	16.03008323	1611	8	0.8	0.281885	0.000030	0.001320	0.000041	0.281845	0.000034	3.0	1.2	2129	1986		OK
12155-039.1	12155-039.1	1931.220158	18.9345641	1949	6	1.0	0.281630	0.000026	0.001210	0.000038	0.281586	0.000030	1.6	1.1	2478	2355		OK
12155-040.1	12155-040.1	1246.641974	13.06202144	1262	12	1.4	0.282155	0.000027	0.001322	0.000041	0.282124	0.000031	5.0	1.1	1741	1577		OK
12155-041.1	12155-041.1	1471.270555	15.21712313	1499	18	2.1	0.281927	0.000030	0.000818	0.000025	0.281904	0.000032	2.6	1.1	2072	1926		OK
12155-043.1	12155-043.1	1262.765667	13.03635827	1249	8	-1.2	0.282115	0.000032	0.001191	0.000037	0.282087	0.000035	3.4	1.2	1830	1671		OK
12155-044.1	12155-044.1	1177.908908	11.99385751	1173	6	-0.5	0.282110	0.000030	0.000360	0.000011	0.282102	0.000030	2.2	1.1	1846	1688		OK
12155-045.1	12155-045.1	1157.581222	12.16926592	1150	12	-0.7	0.282286	0.000026	0.002038	0.000063	0.282242	0.000035	6.6	1.2	1552	1378		OK
12155-046.1	12155-046.1	1593.215194	16.04506427	1593	8	0.0	0.281917	0.000025	0.001448	0.000045	0.281874	0.000030	3.7	1.1	2078	1932		OK
12155-048.1	12155-048.1	1471.89244	17.21635102	1385	30	-7.0	0.281738	0.000026	0.000455	0.000014	0.281726	0.000027	-6.3	0.9	2535	2415		OK
12155-049.1	12155-049.1	2636.469478	24.48955742	2684	4	2.2	0.280919	0.000033	0.000511	0.000016	0.280893	0.000034	-5.9	1.2	3506	3439		OK
12155-050.1	12155-050.1	1229.213269	13.16439722	1182	16	-4.4	0.282095	0.000028	0.000834	0.000026	0.282077	0.000030	1.5	1.1	1897	1742		OK
12155-051.1	12155-051.1	1582.073804	17.14884368	1569	17	-0.9	0.281852	0.000039	0.001166	0.000036	0.281818	0.000041	1.1	1.5	2217	2079		OK
12155-052.1	12155-052.1	1531.243652	16.29844865	1521	15	-0.8	0.281986	0.000028	0.000928	0.000029	0.281960	0.000030	5.1	1.1	1935	1782		OK
12155-056.1	12155-056.1	1486.66379	47.64803978	1474	19	-1.0	0.281985	0.000030	0.001062	0.000033	0.281956	0.000033	3.8	1.2	1975	1823		OK
12155-057.1	12155-057.1	1207.442667	12.40953448	1230	9	2.0	0.282124	0.000030	0.000909	0.000028	0.282103	0.000032	3.5	1.1	1808	1648		OK
12155-060.1	12155-060.1	1471.378084	46.34916167	1494	10	1.7	0.281754	0.000030	0.000374	0.000012	0.281744	0.000030	-3.2	1.1	2428	2302		OK
12155-062.1	12155-062.1	1161.356725	13.16630843	1130	25	-3.0	0.282190	0.000025	0.001415	0.000044	0.282160	0.000030	3.2	1.1	1746	1583		OK

Analyses Name Neptune	Analysis Name SHRIMP	206Pb/238U Age	±1s	207Pb/206Pb Age (Ma)	± 1s	Discordance	176Hf/177Hfm	±2s	176Lu/177 Hf	±2s	176Hf/177 HfINITIAL	±2s	Epsilon Hf	±2s	TDM	TNC		Status
12155-064.1	12155-064.1	1572.985517	16.25763482	1555	10	-1.3	0.281903	0.000026	0.000838	0.000026	0.281879	0.000028	3.0	1.0	2092	1947		OK
12155-066.1	12155-066.1	1113.297438	44.71947244	1157	46	4.1	0.282045	0.000027	0.000505	0.000016	0.282034	0.000028	-0.6	1.0	2006	1857		OK
12155-067.1	12155-067.1	1255.101818	13.21118385	1292	13	3.2	0.282161	0.000028	0.001286	0.000040	0.282130	0.000032	5.9	1.1	1708	1542		OK
12155-068.1	12155-068.1	1773.17339	18.18557985	1876	10	6.3	0.281676	0.000022	0.001018	0.000032	0.281640	0.000025	1.9	0.9	2406	2278		OK
12155-070.1	12155-070.1	1139.875295	12.53420231	1117	14	-2.2	0.282140	0.000033	0.000787	0.000024	0.282124	0.000034	1.7	1.2	1834	1676		OK
12155-071.1	12155-071.1	1138.709819	11.75789328	1147	8	0.8	0.282200	0.000027	0.000716	0.000022	0.282185	0.000028	4.5	1.0	1680	1513		OK
12155-072.1	12155-072.1	2072.988349	19.90462968	2074	5	0.0	0.281248	0.000025	0.000736	0.000023	0.281219	0.000026	-8.5	0.9	3200	3116		OK
12155-073.1	12155-073.1	1157.041191	20.77988468	1167	9	1.0	0.282162	0.000023	0.001001	0.000031	0.282140	0.000026	3.4	0.9	1766	1604		OK
12155-074.1	12155-074.1	1620.190063	16.86094145	1610	13	-0.7	0.281847	0.000025	0.001360	0.000042	0.281806	0.000030	1.6	1.1	2216	2078		OK
12155-075.1	12155-075.1	1580.209916	15.8728846	1594	7	1.0	0.281891	0.000025	0.000482	0.000015	0.281877	0.000026	3.8	0.9	2070	1924		OK
12155-076.1	12155-076.1	1497.610307	15.22727262	1493	8	-0.3	0.282000	0.000023	0.001432	0.000045	0.281960	0.000029	4.4	1.0	1953	1800		OK
12155-077.1	12155-077.1	1537.498787	16.38509087	1541	9	0.3	0.281958	0.000028	0.000763	0.000024	0.281936	0.000029	4.7	1.0	1974	1822		OK
12155-078.1	12155-078.1	1168.994441	12.93028986	1153	14	-1.5	0.282187	0.000024	0.001156	0.000036	0.282162	0.000028	3.8	1.0	1727	1563		OK
12155-083.1	12155-083.1	1899.274836	19.36838518	2121	10	12.0	0.281555	0.000023	0.001239	0.000039	0.281505	0.000027	2.7	1.0	2540	2420		OK
12155-084.1	12155-084.1	1354.580128	13.79885119	1368	8	1.1	0.281948	0.000027	0.000698	0.000022	0.281930	0.000028	0.5	1.0	2100	1956		OK
12155-086.1	12155-086.1	1117.199482	11.78582352	1179	13	5.7	0.282185	0.000029	0.000631	0.000020	0.282171	0.000030	4.7	1.1	1690	1524		OK
12155-088.1	12155-088.1	1174.849045	23.61273959	1159	10	-1.5	0.282261	0.000023	0.001677	0.000052	0.282225	0.000030	6.2	1.1	1585	1412		OK
12155-089.1	12155-089.1	1167.208482	12.13388389	1208	10	3.7	0.282162	0.000023	0.000727	0.000023	0.282146	0.000025	4.5	0.9	1728	1563		OK
12155-090.1	12155-090.1	1208.888604	12.72192384	1237	13	2.5	0.282112	0.000021	0.001573	0.000049	0.282076	0.000028	2.7	1.0	1864	1707		OK
12155-092.1	12155-092.1	2008.868319	19.43831846	1989	5	-1.1	0.281551	0.000026	0.000873	0.000027	0.281518	0.000028	0.2	1.0	2599	2482		OK
12155-093.1	12155-093.1	1589.511546	15.81098707	1600	6	0.8	0.282046	0.000023	0.002386	0.000074	0.281974	0.000036	7.4	1.3	1851	1692		OK
12155-094.1	12155-094.1	1438.245522	14.91044761	1514	11	5.6	0.281939	0.000022	0.001127	0.000035	0.281907	0.000026	3.0	0.9	2056	1909		OK
12155-095.1	12155-095.1	1125.737759	12.17268205	1145	16	1.8	0.282133	0.000022	0.001072	0.000033	0.282110	0.000025	1.8	0.9	1846	1689		OK
12155-097.1	12155-097.1	1524.964544	15.59088834	1596	10	5.0	0.281937	0.000023	0.000865	0.000027	0.281911	0.000025	5.0	0.9	1993	1843		OK
12155-098.1	12155-098.1	1083.04341	11.41237359	1120	12	3.6	0.282253	0.000020	0.002469	0.000077	0.282201	0.000035	4.5	1.2	1662	1494		OK
12155-099.1	12155-099.1	1306.405182	14.28821613	1367	18	4.9	0.282069	0.000024	0.000571	0.000018	0.282055	0.000025	4.9	0.9	1826	1667		OK
12155-100.1	12155-100.1	1404.265427	14.74296612	1521	12	8.5	0.281815	0.000024	0.000915	0.000028	0.281789	0.000026	-1.0	0.9	2311	2179		OK
12155-102.1	12155-102.1	1156.92161	12.57822057	1144	18	-1.2	0.282184	0.000038	0.000522	0.000016	0.282173	0.000038	4.0	1.4	1708	1543		OK
12155-103.1	12155-103.1	1174.916597	12.14730021	1199	9	2.2	0.282018	0.000023	0.000634	0.000020	0.282004	0.000024	-0.7	0.9	2046	1899		OK
12155-124.1	12155-124.1	1131.82057	13.1104133	1144	23	1.2	0.281847	0.000026	0.001053	0.000033	0.281825	0.000029	-8.3	1.0	2472	2349		OK
12155-126.1	12155-126.1	1178.571717	12.4168425	1182	10	0.4	0.282182	0.000024	0.000815	0.000025	0.282164	0.000026	4.6	0.9	1704	1538		OK
12155-127.1	12155-127.1	1454.877298	15.8432604	1455	17	0.0	0.281931	0.000025	0.000846	0.000026	0.281908	0.000027	1.7	1.0	2092	1948		OK
12155-130.1	12155-130.1	1601.967338	16.35555808	1601	9	-0.1	0.281870	0.000028	0.000939	0.000029	0.281842	0.000030	2.7	1.1	2143	2001		OK

Footnote

Reference Values: CHUR-Bouvier et al. (2008); Depleted mantle and New Crust evolution-Dhuime et al. (2011)

176Lu/177Hf calibrated relative to zircon 6266 0.000105. Uncertainty in calibration for each session included quadratically.

176Hf/177Hf measured includes bias correction of 0.000032 based on replicate analyses of 91500, 6266, Temora, MudTank and MUN synthetic zircon during the course of the analtyical session

Appendix 8: OD2016-D2 Hf-isotope standards.

Appendix 8. Hf isotope standsards.

Hf isotopic data of zircon standards during the course of an analytical session.

Standard	n	Rejected	$^{176}Hf/^{177}Hf$	± 2SE	MSWD	Bias in $^{176}Hf/^{177}Hf$	$^{175}Lu/^{177}Hf$	± 2 SE external %
Mud Tank	49	1	0.282477	0.000004	5	0.000033	0.00004	17
6266	87	1	0.281594	0.000003	0.7	0.000035	0.00022	-
Temora 2	46	2	0.282653	0.000005	1.3	0.000032	0.00097	62
91500	128	1	0.282273	0.000003	1.15	0.000033	0.00031	24
MUN4	15	1	0.282111	0.000013	6.9	0.000028	0.00317	67
MUN1	8	0	0.282099	0.000011	1.1	0.000037	0.0022	20

Appendix 9: OD2016-D2 EDS analysis data.

Notes:

A sample number succeeded by -1, or -2 indicates thin section number. Eg. 011-2 is the second thin section from sample 011.

A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 012 has been cut into two halves, one half is 012-a and the other half is 012-b.

Abbreviations:

+: A mineral name with a '+' after the mineral name indicates an impure analysis

Ms: Muscovite

Rt: Rutile

Qz: Quartz

Opx: orthopyroxene

Amp: amphibole

Bt: biotite

Appendix 9.1: OD2016-D
data.

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
1	1	Quartz	100.00																													100	132
1	2	Biotite	39.55	1.79	16.54	17.26		12.01			8.85																					96	121
1	3	Bt + FeO	31.88	0.64	15.01	38.88		10.72	0.45		2.43																					100	102
1	4	Apatite				0.31			48.65			44.81		4.59																1.63		100	144
1	5	Muscovite	49.72		27.43	4.11		2.77			10.96																					95	123
1	6	Apatite							47.02	0.55		43.73		6.08									0.96							1.66		100	128
1	7	Biotite	39.58	2.09	16.20	17.41		12.02			8.70																					96	119
1	8	Muscovite	48.11	0.69	31.51	2.24		1.69			10.75																					95	123
1	9	Rutile +	2.43	94.36	1.06	1.56					0.60																					100	121
1	10	Rutile +	13.81	82.57	0.82	1.02		0.65	0.61			0.52																				100	124
1	11	Biotite	39.24	1.40	17.79	18.65		12.68			6.24																					96	117
1	12	Apatite	0.64						48.67			44.00		5.45																1.24		100	141
1	13	Monazite +	4.87		1.57				1.94	2.04		31.62	2.46		0.46					1.42		13.22	27.56	9.58						3.26		100	104
1	14	Apatite							48.19			44.48		5.42																1.91		100	139
1	15	Biotite	38.95	2.01	17.09	17.70		12.75			7.50																					96	122
1	16	Muscovite	49.44	0.96	29.26	2.67		2.26			10.41																					95	126
1	17	Apatite +	1.48			0.72			47.41		0.36	43.60		4.76																1.68		100	132
1	18	Chlorite +	30.46	0.77	17.56	18.39		14.54			3.26																					85	112
1	19	Biotite	39.58	1.88	16.15	18.28		11.77			8.09				0.24																	96	111
1	20	FeO +	22.00	0.42	8.72	57.38		7.17	0.86		2.34	1.11																				100	101
1	21	FeO +	28.91		6.07	56.62		2.53	1.21	1.96	0.59	2.10																				100	93
1	22	Biotite	39.56	1.81	16.49	17.55		12.04			8.54																					96	120
1	23	Quartz	100.00																													100	138
1	24	Muscovite	49.99	0.71	27.28	3.58		3.36			10.07																					95	110
1	25	Bt + Ms	45.19	0.52	28.60	10.11		7.61			7.97																					100	110
1	26	Apatite +	1.38			0.96			46.70		0.48	43.12		5.47																1.91		100	133
1	27	Biotite	42.48	1.01	17.40	17.88		12.27			4.96																					96	114
1	28	Apatite							48.47			44.52		5.36																1.65		100	144
1	29	Biotite	39.35	2.19	16.47	17.78		12.40			7.81																					96	115
1	30	Rutile +	22.29	56.67	13.39	1.56		1.20			4.88																					100	124
1	31	Rutile +	12.72	86.63		0.66																										100	118
1	32	Quartz	100.00																													100	138
1a	1	Apatite							48.00			43.65		6.69																1.66		100	91
1a	2	Biotite	39.60	1.97	16.44	17.47		12.00			8.52																					96	79
1a	3	Muscovite	48.25	0.63	31.08	2.54		2.05			10.46																					95	79
1a	4	Rutile +	12.71	69.22	5.69	5.79		4.19			2.41																					100	78
1a	5	Quartz	100.00																													100	87
1a	6	Muscovite	49.64	0.84	28.97	2.66		2.52			10.38																					95	81
1a	7	Muscovite	49.07	0.83	28.22	3.45		3.35			10.08																					95	81
1a	8	Chlorite	27.15		20.70	20.96		16.19																								85	73
1a	9	Titanite +	14.82	37.98	8.42	2.27		1.91	17.05		3.14	14.40																				100	79
1a	10	Rutile +	24.83	56.75	6.16	5.85		3.97			2.44																					100	80
1a	11	Biotite	38.12	1.80	17.82	18.97		12.69			6.60																					96	77
1a	12	Biotite	38.87	1.95	16.84	18.24		12.20			7.90																					96	77
1a	13	Biotite	39.55	1.87	16.29	17.36		12.12			8.80																					96	78
1a	14	Quartz	100.00																													100	86
1a	15	Chlorite	32.10		17.89	19.72		15.28																								85	73
2	1	Chlorite	26.55		21.27	21.37		15.81																								85	113
2	2	Rutile +	6.89	78.45	4.97	5.19		4.08			0.41																					100	123
2	3	Biotite	39.86	1.75	17.35	17.53		12.34			7.18																					96	119
2	4	Rutile +	0.72	98.38		0.68					0.22																					100	125
2	5	Rutile +	24.52	64.44	5.77	0.29			0.33	4.66																						100	137
2	6	Quartz	100.00																													100	142
2	7	Mixture	35.67		21.36	19.91		15.47	0.93		0.21	2.87										1.17	2.42									100	120

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
2	8	Albite	69.51		18.96					11.53																						100	140
2	9	Biotite	43.88	1.53	15.96	15.80		11.37	0.75		6.72																					96	131
2	10	Biotite	38.82	1.87	17.12	18.01		12.66			7.52																					96	119
2	11	Chlorite	26.95		20.93	21.33		15.80																								85	110
2	12	Zircon +	44.44		14.61	4.12		1.92	1.33		6.66								26.92													100	102
2	13	Mixture	28.25	45.81	15.73	2.44		1.35			6.41																					100	110
2	14	Biotite	39.72	1.65	17.14	17.88		12.80			6.83																					96	116
2	15	Muscovite	49.29	0.69	26.88	2.89		2.13		0.36	9.93								2.84													95	106
2	16	Mixture	44.49	42.73	7.40	1.48		1.10			2.81																					100	117
2	17	Quartz	100.00																													100	136
2	18	Biotite	40.71	1.39	16.29	21.94		10.38			5.29																					96	126
2	19	Mixture	31.92	37.52	17.57	4.46		4.13			4.41																					100	131
2	20	Bt + Chl	37.49	1.02	18.87	25.20		14.09			3.33																					100	118
2	21	Apatite							48.92		0.24	44.26		4.76																	1.83		100	142
2	22	Apatite							48.28		0.26	44.59		5.00																	1.87		100	143
2	23	Muscovite	49.71	0.70	28.48	3.25		2.86			10.00																					95	125
2	24	Muscovite	49.24	0.51	30.71	2.13		1.77			10.64																					95	124
2	25	Monazite +	18.74		5.69	0.67			1.96	2.84	2.23	20.04	1.42		0.35							12.92	23.58	9.56								100	102
2	26	Muscovite	49.95	0.65	29.38	2.45		2.20			10.36																					95	121
2	27	Muscovite	55.43	0.57	24.59	2.95		2.65			8.81																					95	117
2	28	Quartz	100.00																													100	139
2	29	Muscovite	48.34	0.68	28.99	3.98		3.39			9.61																					95	126
2	30	Biotite	38.74	1.74	17.36	18.86		13.59			5.71																					96	120
2a	1	Apatite							48.67			44.71		5.02																	1.60		100	89
2a	2	Biotite	37.51	1.70	17.90	19.70		13.94			5.25																					96	76
2a	3	Apatite	0.59						48.06		0.28	44.22		5.38																	1.48		100	89
2a	4	Quartz	100.00																													100	88
2a	5	Muscovite	49.13	0.72	30.60	1.94		2.06			10.55																					95	79
2a	6	Chlorite	27.00		21.23	21.12		15.65																								85	72
2a	7	Muscovite	49.44	0.62	29.86	2.25		2.12			10.72																					95	80
2a	8	Chlorite	28.04		20.09	20.70		15.74			0.43																					85	72
2a	9	Zircon +	35.71		12.23	4.08		4.00	2.02		3.03								38.94													100	72
2a	10	Quartz	100.00																													100	88
2a	11	Chlorite	28.53		20.13	20.09		16.24																								85	72
2a	12	Muscovite	49.99	0.50	29.32	2.31		2.24			10.64																					95	81
2a	13	Chlorite	29.14		20.19	19.24		15.67			0.75																					85	74
2a	14	Apatite +	33.97	0.36	12.46	1.29		1.16	20.90		4.63	22.08		3.14																			100	83
3	1	Apatite	0.45						48.84			43.76		5.64																	1.31		100	145
3	2	Quartz	100.00																													100	142
3	3	Quartz	100.00																													100	136
3	4	Biotite	39.45	2.24	16.18	17.77		12.13			8.24																					96	122
3	5	Biotite	39.37	1.87	16.52	17.83		12.21			8.19																					96	131
3	6	Zircon	31.30																68.70													100	144
3	7	Apatite							48.72			44.56		4.86																	1.87		100	151
3	8	Rutile +	1.23	98.33		0.44																											100	132
3	9	Apatite	0.79						49.18			44.22		5.81																			100	141
3	10	Rutile +	1.05	98.13		0.82																											100	127
3	11	Apatite							48.61		0.24	44.05		5.30																	1.80		100	144
3	12	Muscovite	49.33	0.65	29.68	2.72		2.43			10.19																					95	126
3	13	Rutile +	1.28	98.29		0.43																											100	123
3	14	Apatite +	2.85		1.29	1.00			45.20		0.60	42.21		4.83																	2.02		100	148
3	15	Quartz	100.00																													100	143
3	16	Biotite	39.71	1.96	16.48	17.16		11.79			8.90																					96	130
3	17	Biotite	38.64	1.95	17.03	18.26		12.21			7.92																					96	127

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
3	18	Quartz	100.00																													100	142
3	19	Muscovite	47.56	0.63	27.34	5.91		4.75			8.81																					95	128
3	20	Apatite	0.81						48.92			43.99		4.80																1.48		100	143
3	21	Apatite	0.47		0.33	0.32			48.21		0.30	43.70		5.11																1.55		100	153
3	22	Rutile +	0.89	97.94					0.59			0.57																				100	132
3	23	Chlorite	27.13		20.86	21.15		15.87																								85	114
3	24	Biotite	39.50	1.98	16.30	17.46		12.31			8.45																					96	123
3	25	Biotite	40.97		22.21	20.13		8.68			4.00																					96	122
3	26	Biotite	39.42	1.91	16.56	17.58		11.80			8.74																					96	130
4	1	Apatite							48.84			44.35		5.27																1.54		100	147
4	2	Apatite							48.53			44.41		5.43																1.63		100	130
4	3	Biotite	39.48	1.92	16.83	17.69		12.51			7.56																					96	118
4	4	Rutile +	3.72	93.97	0.42	0.55			0.66			0.68																				100	121
4	5	Biotite	41.02	2.47	17.00	15.61		12.09			7.81																					96	121
4	6	Apatite +	2.85		1.67				46.69		0.54	42.69		5.56																		100	136
4	7	Rutile +	1.93	95.96	1.09	0.76					0.25																					100	123
4	8	Quartz	100.00																													100	138
4	9	Biotite	39.09	1.69	17.31	17.91		12.89			7.11																					96	118
4	10	Rutile +	0.92	98.35		0.43					0.30																					100	118
4	11	Monazite +	0.99						1.56			33.22	1.59									16.45	32.31	11.59						2.40		100	110
4	12	Quartz	100.00																													100	136
4	13	Muscovite	47.70	0.51	28.67	5.37		3.78			8.97																					95	118
4	14	Biotite	39.35	1.96	17.08	17.20		12.57			7.83																					96	115
4	15	Biotite	38.69	1.92	17.05	17.97		13.03			7.34																					96	112
4	16	Apatite +	10.74		3.15	0.52			40.29		1.35	38.93		5.02																		100	133
4	17	Rutile +	1.05	95.62		0.50			1.56			1.26																				100	120
4	18	Muscovite	49.94	0.67	29.03	2.33		2.47			10.55																					95	129
4	19	Rutile +	1.05	98.49		0.46																										100	127
4	20	Chlorite	27.21		20.61	21.38		15.79																								85	111
4	21	Quartz	100.00																													100	134
5	1	Quartz	100.00																													100	131
5	2	Quartz	100.00																													100	130
5	3	Quartz	100.00																													100	136
5	4	Quartz +	94.93		3.30	0.31		0.31			1.16																					100	134
5	5	Quartz	100.00																													100	138
5	6	Apatite							48.45			44.51		5.37																1.67		100	140
5	7	Apatite							48.89		0.14	44.64		4.83																1.50		100	141
5	8	Apatite	0.64						48.77			43.91		5.37																1.30		100	140
5	9	Apatite +	1.61						49.20			43.85		5.35																		100	136
5	10	Biotite	36.91	1.87	15.83	21.86		11.95			7.57																					96	118
5	11	Biotite	39.72	1.65	17.64	17.72	0.30	11.48			7.49																					96	116
5	12	Biotite	39.86	2.03	16.19	17.25		12.31			8.37																					96	119
5	13	K-Feldspar	65.07		17.66	1.73		0.87			14.67																					100	127
5	14	Rutile +	5.28	86.34	2.67	2.85		2.18			0.67																					100	120
5	15	Rutile +	4.18	93.23	1.45	0.71					0.43																					100	126
5	16	Rutile +	2.06	94.48	1.23	1.04		0.93			0.26																					100	128
5	17	Rutile +	0.69	98.59		0.72																										100	121
5	18	Monazite +	31.03		14.13	13.83		10.18	0.81		4.74	9.44	1.28									3.18	8.15	3.23								100	121
5	19	Muscovite	46.93	1.04	24.45	8.27		5.49			8.82																					95	119
5	20	Muscovite	49.98	0.83	29.07	2.26		2.31		0.35	10.20																					95	126
6	1	Bt + Chl	34.85		22.73	27.33		13.63			1.46																					100	117
6	2	Quartz	100.00																													100	140
6	3	Apatite							48.58			44.41		5.45																1.56		100	140

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
6	4	Rutile +	24.63	71.74	1.15	1.37		0.57			0.54																					100	117
6	5	Rutile +	5.33	90.65	2.15	0.63					1.25																					100	120
6	6	Monazite +	4.55		1.36				1.98		0.34	32.31	1.51	0.29								15.21	30.88	11.57								100	116
6	7	Monazite +	23.67		3.75	5.20		2.81	1.91			23.13	2.19							1.30		9.65	18.73	7.66								100	110
6	8	Monazite +	1.38		1.34	1.01			2.54			31.36	3.53							1.71		14.14	29.24	10.08						3.70		100	124
6	9	Biotite	39.46	2.16	16.53	17.57		11.72			8.56																					96	128
6	10	Quartz	100.00																													100	136
6	11	Chlorite	28.28		19.18	20.65	0.31	16.58																								85	112
6	12	Biotite	39.21	2.07	16.53	17.46		12.04			8.69																					96	120
6	13	Rutile +	1.02	97.71	0.51	0.76																										100	122
6	14	Biotite	39.69	2.10	16.57	17.41		12.00			8.23																					96	119
6	15	Apatite	0.69						48.60			44.30		5.18																1.23		100	133
6	16	Muscovite	48.05	0.81	32.82	1.44		1.14		0.86	9.88																					95	117
6	17	Biotite	37.74	1.38	18.32	20.46		12.84			5.26																					96	114
6	18	Quartz	100.00																													100	130
6	19	Rutile +	18.46	63.45	12.18	1.09		1.14			3.69																					100	122
6	20	Rutile +	0.61	98.43		0.74					0.22																					100	117
6	21	Biotite	38.55	1.10	18.17	19.84		12.89			5.43																					96	113
6	22	Quartz	99.73			0.27																										100	135
6	23	Chlorite	28.03		20.19	21.15		15.63																								85	112
6	24	Apatite							48.55			44.68		5.09																1.68		100	138
7	1	Apatite							49.06			44.69		4.71																1.54		100	145
7	2	Muscovite	45.89	1.34	23.34	8.90		6.67			8.86																					95	121
7	3	Chlorite +	29.67	0.77	17.70	18.91		14.88			3.07																					85	113
7	4	Apatite	0.56						49.05			44.52		4.75																1.13		100	139
7	5	Apatite +	1.22						49.01			43.97		5.79																		100	138
7	6	Rutile +	0.99	98.53		0.48																										100	125
7	7	Rutile +	0.95	98.25		0.40		0.40																								100	124
7	8	Monazite +	8.38		1.89	9.38			8.07		0.47	29.57	2.16							4.65		11.22	14.59	9.63								100	84
7	9	Rutile +	0.65	98.73		0.62																										100	122
7	10	Biotite	39.48	1.99	16.55	17.60		12.13			8.26																					96	122
7	11	Rutile +	8.96	90.67		0.37																										100	128
7	12	Muscovite	50.46	0.84	28.64	2.56		2.27			10.24																					95	127
7	13	Quartz	100.00																													100	140
7	14	Apatite				0.34			48.23			44.32		5.15																1.96		100	143
7	15	Biotite	39.78	2.03	15.93	17.77		11.93			8.56																					96	123
7	16	Quartz	100.00																													100	139
7	17	Monazite +	9.87						1.38			31.63	0.98	0.33								14.56	30.40	10.84								100	114
7	18	Albite	69.85		18.57					11.58																						100	132
7	19	Biotite	39.84	1.89	16.68	16.93		11.87			8.79																					96	121
7	20	Quartz	99.60			0.40																										100	136
7	21	Rutile +	0.72	98.74		0.53																										100	130
7	22	Muscovite	49.51	0.63	29.76	2.13		2.26			10.71																					95	125
7a	1	Biotite	38.63	1.87	16.39	18.77		12.32			8.03																					96	78
7a	2	Quartz	100.00																													100	89
7a	3	Chlorite	26.61		21.17	21.82		15.40																								85	72
7a	4	Apatite +	2.25						48.47		0.30	44.26		4.71																		100	87
7a	5	Zircon	31.32		0.57	0.58													67.53													100	86
7a	6	Rutile +	2.22	76.74	0.95	2.26		0.47	8.72			8.64																				100	80
7a	7	Apatite				0.42			47.74			44.30		5.15																2.38		100	92
7a	8	Apatite							48.47			43.85		5.67																2.00		100	91
7a	9	Chlorite	27.75		20.91	20.34		15.66			0.34																					85	73
7a	10	Apatite	0.78						48.54			44.57		4.82																1.28		100	91
7a	11	Xenotime +	22.58								1.15					1.85		59.27							2.97	6.01	4.22				1.95	100	53

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
7a	12	Albite	69.90		18.74					11.35																					100	87
7a	13	Apatite +	3.51		1.24				46.94	0.70	0.28	41.64		5.70																		100	89
7a	14	Chlorite	27.10		21.32	20.97		15.61																									85	72
7a	15	Muscovite	49.91	0.50	29.61	2.33		2.24			10.40																					95	79
8	1	Biotite	39.61	2.08	17.10	16.89		11.95			8.37																					96	127
8	2	Apatite							48.63			44.22		5.48																1.67		100	145
8	3	Rutile +	14.54	75.58	4.71	0.55				4.62																						100	145
8	4	Apatite +	6.40		2.61	0.36			43.79		1.06	40.33		5.45																		100	139
8	5	Quartz +	98.80		0.99						0.21																					100	147
8	6	Biotite	48.02	0.44	26.58	7.90		5.49			7.56																					96	130
8	7	Ap + Rt	1.75	37.82	0.84	1.13		0.55	31.64			26.27																			100	132
8	8	Rutile +	0.73	98.80		0.47																													100	131
8	9	Biotite	37.14	1.11	18.08	22.53		12.99			4.15																					96	123
8	10	Albite	70.07		18.35					11.58																						100	141
8	11	Biotite	38.56	1.94	17.07	18.44		12.37			7.61																					96	132
8	12	Biotite	39.78	1.99	15.96	17.40		12.14			8.72																					96	126
8	13	Biotite	39.37	2.05	16.40	17.31		12.17			8.70																					96	126
8	14	Quartz	100.00																														100	144
8	15	Quartz	100.00																														100	144
8	16	Rutile +	9.90	72.28	5.74	6.68		4.65			0.75																					100	131
8	17	Apatite							48.45			44.10		5.82																1.63		100	145
8	18	Rutile +	6.83	91.80	0.50	0.62					0.26																					100	132
8	19	Muscovite	49.34	0.60	29.87	2.90		2.01			10.28																					95	134
8	20	Muscovite	50.12	0.67	29.03	2.27		2.27		0.34	10.30																					95	128
8	21	Muscovite	50.66	0.65	28.92	2.24		2.19			10.33																					95	125
8	22	Biotite	38.41	1.88	17.51	18.41		12.66			7.12																					96	129
9	1	Biotite	39.59	2.05	16.10	17.51		12.00			8.75																					96	133
9	2	Biotite	39.56	2.06	16.68	17.65		11.76			8.28																					96	133
9	3	Bt + Chl	38.45	1.09	19.98	21.47		14.71			4.30																					100	117
9	4	Muscovite	47.11	0.76	33.07	2.13		1.04			10.90																					95	134
9	5	Muscovite	49.36	0.95	27.99	3.64		2.06		0.36	10.64																					95	130
9	6	Muscovite	54.21	0.48	25.12	1.94		1.57		0.41	11.27																					95	134
9	7	Apatite							49.19			44.48		4.78																1.55		100	149
9	8	Apatite							49.26			44.40		4.83																1.50		100	152
9	9	Apatite							48.50			44.65		5.24																1.62		100	141
9	10	Xenotime				0.94									2.76		73.08							3.41	6.36	6.76		6.69			100	79
9	11	Apatite	0.55						48.56			44.42		4.98																1.51		100	148
9	12	Quartz	100.00																														100	145
9	13	Monazite +	22.19		9.24	18.33		3.95	6.96		2.34	18.08	1.00										4.57	10.03	3.33								100	112
9	14	Rutile +	3.17	91.01	1.31	3.56		0.69			0.26																					100	125
9	15	Rutile +	1.19	97.83		0.98																													100	127
9	16	Muscovite	50.26		26.16	4.83		2.92			10.84																					95	130
9	17	Quartz	100.00																														100	148
9	18	Zircon +	29.97		1.22	0.89		0.44	1.20		0.38									64.10									1.79				100	137
9	19	Muscovite	49.07	0.67	30.33	2.57		2.18			10.19																					95	136
9	20	Muscovite	46.95	0.39	28.80	6.17		3.59			9.10																					95	123
9	21	Apatite				0.40			48.21		0.23	44.10		5.40																1.65		100	147
9	22	Biotite	38.09	2.32	17.16	19.39		12.64			6.38																					96	126
9	23	Apatite							49.00			44.58		4.78																1.63		100	148
9	24	Apatite							44.93			43.82		5.84								1.01	2.70							1.69		100	135
10	1	Biotite	43.64	1.63	20.76	12.06		8.95		0.36	8.61																					96	123
10	2	Apatite							48.73			44.71		5.03																1.53		100	138
10	3	Apatite	0.92			0.61			47.14			42.47	1.34	5.87																1.65		100	138
10	4	Monazite +				2.53			3.13			31.33	2.43								2.99		14.65	29.26	9.57							4.11		100	113

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
10	5	Apatite	0.79			0.35			48.40			44.37		4.55																1.55		100	133
10	6	Chlorite	27.19		20.52	20.98		16.31																								85	106
10	7	Quartz +	91.92		4.99	0.77		0.40			1.93																					100	133
10	8	Rutile +	15.37	83.89		0.51					0.23																					100	134
10	9	Quartz	100.00																													100	139
10	10	Muscovite	48.71	0.62	27.61	4.14		3.69			10.23																					95	123
10	11	Quartz	100.00																													100	134
10	12	Biotite	41.03	1.80	18.04	16.42		11.94			6.77																					96	112
10	13	Apatite	0.63						48.82		0.22	44.06		4.99																1.28		100	137
10	14	Quartz +	95.42		1.59	1.73		1.26																								100	124
10	15	Chlorite	27.12		20.64	21.57		15.67																								85	110
10	16	Rutile +	1.43	97.84		0.72																										100	120
10a	1	Apatite	0.49						48.47		0.26	44.27		5.10																1.40		100	144
10a	2	Xenotime +	15.27		8.08	3.12		2.41	4.95		2.16	28.63				0.94		29.66							1.57	3.22						100	125
10a	3	Apatite +	5.22		3.50	0.35		0.39	43.58		1.15	40.74		5.07																		100	144
10a	4	Zircon +	34.08		3.76	0.49		0.48			1.26								59.93													100	147
10a	5	Rutile +	3.92	90.10	2.16	2.19		1.64																								100	127
10a	6	Zircon +	33.33		4.62	0.85		0.73			1.28								57.26									1.92				100	143
10a	7	Rutile +	5.22	83.58	1.81						0.76	3.90											3.25	1.48								100	117
10a	8	Monazite +	39.31		8.32	0.87		0.86	1.17	1.30	1.36	16.69	1.12	0.59								7.63	14.89	5.90								100	123
10a	9	Chlorite	28.71		21.34	19.99		14.30			0.66																					85	121
10a	10	Quartz	100.00																													100	141
10a	11	Muscovite	49.86	0.54	26.49	4.70		3.94			9.46																					95	126
10a	12	Albite	69.00		19.20				0.45	11.34																						100	138
10a	13	Quartz	100.00																													100	142
11	1	Biotite	38.70	1.98	16.86	18.07		12.74			7.66																					96	125
11	2	Rutile +	0.82	97.96	0.46	0.75																										100	128
11	3	Rutile +	7.77	87.36	2.13	1.28		0.62			0.84																					100	126
11	4	Quartz	100.00																													100	144
11	5	K-Feldspar	66.44		17.60	0.30					15.66																					100	140
11	6	Apatite +	1.20						47.66		0.44	43.73		5.67																1.30		100	147
11	7	Zircon +	32.67			0.49													66.84													100	141
11	8	Chlorite	27.13		20.62	21.52		15.73																								85	115
11	9	Muscovite	50.26	0.86	29.05	2.12		2.00			10.70																					95	130
11	10	Albite	69.88		18.68					11.44																						100	137
11	11	Apatite							48.94		0.13	43.98		5.27																1.67		100	143
11	12	Rutile +	5.76	93.76		0.48																										100	131
11	13	Biotite	40.90	1.84	16.92	16.22		12.48			7.63																					96	123
11	14	Rutile +	9.81	88.72	0.46	0.54					0.46																					100	123
11	15	Rutile +	1.72	96.91	0.54	0.49					0.34																					100	122
11	16	Biotite	38.92	2.05	16.81	18.10		12.35			7.78																					96	120
11	17	Apatite +	2.11		1.58	0.30			46.81		0.47	42.48		4.68																1.57		100	138
11	18	Monazite +	35.16		15.68	1.64		2.48	2.90		4.17	11.00	0.85									6.89	13.45	5.79								100	109
11	19	Chlorite +	30.43		19.49	20.66		13.38			1.05																					85	103
11	20	Chlorite	27.46		21.13	20.80		15.42			0.20																					85	114
11	21	Apatite							48.68			44.26		5.46																1.59		100	139
12	1	Muscovite	46.92	0.91	32.30	2.96		0.72		0.34	10.84																					95	120
12	2	Biotite	39.67	1.97	15.82	17.62		12.34			8.59																					96	120
12	3	Rutile +	5.93	84.62	3.20	4.20		2.05																								100	114
12	4	Rutile +	0.71	98.79		0.50																										100	115
12	5	Ap + Rt	2.06	74.70	0.67	0.49			10.86		0.24	10.98																				100	121
12	6	Rutile +	1.40	98.06		0.54																										100	118
12	7	Apatite							48.61		0.23	44.57		5.19																1.41		100	137
12	8	Apatite							48.36			44.50		5.21																1.93		100	145

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
12	9	Biotite	38.84	1.75	16.77	18.45		12.55			7.65																					96	126
12	10	Quartz	100.00																													100	138
12	11	Biotite	38.85	2.06	16.87	17.94		11.86			8.42																					96	123
12	12	Rutile +	1.32	98.12		0.56																										100	123
12	13	Rutile +	2.59	96.87		0.54																										100	123
12	14	K-Feldspar	75.87	0.48	15.09	1.51		1.38			5.66																					100	141
12	15	Biotite	39.50	2.00	16.60	17.47		11.86			8.57																					96	121
12	16	Apatite +	3.61		1.91	0.46		0.36	45.69		0.67	42.19		5.10																		100	138
12	17	Rutile +	1.65	96.37	0.87	0.81					0.29																					100	119
12	18	Muscovite	48.37	0.60	28.91	4.00		3.47			9.65																					95	123
12	19	Apatite +	2.55		1.54	0.38			46.14		0.65	42.54		4.48																1.72		100	138
12a	1	Rutile +	9.99	71.72	5.59	7.47		4.71			0.53																					100	75
12a	2	Biotite	39.74	2.03	16.54	17.78		12.24			7.67																					96	73
12a	3	Quartz	100.00																													100	85
12a	4	Monazite +	37.53		19.18	6.36		5.39			6.58	10.06	0.70									3.02	8.15	3.03								100	67
12a	5	Biotite	37.58	1.73	17.89	20.13		12.84			5.82																					96	74
12a	6	Apatite	0.89		0.55				47.70		0.41	43.74		4.84																1.87		100	86
12a	7	Rutile +	1.82	97.50		0.68																										100	75
12a	8	Biotite	39.52	2.03	17.11	16.74		12.84			7.76																					96	77
12a	9	Muscovite	49.69	0.60	29.70	1.97		2.25			10.79																					95	76
12a	10	Quartz +	92.75		4.29	0.65		0.38			1.93																					100	83
12a	11	Quartz	100.00																													100	83
12a	12	Biotite	39.18	2.02	16.85	17.74		12.27			7.95																					96	77
12a	13	Muscovite	50.12	0.67	29.00	2.47		2.43			10.31																					95	76
12a	14	Chlorite	29.41		20.38	19.67		14.72			0.82																					85	69
13	1	Zircon	31.19																68.81													100	132
13	2	Monazite +	24.27		0.62				1.86			25.32	2.12									12.90	23.75	9.33								100	107
13	3	Rutile +	1.01	97.94		0.82					0.22																					100	117
13	4	Apatite	0.58						48.47			44.64		4.89																1.42		100	134
13	5	Apatite	0.76						48.96			43.96		4.94																1.37		100	133
13	6	Biotite	39.31	1.85	16.70	18.08		12.23			7.83																					96	107
13	7	Rutile +	11.01	82.79	3.13	1.42		0.86			0.79																					100	120
13	8	Biotite	39.65	2.32	16.92	17.83		11.83			7.45																					96	120
13	9	Quartz	100.00																													100	133
13	10	Muscovite	49.72	0.46	27.55	3.60		2.71			10.97																					95	121
13	11	Apatite	0.66			0.31			48.16		0.16	44.17		5.11																1.43		100	141
13	12	Rutile +	2.45	95.97	0.49	1.09																										100	122
13	13	Rutile +	1.09	97.56	0.48	0.87																										100	124
13	14	Biotite	40.55	1.99	16.44	17.02		11.90			8.09																					96	123
13	15	Apatite				0.35			48.60		0.17	44.34		4.85																1.69		100	138
13	16	Rutile +	0.72	98.66		0.62																										100	119
13	17	Rutile +	20.22	79.25		0.53																										100	119
13	18	Apatite	0.49						48.94			44.34		4.99																1.23		100	130
13	19	Rutile +	12.18	79.04	3.28	2.27		1.37		1.57	0.29																					100	121
13	20	Biotite	39.51	1.88	16.90	17.40		12.69			7.62																					96	113
13	21	Biotite	45.23	0.41	26.73	9.82		6.46			7.35																					96	111
13	22	Apatite +	2.31		0.72				47.74		0.45	43.67		5.10																		100	128
13	23	Apatite							48.12			44.84		5.27																1.77		100	129
13	24	Quartz	100.00																													100	128
13	25	Quartz	100.00																													100	132
13	26	Muscovite	48.31	1.08	29.21	3.27		2.49			10.64																					95	116
13	27	Apatite			0.53	0.48			48.05			43.88		5.30																1.75		100	133
13	28	Xenotime +	21.62			0.96					2.41					1.76	1.50	60.54							2.98	6.76					1.46	100	86
14	1	Apatite							48.86			44.68		4.89																1.57		100	144

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
14	2	Apatite							49.20			44.27		4.76																1.77		100	146
14	3	Biotite	40.27	2.02	15.81	17.07		11.77			9.06																					96	124
14	4	Rutile +	9.36	71.43	6.44	7.01		5.29			0.48																					100	128
14	5	Biotite	44.51	1.03	18.85	15.32		9.79			6.50																					96	117
14	6	Rutile +	27.98	68.36	1.39	1.09		1.18																								100	130
14	7	Apatite							48.39			44.04		5.85																1.72		100	143
14	8	Zircon	31.28																68.72													100	141
14	9	Zircon +	28.45		0.60	1.06		0.47	1.43										68.00													100	120
14	10	Biotite	39.65	1.91	16.43	17.37		12.48			8.16																					96	123
14	11	Muscovite	49.79	0.72	29.07	2.36		2.57			10.50																					95	125
14	12	Quartz	100.00																													100	140
14	13	Chlorite	27.17		20.71	20.99		16.13																								85	113
14	14	Apatite +	3.91		1.64				45.30		0.95	42.52		5.69																		100	136
14	15	Biotite	38.17	1.93	15.29	21.19		11.35			8.08																					96	117
14	16	Rutile +	32.94	65.87	0.70	0.48																										100	121
14	17	Biotite	41.80	1.74	17.05	16.21		12.07			7.13																					96	116
14	18	Rutile +	6.67	91.52	0.65	0.91					0.25																					100	125
14	19	Biotite	39.62	1.75	16.77	17.99		11.95			7.93																					96	115
14	20	Rutile +	7.41	90.19	0.85	0.94		0.60																								100	129
14	21	Quartz	100.00																													100	144
14	22	Biotite	39.12	2.02	17.20	17.97		12.87			6.82																					96	129
14	23	Apatite	0.46						48.94		0.16	44.44		4.50																1.51		100	149
15	1	Apatite							48.76			44.88		4.73																1.64		100	144
15	2	Apatite							48.78			44.54		5.12																1.56		100	139
15	3	Zircon	31.76																68.24													100	135
15	4	Biotite	39.23	1.86	16.19	17.69		12.07			8.97																					96	124
15	5	Biotite	39.76	1.82	17.16	17.37		11.78			8.11																					96	119
15	6	Biotite	40.82	1.95	16.61	16.28		12.07			8.28																					96	125
15	7	Quartz	100.00																													100	143
15	8	Quartz	100.00																													100	136
15	9	Apatite							48.90			44.40		5.13																1.57		100	136
15	10	Zircon +	29.07		1.47	1.15		0.46	1.17		0.40								64.69									1.58				100	121
15	11	Apatite	0.62						48.47		0.23	44.43		4.81																1.44		100	134
15	12	Quartz	100.00																													100	130
15	13	Quartz	100.00																													100	132
15	14	Biotite	39.91	1.81	16.20	17.39		12.48			8.22																					96	116
15	15	Muscovite	49.57	0.60	28.97	2.72		2.41			10.74																					95	118
15	16	Apatite	0.56						48.32		0.23	44.49		5.05																1.34		100	136
15	17	Rutile +	34.88	63.00	1.02	1.10																										100	113
15	18	Rutile +	4.18	93.70	0.62	1.50																										100	123
15	19	Muscovite	57.24	0.42	22.48	2.11		1.90		0.49	10.36																					95	118
15	20	Monazite +	45.77						1.25			15.95	1.07									9.42	19.83	6.71								100	136
16	1	Apatite +	1.56		0.87	1.52		0.84	46.17			42.59		4.88																1.57		100	139
16	2	Quartz	100.00																													100	128
16	3	Muscovite	49.00	0.58	29.63	2.98		1.99			10.82																					95	120
16	4	Biotite	39.27	2.24	16.61	17.79		12.03			8.06																					96	116
16	5	Quartz	100.00																													100	135
16	6	Apatite				0.36			47.86			44.16		5.63																1.99		100	134
16	7	Monazite +	22.29		4.88	4.77		4.89	33.91			29.26																				100	132
16	8	Biotite	42.60	1.55	17.15	15.72		11.68			7.31																					96	117
16	9	Muscovite	47.90	0.64	31.26	2.45		1.81		0.33	10.60																					95	123
16	10	Chlorite	26.69		20.93	21.12	0.39	15.86																								85	113
16	11	Biotite	39.51	1.91	16.04	18.11		11.93			8.50																					96	122

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
16	12	Bt + Rt	27.73	29.64	13.40	15.30		10.71			3.22																					100	124
16	13	Apatite +	6.07						46.31			42.68		4.95																		100	144
16	14	Quartz	100.00																													100	131
16	15	K-Feldspar	71.01	0.46	17.95	2.21		1.75			6.63																					100	121
16	16	Muscovite	53.09		25.87	3.13		2.77			10.14																					95	115
16	17	Biotite	39.65	2.03	16.41	17.42		11.82			8.68																					96	117
16	18	Biotite	42.24	0.45	25.84	11.05		9.97			6.44																					96	116
17	1	Biotite	38.29	1.97	16.49	18.92		12.31			8.02																					96	124
17	2	Rutile +	11.00	77.97	7.14	1.05		0.69		0.38	1.78																					100	133
17	3	Quartz +	94.34		3.45	0.47		0.35			1.39																					100	132
17	4	Muscovite	61.89	0.36	20.19	2.59		1.90			8.06																					95	130
17	5	Biotite	39.52	2.16	16.30	17.43		12.18			8.40																					96	120
17	6	Apatite	0.46						48.53			44.13		5.43																1.45		100	139
17	7	Rutile +	9.32	89.45	0.63	0.60																										100	120
17	8	Quartz	100.00																													100	140
17	9	Apatite	0.60			0.44			48.26			44.26		4.94																1.51		100	144
17	10	Biotite	41.63	1.84	16.57	15.74		11.99		0.38	7.84																					96	123
17	11	Albite	69.73		18.85				0.20	11.22																						100	133
17	12	Ms + Qz	67.30	0.50	20.40	2.01		2.14			7.66																					100	131
17	13	Rutile +	3.87	92.79	1.75	0.81					0.78																					100	121
17	14	Biotite	38.91	3.18	16.66	17.57		12.18			7.51																					96	116
17	15	Quartz	100.00																													100	134
17	16	Muscovite	49.55	0.75	27.88	3.33		3.07			10.42																					95	118
17	17	Rutile +	11.89	87.51		0.60																										100	120
17	18	Biotite	39.07	1.99	16.79	17.61		12.32			8.22																					96	121
17	19	Quartz	100.00																													100	137
17	20	Biotite	38.06	1.81	17.36	18.89		13.08			6.80																					96	121
17	21	Rutile +	1.92	83.62		0.52			6.76			7.18																				100	127
17	22	Biotite	39.25	2.67	16.71	17.09		12.01			8.27																					96	123
17	23	Muscovite	49.39	0.81	29.46	2.39		2.35			10.60																					95	126
17	24	Rutile +	11.10	75.28	6.37	3.28		2.74			1.23																					100	125
17	25	Rutile +	1.00	98.08		0.68					0.24																					100	128
17	26	Rutile +	2.72	96.89		0.39																										100	124
17	27	Biotite	39.12	1.95	16.23	17.70		12.30			8.70																					96	124
17	28	Monazite +	8.53		5.65				2.09		1.38	37.21	1.40								1.75		30.83	11.31								100	94
17	29	Chlorite	27.60		19.09	21.30		17.01																								85	112
17	30	Rutile +	0.93	98.39		0.69																										100	127
18	1	Apatite							48.81			44.34		5.38																1.47		100	149
18	2	Apatite							48.89			44.48		5.04																1.60		100	149
18	3	Zircon +	31.44		1.69	0.70					0.39								64.33									1.45				100	149
18	4	Biotite	40.10	1.92	16.04	17.00		12.31			8.62																					96	124
18	5	Muscovite	57.33	0.28	22.08	4.38		2.60		2.34	5.99																					95	122
18	6	Biotite	40.08	1.97	15.75	17.31		12.01			8.89																					96	130
18	7	Rutile +	5.15	91.11	1.84	1.15					0.75																					100	128
18	8	Rutile +	2.00	96.09	0.98	0.63					0.30																					100	130
18	9	Apatite +	4.60		3.05	0.50		0.32	45.34		0.99	41.27		3.92																		100	143
18	10	Biotite	38.87	1.97	16.51	18.22		11.98			8.44																					96	133
18	11	Rutile +	2.33	91.33	1.46	0.90			2.00		0.50	1.48																				100	135
18	12	Apatite				0.35			48.65			44.67		4.89																1.44		100	150
18	13	Rutile +	12.59	75.08	8.60	0.92		0.74			2.07																					100	140
18	14	Rutile +	13.64	74.33	2.82	6.45		1.06	0.46	0.76	0.47																					100	112
18	15	Biotite	40.10	1.98	15.81	17.16		12.05			8.90																					96	128
18	16	Muscovite	48.83	0.60	29.05	3.60		2.87			10.05																					95	128

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
18	17	Biotite	38.52	2.09	17.16	18.60		12.30			7.34																					96	126
18	18	Zircon +	32.59			0.48													66.92													100	132
18	19	Rutile +	7.76	85.09	4.55	0.90					1.70																					100	127
18	20	Rutile +	1.56	96.58	0.66	0.96					0.23																					100	125
18	21	Biotite	41.56	1.33	17.88	16.96		12.21			6.05																					96	120
18	22	Quartz	100.00																													100	139
18	23	Muscovite	49.74	0.81	28.59	2.83		2.48			10.55																					95	123
18	24	Muscovite	48.67	0.54	28.03	4.96		3.43			9.38																					95	120
18	25	Rutile +	2.33	96.33		0.94					0.39																					100	126
18	26	Biotite	39.15	2.05	16.42	17.82		12.34			8.23																					96	132
18	27	Muscovite	49.33	0.60	29.50	2.87		2.57			10.13																					95	134
18a	1	Rutile +	1.00	98.46		0.53																										100	79
18a	2	Apatite	0.56						47.82		0.27	43.54		6.23																1.58		100	91
18a	3	Biotite	38.84	2.10	16.66	17.68		12.35			8.37																					96	78
18a	4	Quartz	100.00																													100	87
18a	5	Quartz	100.00																													100	87
18a	6	Chlorite	27.50		19.95	21.25		16.30																								85	73
18a	7	Muscovite	49.69		30.09	2.33		2.36			10.55																					95	79
18a	8	Chlorite	27.52		20.73	20.66		15.84			0.26																					85	73
18a	9	Muscovite	49.27	0.67	28.21	3.25		3.26			10.36																					95	78
18a	10	Muscovite	49.50	0.66	30.09	2.19		2.00			10.56																					95	80
18a	11	Rutile +	3.35	91.63	2.22	1.21		1.11			0.48																					100	81
18a	12	Zircon +	46.67	0.57	15.70	3.79		2.14	0.69		6.02								24.41													100	70
19	1	Apatite							48.39			44.19		5.65																1.78		100	139
19	2	Biotite	39.27	2.04	16.31	18.29		11.77			8.32																					96	125
19	3	Rutile +	3.23	90.35	2.18	2.07		2.17																								100	124
19	4	Biotite	38.91	1.82	16.65	18.77		13.07			6.78																					96	121
19	5	Rutile +	15.96	79.79	2.11	0.93		0.51			0.69																					100	122
19	6	Apatite	0.75						48.34			43.89		5.77																1.25		100	143
19	7	Quartz	100.00																													100	139
19	8	Muscovite	49.27	0.62	27.68	3.34		3.13			10.95																					95	125
19	9	Zircon +	31.47		2.29	0.66			0.68		0.72								64.17													100	124
19	10	Rutile +	1.91	97.45		0.64																										100	118
19	11	FeO +	21.22		7.10	63.17		2.21	0.89	2.14	1.20	1.71			0.36																	100	95
19	12	Rutile +	1.89	96.57	0.69	0.56					0.30																					100	115
19	13	Apatite					0.33		48.00		0.19	44.47		5.58																1.43		100	136
19	14	Rutile +	2.50	96.64		0.64					0.22																					100	119
19	15	Biotite	38.94	2.13	16.56	18.05		11.88			8.44																					96	120
19	16	Quartz	99.48		0.52																											100	135
19	17	Biotite	39.29	1.95	16.20	17.83		12.40			8.32																					96	118
19	18	Chlorite	27.25		20.62	20.97		16.16																								85	108
19	19	Quartz +	97.29		2.08						0.63																					100	133
19	20	Quartz	100.00																													100	131
19	21	Biotite	37.85	1.29	17.88	21.69		8.66			8.64																					96	118
19	22	Biotite	39.84	1.94	16.48	16.81		12.29			8.63																					96	121
19	23	Rutile +	1.04	98.23		0.72																										100	125
19	24	Apatite	0.51			0.39			48.25		0.22	44.26		4.70																1.66		100	139
19	25	Biotite	39.37	2.03	16.27	17.73		12.30			8.30																					96	121
19a	1	Biotite	40.08	2.11	15.63	17.52		12.77			7.90																					96	79
19a	2	Apatite	0.55		0.37				48.41		0.28	43.57		5.30																1.52		100	93
19a	3	Apatite	1.52		0.87	0.42			47.27		0.40	42.72		5.13																1.67		100	93
19a	4	Quartz	99.09		0.70						0.20																					100	88
19a	5	Muscovite	50.06		30.61	1.88		1.84			10.61																					95	81
19a	6	Chlorite +	38.08		18.37	14.01		10.12	0.38	4.04																						85	75

Table 9.1. EDS chemical analyses of sample OD2016-D2-002-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	Y2O3	ZrO2	Ag2O	Cs2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	HfO2	Ta2O5	WO3	PbO	Total	Actual Total
19a	7	Rutile +	14.50	85.03		0.46																										100	86
19a	8	Monazite +	40.73		16.99	1.29		2.35	1.57	0.72	4.11	11.73										5.61	10.51	4.38								100	71
19a	9	Apatite	5.39		2.65	0.43		0.39	44.46		0.98	41.17		4.53																		100	91
19a	10	Muscovite	48.75	0.68	29.72	3.02		2.51			10.32																					95	80
19a	11	Chlorite	30.77		19.65	19.49		14.49			0.60																					85	71
20	1	Quartz	100.00																													100	138
20	2	Mixture	64.27	24.78	3.38	3.98		3.58																								100	111
20	3	Rutile +	3.05	93.94	1.76	0.67					0.59																					100	127
20	4	Apatite							48.81		0.21	44.54		4.77																1.68		100	141
20	5	Apatite							48.99			44.43		4.90																1.69		100	143
20	6	Rutile +	3.40	84.98	0.65	0.50			5.27		0.27	4.93																				100	127
20	7	Rutile +	1.79	95.64	0.76	1.34		0.48																								100	124
20	8	Apatite	0.61						48.56		0.28	44.20		5.04																1.32		100	144
20	9	Apatite	0.58						48.50			44.40		5.18																1.34		100	142
20	10	Rutile +	1.00	98.48		0.52																										100	128
20	11	Apatite	0.54			0.32			48.69			43.96		4.92																1.57		100	145
20	12	Rutile +	3.79	92.15	1.86	0.90		0.63			0.67																					100	129
20	13	Rutile +	16.84	82.67		0.48																										100	124
20	14	Rutile +	13.36	78.41	4.78	0.75		0.58			2.13																					100	127
20	15	Rutile +	43.26	55.91		0.48			0.35																							100	143
20	16	Apatite	0.54						48.66			44.14		5.30																1.36		100	143
20	17	Rutile +	6.48	80.63	3.97	5.16		3.75																								100	121
20	18	Monazite +	1.35		0.76				6.70			34.78	3.16	0.75								13.26	25.42	10.16						3.65		100	123
20	19	Apatite	0.51		0.34				48.22			44.15		5.10																1.68		100	134
20	20	Biotite	40.43	2.04	16.66	16.91		13.09			6.87																					96	116
20	21	Quartz	100.00																													100	134
20	22	Muscovite	56.95	0.67	24.78	2.05		1.87			8.67																					95	125
20	23	Quartz	100.00																													100	141
20	24	Biotite	37.74	3.22	17.34	18.49		13.18			6.04																					96	125
20	25	Apatite +	3.71		0.96				46.17		0.70	43.13		5.33																		100	141
20	26	Quartz	99.02		0.75						0.23																					100	133
20	27	Muscovite	48.43	0.81	28.55	3.45		3.81			9.96																					95	126
20	28	Biotite	44.40	0.95	21.99	12.35		8.84			7.47																					96	116
20	29	Apatite	0.61			0.36			48.50		0.26	43.88		5.10																1.29		100	141
20a	1	Rutile +	1.31	97.88		0.81																										100	126
20a	2	Apatite							48.61		0.23	44.13		5.32																1.71		100	144
20a	3	Apatite	0.72						48.66			44.10		5.20																1.32		100	143
20a	4	Rutile +	1.43	97.80		0.56					0.22																					100	129
20a	5	Apatite							48.39			44.44		5.30																1.88		100	143
20a	6	Ap + Rt	1.92	68.77	0.68	0.48			11.95		0.41	12.21		3.58																		100	135
20a	7	Apatite +	5.49		3.84	4.48		3.14	43.29			39.76																				100	130
20a	8	Rutile +	1.10	97.73	0.50	0.45					0.22																					100	128
20a	9	Apatite			0.37				48.20		0.20	43.74		5.60																1.88		100	147
20a	10	Rutile +	11.00	74.20	5.73	4.27		4.47			0.33																					100	130
20a	11	Monazite +	27.56		14.02	1.00		1.43	1.22		4.29	18.29	1.08									8.60	16.20	6.31								100	127
20a	12	Chlorite	27.22		20.47	20.85		16.46																								85	116
20a	13	Biotite	39.52	1.71	16.99	18.38		13.16			6.23																					96	122
20a	14	Muscovite	49.83	0.80	28.95	2.37		2.58			10.48																					95	128
20a	15	Biotite	59.72	0.51	24.01	1.76		1.63			8.37																					96	135
20a	16	Quartz	100.00																													100	142

Appendix 9.2: OD2016-D
data.

Table 9.2. EDS chemical analyses of sample OD2016-D2-005.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	F	Cl	ZrO2	WO3	Total	Actual Total
1	1	Quartz	100.00														100	116
1	2	Biotite	39.23	2.32	16.19	20.36		9.20			8.70						96	104
1	3	Biotite	39.39	2.17	17.01	19.37		9.34		0.38	8.32						96	104
1	4	Biotite	39.02	2.12	17.02	20.28		9.47			8.09						96	102
1	5	Muscovite +	56.56	0.49	23.47	3.19		2.15			9.14						95	116
1	6	Mixture	25.97	58.08	10.95	1.21		1.27	0.29	0.58	1.32			0.33			100	108
1	7	Ilmenite	1.10	53.81	0.46	38.74	5.64				0.26						100	98
1	8	Zircon	31.24												68.76		100	109
1	9	Apatite +	0.83		0.40				47.68			43.86	5.63			1.59	100	117
1	10	Quartz	100.00														100	110
1	11	Apatite +	0.61						48.29			44.69	5.15			1.26	100	113
1	12	Biotite	38.90	2.31	17.02	19.94		9.29			8.53						96	94
1	13	Muscovite	49.74	0.69	29.33	2.67		2.15			10.42						95	118

Appendix 9.3: OD2016-D2
data.

Table 9.3. EDS chemical analyses of sample OD2016-D2-011-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	ZrO2	La2O3	Ce2O3	Nd2O3	Yb2O3	HfO2	Total	Actual Total
1	1	Quartz	100.00																		100	50
1	2	Muscovite +	57.48	0.65	26.50	2.83		1.65	0.81	0.53	9.54										100	43
1	3	Rutile +	1.92	97.45		0.63															100	48
1	4	Ilmenite	0.96	52.90	0.69	43.24	2.21														100	49
1	5	Zircon	31.20												68.80						100	55
1	6	Ilmenite		53.46		42.45	4.09														100	50
1	7	Ilmenite +	0.88	45.15		35.37	1.47		8.05			9.07									100	51
1	8	Rutile +	0.89	98.55		0.56															100	50
1	9	Zircon	31.25												68.75						100	61
1	10	Ilmenite		53.95		43.01	3.04														100	52
1	11	Ilmenite +	12.90	41.98	9.65	29.88	2.73	0.69			2.16										100	60
1	12	Rutile +	20.18	78.17	0.61	1.05															100	59
1	13	Rutile +	4.91	90.61	3.64						0.83										100	59
1	14	Zircon	31.26												68.74						100	66
1	15	Ilmenite		53.81		43.65	2.54														100	57
1	16	Ilmenite +	2.40	51.71	1.26	42.30	2.03				0.30										100	53
1	17	Ilmenite		54.14		40.91	4.96														100	54
1	18	Rutile	0.67	98.85		0.48															100	58
1	19	Biotite	42.09	3.04	18.58	24.02		7.32			9.09										96	59
2	1	Rutile +	5.75	89.51	3.10	0.51					1.13										100	98
2	2	Biotite	41.97	2.74	18.64	24.37		7.37			9.11										96	107
2	3	K-Feldspar + Albite	65.93		18.01					2.40	13.66										100	118
2	4	Quartz	100.00																		100	122
2	5	Ilmenite		54.07		43.07	2.86														100	107
2	6	Ilmenite	0.48	53.82		43.32	2.38														100	110
2	8	Rutile	0.59	99.41																	100	109
2	9	Zircon	30.71		1.18	0.76			0.41		0.37				65.01					1.57	100	112
2	10	Rutile +	2.94	94.48	1.44	0.41					0.73										100	106
2	11	Zircon	27.88		0.78	2.10		0.51	1.69						65.28					1.76	100	98
2	12	Ilmenite		54.67		40.13	5.20														100	105
2	13	Chlorite +	36.14	2.17	18.43	29.77		11.75		0.65	0.51		0.57								100	91
2	14	REE carbonate	1.37			0.88			24.39					14.92		14.36	31.31	12.76			100	67
2	15	Rutile +	0.96	98.37		0.67															100	103
2	16	Biotite	41.18	2.85	18.68	24.69		7.65			9.13										96	104
2	17	Zircon	31.15												68.85						100	113
2	18	Ilmenite +	2.11	52.47	1.14	41.44	2.50				0.33										100	99
2	19	Ilmenite		54.10		43.11	2.79														100	102
3	1	Quartz	100.00																		100	111
3	2	Muscovite	52.25	0.75	38.05	1.59		0.62		0.51	11.49										95	103
3	3	Ilmenite		53.58		44.42	2.00														100	100
3	4	Zircon	31.08												68.92						100	116
3	5	Altered Ilmenite		86.53		12.98	0.48														100	108
3	6	Ilmenite		54.01		43.76	2.23														100	106
3	7	Zircon	31.05												68.95						100	121
3	8	Rutile +	1.68	96.64	0.98	0.38					0.32										100	106
3	9	Ilmenite		53.63		42.43	3.94														100	103
3	10	Ilmenite +	1.42	52.48	0.79	43.33	1.98														100	107

Table 9.3. EDS chemical analyses of sample OD2016-D2-011-1.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	ZrO2	La2O3	Ce2O3	Nd2O3	Yb2O3	HfO2	Total	Actual Total
3	11	Zircon	30.98												67.51					1.51	100	125
3	12	Rutile	0.47	99.53																	100	112
3	13	Ilmenite +	0.98	54.22		39.42	5.38														100	109
3	14	Zircon	31.40												68.60						100	125
3	15	Ilmenite		54.04		43.82	2.15														100	110
3	16	Ilmenite	0.58	53.42		43.76	2.23														100	114
3	17	Rutile +	0.65	98.79		0.57															100	113
4	1	Zircon	30.91												67.63					1.46	100	109
4	2	Rutile	0.67	98.50		0.83															100	99
4	3	Ilmenite +	1.11	53.87		43.11	1.90														100	98
4	4	Rutile +	4.39	91.20	2.72	1.01					0.67										100	98
4	5	Biotite	41.58	2.59	18.78	24.62		7.51			9.11										96	103
4	6	Zircon	31.16												68.84						100	114
4	7	Zircon	30.85												69.15						100	110
4	8	Apatite +	3.85		2.85	3.96		1.51	44.66		0.24	42.94									100	107
4	9	Rutile +	4.69	91.06	2.65	0.79					0.81										100	95
4	10	Rutile	0.88	98.80					0.31												100	89
4	11	Biotite	41.77	2.76	18.49	24.48		7.58			9.08										96	100
4	12	K-Feldspar	66.75		17.65						15.60										100	105
4	13	Quartz +	88.48		4.27	3.46		0.62		0.63	1.82		0.71								100	77
4	14	Biotite	41.88	2.59	18.34	24.13		7.84			9.41										96	90
4	15	Quartz	100.00																		100	104.82

Appendix 9.4: OD2016-D2

data.

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
1	1	Quartz	100.00																						100	123
1	2	Albite	69.30		18.83				0.23	11.64															100	120
1	3	Biotite	38.11	2.44	16.36	22.40		7.69			9.01														96	112
1	4	Kfs	66.42		17.62					0.40	15.55														100	121
1	5	Rutile	1.06	98.42	0.52																				100	110
1	6	Muscovite	48.34	0.91	30.05	3.71		1.23			10.77														95	107
1	7	Kfs	66.40		17.65					0.32	15.63														100	112
1	8	Calcite	0.66			1.23	0.64	0.39	53.09																56	58
1	9	Ab+Kfs	63.26		22.78	1.25		0.75		7.96	4.01														100	115
1	10	Biotite	37.17	2.45	17.56	24.07		8.00			6.76														96	107
1	11	Monazite +	9.93		3.62	7.59		1.92	7.77		0.84	15.88		5.48				2.75		11.22	24.03	9.16			100	69
1	12	Albite	67.88		19.98				1.37	10.77															100	123
1	13	Calcite	0.83			1.11	0.78		53.28																56	55
1	14	Albite	69.19		18.94				0.50	11.14	0.23														100	112
1	15	Biotite	37.83	2.55	17.09	22.94		7.50			8.09														96	105
1	16	Kfs	66.33		17.74						15.93														100	116
1	17	Quartz	100.00																						100	119
1	18	Muscovite	49.15	0.67	29.73	3.01		1.78			10.66														95	105
1a	1	K-Feldspar	66.32		18.49						15.19														100	138
1a	2	Biotite	37.15	2.94	16.71	22.91		7.77			8.52														96	137
1a	3	Muscovite	46.88	0.64	32.25	3.41		1.30			10.52														95	136
1a	4	Calcite	2.74			2.44	1.78	0.68	92.37																100	136
1a	5	Muscovite	46.95	0.61	32.00	3.06		1.74		0.38	10.27														95	128
1a	6	Albite	68.36		19.06					12.59															100	126
1a	7	K-Feldspar	65.61		18.32				1.56		14.52														100	130
1a	8	Muscovite	47.82	0.63	31.83	2.55		1.65			10.53														95	99
1a	9	Quartz	100.00																						100	132
1a	10	Chlorite	26.24		18.52	28.18		12.06																	85	123
2	1	Quartz	100.00																						100	117
2	2	Albite	69.53		18.94				0.25	11.28															100	115
2	3	Calcite	0.62			1.11	0.83		53.44																56	52
2	4	Biotite	38.42	2.17	16.81	22.20		7.91			8.49														96	98
2	5	Calcite				0.83	0.53		54.64																56	51
2	6	Biotite	38.35	2.32	16.52	22.46		7.58			8.78														96	101
2	7	Muscovite	49.13	0.59	29.13	3.45		1.91		0.36	10.43														95	101
2	8	Kfs	66.34		17.66					0.58	15.42														100	105
2	9	Calcite	0.91			0.87	0.64		53.58																56	53
2	10	Rutile +	1.11	98.45		0.44																			100	104
2	11	Biotite	38.21	2.31	16.62	22.43		8.06			8.37														96	104
2	12	Rutile	1.60	97.49	0.48	0.43																			100	106
2	13	Biotite	37.29	2.68	16.73	23.09		7.64			8.57														96	104
2	14	Biotite	38.26	2.45	16.64	22.50		7.67			8.49														96	103
2	15	Kfs	66.23		17.84						15.93														100	112
2	16	Muscovite	49.09	0.63	30.12	2.71		1.72			10.74														95	108
2	17	Quartz	100.00																						100	112
2	18	Albite	69.69		18.56					11.46	0.30														100	115
2	19	Albite	69.63		18.79				0.38	11.20															100	112

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
2	20	Quartz	100.00																						100	115
2	21	Quartz	100.00																						100	114
2	22	Albite	69.39		18.73				0.43	11.46															100	118
3	1	Apatite							49.43			44.33		4.48										1.76	100	120
3	2	Quartz	100.00																						100	120
3	3	Calcite	0.58			1.08	0.74		53.60																56	57
3	4	Biotite	39.11	1.79	17.20	22.87		7.97			7.06														96	101
3	5	Kfs	66.56		17.89						15.56														100	113
3	6	Biotite	38.01	2.79	16.60	22.47		7.51			8.62														96	104
3	7	Biotite	38.49	2.54	15.89	23.04		7.73			8.30														96	107
3	8	Biotite	37.81	2.39	15.68	23.10		7.93			9.09														96	105
3	9	Calcite				1.08	0.64	0.40	53.88																56	57
3	10	Muscovite	49.72	0.66	29.78	2.48		1.64			10.72														95	108
3	11	Biotite	38.42	1.85	17.55	22.69		8.63			6.85														96	109
3	12	Kfs	66.63		17.53						15.84														100	108
3	13	Biotite	38.89	1.61	17.07	21.91		7.96			8.55														96	106
3	14	Albite	69.85		18.56					11.59															100	115
3	15	Albite	71.09		17.94					10.97															100	121
3	16	Albite	70.26		19.04					9.90	0.80														100	110
3	17	Muscovite	49.35	0.88	29.22	2.89		1.87			10.78														95	105
3a	1	Kfs	66.59		17.61						15.80														100	116
3a	2	Albite	69.62		19.06					11.32															100	117
3a	3	Albite	69.22		19.09				0.63	11.06															100	117
3a	4	Biotite	38.47	1.91	16.79	22.16		8.10			8.57														96	105
3a	5	Biotite	40.06	1.98	16.33	21.34		8.37			7.93														96	107
3a	6	Muscovite	49.37	0.52	29.81	2.80		1.67			10.82														95	106
3a	7	Biotite	42.07	2.08	15.79	20.85		7.39			7.81														96	113
3a	8	Albite	68.20		21.10	1.78		1.91		4.42	2.59														100	93
3a	9	Albite	69.27		19.18					11.08	0.47														100	116
3a	10	Biotite	38.26	1.73	17.20	23.99		7.82			7.00														96	102
3a	11	Muscovite	48.03		33.12	1.71		0.66		0.34	11.14														95	110
3a	12	Quartz	100.00																						100	119
3a	13	Albite + FeO	41.55		13.84	35.06		1.09	0.77	7.08	0.60														100	99
3a	14	Albite + Pyrite	25.78		8.01	25.84			0.37	5.64			34.37												100	173
4	1	Quartz	100.00																						100	115
4	2	Biotite	37.79	2.42	16.57	23.50		7.73			8.00														96	97
4	3	Albite	70.01		18.58					11.41															100	112
4	4	Calcite	0.73			1.07	0.77		53.44																56	52
4	5	Biotite	37.45	2.38	16.55	24.62		7.91			7.08														96	98
4	6	Rutile +	2.28	97.18	0.54																				100	106
4	7	Biotite	38.71	2.38	16.27	22.31		7.66			8.67														96	104
4	8	Ilmenite +	1.67	52.68		42.09	3.56																		100	102
4	9	Ilmenite +	1.52	53.13		42.52	2.82																		100	104
4	10	Ilmenite +	1.23	52.86		42.66	3.25																		100	103
4	11	Monazite + qtz	36.62		20.39	3.80		1.49			7.84	11.79		0.33						4.62	9.82	3.29			100	97
4	12	Ilmenite	1.14	52.82		43.20	2.85																		100	104
4	13	Ilmenite	1.57	54.41		40.82	3.21																		100	97

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
4	14	Calcite	0.59			0.75	0.82		53.84																56	57
4	15	Kfs	66.44		17.47						16.09														100	115
4	16	Biotite	36.97	2.21	16.87	25.23		8.26			6.47														96	102
4	17	Calcite				0.80	0.76		54.44																56	55
4	18	Biotite	37.61	2.50	16.44	23.96		7.70			7.79														96	100
4	19	Kfs	66.12		17.92					0.30	15.66														100	112
4	20	Biotite	38.89	1.62	16.51	22.34		8.22			8.41														96	104
4	21	Albite	69.59		18.93				0.37	11.11															100	114
4	22	Biotite	37.94	2.33	17.28	22.79		7.61			8.04														96	103
4	23	Bt+Ms	54.62	1.11	24.52	7.60		3.24			8.92														100	95
4	24	Biotite	39.96	0.97	16.39	22.01		8.41			8.26														96	101
4	25	Kfs	63.46		19.54	0.38				0.50	14.57								1.54						100	107
4	26	Kfs	66.23		17.72					0.34	15.71														100	111
4	27	Albite	69.35		19.04				0.32	11.29															100	110
4	28	Biotite	38.89	2.72	17.01	21.15		7.60			8.64														96	101
4	29	Muscovite	49.83	0.82	28.98	2.79		1.89			10.70														95	107
4	30	Biotite	36.02	2.18	17.36	26.69		8.26			5.50														96	101
4	31	Muscovite	49.22	0.69	29.40	2.89		1.90			10.90														95	107
4	32	Kfs	66.02		17.78					0.42	15.78														100	119
4	33	Calcite	0.77			1.13	0.83		53.27																56	58
4	34	Albite	70.05		18.55					11.14	0.26														100	120
5	1	Ilmenite +	1.73	52.70		43.58	2.00																		100	107
5	2	Calcite	0.65			0.91	0.68		53.77																56	54
5	3	Quartz	100.00																						100	117
5	4	Biotite	38.43	2.37	16.73	22.33		7.61			8.52														96	110
5	5	Ilmenite	0.97	53.11		42.03	3.90																		100	110
5	6	Ilmenite	1.08	52.96		42.95	3.01																		100	109
5	7	Muscovite	49.18	0.55	29.86	3.08		1.69			10.65														95	109
5	8	Biotite	37.47	2.58	16.68	23.55		7.54			8.19														96	103
5	9	Kfs	66.04		17.69					0.31	15.96														100	115
5	10	Albite	69.61		18.90				0.24	11.24															100	115
5	11	Kfs	65.77		17.62				0.84	0.34	15.43														100	116
5	12	Biotite	38.26	2.31	16.89	21.94		7.66			8.94														96	107
5	13	Rutile +	1.20	98.80																					100	107
5	14	Rutile	0.97	98.56		0.47																			100	106
5	15	Biotite	38.19	2.64	16.66	22.83		7.56		0.42	7.71														96	111
5	16	Muscovite	48.29	0.86	28.40	4.78		2.11			10.56														95	113
5	17	Quartz	100.00																						100	120
5	18	Albite	69.27		19.05				0.60	11.08															100	119
5	19	Quartz	100.00																						100	125
5	20	Kfs	66.54		17.63					0.61	15.22														100	120
5	21	Muscovite	52.00	0.60	27.12	1.90		1.22			12.17														95	107
5	22	Muscovite	49.03	0.77	28.80	3.68		2.02			10.70														95	105
5	23	Calcite	0.94			0.74	0.71		53.61																56	57
5	24	Biotite	48.20	1.79	13.75	18.19		7.37			6.70														96	103
6	1	Albite	69.87		18.38					11.45	0.30														100	116
6	2	Albite	69.00		19.61					10.49	0.89														100	111

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
6	3	Biotite	36.89	2.54	16.57	25.50		8.03			6.46														96	104
6	4	Muscovite	49.31	0.70	29.93	2.78		1.69			10.58														95	110
6	5	Kfs	66.73		17.58						15.69														100	115
6	6	Mix	34.00	13.46	16.24	22.80		7.41			6.09														100	107
6	7	Biotite	38.47	2.57	16.62	21.99		7.37			8.98														96	108
6	8	Quartz	100.00																						100	122
6	9	Kfs	66.62		17.33						16.05														100	118
6	10	Albite	69.61		18.70				0.40	11.29															100	119
6	11	Muscovite	50.16	0.47	29.18	2.71		1.90		0.32	10.26														95	112
6	12	Albite	67.55		20.78	0.49				9.68	1.50														100	117
6	13	Calcite				1.18	0.69		54.13																56	57
6	14	Muscovite	55.46	0.60	25.63	2.37		1.60		0.31	9.03														95	109
6	15	Apatite	0.63						48.85			44.45		4.71										1.35	100	119
6	16	Ilmenite +	2.16	51.64	0.60	43.21	2.39																		100	103
6	17	Chlorite	26.78		18.91	28.99		10.32																	85	97
6	18	Calcite	1.04			0.85	0.66	0.41	53.04																56	57
6	19	Kfs	66.49		17.65						15.87														100	112
6	20	Calcite	0.93			0.85	0.64	0.41	53.17																56	54
6	21	Muscovite	49.20	0.53	29.68	3.33		1.74			10.52														95	102
6	22	Albite	68.69		19.52	0.28				11.05	0.45														100	113
6	23	Muscovite	51.79	0.48	27.57	3.66		1.79			9.72														95	103
6	24	Quartz	100.00																						100	118
6	25	Muscovite	48.93		31.16	2.54		1.40			10.98														95	104
7	1	Albite	69.86		18.60					11.54															100	115
7	2	Albite	69.23		19.06				0.29	11.07	0.35														100	118
7	3	Albite	69.31		18.91				0.35	11.43															100	118
7	4	Kfs	66.16		17.89					0.39	15.56														100	112
7	5	Muscovite	49.34	0.69	29.41	2.86		1.86		0.47	10.37														95	109
7	6	Muscovite	49.70	0.33	30.49	2.48		1.58			10.42														95	108
7	7	Apatite	0.84						48.30			43.77		5.47										1.62	100	123
7	8	Biotite	37.66	2.41	16.91	23.21		7.74			8.07														96	101
7	9	Biotite	35.73	2.29	17.50	26.58		8.23			5.66														96	103
7	10	Bt+Ms	46.62	0.84	26.49	12.90		4.45			8.70														100	107
7	11	Biotite+	33.07	11.90	15.64	21.95		7.20			6.25														96	109
7	12	Kfs	66.02		18.03					0.30	15.65														100	117
7	13	Quartz	100.00																						100	124
7	14	Kfs	66.33		17.70						15.96														100	114
7	15	Biotite	44.22	1.62	17.07	17.01		6.22			9.86														96	106
7	16	Muscovite	49.70	0.56	29.39	2.65		1.71			10.98														95	105
7	17	Kfs	66.23		17.80					0.31	15.65														100	115
7	18	Quartz	100.00																						100	119
7	19	Muscovite	49.30	0.60	29.15	3.14		1.92			10.91														95	107
7	20	Albite	69.80		18.77					11.43															100	116
7	21	Muscovite	49.34		30.50	2.98		1.33			10.85														95	109
7	22	Ms + Chl	49.40	0.93	26.26	9.36		3.85			10.20														100	106
7	23	Biotite	38.63	2.08	16.89	22.26		7.81		0.47	7.85														96	102
7	24	Ms + Chl	56.48		23.56	8.15		3.08		3.52	5.21														100	101

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
7	25	Calcite	0.78			0.88	0.78	0.45	53.11																56	55
7	26	Ilmenite +	1.61	52.65		43.33	2.41																		100	107
7	27	Calcite	0.95			0.82	0.57		53.65																56	58
7	28	Chlorite	26.63		18.62	29.24		10.12		0.40															85	100
7	29	Biotite	37.91	2.56	16.89	23.34		7.43		0.52	7.34														96	103
7	30	Kfs	64.13		19.76	0.51				0.35	15.24														100	112
8	1	Rutile	0.76	98.21		0.67			0.36																100	115
8	2	Kfs	66.52		17.61						15.86														100	122
8	3	Kfs	66.59		17.58						15.83														100	118
8	4	Biotite	38.01	2.72	17.12	22.18		8.00			7.98														96	110
8	5	Muscovite	49.49	0.77	29.42	2.76		1.77			10.78														95	109
8	6	Quartz	100.00																						100	121
8	7	Calcite	0.57			0.97	0.79	0.39	53.29																56	59
8	8	Biotite +	44.73	1.74	14.70	22.69		7.32			4.82														96	110
8	9	Albite	69.57		19.01					11.11	0.31														100	124
8	10	Calcite	0.62			0.82	0.66		53.89																56	58
8	11	Muscovite	49.00	0.66	29.49	3.03		1.87		0.39	10.56														95	113
8	12	Muscovite	49.48	0.70	29.60	2.95		1.61			10.67														95	111
8	13	Calcite	0.83			1.10	0.72		53.35																56	58
8	14	Muscovite	49.59	0.49	29.17	2.88		1.85		0.33	10.69														95	110
8	15	Bt+Ms	47.81	1.56	20.57	15.70		5.51			8.85														100	109
8	16	Muscovite	49.50	0.43	29.52	2.83		1.78		0.31	10.63														95	108
8	17	Quartz	100.00																						100	123
8	18	Muscovite	50.00		29.17	3.06		1.88			10.89														95	109
8	19	Muscovite	48.47	0.89	28.71	4.30		1.89		0.33	10.40														95	112
8	20	Calcite	0.60			1.06	0.72		53.61																56	59
8	21	Calcite	0.84			0.90	0.72		53.54																56	59
9	1	Biotite	39.24	2.82	15.83	22.99		7.50			7.62														96	115
9	2	Rutile	0.81	99.19																					100	118
9	3	Ilmenite	0.78	52.84		41.85	4.16		0.37																100	117
9	4	Monazite + Quartz	16.08		5.84	12.55		1.61	1.56		0.66	22.37								9.68	21.96	7.69			100	99
9	5	Albite	69.94		18.52					11.54															100	130
9	6	Calcite	0.67			1.19	0.75	0.41	52.98																56	63
9	7	Ilmenite	1.20	60.81		34.21	3.78																		100	118
9	8	Biotite	37.48	2.34	16.43	23.63		7.85			8.28														96	115
9	9	Muscovite	49.51	0.87	29.47	2.70		1.71			10.73														95	121
9	10	Muscovite	49.32	0.73	28.87	3.18		1.80		0.30	10.79														95	120
9	11	Calcite				1.06	0.56		54.38																56	62
9	12	Ilmenite	4.12	60.64		33.34	1.90																		100	119
9	13	Biotite	38.51	2.53	16.87	22.02		7.54			8.53														96	118
9	14	Calcite	0.72			1.05	0.75	0.45	53.03																56	62
9	15	Mix	11.73	0.90	9.72	61.35	1.21	4.06	0.96	2.56	0.84	3.46	1.71		0.92	0.57									100	80
9	16	Monazite + Quartz	8.90		4.04	3.89		2.29	1.73			26.39	1.53					1.00		13.28	27.75	9.20			100	112
9	17	Calcite + mix	7.01		2.21	2.07	2.68	0.99	84.49		0.53														100	66
9	18	Rutile	1.26	98.74																					100	118
9	19	Biotite	38.11	2.42	15.84	23.08		8.04			8.51														96	115
9	20	Calcite	0.61			0.83	0.71		53.84																56	62

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
9	21	Muscovite	48.86	0.52	30.24	2.99		1.77			10.61														95	118
9	22	Biotite	38.23	2.55	15.89	23.09		7.60			8.63														96	114
9	23	Biotite	38.49	2.04	16.88	22.38		7.94			8.28														96	113
9	24	Calcite	0.60			1.01	0.51		53.88																56	59
9	25	Monazite + Quartz	17.94		5.25	1.48			11.39	2.01	2.13	8.88	0.92	4.38				2.36		12.26	22.58	8.41			100	78
9	26	Biotite	37.44	2.48	16.90	23.91		7.97			7.30														96	113
9	27	Calcite	0.88			1.41	0.73	0.41	52.56																56	61
9	28	Quartz	100.00																						100	129
9	29	Calcite +	1.36		0.40	0.86	0.66	0.44	52.29																56	59
9	30	Biotite	37.91	2.28	16.48	23.71		8.10			7.52														96	113
9	31	Calcite	0.63			1.24	0.88	0.57	52.57		0.11														56	63
9	32	Albite	69.86		18.85					11.28															100	126
9	33	Quartz	100.00																						100	128
9	34	Chlorite	26.91		18.77	28.17		11.15																	85	104
9	35	Calcite	0.86			0.91	0.60	0.38	53.25																56	61
9	36	Muscovite	48.74	0.66	28.34	4.35		2.26		0.37	10.29														95	120
9	37	Biotite	38.84	2.42	16.81	22.04		7.27			8.62														96	116
9	38	Biotite	37.24	2.19	16.68	24.31		8.12			7.45														96	113
10	1	Rutile	0.69	99.31																					100	117
10	2	Ilmenite + Quartz	7.39	49.59		39.98	3.03																		100	123
10	3	Biotite	37.95	2.56	16.05	22.67		7.73			9.04														96	113
10	4	Quartz	100.00																						100	126
10	5	Monazite + Quartz	31.08		14.90	31.57		10.63			0.36	4.66								1.87	3.49	1.42			100	99
10	6	Biotite	37.13	2.46	16.10	25.02		7.91			7.39														96	109
10	7	Biotite	37.66	2.64	16.28	23.22		7.80			8.40														96	114
10	8	Monazite + Quartz	46.79		0.86	2.55		0.54	5.30			7.25	0.81	3.83				1.43		8.74	15.96	5.94			100	89
10	9	Biotite	38.11	2.43	16.82	22.60		7.83			8.21														96	115
10	10	Muscovite	49.01	0.71	29.46	3.05		1.97			10.80														95	113
10	11	Kfs	65.91		17.66					0.39	15.37								0.66						100	124
10	12	Muscovite	49.01	0.72	29.79	2.86		1.59			11.03														95	115
10	13	Quartz	99.82								0.18														100	126
10	14	Albite	69.69		18.53	0.37				11.41															100	122
10	15	Biotite	37.96	2.19	16.51	22.76		7.72			8.85														96	112
10	16	Kfs	66.27		17.56					0.30	15.87														100	121
10	17	Albite	70.14		18.54					11.32															100	122
10	18	Chlorite	27.06		18.23	28.00		11.71																	85	104
10	19	Quartz	99.71	0.29																					100	129
10	20	Calcite	1.94	1.95	0.56	0.84	2.86		47.85																56	64
10	21	Quartz	99.50			0.50																			100	129
10	22	Biotite	38.36	2.50	16.72	21.84		7.66			8.92														96	122
10	23	Ilmenite	0.98	53.15		43.36	2.51																		100	119
10	24	Muscovite	48.45	0.80	28.46	4.60		2.39			10.31														95	118
10	25	Albite	68.71		19.53					10.94	0.82														100	127
10	26	Muscovite	49.12	0.73	29.28	2.86		1.77		0.31	10.93														95	114
10	27	Quartz	100.00																						100	130
10	28	Ilmenite + Quartz	5.85	50.54		41.61	2.00																		100	113
11	1	Apatite	0.59						48.72			44.38		4.70										1.61	100	134

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
11	2	Biotite	36.86	2.68	16.97	23.90		7.47			8.11														96	112
11	3	Kfs	66.62		17.37					0.47	15.54														100	125
11	4	Albite	70.14		18.46					11.40															100	126
11	5	Biotite	37.95	2.47	16.56	22.99		7.64			8.39														96	112
11	6	Muscovite	48.40	1.05	26.92	5.95		2.55			10.13														95	115
11	7	Calcite	0.73			0.97	0.69	0.40	53.20																56	60
11	8	Biotite+	37.12	2.48	15.94	21.36		7.53	1.76		8.37	1.45													96	115
11	9	Albite	69.98		18.56					11.46															100	126
11	10	Biotite	37.76	2.37	16.78	22.52		7.83			8.74														96	110
11	11	Kfs	66.56		17.45					0.50	15.49														100	122
11	12	Biotite	36.62	2.21	17.56	24.06		7.91			7.64														96	110
11	13	Biotite	38.92	1.78	15.77	22.70		8.53			8.30														96	110
11	14	Biotite	38.14	2.27	16.99	22.64		7.93		0.49	7.55														96	108
11	15	Muscovite	49.12	0.70	29.58	3.03		1.79			10.77														95	112
11	16	Muscovite	49.59	0.59	28.31	3.38		2.17		0.50	10.45														95	109
11	17	Muscovite	49.03	0.78	29.92	2.77		1.74			10.76														95	118
11	18	Biotite	37.55	2.41	16.87	23.15		7.89			8.14														96	113
11	19	Biotite	38.10	2.81	16.71	22.69		7.63			8.04														96	112
11	20	Rutile	0.92	98.61		0.47																			100	121
11	21	Biotite	38.09	2.51	16.63	22.26		7.47			9.04														96	118
11	22	Muscovite	49.70	0.49	29.84	2.79		1.62			10.55														95	115
11	23	Biotite	37.98	2.27	16.40	23.19		7.93			8.23														96	115
11	24	Albite	69.42		18.97				0.26	11.34															100	128
11	25	Calcite	0.71			0.94	0.62		53.74																56	61
11	26	Calcite +	1.83			0.95	0.66		52.56																56	60
11	27	Calcite	0.87			0.95	0.58		53.59																56	60
11	28	Muscovite	47.60	0.67	28.56	5.34		2.39			10.43														95	115
11	29	Qtz+Ab	87.23		7.01					5.76															100	123
11	30	Calcite	0.73			1.14	0.72		53.41																56	62
12	1	Biotite	37.83	2.71	16.75	22.69		7.32			8.71														96	107
12	2	Zircon	31.03						0.47								68.50								100	116
12	3	Biotite	38.05	2.53	16.89	22.60		7.37			8.55														96	109
12	4	Muscovite	49.07	0.82	29.75	2.72		1.74			10.91														95	110
12	5	Kfs	66.32		17.56						16.12														100	118
12	6	Biotite	38.51	2.35	16.74	22.28		7.27			8.84														96	110
12	7	Ilmenite	1.08	52.88		42.42	3.61																		100	104
12	8	Ilmenite	0.87	53.17		43.37	2.58																		100	105
12	9	Albite	69.52		18.84					11.35	0.29														100	117
12	10	Biotite	36.72	2.23	17.16	25.35		8.23		0.55	5.77														96	102
12	11	Muscovite	49.30	0.85	29.48	2.79		1.79			10.80														95	107
12	12	Muscovite	49.49	0.70	29.01	2.97		2.19			10.63														95	108
12	13	Biotite	39.79	1.60	19.84	20.57		6.57			7.63														96	107
12	14	Calcite	0.81			1.09	0.64	0.46	53.00																56	58
12	15	Albite	69.75		18.91				0.30	11.05															100	122
12	16	Muscovite	49.83		29.03	3.01		2.11			11.02														95	112
12	17	Biotite	38.46	2.56	16.43	22.18		7.56			8.79														96	111
12	18	Muscovite	49.31	0.79	29.60	2.82		1.74			10.74														95	112

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
12	19	Calcite	0.57			0.97	0.59		53.87																56	59
12	20	Albite	68.12		17.81				2.51	11.28	0.29														100	123
12	21	Muscovite	47.97	0.73	27.75	5.66		2.62			10.27														95	113
12	22	Biotite	37.96	2.38	16.86	22.90		8.05			7.85														96	111
12	23	Muscovite	49.72	0.67	28.98	3.06		1.97			10.60														95	116
12	24	Biotite	38.39	2.46	16.49	22.37		7.56			8.73														96	106
12	25	Albite	64.52		19.84	3.61		0.76		9.95	1.31														100	115
12	26	Albite	70.10		18.76					11.14															100	116
12	27	Kfs	67.67		17.93					6.80	7.60														100	114
12	28	Biotite	38.12	2.20	16.68	23.17		7.96			7.87														96	106
12	29	Muscovite	49.62	0.75	29.23	2.94		1.81			10.65														95	108
12	30	Calcite	0.92			0.80	0.56		53.73																56	56
12	31	Muscovite	49.91	0.60	27.90	3.97		2.18		0.51	9.94														95	106
12	32	Calcite	0.74			0.61	0.60	0.41	53.64																56	55
12	33	Kfs	66.58		17.52					0.44	15.47														100	120
12	34	Muscovite	49.54	0.53	29.64	2.73		1.74			10.82														95	112
12	35	Ilmenite +	1.11	52.49		42.16	4.24																		100	114
13	1	Kfs	66.09		17.69					0.43	15.79														100	115
13	2	Muscovite	49.10	0.48	30.44	2.70		1.65			10.64														95	104
13	3	Biotite	38.14	2.32	16.65	23.21		7.66			8.02														96	101
13	4	Biotite	37.99	2.48	15.83	23.91		7.65			8.14														96	99
13	5	Kfs	66.50		17.77						15.73														100	120
13	6	Biotite	38.57	2.37	16.55	22.06		7.88			8.57														96	109
13	7	Orthopyroxene	53.71	0.70	1.22	21.84	0.43	16.58	5.52																100	112
13	8	Muscovite	49.73	0.78	29.29	2.70		1.77			10.74														95	106
13	9	Biotite	38.16	2.49	16.79	22.50		7.35			8.72														96	104
13	10	Calcite	0.74			0.95	0.72		53.59																56	55
13	11	Albite	69.84		18.77					11.38															100	113
13	12	Muscovite	48.26	0.69	26.71	6.00		3.14			10.20														95	109
13	13	Albite	70.00		18.59					11.41															100	118
13	14	Kfs	66.61		17.62						15.76														100	115
13	15	Biotite	37.62	2.37	16.90	23.64		7.64			7.82														96	105
13	16	Quartz	100.00																						100	118
13a	1	Muscovite	47.70	0.36	32.33	2.62		1.81			10.19														95	132
13a	2	Quartz	100.00																						100	129
13a	3	Quartz	100.00																						100	133
13a	4	Quartz	100.00																						100	107
13a	5	Quartz	100.00																						100	133
13a	6	Quartz	100.00																						100	138
13a	7	Quartz	100.00																						100	134
13a	8	Muscovite	48.02	0.80	30.77	3.09		2.10			10.22														95	136
13a	9	Muscovite	53.89	0.55	27.30	2.44		1.96		0.33	8.53														95	140
13a	10	Muscovite	50.52	0.73	29.66	2.58		1.60		0.40	9.51														95	128
13a	11	Calcite	2.10			1.52	1.10	0.60	94.67																100	131
13a	12	Muscovite	48.12	0.44	31.17	2.84		1.97			10.46														95	137
13a	13	Muscovite	48.07	0.53	31.35	2.74		1.81		0.37	10.13														95	138
14	1	Zircon	29.40		0.80	0.87		0.46	1.14								64.55						2.78		100	93

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
14	2	Biotite	38.37	2.40	16.53	22.19		7.77			8.74														96	98
14	3	Muscovite	49.31	0.46	30.23	2.74		1.55			10.72														95	100
14	4	Calcite				0.99	0.83	0.41	53.77																56	52
14	5	Monazite + Quartz	2.82		0.75				1.47		0.48	32.03	1.67	-0.72						16.36	33.86	11.28			100	96
14	6	Kfs	66.83		17.60						15.57														100	109
14	7	Biotite	38.27	2.51	16.70	22.45		7.49			8.58														96	100
14	8	Biotite	38.52	2.74	16.83	22.14		7.41			8.37														96	98
14	9	Albite	68.91		19.63					10.91	0.55														100	108
14	10	Biotite	38.15	2.38	16.62	22.56		7.53			8.76														96	98
14	11	Muscovite	49.56	0.73	29.40	2.52		1.81		0.32	10.65														95	100
14	12	Calcite	0.59			0.94	0.71		53.76																56	50
14	13	Kfs	66.42		17.57					0.45	15.56														100	111
14	14	Albite	69.59		19.00					11.40															100	110
14	15	Kfs	66.62		18.03					0.67	14.68														100	110
14	16	Kfs	66.16		17.99						15.84														100	112
14	17	Biotite	36.80	1.76	17.69	24.73		8.63			6.39														96	101
14	18	Kfs	66.93		17.20						15.86														100	115
14	19	Quartz	100.00																						100	119
14	20	Calcite	0.67			0.94	0.68		53.71																56	54
14	21	Albite	70.04		18.38					11.58															100	112
14	22	Quartz	100.00																						100	111
14	23	Chlorite	26.78		19.00	28.82		10.40																	85	93
15	1	Ilmenite	1.04	53.48		43.57	1.92																		100	101
15	2	Biotite	36.11	1.80	17.84	26.37		8.24			5.64														96	97
15	3	Calcite				1.74	1.16	0.48	52.62																56	54
15	4	Muscovite	48.22	0.92	31.38	2.24		1.42			10.82														95	103
15	5	Biotite	37.08	2.50	16.59	24.74		8.11			6.99														96	99
15	6	Biotite	38.36	2.78	16.18	22.64		7.27			8.76														96	107
15	7	Calcite	0.54			1.13	0.59		53.75																56	53
15	8	Kfs	66.43		17.68						15.89														100	104
15	9	Biotite	37.84	2.13	17.14	23.16		7.51			8.23														96	96
15	10	Muscovite	49.39	0.86	29.58	2.90		1.69			10.58														95	100
15	11	Biotite	37.89	2.07	16.64	24.19		7.94			7.27														96	97
15	12	Calcite	0.77			0.99	0.73		53.51																56	53
15	13	Muscovite	49.34	0.67	29.64	2.59		1.93			10.83														95	99
15	14	Muscovite	49.57	0.54	28.88	3.29		2.08			10.64														95	101
15	15	Muscovite	49.17	0.57	29.52	2.99		1.91			10.84														95	105
15	16	Quartz	100.00																						100	114
15	17	Albite	69.18		18.98				0.47	11.36															100	110
16	1	Apatite							48.43			44.06		5.23										2.28	100	113
16	2	Apatite							48.73			44.44		4.86										1.97	100	113
16	3	Biotite	37.70	2.30	16.49	23.31		7.95			8.25														96	95
16	4	Biotite	37.77	2.40	16.58	23.47		8.07			7.71														96	104
16	5	Biotite	38.31	2.70	15.88	23.16		7.48			8.48														96	99
16	6	Albite	68.13		19.88	0.42				10.28	1.29														100	109
16	7	Muscovite	47.87	0.66	28.69	4.80		2.22		0.48	10.28														95	97
16	8	Calcite	0.66			0.75	0.54		54.05																56	51

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
16	9	Calcite				0.81	0.75		54.44																56	49
16	10	Muscovite	48.86	0.53	30.50	2.95		1.51			10.66														95	104
16	11	Kfs	65.62		18.45	0.37					15.56														100	113
16	12	Biotite	38.06	2.77	16.44	22.82		7.58			8.32														96	105
16	13	Muscovite	49.15	0.71	28.42	4.12		2.23			10.36														95	106
16	14	Biotite	37.90	2.42	16.25	24.06		7.75			7.62														96	97
16	15	Kfs	66.49		17.81						15.70														100	105
16	16	Quartz	100.00																						100	112
16	17	Albite	69.32		19.36				0.31	11.01															100	101
16	18	Albite	69.95		18.60					11.45															100	108
16	19	Quartz	100.00																						100	112
17	1	Biotite	38.02	2.72	16.65	22.43		7.59			8.60														96	99
17	2	Biotite	37.21	2.21	17.18	23.85		7.97			7.58														96	103
17	3	Muscovite	49.72	0.76	28.98	3.08		1.80			10.67														95	104
17	4	Biotite	39.21	2.28	16.02	22.57		7.76			8.16														96	105
17	5	Quartz	99.57			0.43																			100	119
17	6	Rutile	0.79	96.95					2.26																100	105
17	7	Zircon	29.92			0.77		0.54	0.82	0.47							67.48								100	104
17	8	Quartz	100.00																						100	119
17	9	Biotite	37.71	2.36	17.15	22.82		7.78			8.19														96	104
17	10	Kfs	66.61		17.57						15.82														100	114
17	11	Cal+Kfs	13.40		8.14	1.77	1.09	1.07	72.21		2.32														100	66
17	12	Biotite	38.29	2.35	16.88	22.01		7.82			8.65														96	103
17	13	Kfs	66.30		17.68					0.35	15.67														100	111
17	14	Quartz	100.00																						100	118
17	15	Albite	69.64		18.86					11.17	0.33														100	111
17	16	Calcite				0.97	0.73	0.44	53.86																56	55
17	17	Kfs	66.44		17.44					0.38	15.74														100	113
17	18	Calcite	0.70			1.01	0.70	0.55	53.04																56	57
17	19	Biotite	37.89	2.53	16.57	22.98		7.68			8.34														96	107
17	20	Muscovite	49.42	0.84	29.66	2.75		1.77			10.56														95	108
17	21	Biotite	38.06	2.00	16.35	23.28		8.31			8.00														96	108
17	22	Kfs	67.25		17.81					0.60	14.34														100	116
17	23	Quartz	100.00																						100	117
17	24	Muscovite	49.62	0.68	28.24	3.69		2.25			10.52														95	101
17	25	Ilmenite	1.34	52.75		42.89	3.02																		100	100
18	1	Biotite	37.76	2.60	16.65	22.96		7.78			8.26														96	106
18	2	Biotite	35.40	2.26	17.53	27.29		8.57			4.95														96	105
18	3	Kfs	66.03		17.72					0.35	15.90														100	119
18	4	Biotite	37.10	2.38	16.79	24.10		7.88			7.75														96	104
18	5	Calcite	0.57			0.92	0.70		53.81																56	57
18	6	Muscovite	51.32	0.51	27.08	2.75		1.51		0.42	11.41														95	107
18	7	Albite	69.85		18.89					11.26															100	122
18	8	Biotite	37.95	2.33	16.77	22.77		7.54			8.64														96	109
18	9	Calcite				0.98	0.83		54.19																56	56
18	10	Calcite	0.71			1.08	0.80		53.41																56	56
18	11	Biotite	37.51	2.61	16.68	23.63		7.79			7.80														96	104

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
18	12	Biotite	40.04	2.05	18.72	20.30		6.70			8.20														96	103
18	13	Biotite	38.55	2.49	16.67	21.99		7.39			8.91														96	104
18	14	Kfs	66.33		17.43					0.35	15.89														100	112
18	15	Biotite	38.13	2.26	16.44	23.63		7.98			7.57														96	108
18	16	Muscovite	49.27	0.64	29.60	2.89		1.61			10.99														95	105
18	17	Calcite	0.89			1.14	0.66	0.50	52.80																56	57
18	18	Kfs	66.32		17.47	0.36					15.85														100	113
18	19	Biotite	37.22	2.33	16.68	23.79		8.02			7.97														96	107
18	20	Muscovite	49.28	0.77	29.22	2.76		1.81		0.48	10.69														95	107
18	21	Calcite	0.91			0.88	0.53		53.68																56	57
18	22	Quartz	100.00																						100	123
18	23	Muscovite	49.87	0.58	29.77	2.67		1.66			10.45														95	109
19	1	Zircon	31.93														68.07								100	124
19	2	Muscovite	49.43	0.69	29.36	2.62		1.77		0.32	10.80														95	114
19	3	Biotite	37.65	2.15	16.77	23.88		8.19			7.35														96	110
19	4	Rutile	1.15	98.61					0.25																100	116
19	5	Albite	69.87		18.72					11.01	0.41														100	121
19	6	Apatite	0.91						49.21			44.21		4.47										1.20	100	134
19	7	Calcite				1.18	0.89		53.93																56	60
19	8	Quartz	100.00																						100	131
19	9	Ilmenite +	3.37	52.22		41.29	3.11																		100	109
19	10	Kfs	66.21		17.59					0.43	15.77														100	125
19	11	Biotite	38.07	2.29	17.07	22.92		7.80			7.84														96	113
19	12	Calcite	0.86			0.97	0.87		53.30																56	59
19	13	Calcite	0.74			0.89	0.59	0.48	53.31																56	60
19	14	Kfs	65.60		18.19					0.42	15.78														100	118
19	15	Biotite	41.65	2.09	15.18	21.25		7.54			8.28														96	110
19	16	Biotite	39.97	2.17	19.03	20.74		6.21		0.51	7.37														96	104
19	17	Muscovite	49.69	0.72	28.97	2.92		1.83			10.87														95	108
19	18	Quartz	100.00																						100	125
20	1	Rutile + Quartz	7.45	89.08	1.86						1.61														100	119
20	2	Biotite	36.75	2.49	16.79	24.54		8.15			7.28														96	114
20	3	Biotite	37.88	2.48	16.26	22.67		7.91			8.80														96	120
20	4	Biotite	37.77	2.28	16.48	23.51		7.99			7.97														96	119
20	5	Rutile +	10.47	89.53																					100	128
20	6	Biotite	37.79	2.57	16.64	23.38		7.67			7.94														96	121
20	7	Biotite	37.44	2.54	16.60	24.11		7.92			7.39														96	116
20	8	Calcite				1.05	0.80	0.47	53.68																56	61
20	9	Muscovite	48.73	0.59	29.55	3.38		1.83			10.92														95	116
20	10	Biotite	38.13	2.75	16.55	22.78		7.25			8.55														96	116
20	11	Biotite	37.45	2.72	16.68	23.19		7.45		0.40	8.10														96	119
20	12	Quartz	100.00																						100	132
20	13	Biotite	38.48	2.54	16.63	21.84		7.56			8.96														96	117
20	14	Biotite	37.70	2.81	16.10	23.60		7.71		0.44	7.64														96	116
20	15	Muscovite	49.28	0.78	29.78	2.81		1.76			10.59														95	122
20	16	Quartz	100.00																						100	133
20	17	Muscovite	49.34	0.76	29.10	2.81		1.88			11.11														95	119

Table 9.4. EDS chemical analyses of sample OD2016-D2-011-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
20	18	Muscovite	48.71	0.84	29.03	3.90		1.84			10.68														95	122
20	19	Albite	70.30		18.42					11.28															100	129
20	20	Albite	69.89		18.72					11.39															100	128
20	21	Quartz	100.00																						100	133
20	22	Ilmenite +	1.71	52.86		42.38	3.05																		100	116
20	23	Bt+Ms	48.94	1.21	26.32	9.38		3.66		0.42	10.07														100	122

Appendix 9.5: OD2016-D
data.

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
1	1	Albite	69.26		18.80				0.25	11.68																					100	122
1	2	Ilmenite +	15.73	52.72	0.93	28.26	1.07												1.29												100	101
1	3	Ilmenite +	9.09	58.67		29.96	1.04												1.23												100	106
1	4	Rutile	0.72	98.57		0.71																									100	109
1	5	Apatite							47.80			44.19		6.37															1.64		100	127
1	6	Apatite				0.34			47.54			44.00		6.55															1.58		100	125
1	7	Ilmenite +	2.54	73.88	1.31	20.90	0.52		0.27	0.59																					100	101
1	8	Ilmenite +	1.16	56.99		38.57	1.43												1.84												100	103
1	9	Ilmenite +	9.16	57.89	3.56	24.17	0.65		0.36	2.86	0.28								1.07												100	110
1	10	Rutile +	3.48	85.42	1.94	7.53		0.73	0.31	0.60																					100	103
1	11	Chlorite	26.52			0.40															58.08										85	122
1	12	Ilmenite +	2.03	54.51	0.68	37.37	1.84												3.57												100	106
1	13	Ilmenite +	1.73	52.79		41.10	1.81												2.56												100	103
1	14	Quartz	100.00																												100	125
1	15	Mix	27.46		18.80	33.91		11.87		3.05	1.82	0.85			2.23																100	100
1	16	Muscovite	49.24	0.43	31.19	2.23		1.57		0.43	9.91																				95	110
1	17	Chlorite	26.95		20.77	24.31		12.97																							85	101
1	18	Muscovite	49.58	0.61	30.27	2.39		1.64		0.36	10.15																				95	112
1	19	Ilmenite	0.86	55.49		39.26	1.78												2.62												100	105
1	20	Rutile	3.14	91.06	2.24	2.10		1.04			0.42																				100	106
1	21	Chlorite +	29.04		18.76	23.11		12.24		0.70	1.16																				85	95
1	22	Muscovite	50.43		30.30	2.04		1.76			10.47																				95	109
1	23	Albite	67.29		20.25	0.39				10.77	1.30																				100	117
1	24	Quartz	100.00																												100	121
1	25	Chlorite	27.02		20.43	24.76		12.79																							85	98
1	26	Albite	69.31		18.89					11.80																					100	120
1	27	Albite	69.66		18.56					11.78																					100	122
1	28	Chlorite	26.84		20.71	24.35		13.10																							85	100
1	29	Muscovite	49.66	0.58	30.53	2.19		1.64			10.40																				95	111
1	30	Chlorite	28.38		20.26	23.83		11.81		0.72																					85	106
1	31	Chlorite	26.89		20.18	24.42		13.52																							85	104
1	32	Ilmenite +	2.60	61.30	1.68	31.12	1.30												2.00												100	100
2	1	Albite	69.16		19.25				0.33	11.27																					100	117
2	2	Ilmenite	5.72	70.29	2.79	18.29	0.56	0.80		0.54									1.01												100	100
2	3	Zircon	31.45																		68.55										100	120
2	4	Ilmenite	0.78	54.83		36.60	1.89												5.90												100	104
2	5	Ilmenite	3.24	55.13		38.42	1.32												1.89												100	100
2	6	Apatite +	8.13			1.56			0.76		0.42	39.03						1.06		39.25						2.06	3.62	4.10			100	92
2	7	Chlorite	28.48		19.68	22.72		12.97		0.43	0.72																				85	98
2	8	Quartz	100.00																												100	122
2	9	Chlorite	27.25		20.44	24.61		12.39			0.31																				85	98
2	10	Muscovite	49.88		31.57	1.85		1.40			10.31																				95	108
2	11	Albite	69.69		18.74					11.57																					100	120
2	12	Albite	69.19		19.10				0.21	11.50																					100	119
2	13	Muscovite	51.21	0.39	29.57	2.20		1.74		0.58	9.31																				95	114
2	14	Chlorite	27.68		20.66	24.00		12.67																							85	102
2	15	Quartz	100.00																												100	121
2	16	Chlorite	27.23		20.98	24.21		12.21			0.37																				85	98
2	17	Albite	69.31		19.01					11.52	0.15																				100	121
2	18	Muscovite	49.83	0.42	30.12	2.28		1.73		0.35	10.28																				95	109
2	19	Muscovite	53.27	0.39	27.91	2.57		1.67			9.19																				95	106
2	20	Albite	69.53		18.90				0.22	11.35																					100	121
2	21	Chlorite	28.64		20.38	23.59		12.04			0.35																				85	102
2	22	Chlorite	27.43		19.82	23.98		13.46			0.31																				85	98
2	23	Albite	69.81		18.63					11.55																					100	120
2	24	Muscovite	49.21	0.56	31.17	2.35		1.55			10.17																				95	110
2	25	Apatite +	5.80	4.14	1.95				41.54	2.24	0.35	37.69		5.63	0.65																100	119

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
2	26	Albite	69.27		18.70				0.24	11.79																					100	120
3	1	Albite	69.91		18.65					11.45																					100	121
3	2	Rutile +	4.96	79.34	2.45	11.38		0.47	0.37	0.58	0.45																				100	102
3	3	Rutile +	4.09	79.98	1.42	1.11				9.75	0.28				3.37																100	110
3	4	Ilmenite +	1.35	61.69		31.41	1.50												4.05												100	101
3	5	Albite	69.12		18.99				0.26	11.62																					100	118
3	6	Chlorite	26.55		20.66	25.12		12.67																							85	99
3	7	Muscovite	49.32	0.46	30.75	2.62		1.37		0.34	10.14																				95	109
3	8	Chlorite	27.02		19.68	24.76		12.55		0.57	0.21				0.20																85	97
3	9	Albite	69.43		18.87				0.31	11.39																					100	122
3	10	Quartz	100.00																												100	122
3	11	Ilmenite +	3.17	50.65	2.37	38.70	1.94				0.51								2.67												100	105
3	12	Albite	69.40		18.94					11.65																					100	120
3	13	Albite	69.78		18.65					11.57																					100	121
3	14	Muscovite	49.95	0.51	29.06	2.57		2.06		0.50	10.35																				95	110
3	15	Chlorite	27.45		21.33	23.26		12.09			0.88																				85	103
3	16	Chlorite	27.96		20.08	23.87		12.76			0.32																				85	98
3	17	Quartz	100.00																												100	125
3	18	Quartz	100.00																												100	121
3	19	Quartz	100.00																												100	121
3	20	Albite	69.65		18.83					11.33	0.19																				100	119
3	21	Muscovite	49.93		30.21	2.57		1.80		0.48	10.01																				95	108
3	22	Chlorite	26.81		20.74	24.49		12.96																							85	98
3	23	Muscovite	49.47	0.42	30.21	2.84		1.99			10.08																				95	107
3	24	Albite	69.77		18.70					11.53																					100	118
3	25	Quartz	100.00																												100	121
3	26	Albite	69.65		18.78				0.27	11.30																					100	119
3	27	Chlorite +	28.21		19.71	23.21		12.00		0.48	1.13				0.26																85	97
4	1	Rutile +	6.34	91.47	1.28	0.42					0.49																				100	106
4	2	Chlorite	26.88		21.19	24.00		12.94																							85	99
4	3	Albite	69.57		18.67					11.76																					100	121
4	4	Chlorite	27.17		20.43	24.30		12.74			0.35																				85	100
4	5	Quartz	100.00																												100	122
4	6	Ilmenite	0.97	53.19		39.34	2.00												4.50												100	104
4	7	Rutile	0.98	99.02																											100	107
4	8	FeOhy +	13.94		9.84	65.92		4.67	0.51	0.92	1.32	2.35			0.54																100	88
4	9	Chlorite +	32.94		16.88	25.86		5.78		0.66	2.88																				85	102
4	10	FeOhy +	23.59	0.61	15.33	49.80		4.08	0.36	1.73	1.93	1.74			0.28	0.54															100	96
4	11	Ilmenite +	1.23	56.80		38.31	1.46												2.20												100	102
4	12	Chlorite	27.71		20.00	23.94		13.35																							85	100
4	13	Rutile +	1.33	98.09		0.58																									100	107
4	14	Chl + ms	35.55		21.45	26.55		12.53			3.92																				100	98
4	15	Chlorite	26.73		20.54	24.45		13.28																							85	98
4	16	Apatite	0.61		0.37				46.53		0.41	43.83		6.56															1.68		100	126
4	17	Biotite	38.33	1.08	19.03	24.45		8.93			4.19																				96	102
4	18	Muscovite	49.61	0.36	31.68	1.88		1.27			10.19																				95	112
4	19	Albite	68.70		19.36				0.22	11.38	0.34																				100	122
4	20	Ilmenite +	2.55	57.11	0.97	35.48	1.35												2.55												100	103
4	21	Chlorite	26.39		21.55	24.62		12.44																							85	103
4	22	Apatite							47.92			44.12		6.10															1.86		100	127
4	23	Albite	69.41		18.90					11.68																					100	123
4	24	Muscovite	48.11	0.39	30.24	2.01		1.30		0.32	9.94			2.68																	95	116
4	25	Chlorite +	27.21	0.40	18.47	24.88		11.12		0.81	1.75				0.37																85	95
4	26	FeO+	8.60	1.07	7.39	73.68		3.84	0.52	1.19		3.16			0.55																100	82
4	27	Biotite	41.16	0.52	19.51	26.20		2.17			6.44																				96	92
5	1	Ilmenite	0.68	56.69		38.34	1.72												2.56												100	104
5	2	Ilmenite +	1.68	61.79	0.74	32.29	1.26				0.25								1.99												100	103

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
5	3	Ilmenite	0.67	57.24		37.90	1.50												2.68												100	106
5	4	Ilmenite +	7.35	58.86		31.17	1.11												1.50												100	100
5	5	Ilmenite +	4.19	54.54	2.61	32.59	1.24	0.72			0.64								3.47												100	105
5	6	Ilmenite +	2.14	66.93	1.17	26.94	1.06				0.33								1.43												100	102
5	7	Ilmenite	0.73	56.46		37.16	1.70												3.95												100	103
5	8	Ilmenite +	3.02	56.00		38.08	1.32												1.59												100	103
5	9	Ilmenite +	1.25	55.11		39.37	1.69												2.58												100	104
5	10	Apatite	1.35			0.55			46.95		0.40	42.99		6.40															1.37		100	124
5	11	Chlorite	26.17		21.10	24.28		12.63		0.58	0.25																				85	96
5	12	Albite	69.83		18.66					11.52																					100	119
5	13	Muscovite	49.45	0.55	29.97	2.54		1.78		0.38	10.33																				95	107
5	14	Albite	69.72		18.61				0.23	11.45																					100	119
5	15	Albite	69.16		19.06					11.79																					100	121
5	16	Muscovite	50.15	0.35	30.06	2.31		1.89			10.24																				95	112
5	17	Albite	69.42		18.69					11.66	0.23																				100	123
5	18	Chlorite	26.47		21.03	24.27		12.68		0.55																					85	97
5	19	Muscovite	49.72	0.41	29.63	2.71		2.12		0.33	10.08																				95	110
5	20	Chlorite	27.45		20.81	23.42		12.37		0.65	0.30																				85	97
5	21	Muscovite	50.36	0.64	29.19	2.49		2.08			10.24																				95	109
6	1	Chlorite	26.77		20.53	24.21		12.59		0.69	0.20																				85	97
6	2	Rutile +	1.99	77.14	1.10	17.70	0.75												1.32												100	101
6	3	Ilmenite	1.05	57.68	0.69	35.75	1.47												3.37												100	102
6	4	Ilmenite	0.80	64.58		31.34	1.30												1.98												100	103
6	5	Apatite							48.12		0.21	44.33		5.66															1.69		100	126
6	6	Ilmenite +	1.40	65.28	0.64	29.99	0.74			0.37	0.24								1.35												100	103
6	7	Ilmenite +	3.70	49.53	2.39	38.03	1.55				0.75								4.03												100	107
6	8	Ilmenite	0.73	58.01		37.36	1.20				0.34								2.36												100	103
6	9	Ilmenite	1.07	56.59	0.69	38.02	1.33												2.29												100	104
6	10	Ilmenite	0.84	54.58		38.61	1.71												4.25												100	102
6	11	Albite	69.44		18.79					11.78																					100	121
6	12	Muscovite	50.07	0.39	29.69	2.56		2.19			10.11																				95	110
6	13	Albite	68.67		18.62					11.20	1.50																				100	115
6	14	Muscovite	49.21	0.73	29.92	2.83		2.26			10.05																				95	107
6	15	Chlorite	27.91		19.81	23.06		13.13		0.77	0.33																				85	95
6	16	Muscovite	49.73	0.61	30.00	2.50		1.93		0.43	9.81																				95	110
6	17	Chlorite	26.72		20.86	23.66	0.31	12.14		0.78	0.54																				85	96
6	18	Albite	69.60		18.84					10.80	0.76																				100	113
6	19	Ilmenite +	23.11	18.48	14.82	35.75		5.62		1.00	1.22																				100	90
6	20	Chlorite	27.33		2.37	0.64		0.46			0.69										53.52										85	116
6	21	Albite	69.55		18.72					11.54	0.18																				100	123
6	22	Quartz	100.00																												100	122
6	23	Chlorite	27.21		19.42	24.65		12.66		0.71	0.36																				85	93
6	24	Chlorite	26.88		20.50	24.14		12.42		0.74	0.32																				85	94
7	1	Rutile	1.01	98.52	0.46																										100	110
7	2	Apatite	0.58						47.77			43.73		6.43															1.49		100	126
7	3	Chlorite +	29.15		18.37	28.70		5.63			1.91				1.24																85	73
7	4	Chlorite	28.08		20.10	24.25		12.56																							85	99
7	5	Biotite	38.72	1.89	16.78	21.90		9.51			7.20																				96	107
7	6	Muscovite	49.97		31.13	2.02		1.47		0.56	9.84																				95	110
7	7	Muscovite	49.66	0.58	30.66	2.20		1.39		0.31	10.19																				95	110
7	8	Chlorite	27.41		20.20	24.51		12.88																							85	98
7	9	Muscovite	50.17	0.41	30.67	2.29		1.52			9.95																				95	110
7	10	Chlorite	26.94		21.21	24.01		12.84																							85	100
7	11	Chlorite	26.71		21.04	24.51		12.74																							85	98
7	12	Muscovite	50.98		30.31	1.95		1.62			10.14																				95	109
7	13	Quartz	100.00																												100	120
7	14	Muscovite	50.84	0.41	29.87	2.28		1.63			9.96																				95	112

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
7	15	Monazite +	6.60		3.50				6.69		0.76	31.50	2.59	0.07									11.84	22.40	10.50					3.55	100	91
7	16	Chlorite +	31.73		18.18	21.76		11.54		0.60	1.18																				85	101
7	17	Chlorite	26.19		20.66	24.80		12.55		0.81																					85	98
7	18	Chlorite	27.05		20.97	24.44		12.55																							85	101
7	19	Muscovite	49.06	0.67	28.96	3.73		2.37			10.20																				95	105
7	20	Muscovite	49.48		31.53	2.19		1.48			10.31																				95	111
7	21	Quartz	100.00																												100	123
7	22	Albite	69.28		18.97				0.31	11.43																					100	122
7	23	Quartz	100.00																												100	122
7	24	Chlorite	27.28		20.75	24.47		12.50																							85	100
7	25	Albite	68.84		18.81	0.32				11.45	0.58																				100	121
7	26	Quartz	100.00																												100	121
7	27	Chlorite +	29.15	4.73	16.53	25.33		6.11		0.55	2.59																				85	102
7	28	Quartz	100.00																												100	121
8	1	Rutile +	2.10	97.19		0.71																									100	107
8	2	Ilmenite +	3.28	59.30	2.53	31.15	1.05	0.81											1.87												100	106
8	3	Ilmenite +	1.17	58.82		36.94	1.57												1.50												100	104
8	4	Ilmenite +	2.23	69.86	1.18	20.90	1.25												4.58												100	102
8	5	Ilmenite	0.76	55.84		37.91	2.01												3.48												100	106
8	6	Ilmenite +	3.47	54.38	0.66	36.07	1.54		0.35			1.31							2.22												100	103
8	7	Ilmenite +	2.71	54.34	1.64	37.90	1.33				0.59								1.50												100	104
8	8	Ilmenite +	1.46	62.28		33.19	1.15												1.92												100	102
8	9	Ilmenite +	1.84	67.34	1.10	26.69	1.00		0.32										1.71												100	101
8	10	Ilmenite +	1.22	55.84		39.57	1.29												2.08												100	98
8	11	Apatite							47.46		0.27	43.82		6.24															2.22		100	122
8	12	Apatite			0.36				47.80		0.21	44.16		5.90															1.57		100	126
8	13	Chlorite	27.25		20.33	24.32		12.14		0.58	0.39																				85	98
8	14	Ilmenite +	3.98	53.22	2.96	35.13	1.21	0.62			0.40								2.48												100	107
8	15	Ilmenite +	1.24	55.70		39.83	1.41												1.81												100	105
8	16	Quartz	100.00																												100	121
8	17	Quartz	100.00																												100	122
8	18	Chlorite	27.46		20.10	24.22		13.22																							85	97
8	19	Muscovite	49.98	0.44	30.01	2.33		1.97			10.28																				95	109
8	20	Chlorite	26.95		20.22	25.19		12.42			0.23																				85	98
8	21	Chlorite	26.81		20.61	24.12		12.72		0.47	0.26																				85	98
8	22	Muscovite	49.29	0.62	31.15	2.26		1.48			10.20																				95	111
8	23	Albite	68.80		19.24				0.37	11.59																					100	122
8	24	Quartz	100.00																												100	124
8	25	Quartz	100.00																												100	122
8	26	Chlorite	27.26		20.31	23.93		13.50																							85	99
9	1	Chlorite	26.04		20.52	24.24		12.42		0.80					0.99																85	100
9	2	Ilmenite	1.04	55.02	0.56	38.63	2.08												2.66												100	107
9	3	Ilmenite +	1.38	58.92	0.65	34.29	1.44				0.25								3.08												100	105
9	4	Ilmenite +	7.74	56.68	6.19	24.53		1.45	0.62	0.90	0.49	1.04			0.37																100	95
9	5	Ilmenite		54.19		40.69	1.97												3.15												100	105
9	6	Ilmenite	1.07	54.63		39.88	1.82												2.60												100	105
9	7	Ilmenite +	1.38	53.44	0.70	39.58	2.21												2.70												100	103
9	8	Chlorite	27.66		20.11	23.62		12.00		0.48	0.88				0.25																85	97
9	9	Muscovite	48.83	0.48	29.89	2.59		1.96		0.63	10.19				0.42																95	107
9	10	Rutile +	16.83	73.96	2.02	6.42			0.46		0.32																				100	92
9	11	Chlorite	26.99		20.54	24.62		12.59			0.26																				85	97
9	12	Muscovite	49.89	0.42	30.20	2.22		1.69		0.34	10.23																				95	109
9	13	Quartz	100.00																												100	122
9	14	Chlorite +	31.13		18.03	27.47		6.34			2.03																				85	98
9	15	Muscovite	50.35	0.56	28.88	2.57		1.92		0.46	10.27																				95	105
9	16	Albite	69.41		19.12					11.47																					100	120
9	17	Chlorite +	32.16		18.64	25.40		6.21		0.46	2.13																				85	99

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
9	18	Rutile +	12.48	74.74	6.02	3.67		0.98			2.11																				100	92
9	19	Quartz	100.00																												100	122
9	20	Chlorite	27.36		20.35	24.41		12.67			0.21																				85	99
9	21	Quartz	100.00																												100	122
9	22	Quartz	100.00																												100	123
9	23	Oligoclase	61.59	5.87	16.60	0.30			4.53	10.96	0.15																				100	130
9	24	Albite	69.86		18.64					11.50																					100	122
9	25	Chlorite	27.68		19.86	23.58		12.92		0.46	0.50																				85	100
10	1	Apatite							48.06			44.25		6.03															1.66		100	128
10	2	Apatite							47.76			44.16		6.24															1.84		100	127
10	3	Rutile +	2.54	97.46																											100	107
10	4	Rutile +	3.00	96.15	0.46	0.38																									100	107
10	5	Ilmenite +	21.77	35.19	14.41	22.41		4.55			1.68																				100	106
10	6	Chlorite +	31.71		17.77	26.31		6.09		0.54	2.58																				85	98
10	7	Chlorite	26.97		20.68	24.18		13.16																							85	100
10	8	Muscovite	50.38		30.15	2.29		1.72			10.46																				95	112
10	9	Quartz	100.00																												100	123
10	10	Monazite +	5.05		2.55				1.40		0.50	32.64	2.36										14.65	30.06	10.80						100	109
10	11	Ilmenite +	25.24	63.38	1.97	8.45		0.57			0.39																				100	106
10	12	Albite	69.50		18.81					11.68																					100	121
10	13	Mix	33.25		19.41	36.61		3.04			4.25	1.43	0.85		1.17																100	53
10	14	Quartz	100.00																												100	123
10	15	Quartz+	98.16							1.08					0.76																100	124
10	16	Chlorite +	34.18		18.52	19.43		9.47		1.75	1.65																				85	103
10	17	Albite	70.01		18.49					11.49																					100	119
10	18	Chlorite +	32.24		18.24	24.63		6.08		0.69	2.62				0.50																85	101
10	19	Muscovite	50.11	0.69	29.63	2.44		1.90			10.22																				95	112
10	20	Muscovite	50.16	0.51	30.58	2.02		1.54			10.18																				95	114
10	21	Qz +	76.66		7.57	3.14		1.47			1.76				0.46						8.94										100	90
10	22	Muscovite	49.72		30.17	2.33		1.88		0.35	10.55																				95	113
11	1	Apatite	0.78						48.26			43.92		5.84															1.20		100	126
11	2	Quartz	100.00																												100	123
11	3	Chlorite +	29.35		18.37	22.66		12.54		0.63	1.46																				85	99
11	4	Rutile +	10.01	81.75	1.50	5.78			0.51		0.24				0.20																100	103
11	5	Albite	69.51		18.63					11.86																					100	123
11	6	Chlorite	26.92		21.11	24.46		12.51																							85	100
11	7	Muscovite	48.76	0.48	29.32	2.78		1.90		0.81	10.00				0.94																95	111
11	8	Quartz	100.00																												100	122
11	9	Chlorite +	29.76		19.13	21.76		11.42		0.49	2.20				0.23																85	95
11	10	Muscovite	49.87		30.60	2.62		1.61		0.37	9.94																				95	108
11	11	Quartz	100.00																												100	124
11	12	Chlorite	26.84		20.78	22.48		11.35		1.14	0.73				1.67																85	104
11	13	Muscovite	49.46	0.64	29.92	2.50		1.91			10.58																				95	108
11	14	Chlorite	27.61		21.05	23.38		12.19			0.77																				85	100
11	15	Ilmenite +	4.88	66.42	3.40	22.72		1.66	0.30		0.27				0.35																100	92
11	16	Quartz	100.00																												100	122
11	17	Muscovite	49.71	0.47	30.29	2.33		1.87			10.33																				95	110
11	18	Chlorite	30.01		18.28	22.77		12.58		0.47	0.89																				85	101
12	1	Chlorite	26.97																		58.03										85	118
12	2	Albite	69.66		18.61					11.72																					100	120
12	3	Albite	69.16		19.20					11.64																					100	120
12	4	Albite	69.54		18.90					11.55																					100	121
12	5	Ilmenite +	4.64	64.38	1.20	26.58	1.43				0.27								1.50												100	106
12	6	Ilmenite +	3.28	60.03		32.82	1.63												2.25												100	104
12	7	Ilmenite +	0.85	54.89		40.98	1.62												1.66												100	106
12	8	Rutile +	1.31	97.66	0.76						0.27																				100	109
12	9	Ilmenite +	3.08	52.59	0.90	36.74	1.87												4.82												100	108

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
12	10	Muscovite	49.67	0.64	29.88	2.52		1.85			10.45																				95	110
12	11	Quartz	99.44			0.56																									100	122
12	12	Quartz	100.00																												100	121
12	13	Chlorite	26.15		20.75	25.42		12.69																							85	97
12	14	Muscovite	51.10	0.34	29.19	2.43		1.66		0.60	9.68																				95	111
12	15	Chlorite	28.18		20.67	23.61		11.63			0.92																				85	98
12	16	Chlorite +	29.71	2.27	18.11	26.13		6.10		0.58	1.88				0.22																85	102
12	17	Chlorite	27.58		19.69	25.07		12.45			0.21																				85	100
12	18	Muscovite	49.80	0.52	29.94	2.38		1.85		0.33	10.16																				95	110
12	19	Muscovite	49.81	0.59	30.51	2.21		1.82			10.05																				95	113
12	20	Chlorite	39.11		16.52	18.50		10.23			0.65																				85	100
12	21	Quartz	100.00																												100	121
12	22	Chlorite	27.18		20.46	23.92		13.14			0.30																				85	101
12	23	Muscovite	49.50	0.53	30.57	2.56		1.70			10.15																				95	110
12	24	Quartz	100.00																												100	121
12	25	Chl + Ms	40.15		23.57	20.68		9.42		0.67	5.51																				100	100
12	26	Albite	69.52		18.80					11.68																					100	120
12	27	Quartz	100.00																												100	122
13	1	Quartz	100.00																												100	120
13	2	Ilmenite +	17.00	46.80		32.97	1.40												1.83												100	111
13	3	Ilmenite +	3.15	52.93	2.16	36.26	1.56	1.03											2.92												100	106
13	4	Rutile +	2.27	79.15	0.97	16.06	0.69		0.30	0.56																					100	103
13	5	Ilmenite +	2.77	62.94	1.03	30.32	1.15				0.60								1.20												100	97
13	6	Ilmenite	0.91	56.68		38.65	1.88												1.88												100	103
13	7	Ilmenite		58.50		38.88	1.32												1.30												100	102
13	8	Ilmenite +	1.18	57.05		37.38	1.66												2.74												100	104
13	9	Ilmenite +	5.00	50.26	2.36	35.73	2.10				1.39								3.16												100	100
13	10	Ilmenite +	2.59	53.83		38.41	1.75												3.42												100	107
13	11	Ilmenite +	1.55	58.26		35.93	1.57												2.70												100	102
13	12	Apatite	0.81		0.58				47.18		0.20	43.54		5.94															1.75		100	128
13	13	Ilmenite +	1.97	64.18	1.08	29.40	1.15												2.23												100	100
13	14	Chlorite	26.85		21.25	23.48		11.97		0.71	0.47				0.27																85	96
13	15	Muscovite	48.90	0.79	30.57	2.31		1.80		0.37	10.27																				95	109
13	16	Quartz	100.00																												100	123
13	17	Quartz	100.00																												100	121
13	18	Quartz	100.00																												100	124
13	19	Muscovite	49.66	0.66	30.09	2.33		1.86		0.39	10.01																				95	112
13	20	Chlorite	27.80		20.30	23.31		12.05		0.60	0.95																				85	98
13	21	Chlorite	27.26		20.34	24.55		12.49			0.37																				85	99
13	22	Quartz	100.00																												100	122
13	23	Chlorite +	31.67		21.09	20.18		9.88		0.43	1.75																				85	96
13	24	Chlorite	28.33		20.17	23.50		12.30		0.70																					85	100
13	25	Ilmenite +	2.55	66.48	1.37	26.88	1.15												1.57												100	101
13	26	Ilmenite	0.92	55.49		39.19	1.92												2.49												100	104
13	27	Ilmenite +	1.46	60.83	0.58	33.29	1.27												2.57												100	101
14	1	Albite	69.19		18.79				0.24	11.78																					100	120
14	2	Albite	69.46		18.93					11.60																					100	120
14	3	Albite	69.71		18.56					11.73																					100	121
14	4	Quartz	100.00																												100	121
14	5	Ilmenite +	3.75	69.57	2.45	21.51		0.63	0.50	0.58									1.01												100	100
14	6	Rutile +	8.14	86.65	2.56					2.65																					100	116
14	7	Monazite				3.33			1.41			32.39	1.47									2.11	15.00	31.03	10.63				2.64		100	104
14	8	Ilmenite		55.54		39.41	1.79												3.27												100	105
14	9	Monazite +	3.97		2.02				8.84		0.58	30.26	3.77	1.56	0.74				-0.24			2.67	17.28	17.16	11.38						100	81
14	10	Rutile	0.86	96.75	0.47	0.59						0.63					0.70														100	105
14	11	Apatite	0.60						48.09		0.18	43.80		5.89															1.44		100	124
14	12	Rutile +	1.95	79.40		17.41	0.45												0.79												100	99

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
14	13	Ilmenite +	2.29	60.19	0.76	31.82	1.39												3.56												100	102
14	14	Rutile +	1.63	96.51	1.07	0.55					0.25																				100	106
14	15	Ilmenite +	1.52	60.90		33.98	1.11												2.50												100	100
14	16	Chlorite	27.15		20.15	24.79		12.46			0.44																				85	99
14	17	Quartz	100.00																												100	121
14	18	Chlorite	27.32		19.69	25.01		12.98																							85	97
14	19	Muscovite	50.24		30.91	2.14		1.64			10.07																				95	108
14	20	Ilmenite	7.50	59.57	4.95	24.19	0.43	1.36	0.37	0.62	1.01																				100	95
14	21	Chlorite	28.07		21.21	23.30		11.51			0.69								0.23												85	100
14	22	Muscovite	50.06	0.46	29.51	2.71		1.79		0.45	10.04																				95	109
14	23	Albite	66.22		18.46	0.40				10.71	0.40			3.81																	100	120
14	24	Muscovite	50.27	0.48	29.46	2.57		1.99			10.24																				95	110
14	25	Chlorite +	34.14		17.70	20.83		10.62			1.71																				85	98
14	26	Chlorite +	31.96		18.51	25.63		6.10		0.55	2.24																				85	94
14	27	Muscovite	50.06	0.47	29.41	2.95		2.10			10.00																				95	108
14	28	Chlorite	27.51		20.15	24.44		12.53			0.37																				85	97
14	29	Muscovite	50.06	0.44	30.62	2.27		1.69			9.92																				95	104
14	30	Chl + Ms	40.04		22.52	22.40		11.14		2.45	1.45																				100	105
14	31	Quartz	100.00																												100	123
14	32	Chlorite	26.49	0.43	20.94	24.65		12.50																							85	100
14	33	Ilmenite +	1.55	60.80	0.62	32.75	1.20												3.09												100	104
15	1	Ilmenite +	1.10	56.27	0.82	36.82	1.50				0.27								3.22												100	103
15	2	Ilmenite +	3.66	55.61	1.99	34.15	1.12				0.84								2.63												100	102
15	3	Ilmenite +	2.00	56.57	1.39	36.73	1.40				0.29								1.62												100	104
15	4	Ilmenite +	2.24	58.21	0.74	35.14	1.48				0.32								1.86												100	104
15	5	Chlorite	26.11	2.87	19.71	23.76		12.33			0.20																				85	99
15	6	Rutile +	3.25	94.97	1.06						0.73																				100	105
15	7	Ilmenite +	1.10	52.98		41.49	1.72				0.30								2.42												100	103
15	8	Ilmenite +	1.26	55.40	0.52	39.62	1.48				0.25								1.46												100	105
15	9	Ilmenite	0.81	53.18		40.73	1.84				0.27								3.16												100	106
15	10	Ilmenite +	2.09	56.73	1.40	35.66	1.02	0.58		0.57									1.95												100	100
15	11	Ilmenite +	15.75	59.11	1.58	21.88	0.74												0.94												100	101
15	12	Rutile +	2.66	95.10	1.67						0.57																				100	108
15	13	Ilmenite	0.87	57.70		37.22	1.63												2.57												100	101
15	14	Muscovite	49.85	0.53	30.26	2.11		1.98			10.28																				95	107
15	15	Quartz	100.00																												100	120
15	16	Chlorite	27.08		21.00	24.00		12.49		0.44																					85	95
15	17	Muscovite	49.97		29.61	2.59		2.20			10.61																				95	111
15	18	Albite	69.65		18.59					11.36	0.40																				100	118
15	19	Ilmenite +	6.11	55.65	4.04	31.42		1.03	0.49		0.83								0.43												100	94
15	20	Albite	69.38		18.84				0.23	11.56																					100	119
15	21	Muscovite	49.81	0.57	30.12	2.34		1.85			10.31																				95	109
15	22	Chlorite	30.48		20.42	21.61		11.36		0.56	0.56																				85	93
15	23	Muscovite	49.70	0.66	29.43	2.74		1.95		0.32	10.20																				95	112
15	24	Muscovite	50.23		29.65	2.54		2.02			10.56																				95	112
15	25	Albite	69.45		18.80					11.74																					100	119
15	26	Chlorite	26.59		20.98	24.96		12.47																							85	97
15	27	Chl + Ms	36.62		25.86	23.58		11.15			2.79																				100	102
15	28	Quartz +	95.10	0.62	2.58	0.96				0.40	0.34																				100	117
16	1	Ilmenite +	1.34	58.60	0.58	36.41	1.17												1.90												100	102
16	2	Ilmenite	1.01	61.62		35.86	1.10				0.40																				100	97
16	3	Rutile	0.76	96.87	0.59	1.56					0.22																				100	104
16	4	Ilmenite +	1.56	56.74	0.86	38.10	1.43												1.31												100	101
16	5	Rutile +	5.09	76.72	2.17	14.99				1.02																					100	102
16	6	Rutile	0.93	97.40	0.73	0.71					0.24																				100	106
16	7	Ilmenite +	2.90	73.91	1.60	19.59	0.80				0.49								0.72												100	101
16	8	Apatite							47.34		0.25	44.32		6.35																1.74		100	125

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
16	9	Chlorite	26.31		20.83	25.02		12.31		0.54																					85	96
16	10	Albite	69.52		18.83					11.65																					100	120
16	11	Chlorite	26.35		20.83	24.87		12.20		0.54	0.21																				85	94
16	12	Muscovite	49.36	0.61	30.35	2.53		1.63		0.39	10.13																				95	106
16	13	Chlorite	27.41		20.97	23.34		12.10		0.65	0.52																				85	98
16	14	Muscovite	49.94	0.65	28.75	3.44		2.54			9.69																				95	108
16	15	Chlorite	27.93		19.92	22.73		13.30		0.71	0.41																				85	95
16	16	Chlorite	27.12		19.98	23.76		13.23		0.69	0.21																				85	96
16	17	Albite	69.57		18.66				0.26	11.51																					100	121
16	18	Ilmenite +	1.45	54.12	0.75	38.91	1.79				0.29								2.69												100	103
16	19	Ilmenite +	4.33	72.91	1.00	19.68	0.79			0.34									0.95												100	100
16	20	Muscovite	50.20	0.52	29.51	2.91		1.90			9.96																				95	110
16	21	Albite	69.00		18.83	0.38				11.37	0.43																				100	120
16	22	Muscovite	50.16	0.56	30.21	2.34		1.73			10.00																				95	110
16	23	Ilmenite +	12.74	46.20	5.81	30.98	0.89	0.56			2.44								0.39												100	95
16	24	Ilmenite +	1.62	53.77	1.16	39.43	1.56	0.74											1.72												100	106
16	25	Ilmenite +	3.82	62.32	3.05	26.87	1.02	0.93		0.35	0.42								1.22												100	104
17	1	Albite	69.29		18.68	0.38				11.65																					100	121
17	2	Chlorite	27.63		20.00	23.34		14.03																							85	99
17	3	Apatite	0.56						47.79			44.03		6.32															1.30		100	127
17	4	Ilmenite +	1.40	57.72		37.95	0.81				0.36								1.75												100	103
17	5	Quartz	100.00																												100	121
17	6	Biotite	39.63	2.19	17.43	21.53		7.85			7.08				0.30																96	80
17	7	Chlorite	27.03		20.62	24.29		12.86			0.20																				85	99
17	8	Albite	68.45		19.72				0.65	11.17																					100	124
17	9	Muscovite	47.32		29.31	5.70		3.52			9.15																				95	104
17	10	Ilmenite +	2.10	59.93	0.91	33.97	1.00	0.70			0.33								1.06												100	102
17	11	Muscovite	51.29	0.53	28.06	2.48		2.56			10.08																				95	112
17	12	Albite	69.47		18.71				0.36	11.45																					100	118
17	13	Muscovite	49.89	0.37	30.65	2.11		1.62			10.37																				95	110
17	14	Chlorite	29.47		19.32	22.18		12.77		0.99	0.28																				85	104
17	15	Chlorite	27.28		20.32	24.29		13.12																							85	100
17	16	Albite	69.39		18.96					11.65																					100	123
17	17	Muscovite	49.93	0.58	30.01	2.33		1.86			10.30																				95	110
17	18	Quartz	99.02		0.75						0.23																				100	125
17	19	Albite	67.87		19.59				1.32	11.08	0.16																				100	122
17	20	Quartz	100.00																												100	121
17	21	Muscovite	47.31	1.14	34.27	0.78		0.41		0.59	10.50																				95	110
17	22	Quartz	100.00																												100	122
17	23	Chlorite	29.87		20.25	22.38		11.55		0.77	0.19																				85	103
18	1	Chlorite	26.53		20.57	24.62		13.28																							85	99
18	2	Rutile	0.80	99.20																											100	107
18	3	Monazite +	3.72		1.74	8.85			5.31			19.80	2.33	3.89	0.69							1.87	17.54	23.60	10.66						100	82
18	4	Rutile +	1.51	98.49																											100	103
18	5	Monazite				1.09			8.15			32.22	3.46	1.20	0.72							2.36	17.44	21.20	12.16						100	85
18	6	Rutile +	9.86	89.16	0.58	0.40																									100	104
18	7	Ilmenite	0.77	56.77		39.08	1.68												1.70												100	101
18	8	Apatite	0.62		0.36				47.58			43.88		6.28															1.28		100	124
18	9	Ilmenite +	2.59	62.93		32.37	1.14												0.98												100	98
18	10	Ilmenite	1.01	56.44		39.72	1.52												1.31												100	102
18	11	Ilmenite	0.94	58.93		36.28	1.47												2.38												100	104
18	12	Chlorite	27.01		20.67	24.45		12.63			0.25																				85	102
18	13	Muscovite	49.12	0.40	31.45	2.18		1.54			10.32																				95	112
18	14	Albite	69.73		18.73					11.54																					100	122
18	15	Quartz	100.00																												100	124
18	16	Rutile +	7.85	86.28	1.36	3.74			0.29		0.48																				100	98
18	17	Quartz	100.00																												100	123

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
18	18	Muscovite	49.92		31.05	2.25		1.81			9.97																				95	112
18	19	Quartz	100.00																												100	123
18	20	Muscovite	49.12	0.73	30.41	2.32		1.84		0.40	10.18																				95	113
18	21	Chlorite	26.46		20.76	24.91		12.88																							85	100
18	22	Quartz	100.00																												100	123
18	23	Chlorite	28.86																		56.14										85	123
18	24	Chlorite	27.35		19.81	24.28		13.56																							85	99
18	25	Muscovite	49.56	0.39	29.21	2.95		2.10		0.39	10.41																				95	105
18	26	Quartz	100.00																												100	121
18	27	Muscovite	49.94	0.74	29.62	2.52		2.00			10.18																				95	112
18	28	Chlorite	27.67		19.77	23.96		12.22		0.47	0.91																				85	98
18	29	Muscovite	49.00	0.59	29.61	3.15		2.26		0.40	9.98																				95	110
18	30	Quartz	100.00																												100	123
18	31	Muscovite	49.43	0.69	29.44	2.99		1.97		0.37	10.11																				95	109
18	32	Chlorite	27.06		20.96	24.27		12.71																							85	98
18	33	Chlorite	26.24		20.93	25.53		12.31																							85	97
18	34	Muscovite	48.94	0.59	29.24	3.87		2.82			9.55																				95	102
18	35	Muscovite	49.81	0.52	30.90	1.96		1.57		0.35	9.89																				95	113
18	36	Ilmenite +	14.30	45.91	0.89	34.27	1.78												2.85												100	106
18	37	Albite	69.08		19.03				0.20	11.69																					100	123
18	38	Quartz	100.00																												100	123
19	1	Albite	69.28		18.93					11.57	0.21																				100	123
19	2	Albite	69.78		18.54					11.68																					100	118
19	3	Ilmenite +	2.57	53.18		39.82	1.53				0.29								2.60												100	102
19	4	Apatite	0.58						47.85			44.43		5.66															1.49		100	123
19	5	Apatite	1.91			3.39			44.06			40.69	4.44	5.51																	100	124
19	6	Ilmenite	0.86	53.24		38.21	1.92												5.76												100	104
19	7	Albite	69.50		18.90					11.59																					100	121
19	8	Ilmenite +	33.30	11.81	19.57	24.54		7.40		0.63	2.76																				100	105
19	9	Rutile +	3.09	94.20	1.28	1.16					0.27																				100	107
19	10	Ilmenite +	1.65	54.71		38.82	1.68												3.14												100	104
19	11	Ilmenite +	1.89	53.12	0.81	39.25	1.65												3.29												100	103
19	12	Chlorite	27.81	0.31	19.83	23.69		13.14			0.21																				85	101
19	13	Muscovite	50.53	0.36	30.02	2.27		1.77			10.05																				95	111
19	14	Chlorite	27.72		21.09	23.63		11.81			0.76																				85	99
19	15	Chlorite	26.40		21.06	25.01		12.53																							85	100
19	16	Chlorite +	29.03	0.33	18.13	28.58		6.34		0.56	1.79				0.25																85	98
19	17	Muscovite	50.89		30.86	1.72		1.47			10.06																				95	111
19	18	Rutile +	3.67	90.67	1.78	3.20		0.68																							100	107
19	19	Chlorite +	28.99		18.18	31.03		4.87		0.46	1.48																				85	98
19	20	Muscovite	49.45	0.35	30.60	2.57		1.75		0.43	9.85																				95	115
19	21	Albite	69.47		18.83					11.69																					100	124
19	22	Quartz	100.00																												100	124
19	23	Albite	68.78		19.03	0.44				11.75																					100	121
19	24	Muscovite	50.19		30.83	1.96		1.49		0.47	10.07																				95	111
19	25	Chlorite +	28.24		19.30	23.33		12.28		0.74	1.12																				85	97
19	26	Muscovite	49.35	0.47	30.56	2.26		1.64		0.36	10.36																				95	111
19	27	Chlorite	27.40		20.04	23.12		13.31		0.81	0.32																				85	97
19	28	Muscovite	49.80	0.34	30.61	2.38		1.68		0.34	9.84																				95	110
19	29	Albite	68.97		19.00				0.35	11.54	0.14																				100	119
19	30	Chlorite	27.16		20.14	24.74		12.95																							85	99
19	31	Albite	69.47		18.75					11.78																					100	121
19	32	Quartz	100.00																												100	124
19	33	Chlorite	27.23		19.92	24.27		13.57																							85	100
19	34	Muscovite	49.84	0.45	31.18	1.98		1.48			10.08																				95	110
19	35	Chlorite	28.55		20.32	23.48		12.26			0.39																				85	98
19	36	Chlorite	26.97		20.48	24.94		12.61																							85	101

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
19	37	Quartz	100.00																												100	122
20	1	Quartz	99.35		0.53						0.11																				100	124
20	2	FeOhy +	5.95		3.30	83.35		2.20	0.48	1.14		2.67			0.91																100	79
20	3	Apatite	7.97		4.95	1.63		0.42	40.15		1.81	37.77		5.30																	100	120
20	4	Muscovite	48.62	0.48	28.80	5.07		2.66			9.37																				95	113
20	5	FeOhy +	6.54		4.02	81.32		3.60		0.87		2.73			0.91																100	79
20	6	Muscovite	48.74	0.58	30.32	3.24		1.81		0.36	9.96																				95	111
20	7	Chlorite	26.53		20.51	24.89		13.07																							85	101
20	8	Rutile	0.82	97.88		0.99					0.31																				100	108
20	9	Chlorite	25.91		19.84	26.76		12.50																							85	95
20	10	Muscovite	50.59	0.62	28.17	2.82		2.59			10.21																				95	112
20	11	Chlorite	26.97		20.20	24.87		12.96																							85	101
20	12	Chlorite	26.82		21.19	24.13		12.86																							85	102
20	13	Muscovite	49.88	0.49	30.31	2.47		1.82			10.01																				95	109
20	14	Chlorite	28.65		19.47	24.17		11.65			1.05																				85	100
20	15	Quartz	100.00																												100	121
20	16	Chlorite	27.91		19.78	23.90		12.99			0.42																				85	97
20	17	Muscovite	47.58	0.56	32.28	2.67		1.42			10.50																				95	109
20	18	Apatite	0.56						48.13		0.21	43.67		6.16															1.27		100	122
20	19	Albite	69.63		18.57					11.80																					100	123
20	20	Chlorite +	28.78		19.53	22.05		12.48		0.55	1.42				0.19																85	100
20	21	Quartz	100.00																												100	124
20	22	Quartz	100.00																												100	126
20	23	Chlorite	26.89		19.97	24.79		13.35																							85	101
20	24	Muscovite	49.70	0.47	30.74	2.38		1.65			10.06																				95	113
20	25	Quartz	99.60			0.40																									100	121
20	26	FeOhy+	7.83		4.40	78.97		3.59	0.45	1.00		2.95			0.81																100	78
20	27	Chlorite	26.88		20.17	24.77		13.18																							85	98
20	28	Chlorite	26.15		20.52	26.05		12.28																							85	98
20	29	FeOhy+	7.92		4.50	79.31		3.40	0.41	0.91		2.67			0.87																100	82
20	30	Muscovite	48.70	0.50	28.83	4.90		2.34			9.73																				95	113
20	31	Quartz	99.39			0.61																									100	125
20	32	Muscovite	50.15	0.38	30.43	2.16		1.70			10.19																				95	111
20	33	Chlorite	26.73		20.05	25.32		12.89																							85	98
20	34	Muscovite	50.11	0.54	29.42	2.70		2.00			10.22																				95	111
20	35	Quartz	99.60	0.40																											100	125
14a	1	Rutile +	1.11	97.47	0.50	0.51											0.42														100	107
14a	2	Monazite +	5.94		3.26	0.90		0.77	7.91		0.77	28.62	3.64	4.08	0.80				0.13			3.13	14.74	15.08	10.24						100	91
14a	3	Monazite +	6.15		4.14				7.22		1.30	24.43	2.86	3.08	0.93				-0.17			2.70	16.65	18.99	11.72						100	91
14a	4	Monazite +	1.40						4.27			13.94	1.64	13.49	0.62							1.59	19.93	29.54	13.60						100	79
14a	5	Monazite +	4.87		2.62			0.81	9.53		0.54	32.37	4.17		0.59							3.08	15.37	14.57	11.47						100	87
14a	6	Rutile	0.65	98.32		0.41											0.61														100	109
14a	7	Monazite +	1.46			0.73			8.29			26.00	3.56	3.61	0.66								18.04	20.49	12.69					4.45	100	86
14a	8	Monazite	1.13		0.79	1.27			2.18			31.53	1.75	0.09								2.59	15.22	29.98	10.98				2.50		100	103
14a	9	Monazite							8.84			31.18	3.65	0.69	0.90				0.32			2.34	18.31	19.12	12.07				2.58		100	84
14a	10	Monazite +	2.32		1.92	1.29			3.52			31.85	2.09	0.32								2.87	13.98	27.42	9.71				2.71		100	100
14a	11	Monazite +	2.36	45.00		0.84			1.54			21.94	1.27									1.95		18.02	7.08						100	91
14a	12	Monazite +	3.52		1.76				4.12			35.30	2.71	-0.29								3.40	14.34	24.81	10.32						100	109
14a	13	Ilmenite +	6.48	55.62	4.58	29.60	0.55	1.38	0.29		0.75								0.76												100	95
14a	14	Zircon +	29.56		3.93	3.86		2.28	0.86		0.49										59.03										100	107
14a	15	Quartz	100.00																												100	125
14a	16	Muscovite	49.13	0.61	30.55	2.70		1.71			10.30																				95	112
14a	17	Muscovite	48.51	0.74	31.72	2.34		1.31			10.38																				95	112
14a	18	Quartz +	95.83		3.08					0.74	0.36																				100	120
14a	19	Monazite +	2.15		1.14				8.65			31.93	3.62	2.09	0.73							2.67	16.72	17.52	12.78						100	88
14a	20	FeOhy +	11.79		9.30	69.07		3.30	0.58	1.13	0.74	2.80			1.29																100	58
18a	1	Rutile	1.06	98.94																											100	111

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
18a	2	Monazite				0.76			3.71			26.96	1.99	3.75	0.47								18.69	30.99	12.68						100	91
18a	3	Rutile +	15.99	84.01																											100	106
18a	4	Chlorite	26.63		19.91	24.78	0.29	13.39																							85	103
18a	5	Muscovite	49.91		30.31	2.25		1.72		0.32	10.49																				95	114
18a	6	Quartz	100.00																												100	125
18a	7	Quartz	100.00																												100	127
18a	8	Rutile	0.76	98.66		0.37					0.22																				100	114
18a	9	Chlorite	26.35		20.65	25.40		12.60																							85	102
18a	10	Muscovite	49.98		28.58	3.43		2.34			10.68																				95	115
18a	11	Muscovite	49.40	0.74	29.89	2.51		1.84			10.62																				95	112
18a	12	Chlorite	29.41		19.91	23.02		11.30		0.88	0.48																				85	103
1a	1	Rutile		99.78							0.22																				100	107
1a	2	Zircon	31.00			0.42															68.58										100	120
1a	3	Ilmenite +	1.79	54.16	0.77	38.14	1.69				0.27								3.18												100	103
1a	4	Ilmenite +	1.03	56.34	0.50	38.01	1.63				0.27								2.22												100	106
1a	5	Chl + Ms	32.32		21.47	30.01		13.10		0.79	1.94				0.38																100	95
1a	6	Muscovite	49.62	0.72	29.07	2.78		2.06		0.46	10.29																				95	102
1a	7	Ilmenite +	21.57	27.62	8.63	33.80	0.67	0.96		4.47	1.15								1.14												100	113
1a	8	Chlorite	27.12		19.76	24.56		12.62		0.48	0.27				0.19																85	96
1a	9	Muscovite	50.11	0.48	29.58	2.59		1.81		0.61	9.81																				95	108
1a	10	Quartz	100.00																												100	122
1a	11	Albite	67.45		18.90	1.98				11.15	0.52																				100	116
1a	12	Muscovite	48.26	1.02	27.67	4.24		2.32		0.97	10.20				0.33																95	110
1a	13	Albite	63.84		21.36	1.45		0.61		9.74	3.01																				100	125
1a	14	Rutile +	2.42	73.01	1.20	14.19			1.15	1.45	0.30	3.88	0.79		0.30										1.32						100	98
2a	1	Quartz	100.00																												100	122
2a	2	Ilmenite +	7.29	50.54		36.23	1.75												4.19												100	102
2a	3	Zircon	31.38																		68.62										100	122
2a	4	Ilmenite +	20.27	41.74	7.14	25.50	0.77	0.99			1.85				0.24				1.49												100	99
2a	5	Muscovite	49.75	0.41	30.18	2.37		1.74		0.43	10.14																				95	110
2a	6	Albite	69.51		18.85					11.63																					100	120
2a	7	Muscovite	48.86		29.59	3.97		2.56		0.45	9.57																				95	109
2a	8	Apatite +	7.62		4.21	0.54		0.50	40.50		1.10	38.81		6.72																	100	112
2a	9	Chlorite	29.05		21.07	22.64		10.58		0.47	1.19																				85	99
2a	10	Chl + Ms	41.33	0.82	20.51	25.46		7.04		1.45	3.14				0.24																100	103
2a	11	Albite	69.18		18.86				0.32	11.64																					100	121
4a	1	Ilmenite +	1.23	53.03		39.62	1.77												4.36												100	109
4a	2	FeOhy +	28.02	0.54	15.42	46.82		2.25		1.16	4.18	1.36			0.24																100	93
4a	3	Ilmenite +	1.15	57.45		37.78	1.42				0.24								1.96												100	107
4a	4	Ilmenite +	1.46	56.71	0.58	38.02	1.38												1.85												100	107
4a	5	Chlorite	27.51		19.99	24.62		12.39			0.50																				85	103
4a	6	Chl + Ms	38.62		22.50	22.89		11.76		0.86	3.37																				100	100
4a	7	Albite	69.53		18.73				0.23	11.52																					100	122
4a	8	Rutile	0.79	99.21																											100	111
4a	9	Muscovite	48.59	0.80	30.85	2.92		1.44			10.40																				95	111
4a	10	Muscovite	52.03	0.59	28.34	2.15		1.51		1.60	8.79																				95	118
4a	11	Chlorite	28.29		19.44	24.21		12.04		1.03																					85	105
4a	12	Albite	69.52		18.80				0.20	11.47																					100	123
4a	13	Muscovite	50.15	0.42	30.38	2.05		1.72			10.29																				95	114
4a	14	Apatite	0.80		0.37	0.45			48.06		0.29	43.60		4.85															1.58		100	126
4a	15	Chlorite	26.18		20.46	25.98		12.38																							85	99
4a	16	Albite	68.71	1.15	18.75					11.40																					100	124
4a	17	Chlorite +	47.88		12.15	18.83		3.96		0.37	1.59				0.22																85	91
4b	1	Rutile +	0.96	97.51	0.82	0.72																									100	112
4b	2	Albite	69.52		18.63	0.29				11.56																					100	123
4b	3	Chlorite	27.33		19.68	24.05		13.52		0.43																					85	100
4b	4	Muscovite	49.00	0.57	31.04	2.35		1.56			10.49																				95	113

Table 9.5. EDS chemical analyses of sample OD2016-D2-012-A.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	V2O5	Cr2O3	CoO	ZnO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Yb2O3	WO3	ThO2	Total	Actual Total
4b	5	Muscovite	49.55	0.56	30.45	2.25		1.48		0.35	10.35																				95	114
4b	6	Quartz	100.00																												100	126
4b	7	Albite	69.84		18.62				0.21	11.34																					100	121
4b	8	Chl + Ms	34.77	0.37	21.17	26.45		12.70		0.83	3.46				0.24																100	102
4b	9	Rutile +	1.13	96.59	0.81	1.47																									100	108
4b	10	FeOhy +	5.77	3.19	5.79	76.90		2.76	0.57	1.15		3.36			0.52																100	81
4b	11	FeOhy +	27.57		17.75	42.81		8.43		0.65	1.55	0.93			0.32																100	91
4b	12	Rutile +	8.61	84.49	3.48	1.99				0.90	0.53																				100	112
4b	13	FeOhy +	41.17		13.54	37.23		1.66	0.49	3.05	1.16	1.28			0.41																100	77
4b	14	FeOhy +	12.15		8.81	70.68		3.23		0.97	1.22	2.51			0.43																100	80
4b	15	Albite	69.47		18.96					11.57																					100	123
4b	16	Muscovite	49.37	0.39	31.43	2.12		1.40			10.29																				95	113
4b	17	FeOhy +	46.31	0.46	5.97	41.73		1.75	0.33	0.63	0.81	1.60			0.41																100	93
5a	1	Ilmenite +	11.86	28.73	6.76	46.24	0.66	1.58		2.27	0.81	1.09																			100	101
5a	2	Chlorite	27.01		20.31	24.62		12.55		0.51																					85	98
5a	3	Chlorite	26.30		20.64	24.72		12.42		0.59	0.34																				85	97
5a	4	Muscovite	46.96	0.41	28.61	6.64		3.91			8.46																				95	110
5a	5	Muscovite	49.63	0.44	30.44	2.58		1.76			10.16																				95	112
5a	6	Albite	64.69		21.05	1.01		0.44		9.69	3.12																				100	121
5a	7	Albite	69.43		18.73					11.44	0.40																				100	122
5a	8	Chlorite	29.66		19.99	22.53		11.21		0.94	0.67																				85	97
5a	9	Muscovite	49.13	0.59	30.76	2.48		1.61		0.30	10.13																				95	110
9a	1	Chlorite	26.83		19.84	24.97		12.97			0.39																				85	99
9a	2	Muscovite	50.68	0.41	29.50	2.21		1.74		0.32	10.14																				95	110
9a	3	Chlorite	26.89		20.65	24.47		12.75			0.24																				85	101
9a	4	Rutile +	5.65	88.12	3.11	1.86		0.50			0.76																				100	106
9a	5	Chlorite	27.15		20.34	24.67		12.55			0.29																				85	101
9a	6	Chlorite	26.77		20.81	24.97		12.45																							85	100
9a	7	Muscovite	50.57		30.58	1.99		1.56			10.31																				95	110
9a	8	Quartz	100.00																												100	123
9a	9	Quartz	100.00																												100	123
9a	10	Ilmenite +	12.32	38.37	9.03	31.27	1.26	2.22			1.48								4.05												100	108
9a	11	Zircon +	27.15		9.86	16.98		6.06	1.63	1.63	0.96				1.05						33.66	1.03									100	88
9b	1	Ilmenite +	0.69	53.99		40.69	1.81												2.82												100	106
9b	2	Zircon +	43.58	0.52	20.79	2.82		1.78			7.60			2.75							20.16										100	106
9b	3	Apatite +	7.30		0.54	0.36			46.07			40.46		5.28																	100	118
9b	4	Quartz	98.47		0.54	0.68		0.31																							100	123
9b	5	Quartz	100.00																												100	121
9b	6	Chlorite	27.05		20.62	24.86		12.20			0.27																				85	96
9b	7	Chl + Ms	34.21		22.10	27.26		13.21		0.62	2.09				0.51																100	93
9b	8	Muscovite	45.64	0.52	28.96	7.89		3.29			8.71																				95	106
9b	9	Quartz	100.00																												100	123
9b	10	Quartz	99.05		0.79						0.16																				100	121
9b	11	Chl + Ms	35.61		24.05	24.95		11.87		1.01	2.24				0.27																100	100
9b	12	Muscovite	49.50	0.40	30.28	2.43		1.76		0.32	10.31																				95	112
9b	13	Muscovite	49.60	0.67	29.79	2.64		2.03			10.26																				95	110
9b	14	Quartz	100.00																												100	123
9b	15	Muscovite	49.19	0.35	31.22	2.14		1.46		0.43	10.21																				95	109
9b	16	Zircon +	65.30		4.90	6.05		1.48	0.41	0.54	1.34										20.00										100	101
9b	17	Quartz	100.00																												100	122
9b	18	Chl + Ms	34.84		24.40	25.67		12.34		0.81	1.95																				100	99
9b	19	Chlorite +	43.61		13.72	19.01		8.48			0.18																				85	107

Appendix 9.6: OD2016-D2
data.

Appendix 9.7: OD2016-D2-022-2 EDS analysis data.

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
1	1	Zircon	31.15																68.85									100	129
1	2	Quartz	100.00																									100	140
1	3	Biotite	37.82	2.13	16.78	22.69		8.30			8.29																	96	123
1	4	Biotite	38.40	2.45	16.39	22.83		7.79			8.15																	96	111
1	5	Muscovite	49.08	0.35	30.43	2.72		1.59			10.84																	95	117
1	6	Ms + Ab	59.67		25.81	1.50		0.97		6.23	5.83																	100	132
1	7	Biotite +	37.11	2.34	15.79	22.35		7.91	1.56		7.80	1.13																96	119
1	8	Biotite	38.20	2.08	16.14	23.10		8.06			8.42																	96	124
1	9	Chlorite	27.38		18.66	27.01		11.96																				85	107
1	10	Albite	70.05		18.51					11.44																		100	132
1	11	Muscovite	49.72	0.48	29.68	2.57		1.90			10.65																	95	118
1	12	Apatite	1.05		0.60	0.51			47.83			43.40		4.77													1.83	100	135
1	13	Muscovite	49.54	0.66	28.52	3.53		2.49			10.26																	95	125
1	14	Chlorite	26.72		20.06	26.65		11.19			0.38																	85	107
1	15	Biotite	38.30	2.20	16.28	22.84		8.12			8.26																	96	115
1	16	Biotite	38.58	2.29	16.85	21.30		8.23			8.75																	96	118
1	17	Quartz	100.00																									100	139
1	18	Muscovite	49.49	0.41	29.29	3.12		1.85		0.35	10.50																	95	118
1	19	Albite	69.59		18.66					11.40	0.35																	100	134
1	20	Muscovite	49.31	0.61	29.55	3.08		2.01			10.43																	95	127
1	21	Albite	69.51		18.88					11.61																		100	128
1	22	Chlorite +	27.51		19.03	25.21		10.64		0.76	1.61				0.24													85	105
1	23	Quartz	100.00																									100	131
1	24	Quartz	100.00																									100	138
1	25	Chlorite	26.49		20.26	26.49		11.75																				85	109
1	26	Biotite	38.59	2.35	16.86	21.74		8.40			8.05																	96	116
1	27	Chlorite	25.76		19.95	27.48		11.51							0.31													85	64
1a	1	Apatite							48.63			44.40		4.61													2.36	100	121
1a	2	Zircon	31.08																68.92									100	122
1a	3	Muscovite	49.16	0.34	30.55	2.82		1.82			10.31																	95	110
1a	4	Biotite	38.61	2.33	17.01	21.84		8.81			7.39																	96	106
1a	5	Muscovite	50.08	0.47	29.87	2.50		1.76			10.33																	95	113
1a	6	Quartz	100.00																									100	124
1a	7	Muscovite	49.41		28.16	4.03		2.33		0.44	10.63																	95	92
1a	8	Chlorite	34.43		19.44	19.65		9.63		1.65	0.20																	85	105
1b	1	Chlorite	28.38		18.65	26.59		11.38																				85	98
1b	2	Muscovite	49.26	0.48	30.45	2.80		1.47			10.52																	95	112
1b	3	Albite	69.39		18.93					11.68																		100	122
1b	4	Quartz	100.00																									100	124
1b	5	Chlorite	28.31		19.76	24.42		11.65		0.43	0.42																	85	98
1b	6	Chlorite	35.72		15.30	22.71		8.82		0.70	0.92				0.83													85	44
1b	7	Muscovite	51.29	0.54	28.15	2.66		1.94		0.42	10.01																	95	111
1b	8	Muscovite	46.89	0.41	25.51	8.35		4.70			9.14																	95	109
2	1	Qz + Ms	89.61		6.91	0.55		0.57			2.36																	100	123
2	2	Albite	69.43		18.71				0.22	11.43	0.21																	100	127
2	3	Chlorite	25.57		21.05	27.14		11.24																				85	103
2	4	Muscovite	50.01		28.90	3.05		1.95		0.37	10.73																	95	108
2	5	Ms + Chl	49.18	0.63	28.06	8.32		4.35			9.46																	100	114
2	6	Chlorite	25.98		20.19	26.97		11.33		0.54																		85	97
2	7	Biotite	37.81	2.30	16.75	23.01		8.27			7.85																	96	117
2	8	Albite	69.42		18.56	0.30				10.84	0.88																	100	131
2	9	Quartz	100.00																									100	138
2	10	Muscovite	48.36	0.55	29.69	3.91		2.01			10.48																	95	124
2	11	Zircon	31.81																68.19									100	135
2	12	Chlorite	26.43		19.85	27.34		11.38																				85	110
2	13	Chlorite	25.89		20.35	27.00		11.76																				85	110
2	14	Muscovite	49.50	0.40	29.96	2.74		1.80			10.61																	95	120

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
2	15	Chlorite	26.01		19.67	27.81		11.51																				85	100
2	16	Albite	69.11		19.04				0.38	11.27	0.20																	100	130
2	17	Muscovite	49.78	0.42	29.86	2.54		1.64			10.77																	95	119
2	18	Chlorite	26.55		19.95	26.83		11.67																				85	105
2	19	Quartz	100.00																									100	129
2	20	Muscovite	50.88	0.37	28.26	3.21		2.04		0.69	9.55																	95	115
2	21	Chlorite	26.37		20.29	26.61		11.31			0.43																	85	105
2	22	Chlorite	26.13		20.39	27.13		11.35																				85	105
2	23	Albite	69.98		18.54					11.13	0.35																	100	128
2	24	Quartz	100.00																									100	131
2	25	Ms + Chl	49.70	0.58	23.57	12.45		5.48			8.22																	100	117
2	26	Muscovite	49.58	0.51	29.56	2.96		1.72		0.36	10.30																	95	111
3	1	Apatite	0.48						48.38			44.34		5.51													1.28	100	120
3	2	Biotite	38.59	2.33	16.55	22.10		8.15			8.28																	96	108
3	3	Muscovite	49.42		30.34	2.90		1.61			10.74																	95	110
3	4	Muscovite	49.90	0.47	29.75	2.69		1.72			10.47																	95	112
3	5	Chlorite	26.28		20.32	26.70		11.70																				85	101
3	6	Chlorite	26.48		20.67	26.66		11.19																				85	100
3	7	Chlorite	26.85		19.98	25.72		11.65		0.53	0.26																	85	101
3	8	Chlorite	27.31		19.12	25.89		11.47		0.48	0.73																	85	102
3	9	Biotite	37.45	2.31	16.85	23.44		8.34			7.60																	96	111
3	10	Biotite	37.54	2.20	16.46	23.78		8.09			7.93																	96	113
3	11	Muscovite	49.60	0.49	29.20	2.99		1.99			10.72																	95	116
3	12	Albite	68.17		19.77					11.11	0.96																	100	126
3	13	Muscovite	48.86	0.39	30.14	2.95		1.71		0.35	10.60																	95	115
3	14	Muscovite	49.14	0.54	30.09	2.76		1.77			10.70																	95	119
3	15	Biotite	38.10	2.22	16.77	22.50		7.74			8.67																	96	118
3	16	Chlorite	26.75		19.31	26.66		12.28																				85	100
3	17	Quartz	100.00																									100	127
3	18	Quartz	100.00																									100	127
3	19	Biotite	39.20	2.26	17.54	20.27		8.04			8.69																	96	107
3	20	Biotite	38.48	2.86	17.17	21.41		8.04			8.05																	96	106
3	21	Muscovite	49.55	0.57	29.13	3.29		2.08			10.38																	95	109
3	22	Chlorite	26.28		20.74	27.01		10.97																				85	97
3	23	Muscovite	49.92	0.50	29.61	2.57		1.84			10.55																	95	108
3	24	Chlorite +	27.17		19.15	26.95		10.50			1.23																	85	86
3	25	Quartz	100.00																									100	122
3	26	Muscovite	49.51	0.51	29.22	3.12		2.00			10.63																	95	116
3	27	Apatite	0.72			0.53			47.59			43.77		5.95													1.45	100	125
3	28	Apatite							46.91			44.33		6.18													2.57	100	128
3	29	Muscovite	50.23	0.68	29.34	2.88		1.80			10.06																	95	114
3	30	Chlorite	27.33		20.27	25.76		11.64																				85	103
3	31	Quartz	100.00																									100	127
3	32	Muscovite	49.18	0.38	30.15	2.68		1.77			10.84																	95	108
4	1	Quartz	100.00																									100	120
4	2	Biotite	38.70	2.50	16.51	22.04		8.17			8.08																	96	108
4	3	Muscovite	49.00	0.51	30.24	2.81		1.67		0.32	10.44																	95	110
4	4	Chlorite	26.37		20.19	27.35		11.09																				85	99
4	5	Muscovite	49.94		29.94	2.63		1.74			10.74																	95	109
4	6	Apatite	0.55					0.41	48.79	1.27		37.11	1.50	8.65													1.72	100	113
4	7	Chlorite	26.05		20.16	27.52		11.26																				85	95
4	8	Albite	69.06		19.44					10.63	0.86																	100	111
4	9	Ab + Ms	63.36		21.30	3.04		1.27		8.94	2.09																	100	113
4	10	Chlorite	26.73		19.16	26.34		12.33		0.44																		85	90
4	11	Chlorite	27.48		19.49	25.73		11.61			0.69																	85	90
4	12	Chlorite	26.34		20.50	26.24		11.46		0.46																		85	90
4	13	Albite	67.90		19.23	0.42		0.41		9.78	1.07			1.19														100	122

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
4	14	Ilmenite +	11.30	51.52		32.17	2.90	0.62		0.77						0.72												100	98
4	15	Chlorite +	31.82		17.81	23.67		8.40		0.49	2.48				0.33													85	95
4	16	Biotite	38.31	2.40	16.45	22.34		8.02			8.49																	96	110
4	17	Albite	69.05		19.25					11.02	0.68																	100	121
4	18	Chlorite	28.55		18.42	25.37		11.80			0.86																	85	97
4	19	Muscovite	48.74	0.62	28.58	4.04		2.38			10.65																	95	111
4	20	Biotite	37.98	2.34	16.84	22.69		8.24		0.42	7.49																	96	111
4	21	Ms + Ab	62.04		23.84	1.31		0.62		7.24	4.95																	100	120
4	22	Biotite	38.45	2.72	16.58	22.01		8.23			8.02																	96	115
4	23	Albite	69.59		18.76					11.65																		100	134
4	24	Chlorite	25.97		20.94	26.49		11.61																				85	103
4	25	Albite	69.84		18.63					11.53																		100	123
4	26	Chlorite	26.36		20.14	27.04		11.46																				85	102
4	27	Ms + Chl	48.27		28.81	9.48		4.13			9.32																	100	109
4	28	Chlorite +	29.30		17.93	24.18		11.20		0.76	1.62																	85	97
4	29	Albite	68.59		19.31				0.60	11.25	0.26																	100	118
4	30	Muscovite	50.06	0.63	29.15	2.87		2.06			10.23																	95	109
4	31	Quartz	100.00																									100	125
4	32	Albite	69.02		19.11				0.37	11.51																		100	113
4	33	Quartz	100.00																									100	119
4	34	Muscovite	50.24	0.39	29.21	2.69		1.88			10.59																	95	109
4	35	Chlorite	27.36		20.11	25.93		11.14			0.46																	85	94
4	36	Biotite	38.64	2.60	17.16	21.47		7.66			8.48																	96	108
4	37	Albite	69.80		18.82					11.37																		100	115
5	1	Chlorite +	30.74	1.63	14.31	24.61		7.14			6.56																	85	101
5	2	Monazite +	2.65		0.62				7.06			36.19	2.05	0.63	0.39						16.92	24.79	8.69					100	95
5	3	Quartz	100.00																									100	119
5	4	Albite	69.62		18.81					11.56																		100	118
5	5	Muscovite	49.50	0.54	29.90	2.59		1.66		0.34	10.47																	95	108
5	6	Biotite	38.50	2.39	18.17	21.44		7.78			7.73																	96	106
5	7	Chlorite	25.60		20.41	27.91		11.08																				85	100
5	8	Biotite	46.28	1.96	14.34	19.11		6.77		0.41	7.13																	96	101
5	9	Muscovite	48.52	0.54	30.16	3.52		1.87			10.39																	95	102
5	10	Albite +	52.86		21.06	14.30		5.92		4.22	1.64																	100	90
5	11	Zircon	30.90		1.10	0.65					0.30								65.61							1.44		100	124
5	12	Muscovite	49.76	0.44	28.99	3.09		1.86		0.36	10.51																	95	105
5	13	Chlorite	26.44		20.09	27.03		11.44																				85	95
5	14	Chlorite	13.92	23.93	11.93	26.73	0.94	7.54																				85	103
5	15	Chlorite	26.63		20.67	25.87		11.83																				85	87
5	16	Muscovite	50.41	0.51	29.65	2.66		1.72			10.05																	95	106
5	17	Biotite	38.41	2.76	16.92	21.66		8.31			7.93																	96	99
5	18	Muscovite	49.30	0.48	29.66	2.98		1.76			10.83																	95	100
5	19	Chlorite	26.01		20.22	26.69		12.08																				85	91
5	20	Albite	69.07		19.34				0.46	11.13																		100	109
5	21	Biotite	38.63	2.58	17.45	20.87		7.94			8.52																	96	102
5	22	Quartz	100.00																									100	118
5	23	Quartz	100.00																									100	117
5	24	Ms + Chl	50.09	0.57	28.87	7.81		3.73			8.94																	100	111
5	25	Muscovite	49.11	0.46	29.30	3.13		1.91		0.37	10.72																	95	112
5	26	Chl + Ms	37.11	0.90	20.37	26.94		10.53			3.88				0.27													100	94
5	27	Muscovite	48.96	0.60	28.53	3.71		2.07			11.14																	95	95
6	1	Quartz	100.00																									100	117
6	2	Monazite +	2.64						1.88			32.77	1.57	0.14							16.07	31.33	10.77				2.82	100	99
6	3	Apatite							47.96			44.31		5.83													1.90	100	120
6	4	Muscovite	49.04	0.42	29.77	3.31		1.88			10.58																	95	103
6	5	Biotite	38.08	1.94	16.91	23.16		8.48			7.43																	96	101
6	6	Muscovite	49.36	0.57	26.99	3.37		1.78		0.50	10.14			2.29														95	87

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
6	7	Chlorite	26.72		20.09	26.28		11.70			0.21																	85	92
6	8	Albite	69.70		18.72					11.57																		100	112
6	9	Muscovite	49.88	0.43	29.81	3.50		2.02		0.52	8.84																	95	100
6	10	Chlorite	26.38		19.74	27.34		11.54																				85	90
6	11	Quartz	100.00																									100	110
6	12	Apatite							47.96			44.04		5.31													2.69	100	121
6	13	Biotite	38.63	2.18	16.64	22.12		8.03			8.41																	96	106
6	14	Chlorite	26.45		20.00	26.74		11.54			0.26																	85	95
6	15	Muscovite	50.76	0.38	28.05	2.51		2.15		0.48	10.67																	95	106
6	16	Rutile +	1.56	96.62	0.55	1.28																						100	108
6	17	Ilmenite +	1.61	61.93		32.91	2.65									0.90												100	101
6	18	Apatite							49.48			43.83		3.82													2.87	100	113
6	19	Chlorite	26.21		20.50	26.96		11.32																				85	91
6	20	Biotite	35.71	2.08	15.71	26.74		8.08			7.68																	96	96
6	21	Biotite	38.14	2.05	17.37	21.99		8.14			8.31																	96	95
6	22	Albite	69.59		18.62					11.79																		100	108
6	23	Chlorite	26.32		20.49	26.91		11.28																				85	87
6	24	Quartz	100.00																									100	112
6	25	Muscovite	49.52	0.38	30.48	2.59		1.48		0.50	10.04																	95	109
6	26	Albite	65.98		20.92	0.65				9.99	2.46																	100	116
6	27	Ab + Ms	65.02		21.04	0.78		0.96	0.88	6.15	2.79			2.37														100	103
6	28	Albite	69.66		18.85					11.49																		100	108
6	29	Biotite	38.51	2.14	16.94	22.36		8.28			7.78																	96	105
6	30	Muscovite	49.06	0.49	30.15	2.91		1.74			10.66																	95	106
6	31	Chl + Ms	35.50	0.70	20.73	28.05		12.60			2.42																	100	97
7	1	Albite	69.80		18.65					11.54																		100	110
7	2	Albite	69.97		18.78					11.25																		100	122
7	3	Albite	69.20		19.34				0.30	11.15																		100	119
7	4	Albite	69.82		18.66					11.52																		100	113
7	5	Ilmenite	0.84	54.18		40.07	3.51			0.34						1.05												100	102
7	6	Biotite	37.90	2.40	16.67	22.87		8.31			7.85																	96	105
7	7	Chlorite	26.58		20.49	26.47		11.46																				85	96
7	8	Muscovite	47.77	0.57	29.01	3.17		1.81			10.16			2.51														95	108
7	9	Biotite	38.45	2.44	16.47	22.06		8.06			8.52																	96	103
7	10	Muscovite	48.88	0.46	29.70	3.06		1.94		0.35	10.62																	95	104
7	11	Biotite	38.99	2.31	16.80	21.39		8.35			8.16																	96	106
7	12	Muscovite	48.85	0.58	29.59	3.30		2.04			10.64																	95	107
7	13	Muscovite	49.80	0.48	29.65	2.80		1.59			10.69					-0.01												95	104
7	14	Albite	69.75		18.76					11.50																		100	116
7	15	Chlorite	26.51		20.48	26.48		11.09		0.43																		85	96
7	16	Biotite	38.44	2.15	16.79	22.24		8.06			8.31																	96	107
7	17	Apatite							48.34			43.92		5.55													2.19	100	126
7	18	Apatite							48.21			43.81		5.78													2.19	100	126
7	19	Chlorite	26.66		20.23	26.20		11.50			0.42																	85	97
7	20	Biotite	37.13	1.85	16.48	24.74		8.32			7.47																	96	107
7	21	Muscovite	49.59	0.48	29.49	2.94		1.80			10.71																	95	109
7	22	Monazite +	11.70		6.13	0.99			1.48	1.42	0.80	26.59	1.19	0.55							13.82	26.76	8.59					100	115
7	23	Muscovite	50.02	0.50	29.22	2.75		1.99			10.52																	95	109
7	24	Albite	69.60		18.78					11.63																		100	117
7	25	Biotite	39.88	1.88	18.55	20.04		8.43			7.23																	96	102
7	26	Muscovite	49.51	0.50	29.99	2.88		1.73			10.38																	95	108
7	27	Chlorite	29.02		20.69	23.43		11.52			0.35																	85	100
7	28	Chlorite	26.39		20.65	26.63		11.33																				85	99
7	29	Apatite							48.77			44.09		5.32													1.83	100	122
7	30	Biotite	38.69	2.52	16.57	21.68		8.05			8.50																	96	107
7	31	Albite	69.91		18.39					11.70																		100	124
7	32	Biotite	38.21	2.53	16.88	22.08		7.82			8.48																	96	108

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
7	33	Chlorite	25.76		20.85	26.82		11.57																				85	95
7a	1	Biotite	38.52	2.19	16.63	21.98		8.37			8.30																	96	110
7a	2	Albite	69.79		18.90					11.31																		100	123
7a	3	Muscovite	50.28	0.75	26.93	3.87		2.61			10.56																	95	110
7a	4	Muscovite	48.99	0.45	30.35	2.95		1.55		0.34	10.36																	95	111
7a	5	Muscovite	48.92	0.76	27.60	4.91		2.64			10.16																	95	109
7a	6	Albite	69.87		18.63					11.49																		100	121
7a	7	Quartz	100.00																									100	126
7a	8	Muscovite	49.60	0.43	29.88	2.82		1.87			10.40																	95	110
7a	9	Muscovite	49.31	0.68	30.35	2.62		1.62			10.40																	95	108
8	1	Quartz	100.00																									100	127
8	2	Biotite	37.69	2.58	16.78	23.99		8.69			6.28																	96	107
8	3	Apatite							48.54			44.27		4.54													2.65	100	123
8	4	Albite	69.94		18.60					11.46																		100	119
8	5	Biotite	37.63	2.51	16.94	23.53		8.32			7.08																	96	106
8	6	Muscovite	48.32	0.61	29.93	4.07		2.09			9.99																	95	109
8	7	Albite	69.67		18.72					11.62																		100	117
8	8	Biotite	38.29	2.51	16.64	22.27		8.06			8.22																	96	107
8	9	Ilmenite +	5.29	57.79	2.75	30.03	2.11			0.50	0.53					1.00												100	107
8	10	Biotite	37.87	2.33	16.56	22.97		8.21			8.05																	96	107
8	11	Muscovite	49.23	0.54	30.49	2.67		1.50		0.39	10.18																	95	113
8	12	Muscovite	49.77	0.47	29.16	2.79		1.81		0.36	10.65																	95	116
8	13	Chlorite	25.70		20.85	27.17		11.28																				85	105
8	14	Albite	70.06		18.61					11.33																		100	124
8	15	Chlorite	26.17		19.16	27.59		11.08		0.63	0.37																	85	93
8	16	Albite	69.49		18.68				0.26	11.32	0.24																	100	123
8	17	Chlorite	25.76		20.52	26.75		11.98																				85	103
8	18	Biotite	38.22	2.30	16.79	22.59		8.30			7.79																	96	110
8	19	Chlorite	26.15		19.91	27.15		11.80																				85	108
8	20	Muscovite	49.70	0.52	28.85	3.34		2.08			10.51																	95	119
8a	1	Albite	69.91		18.66					11.43																		100	121
8a	2	Muscovite	49.74	0.61	29.85	2.73		1.70			10.37																	95	113
8a	3	Muscovite	50.38	0.39	29.88	2.52		1.67		0.40	9.76																	95	116
8a	4	Biotite	37.29	2.33	17.59	23.75		8.48			6.57																	96	108
8a	5	Apatite							47.59			43.90		5.46													3.05	100	126
8a	6	Biotite	38.79	2.30	17.00	21.66		8.20			8.05																	96	110
8a	7	Biotite	41.00	3.01	15.95	20.69		7.23		0.47	7.65																	96	104
8a	8	Muscovite	49.52	0.59	28.67	3.84		2.19			10.19																	95	108
8a	9	Quartz	100.00																									100	124
8a	10	Albite	69.27		18.79	0.31			0.23	11.40																		100	124
8a	11	Muscovite	49.00	0.40	29.56	3.35		1.88		0.33	10.48																	95	113
9	1	Chlorite	26.50		19.78	27.25		11.47																				85	100
9	2	Biotite	37.97	2.33	16.61	22.75		8.22			8.12																	96	113
9	3	Albite	69.83		18.55					11.62																		100	126
9	4	Muscovite	49.30	0.41	29.75	3.04		1.73			10.77																	95	111
9	5	Albite	69.99		18.51					11.50																		100	125
9	6	Muscovite	49.35	0.36	30.20	3.10		1.90		0.34	9.75																	95	120
9	7	Biotite	38.16	1.69	16.47	23.68		8.57			7.42																	96	111
9	8	Chlorite	26.71		19.67	26.40		11.65		0.58																		85	101
9	9	Apatite	3.63		1.59	0.59			44.60		0.85	41.05		5.77													1.93	100	127
9	10	Biotite	38.85	2.23	16.67	21.51		8.18			8.56																	96	123
9	11	Ms +	54.49	0.50	27.00	5.95		2.93		1.25	7.89																	100	115
9	12	Ms + Chl	49.80	0.66	28.31	7.41		3.63			10.19																	100	118
9	13	Chlorite	26.51		20.36	26.53		11.60																				85	102
9	14	Muscovite	49.82		28.58	2.67		1.70			10.76	1.47																95	84
9	15	Biotite	38.65	2.07	16.85	21.60		8.24			8.60																	96	118
9	16	Chlorite	26.08		20.39	26.75		11.79																				85	107

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
9	17	Muscovite	51.49		27.36	2.13		1.72			9.69	0.84										1.78						95	109
9	18	Muscovite	49.75	0.60	29.44	2.73		1.80			10.70																	95	116
9	19	Albite	69.30		19.01				0.50	11.19																		100	128
9	20	Quartz	100.00																									100	130
9	21	Biotite	39.21	2.22	17.55	21.36		8.23			7.44																	96	107
9	22	Quartz	100.00																									100	124
9	23	Muscovite	49.19	0.59	29.48	2.93		1.66			11.15																	95	101
9	24	Albite	68.97		19.30				0.27	11.47																		100	121
9	25	Albite	69.39		19.06					11.56																		100	118
9a	1	Chlorite	27.06		20.66	25.95		10.98			0.35																	85	100
9a	2	Quartz	99.74			0.26																						100	124
9a	3	Muscovite	49.79	0.74	29.23	2.79		1.91			10.53																	95	111
9a	4	Chlorite	26.04		20.86	26.30		11.81																				85	101
9a	5	Biotite	38.45	2.39	16.98	21.94		8.42			7.81																	96	111
9a	6	Chlorite	26.14		20.68	26.73		11.45																				85	101
9a	7	Chlorite	26.63		20.09	26.38		11.90																				85	102
9a	8	Muscovite	49.22	0.48	29.83	3.46		2.11			9.90																	95	111
9a	9	Albite	69.77		18.61					11.62																		100	122
9a	10	Quartz	99.53			0.47																						100	122
9a	11	Albite	69.49		18.54				0.20	11.28	0.49																	100	121
10	1	Albite +	65.60		22.07	0.78		0.44		8.26	2.86																	100	128
10	2	Biotite	38.50	2.19	16.45	22.53		8.38			7.95																	96	116
10	3	Muscovite	49.54		29.20	3.71		2.11			10.44																	95	119
10	4	Apatite							48.66			44.20		4.70														2.44	100	135
10	5	Biotite	38.49	2.50	16.48	22.39		7.98			8.16																	96	117
10	6	Albite	69.47		18.80	0.29				11.44																		100	128
10	7	Biotite	38.44	2.64	16.85	21.86		7.60			8.60																	96	114
10	8	Muscovite	49.04	0.41	30.39	2.56		1.53		0.37	10.71																	95	120
10	9	Apatite							48.65			43.33		6.19														1.82	100	133
10	10	Albite	69.82		18.61					11.57																		100	135
10	11	Apatite							48.02			43.88		5.41														2.70	100	143
10	12	Chlorite	26.72		19.79	26.59		11.91																				85	113
10	13	Monazite +	13.66		3.19				1.40		1.30	27.06	1.41	1.46								14.59	26.92	9.01					100	92
10	14	Biotite	37.38	2.13	16.90	23.34		8.33			7.92																	96	117
10	15	Muscovite	48.90	0.53	30.07	3.21		1.81			10.48																	95	119
10	16	Muscovite	49.06	0.61	29.71	2.91		1.83		0.32	10.56																	95	122
10	17	Quartz	100.00																									100	129
10	18	Muscovite	49.55	0.41	30.01	2.66		1.62			10.76																	95	115
10	19	Chlorite	26.35		20.33	26.48		11.62			0.22																	85	106
10	20	Chlorite	25.69		20.57	27.16		11.59																				85	106
10	21	Muscovite	49.48	0.33	30.03	2.48		1.72		0.37	10.58																	95	127
10	22	Bt + Chl	36.00	2.10	16.49	30.36		8.15			6.89																	100	116
10	23	Muscovite	49.62	0.56	28.80	3.41		1.89			10.72																	95	123
10	24	Muscovite	47.87		33.34	1.61		0.74		0.42	11.03																	95	116
10	25	Quartz	100.00																									100	134
10	26	Chlorite	26.30		19.96	27.23		11.52																				85	106
10a	1	Rutile +	3.99	70.18		23.09	0.85	0.96	0.38	0.55																			100	104
10a	2	Biotite	37.49	2.32	16.77	23.28		8.07			8.06																	96	105
10a	3	Muscovite	50.01	0.59	28.79	2.92		1.98		0.33	10.39																	95	110
10a	4	Apatite							48.06			44.66		5.44														1.83	100	122
10a	5	Chlorite	26.67		19.95	26.10		12.28																				85	100
10a	6	Muscovite	49.70	0.46	29.57	2.88		1.85		0.40	10.15																	95	111
10a	7	Albite	70.26		18.61					11.13																		100	113
10a	8	Chlorite	26.52		20.96	25.81		11.71																				85	100
10a	9	Quartz	100.00																									100	125
10a	10	Chlorite	26.57		20.52	26.04		11.67			0.20																	85	99
10a	11	Muscovite	49.38	0.39	30.76	2.79		1.45			10.23																	95	116

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
10a	12	Chlorite	26.61		20.71	25.65		12.03																				85	101
10a	13	Chlorite	26.80		20.58	25.39		11.09		0.61	0.54																	85	88
10a	14	Chlorite	26.18		20.35	27.07		11.40																				85	100
10a	15	Chlorite	26.67		20.31	26.27		11.75																				85	102
10b	1	Biotite	37.02	2.24	16.52	24.95		8.04			7.23																	96	105
10b	2	Muscovite	49.52	0.55	29.10	3.13		1.97		0.32	10.41																	95	107
10b	3	Chlorite	26.14		20.10	26.98		11.77																				85	99
10b	4	Muscovite	49.46	0.39	29.20	3.87		2.25		0.38	9.45																	95	97
10b	5	Quartz	100.00																									100	126
10b	6	Quartz	100.00																									100	123
10b	7	Muscovite	50.08	0.34	30.72	2.28		1.58		0.34	9.65																	95	121
10b	8	Muscovite	50.59	0.41	29.39	3.13		1.89			9.58																	95	89
10b	9	Chlorite	37.04		15.04	22.49		9.65			0.78																	85	97
11	1	Biotite	38.55	2.17	16.69	21.99		8.31			8.28																	96	116
11	2	Muscovite	49.59	0.56	29.41	3.08		1.96			10.40																	95	116
11	3	Quartz	100.00																									100	136
11	4	Albite	69.82		18.70					11.48																		100	133
11	5	Chlorite	26.11		20.08	26.89		11.47		0.45																		85	109
11	6	Albite	69.82		18.72					11.45																		100	127
11	7	Muscovite	51.12	0.55	28.00	2.75		1.99			10.58																	95	120
11	8	Albite	69.02		19.20				0.22	11.00	0.55																	100	127
11	9	Ms + Chl	44.70		29.26	13.44		5.80			6.81																	100	122
11	10	Chlorite	25.96		20.28	27.11		11.65																				85	107
11	11	Quartz	100.00																									100	125
11	12	Chlorite	26.79		20.90	25.16		11.70		0.44																		85	105
11	13	Muscovite	49.27	0.35	30.20	2.70		1.53			10.95																	95	121
11	14	Quartz	100.00																									100	128
11	15	Chlorite	25.87		19.75	27.57		11.31		0.51																		85	102
11	16	Chlorite	26.26		20.77	26.28		11.70																				85	108
11	17	Albite	68.40		18.46				0.31	11.48				1.35														100	139
11	18	Chlorite	26.12		20.04	27.63		11.21																				85	109
11	19	Bt+ms	51.33	0.56	29.25	5.25		2.96		0.38	10.28																	100	111
11	20	Chlorite	26.26		20.17	27.21		11.36																				85	105
11a	1	Albite	69.23		19.12					11.44	0.21																	100	122
11a	2	Muscovite	49.72	0.51	29.57	3.00		1.99			10.20																	95	111
11a	3	Chlorite	27.50		19.28	24.91	0.30	11.34		0.67	1.01																	85	98
11a	4	Muscovite	48.70		30.82	3.01		1.62		0.42	10.44																	95	112
11a	5	Chlorite	27.72		18.69	25.68		11.06		0.60	1.26																	85	99
11a	6	Biotite	37.72	2.65	17.17	22.30		8.66			7.50																	96	110
11a	7	Quartz	100.00																									100	126
11a	8	Albite	69.40		19.05				0.34	11.21																		100	121
11a	9	Biotite	38.58	2.51	17.21	22.04		8.77			6.88																	96	108
11a	10	Muscovite	48.98	0.39	30.18	2.72		1.75		0.36	10.62																	95	104
11a	11	Zircon	33.15			0.56													66.29									100	118
11a	12	Chlorite	28.38		19.62	25.13		11.38		0.48																		85	104
11a	13	Quartz	100.00																									100	124
12	1	Biotite	38.23	2.31	16.64	22.24		8.30			8.27																	96	114
12	2	Ms + Ab	57.98		28.46	1.37		0.41		4.60	7.18																	100	117
12	3	Albite	69.16		19.02				0.25	11.26	0.32																	100	123
12	4	Albite	70.41		18.74					8.19	2.66																	100	99
12	5	Chlorite	26.19		20.63	26.61		11.58																				85	101
12	6	Bt+ms	46.46	1.14	24.58	13.18		5.61			9.04																	100	114
12	7	Biotite	38.06	2.21	16.57	23.28		8.58			7.30																	96	113
12	8	Muscovite	49.06	0.37	31.03	2.38		1.33		0.38	10.46																	95	115
12	9	Chlorite +	29.65		17.52	23.75		10.84		0.59	2.47				0.20													85	103
12	10	Muscovite	50.14	0.60	29.07	3.05		1.89			10.25																	95	119
12	11	Albite	70.03		18.47					11.50																		100	130

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
12	12	Albite	69.74		18.39				0.29	11.58																		100	122
12	13	Muscovite +	53.94	0.35	26.58	2.05		1.27		2.57	8.24																	95	114
12	14	Calcite +	6.20		1.86	4.06	1.65	1.61	84.09		0.54																	100	67
12	15	Muscovite	49.36	0.55	29.85	2.78		1.66			10.79																	95	118
12	16	Quartz	100.00																									100	131
12	17	Biotite	38.49	2.34	16.64	21.83		8.24			8.47																	96	113
12	18	Chlorite	27.81		18.88	25.59		11.13		0.56	1.03																	85	98
12	19	Chlorite	27.20		20.21	25.83		11.44			0.32																	85	103
12	20	Albite	69.87		18.65					11.48																		100	123
12	21	Chlorite	27.76		18.52	26.53		11.60		0.59																		85	99
12	22	Muscovite	48.91	0.46	29.68	3.53		2.00		0.46	9.98																	95	111
12a	1	Albite	69.79		18.65					11.56																		100	123
12a	2	Pyrite +	19.85		6.07	37.07				4.76			32.25															100	155
12a	3	Chlorite	26.72		20.56	26.09		11.63																				85	102
12a	4	Chlorite	26.48		20.76	25.84		11.92																				85	104
12a	5	Muscovite	48.64	0.67	27.52	5.07		2.76		0.30	10.03																	95	111
12a	6	Albite	69.60		18.63				0.35	11.42																		100	121
12a	7	Muscovite	49.54	0.32	29.72	2.87		1.86			10.69																	95	111
12a	8	Quartz	100.00																									100	126
12a	9	Muscovite	49.59	0.58	30.42	2.57		1.66			10.17																	95	118
12a	10	Muscovite	50.63	0.43	29.40	2.84		1.73			9.98																	95	105
12a	11	Quartz	100.00																									100	128
12a	12	Muscovite	50.15	0.49	29.35	2.84		1.82			10.33																	95	110
13	1	Albite	69.62		18.64					11.37	0.37																	100	116
13	2	Biotite	38.13	2.57	16.44	22.61		8.16			8.09																	96	107
13	3	Chlorite	25.97		20.47	27.08		11.48																				85	98
13	4	Muscovite	48.43	0.35	30.33	3.07		1.75		0.35	10.72																	95	108
13	5	Muscovite	49.59	0.53	29.85	2.87		1.97			10.19																	95	116
13	6	Quartz	100.00																									100	128
13	7	Quartz	100.00																									100	123
13	8	Biotite	38.38	2.72	16.93	21.84		7.87			8.27																	96	107
13	9	Muscovite	49.02	0.55	29.03	4.23		1.92			10.25																	95	109
13	10	Muscovite	49.75	0.64	29.06	2.92		1.95			10.69																	95	107
13	11	Albite	68.79		19.15				0.49	11.56																		100	122
13	12	Chlorite	26.94		19.25	26.63		12.18																				85	100
13	13	Muscovite	49.35	0.53	30.71	2.45		1.47			10.48																	95	115
13	14	Albite	70.12		18.71					11.17																		100	117
13	15	Albite	68.47		19.91					10.88	0.75																	100	121
13	16	Chlorite	26.77		20.19	26.62		11.43																				85	104
13	17	Biotite	38.62	2.29	16.79	21.95		7.94			8.41																	96	116
13	18	Muscovite	48.36		30.42	3.72		1.77			10.74																	95	116
13	19	Muscovite	49.69	0.44	29.96	2.95		2.00			9.97																	95	121
13	20	Chlorite	26.52		21.28	25.50		11.70																				85	102
13	21	Muscovite	48.74	0.47	30.57	2.78		1.69			10.74																	95	111
13	22	Chlorite	26.98		19.00	26.34		12.11		0.58																		85	92
13	23	Bt+ms	48.17		29.34	9.60		4.18		0.53	8.17																	100	107
13	24	Albite	69.32		18.96					11.26	0.47																	100	123
13	25	Biotite	38.24	2.57	16.47	22.28		7.87			8.56																	96	110
13	26	Quartz	100.00																									100	121
13a	1	Muscovite	49.91	0.48	28.87	3.20		2.09			10.44																	95	111
13a	2	Chlorite	32.24		22.69	19.68		8.13			2.26																	85	107
13a	3	Chlorite	26.60		20.29	25.98		11.19		0.54	0.42																	85	97
13a	4	Albite	69.34		18.77	0.27				11.23	0.40																	100	121
13a	5	Rutile +	5.89	78.82	2.66	11.33		0.68	0.63																			100	102
13a	6	Quartz	100.00																									100	125
13a	7	Muscovite	49.38	0.52	29.00	3.46		2.13		0.56	9.95																	95	112
13a	8	Quartz	100.00																									100	126

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
14	1	Biotite	38.16	2.20	16.88	22.03		8.18			8.55																	96	103
14	2	Zircon	30.59		0.61	0.60			0.41										67.80									100	105
14	3	Zircon	32.24																67.76									100	111
14	4	Zircon	32.09			0.53													67.38									100	113
14	5	Biotite	38.46	2.08	16.99	22.08		8.03			8.36																	96	103
14	6	Muscovite	49.25	0.57	29.40	3.17		1.88			10.73																	95	104
14	7	Albite	69.89		18.72					11.39																		100	112
14	8	Muscovite +	54.54	0.55	25.93	2.61		1.18		1.51	8.67																	95	83
14	9	Muscovite	48.97	0.51	30.20	2.43		1.35		0.44	11.10																	95	106
14	10	Quartz	100.00																									100	120
14	11	Quartz	100.00																									100	117
14	12	Quartz	100.00																									100	126
14	13	Muscovite	49.53	0.48	30.15	2.68		1.63			10.53																	95	107
14	14	Biotite	37.12	2.64	14.99	25.38		6.43			9.45																	96	91
14	15	Apatite	1.80		0.41	0.38			49.22			41.83		4.54													1.82	100	110
14	16	Muscovite	49.37	0.70	28.91	3.21		2.06		0.48	10.27																	95	105
14	17	Chlorite	26.76		18.34	27.24		11.12		0.52	1.03																	85	87
14	18	Ilm + Ms	19.93	37.28	10.28	25.76	1.57	0.61		0.57	3.19					0.80												100	100
14	19	Chlorite	25.76		20.41	26.85		11.98																				85	98
14	20	Quartz	100.00																									100	120
14	21	Chlorite	26.83		19.67	27.32		11.18																				85	102
14	22	Muscovite	50.11	0.47	29.61	2.38		1.70		0.41	10.33																	95	107
14	23	Biotite	37.81	2.17	16.83	22.44		8.95			7.80																	96	109
14a	1	Chlorite	26.37		20.25	26.08		11.62		0.48	0.20																	85	100
14a	2	Muscovite	49.76	0.36	29.80	2.97		1.75		0.33	10.02																	95	113
14a	3	Biotite	38.54	2.12	17.15	22.00		8.16			8.03																	96	111
14a	4	Biotite	38.13	2.37	17.29	21.98		8.26			7.97																	96	113
14a	5	Quartz	100.00																									100	126
14a	6	Chlorite	28.36		20.23	23.71		11.23		0.68	0.80																	85	96
14a	7	Albite	69.86		18.52					11.63																		100	125
14a	8	Quartz	100.00																									100	126
14a	9	Muscovite	48.60	0.40	30.39	3.05		1.65		0.36	10.55																	95	113
14a	10	Muscovite	49.86	0.49	29.55	2.83		1.73		0.40	10.15																	95	100
14a	11	Quartz	100.00																									100	133
15	1	Biotite	37.62	2.23	16.55	22.89		8.28			8.44																	96	103
15	2	Monazite +	1.16						1.35			33.00		0.29							18.30	33.14	10.35				2.39	100	95
15	3	Biotite	38.69	2.33	16.70	22.19		8.04			8.04																	96	107
15	4	Chlorite	25.86		20.48	27.17		11.49																				85	94
15	5	Muscovite	49.64	0.67	29.37	2.88		1.93			10.51																	95	105
15	6	Albite	69.85		18.63					11.52																		100	114
15	7	Biotite	40.48	2.27	19.89	18.60		7.74		0.46	6.57																	96	103
15	8	Muscovite	60.32		21.92	2.31		1.29			9.17																	95	61
15	9	Quartz + Bt	73.90	1.36	7.13	10.50		3.09			4.01																	100	97
15	10	Muscovite	49.76	0.52	29.69	2.77		1.77			10.49																	95	103
15	11	Albite	68.32		19.61				0.38	11.15	0.53																	100	112
15	12	Chlorite	26.49		20.41	26.11		11.99																				85	90
15	13	Chlorite +	29.48		17.97	23.70		11.24		0.63	1.69				0.28													85	80
15	14	Chlorite	27.18		19.38	26.10		12.33																				85	86
15	15	Albite	69.81		18.57					11.62																		100	109
15	16	Muscovite +	51.38	0.37	27.99	2.69		1.67		1.73	9.17																	95	102
15	17	Albite	68.91		18.09					9.47	3.52																	100	111
15	18	Muscovite	48.86	0.47	30.00	3.32		1.66			10.68																	95	104
15	19	Chlorite	25.82		20.49	27.45		11.24																				85	90
15	20	Albite	68.61		18.45	0.35				10.85	0.64			1.10														100	118
15	21	Quartz	100.00																									100	122
15	22	Albite	69.80		18.40				0.56	11.24																		100	117
15	23	Albite	69.65		18.75					11.60																		100	117

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
15	24	Quartz	100.00																									100	119
15	25	Chlorite	26.51		20.38	26.28		11.08		0.77																		85	91
16	1	Biotite	37.19	2.02	16.72	23.78		8.38			7.91																	96	100
16	2	Biotite	37.37	2.46	17.16	23.26		8.32			7.43																	96	101
16	3	Chlorite	26.59		19.98	27.11		11.32																				85	93
16	4	Chlorite	27.40		20.04	25.41		10.81		0.48	0.86																	85	93
16	5	Muscovite	49.76	0.50	29.90	2.60		1.69			10.54																	95	103
16	6	Biotite	37.94	2.42	16.17	23.65		7.63			8.19																	96	91
16	7	Albite	66.47		21.16	0.75		0.47		9.02	2.14																	100	110
16	8	Albite	69.74		18.69					10.94	0.63																	100	111
16	9	Chlorite	27.00		19.42	27.14		10.28		0.58	0.58																	85	83
16	10	Quartz	100.00																									100	122
16	11	Chlorite	25.86		20.42	27.39		11.34																				85	93
16	12	Muscovite	49.77	0.47	29.63	2.75		1.66			10.73																	95	106
16	13	Albite	69.83		18.53					11.64																		100	111
16	14	Biotite	39.13	2.24	16.90	21.87		8.53			7.33																	96	99
16	15	Chlorite	27.57		18.73	25.73		12.64			0.33																	85	88
16	16	Quartz	100.00																									100	114
16	17	Muscovite +	52.74		27.28	2.49		1.23		2.72	8.54																	95	98
16	18	Muscovite	50.43	0.44	28.37	3.29		1.96			10.53																	95	93
16	19	Quartz	100.00																									100	105
16	20	Quartz	100.00																									100	117
16	21	Chlorite	35.79		16.24	21.58		10.02		0.69	0.69																	85	85
16	22	Muscovite +	54.44		27.04	2.47		1.38		2.81	6.87																	95	99
16	23	Albite	67.68		20.25	0.39			0.64	9.76	1.28																	100	107
16A	1	Biotite	38.26	2.36	16.31	22.42		8.43			8.23																	96	107
16A	2	Ilmenite +	3.12	53.01	0.91	37.39	3.39				0.28					1.90												100	105
16A	3	Xenotime	25.93		5.87	1.10					2.14	27.68						31.97						1.84	3.47			100	93
16A	4	Chlorite	26.82		19.83	26.64		11.40			0.31																	85	95
16A	5	Muscovite	49.81	0.52	29.83	2.58		1.81			10.43																	95	112
16A	6	Chlorite	27.81		19.95	25.98		11.26																				85	97
16A	7	Muscovite	49.93	0.43	29.05	2.99		1.91			10.70																	95	105
16A	8	Biotite	39.57	1.69	18.04	21.28		8.14			7.28																	96	108
16A	9	Muscovite	49.11	0.46	29.06	3.92		2.17		0.35	9.93																	95	109
16A	10	Muscovite	49.61	0.48	30.63	2.55		1.41			10.33																	95	100
16A	11	Albite	69.82		18.52				0.25	11.20	0.22																	100	118
16A	12	Muscovite	49.31	0.63	30.50	2.54		1.59			10.44																	95	111
16A	13	Muscovite	49.30		30.23	2.95		1.74			10.78																	95	109
16A	14	Quartz	100.00																									100	123
17	1	Biotite	37.15	2.18	17.33	23.69		8.53			7.12																	96	110
17	2	Albite	69.13		18.82				0.41	11.36	0.28																	100	123
17	3	Chlorite	26.45		19.13	26.87		12.02		0.54																		85	97
17	4	Muscovite	46.07	0.57	28.09	2.97		1.72		0.48	10.32			4.59	0.20													95	100
17	5	Chlorite	25.89		21.19	26.77		11.15																				85	100
17	6	Chlorite +	27.93		18.70	25.09		11.49		0.66	1.13																	85	99
17	7	Biotite	38.33	1.89	16.84	22.74		9.30			6.89																	96	110
17	8	Quartz	100.00																									100	132
17	9	Apatite	3.59		0.78				46.69	0.51	0.33	40.53		5.21													2.36	100	126
17	10	Biotite	38.55	2.37	16.55	22.10		8.18			8.25																	96	108
17	11	Quartz	100.00																									100	119
17	12	Muscovite	49.21	0.53	30.12	2.98		1.95		0.34	9.87																	95	115
17	13	Chlorite	26.17		21.05	26.38		11.39																				85	99
17	14	Chlorite	25.96		20.43	27.17		11.43																				85	100
17	15	Chlorite +	28.16		19.24	24.53		11.18		0.69	1.21																	85	99
17	16	Muscovite +	51.60	0.41	27.19	3.42		2.00		1.50	8.88																	95	112
17	17	Halite +	1.31						0.43	45.07	0.40				52.80													100	133
17	18	Chlorite	26.95		19.80	25.62		11.70		0.51	0.43																	85	103

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
17	19	Muscovite	48.58	0.40	30.41	2.92		1.78		0.39	10.53																	95	113
17	20	Quartz	98.79		0.89						0.32																	100	124
17	21	Quartz +	84.84		8.37	1.69		0.97		0.67	3.09				0.36													100	97
17	22	Halite +	3.45							48.91	0.31				47.33													100	154
17	23	Sylvite +	4.25		0.83	0.40				10.06	43.63				40.83													100	110
18	1	Biotite	37.19	2.65	17.09	23.66		8.15			7.26																	96	110
18	2	Albite	69.71		18.86					11.43																		100	125
18	3	Albite	68.96		18.65	0.53		0.40		11.18	0.28																	100	125
18	4	Albite	70.10		18.43					11.47																		100	125
18	5	Albite	70.07		18.67					11.26																		100	130
18	6	Albite	69.98		18.48					11.54																		100	120
18	7	Quartz	100.00																									100	125
18	8	Albite	69.83		18.53				0.23	11.41																		100	120
18	9	Biotite	38.83	2.40	16.52	22.50		7.91			7.83																	96	108
18	10	Albite	70.38		18.69				0.29	10.65																		100	109
18	11	Quartz	100.00																									100	125
18	12	Rutile	0.71	99.29																								100	111
18	13	Chlorite +	29.85		18.11	24.65		10.51		0.60	1.29																	85	99
18	14	Rutile +	3.56	87.67	1.69	7.07																						100	94
18	15	Chlorite	26.26		20.60	26.27		11.87																				85	103
18	16	Muscovite	49.43	0.45	30.13	2.90		1.60			10.50																	95	113
18	17	Biotite	42.18	1.78	16.05	20.98		8.28			6.73																	96	110
18	18	Muscovite	48.95	0.43	29.89	2.99		1.60			11.14																	95	107
18	19	Muscovite	48.93	0.47	28.86	4.03		2.21			10.51																	95	117
18	20	Albite	69.76		18.78					11.46																		100	124
18	21	Chlorite	26.78		19.17	26.99		12.07																				85	103
18	22	Muscovite	49.72	0.57	29.98	2.66		1.63			10.43																	95	116
18	23	Apatite							48.09			44.48		5.35													2.08	100	136
18	24	Biotite	37.95	1.86	16.31	23.16		7.88		0.50	8.33																	96	106
18	25	Albite	72.25		17.52				0.89	9.34																		100	131
18	26	Biotite	38.27	1.97	17.41	23.38		8.67			6.30																	96	114
18	27	Albite +	65.70		21.85	1.00		0.63		7.65	3.17																	100	116
18	28	Chlorite	25.81		20.84	26.65		11.70																				85	107
18	29	Mixture	50.95	0.75	26.63	7.42		3.00		1.00	10.24																	100	101
18	30	Chlorite	26.45		20.70	25.99		11.87																				85	107
18	31	Muscovite	49.98	0.41	28.64	3.10		2.14			10.73																	95	117
18	32	Quartz	100.00																									100	129
18	33	Apatite	2.58		0.55				46.63			42.85		4.60													2.78	100	134
18	34	Albite	66.76		20.96				1.34	10.10	0.85																	100	131
18	35	Rutile +	3.23	94.82	1.60						0.35																	100	116
18	36	Quartz	100.00																									100	125
19	1	Biotite	38.10	2.11	16.83	22.18		8.44			8.34																	96	115
19	2	Albite	69.55		18.98				0.22	11.25																		100	125
19	3	Albite	69.33		18.35	0.62				10.05	1.66																	100	126
19	4	Biotite	37.32	2.45	17.08	23.55		8.83			6.78																	96	114
19	5	Biotite	36.70	2.76	16.32	24.67		8.22			7.32																	96	114
19	6	Biotite	38.15	2.37	16.40	22.36		8.13			8.59																	96	117
19	7	Muscovite	49.92		29.45	2.78		1.97			10.88																	95	123
19	8	Apatite	3.79		1.57	0.71			46.59		0.53	42.02		4.80														100	122
19	9	Albite	69.58		18.99					11.43																		100	129
19	10	Albite	66.50		18.94	3.29		0.84		8.63	1.80																	100	105
19	11	Biotite	37.73	2.36	16.14	23.38		8.30			8.09																	96	120
19	12	Chlorite	27.47		20.75	24.51		11.20		0.63	0.44																	85	111
19	13	Muscovite	50.54	0.39	28.63	3.50		2.02			9.92																	95	118
19	14	Chlorite	26.83		20.54	25.88		11.48			0.26																	85	115
19	15	Apatite	0.56						47.05			44.11		5.99													2.29	100	145
19	16	Chlorite	25.97		20.81	26.81		11.41																				85	109

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
19	17	Albite	69.93		18.68					11.38																		100	133
19	18	Chlorite	27.46		19.85	25.45		11.06		0.71	0.47																	85	105
19	19	Chlorite	27.03		19.42	26.01		12.05		0.48																		85	101
19	20	Albite	69.95		18.77					11.28																		100	130
19	21	Albite	68.82		18.92				0.72	11.54																		100	133
19	22	Albite	69.87		18.48					11.65																		100	128
19	23	Quartz	100.00																									100	131
19	24	Quartz	100.00																									100	125
19	25	Quartz	100.00																									100	131
19	26	Chlorite	27.93		19.05	25.33		11.47		0.62	0.60																	85	107
19A	1	Biotite	38.95	2.56	16.43	21.79		7.91			8.36																	96	109
19A	2	Ilmenite +	6.37	48.60	0.72	42.77	1.15				0.39																	100	107
19A	3	Rutile +	5.16	76.38	3.00	13.33		0.72	0.61			0.79																100	101
19A	4	Monazite +	33.35	4.92	13.16	1.74		1.13	0.77	4.11	2.40	20.11		-1.06								13.94	5.43					100	100
19A	5	Rutile +	5.28	92.80	1.92																							100	107
19A	6	Ilmenite +	27.24	38.16		33.62	0.97																					100	117
19A	7	Ilmenite +	6.69	55.69	0.60	35.00	1.26									0.76												100	99
19A	8	Monazite +	21.79		9.67	2.72		2.27	1.10	1.27	2.01	22.39	0.95								9.37	19.83	6.62					100	112
19A	9	Rt + Bt	15.97	63.90	7.46	7.05		3.52			2.10																	100	98
19A	10	Chlorite	26.66		20.05	26.97		11.32																				85	96
19A	11	Albite	68.73		19.45	0.32				10.71	0.78																	100	114
19A	12	Quartz	100.00																									100	121
19A	13	Muscovite	49.34	0.62	29.36	3.04		1.90		0.32	10.42																	95	110
19A	14	Biotite	40.00	2.50	17.15	23.32		8.50			8.53																	100	106
20	1	Biotite	38.33	2.51	16.80	21.99		8.26			8.11																	96	114
20	2	Albite	69.76		19.08					11.16																		100	125
20	3	Quartz	100.00																									100	122
20	4	Quartz	100.00																									100	124
20	5	Muscovite	49.82	0.50	29.64	2.50		1.72			10.82																	95	117
20	6	Biotite	37.82	2.63	16.81	23.08		8.09			7.56																	96	109
20	7	Chlorite	26.47		20.02	26.73		11.78																				85	94
20	8	Monazite +	4.54		1.01				0.89			38.79		-1.24							16.65	28.59	10.78					100	101
20	9	Ms + Bt	47.43	0.75	27.08	10.73		4.90		0.41	8.70																	100	113
20	10	Muscovite	49.07	0.57	28.94	3.79		2.07		0.35	10.20																	95	112
20	11	Chlorite	24.83		19.41	29.44		10.77		0.54																		85	95
20	12	Muscovite	49.35	0.51	29.35	3.16		2.06			10.56																	95	115
20	13	Albite	69.54		18.61					11.86																		100	129
20	14	Monazite +	2.94		1.55	2.40			4.61			31.09	3.39							4.49	13.10	23.33	9.18				3.93	100	99
20	15	Ms + Ab	57.37		25.70	4.84		1.74		4.69	5.66																	100	117
20	16	Ms + Chl	49.05	0.61	29.23	6.92		3.42			10.78																	100	112
20	17	Chlorite	26.62		19.40	27.31		11.23			0.44																	85	103
20	18	Albite	69.46		18.78				0.52	11.23																		100	122
20	19	Albite	69.99		18.36					11.65																		100	123
20	20	Chlorite	32.13		19.22	22.87		9.38		0.94	0.46																	85	98
20	21	Albite	69.99		18.44					11.57																		100	121
20	22	Ms + Chl	49.72	0.69	27.71	7.89		4.68			9.30																	100	111
20	23	Biotite	37.68	2.08	17.35	22.44		8.73			7.72																	96	110
20	24	Chlorite	27.06		20.14	25.38		11.28		0.48	0.66																	85	98
20	25	Muscovite	49.13	0.39	29.24	3.31		1.99		0.34	10.60																	95	109
20	26	Albite	69.73		18.52					11.55	0.20																	100	118
20	27	Chlorite +	28.94		17.93	24.79		10.89		0.65	1.80																	85	99
20	28	Quartz	100.00																									100	124
20	29	Albite	69.11		19.30				0.46	11.13																		100	121
20	30	Rutile +	4.60	77.18	1.17	15.69	0.85		0.50																			100	98
20	31	Muscovite	49.82	0.38	29.30	2.75		1.61		0.45	10.71																	95	106
20	32	Biotite	38.57	2.22	16.45	22.06		8.63			8.06																	96	110
20	33	Chlorite	27.07		20.24	26.10		11.59																				85	97

Table 9.7. EDS chemical analyses of sample OD2016-D2-022-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	NiO	Y2O3	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	HfO2	WO3	Total	Actual Total
20a	1	Muscovite	49.73	0.54	30.62	2.22		1.52			10.37																	95	115
20a	2	Monazite	16.60									30.05		1.43			-0.04				17.59	28.64	5.73					100	115
20a	3	Biotite	39.26	2.30	17.34	21.00		8.44			7.65																	96	116
20a	4	Ms + Qz	73.82		16.63	2.08		1.44			5.66				0.37													100	78
20a	5	Albite	69.16		19.06				0.38	11.41																		100	123
20a	6	Muscovite	49.22		30.11	3.26		1.77		0.48	10.17																	95	111
20a	7	Chlorite	26.36		20.88	25.60		11.73		0.42																		85	102
20a	8	Chlorite	33.75		18.09	22.13		10.56		0.48																		85	112
20a	9	Quartz	100.00																									100	128
20a	10	Chlorite	27.92		20.61	24.19		11.81			0.48																	85	103
20a	11	Chlorite	28.99		19.18	25.53		10.96			0.33																	85	103
20a	12	Chlorite	26.01		20.73	26.44		11.82																				85	102
20a	13	Muscovite	46.87	0.73	27.45	7.30		2.96		0.35	9.33																	95	115

Appendix 9.8: OD2016-D2-027 EDS analysis data.

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
1	1	Zircon	27.64		0.89	1.04		0.66	1.62	0.54											67.61														100	98
1	2	Zircon	31.81																		68.19														100	120
1	3	Zircon	31.21			0.82															67.97														100	111
1	4	FeOhy +	7.66		1.72	89.24		1.38																											100	76
1	5	Chlorite	25.60		21.15	26.70		11.54																											85	97
1	6	FeOhy +	6.40		2.44	88.67		1.39				1.10																							100	80
1	7	Apatite							48.82			43.86		5.83																		1.49			100	123
1	8	Biotite	38.12	2.01	16.38	22.59		8.87			8.04																								96	105
1	9	Quartz	100.00																																100	119
1	10	FeOhy +	9.16		2.12	86.18		2.54																											100	69
1	11	Rutile +	2.12	95.88	0.76	0.95					0.29																								100	103
1	12	FeOhy +	14.14		8.05	74.86		1.76			1.19																								100	89
1	13	FeOhy +	7.98		3.29	86.61		1.46	0.66																										100	80
1	14	Muscovite	46.02		14.09	22.32		2.44			9.31												0.82												95	102
1	15	FeOhy +	7.04		2.74	88.71		1.51																											100	81
1	16	FeOhy +	7.77		3.51	85.10		2.12			0.47	1.03																							100	80
1	17	FeOhy +	8.88		1.95	87.54		1.63																											100	77
1	18	Biotite	38.26	2.16	16.58	21.98		8.44			8.58																								96	109
1	19	Apatite							48.75			44.52		5.20																		1.54			100	124
1	20	Zircon	50.80			0.98															48.22														100	101
1	21	Apatite				0.40			48.05			44.08		5.55																		1.92			100	122
1	22	Quartz	99.64			0.36																													100	118
1	23	Biotite	38.22	2.18	15.85	22.24		8.69			8.82																								96	105
1	24	Apatite	0.53			0.54			48.22			43.49		5.95																		1.26			100	125
2	1	Biotite	37.46	2.06	17.31	22.47		8.74			7.96																								96	101
2	2	Ilmenite +	2.03	52.54		40.90	2.71												1.82																100	105
2	3	Zircon	31.47			0.55															67.98														100	116
2	4	Zircon	31.64																		68.36														100	111
2	5	Zircon	31.25																		68.75														100	110
2	6	Rutile +	2.44	95.62	1.36	0.58																													100	99
2	7	Rutile +	1.03	97.67	0.72	0.58																													100	100
2	8	Xenotime +	3.76			1.25						37.35								43.92							2.40	4.60	3.74	2.98					100	107
2	9	Quartz +	91.11		5.69	0.67		0.53			2.00																								100	117
2	10	Quartz	100.00																																100	116
2	11	Biotite	38.68	2.13	16.83	21.11		8.76			8.50																								96	106
2	12	Muscovite	54.45		25.97	2.56		1.50		2.79	7.72																								95	106
2	13	Quartz	100.00																																100	114
2	14	Rutile +	2.35	96.44	0.55	0.66																													100	107
2	15	FeOhy +	7.32		9.07	80.74		1.63				1.24																							100	77
2	16	Chlorite	26.13		20.54	26.42		11.60			0.31																								85	98
2	17	Ilmenite +	1.82	52.97		40.35	2.71												2.15																100	105
2	18	Biotite	37.82	1.96	16.88	22.57		8.59			8.18																								96	106
2	19	Biotite	38.02	1.96	16.54	21.92		8.53			9.02																								96	93
2	20	Albite	69.58		18.57					11.85																									100	108
2	21	Quartz	100.00																																100	112
2	22	Biotite	38.11	2.15	16.56	21.87		8.88			8.43																								96	104
2	23	Quartz	99.61			0.39																													100	114
2	24	Chl + Bt	35.34	0.50	23.85	25.65		11.41			3.24																								100	95
2	25	Muscovite	46.10	0.90	27.00	7.98		3.14			9.88																								95	107
2a	1	Xenotime	6.53			1.07										1.79				73.64							3.86	7.20		4.01				1.90	100	70
2a	2	Albite	69.45		18.60	0.26				11.69																									100	122
2a	3	Chlorite	26.55		20.55	25.65		12.25																											85	101
2a	4	Biotite	38.95	2.20	16.26	20.89		9.02			8.68																								96	112
2a	5	Muscovite	48.31	0.62	32.20	1.85		1.16		0.49	10.37																								95	111
2a	6	Quartz	100.00																																100	124
2a	7	Quartz	100.00																																100	125
2a	8	Apatite	0.86		0.50				46.84		0.19	43.68		6.52																		1.40			100	127
2a	9	Muscovite	48.64	0.70	29.19	4.07		2.18		0.35	9.88																								95	112
2a	10	Ms + Chl	41.75	0.48	18.63	25.49		11.54		0.46	1.64																								100	101
3	1	FeOhy +	7.89		2.12	85.65		2.30							0.66			1.38																	100	73
3	2	Zircon	31.21																		68.79														100	108
3	3	Ilmenite +	1.16	52.37		39.43	2.57												4.47																100	94
3	4	Rutile +	2.85	94.09	0.76	0.68			0.70			0.92																							100	97
3	5	Biotite	38.36	2.26	16.62	21.48		8.37			8.92																								96	96

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
3	6	Rutile +	5.28	92.42	1.27	1.03																													100	99
3	7	Ab + Rt	39.30	45.39	9.98				0.34	5.00																									100	96
3	8	Zircon	28.15		0.83	1.12			1.32												68.58														100	95
3	9	FeOhy +	9.20		3.80	81.61		1.97				1.28			0.41			1.74																	100	67
3	10	Biotite	38.46	2.13	16.45	21.64		8.53			8.78																								96	100
3	11	Zircon	29.37		0.96	0.82			1.43												67.42														100	87
3	12	Quartz	100.00																																100	109
3	13	FeOhy +	9.44			87.77		1.16							0.42			1.22																	100	62
3	14	Chl + Bt	36.37	1.42	19.88	26.24		11.29			4.81																								100	86
3	15	Albite	71.96		16.59	1.20				7.44	2.81																								100	100
3	16	Albite	67.15		19.40	1.34		0.45		10.50	1.16																								100	99
3	17	Rutile +	8.32	75.89	4.46	9.11		0.63			1.59																								100	89
3	18	Rutile +	1.50	97.93	0.57																														100	91
3	19	Ilmenite +	16.28	40.08	5.03	25.33	1.88			5.96									5.43																100	103
3a	1	Quartz	100.00																																100	118
3a	2	Monazite +	12.24		3.97	1.11			1.64	2.21	0.41	26.30	2.10	-0.07										12.59	26.99	10.52									100	101
3a	3	Monazite +	22.78		10.88	3.51		2.11	1.64		2.93	20.30	1.87	0.78										8.17	18.23	6.79									100	98
3a	4	Monazite +	7.19		2.02	2.17			2.38			30.63	2.77	1.00										13.69	28.90	9.26									100	98
3a	5	Monazite +	2.80		1.93	1.44		1.03	2.24			29.65	2.75											14.51	30.42	10.36						2.88			100	98
3a	6	Monazite +	4.92		2.80	8.35		1.36	2.69			27.03	2.42											13.19	27.54	9.70									100	95
3a	7	Monazite +	16.92		11.39	10.14		6.20	2.49		0.71	18.15	2.92											8.02	17.28	5.77									100	107
3a	8	Chl + Bt	32.82	0.43	18.22	36.81		6.48		0.66	4.59																								100	92
3a	9	Muscovite	48.92	0.43	31.13	2.40		1.45			10.67																								95	106
3a	10	Muscovite	50.11		29.40	2.99		2.03			10.46																								95	107
3a	11	Chl + Bt	40.43		11.83	39.24		2.12			2.59										3.78														100	94
3aa	1	FeOhy +	38.88		12.62	38.42		2.20		0.77	2.67							0.68			3.76														100	101
3aa	2	FeOhy +	26.23	1.04	11.79	49.42		6.38			3.54	0.94						0.65																	100	98
3aa	3	Ms + Chl	45.11	1.22	18.25	20.18		9.33		0.71	5.19																								100	113
3aa	4	Monazite	19.29		9.05	3.42		2.64	1.51		1.92	23.12	2.00											9.66	20.29	7.09									100	106
3aa	5	Chlorite	27.71		20.66	24.94		11.50			0.19																								85	103
3aa	6	Muscovite	53.64	0.38	26.55	3.65		2.06		1.46	7.26																								95	104
3aa	7	Monazite	1.57		0.99	8.07			2.50			31.05	2.89	0.98										12.94	26.42	9.34						3.25			100	97
3aa	8	Monazite	23.32		11.03	8.64		5.64	1.65		0.56	16.09	1.60											8.37	17.18	5.93									100	118
3aa	9	Quartz +	96.43		1.40	1.41		0.76																											100	120
3aa	10	Quartz	100.00																																100	125
3aa	11	Quartz +	93.59		3.20	1.14		0.79			1.29																								100	111
3aa	12	Muscovite	50.30	0.54	26.69	5.21		2.51		0.37	9.38																								95	109
3ab	1	Monazite	3.40		2.36	7.10		0.91	2.80			27.94	2.56											13.23	26.59	10.29						2.83			100	105
3ab	2	Chlorite	25.89		12.20	38.37		3.41		2.30	2.03	0.81																							85	99
3ab	3	Biotite	39.53	1.68	16.95	20.45		8.82			8.56																								96	112
3ab	4	Chlorite	27.81		20.95	24.10	0.29	10.76		0.46	0.63																								85	102
3ab	5	Muscovite	47.90	0.63	29.16	5.29		2.76			9.26																								95	110
3ab	6	Muscovite	50.74		29.27	2.75		2.11			10.14																								95	114
3ab	7	Quartz	99.71			0.29																													100	126
3ab	8	Ms + Chl	45.77		22.74	18.84		8.96		0.99	2.70																								100	114
3ab	9	Muscovite	46.10	0.70	24.93	9.04		4.47		0.35	9.41																								95	104
3ab	10	Ms + Chl	53.76		14.56	25.49		1.82			4.38																								100	111
4	1	Quartz	100.00																																100	118
4	2	FeOhy +	7.59		2.82	87.82		1.77																											100	101
4	3	FeOhy +	6.46		4.12	85.73		1.81				1.88																							100	98
4	4	FeOhy +	15.15		8.43	68.78		3.75			1.60	1.37						0.91																	100	98
4	5	FeOhy +	22.63		11.92	58.57		6.40			0.48																								100	98
4	6	Xenotime +				1.05						39.43				1.50				45.47							1.64	3.17		4.20	3.54				100	95
4	7	Ilmenite +	4.00	49.73	1.64	33.82	2.72				0.49								7.59																100	107
4	8	Chlorite	26.26		20.30	26.54		11.91																											85	92
4	9	Rutile +	11.15	79.37	5.93	1.11		0.50			1.94																								100	106
4	10	Biotite +	38.77	1.96	15.45	19.73		7.72			7.33										5.04														96	107
4	11	Mix	12.90	49.37	3.33	4.34		0.96	13.38		0.88	13.04		1.81																					100	94
4	12	Rutile +	1.67	95.60	1.08	1.16					0.49																								100	113
4	13	Apatite							48.33			44.00		5.99																		1.68			100	74
4	14	Rutile +	8.34	84.29	2.15	4.88					0.34																								100	78
4	15	Rutile +	1.97	95.73	0.83				0.71			0.76																							100	78
4	16	Chl + Bt	35.48	0.95	20.39	28.00		11.34			3.84																								100	82
4	17	Quartz	100.00																																100	102

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
4	18	Chlorite	26.71		20.33	26.26		11.70																											85	106
4	19	Muscovite	49.30		28.22	4.43		2.32			10.74																								95	93
4	20	Apatite	0.56						47.88			44.09		5.70																		1.78			100	106
5	1	Biotite	38.46	2.10	16.16	21.65		8.85			8.77																								96	96
5	2	Monazite +	4.83		2.12	2.44			2.32			29.81	2.35	1.11								1.29		14.06	29.40	10.28									100	88
5	3	Monazite +	10.12		5.16	6.15		2.82	9.01		1.02	25.97	4.00						0.36			4.02		10.24	12.18	8.96									100	100
5	4	Rutile +	2.57	95.27	1.34	0.82																													100	117
5	5	Rutile +	4.96	90.36	3.36	0.72					0.60																								100	98
5	6	Monazite +	4.32		1.83				1.93		0.55	32.91	2.95	-0.87										14.75	31.45	10.17									100	108
5	7	Rutile +	1.78	95.04	1.28	0.91					0.28	0.71																							100	99
5	8	Rutile +	1.60	97.19	0.59	0.62																													100	119
5	9	Rutile +	3.59	91.84	1.53	2.33						0.71																							100	94
5	10	Quartz	100.00																																100	102
5	11	Albite	69.32		19.18					11.50																									100	119
5	12	Monazite +	37.50		3.25	20.73		1.26	3.50		0.67	12.58	1.70											6.23	8.06	4.51									100	97
5	13	Ilmenite +	11.94	59.49	3.48	23.09		1.31			0.69																								100	88
5	14	Rutile +	8.02	87.86	2.38	0.69					1.05																								100	82
5	15	Biotite	38.23	1.96	16.47	21.85		8.97			8.52																								96	99
5	16	Quartz	100.00																																100	95
5	17	Rutile +	2.50	96.97					0.53																										100	89
5	18	Quartz	100.00																																100	100
5	19	Ilmenite +	4.39	47.73	3.17	36.30	2.14	1.19											5.08																100	101
5	20	Quartz	100.00																																100	96
6	1	Biotite	38.99	1.80	16.36	20.97		8.90			8.98																								96	107
6	2	Monazite +	2.15			3.02			8.19			30.10	2.53	2.85								2.54		17.16	19.19	12.27									100	111
6	3	FeOhy +	16.54		7.09	67.77		3.15	0.64		1.70	2.70			0.41																				100	78
6	4	Zircon	30.40		0.70	0.69			0.91												67.30														100	89
6	5	Monazite +	3.02		1.02	3.81			8.54	1.32	0.67	32.21	2.70											14.98	15.96	10.98							4.80		100	93
6	6	Rutile +	6.31	92.01	0.94	0.50					0.24																								100	99
6	7	Rutile +	3.29	92.27	2.42	0.90			0.59		0.53																								100	105
6	8	Rutile +	9.99	83.48	3.55	0.54				1.90	0.54																								100	97
6	9	Rutile +	12.71	82.78	2.63	0.54				0.61	0.73																								100	110
6	10	Chlorite +	28.04	0.68	17.70	26.10		10.54			1.94																								85	93
6	11	Quartz +	85.69		8.92	0.55				3.11	1.73																								100	111
6	12	Quartz	100.00																																100	96
6	13	Rutile +	11.19	86.72	1.17					0.59	0.33																								100	77
6	14	Biotite	38.48	2.20	16.05	21.47		9.01			8.78																								96	72
6	15	Biotite	38.67	2.18	16.62	21.18		8.61			8.75																								96	94
6	16	Rutile +	27.26	70.15	1.87						0.72																								100	80
6	17	FeOhy +	25.37	1.08	12.28	50.46		5.74			3.99	1.08																							100	101
6	18	Chlorite +	26.44		16.92	31.45		8.68			1.51																								85	100
6	19	Rutile +	1.78	95.45	2.15	0.62																													100	95
6	20	Quartz	100.00																																100	97
6	21	Rutile +	3.38	94.31	1.55	0.76																													100	92
6	22	Rutile +	1.07	98.40	0.53																														100	99
6	23	Rutile +	2.87	76.66	1.17	19.30																													100	107
6	24	Biotite	38.11	2.20	16.62	21.93		8.56			8.58																								96	100
7	1	Biotite	39.00	2.06	16.18	21.24		8.87			8.65																								96	95
7	2	FeOhy +	4.21		1.08	91.14		1.59	0.48			1.05			0.45																				100	95
7	3	Monazite +	8.81		4.25	48.79		1.92	3.65		0.53	14.88	1.52											5.37	6.47	3.80									100	94
7	4	Rutile +	5.93	89.05	3.53	0.71					0.78																								100	77
7	5	Rutile +	5.63	92.24	1.36	0.77																													100	84
7	6	Albite	68.98		19.29				0.46	11.27																									100	96
7	7	Rutile +	10.16	82.54	4.69	0.91					1.70																								100	108
7	8	Biotite	38.72	2.08	16.57	21.38		9.09			8.16																								96	95
7	9	Biotite	38.90	2.18	16.23	20.72		8.99			8.98																								96	94
7	10	Rutile +	6.65	70.62	3.29	18.05		0.76			0.63																								100	86
7	11	Xenotime +	6.50			0.76					0.67	37.98				1.78	1.23			46.06							1.57	3.44							100	95
7	12	Chlorite	23.83		17.30	34.63		8.74			0.51																								85	100
7	13	Rutile +	4.19	94.40	1.02						0.39																								100	77
7	14	Biotite	38.20	2.11	16.64	22.68		8.34			8.04																								96	73
7	15	Ms + Rt	32.15	37.23	20.52	2.02		1.23			6.84																								100	99
7	16	Quartz	100.00																																100	96
7	17	Rutile +	7.66	88.37	2.80	0.75					0.42																								100	109

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
7	18	Mix	27.01	19.60	11.94	26.78	0.63	6.78			5.90								1.36																100	95
7	19	Quartz	100.00																																100	103
7	20	Biotite	38.09	1.99	16.44	21.77		8.95			8.77																								96	102
7	21	FeOhy +	9.95		5.71	75.61		2.77	0.53	1.95		1.76			0.78			0.94																	100	95
7a	1	Biotite	38.05	1.94	16.58	21.81		8.98			8.65																								96	102
7a	2	Zircon	39.48		15.36	2.82		1.33	0.83	0.81	5.17										34.21														100	104
7a	3	Apatite	1.11	8.87	0.68	0.63			42.68		0.30	39.08		5.19																		1.46			100	116
7a	4	Quartz	100.00																																100	116
7a	5	Muscovite	49.98		29.03	3.54		1.59			10.86																								95	105
7a	6	Muscovite	48.96	0.65	30.55	2.57		1.55			10.73																								95	102
7a	7	Apatite	1.13		0.74				47.24		0.42	43.15		5.85																		1.48			100	119
7a	8	Rutile +	6.46	85.93	4.67	1.48		0.63			0.83																								100	106
7a	9	Apatite	1.78		1.11	0.40			46.40		0.57	42.83		5.00																		1.90			100	119
8	1	Albite	69.56		18.99					11.46																									100	96
8	2	Biotite	38.18	2.13	16.64	21.66		8.41			8.99																								96	85
8	3	Biotite	38.05	2.02	16.43	21.84		8.77			8.89																								96	102
8	4	Quartz	100.00																																100	95
8	5	Albite	68.82		18.76				0.35	11.37			0.70																						100	100
8	6	Quartz	100.00																																100	110
8	7	Rutile +	6.55	90.26	1.72	0.73				0.74																									100	101
8	8	Ilmenite +	1.48	52.62	0.60	41.50	2.44												1.36																100	96
8	9	Rutile +	11.34	78.47	6.41	1.54				0.53	1.71																								100	109
8	10	FeOhy +	25.82	1.17	14.34	48.09		7.11			3.47																								100	105
8	11	Ilmenite +	3.29	56.00	0.77	36.05	1.82												2.07																100	72
8	12	Ilmenite +	2.40	52.00	0.81	41.14	2.44												1.21																100	102
8	13	Monazite +	18.08		5.86	2.12			1.33	5.03		21.88	1.32											11.32	24.55	8.53									100	104
8	14	Rutile +	6.74	91.64	0.94	0.68																													100	116
8	15	Rutile +	3.06	93.68	1.06	1.92					0.28																								100	116
8	16	Zircon	31.79		1.47	1.04				0.62											65.08														100	105
8	17	Rutile +	6.52	71.90	3.12	9.35		0.58	3.81	0.80		3.92																							100	102
8	18	Mix	13.13	17.05	7.97	47.78		1.36	2.21		1.49	6.94														2.06									100	119
8	19	Ilmenite +	2.01	51.22	0.87	39.69	2.79												3.42																100	106
8	20	Quartz	100.00																																100	119
8	21	Ilmenite +	5.48	46.16	3.63	38.02	2.10	1.99			0.48								2.13																100	112
8	22	Rutile +	2.11	96.96		0.67					0.26																								100	102
8	23	FeOhy +	13.22		5.01	79.37		2.04			0.36																								100	106
8	24	Ms + Rt	29.09	43.69	17.55	2.05		1.09			6.53																								100	117
8	25	Biotite	38.86	1.96	16.20	20.96		9.20			8.82																								96	115
8	26	Biotite	37.99	2.15	16.58	21.77		8.58			8.93																								96	123
9	1	Biotite	38.67	2.37	16.36	21.33		8.64			8.63																								96	109
9	2	FeOhy +	8.13		1.42	88.31		2.14																											100	103
9	3	FeOhy +	22.74		16.85	49.95		10.46																											100	110
9	4	Rutile +	1.54	97.97	0.49																														100	93
9	5	Biotite	38.07	2.34	16.34	22.39		8.13			8.73																								96	102
9	6	Ilmenite +	4.96	51.59	0.62	36.59	2.54												3.70																100	111
9	7	Xenotime +				1.27						37.35								41.95							2.13	4.59	3.67	2.81	6.23				100	119
9	8	Xenotime +									0.35	37.48				1.72				44.10							2.44	4.14		4.19	5.58				100	111
9	9	Rutile +	4.98	93.06	0.96	0.63					0.37																								100	106
9	10	Apatite	0.49			0.41			48.48			44.11		5.30																		1.20			100	117
9	11	FeOhy +	16.22		1.02	81.07		1.69																											100	101
9	12	Rutile +	2.76	91.74	1.98	3.52																													100	79
9	13	Quartz	100.00																																100	101
9	14	Biotite	38.18	1.97	16.48	21.91		8.59			8.87																								96	116
9	15	Chlorite	26.49		19.66	27.16		11.42			0.28																								85	110
9	16	Ms + Chl	44.99	0.50	29.36	12.38		5.24			7.54																								100	111
9	17	Biotite	38.74	2.06	16.31	21.39		8.63			8.87																								96	75
9a	1	Zircon +	35.07		11.34	1.96		0.94	0.95	0.63	3.99										45.12														100	111
9a	2	Biotite	39.04	2.08	16.71	20.76		8.97			8.44																								96	114
9a	3	Quartz	100.00																																100	127
9a	4	Apatite	7.73		2.96	2.86		1.48	40.97		0.57	37.86		5.55																					100	123
9a	5	Chlorite	27.07		19.39	26.20	0.29	12.05																											85	100
9a	6	Albite	68.01		19.91				1.29	10.79																									100	124
9a	7	Muscovite	52.26		27.41	2.76		2.20		0.67	9.71																								95	115
9a	8	Quartz	99.53			0.47																													100	126

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
9a	9	Biotite	38.84	2.22	16.55	21.36		8.38			8.65																								96	111
9a	10	Muscovite	49.43	0.60	30.68	2.43		1.49			10.37																								95	114
9b	1	Quartz	99.72			0.28																													100	126
9b	2	FeOhy +	12.70		8.74	71.81		3.51			1.36	0.92						0.95																	100	87
9b	3	Chlorite	26.26		20.27	26.49		11.98																											85	103
9b	4	Muscovite	47.03	0.48	29.44	6.38		2.91		0.33	8.43																								95	114
9b	5	Chl + Ms	38.01		23.60	24.93		10.94		0.61	1.90																								100	106
9b	6	Biotite	38.30	2.08	16.69	21.32		9.02			8.58																								96	113
9b	7	Quartz	99.57			0.43																													100	127
9b	8	Xenotime	27.69		9.45	4.16		2.31		2.93	1.02					1.26				45.29							1.92	3.96							100	88
9b	9	Zircon +	39.27		17.32	2.14		1.31	0.59	0.38	6.37										32.62														100	113
9b	10	Muscovite	49.31	0.58	30.48	2.52		1.45		0.51	10.15																								95	116
9b	11	Albite	69.13		18.79	0.40				11.68																									100	125
9b	12	Apatite	10.08		5.30	1.38		0.71	39.26	0.90	1.55	35.43		5.38																					100	126
9b	13	Biotite	38.36	1.95	16.95	20.88		9.01			8.84																								96	112
9b	14	Quartz	99.71			0.29																													100	126
9b	15	FeOhy +	27.42		9.80	54.16		6.45	0.29		0.29	1.01						0.57																	100	98
10	1	FeOhy +	7.04		2.87	88.40		1.69																											100	111
10	2	Ilmenite	0.88	53.89		40.59	2.22												2.42																100	103
10	3	Bt + Chl	35.37	1.98	15.89	31.71		8.04			7.01																								100	107
10	4	Zircon	28.86		0.81	1.16			1.60												67.57														100	110
10	5	FeOhy +	10.55		2.74	81.49		2.95	0.53									1.74																	100	79
10	6	FeOhy +	8.86		1.15	87.62		1.39										0.98																	100	95
10	7	FeOhy +	7.29		2.44	89.04		1.23																											100	112
10	8	FeOhy +	8.88		2.19	85.10		2.39										1.44																	100	104
10	9	Quartz	99.52			0.48																													100	114
10	10	Biotite	37.99	2.06	15.68	22.28		9.04			8.95																								96	116
10	11	Biotite	40.38	2.39	16.36	20.21		8.10			8.55																								96	109
10	12	Quartz	100.00																																100	107
10	13	Muscovite	49.25	0.46	30.15	3.03		1.63			10.48																								95	125
10	14	Biotite	37.54	2.08	16.49	22.81		8.50			8.58																								96	84
10	15	FeOhy +	8.02			90.59		1.39																											100	106
10	16	Chlorite	26.17		19.50	27.63		11.70																											85	123
11	1	Zircon	31.85			0.64															67.51														100	111
11	2	Albite	69.49		18.78				0.32	11.41																									100	98
11	3	Apatite	0.75						48.30			43.42		6.05																		1.49			100	108
11	4	Biotite	38.61	1.96	15.98	21.84		8.83			8.78																								96	113
11	5	Rutile +	2.52	95.69	1.28	0.51																													100	76
11	6	Chlorite	26.35		20.11	26.84		11.70																											85	101
11	7	FeOhy +	12.45		5.25	75.48		2.40	0.53		0.41	1.56			0.34			1.58																	100	96
11	8	Ilmenite +	1.95	51.52	0.98	40.86	2.57												2.12																100	93
11	9	Biotite	38.38	2.02	16.46	22.20		8.74			8.21																								96	74
11	10	Quartz	100.00																																100	73
11	11	Apatite	0.66			0.57			47.85			43.67		5.81																		1.44			100	73
11	12	Chlorite	26.71		20.93	25.61		11.76																											85	74
11	13	Muscovite	49.24	0.46	29.72	2.91		1.81			10.87																								95	118
11	14	Rutile +	1.22	98.10		0.68																													100	104
11	15	Muscovite	49.01	0.86	28.73	4.18		1.65			10.57																								95	97
11	16	Biotite	37.84	2.42	15.68	22.86		8.22			8.98																								96	117
11	17	Biotite	38.75	1.99	16.27	21.43		8.64			8.93																								96	101
11	18	Quartz	100.00																																100	104
12	1	Albite	70.08		18.61					11.31																									100	77
12	2	Biotite	38.22	2.13	16.29	21.87		8.74			8.75																								96	82
12	3	Quartz	100.00																																100	111
12	4	Ilmenite	1.69	52.62		39.77	2.61												3.31																100	108
12	5	FeOhy +	13.78	16.06	4.88	59.22		1.14	1.74			3.19																							100	113
12	6	Chlorite	26.09		20.26	26.65		12.01																											85	101
12	7	Muscovite	48.83	0.54	30.32	2.95		1.87			10.48																								95	99
12	8	FeOhy +	8.98		1.98	87.10		1.94																											100	94
12	9	Monazite +	4.04		1.80	8.85		1.26	7.72			28.57	1.97	2.67								3.03		15.32	13.48	11.30									100	72
12	10	Monazite +	3.57		2.25	2.79			2.49			29.93	2.85	-0.27								1.28		13.43	29.14	9.35						3.20			100	96
12	11	FeOhy +	8.49		2.57	84.03		2.40				1.15						1.36																	100	89
12	12	Biotite	38.27	2.04	16.50	21.89		8.50			8.80																								96	114
12	13	Apatite	0.53			0.51			48.62			44.06		4.87																		1.41			100	117

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
12	14	Ilmenite +	22.27	34.85	6.20	21.83	1.37			5.27	0.31								7.91																100	94
12	15	Apatite			0.40				48.28			43.60		6.23																		1.49			100	104
12	16	Muscovite	48.57	0.68	27.95	4.68		2.71			10.40																								95	102
12	17	Muscovite	50.08	0.48	29.44	2.70		1.80			10.51																								95	102
12	18	Zircon	38.93		1.57	0.90			0.50		0.35										57.75														100	94
12	19	Zircon	31.32		0.79	0.84															67.05														100	101
13	1	FeOhy +	4.28			92.56	0.99	1.81							0.36																				100	117
13	2	Quartz	100.00																																100	105
13	3	Biotite	38.86	2.01	16.75	20.52		9.01			8.84																								96	94
13	4	Monazite +	14.10		4.78	6.05		2.49	6.41		0.58	26.97	2.42									2.14		10.98	14.55	8.57									100	109
13	5	Monazite +	7.14		3.44	22.73		1.61	5.25		0.55	20.55	1.77									1.91		10.76	16.73	7.55									100	90
13	6	Apatite				0.35			47.88			44.77		5.05																		1.94			100	78
13	7	Rutile	0.66	98.80		0.54																													100	88
13	8	FeOhy +	10.65		4.84	76.86		2.93	0.77			2.91						1.04																	100	99
13	9	Biotite	38.95	2.03	16.05	21.50		8.75			8.71																								96	71
13	10	Quartz	100.00																																100	75
13	11	FeOhy +	7.74		4.38	81.31		2.95	0.49			1.51			0.52			1.10																	100	95
13	12	Rutile +	3.04	94.03	1.80	1.13																													100	73
13	13	Rutile +	19.02	78.62	1.61					0.75																									100	94
13	14	Zircon	34.57		4.76	1.40			1.37	1.79	1.11										55.00														100	106
13	15	Quartz	100.00																																100	98
13	16	Biotite	38.50	1.94	16.80	21.28		8.77			8.71																								96	113
13	17	Quartz	100.00																																100	92
13	18	Biotite	38.63	1.96	15.91	21.55		8.98			8.98																								96	97
13	19	Rutile +	4.92	75.60	2.04	16.35		0.75			0.34																								100	106
13	20	Zircon	34.80		6.03	1.27		0.76	1.23	1.05	1.92										52.94														100	103
13	21	Qz + Rt	66.09	30.98	2.14						0.79																								100	72
14	1	Quartz	100.00																																100	107
14	2	Zircon	31.62		0.77	0.91															66.70														100	97
14	3	Rutile +	3.66	93.87	1.55	0.51					0.41																								100	78
14	4	Monazite +	1.52						1.68			33.09	2.40	1.06										15.89	33.83	10.54									100	78
14	5	Rutile +	4.24	92.22	2.32	0.58					0.64																								100	116
14	6	Biotite	38.22	2.18	16.52	21.48		8.85			8.76																								96	103
14	7	Apatite	0.66						48.36			43.81		5.86																		1.32			100	66
14	8	Quartz	100.00																																100	95
14	9	Zircon	28.75		2.40	1.85		0.95	2.06		0.59										63.40														100	107
14	10	Apatite							48.31			44.22		5.68																		1.79			100	68
14	11	Biotite	38.19	2.23	16.98	21.63		8.44			8.53																								96	96
14	12	Muscovite	48.28	0.64	30.39	3.42		1.81			10.46																								95	94
14	13	Quartz	100.00																																100	89
14	14	Chlorite	27.16		19.39	25.79		12.36			0.30																								85	105
14	15	Zircon	35.12	4.27	8.52	1.88		0.99	1.68	1.20	2.76										43.58														100	95
14	16	Biotite	38.65	1.84	16.54	21.77		8.44			8.76																								96	105
14	17	Rutile +	11.23	71.22	3.80	12.12			0.71		0.92																								100	102
14	18	Biotite	38.19	2.08	16.91	21.66		8.45			8.71																								96	91
14	19	Quartz	100.00																																100	90
14	20	Quartz	100.00																																100	91
15	1	Biotite	38.87	1.84	17.00	21.52		8.07			8.70																								96	102
15	2	Monazite +	1.78		1.27	3.01			5.89			31.61	3.60	-0.77										14.44	24.39	11.51						3.28			100	102
15	3	Monazite +	1.88			1.71			7.27			27.88	2.38	2.50	0.52									16.80	22.09	12.13							4.83		100	95
15	4	FeOhy +	15.25		6.86	71.60		3.18			1.23	1.88																							100	84
15	5	FeOhy +	9.63		4.31	80.67		3.20				1.54			0.65																				100	91
15	6	Rutile +	1.28	97.47	0.53	0.72																													100	91
15	7	FeOhy +	8.73		6.18	80.91		2.62				1.56																							100	103
15	8	Rutile +	1.77	98.23																															100	111
15	9	Biotite	38.69	2.01	15.82	22.31		8.47			8.71																								96	77
15	10	Mix	30.74	48.51	12.09	0.98				5.27	2.40																								100	109
15	11	Rutile +	1.18	95.01	0.57	2.98					0.26																								100	92
15	12	Biotite	38.92	1.99	16.20	20.99		8.85			9.06																								96	93
15	13	Muscovite	49.29	0.55	29.85	2.63		1.92			10.76																								95	104
15	14	Biotite	37.55	1.85	16.96	23.06		8.63			7.95																								96	85
15	15	Quartz	100.00																																100	83
15	16	Muscovite	46.33	0.78	28.19	6.96		3.61			9.13																								95	96
15	17	Muscovite	49.09	0.60	30.18	2.68		1.65			10.80																								95	86

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
15	18	Quartz	100.00																																100	94
15	19	Monazite +	6.67		2.72	1.80			6.25		0.89	27.36	2.97	0.11								1.84		15.19	22.84	11.37									100	107
15	20	Ab + Rt	58.89	21.27	12.92				0.73	6.19																									100	106
15	21	Monazite +	1.54			0.78			1.60			33.44	2.30	-0.40										16.11	33.73	10.89									100	85
15	22	Rutile +	6.85	83.67	3.04	4.67				1.43	0.34																								100	77
16	1	Biotite	38.49	2.04	16.66	21.38		8.71			8.73																								96	73
16	2	Zircon	30.48						0.39												69.13														100	72
16	3	Rutile +	9.46	80.80	6.00	1.11					2.63																								100	63
16	4	Ms + Rt	28.90	48.02	14.89	2.01		0.81			5.37																								100	99
16	5	Apatite							49.15			44.61		4.75																		1.49			100	66
16	6	Rutile +	14.08	77.26	4.61	0.81				3.24																									100	99
16	7	Biotite	39.01	2.15	15.69	21.40		9.14			8.61																								96	89
16	8	Rutile +	15.19	81.37	1.89	0.62					0.93																								100	101
16	9	FeOhy +	9.28		7.12	78.97		2.54				2.09																							100	93
16	10	Rutile +	3.06	94.75	1.72						0.47																								100	96
16	11	Chl + Ap	26.59	0.57	19.22	25.56		10.84	7.70			9.51																							100	98
16	12	Biotite	37.86	2.26	16.52	21.66		8.92			8.78																								96	98
16	13	Biotite	38.44	2.21	16.05	21.69		8.80			8.80																								96	108
16	14	Biotite	39.32	2.02	16.17	20.51		9.26			8.73																								96	96
16	15	Ms + Rt +	29.78	37.85	16.23	8.58		1.19		0.58	5.78																								100	94
16	16	Chl + Bt	42.91	0.88	18.18	24.20		10.25			3.58																								100	99
16	17	Rutile +	4.13	92.52	1.83	0.94					0.58																								100	69
16	18	Chlorite	40.02		15.28	20.27		8.64			0.80																								85	95
16	19	Muscovite	49.09	0.73	29.35	3.75		1.82			10.26																								95	90
16	20	Muscovite	50.45		27.81	3.87		2.41			10.46																								95	98
16	21	Albite	67.05		18.44	2.17		0.48		10.25	1.61																								100	93
16	22	Rutile +	1.26	98.74																															100	98
16	23	Apatite	0.62						48.66			43.58		5.89																		1.24			100	59
16	24	Ab + Ilm	56.92	14.46	13.21	6.51			0.43	8.47																									100	98
16	25	Quartz	100.00																																100	104
16	26	Rutile +	13.39	82.56	3.19	0.86																													100	99
16	27	Zircon	31.85		1.10	0.58					0.43										66.04														100	93
17	1	FeOhy +	8.11		2.95	82.86		2.29	0.52			1.42			0.47			1.38																	100	94
17	2	Biotite	38.03	1.92	16.84	21.61		9.02			8.58																								96	69
17	3	Quartz	100.00																																100	91
17	4	Monazite +	9.67		5.71	8.01		3.78	9.71			22.11	2.25									2.21		11.55	15.80	9.18									100	92
17	5	Zircon	31.33		5.59	4.63		2.01	1.02	0.65	0.73										54.04														100	99
17	6	Rutile +	2.52	95.33	0.87	0.54			0.48		0.26																								100	93
17	7	Chl + Mnz	28.62		15.42	28.10		7.33	0.80		0.64	6.94												2.94	6.75	2.47									100	94
17	8	Rutile +	1.39	97.04	0.81	0.50					0.26																								100	86
17	9	Muscovite	48.97	0.45	29.74	3.07		1.96			10.81																								95	86
17	10	Quartz	100.00																																100	88
17	11	Biotite	38.55	2.18	16.36	21.16		8.92			8.83																								96	86
17	12	Biotite	45.86	0.65	26.61	9.27		4.62			8.99																								96	91
17	13	Rutile +	6.78	89.82	2.19	0.78					0.43																								100	89
17	14	Apatite	0.68						48.93			43.47		5.58																		1.34			100	100
17	15	Apatite							48.19			44.18		5.69																		1.94			100	96
17	16	Muscovite	48.14	0.55	30.96	3.03		1.68			10.64																								95	103
17	17	Apatite	0.81						49.08			44.29		5.82																					100	99
17	18	FeOhy +	8.88		5.42	79.49		3.08				1.92						1.21																	100	107
17	19	Apatite	5.67		3.99	5.06		2.01	41.66			36.91		4.71																					100	90
17	20	Apatite	0.94						48.15			43.30		6.20																		1.41			100	100
17	21	Rutile +	2.74	94.97	1.49	0.80																													100	63
17	22	Rutile +	1.17	98.06		0.77																													100	94
17	23	Biotite	37.82	1.96	16.07	22.58		9.04			8.53																								96	104
18	1	Albite	69.54		18.78					11.68																									100	68
18	2	FeOhy +	5.05		11.58	79.14		2.12				2.11																							100	88
18	3	Apatite				0.76			48.03			43.70		5.82																		1.69			100	97
18	4	Biotite	38.79	1.96	16.38	21.51		8.90			8.46																								96	69
18	5	Ilmenite	1.07	52.69		40.86	2.60												2.78																100	93
18	6	Rutile	0.92	98.63		0.45																													100	91
18	7	Xenotime +	9.22			6.66		3.22			0.49	33.80								40.01									3.44	3.17					100	102
18	8	Ilmenite +	3.36	50.84	1.28	35.68	2.52		0.48										5.84																100	92
18	9	Ilmenite +	3.04	51.07	1.23	36.97	2.50				0.45								4.74																100	89

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
18	10	Ilmenite +	5.07	50.25		34.04	2.26		1.05										7.33																100	97
18	11	Rutile +	5.31	91.01	1.59	0.57				1.52																									100	108
18	12	Biotite	37.27	2.06	16.17	23.70		8.37			8.42																								96	106
18	13	Ms + Rt	58.94	27.62	8.30	1.09		0.50		1.24	2.31																								100	96
18	14	Apatite	0.62						48.71			44.06		5.30																			1.30			100	99
18	15	Muscovite	50.83		26.60	3.81		2.78			10.97																								95	65
18	16	Biotite	38.81	2.25	16.56	21.16		8.68			8.54																								96	98
18	17	Rutile +	4.51	91.55	1.89	0.72			0.57		0.76																								100	105
18	18	Muscovite	54.23	0.57	25.53	3.41		2.13		1.13	8.01																								95	90
18	19	Chlorite	26.76		19.97	26.13		12.15																											85	96
18	20	Monazite +	9.50		4.35	1.69		1.26	2.13		0.40	28.66	2.02	-0.20											13.04	27.21	9.94									100	94
18	21	Ilmenite +	2.22	50.99	1.38	37.44	2.49				0.34								5.14																	100	109
18	22	Quartz	100.00																																	100	75
18	23	Mz + Qz	46.59		4.21	6.87		2.04	1.39		0.66	17.14	1.70													13.74	5.66									100	113
18	24	Rutile +	2.33	96.92		0.75																														100	91
18	25	Ilmenite +	1.18	52.93		38.66	2.62												4.61																	100	94
18	26	Muscovite	48.62	0.62	29.77	3.33		2.20			10.46																								95	97
18	27	Biotite	37.46	2.35	16.87	21.78		9.10			8.43																								96	89
18	28	Apatite	0.68						49.07			43.79		5.17																			1.30			100	93
18	29	Monazite +	13.80		7.12	8.27		2.27	2.94		1.65	28.85	3.32													22.78	8.99									100	93
18	30	Chlorite	25.60		20.80	27.07		11.53																											85	91
18	31	Muscovite	49.33	0.60	29.86	2.70		1.55			10.96																								95	104
19	1	Zircon	31.13						0.69												68.18															100	93
19	2	Ilmenite +	3.38	51.40		37.80	2.54												4.88																	100	100
19	3	Zircon	31.25																		68.75															100	109
19	4	Ilmenite +	2.10	53.04		39.08	2.38												3.40																	100	96
19	5	Ilmenite +	1.65	52.98		35.53	2.83												7.01																	100	95
19	6	Ilmenite +	7.87	48.49	1.15	35.61	2.53												4.36																	100	94
19	7	Rutile +	1.26	98.74																																100	94
19	8	Rutile +	2.33	96.30	0.70	0.67																														100	86
19	9	Biotite	38.50	2.32	16.26	21.29		8.78			8.84																								96	91
19	10	Biotite	38.87	2.13	16.18	21.37		8.63			8.82																								96	101
19	11	Monazite +	53.28		21.37	6.02		0.90	5.62		4.46													2.39	4.46	1.49										100	109
19	12	Quartz	100.00																																	100	67
19	13	Quartz	100.00																																	100	96
19	14	Zircon	29.83		1.30	1.05			0.91		0.36										66.55															100	92
19	15	Muscovite	49.89	0.50	27.36	3.90		2.58			10.76																								95	93
19	16	Biotite	38.38	2.25	16.42	21.48		8.59			8.89																								96	94
19	17	Muscovite	48.10	0.55	30.56	3.25		1.72		0.36	10.46																								95	114
19	18	Chl + Ms	38.36		27.53	21.30		8.80			4.00																								100	66
19	19	Ab + Kfs	58.78		23.47	4.30		1.74		6.89	4.82																								100	92
19	20	Biotite +	45.66		19.97	17.77		7.61		1.87	3.12																								96	95
19	21	Muscovite	50.51	0.50	29.38	2.83		1.77			10.00																								95	95
19	22	Albite	69.77		18.91					11.32																									100	94
19	23	Quartz	100.00																																	100	107
19	24	Quartz +	84.29	15.71																																100	92
19	25	Rutile +	1.24	98.06	0.70																															100	99
19	26	Biotite	38.75	2.06	16.55	21.09		8.83			8.72																								96	97
19	27	Muscovite	51.76	0.71	25.87	4.61		2.41		0.63	9.02																								95	96
19	28	Apatite	0.51						48.31			43.79		6.13																			1.27			100	98
20	1	Biotite	38.66	2.10	16.21	21.55		9.12			8.35																								96	97
20	2	FeOhy +	5.24			94.76																														100	94
20	3	FeOhy +	4.28			94.54		1.18																												100	101
20	4	FeOhy +	8.66		2.65	83.94		3.03	0.49									1.23																		100	111
20	5	Ilmenite +	14.14	46.25		35.86	2.14												1.61																	100	104
20	6	FeOhy +	8.86		3.70	80.41		2.59	0.56			1.97			0.40			1.51																		100	98
20	7	Ilmenite	2.12	51.97	0.72	40.25	2.85												2.09																	100	99
20	8	FeOhy +	9.16		3.29	84.68		2.87																												100	98
20	9	Biotite	38.27	1.87	15.78	23.51		7.67			8.89																								96	100
20	10	Albite	68.45		18.78	0.49			1.01	11.27																									100	97
20	11	Albite	63.16		22.75	0.99				9.03	4.07																								100	98
20	12	Quartz	100.00																																	100	87
20	13	Monazite +	15.27		5.71	3.46		1.11	2.53	2.02	1.00	31.76	2.80	0.72												24.24	9.39									100	97
20	14	Rutile +	7.32	89.32	1.21	1.74			0.41																											100	110

Table 9.8. EDS chemical analyses of sample OD2016-D2-027.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CoO	NiO	CuO	ZnO	Y2O3	ZrO2	Ag2O	BaO	La2O3	Ce2O3	Nd2O3	Gd2O3	Dy2O3	Er2O3	Yb2O3	Ta2O5	WO3	ThO2	PbO	Total	Actual Total
20	15	Zircon	27.13		1.55	1.75		1.29	2.62	0.66											65.00														100	106
20	16	Ilmenite +	5.82	51.05	0.76	33.46	2.34												6.57																100	104
20	17	Monazite +	8.09		3.33	1.78			2.76		0.55	29.18	2.92											13.12	28.95	10.25									101	100
20	18	Zircon	44.36		2.42	3.67		1.38			0.33										47.85														100	96
20	19	Muscovite	49.75	0.45	30.29	2.49		1.75			10.28																								95	99
20	20	Biotite	38.85	2.11	16.29	20.97		8.44		0.47	8.87																								96	111
20	21	Apatite				0.42			47.81			43.56		6.49																		1.71			100	95
20	22	Chl + Ms	35.96		23.32	25.92		11.28		0.62	2.91																								100	70
20	23	Quartz	100.00																																100	70
20	24	Biotite	37.29	2.34	17.13	22.75		8.56			7.92																								96	69
20	25	Albite	69.36		18.97					11.66																									100	100

Appendix 9.9: OD2016-D2-034 EDS analysis data.

Table 9.9. EDS chemical analyses of sample OD2016-D2-034.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	WO3	Total	Actual Total
1	1	Chlorite	34.55		29.18	40.01	0.49	13.41															85	121
1	2	FeOhy +	3.88		0.83	94.48		0.81															100	109
1	3	Quartz	100.00																				100	95
1	4	Quartz	100.00																				100	112
1	5	Chlorite	37.13		28.47	37.78	0.47	13.11			0.69												85	118
1	6	Muscovite	54.49	0.89	33.67	2.95		1.80		0.40	11.04												95	108
1	7	Ilmenite +	0.95	56.90	0.46	39.30	2.38																100	104
1	8	Rutile +	2.71	94.22	1.92	0.83					0.32												100	94
1	9	Muscovite	53.14	0.66	36.42	1.51		1.12		0.38	12.02												95	112
1	10	Albite	68.30		19.36	0.34			1.10	10.90													100	94
1	11	Muscovite	53.79	0.54	33.80	4.16		1.58		0.40	11.00												95	83
1	12	Apatite							47.62		0.20	43.89		6.44								1.85	100	118
2	1	Apatite				0.31			48.61			44.02		5.42								1.63	100	90
2	2	Rutile +	1.42	98.58																			100	109
2	3	Quartz	100.00																				100	100
2	4	Ilmenite +	1.29	54.17		41.59	2.95																100	109
2	5	Rutile +	1.05	98.95																			100	99
2	6	Chlorite	36.52		29.11	38.22		13.47			0.33												85	106
2	7	Muscovite	55.48	0.43	32.94	3.05		2.04			11.32												95	95
2	8	Muscovite	54.07	0.77	33.92	4.13		1.69			10.68												95	96
2	9	Chlorite	36.84		28.40	36.99		13.81		0.75	0.86												85	117
2	10	Chlorite	36.17		28.40	38.06	0.42	14.58															85	101
2	11	Apatite	0.69						47.87			43.58		6.35								1.51	100	103
2	12	Muscovite +	51.16	0.35	32.82	9.23		3.13			8.56												95	98
2	13	Chlorite	36.07		28.95	38.15	0.39	14.08															85	106
3	1	Apatite							47.78			43.68		6.80								1.74	100	97
3	2	Chlorite	41.55		25.73	34.55		12.03		1.95	1.81												85	92
3	3	Rutile +	4.09	93.95	1.12	0.43					0.41												100	107
3	4	Rutile +	1.63	97.31	0.61	0.45																	100	119
3	5	Ilmenite +	10.33	46.14	2.51	35.36	2.67			2.99													100	104
3	6	Quartz	100.00																				100	100
3	7	Albite	69.82		18.64					11.54													100	75
3	8	Muscovite	55.48	0.36	32.71	3.23		1.96		0.47	11.03												95	86
3	9	Muscovite	56.05	0.57	33.30	2.82		1.75			10.76												95	94
3	10	Chlorite	45.06		31.01	26.35		9.73		0.53	4.96												85	102
3	11	Muscovite	58.35	0.34	27.76	7.92		2.60		0.81	7.49												95	99
3	12	Muscovite	55.27	0.53	33.66	2.59		1.64		0.40	11.17												95	87
3	13	Quartz	100.00																				100	107
3	14	Chlorite	40.93		26.53	34.32		11.97		0.86	3.08												85	100
4	1	Rutile	0.54	99.46																			100	119
4	2	Monazite +	4.00		1.33	1.60			8.71	1.85		33.17	4.28	0.57	0.57			2.67	12.21	18.09	10.94		100	89
4	3	FeOhy +	24.49		13.55	53.36		3.44	0.35	1.12	1.74	1.58			0.38								100	119
4	4	Zircon	31.14			0.48											68.39						100	106
4	5	Chlorite	35.57		29.13	38.67	0.46	13.80															85	89
4	6	Quartz	100.00																				100	107
4	7	Chlorite	34.99		29.55	39.41		13.69															85	93
4	8	Muscovite	54.79	0.63	33.64	2.95		1.75		0.35	11.16												95	110
4	9	Quartz	99.66			0.34																	100	110
4	10	Rutile +	0.78	98.07	0.58	0.58																	100	93

Table 9.9. EDS chemical analyses of sample OD2016-D2-034.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	WO3	Total	Actual Total
4	11	Muscovite	54.19	0.39	34.85	2.91		1.56		0.43	10.96												95	122
4	12	Muscovite	54.93	0.47	33.71	2.90		1.78		0.39	11.05												95	110
4	13	Chlorite	36.08		29.25	38.22		13.86			0.24												85	118
4	14	Chlorite	36.35		28.28	38.34	0.39	13.99			0.29												85	106
4	15	Muscovite +	48.66	0.48	30.22	14.05		2.25		0.41	9.20												95	109
5	1	Zircon	29.67			1.18			1.74							0.80	66.61						100	106
5	2	Ilmenite +	2.23	53.62	0.65	39.34	3.05									1.12							100	95
5	3	Rutile + Quartz	31.72	66.72	1.01						0.32					0.23							100	121
5	4	Chlorite	36.61		28.65	37.18	0.39	14.08			0.74												85	97
5	5	Chlorite	36.34		29.04	37.53		14.05								0.69							85	116
5	6	Quartz	99.70													0.30							100	123
5	7	Quartz	99.70													0.30							100	96
5	8	Chlorite	40.29		25.79	34.35		12.74		1.48	2.99												85	94
5	9	Muscovite	55.09	0.66	33.83	3.04		1.73			10.91												95	99
5	10	Muscovite	55.17	0.53	33.50	2.77		1.74		0.74	10.84												95	103
5	11	Chlorite	40.95		27.27	30.67		11.12		3.08	3.80				0.75								85	106
5	12	Muscovite	55.24		32.92	4.06		2.26		0.91	9.90												95	97
5	13	Muscovite	54.80	0.62	33.69	2.83		1.69		0.62	11.00												95	111
5	14	Chlorite	35.71		29.11	38.19		14.10								0.56							85	101
6	1	Rutile +	2.32	97.68																			100	107
6	2	Quartz	100.00																				100	110
6	3	Muscovite	54.21	1.24	34.40	2.59		1.67			11.14												95	108
6	4	Chlorite	35.29		29.18	38.62	0.48	14.07															85	107
6	5	Ilmenite +	2.13	53.19	0.97	40.34	3.02				0.35												100	95
6	6	Chlorite	39.45		30.19	33.33	0.38	12.26			2.05												85	116
6	7	Albite +	62.31		23.41	1.05		0.59		8.28	4.36												100	117
6	8	Muscovite	57.74		32.60	2.73		1.60			10.60												95	119
6	9	Quartz	100.00																				100	98
6	10	Chlorite	38.44		28.17	36.76		14.25															85	114
6	11	Muscovite	52.25	0.53	32.87	6.36		2.62		0.61	10.01												95	95
7	1	Apatite							47.66			44.24		6.37								1.73	100	105
7	2	Ilmenite +	7.27	53.13	0.75	36.69	2.16																100	101
7	3	Rutile +	4.44	91.63	1.26	1.61				0.63	0.43												100	106
7	4	Quartz	100.00																				100	111
7	5	Chlorite	35.72		28.63	38.76	0.40	14.17															85	108
7	6	Muscovite	52.17	0.53	33.20	6.59		2.98			9.81												95	105
7	7	Chlorite	35.66		29.32	38.59		14.08															85	107
7	8	Muscovite	56.48	0.57	32.00	3.94		1.76		0.63	9.87												95	125
7	9	Muscovite	55.15	0.78	32.85	3.78		1.81		0.36	10.54												95	108
7	10	Chlorite	35.60		28.85	38.71	0.44	13.66			0.40												85	94
8	1	Rutile +	7.16	85.29	4.43	1.14		0.38			1.59												100	109
8	2	Chlorite	34.82		29.52	39.02	0.51	13.78															85	101
8	3	Ilmenite +	1.15	53.62		41.93	3.30																100	70
8	4	Zircon	29.98		0.57	0.75			0.65								68.05						100	125
8	5	Ilmenite +	1.00	54.23		41.41	3.36																100	96
8	6	Quartz	100.00																				100	110
8	7	Muscovite	55.01	0.44	33.65	2.83		1.77		0.54	11.01												95	91
8	8	Chlorite	36.33		27.92	38.88		14.52															85	105
8	9	Muscovite	55.62	0.37	32.80	3.05		1.86		0.35	11.20												95	125

Table 9.9. EDS chemical analyses of sample OD2016-D2-034.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	WO3	Total	Actual Total
8	10	Chlorite	35.86		28.63	37.37	0.44	14.01		1.12	0.25												85	116
8	11	Muscovite	53.51	2.45	32.43	3.16		1.65		0.34	11.73												95	101
8	12	Chlorite	35.72		28.79	38.71		14.44															85	89
8	13	Chlorite	38.24		29.41	36.27		13.01			0.72												85	107
8	14	Muscovite	54.91	0.52	33.73	3.02		1.64		0.38	11.09												95	111
9	1	Ilmenite +	6.92	51.18		38.99	2.91																100	107
9	2	Muscovite	55.37	0.60	33.25	2.78		1.68		0.42	11.16												95	99
9	3	Quartz	99.76			0.24																	100	110
9	4	Chlorite	37.52		27.58	36.58		14.31		0.73	0.95												85	81
9	5	Muscovite	55.54	0.51	32.94	2.79		1.83		0.37	11.26												95	111
9	6	Chlorite	40.60		28.71	32.02		11.90		0.93	3.46												85	80
9	7	Muscovite	54.74	0.66	33.72	2.89		1.67		0.38	11.20												95	111
9	8	Muscovite	58.07	0.49	31.90	2.51		1.46		0.38	10.47												95	99
9	9	Muscovite	55.87	0.53	33.47	2.80		1.57		0.47	10.54												95	107
9	10	Chlorite	37.31		27.98	36.84		13.74		0.78	1.01												85	119
10	1	Quartz	100.00																				100	94
10	2	Chlorite	50.87		23.31	31.75		11.34			0.38												85	99
10	3	Rutile +	3.49	95.49	0.82						0.20												100	107
10	4	Ilmenite +	5.39	55.90	0.78	35.43	2.09				0.42												100	85
10	5	Rutile +	1.84	96.01	0.74	1.02		0.38															100	94
10	6	Apatite	0.45			0.30			47.77			43.89		6.05								1.54	100	107
10	7	Chlorite	37.99		27.64	35.72	0.44	13.64		0.80	1.44												85	122
10	8	Muscovite	53.31	0.67	35.03	3.38		1.19		0.53	11.16												95	102
10	9	Muscovite	55.20	0.66	33.56	2.95		1.83			11.06												95	109
10	10	Muscovite	54.91	0.72	33.80	2.86		1.52		0.41	11.05												95	113
10	11	Chlorite	40.72		26.60	33.68		12.32		0.86	3.47												85	97
10	12	Muscovite	56.33	0.58	32.22	2.55		1.48		1.61	10.51												95	103
10	13	Apatite	0.67						47.63			43.91		6.05								1.75	100	115
10	14	Muscovite	54.79	0.35	34.16	3.00		1.84			11.13												95	121
10	15	Muscovite	55.08	0.37	34.79	2.52		1.48			11.02												95	111
10	16	Apatite +	1.37		0.44	0.30			46.42			43.41		6.12								1.94	100	99

Appendix 9.10: OD2016-
data.

Table 9.10. EDS chemical analyses of sample OD2016-D2-040.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CuO	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
1	1	Ilmenite +	7.71	50.41		38.52	2.51										0.85								100	107
1	2	Quartz	100.00																						100	122
1	3	Biotite	47.90	1.80	17.53	20.26		8.74			7.95														96	119
1	4	Ab + Kfs	62.90		23.04	2.71		1.88		5.98	3.49														100	111
1	5	Apatite +	2.93		1.21	1.93		0.45	44.17		0.88	41.43		5.06										1.95	100	130
1	6	Chlorite	36.53		28.21	36.22		16.68																	85	97
1	7	Muscovite	65.13	0.49	25.46	2.53		1.77		1.36	8.50														95	110
1	8	Muscovite	64.88	0.34	25.25	3.20		1.84		2.15	7.65														95	111
1	9	Quartz	100.00																						100	126
1	10	Quartz	100.00																						100	120
1	11	Biotite	42.08	2.22	17.85	23.27		9.49			9.25														96	117
1	12	Biotite	42.03	2.41	17.99	22.88		9.39			9.48														96	105
1	13	Muscovite +	59.66	0.40	27.78	5.43		1.85		3.56	6.58														95	112
1	14	Quartz	100.00																						100	125
1	15	Albite	67.43		20.05				1.55	10.96															100	124
2	1	Quartz	100.00																						100	124
2	2	Biotite	41.89	2.34	17.99	22.91		9.71			9.33														96	104
2	3	Albite	69.18		18.88				0.48	11.47															100	118
2	4	Biotite	42.26	2.25	17.88	22.56		9.64			9.58														96	108
2	5	Quartz	99.64			0.25					0.11														100	119
2	6	Quartz	100.00																						100	120
2	7	Rutile +	11.72	74.80	5.08	3.58		0.70	1.15	1.04	1.05	0.88													100	116
2	8	Muscovite	54.54	0.61	32.94	3.31		2.00		0.53	11.36														95	116
2	9	Ilmenite +	1.16	53.46		41.42	2.91										1.05								100	107
2	10	Biotite	41.80	2.36	18.10	22.79		9.52			9.55														96	112
2	11	Ilmenite +	5.01	51.07	2.26	36.59	2.39				0.55						2.12								100	110
2	12	Monazite +	14.97		9.21	8.51		3.32	2.25		1.22	21.70	2.30						1.32	8.94	19.58	6.67			100	103
2	13	Rutile + Bt	29.71	26.53	17.22	18.18	0.58	1.34		0.69	5.75														100	99
2	14	Biotite	42.28	2.31	18.13	22.66		9.45			9.34														96	104
3	1	FeOhy +	7.67		1.08	89.57		1.68																	100	82
3	2	Biotite	41.59	2.01	17.67	24.26		9.80			8.83														96	114
3	3	Muscovite	57.56	0.63	30.88	2.74		1.92		0.65	10.91														95	112
3	4	Biotite	42.30	2.19	17.75	22.54		10.00			9.39														96	118
3	5	Quartz	100.00																						100	128
3	6	Quartz	99.20		0.68						0.11														100	124
3	7	FeOhy +	7.55		0.93	89.03		1.53							0.37	0.60									100	82
3	8	Muscovite	58.37	0.53	29.79	3.21		2.07		1.25	10.05														95	117
3	9	Biotite	42.30	2.18	17.80	22.70		9.81			9.40														96	114
3	10	Biotite	41.83	2.47	17.63	23.01		9.70			9.53														96	124
3	11	Quartz	100.00																						100	137
3	12	Chlorite +	43.27	0.42	29.74	27.72		12.28		0.52	3.74														85	113
3	13	Muscovite	54.69	0.79	28.13	6.58		3.32		1.72	10.06														95	116
3	14	Biotite	41.63	2.24	17.92	23.18		9.67			9.55														96	118
3	15	Quartz +	98.87			0.45							0.68												100	129
4	1	Quartz	100.00																						100	133
4	2	Chlorite	36.45		28.24	36.01	0.38	16.58																	85	105

Table 9.10. EDS chemical analyses of sample OD2016-D2-040.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CuO	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
4	3	Apatite				0.29			48.15			44.80		5.14										1.62	100	135
4	4	Ilmenite +	3.57	52.29		38.65	2.71										2.78								100	110
4	5	Muscovite	51.98	1.04	35.84	3.08		0.78		0.58	11.94														95	119
4	6	Biotite	42.27	2.24	18.04	22.65		9.57			9.37														96	111
4	7	Muscovite + Qz	69.20	0.46	20.38	4.64		2.63		0.32	7.63														95	117
4	8	Ilmenite +	3.18	52.49		40.32	2.78										1.23								100	109
4	9	Quartz	100.00																						100	116
4	10	Muscovite + Chl	52.46	0.43	32.12	6.66		3.51			10.08														95	117
4	11	Biotite	41.76	2.53	18.36	23.02		9.19			9.30														96	114
4	12	Chlorite +	42.10		29.89	28.22		13.40		0.47	3.54														85	109
4	13	Rutile + Mixture	64.30	22.82	9.06	0.76		0.48			2.58														100	136
5	1	Chlorite	35.82		28.03	37.33		15.95		0.54															85	101
5	2	Biotite	41.72	2.38	18.32	23.08		9.14			9.53														96	109
5	3	Apatite							48.48			44.21		5.88										1.43	100	127
5	4	Apatite							48.52			44.11		5.95										1.42	100	122
5	5	Hematite	8.09		3.63	82.04		2.77	0.46			1.79				1.22									100	78
5	6	Biotite	41.35	2.65	17.99	23.47		9.27			9.46														96	114
5	7	Quartz	100.00																						100	135
5	8	Albite	66.46		20.61	0.60		0.39		9.85	2.09														100	119
5	9	Albite	69.53		18.82					11.65															100	128
5	10	Quartz	100.00																						100	131
5	11	Muscovite	59.75	0.45	27.89	2.83		1.62		3.86	8.85														95	121
5	12	Biotite	42.70	2.22	19.30	21.51		9.26			9.18														96	117
5	13	Chlorite	36.52		28.44	36.41		15.79		0.49															85	104
6	1	FeOhy +	7.22		1.17	89.15		1.67								0.79									100	87
6	2	Monazite +	28.03		16.13	22.19		8.55	1.93	0.75	0.46	7.59	0.87							3.91	6.98	2.63			100	98
6	3	Biotite	42.11	2.06	17.52	23.35		9.57			9.57														96	113
6	4	K-Feldspar + Chl?	55.11	0.31	24.51	8.43		2.29		3.90	5.46														100	120
6	5	Muscovite	54.64	0.63	32.71	3.08		2.15		0.39	11.64														95	114
6	6	Ilmenite +	4.54	51.67		38.76	2.58										2.45								100	112
6	7	Biotite	42.15	2.26	17.66	23.11		9.33			9.66														96	113
6	8	Quartz	100.00																						100	132
6	9	Quartz	100.00																						100	123
6	10	Biotite	41.91	2.68	18.01	23.20		9.44			8.92														96	107
6	11	Muscovite	54.72	0.81	30.14	4.77		2.93			11.91														95	115
6	12	Biotite	40.63	2.09	18.44	25.28		9.46			8.25														96	107
6	13	FeOhy +	7.19			91.35		1.46																	100	90
6	14	Biotite	41.50	2.33	17.47	23.81		9.39			9.67														96	115
6	15	Apatite	0.75						47.89			43.90		5.95										1.50	100	125
7	1	Rutile +	1.23	97.73	0.51	0.53																			100	111
7	2	Rutile +	2.52	94.37	0.91	1.37		0.46			0.36														100	119
7	3	FeOhy +	10.32	4.39	2.27	78.50		1.57	0.46	1.55						0.94									100	94
7	4	Muscovite	55.36	0.61	32.20	3.04		2.05		0.93	11.05														95	118
7	5	Biotite	41.95	2.31	18.09	23.15		9.43			9.24														96	111
7	6	Chloritized Biotite	47.28	0.51	31.25	23.24		9.66		0.61	5.13														85	118
7	7	Biotite	41.70	2.18	18.54	22.71		9.34		0.41	9.29														96	119

Table 9.10. EDS chemical analyses of sample OD2016-D2-040.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CuO	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
7	8	Muscovite	53.65	0.91	31.35	4.82		2.35		0.39	11.83														95	113
7	9	Biotite	42.54	2.11	17.52	22.97		9.79			9.23														96	114
7	10	Quartz	100.00																						100	124
7	11	Albite	58.86	0.42	25.21	2.44		1.55		4.32	7.20														100	123
7	12	Quartz	100.00																						100	129
7	13	Ilmenite +	7.08	49.57	1.27	35.67	2.89				0.32						3.20								100	109
7	14	Quartz	100.00																						100	123
7	15	Quartz	100.00																						100	121
7	16	Muscovite	54.92	0.68	32.39	3.48		2.26		0.38	11.16														95	111
7	17	Chlorite	35.81		29.02	36.39		16.42																	85	109
8	1	Quartz	100.00																						100	133
8	2	Monazite +	7.55		3.48	1.14			8.15		1.43	29.57	2.47	0.17					1.39	12.56	22.40	9.69			100	102
8	3	Chlorite +	37.26		27.11	36.21	0.39	15.61			1.05														85	104
8	4	Biotite	42.29	2.16	17.34	23.01		10.05			9.31														96	121
8	5	Chlorite +	45.17	0.89	28.03	27.96		11.61		2.08	1.87														85	110
8	6	Biotite	41.38	2.29	18.59	23.83		9.36			8.71														96	118
8	7	Rutile +	12.42	81.64	3.35	0.34				1.99	0.25														100	109
8	8	Ilmenite +	2.15	52.08	1.21	40.29	2.67				0.45						1.15								100	123
8	9	Quartz	100.00																						100	118
8	10	Albite	66.08		21.07	0.96		0.53		9.28	2.08														100	126
8	11	Rutile +	12.48	79.49	4.45	0.36				3.22															100	113
8	12	Biotite	42.20	2.20	18.21	22.70		9.46			9.41														96	111
8	13	Muscovite	60.95	0.69	28.05	2.80		1.94		2.28	8.53														95	108
8a	1	Biotite	41.84	2.15	18.08	23.38		10.01			8.71														96	110
8a	2	Muscovite	55.70	0.32	32.31	3.13		2.23			11.60														95	105
8a	3	Biotite	43.94	1.35	20.61	23.30		6.04		1.55	7.34														96	114
8a	4	Monazite +	12.85		3.38	0.96			10.64		0.83	33.46	1.12	0.25						9.01	19.67	7.85			100	116
8a	6	Quartz	100.00																						100	122
8a	7	Muscovite	54.33	0.67	33.53	3.04		2.14		0.33	11.20														95	112
8a	8	Chlorite	36.79		29.58	35.55		15.73																	85	101
8a	9	Monazite +	45.90		13.17				3.06	7.96	0.74	11.40	1.43	1.14						4.01	7.79	3.39			100	116
8a	10	Apatite +	17.06		9.79	2.92		1.34	30.04	0.45	3.59	30.20		4.61											100	122
8a	11	Chlorite	39.55		29.60	32.19		15.47			0.86														85	107
8a	12	Apatite				0.27			47.71			44.36		5.91										1.75	100	123
8a	13	Albite	69.28		18.77				0.30	11.51	0.14														100	121
8a	14	Muscovite	54.89	0.64	33.25	2.79		1.93		0.47	11.28														95	110
8a	15	Quartz	100.00																						100	121
8a	16	Muscovite + Biotite	65.81	1.27	11.61	15.02		6.38			5.17														95	105
9	1	Biotite	42.15	2.19	17.59	22.91		9.64			9.72														96	106
9	2	Rutile +	6.42	91.09	1.85	0.42					0.22														100	100
9	3	Quartz	100.00																						100	121
9	4	Chlorite	36.64		28.24	36.16		16.61																	85	104
9	5	Zircon	31.32															68.68							100	120
9	6	Quartz	100.00																						100	125
9	7	Muscovite	56.91	0.60	27.95	6.31		3.28			10.22														95	105
9	8	Muscovite	55.08	0.55	29.86	5.01		3.39			11.37														95	100

Table 9.10. EDS chemical analyses of sample OD2016-D2-040.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	CuO	ZnO	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
9	9	Biotite	42.13	2.10	18.05	22.70		10.08			9.10														96	103
9	10	Quartz	100.00																						100	120
9	11	Monazite	3.86		1.02	1.94			8.37		0.66	29.76	2.58	2.43					1.42	13.34	24.69	9.94			100	91
9	12	Albite + Kfs	60.82	0.35	24.04	2.19		1.62		4.67	6.31														100	109
10	1	Zircon	31.18															67.39					1.43		100	125
10	2	Biotite	42.37	2.25	17.57	22.81		9.72			9.43														96	98
10	3	Quartz	100.00																						100	120
10	4	Apatite							48.20			44.14		6.29										1.38	100	123
10	5	Biotite	42.28	2.59	17.65	23.05		9.64			8.93														96	108
10	6	Quartz	100.00																						100	128
10	7	Albite + Quartz	80.00		12.47					7.53															100	130
10	8	Muscovite	56.25	0.43	30.41	3.62		2.87			11.70														95	115
10	9	Biotite	42.56	3.24	18.66	21.86		8.82			9.05														96	105
10	10	Albite	67.72		19.17	1.30		0.60	0.25	10.97															100	114
10	11	Quartz	100.00																						100	123
10	12	FeOhy +	8.94		2.72	84.21		2.38	0.43							1.32									100	75
10	13	Rutile +	6.68	87.57	2.36	2.63		0.47			0.28														100	103
11	1	Chlorite	48.07	38.24	0.62	27.91	1.65				0.54						0.62								85	111
11	2	FeOhy + Biotite	33.97	0.51	19.00	37.67		1.98			6.58				0.29										100	84
11	3	Ilmenite +	1.31	48.59	0.61	40.49	1.98		2.90	0.47		2.85					0.81								100	105
11	4	Apatite				0.37			47.86			44.27		5.83										1.67	100	121
11	5	Quartz	100.00																						100	101
11	6	Biotite	41.71	2.26	17.58	22.86		9.68		0.51	9.56														96	105
11	7	Albite + Kfs	67.93		20.15	0.36				10.33	1.23														100	116
11	8	Quartz	100.00																						100	125
11	9	Albite + Kfs	58.93		22.36	7.89		4.38		4.55	1.89														100	94
11	10	Quartz + muscovite	82.12		11.62	1.03		0.67			4.56														100	105
11	11	Rutile +	4.87	87.68	2.13	4.45			0.43		0.43														100	104
11	12	Biotite	42.56	2.34	17.63	22.59		9.52			9.52														96	111
11	13	Quartz	100.00																						100	117
12	1	Biotite	42.23	2.16	17.82	22.65		9.85			9.46														96	104
12	2	Biotite	41.96	2.33	17.78	23.31		9.97			8.81														96	107
12	3	Monazite +	1.25		0.60	1.39		0.69	9.39			32.86	3.32	0.30					2.11	13.00	23.21	9.55		2.32	100	89
12	4	Quartz	100.00																						100	117
12	5	Quartz	100.00																						100	125
12	6	Muscovite	55.38	0.66	33.21	2.66		1.85		0.38	11.12														95	109
12	7	Muscovite	51.58	0.48	31.35	8.87		4.02		0.43	8.54														95	98
12	8	Apatite	0.81			0.38			48.14			44.12		5.40										1.15	100	127
12	9	Biotite	39.13	8.63	17.43	21.35		9.05			8.61														96	109
12	10	Muscovite	54.33	0.64	32.55	3.67		2.25		0.33	11.46														95	115
12	11	Ilmenite +	1.66	57.60		37.96	1.56										1.22								100	108
12	12	Chlorite	36.59		27.75	36.55	0.44	16.32																	85	104
12	13	Quartz	100.00																						100	127
12	14	Biotite	40.82	2.00	18.66	24.10		10.63			7.96														96	100
12	15	Muscovite	52.78	0.78	29.19	7.58		3.70		0.87	10.34														95	101
12	16	Quartz	100.00																						100	122

Appendix 9.11: OD2016-I
data.

Table 9.11. EDS chemical analyses of sample OD2016-D2-050-2.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MgO	CaO	Na2O	K2O	P2O5	F	Cl	ZrO2	Ce2O3	WO3	B2O3	Total	Actual Total
1	10	Albite	69.67		18.73			0.18	11.42									100	94
2	2	Albite	67.81		19.65	0.52		1.18	10.84									100	87
2	4	Albite	69.36		18.73	0.38		0.26	11.26									100	92
3	7	Albite	68.70		18.84	0.30		0.34	11.40	0.41								100	114
1	12	Apatite	0.38					48.34			44.30	5.70				1.28		100	83
1	8	Chlorite	39.42		26.98	33.15	14.48			1.15	1.29				1.16			85	126
1	9	Chlorite	38.59		27.33	34.54	16.61			0.58								85	188
2	3	Chlorite	36.98		27.94	34.98	17.75											85	102
2	6	Chlorite	36.56		28.52	34.20	18.36											85	97
2	9	Chlorite	37.82		27.59	34.52	17.40			0.32								85	119
3	6	Chlorite	37.91		29.26	32.67	17.55			0.26								85	106
1	11	Chlorite +	30.70		24.03	29.84	15.43											100	138
1	1	FeOhy +	17.66		10.72	67.05	3.94			0.63								100	81
1	2	FeOhy +	7.29		2.51	88.65	1.56											100	122
1	3	FeOhy +	21.97		12.13	58.60	6.03		0.54	0.73								100	100
1	5	FeOhy +	6.41		1.90	90.43	1.26											100	121
2	1	FeOhy +	6.42			90.35	1.67	0.34			1.22							100	111
2	8	FeOhy +	3.83			94.63	1.54											100	97
2	7	FeOhy + Mixture	8.98		5.64	39.58	2.22	2.58	1.48		6.50		0.74		32.29			100	50
3	11	Ms + Chl	52.09		21.74	15.80	4.81		2.04	3.52								100	77
2	10	Muscovite	55.89	0.67	31.08	3.32	2.62		0.73	10.94								95	95
3	4	Muscovite	53.95	0.63	33.18	3.63	2.05			11.82								95	101
3	5	Muscovite	59.27	0.53	28.54	3.44	2.44		1.89	9.15								95	113
1	4	Muscovite +	50.37	0.67	31.20	9.76	3.41		0.63	9.20								95	95
3	2	Muscovite +	43.48	17.84	25.96	7.43	2.65			7.92								95	114
1	6	Quartz	99.25			0.75												100	106
3	1	Quartz	100.00															100	106
3	8	Quartz	100.00															100	92
2	5	Rutile +	8.94	89.27	1.04	0.76												100	111
3	9	Rutile +	3.12	90.81	2.26	2.57	0.97			0.27								100	112
3	10	Rutile +	1.44	96.92	0.86	0.78												100	96
3	3	Zircon	31.44											68.56				100	104
1	7	Zircon +	21.32			0.77								44.59			33.33	100	74

Appendix 9.12: OD2016-
data.

Table 9.12. EDS chemical analyses of sample OD2016-D2-060.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
1	1	Zircon	31.13													67.43					1.44		100	90
1	2	Rutile +	16.58	67.30	11.22	1.05		0.62			3.23												100	109
1	3	Zircon	30.46						0.32							67.76					1.45		100	119
1	4	Apatite				2.35			13.18	1.11		37.29	2.99		0.62		4.34		26.04	9.84		3.28	100	78
1	5	Rutile +	1.27	97.02	0.69	1.03																	100	106
1	6	Muscovite	55.36	0.49	32.65	2.86		2.20			11.69												95	104
1	7	Rutile +	2.74	93.48	1.39	1.63		0.76															100	120
1	8	Apatite							48.00	0.34		44.16		5.08								2.41	100	105
1	9	Biotite	41.69	2.79	18.91	22.81		9.50			8.48												96	103
1	10	Quartz	100.00																				100	105
1	11	Biotite	42.19	2.27	19.18	22.27		9.66			8.58												96	111
1	12	Muscovite	55.04	0.69	32.91	2.61		2.13		0.45	11.47												95	97
1	13	Rutile +	12.16	69.08	5.97	8.00		3.91			0.87												100	92
1	14	Quartz	100.00																				100	113
1	15	Zircon	41.19		2.06	0.83					0.71					55.21							100	111
1	16	Rutile +	1.33	97.53	0.56	0.35					0.23												100	90
1	17	Rutile +	0.50	99.11		0.39																	100	99
1	18	Albite + Ms	72.88		16.26	1.60		1.03		4.52	3.71												100	121
1	19	Biotite	38.09	1.63	20.73	27.52		12.42			3.78												96	95
2	1	Chlorite	36.26		28.44	35.75	0.42	16.75															85	103
2	2	Albite	69.05		18.80	0.46			0.20	10.95	0.54												100	120
2	3	Zircon	31.46													68.54							100	100
2	4	Quartz	100.00																				100	119
2	5	Muscovite	55.49	0.52	30.78	4.11		2.97			11.42												95	111
2	6	Biotite	41.18	2.27	18.59	24.02		9.88			8.20												96	102
2	7	Zircon	31.22													67.28					1.50		100	107
2	8	Apatite	0.67						48.48			44.10		5.33								1.43	100	110
2	9	Quartz	99.63			0.37																	100	117
2	10	Quartz	100.00																				100	88
3	1	Zircon	28.14		1.18	1.48		0.74	1.53						0.40	64.61					1.92		100	117
3	2	Zircon	31.51													68.49							100	101
3	3	Biotite + Rutile	31.96	31.99	11.45	18.11		3.12	0.38	0.60	2.39												100	105
3	4	Rutile		99.56		0.44																	100	105
3	5	Zircon	31.34													68.66							100	105
3	6	Rutile		99.63		0.37																	100	97
3	7	Rutile +	0.61	98.91		0.48																	100	124
3	8	Rutile +	1.78	96.87	1.01						0.34												100	106
3	9	Muscovite	54.58	0.58	32.32	3.57		2.37			11.85												95	107
3	10	Biotite	39.39	1.64	19.88	26.25		11.83			5.20												96	95
3	11	Quartz	100.00																				100	112
3	12	Muscovite	53.12	0.78	32.44	5.08		3.09			10.75												95	111
3	13	Biotite	40.09	2.36	18.72	25.57		10.19			7.23												96	116
3	14	Quartz	100.00																				100	89
3	15	Zircon	30.98													67.64					1.38		100	91
3	16	Rutile +	1.17	98.83																			100	111
4	1	Quartz	100.00																				100	104
4	2	Biotite	39.98	1.76	19.71	25.71		12.53			4.47												96	108

Table 9.12. EDS chemical analyses of sample OD2016-D2-060.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	SO3	F	Cl	ZrO2	Ag2O	La2O3	Ce2O3	Nd2O3	HfO2	WO3	Total	Actual Total
4	3	Monazite	6.86		3.91	5.15		2.58	6.45			21.90	1.97	4.45				13.45	24.50	8.78			100	116
4	4	Apatite	0.61						48.68			44.14		5.22								1.35	100	113
4	5	Apatite							49.03			44.01		5.18								1.78	100	114
4	6	Muscovite	55.86	0.61	32.49	2.72		1.91		0.36	11.32												95	109
4	7	Albite	68.00		18.95	1.30		0.63		10.52	0.60												100	107
4	8	Quartz	100.00																				100	116
4	9	Rutile +	0.71	99.29																			100	96
4	10	Quartz	100.00																				100	106
4	11	Muscovite	54.92	0.69	32.94	3.01		2.09			11.58												95	103

Appendix 9.13: OD2016-I
data.

Table 9.13. EDS chemical analyses of sample OD2016-D2-069.

Site	Position	Mineral	SiO2	TiO2	Al2O3	FeO	MgO	CaO	Na2O	K2O	P2O5	F	Cl	La2O3	Ce2O3	Nd2O3	WO3	Total	Actual Total
1	1	Tourmaline	38.61	0.78	31.98	4.28	7.11	0.23	2.01									85	125.79
1	2	F-Apatite	0.85					47.98			43.83	6.06					1.27	100	112.85
1	3	Albite	69.49		18.74				11.77									100	101.61
1	4	Quartz	100.00															100	125.42
1	5	Muscovite	56.03	0.46	32.80	2.53	2.14			11.31								95	109.74
1	6	Monazite +	9.50		5.51	3.53	3.77	0.67			26.70			10.28	27.16	12.88		100	64.75
1	7	FeOhy +	7.69		8.29	78.36	2.53	0.66			2.05		0.40					100	99.8
1	8	Rutile +	0.74	98.89		0.37												100	111.09
1	9	Chlorite +	39.53	0.80	22.18	27.27	7.06		0.47	2.70								100	126.03
1	10	Muscovite	55.67	0.84	31.87	3.17	2.53			11.18								95	89.57
1	11	Albite	68.98		19.02			0.31	11.70									100	125.51
1	12	Chlorite	38.36		28.12	33.43	17.77											85	125.04
1	13	Muscovite	55.05	0.66	33.38	2.47	2.05		0.31	11.34								95	116.44
1	14	Quartz	100.00															100	99.31
1	15	Tourmaline	38.52	1.11	31.31	4.70	7.11	0.28	1.97									85	101.81

Appendix 9.14: OD2016-D2-072 EDS analysis data.

Appendix 10: OD2016-D2 BSE imagery.

Notes:

A sample number succeeded by -1, or -2 indicates thin section number. Eg. 011-2 is the second thin section from sample 011.

A sample number succeeded by -a, or -b indicates a piece of a sample. Eg. Sample 012 has been cut into two halves, one half is 012-a and the other half is 012-b.

Abbreviations:

DT: detrital

DG: diagenetic

HD: hydrothermal

Appendix 10.1: OD2016-I

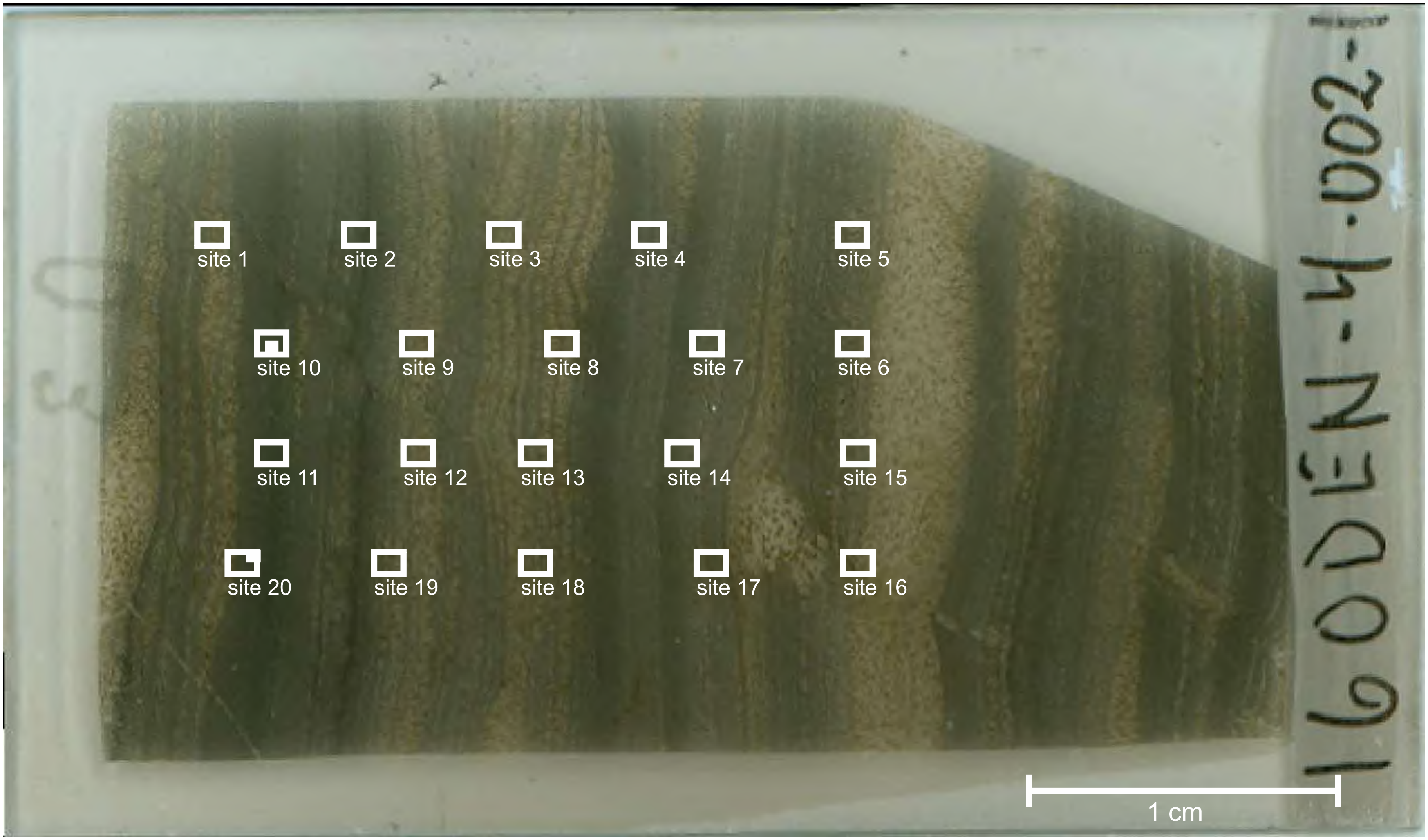


Figure 10.1-1: Slide OD2016-D2-002-1

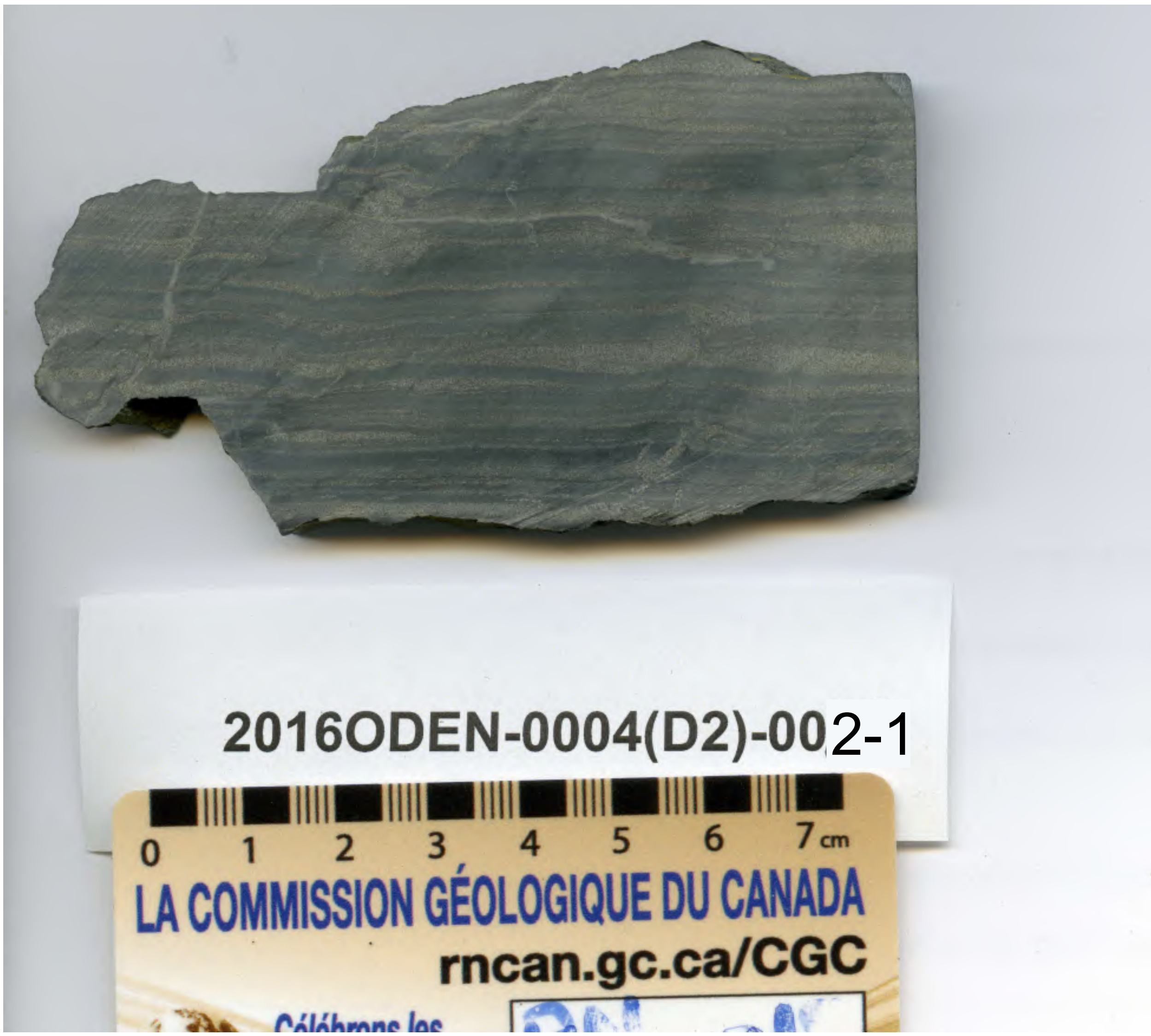
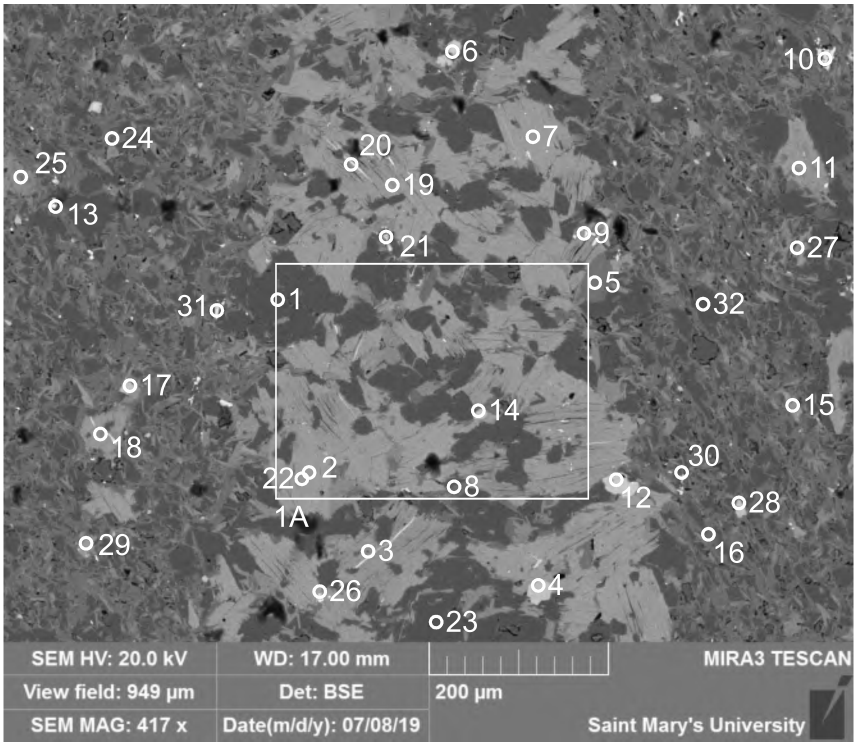
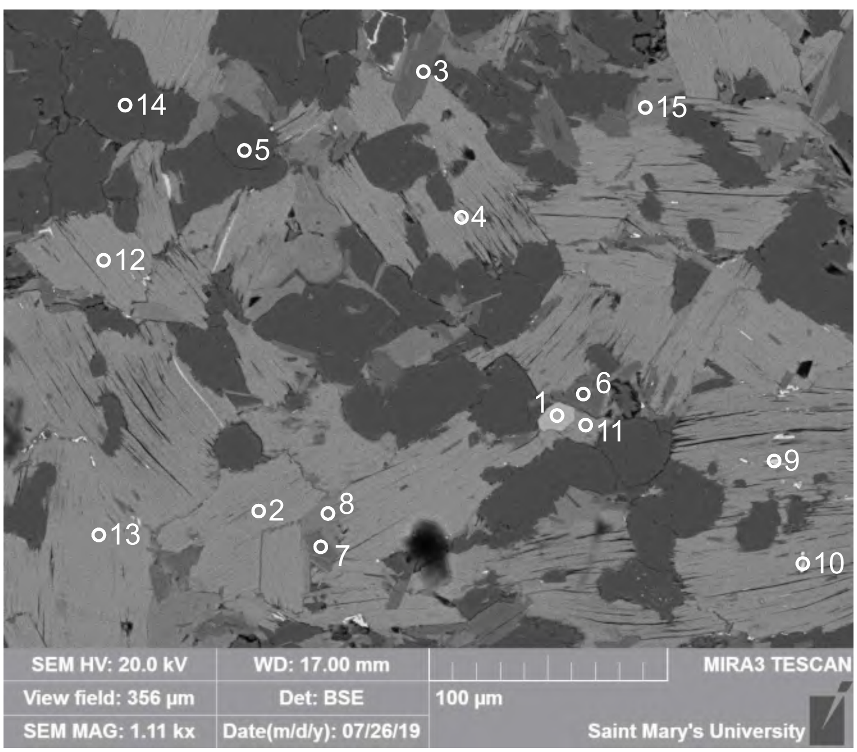


Figure 10.1-2: Sample OD2016-D2-002-1. Rock cross-section



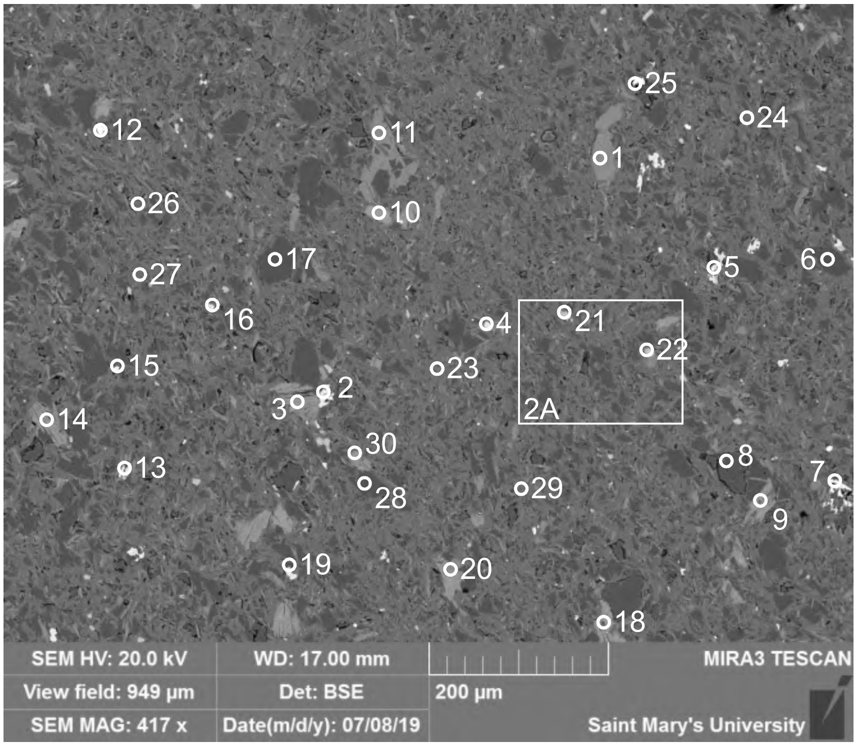
1. Quartz
2. Biotite
3. Bt+ Feohy
4. Apatite
5. Muscovite
6. Apatite
7. Biotite
8. Muscovite
9. TiO2+
10. TiO2+
11. Biotite
12. Apatite
13. Monazite+
14. Apatite
15. Biotite
16. Muscovite
17. Apatite+
18. Chlorite+
19. Biotite
20. Feohy+
21. Feohy+
22. Biotite
23. Quartz
24. Muscovite
25. Bt+ Ms
26. Apatite+
27. Biotite
28. Apatite
29. Biotite
30. TiO2+
31. TiO2+
32. Quartz

Figure 10.1-3. Sample OD2016-D2-002-1 site 1. Coarse grained layer of biotite and quartz. DT: Apatite?, Quartz; DG: Biotite, Muscovite; HD: TiO2.



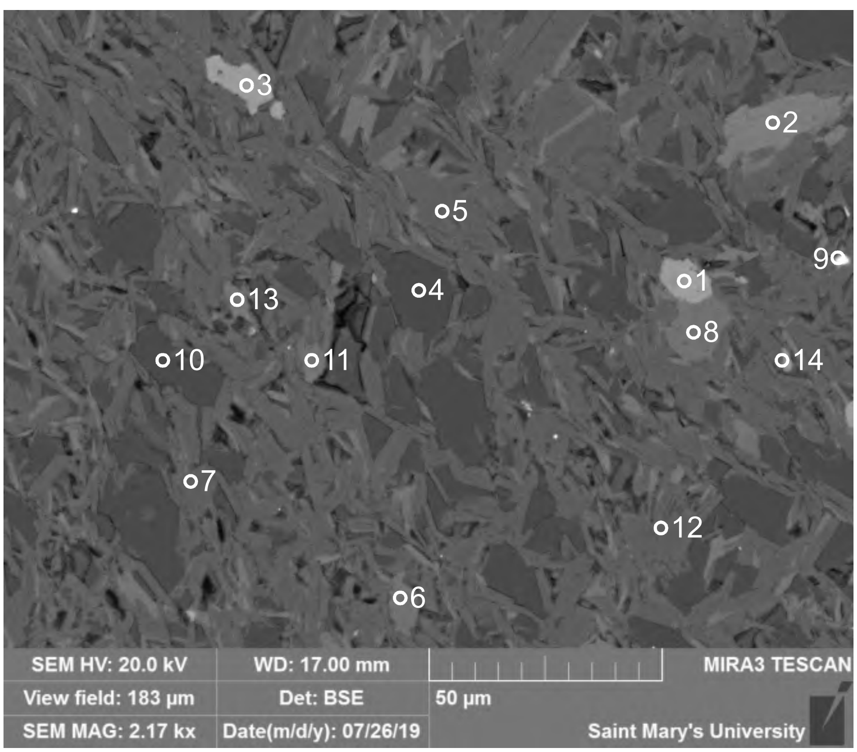
1. Apatite
2. Biotite
3. Muscovite
4. TiO2+
5. Quartz
6. Muscovite
7. Muscovite
8. Chlorite
9. Titanite+
10. TiO2+
11. Biotite
12. Biotite
13. Biotite
14. Quartz
15. Chlorite

Figure 10.1-4. Sample OD2016-D2-002-1 site 1a. Zoom in of coarse grained layer of biotite and quartz. DT: (1) Apatite?, Quartz; DG: Biotite, Muscovite; HD: TiO2.



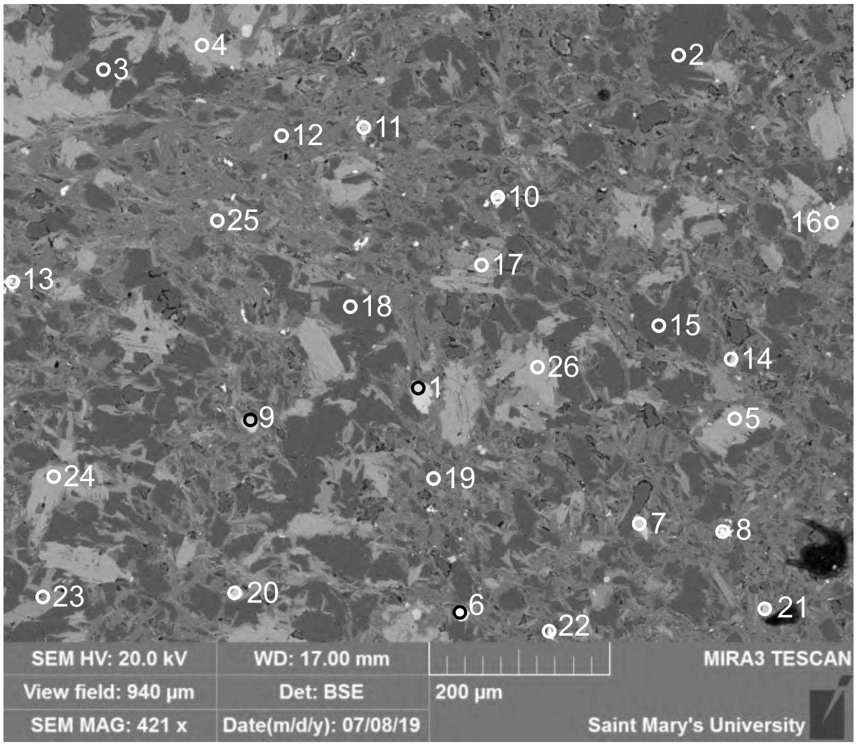
1. Chlorite
2. TiO2+
3. Biotite
4. TiO2+
5. TiO2+
6. Quartz
7. Mixture
8. Albite
9. Biotite
10. Biotite
11. Chlorite
12. Zircon+
13. Mixture
14. Biotite
15. Muscovite
16. Mixture
17. Quartz
18. Biotite
19. Mixture
20. Bt+ Chl
21. Apatite
22. Apatite
23. Muscovite
24. Muscovite
25. Monazite+
26. Muscovite
27. Muscovite
28. Quartz
29. Muscovite
30. Biotite

Figure 10.1-5. Sample OD2016-D2-002-1 site 2. DT: Apatite?, Quartz; DG: Biotite, Chlorite, Muscovite.



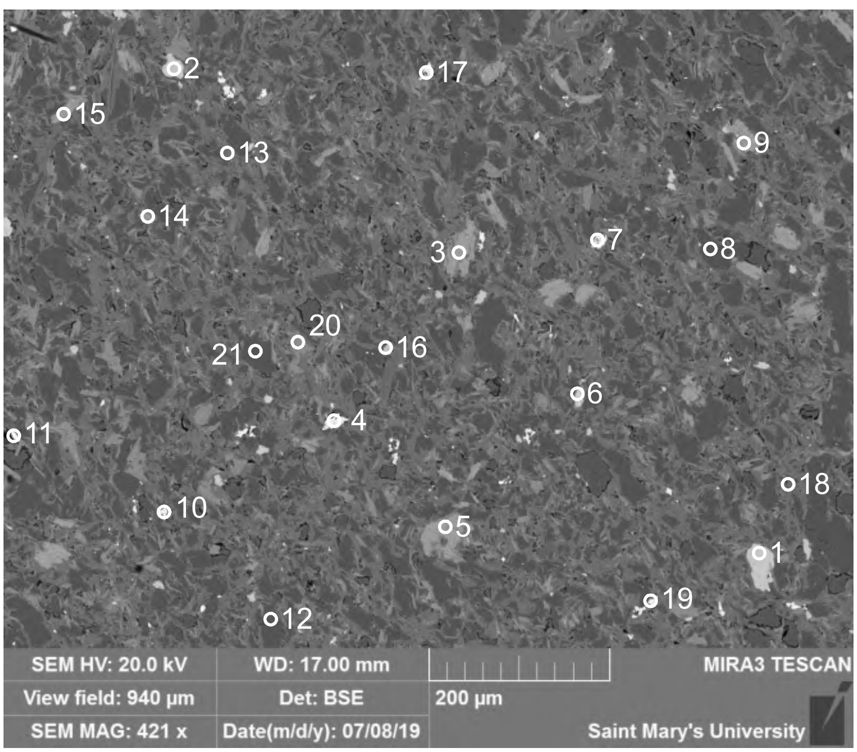
1. Apatite
2. Biotite
3. Apatite
4. Quartz
5. Muscovite
6. Chlorite
7. Muscovite
8. Chlorite
9. Zircon+
10. Quartz
11. Chlorite
12. Muscovite
13. Chlorite
14. Apatite+

Figure 10.1-6. Sample OD2016-D2-002-1 site 2a. DT: Apatite?, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite.



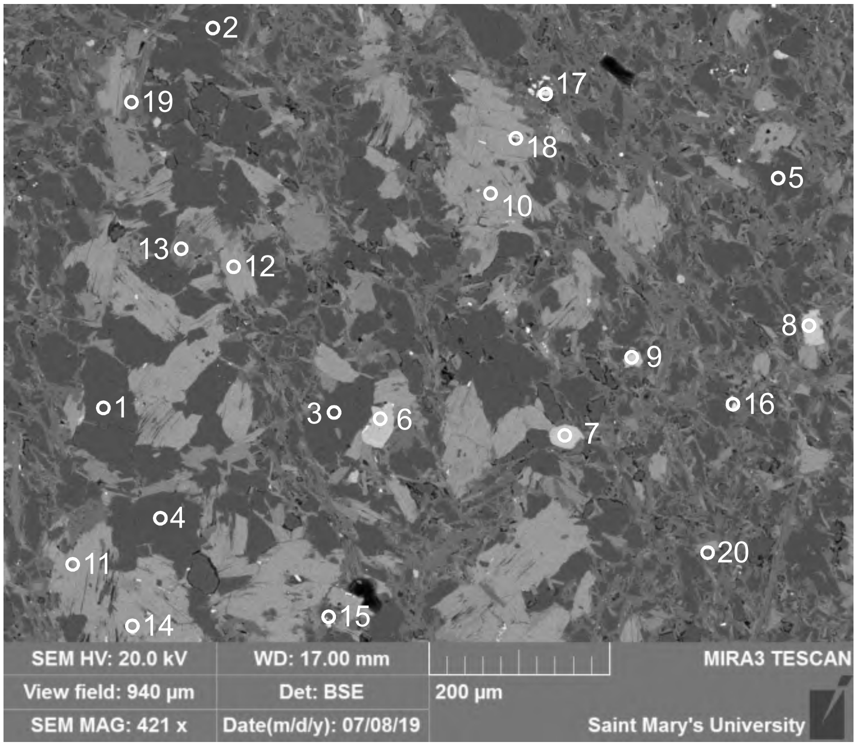
1. Apaite
2. Quartz
3. Quartz
4. Biotite
5. Biotite
6. Zircon
7. Apaite
8. TiO2+
9. Apatite
10. TiO2+
11. Apatite
12. Muscovite
13. TiO2+
14. Apatite+
15. Quartz
16. Biotite
17. Biotite
18. Quartz
19. Muscovite
20. Apatite
21. Apatite
22. TiO2+
23. Chlorite
24. Biotite
25. Biotite
26. Biotite

Figure 10.1-7. Sample OD2016-D2-002-1 site 3. DT: Apatite?, Quartz; DG: Biotite, Chlorite, Muscovite, TiO2.



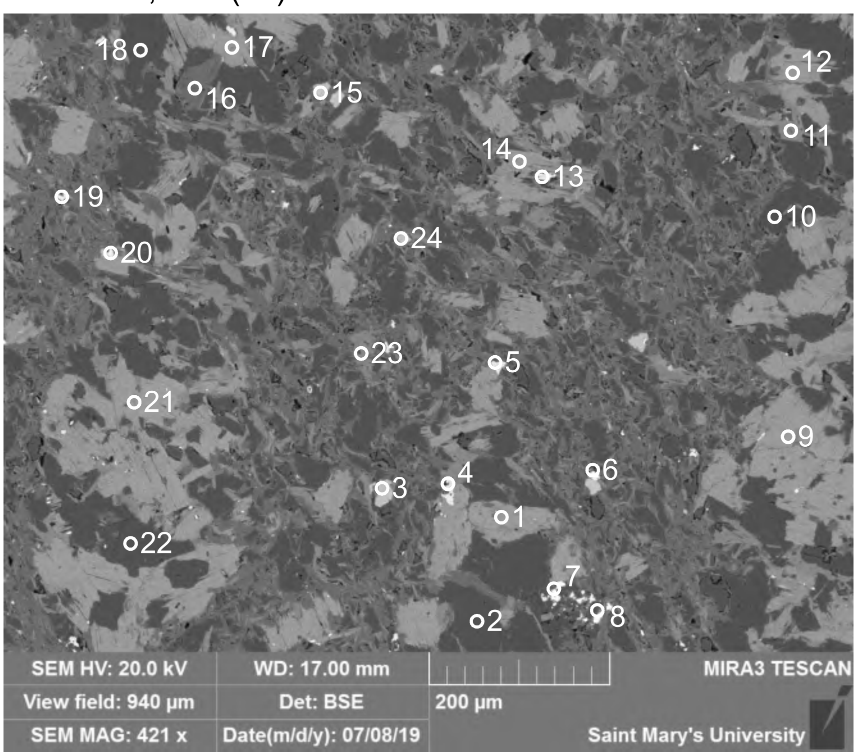
1. Apatite
2. Apatite
3. Biotite
4. TiO2+
5. Biotite
6. Apatite+
7. TiO2+
8. Quartz
9. Biotite
10. TiO2+
11. Monazite
12. Quartz
13. Muscovite
14. Biotite
15. Biotite
16. Apatite+
17. TiO2+
18. Muscovite
19. TiO2+
20. Chlorite
21. Quartz

Figure 10.1-8. Sample OD2016-D2-002-1 site 4. DT: Apatite?, Monazite?, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO2.



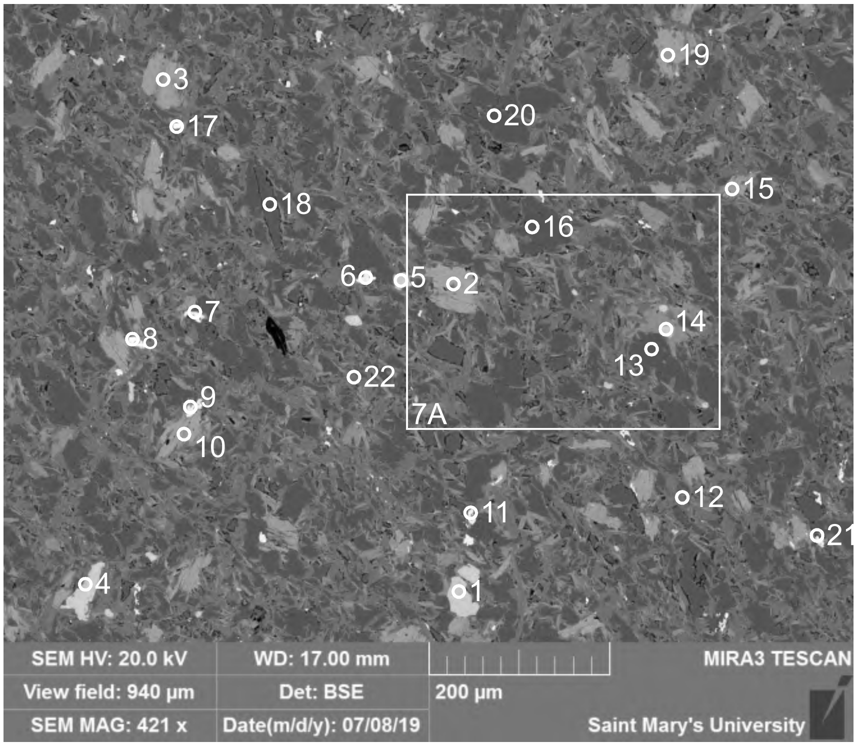
1. Quartz
2. Quartz
3. Quartz
4. Quartz+
5. Quartz
6. Apatite
7. Apatite
8. Apatite
9. Apatite+
10. Biotite
11. Biotite
12. Biotite
13. K-Feldspar
14. TiO2+
15. TiO2+
16. TiO2+
17. TiO2+
18. Monazite+
19. Muscovite
20. Muscovite

Figure 10.1-9. Sample OD2016-D2-002-1 site 5. DT: (6) Apatite, Quartz, Zircon; DG: Biotite, Chlorite, K-Feldspar, Muscovite; HD: (18) Monazite.



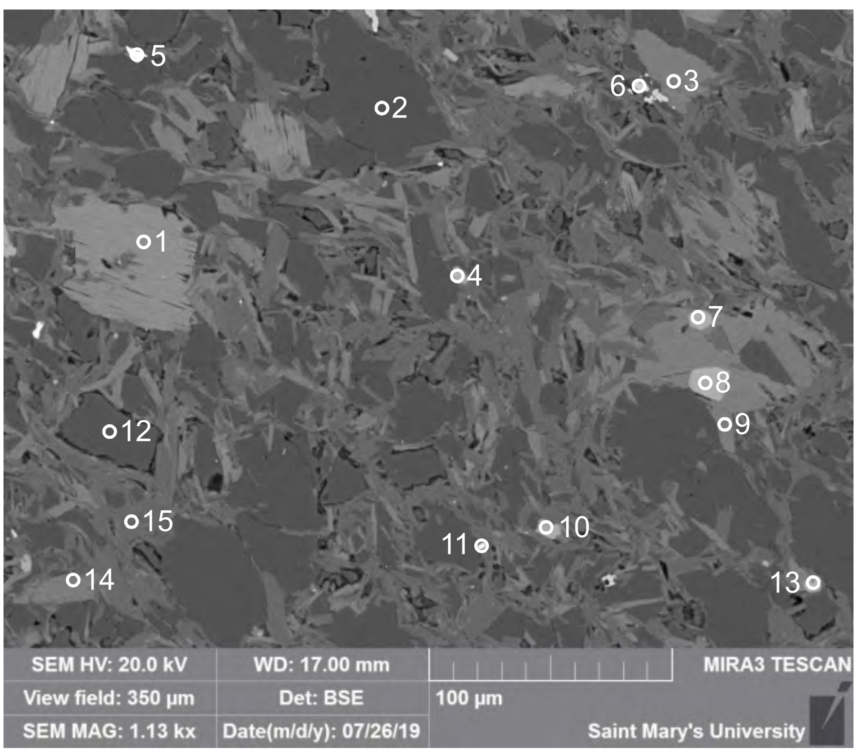
1. Bt+ Chl
2. Quartz
3. Apatite
4. TiO2+
5. TiO2+
6. Monazite+
7. Monazite+
8. Monazite+
9. Biotite
10. Quartz
11. Chlorite
12. Biotite
13. TiO2+
14. Biotite
15. Apatite
16. Muscovite
17. Biotite
18. Quartz
19. TiO2+
20. TiO2+
21. Biotite
22. Quartz
23. Chlorite
24. Apatite

Figure 10.1-10. Sample OD2016-D2-002-1 site 6. TiO2 forming clots. DT: Apatite?, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO2.



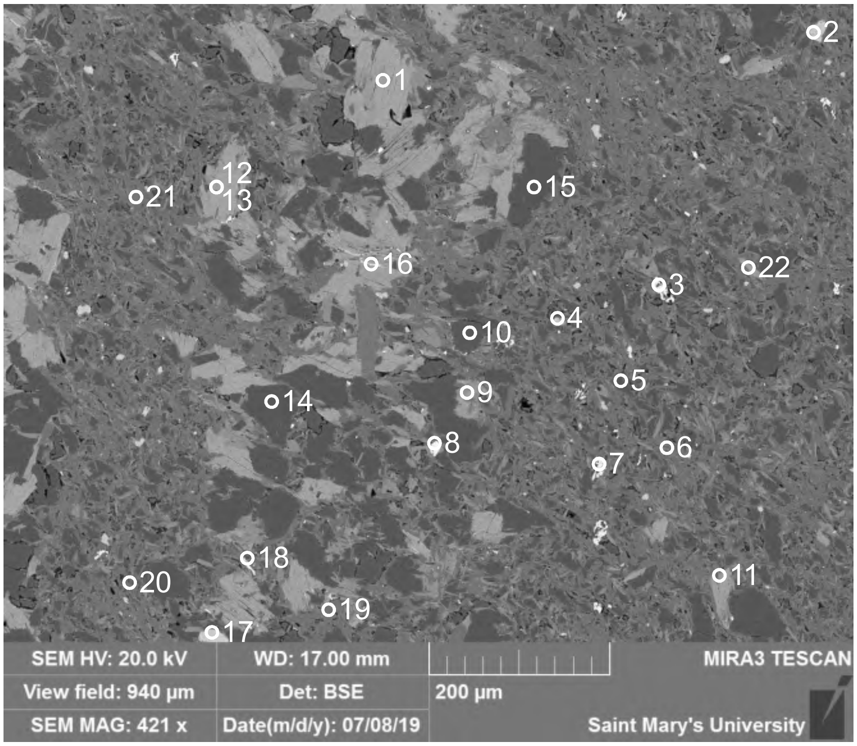
1. Apatite
2. Muscovite
3. Chlorite+
4. Apatite
5. Apatite+
6. TiO2+
7. TiO2+
8. Monazite+
9. TiO2+
10. Biotite
11. TiO2+
12. Muscovite
13. Quartz
14. Apatite
15. Biotite
16. Quartz
17. Monazite+
18. Albite
19. Biotite
20. Quartz
21. TiO2+
22. Muscovite

Figure 10.1-11. Sample OD2016-D2-002-1 site 7. DT: Apatite, Monazite, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO2.



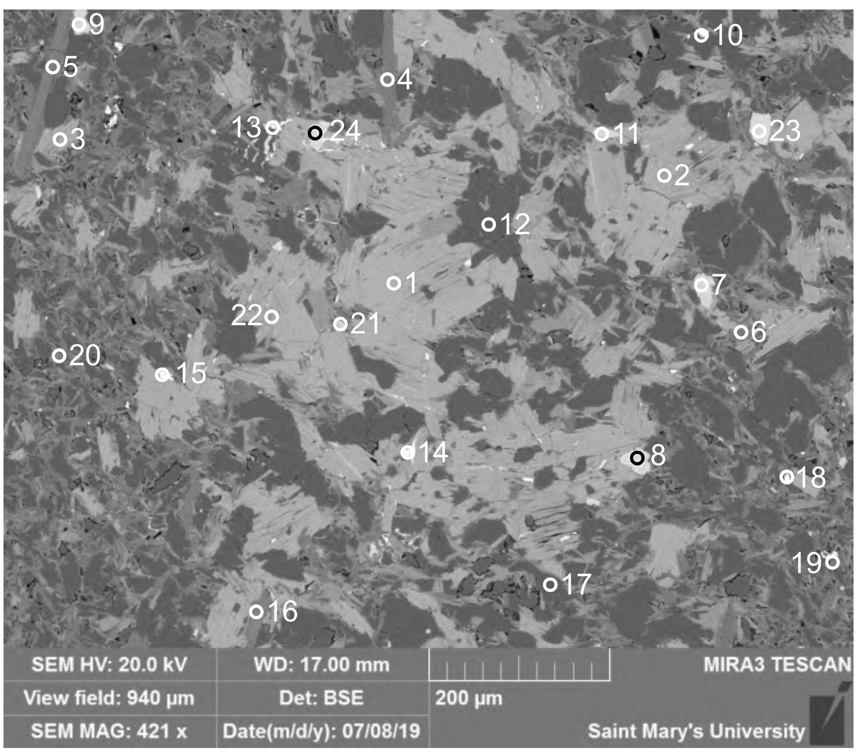
1. Biotite
2. Quartz
3. Chlorite
4. Apatite
5. Zircon
6. TiO2+
7. Apatite
8. Apatite
9. Chlorite
10. Apatite
11. Xenotime+
12. Albite
13. Apatite
14. Chlorite
15. Muscovite

Figure 10.1-12. Sample OD2016-D2-002-1 site 7a. DT: Albite, Apatite, Monazite, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO2, Xenotime.



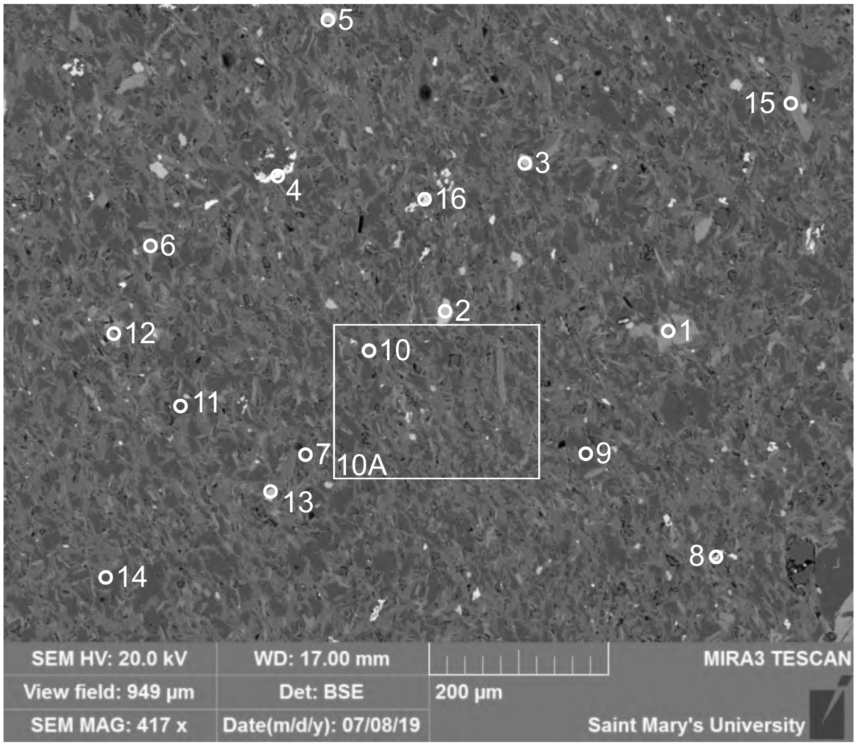
1. Biotite
2. Apatite
3. TiO2+
4. Apatite+
5. Quartz+
6. Biotite
7. Ap+ TiO2
8. TiO2+
9. Biotite
10. Albite
11. Biotite
12. Biotite
13. Biotite
14. Quartz
15. Quartz
16. TiO2+
17. Apatite
18. TiO2+
19. Muscovite
20. Muscovite
21. Muscovite
22. Biotite

Figure 10.1-13. Sample OD2016-D2-002-1 site 8. DT: Albite, Apatite, Monazite, Quartz; DG: Biotite, Muscovite, TiO2.



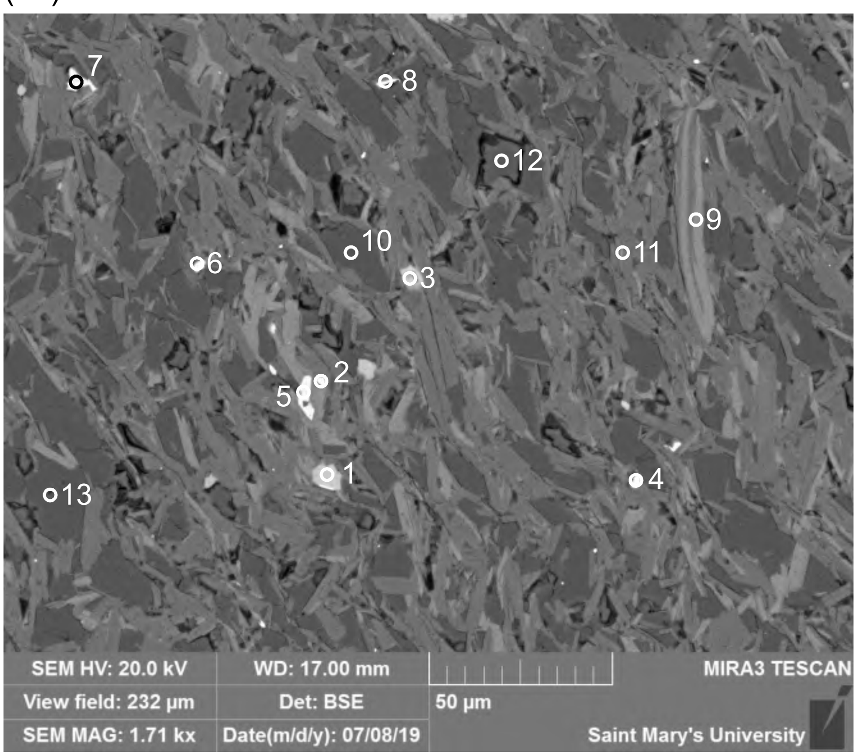
1. Biotite
2. Biotite
3. Bt+ Chl
4. Muscovite
5. Muscovite
6. Muscovite
7. Apatite
8. Apatite
9. Apatite
10. Xenotime
11. Apatite
12. Quartz
13. Monazite+
14. TiO2+
15. TiO2+
16. Muscovite
17. Quartz
18. Zircon+
19. Muscovite
20. Muscovite
21. Apatite
22. Biotite
23. Apatite
24. Apatite

Figure 10.1-14. Sample OD2016-D2-002-1 site 9. DT: Apatite, Quartz; DG: Biotite, Chlorite, Muscovite, TiO2, Xenotime; HD: (13) Monazite.



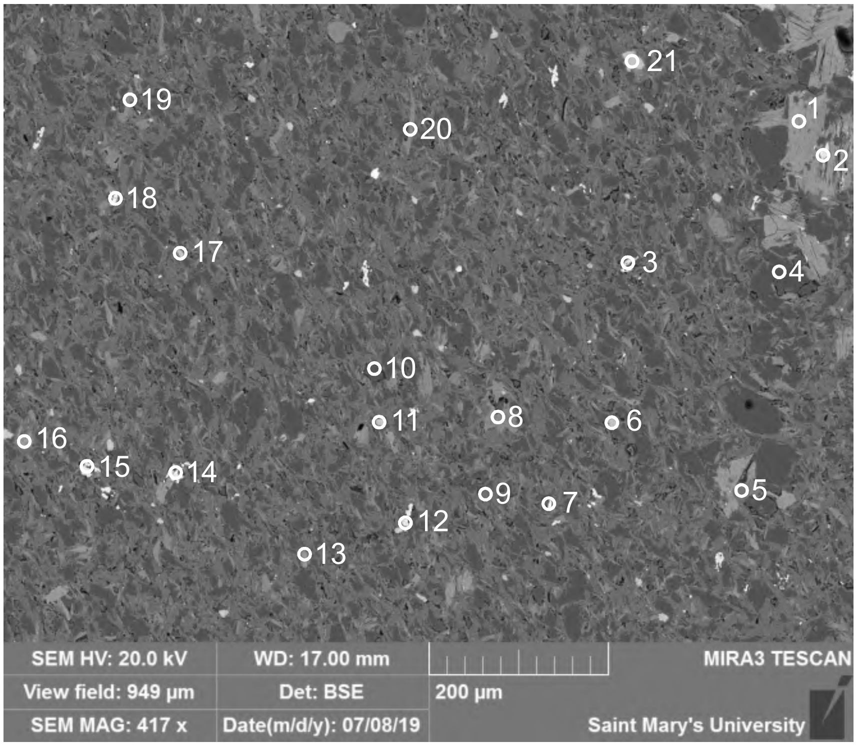
1. Biotite
2. Apatite
3. Apatite
4. Monazite+
5. Apatite
6. Chlorite
7. Quartz+
8. TiO2+
9. Quartz
10. Muscovite
11. Quartz
12. Biotite
13. Apatite
14. Quartz+
15. Chlorite
16. TiO2+

Figure 10.1-15. Sample OD2016-D2-002-1 site 10. DT: Apatite, Quartz; DG: Biotite, Chlorite, Muscovite, TiO2; HD: (13) Monazite.



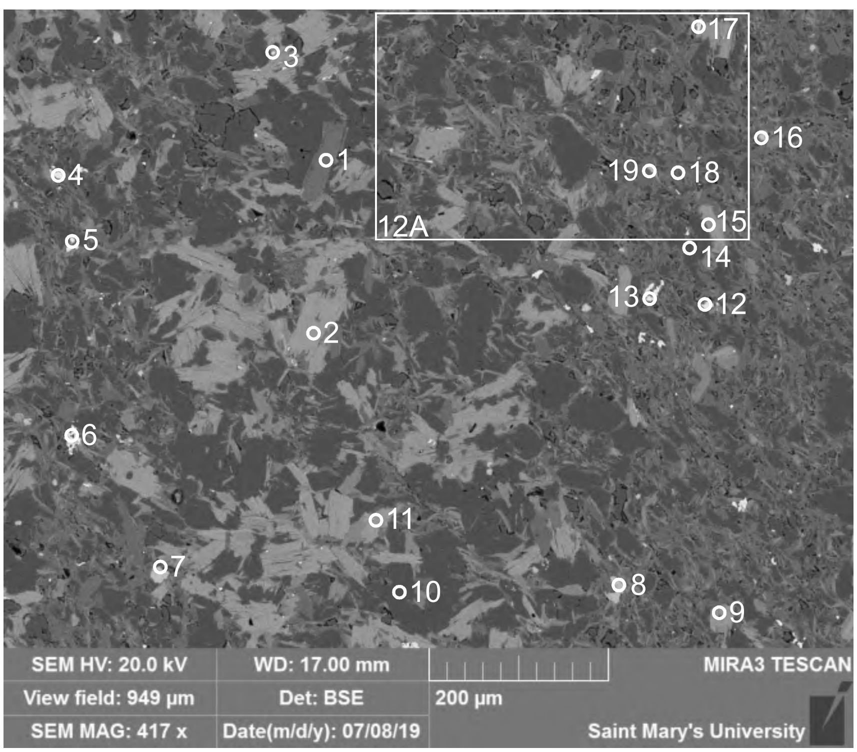
1. Apatite
2. Xenotime+
3. Apatite+
4. Zircon+
5. TiO2+
6. Zircon+
7. TiO2+
8. Monazite+
9. Chlorite
10. Quartz
11. Muscovite
12. Albite
13. Quartz

Figure 10.1-16. Sample OD2016-D2-002-1 site 10a. DT: Apatite, (9) Chlorite, Quartz, Zircon; DG: Monazite, Muscovite, TiO2, Xenotime.



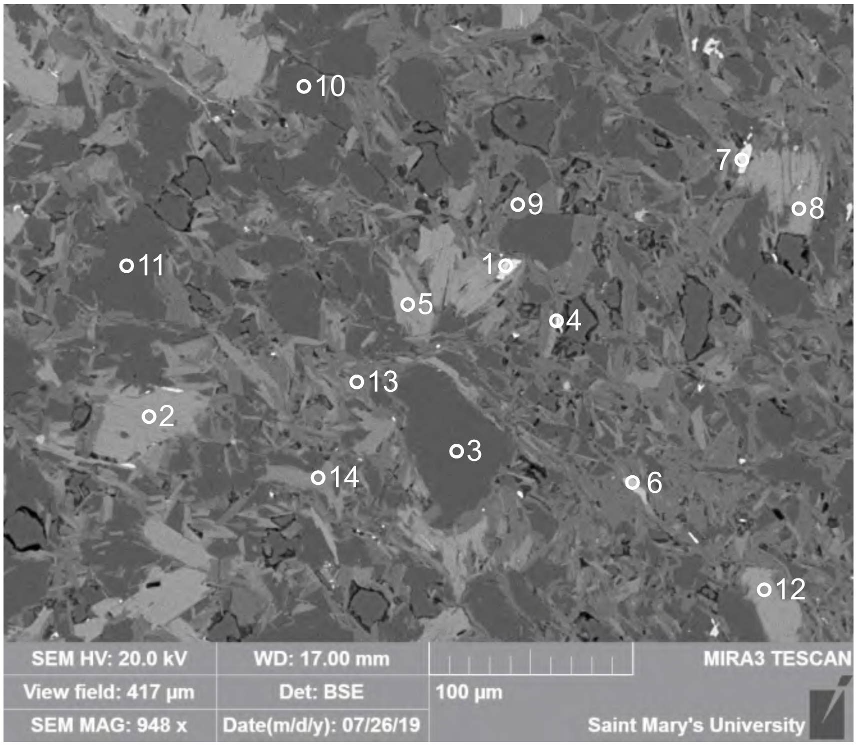
1. Biotite
2. TiO2+
3. TiO2+
4. Quartz
5. K-Feldspar
6. Apatite+
7. Zircon+
8. Chlorite
9. Muscovite
10. Albite
11. Apatite
12. TiO2+
13. Biotite
14. TiO2+
15. TiO2+
16. Biotite
17. Apatite+
18. Monazite+
19. Chlorite+
20. Chlorite
21. Apatite

Figure 10.1-17. Sample OD2016-D2-002-1 site 11. DT: Apatite, Quartz, Zircon; DG: Biotite, Chlorite, K-Feldspar, Monazite, Muscovite, TiO_2.



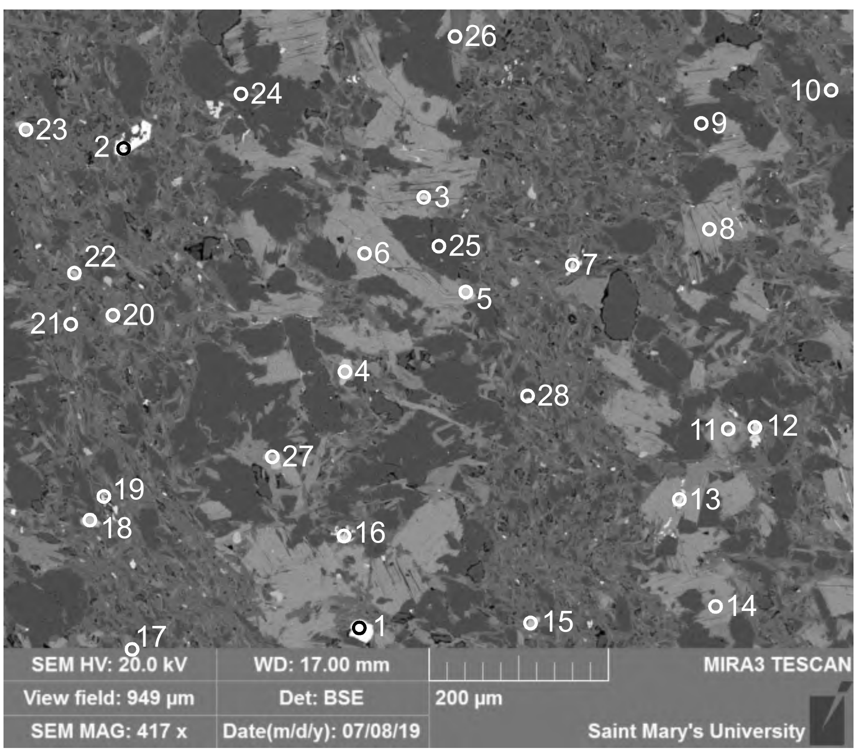
1. Muscovite
2. Biotite
3. TiO2+
4. TiO2+
5. Ap+ TiO2
6. TiO2+
7. Apatite
8. Apatite
9. Biotite
10. Quartz
11. Biotite
12. TiO2+
13. TiO2+
14. K-Feldspar
15. Biotite
16. Apatite+
17. TiO2+
18. Muscovite
19. Apatite+

Figure 10.1-18. Sample OD2016-D2-002-1 site 12. DT: Apatite, Quartz; DG: Biotite, K-Feldspar, Muscovite, TiO_2.



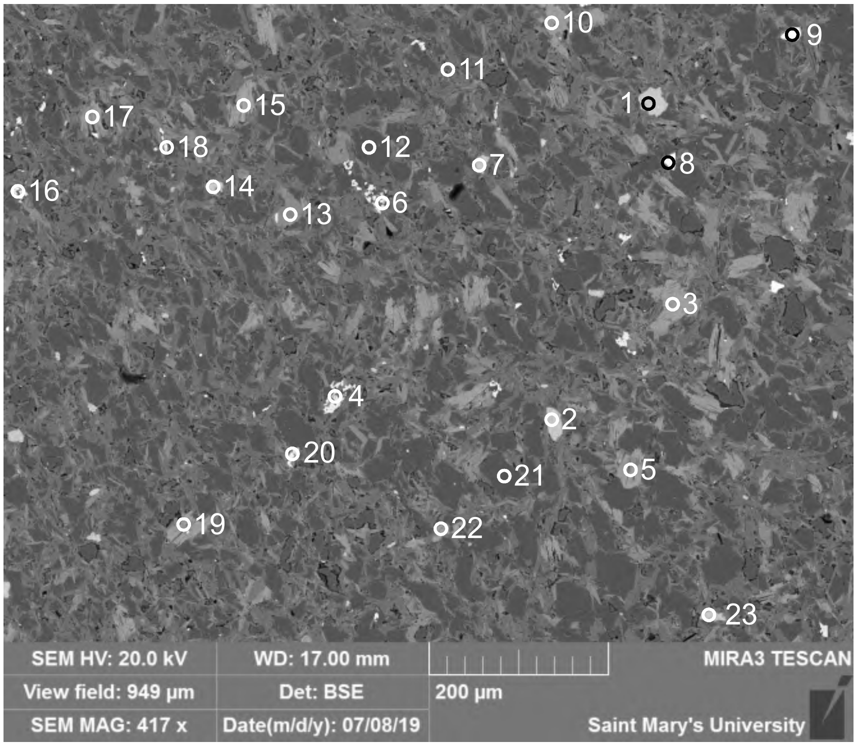
1. TiO2+
2. Biotite
3. Quartz
4. Monazite
5. Biotite
6. Apatite
7. TiO2+
8. Biotite
9. Muscovite
10. Quartz+
11. Quartz
12. Biotite
13. Muscovite
14. Chlorite

Figure 10.1-19. Sample OD2016-D2-002-1 site 12a. DT: Apatite, Quartz; DG: Biotite, Chlorite, Monazite, Muscovite, TiO2.



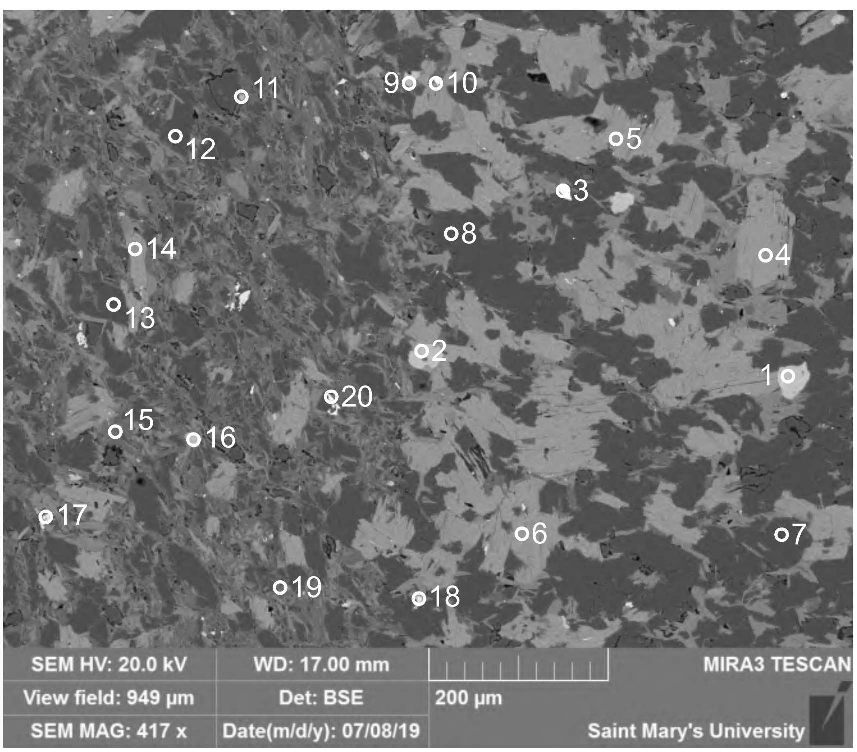
1. Zircon
2. Monazite+
3. TiO2+
4. Apatite
5. Apatite
6. Biotite
7. TiO2+
8. Biotite
9. Quartz
10. Muscovite
11. Apatite
12. TiO2+
13. TiO2+
14. Biotite
15. Apatite
16. TiO2+
17. TiO2+
18. Apatite
19. TiO2+
20. Biotite
21. Biotite
22. Apatite+
23. Apatite
24. Quartz
25. Quartz
26. Muscovite
27. Apatite
28. Xenotime +

Figure 10.1-20. Sample OD2016-D2-002-1 site 13. (2) Euhedral diagenetic monazite growing around quartz grain.



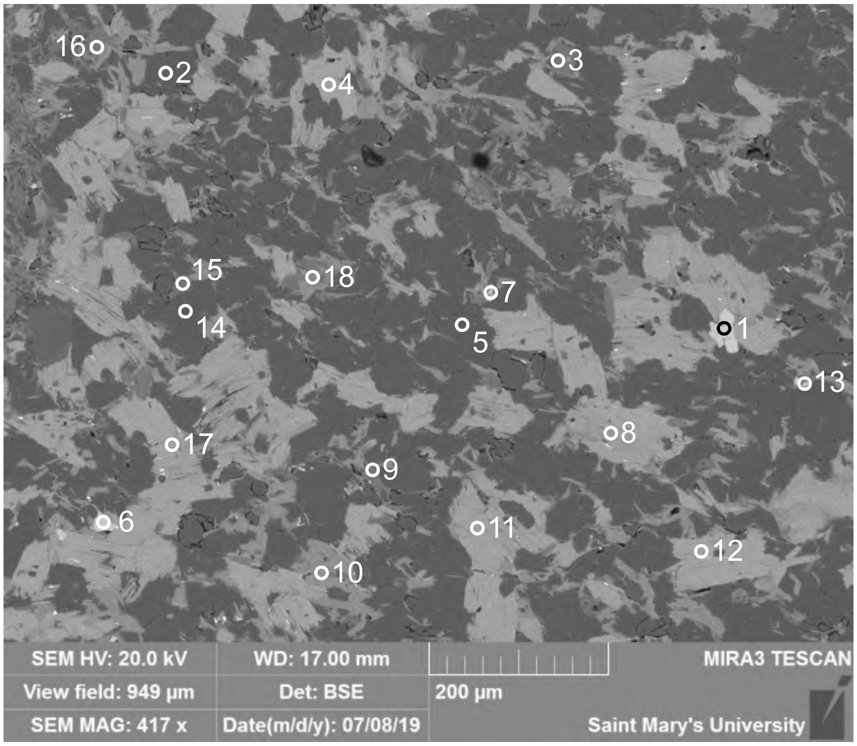
1. Apatite
2. Apatite
3. Biotite
4. TiO2+
5. Biotite
6. TiO2+
7. Apatite
8. Zircon
9. Zircon+
10. Biotite
11. Muscovite
12. Quartz
13. Chlorite
14. Apatite+
15. Biotite
16. TiO2+
17. Biotite
18. TiO2+
19. Biotite
20. TiO2+
21. Quartz
22. Biotite
23. Apatite

Figure 10.1-21. Sample OD2016-D2-002-1 site 14. DT: Apatite, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO_2.



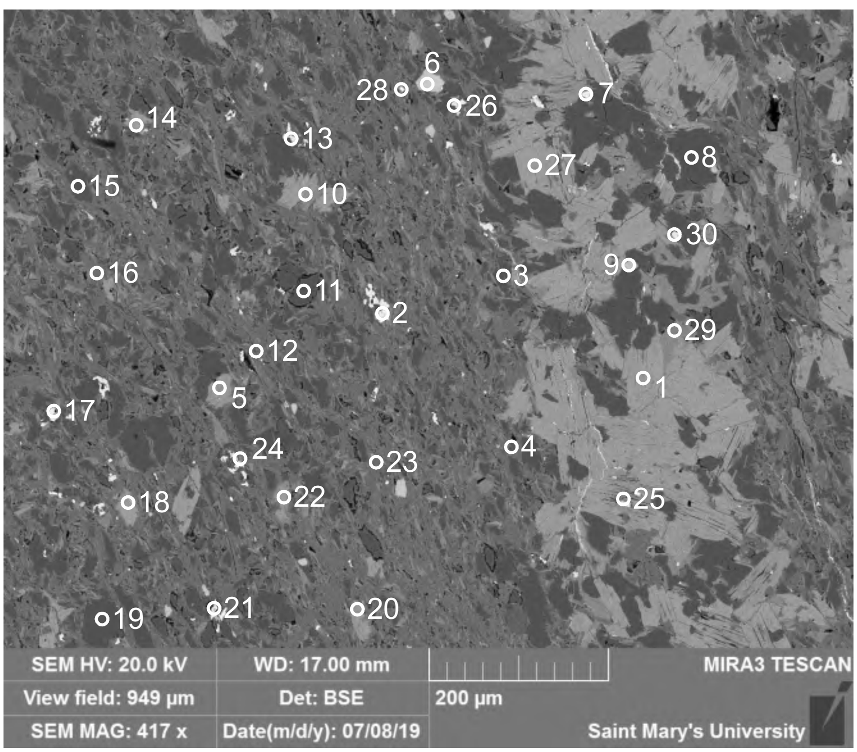
1. Apatite
2. Apatite
3. Zircon
4. Biotite
5. Biotite
6. Biotite
7. Quartz
8. Quartz
9. Apatite
10. Zircon+
11. Apatite
12. Quartz
13. Quartz
14. Biotite
15. Muscovite
16. Apatite
17. TiO2+
18. TiO2+
19. Muscovite
20. Monazite+

Figure 10.1-22. Sample OD2016-D2-002-1 site 15. DT: Apatite, Quartz, Zircon; DG: Biotite, Monazite, Muscovite, TiO_2.



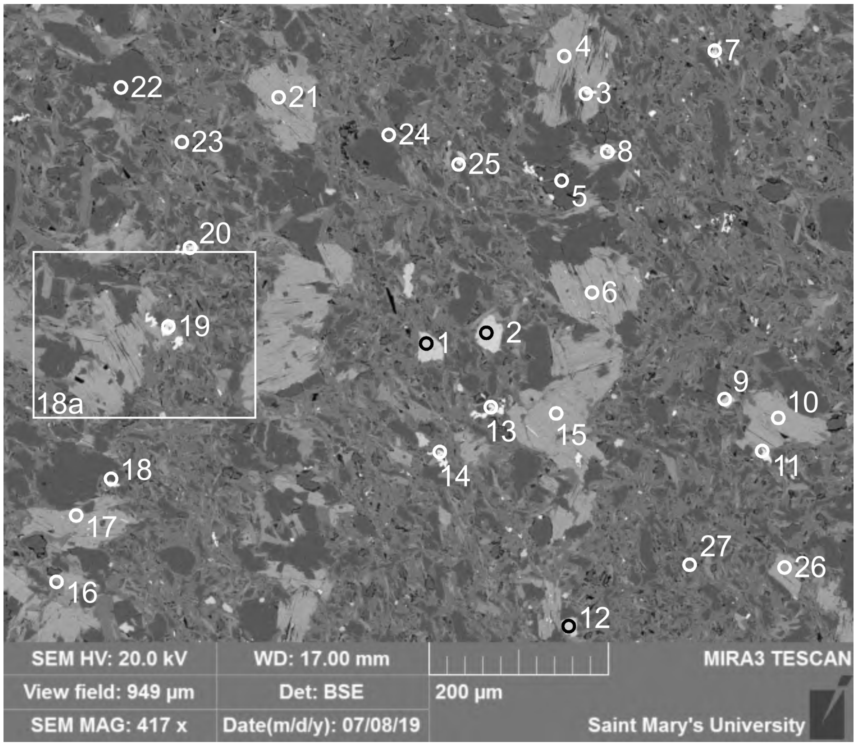
1. Apatite+
2. Quartz
3. Muscovite
4. Biotite
5. Quartz
6. Apatite
7. Monazite+
8. Biotite
9. Muscovite
10. Chlorite
11. Biotite
12. Bt+ Rt
13. Apatite+
14. Quartz
15. K-Feldspar
16. Muscovite
17. Biotite
18. Biotite

Figure 10.1-23. Sample OD2016-D2-002-1 site 16. DT: Apatite, Quartz, Zircon; DG: Biotite, Chlorite, K-Feldspar, Monazite, Muscovite, TiO2.



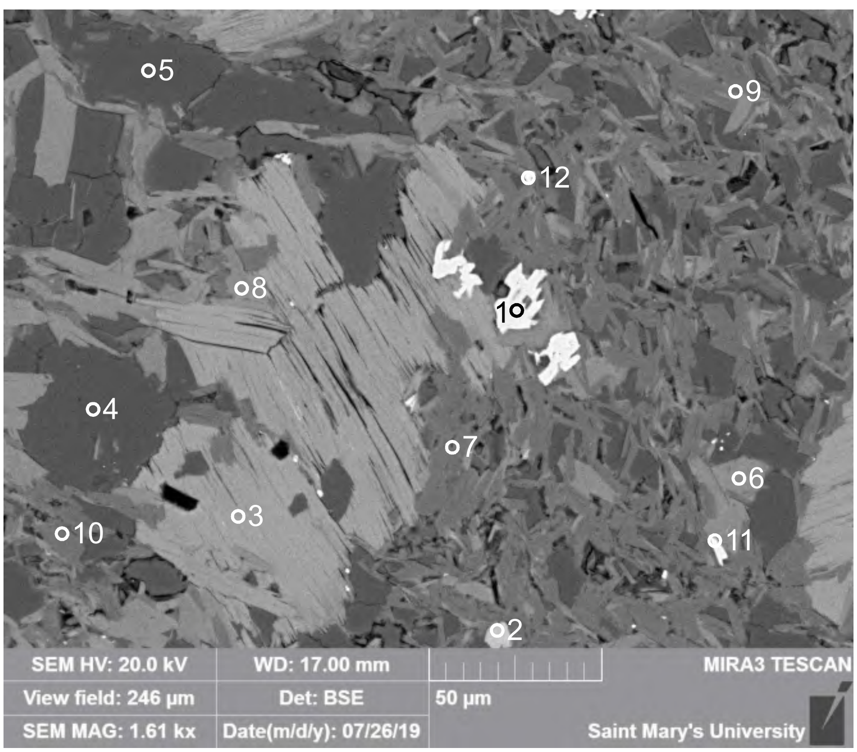
1. Biotite
2. TiO2+
3. Quartz+
4. Muscovite
5. Biotite
6. Apatite
7. TiO2+
8. Quartz
9. Apatite
10. Biotite
11. Albite
12. Ms+ Qz
13. TiO2+
14. Biotite
15. Quartz
16. Muscovite
17. TiO2+
18. Biotite
19. Quartz
20. Biotite
21. TiO2+
22. Biotite
23. Muscovite
24. TiO2+
25. TiO2+
26. TiO2+
27. Biotite
28. Monazite+
29. Chlorite
30. TiO2+

Figure 10.1-24. Sample OD2016-D2-002-1 site 17. DT: Apatite, Quartz; DG: Biotite, Chlorite, Monazite, Muscovite, TiO2.



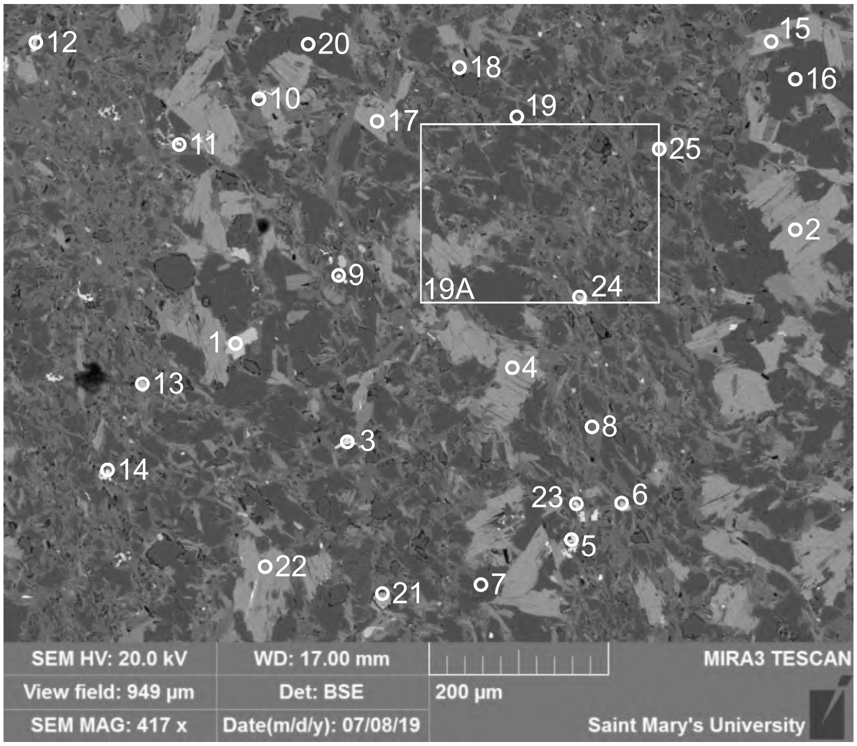
1. Apatite
2. Apatite
3. Zircon+
4. Biotite
5. Muscovite
6. Biotite
7. TiO2+
8. TiO2+
9. Apatite+
10. Biotite
11. TiO2+
12. Apatite
13. TiO2+
14. TiO2+
15. Biotite
16. Muscovite
17. Biotite
18. Zircon+
19. TiO2+
20. TiO2+
21. Biotite
22. Quartz
23. Muscovite
24. Muscovite
25. TiO2+
26. Biotite
27. Muscovite

Figure 10.1-25. Sample OD2016-D2-002-1 site 18. DT: Apatite, Quartz, Zircon; DG: Biotite, Muscovite, TiO2.



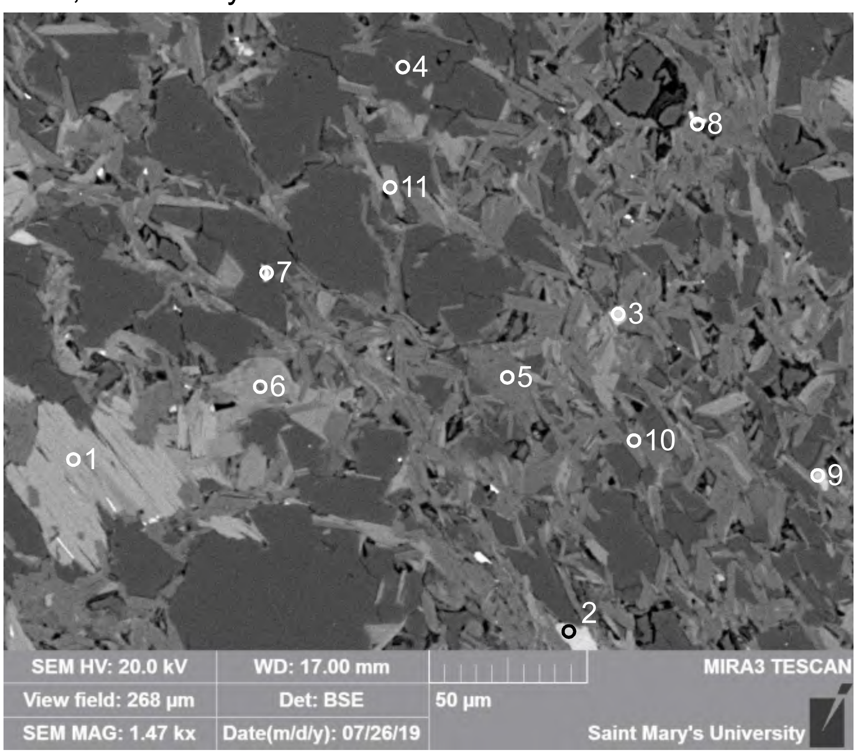
1. TiO2+
2. Apatite
3. Biotite
4. Quartz
5. Quartz
6. Chlorite
7. Muscovite
8. Chlorite
9. Muscovite
10. Muscovite
11. TiO2+
12. Zircon+

Figure 10.1-26. Sample OD2016-D2-002-1 site 18a. DT: Apatite, Quartz, Zircon; DG: Biotite, Muscovite, TiO2.



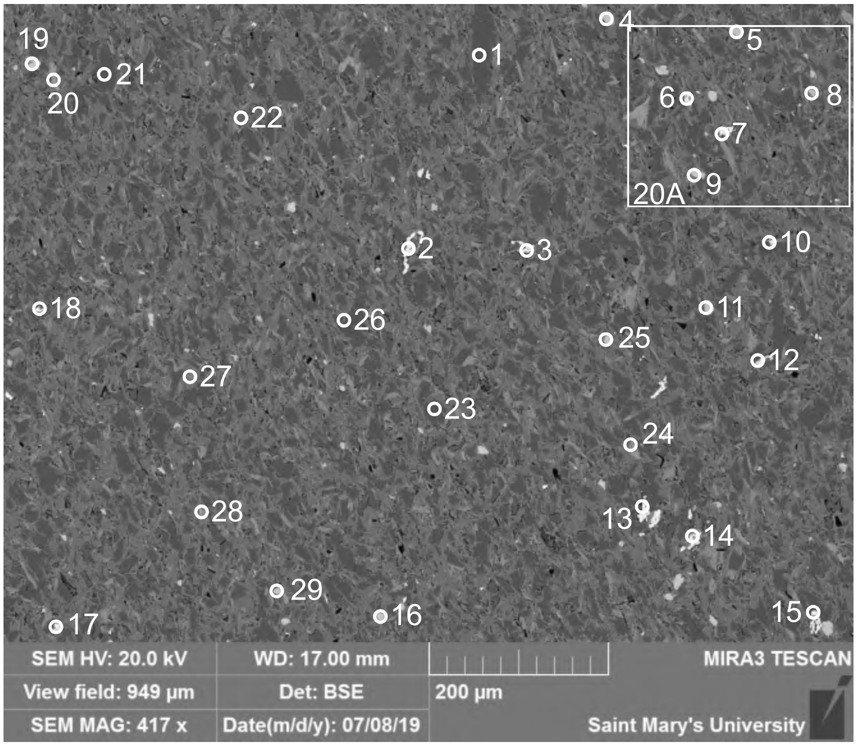
1. Apatite
2. Biotite
3. TiO2+
4. Biotite
5. TiO2+
6. Apatite
7. Quartz
8. Muscovite
9. Zircon+
10. TiO2+
11. Feohy+
12. TiO2+
13. Apatite
14. TiO2+
15. Biotite
16. Quartz
17. Biotite
18. Chlorite
19. Quartz+
20. Quartz
21. Biotite
22. Biotite
23. TiO2+
24. Apatite
25. Biotite

Figure 10.1-27. Sample OD2016-D2-002-1 site 19. DT: Apatite, Quartz, Zircon; DG: Biotite, Chlorite, Muscovite, TiO2; HD: Feohy.



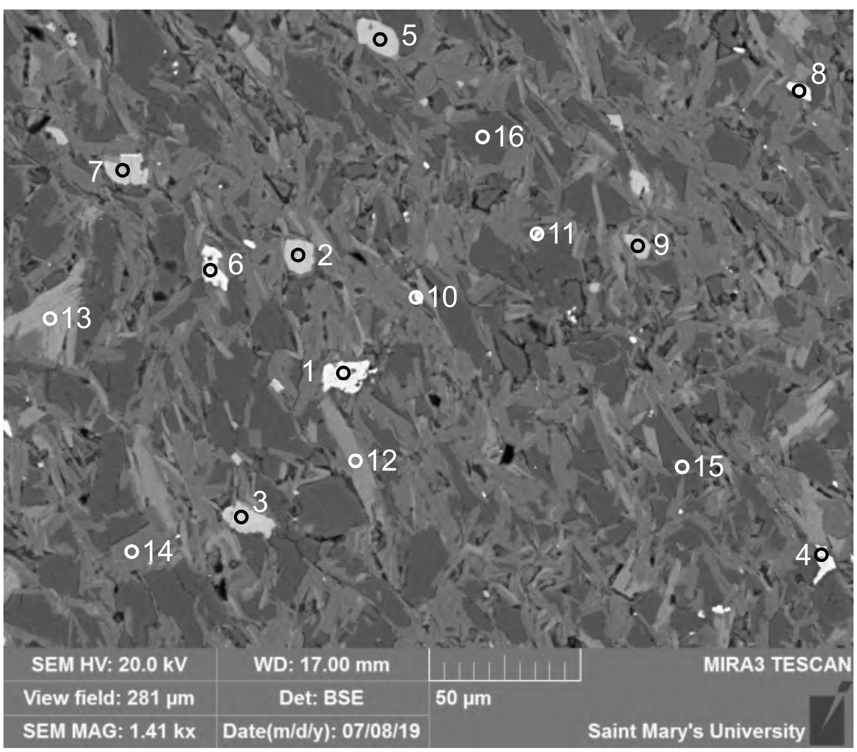
1. Biotite
2. Apatite
3. Apatite
4. Quartz
5. Muscovite
6. Chlorite+
7. TiO2+
8. Monazite+
9. Apatite
10. Muscovite
11. Chlorite

Figure 10.1-28. Sample OD2016-D2-002-1 site 19a. DT: Apatite, Quartz; DG: Biotite, Chlorite, Monazite, Muscovite, TiO2.



1. Quartz
2. Mixture
3. TiO2+
4. Apatite
5. Apatite
6. TiO2+
7. Apatite
8. Apatite
9. Apatite
10. TiO2+
11. Apatite
12. TiO2+
13. TiO2+
14. TiO2+
15. TiO2+
16. Apatite
17. TiO2+
18. Monazite+
19. Apatite
20. Biotite
21. Quartz
22. Muscovite
23. Quartz
24. Biotite
25. Apatite+
26. Quartz
27. Muscovite
28. Biotite
29.Apatite

Figure 10.1-29. Sample OD2016-D2-002-1 site 20. DT: Apatite, Quartz; DG: Biotite, Monazite, Muscovite, TiO2.



1. TiO2+
2. Apatite
3. Apatite
4. TiO2+
5. Apatite
6. Ap+ TiO2
7. Apatite+
8. TiO2+
9. Apatite
10. TiO2+
11. Monazite+
12. Chlorite
13. Biotite
14. Muscovite
15. Biotite
16. Quartz

Figure 10.1-30. Sample OD2016-D2-002-1 site 20a. DT: Apatite, Quartz; DG: Biotite, Chlorite, Monazite, Muscovite, TiO2.

Appendix 10.2: OD2016-I

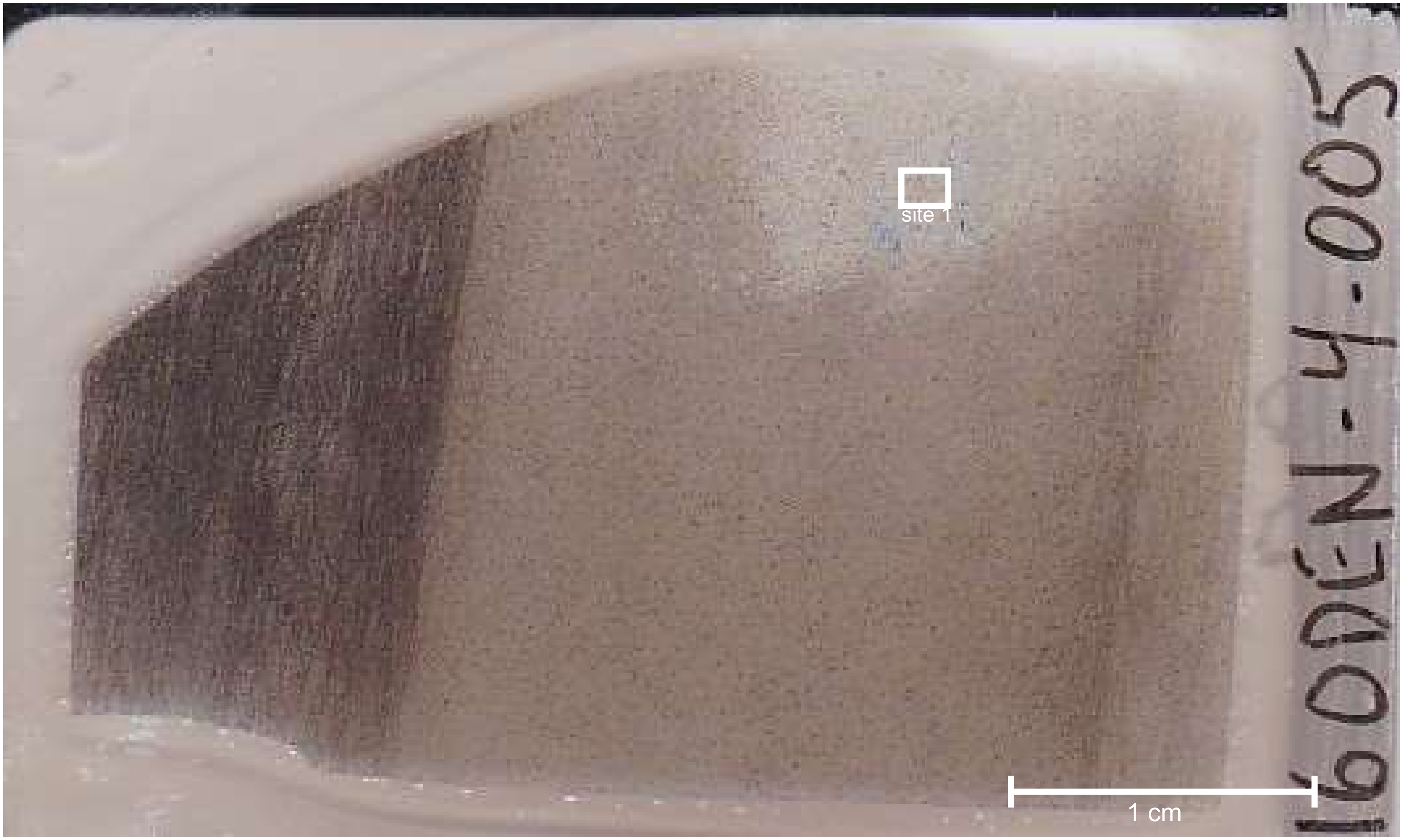
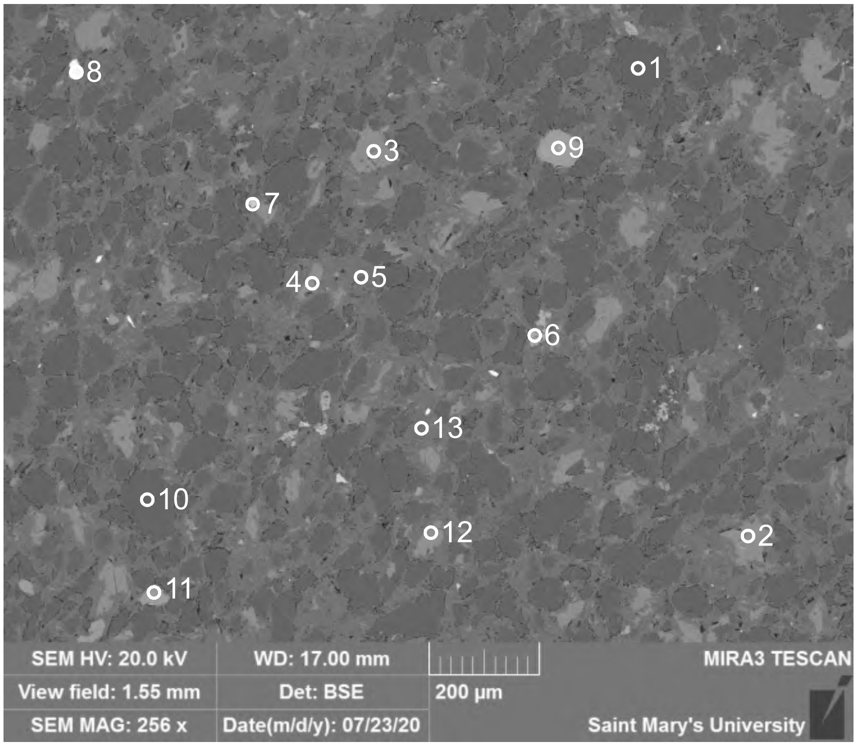


Figure 10.2-1: Slide OD2016-D2-0005.

Figure 10.2-2: Sample OD2016-D2-005.



1. Quartz
2. Biotite
3. Biotite
4. Biotite
5. Muscovite +
6. Mixture
7. Ilmentite +
8. Zircon
9. Apatite
10. Quartz
11. Apatite
12. Biotite
13. Muscovite

Figure 10.2-3. Sample OD2016-D2-005 site 1. DT: Apatite, Ilmenite, Quartz, Zircon. DG: Biotite, Muscovite.

Appendix 10.3: OD2016-D2-011-1 BSE imagery.

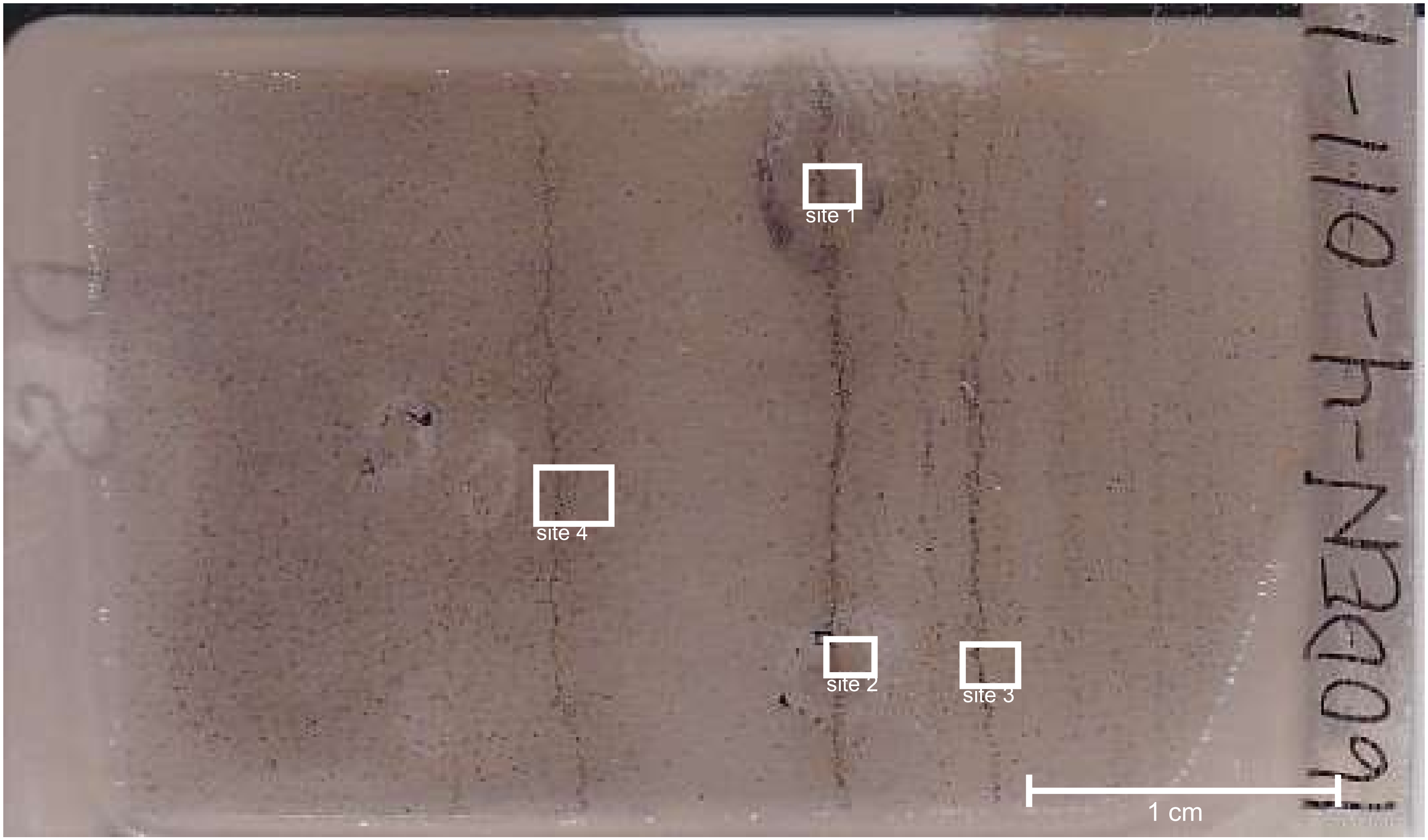


Figure 10.3-1: Slide OD2016-D2-0011-1.

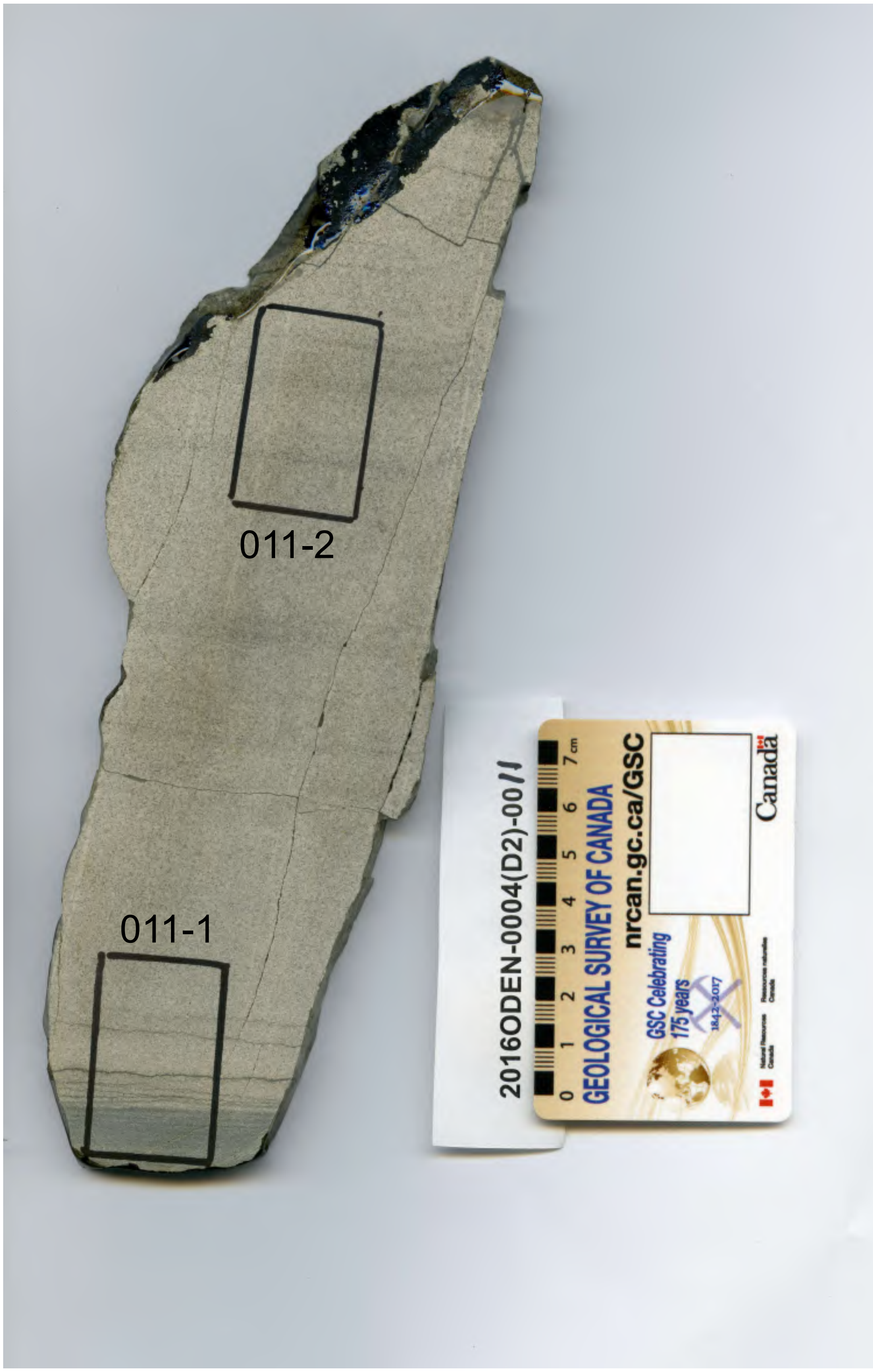
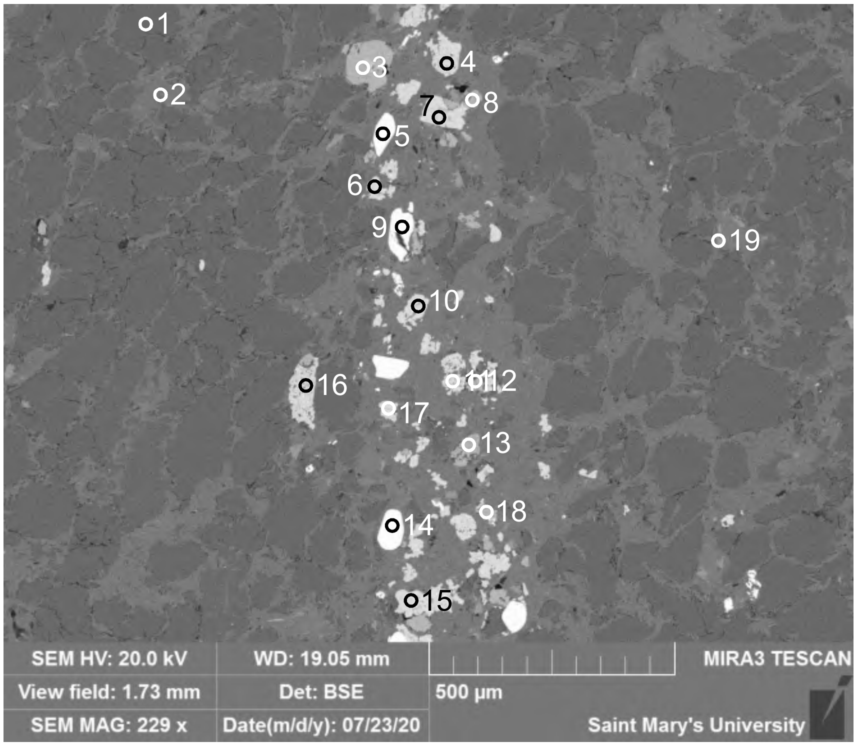
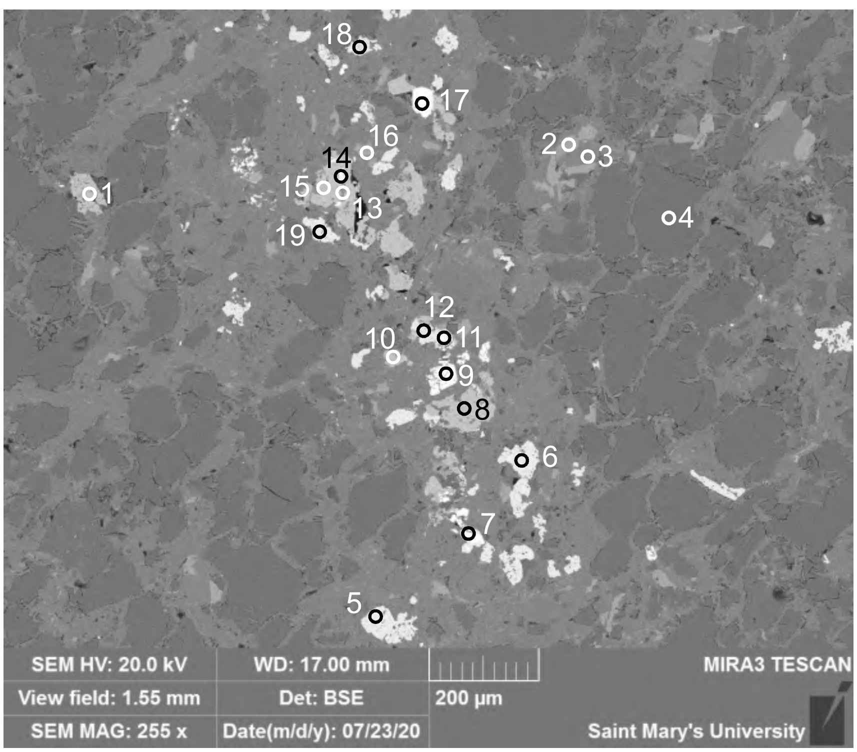


Figure 10.3-2: Sample OD2016-D2-011.



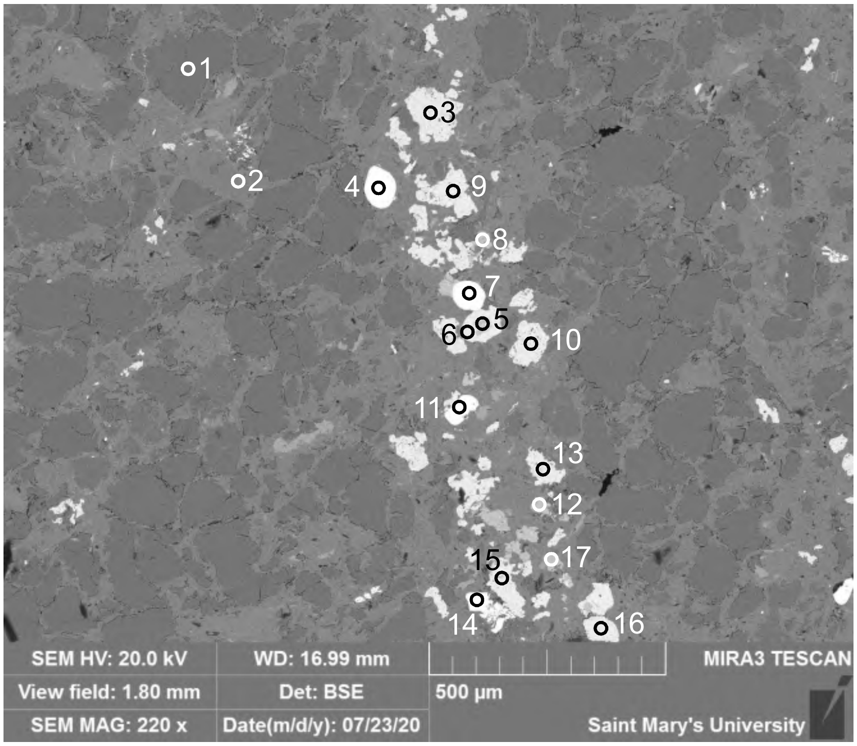
1. Quartz
2. Muscovite +
3. Rutile +
4. Ilmenite +
5. Zircon
6. Ilmenite
7. Ilmenite +
8. Rutile +
9. Zircon
10. Ilmenite
11. Ilmenite +
12. Rutile +
13. Rutile +
14. Zircon
15. Ilmenite
16. Ilmenite +
17. Ilmenite
18. Rutile +
19. Biotite

Figure 10.3-3. Sample OD2016-D2-011-1 site 1. DT: . DG: . HD: .



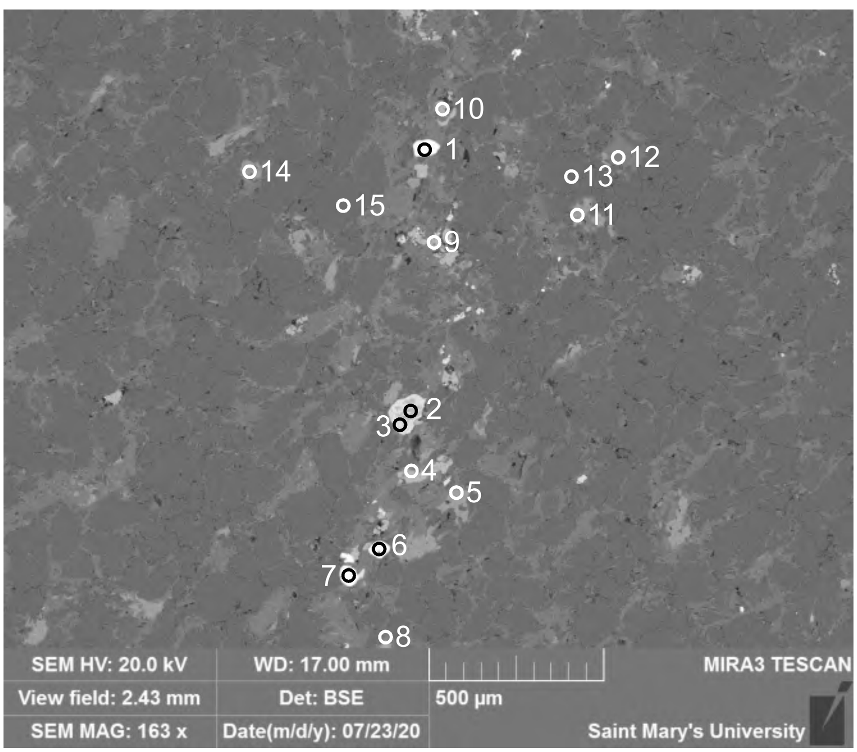
1. Rutile +
2. Biotite
3. K-Feldspar +
4. Quartz
5. Ilmenite
6. Ilmenite
7. Xenotime
8. Rutile
9. Zircon
10. Rutile +
11. Zircon
12. Ilmenite
13. Chlorite +
14. Monazite +
15. Rutlie
16. Biotite
17. Zircon
18. Ilmenite +
19. Ilmenite

Figure 10.3-4. Sample OD2016-D2-011-1 site 2. DT: . DG: . HD: .



1. Quartz
2. Muscovite
3. Ilmenite
4. Zircon
5. Rutile +
6. Ilmenite
7. Zircon
8. Rutile +
9. Ilmenite
10. Ilmenite +
11. Zircon
12. Rutile
13. Ilmenite +
14. Zircon
15. Ilmenite
16. Ilmenite
17. Rutile +

Figure 10.3-5. Sample OD2016-D2-011-1 site 3. DT: . DG: . HD: .



1. Zircon
2. Rutile +
3. Ilmenite +
4. Rutile +
5. Biotite
6. Zircon
7. Zircon
8. Apatite +
9. Rutile +
10. Rutile +
11. Biotite
12. K-Feldpsar
13. Quartz +
14. Biotite
15. Quartz

Figure 10.3-6. Sample OD2016-D2-011-1 site 4. DT: . DG: . HD: .

Appendix 10.4: OD2016 imagery.

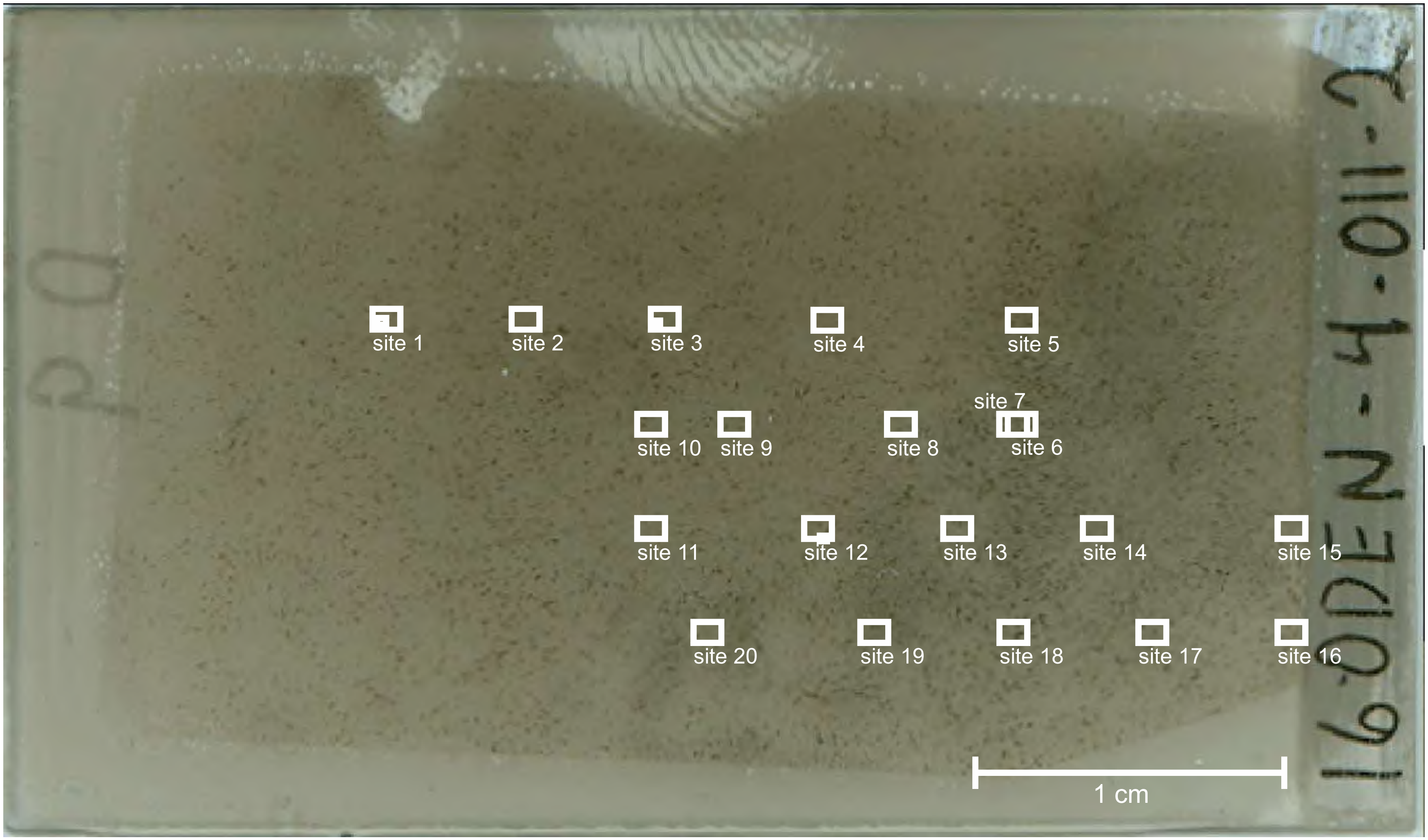


Figure 10.4-1: Slide OD2016-D2-011-2.

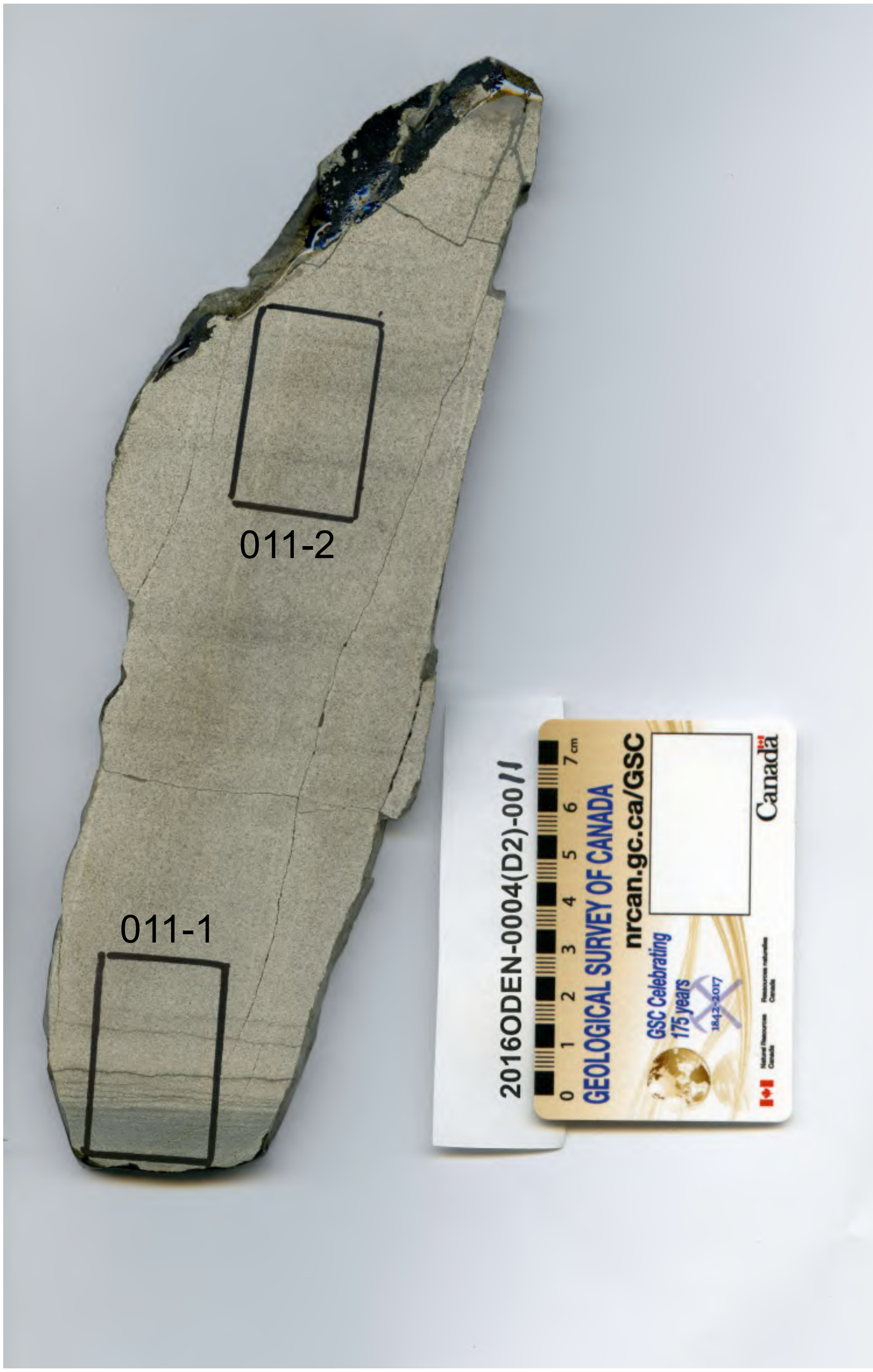
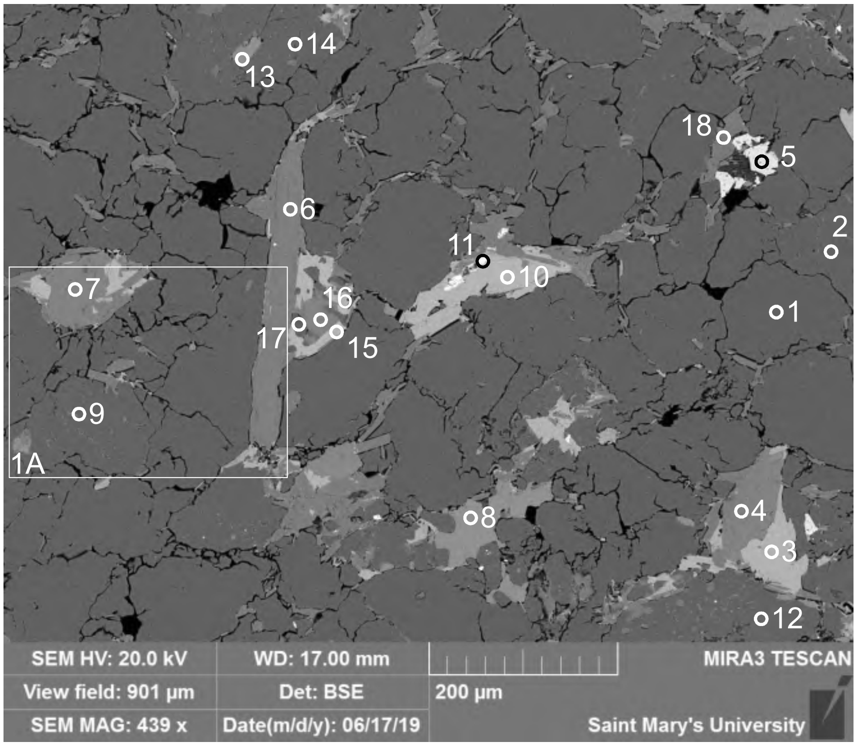
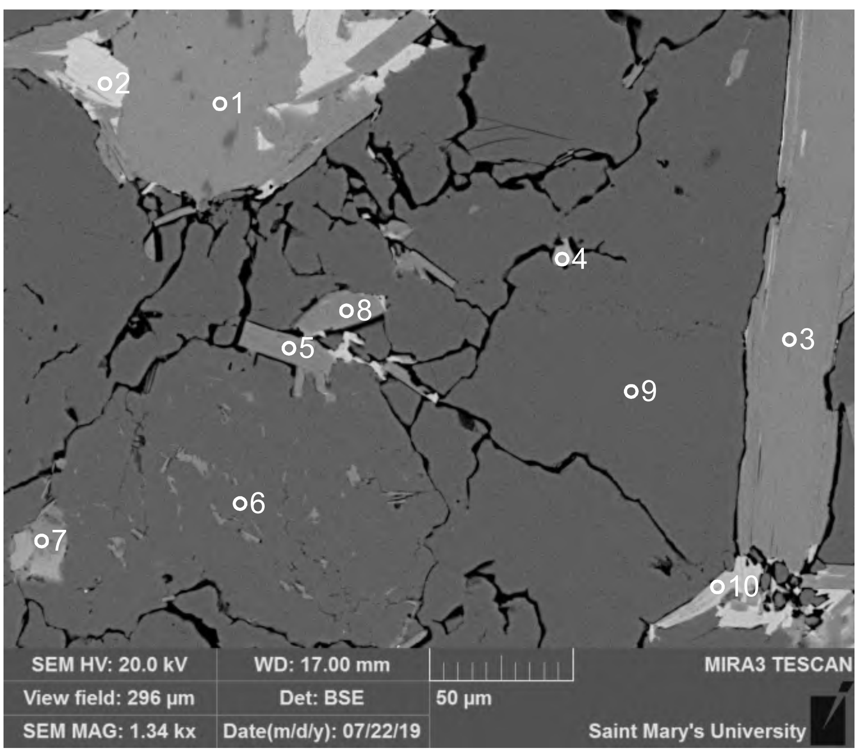


Figure 10.4-2: Sample OD2016-D2-011.



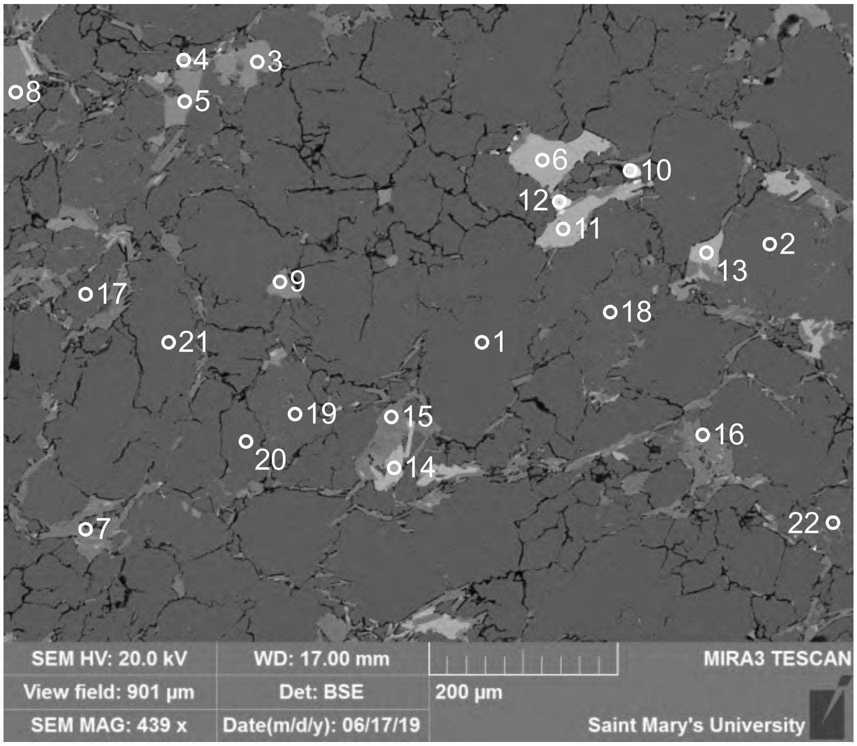
1. Quartz
2. Albite
3. Biotite
4. K-Feldspar
5. TiO2
6. Muscovite
7. K-Feldspar
8. Calcite
9. Albite+
10. Biotite
11. Mz + Qz
12. Albite
13. Calcite
14. Albite
15. Biotite
16. K-Feldspar
17. Quartz
18. Muscovite

Figure 10.4-3. Sample OD2016-D2-011-2 site 1. DT: Albite, Quartz, (6) Muscovite. DG: Biotite, K-Feldspar, Muscovite. HD: TiO_2.



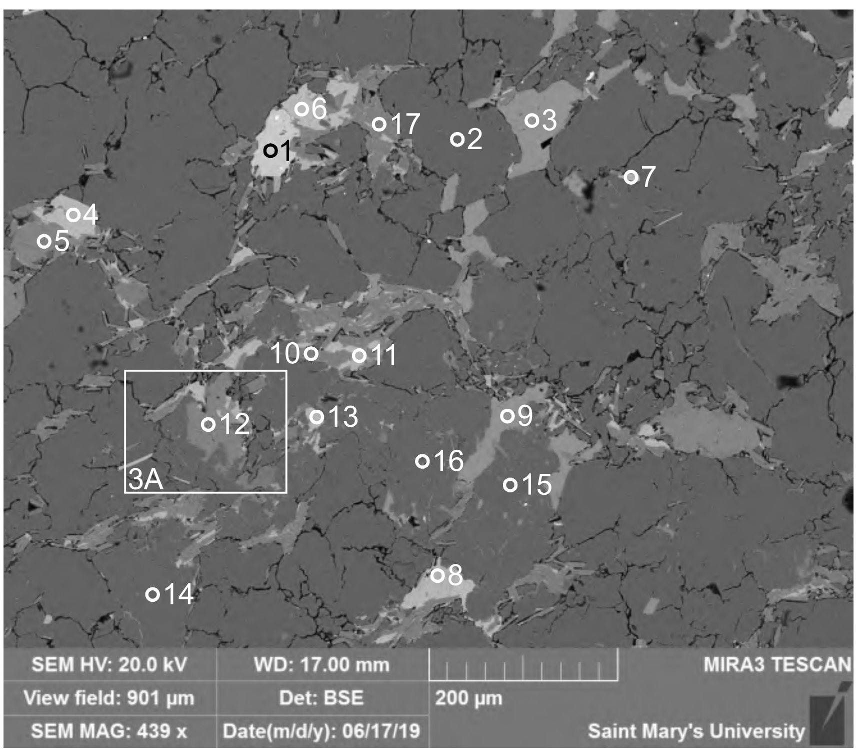
1. K-Feldspar
2. Biotite
3. Muscovite
4. Calcite
5. Muscovite
6. Albite
7. K-Felspar
8. Muscovite
9. Quartz
10. Chlorite

Figure 10.4-4. Sample OD2016-D2-011-2 site 1A. (9) Quartz grains showing recrystallization and suturing.



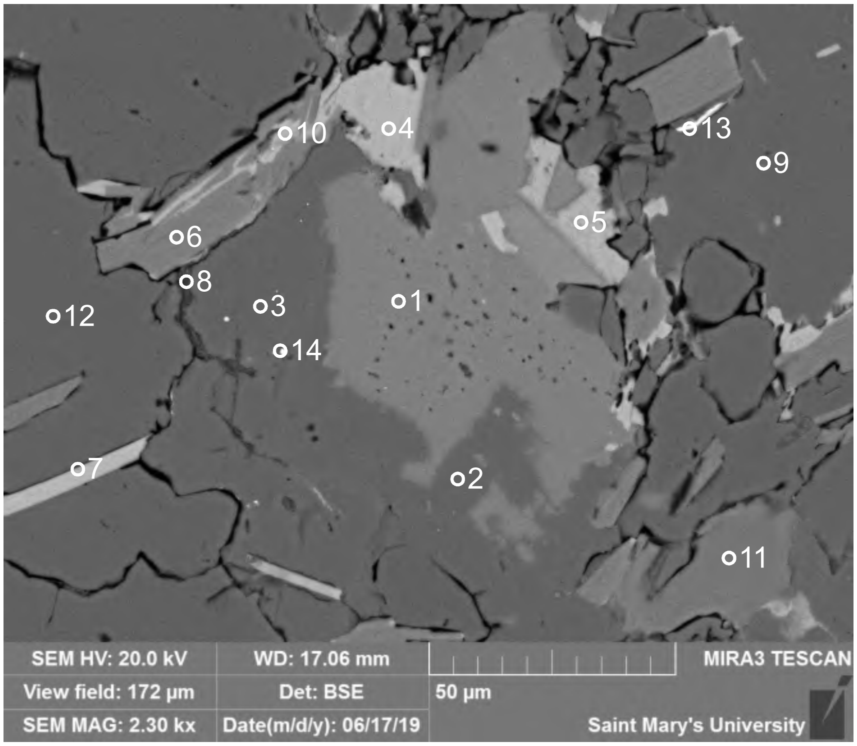
1. Quartz
2. Albite
3. Calcite
4. Biotite
5. Calcite
6. Biotite
7. Muscovite
8. K-Feldspar
9. Calcite
10. TiO2+
11. Biotite
12. TiO2
13. Biotite
14. Biotite
15. K-Feldspar
16. Muscovite
17. Quartz
18. Albite
19. Albite
20. Quartz
21. Quartz
22. Albite

Figure 10.4-5. Sample OD2016-D2-011-2 site 2. (3, 5, 9) Late HD calcite infilling voids.



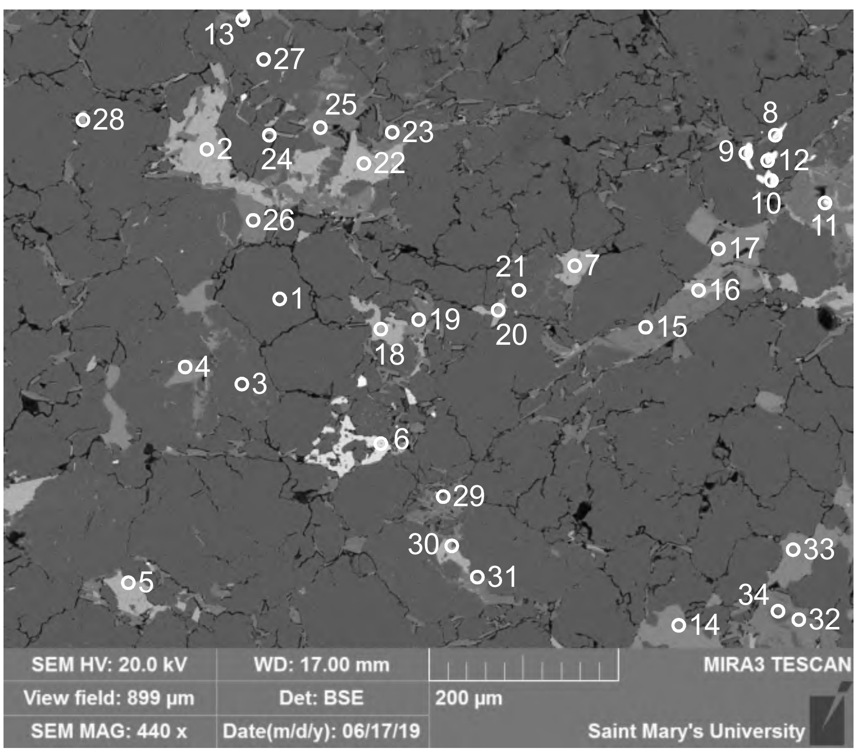
1. Apatite
2. Quartz
3. Calcite
4. Biotite
5. K-Feldspar
6. Biotite
7. Biotite
8. Biotite
9. Calcite
10. Muscovite
11. Biotite
12. K-Feldspar
13. Biotite
14. Albite
15. Albite
16. Albite
17. Muscovite

Figure 10.4-6. Sample OD2016-D2-011-2 site 3. Late calcite infilling pores. DG: Apatite.



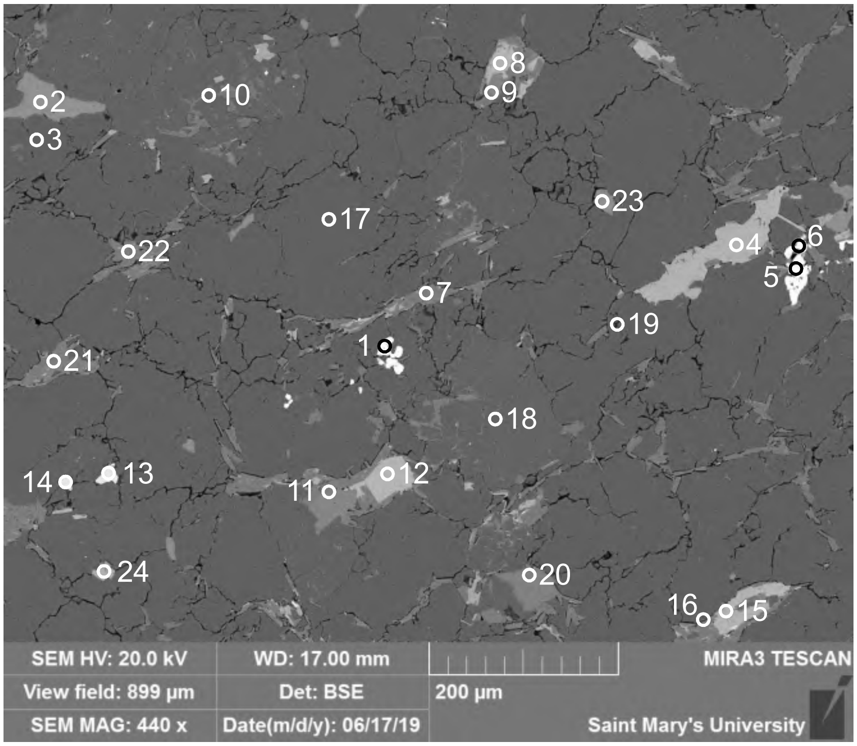
1. K-Feldspar
2. Albite
3. Albite
4. Biotite
5. Biotite
6. Muscovite
7. Biotite
8. Albite
9. Albite
10. Biotite
11. Muscovite
12. Quartz
13. Ab+ Feohy
14. Ab+ Pyrite

Figure 10.4-7. Sample OD2016-D2-011-2 site 3a. Possible granitic lithic clast.



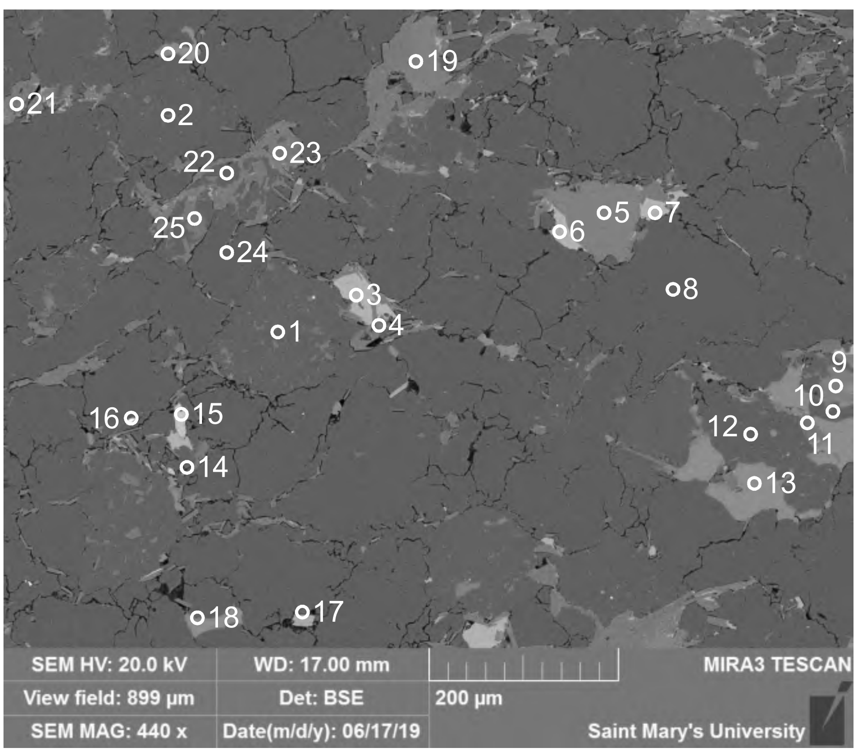
1. Quartz
2. Biotite
3. Albite
4. Calcite
5. Biotite
6. TiO2+
7. Biotite
8. Ilmenite+
9. Ilmenite+
10. Ilmenite+
11. Mz+ Qz
12. Ilmenite+
13. Ilmenite+
14. Calcite
15. K-Feldspar
16. Biotite
17. Calcite
18. Biotite
19. K-feldspar
20. Biotite
21. Albite
22. Biotite
23. Biotite+
24. Biotite
25. K-Feldspar
26. K-Feldspar
27. Albite
28. Biotite
29. Muscovite
30. Biotite
31. Muscovite
32. K-Feldspar
33. Calcite
34. Albite

Figure 10.4-8. Sample OD2016-D2-011-2 site 4. Secondary TiO_2 and ilmenite filling pores.



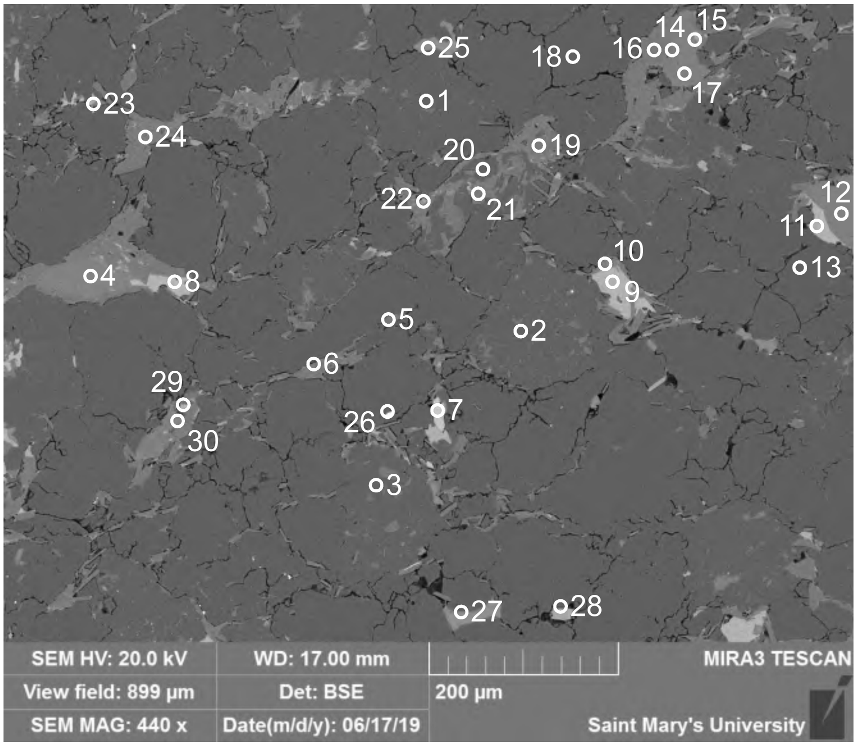
1. Ilmenite+
2. Calcite
3. Quartz
4. Biotite
5. Ilmenite
6. Ilmenite
7. Muscovite
8. Biotite
9. K-Feldspar
10. Albite
11. K-Feldspar
12. Biotite
13. TiO_2+
14. TiO_2
15. Biotite
16. Muscovite
17. Quartz
18. Albite
19. Quartz
20. K-Feldspar
21. Muscovite
22. Muscovite
23. Calcite
24. Biotite

Figure 10.4-9. Sample OD2016-D2-011-2 site 5.



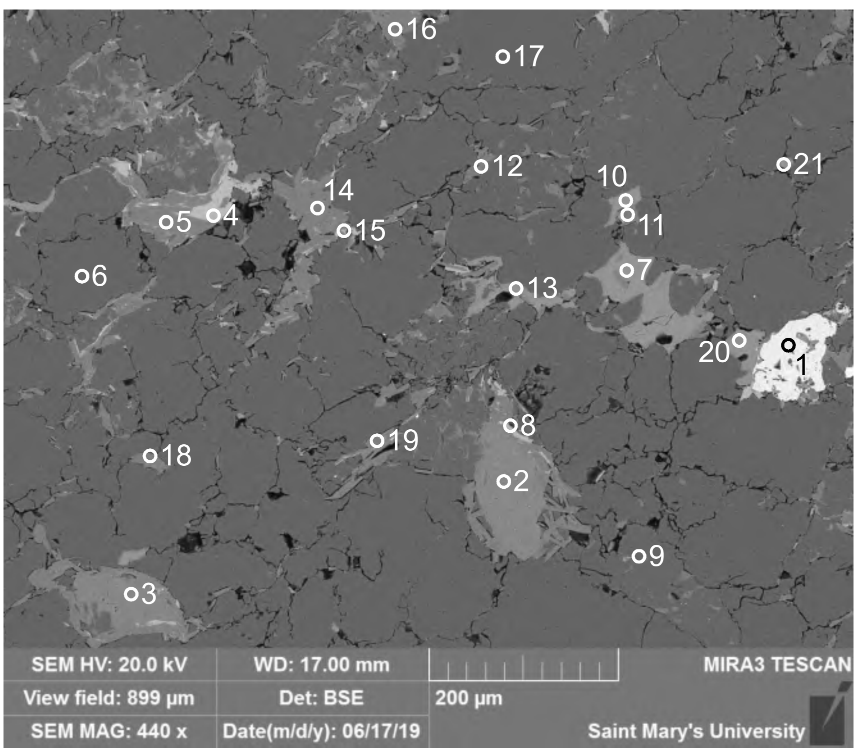
1. Albite
2. Albite
3. Biotite
4. Muscovite
5. K-Feldspar
6. Mixture
7. Biotite
8. Quartz
9. K-Feldspar
10. Albite
11. Muscovite
12. Albite
13. Calcite
14. Muscovite
15. Apatite
16. Ilmenite+
17. Chlorite
18. Calcite
19. K-Feldspar
20. Calcite
21. Muscovite
22. Albite
23. Muscovite
24. Quartz
25. Muscovite

Figure 10.4-10. Sample OD2016-D2-011-2 site 6. (1) Albite showing alteration.



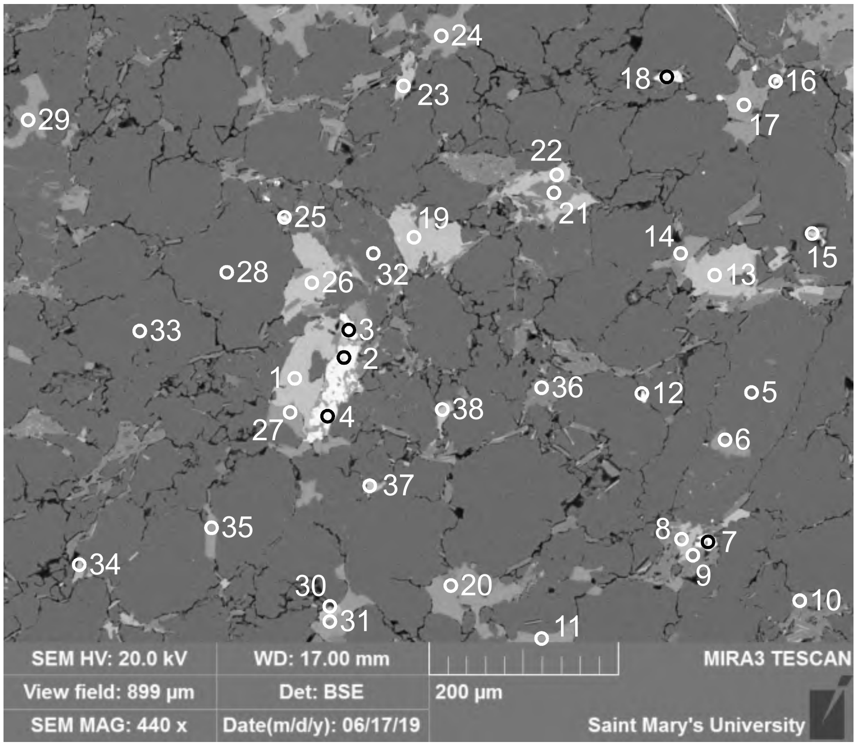
1. Albite
2. Albite
3. Albite
4. K-Feldspar
5. Muscovite
6. Muscovite
7. Apatite
8. Biotite
9. Biotite
10. Biotite+
11. Biotite
12. K-Feldspar
13. Quartz
14. K-Feldspar
15. Biotite
16. Muscovite
17. K-Feldspar
18. Quartz
19. Muscovite
20. Albite
21. Muscovite
22. Ms+ Chl
23. Biotite
24. Ms+ Chl
25. Calcite
26. Ilmenite+
27. Calcite
28. Chlorite
29. Biotite
30. K-Feldspar

Figure 10.4-11. Sample OD2016-D2-011-2 site 7.



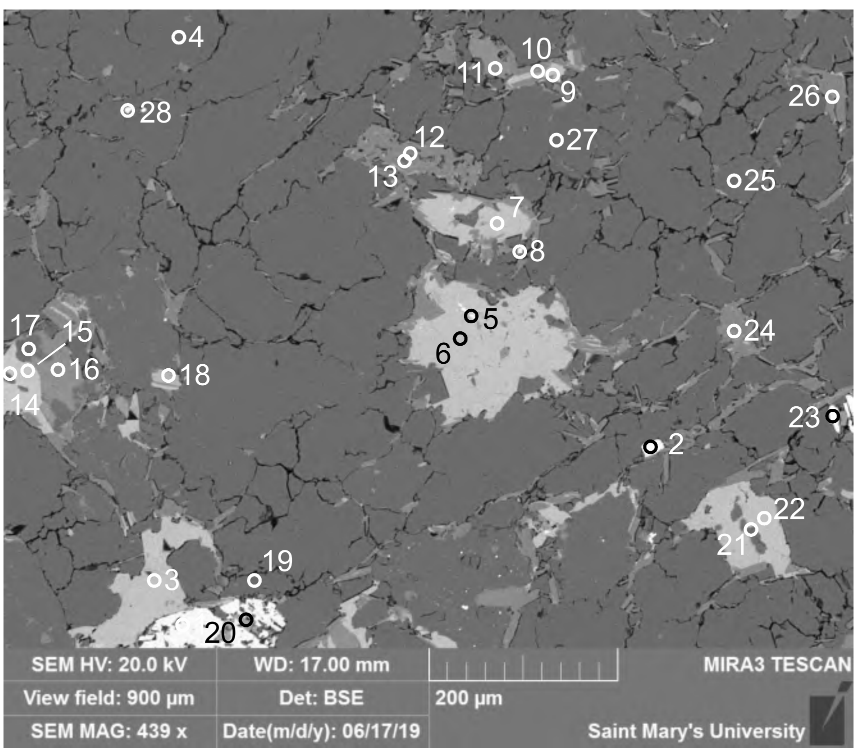
1. TiO_2
2. K-Feldspar
3. K-Feldspar
4. Biotite
5. Muscovite
6. Quartz
7. Calcite
8. Biotite+
9. Albite
10. Calcite
11. Muscovite
12. Muscovite
13. Calcite
14. Muscovite
15. Bt+ Ms
16. Muscovite
17. Quartz
18. Muscovite
19. Muscovite
20. Calcite
21. Calcite

Figure 10.4-12. Sample OD2016-D2-011-2 site 8.



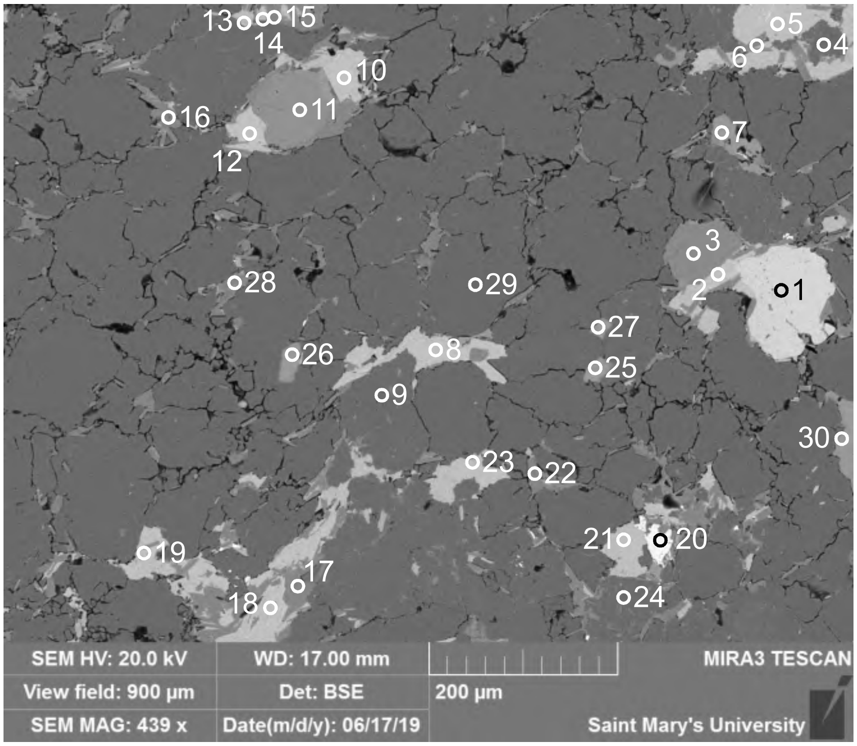
1. Biotite
2. TiO2
3. Ilmenite
4. Mz+ Qz
5. Albite
6. Calcite
7. Ilmenite
8. Biotite
9. Muscovite
10. Muscovite
11. Calcite
12. Ilmenite
13. Biotite
14. Calcite
15. Mixture
16. Mz+ Qz
17. Calcite+
18. TiO2
19. Biotite
20. Calcite
21. Muscovite
22. Biotite
23. Biotite
24. Calcite
25. Mz+ Qz
26. Biotite
27. Calcite
28. Quartz
29. Calcite
30. Biotite
31. Calcite
32. Albite
33. Quartz
34. Chlorite
35. Calcite+
36. Muscovite
37. Biotite
38. Biotite

Figure 10.4-13. Sample OD2016-D2-011-2 site 9.



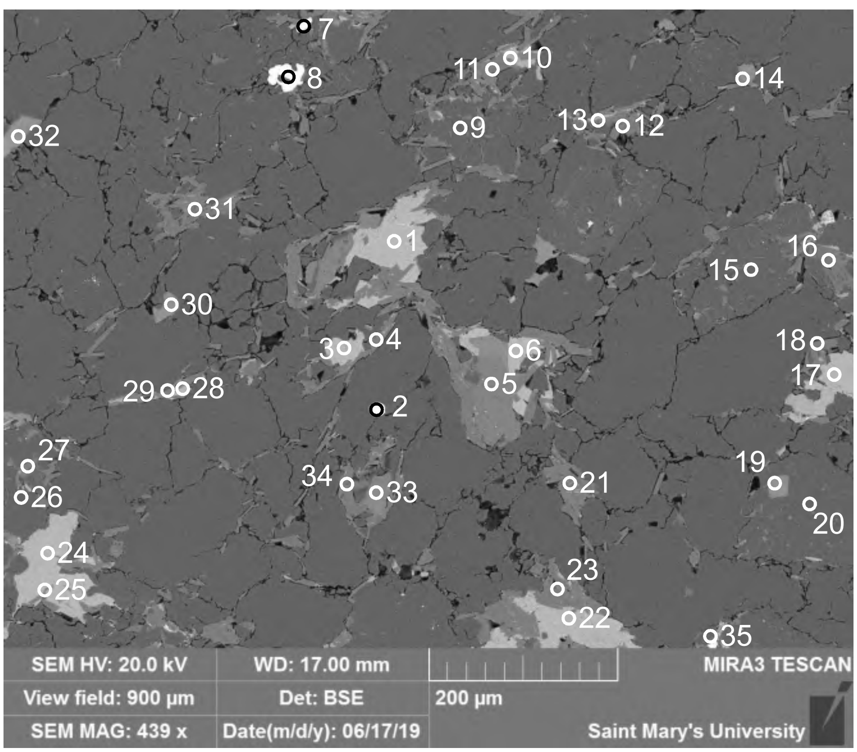
1. TiO2
2. Ilm+ Qz
3. Biotite
4. Quartz
5. Mz+ Qz
6. Biotite
7. Biotite
8. Mz+ Qz
9. Biotite
10. Muscovite
11. K-Feldspar
12. Muscovite
13. Quartz
14. Albite
15. Biotite
16. K-Feldspar
17. Albite
18. Chlorite
19. Quartz
20. Calcite
21. Quartz
22. Biotite
23. Ilmenite
24. Muscovite
25. Albite
26. Muscovite
27. Quartz
28. Ilm+ Qz

Figure 10.4-14. Sample OD2016-D2-011-2 site 10.



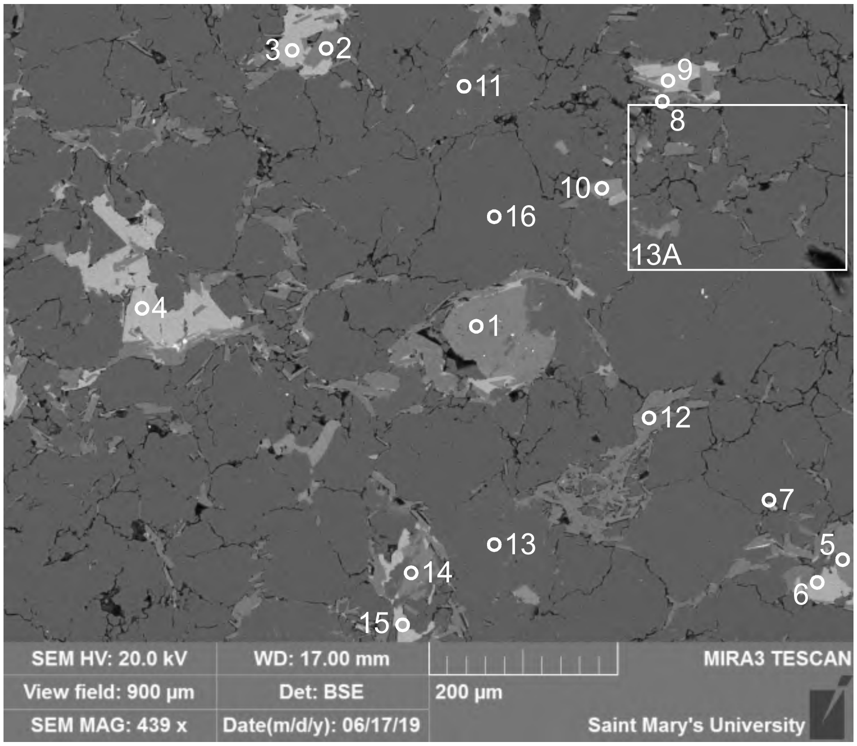
1. Apatite
2. Biotite
3. K-Feldspar
4. Albite
5. Biotite
6. Muscovite
7. Calcite
8. Biotite
9. Albite
10. Biotite
11. K-Feldspar
12. Biotite
13. Biotite
14. Biotite
15. Muscovite
16. Muscovite
17. Muscovite
18. Biotite
19. Biotite
20. TiO2
21. Biotite
22. Muscovite
23. Biotite
24. Albite
25. Calcite
26. Calcite+
27. Calcite
28. Muscovite
29. Quartz+
30. Calciite

Figure 10.4-15. Sample OD2016-D2-011-2 site 11. (1) anhedral secondary apatite with <10µm mineral inclusions.



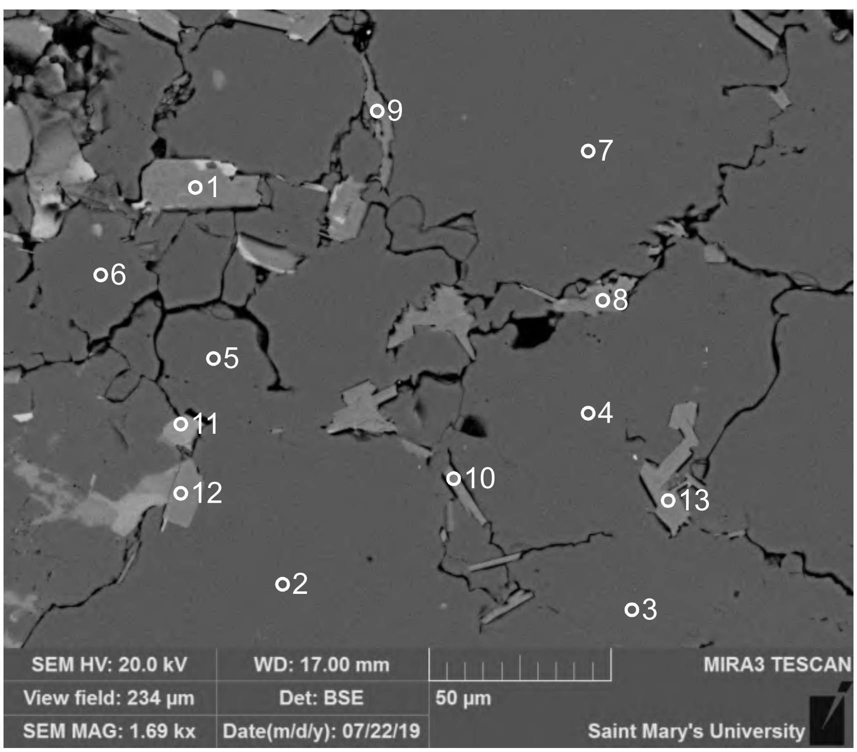
1. Biotite
2. Zircon
3. Biotite
4. Muscovite
5. K-Feldspar
6. Biotite
7. Ilmenite
8. Ilmenite
9. Albite
10. Biotite
11. Muscovite
12. Muscovite
13. Biotite
14. Calcite
15. Albite
16. Muscovite
17. Biotite
18. Muscovite
19. Calcite
20. Albite
21. Muscovite
22. Biotite
23. Muscovite
24. Biotite
25. Albite
26. Albite
27. K-Feldspar
28. Biotite
29. Muscovite
30. Calcite
31. Muscovite
32. Calcite
33. K-Feldspar
34. Muscovite
35. Ilmenite+

Figure 10.4-16. Sample OD2016-D2-011-2 site 12.



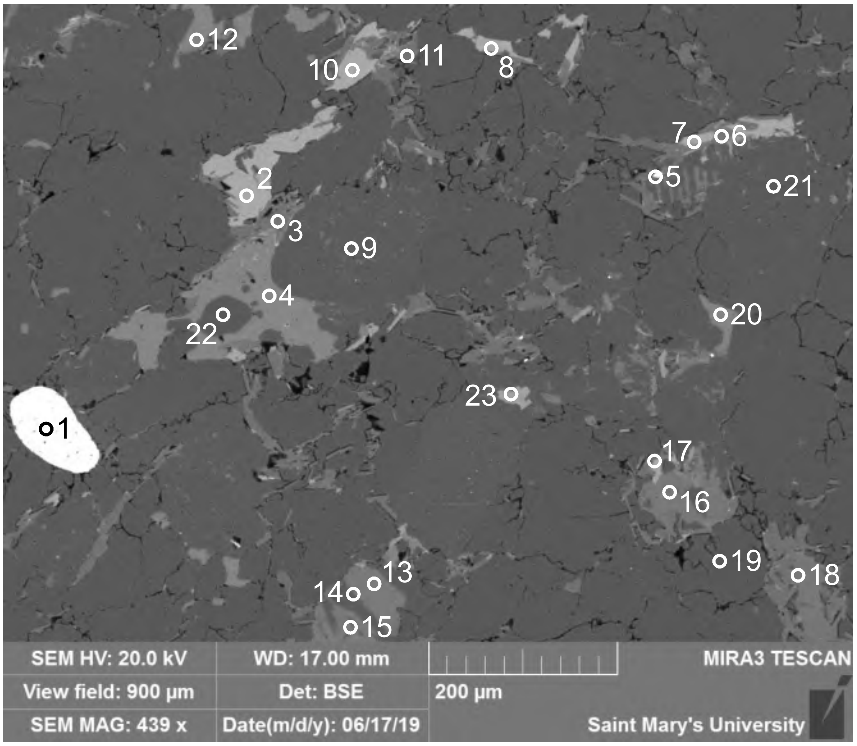
1. K-Feldspar
2. Muscovite
3. Biotite
4. Biotite
5. K-Feldspar
6. Biotite
7. Orthopyroxene
8. Muscovite
9. Biotite
10. Calcite
11. Albite
12. Muscovite
13. Albite
14. K-Feldspar
15. Biotite
16. Quartz

Figure 10.4-17. Sample OD2016-D2-011-2 site 13.



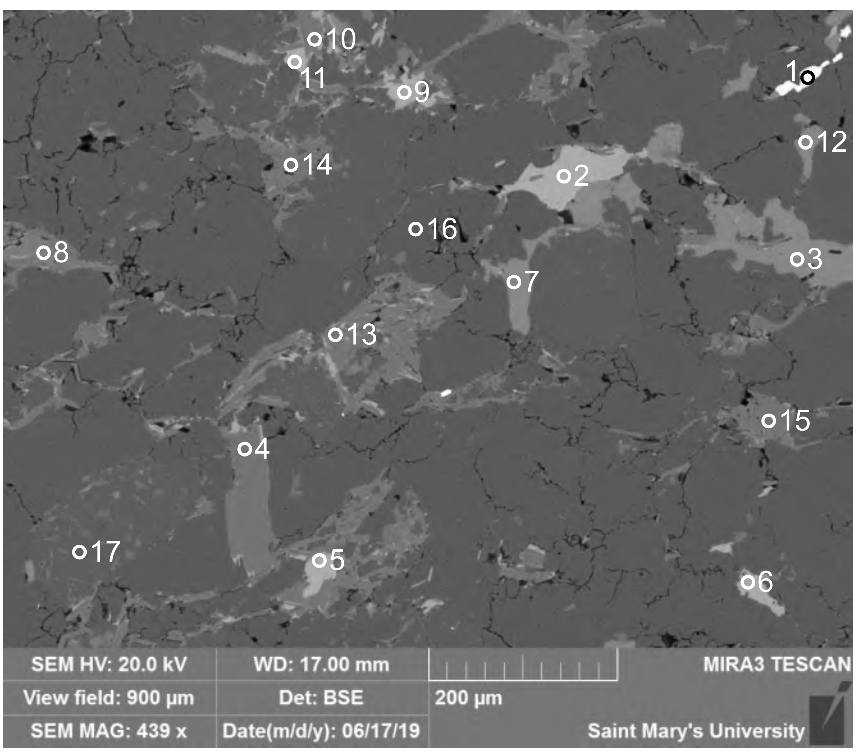
1. Muscovite
2. Quartz
3. Quartz
4. Quartz
5. Quartz
6. Quartz
7. Quartz
8. Muscovite
9. Muscovite
10. Muscovite
11. Calcite
12. Muscovite
13.Muscovite

Figure 10.4-18. Sample OD2016-D2-011-2 site 13A. (1, 13) Muscovite grains with euhedral faces interpreted to be recrystallized.



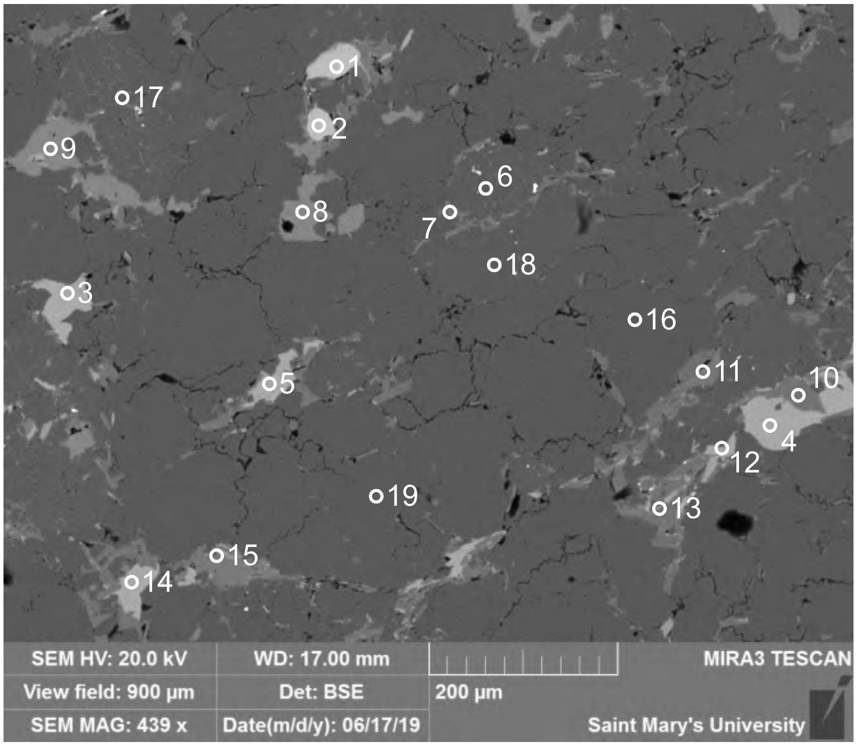
1. Zircon
2. Biotite
3. Muscovite
4. Calcite
5. Monazite+ Quartz
6. K-Feldspar
7. Biotite
8. Biotite
9. Albite
10. Biotite
11. Muscovite
12. Calcite
13. K-Feldspar
14. Albite
15. K-Feldspar
16. K-Feldspar
17. Biotite
18. K-Feldspar
19. Quartz
20. Calcite
21. Albite
22. Quartz
23. Chlorite

Figure 10.4-19. Sample OD2016-D2-011-2 site 14. (1) Well-rounded detrital zircon grain.



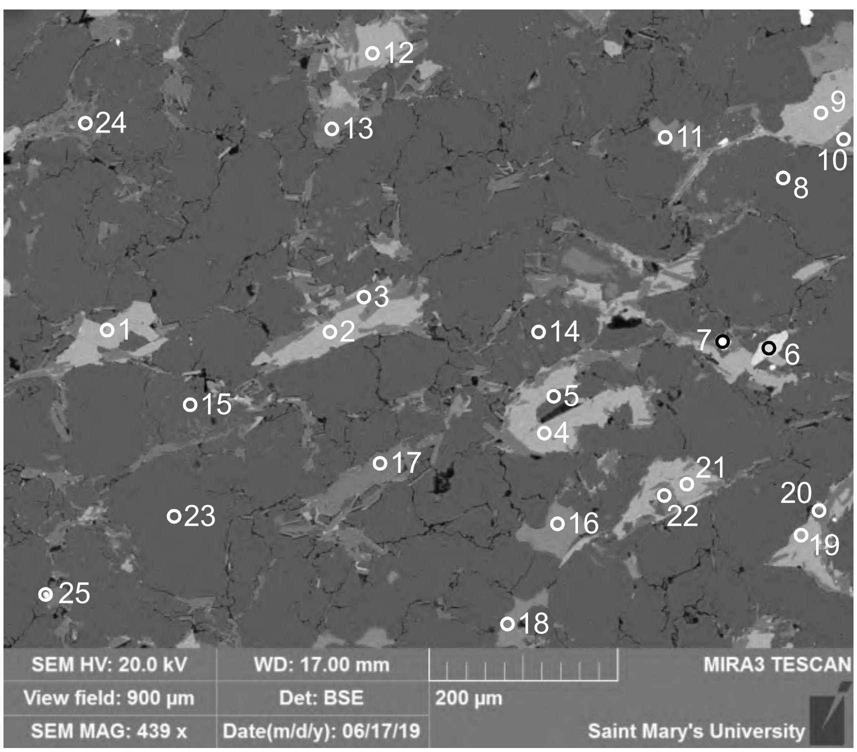
1. Ilmenite
2. Biotite
3. Calcite
4. Muscovite
5. Biotite
6. Biotite
7. Calcite
8. K-Feldspar
9. Biotite
10. Muscovite
11. Biotite
12. Calcite
13. Muscovite
14. Muscovite
15. Muscovite
16. Quartz
17. Albite

Figure 10.4-20. Sample OD2016-D2-011-2 site 15.



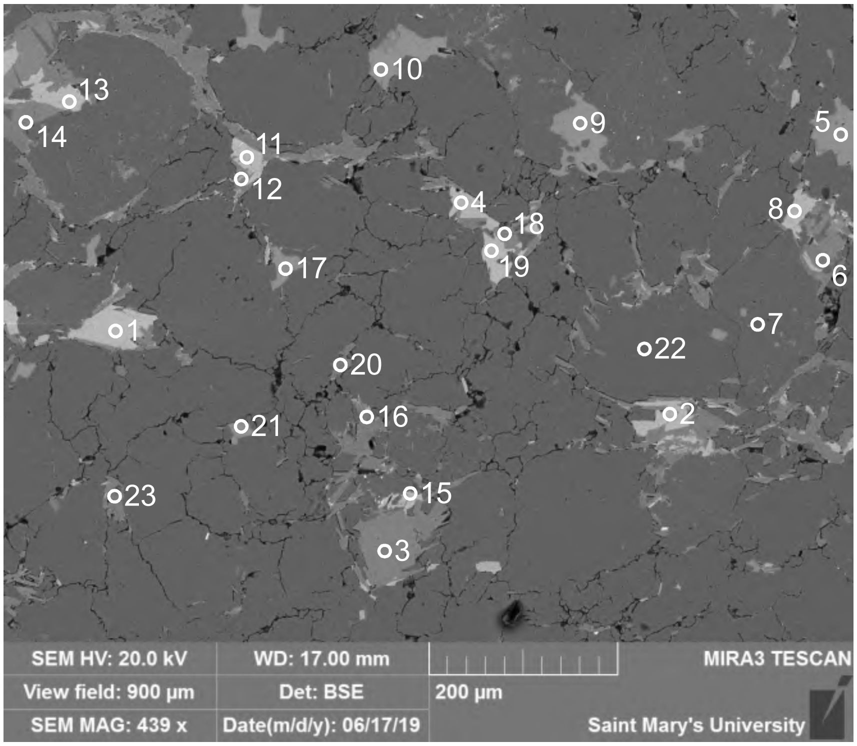
1. Apatite
2. Apatite
3. Biotite
4. Biotite
5. Biotite
6. Albite
7. Muscovite
8. Calcite
9. Calcite
10. Muscovite
11. K-Feldspar
12. Biotite
13. Muscovite
14. Biotite
15. K-Feldspar
16. Quartz
17. Albite
18. Albite
19. Quartz

Figure 10.4-21. Sample OD2016-D2-011-2 site 16.



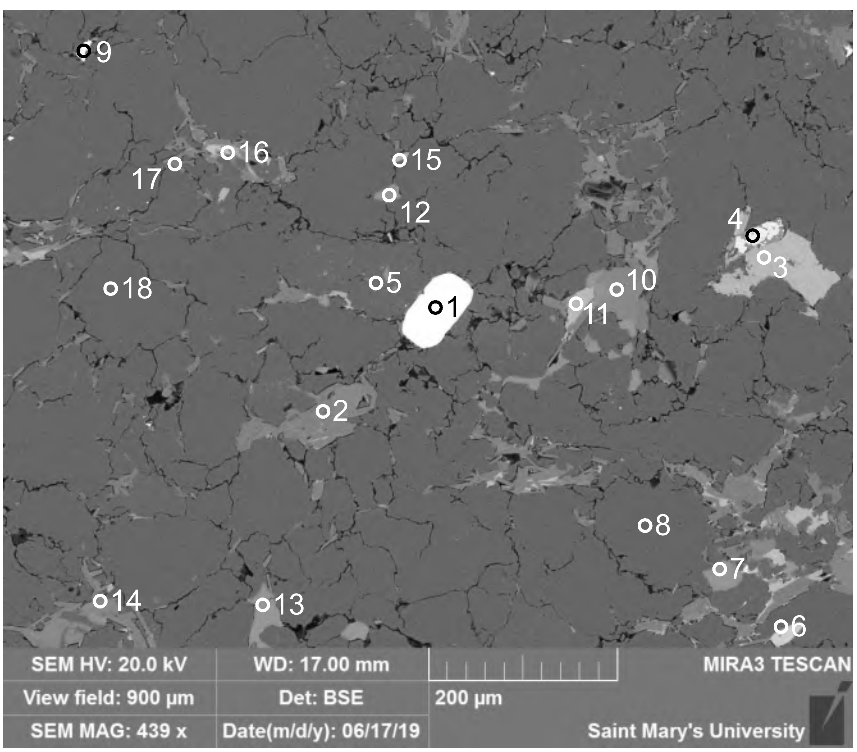
1. Biotite
2. Biotite
3. Muscovite
4. Biotite
5. Quartz
6. TiO_2
7. Zircon
8. Quartz
9. Biotite
10. K-Feldspar
11. Calcite+
12. Biotite
13. K-Feldspar
14. Quartz
15. Albite
16. Calcite
17. K-Feldspar
18. Calcite
19. Biotite
20. Muscovite
21. Biotite
22. K-Feldspar
23. Quartz
24. Muscovite
25. Ilmenite

Figure 10.4-22. Sample OD2016-D2-011-2 site 17. Micas predominantly show SW-NE orientation at this site.



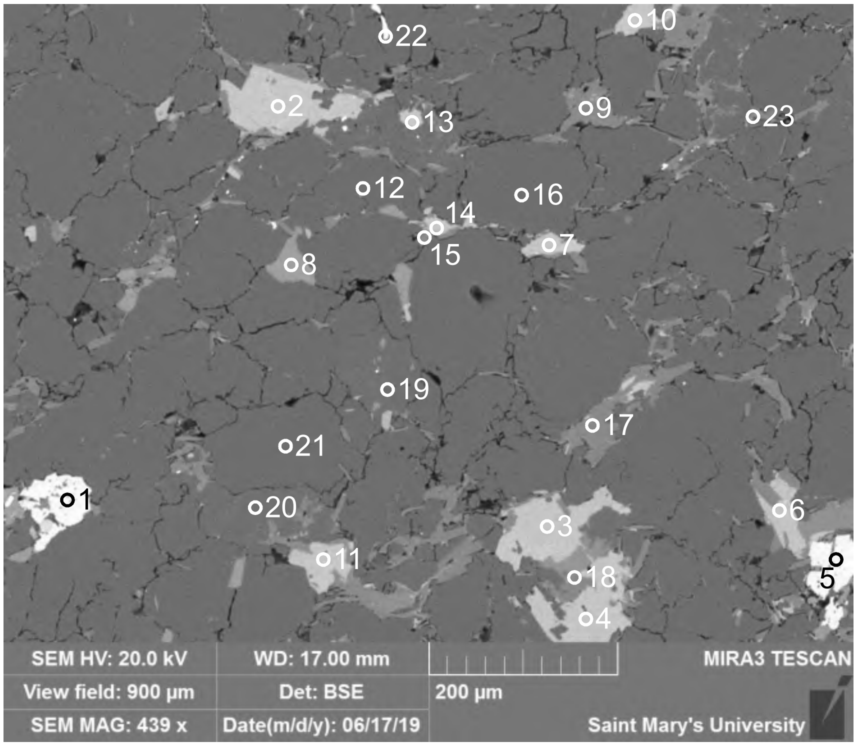
1. Biotite
2. Biotite
3. K-Feldspar
4. Biotite
5. Calcite
6. Muscovite
7. Albite
8. Biotite
9. Calcite
10. Calcite
11. Biotite
12. Biotite
13. Biotite
14. K-Feldspar
15. Biotite
16. Muscovite
17. Calcite
18. K-Feldspar
19. Biotite
20. Muscovite
21. Calcite
22. Quartz
23. Muscovite

Figure 10.4-23. Sample OD2016-D2-011-2 site 18.



1. Zircon
2. Muscovite
3. Biotite
4. TiO_2
5. Albite
6. Apatite
7. Calcite
8. Quartz
9. Ilmenite+
10. K-Feldspar
11. Biotite
12. Calcite
13. Calcite
14. K-Feldspar
15. Biotite
16. Biotite
17. Muscovite
18. Quartz

Figure 10.4-24. Sample OD2016-D2-011-2 site 19.



1. TiO2+ Qz
2. Biotite
3. Biotite
4. Biotite
5. TiO2+
6. Biotite
7. Biotite
8. Calcite
9. Muscovite
10. Biotite
11. Biotite
12. Quartz
13. Biotite
14. Biotite
15. Muscovite
16. Quartz
17. Muscovite
18. Muscovite
19. Albite
20. Albite
21. Quartz
22. Ilmenite+
23. Bt+ Ms

Figure 10.4-25. Sample OD2016-D2-011-2 site 20.

Appendix 10.5: OD2016-

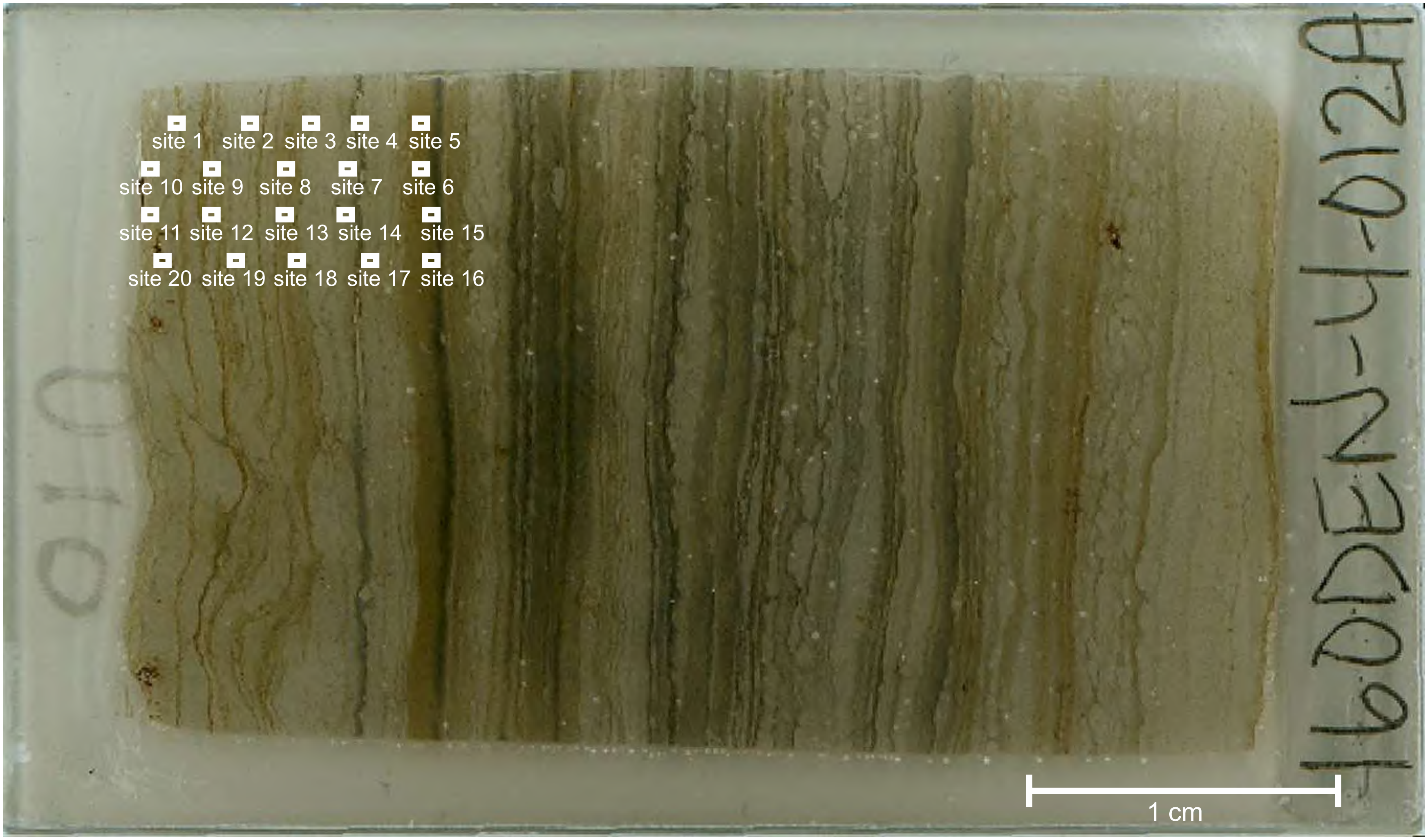
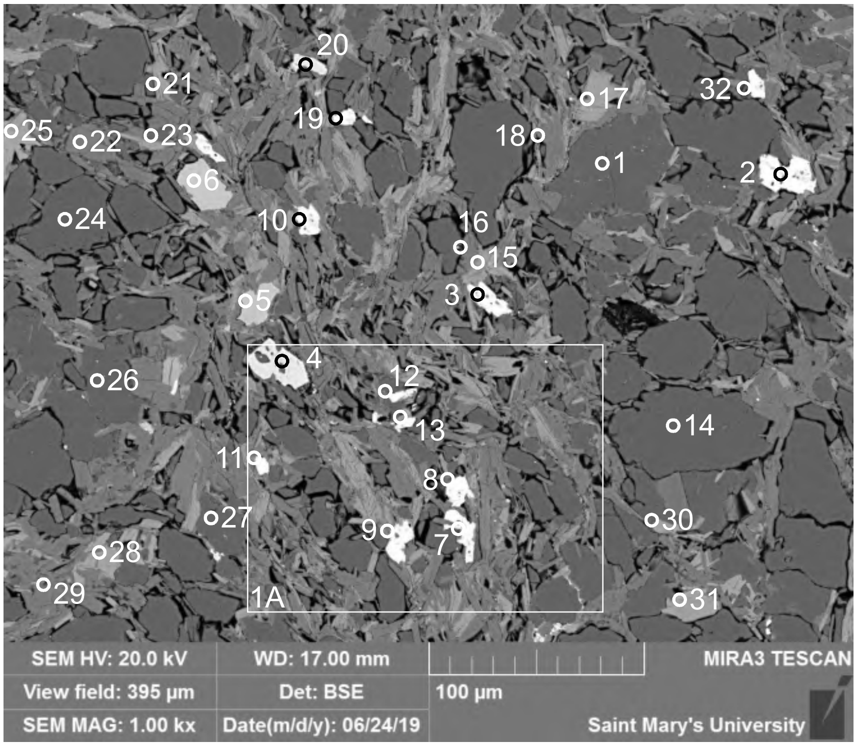


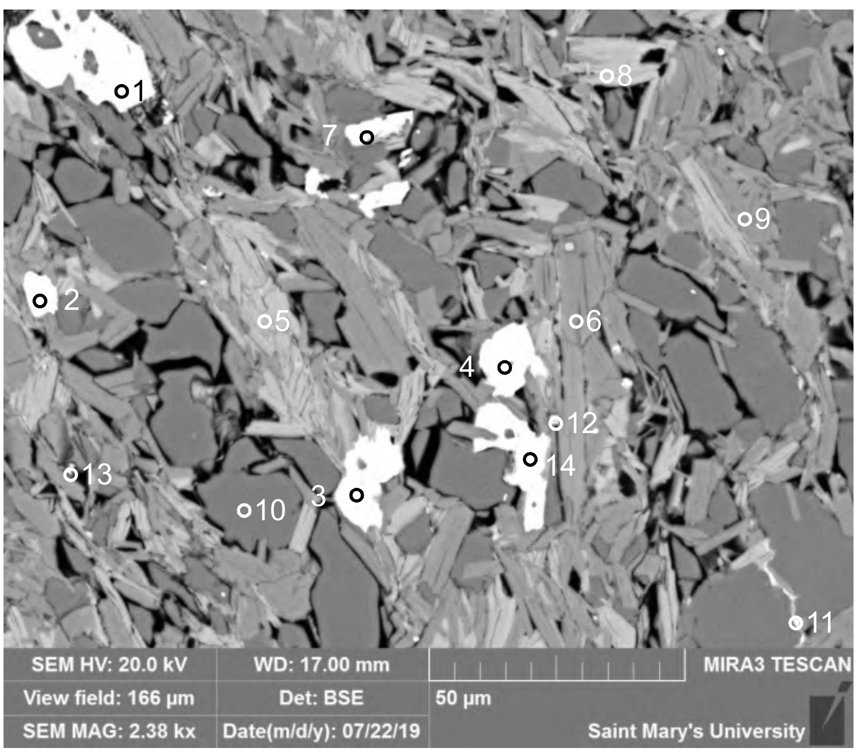
Figure 10.5-1: Slide OD2016-D2-012A.

Figure 10.5-2: Sample OD2016-D2-012A.



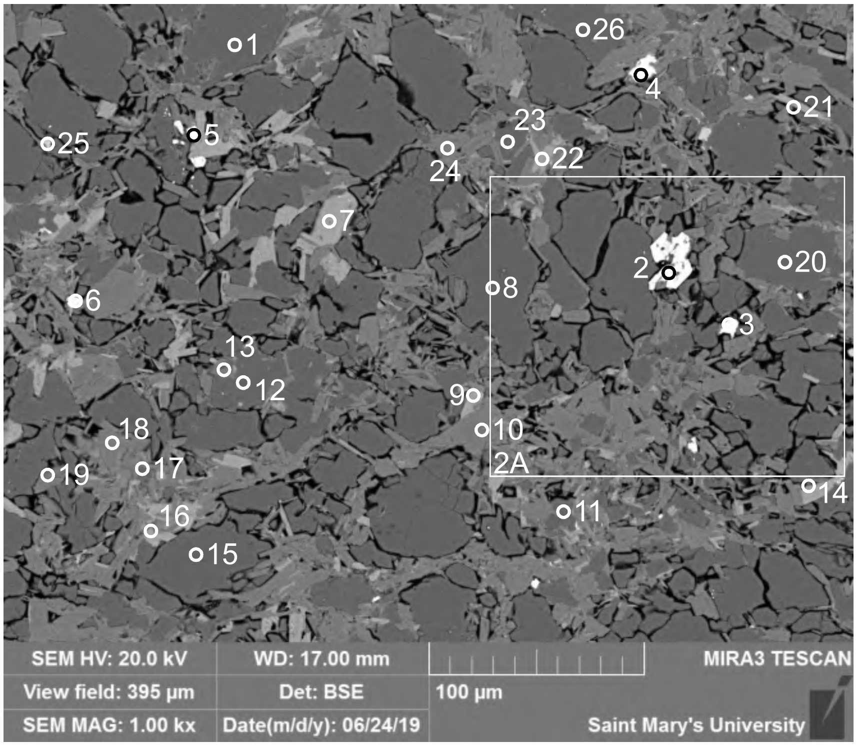
1. Albite
2. Ilmenite+
3. Ilmenite+
4. TiO2
5. Apatite
6. Apatite
7. Ilmenite+
8. Ilmenite+
9. Ilmenite+
10. TiO2+
11. Zircon
12. Ilmenite+
13. Ilmenite+
14. Quartz
15. Mixture
16. Muscovite
17. Chlorite
18. Muscovite
19. Ilmenite
20. TiO2
21. Chlorite+
22. Muscovite
23. Albite
24. Quartz
25. Chlorite
26. Albite
27. Albite
28. Chlorite
29. Muscovite
30. Chlorite
31. Chlorite
32. Ilmenite+

Figure 10.5-3. Sample OD2016-D2-012-A site 1. DT: Apatite, Quartz; DG: Albite, Chlorite, Ilmentite, Muscovite, TiO2.



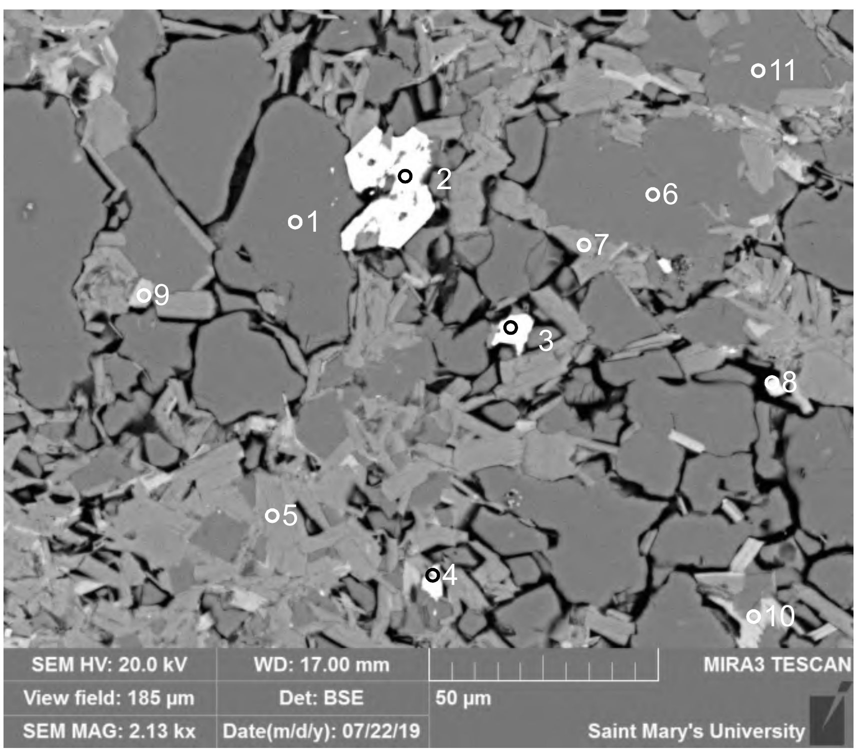
1. TiO2
2. Zircon
3. Ilmenite+
4. Ilmenite+
5. Chl + Ms
6. Muscovite
7. Ilmenite+
8. Chlorite
9. Muscovite
10. Quartz
11. Albite
12. Muscovite
13. Albite
14. TiO2+

Figure 10.5-4. Sample OD2016-D2-012-A site 1A. DT: Apatite, Quartz, Zircon; DG: Albite, Chlorite, Ilmentite, Muscovite, TiO2.



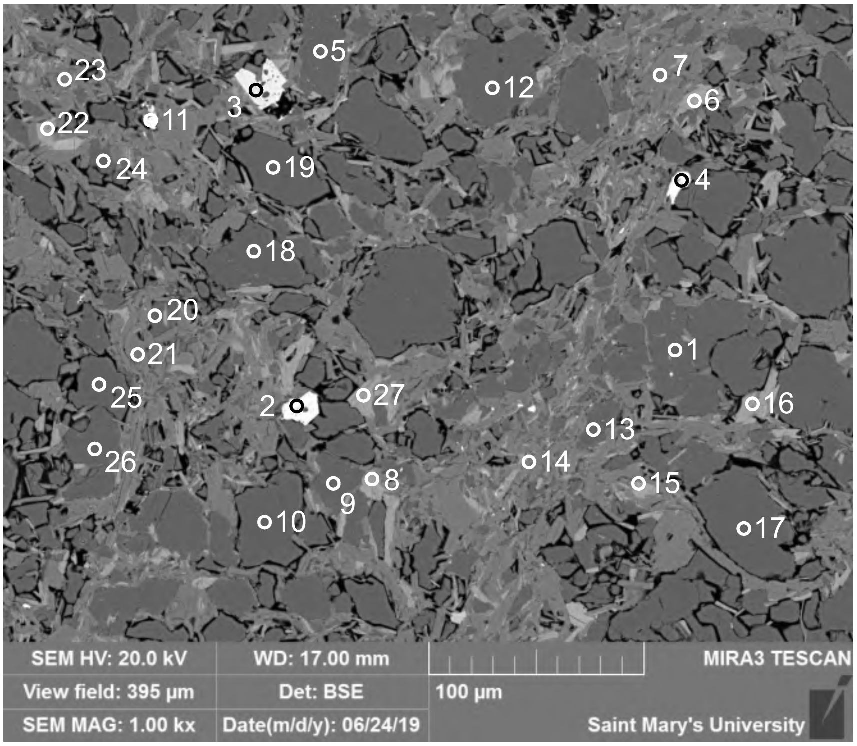
1. Albite
2. Ilmenite
3. Zircon
4. Ilmenite
5. Ilmenite
6. Apatite+
7. Chlorite
8. Quartz
9. Chlorite
10. Muscovite
11. Albite
12. Albite
13. Muscovite
14. Chlorite
15. Quartz
16. Chlorite
17. Albite
18. Muscovite
19. Muscovite
20. Albite
21. Chlorite
22. Chlorite
23. Albite
24. Muscovite
25. Apatite+
26. Albite

Figure 10.5-5. Sample OD2016-D2-012-A site 2. DT: Apatite, Quartz, Zircon; DG: Albite, Chlorite, Ilmentite, Muscovite.



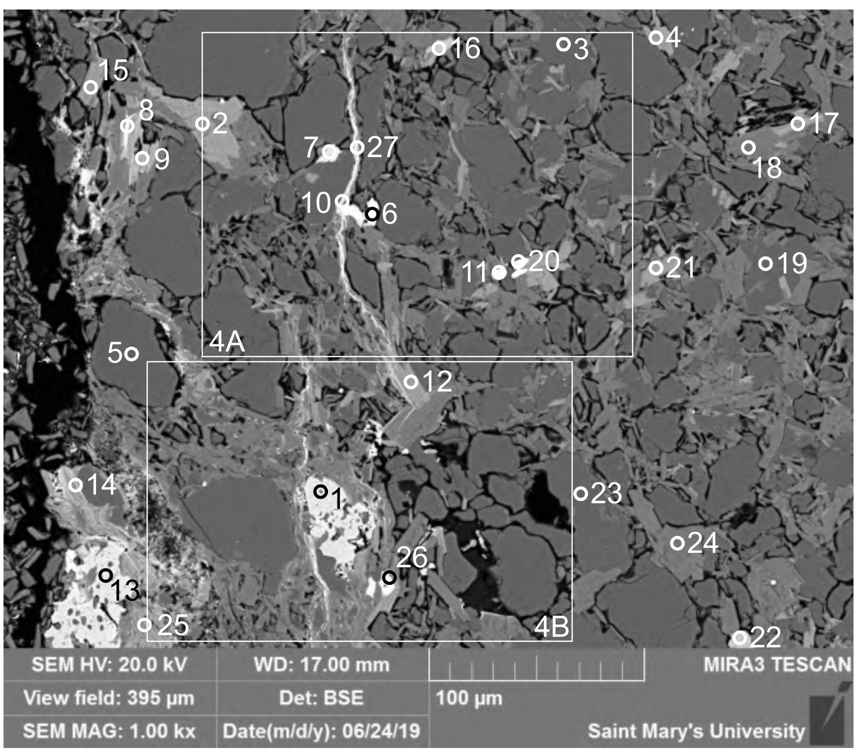
1. Quartz
2. Ilmenite+
3. Zircon
4. Ilmenite+
5. Muscovite
6. Albite
7. Muscovite
8. Apatite+
9. Chlorite
10. Chl + Ms
11. Albite

Figure 10.5-6. Sample OD2016-D2-012-A site 2A. DT: Apatite, Quartz, Zircon; DG: Albite, Chlorite, Ilmentite, Muscovite, TiO2.



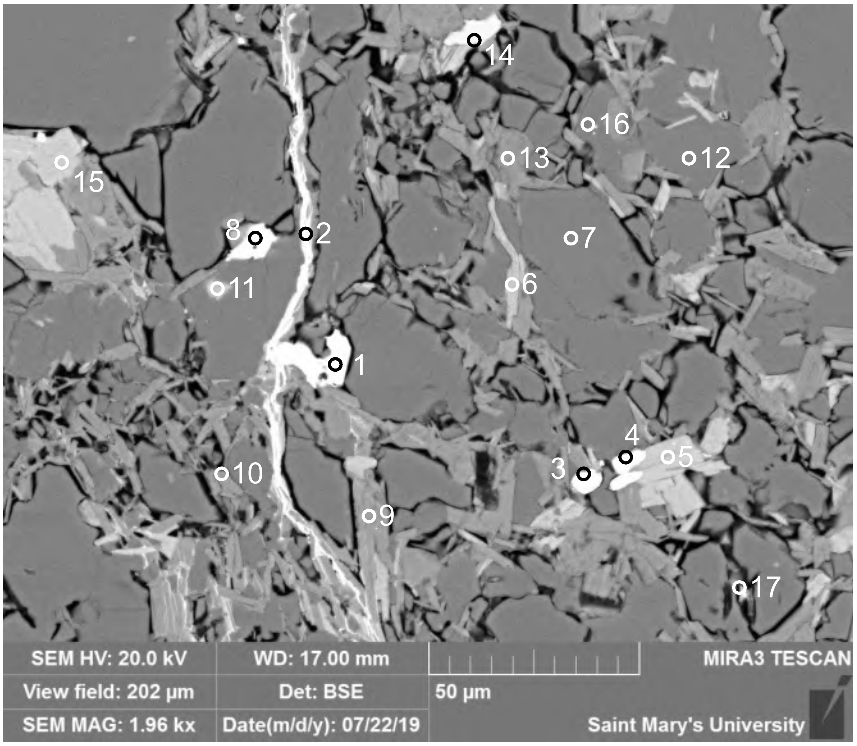
1. Albite
2. TiO2+
3. TiO2+
4. Ilmenite+
5. Albite
6. Chlorite
7. Muscovite
8. Chlorite
9. Albite
10. Quartz
11. Ilmenite+
12. Albite
13. Albite
14. Muscovite
15. Chlorite
16. Chlorite
17. Quartz
18. Quartz
19. Quartz
20. Albite
21. Muscovite
22. Chlorite
23. Muscovite
24. Albite
25. Quartz
26. Albite
27. Chlorite+

Figure 10.5-7. Sample OD2016-D2-012-A site 3. DT: Apatite, Quartz; DG: Albite, Chlorite, Ilmentite, Muscovite, TiO2.



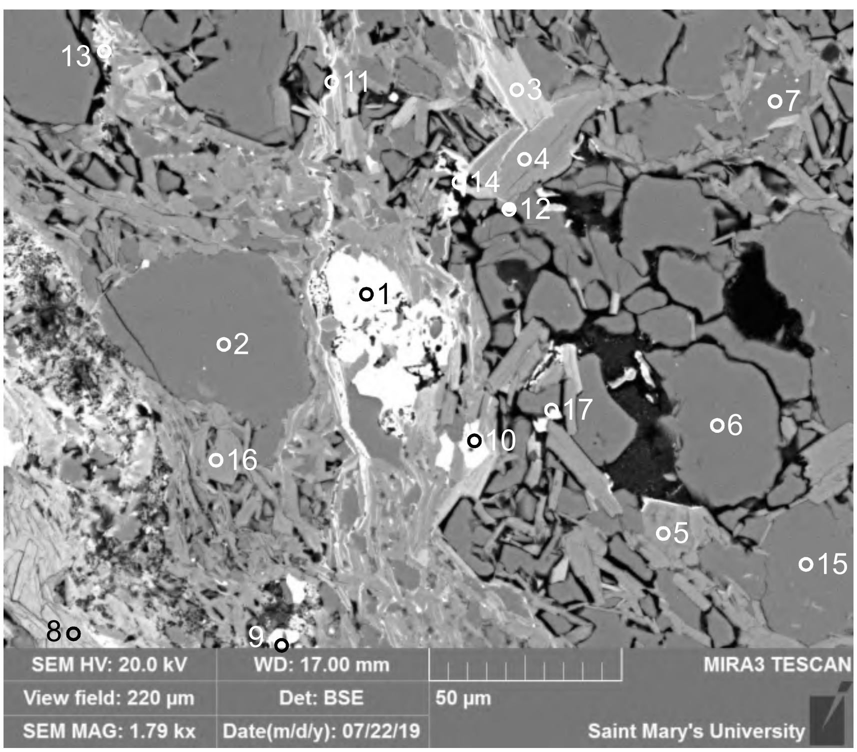
1. TiO2+
2. Chlorite
3. Albite
4. Chlorite
5. Quartz
6. Ilmenite
7. TiO2
8. Feohy+
9. Chlorite+
10. Feohy+
11. Ilmenite+
12. Chlorite
13. TiO2+
14. Chl+ Ms
15. Chlorite
16. Apatite
17. Biotite
18. Muscovite
19. Albite
20. Ilmenite+
21. Chlorite
22. Apatite
23. Albite
24. Muscovite
25. Chlorite+
26. Feohy+
27. Biotite

Figure 10.5-8. Sample OD2016-D2-012-A site 4. DT: Apatite, Quartz; DG: Albite, Biotite, Chlorite, Ilmentite, Muscovite, TiO2; HD: Feohy.



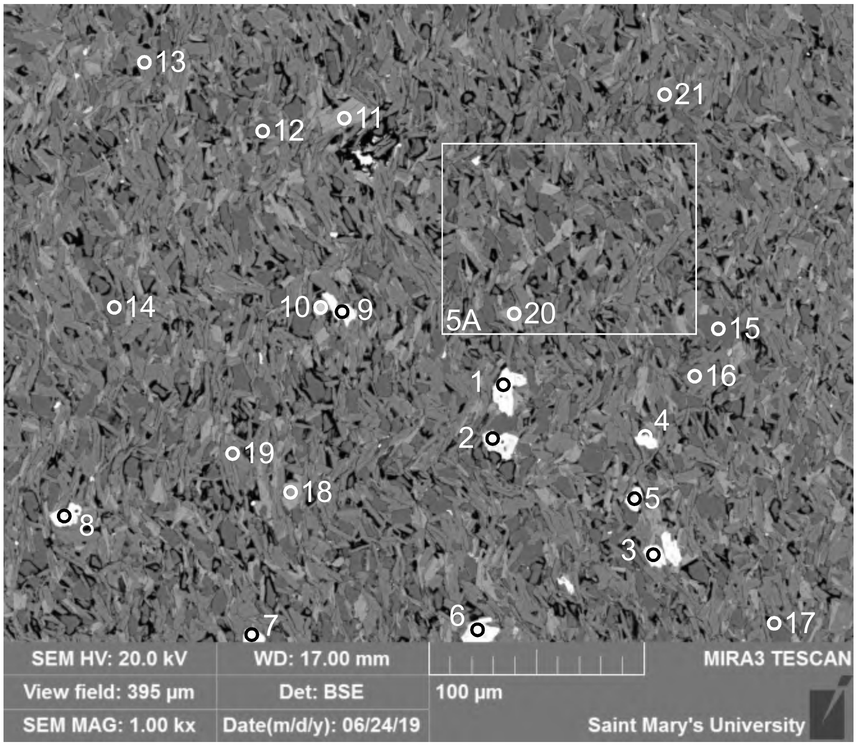
1. Ilmenite+
2. Feohy+
3. Ilmenite+
4. Ilmenite+
5. Chlorite
6. Chl + Ms
7. Albite
8. TiO2
9. Muscovite
10. Muscovite
11. Chlorite
12. Albite
13. Muscovite
14. Apatite
15. Chlorite
16. Albite
17. Chlorite+

Figure 10.5-9. Sample OD2016-D2-012-A site 4A. DT: Apatite, Quartz; DG: Albite, Chlorite, Ilmentite, Muscovite, TiO2.



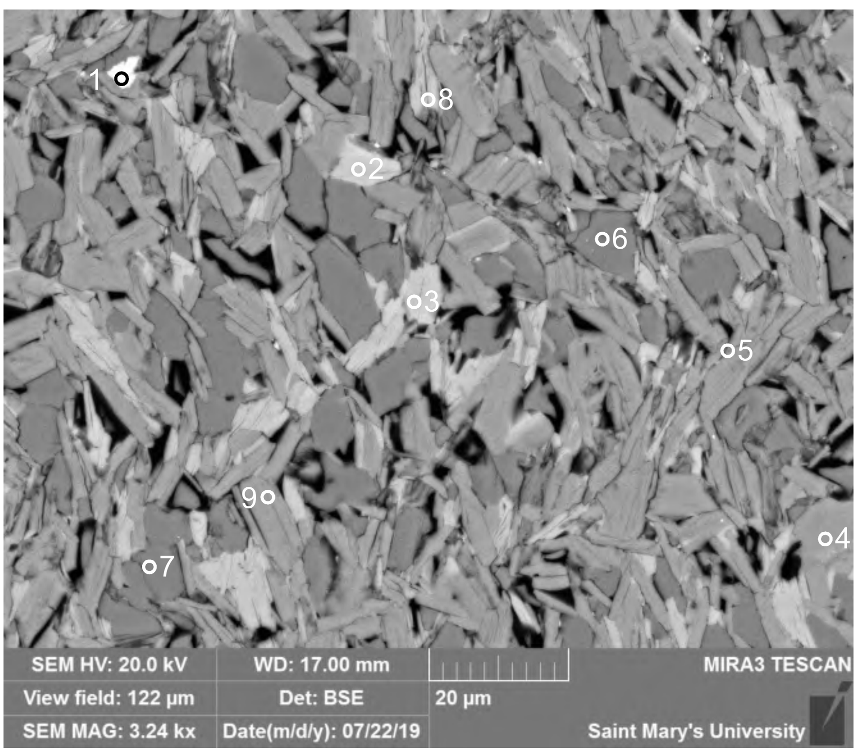
1. TiO2+
2. Albite
3. Chlorite
4. Muscovite
5. Muscovite
6. Quartz
7. Albite
8. Chl + Ms
9. TiO2+
10. Feohy+
11. Feohy+
12. TiO2+
13. Feohy+
14. Feohy+
15. Albite
16. Muscovite
17. Feohy+

Figure 10.5-10. Sample OD2016-D2-012-A site 4B. DT: Quartz; DG: Albite, Chlorite, Muscovite, TiO2.



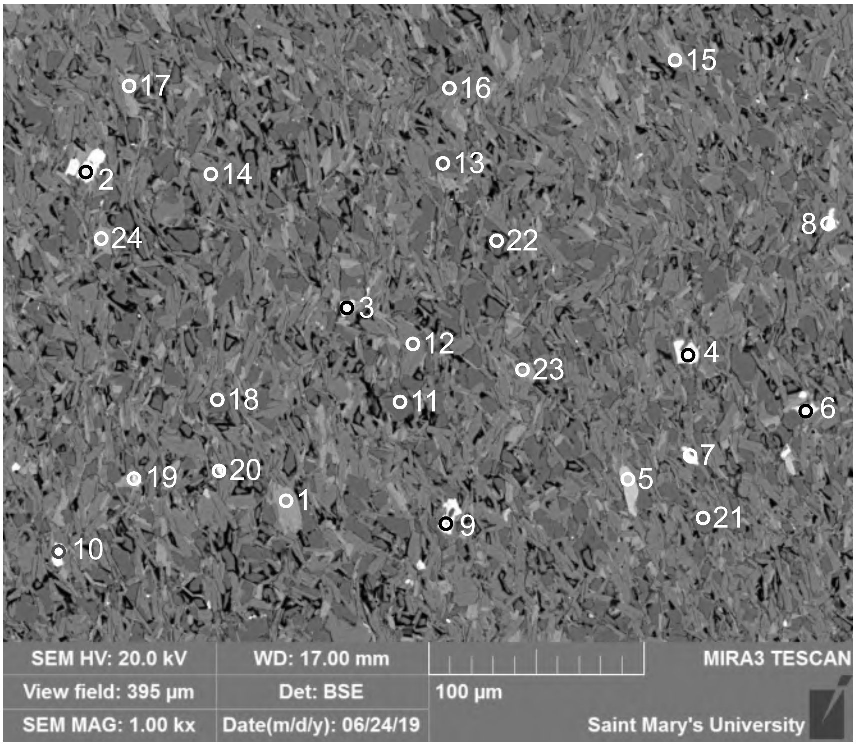
1. Ilmenite
2. Ilmenite+
3. Ilmenite
4. Ilmenite+
5. Ilmenite+
6. Ilmenite+
7. Ilmenite
8. Ilmenite+
9. Ilmenite+
10. Apatite
11. Chlorite
12. Albite
13. Muscovite
14. Albite
15. Albite
16. Muscovite
17. Albite
18. Chlorite
19. Muscovite
20. Chlorite
21. Muscovite

Figure 10.5-11. Sample OD2016-D2-12-A site 5. DT: Apatite; DG: Albite, Chlorite, Ilmentite, Muscovite.



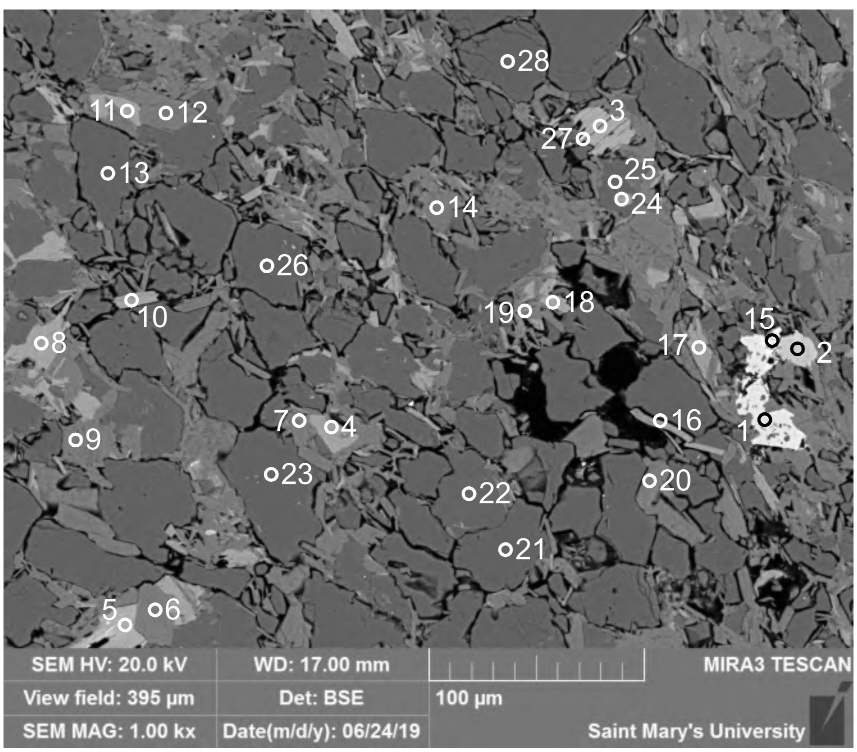
1. Ilmenite+
2. Chlorite
3. Chlorite
4. Muscovite
5. Muscovite
6. Albite
7. Albite
8. Chlorite
9. Muscovite

Figure 10.5-12. Sample OD2016-D2-012-A site 5A. DG: Albite, Chlorite, Ilmentite, Muscovite.



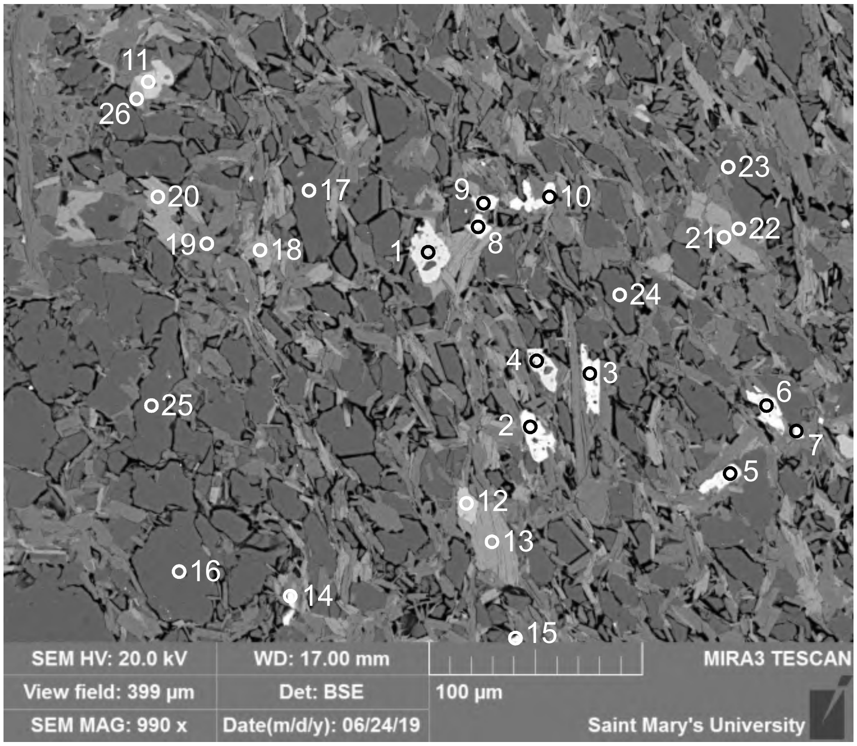
1. Chlorite
2. TiO2+
3. Ilmenite
4. Ilmenite
5. Apatite
6. Ilmenite+
7. Ilmenite+
8. Ilmenite
9. Ilmenite
10. Ilmenite
11. Albite
12. Muscovite
13. Albite
14. Muscovite
15. Chlorite
16. Muscovite
17. Chlorite
18. Albite
19. Ilmenite+
20. Chlorite
21. Albite
22. Quartz
23. Chlorite
24. Chlorite

Figure 10.5-13. Sample OD2016-D2-012-A site 6. Some folding present in the mineral fabric.



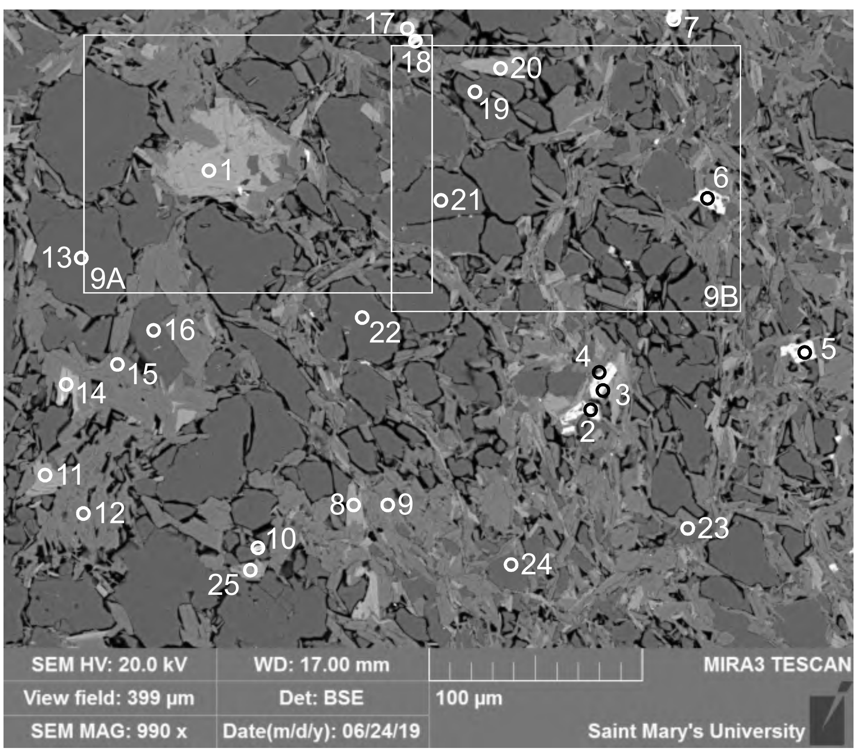
1. TiO2
2. Apatite
3. Chlorite+
4. Chlorite
5. Biotite
6. Muscovite
7. Muscovite
8. Chlorite
9. Muscovite
10. Chlorite
11. Chlorite
12. Muscovite
13. Quartz
14. Muscovite
15. Monazite+
16. Chlorite+
17. Chlorite
18. Chlorite
19. Muscovite
20. Muscovite
21. Quartz
22. Albite
23. Quartz
24. Chlorite
25. Albite
26. Quartz
27. Chlorite+
28. Quartz

Figure 10.5-14. Sample OD2016-D2-012-A site 7.



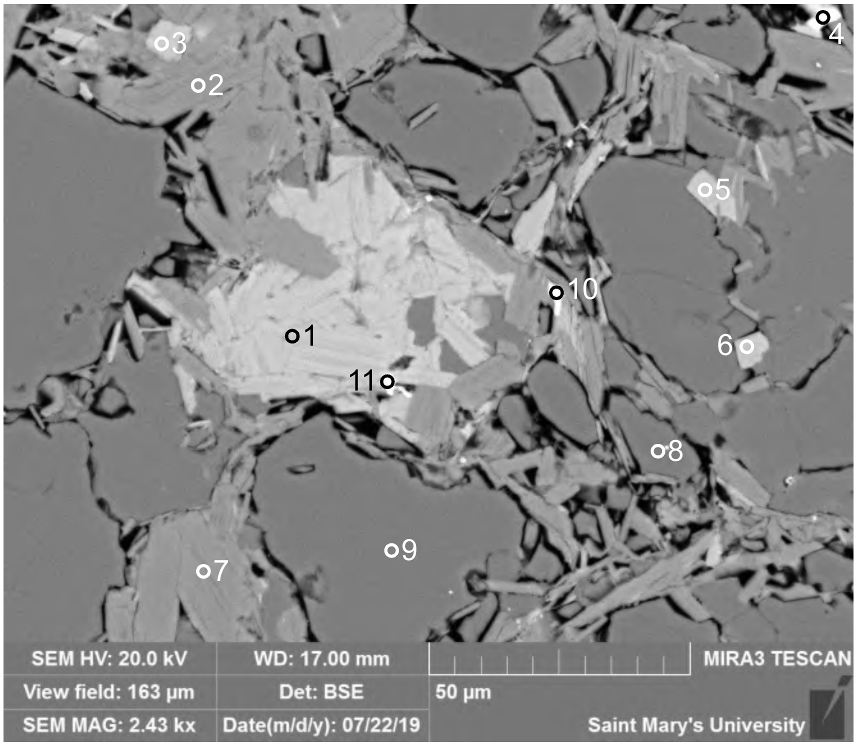
1. TiO_2+
2. Ilmenite+
3. Ilmenite+
4. Ilmenite+
5. Ilmenite
6. Ilmenite+
7. Ilmenite+
8. Ilmenite+
9. Ilmenite+
10. Ilmenite+
11. Apatite
12. Apatite
13. Chlorite
14. Ilmenite+
15. Ilmenite+
16. Quartz
17. Quartz
18. Chlorite
19. Muscovite
20. Chlorite
21. Chlorite
22. Muscovite
23. Albite
24. Quartz
25. Quartz
26. Chlorite

Figure 10.5-15. Sample OD2016-D2-012-A site 8.



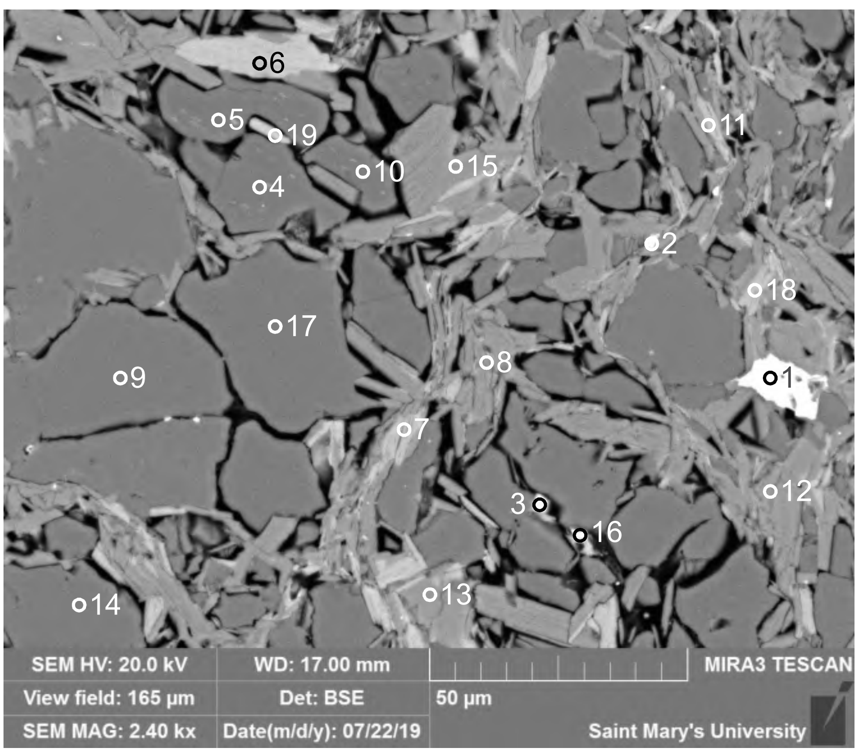
1. Chlorite
2. Ilmenite
3. Ilmenite+
4. Ilmenite+
5. Ilmenite
6. Ilmenite
7. Ilmenite+
8. Chlorite
9. Muscovite
10. TiO_2+
11. Chlorite
12. Muscovite
13. Quartz
14. Chlorite+
15. Muscovite
16. Albite
17. Chlorite+
18. TiO_2+
19. Quartz
20. Chlorite
21. Quartz
22. Quartz
23. Oligoclase
24. Albite
25. Chlorite

Figure 10.5-16. Sample OD2016-D2-012-A site 9.



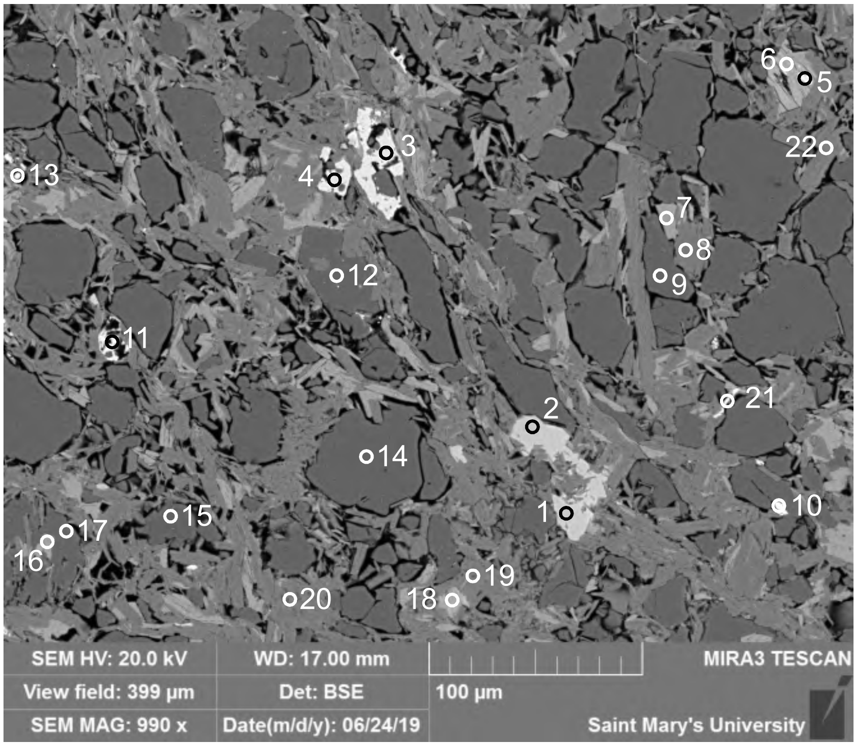
1. Chlorite
2. Muscovite
3. Chlorite
4. TiO2+
5. Chlorite
6. Chlrote
7. Muscovite
8. Quartz
9. Quartz
10. Ilmenite+
11. Zircon+

Figure 10.5-17. Sample OD2016-D2-012-A site 9A.



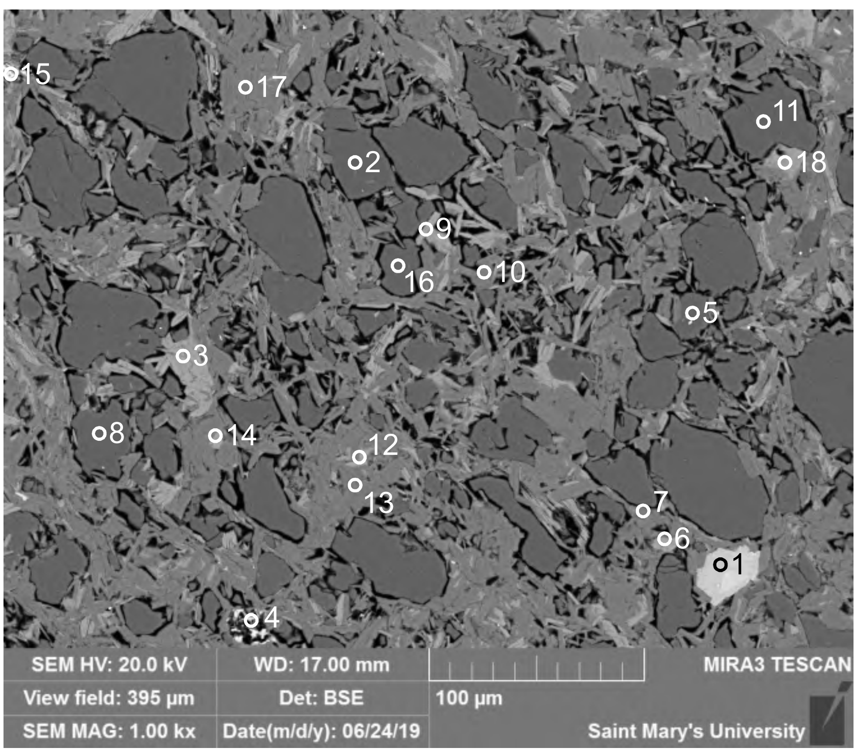
1. Ilmenite+
2. Zircon+
3. Apatite+
4. Quartz
5. Quartz
6. Chlorite
7. Chl + Ms
8. Muscovite
9. Quartz
10. Quartz
11. Chl + Ms
12. Muscovite
13. Muscovite
14. Quartz
15. Muscovite
16. Zircon+
17. Quartz
18. Chl + Ms
19. Chlorite+

Figure 10.5-18. Sample OD2016-D2-012-A site 9B.



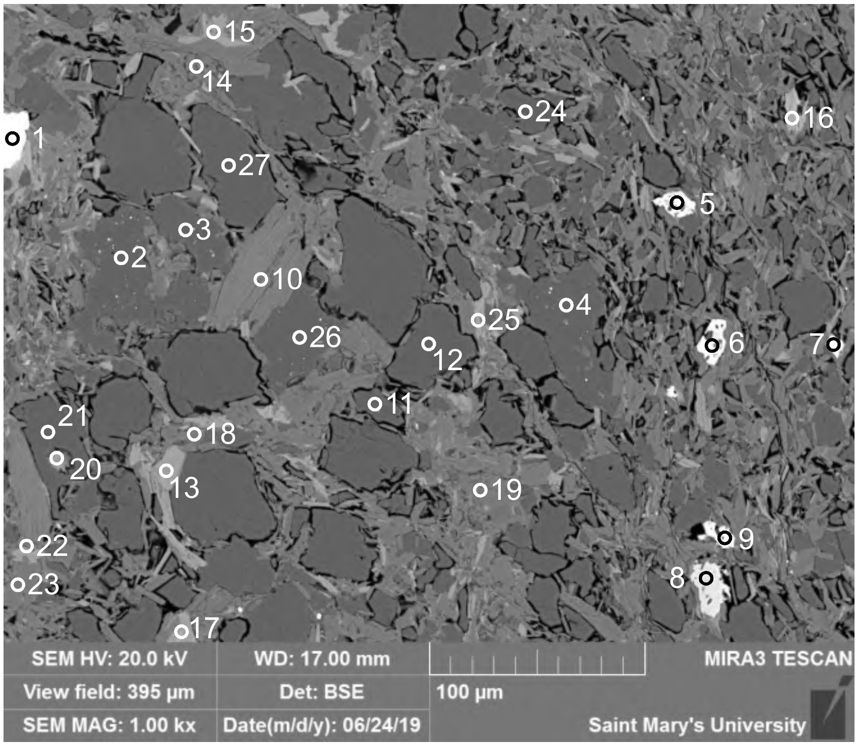
1. Apatite
2. Apatite
3. TiO2+
4. TiO2+
5. Ilmenite+
6. Chlorite+
7. Chlorite
8. Muscovite
9. Quartz
10. Monazite+
11. Ilmenite+
12. Albite
13. Mixture
14. Quartz
15. Quartz+
16. Chlorite+
17. Albite
18. Chlorite+
19. Muscovite
20. Muscovite
21. Quartz+
22. Muscovite

Figure 10.5-19. Sample OD2016-D2-012-A site 10. DG: Apatite, Monazite.



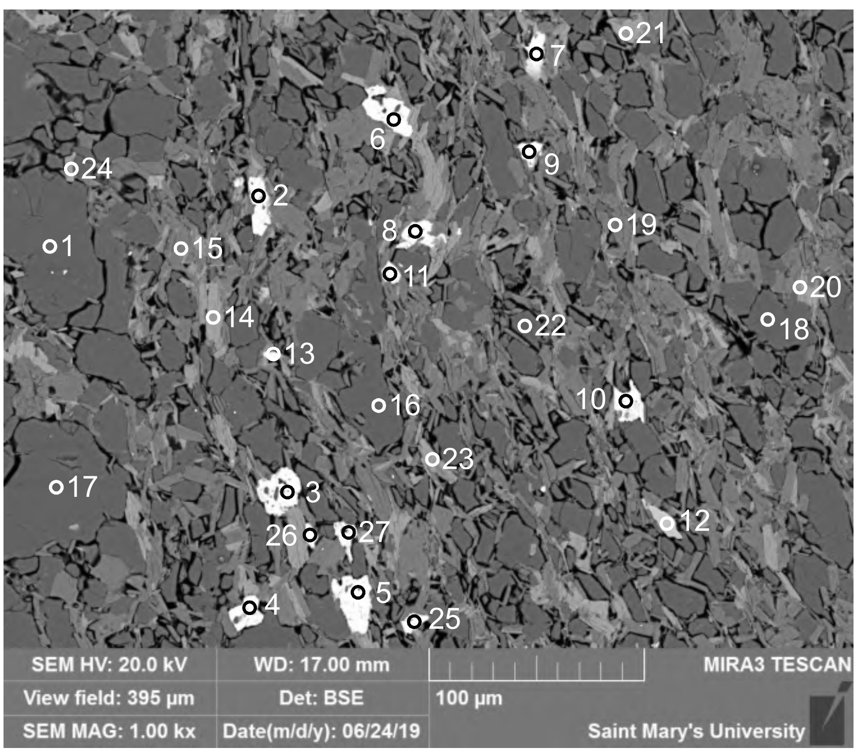
1. Apatite
2. Quartz
3. Chlorite
4. TiO2+
5. Albite
6. Chlorite
7. Muscovite
8. Quartz
9. Chlorite+
10. Muscovite
11. Quartz
12. Chlorite
13. Muscovite
14. Chlorite
15. Ilmenite+
16. Quartz
17. Muscovite
18. Chlorite

Figure 10.5-20. Sample OD2016-D2-012-A site 11.



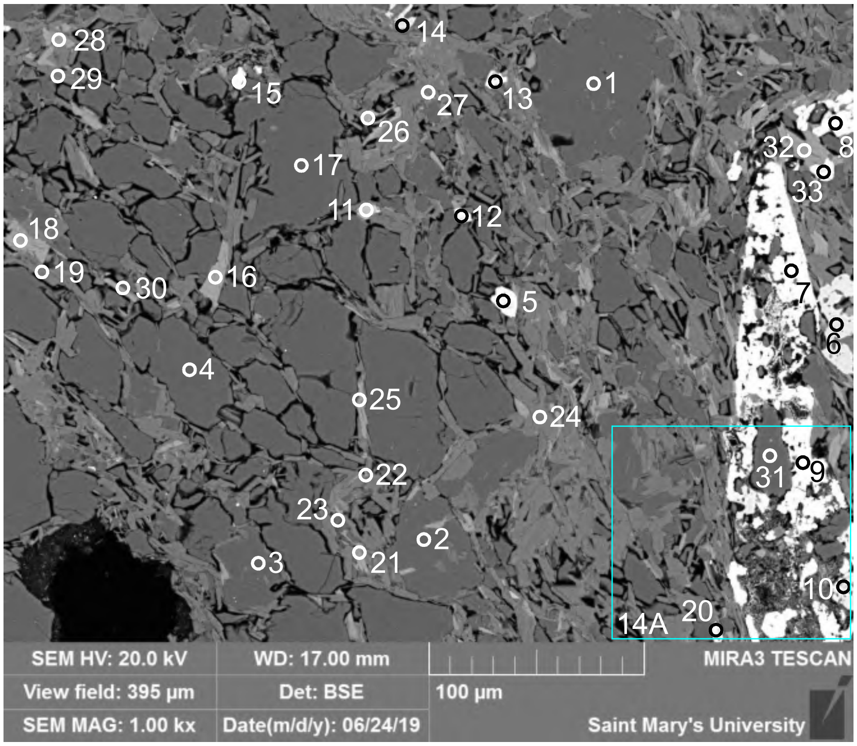
1. Chlorite
2. Albite
3. Albite
4. Albite
5. Ilmenite+
6. Ilmenite+
7. Ilmenite+
8. TiO2+
9. Ilmenite+
10. Muscovite
11. Quartz
12. Quartz
13. Chlorite
14. Muscovite
15. Chlorite
16. Chlorite+
17. Chlorite
18. Muscovite
19. Muscovite
20. Chlorite
21. Quartz
22. Chlorite
23. Muscovite
24. Quartz
25. Chl+ Ms
26. Albite
27. Quartz

Figure 10.5-21. Sample OD2016-D2-012-A site 12.



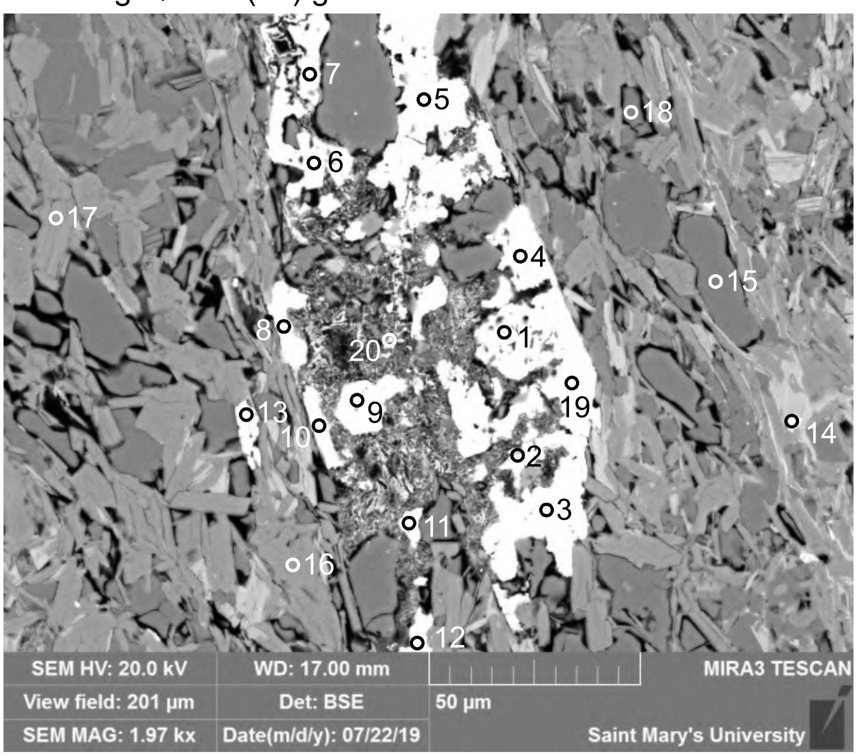
1. Quartz
2. Ilmenite+
3. Ilmenite+
4. TiO2+
5. Ilmenite+
6. Ilmenite
7. Ilmenite
8. Ilmenite+
9. Ilmenite+
10. Ilmenite+
11. Ilmenite+
12. Apatite
13. Ilmenite+
14. Chlorite
15. Muscovite
16. Quartz
17. Quartz
18. Quartz
19. Muscovite
20. Chlorite
21.Chlorite
22. Quartz
23. Chlorite+
24. Chlorite
25. Ilmenite+
26. Ilmenite
27. Ilmenite+

Figure 10.5-22. Sample OD2016-D2-012-A site 13.



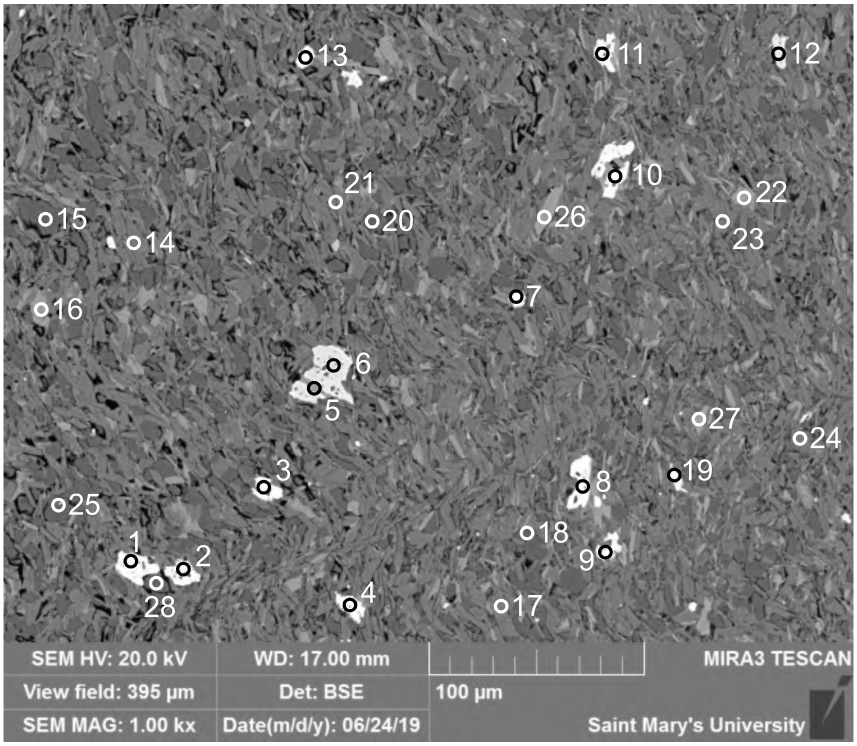
1. Albite
2. Albite
3. Albite
4. Quartz
5. Ilmenite+
6. TiO2+
7. Monazite
8. Ilmenite
9. Monazite+
10. TiO2
11. Apatite
12. TiO2+
13. Ilmenite+
14. TiO2+
15. Ilmenite+
16. Chlorite
17. Quartz
18. Chlorite
19. Muscovite
20. Ilmenite+
21. Chlorite
22. Muscovite
23. Albite
24. Muscovite
25. Chlorite+
26. Chlorite+
27. Muscovite
28. Chlorite
29. Muscovite
30. Chl+ Ms
31. Quartz
32. Chlorite
33. Ilmenite+

Figure 10.5-23. Sample OD2016-D2-012-A site 14. Euhedral diagenetic Monazite (9) replacing matrix and encasing Quartz (31) grains.



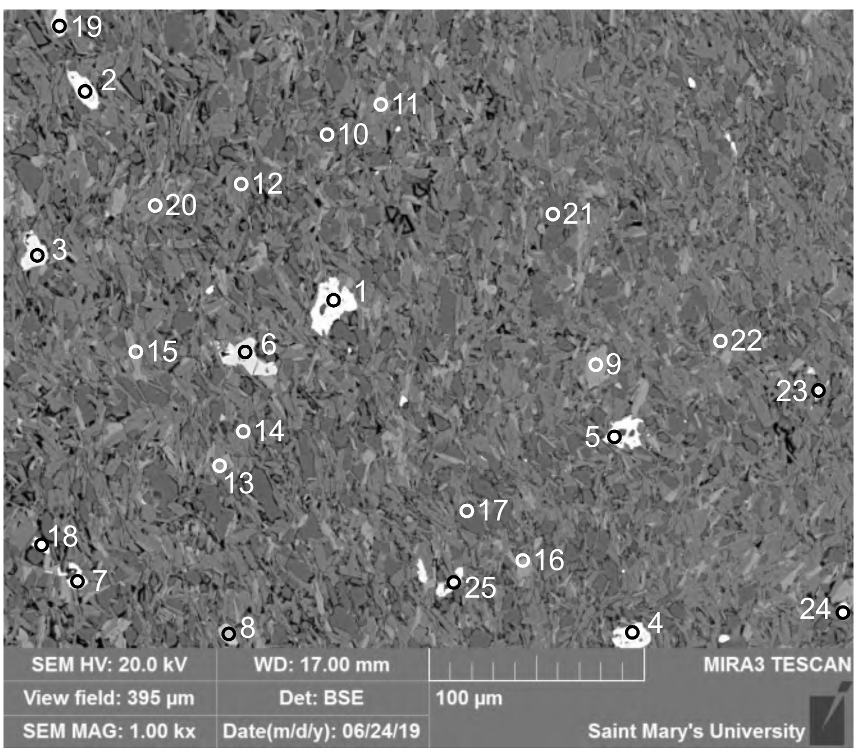
1. TiO2+
2. Monazite+
3. Monazite+
4. Monazite+
5. Monazite+
6. TiO2
7. Monazite+
8. Monazite
9. Monazite
10. Monazite+
11. Monazite+
12. Monazite+
13. Ilmenite
14. Zircon +
15. Quartz
16. Muscovite
17. Muscovite
18. Quartz +
19. Monazite+
20. Feohy+

Figure 10.5-24. Sample OD2016-D2-012-A site 14A.



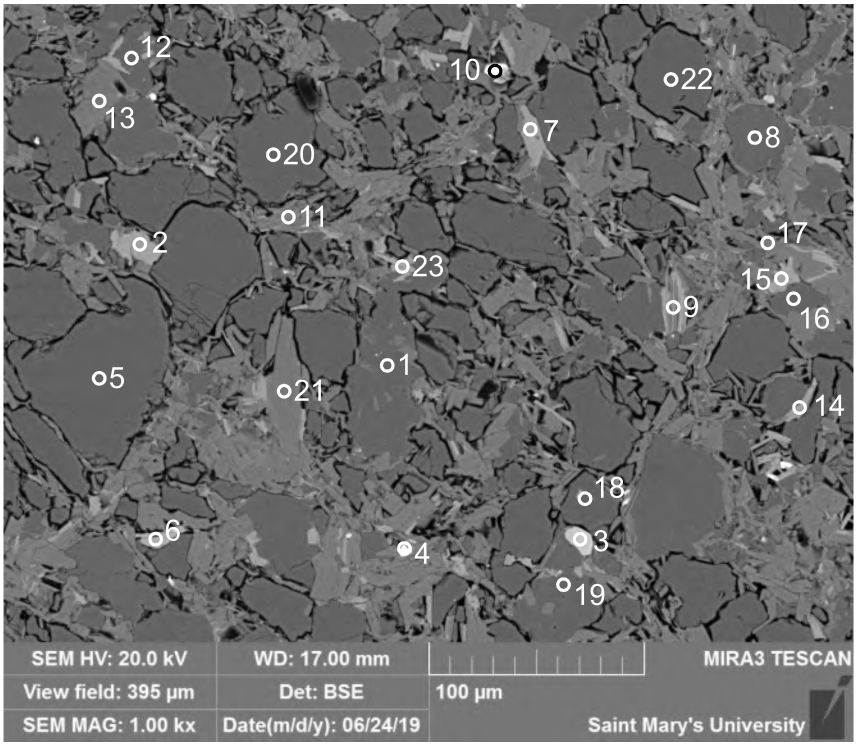
1. Ilmenite+
2. Ilmenite+
3. Ilmenite+
4. Ilmenite+
5. Chlorite
6. TiO2+
7. Ilmenite+
8. Ilmenite+
9. Ilmenite
10. Ilmenite+
11. Ilmenite+
12. TiO2+
13. Ilmenite
14. Muscovite
15. Quartz
16. Chlorite
17. Muscovite
18. Albite
19. Ilmenite+
20. Albite
21. Muscovite
22. Chlorite
23. Muscovite
24. Muscovite
25. Albite
26. Chlorite
27. Chl+ Ms
28. Quartz+

Figure 10.5-25. Sample OD2016-D2-012-A site 15.



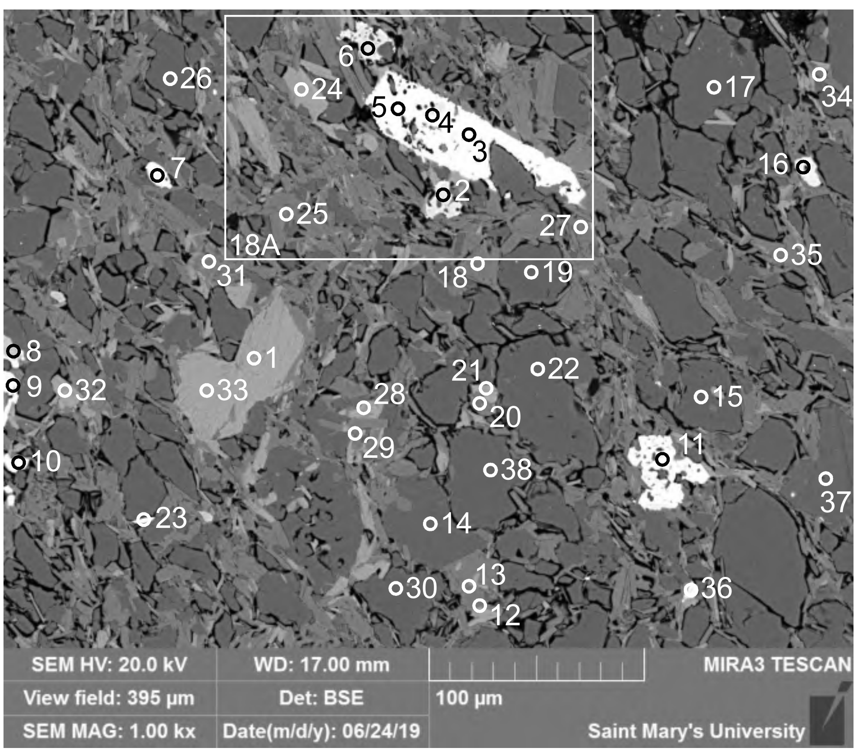
1. Ilmenite+
2. Ilmenite
3. TiO2
4. Ilmenite+
5. TiO2+
6. TiO2
7. Ilmenite+
8. Apatite
9. Chlorite
10. Albite
11. Chlorite
12. Muscovite
13. Chlorite
14. Muscovite
15. Chlorite
16. Chlorite
17. Albite
18. Ilmenite+
19. Ilmenite+
20. Muscovite
21. Albite
22. Muscovite
23. Ilmenite+
24. Ilmenite+
25. Ilmenite+

Figure 10.5-26. Sample OD2016-D2-012-A site 16.



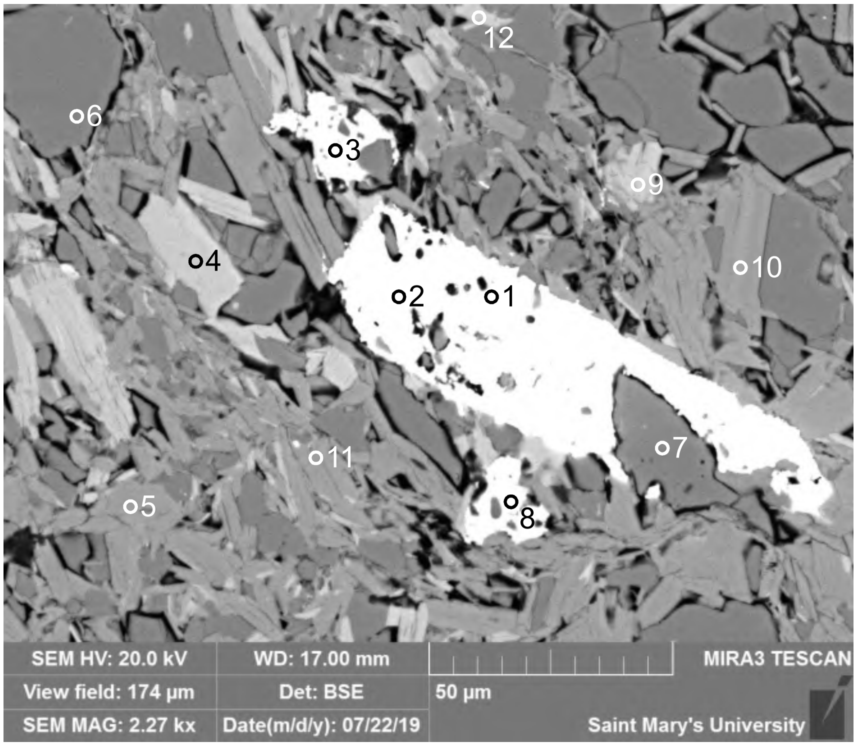
1. Albite
2. Chlorite
3. Apatite
4. Ilmenite+
5. Quartz
6. Biotite
7. Chlorite
8. Albite
9. Muscovite
10. Ilmenite+
11. Muscovite
12. Albite
13. Muscovite
14. Chlorite
15. Chlorite
16. Albite
17. Muscovite
18. Quartz
19. Albite
20. Quartz
21. Muscovite
22. Quartz
23. Chlorite

Figure 10.5-27. Sample OD2016-D2-012-A site 17.



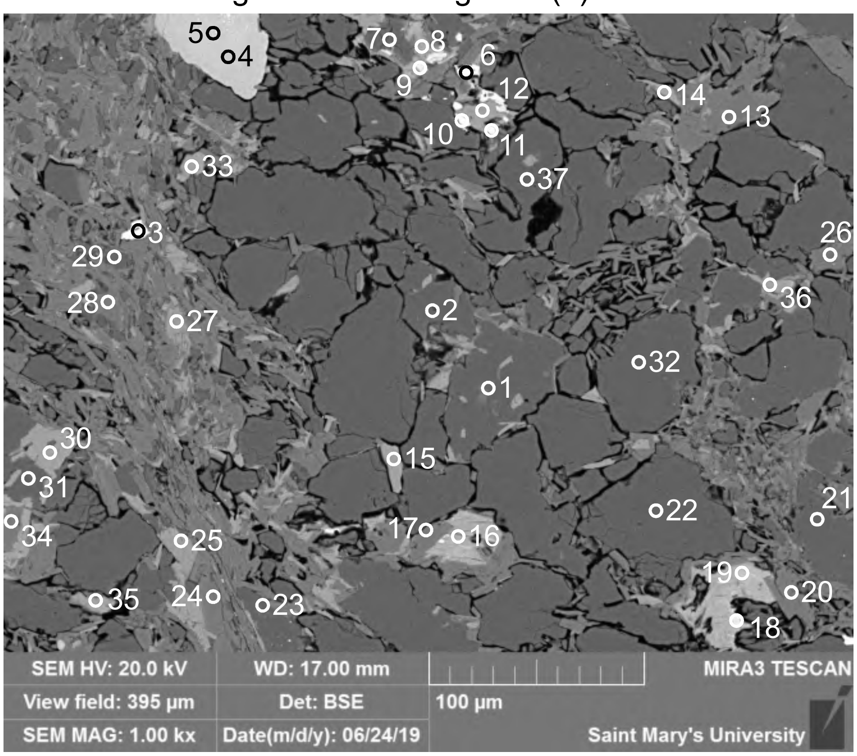
1. Chlorite
2. TiO2
3. Monazite+
4. TiO2+
5. Monazite
6. TiO2+
7. Ilmenite
8. Apatite
9. Ilmenite+
10. Ilmenite
11. Ilmenite
12. Chlorite
13. Muscovite
14. Albite
15. Quartz
16. TiO2+
17. Quartz
18. Muscovite
19. Quartz
20. Muscovite
21. Chlorite
22. Quartz
23. Zircon
24. Chlorite
25. Muscovite
26. Quartz
27. Muscovite
28. Chlorite
29. Muscovite
30. Quartz
31. Muscovite
32. Chlorite
33. Chlorite
34. Muscovite
35. Muscovite
36. Ilmenite+
37. Albite
38. Quartz

Figure 10.5-28. Sample OD2016-D2-012-A site 18.



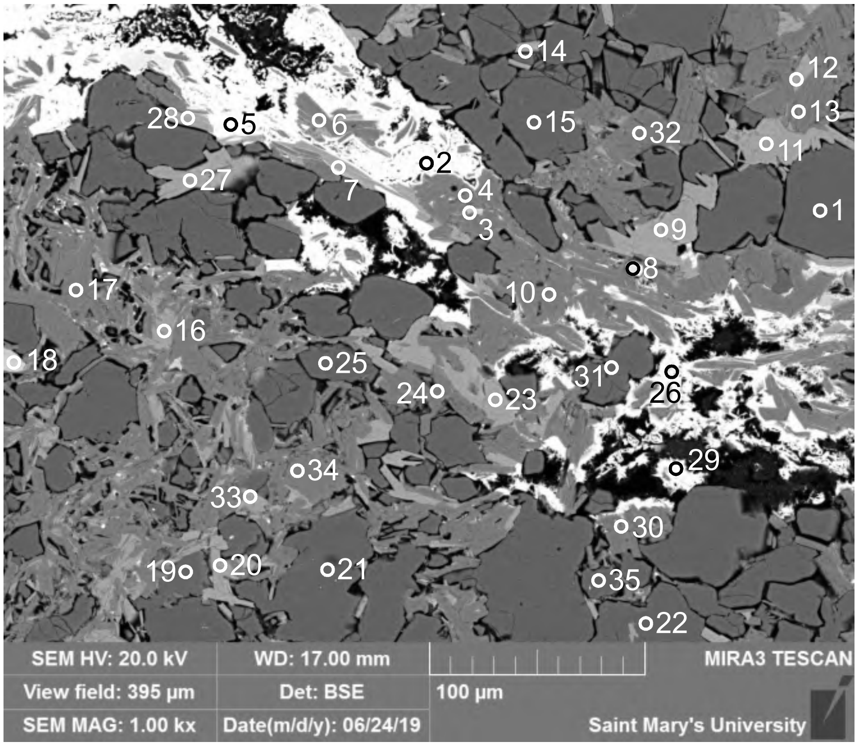
1. TiO_2
2. Monazite
3. TiO_2+
4. Chlorite
5. Muscovite
6. Quartz
7. Quartz
8. TiO_2
9. Chlorite
10. Muscovite
11. Muscovite
12. Chlorite

Figure 10.5-29. Sample OD2016-D2-012-A site 18A. Euhedral diagenetic monazite (2) surrounding TiO_2 (1). TiO_2 surrounding other mineral grains (3).



1. Albite
2. Albite
3. Ilmenite+
4. Apatite
5. Apatite
6. Ilmenite
7. Albite
8. Ilmenite+
9. TiO_2+
10. Ilmenite+
11. Ilmenite+
12. Chlorite
13. Muscovite
14. Chlorite
15. Chlorite
16. Chlorite+
17. Muscovite
18. TiO_2+
19. Chlorite+
20. Muscovite
21. Albite
22. Quartz
23. Albite
24. Muscovite
25. Chlorite+
26. Muscovite
27. Chlorite
28. Muscovite
29. Albite
30. Chlorite
31. Albite
32. Quartz
33. Chlorite
34. Muscovite
35. Chlorite
36. Chlorite
37. Quartz

Figure 10.5-30. Sample OD2016-D2-012-A site 19.



1. Quartz
2. Feohy+
3. Apatite
4. Muscovite
5. Feohy+
6. Muscovite
7. Chlorite
8. TiO_2
9. Chlorite
10. Muscovite
11. Chlorite
12. Chlorite
13. Muscovite
14. Chlorite
15. Quartz
16. Chlorite
17. Muscovite
18. Apatite
19. Albite
20. Chlorite+
21. Quartz
22. Quartz
23. Chlorite
24. Muscovite
25. Quartz
26. Feohy+
27. Chlorite
28. Chlorite
29. Feohy+
30. Muscovite
31. Quartz
32. Muscovite
33. Chlorite
34. Muscovite
35. Quartz

Figure 10.5-31. Sample OD2016-D2-012-A site 20. HD: Feohy.

Appendix 10.6: OD2016 imagery.

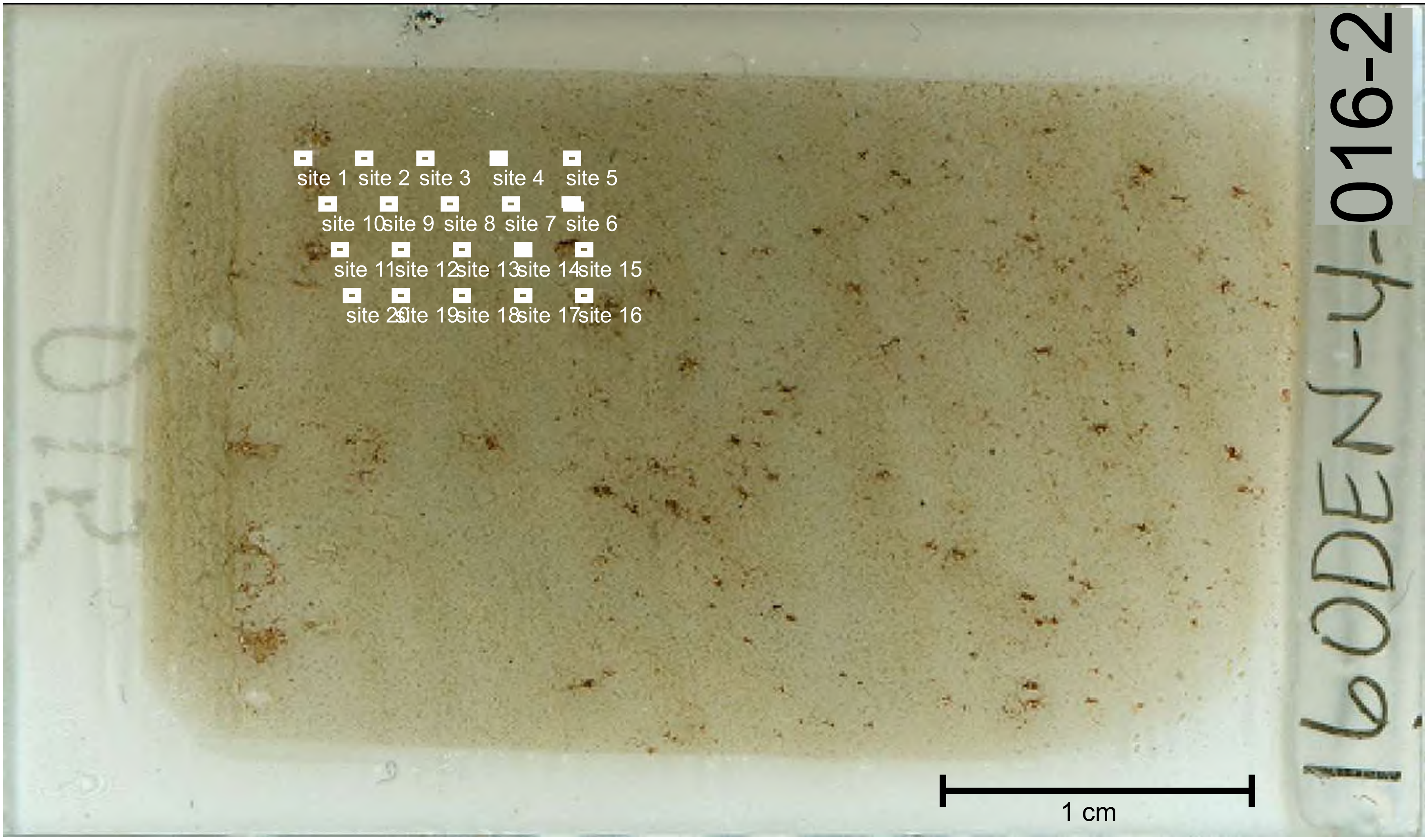
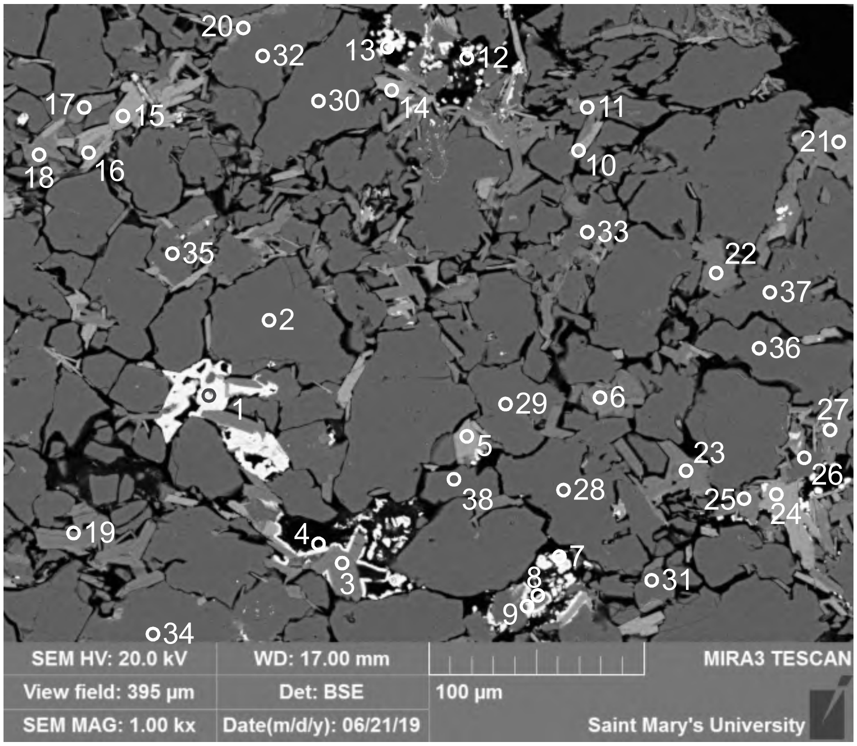


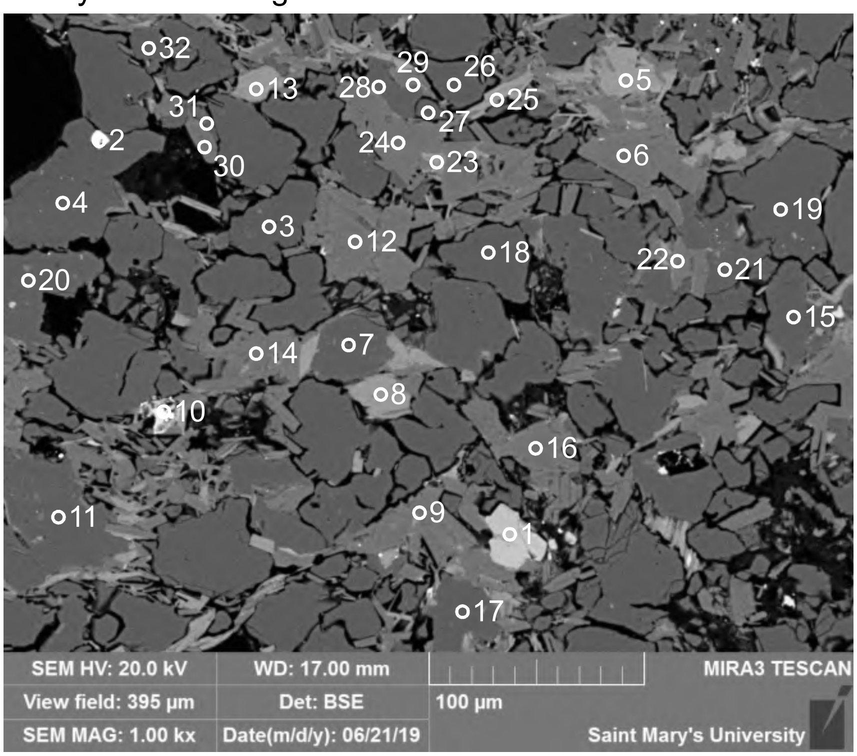
Figure 10.6-1: Slide OD2016-D2-016-2.

Figure 10.6-2: Sample OD2016-D2-016.



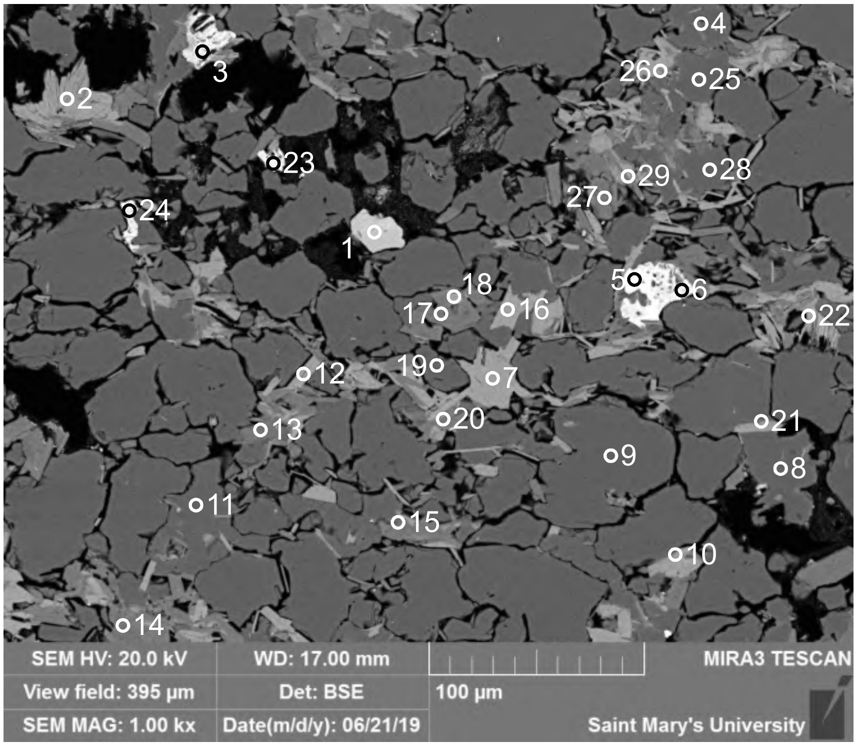
1. Feohy+
2. Quartz
3. Muscovite
4. Feohy+
5. Chlorite
6. Muscovite
7. Feohy+
8. Muscovite
9. Feohy+
10. Chlorite
11. Muscovite
12. Feohy+
13. Feohy+
14. Chlorite
15. Chlorite
16. Muscovite
17. Muscovite
18. Muscovite
19. Muscovite
20. Muscovite
21. Muscovite
22. Muscovite
23. Muscovite
24. Chlorite
25. Muscovite
26. Albite
27. Muscovite
28. Quartz
29. Albite
30. Quartz
31. Albite
32. Albite
33. Albite
34. Albite
35. Albite
36. Quartz
37. Quartz
38. Quartz

Figure 10.6-3. Sample OD2016-D2-016-2 site 1. DT quartz and albite with interstitial DG chlorite & muscovite. Late HD Feohy+ rims other grains.



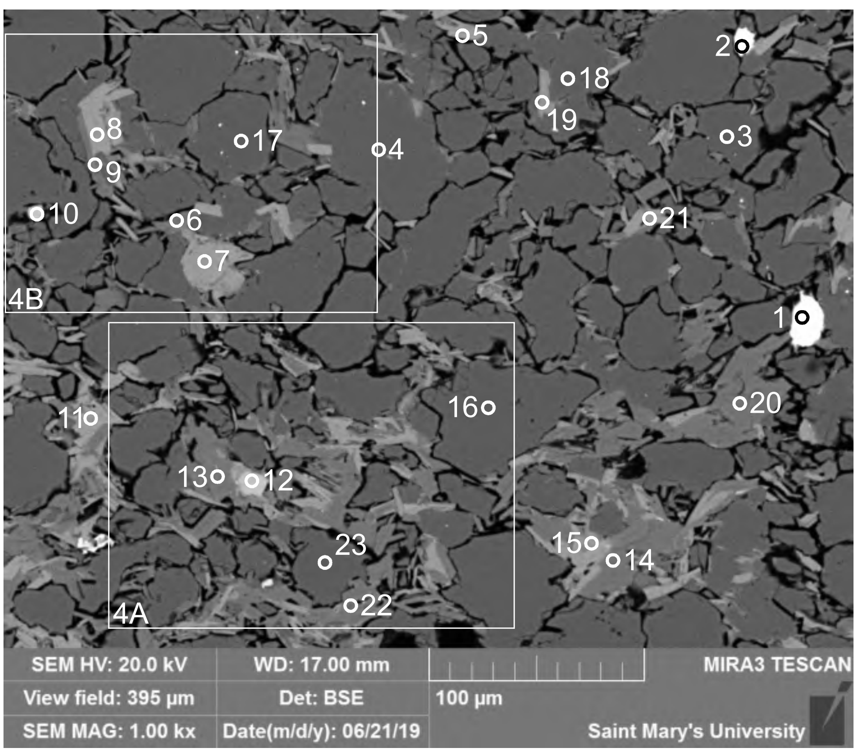
1. Apatite
2. Monazite+
3. Quartz
4. Albite
5. Chlorite
6. Muscovite
7. Albite
8. Chlorite
9. Muscovite
10. Monazite+
11. Albite
12. Muscovite
13. Chlorite
14. Muscovite
15. Albite
16. Muscovite
17. Albite
18. Quartz
19. Quartz
20. Albite
21. Albite
22. Muscovite
23. Chlorite
24. Muscovite
25. Chlorite
26. Quartz
27. Quartz
28. Albite
29. Muscovite
30. Muscovite
31. Albite
32. Albite

Figure 10.6-4. Sample OD2016-D2-016-2 site 2. DT: Albite, Apatite, Quartz; DG: Chlorite, Monazite, Muscovite; HD: Feohy.



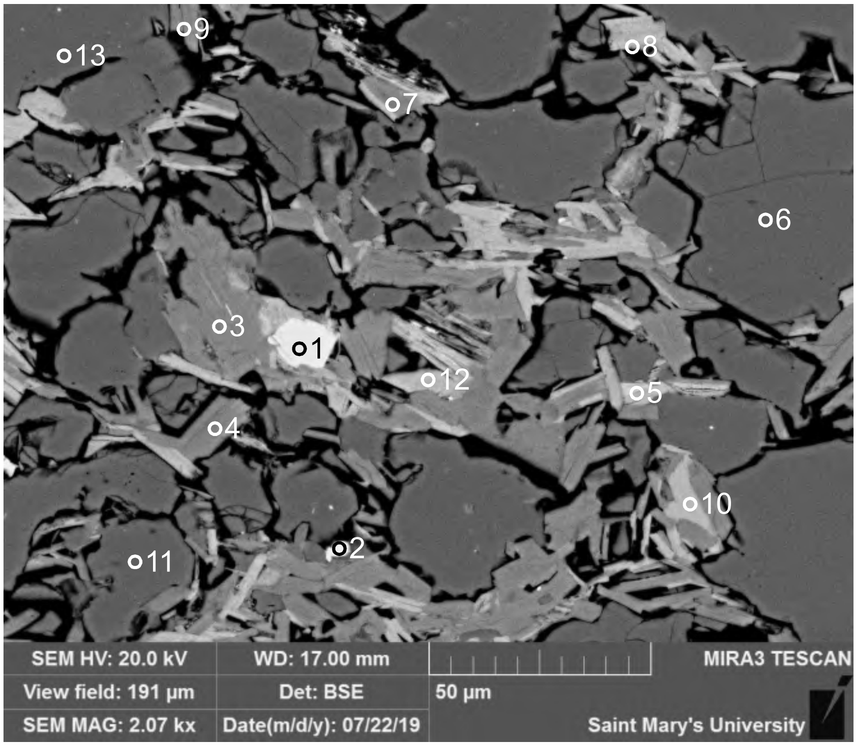
1. Apatite
2. Chlorite
3. TiO2+
4. Albite
5. Ilmenite
6. TiO2+
7. Chlorite
8. Albite
9. Quartz
10. Chlorite
11. Albite
12. Chlorite
13. Muscovite
14. Muscovite
15. Muscovite
16. Chlorite
17. Muscovite
18. Chlorite
19. Quartz
20. Muscovite
21. Chlorite
22. Chlorite+
23. TiO2+
24. TiO2+
25. Albite
26. Chlorite+
27. Ms+ Chl
28. Albite
29. Biotite

Figure 10.6-5. Sample OD2016-D2-016-2 site 3.
DT: Albite, Quartz; DG: Apatite, Ilmenite, Muscovite, Chlorite, TiO2.



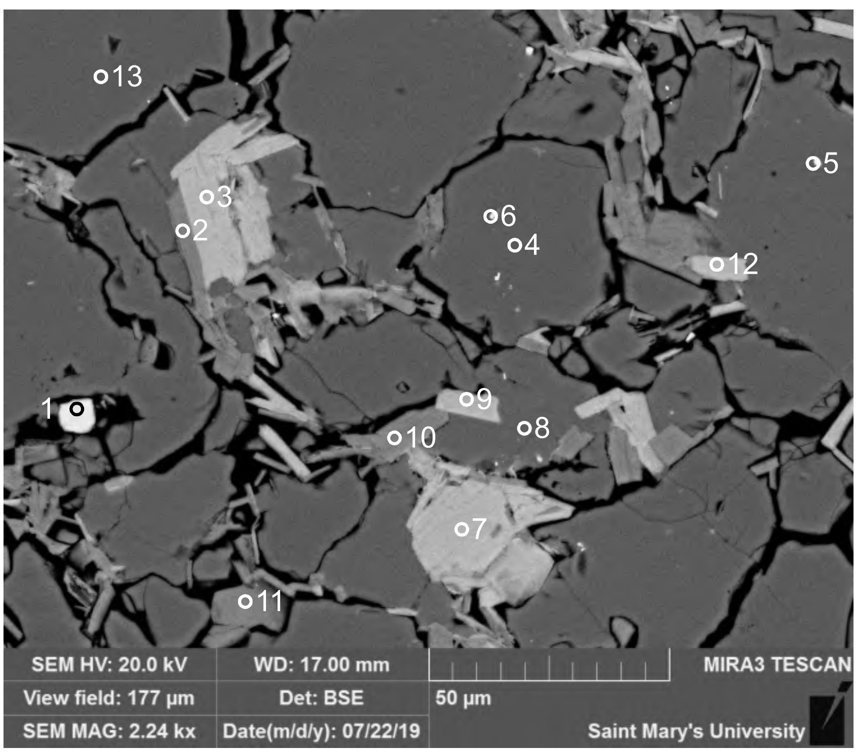
1. Zircon
2. Zircon
3. Quartz
4. Albite
5. Chlorite
6. Muscovite
7. Chlorite
8. Chlorite
9. Muscovite+
10. Apatite
11. Chlorite
12. Apatite
13. Muscovite
14. Muscovite
15. Chlorite
16. Quartz
17. Quartz
18. Albite
19. Chlorite
20. Muscovite
21. Chlorite
22. Muscovite
23. Quartz

Figure 10.6-6. Sample OD2016-D2-016-2 site 4.
DT: Albite, Quartz, Zircon; DG: Apatite, Muscovite, Chlorite.



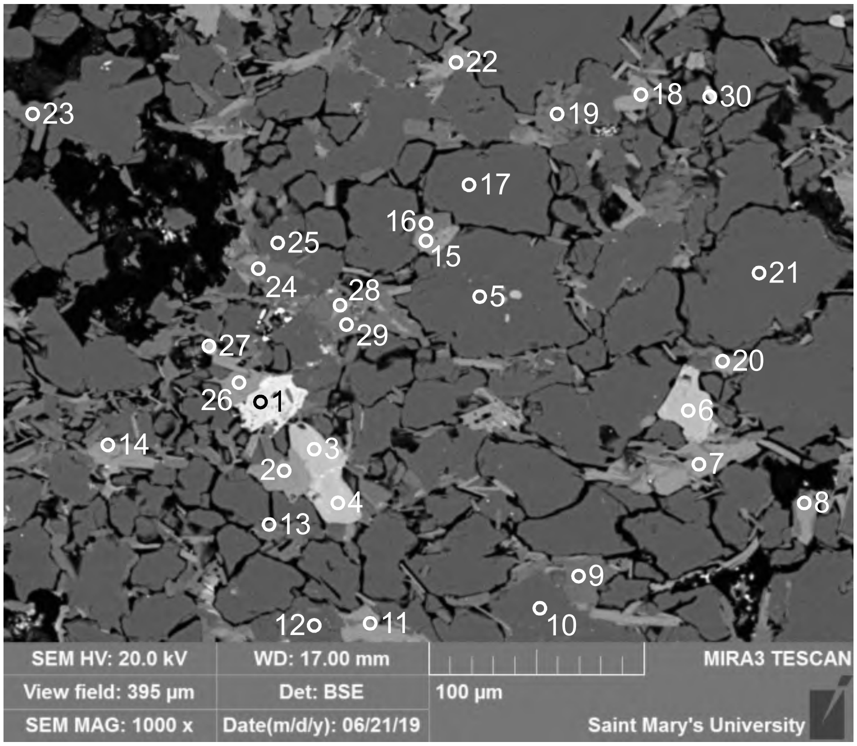
1. Apatite
2. TiO2+
3. Muscovite
4. Muscovite
5. Chl+ Ms
6. Quartz
7. Muscovite
8. Chlorite
9. Muscovite
10. Chl+ Ms
11. Quartz
12. Chl+ Ms
13. Quartz

Figure 10.6-7. Sample OD2016-D2-016-2 site 4A.
DT: Apatite, Quartz; DG: TiO_2, Muscovite, Chlorite.



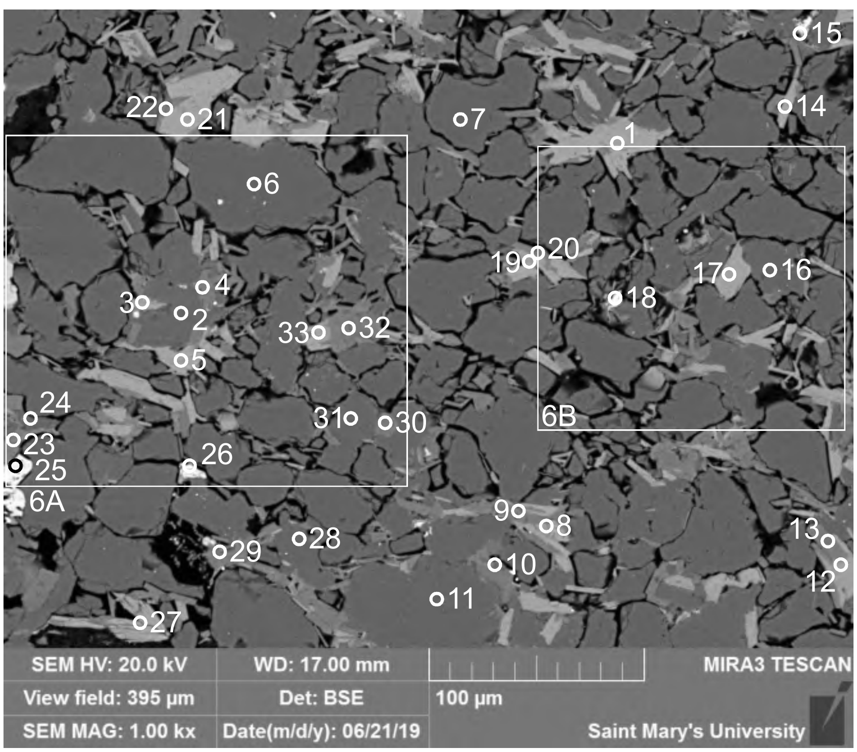
1. Apatite
2. Muscovite
3. Chlorite
4. Quartz
5. Zircon+
6. Mixture
7. Chlorite
8. Albite
9. Chlorite
10. Muscovite
11. Muscovite
12. Chlorite
13. Quartz

Figure 10.6-8. Sample OD2016-D2-016-2 site 4B.
DT: Albite, Quartz, Zircon; DG: Apatite, Muscovite, Chlorite, TiO_2.



1. TiO2+
2. Chlorite
3. Apatite
4. Apatite
5. Quartz
6. Apatite
7. Chlorite
8. Chlorite
9. Muscovite
10. Albite
11. Chlorite
12. Albite
13. Muscovite
14. Chlorite
15. Chlorite
16. Muscovite
17. Quartz
18. Chlorite
19. Muscovite
20. Chlorite
21. Quartz
22. Chlorite
23. Muscovite
24. Muscovite
25. Albite
26. Chlorite
27. Apatite
28. Chlorite
29. Muscovite
30. TiO2

Figure 10.6-9. Sample OD2016-D2-016-2 site 5. Quartz in TiO2 suggests TiO2 is late. DT: Albite, Quartz; DG: Apatite, TiO2, Muscovite, Chlorite.



1. Chlorite
2. Albite
3. Chlorite
4. Muscovite
5. Chlorite
6. Quartz
7. Quartz
8. Chlorite
9. Muscovite
10. Muscovite
11. Albite
12. Chlorite
13. Muscovite
14. Chlorite
15. Mixture
16. Albite
17. Chlorite
18. Mixture
19. Chlorite
20. Muscovite
21. Chlorite
22. Muscovite
23. Muscovite
24. Albite
25. TiO2+
26. TiO2+
27. Chlorite
28. Albite
29. Muscovite
30. Muscovite
31. Albite
32. Muscovite
33. Chlorite

Figure 10.6-10 Sample OD2016-D2-016-2 site 6. DT: Albite, Quartz; DG: TiO2, Muscovite, Chlorite.

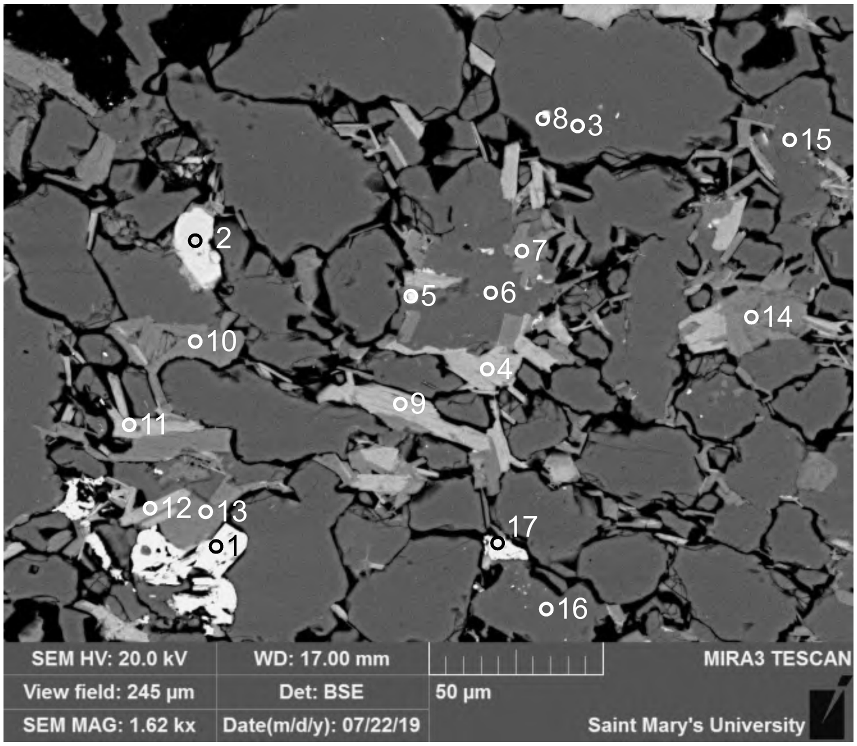


Figure 10.6-11. Sample OD2016-D2-016-2 site 6A. DT: Albite, Apatite, Ilmenite, Quartz; DG: Muscovite, Chlorite, TiO_2.

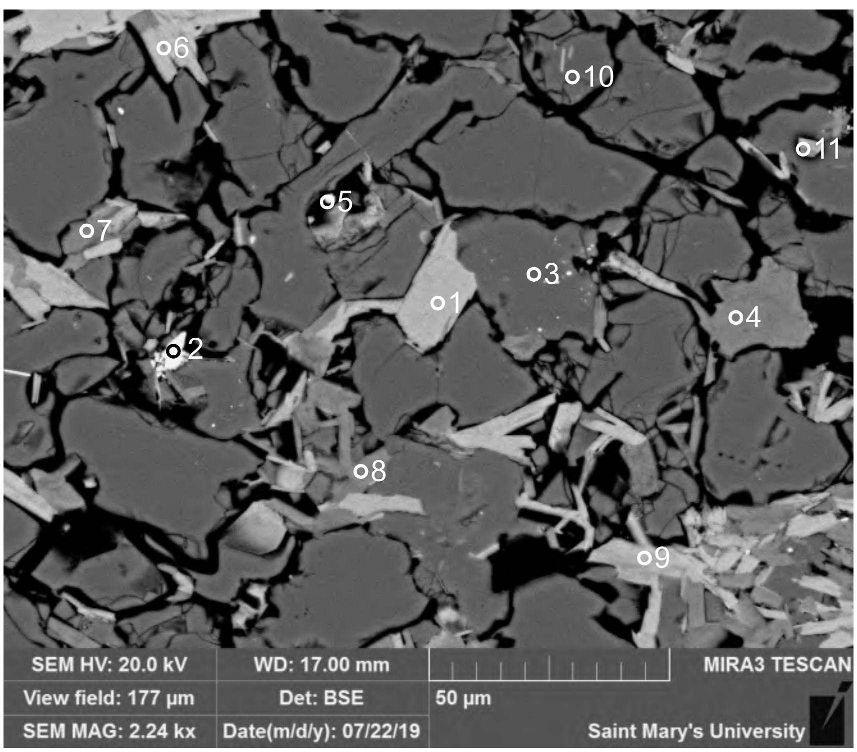
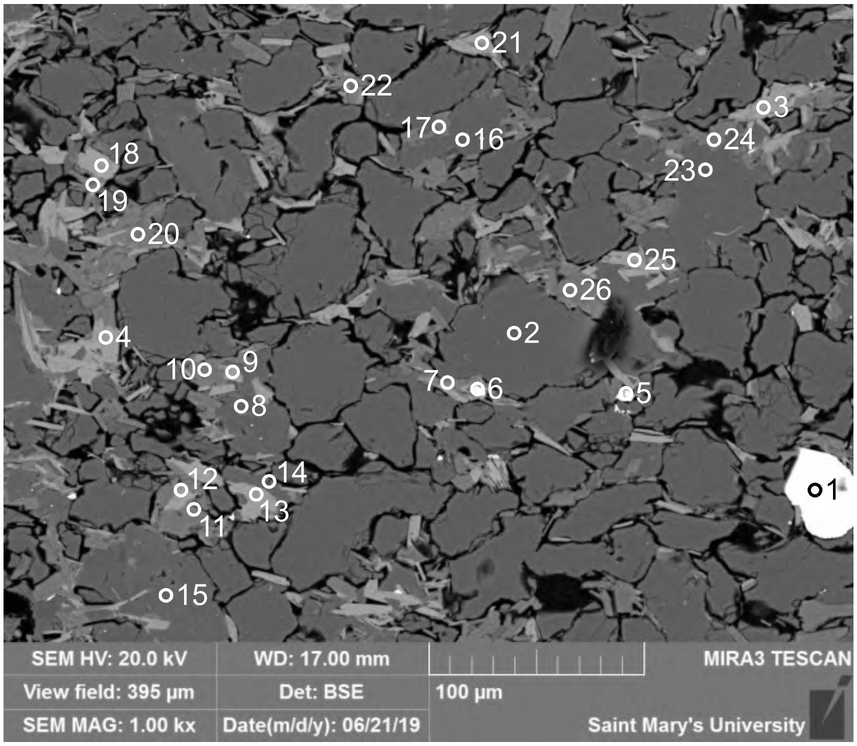
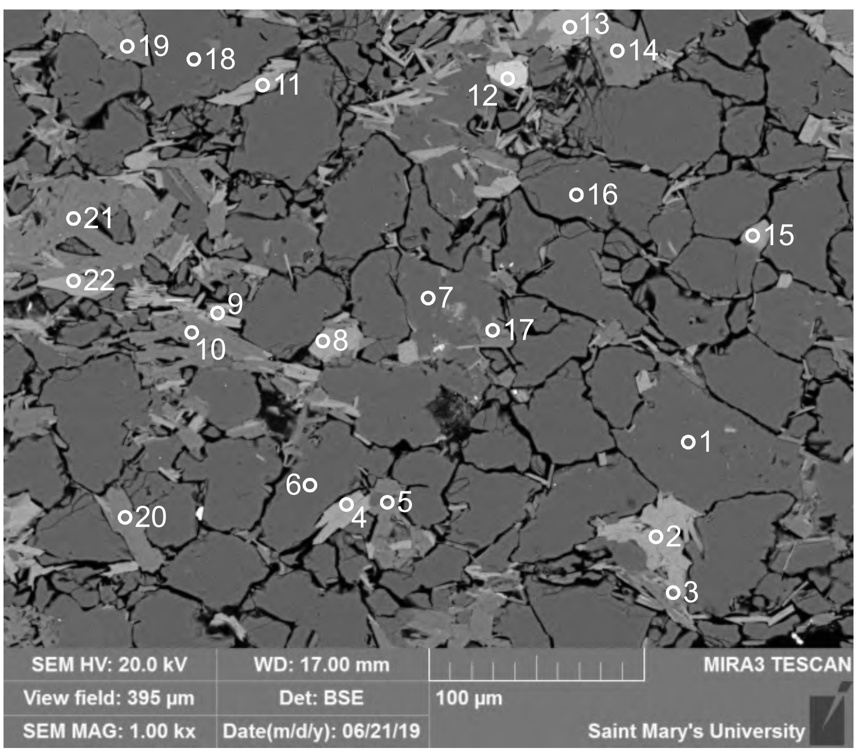


Figure 10.6-12. Sample OD2016-D2-016-2 site 6B. DT: Albite, Apatite, Quartz; DG: Muscovite, Chlorite.



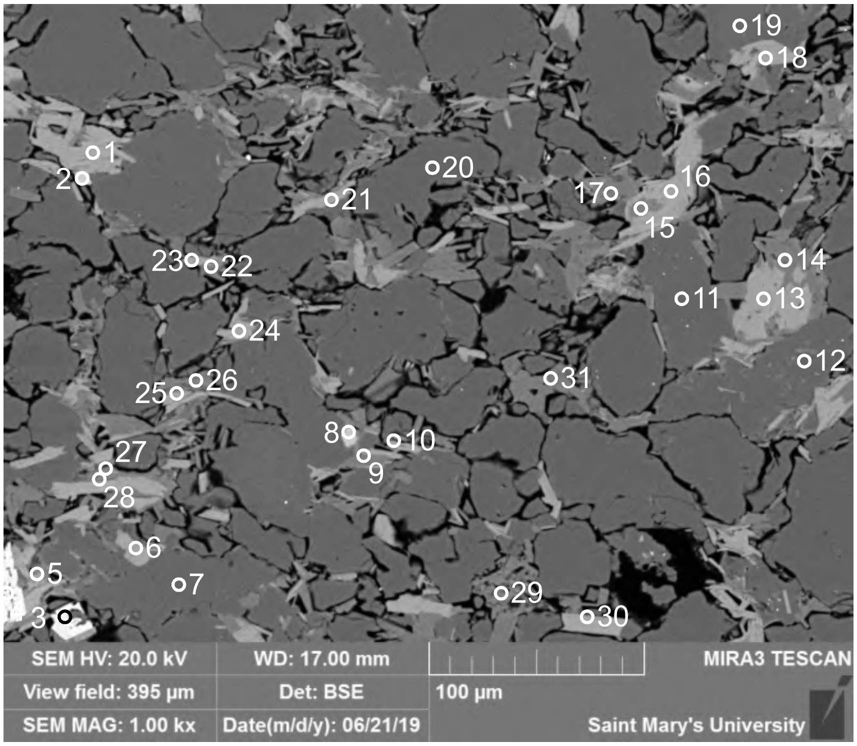
1. Zircon
2. Quartz
3. Chlorite
4. Chlorite
5. Ilmenite+
6. Zircon
7. Chlorite
8. Albite
9. Chlorite
10. Muscovite
11. Muscovite
12. Chlorite
13. Chlorite
14. Albite
15. Albite
16. Albite
17. Muscovite
18. Chlorite
19. Muscovite
20. Muscovite
21. Chlorite
22. Ms+ Chl
23. Albite
24. Muscovite
25. Chlorite
26. Muscovite

Figure 10.6-13. Sample OD2016-D2-016-2 site 7.
DT: Albite, Quartz, Zircon; DG: Muscovite, Chlorite.



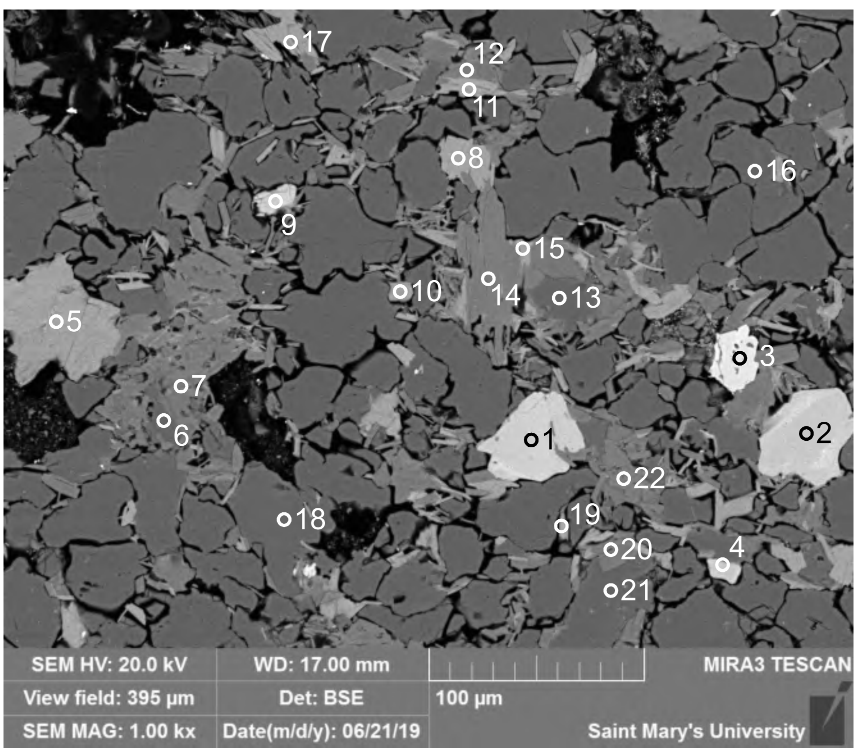
1. Albite
2. Chlorite
3. Muscovite
4. Chlorite
5. Muscovite
6. Quartz
7. Albite
8. Chlorite
9. Chlorite
10. Muscovite
11. Chlorite
12. Apatite
13. Chlorite
14. Muscovite
15. Chlorite
16. Quartz
17. Muscovite
18. Quartz
19. Muscovite
20. Muscovite
21. Muscovite
22. Chlorite

Figure 10.6-14. Sample OD2016-D2-016-2 site 8.
DT: Apatite, Albite, Quartz; DG: Muscovite, Chlorite.



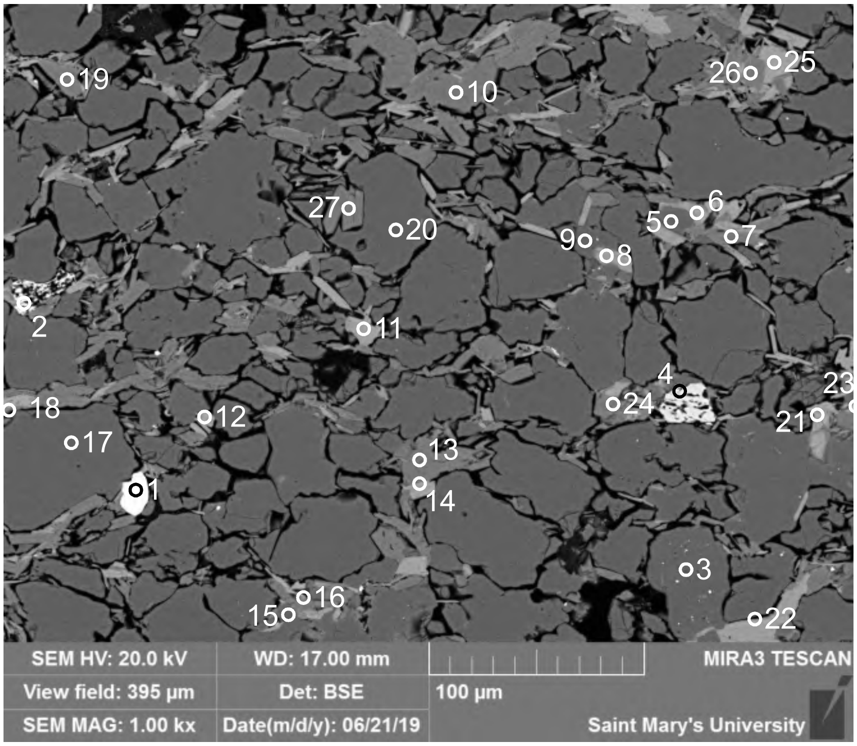
1. Chlorite
2. Apatite
3. TiO2+
4. TiO2+
5. Chlorite
6. Chlorite
7. Albite
8. Apatite
9. Muscovite
10. Chlorite
11. Albite
12. Albite
13. Chlorite
14. Muscovite
15. Muscovite
16. Chlorite
17. Muscovite
18. Chlorite
19. Muscovite
20. Quartz
21. Chlorite
22. Muscovite
23. Chlorite
24. Chlorite
25. Chlorite
26. Muscovite
27. Ms+ Chl
28. Chlorite
29. Muscovite
30. Chlorite
31. Muscovite

Figure 10.6-15. Sample OD2016-D2-016-2 site 9. DT: Albite, Quartz; DG: Apatite, Chlorite, Muscovite, TiO2.



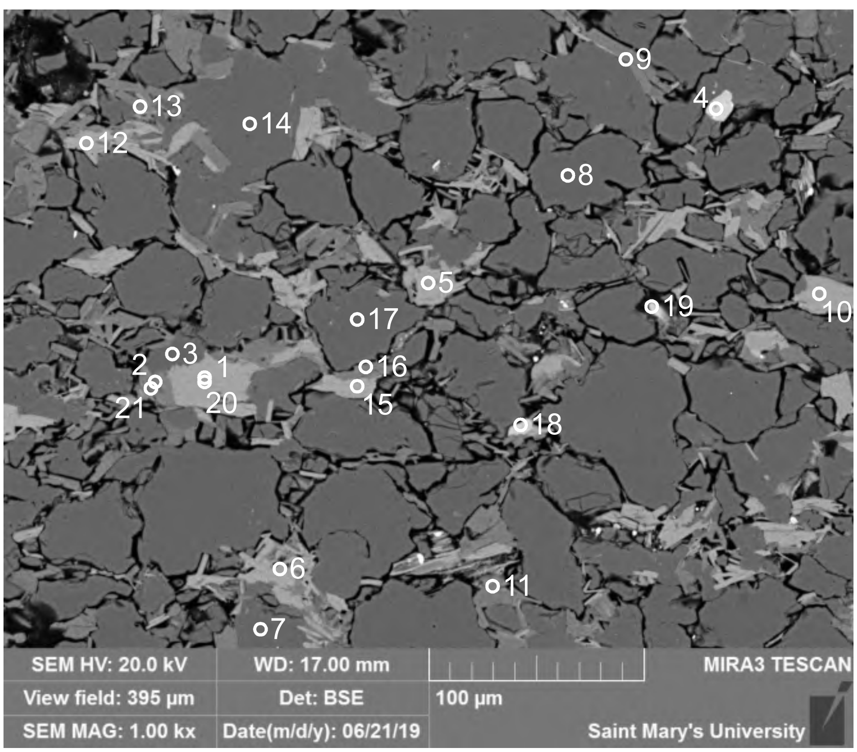
1. Apatite
2. Apatite
3. TiO2+
4. Apatite
5. Chlorite
6. Albite
7. Muscovite
8. Chlorite
9. Apatite
10. Chlorite
11. Chlorite
12. Muscovite
13. Albite
14. Muscovite
15. Chlorite
16. Albite
17. Chl+ Ms
18. Albite
19. Chlorite
20. Muscovite
21. Albite
22. Muscovite

Figure 10.6-16. Sample OD2016-D2-016-2 site 10. DT: Apatite, Albite, Quartz; DG: Chlorite, Muscovite, TiO2.



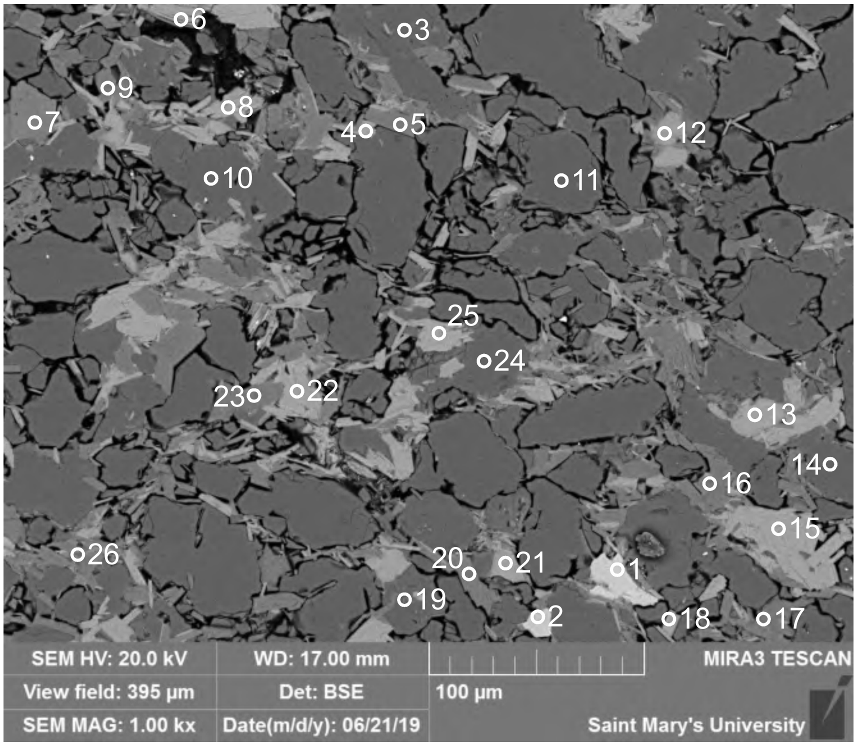
1. Zircon
2. Ilmenite+
3. Albite
4. TiO2
5. Albite
6. Chlorite
7. Muscovite
8. Chlorite
9. Albite
10. Muscovite
11. Chlorite
12. Chlorite
13. Muscovite
14. Chlorite
15. Albite
16. Muscovite
17. Quartz
18. Muscovite
19. Muscovite
20. Quartz
21. Chlorite
22. Chlorite
23. Albite
24. Muscovite
25. Chlorite
26. Muscovite
27. Muscovite

Figure 10.6-17. Sample OD2016-D2-016-2 site 11. DT: Albite, Ilmenite, Quartz, Zircon; DG: Chlorite, Muscovite, TiO_2.



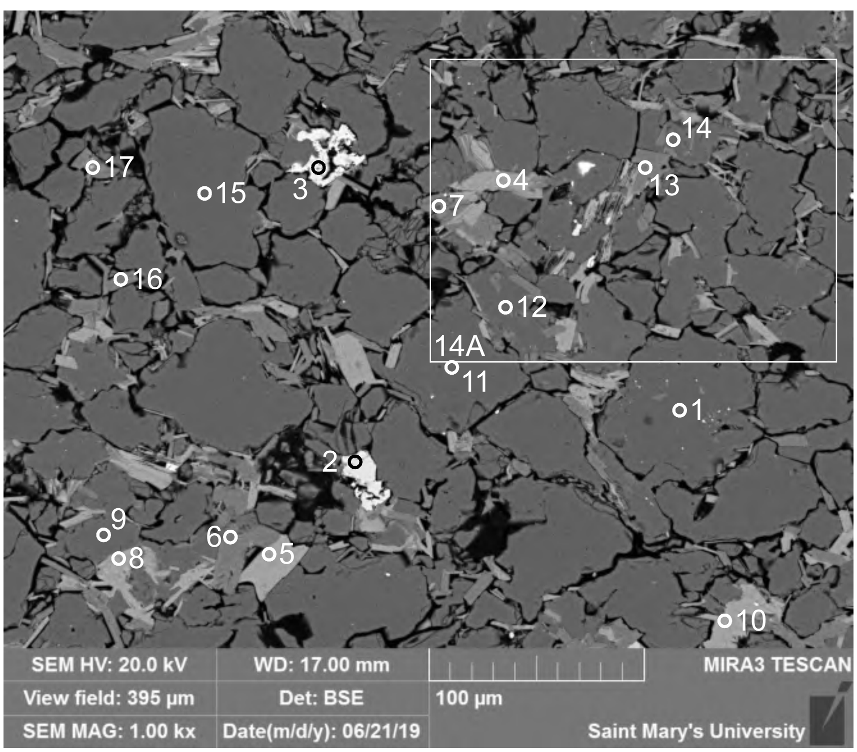
1. Chlorite
2. Muscovite
3. Albite
4. Apatite
5. Chlorite
6. Chlorite
7. Albite
8. Quartz
9. Muscovite
10. Chlorite
11. Muscovite
12. Chlorite
13. Muscovite
14. Albite
15. Chlorite
16. Muscovite
17. Quartz
18. Apatite
19. Apatite
20. Chlorite
21. Muscovite

Figure 10.6-18. Sample OD2016-D2-016-2 site 12. DT: Quartz, Apatite; DG: Chlorite, Muscovite; LC: Albite (3), Biotite, Chlorite, Muscovite.



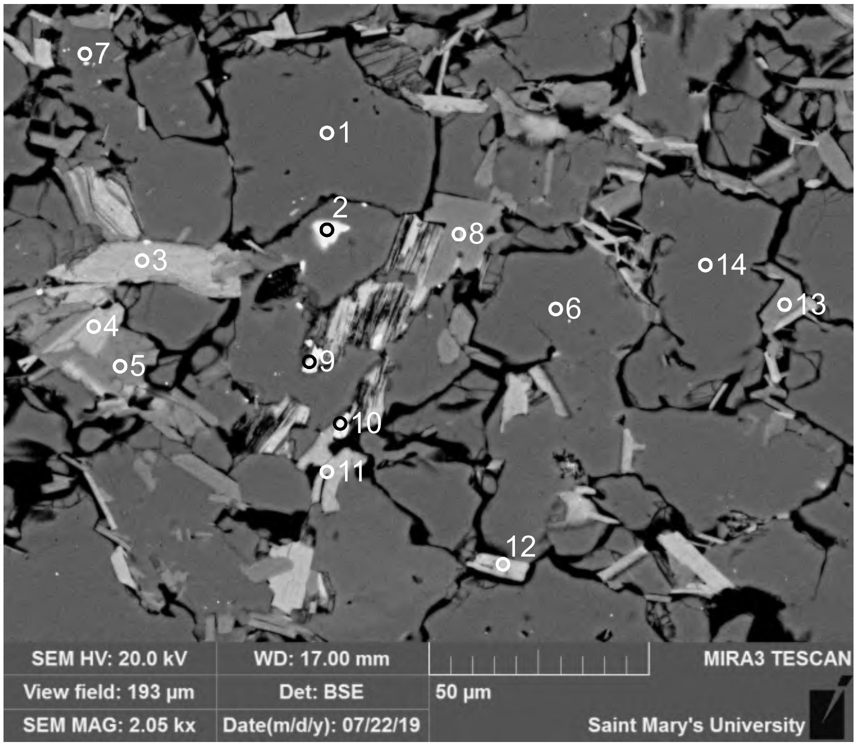
1. Apatite
2. Apatite
3. Ab+ Ms
4. Chlorite
5. Muscovite
6. Chlorite+
7. Muscovite
8. Chlorite
9. Muscovite
10. Albite
11. Quartz
12. Chlorite
13. Chlorite
14. Albite
15. Chlorite
16. Muscovite
17. Muscovite
18. Chlorite
19. Albite
20. Muscovite
21. Chlorite
22. Chlorite
23. Muscovite
24. Albite
25. Chlorite
26. Mixture

Figure 10.6-19. Sample OD2016-D2-016-2 site 13. DT: Quartz, Albite; DG: Apatite, Chlorite, Muscovite



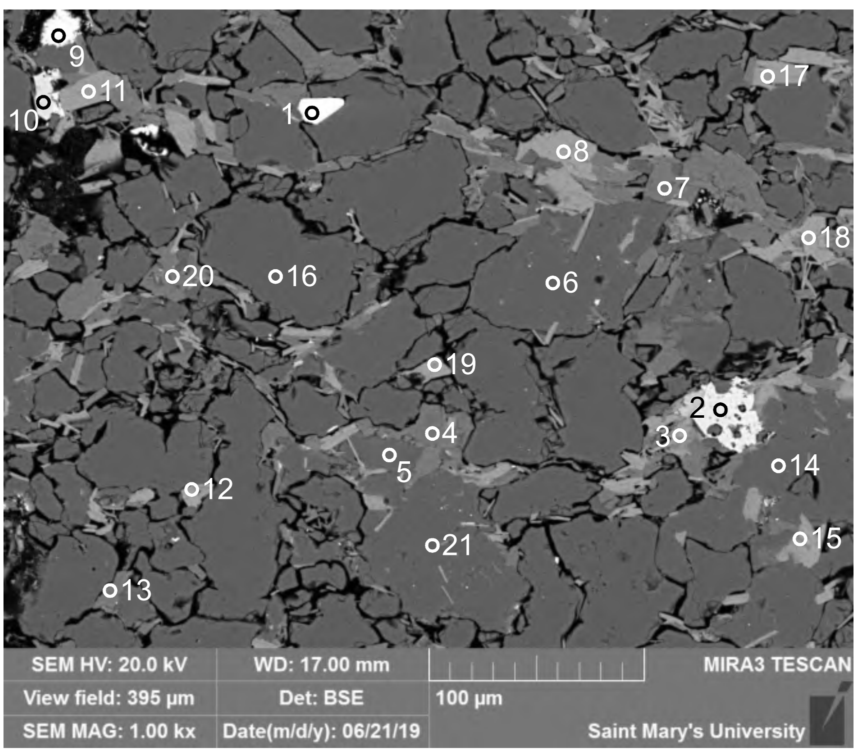
1. Quartz
2. TiO2+
3. TiO2+
4. Chlorite
5. Chlorite
6. Muscovite
7. Muscovite
8. Chlorite
9. Albite
10. Chlorite
11. Quartz
12. Albite+
13. Ms+ Chl
14. Albite
15. Quartz
16. Muscovite
17. TiO2+

Figure 10.6-20. Sample OD2016-D2-016-2 site 14. DT: Quartz, Albite; DT: Chlorite, Muscovite, TiO2



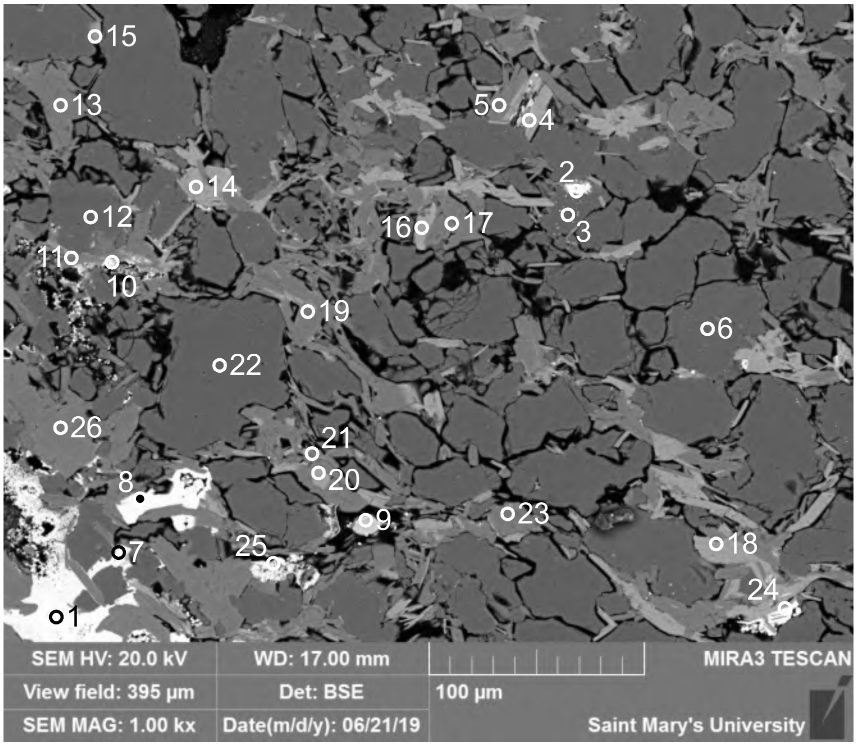
1. Quartz
2. Monazite
3. Chlorite
4. Chlorite
5. Muscovite
6. Albite
7. Albite
8. Ms+ Chl
9. TiO2+
10. TiO2+
12. Chlorite
13. Muscovite+
14. Quartz

Figure 10.6-21. Sample OD2016-D2-016-2 site 14A.



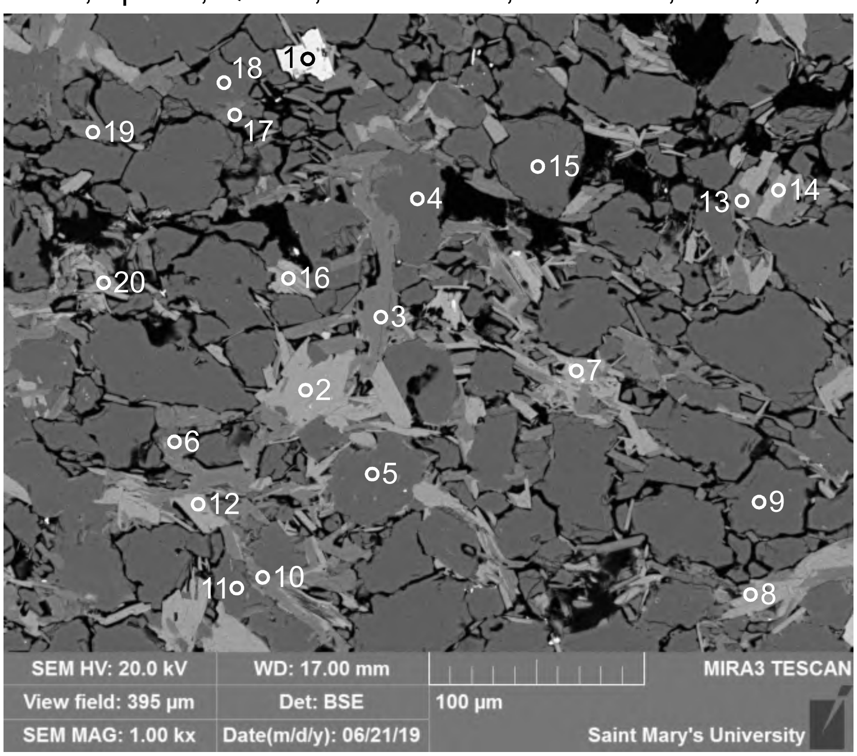
1. Zircon
2. TiO2+
3. Ms+ Chl
4. Muscovite
5. Albite
6. Albite
7. Muscovite
8. Chlorite
9. Feohy+
10. Rutile
11. Chlorite
12. Chlorite
13. Muscovite
14. Albite
15. Chlorite
16. Quartz
17. Chlorite
18. Chlorite
19. Chlorite
20. Muscovite
21. Albite

Figure 10.6-22. Sample OD2016-D2-016-2 site 15.



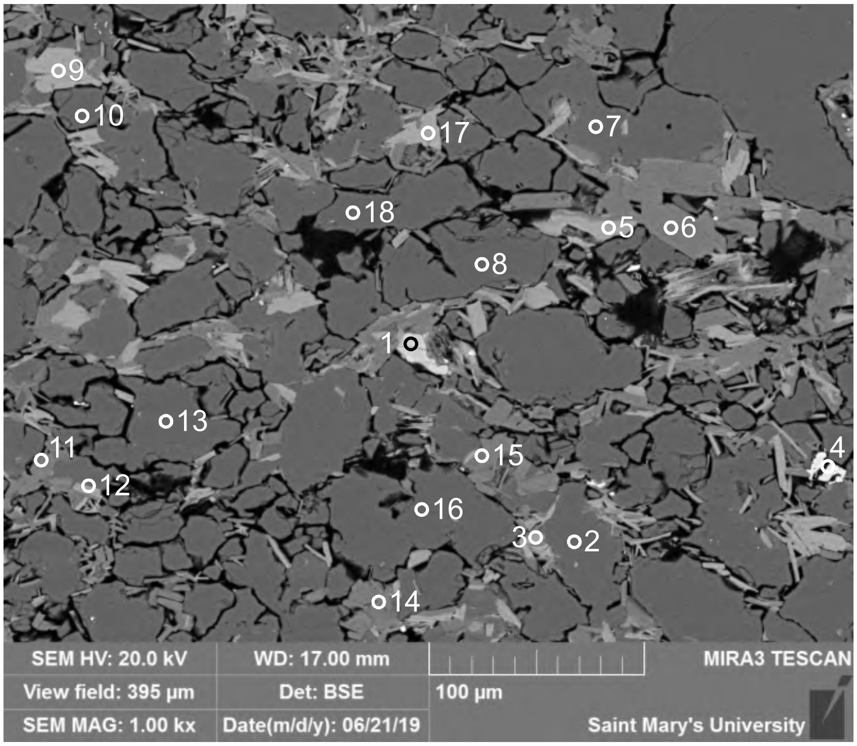
1. Feohy+
2. Feohy+
3. Albite
4. Chlorite+
5. Muscovite
6. Albite
7. Feohy+
8. Feohy+
9. Apatite
10. Feohy+
11. Muscovite
12. Albite
13. Muscovite
14. Chlorite
15. Chlorite
16. Chlorite
17. Muscovite
18. Chlorite
19. Muscovite
20. Chlorite
21. Muscovite
22. Quartz
23. Muscovite
24. Feohy+
25. TiO2+
26. Muscovite

Figure 10.6-23. Sample OD2016-D2-016-2 site 16. Late Feohy infilling spaces and coating DT and HD grains. DT: Albite, Apatite, Quartz; HD: Chlorite, Muscovite, TiO2,



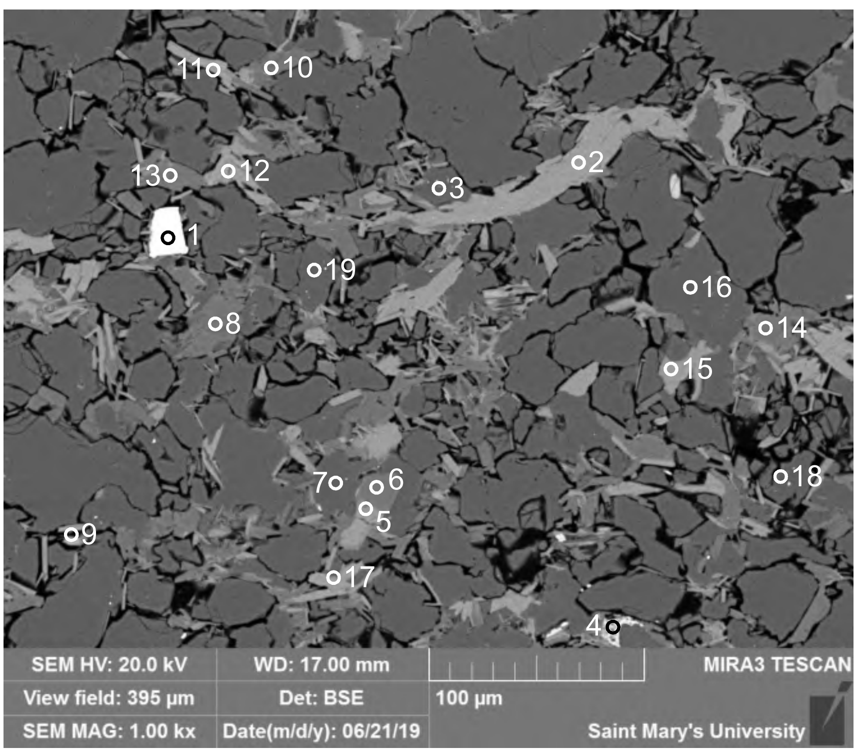
1. Rutile
2. Chlorite
3. Muscovite
4. Albite
5. Albite
6. Muscovite
7. Chlorite
8. Chlorite
9. Quartz
10. Muscovite
11. Albite
12. Chlorite
13. Muscovite
14. Chlorite
15. Quartz
16. Mixture
17. Muscovite
18. Albite
19. Muscovite
20. Chlorite

Figure 10.6-24. Sample OD2016-D2-016-2 site 17.



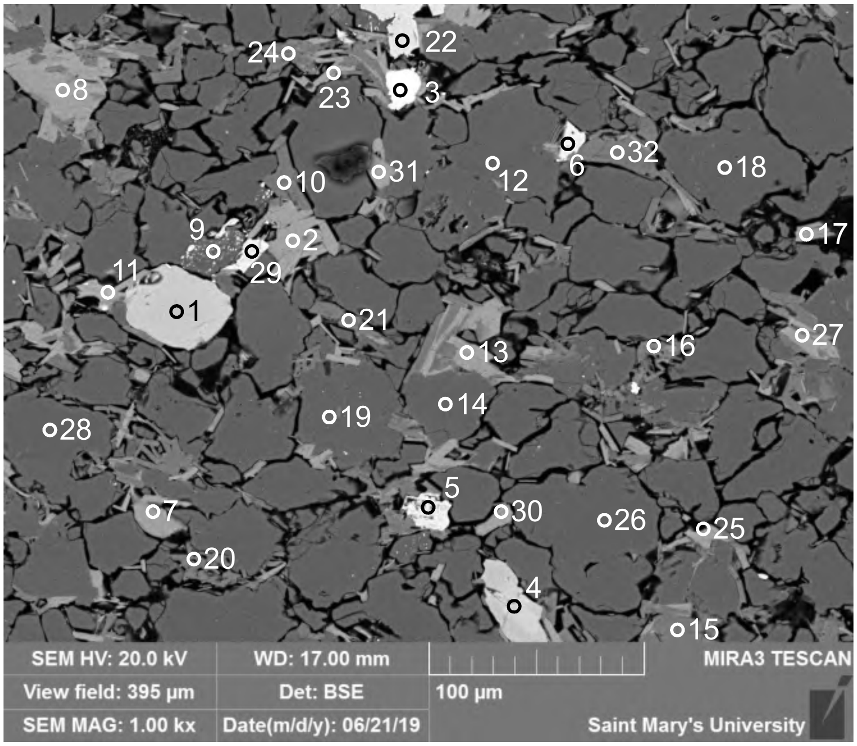
1. Apatite
2. Albite
3. Ms+ Chl
4. TiO2+
5. Chlorite
6. Muscovite
7. Albite
8. Quartz
9. Chlorite
10. Quartz
11. Muscovite
12. Chlorite
13. Quartz
14. Muscovite
15. Muscovite
16. Quartz
17. Chlorite
18. Quartz

Figure 10.6-25. Sample OD2016-D2-016-2 site 18.



1. Zircon
2. Chlorite
3. Albite
4. TiO2+
5. Chlorite
6. Muscovite
7. Albite
8. Muscovite
9. Chlorite
10. Muscovite
11. Chlorite
12. Ms+ Chl
13. Muscovite
14. Muscovite
15. Chlorite
16. Albite
17. Chlorite
18. Quartz
19. Albite

Figure 10.6-26. Sample OD2016-D2-016-2 site 19. Possible detrital Chlorite (2).



1. Apatite
2. Chlorite
3. Zircon
4. Apatite
5. TiO2+
6. Rutile
7. Chlorite
8. Chlorite
9. Quartz+
10. Muscovite
11. Chlorite+
12. Albite
13. Chlorite
14. Albite
15. Muscovite
16. Muscovite
17. Chlorite+
18. Quartz
19. Albite
20. Muscovite
21. Muscovite
22. Rutile
23. Chlorite+
24. Muscovite
25. Chlorite
26. Quartz
27. Chlorite
28. Quartz
29. TiO2+
30. Chlorite
31. Chlorite
32. Muscovite

Figure 10.6-27. Sample OD2016-D2-016-2 site 20.

Appendix 10.7: OD2016-D2-022-2 BSE imagery.

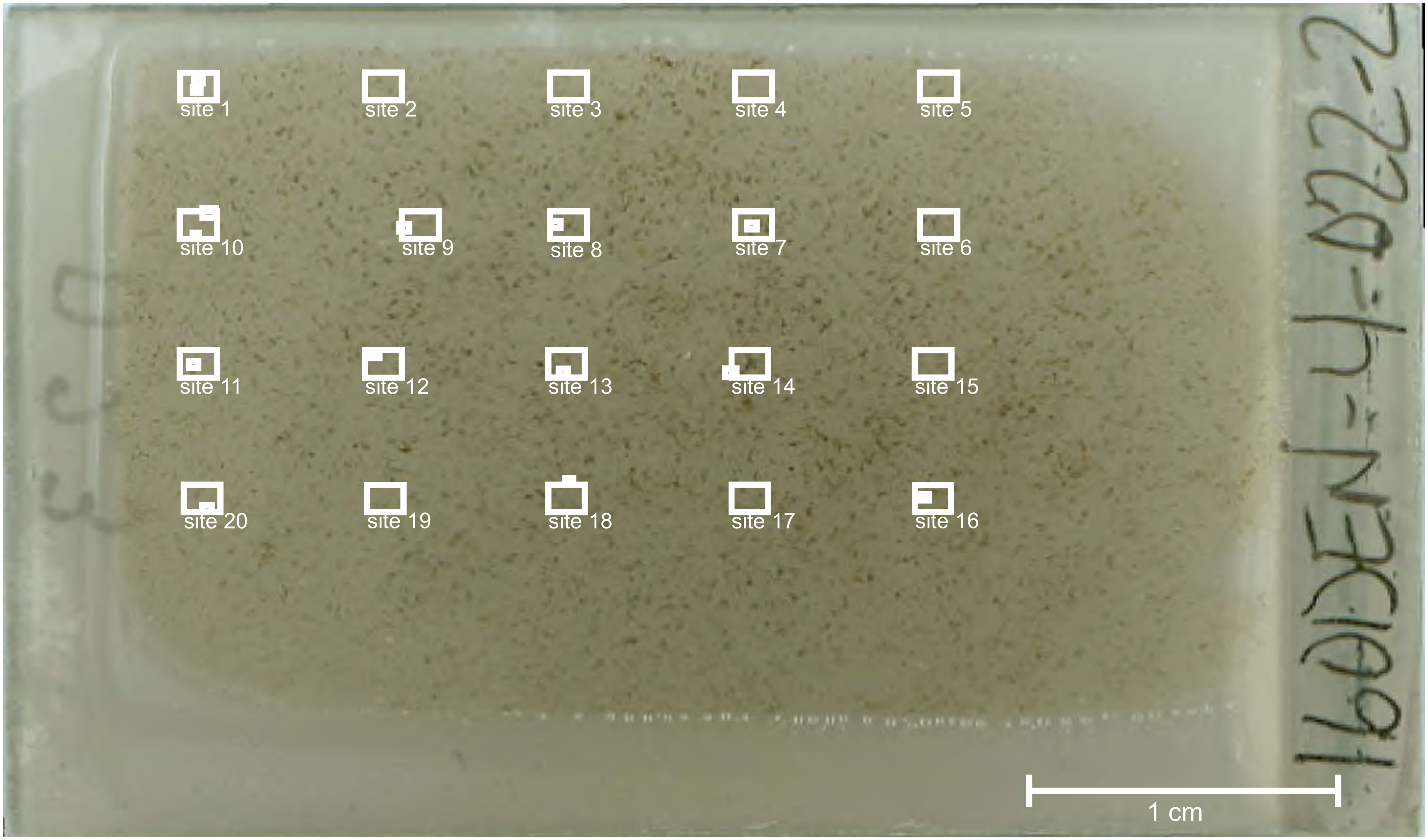
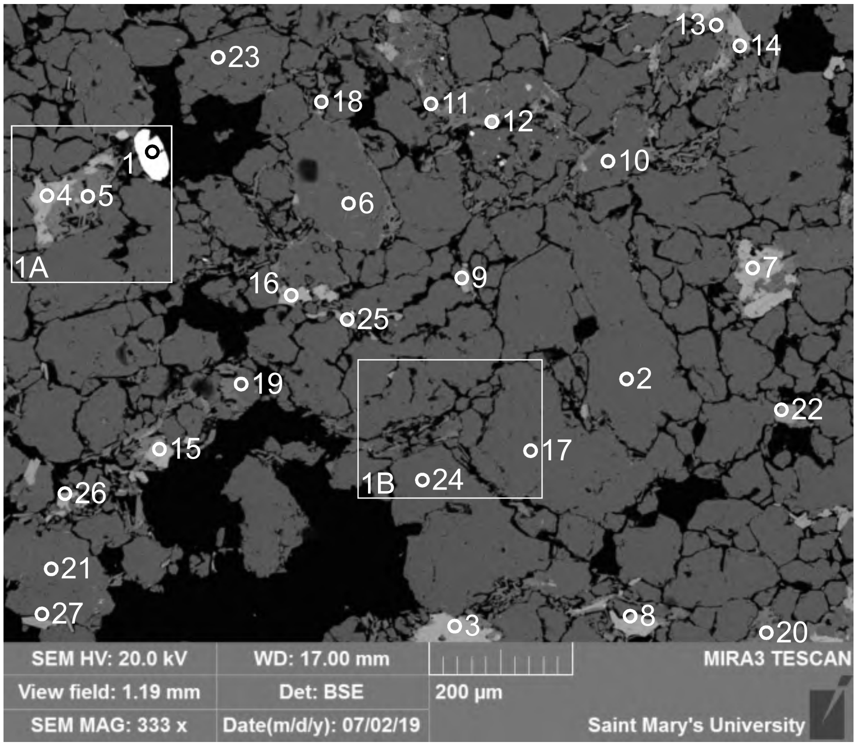


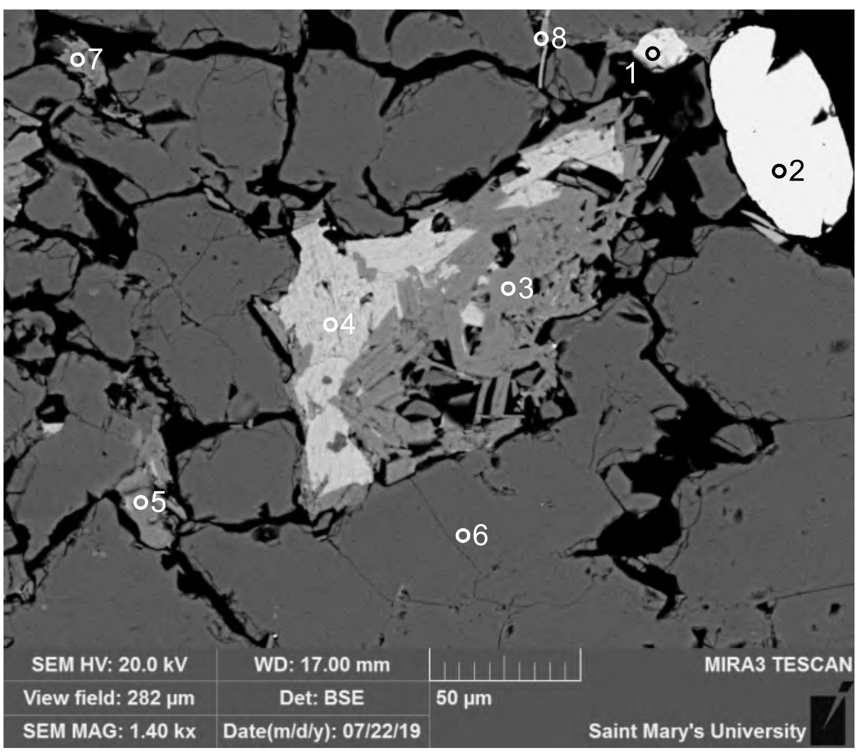
Figure 10.7-1: Slide OD2016-D2-022-2.

Figure 10.7-2: Sample OD2016-D2-022B.



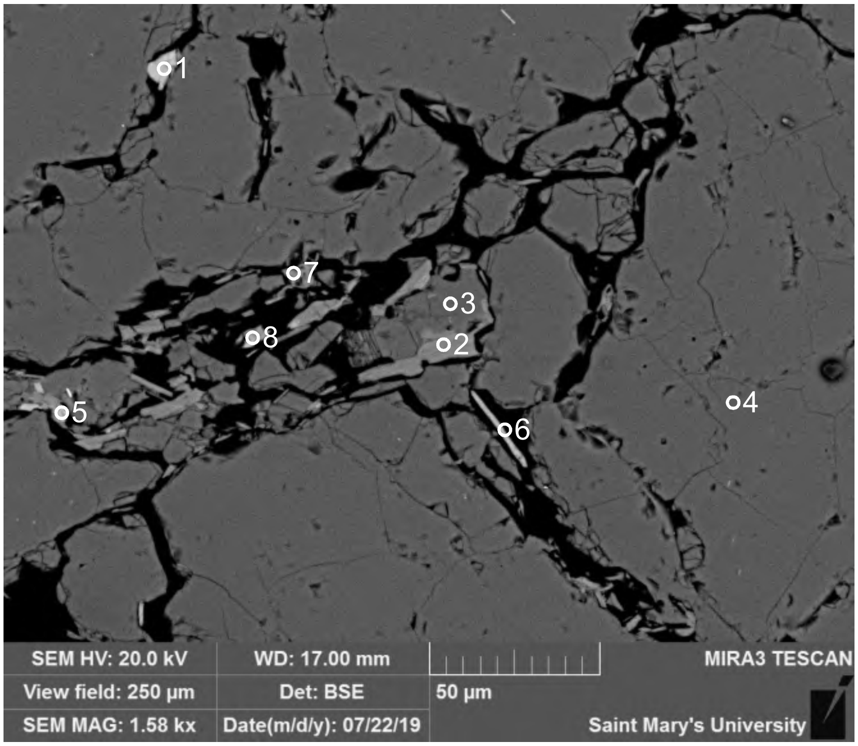
1. Zircon
2. Quartz
3. Biotite
4. Biotite
5. Muscovite
6. Ms+ Ab
7. Biotite
8. Biotite
9. Chlorite
10. Albite
11. Muscovite
12. Apatite
13. Muscovite
14. Chlorite
15. Biotite
16. Biotite
17. Quartz
18. Muscovite
19. Albite
20. Muscovite
21. Albite
22. Chlorite+
23. Quartz
24. Quartz
25. Chlorite
26. Biotite
27. Chlorite

Figure 10.7-3. Sample OD2016-D2-022-2 site 1. Quartz suturing between quartz grains. DT: Albite, Quartz, Zircon; DG: Biotite, Muscovite, Chlorite.



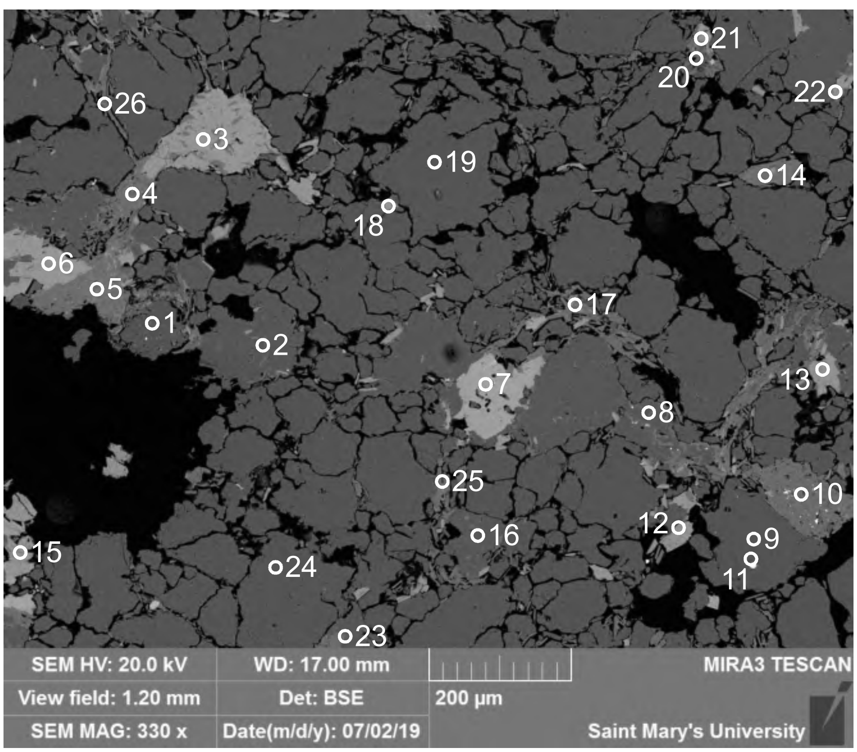
1. Apatite
2. Zircon
3. Muscovite
4. Biotite
5. Muscovite
6. Quartz
7. Muscovite
8. Chlorite

Figure 10.7-4. Sample OD2016-D2-022-2 site 1A. DT: Apatite.



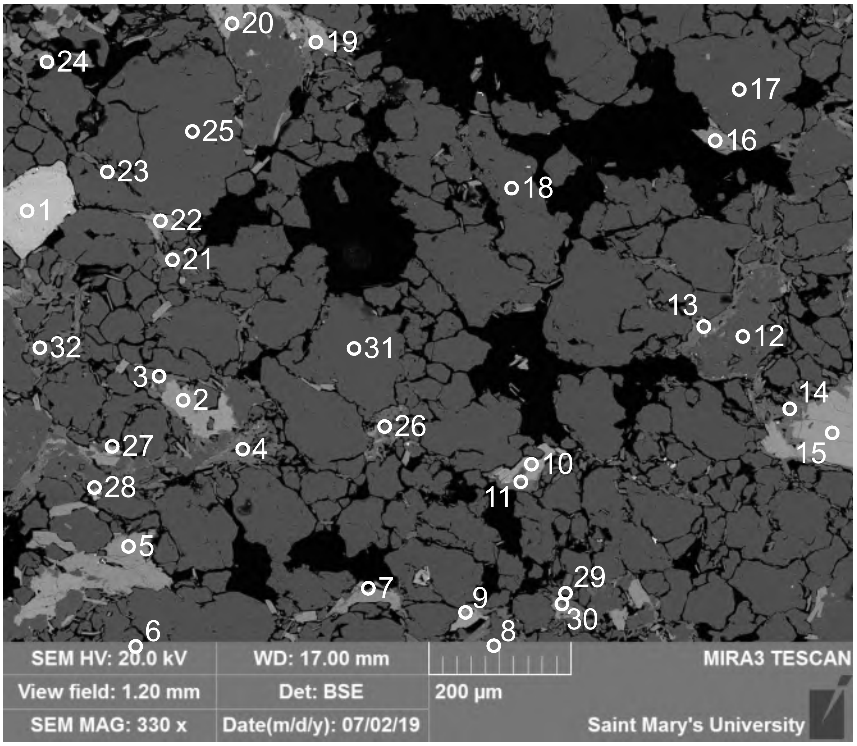
1. Chlorite
2. Muscovite
3. Albite
4. Quartz
5. Chlorite
6. Chlorite
7. Muscovite
8. Muscovite

Figure 10.7-5. Sample OD2016-D2-022-2 site 1B.



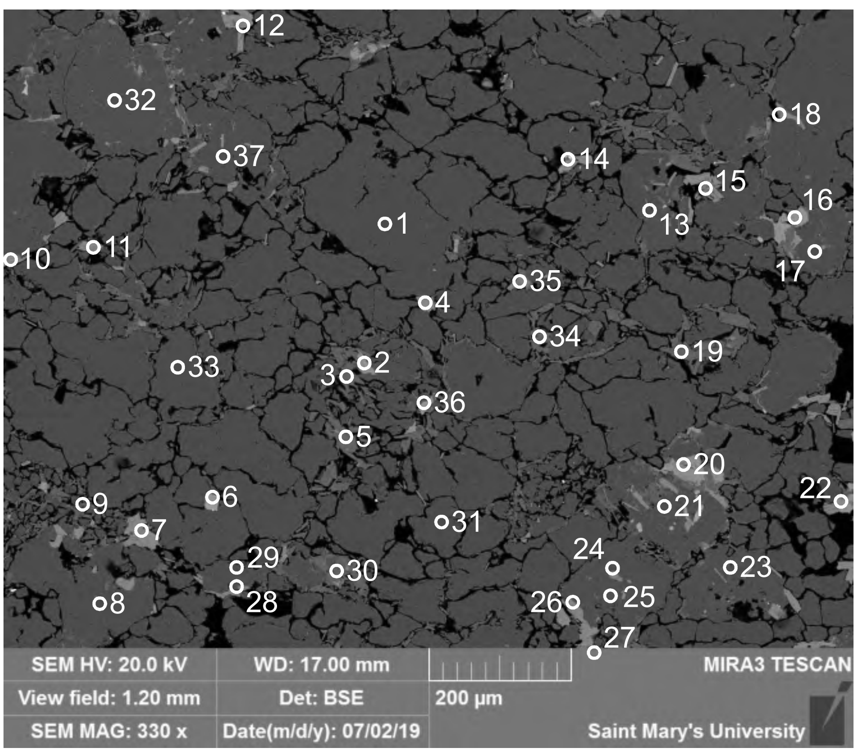
1. Qz+ Ms
2. Albite
3. Chlorite
4. Muscovite
5. Ms+ Chl
6. Chlorite
7. Biotite
8. Albite
9. Quartz
10. Muscovite
11. Zircon
12. Chlorite
13. Chlorite
14. Muscovite
15. Chlorite
16. Albite
17. Muscovite
18. Chlorite
19. Quartz
20. Muscovite
21. Chlorite
22. Chlorite
23. Albite
24. Quartz
25. Ms+ Chl
26. Muscovite

Figure 10.7-6. Sample OD2016-D2-022-2 site 2. DG: Chlorite (3).



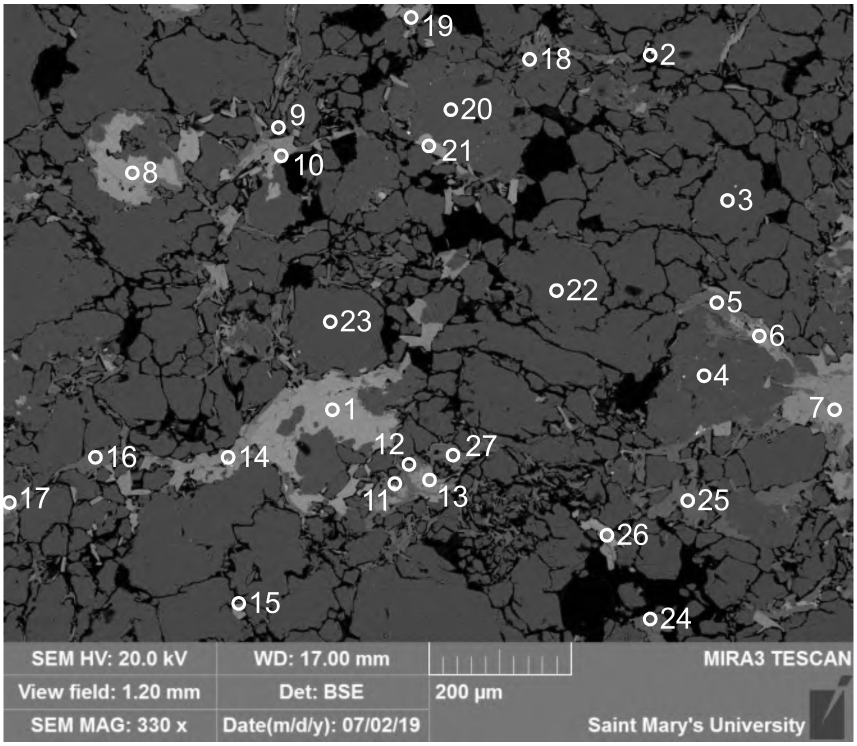
1. Apatite
2. Biotite
3. Muscovite
4. Muscovite
5. Chlorite
6. Chlorite
7. Chlorite
8. Chlorite
9. Biotite
10. Biotite
11. Muscovite
12. Albite
13. Muscovite
14. Muscovite
15. Biotite
16. Chlorite
17. Quartz
18. Quartz
19. Biotite
20. Biotite
21. Muscovite
22. Chlorite
23. Muscovite
24. Chlorite+
25. Quartz
26. Muscovite
27. Apatite
28. Apatite
29. Muscovite
30. Chlorite
31. Quartz
32. Muscovite

Figure 10.7-7. Sample OD2016-D2-022-2 site 3. DT: Apatite.



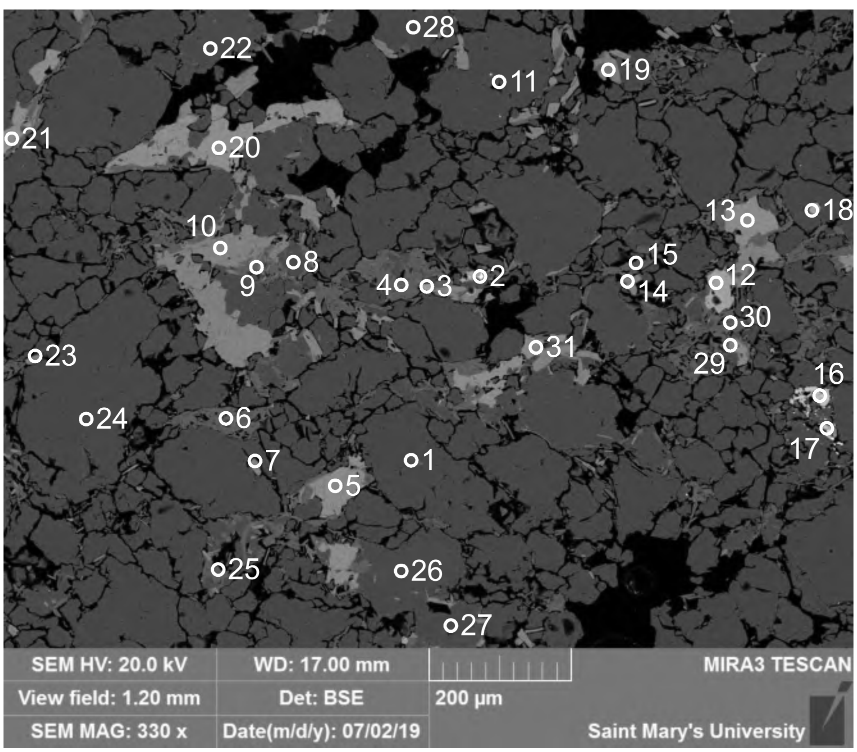
1. Quartz
2. Biotite
3. Muscovite
4. Chlorite
5. Muscovite
6. Apatite
7. Chlorite
8. Albite
9. Ab+ Ms
10. Chlorite
11. Chlorite
12. Chlorite
13. Albite
14. Ilmenite+
15. Chlorite+
16. Biotite
17. Albite
18. Chlorite
19. Muscovite
20. Biotite
21. Ms+ Ab
22. Biotite
23. Albite
24. Chlorite
25. Albite
26. Chlorite
27. Ms+ Chl
28. Chlorite+
29. Albite
30. Muscovite
31. Quartz
32. Albite
33. Quartz
34. Muscovite
35. Chlorite
36. Biotite
37. Albite

Figure 10.7-8. Sample OD2016-D2-022-2 site 4. Sutured Quartz grains (1). DG: Biotite, Chlorite, Muscovite; LC: (20) Biotite, (21) Albite.



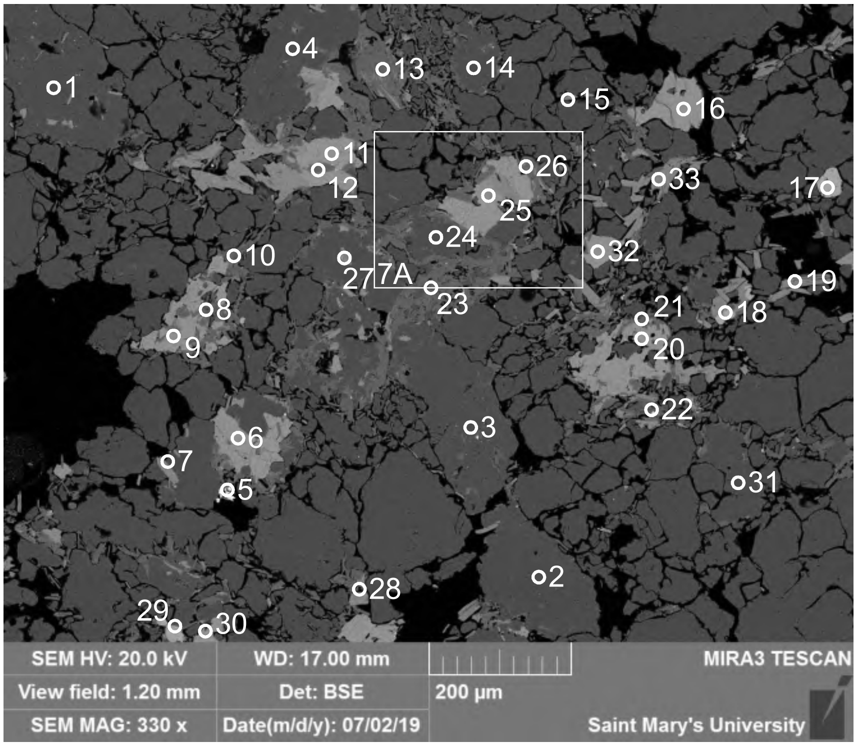
1. Chlorite+
2. Monazite+
3. Quartz
4. Albite
5. Muscovite
6. Biotite
7. Chlorite
8. Biotite
9. Muscovite
10. Albite+
11. Zircon
12. Muscovite
13. Chlorite
14. Chlorite
15. Chlorite
16. Muscovite
17. Biotite
18. Muscovite
19. Chlorite
20. Albite
21. Biotite
22. Quartz
23. Quartz
24. Ms+ Chl
25. Muscovite
26. Chl+Ms
27. Muscovite

Figure 10.7-9. Sample OD2016-D2-022-2 site 5. DT: Albite, Quartz, Zircon; DG: Biotite, Chlorite, Monazite, Muscovite.



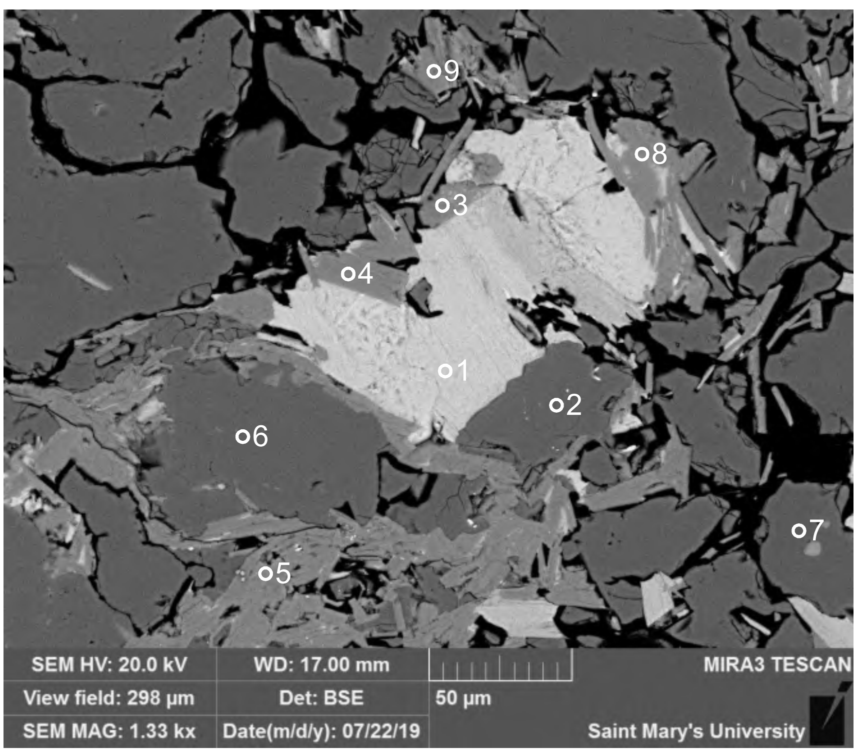
1. Quartz
2. Monazite+
3. Apatite
4. Muscovite
5. Biotite
6. Muscovite
7. Chlorite
8. Albite
9. Muscovite
10. Chlorite
11. Quartz
12. Apatite
13. Biotite
14. Chlorite
15. Muscovite
16. TiO2+
17. Ilmenite+
18. Apatite
19. Chlorite
20. Biotite
21. Biotite
22. Albite
23. Chlorite
24. Quartz
25. Muscovite
26. Albite
27. Ab+ Ms
28. Albite
29. Biotite
30. Muscovite
31. Chl+ Ms

Figure 10.7-10. Sample OD2016-D2-022-2 site 6. DT: Albite, Apatite (18), Quartz, Zircon; DG: Apatite (12) Biotite, Chlorite, Monazite, Muscovite, TiO2.



1. Albite
2. Albite
3. Albite
4. Albite
5. Ilmenite
6. Biotite
7. Chlorite
8. Muscovite
9. Biotite
10. Muscovite
11. Biotite
12. Muscovite
13. Muscovite
14. Albite
15. Chlorite
16. Biotite
17. Apatite
18. Apatite
19. Chlorite
20. Biotite
21. Muscovite
22. Monazite+
23. Muscovite
24. Albite
25. Biotite
26. Muscovite
27. Chlorite
28. Chlorite
29. Apatite
30. Biotite
31. Albite
32. Biotite
33. Chlorite

Figure 10.7-11. Sample OD2016-D2-022-2 site 7. DT: Albite, Quartz; DG: Biotite, Chlorite, Monazite, Muscovite.



1. Biotite
2. Albite
3. Muscovite
4. Muscovite
5. Muscovite
6. Albite
7. Quartz
8. Muscovite
9. Muscovite

Figure 10.7-12. Sample OD2016-D2-022-2 site 7A.

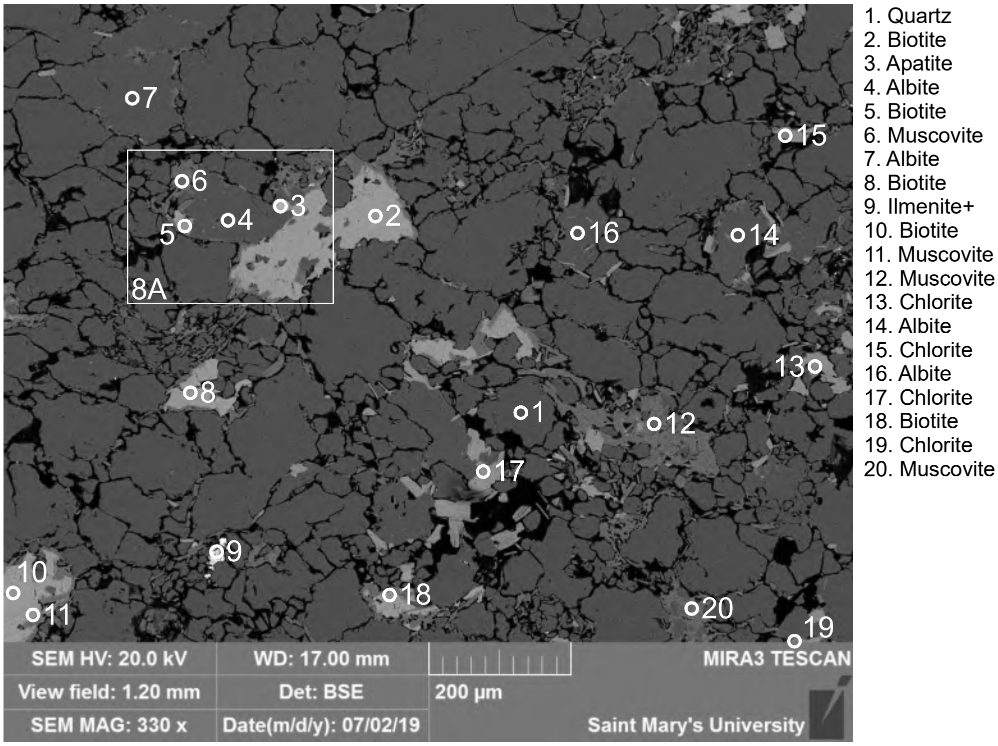


Figure 10.7-13. Sample OD2016-D2-022-2 site 8.

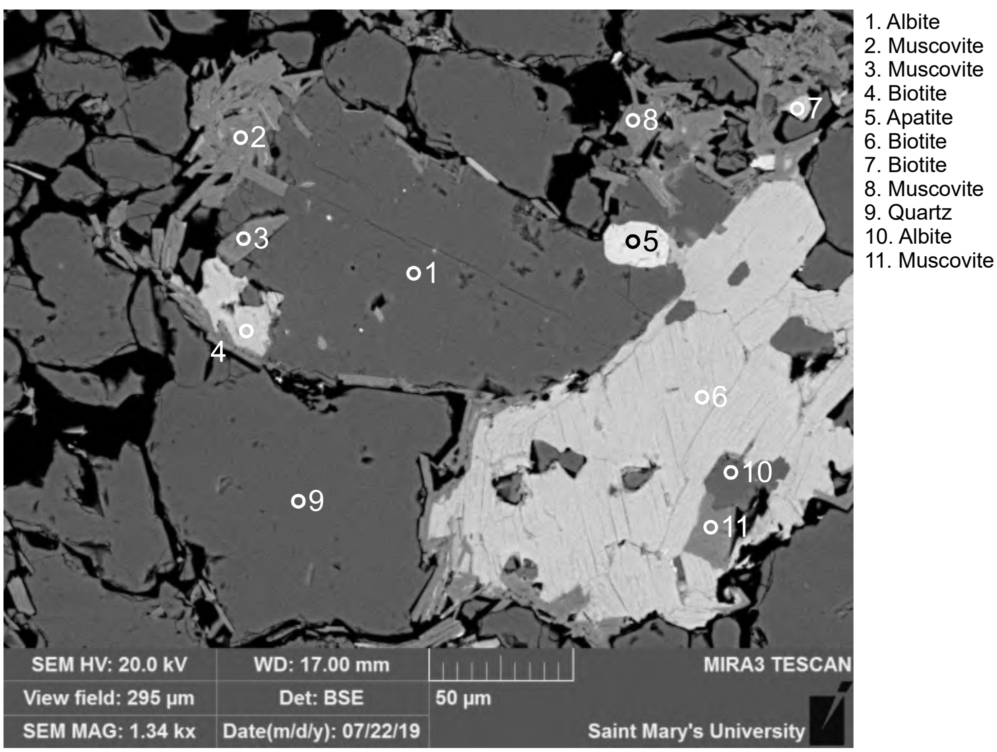
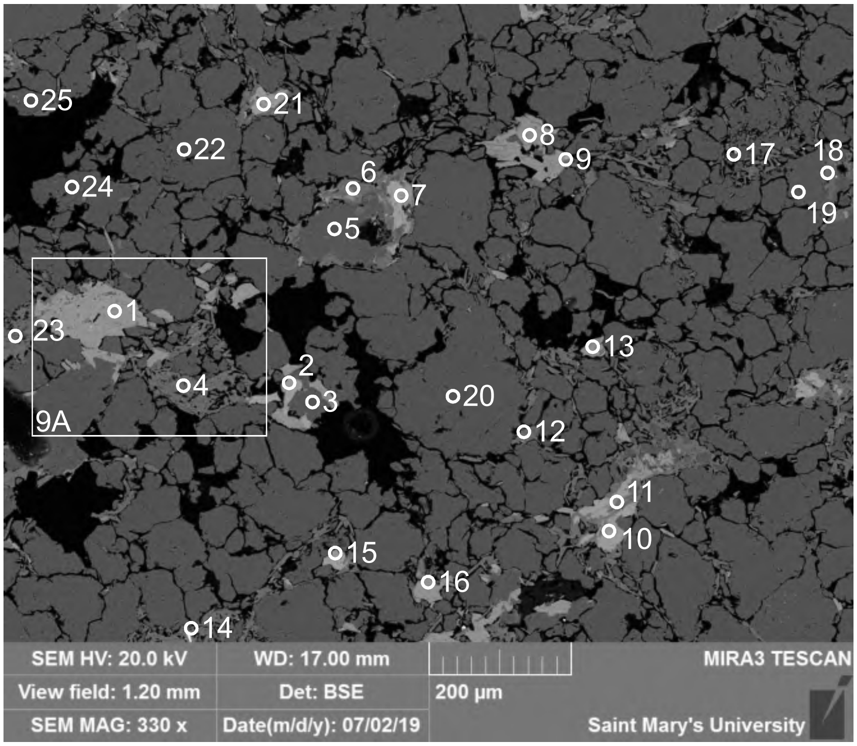
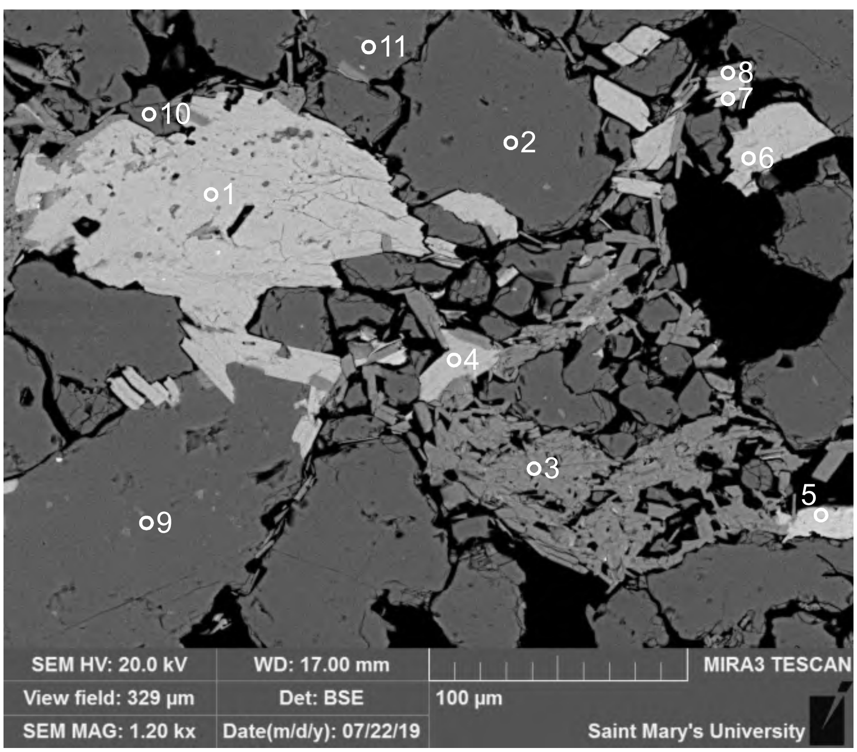


Figure 10.7-14. Sample OD2016-D2-022-2 site 8A. DT: Albite, Apatite, Quartz; DG: Biotite, Muscovite.



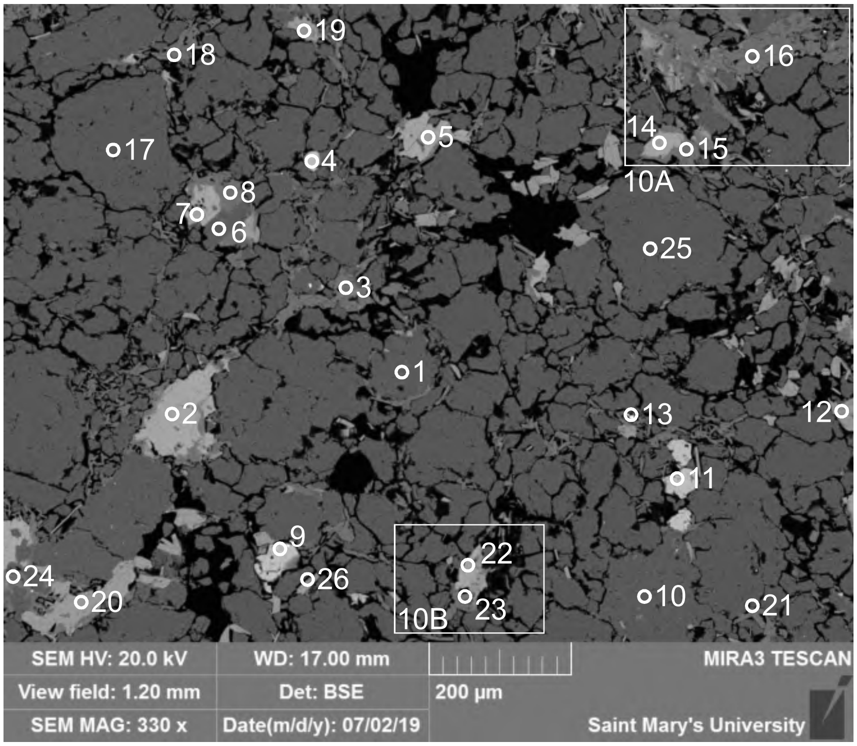
1. Chlorite
2. Biotite
3. Albite
4. Muscovite
5. Albite
6. Muscovite
7. Biotite
8. Chlorite
9. Apatite
10. Biotite
11. Ms+
12. Ms+ Chl
13. Chlorite
14. Muscovite
15. Biotite
16. Chlorite
17. Muscovite
18. Muscovite
19. Albite
20. Quartz
21. Biotite
22. Quartz
23. Muscovite
24. Albite
25. Albite

Figure 10.7-15. Sample OD2016-D2-022-2 site 9.



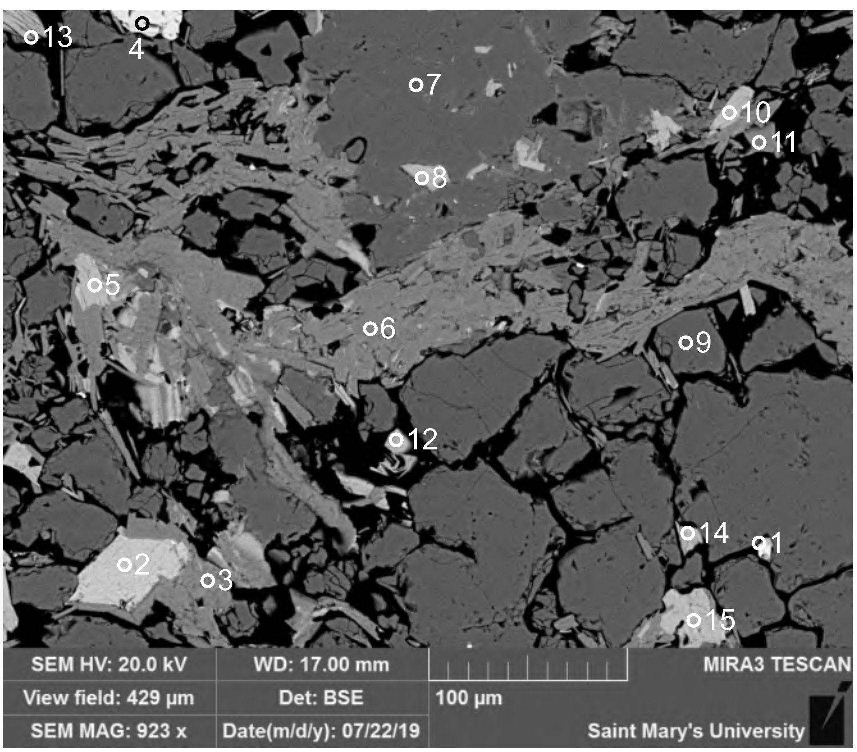
1. Chlorite
2. Quartz
3. Muscovite
4. Chlorite
5. Biotite
6. Chlorite
7. Chlorite
8. Muscovite
9. Albite
10. Quartz
11. Albite

Figure 10.7-16. Sample OD2016-D2-022-2 site 9A.



1. Albite+
2. Biotite
3. Muscovite
4. Apatite
5. Biotite
6. Albite
7. Biotite
8. Muscovite
9. Apatite
10. Albite
11. Apatite
12. Chlorite
13. Monazite+
14. Biotite
15. Muscovite
16. Muscovite
17. Quartz
18. Muscovite
19. Chlorite
20. Chlorite
21. Muscovite
22. Bt+ Chl
23. Muscovite
24. Muscovite
25. Quartz
26. Chlorite

Figure 10.7-17. Sample OD2016-D2-022-2 site 10. DT: Apatite (4, 11).



1. TiO2+
2. Biotite
3. Muscovite
4. Apatite
5. Chlorite
6. Muscovite
7. Albite
8. Chlorite
9. Quartz
10. Chlorite
11. Muscovite
12. Chlorite
13. Chlorite
14. Chlorite
15. Chlorite

Figure 10.7-18. Sample OD2016-D2-022-2 site 10A. Mica grains appear to be either bent or filling spaces between detrital grains.

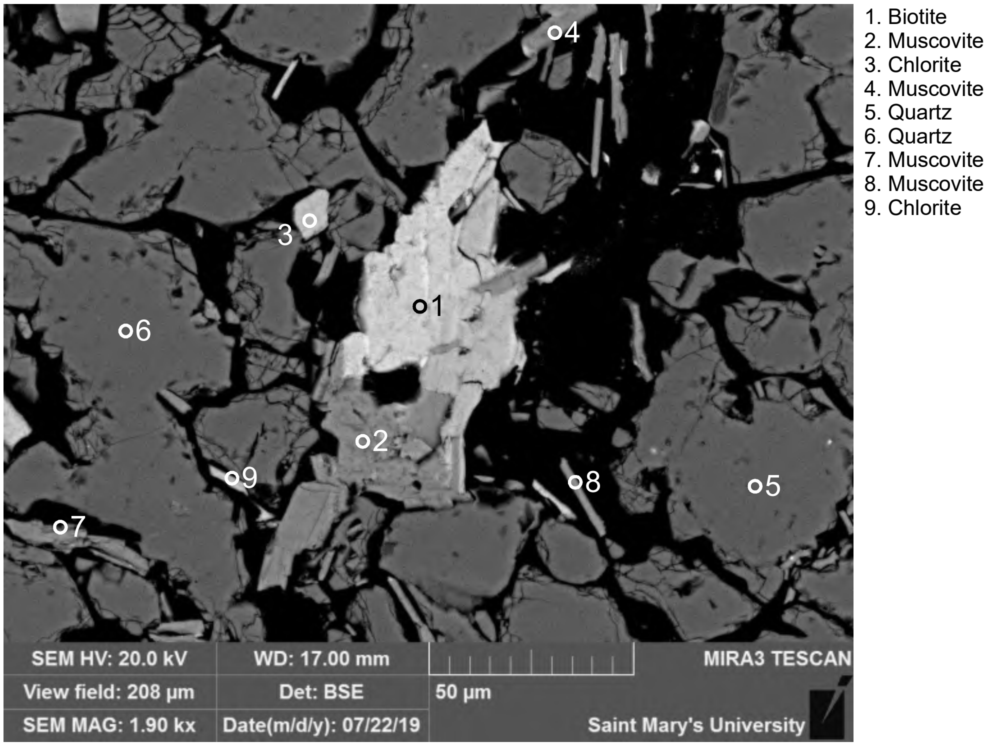


Figure 10.7-19. Sample OD2016-D2-022-2 site 10B.

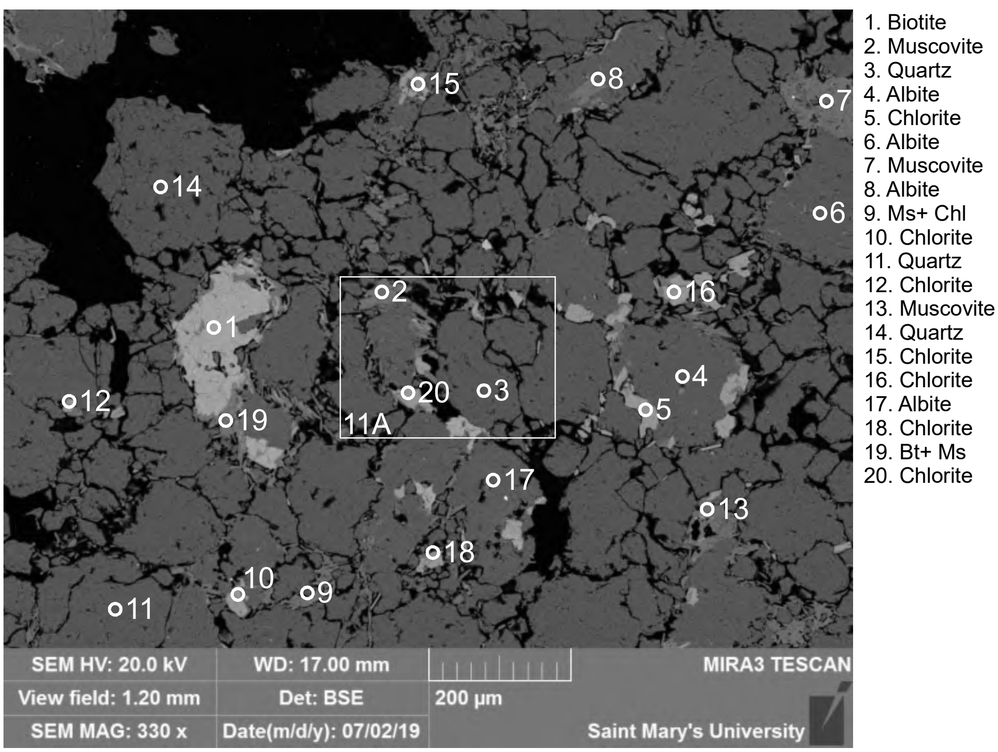


Figure 10.7-20. Sample OD2016-D2-022-2 site 11.

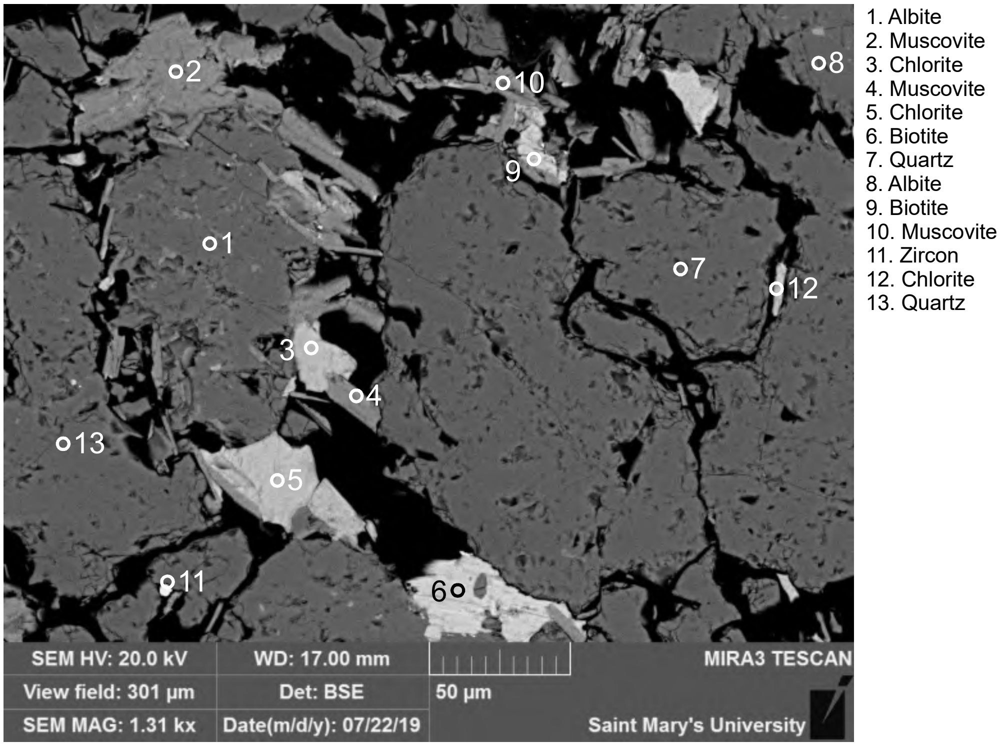


Figure 10.7-21. Sample OD2016-D2-022-2 site 11A.

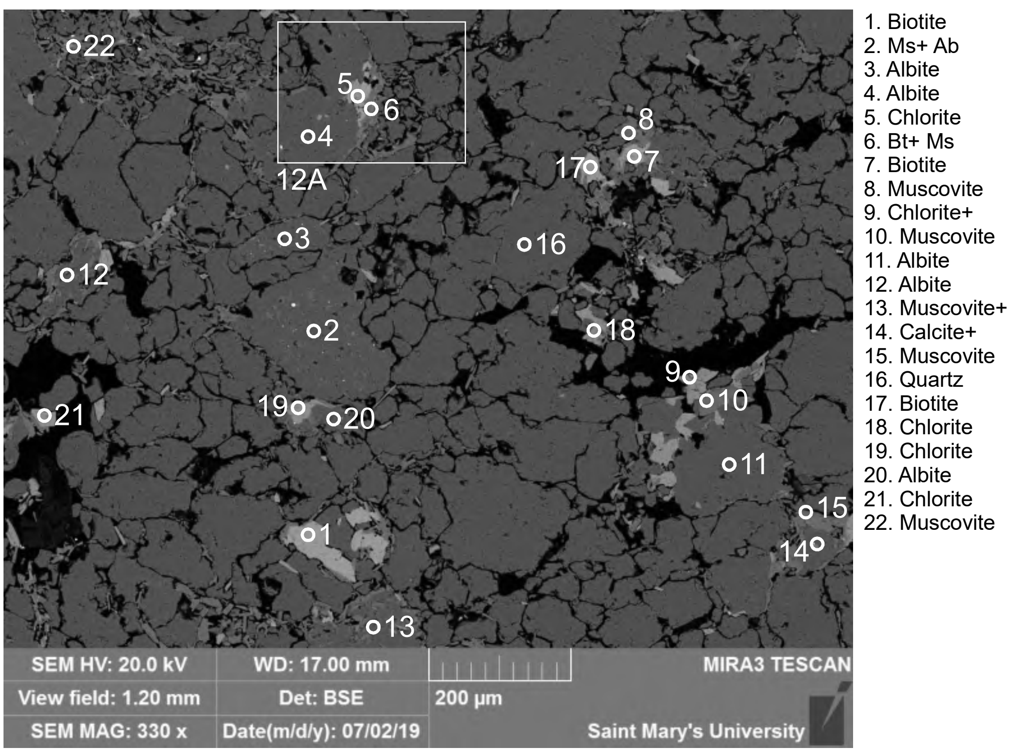


Figure 10.7-22. Sample OD2016-D2-022-2 site 12. HD: Calcite (14).

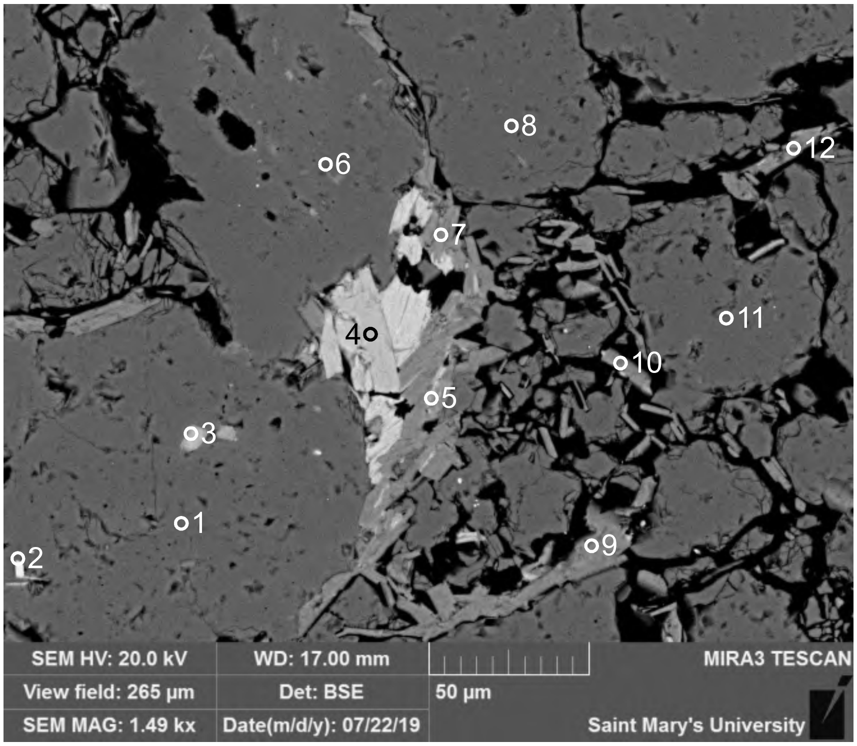


Figure 10.7-23. Sample OD2016-D2-022-2 site 12A. Rare pyrite present in albite grain.

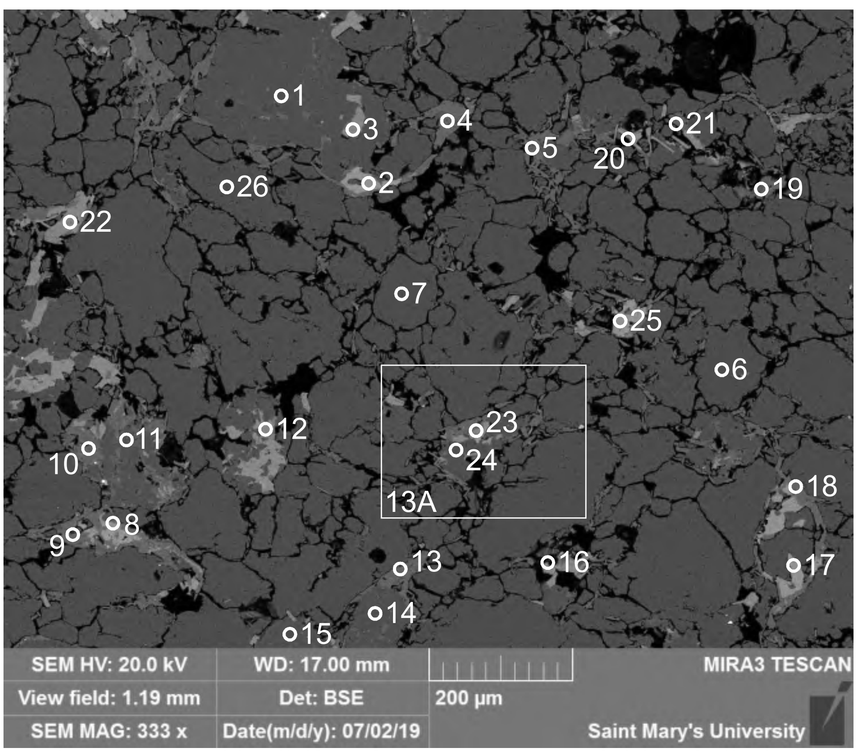
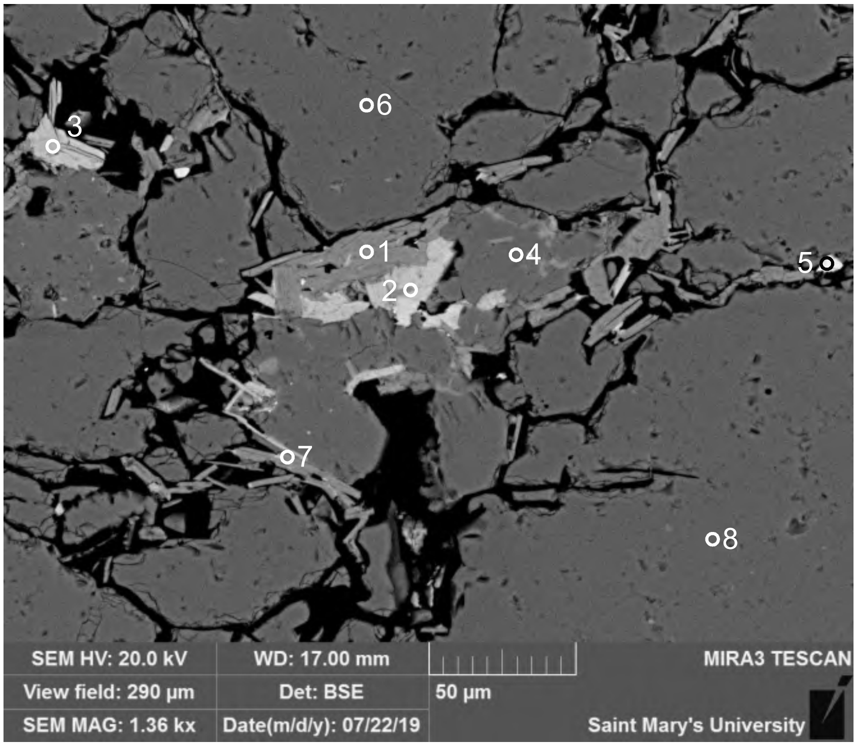
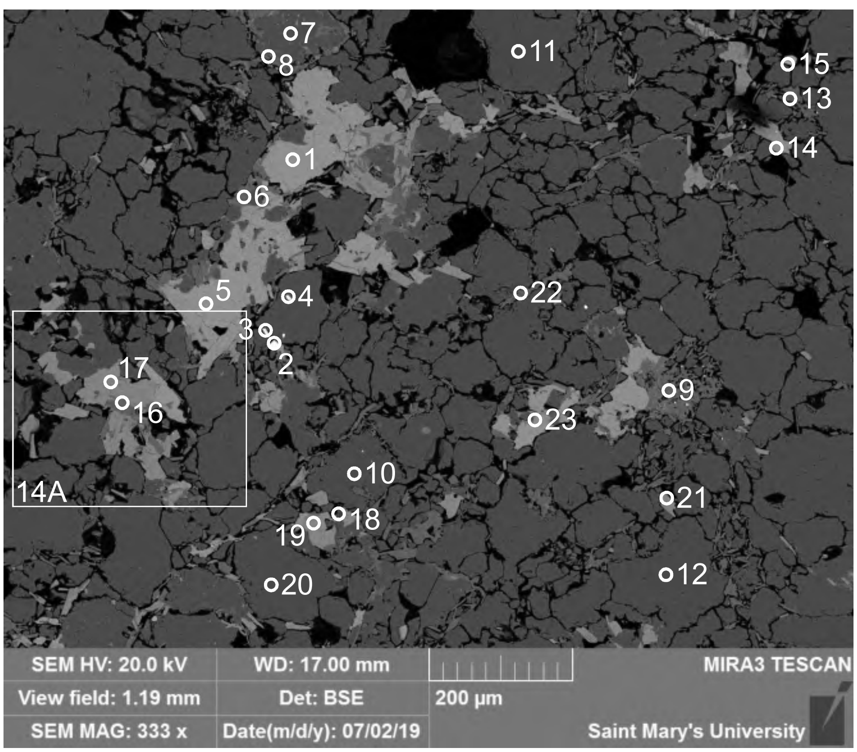


Figure 10.7-24. Sample OD2016-D2-022-2 site 13.



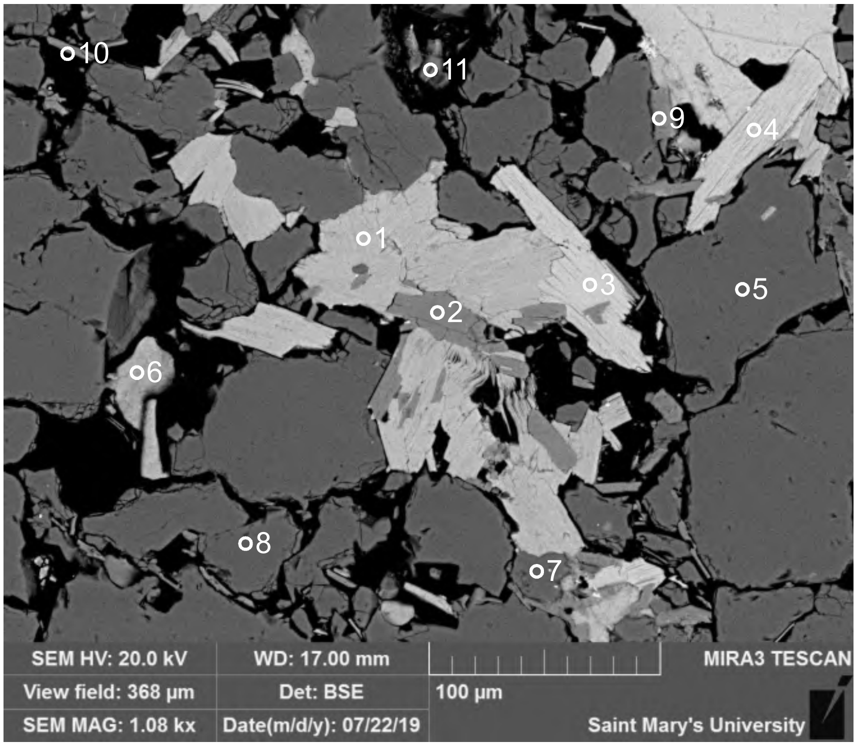
1. Muscovite
2. Chlorite
3. Chlorite
4. Albite
5. TiO2+
6. Quartz
7. Muscovite
8. Quartz

Figure 10.7-25. Sample OD2016-D2-022-2 site 13A.



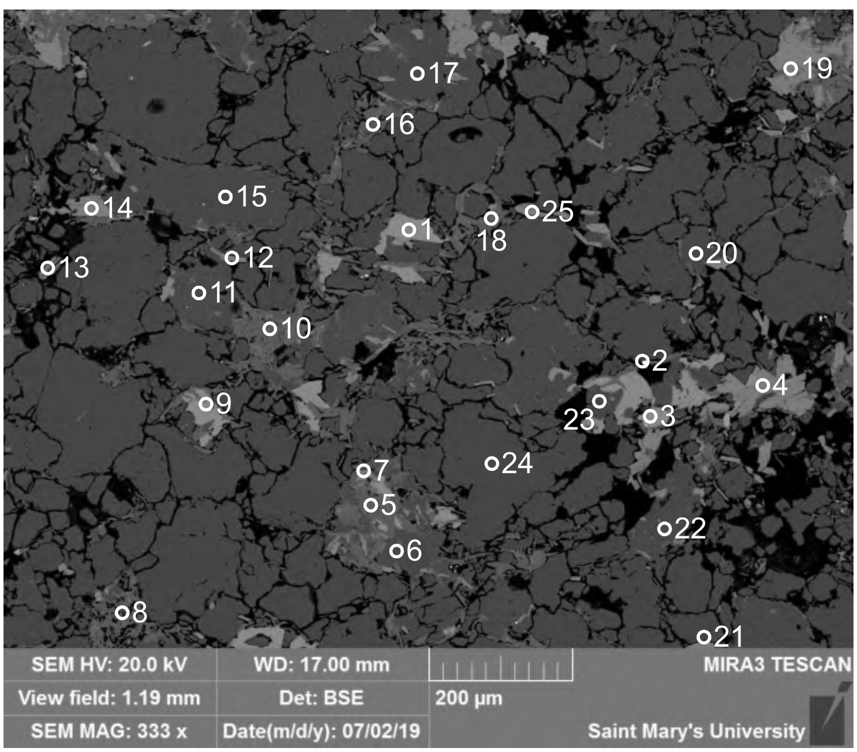
1. Biotite
2. Zircon
3. Zircon
4. Zircon
5. Biotite
6. Muscovite
7. Albite
8. Muscovite+
9. Muscovite
10. Quartz
11. Quartz
12. Quartz
13. Muscovite
14. Biotite
15. Apatite
16. Muscovite
17. Chlorite
18. Ilm+ Ms
19. Chlorite
20. Quartz
21. Chlorite
22. Muscovite
23. Biotite

Figure 10.7-26. Sample OD2016-D2-022-2 site 14.



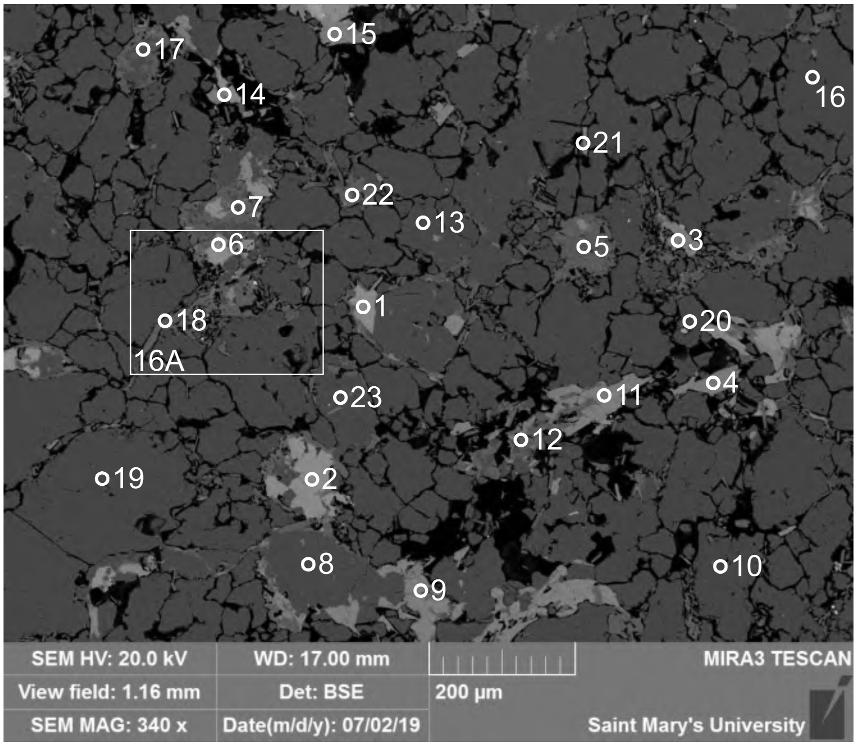
1. Chlorite
2. Muscovite
3. Biotite
4. Biotite
5. Quartz
6. Chlorite
7. Albite
8. Quartz
9. Muscovite
10. Muscovite
11. Quartz

Figure 10.7-27. Sample OD2016-D2-022-2 site 14A.



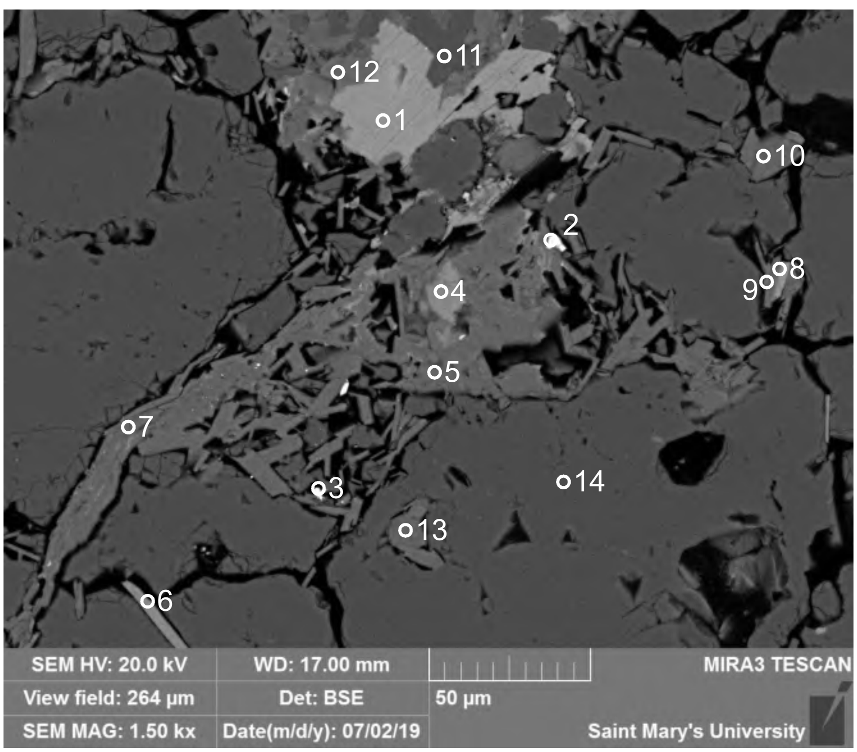
1. Biotite
2. Monazite
3. Biotite
4. Chlorite
5. Muscovite
6. Albite
7. Biotite
8. Muscovite
9. Qz+ Bt
10. Muscovite
11. Albite
12. Chlorite
13. Chlorite+
14. Chlorite
15. Albite
16. Muscovite+
17. Albite
18. Muscovite
19. Chlorite
20. Albite
21. Quartz
22. Albite
23. Albite
24. Quartz
25. Chlorite

Figure 10.7-28. Sample OD2016-D2-022-2 site 15.



1. Biotite
2. Biotite
3. Chlorite
4. Chlorite
5. Muscovite
6. Biotite
7. Albite
8. Albite
9. Chlorite
10. Quartz
11. Chlorite
12. Muscovite
13. Albite
14. Biotite
15. Chlorite
16. Quartz
17. Muscovite+
18. Muscovite
19. Quartz
20. Quartz
21. Chlorite
22. Muscovite
23. Albite

Figure 10.7-29. Sample OD2016-D2-022-2 site 16.



1. Biotite
2. Ilmenite+
3. Xenotime
4. Chlorite
5. Muscovite
6. Chlorite
7. Muscovite
8. Biotite
9. Muscovite
10. Muscovite
11. Albite
12. Muscovite
13. Muscovite
14. Quartz

Figure 10.7-30. Sample OD2016-D2-022-2 site 16A.

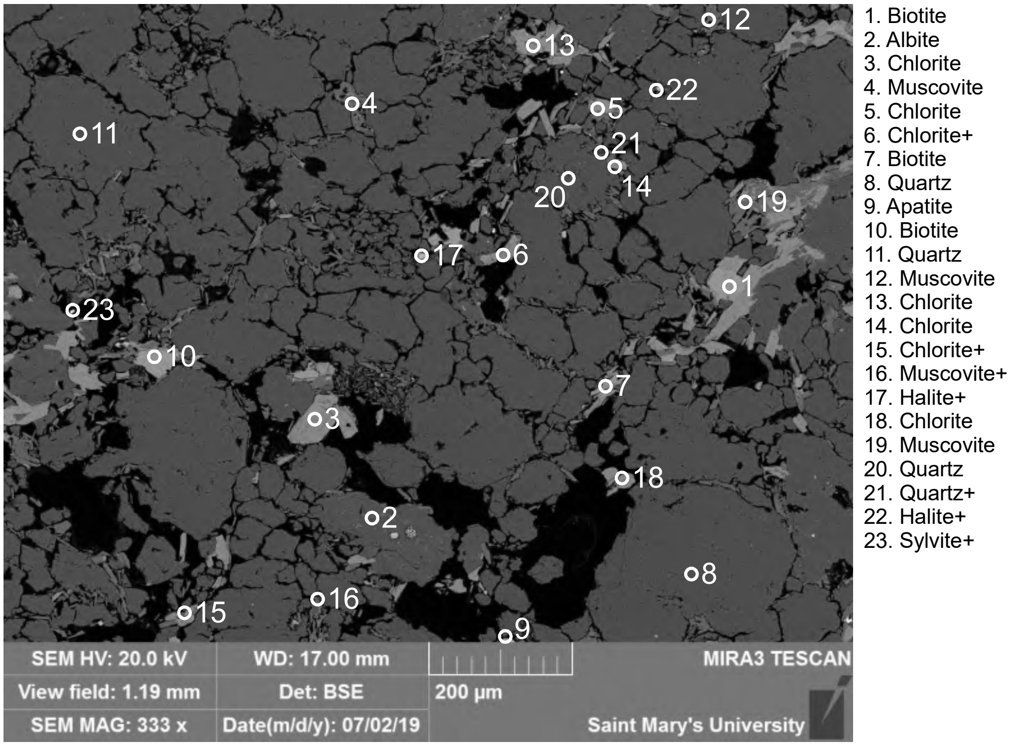


Figure 10.7-31. Sample OD2016-D2-022-2 site 17. Halite (17, 22) and Sylvite (23) may represent contamination.

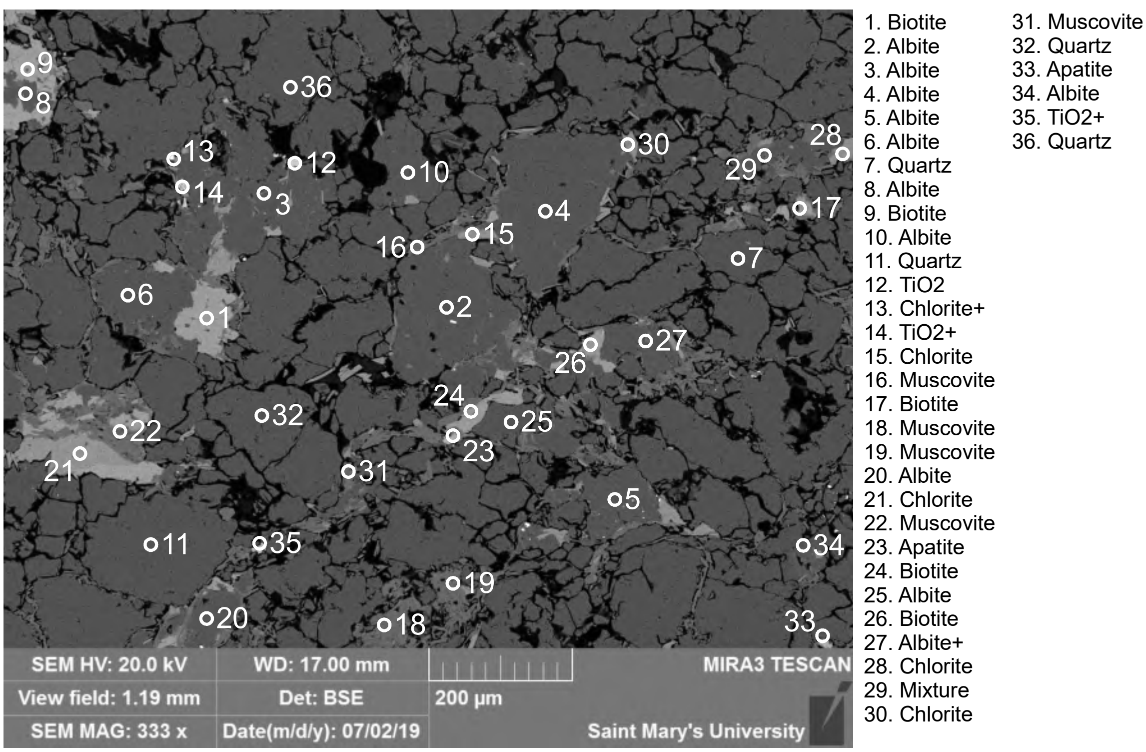
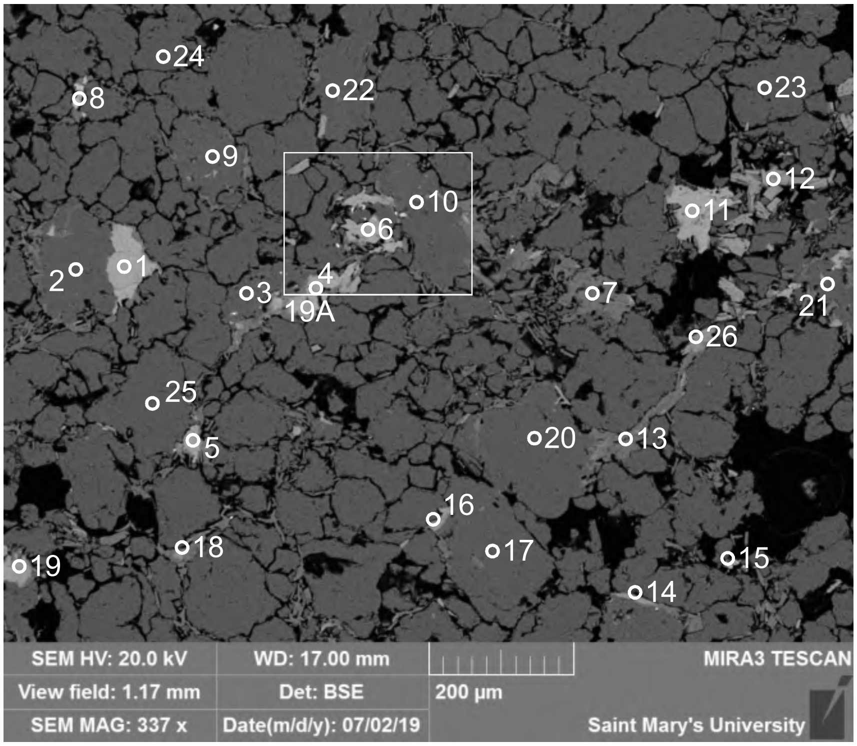
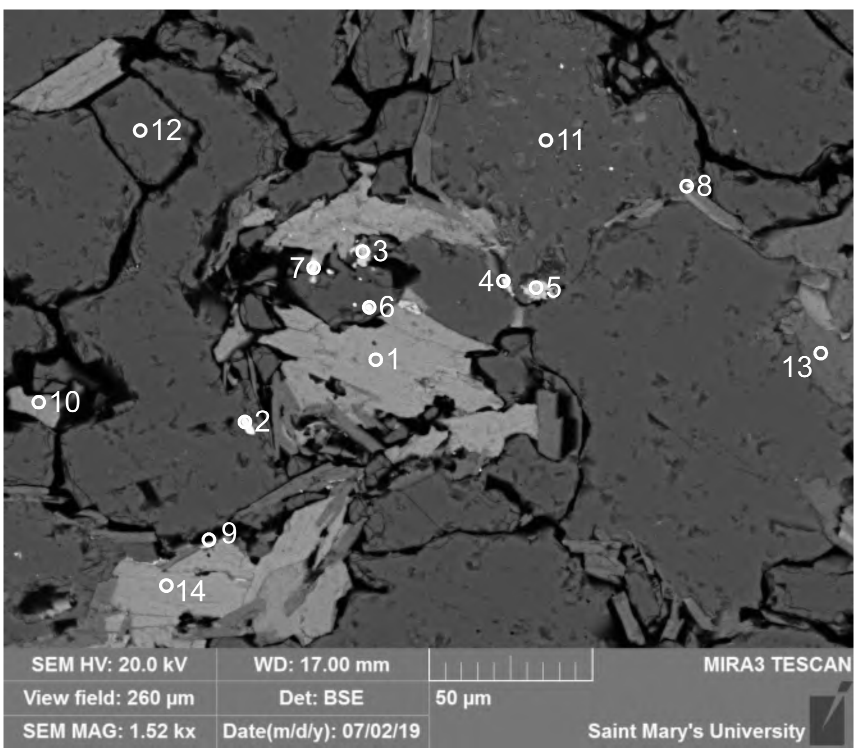


Figure 10.7-32. Sample OD2016-D2-022-2 site 18.



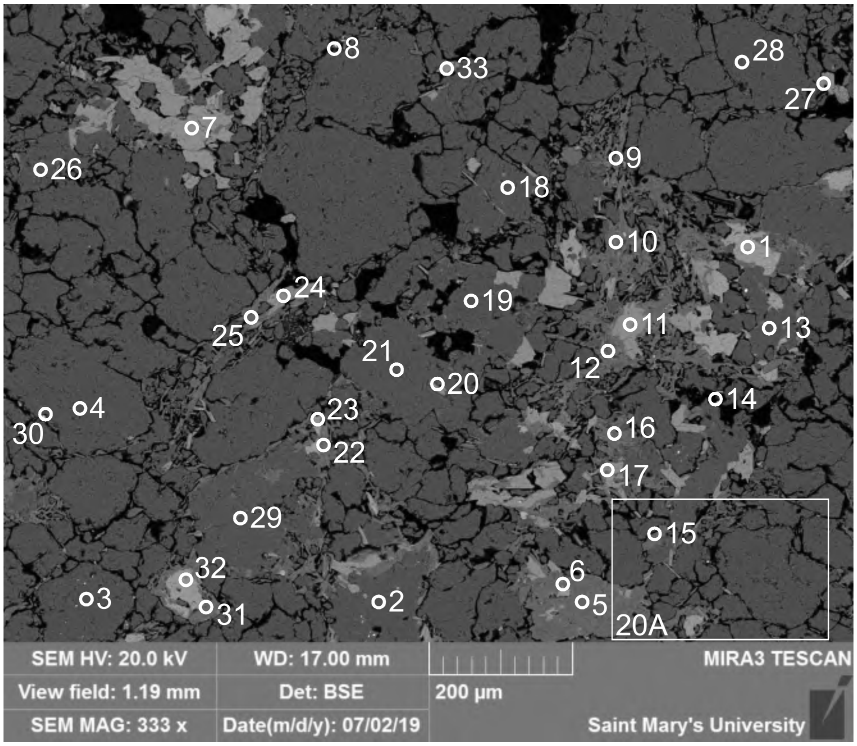
1. Biotite
2. Albite
3. Albite
4. Biotite
5. Biotite
6. Biotite
7. Muscovite
8. Apatite
9. Albite
10. Albite
11. Biotite
12. Chlorite
13. Muscovite
14. Chlorite
15. Albite
16. Chlorite
17. Albite
18. Chlorite
19. Chlorite
20. Albite
21. Albite
22. Albite
23. Quartz
24. Quartz
25. Quartz
26. Chlorite

Figure 10.7-33. Sample OD2016-D2-022-2 site 19.



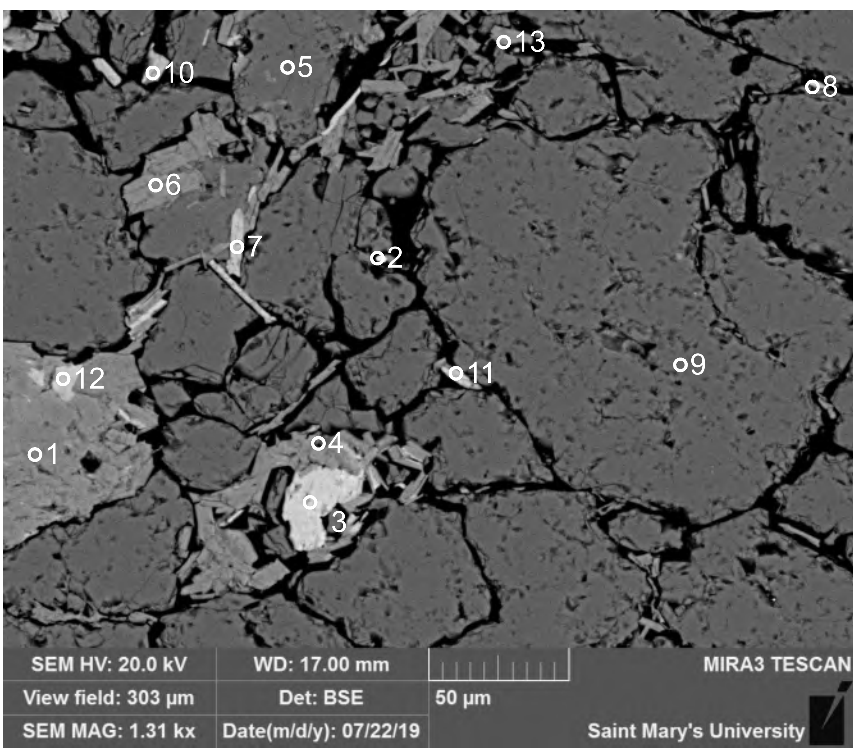
1. Biotite
2. Ilmenite+
3. TiO_2+
4. Monazite+
5. TiO_2+
6. Ilmenite+
7. Ilmenite+
8. Monazite+
9. TiO_2 + Bt
10. Chlorite
11. Albite
12. Quartz
13. Muscovite
14. Biotite

Figure 10.7-34. Sample OD2016-D2-022-2 site 19A.



1. Biotite
2. Albite
3. Quartz
4. Quartz
5. Muscovite
6. Biotite
7. Chlorite
8. Monazite+
9. Ms+ Bt
10. Muscovite
11. Chlorite
12. Muscovite
13. Albite
14. Monazite
15. Ms+ Ab
16. Ms+ Chl
17. Chlorite
18. Albite
19. Albite
20. Chlorite
21. Albite
22. Ms+ Chl
23. Biotite
24. Chlorite
25. Muscovite
26. Albite
27. Chlorite
28. Quartz
29. Albite
30. TiO2+
31. Muscovite
32. Biotite
33. Chlorite

Figure 10.7-35. Sample OD2016-D2-022-2 site 20.



1. Muscovite
2. Monazite
3. Biotite
4. Ms+ Qz
5. Albite
6. Muscovite
7. Chlorite
8. Chlorite
9. Quartz
10. Chlorite
11. Chlorite
12. Chlorite
13. Muscovite

Figure 10.7-36. Sample OD2016-D2-022-2 site 20A.

Appendix 10.8: OD2016-D2-027 BSE imagery.

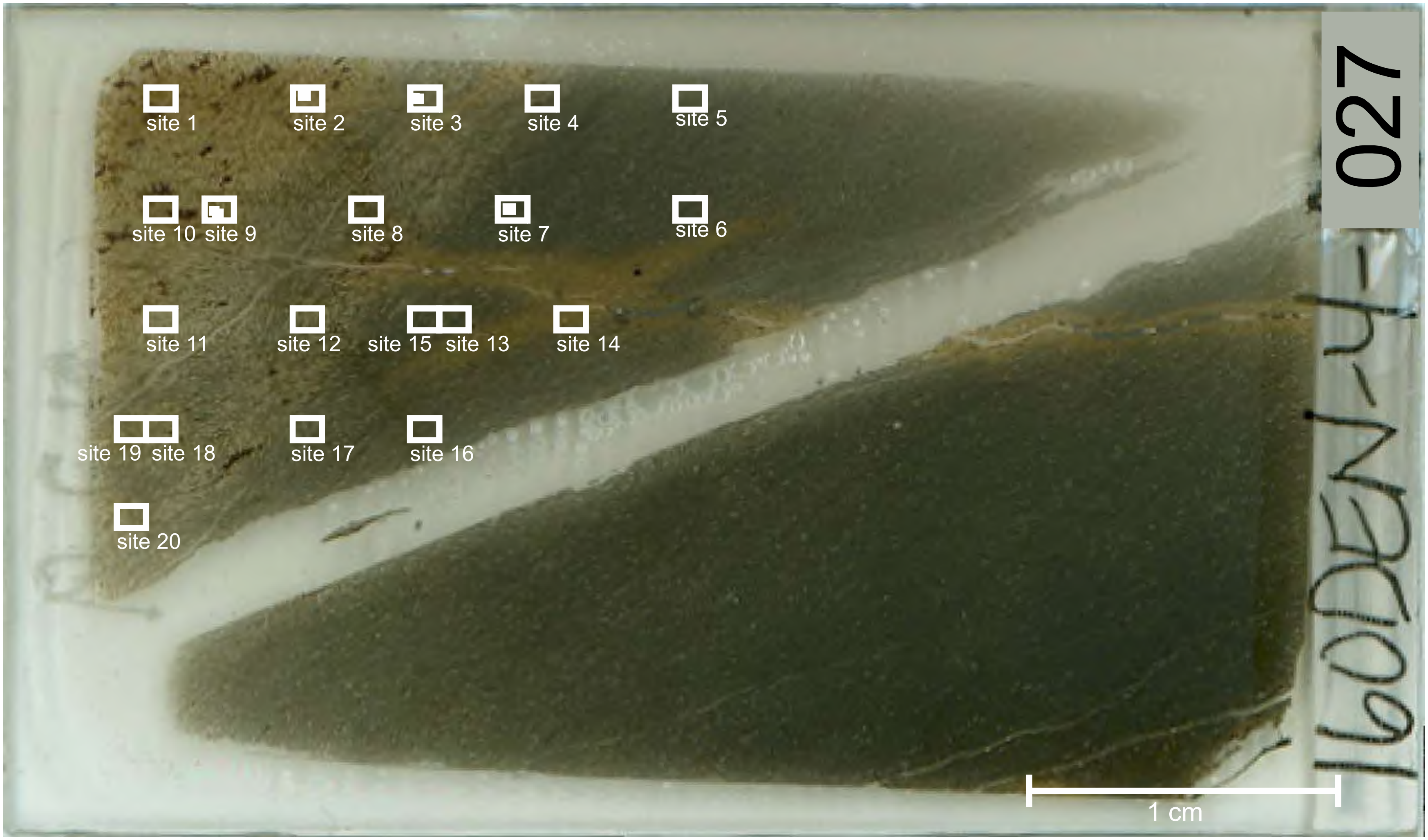


Figure 10.8-1: Slide OD2016-D2-027.

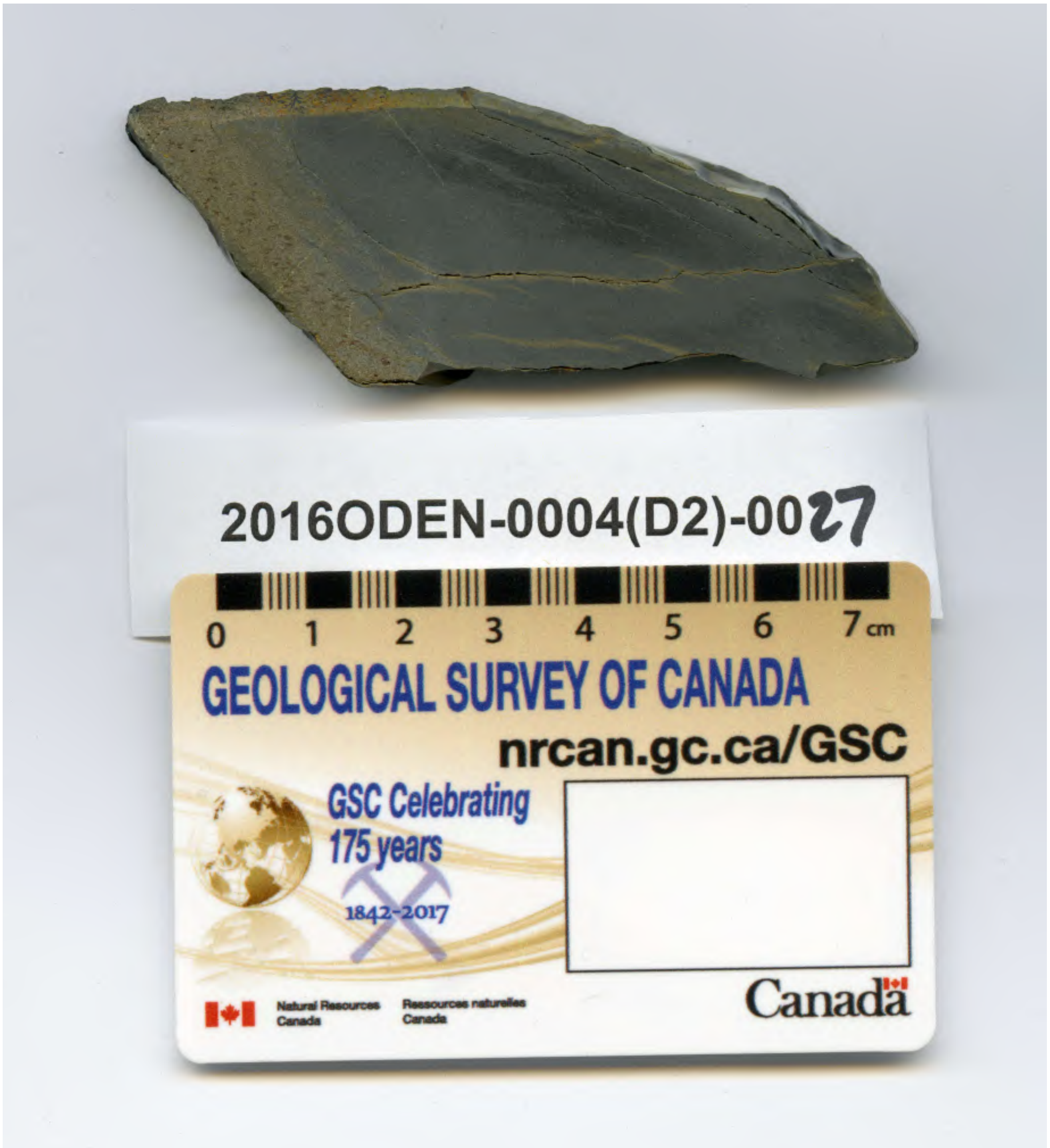
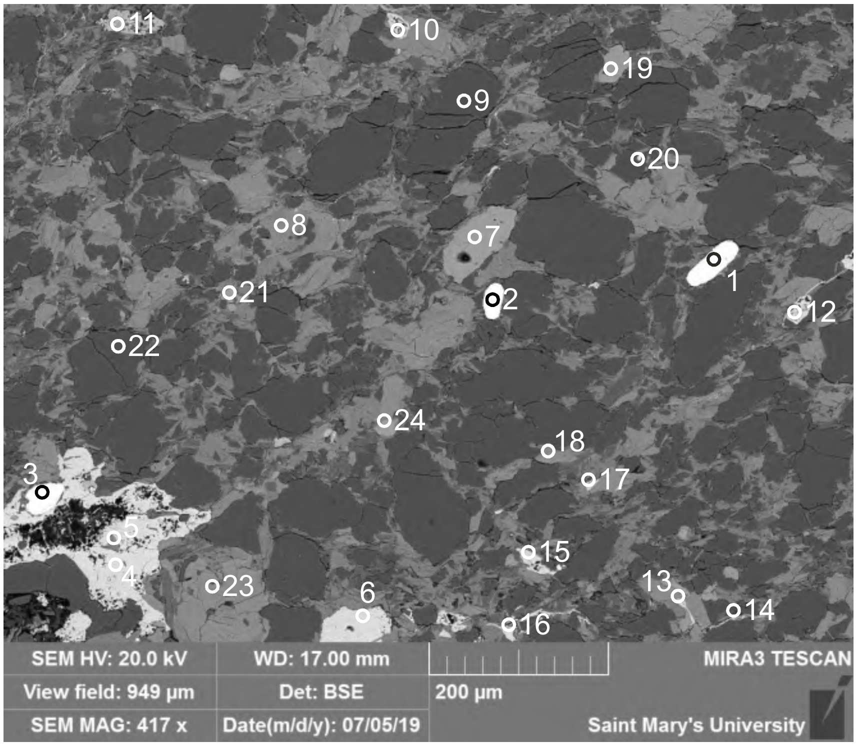
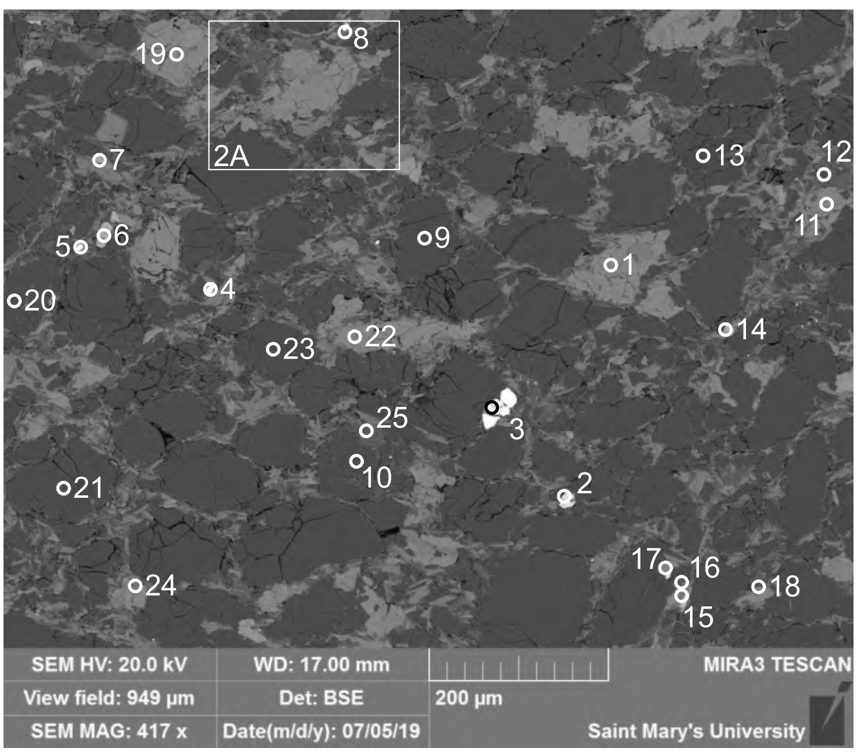


Figure 10.8-2: Sample OD2016-D2-027.



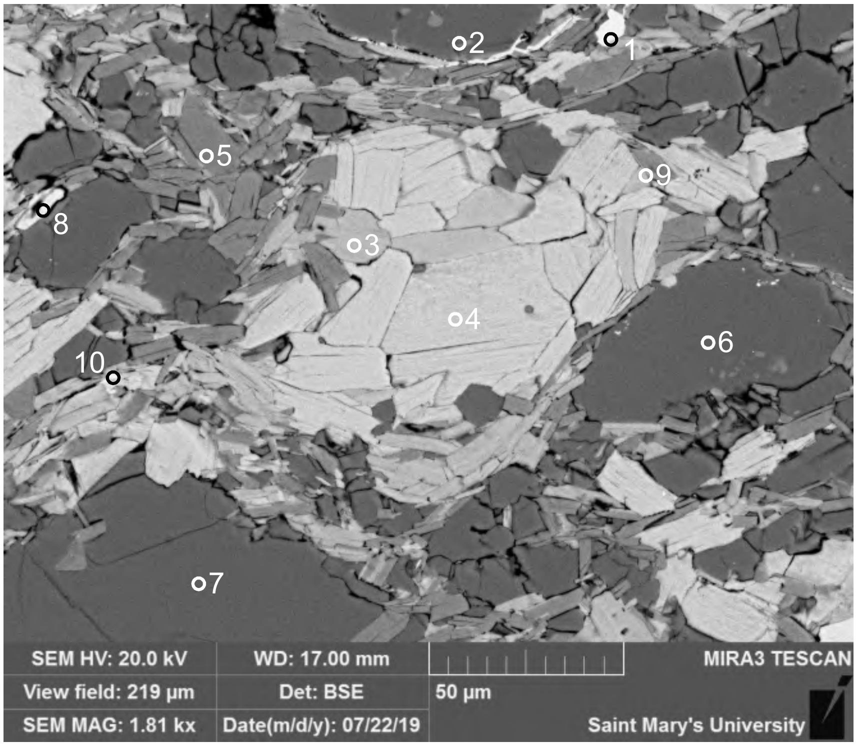
1. Zircon
2. Zircon
3. Zircon
4. Feohy+
5. Chlorite
6. Feohy+
7. Apatite
8. Biotite
9. Quartz
10. Feohy+
11. TiO2+
12. Feohy+
13. Feohy+
14. Muscovite
15. Feohy+
16. Feohy+
17. Feohy+
18. Biotite
19. Apatite
20. Zircon
21. Apatite
22. Quartz
23. Biotite
24. Apatite

Figure 10.8-3. Sample OD2016-D2-027 site 1. DT: Quartz, Zircon, Apatite; DG: Biotite, Muscovite; HD: Feohy.



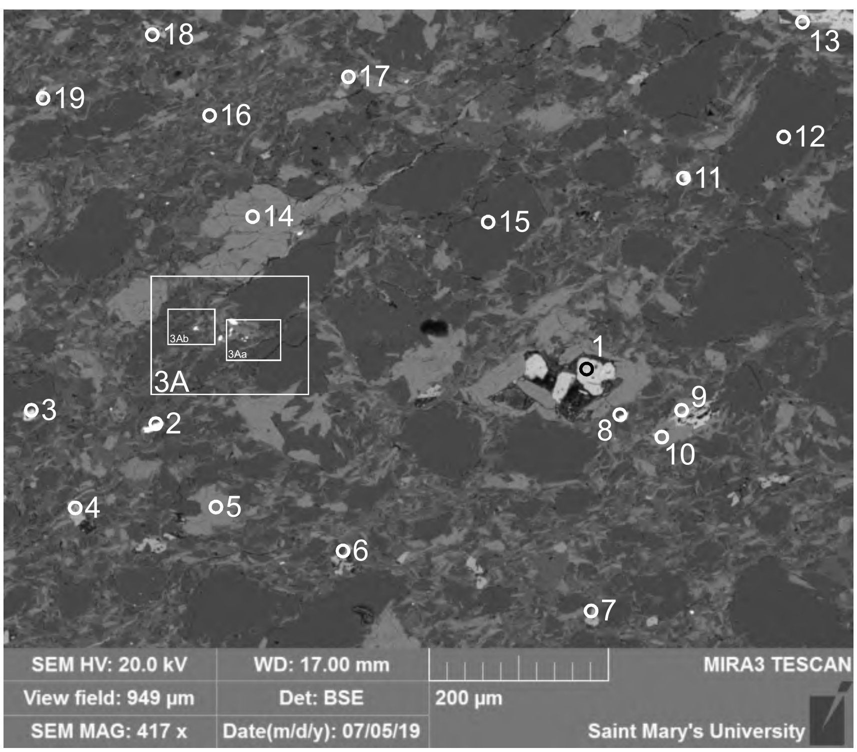
1. Biotite
2. Ilmenite+
3. Zircon
4. Zircon
5. Zircon
6. TiO2+
7. TiO2+
8. Xenotime+
9. Quartz+
10. Quartz
11. Biotite
12. Muscovite
13. Quartz
14. TiO2+
15. Feohy+
16. Chlorite
17. Ilmenite+
18. Biotite
19. Biotite
20. Albite
21. Quartz
22. Biotite
23. Quartz
24. Chl+ Bt
25. Muscovite

Figure 10.8-4. Sample OD2016-D2-027 site 2. DT: Quartz, Zircon, Apatite; DG: Biotite, Muscovite; HD: Feohy.



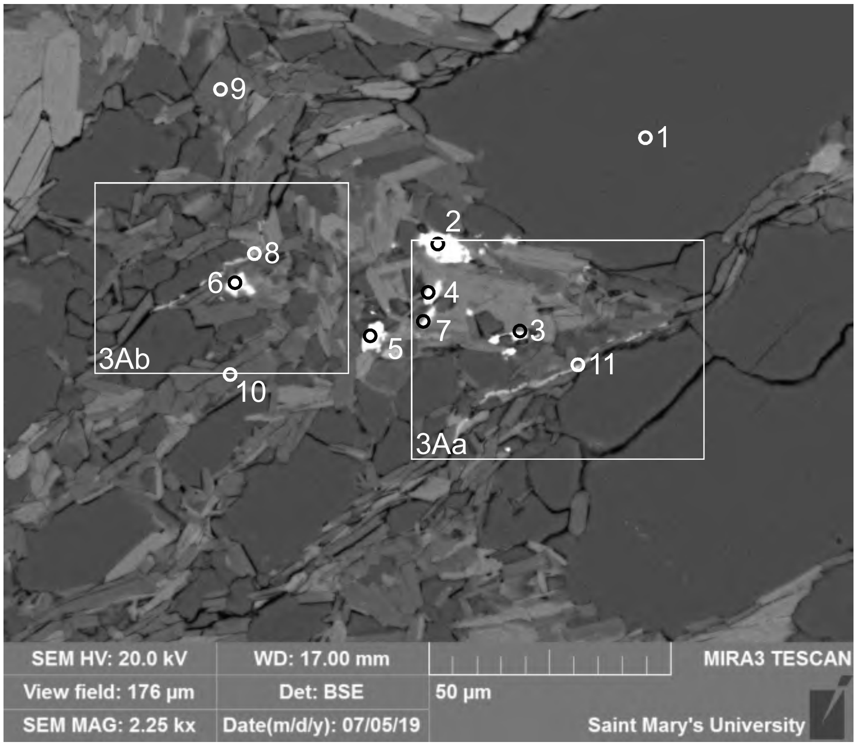
1. Xenotime
2. Albite
3. Chlorite
4. Biotite
5. Muscovite
6. Quartz
7. Quartz
8. Apatite
9. Muscovite
10. Ms+ Chl

Figure 10.8-5. Sample OD2016-D2-027 site 2A. DT: Quartz; DG: Apatite(?), Biotite, Muscovite, Xenotime.



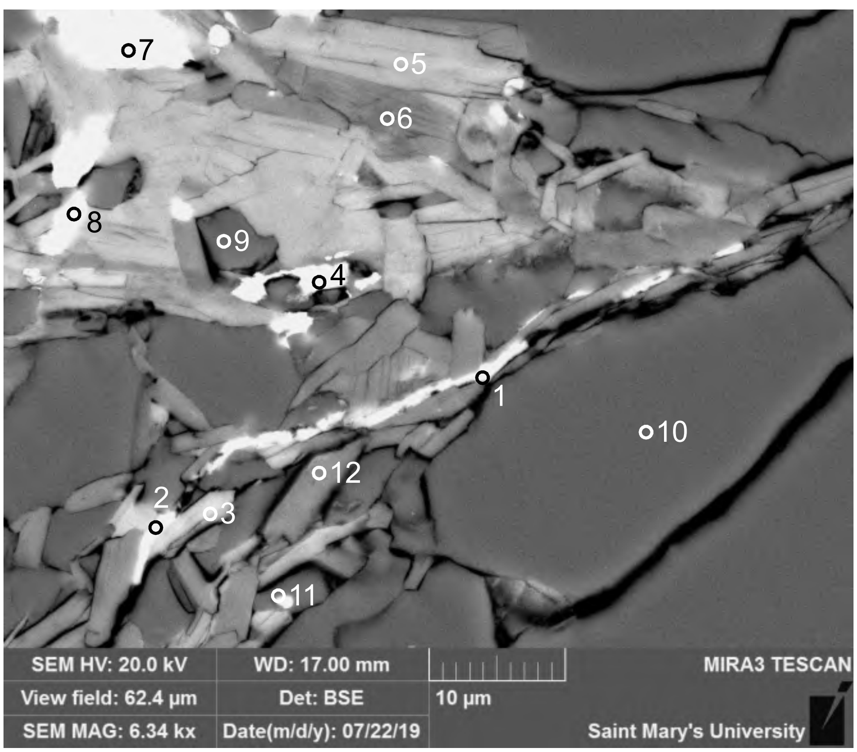
1. Feohy+
2. Zircon
3. Ilmenite
4. TiO2+
5. Biotite
6. TiO2+
7. Ab + TiO2
8. Zircon
9. Feohy+
10. Biotite
11. Zircon
12. Quartz
13. Feohy+
14. Chl+ Bt
15. Albite
16. Albite
17. TiO2+
18. TiO2+
19. Ilmenite

Figure 10.8-6. Sample OD2016-D2-027 site 3. DT: Albite (15), Quartz, Zircon; DG: Biotite, Ilmenite, Muscovite,



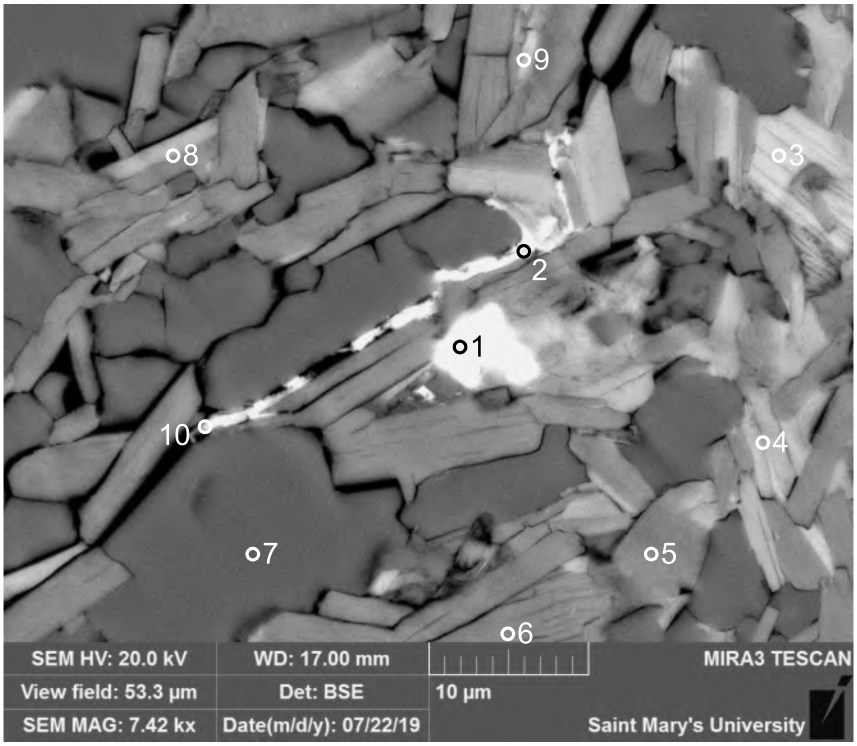
1. Quartz
2. Monazite+
3. Monazite+
4. Monazite+
5. Monazite+
6. Monazite+
7. Monazite+
8. Chl+ Bt
9. Muscovite
10. Muscovite
11. Chl+ Bt

Figure 10.8-7. Sample OD2016-D2-027 site 3A. Cluster of diagenetic monazite.



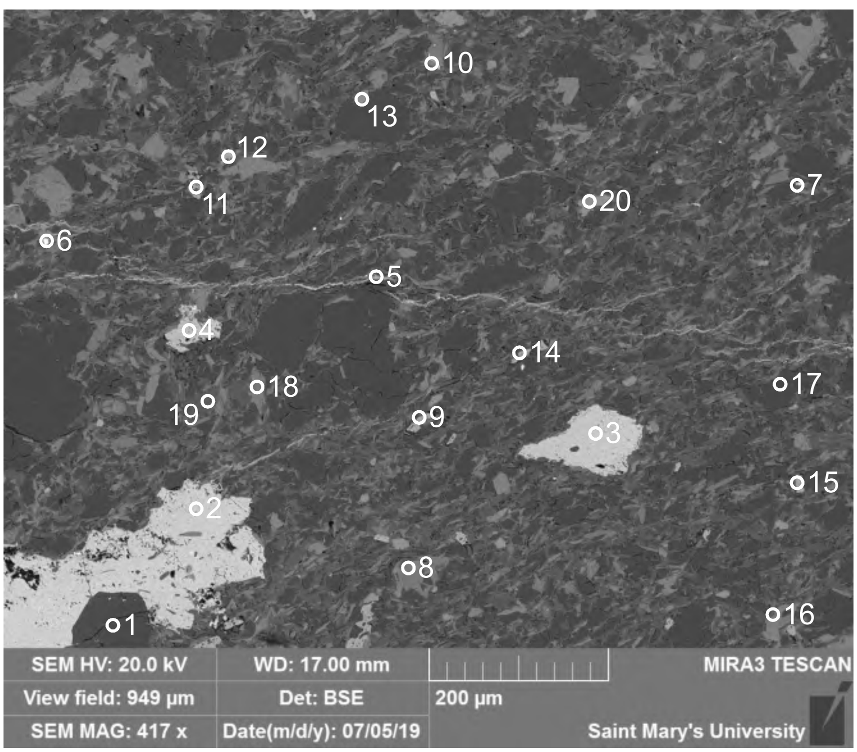
1. Feohy+
2. Feohy+
3. Ms+ Chl
4. Monazite
5. Chlorite
6. Muscovite
7. Monazite
8. Monazite
9. Quartz+
10. Quartz
11. Quartz+
12. Muscovite

Figure 10.8-8. Sample OD2016-D2-027 site 3Aa. Hydrothermal Feohy (1) filling in fractures.



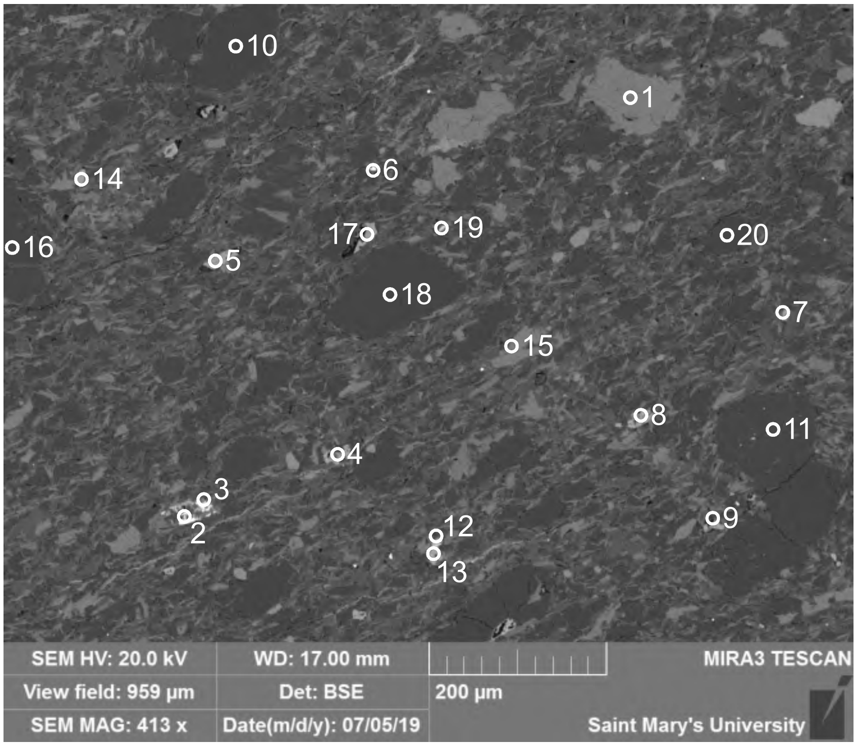
1. Monazite
2. Chlorite
3. Biotite
4. Chlorite
5. Muscovite
6. Muscovite
7. Quartz
8. Ms+ Chl
9. Muscovite
10. Ms+ Chl

Figure 10.8-9. Sample OD2016-D2-027 site 3Ab. Euhedral micas interpreted to have diagenetic origin.



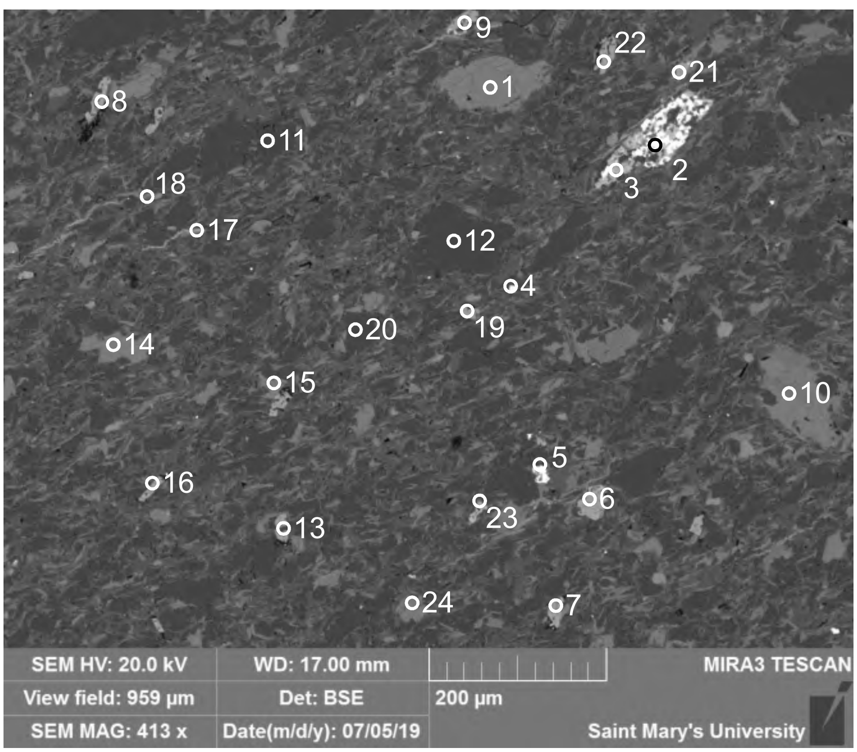
1. Quartz
2. Feohy+
3. Feohy+
4. Feohy+
5. Feohy+
6. Xenotime+
7. Ilmenite+
8. Chlorite
9. TiO2+
10. Biotite
11. Mixture
12. TiO2+
13. Apatite
14. TiO2+
15. TiO2+
16. Chl+ Bt
17. Quartz
18. Chlorite
19. Muscovite
20. Apatite

Figure 10.8-10. Sample OD2016-D2-027 site 4. (1) Recrystallized Quartz grain with euhedral faces. Large filling of Feohy (2) and Feohy filling fractures (5).



1. Biotite
2. Monazite+
3. Monazite+
4. TiO2+
5. TiO2+
6. Monazite+
7. TiO2+
8. TiO2+
9. TiO2+
10. Quartz
11. Albite
12. Monazite+
13. Ilmenite+
14. TiO2+
15. Biotite
16. Quartz
17. TiO2+
18. Quartz
19. Ilmenite+
20. Quartz

Figure 10.8-11. Sample OD2016-D2-027 site 5. DT: Albite, Biotite(2?), Quartz; DG: Biotite, Monazite, Ilmentite.



1. Biotite
2. Monazite+
3. Feohy+
4. Zircon
5. Monazite+
6. TiO2+
7. TiO2+
8. TiO2+
9. TiO2+
10. Chlorite+
11. Quartz+
12. Quartz
13. TiO2+
14. Biotite
15. Biotite
16. TiO2+
17. Feohy+
18. Chlorite+
19. TiO2+
20. Quartz
21. TiO2+
22. TiO2+
23. TiO2+
24. Biotite

Figure 10.8-12. Sample OD2016-D2-027 site 6. Diagenetic Monazite(2) mixed with Feohy(3).

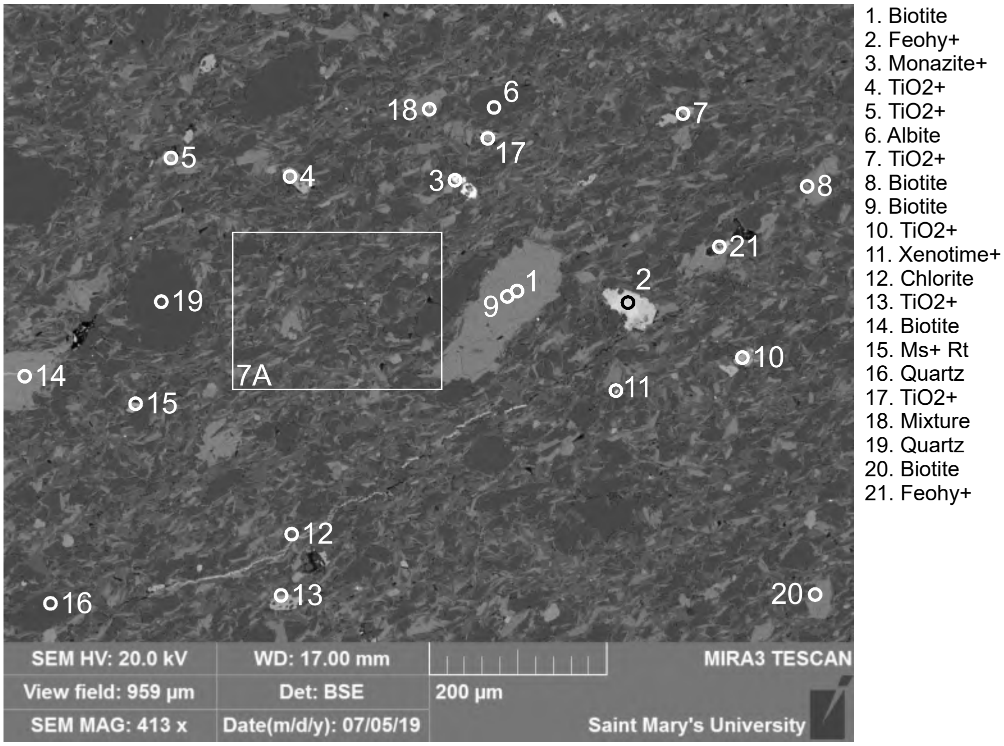


Figure 10.8-13. Sample OD2016-D2-027 site 7.

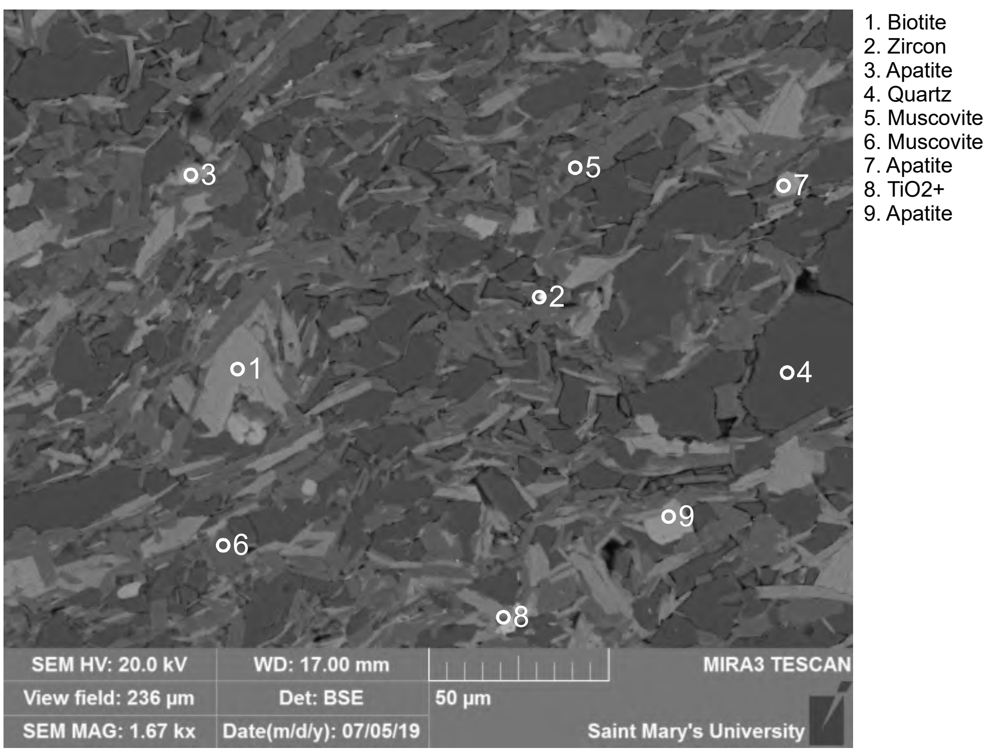
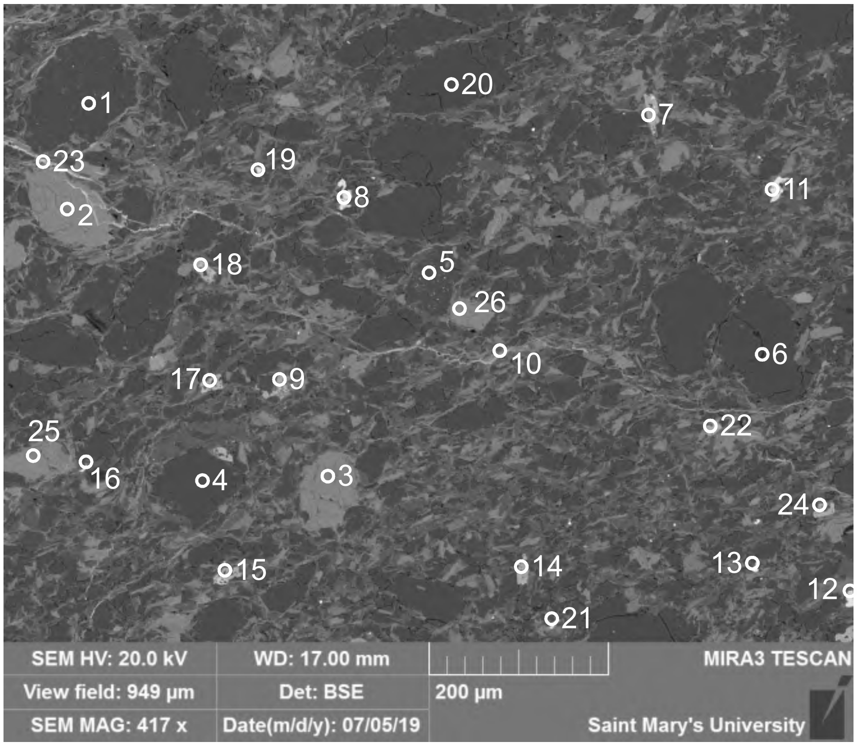
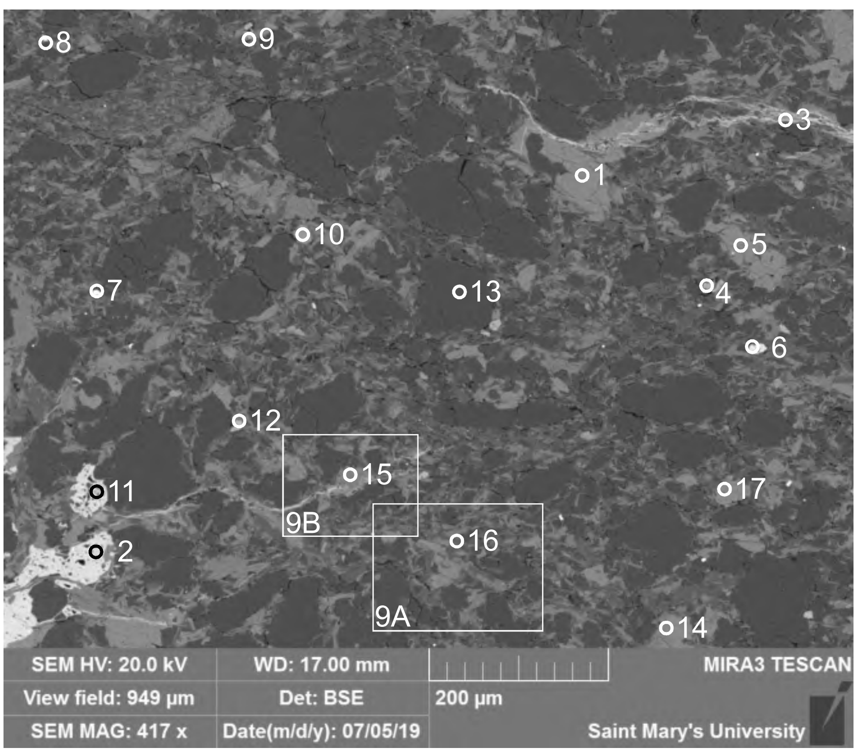


Figure 10.8-14. Sample OD2016-D2-027 site 7A.



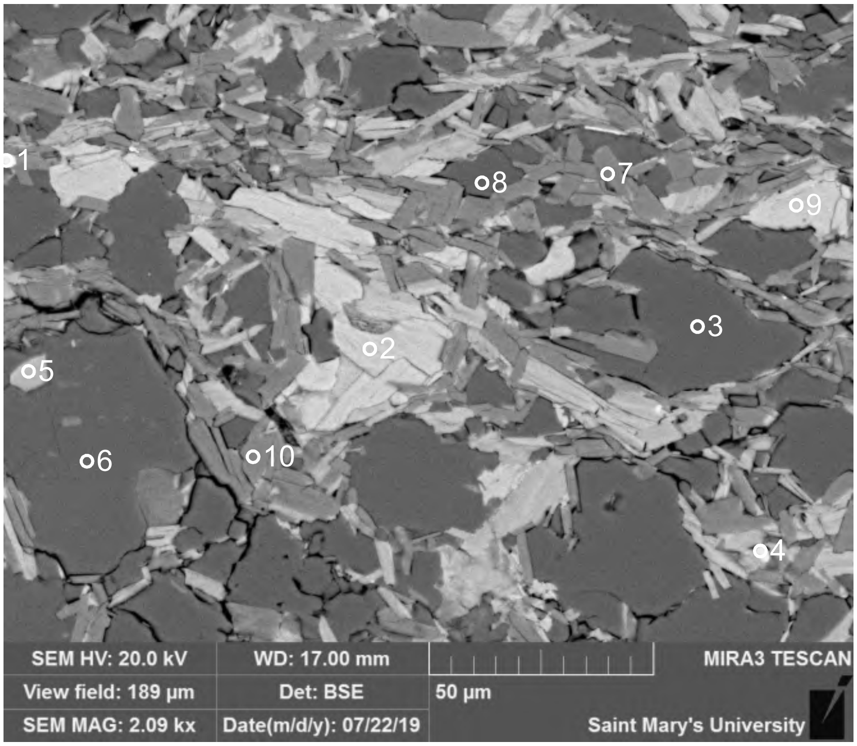
1. Albite
2. Biotite
3. Biotite
4. Quartz
5. Albite
6. Quartz
7. TiO2+
8. Ilmenite+
9. TiO2+
10. Feohy+
11. Ilmenite+
12. Ilmenite+
13. Monazite+
14. TiO2+
15. TiO2+
16. Zircon
17. TiO2+
18. Mixture
19. Ilmenite+
20. Quartz
21. Ilmenite+
22. TiO2+
23. Feohy+
24. Ms+ Rt
25. Biotite
26. Biotite

Figure 10.8-15. Sample OD2016-D2-027 site 8. Fractures filled with Feohy.



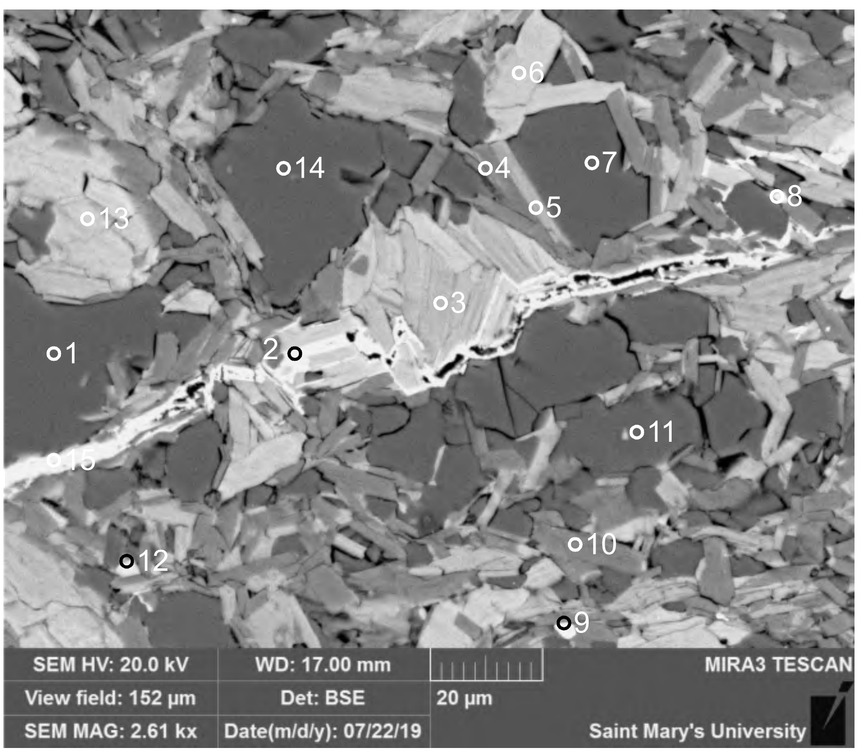
1. Biotite
2. Feohy+
3. Feohy+
4. TiO2+
5. Biotite
6. Ilmenite+
7. Xenotime+
8. Xenotime+
9. TiO2+
10. Apatite
11. Feohy+
12. TiO2+
13. Quartz
14. Biotite
15. Chlorite
16. Ms+ Chl
17. Biotite

Figure 10.8-16. Sample OD2016-D2-027 site 9.



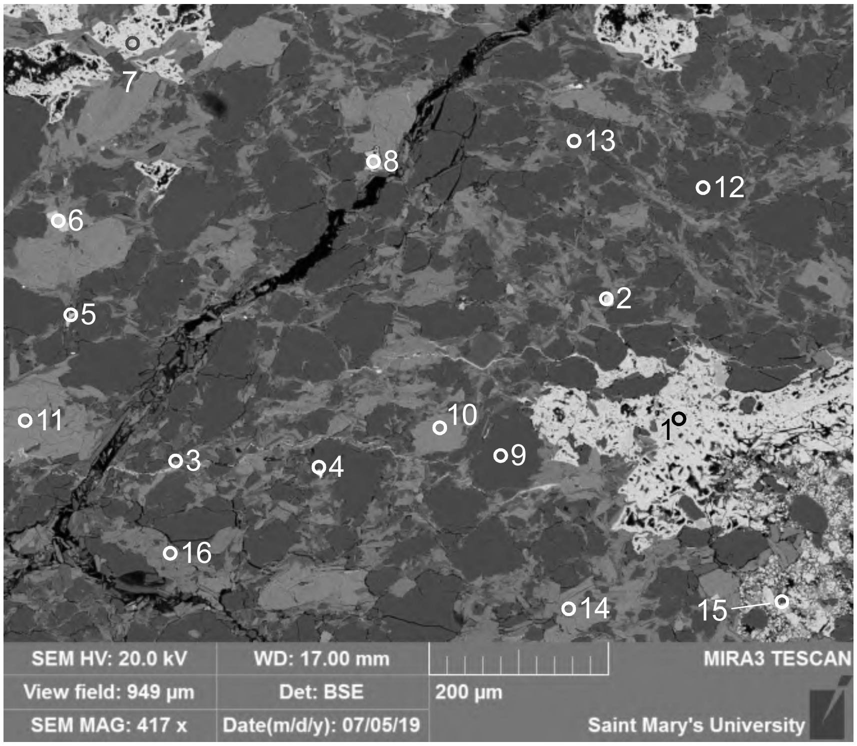
1. Zircon+
2. Biotite
3. Quartz
4. Apatite
5. Chlorite
6. Albite
7. Muscovite
8. Quartz
9. Biotite
10. Muscovite

Figure 10.8-17. Sample OD2016-D2-027 site 9A.



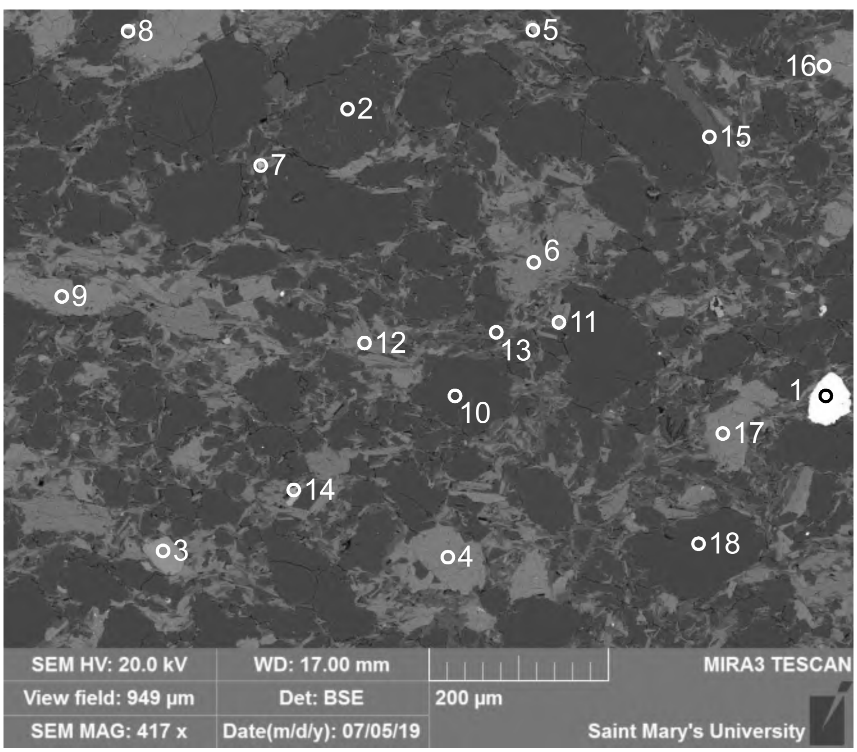
1. Quartz
2. Feohy+
3. Chlorite
4. Muscovite
5. Chl+ Ms
6. Biotite
7. Quartz
8. Xenotime
9. Zircon+
10. Muscovite
11. Albite
12. Apatite
13. Biotite
14. Quartz
15. Feohy+

Figure 10.8-18. Sample OD2016-D2-027 site 9B.



1. Feohy+
2. Ilmenite
3. Bt+ Chl
4. Zircon
5. Feohy+
6. Feohy+
7. Feohy+
8. Feohy+
9. Quartz
10. Biotite
11. Biotite
12. Quartz
13. Muscovite
14. Biotite
15. Feohy+
16. Chlorite

Figure 10.8-19. Sample OD2016-D2-027 site 10. DG: Ilmenite(2?).



1. Zircon
2. Albite
3. Apatite
4. Biotite
5. TiO2+
6. Chlorite
7. Feohy+
8. Ilmenite+
9. Biotite
10. Quartz
11. Apatite
12. Chlorite
13. Muscovite
14. TiO2+
15. Muscovite
16. Biotite
17. Biotite
18. Quartz

Figure 10.8-20. Sample OD2016-D2-027 site 11. DG: TiO2(5?).

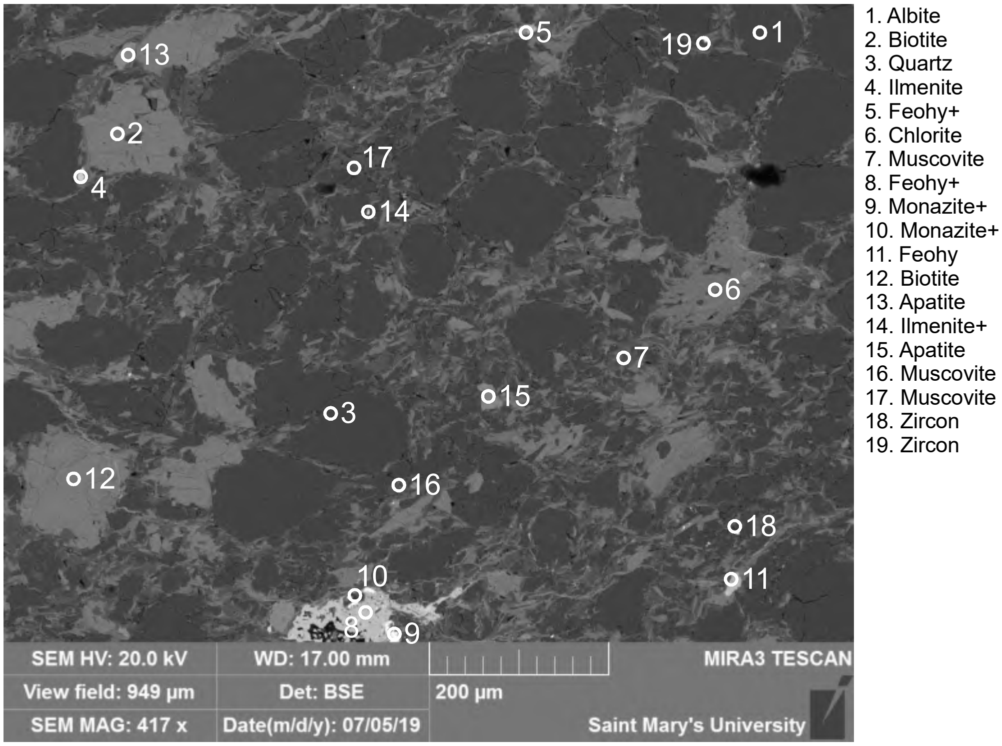


Figure 10.8-21. Sample OD2016-D2-027 site 12. Monazite (9, 10) associated with Feohy (8).

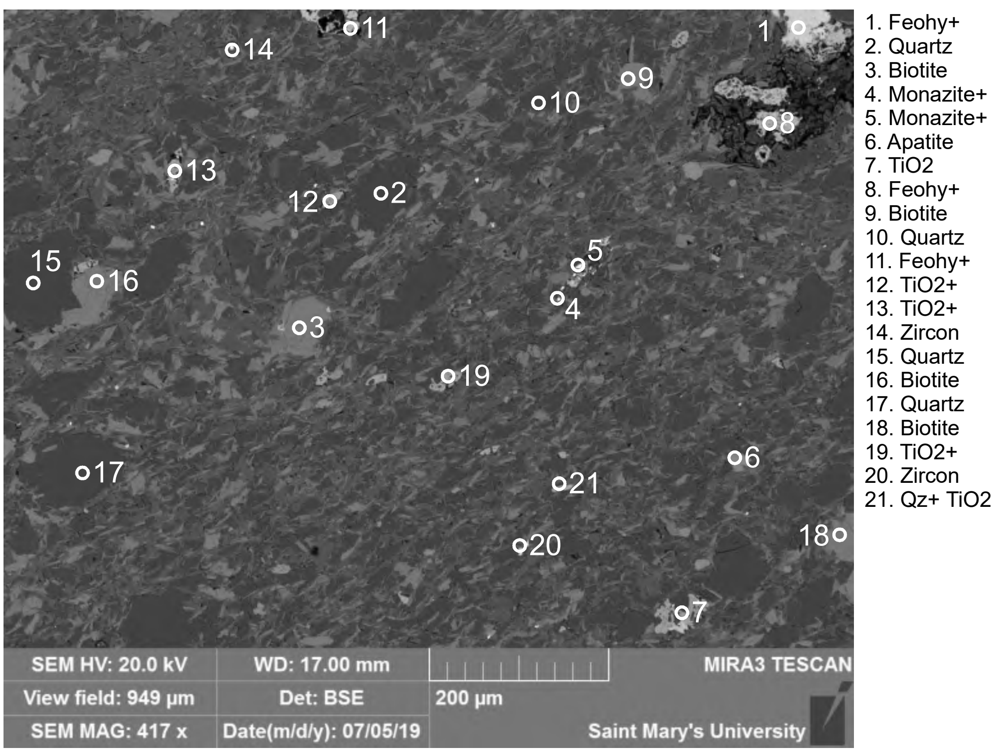
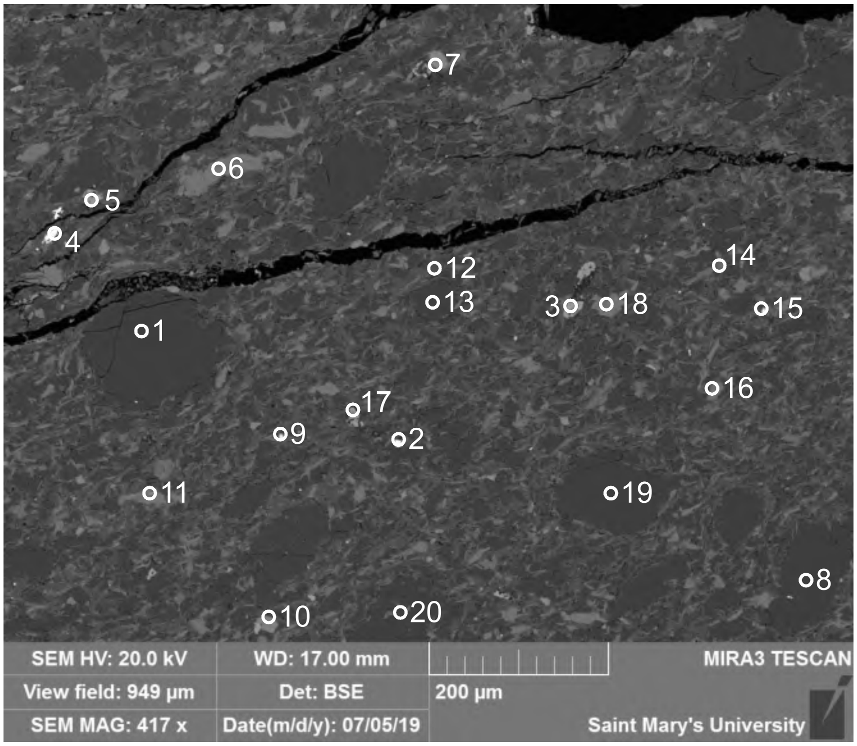
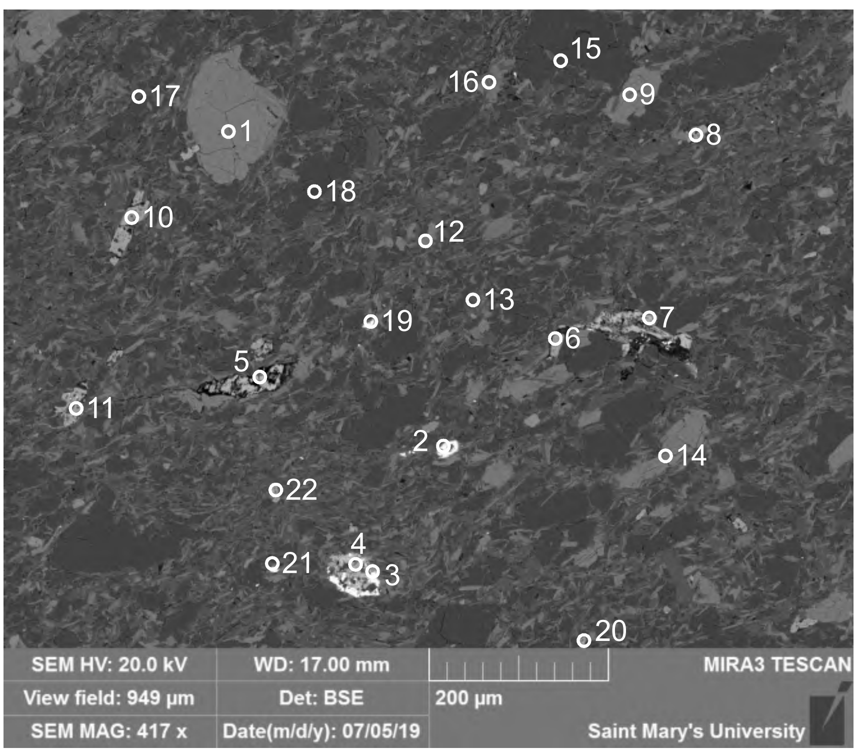


Figure 10.8-22. Sample OD2016-D2-027 site 13.



1. Quartz
2. Zircon
3. TiO2+
4. Monazite+
5. TiO2+
6. Biotite
7. Apatite
8. Quartz
9. Zircon
10. Apatite
11. Biotite
12. Muscovite
13. Quartz
14. Chlorite
15. Zircon
16. Biotite
17. TiO2+
18. Biotite
19. Quartz
20. Quartz

Figure 10.8-23. Sample OD2016-D2-027 site 14.



1. Biotite
2. Monazite+
3. Monazite+
4. Feohy+
5. Feohy+
6. TiO2+
7. Feohy+
8. TiO2+
9. Biotite
10. Mixture
11. TiO2+
12. Biotite
13. Muscovite
14. Biotite
15. Quartz
16. Muscovite
17. Muscovite
18. Quartz
19. Monazite+
20. Ab+ Rt
21. Monazite+
22. TiO2+

Figure 10.8-24. Sample OD2016-D2-027 site 15. Monazite (3) associated with Feohy (4). Possible detrital biotite (1).

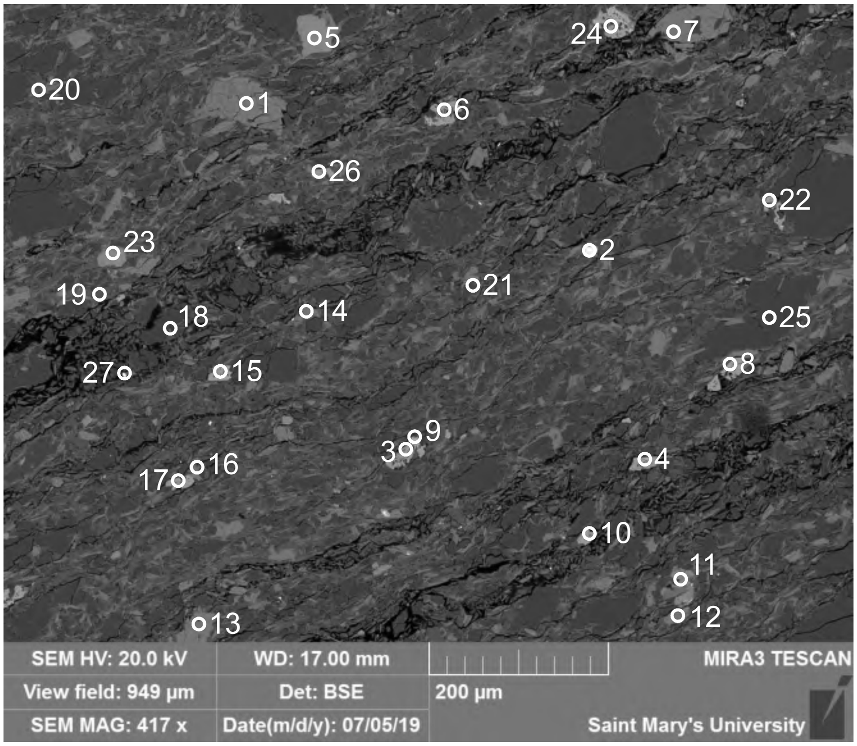


Figure 10.8-25. Sample OD2016-D2-027 site 16. Pervasive fracturing in the same orientation as mineral alignment.

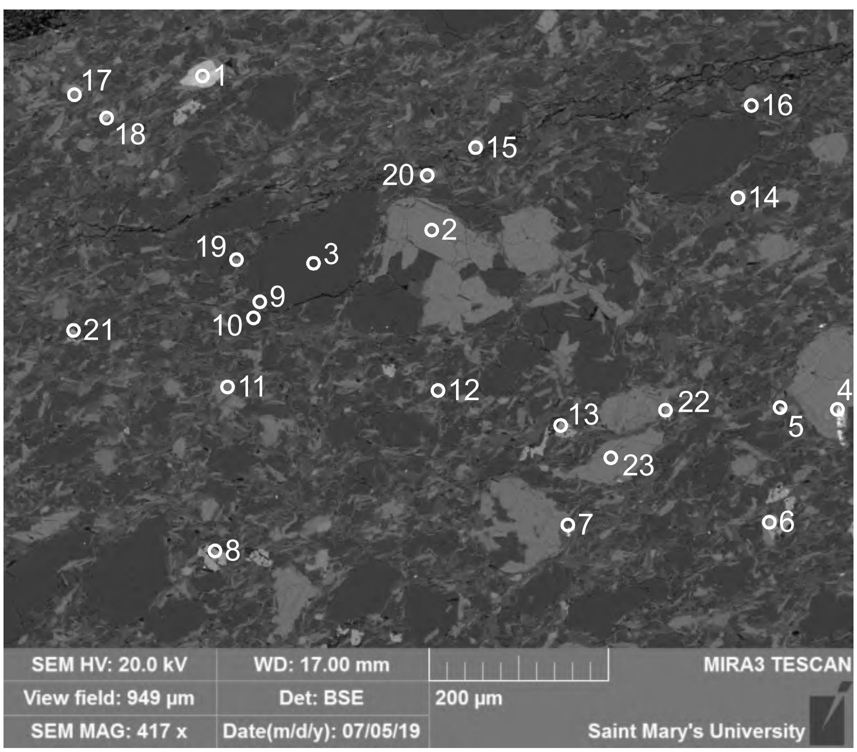
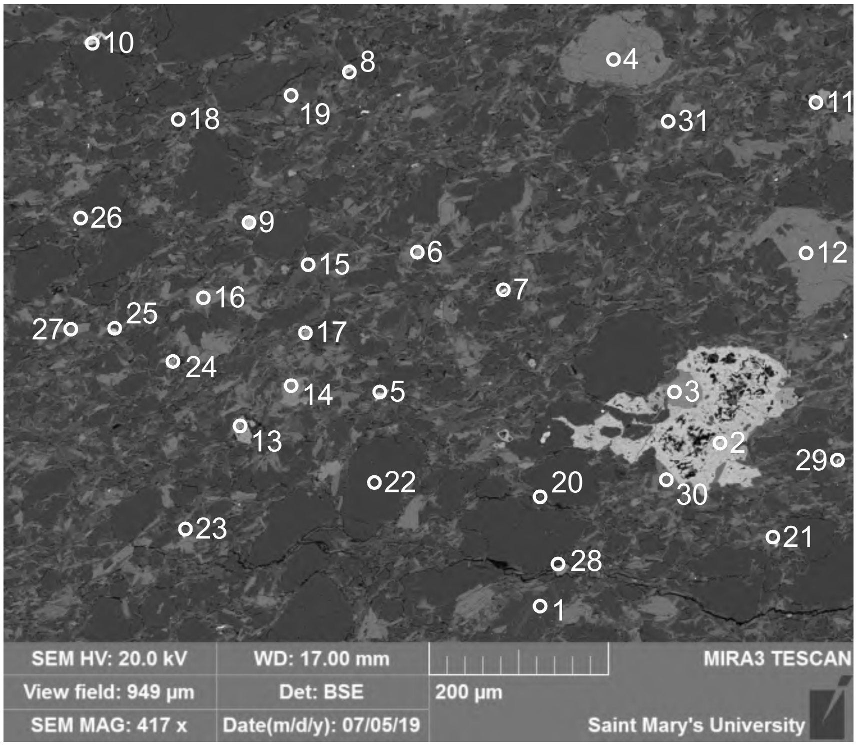
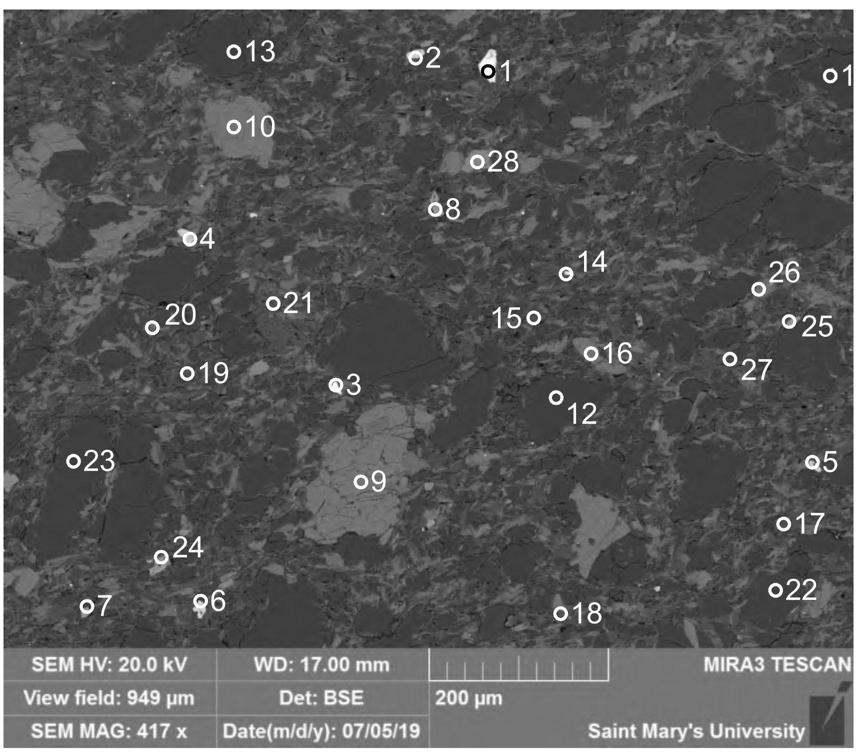


Figure 10.8-26. Sample OD2016-D2-027 site 17.



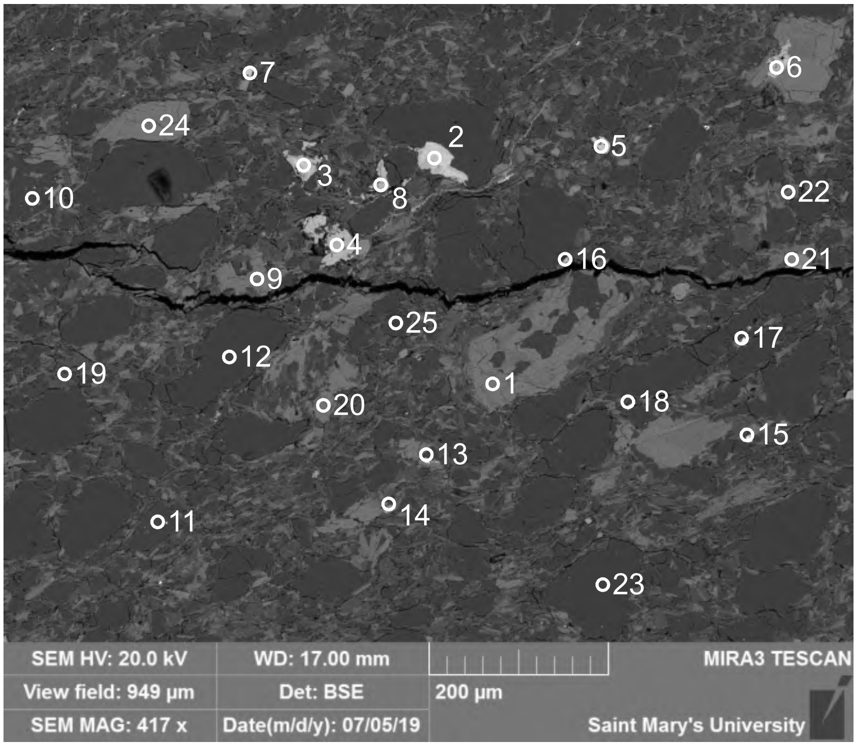
1. Albite
2. Feohy+
3. Apatite
4. Biotite
5. Ilmenite
6. Rutile
7. Xenotime+
8. Ilmenite+
9. Ilmenite+
10. Ilmenite+
11. TiO2+
12. Biotite
13. Ms+ Rt
14. Apatite
15. Muscovite
16. Biotite
17. TiO2+
18. Muscovite
19. Chlorite
20. Monazite+
21. Ilmenite+
22. Quartz
23. Mz+ Qz
24. TiO2+
25. Ilmenite+
26. Muscovite
27. Biotite
28. Apatite
29. Monazite+
30. Chlorite
31. Muscovite

Figure 10.8-27\. Sample OD2016-D2-027 site 18.



1. Zircon
2. Ilmenite+
3. Zircon
4. Ilmenite+
5. Ilmenite+
6. Ilmenite+
7. TiO2+
8. TiO2+
9. Biotite
10. Biotite
11. Monazite+
12. Quartz
13. Quartz
14. Zircon
15. Muscovite
16. Biotite
17. Muscovite
18. Chl+ Ms
19. Ab+ Kfs
20. Biotite
21. Muscovite
22. Albite
23. Quartz
24. Quartz+
25. TiO2+
26. Biotite
27. Muscovite
28. Apatite

Figure 10.8-28\. Sample OD2016-D2-027 site 19.



1. Biotite
2. Feohy+
3. Feohy+
4. Feohy+
5. Ilmenite+
6. Feohy+
7. Ilmenite
8. Feohy+
9. Biotite
10. Albite
11. Albite
12. Quartz
13. Monazite+
14. TiO2+
15. Zircon
16. Ilmenite+
17. Monazite+
18. Zircon
19. Muscovite
20. Biotite
21. Apatite
22. Chl+ Ms
23. Quartz
24. Biotite
25. Albite

Figure 10.8-29. Sample OD2016-D2-027 site 20.

Appendix 10.9: OD2016-D2-034 BSE imagery.

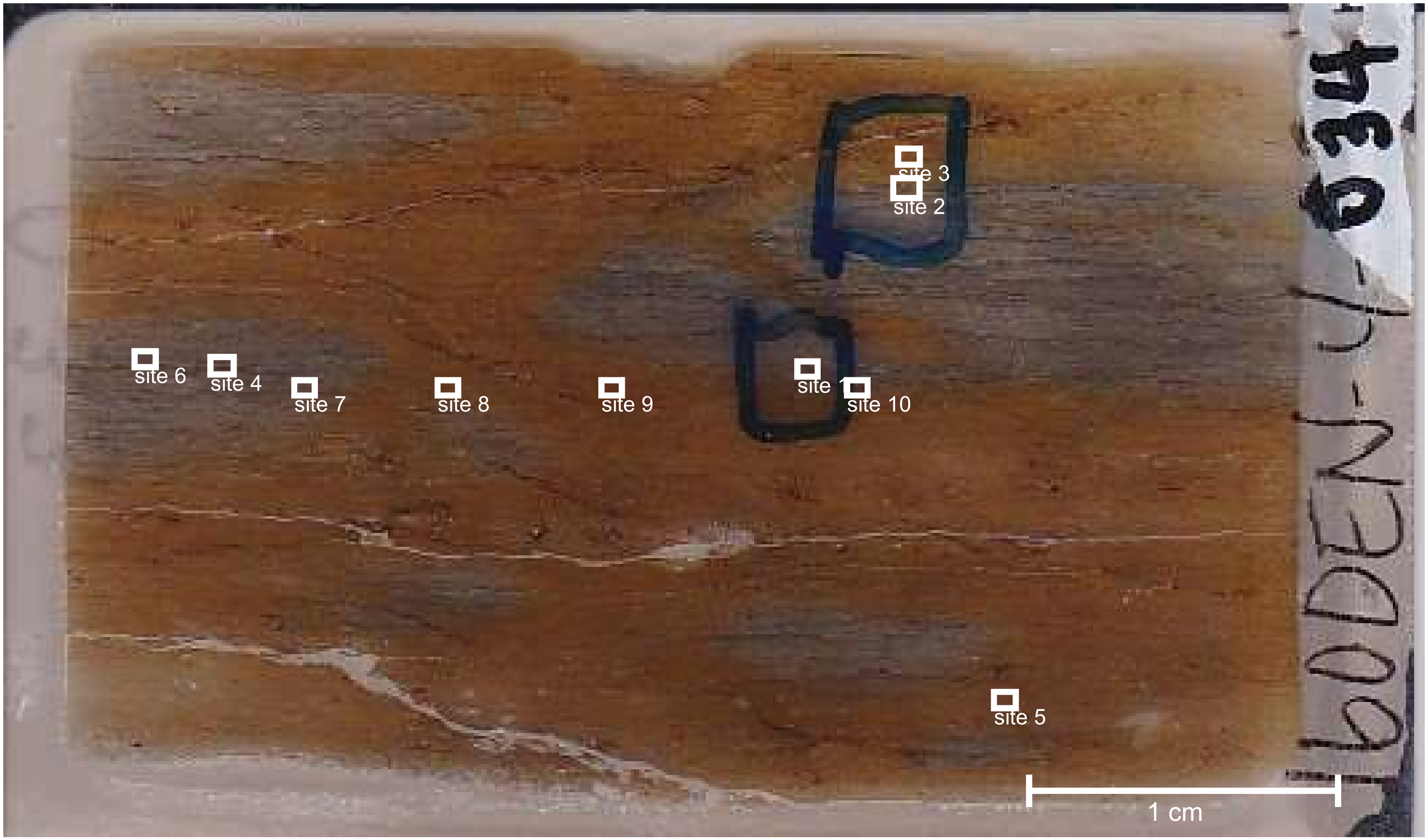


Figure 10.9-1: Slide OD2016-D2-0034.

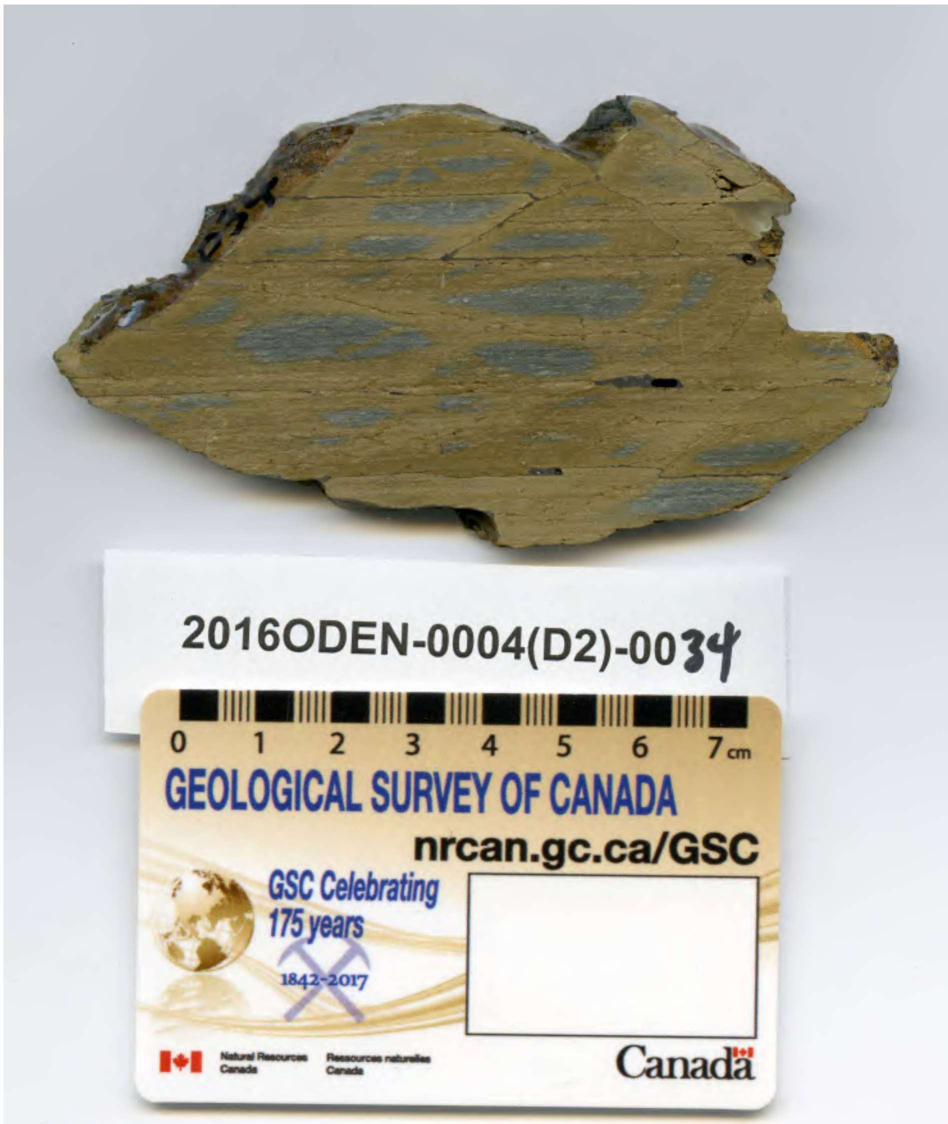
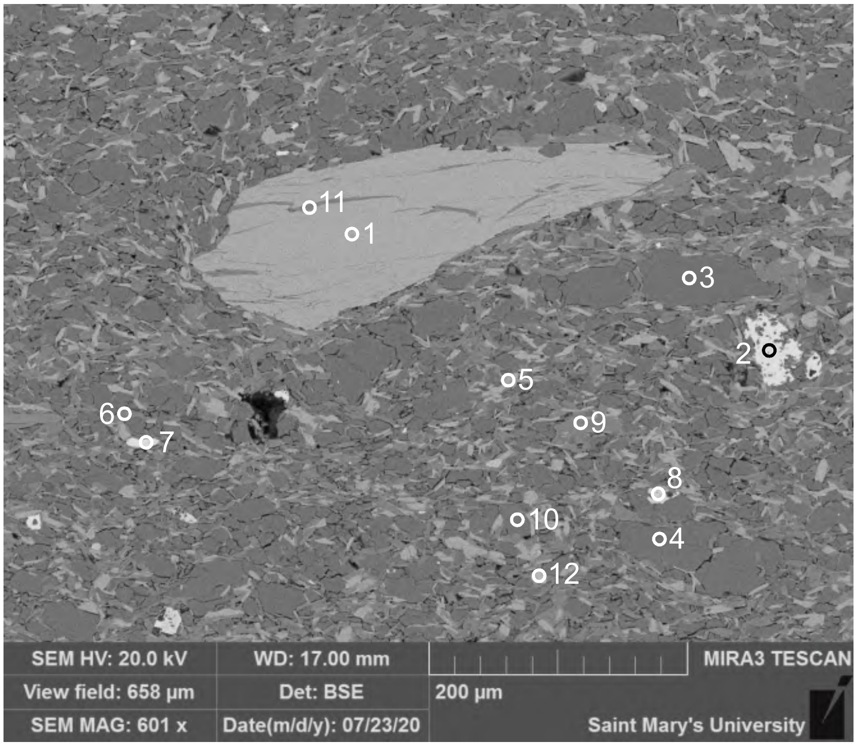
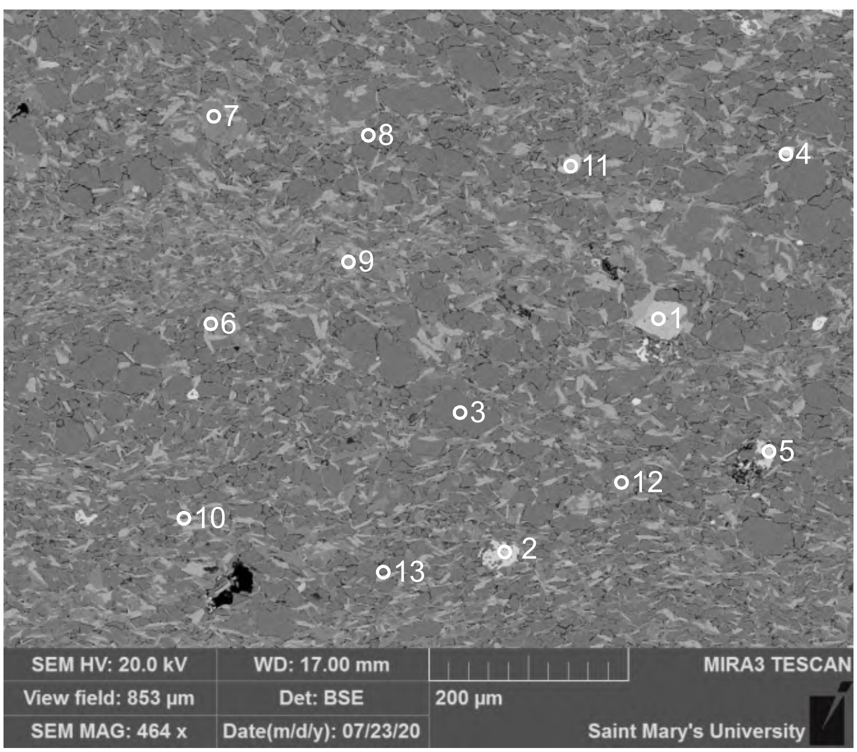


Figure 10.9-2: Sample OD2016-D2-0034.



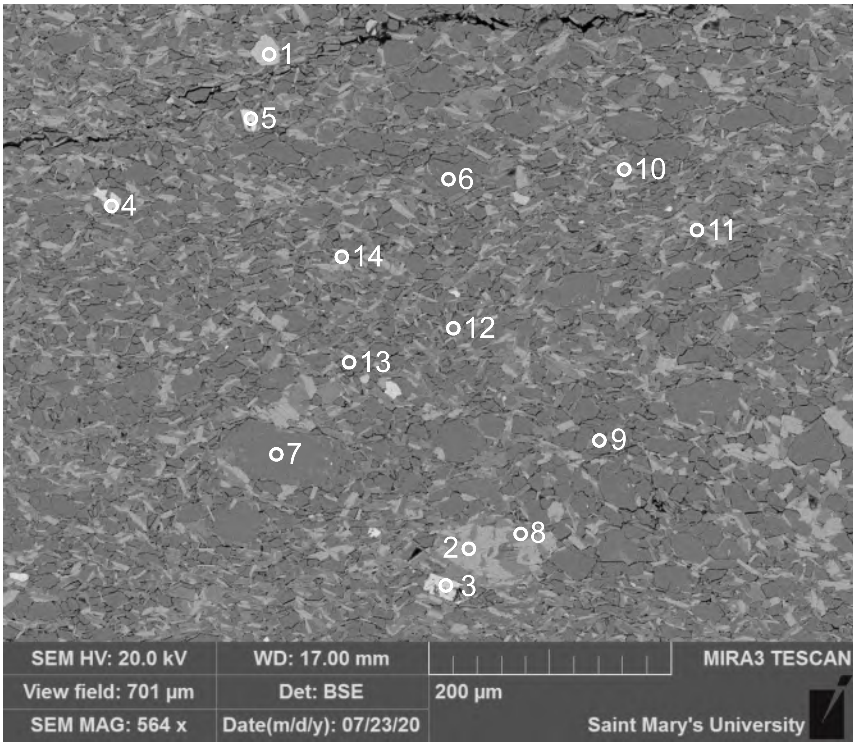
1. Chlorite
2. FeOhy +
3. Quartz
4. Quartz
5. Chlorite
6. Muscovite
7. Ilmenite +
8. Rutile +
9. Muscovite
10. Albite
11. Muscovite
12. Apatite

Figure 10.9-3. Sample OD2016-D2-034 site 1.



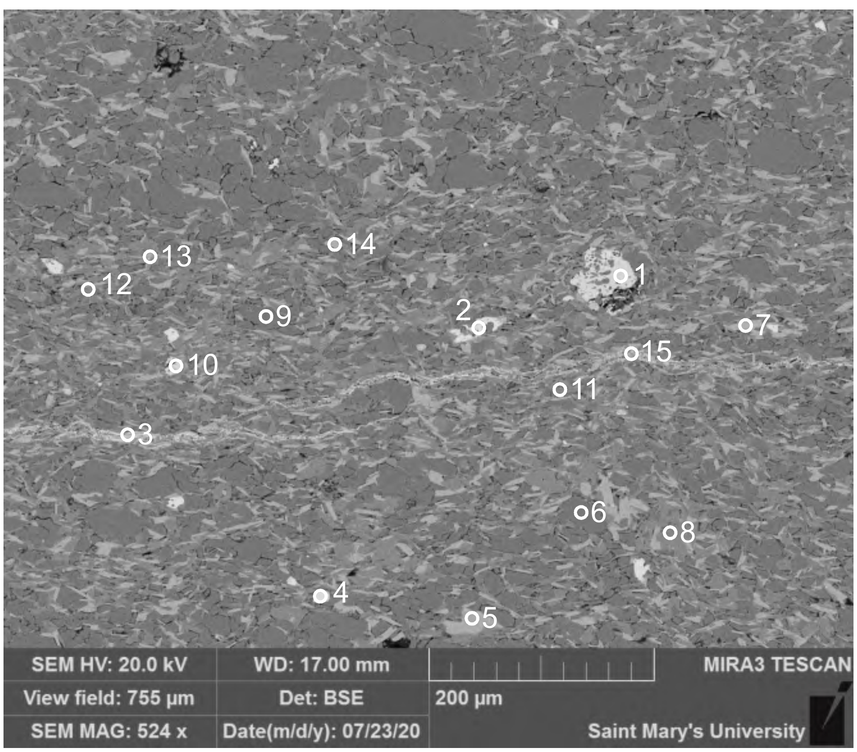
1. Apatite
2. Rutile +
3. Quartz
4. Ilmenite +
5. Rutile +
6. Chlorite
7. Muscovite
8. Muscovite
9. Chlorite
10. Chlorite
11. Apatite
12. Muscovite
13. Chlorite

Figure 10.9-4. Sample OD2016-D2-034 site 2.



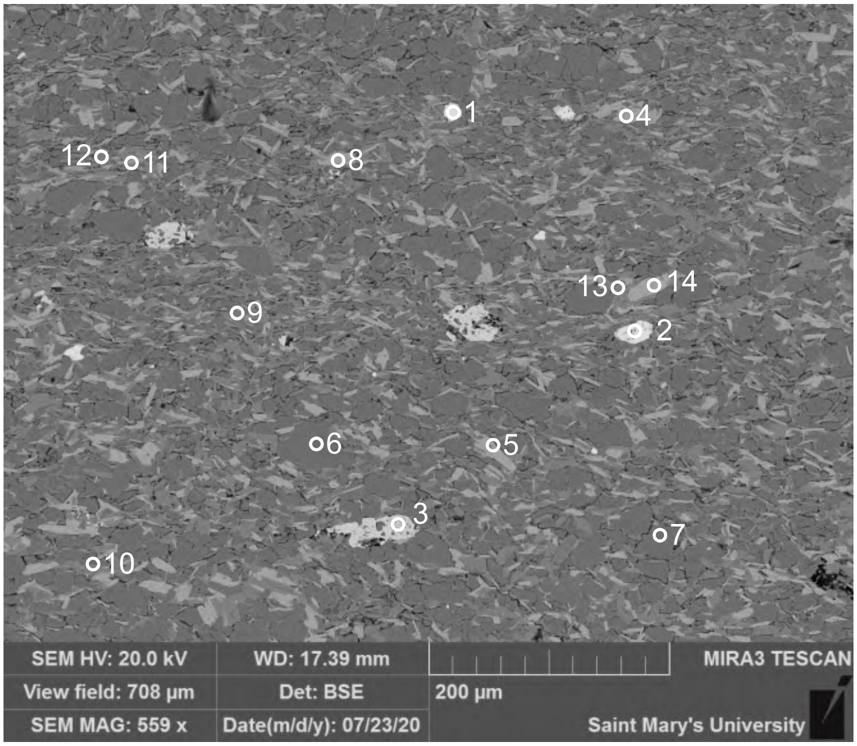
1. Apatite
2. Chlorite
3. Rutile +
4. Rutile +
5. Ilmenite +
6. Quartz
7. Albite
8. Muscovite
9. Muscovite
10. Chlorite
11. Muscovite
12. Muscovite
13. Quartz
14. Chlorite

Figure 10.9-5. Sample OD2016-D2-034 site 3.



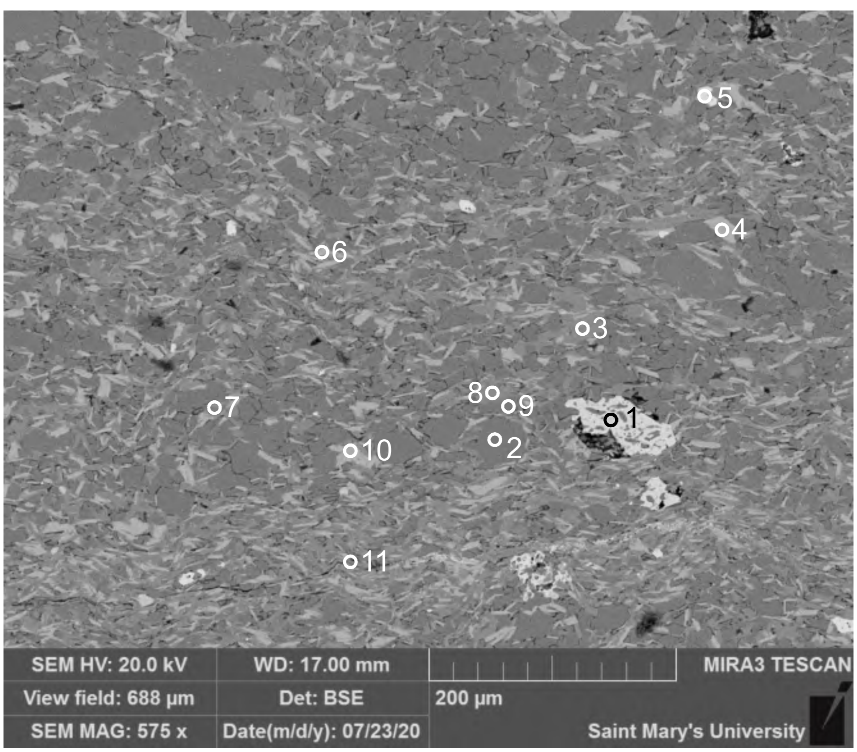
1. Rutile
2. Monazite
3. FeOhy +
4. Zircon
5. Chlorite
6. Quartz
7. Chlorite
8. Muscovite
9. Quartz
10. Rutile +
11. Muscovite
12. Muscovite
13. Chlorite
14. Chlorite
15. Muscovite

Figure 10.9-6. Sample OD2016-D2-034 site 4.



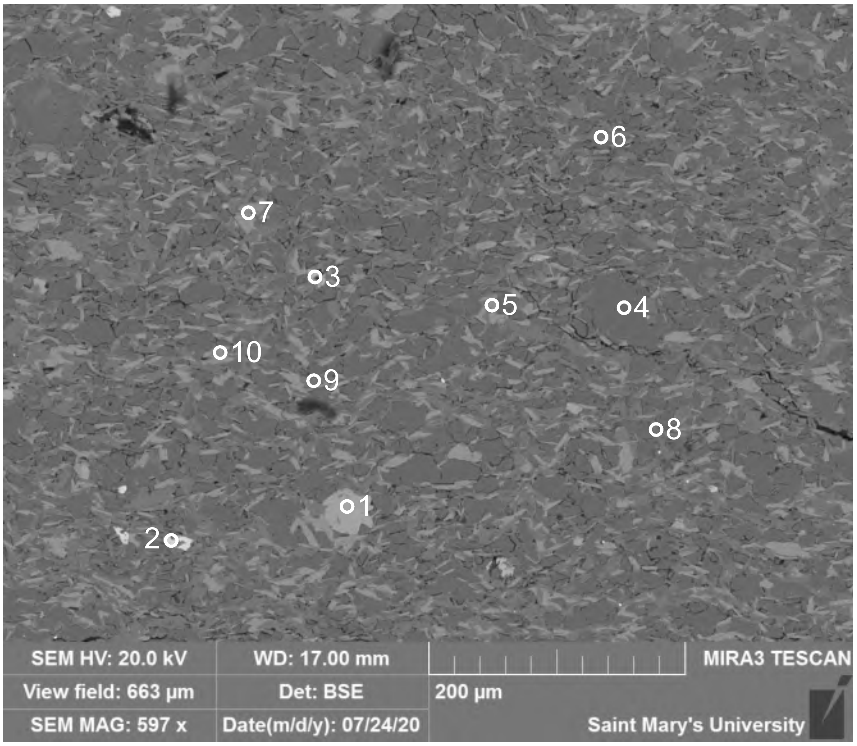
1. Zircon
2. Ilmenite +
3. Rutile + Quartz
4. Chlorite
5. Chlorite
6. Quartz
7. Quartz
8. Chlorite
9. Muscovite
10. Muscovite
11. Chlorite
12. Muscovite
13. Muscovite
14. Chlorite

Figure 10.9-7. Sample OD2016-D2-034 site 5. DT:



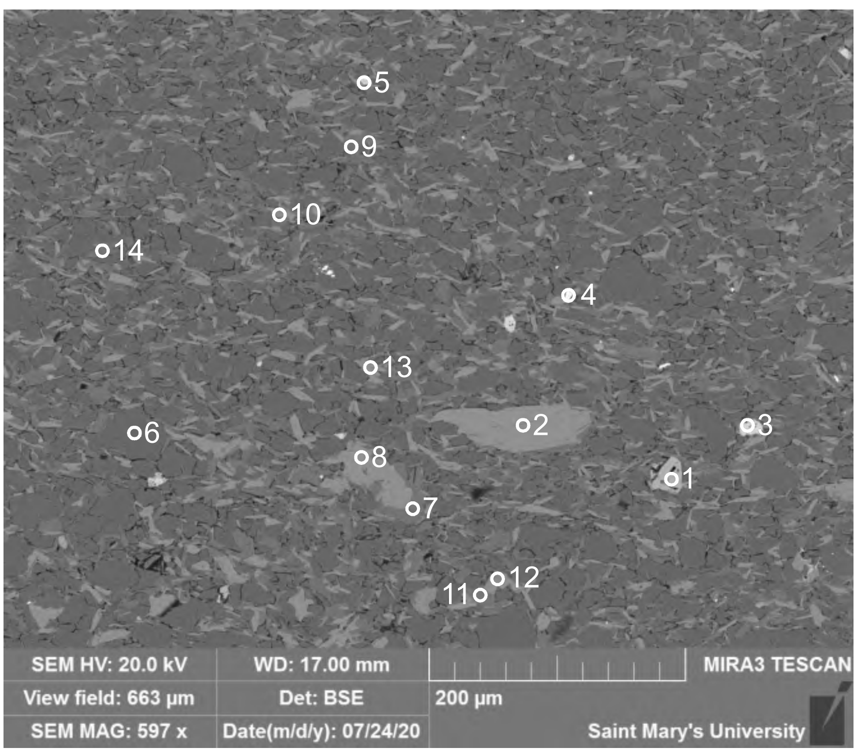
1. Rutile +
2. Quartz
3. Muscovite
4. Chlorite
5. Ilmenite +
6. Chlorite
7. Albite +
8. Muscovite
9. Quartz
10. Chlorite
11. Muscovite

Figure 10.9-8. Sample OD2016-D2-034 site 6.



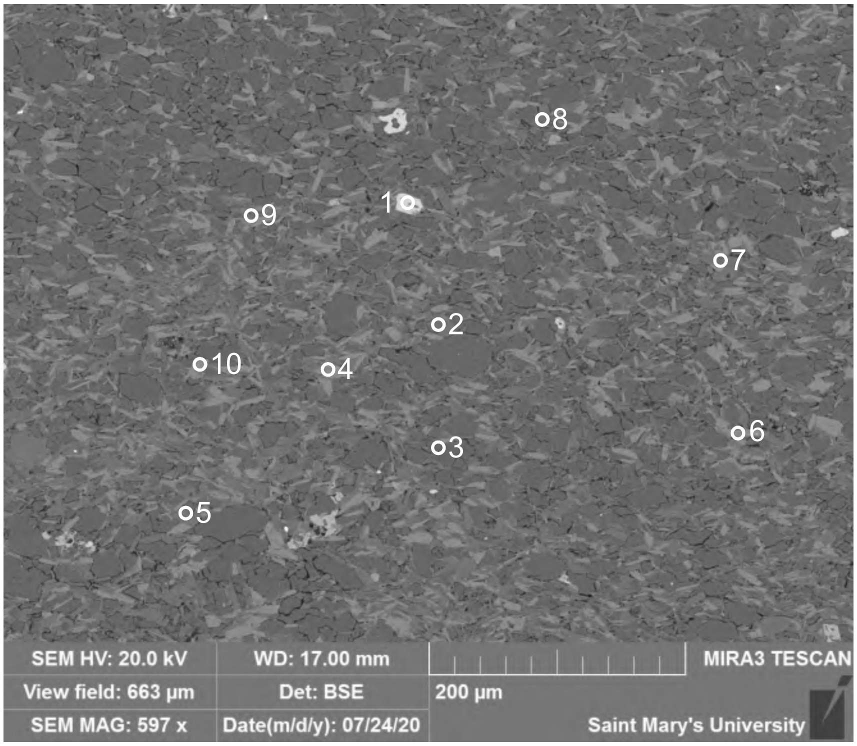
1. Apatite
2. Ilmenite +
3. Rutile +
4. Quartz
5. Chlorite
6. Muscovite
7. Chlorite
8. Muscovite
9. Muscovite
10. Chlorite

Figure 10.9-9. Sample OD2016-D2-034 site 7.



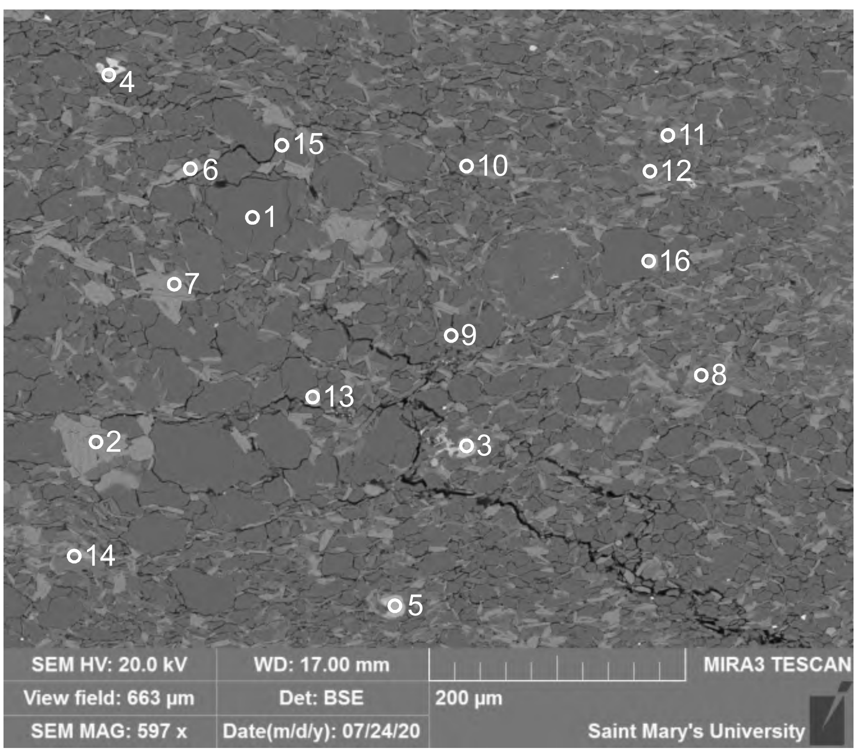
1. Rutile +
2. Chlorite
3. Ilmenite +
4. Zircon
5. Ilmenite +
6. Quartz
7. Muscovite
8. Chlorite
9. Muscovite
10. Chlorite
11. Muscovite
12. Chlorite
13. Chlorite
14. Muscovite

Figure 10.9-10. Sample OD2016-D2-034 site 8.



1. Ilmenite +
2. Muscovite
3. Quartz
4. Chlorite
5. Muscovite
6. Chlorite
7. Muscovite
8. Muscovite
9. Muscovite
10. Chlorite

Figure 10.9-11. Sample OD2016-D2-034 site 9.



1. Quartz
2. Chlorite
3. Rutile +
4. Ilmenite +
5. Rutile +
6. Apatite
7. Chlorite
8. Muscovite
9. Muscovite
10. Muscovite
11. Chlorite
12. Muscovite
13. Apatite
14. Muscovite
15. Muscovite
16. Apatite +

Figure 10.9-12. Sample OD2016-D2-034 site 10.

Appendix 10.10: OD201
imagery.

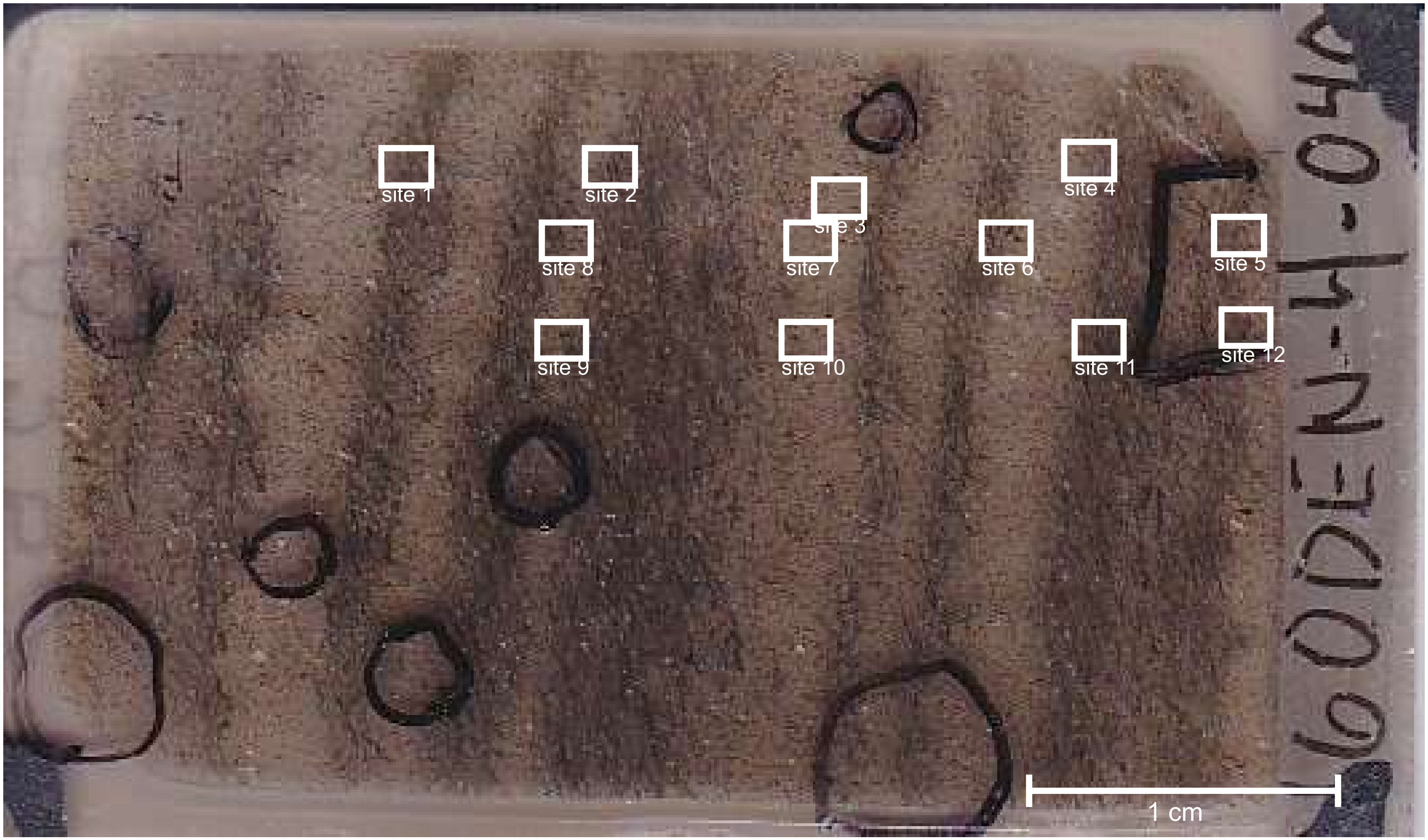


Figure 10.10-1: Slide OD2016-D2-0040.

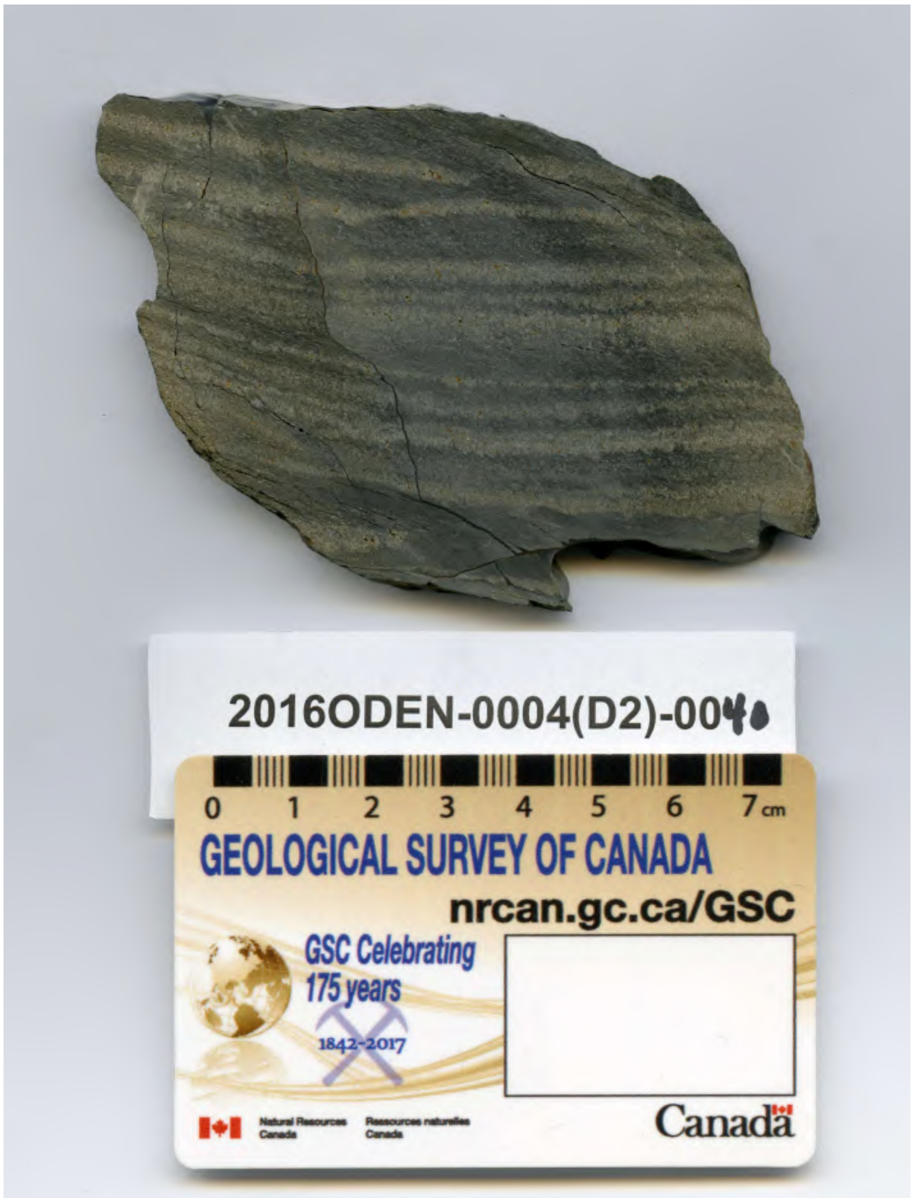
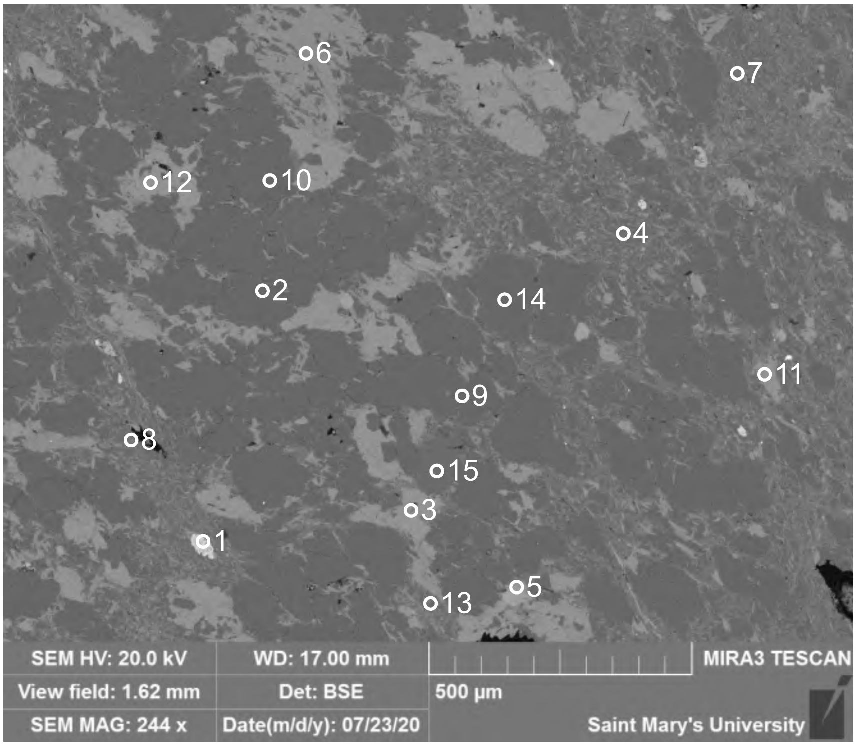
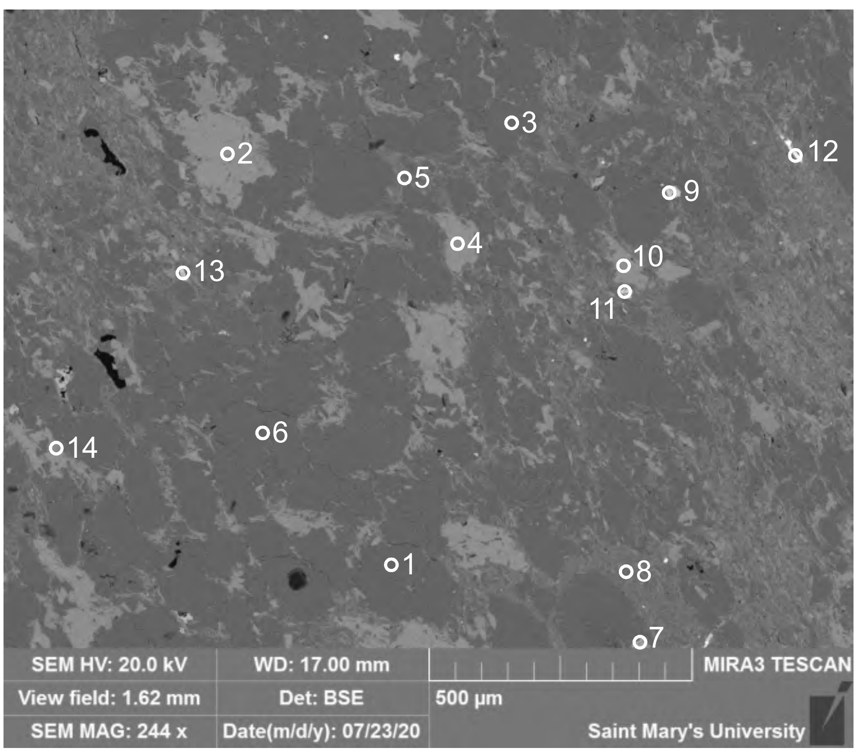


Figure 10.10-2: Sample OD2016-D2-0040.



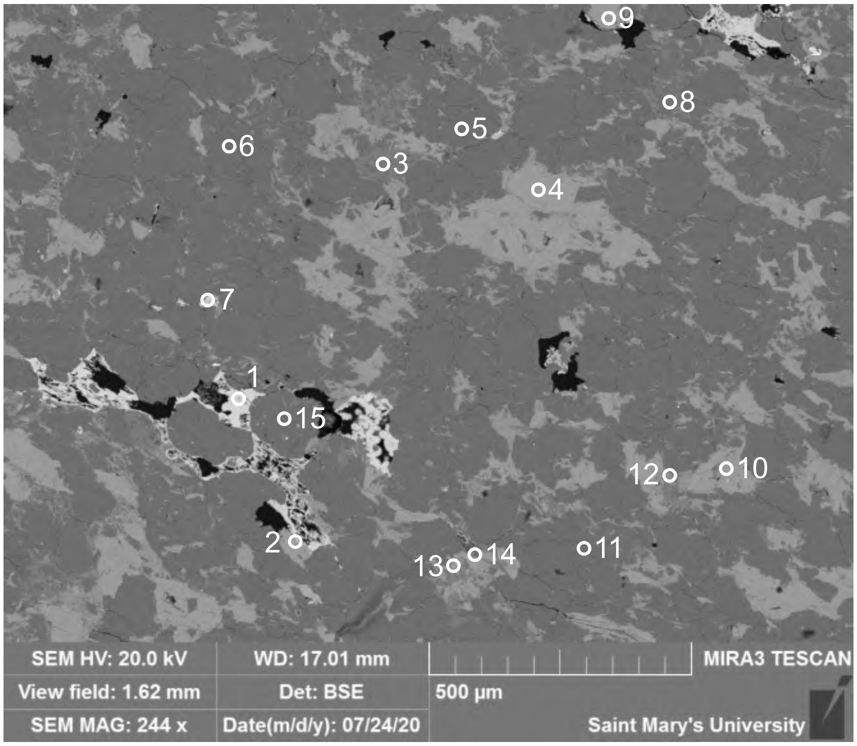
1. Ilmenite +
2. Quartz
3. Biotite
4. Albite
5. Apatite +
6. Chlorite
7. Muscovite
8. Muscovite
9. Quartz
10. Quartz
11. Biotite
12. Biotite
13. Muscovite
14. Quartz
15. Albite

Figure 10.10-3. Sample OD2016-D2-040 site 1. DT: Albite, Apatite, Ilmenite, Quartz. DG: Chlorite, Muscovite.



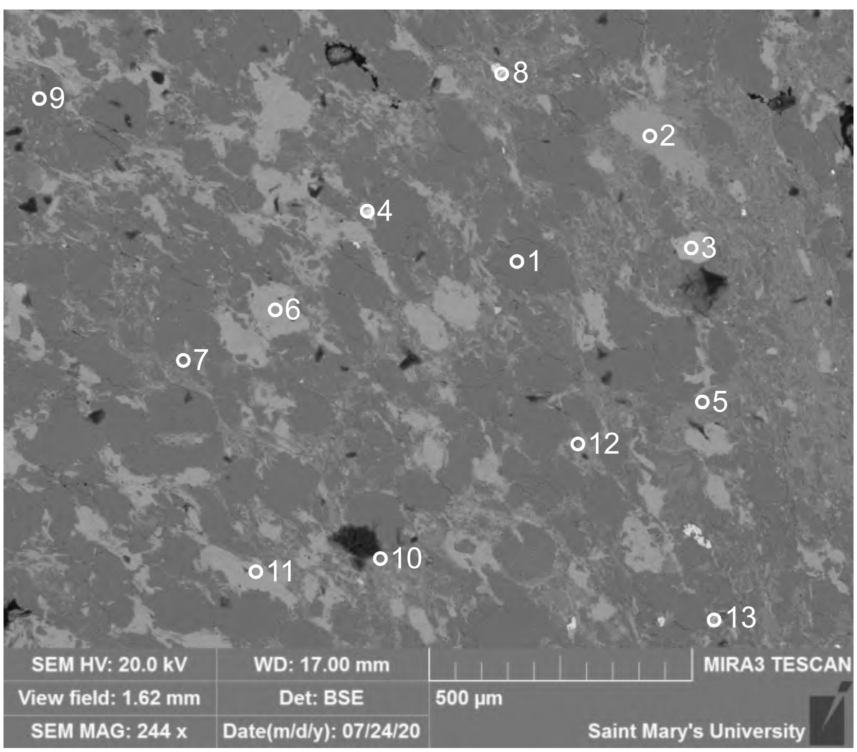
1. Quartz
2. Biotite
3. Albite
4. Biotite
5. Quartz
6. Quartz
7. Rutile +
8. Muscovite
9. Ilmenite +
10. Biotite
11. Ilmenite +
12. Monazite
13. Rutile + Biotite
14. Biotite

Figure 10.10-4. Sample OD2016-D2-040 site 2. DG: Monazite.



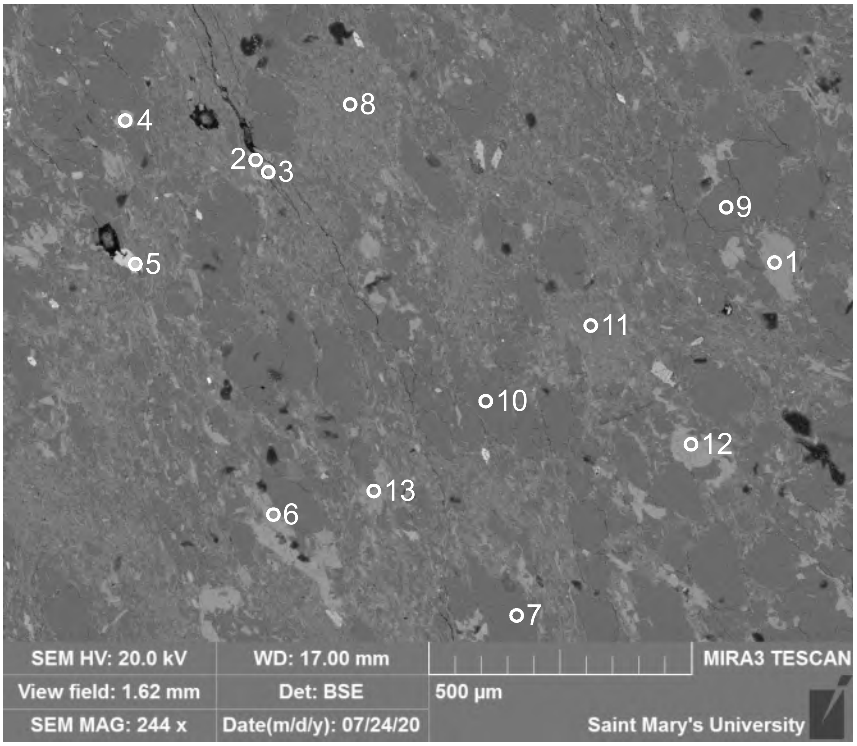
1. FeOhy +
2. Biotite
3. Muscovite
4. Biotite
5. Quartz
6. Quartz
7. FeOhy +
8. Muscovite
9. Biotite
10. Biotite
11. Quartz
12. Chlorite +
13. Muscovite
14. Biotite
15. Quartz +

Figure 10.10-5. Sample OD2016-D2-040 site 3. DT: Quartz. DG: Biotite, Chlorite, Muscovite. HD: FeOhy.



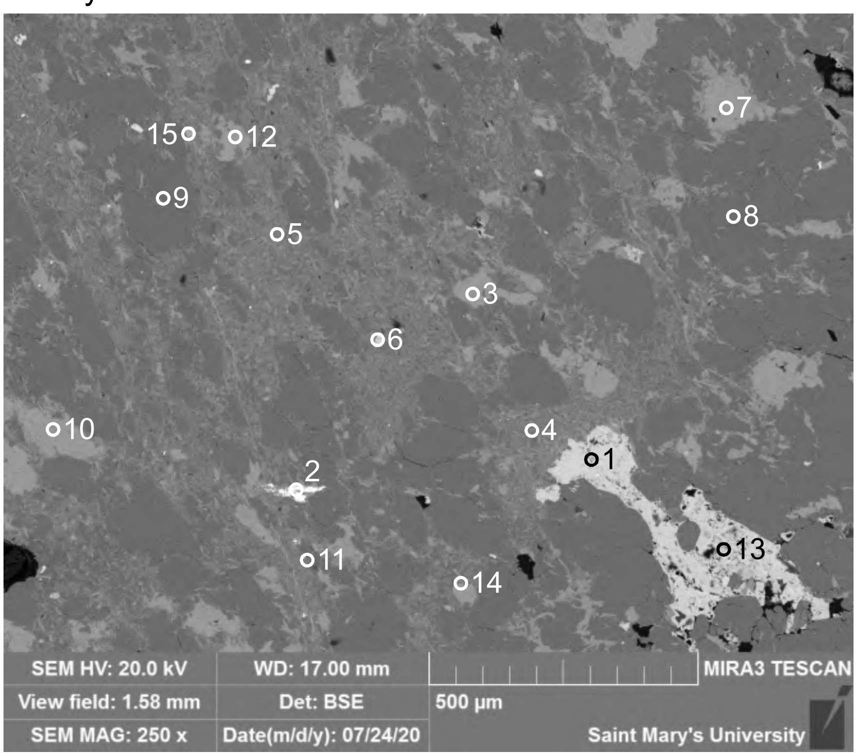
1. Quartz
2. Chlorite
3. Apatite
4. Ilmenite +
5. Muscovite
6. Biotite
7. Muscovite
8. Ilmenite +
9. Quartz
10. Muscovite
11. Biotite
12. Chlorite +
13. Rutile + Mixture

Figure 10.10-6. Sample OD2016-D2-040 site 4. DT: Apatite, Ilmenite.



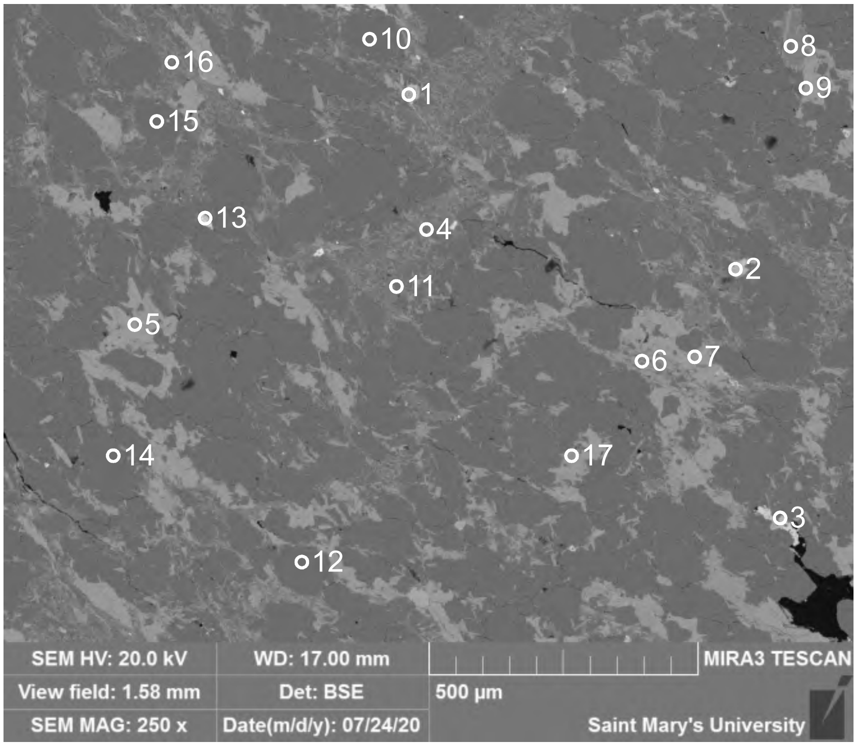
1. Chlorite
2. Biotite
3. Apatite
4. Apatite
5. FeOhy +
6. Biotite
7. Quartz
8. Albite
9. Albite
10. Quartz
11. Muscovite
12. Biotite
13. Chlorite

Figure 10.10-7. Sample OD2016-D2-040 site 5. DT: Albite, Apatite, Quartz. DG: Biotite, Chlorite, Muscovite. HD: FeOhy.



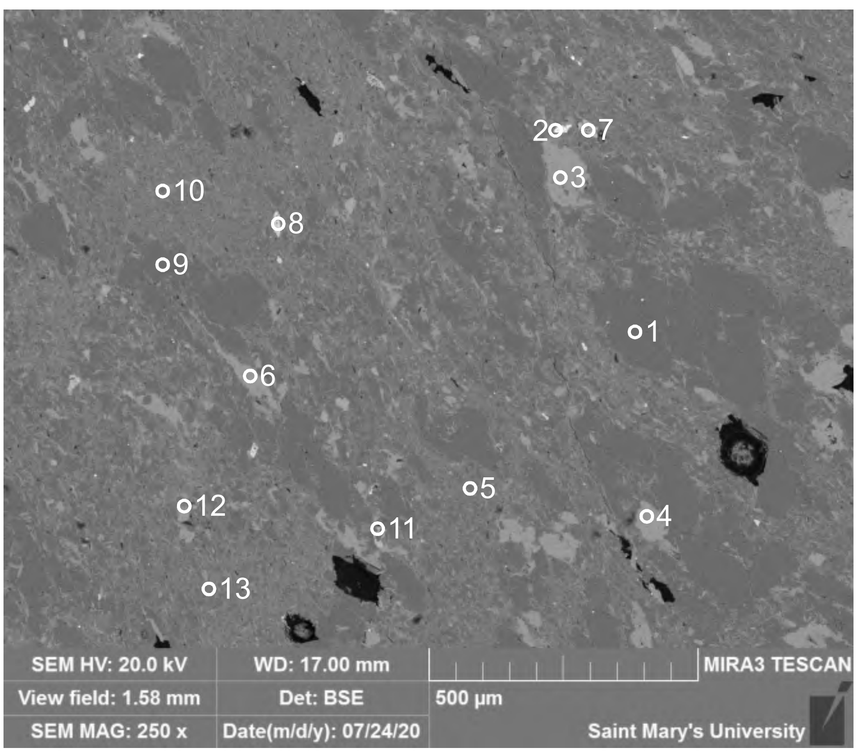
1. FeOhy +
2. Monazite
3. Biotite
4. Muscovite
5. Muscovite
6. Ilmenite
7. Biotite
8. Quartz
9. Quartz
10. Biotite
11. Muscovite
12. Biotite
13. FeOhy +
14. Biotite
15. Apatite

Figure 10.10-8. Sample OD2016-D2-040 site 6. DT: Albite, Apatite, Ilmenite, Quartz. DG: Biotite, Chlorite, Monazite, Muscovite. HD: FeOhy.



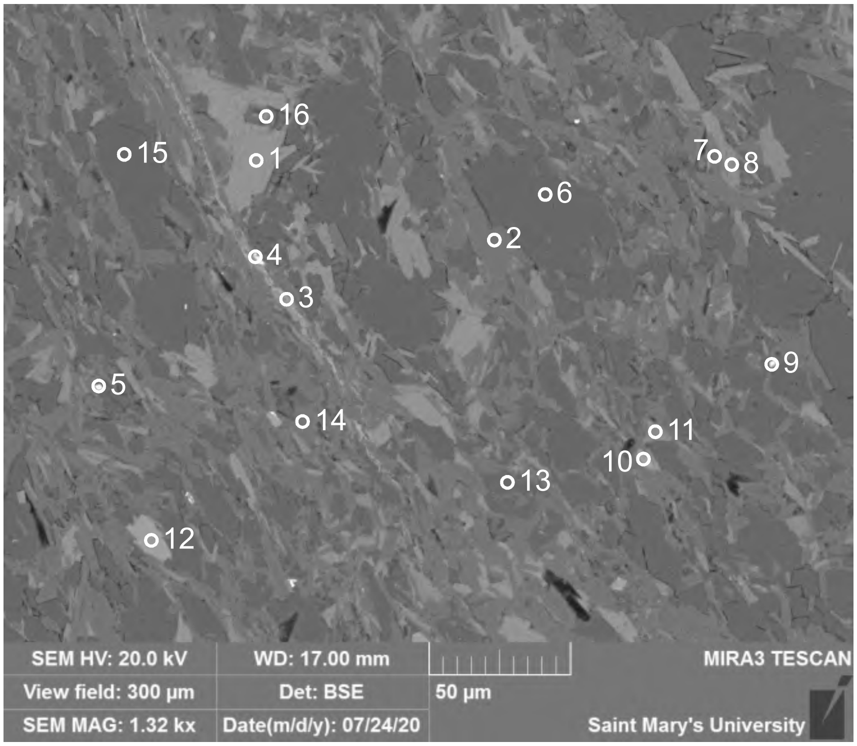
1. Rutile +
2. Rutile +
3. FeOhy +
4. Muscovite
5. Biotite
6. Biotite
7. Biotite
8. Muscovite
9. Biotite
10. Quartz
11. Albite
12. Quartz
13. Ilmenite +
14. Quartz
15. Quartz
16. Muscovite
17. Chlorite

Figure 10.10-9. Sample OD2016-D2-040 site 7.



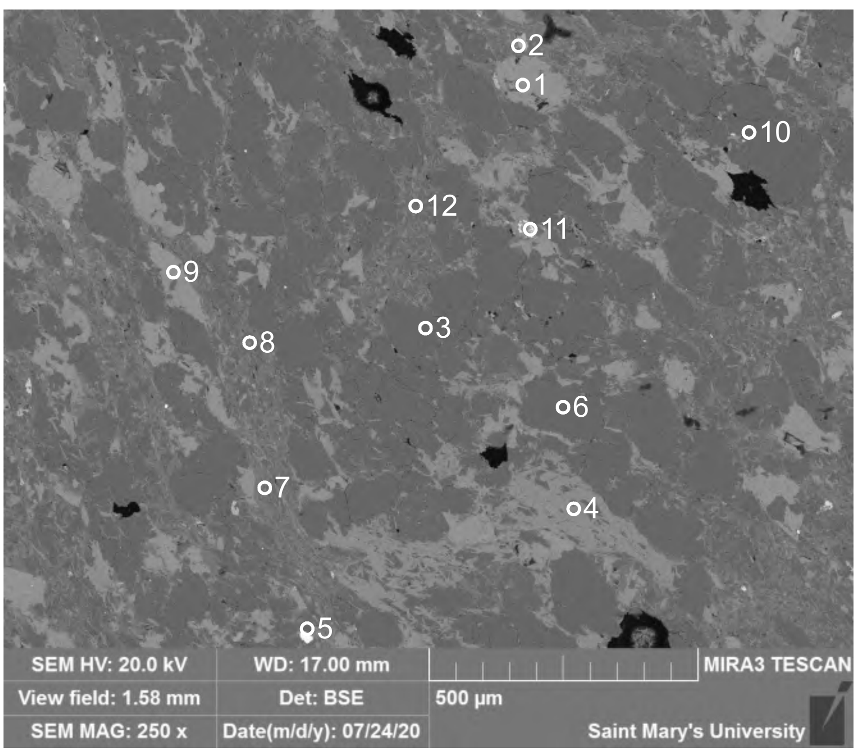
1. Quartz
2. Monazite
3. Chlorite
4. Biotite
5. Chlorite +
6. Biotite
7. Rutile +
8. Ilmenite +
9. Quartz
10. Albite
11. Rutile +
12. Biotite
13. Muscovite

Figure 10.10-10. Sample OD2016-D2-040 site 8.



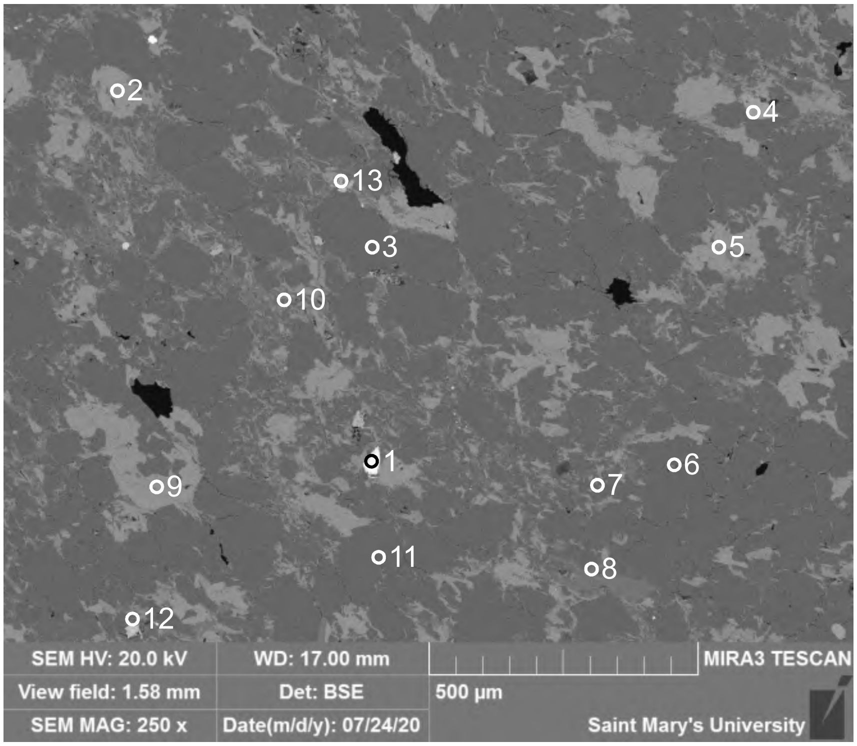
1. Biotite
2. Muscovite
3. Biotite
4. Monazite
5. Xenotime
6. Quartz
7. Muscovite
8. Chlorite
9. Monazite +
10. Apatite +
11. Chlorite
12. Apatite
13. Albite
14. Muscovite
15. Quartz
16. Muscovite + Biotite

Figure 10.10-11. Sample OD2016-D2-040 site 8a.



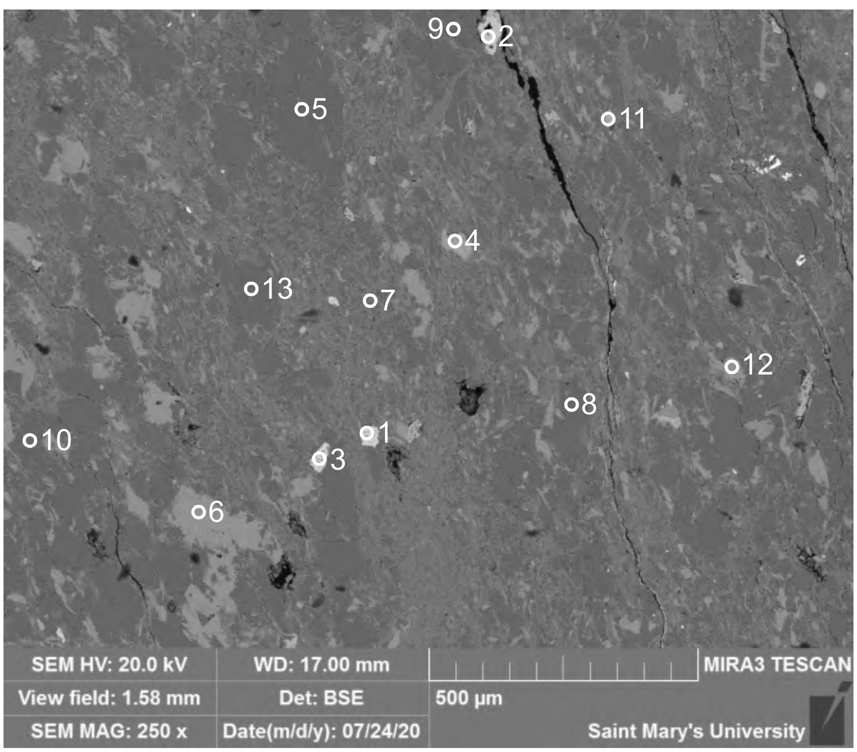
1. Biotite
2. Rutile +
3. Quartz
4. Chlorite
5. Zircon
6. Quartz
7. Muscovite
8. Muscovite
9. Biotite
10. Quartz
11. Monazite
12. Albite

Figure 10.10-12. Sample OD2016-D2-040 site 9.



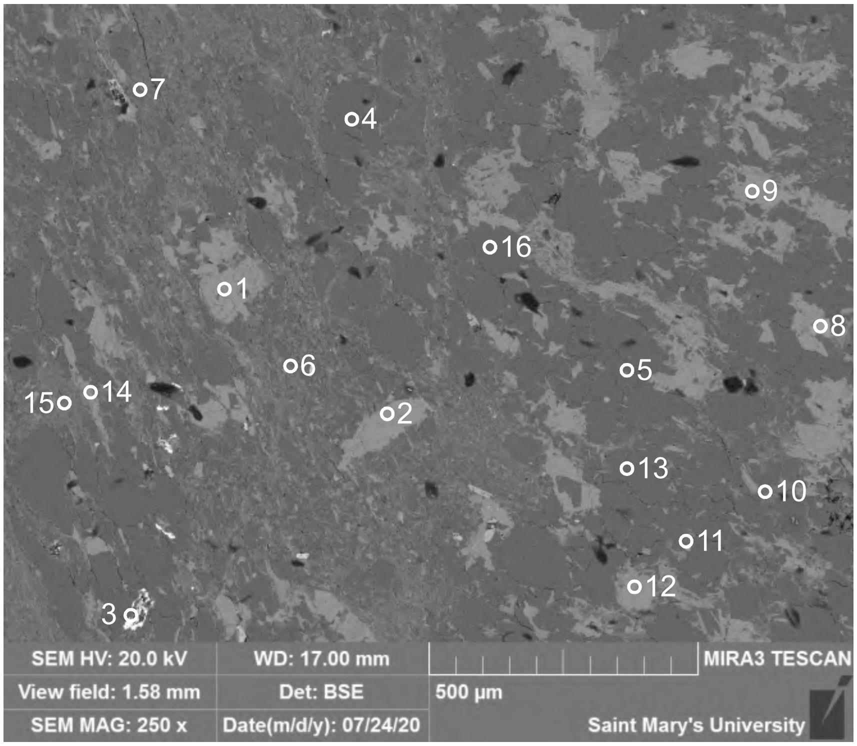
1. Zircon
2. Biotite
3. Quartz
4. Apatite
5. Biotite
6. Quartz
7. Albite + Quartz
8. Muscovite
9. Biotite
10. Albite
11. Quartz
12. FeOhy +
13. Rutile +

Figure 10.10-13. Sample OD2016-D2-040 site 10.



1. Chlorite
2. FeOhy + Biotite
3. Ilmenite +
4. Apatite
5. Quartz
6. Biotite
7. Albite
8. Quartz
9. Albite
10. Quartz + Muscovite
11. Rutile +
12. Biotite
13. Quartz

Figure 10.10-14. Sample OD2016-D2-040 site 11.



1. Biotite
2. Biotite
3. Mixture
4. Quartz
5. Quartz
6. Muscovite
7. Muscovite
8. Monazite
9. Biotite
10. Muscovite
11. Ilmenite +
12. Chlorite
13. Quartz
14. Biotite
15. Muscovite
16. Quartz

Figure 10.10-15. Sample OD2016-D2-040 site 12.

Appendix 10.11: OD201
imagery.

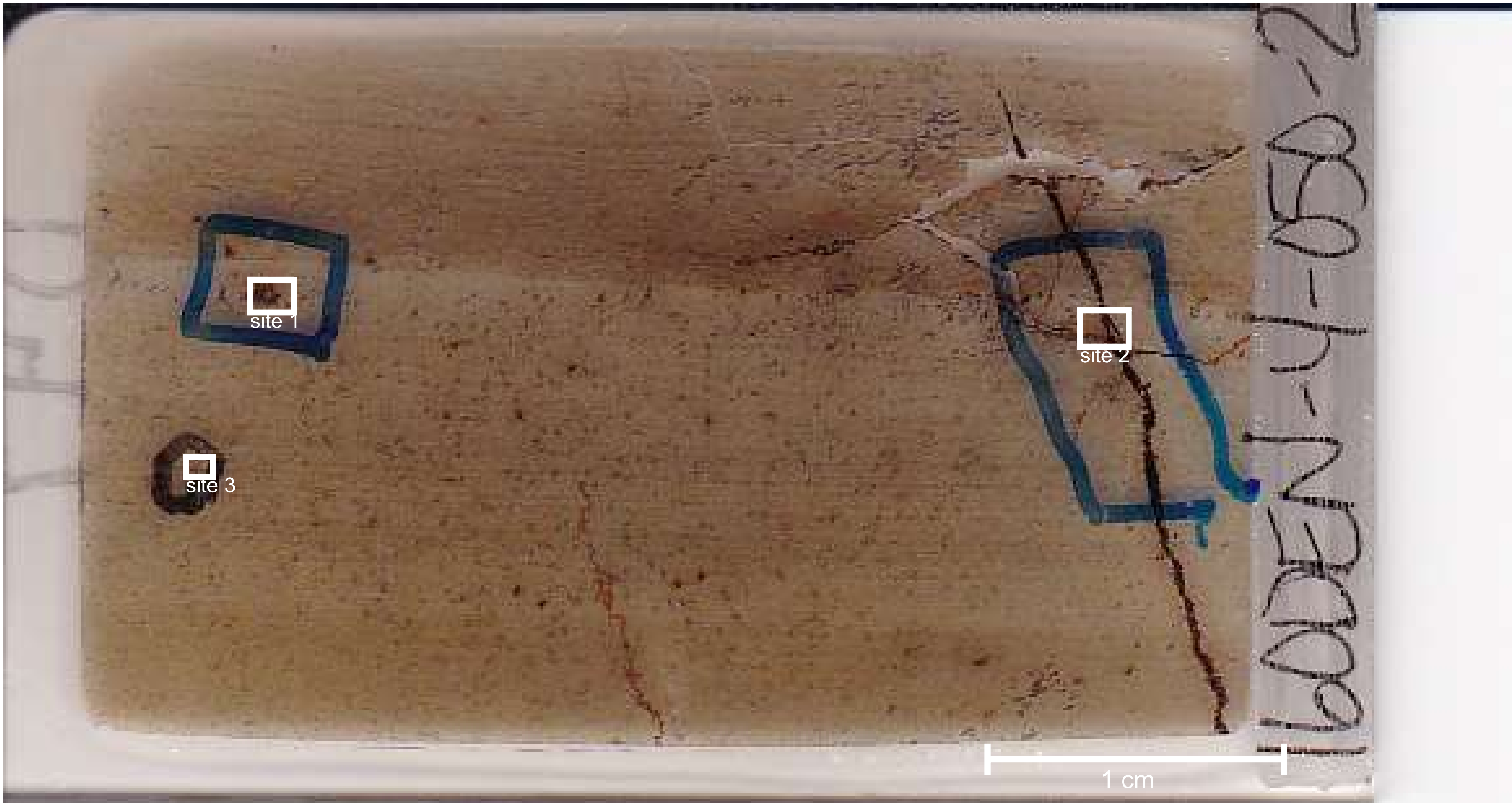


Figure 10.11-1: Sample OD2016-D2-0050-2.

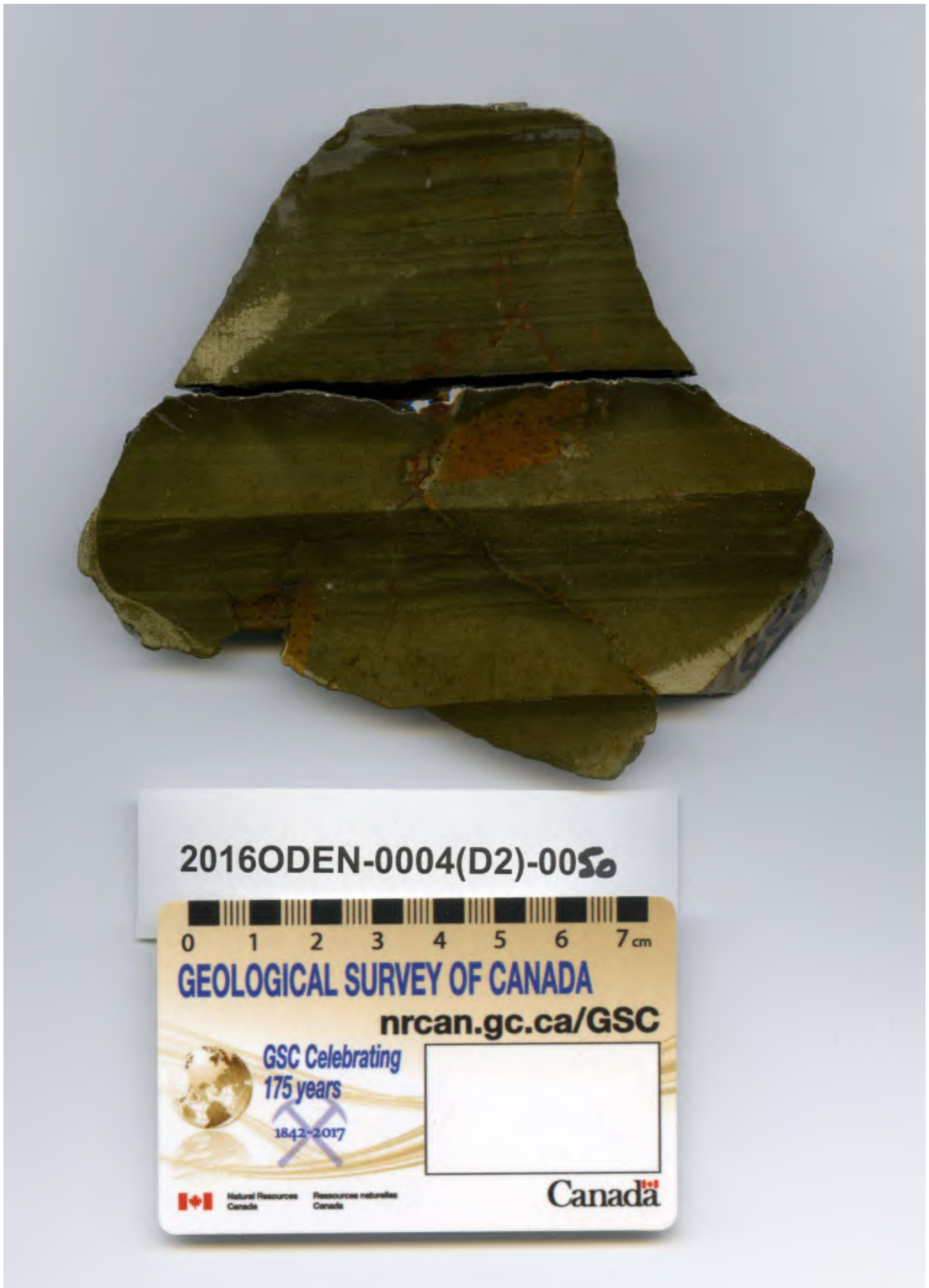
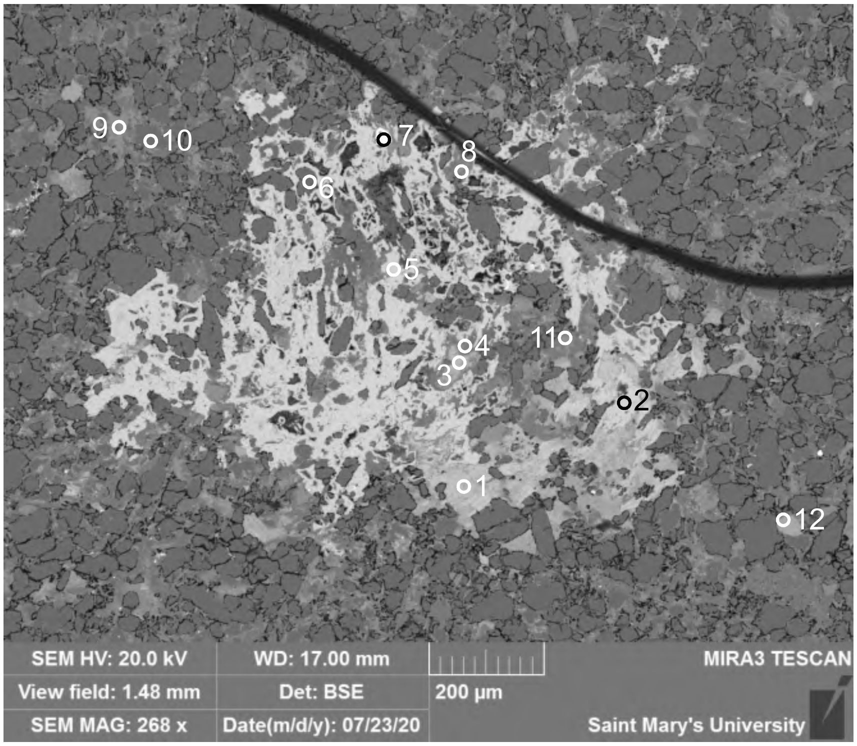
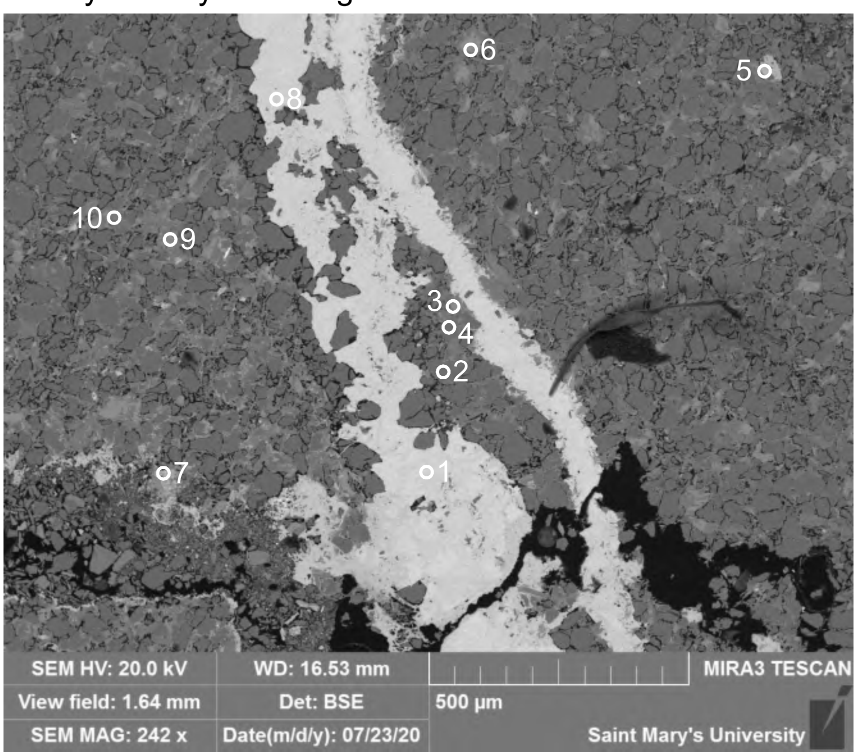


Figure 10.11-2: Sample OD2016-D2-0050. This is the 0050 sample, 0050-2 refers to the thin section.



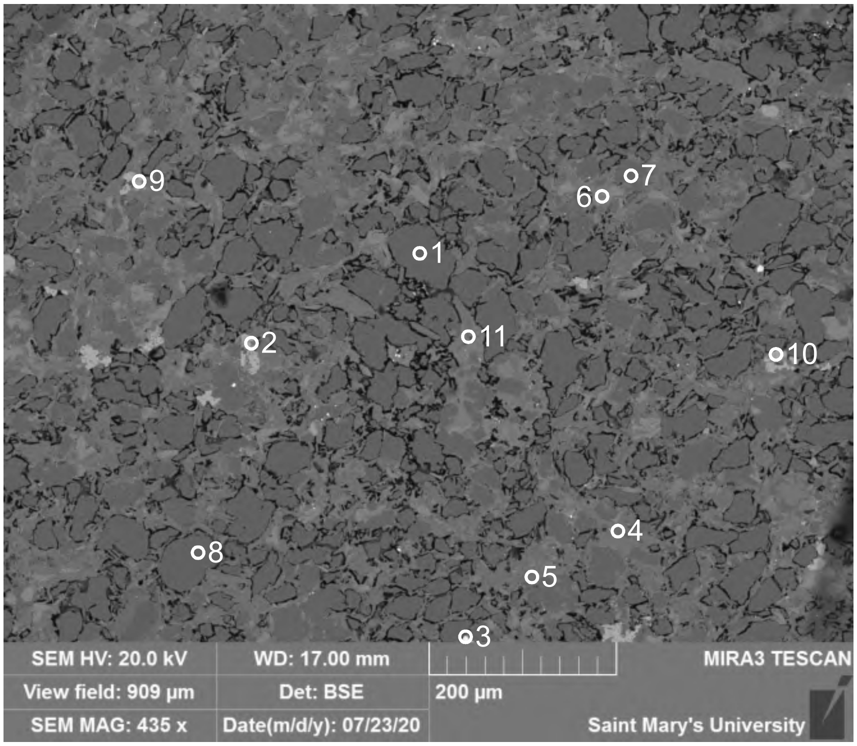
1. FeOhy +
2. FeOhy +
3. FeOhy +
4. Muscovite
5. FeOhy +
6. Quartz
7. Zircon +
8. Chlorite
9. Chlorite
10. Albite
11. Chlorite
12. Apatite

Figure 10.11-3. Sample OD2016-D2-050-2 site 1. DT: Albite, Apatite, Quartz, Zircon. DG: Chlorite, Muscovite. HD: FeOhy. FeOhy occurring as a nodule.



1. FeOhy +
2. Albite
3. Rutile +
4. Albite
5. Rutile +
6. Chlorite
7. FeOhy + Mixture
8. FeOhy +
9. Chlorite
10. Muscovite

Figure 10.11-4. Sample OD2016-D2-050-2 site 2. DT: Rutile. FeOhy is filling fractures in the rock.



1. Quartz
2. Muscovite
3. Zircon
4. Muscovite
5. Muscovite
6. Chlorite
7. Albite
8. Quartz
9. Rutile +
10. Rutile +
11. Ms + Chl

Figure 10.11-5. Sample OD2016-D2-050-2 site 3.

Appendix 10.12: OD201
imagery.

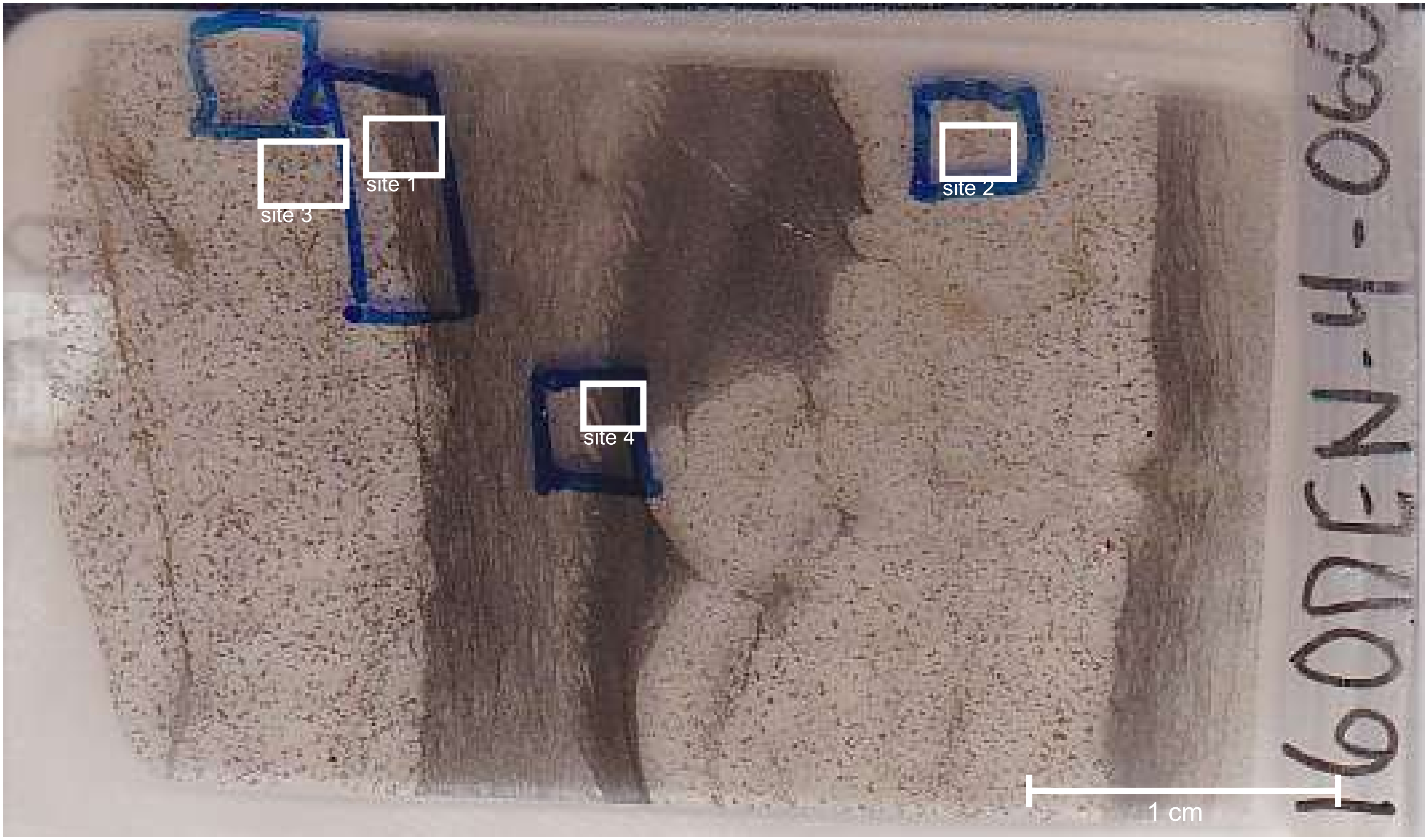
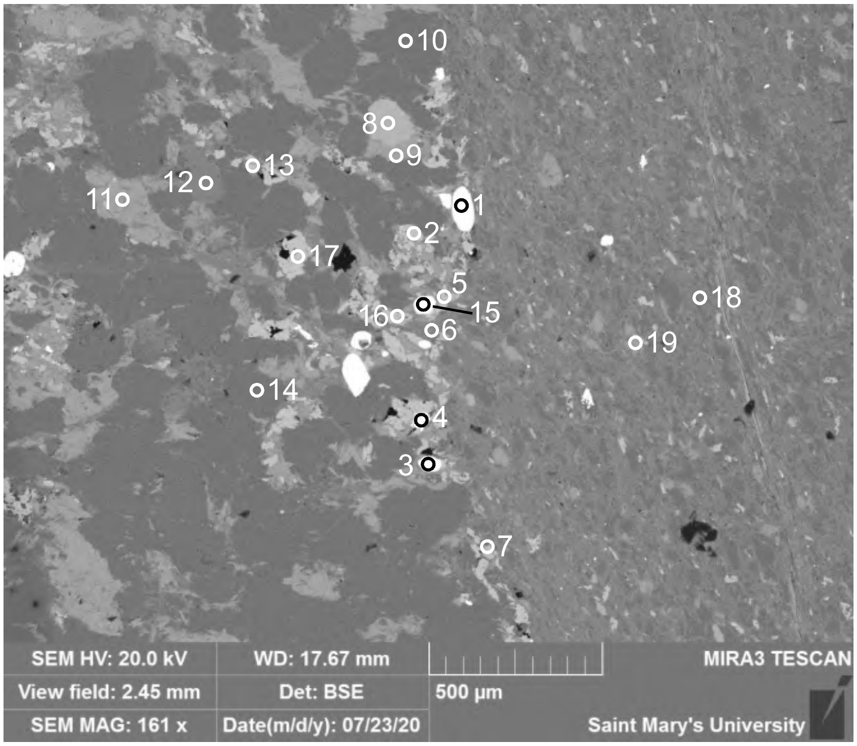


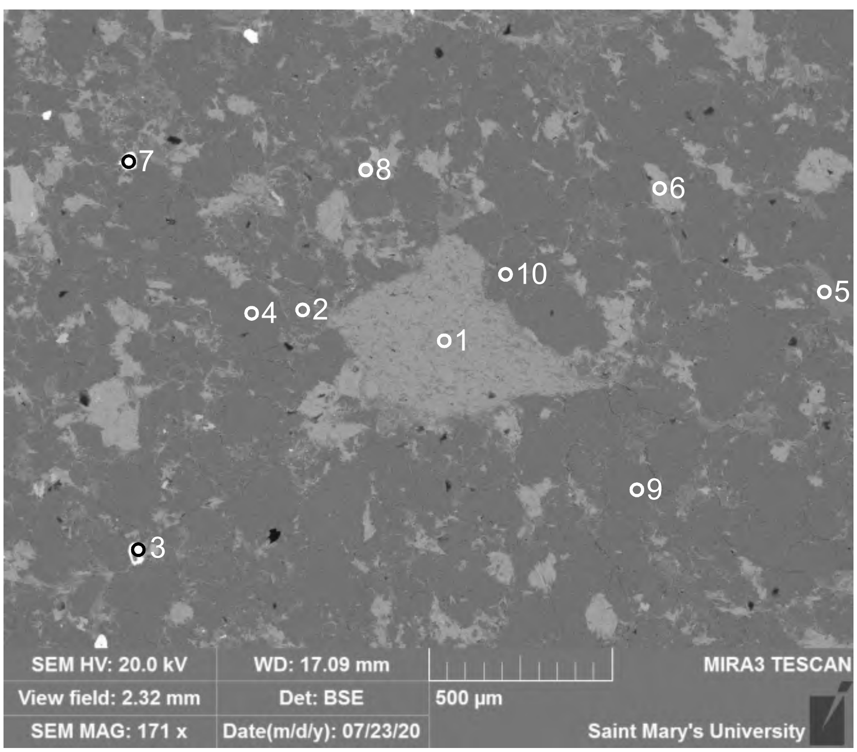
Figure 10.12-1: Slide OD2016-D2-0060.

Figure 10.12-2: Sample OD2016-D2-0060.



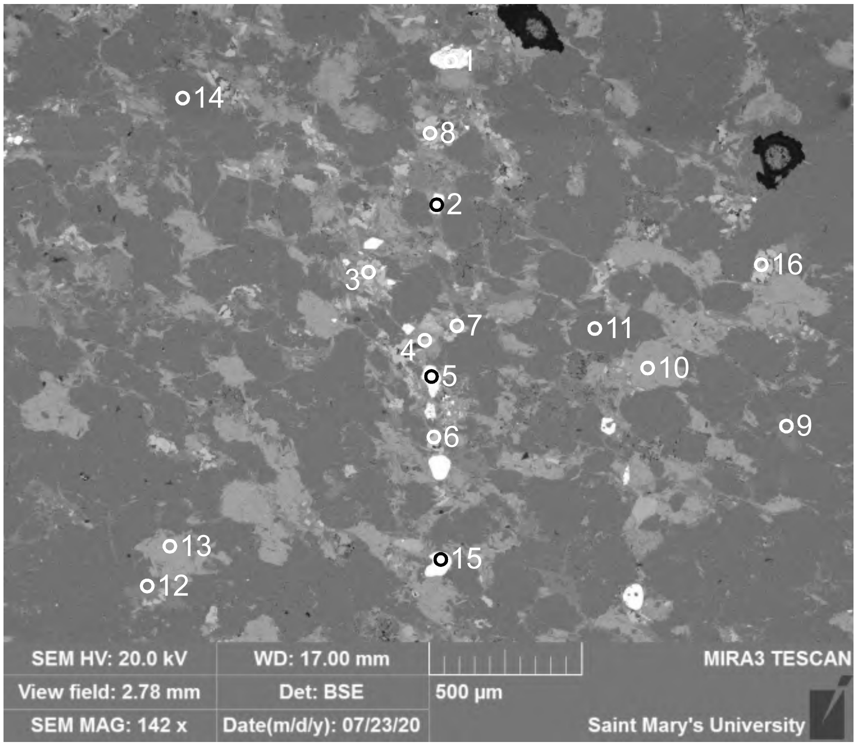
1. Zircon
2. Rutile +
3. Zircon
4. Apatite
5. Rutile +
6. Muscovite
7. Rutile +
8. Apatite
9. Biotite
10. Quartz
11. Biotite
12. Muscovite
13. Rutile +
14. Quartz
15. Zircon
16. Rutile +
17. Rutile +
18. Albite
19. Biotite

Figure 10.12-3. Sample OD2016-D2-0060 site 1. DT: Apatite, Quartz, Rutile, Zircon. DG: Biotite, Muscovite.



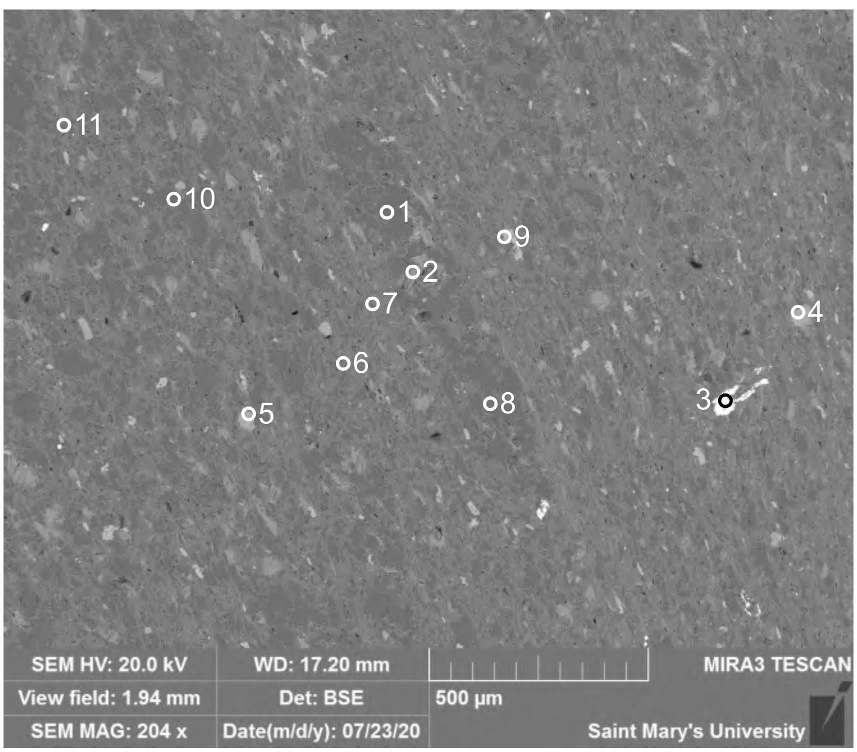
1. Chlorite
2. Albite
3. Zircon
4. Quartz
5. Muscovite
6. Biotite
7. Zircon
8. Apatite
9. Quartz
10. Quartz

Figure 10.12-4. Sample OD2016-D2-0060 site 2. DT: Albite, Apatite, Quartz, Zircon. DG: Biotite, Chlorite, Muscovite.



1. Zircon
2. Zircon
3. Biotite + Rutile
4. Rutile
5. Zircon
6. Rutile
7. Rutile +
8. Rutile +
9. Muscovite
10. Biotite
11. Quartz
12. Muscovite
13. Biotite
14. Quartz
15. Zircon
16. Rutile +

Figure 10.12-5. Sample OD2016-D2-0060 site 3. Detrital zircon and rutile are concentrated in a heavy mineral bed.



1. Quartz
2. Biotite
3. Monazite
4. Apatite
5. Apatite
6. Muscovite
7. Albite
8. Quartz
9. Rutile +
10. Quartz
11. Muscovite

Figure 10.12-6. Sample OD2016-D2-0060 site 4. Sheared texture, quartz grains (1, 8) are sheared in muddy matrix.

Appendix 10.13: OD2016-D2-069 BSE imagery.

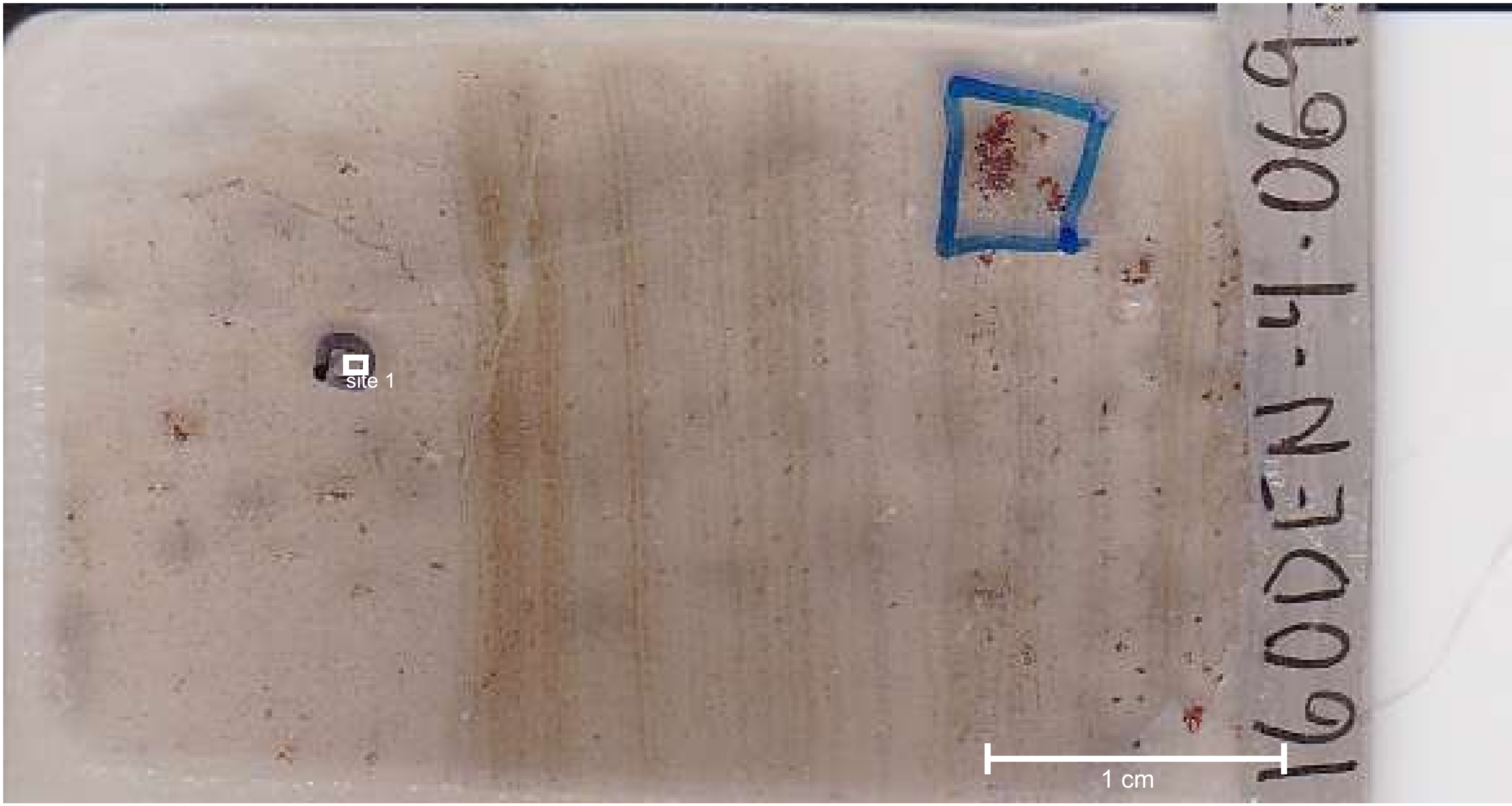


Figure 10.13-1: Slide OD2016-D2-0069.

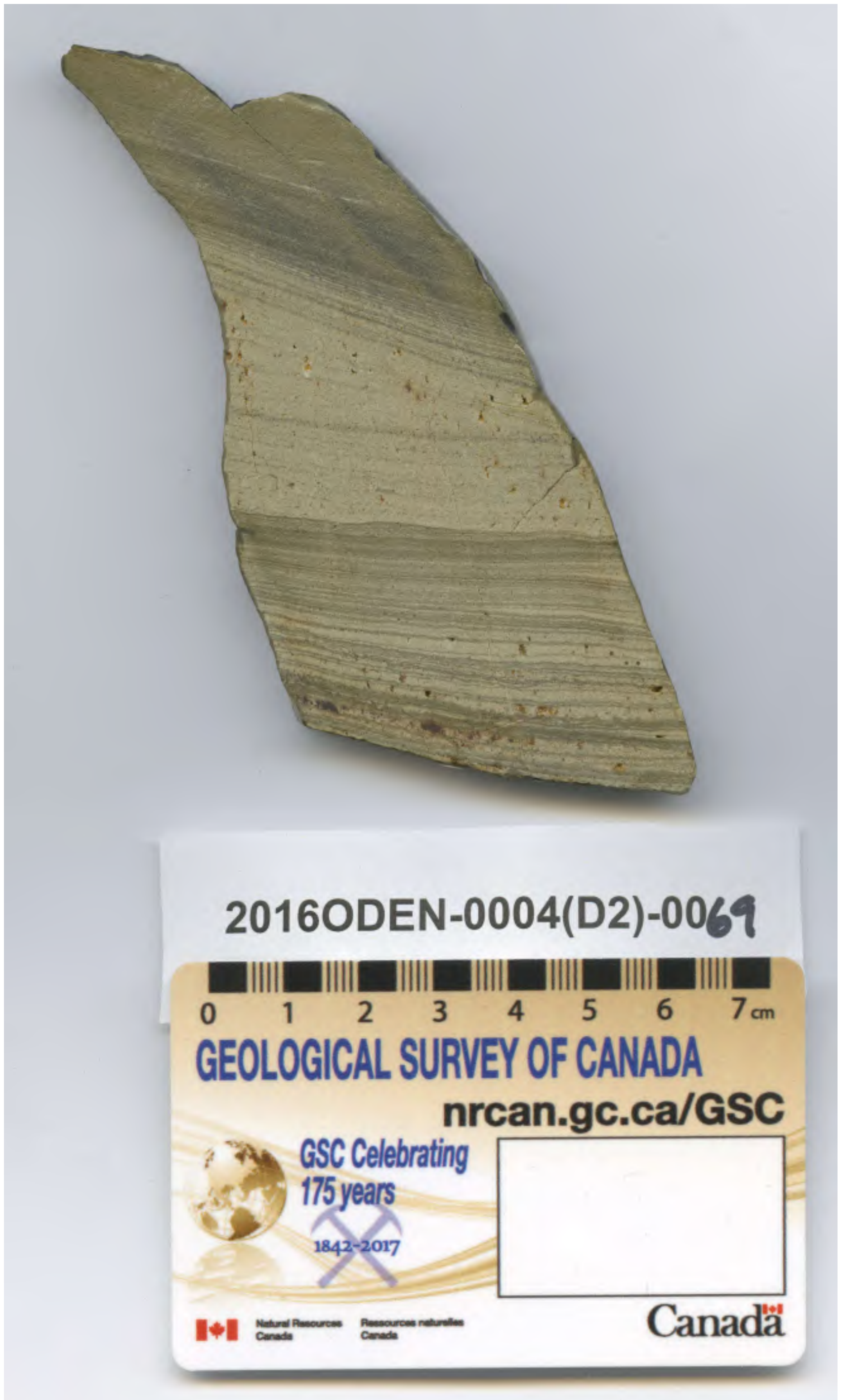
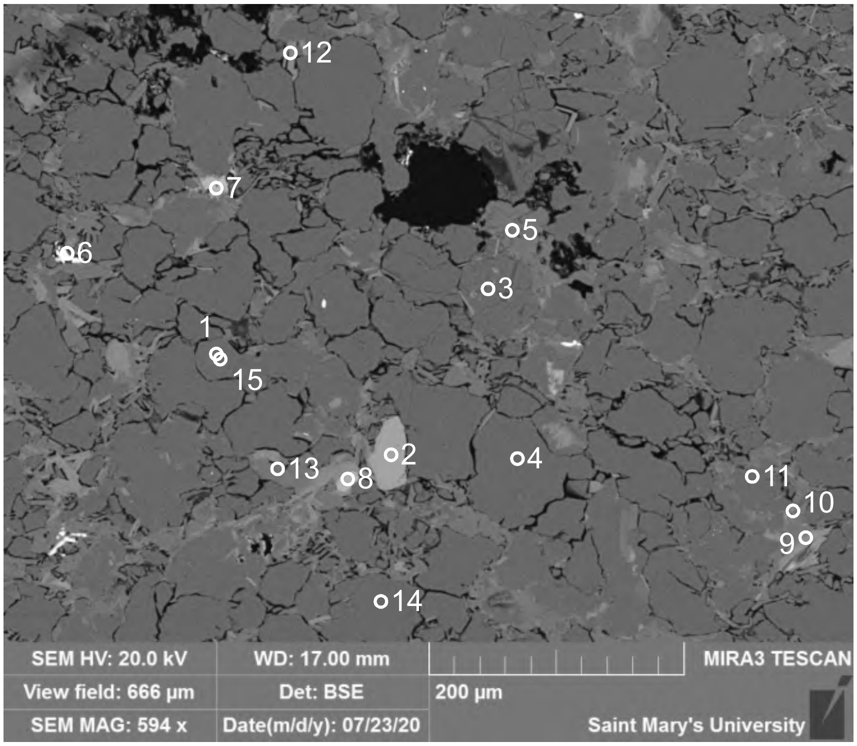


Figure 10.13-2: Sample OD2016-D2-0069.



1. Tourmaline
2. Apatite
3. Albite
4. Quartz
5. Muscovite
6. Monazite
7. FeOhy +
8. Rutile +
9. Chlorite
10. Muscovite
11. Albite
12. Chlorite
13. Muscovite
14. Quartz
15. Tourmaline

Figure 10.13-3. Sample OD2016-D2-0069 site 1. DT: Apatite. Quartz, Tourmaline. DG: Chlorite, Monazite, Muscovite, Rutile. HD: FeOhy. Euhedral tourmaline grain (1, 15) is yellow and shows zoning in petrographic microscope.

Appendix 10.14: OD2016-D2-072 BSE imagery.

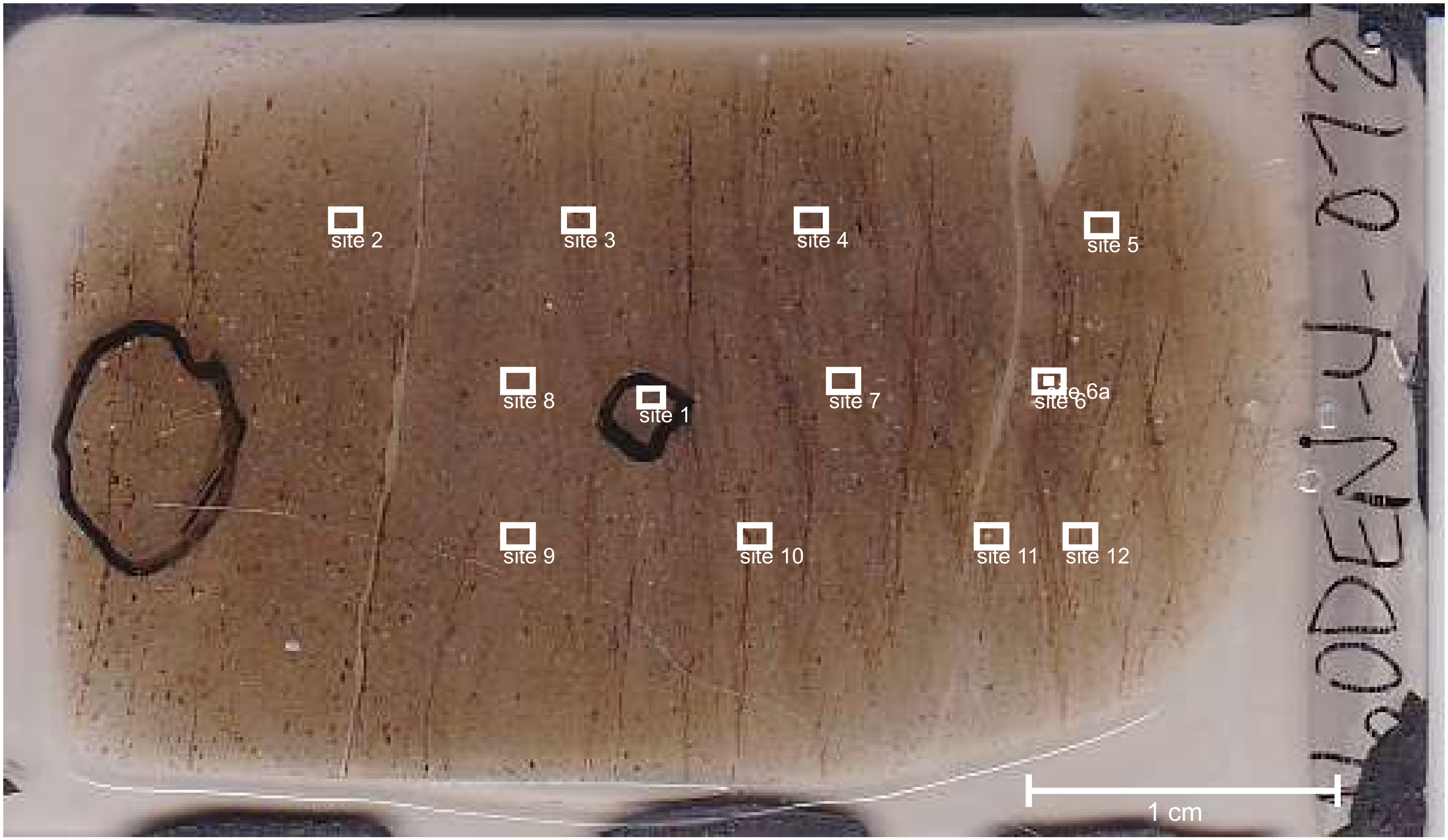
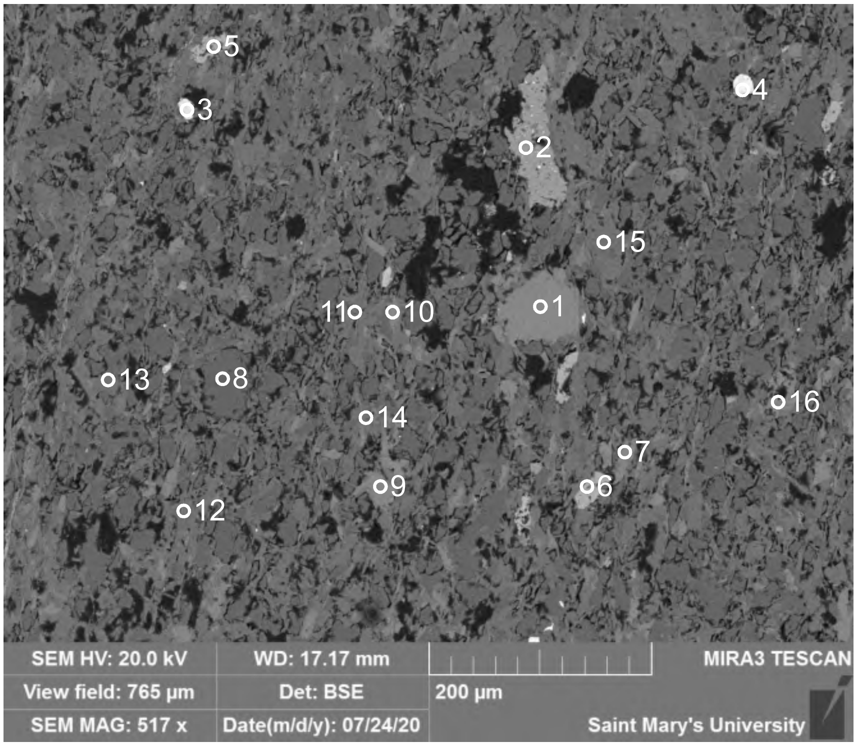


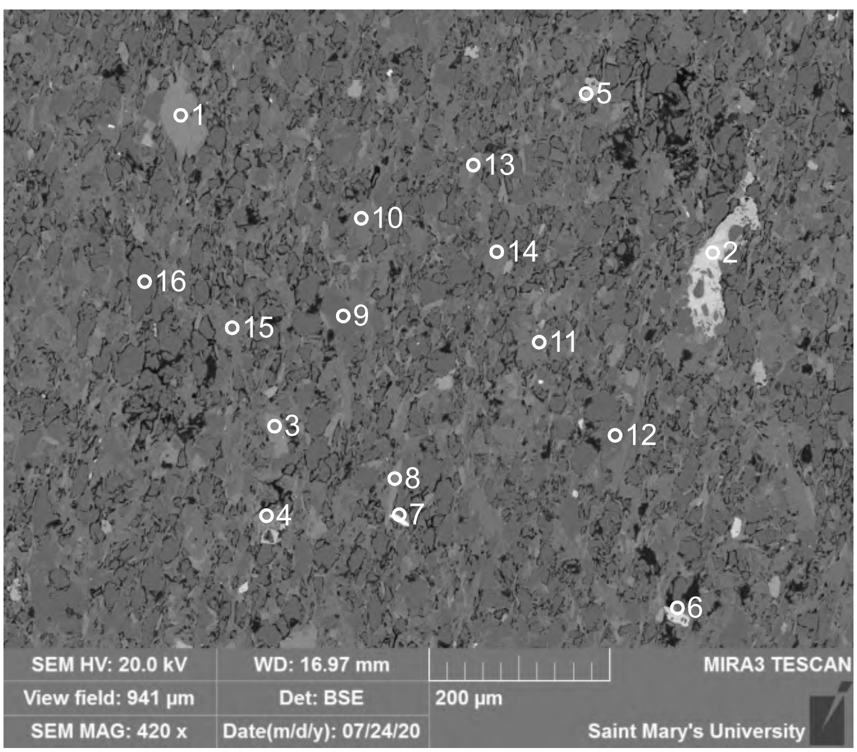
Figure 10.14-1: Slide OD2016-D2-0072.

Figure 10.14-2: Sample OD2016-D2-0072.



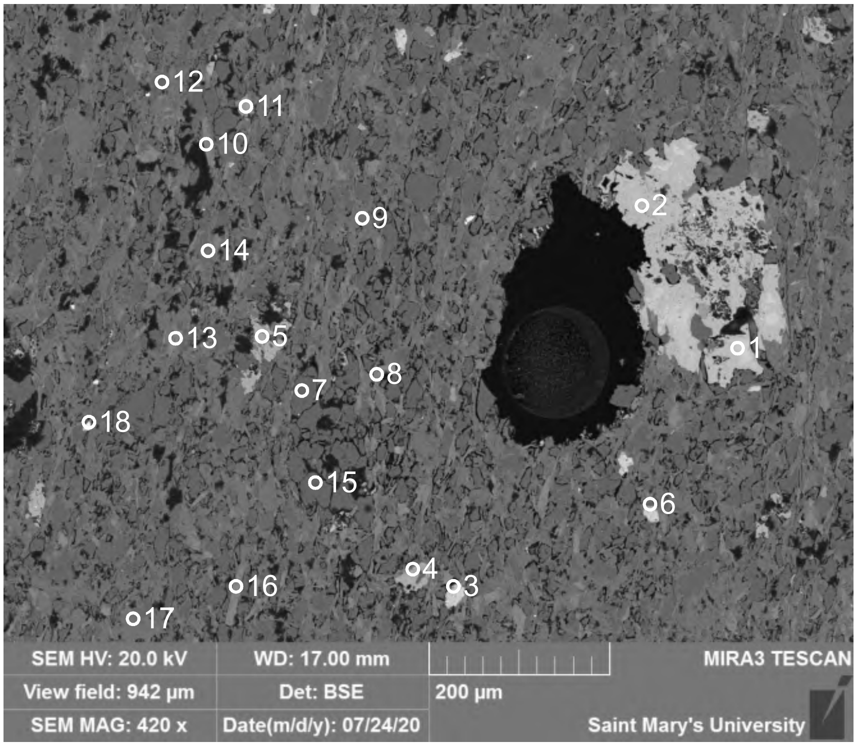
1. Chlorite
2. Apatite
3. Zircon
4. Zircon
5. Rutile +
6. Rutile +
7. Chlorite
8. Quartz
9. Chlorite
10.Chlorite
11. Muscovite
12. Muscovite
13. Muscovite
14. Muscovite
15. Muscovite
16. Chlorite

Figure 10.14-3. Sample OD2016-D2-0072 site 1. DT: Apatite, Chlorite (1), Muscovite, Quartz, Zircon. DG:



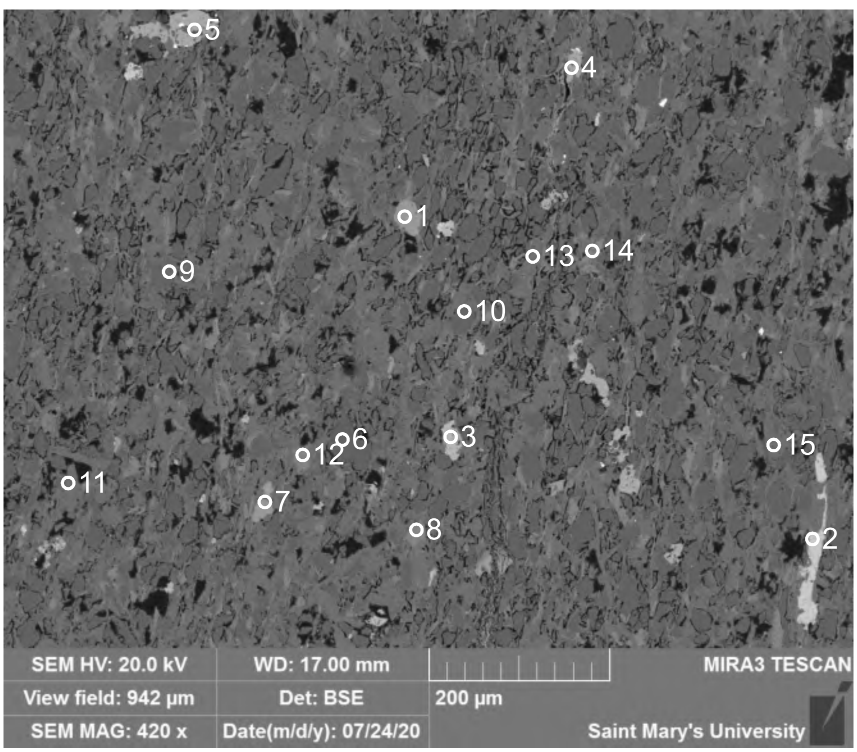
1. Chlorite
2. FeOhy +
3. Chlorite
4. Chlorite
5. Rutile +
6. Ilmenite +
7. Zircon
8. Chlorite
9. Albite
10. Muscovite
11. Muscovite
12. Albite
13. Chlorite
14. Muscovite
15. Muscovite
16. Quartz

Figure 10.14-4. Sample OD2016-D2-0072 site 2. DT: Albite, Ilmenite. HD: FeOhy.



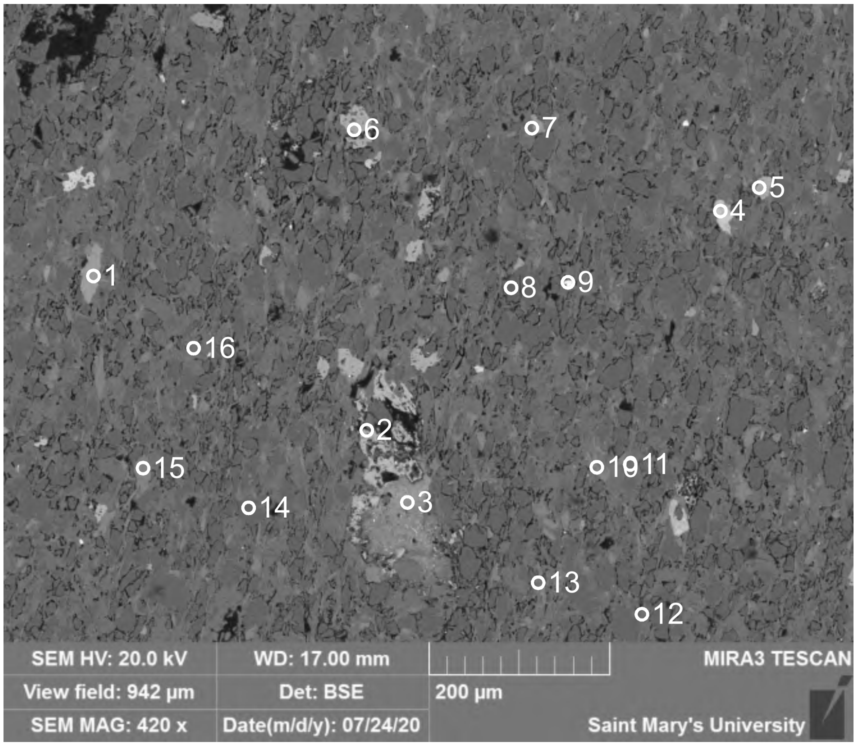
1. FeOhy +
2. FeOhy +
3. Ilmenite +
4. Rutile +
5. Rutile +
6. Ilmenite +
7. Quartz
8. Chlorite
9. Muscovite
10. Chlorite
11. Apatite
12. Albite
13. Chlorite
14. Muscovite
15. Quartz
16. Chlorite
17. Muscovite
18. Zircon

Figure 10.14-5. Sample OD2016-D2-0072 site 3.



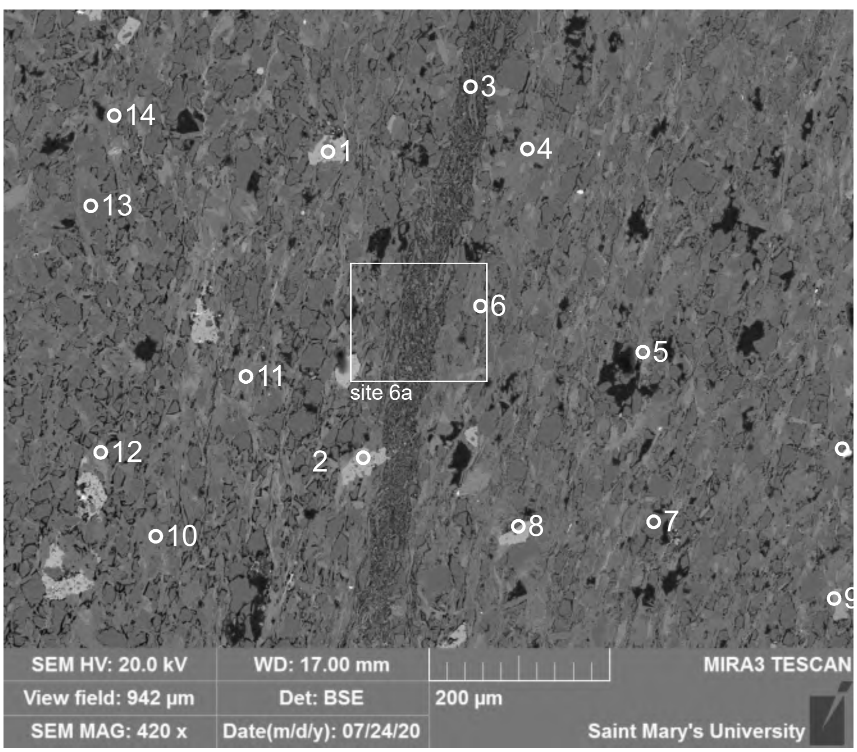
1. Apatite
2. FeOhy +
3. FeOhy +
4. Rutile +
5. Rutile +
6. Quartz
7. Apatite
8. Chlorite
9. Muscovite
10. Albite
11. Muscovite
12. Chlorite
13. Muscovite
14. Chlorite
15. Muscovite

Figure 10.14-6. Sample OD2016-D2-0072 site 4.



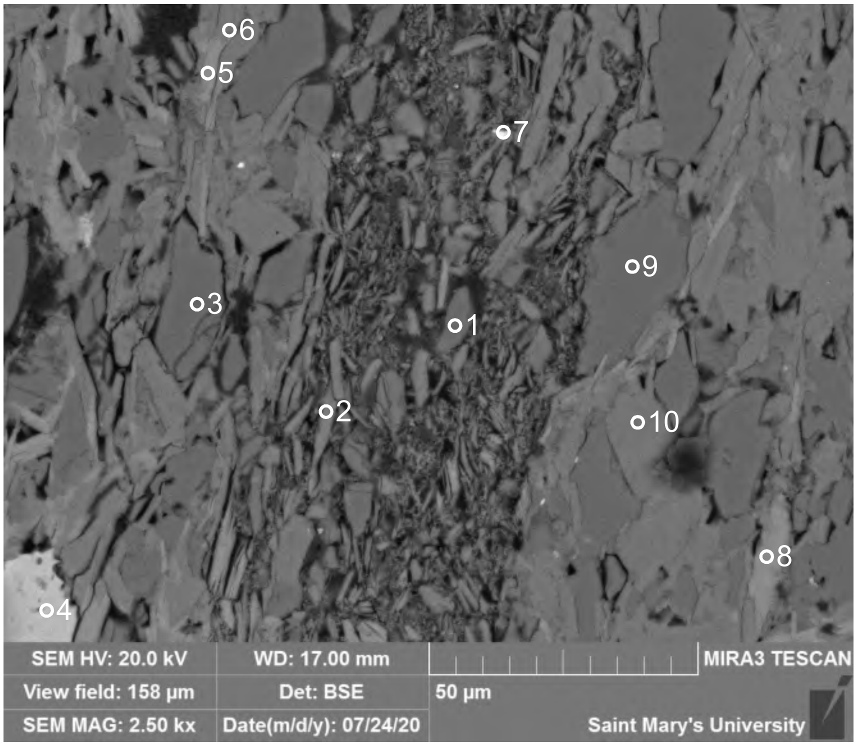
1. Apatite
2. FeOhy +
3. Biotite
4. FeOhy +
5. Rutile +
6. Rutile
7. Apatite
8. Quartz
9. Zircon
10. Chlorite
11. Muscovite
12. Muscovite
13. Chlorite
14. Albite
15. Chlorite
16. Muscovite

Figure 10.14-7. Sample OD2016-D2-0072 site 5.



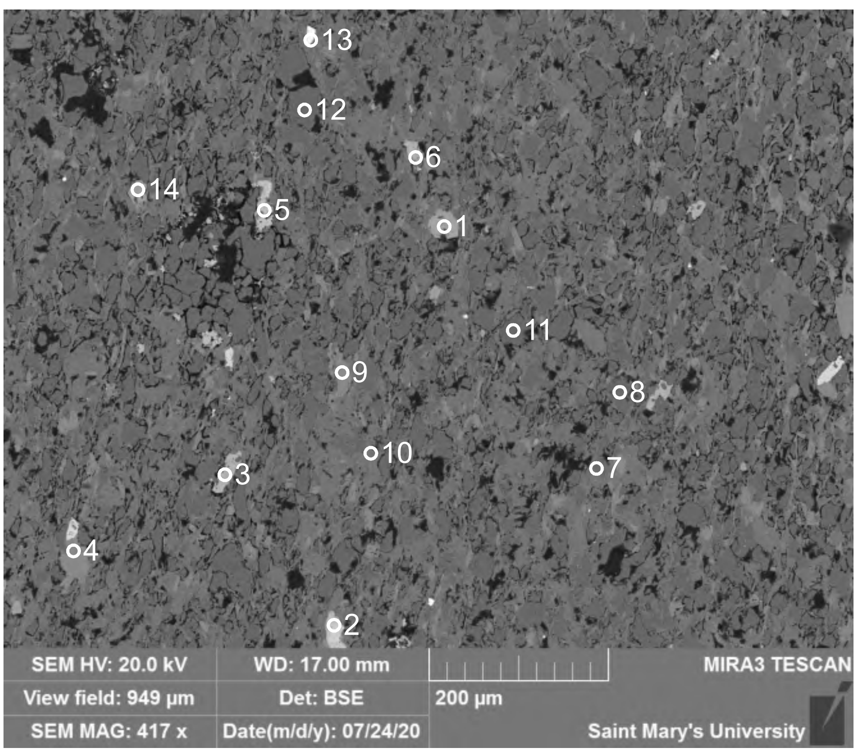
1. Rutile +
2. Rutile +
3. Biotite
4. Muscovite
5. Chlorite +
6. Muscovite
7. Quartz
8. Rutile +
9. Apatite
10. Muscovite
11. Muscovite
12. Chlorite
13. Albite
14. Biotite
15. Zircon

Figure 10.14-8. Sample OD2016-D2-0072 site 6. Fine grain material interpreted to have been sheared.



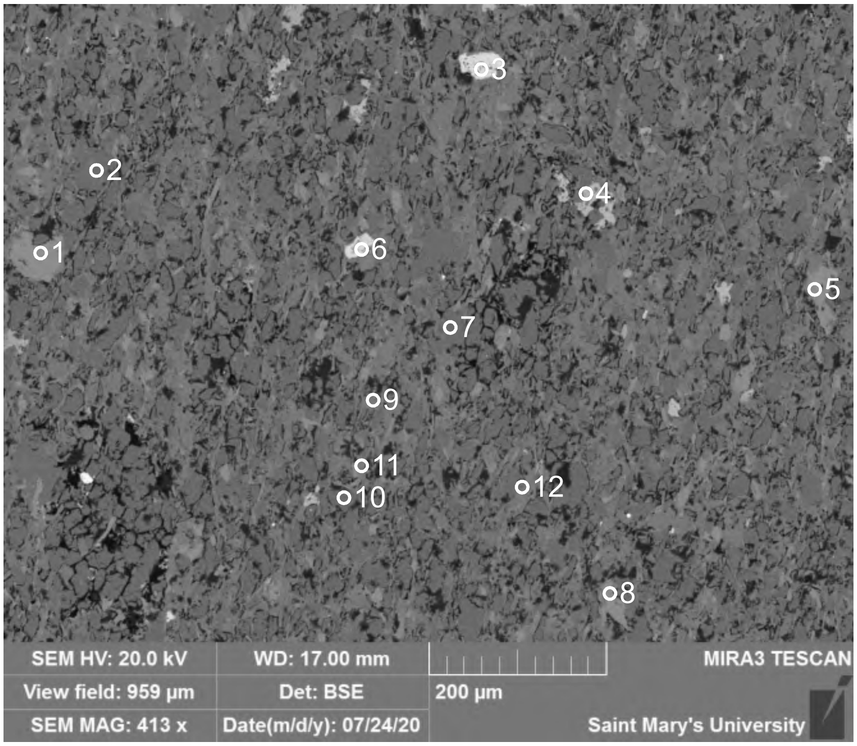
1. Quartz
2. Muscovite
3. Quartz
4. Rutile +
5. Biotite
6. Muscovite
7. Mixture
8. Chlorite
9. Albite
10. Muscovite

Figure 10.14-9. Sample OD2016-D2-0072 site 6a.



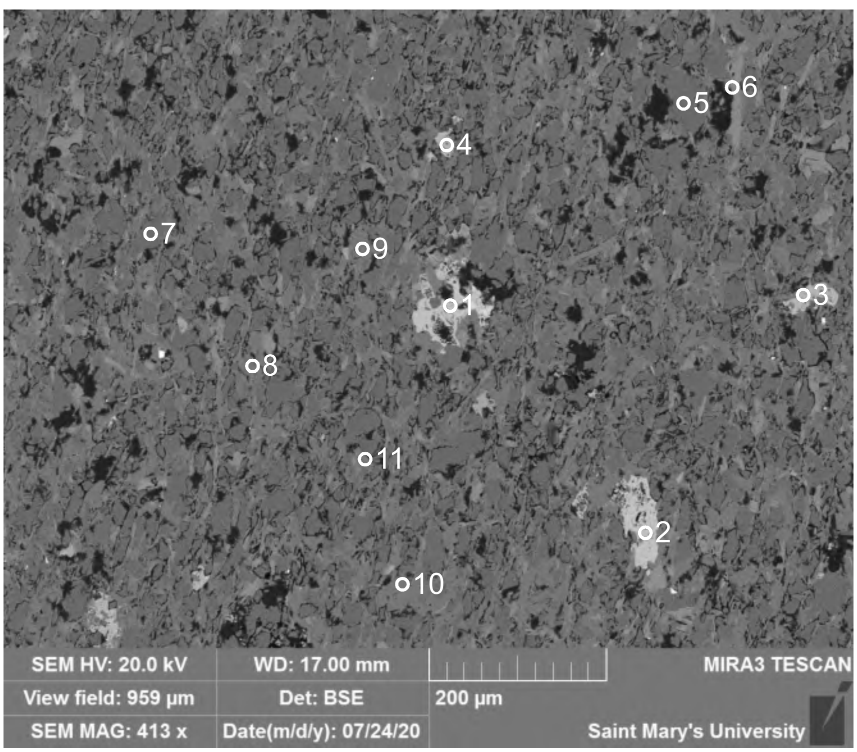
1. Apatite
2. FeOhy +
3. Rutile +
4. Chlorite
5. FeOhy +
6. Rutile +
7. Muscovite
8. Albite +
9. Chlorite
10. Muscovite
11. Quartz
12. Quartz
13. Zircon
14. Apatite

Figure 10.14-10. Sample OD2016-D2-0072 site 7.



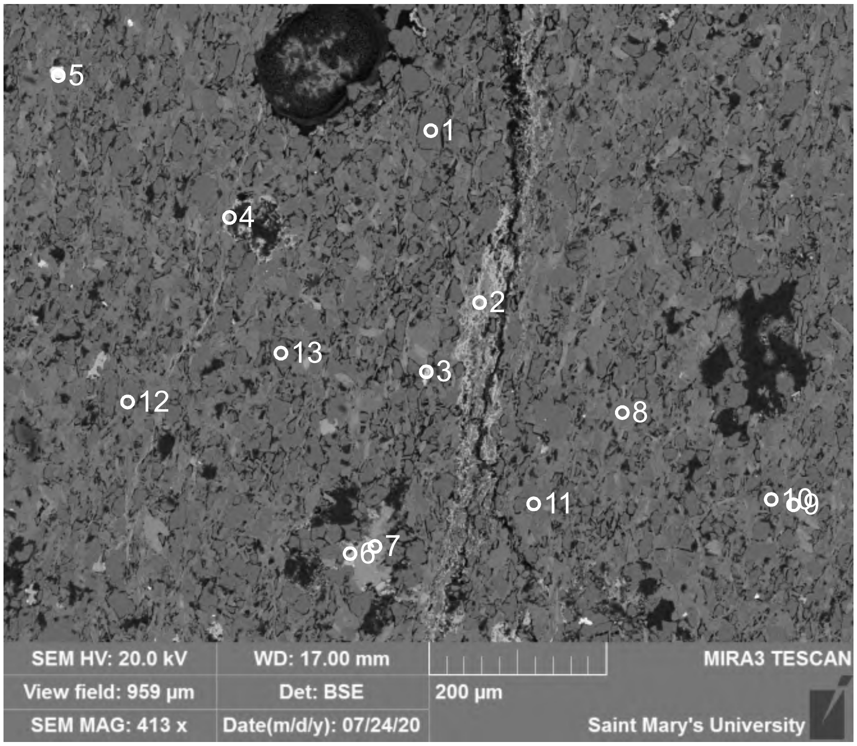
1. Chlorite
2. Albite
3. Ilmenite +
4. Rutile +
5. Chlorite
6. Ilmenite +
7. Albite
8. Chlorite
9. Muscovite
10. Quartz
11. Muscovite
12. Muscovite

Figure 10.14-11. Sample OD2016-D2-0072 site 8. DT: Albite, Chlorite, Ilmenite, Muscovite, Quartz. DG: Rutile.



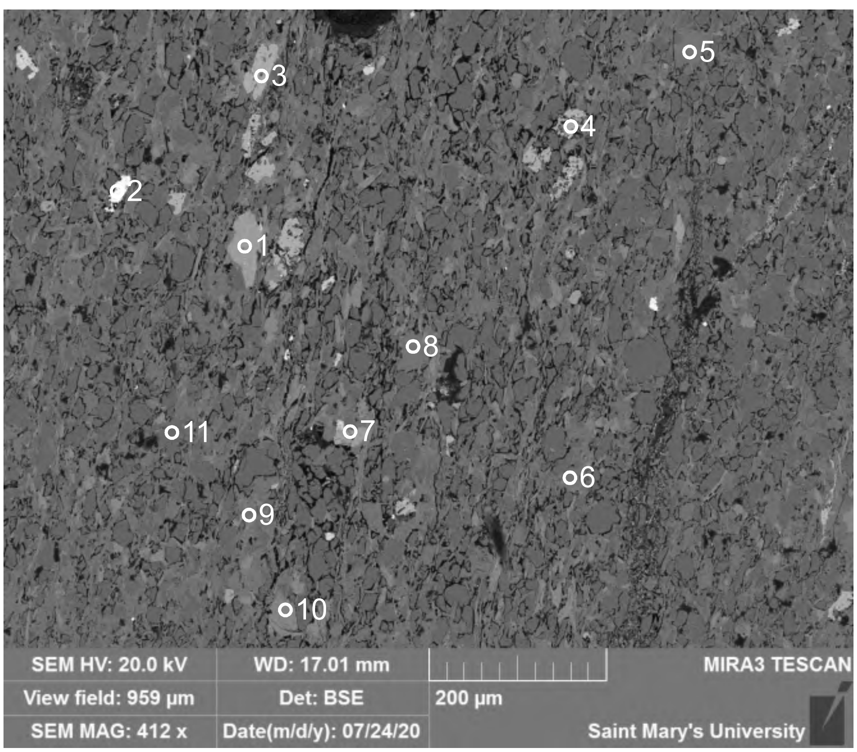
1. FeOhy +
2. FeOhy +
3. Rutile +
4. Rutile +
5. Albite
6. Chlorite
7. Albite
8. Muscovite
9. Muscovite
10. Muscovite
11. Muscovite

Figure 10.14-12. Sample OD2016-D2-0072 site 9. HD: FeOhy.



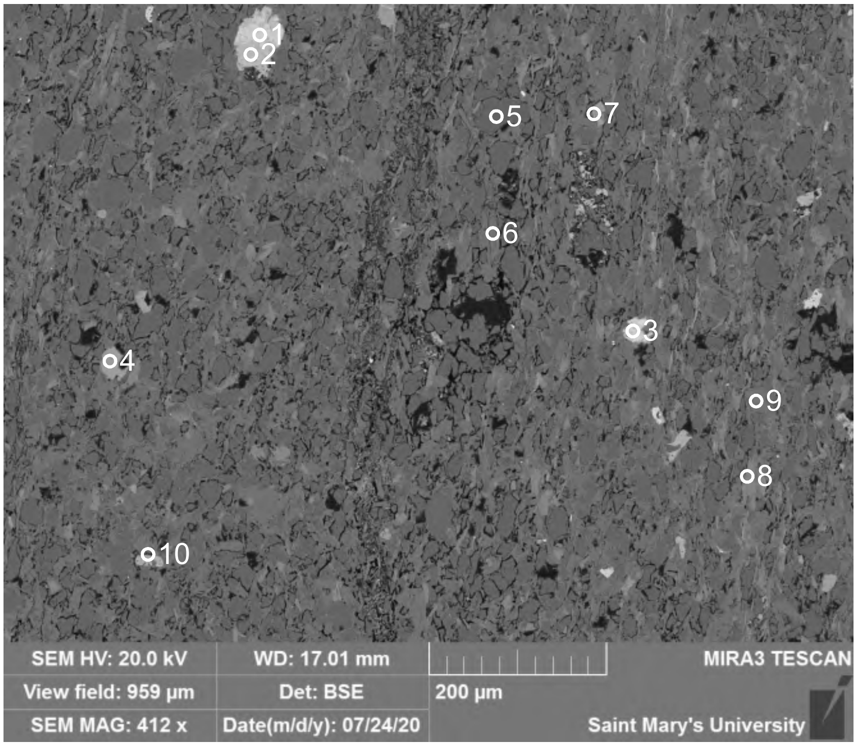
1. Quartz
2. FeOhy +
3. Ilmenite +
4. FeOhy +
5. Zircon
6. FeOhy +
7. Biotite
8. Muscovite
9. Chlorite
10. Albite
11. Albite
12. Quartz
13. Quartz

Figure 10.14-13. Sample OD2016-D2-0072 site 10. Late hydrothermal FeOhy precipitation along a fracture (2).



1. Apatite
2. Monazite +
3. Muscovite + Rutile
4. Rutile +
5. Muscovite +
6. Muscovite +
7. Apatite + Quartz
8. Muscovite +
9. Biotite
10. Chlorite
11. Albite

Figure 10.14-14. Sample OD2016-D2-0072 site 11.



1. FeOhy +
2. FeOhy +
3. Ilmenite +
4. Apatite
5. Quartz
6. Muscovite +
7. Apatite +
8. Chlorite
9. Muscovite +
10. Rutile +

Figure 10.14-15. Sample OD2016-D2-0072 site 12.

Appendix 11: OD2016-D2 Microprobe analysis data.

Abbreviations:

Opx: orthopyroxene

S: site on the thin section for probe analysis

P: position of the individual analysis for a given site

Appendix 11. OD2016-D2 microprobe data for silicates.

SAMPLE	K2O	CaO	TiO2	Cr2O3	Na2O	MgO	Al2O3	FeO	MnO	SiO2	Cl	F	TOTAL
Silicates OD2016-D2 - 011 S11 P6 OPX	0.05	0.62	0.07	0.00	0.01	12.38	0.74	35.19	0.72	49.69	0.00	0.00	99.48
Silicates OD2016-D2 - 011 S11 P7 OPX	0.03	0.76	0.09	0.00	0.02	12.44	0.74	35.01	0.70	49.67	0.00	0.00	99.46
Silicates OD2016-D2 - 011 S14 P14 OPX	0.05	0.82	0.14	0.00	0.00	12.86	0.60	34.17	0.72	49.91	0.00	0.00	99.27
SAMPLE	K2O	CaO	TiO2	Cr2O3	Na2O	MgO	Al2O3	FeO	MnO	SiO2	Cl	F	TOTAL
OD2016-D2-11 amphibole s1 p9	1.71	11.51	1.94	0.01	1.81	13.04	10.32	13.05	0.29	42.74	0.39	0.72	97.54
OD2016-D2-11 amphibole s5 p6	1.46	11.69	1.91	0.01	1.78	11.03	10.24	15.73	0.26	42.69	0.16	0.28	97.25
OD2016-D2-11 amphibole s15 p16	1.62	11.74	1.95	0.00	1.53	13.04	10.48	12.67	0.16	43.06	0.26	0.35	96.87
OD2016-D2-11 amphibole s10 p7	1.84	10.95	1.95	0.02	1.76	7.64	11.24	20.72	0.18	40.50	0.52	0.43	97.77
OD2016-D2-11 amphibole s13 p12	2.21	11.27	1.90	0.07	1.46	7.71	11.98	19.88	0.15	39.76	0.72	0.48	97.59
OD2016-D2-11 amphibole s11 p14	1.81	11.15	1.98	0.00	1.68	7.85	11.05	20.33	0.17	40.65	0.43	0.36	97.45
SAMPLE	K2O	CaO	TiO2	Cr2O3	Na2O	MgO	Al2O3	FeO	MnO	SiO2	Cl	F	TOTAL
OD2016-D2-11 bioite s1 p5	7.78	0.03	2.33	0.00	0.04	7.39	16.86	23.74	0.11	34.88	0.02	0.07	93.26
OD2016-D2-11 bioite s5 p7	8.35	0.07	2.33	0.01	0.02	7.22	16.67	23.68	0.11	35.52	0.01	0.02	94.02
OD2016-D2-11 bioite s9 p9	6.74	0.03	1.93	0.00	0.11	7.39	16.48	25.39	0.12	33.81	0.06	0.17	92.23
OD2016-D2-60 bioite s1 p5	8.90	0.01	2.06	0.02	0.03	8.49	16.93	22.34	0.12	35.89	0.01	0.12	94.90
OD2016-D2-60 bioite s6 p12	8.21	0.05	2.04	0.02	0.07	8.48	16.61	21.79	0.13	35.00	0.01	0.16	92.56
OD2016-D2-60 bioite s11 p13	8.83	0.02	2.00	0.00	0.04	8.47	16.64	22.51	0.14	35.46	0.00	0.07	94.19
OD2016-D2-29 bioite s1 p9	8.37	0.02	2.26	0.04	0.02	7.94	16.97	22.84	0.15	35.19	0.01	0.10	93.91
OD2016-D2-29 bioite s2 p12	8.34	0.02	2.21	0.02	0.02	8.24	16.62	22.32	0.09	35.31	0.01	0.06	93.26
OD2016-D2-29 bioite s5 p23	9.67	0.04	1.93	0.06	0.07	12.43	18.01	15.46	0.28	36.99	0.07	0.25	95.27

Appendix 12: OD2016-D2 XRD report.

Contribution to the UNCLOS Program

QUANTITATIVE X-RAY DIFFRACTION ANALYSES

By
Igor Bilot & Jeanne B. Percival
Central Canada Division

October, 2018

For
Gordon Oakey
GSC-Atlantic

MPP Technical Report Min 18-6
LSA-19-4-003

X-ray Diffraction Analysis

The mineralogy of bulk materials and clay-size separates is determined by X-ray powder diffraction analysis (XRD). Bulk samples are micronized using a McCrone mill in isopropyl alcohol or distilled water until a grain size of about 5- 10 µm is obtained. The samples are dried and then back pressed into an aluminum holder to produce a randomly oriented specimen. For clay-size separates, 40 mg are suspended in distilled water and are pipetted onto glass slides and air-dried overnight to produce oriented mounts. X-ray patterns of the pressed powders or air-dried samples are recorded on a Bruker D8 Advance Powder Diffractometer equipped with a Lynx-Eye Detector, Co Kα radiation set at 35 kV and 35 mA. The samples are also X-rayed following saturation with ethylene glycol and heat treatment (550 EC).

Treatments:	
air-dried:	2-86 E2Θ
glycolation:	2-86 E2Θ
heat (550 EC for 2 hours):	2-35 E2Θ

Mineral Identification and Quantitative Analysis

Initial identification of minerals is made using EVA (Bruker AXS Inc.) software with comparison to reference mineral patterns using Powder Diffraction Files (PDF) of the International Centre for Diffraction Data (ICDD) and other available databases. Quantitative analysis is carried out using TOPAS (Bruker AXS Inc.), a PC-based program that performs Rietveld refinement (RR) of XRD spectra. This is based on a whole pattern fitting algorithm. It relies on having particular mineralogical structure files (.cif) such that the reference minerals are as close a match to the unknown as possible.

Quantitative analyses appear reasonable when minerals in the samples can be matched to the standards. The lower the Goodness of Fit (GoF) value, the closer the standards match the unknowns and the better the results. Difficulty arises when clay minerals of varying composition (e.g., expandable layers, mixed-layers) are encountered, or when mineral species have overlapping X-ray peaks (e.g., kaolinite and chlorite; quartz and graphite). Also, there are a limited number of reference minerals available as structure files; these may not be an exact match to the mineral being analyzed (e.g., using actinolite rather than ferro-hornblende). Differences in estimation will also arise if using a pressed powder (preferable for RR) vs. smear (oriented) samples. Smear samples can be used if insufficient material is available. Occasionally smear mounts are made in order to better identify clay minerals that are found in minor to trace amounts, as the orientation enhances the *00l* peaks relative to the *hkl* peaks.

Results

Quantitative mineral analyses (wt%) were completed for 42 samples derived from the Lomonosov Ridge. These samples represent a diverse assemblage of sedimentary rocks requiring a variety of analyses to determine their composition, depositional environment, provenance and metamorphic overprinting.

Results are given in Table 1 and summary statistics in Table 2. These samples are all very similar in their mineralogical composition. They are dominated by quartz (13-78 w%, mean=47 wt%) and muscovite (7- 70 wt%, mean=32 wt%). They all are comprised of subordinate plagioclase feldspar (2-26 wt%, mean=16 wt%) and minor to trace chlorite (trace-12 wt%, mean=4 wt%). Two samples contain trace amounts of K-feldspar, one with minor biotite, one with trace kaolinite, one with minor calcite and one with abundant goethite. Sample OD2016-D2-039 contains equal amounts of goethite and muscovite (34 wt%), minor quartz (15 wt%), plagioclase feldspar (9 wt%) and chlorite (8 wt%). This samples was also highly amorphous (calculated from EVA at ~55 %) (Table 3). The goodness of fit for all samples is good to moderate with a mean value of 2.57.

Examples of diffractograms for several samples are provided in Figures 1, 3 and 6. Sample OD2016-D2-001 is the only sample with detectable minor calcite and biotite (Figure 1). The results of the search match are based on EVA software (Bruker AXS, Inc.) and ICCD reference mineral database. In Figure 1, only the match with muscovite is shown, as biotite X-ray peaks are coincident with muscovite. The difference noted between these two minerals is a decrease in the intensity of the 5 Å peak (*002*) for biotite (e.g., 5 % intensity) relative to muscovite (50 % intensity). As the intensity of this X-ray peak is between these values relative to the 10 Å (*001*; 100% intensity) peak, it is assumed that there is a mixture. The quantitative results based on TOPAS (Bruker AXS, Inc.) shows both biotite and muscovite selected as reference minerals (Figure 2).

Sample OD2016-D2-028 is illustrated in Figure 3 and quantitative results in Figure 4. This was selected because there is a minor amount of a mixed-layer (ML) clay mineral observed in the sample. There are X-ray peaks at about 15 Å and 8 Å, most probably a chlorite-smectite (C/S) ML mineral. These ML minerals were also observed in three other samples (OD2016-D2-034, -068, and -073). These minerals were detected in the original 10 samples analyzed earlier and are reported in MPP Technical Report MIN 18-4 (Figure 5). Based on detailed analyses of the 2016-ODEN-047 sample, the ML mineral was detected in the bulk fraction and not the clay-size fraction. There was also evidence for the presence of an I/S ML clay mineral. Trace amounts of an I/S or C/S ML are observed in six other samples (see Table 3).

Sample OD2016-D2-039 is shown in Figure 6 and quantitative results in Figure 7. In Figure 6, the main goethite X-ray peak (~4.18 Å) is located as a shoulder to one of the main (first) quartz X-ray peaks (~4.26 Å). The amorphous nature of the sample is illustrated in Figure 7, which shows the results of the quantitative analysis. In Figure 6, the background is removed enabling better matching of reference minerals to the unknowns, but when performing pattern fitting with Rietveld refinement the raw data is used. Note the increase in background (slope) from the low 2-theta angles to the high

2-theta angles. The EVA software was used to estimate the amount of amorphous material. This is the only sample that contained amorphous material, which is related to the poor crystallinity of goethite.

Table 1. Quantitative mineralogy (wt%) based on XRD analyses and Rietveld refinement.

Sample No.	Qtz	Pl	Kfs	Ms	Bt	Chl	Kln	Cal	Gt	GoF
OD2016-D2-001	63	18		7	8	tr		4		2.36
OD2016-D2-002	38	2	tr	48		12				2.05
OD2016-D2-004	70	17		13		tr				2.57
OD2016-D2-005	34	9		57		tr				2.76
OD2016-D2-006	71	9		18		1	1			2.96
OD2016-D2-011	78	8	tr	14						2.21
OD2016-D2-012A	28	15		54		3				2.29
OD2016-D2-013	71	6		21		2				2.35
OD2016-D2-017	70	15		14		1				2.92
OD2016-D2-020	31	19		46		4				2.34
OD2016-D2-021	27	22		45		6				2.23
OD2016-D2-024	28	18		46		8				2.32
OD2016-D2-025	35	20		39		6				2.28
OD2016-D2-026	24	22		48		6				2.33
OD2016-D2-027	33	17		40		10				2.95
OD2016-D2-028	39	16		40		5				2.85
OD2016-D2-029	51	22		23		4				2.42
OD2016-D2-034	36	24		34		6				2.55
OD2016-D2-035	70	12		16		2				2.64
OD2016-D2-036	68	18		13		1				2.94
OD2016-D2-039	15	9		34		8			34	1.86
OD2016-D2-040	50	14		29		7				3.04
OD2016-D2-041	67	23		10		tr				2.97
OD2016-D2-043	31	20		45		4				2.52
OD2016-D2-044	29	20		48		3				2.27
OD2016-D2-045	47	8		42		2				2.99
OD2016-D2-049	66	19		15		tr				3.02
OD2016-D2-050	36	19		40		5				2.17
OD2016-D2-052	48	11		41		tr				2.66
OD2016-D2-054	53	13		28		6				3.01
OD2016-D2-060	59	10		27		4				2.97
OD2016-D2-063	13	13		70		4				2.79
OD2016-D2-065	73	12		14		1				2.65
OD2016-D2-068	33	25		37		5				2.69
OD2016-D2-072	30	24		42		4				2.27
OD2016-D2-073	25	22		48		5				2.30
OD2016-D2-076	77	9		12		1				2.97
OD2016-D2-077	66	14		19		1				2.68
OD2016-D2-080	42	26		29		3				2.41
OD2016-D2-081	69	15		14		2				2.77
OD2016-D2-085	27	22		45		6				2.21
OD2016-D2-086	38	26		29		7				2.36

Qtz: quartz; Pl: plagioclase; Kfs: K-feldspar; Ms: muscovite; Bt: biotite; Chl; chlorite; Cal: calcite; Gt: goethite; GoF: goodness of fit; tr: trace

Table 2. Summary statistics of the main mineral phases.
Trace calculated as 0.1 wt%.

Parameter	Qtz	Pl	Ms	Chl	GoF
Min	13	2	7	0.1	1.86
Max	78	26	70	12	3.04
Mean	46.64	16.26	32.24	3.80	2.57
Std.Dev.	19.01	5.98	15.41	2.92	0.32
N	42	42	42	41	42

Table 3. Additional notes regarding XRD analyses.

Sample No.	Comments
OD2016-D2-024	trace ML
OD2016-D2-026	trace ML
OD2016-D2-028	ML
OD2016-D2-034	ML
OD2016-D2-039	55 % amorphous
OD2016-D2-040	trace ML
OD2016-D2-043	trace ML
OD2016-D2-044	trace ML
OD2016-D2-050	trace ML
OD2016-D2-068	ML
OD2016-D2-073	ML

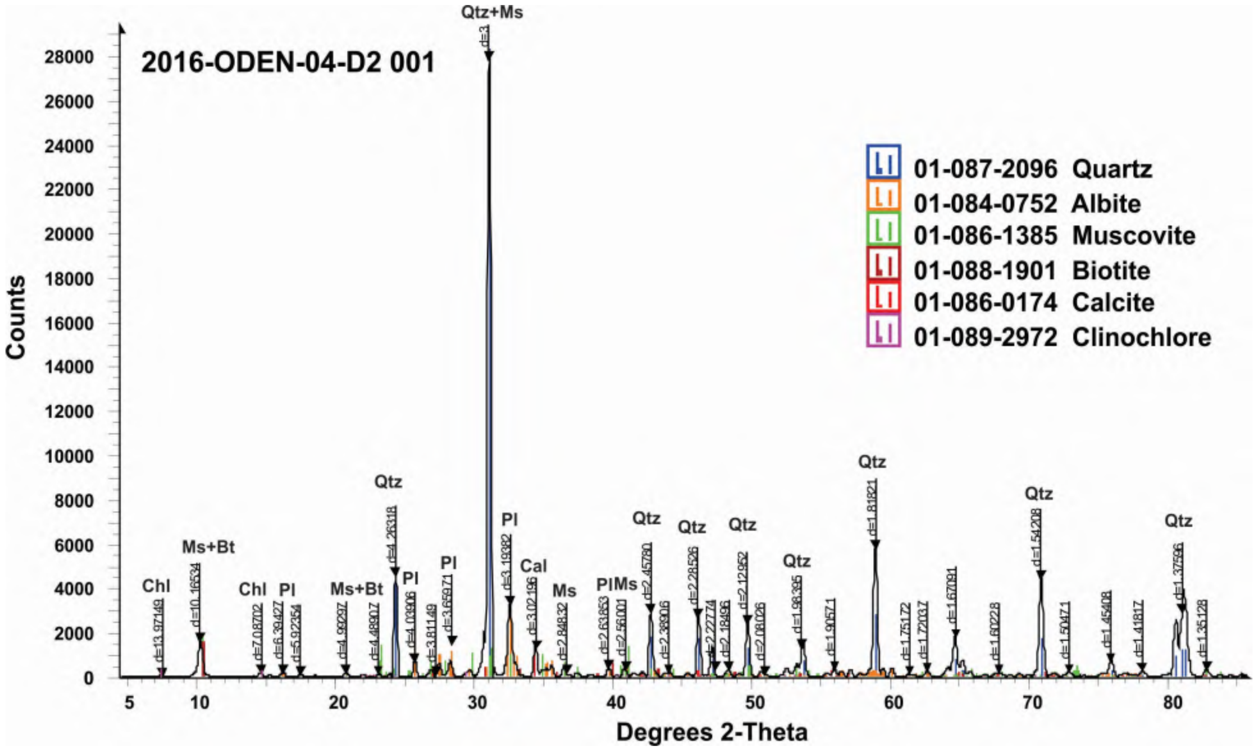


Figure 1. Results for search match using EVA software (Bruker AXS, Inc.) and ICDD database for sample 2016-ODEN-04-D2-001.

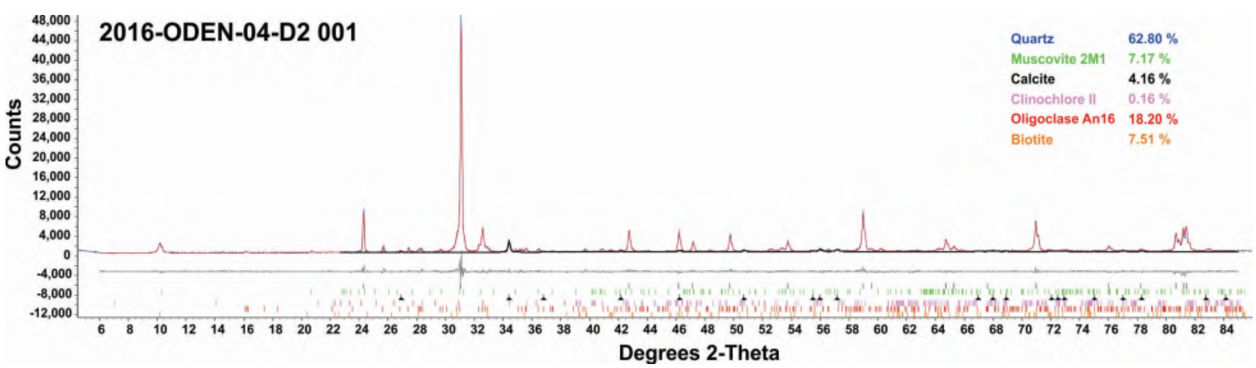


Figure 2. Results from Rietveld refinement using TOPAS software (Bruker AXS. Inc.). Red trace is sample and overlying black shows calcite match. Residual of whole pattern match shown in grey.

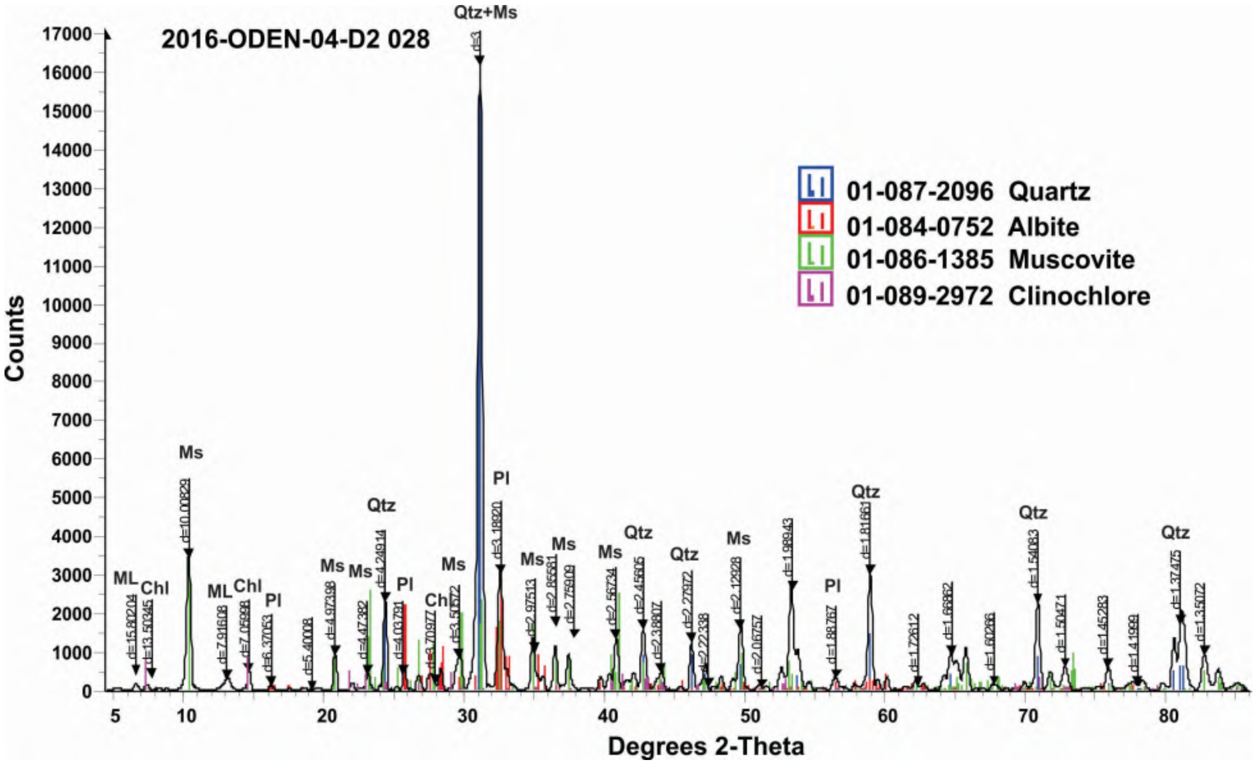


Figure 3. Results for search match using EVA software (Bruker AXS, Inc.) and ICDD database for sample 2016-ODEN-04-D2-028.

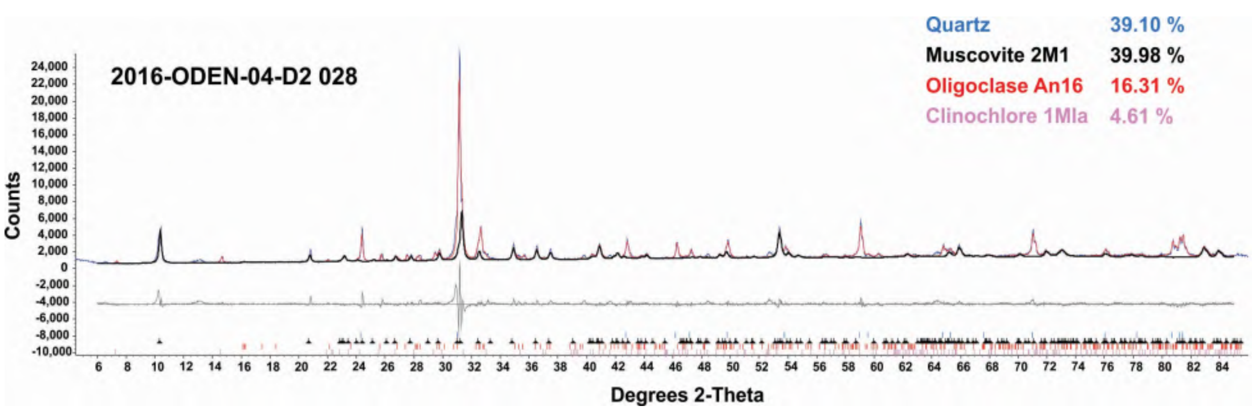


Figure 4. Results from Rietveld refinement using TOPAS software (Bruker AXS. Inc.). Red trace is sample and overlying black shows mica match. Residual of whole pattern match shown in grey.

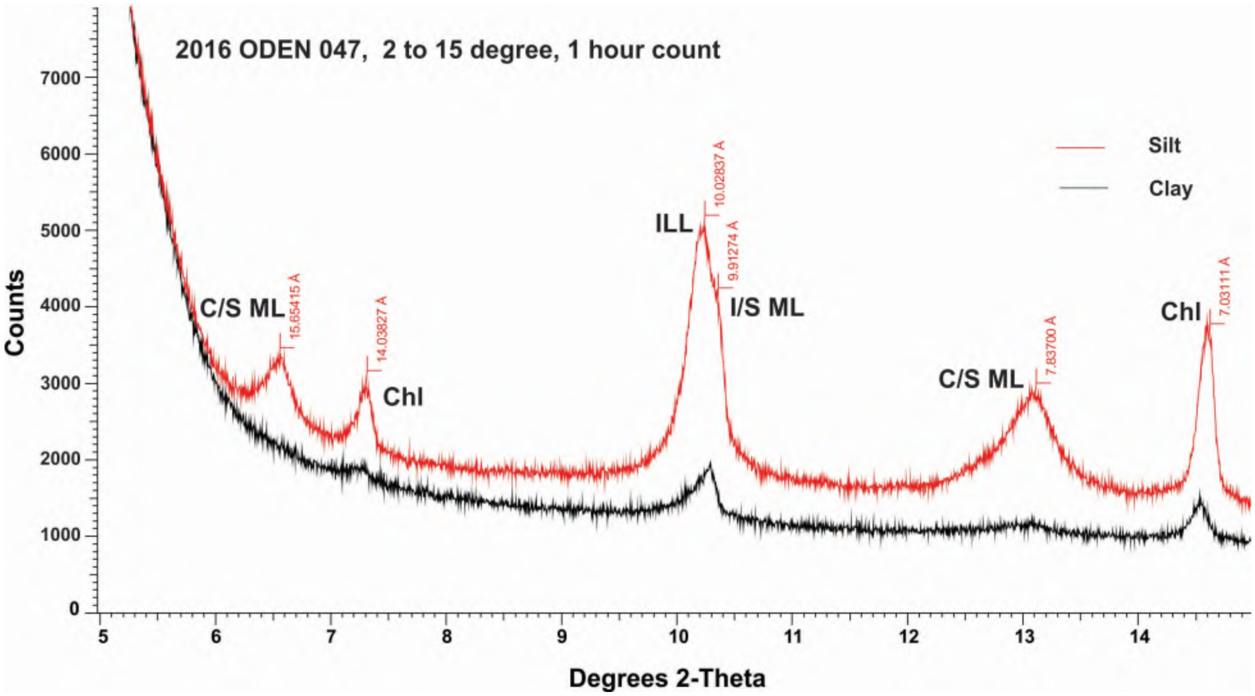


Figure 5. Example from Report MIN 18-4 for sample 2016-ODEN-047 showing the presence of a mixed-layer clay mineral, likely C/S present in the bulk sample relative to the clay-size sample.

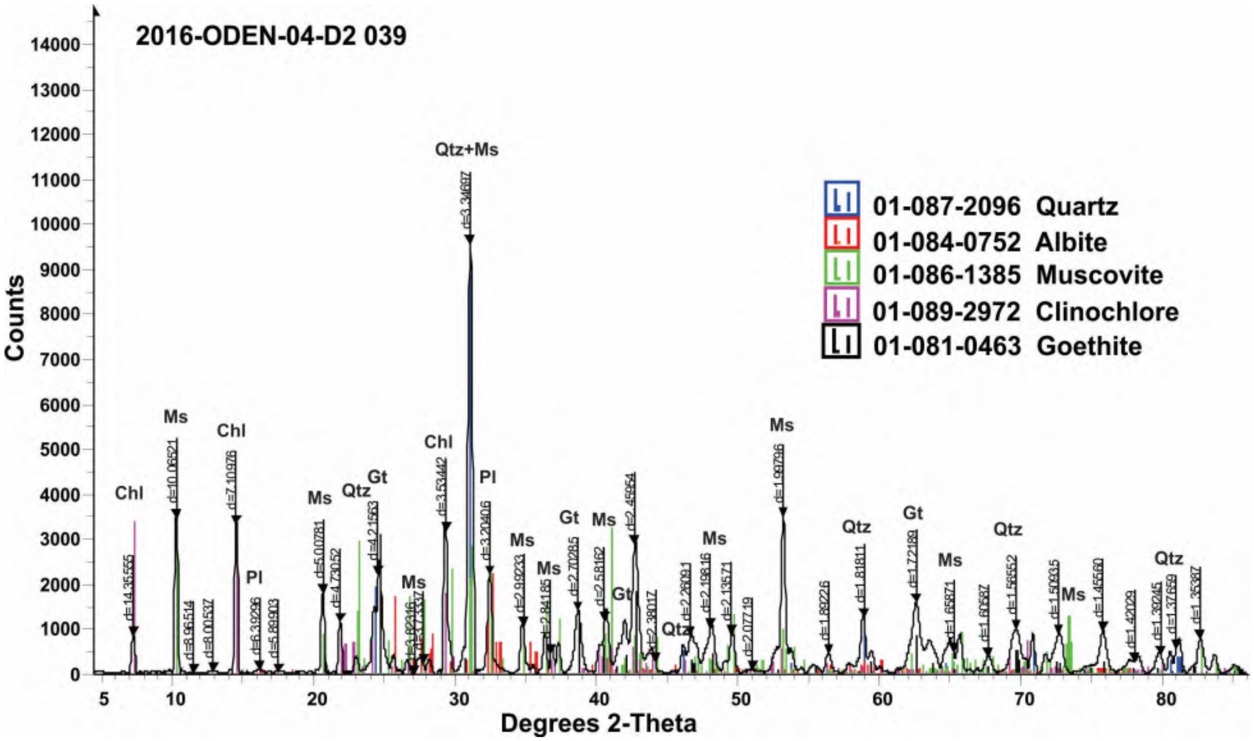


Figure 6. Results for search match using EVA software (Bruker AXS, Inc.) and ICDD database for sample 2016-ODEN-04-D2-039.

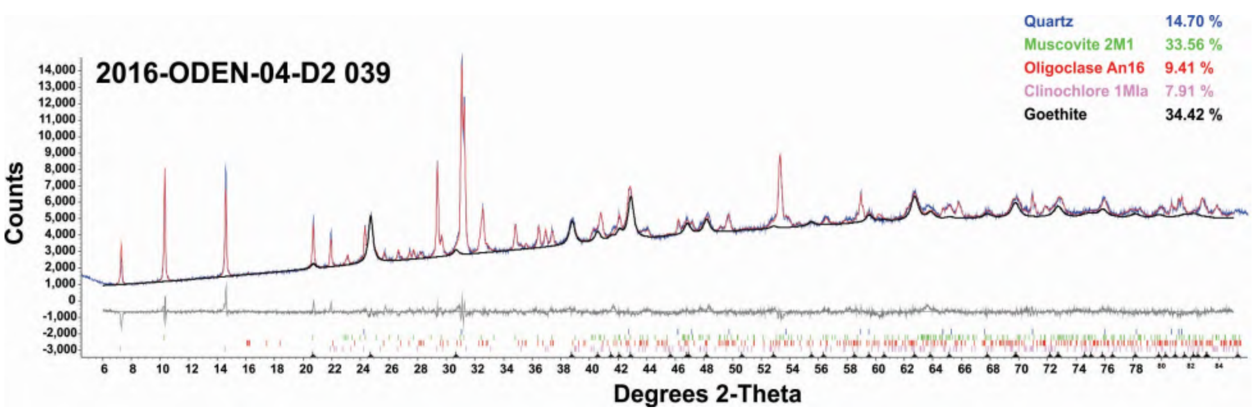


Figure 7. Results from Rietveld refinement using TOPAS software (Bruker AXS. Inc.). Red trace is sample and overlying black shows goethite match. Residual of whole pattern match shown in grey. Note the increasing background indicating presence of amorphous material.

Appendix 13: OD2016-D2 XRD analysis data.

Abbreviations:

ML: Mixed-layer clays

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OD2016-D2-001	63	18		7	8	tr		4		2.36
OD2016-D2-002	38	2	tr	48		12				2.05
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OD2016-D2-060	59	10		27		4				2.97
OD2016-D2-063	13	13		70		4				2.79
OD2016-D2-065	73	12		14		1				2.65
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OD2016-D2-077	66	14		19		1				2.68
OD2016-D2-080	42	26		29		3				2.41
OD2016-D2-081	69	15		14		2				2.77
OD2016-D2-085	27	22		45		6				2.21
OD2016-D2-086	38	26		29		7				2.36

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	46.64	16.26	32.24	3.8	2.57
	19.01	5.98	15.41	2.92	0.32
	42	42	42	41	42

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OD2016-D2-024	trace ML

OD2016-D2-026	trace ML
OD2016-D2-028	ML
OD2016-D2-034	ML
OD2016-D2-039	55 % amorphous
OD2016-D2-040	trace ML
OD2016-D2-043	trace ML
OD2016-D2-044	trace ML
OD2016-D2-050	trace ML
OD2016-D2-068	ML
OD2016-D2-073	ML

Appendix 14: OD2016-D2 Whole rock analysis data.

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