REE and other minerals in the West Moose River Pluton and associated rocks, Cobequid Highlands, Nova Scotia, and their association with fracturing

By

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Certification

I certify that this thesis was submitted by Joshua Wisen in fulfillment of the honours degree requirement for the Bachelor of Science Honours degree in Geology at Saint Mary's University, Halifax, Nova Scotia. This thesis truly represents the original work carried out by Mr. Wisen under my supervision.

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Abstract

The West Moose River pluton consists principally of an A-type granite emplaced immediately north of the Cobequid fault into Avalon terrane rocks in the latest Devonian-Early Carboniferous. Continued strike-slip fault movement in the shear zone caused the formation of pervasive fractures within the pluton, which have been shown to host REE-bearing minerals. The purpose of this study was to gain a better understanding of the source, timing, and distribution of REE-bearing minerals and their relation to regional events. Samples were collected from late mafic dykes, surrounding country rock, and the granite itself. Primary and secondary mineralogy were investigated using petrographic microscope, scanning electron microscope, and whole rock analysis.

In total, 7 REE-bearing hydrothermal minerals were identified, with both the LREE- and HREE- type found in each lithology. The A-type granite seems the most likely source of hydrothermal REEs, and magmatic zircon for HREEs in particular; HREE-bearing zircon was the only primary REE-mineral identified, and occurred exclusively in the granite. Due to paragenetic association with carbonates, Fe-oxyhydroxides, and chalcopyrite, LREE remobilization likely occurred during the 323 Ma iron-oxide-copper-gold mineralization event. Hydrothermal HREE-minerals are either coeval with, or predate this event, and often contain Nb and Ti. LREE-minerals are most concentrated in late minette dykes, which show a positive correlation between REE concentrations and the amount of fracturing. The halogen rich content of minettes may provide favourable conditions for the precipitation of LREEs, and should be considered as future exploration targets and areas of research.

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List of Abbreviations

Al	aluminum
Al^{IV}	tetrahedral aluminum
Al^{VI}	octahedral aluminum
Al-P	aluminum phosphate
Ar^{40}/Ar^{39}	dating technique based on measuring the abundance of argon (Ar) isotopes
Ccp	chalcopyrite
Ce	cerium
Chl	chlorite
Cu	copper
Dy	dysprosium
EDS	energy dispersive X-ray spectroscopy
Er	erbium
Eu	europium
Fe	iron
Fe-oxide	iron oxide mineral (oxidation state of iron is unspecified)
Gd	gadolinium
Ho	holmium
HREE	heavy rare earth elements (Tb – Lu)
ICP-MS	inductively coupled plasma mass spectrometry
IOCG	iron-oxide-copper-gold
La	lanthanum
LREE	light rare earth elements (La – Gd)
Lu	lutetium
Nb	niobium
Nd	neodymium
Ppm	parts per million
Pr	praseodymium
Py	pyrite
Qz	quartz

REE	rare earth elements
SEM	scanning electron microscope
Sm	samarium
Ti	titanium
Tm	thulium
WMRP	West Moose River Pluton
WRA	whole rock analysis
Y	yttrium
Yb	ytterbium

Chapter 1: Introduction

The Cobequid Highlands are located directly north of the boundary between the Avalon and Meguma terranes, in the Canadian Appalachians (Fig. 1). They consist of a series of granitic plutons with lesser amounts of gabbro that were emplaced in the latest Devonian to early Carboniferous (Pe-Piper and Piper 2003). The Cobequid Highlands are bound to the south by the Cobequid Fault, which facilitated emplacement of plutons through the oblique convergence of the Avalon and Meguma terranes (Pe-Piper and Piper 2003). Continued movement along this fault caused both ductile and brittle deformation, as expressed by pervasive fractures throughout many of the plutons (Pe-Piper et al. 1991), as well as mylonitization in areas directly adjacent to the fault (Donohoe and Wallace 1985, Pe-Piper et al. 1991).

Previous work has shown the Cobequid Fault Zone to record a complex history of hydrothermal alteration and mineralization (Pe-Piper et al. 2004). In some areas hydrothermal activity includes the precipitation of REE minerals, such as in the A-type granite of the Wentworth Pluton (Papoutsa and Pe-Piper 2013). The West Moose River Pluton is another A-type granite in the Cobequid Highlands which shares a similar history of pluton emplacement, brittle deformation, and hydrothermal activity as in other Early Carboniferous plutons of the Cobequid Highlands (Pe-Piper and Piper 2003). Previous work has shown fractures in West Moose River Pluton to host hydrothermal alteration of ferromagnesian stringers consisting of green biotite, chlorite, and opaques (ilmenite, titaniferous magnetite, and pyrite). (Pe-Piper et al. 1991). However, secondary assemblages containing REE minerals have yet to be described.

The purpose of this study is to gain a better understanding of source, timing, and distribution of REE and associated minerals throughout the West Moose River Pluton as well as surrounding country rock. In particular the following questions were addressed:

(1) What is the distribution and extent of hydrothermal alteration throughout the pluton; is it exclusively in fractures?

(2) What is the relative timing of REE mineral precipitation in relation to other geological events?

(3) What is the ultimate source of the REEs in the pluton itself and the country rock?

Chapter 2: Geological Setting

2.1: The Cobequid Highlands and the Cobequid Fault zone

The Cobequid Highlands constitute a horst lying directly north of the Cobequid Fault, exposing Neoproterozoic basement rocks of the Avalon terrane (Pe-Piper and Piper 2003). The Cobequid Highlands can be further subdivided into the northwestern Jeffers Block and the southeastern Bass River Block which are separated by the Rockland Brook Fault. Neoproterozoic rocks of the Bass River Block consist primarily of tectonically juxtaposed shelf sediments and ocean floor basalts, whereas those in the Jeffers block consist primarily of the Jeffers Group: a series of volcanic and volcaniclastic sedimentary rocks several hundred meters thick (Pe-Piper and Piper 1987, 1989). Neoproterozoic rocks of the Cobequid Highlands form a geographic link between Avalon terrane rocks of southern New Brunswick to the west, and those of the Antigonish Highlands and Southern Cape Breton Island to the East.

Oblique convergence between Meguma and Avalon terranes occurred in the Late Devonian-early Carboniferous, as indicated by the onset of shear deformation in the Cobequid Highlands (Pe-Piper and Piper 2003). Oblique convergence facilitated the emplacement of granite and gabbro plutons, as well as their extrusive equivalents in the Fountain Lake Group. The plutons show a high structural level that shallows northward (Murphy et al. 2011). These units have yielded ages of 365 to 358 Ma ± 4 as indicated by U-Pb on zircon and $^{40}Ar/^{39}Ar$ on amphibole (Murphy et al. 2011). Granite plutons range from alkaline to subalkaline and have an A-type granite geochemical signature (Pe-Piper et al. 1991).

The Cobequid Fault Zone, also referred to as the Minas Fault Zone (Murphy et al. 2011), encompasses an anastomosing network of parallel and sub-parallel faults that predominantly trend E-W, and whose surface trace is located close to the Meguma-Avalon terrane boundary (Murphy et al. 2011). The Rockland Brook Fault in the West and the Kirkhill Fault in the East appear to merge with the larger Cobequid-Chedabucto Fault in their Southwestern terminations (Murphy et al. 2011). Post-accretionary movement between Meguma and Avalon terranes was ultimately linked to movement between Laurentia and Gondwana, which involved several episodes of oblique collision from the Late Devonian to Early carboniferous (Murphy et al. 2011). This oblique convergence was responsible for basin formations as well as pluton emplacement (Murphy et al. 2011). The Minas Fault Zone acted as a conduit for magmas (Koukouvelas and Pe-Piper 1996), as plutons were emplaced along the Rockland Brook, Kirkhill, and Cobequid Faults (Doig et al. 1998).

Syn-magmatic deformation of these plutons is expressed through north-vergent thrusting and south-vergent ductile deformation, both associated with dextral shear (Koukouvelas el al., 1996). Other evidence of syn-magmatic deformation includes the presence of clasts in the Horton Group derived from the Pleasant Hills Pluton - the same pluton that also cross-cuts the Horton group (Piper 1994). A regional post-magmatic deformational event occurred during the Visean as indicated by mylonitic fabric from Cape Chignecto Pluton adjacent to the Kirkhill Fault. Secondary biotite from this zone has been dated at 341 ± 3 Ma (Pe-Piper et al. 2004). Later uplift of the Cobequid Highlands is recognized in sediments and metamorphic rocks of Serpukhovian – Bashkirian age (Murphy et al. 2011). The Clarke Head breccia contains Serpukhovian aged continental clastic rocks, indicating an age no older than the Serpukhovian for the breccia (Murphy et al. 2011). In the southern Cobequid Highlands, the Clarke Head breccia is unconformably overlain by the Bashkirian Parrsboro Formation containing granitic clasts (Murphy et al. 2011). Uplift during the Serpukhovian – Bashkirian is interpreted to be related to final movement along the Rockland Brook Fault (Pe-Piper et al. 2004).

The Minas Fault Zone acted as a metallotect localizing Fe, Ba, Cu, Ni, and Au, with much of the mineralization being post-Visean in age (Murphy et al. 2011). Mineralization occurs in veins, breccia zones, or areas of intense alteration associated with regional movement of Minas Fault Zone. The regional geological setting and features of this deposit share similarities to iron oxide-copper-gold (IOCG) mineralizations worldwide (Murphy et al. 2011).

2.2: The West Moose River Pluton

The West Moose River Pluton (Fig. 1) is a bimodal pluton, consisting primarily of granite (95%) with lesser amounts of earlier gabbro (Clerk 1987). It is bound to the south by the Cobequid-Chedabucto Fault and to the north by unconformably overlying Carboniferous strata (Clerk 1987). Granite adjacent to the Cobequid-Chedabucto Fault is mylonitized (Clerk 1987). The pluton is also cut by numerous north-south faults which contribute to the irregularity of its shape (Clerk 1987). Granite consists primarily of a coarse grained pink variety, rich in K-feldspar and with lesser amounts of ferromagnesian minerals. White granites are present in the central part of the pluton, as veins in roof pendant or as larger albitized bodies that cut earlier pink granites in contacts with gabbro (Pe-Piper et al. 1991). They are generally finer grained compared to the pink granite and consists primarily of plagioclase, quartz and primary biotite. Porphyries are present at the contact between felsic and mafic bodies, probably representing a mixing of the two magmas (Pe-Piper et al. 1991). Alteration of granite hinders the determination of protolith of some granitic bodies from whole rock geochemistry alone. However, the vast majority of granites are classified as A-type granite using their enrichment in Nb, Y, and Ga/Al, (Pe-Piper et al. 1991) as well as their mineralogy.

The West Moose River Pluton is fractured and cut by later mafic dykes, some of which pre-date and others that postdate a Namurian compressional event (Pe-Piper et al. 1991). Rocks from the central part of the pluton are pervasively fractured on sub-parallel joint sets, many of which run parallel to regional east-west faults (Pe-Piper et al. 1991). At the margins of some dykes fracturing is more irregular (Pe-Piper et al. 1991). Fractures are mostly filled by ferromagnesian stringers, quartz veins, and diabase (Pe-

Piper et al. 1991). The West Moose River Pluton intruded rocks of the Horton Group and has been dated at 361 +5/-3.5 Ma using U-Pb from zircon (Dunning et al. 2002). Mylonitized granite near the Cobequid Fault is cut by irregular fractures occupied by riebeckite which has yielded $^{40}Ar/^{39}Ar$ ages of 352 ± 4Ma (Pe-Piper et al. 2004).

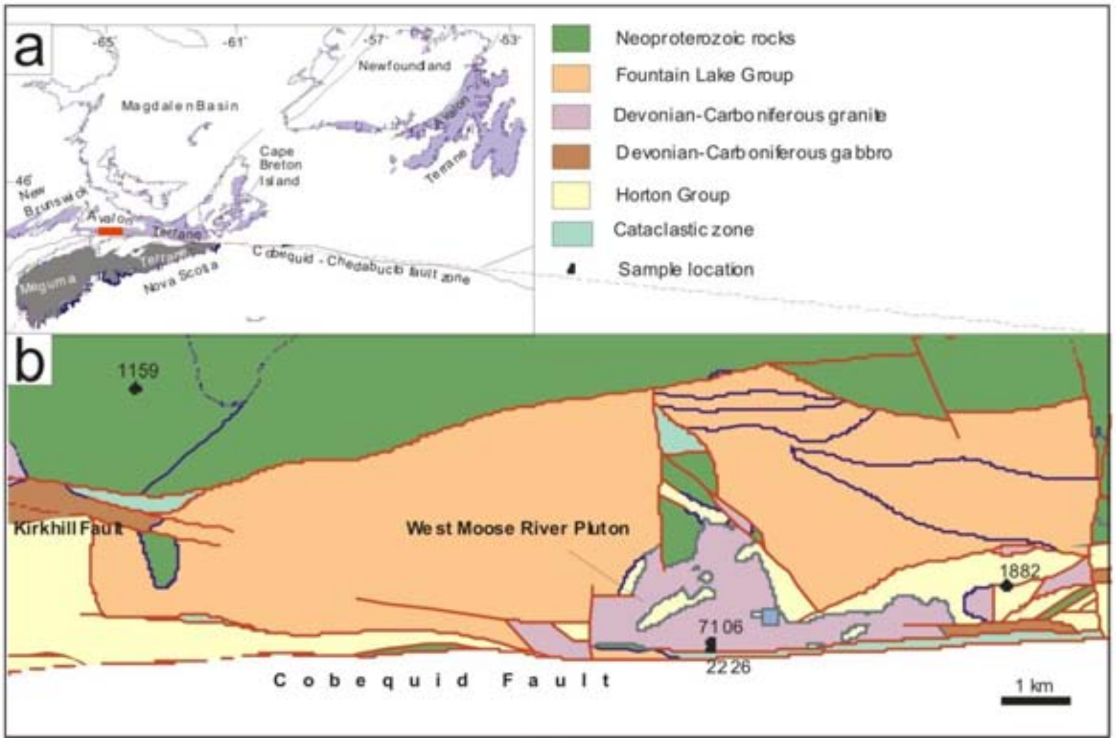

Figure 1: Simplified geological map of eastern Canada showing the location of the Avalon and Meguma terranes (a) in relation to the Cobequid Fault and the West Moose River Pluton (b). Black dots show the locations of samples collected from mafic (minette) dykes and sills.

Chapter 3: Materials And Methods

Samples were collected from the granite pluton, the surrounding Horton Group country rock, and from mafic dykes that intruded the granite pluton as well as surrounding lithologies (Fig. 1). Samples of granite were selected from field observations based on the presence of fracturing or alteration. Whole rock geochemical analysis of major elements for sample 1882 was available (Pe-Piper et al. 1991) and samples 1159, C2226, and 7106 were analyzed for both major and trace elements. All of these geochemical analyses were made by Activation Laboratories Ltd. according to their codes 4Lithoresearch and 4B1 (Activation Laboratories Ltd., 2014), which combine lithium metaborate/tetraborate fusion ICP analysis with a trace element ICP-MS package. Samples were examined with petrographic microscope in order to determine primary mineralogy, texture, as well as the distribution and volume of fracturing. Minerals that could not be identified using the petrographic microscope were analyzed in carbon-coated thin sections using a LEO 1450 VP scanning electron microscope (SEM) in addition to energy dispersive X-ray spectroscopy (EDS) for chemical analyses, using an INCA X-max 80mm 2 EDS system. In total, 11 samples (Table 1) were analyzed using SEM and EDS; 3 samples from Horton Group country rocks (274, 2349A, & 2349B), 4 from granite (9873, 9874, 9876, & 9878), one from the contact between granite and country rock (sample 9877) and 3 from mafic dykes (1159, C2226, 7106). Primary and secondary mineralogy were determined (Table 1). Back scattered electron images from the SEM as well as corresponding EDS analyses are provided in appendices 1-3.

For each sample the total volume of fractures was estimated by high resolution scanning of the polished thin section. Scanned images were then imported into CorelDraw, where a grid consisting of at least 300 points was superimposed on the image. The total area of fractures was estimated by point-counting.

Selected hydrothermal chlorite analyses were used for geothermometric calculations (Kranidiotis and McLean 1987) in order to determine the temperature and events of mineral precipitation in fractures.

Table 1: Sample summary including type of data collected and petrography

Group	Sample	Lithology & Field observations	SEM analyses	Whole Rock Geochemistry	Host Rock Mineralogy	Fracture and Vein Mineralogy
Country Rock	274	marble	x		calcite, dolomite, tremolite, fluorapatite, Mg-chlorite(?)	pyrite, chalcopyrite, magnetite, Mg-chlorite(?)
	2349A	subarkosic arenite siltstone	x		quartz, albite, calcite, rutile, pyrite, zircon, muscovite?(matrix?), xenotime(?)	monazite, thorite, zircon, TiO_2
	2349B	quartz arenite siltstone with laminae of carbonate	x		quartz, calcite, pyrite, fluorapatite	xenotime(?), synchysite, monazite, thorite, zircon, TiO_2
Granite	9873	part of conjugate set of planar black veins:	x		K-feldspar, albite, quartz, zircon, magnetite	tourmaline, zircon, aeschynite-euxenite, pyrochlore, Fe-oxide, TiO_2, chlorite, thorite(?), xenotime
	9874	part of conjugate set of planar black veins. some shearing	x		K-feldspar, albite, quartz, zircon, magnetite	zircon, Fe-oxide, samarskite, pyrochlore, aeschynite-euxenite, chlorite, muscovite (?), cerianite, TiO_2
	9876	cataclastic shear zone with discontinuous black veins.	x		K-feldspar, albite, quartz	aeschynite-euxenite, Fe-hingganite-Y, Cerianite, chlorite, Fe-oxide, muscovite, TiO_2
	9878	alteration zone	x		K-feldspar, albite, zircon	aeschynite-euxenite, pyrochlore, cerianite, thorite,
Granite and Horton Group contact	9877	Metasoma-tized siltone	x		quartz, albite, K-feldspar, ilmenite(?), muscovite?(metasomatic?), biotite(?), zircon, monazite?(detrital?)	Fe-oxide mixture (likely containing crystallites of chlorite, phosphate, pyrite and chalcopyrite) epidote, TiO_2, pyrite, chalcopyrite, biotite, xenotime, chlorite, zircon, barite, ilmenite, aeschynite-euxenite, samarskite, pyrochlore, thorite, molybdenite
	9877	whitish granite			quartz, albite, K-feldspar	
Mafic dykes	1159	lamprophyre dyke	x	x	biotite, albite, epidote, titanite, pyrite	none
	1882	lamprophyre dyke		x	biotite, magnetite, albite, pyroxene	calcite, chlorite
	C2226	lamprophyre dyke	x	x	biotite, albite, pyrite, ilmenite, rutile, xenotime	calcite, synchysite, xenotime
	7106	lamprophyre sill	x	x	biotite albite,	chlorite, calcite, fluorite, synchysite, barite, pyrite, albite, TiO_2, quartz(?)

Chapter 4: Results

Secondary assemblages of REE-bearing minerals of hydrothermal origin were found in 9 of the 11 samples analyzed using SEM (Table 1). In addition, hydrothermal chlorite was found in 6 samples, including country rock, granite, and lamprophyres.

4.1: Country Rock

Sample 274 is a tremolite-bearing argillaceous marble. The marble is made up of calcite, dolomite, Mg-rich chlorite, and tremolite. Trace amounts of detrital zircon and fluorapatite are also present. Secondary barite is present along calcite and dolomite grain boundaries (Fig.2, App. 1-1). Pyrite is present and is associated with chalcopyrite in composite veins, both probably of hydrothermal origin (Figs. 2a and 2b). Fractures are few and narrow, and filled with magnetite and Mg-chlorite (Fig. 3a). Hydrothermal zircon and magnetite occur in dissolution voids, however no REE-minerals were found.

Samples 2349A and 2349B are predominantly siliclastic rocks with calcite cements. Sample 2349A is a subarkosic arenite siltstone with a considerable amount of interstitial muscovite (Fig. 2c), in addition to detrital albite, rutile, zircon, and some biotite. Sample 2349B is predominantly a quartz arenite siltstone, with lesser detrital fluorapatite, and contains intervals of carbonate laminae. Both samples contain partially oxidized pyrite rimmed by later Fe-oxide (Fig. 4). Also, both samples contain secondary monazite, thorite, zircon, and TiO_2 phases. Monazite appears to fill porosity and has sharp euhedral crystal outlines that cut detrital quartz and contains inclusions of quartz (Fig. 3b-3d). Thorite occurs in association with zircon (Fig. 2c and 2d) or else forms a monomineralic assemblage that fills porosity (Fig. 2e). Sample 2349B contains the rare earth mineral synchysite-Ce that has precipitated in fractures (Fig. 2f). Xenotime (Fig. 4 and Fig. 10, App. 1-3) and fluorapatite (Fig. 13, App. 1-3) are also present. However, it is difficult to determine whether they are primary or secondary based on textural evidence alone.

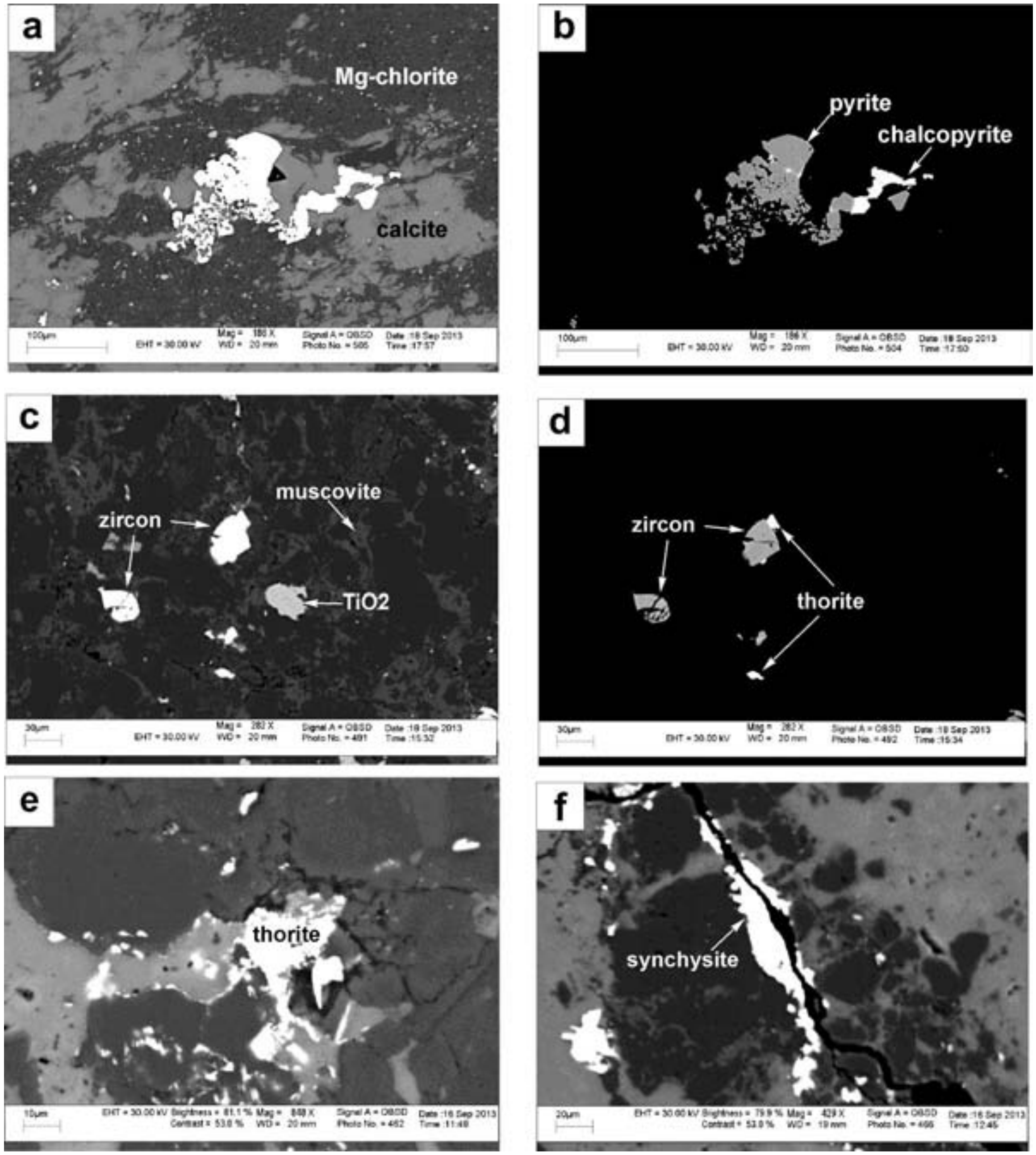

Figure 2: Backscattered electron images of samples of Horton Group Country rock and hydrothermal mineral assemblages. a,b: 274, argillaceous marble; c,d: 2349A, subarkosic arenite siltstone; e,f: 2349B, quartz arenite siltstone.

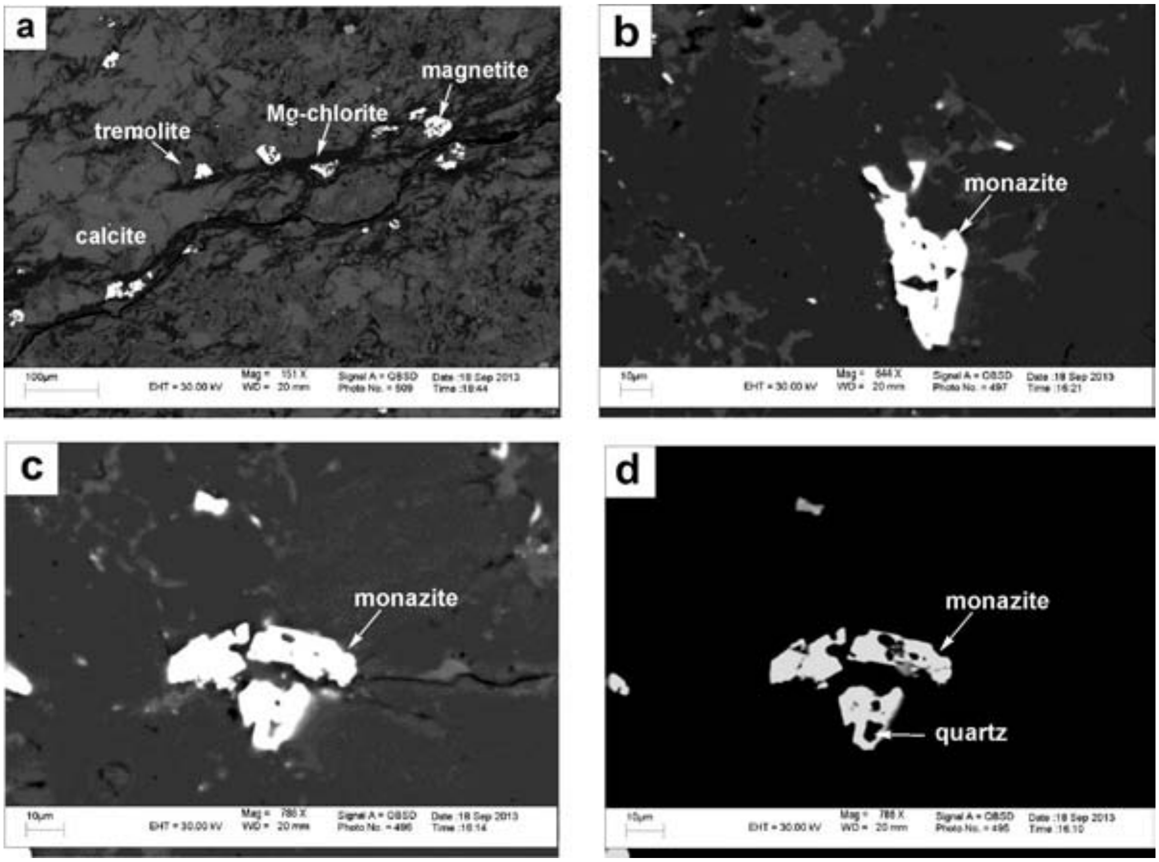

Figure 3: Backscattered electron images of samples of Horton Group country rock and hydrothermal mineral assemblage. a: 274, hydrothermal magnetite and Mg-chlorite along a fracture in sample 272. b,c: hydrothermal monazite from 2349B and 2349B, respectively.

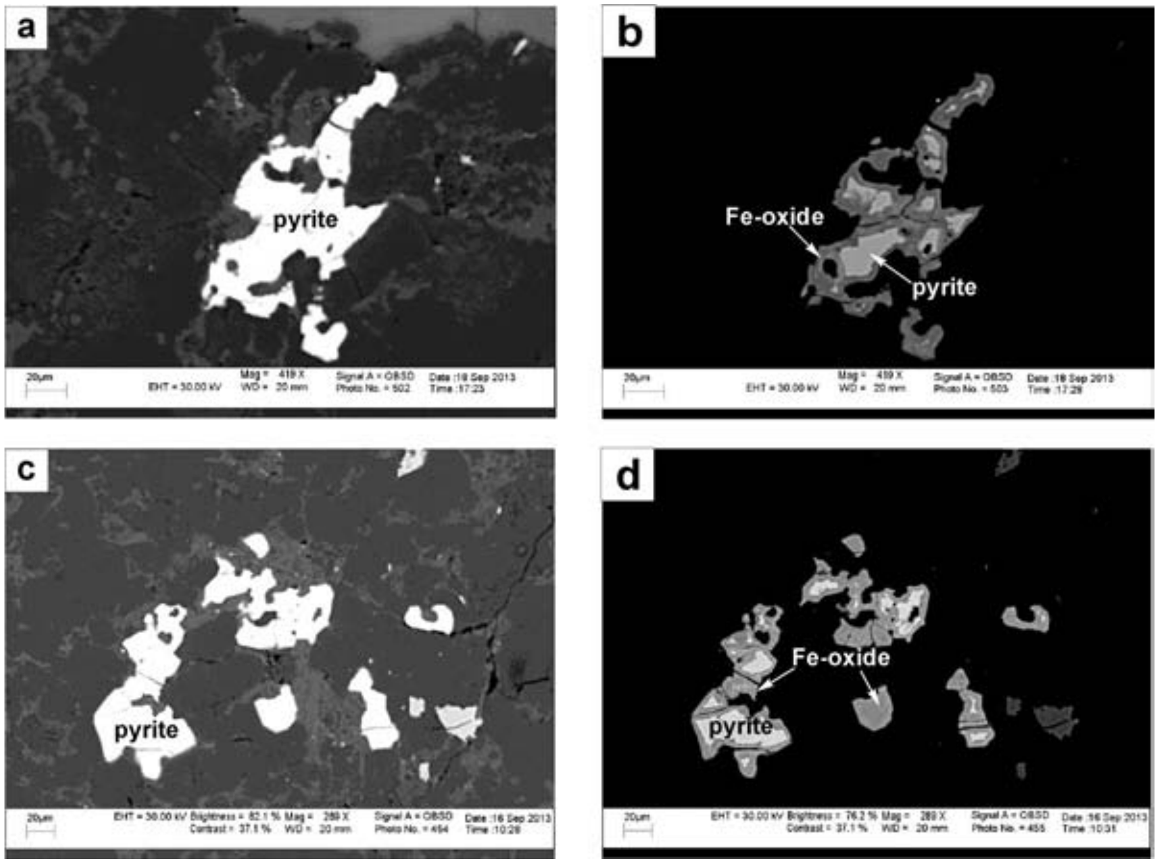

Figure 4: Backscattered electron images of samples of pyrite from Horton Group country rock. Pyrite is partially oxidized and rimmed by later Fe-oxide. a,b: 2349A; c,d: 2349B.

4.2: Granites

4.2.1: Introduction

The granites consist predominantly of perthitic feldspar and quartz, with accessory to minor amounts of zircon and magnetite. In places these granites are highly fractured and it seems that there is more than one generation of fractures (Fig. 5). In total, 5 different REE-bearing minerals were found in the granites, all of which are considered to be exclusively secondary. They seem to occur in dissolution voids, fractures, along cleavage planes of primary igneous minerals, and along intergranular boundaries. These

Figure 5: Photograph of an outcrop of West Moose River Pluton Granite. In places these granites are highly fractured and it seems that there are multiple generations of fractures.

Figure 6: Black vein cutting granite; close to field location of sample 9873. Pen (left) for scale.

REE-bearing minerals consist of aeschynite-euxenite, pyrochlore, xenotime, cerianite, and Fe-rich hingganite-Y. Associated hydrothermal minerals include thorite, chlorite,

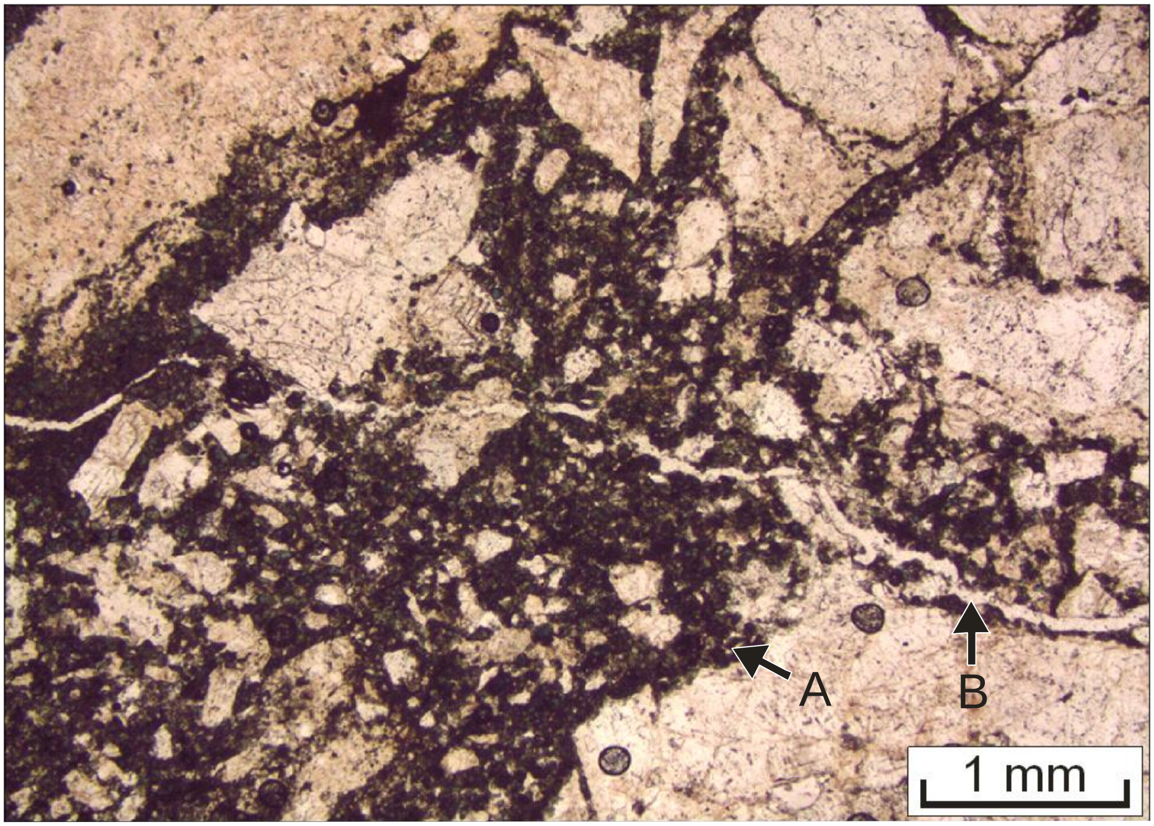

Figure 7: Microphotograph of sample 9873 showing vein from figure 6 at 4x magnification. Tourmaline-filled vein (arrow A, bottom left to top right) is cut by later barren fractures (arrow B, left to right).

muscovite, Fe-oxide phases, ilmenite, a TiO_2 phase, tourmaline, zircon, as well as an unidentified mixture of Fe-oxide and Nb.

4.2.2: Sample 9873

Sample 9873 contains one of a conjugate set of, black, planar veins cutting granite (Fig. 6) striking 345° and dipping steeply east. The vein is predominantly composed of heavily fractured feldspar and quartz, infilled by green tourmaline, and is cut by later barren fractures (Fig. 7). The sample shows a high degree of fracturing and dissolution. In places (Fig. 8e and 8f) zircon contains thorite in dissolution voids and in other places it is enriched in Y (Fig. 8). Texture suggest the presence of Y-bearing minerals that formed during hydrothermal alteration of magmatic zircon. Hydrothermal zircon seems to postdate the precipitation of tourmaline. Ti-magnetite alters to TiO_2 (Fig. 9a). In places, magnetite filling porosity (Fig. 9b) is rich in Nb that probably substituted for Ti. Skeletal Fe-oxide has been seen to rim dissolved minerals (Fig. 9c) which suggests that corrosive

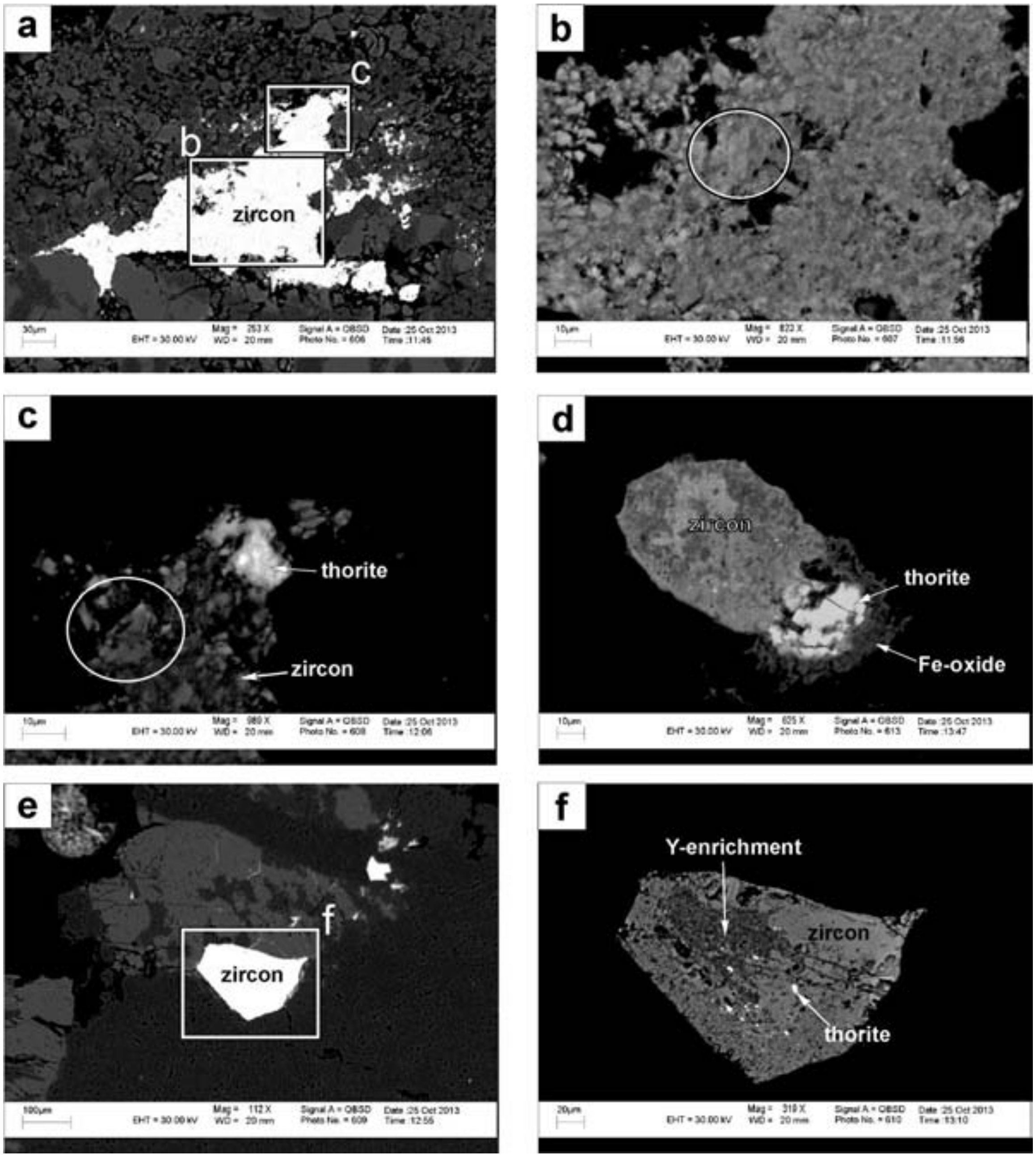

Figure 8: BSE images of zircon from sample 9873. Darker areas correspond to enrichment in Y and Yb, whereas brighter areas represent more pure zircon analysis.

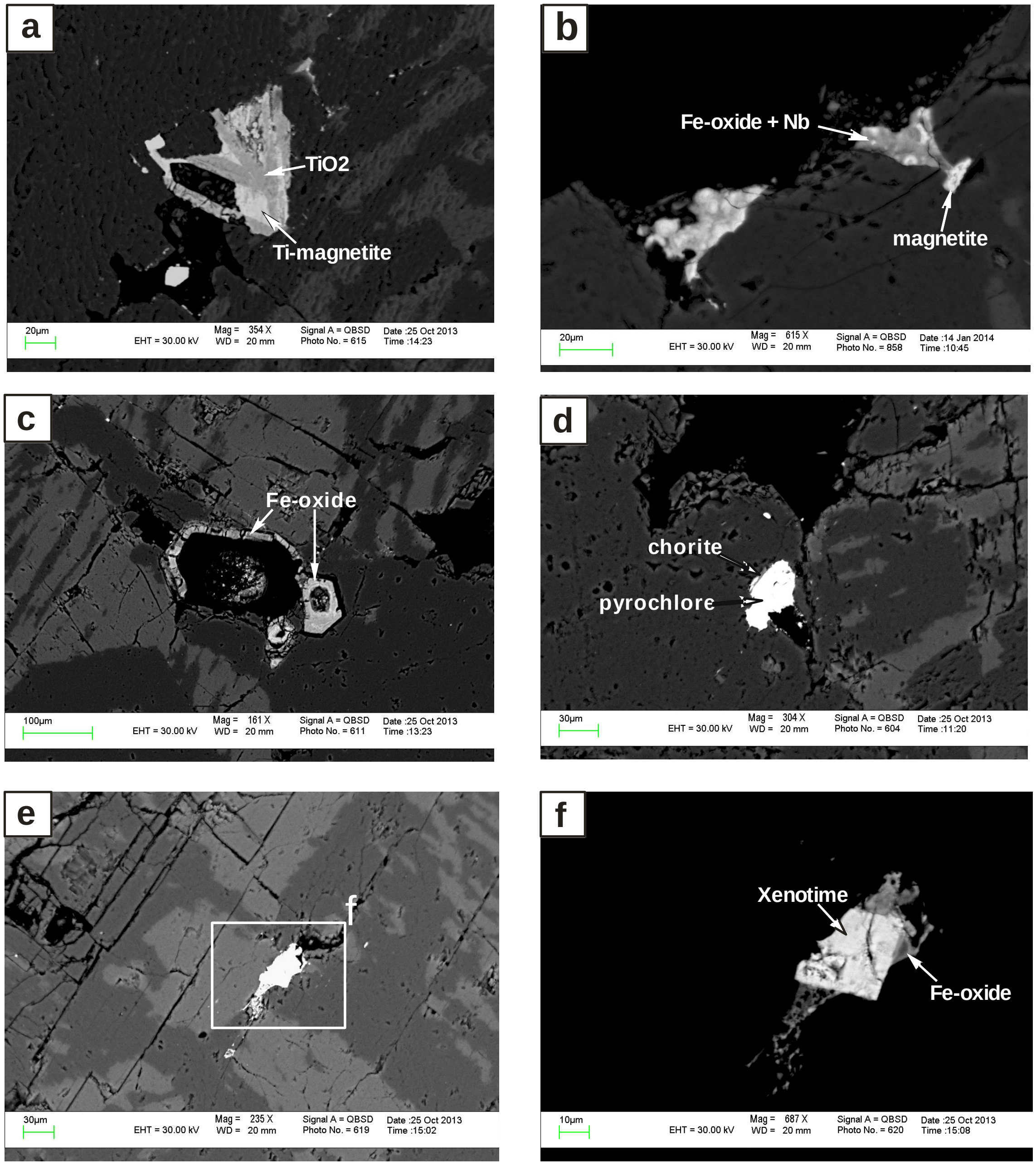

Figure 9: BSE images of figure 9873. a: Ti-magnetite alters to TiO_2. b: secondary Fe-oxide rich in Nb which has probably substituted for Ti. c: Fe-oxide rims a dissolution void. d: grain of pyrochlore that has precipitated in a fracture. e and f: Fe-oxide and later xenotime that have precipitated in feldspar cleavage

fluids created high secondary porosity in this sample. Xenotime together with Nb-rich magnetite have precipitated along feldspar cleavage (Fig. 9e and 9f). Xenotime seems to postdate magnetite. The later fractures are mostly barren with the exception of rare Fe-oxide and thorite (Fig. 22, App. 2-1). Some Fe-oxide and thorite thus seem to postdate some of the barren fracture.

Figure 10: Sheared granite of the West Moose River Pluton cut by black vein. Sample 9874 contains, and was cut perpendicular to, vein. Pen (right) for scale.

4.2.3: Sample 9874

A secondary set of planar veins striking 110º and dipping ~65 º is conjugate to the set of 9873 (Fig. 10). The hydrothermal minerals in this sample fill dissolution voids, line fracture walls, or fill fractures and intergranular boundaries. Zircon is of both magmatic and hydrothermal origin. The magmatic zircon is inhomogeneous and contains small amounts of Y, Yb, and Fe, whereas hydrothermal zircon is homogenous with a pure composition (Figs. 11a-d). It seems that hydrothermal zircon postdates Fe-oxides in voids where the two occur together (Fig. 11b).Quartz grains show abundant dissolution voids that range from hundreds of microns between grain boundaries (Fig. 11e), down to a few microns within quartz grains (Fig 11a). It is possible that quartz is preferentially dissolved compared to feldspar (Fig. 11a). Dissolution voids are completely or partially filled by the Nb-Ti-Y-REE minerals that include aeshcynite-euxenite, pyrochlore, and

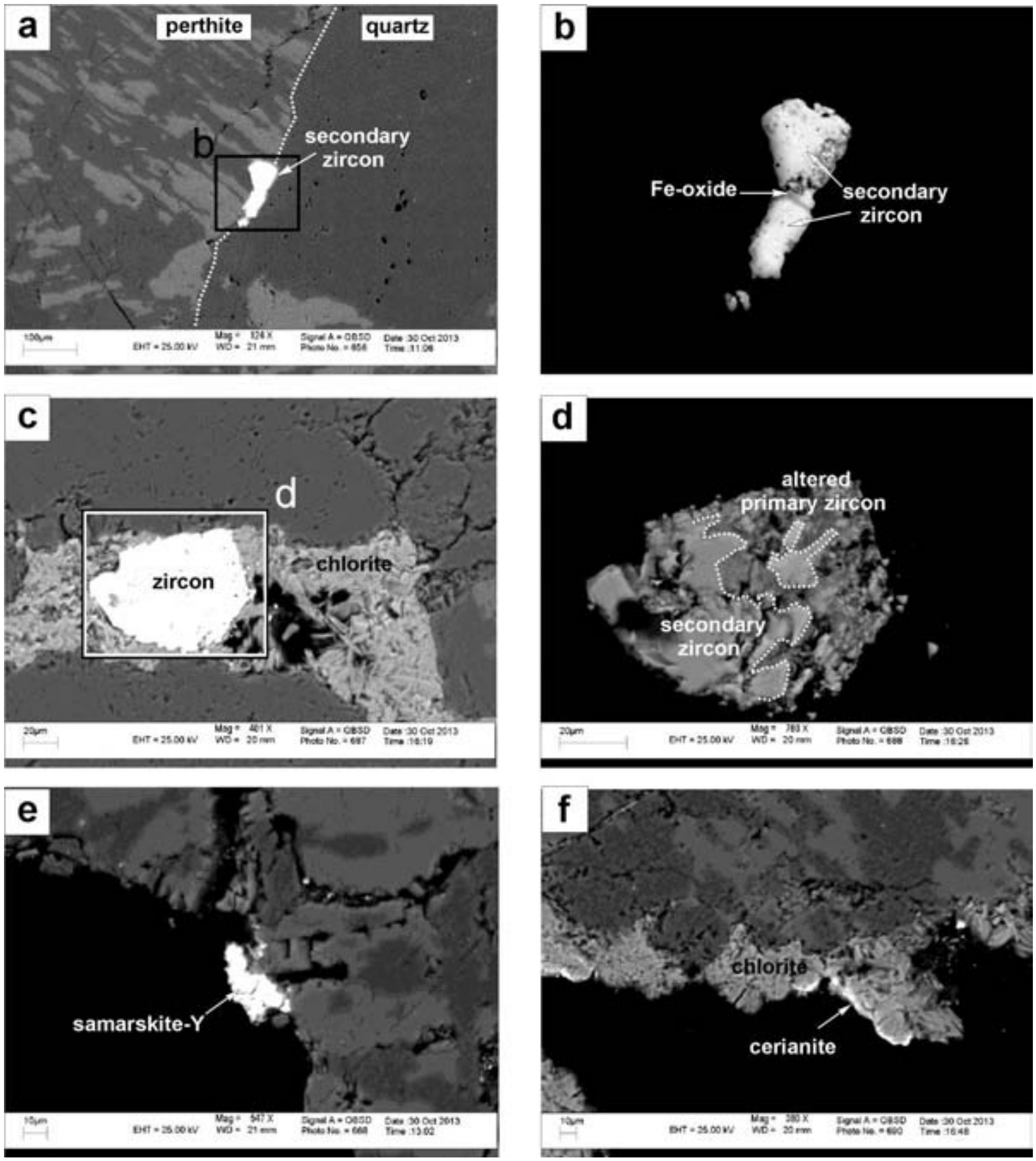

Figure 11: BSE images of sample 9874. a,b,c,and d: inhomogeneous and homogeneous textures of magmatic and hydrothermal zircon, respectively. Magmatic zircon (darker phase, d) is being replaced by hydrothermal zircon (brighter phase, d) which has a more homogenous texture. In both cases primary zircon contains Y and Yb, whereas secondary zircon does not. e: samarskite-Y precipitated in dissolution void. f: hydrothermal chlorite rimmed by later cerianite.

samarskite-Y (Fig. 11e). A black vein cutting the sample is lined predominantly by hydrothermal chlorite, with lesser amounts of muscovite, and zircon. In some places hydrothermal chlorite is rimmed by later cerianite (Fig. 11f). Zircon precipitates along chlorite cleavage (Fig 32, App. 2-2). Hydrothermal muscovite is also present (Fig 32, App. 2-2).

4.4.4: Sample 9876

Sample 9876 is from a cataclastic shear zone and has a large volume of secondary porosity compared to other fractured granite samples (Fig. 12). Porosity is partially filled by hydrothermal minerals which include: chlorite, Fe-oxide, TiO_2, and, of the REE-bearing minerals aeshcynite-euxenite, Fe-rich hingganite-Y (Fig. 13b), and cerianite. Cerianite rims, and thus postdates, both muscovite and chlorite (Fig. 13a). In other places, cerianite, along with TiO_2 has precipitated along chlorite cleavage (Fig. 11, App. 2-3).

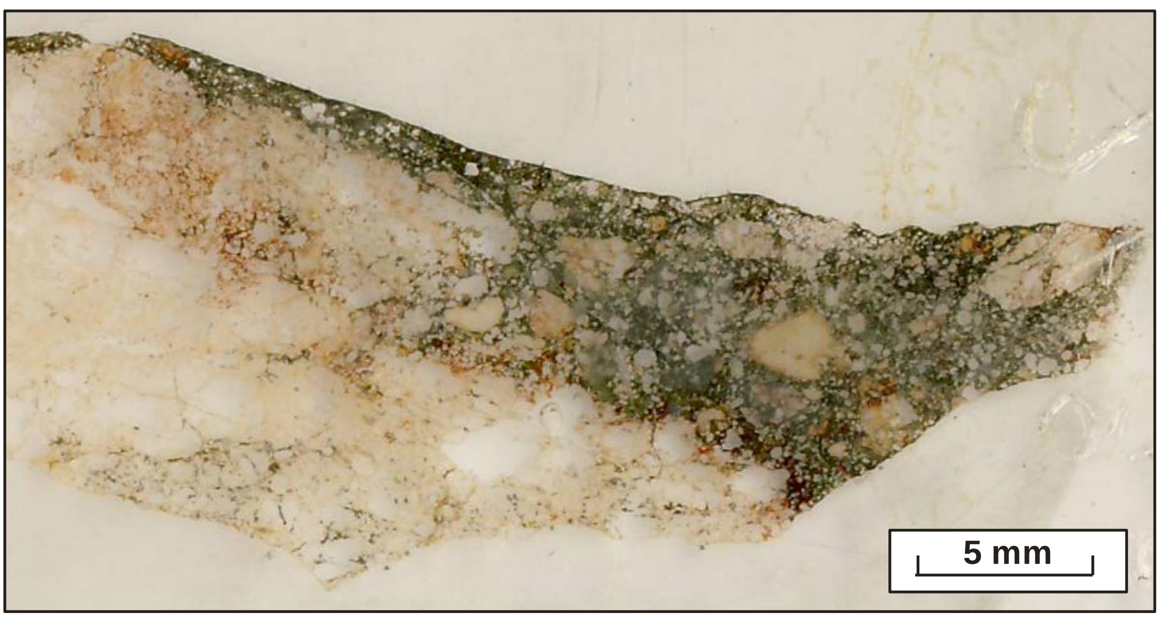

Figure 12: Photograph of a thin section from sample 9876. Chlorite, in green, is the predominant mineral filling cataclastic porosity.

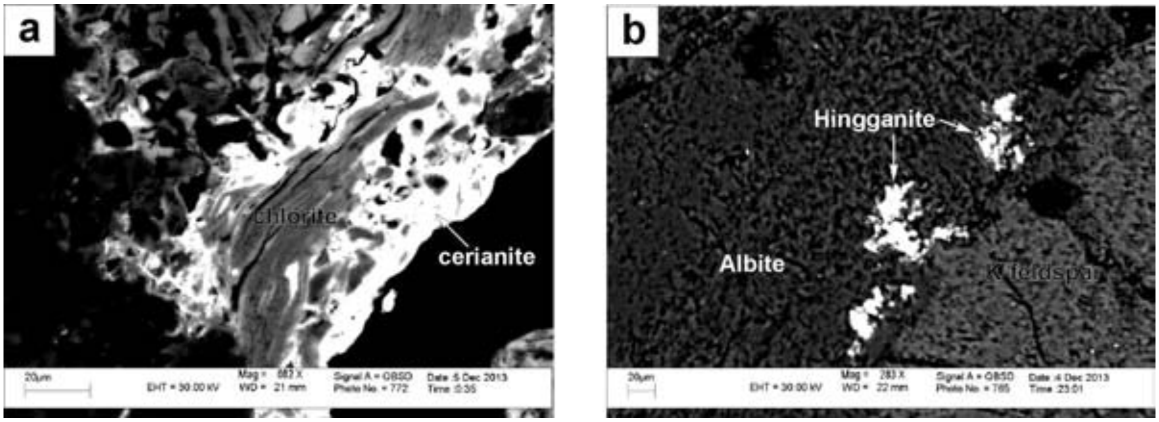

Figure 13: BSE images of sample 9876.a: chlorite is rimmed by later cerianite. b: Fe-rich hingganite-Y fills porosity in feldspar.

4.2.5: Sample 9878

Sample 9878 is from granite in an alteration zone . The secondary REE-bearing minerals in this sample include aeschynite-euxenite, cerianite that fills fractures in feldspar (Fig. 14a) and in places engulfs quartz, and thorite that in places fills pores created by the partial dissolution of primary Fe-oxide (Fig. 14b). Zircon in this sample contains Y and Yb, and is inhomogeneous in the texture with extensive corrosion (Fig. 6, App. 2-4).

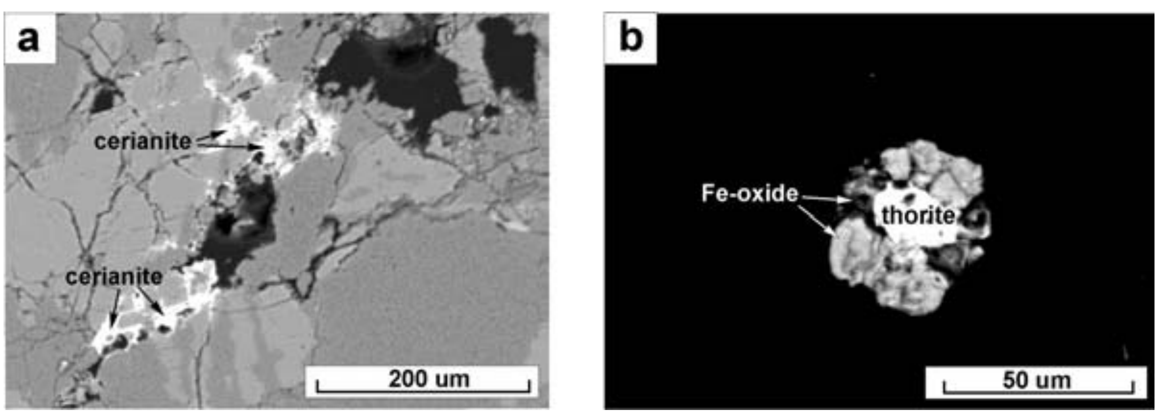

Figure 14: BSE images of sample 9878. a: cerianite rims primary feldspar in fracture. b: thorite postdates Fe-oxide mineral.

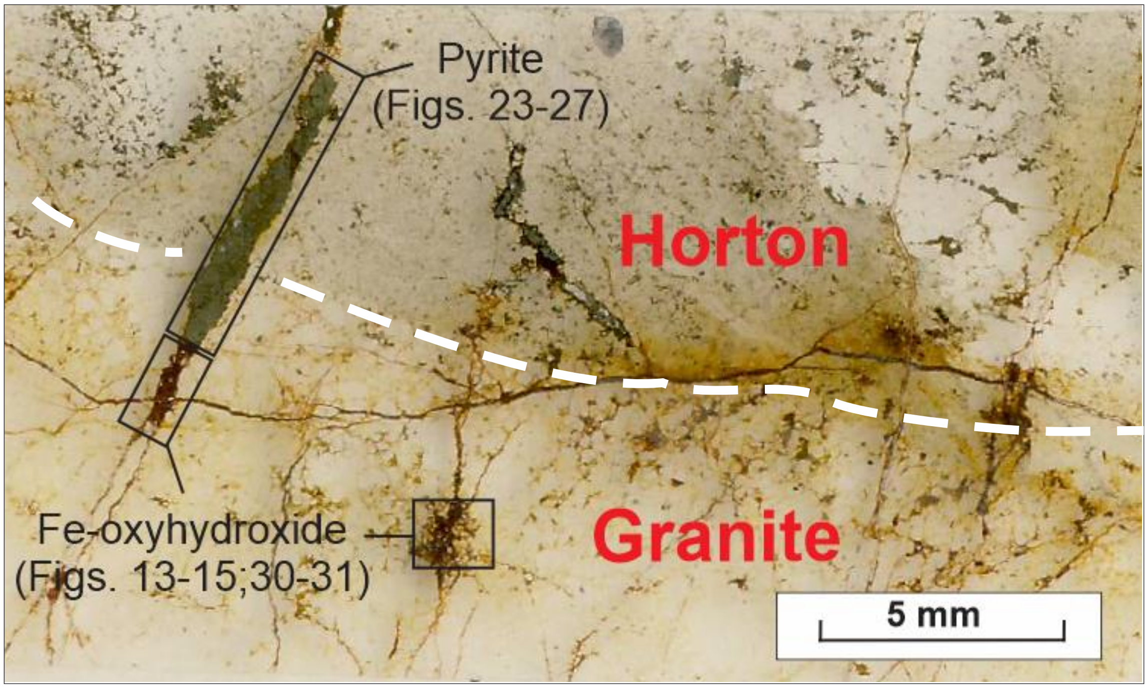

Figure 15: Photographed thin section of sample 9877. The white dotted line marks the contact between the Horton group (on top) and the granite of the West Moose River Pluton (below). Pyrite (green) and Fe-oxyhydroxide (brown) fill fractures and veins. Position of figures are referenced in appendix 2-5.

4.2.6: Contact Between Granite and Horton Group: Sample 9877

Sample 9877 is from the contact between a whitish granite of the West Moose River Pluton, and Horton Group hornfels (Fig. 15).The sample is highly fractured and cut by several subvertical black veins of various width. The hydrothermal minerals in these sub-vertical fractures seem to dominate both the granite and the Horton Group hornfels. The main characteristics of sample 9877 are the presence and variability of mode of occurrence, of a very fine grained hydrothermal paragenesis. Based on its EDS analysis (Appendix 2-5) this paragenesis is most likely a mixture of Fe-oxyhydroxide, pyrite, chalcopyrite, chlorite, aluminum-phosphate, and quartz, with Fe-oxyhydroxide as the dominant component. This very fined grained mineral paragenesis fills dissolution voids of various sizes, coats grains in breccia of fracture zones (Fig 16a), coats magmatic minerals (Fig. 16b), and precipitates along cleavage planes of feldspar (Fig. 16c) and

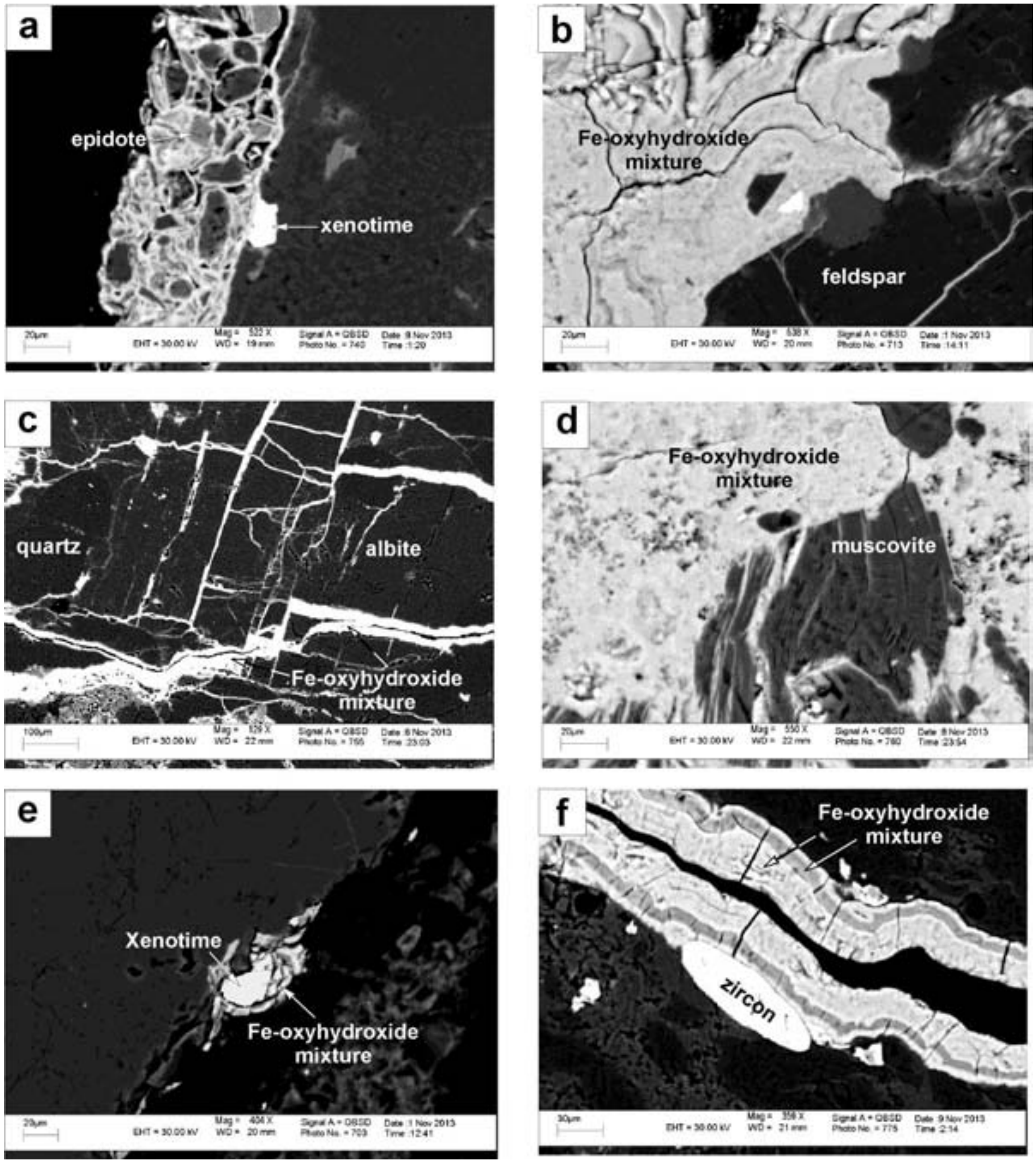

Figure 16: BSE images of various modes of occurrence of hydrothermal fine grained paragenesis in sample 9877. The paragenesis is predominantly Fe-oxyhydroxide; as such it is referred to as "Fe-oxyhydroxide" in the figures. a: Fe-oxyhydroxide rims breccia in fracture zone. b: Fe-oxyhydroxide concentrically rims primary feldspar. c and d: Fe-oxyhydroxide fills cleavage of primary minerals. e: Fe-oxyhydroxide rims xenotime in a fracture. f: Fe-oxyhydroxide lines wall of fracture and shows zoning as well as cooling cracks.

muscovite (Fig 16d). Fractures that accommodate this mineral assemblage may be completely filled, partially filled, or only be lined by them, suggesting repeated fracturing had occurred. Along the fractures, this fine-grained mineral assemblage often precipitates concentrically (Fig. 16e), or in successive zones (Figs. 16f and 17f). Such zones often show cooling cracks, suggesting rapid cooling (Fig. 16f). This mineral assemblage is often accompanied by euhedral to subhedral xenotime (Figs. 16b, 17a, and 18b).

In addition to the fine grained mineral assemblage, the fractures are predominantly filled by pyrite (Fig. 15). In one case, pyrite is rimmed by chalcopyrite and K-feldspar (Fig. 17b). In most places, pyrite is partially replaced by the fine grained mineral assemblage (Fig 17c), and in others appears to be completely pseudomorphed by it (Fig. 17d). Fractures in pyrite are filled by both the fine grained mineral assemblage (Figs. 17b and 17c) and xenotime (Fig. 17e). There has also been later fracturing that produced mostly barren fractures (Fig 17f). Occasionally in the fractures and the dissolution voids there is barite (Fig. 18a), zircon, ilmenite, rare small monazite grains, and molybdenite. We consider all of these minerals to be of hydrothermal origin.

In addition to monazite and xenotime, the REE bearing mineral assemblages in this sample include samarskite-Y, aeschynite-euxenite, and pyrochlore (Fig 18c). All of these minerals fill dissolution voids, fractures or other paths of weakness such as cleavage planes or intergranular boundaries. As such, we consider all of these minerals to be of hydrothermal origin.

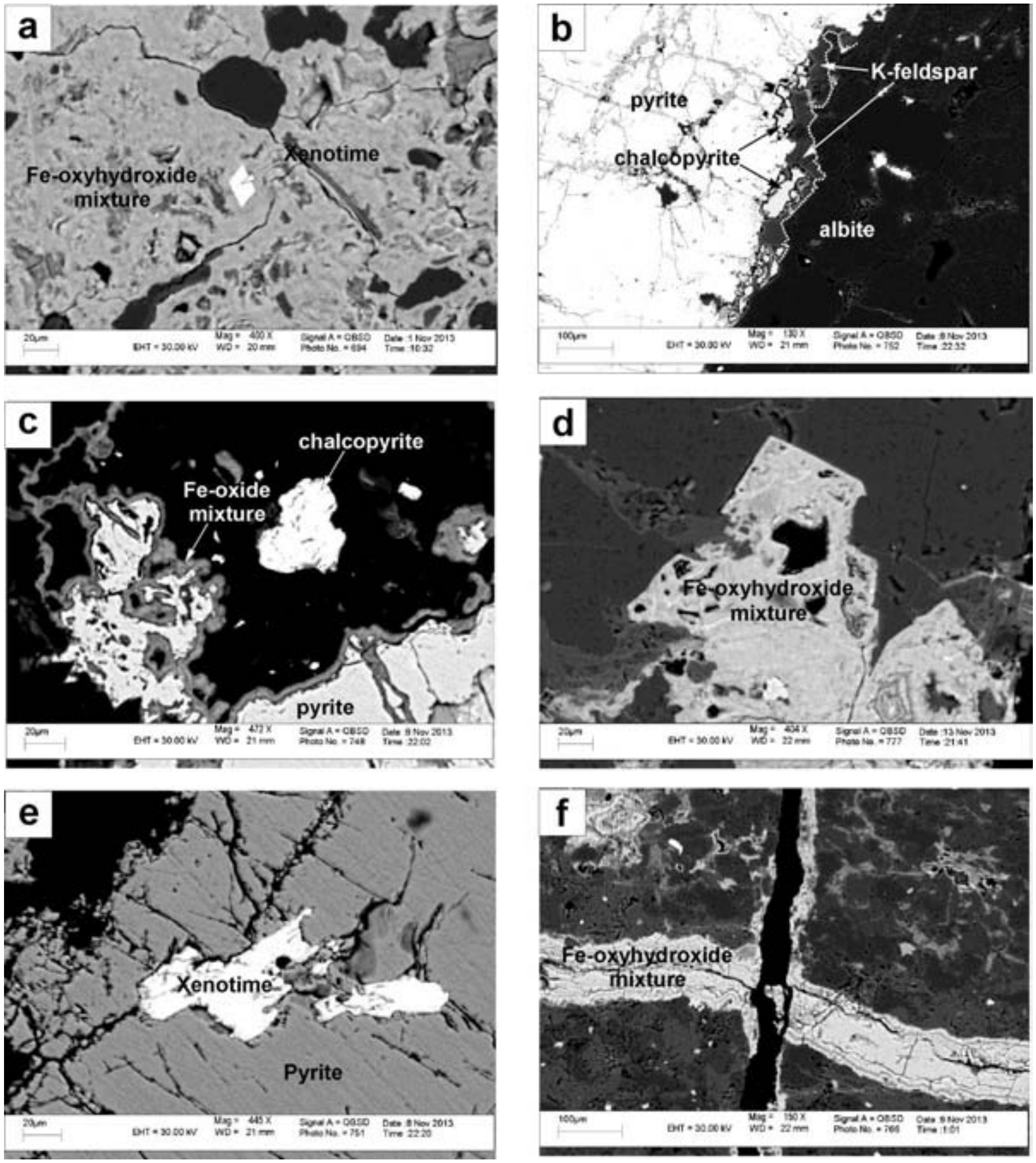

Figure 17: BSE images of sample 9877. a: Fe-oxyhydroxide associated with euhedral xenotime. b: pyrite rimmed by later chalcopyrite and K-feldspar. c: pyrite rimmed and partially replaced by Fe-oxyhydroxide. d: Fe-oxyhydroxide pseudomorph after pyrite. e: xenotime precipitated in fractures of pyrite. f: Fe-oxyhydroxide cut by later barren fracture.

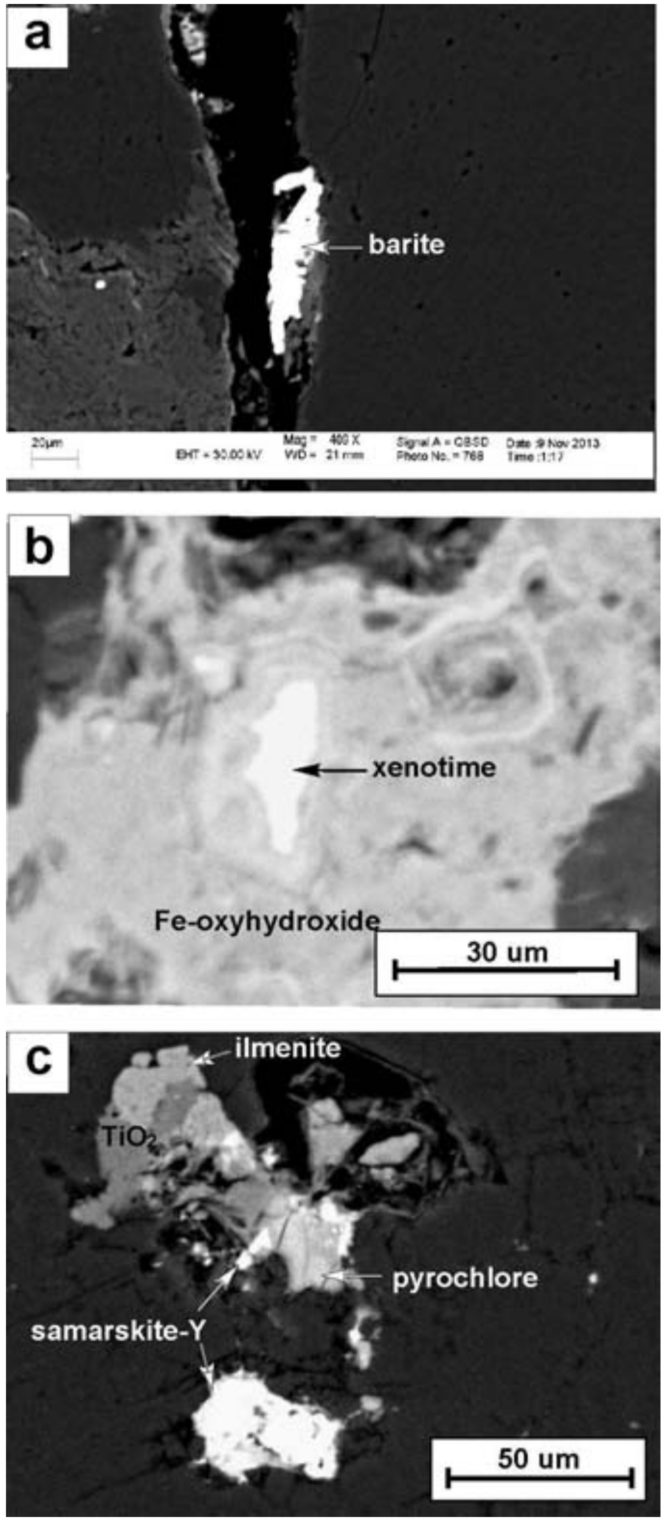

Figure 18: BSE images from sample 9877. a: barite precipitated in late, mostly barren fracture. b: Fe-oxyhydroxide rims xenotime. c: ilmenite engulfs TiO_2 and samarskite-Y partially replaces pyrochlore along a dissolution void.

4.3: Petrography of late mafic rocks associated with the REE-bearing hydrothermal minerals

All mafic rocks contained primary albite and biotite (Table 2). Due to the abundance of biotite (vol. 50-70%) the rocks were classified as minettes (Wooley et al. 1996). Samples collected closer to the Cobequid Fault (samples 7106 and C2226) were more fractured than those collected farther away (sample 1159). The only REE-bearing minerals discovered within the minettes were the fluorocarbonate synchysite-Ce, and less abundant xenotime. Synchysite-Ce was found exclusively as a secondary phase that has precipitated in calcite veins. Xenotime is likely, although less certainly, of secondary origin as well.

4.3.1: Sample 1159

Sample 1159 is from a minette dyke intruding the Jeffers Brook Formation several kilometers away from the Cobequid Fault. In addition to biotite and albite, sample 1159 contains primary titanite, epidote, magnetite, and pyrite. The pyrite contained inclusions of titanite. Fractures in this sample were the least abundant and most narrow. Chlorite and magnetite were found precipitated along fractures (Fig. 19a). However, no REE-bearing minerals were identified.

Table 2: Petrography of lamprophyres with fracture volume and type.

Sample	Rock Type	Main Mineralogy	% Total fractures	fracture types	Notes	REE (ppm, WRA*)
1159	Minette	Green biotite, albite	0.7	chlorite-rich	Mafic dyke intruding rock of the Jeffers Brook Formation northwest of the West Moose River pluton. Dated sample.	74.28
2226	Minette	Green biotite, albite	2.7	calcite-rich	Mafic dyke in West Moose River Pluton just north of Cobequid Fault. Dated sample with a disturbed Ar-Ar plateau	79.47
1882	Minette	brown-green biotite, albite	3.5	quartz-chlorite-rich	Mafic dyke intruding sedimentary rocks of the Horton Group in McCarthy Brook, close to the Cobequid Fault	182.9
7106	Minette	pale green biotite, albite	5.5	calcite-rich, chlorite-oxide-rich	Strongly fractured, flat-lying mafic sill just north of the Cobequid Fault	1566

*WRA= whole rock geochemical analysis

4.3.2: Sample C2226

Sample 2226 is a minette dyke intruding West Moose River Pluton granite in proximity to the Cobequid Fault Zone. The minerals present include biotite, albite, and calcite with accessory ilmenite, TiO_2, and pyrite (Fig. 19b). Secondary xenotime replaces earlier pyrite (Fig. 19c). The sample is cut by calcite veins that host the REE-bearing fluorocarbonate synchysite-Ce (Fig. 19d).

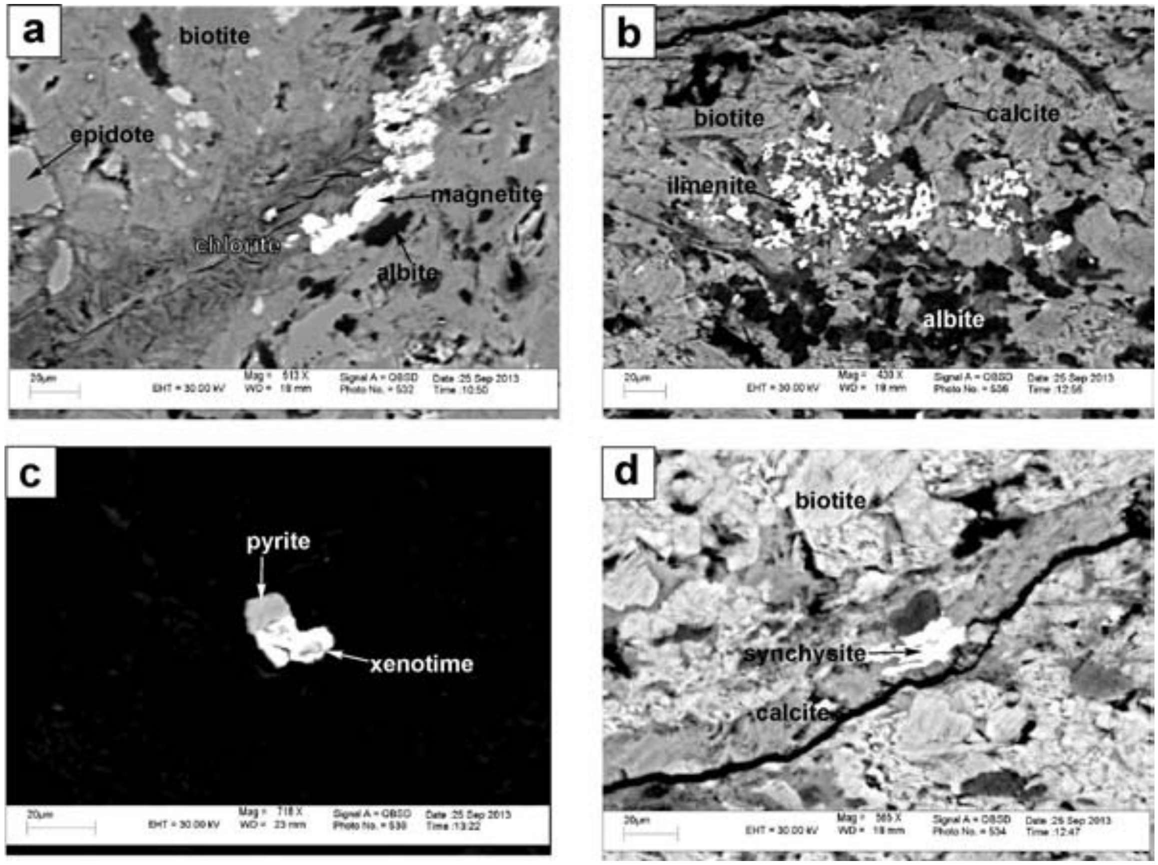

Figure 19: BSE images from samples 1159(a) and C2226 (b-d). a: hydrothermal chlorite and magnetite precipitated along fracture. b: dispersed ilmenite and calcite. c: xenotime replacing pyrite. d: synchysite-Ce precipitated in calcite vein.

4.3.3: Sample 7106

Sample 7106 is from a minette sill intruding West Moose River Pluton granite in proximity to the Cobequid Fault. The primary minerals consist of biotite, albite and composite grains of ilmenite and magnetite. Based on crosscutting relationships, the rock contain at least two generations of veins. The oldest veins are predominantly composed of chlorite, with lesser amounts of Fe- and Ti-oxides (Fig. 20c). These are cut by later calcite-rich veins with varying amounts of coveval fluorite and synchysite-Ce (Fig 20). In one case, calcite-rich veins are associated with barite and

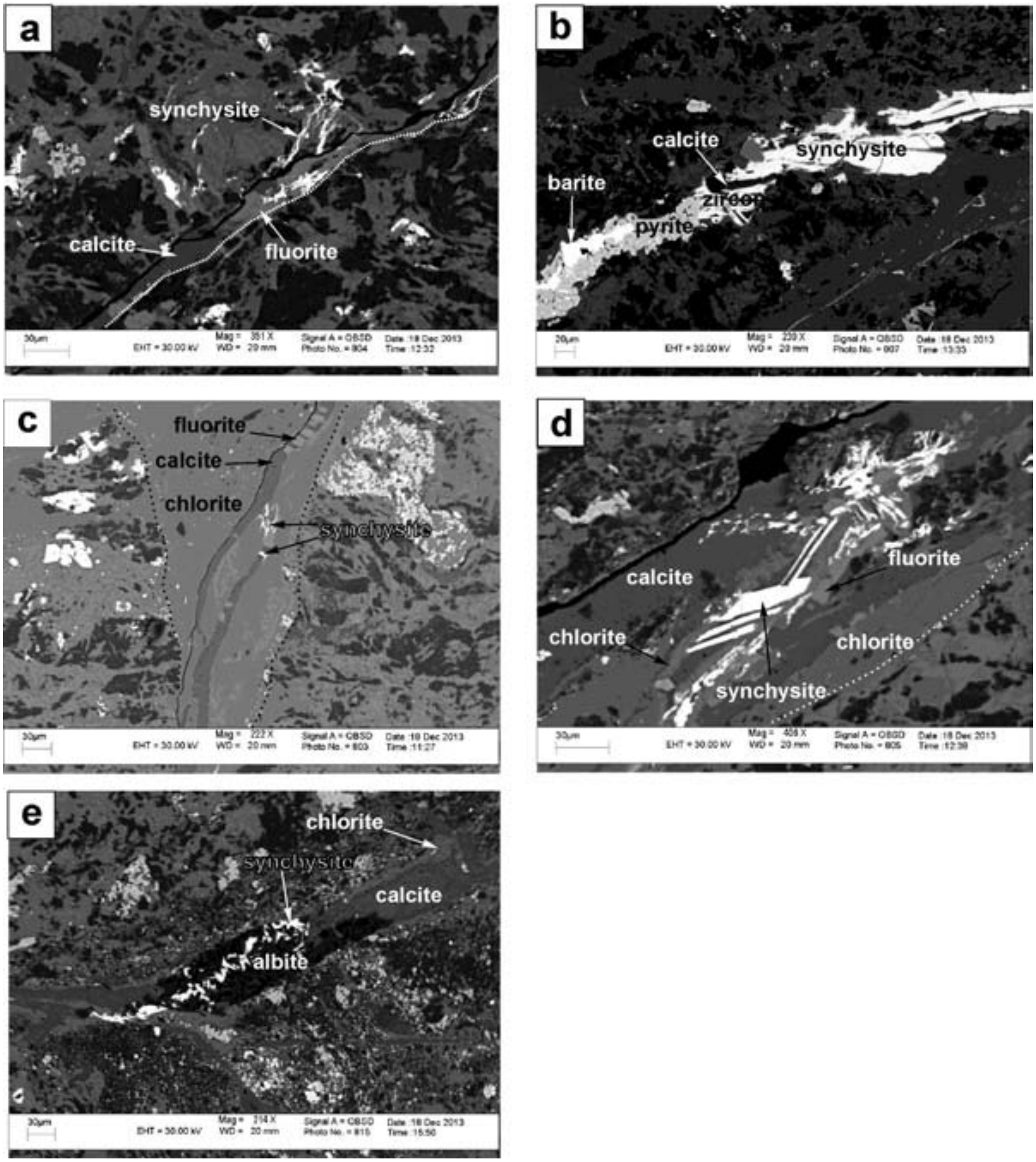

Figure 20: BSE imagess of fractures and veins in sample 7106. a: calcite-fluorite vein containing syncysite-Ce. b: synchysite-Ce and barite postdate pyrite in vein. c and d: composite vein with earlier chlorite-rich vein cut by later calcite-fluorite-synchsysite-Ce vein. e: composite vein with mineral paragenesis albite → chlorite → calcite and synchysite-Ce. Synchysite-Ce fills dissolution voids in albite.

pyrite (Fig 20b); barite, calcite, and synchysite-Ce appear to postdate pyrite. Composite veins also occur, containing both earlier chlorite-rich type and later calcite-rich type veins (Fig 20c). A rare vein was found that contained relics of corroded hydrothermal albite partially replaced by chlorite and later calcite. The chemistry of this secondary albite is more sodium rich than primary albite in the minette.

Chapter 5: Discussion And Conclusion

5.1: REE mineral occurrence, distribution and source

The REE-bearing minerals of this study are almost exclusively secondary and occur in fractures, veins, primary pores and dissolution voids in the Horton Group country rock, the West Moose River Pluton (WMRP) granite, and late minette dykes. The only samples not containing REE-bearing minerals are samples 274 and 1159. Sample 274 is from a metacarbonate country rock that contains only few fractures, pores, or other paths of weakness. Likewise, sample 1159 is the least fractured minette, and is several kilometers away from the Cobequid Fault Zone. In country rock samples 2349A and 2349B, REE-bearing minerals precipitate in intergranular porosity (Fig. 2e and Fig 3b) and fractures (Fig 2f and Fig. 3c). In the minettes, the degree of fracturing shows a positive correlation with REE concentrations (Table 2). Hence, the presence of fracturing, or other fluid paths, seems to be a prerequisite for the concentration of REE-bearing minerals, rather than any particular lithology. Furthermore, hydrothermal fluids appear to have created secondary porosity through dissolution voids of minerals, which in some cases host REE-bearing and other hydrothermal minerals (Figs. 8a, 9, 11a, 13b, and 18c). The hydrothermal minerals throughout the study area consist of zircon, magnetite, pyrite, chalcopyrite, chlorite, muscovite, tourmaline, TiO_2 minerals, Fe-oxyhydroxide, barite, molybdenite, calcite, albite, and fluorite, as well as the REE-bearing minerals thorite, xenotime, synchysite-Ce, cerianite, Fe-hingganite-Y, pyrochlore, samarskite-Y, and aeschynite-euxenite (Table 3).

Table 3: Summary and distribution of hydrothermal REE-bearing minerals in each lithology (X indicates the presence of mineral).

	LREE-bearing			HREE-bearing			
	monazite	cerianite	Synchysite-Ce	xenotime	thorite	Fe-hingganite-Y	Nb-Ti-Y-REE minerals
country rock	x		x	x	x		
contact	x			x	x		x
granite		x		x	x	x	x
minettes			x	x			

Xenotime is the most widely distributed hydrothermal REE-bearing mineral and is the only one present in all 3 lithologies (Table 3). Xenotime is enriched in the medium (MREE) to heavy (HREE) REE`s Gd, Dy, Er, and Yb, which make up 10 -17 oxide wt% of analyses (Fig. 21). In all xenotime analyses, the REE dysprosium (Dy) is in the highest abundance. It is difficult to determine if xenotime found in the country rock is hydrothermal or detrital, based on textural evidence alone. However, the similarity between its chemistry and that of hydrothermal xenotime in the granite (Figure 21), suggests that xenotime is likely hydrothermal as well. HREEs are also present in Fe-rich hingganite-Y, and the Nb-Ti-Y-REE minerals (samarskite-Y, aeschynite-euxenite, and pyrochlore), that both occur exclusively in the granite. LREE are present in the mineral synchysite-Ce that precipitated in calcite-rich veins cutting the minettes (Figs. 19d and 20), and in fractures in siliclastic country rock with calcite cement (Fig. 2f). LREEs are also present in cerianite (CeO_2) that occurs in the granites, as well as the phosphate mineral monazite-Ce that occurs in the country rock. The distribution of LREEs in monazite closely resembles that of synchysite-Ce (Fig. 22). In general, both LREEs and HREEs are present in each lithology, in various minerals that include hydrothermal phosphates, fluorocarbonates, and oxides.

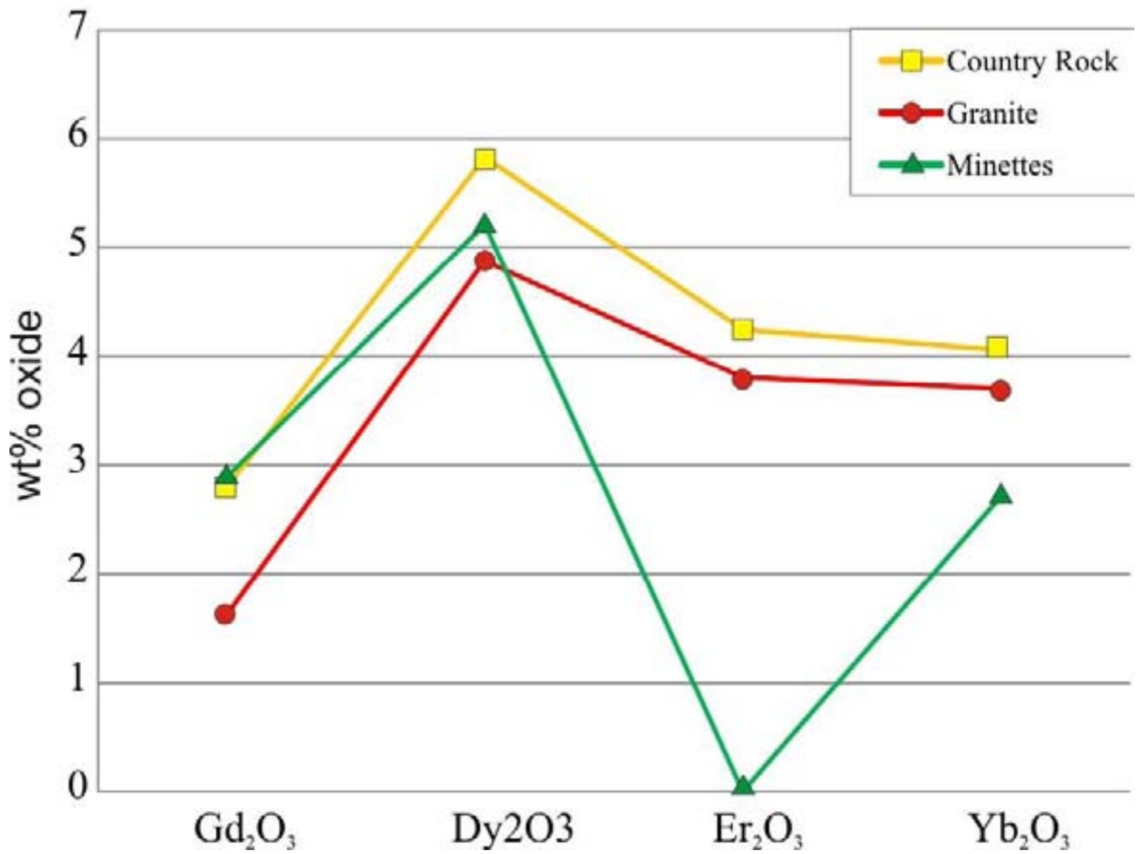

Figure 21: Average concentration of REE-oxides, by weight %, in xenotime from each lithology.

According to the chemistry, and mineralogy of all rock types present in the Cobequid Highlands, it is likely that the A-type granites are the primary source of REE in hydrothermal fluids. Other A-type granites in the Cobequid Highlands have been shown to contain magmatic REE-minerals (Papoutsa and Pe-Piper 2013). The mafic dykes were not shown to contain primary REE-minerals. Sample 1159, which was the least fractured minette, and the furthest from both the granite and the Cobequid Fault, did not contain

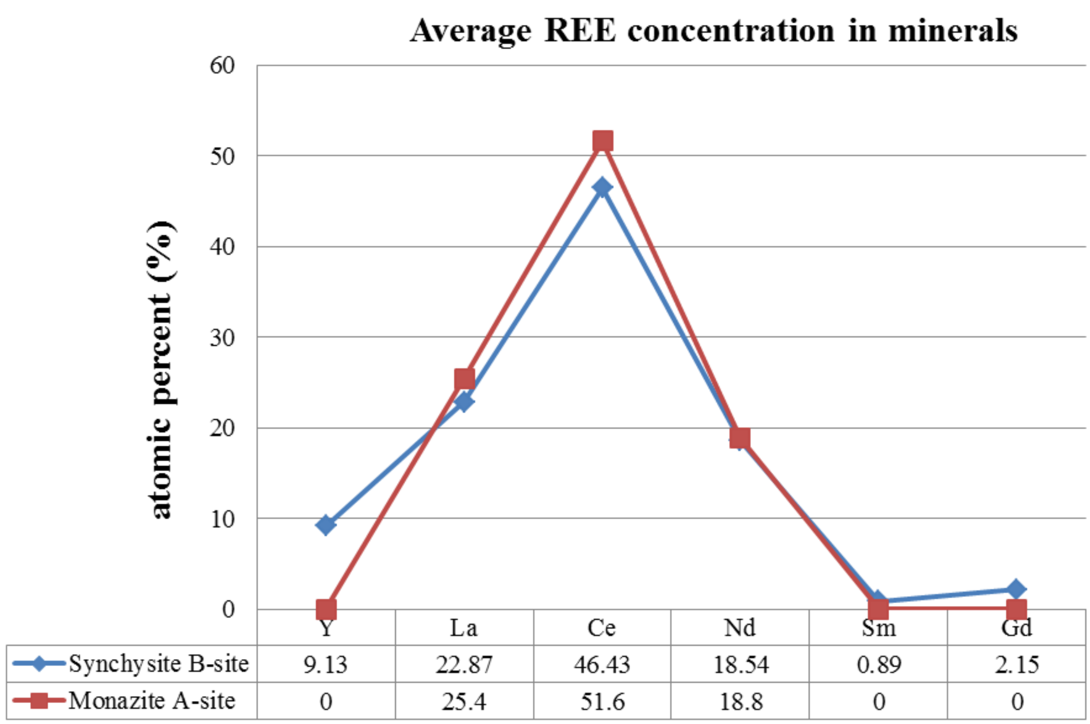

Figure 22: Relative proportion of REEs in synchysite-Ce and monazite. In synchysite, REEs and Y occupy the B-site, whereas in monazite they occupy the A-site.

any REE-bearing phases. The only primary REE-bearing mineral found in this study was zircon containing Y and Yb (samples 9873, 9874, and 9878). This zircon was found as magmatic grains in the granite (Figs. 8e, 8f, 11c and 11d), and as detrital grains in country rock (Fig. 5, App. 1-2). In both lithologies, primary zircon was inhomogeneous, and partially altered to REE-deficient hydrothermal zircon. As such, magmatic zircon in the granite is a likely source of HREEs in the hydrothermal fluids.

5.2: Minettes

Previous work by Pe-Piper et al. (2004), using the Ar^{40}/Ar^{39} dating method on biotite, and recalculated by Murphy et al. (2011), has dated samples 1159 and C2226 at 334 ± 3 Ma and 326 ± 2 Ma, respectively (Fig. 23). Sample 1159, from an unaltered minette, displays a relatively flat plateau. Sample C2226, from a fractured minette, shows a dip in age that deviates from the otherwise flat plateau at approximately 330 Ma (yielding an average age of 326 ± 2 Ma with the dip). This dip suggests that the biotite in the sample was effected by hydrothermal fluids.

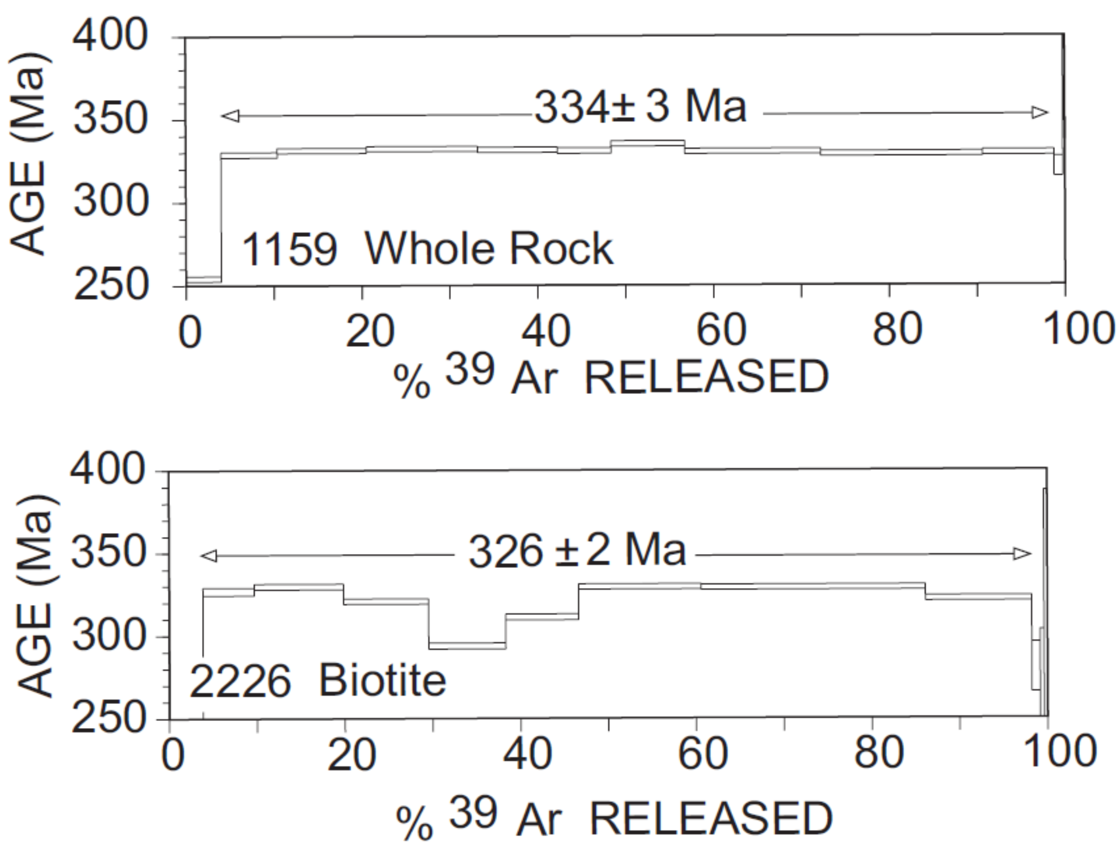

Figure 23: Ar^{40}/Ar^{39} dates from biotite separates taken from the minettes. The dates have been recalculated by Murphy et al. (2011) from original data from Pe-Piper et al. (2004).

In the minettes, REE concentrations show a positive correlation with the amount of fracturing (Table 2) and a decreasing trend going from LREEs to HREEs (Fig. 24). Both observations are attributed to the presence of hydrothermal synchysite-Ce, that precipitated in the fractures and which has a preference for LREE. However, in respect to the latter, it should be noted that sample 1159, which does not contain secondary REE minerals, shows the same decreasing trend from LREE to HREE. Sample C2226 shows the least steep trend, likely related to the presence of HREE-bearing xenotime (Fig. 19c). Sample 1159 does not show a depletion in Eu^{2+}, possibly related to the chemical composition of the parent magma.

Fractured minettes may provide favourable conditions for the precipitation of LREE due to their biotite-rich primary composition. As Migdisov et al. (2009) have shown, halogens form highly stable complexes with LREE. These complexes were likely responsible for the mobilization of LREE along with carbonate rich fluids, as evident from the calcite-fluorite-synchysite-rich veins. Due to their biotite-rich composition, the minettes are especially rich in the volatile halogens chlorine and fluorine. Ar^{40}/Ar^{39} dates suggest that fractured minettes experienced hydrothermal alteration, and it is possible that high amounts of fluorine in the biotite led to an oversaturation of fluorine during fluid-rock interaction. In this case, precipitating fluorine would act as a sink for LREE from the hydrothermal solution. The oversaturation hypothesis is supported by the fact that synchysite-Ce is a fluorocarbonate mineral, as well as the presence of precipitated fluorite in sample 7106. The exclusive presence of fluorite only in sample 7106 could relate to it being the most fractured lamprophyre sample; it would have experienced the greatest amount of hydrothermal fluid-rock interaction and release of halogens in the fluids. Further investigation is required to fully understand the relationship between biotite, fracturing, halogens, and REE concentrations in the minettes. However, it is evident that fluorine is associated with LREE in the hydrothermal system, and that the minettes contain high concentrations of both fluorine and LREEs.

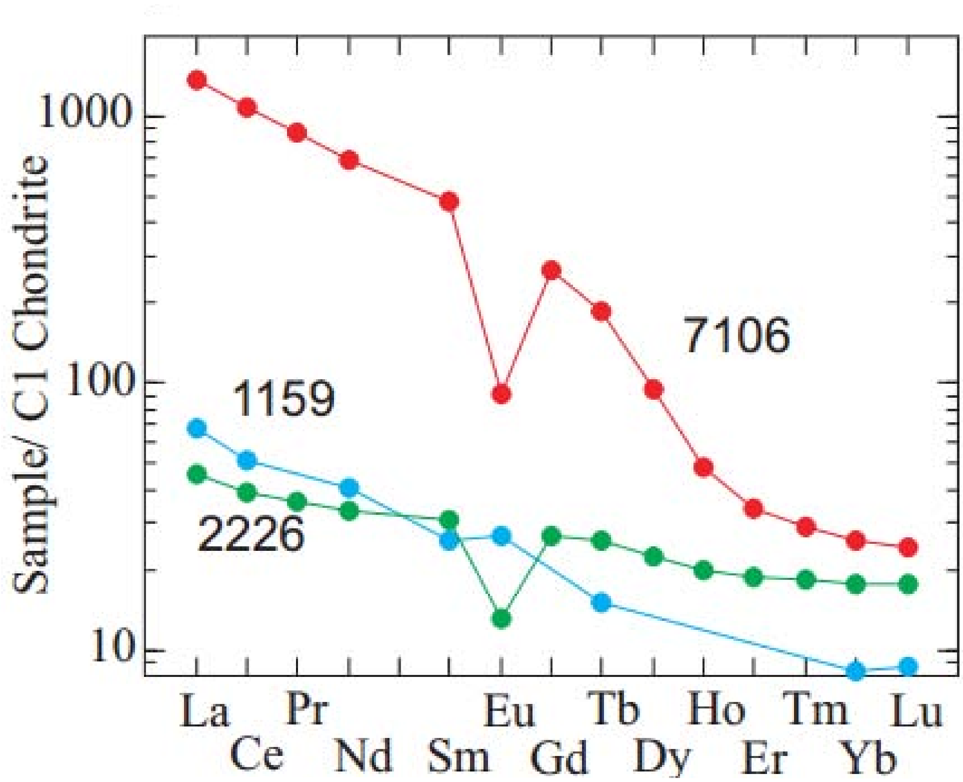

Figure 24: REE distribution of minettes from whole rock geochemistry, normalized to C1 chondrites.

5.3: Hydrothermal mineral paragenesis

There are many hydrothermal minerals present in the studies samples, and it is difficult to determine the complete mineral paragenetic sequence with certainty. However, there are some textural relationships between minerals that serve to establish at least a partial paragenesis. Ti-magnetite, chlorite, and pyrite seem to be the earliest hydrothermal phases. Ti-magnetite is often partially replaced by TiO_2 minerals (Fig. 9a), and is, in some dissolution voids, enriched in Nb, that has likely substituted for Ti (Fig 9b). This Nb-rich Fe-oxide is cut by later xenotime (Fig. 9f). Chlorite is rimmed by later zircon (Fig. 32, App. 2-2), TiO_2 minerals (Fig. 11, App. 2-3), and cerianite (Fig 11f and 13a) in the granites. Chlorite geothermometry yielded two temperature groups (Table 4): an average of 180 º C for chlorite in the granite and country rock, and an average of 255 º C for chlorite in minette veins. Thus, chlorite seems to have precipitated at 2 different temperatures; at a higher temperature in the minettes than the granite and country rock. In the minettes, chlorite-rich veins are cut by later calcite-fluorite-synchysite veins (Fig 20). In one case, synchysite and barite occur in the same vein, and both cut earlier pyrite (Fig. 20b). Throughout the study area pyrite is rimmed by later chalcopyrite (Figs. 2a, and 17b) and by the Fe-oxyhydroxide fine grained mixture of the Horton Group and granite contact zone (Fig 17c). Xenotime precipitated in fractures of pyrite (Fig 17e), and in some places, appears to have partially replaced it (Fig. 6, App. 3-2). In some places the fine grained Fe-oxyhydroxide mixture is cut by xenotime (Fig. 17a), whereas in other places it concentrically rims xenotime (Figs. 16e and 18b). As such, it is likely that the two minerals are coeval. The Fe-oxyhydroxide mixture postdates zircon in the contact zones (Fig. 16f). Both pyrite and Fe-oxyhydroxide are cut by later mostly barren fractures containing rare amounts of barite (Fig. 18a). Lastly, both Fe-rich-hingganite and Nb-Ti-Y-REE minerals occur exclusively in dissolution voids throughout the granite samples.

It is possible to associate some of these paragenetic observations with known and dated hydrothermal events in the Cobequid Highlands. In sample 9877, coeval chalcopyrite and fine grained Fe-oxyhydroxide appear to be the latest hydrothermal phase to precipitate since they are mostly cut by barren fractures. Both their composition and their lateness suggest they may be associated with the iron-oxide-copper-gold (IOCG) mineralization along the Cobequid Fault. This event has been dated from monazite at 320 Ma (Kontak et al. 2008), and is constrained stratigraphically to the Serpukhovian - Bashkirian boundary at 323 Ma (Kontak 2006). This event likely involved large amounts

Table 4: Geothermometry of hydrothermal chlorite. Analysis recalculated to 20 cations, 48 apfu.

Sample	Site	Pos.	Occurrence	Si	Al^{IV}	Al^{VI}	Fe	Mn	Mg	Ca	Na	K	Cl	Ce	Zn		Temperature ^oC (Kranidiotis and Mclean 1987)
L1159	11	3	hairline fracture	7.42	0.58	2.93	3.48	0.07	5.28	0.10	0	0.13	0	0	0		**109.20**
274	6	2	interstitial metacarbonate	6.51	1.49	2.42	1.10	0.04	8.43	0	0	0	0	0	0		184.67
274	9	1	interstitial metacarbonate	6.60	1.40	2.12	0.97	0.03	8.82	0.06	0	0	0	0	0		173.74
																average:	**179.20**
9874	34	5	black stringer	6.87	1.13	4.25	5.22	0	2.44	0	0	0	0	0	0.08		188.60
9874	34	8	black stringer	7.00	1.00	4.14	4.80	0	2.86	0	0	0	0	0	0.21		170.06
9874	36	3	black stringer	7.47	0.53	4.27	4.57	0	3.01	0	0	0.07	0	0	0.08		118.72
9874	37	1	black stringer	6.99	1.01	3.71	5.42	0.04	2.77	0	0	0	0	0	0.06		174.70
9874	37	4	black stringer	6.71	1.29	3.74	5.76	0.04	2.38	0	0	0	0	0	0.08		207.29
9874	40	2	black stringer rimmed by cerianite	7.17	0.83	3.56	5.14	0	3.03	0.06	0	0	0	0	0.21		152.88
9874	41	4	black stringer rimmed by cerianite	6.75	1.25	3.72	5.86	0	2.38	0	0	0	0	0	0.04		203.15
9876	19	9	in dissolution void with Cerianite	6.80	1.20	4.39	3.96	0.04	3.62	0	0	0	0	0	0		183.44
9876	19	13	in dissolution void with Cerianite	6.49	1.51	3.97	3.38	0.14	3.87	0	0.22	0	0	0.37	0.06		213.06
9876	20	1	in dissolution void. cerianite on cleavage	6.57	1.43	3.77	3.28	0.17	4.45	0	0	0	0	0.28	0.05		201.20
																average:	**181.31**
7106	3	1	vein	6.17	1.83	3.38	4.84	0.03	3.76	0	0	0	0	0	0		253.46
7106	3	2	vein	6.26	1.74	3.79	5.47	0.08	2.49	0.06	0	0	0	0	0.10		253.38
7106	3	3	vein	6.39	1.61	3.89	5.51	0.08	2.43	0	0	0	0	0	0.09		239.91
7106	3	4	vein	6.29	1.71	3.78	5.61	0.08	2.43	0	0	0	0	0	0.09		251.24
7106	5	2	vein	6.21	1.79	3.27	5.25	0.08	2.91	0.42	0	0	0	0	0.06		255.38
7106	5	4	vein	5.82	2.18	2.64	4.92	0.08	2.78	1.52	0	0	0	0	0.05		296.38
7106	5	9	vein	6.26	1.74	3.55	5.25	0.08	2.48	0.58	0	0	0	0	0.07		252.38
7106	7	1	vein	6.02	1.98	3.25	4.64	0.02	3.88	0	0	0.17	0.05	0	0		268.54
7106	7	19	vein	6.10	1.90	3.35	4.73	0.02	3.81	0	0	0.08	0	0	0		261.02
7106	8	1	vein	6.59	1.41	2.54	4.52	0.03	4.39	0.45	0	0	0	0.06	0		205.20
7106	8	7	vein	6.35	1.65	3.30	4.51	0	3.39	0	0.67	0.07	0.05	0	0		235.27
7106	8	13	vein	6.12	1.88	3.33	4.68	0	3.87	0	0	0.07	0.05	0	0		257.57
7106	11	15	vein	6.19	1.81	3.28	4.73	0.03	3.82	0	0	0.08	0.05	0	0		250.63
7106	11	17	vein	5.77	2.23	2.23	4.17	0.05	3.61	1.95	0	0	0	0	0		294.47
																average:	**255.34**

of Cl ions in circulating fluids derived from the Windsor Group evaporites, that were uplifted about this time (Murphy et al. 2011). Such fluids would be capable of remobilizing LREE, and hence this event may be related to the precipitation of monazite, synchysite-Ce, and cerianite in the study area. Due to the previously established coeval precipitation of monazite and its similar chemistry (LREE-bearing) to synchysite-Ce, the first two minerals seem likely to be related to the late event. Furthermore, the IOCG mineralization involved carbonate fluids such as those that precipitated in the Londonderry deposit (Murphy et al. 2011); synchysite-Ce occurs in carbonate-rich veins. In the granites, textural evidence suggests that cerianite is the latest phase to precipitate. Furthermore, work done by Bau (1999) indicates that the oxidation of Ce^{3+} to Ce^{4+}, and hence, precipitation of cerianite is facilitated by the simultaneous precipitation of Fe-oxyhydroxides such as those in sample 9877 from the Horton -granite contact, as well as the other granite samples.

It is more difficult to associate the HREE-bearing minerals with regional hydrothermal events, and to determine their paragenetic relationship to the LREE-bearing species described above. Textural evidence suggests that xenotime is coeval with Fe-oxyhydroxide at least in sample 9877. Other HREE-bearing minerals, samarskite-Y, aeschynite-euxenite, pyrochlore, and Fe-hingganite-Y, occur exclusively in dissolution voids, and do not offer much textural evidence for determining paragenesis. However, the Nb-Ti-Y-REE minerals do in places occur with hydrothermal zircon, which predates the Fe-oxyhydroxide, in dissolution voids (Fig. 3, App. 2-1; Fig. 84, App. 2-4). Also, there is textural evidence to suggest that Nb-rich Fe-oxide may predate xenotime. As such, it is possible that Nb-Ti-Y-HREE-bearing minerals predate the IOCG mineralization event that precipitated LREE-minerals and xenotime. Furthermore, the former mineral type (Nb-Ti-Y-HREE) is absent in the minettes and thus may predate intrusion of fractured dykes at circa 330 Ma. However, more data would be required to confirm or deny this.

Given these observations, a plausible paragenesis for all hydrothermal minerals throughout the study area would follow: (1) chlorite, pyrite, and magnetite → (2) Nb-enrichment of magnetite, TiO_2 minerals, zircon, Nb-Ti-Y-REE-minerals (samarskite-Y, aeschynite-euxenite, and pyrochlore), and possibly Fe-hingganite-Y (due to HREE content plus occurrence in dissolution voids) → (3) Fe-oxyhydroxide, chalcopyrite, barite, calcite, xenotime and LREE-minerals (monazite-Ce, synchysite-Ce, and cerianite) and barite.

5.4: Conclusion

The West Moose River pluton experienced significant hydrothermal alteration that remobilized LREEs and HREE's into pervasive fluids, which precipitated REE-bearing minerals in fractures, cleavage planes of minerals, dissolution voids, primary porosity, and other paths of weakness. REE's seem most likely to originate from the A-type granite, with HREE specifically from zircon, but have been extensively redistributed in the granite itself, the surrounding country rock, and mafic intrusions. The remobilization of LREE is related to the 323 Ma IOCG mineralization that occurred along the Cobequid Fault, whereas HREE may be earlier. The halogen-rich content of biotites in the intrusive minettes, provides favourable conditions for the precipitation of LREE's, specifically in the mineral synchysite. Fractured minette dykes in the Cobequid Highlands should be considered a future area of research and exploration target for LREE-minerals.

5.5: Recommendations

As mentioned, further research investigating the intrusive minettes is required, to fully understand the relationship between halogen in the biotite, fracturing, and the precipitation of LREE-bearing minerals. Biotites need to be further analyzed with an electron microprobe, as the EDS analysis done does not provide reliable data for halogens content. Also, it should be investigated, whether multiple generations of biotite exist in the minettes, as they have likely experienced repeated hydrothermal alteration. Sample 1882 was not analyzed with EDS or investigated for hydrothermal REE-bearing minerals, due to time constraint. As such, this should be accomplished by the author in the near future in order to compare relationship between fractures and LREE-minerals to analyzed minettes.

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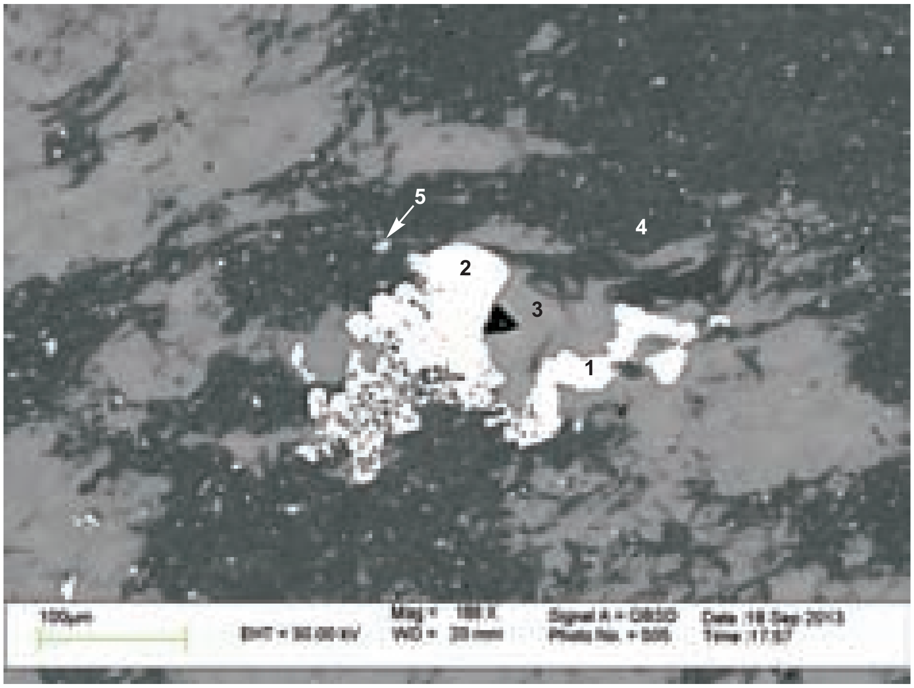
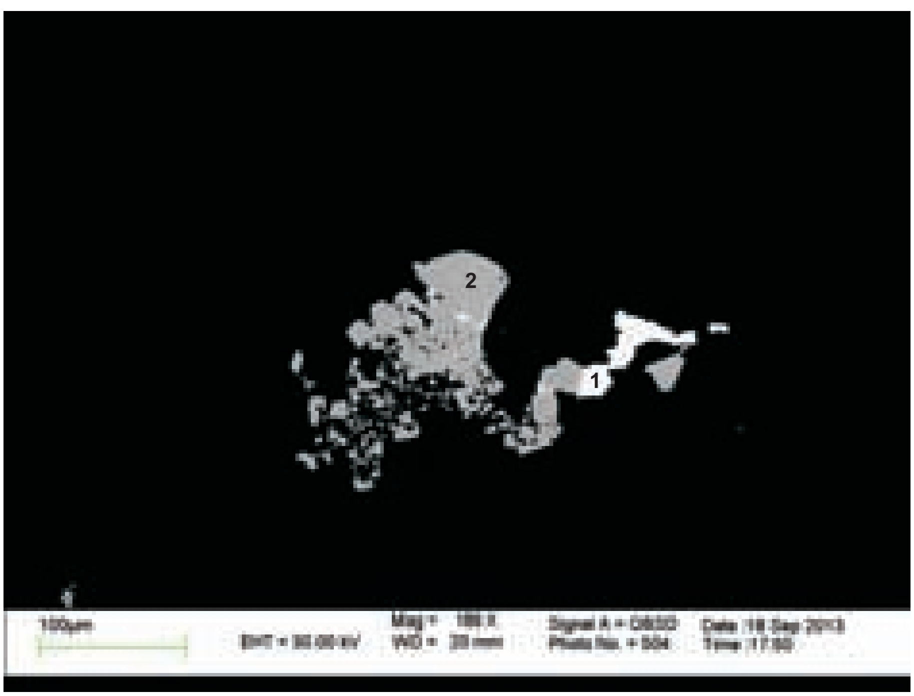
Appendix 1: BSE images and EDS analyses of minerals from the country rock

Appendix 1-1: BSE images and EDS mineral analyses of sample 274 (tremolite bearing argillaceous marble)



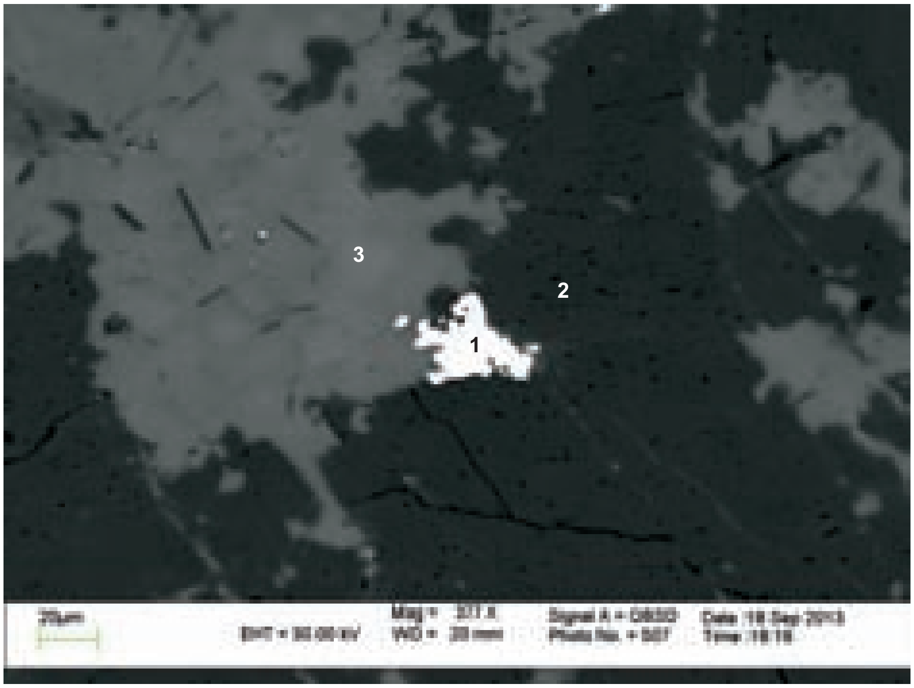
1:Chalcopyrite
2:Pyrite
3:Calcite
4:Mg-rich chlorite
5:Mix (Ap + Chl)

Figure 1-1.1a: Sample 274 site 1; composite vein of pyrite and chalcopyrite.



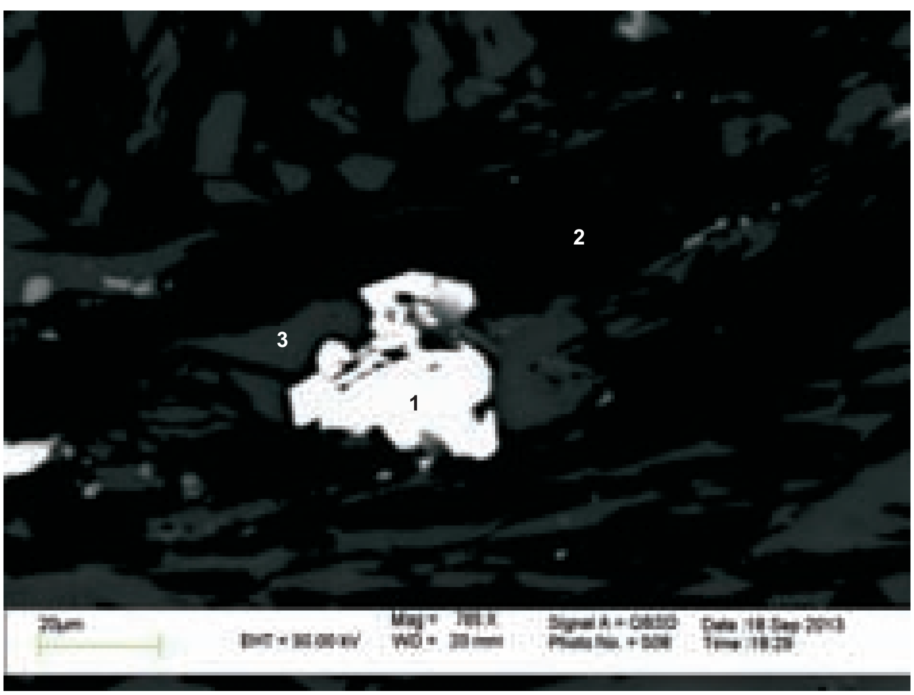
1:Chalcopyrite
2:Pyrite

Figure 1-1.1b: Sample 274 site 1; darker BSE image of figure 1a. Composite vein of pyrite and chalcopyrite.



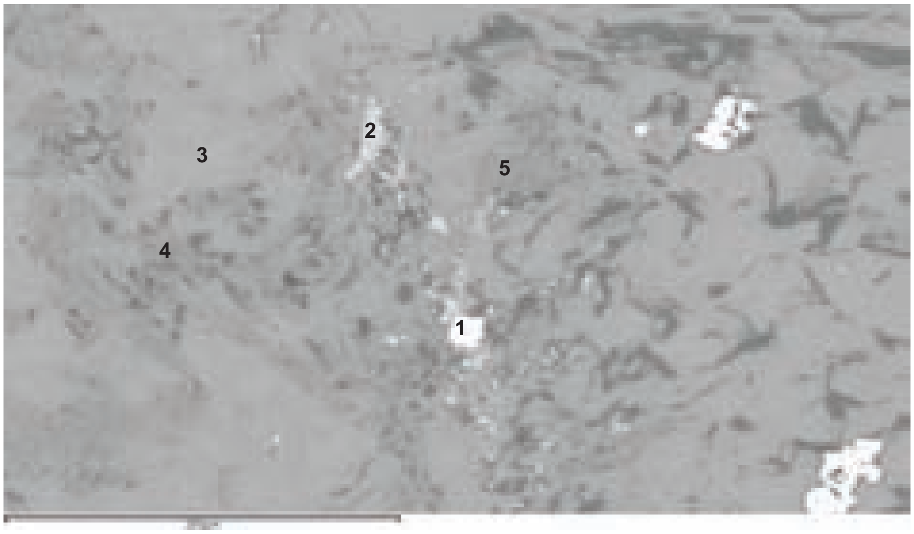
1:Barite
2:Dolomite
3:Calcite

Figure 1-1.2: Sample 274 site 3; barite (analysis 1) postdates calcite and dolomite.



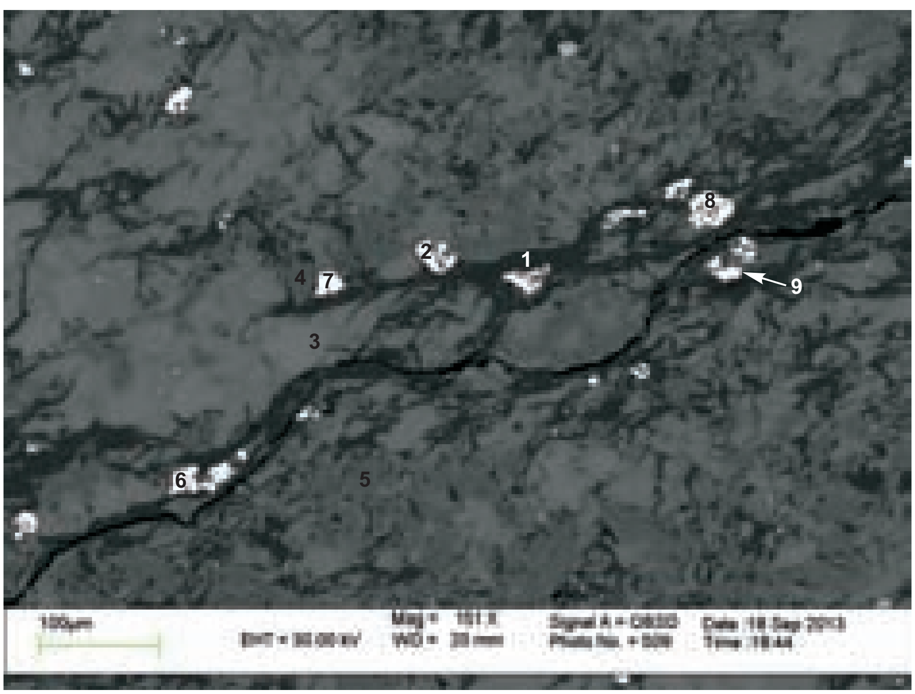
1:Fe-oxide
2:Mg-chlorite
3:Calcite

Figure 1-1.3: Sample 274 site 6; Fe-oxide (analysis 1) postdates calcite and Mg-chlorite.



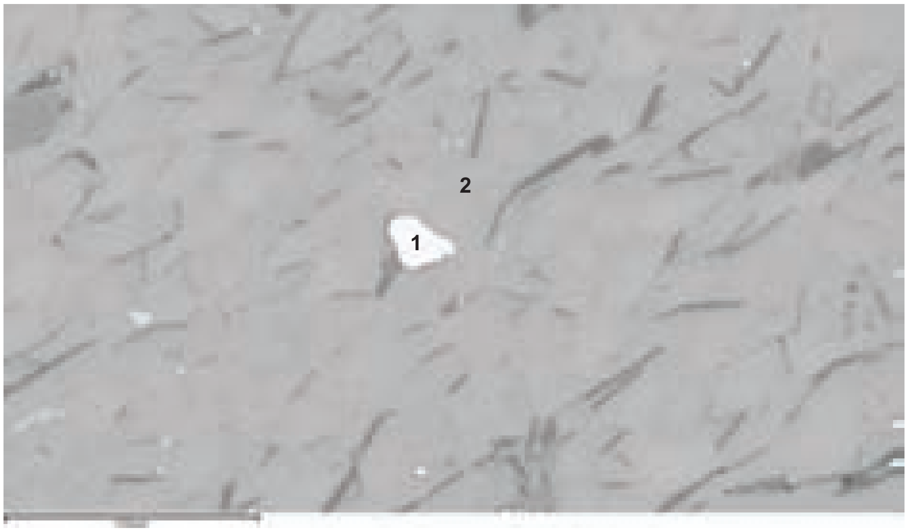
1: Zircon
2: Fluorapatite
3: Calcite
4:Tremolite
5:Tremolite

Figure 1-1.4: Sample 274 site 7; component minerals include: detrital zircon (analysis 1), fluorapatite (analysis 2), calcite (analysis 3), and tremolite (analyses 4&5).



1:Mg-chlorite
2:Fe-oxide
3:Calcite
4:Tremolite
5:Tremolite
6:Fe-oxide
7:Fe-oxide
8:Fe-oxide
9:Fe-oxide

Figure 1-1.5: Sample 274 site 9; fracture filled with Fe-oxide and Mg-chlorite.



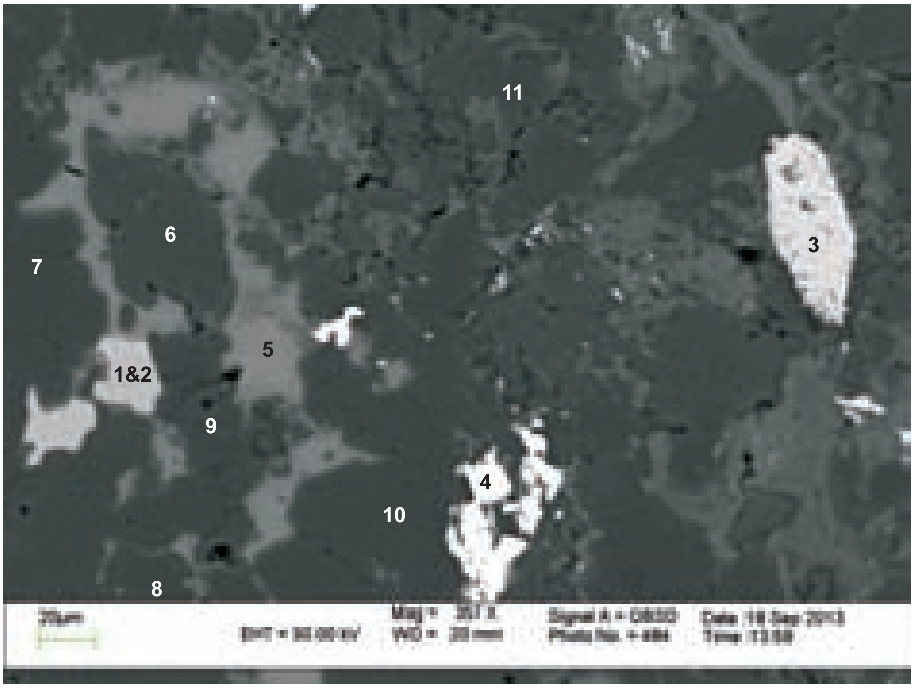
1:Zircon
2:Calcite

Figure 1-1.6: Sample 274 site 4; detrital zircon.

Table 1-1: EDS analyses of sample 274 from North River Marble

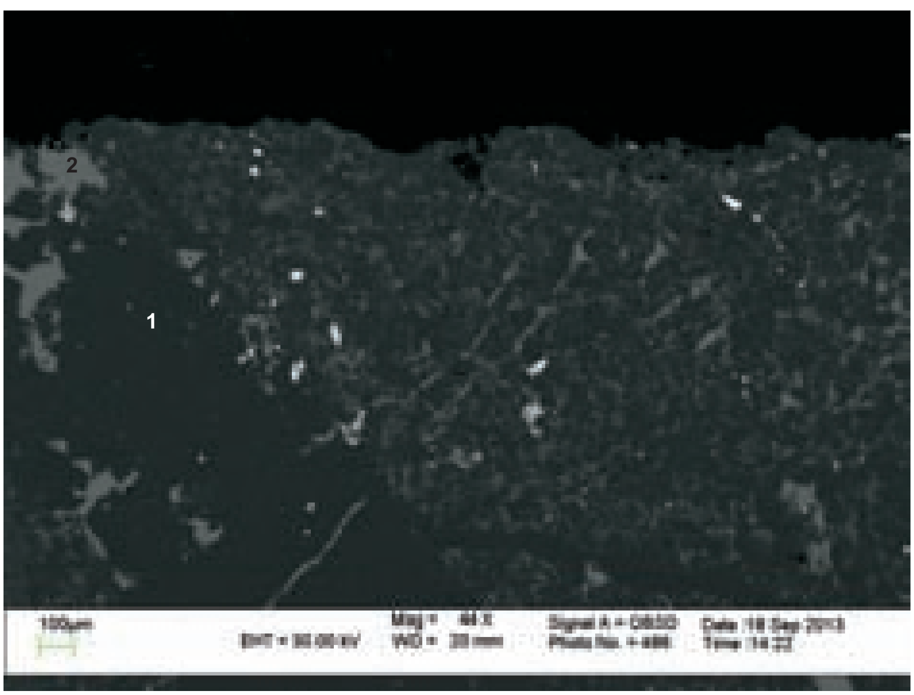
Sample	Site	Pos.	Mineral	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	P_2O_5	SO_3	F	CuO	ZrO_2	BaO	HfO_2	B_2O_3	Total	Actual Total
274	1	1	Chalcopyrite			22.33			0.41		53.91		23.36					100.01	232.94
274	1	2	Pyrite			27.71					72.29							100	275.09
274	1	3	Calcite			0.54	1.02	1.34	97.09									99.99	68.63
274	1	4	Mg-Chlorite	37.65	19.75	7.73	0.27	34.62										100.02	123.96
274	1	5	Mix(Ap+Chl)	23.98	11.41	4.84	0.31	24.96	29.65	4.86								100.01	111.01
274	2	1	Fe-oxide	1.07		97.17			1.78									100.02	107.9
274	2	2	Chalcopyrite			22.01			0.7		53.99		23.3					100	228.65
274	2	3	Mix(Barite+Calcite)						24.77		29.29				45.94			100	123.33
274	2	4	Pyrite			27.75			0.76		71.49							100	275.03
274	3	1	Barite						1.11		37.56				61.34			100.01	134.48
274	3	2	Dolomite			0.64	0.59	42.22	56.56									100.01	70.77
274	3	3	Calcite				1.03	2.19	96.77									99.99	66.76
274	4	1	Zircon	23.96					0.29					48.41		0.87		73.53	155.38
274	4	2	Calcite				0.97	1.92	97.12									100.01	69.23
274	5	1	Barite						0.78		22.37				40.11		36.75	100.01	215.39
274	5	2	Chalcopyrite			22.75					53.79		23.48					100.02	279.33
274	6	1	Fe-oxide			99.2			0.8									100	114.33
274	6	2	Mg-Chlorite	38.59	19.7	7.81	0.36	33.54										100	125.08
274	6	3	Calcite	3.86	1.87	2.39	1.03	5.13	85.73									100	73.11
274	7	1	Zircon	31.75					0.36					66.77		1.12		100	155.33
274	7	2	Fluorapatite			0.23			48.73	44.5		6.55						100.01	153.65
274	7	3	Calcite	1.07		0.46	1.12	1.54	95.79									99.98	69.71
274	7	4	Tremolite	59.56		2.74		23.13	14.58									100.01	142.42
274	7	5	Tremolite	58.7	1.87	4.27	0.53	21.41	13.22									100	147.07
274	8	1	Pyrtite	0.21		27.84					71.97							100.02	219.42
274	9	1	Mg-Chlorite	39.38	17.82	6.95	0.22	35.32	0.31									100	129.62
274	9	2	Fe-oxide(+others)	2.44	1.36	88.19		4.15	3.88									100.02	123.23
274	9	3	Calcite				0.84		99.16									100	66.66
274	9	4	Tremolite	59.58	1.04	3.92	0.27	22.5	12.69									100	144.75
274	9	5	Tremolite	59.23	1.3	3.9	0.21	22.53	12.82									99.99	144.5
274	9	6	Tremolite	2.33	0.94	91.3		1.82	3.58									99.97	113.74
274	9	7	Fe-oxide			98.81			1.19									100	114.56
274	9	8	Fe-oxide			99.01			0.99									100	121.65
274	9	9	Fe-oxide	0.79		94.02		0.9	4.3									100.01	121.3

Appendix 1-2: BSE images and EDS mineral analyses of sample 2349A (subarkosic arenites)



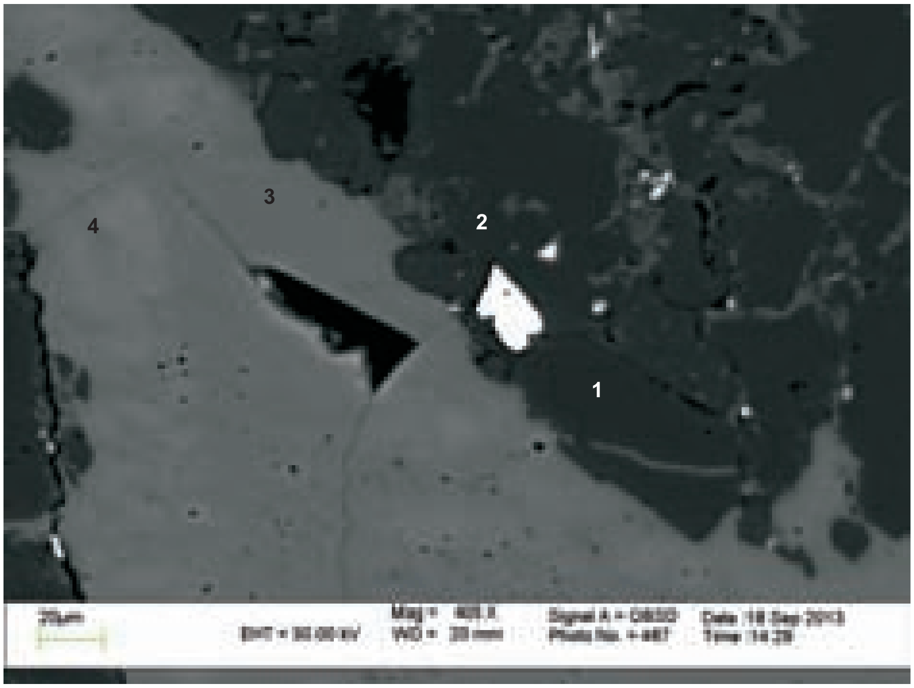
1:Fluorapatite
2:Fluorapatite
3:TiO_2
4:Zircon
5:Calcite
6:Albite
7:Quartz
8:Quartz
9:Quartz
10:Quartz
11:Albite

Figure 1-2.1:Horton Group sample 2349A site 1.



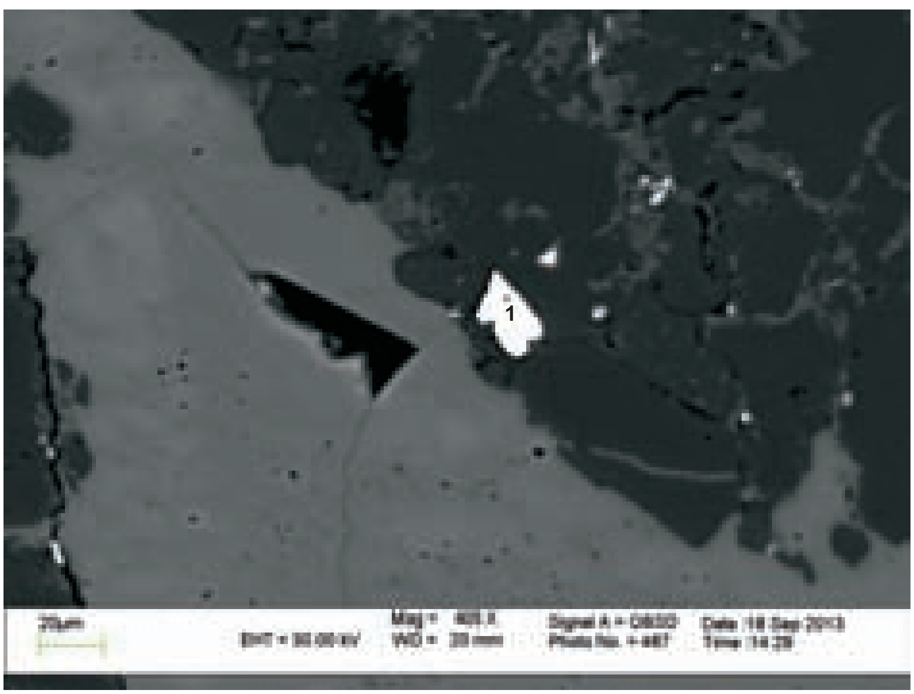
1:Quartz
2:Calcite

Figure 1-2.2:Horton Group sample 2349A site 3.



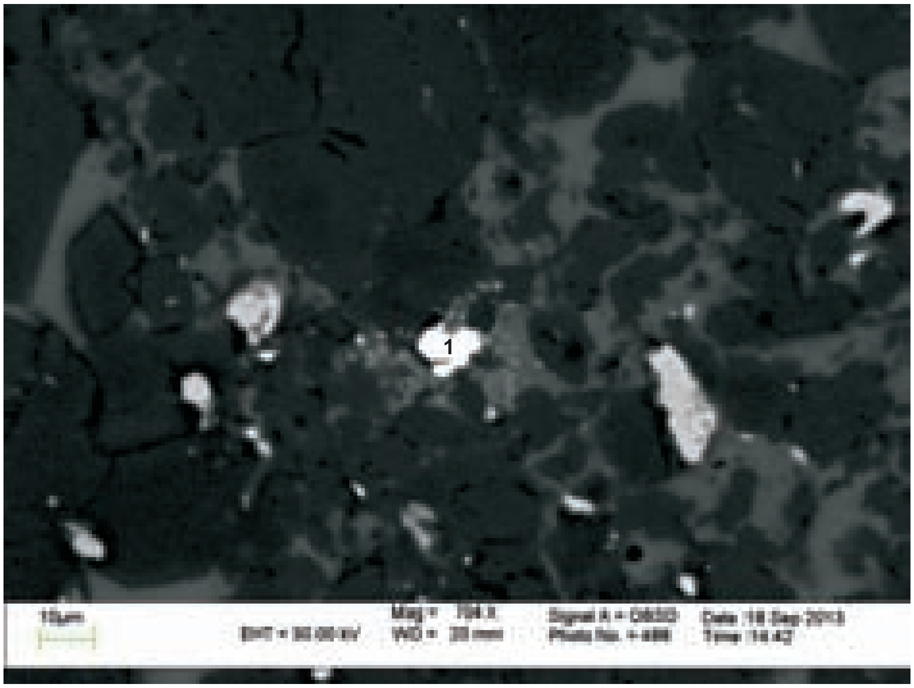
1:Quartz
2:Quartz
3:Calcite
4:Mn-calcite

Figure 1-2.3a: Horton group sample 2349A site 7.



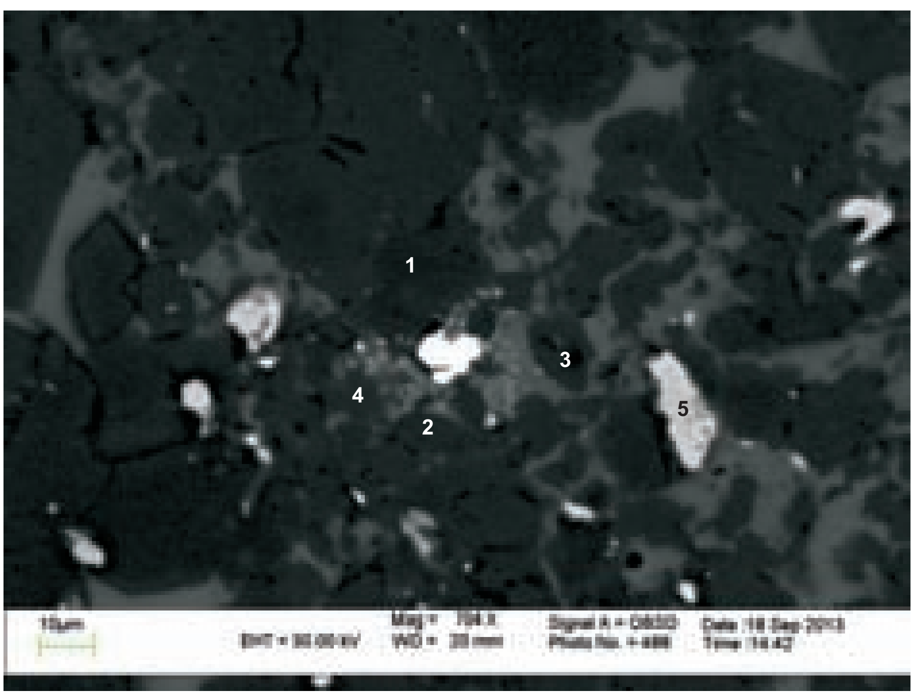
1:Monazite

Figure 1-2.3b: Horton group sample 2349A site 4.



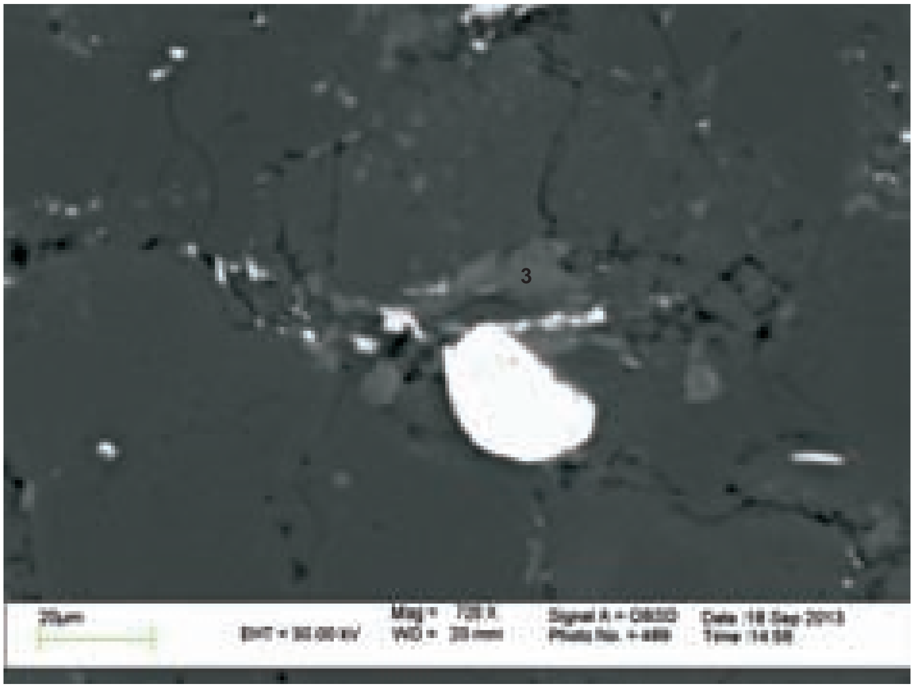
1:Thorite

Figure 1-2.4: Horton group sample 2349A site 9.



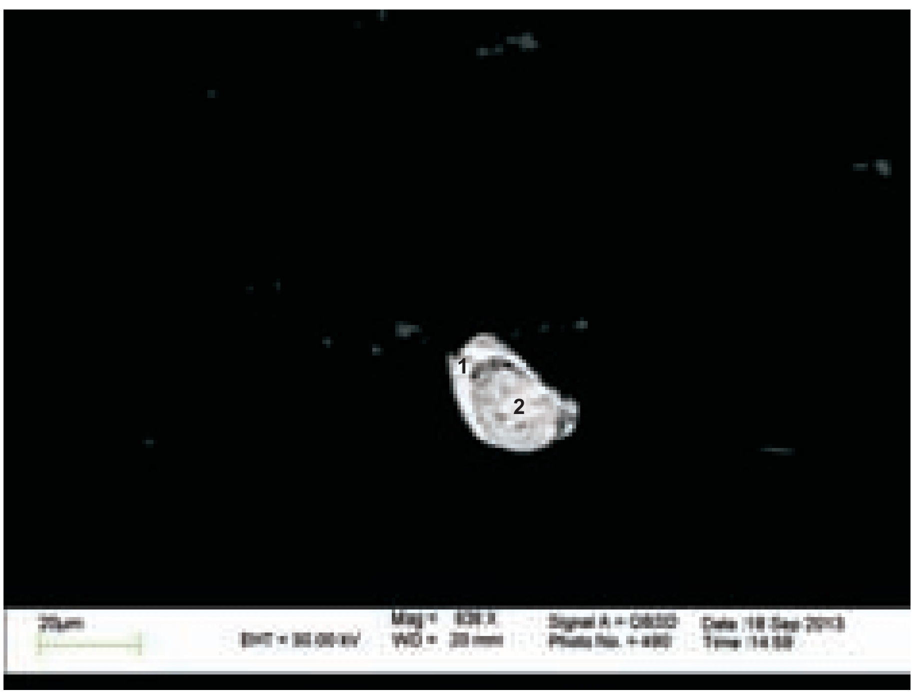
1:Quartz
2:Albite
3:Albite
4:Mix
5:TiO_2

Figure 1-2.4b: Horton Group sample 2349A site 10.



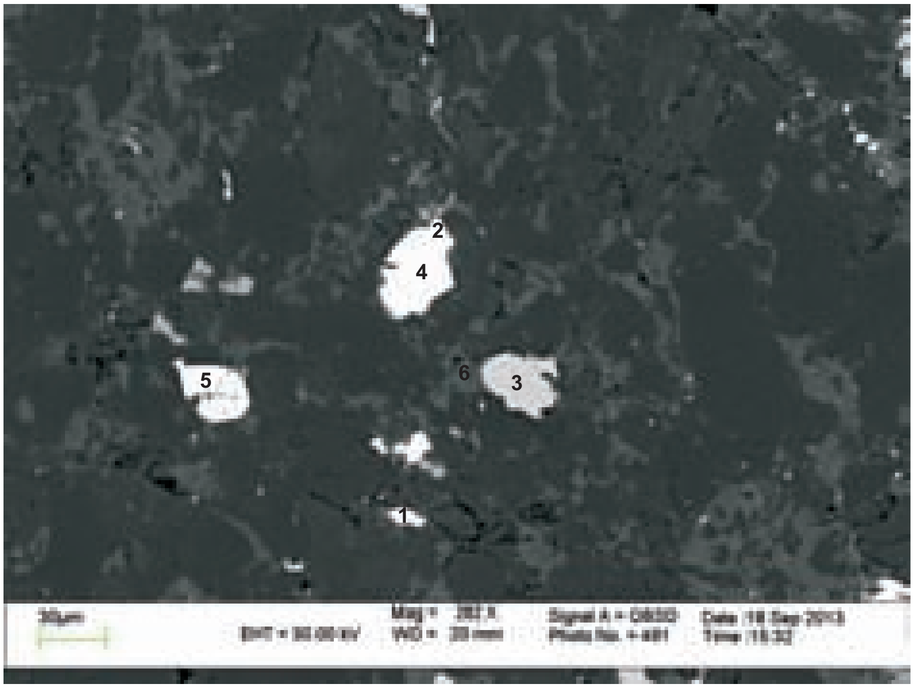
3: Muscovite(+others)

Figure 1-2.5a: Horton group sample 2349A site 14.



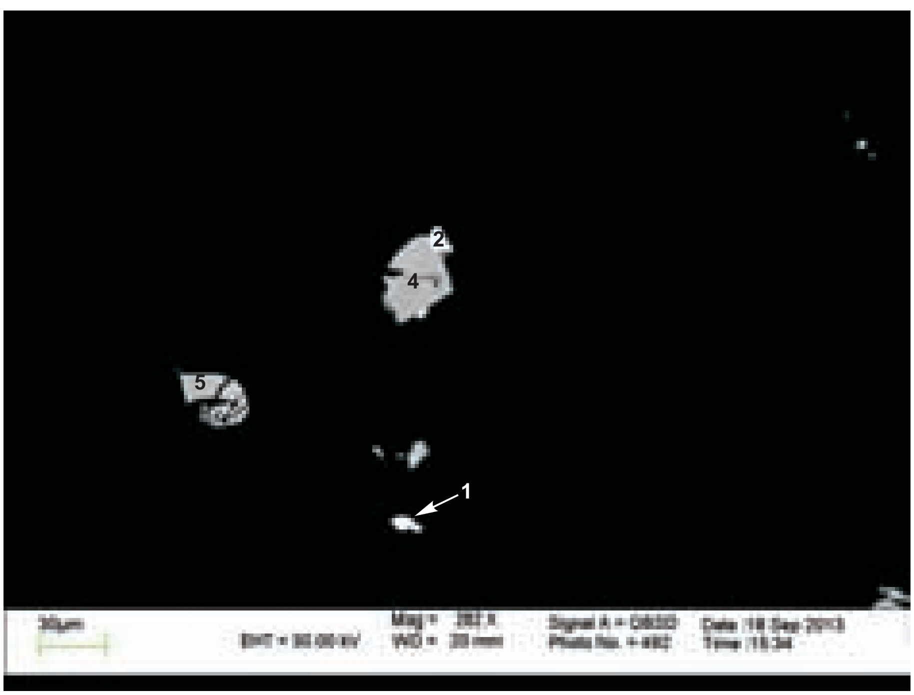
1: Zircon (2% Yttrium)
2: Zircon

Figure 1-2.5b: Horton group sample 2349A site 14; detrital zircon (analysis 2) enriched in Y, with rim of hydrothermal zircon (analysis 1) with a more pure composition.



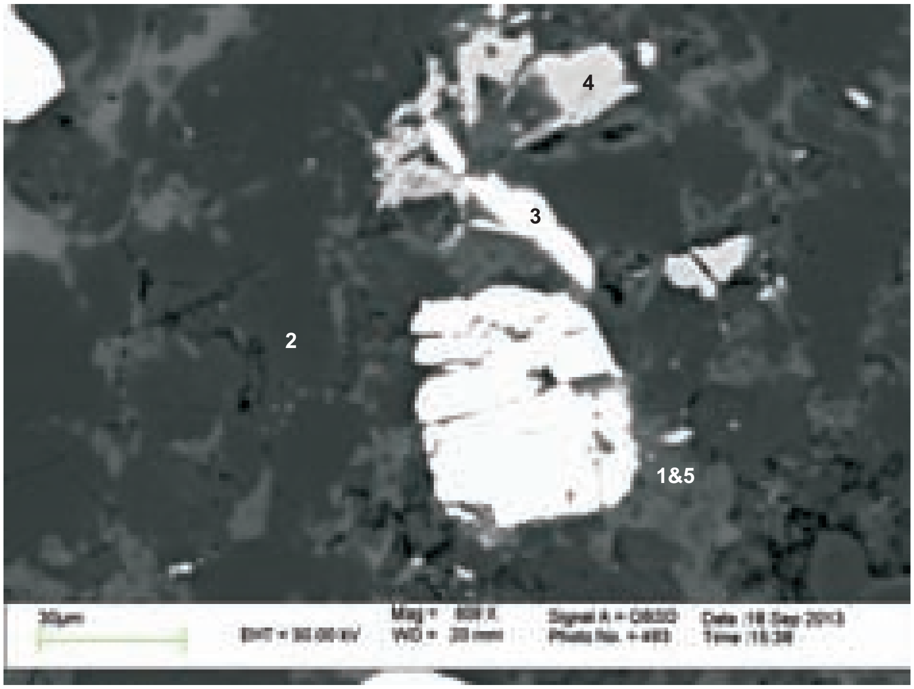
1:Thorite
2:Thorite
3:TiO2
4:Zircon
5:Zircon
6:Muscovite

Figure 1-2.6a: Horton group sample 2349A site 16; zircon (analysis 4) is associated with thorite (analysis 2) close to a hairline fracture. It may be that this thorite is the result of hydrothermal activity associated with fracturing.



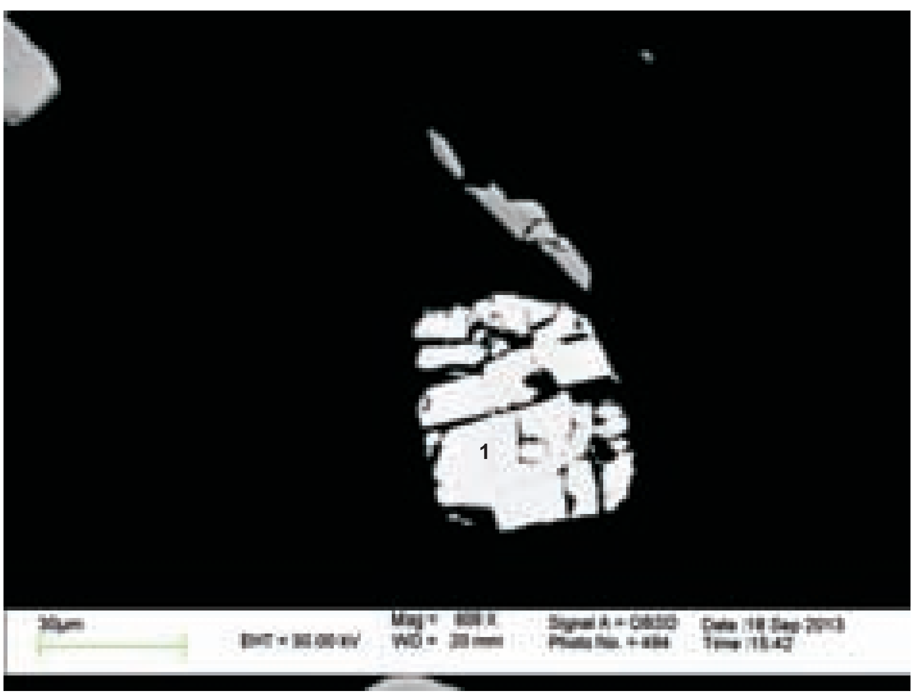
1:Thorite
2:Thorite
3:TiO2
4:Zircon
5:Zircon
6:Muscovite

Figure 1-2.6b: Horton group sample 2349A site 16; darker BSE image of figure 6a.



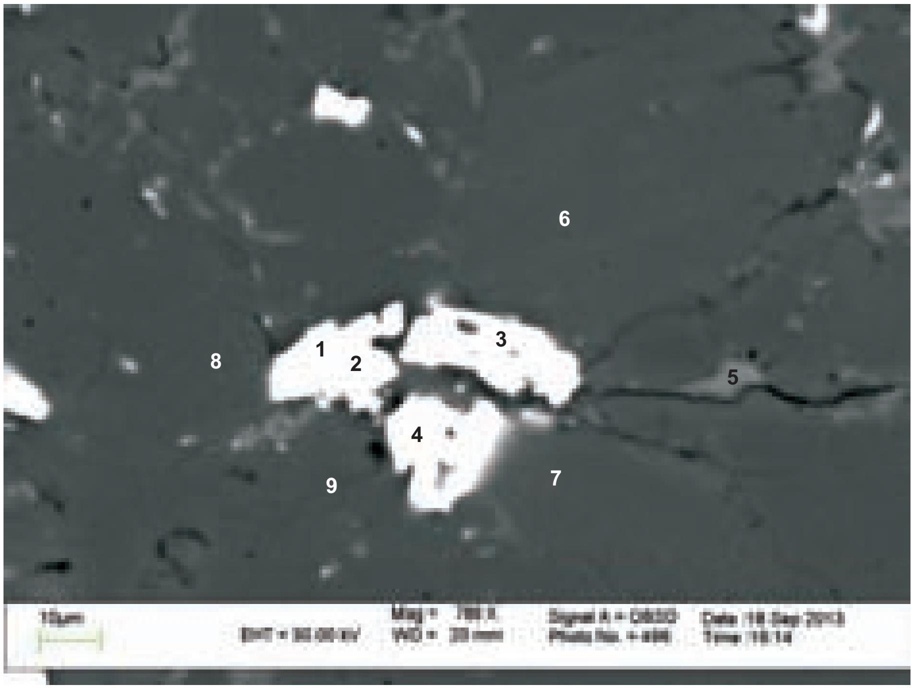
1:Muscovite
2:Quartz
3:Zircon
4:TiO_2
5:Muscovite

Figure 1-2.7a: Horton group sample 2349A site 20.



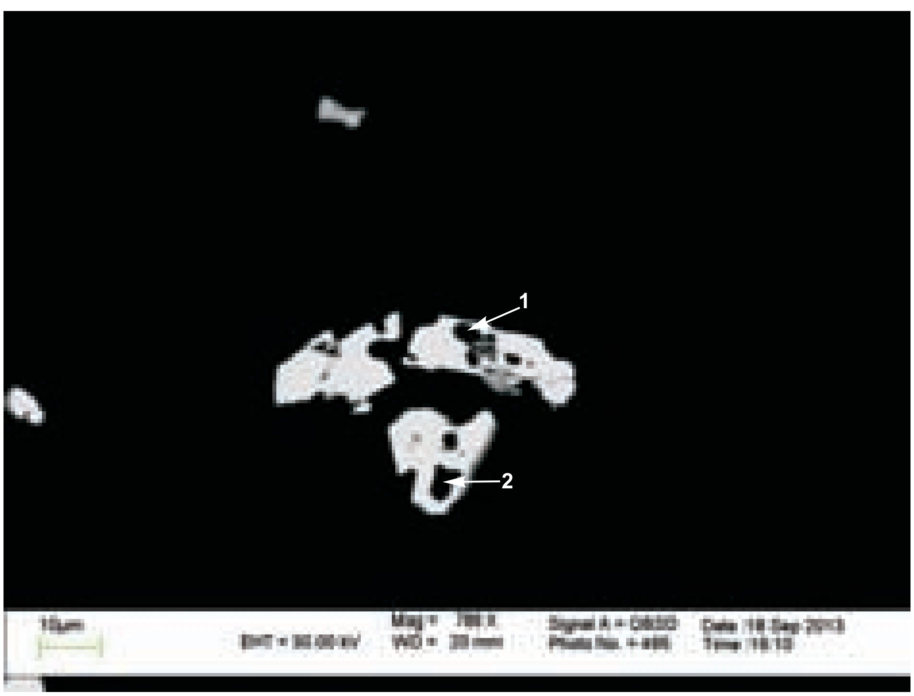
1:Xenotime

Figure 1-2.7b: Horton group sample 2349A site 19; darker BSE image of figure 7a. Xenotime, unclear whether it is of detrital or hydrothermal origin.



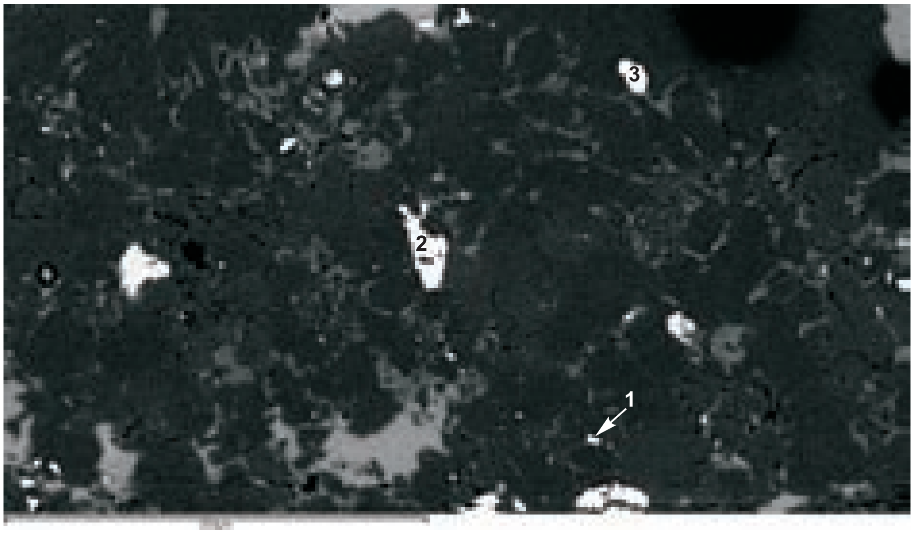
1:Monazite
2:Monazite(+others)
3:Monazite
4:Monazite
5:Mix(calcite+others)
6:Albite
7:Albite
8:Quartz
9:Quartz

Figure 8a: Horton group sample 2349A site 21; clot of monazite (analyses 1-4) that seems to probably fill porosity. Crystals have sharp euhedral outlines suggesting a secondary origin.



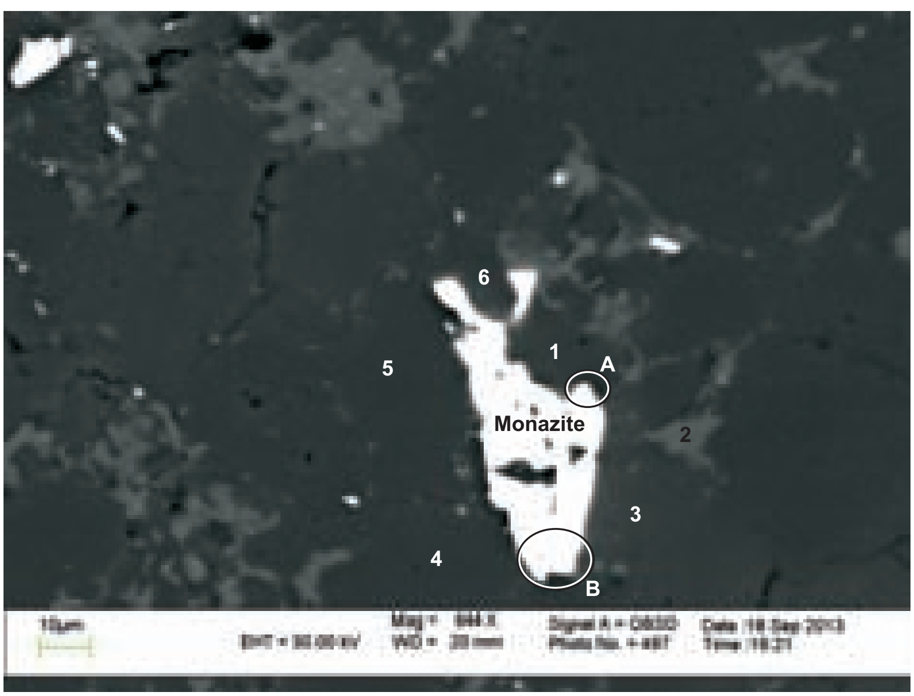
1:Quartz(+others)
2:Quartz(+others)

Figure 8b: Horton group sample 2349A site 22; darker BSE image of figure 8b. The monazite crystals contain quartz inclusions.



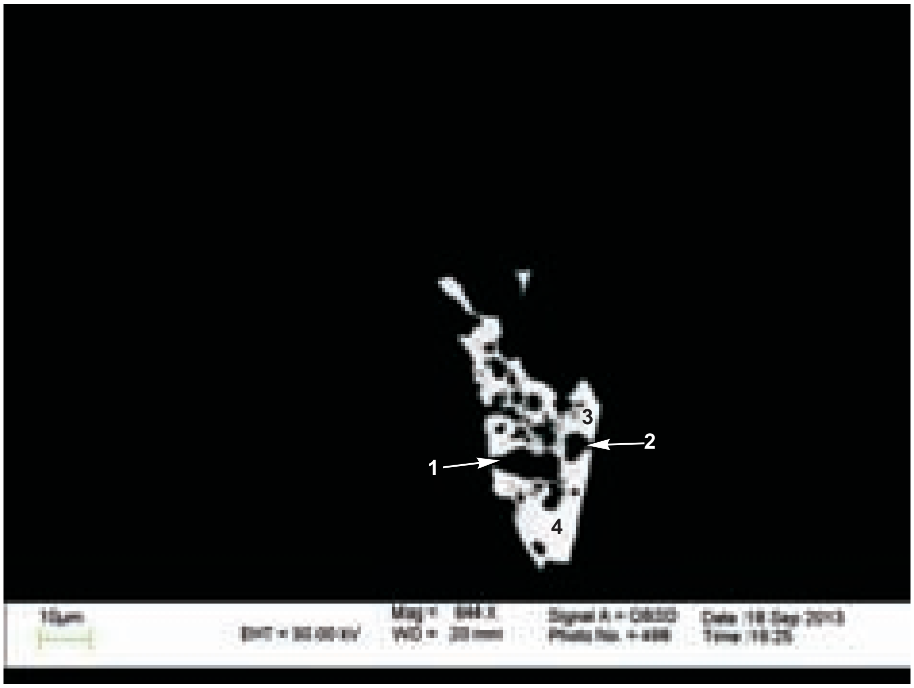
1:Zircon
2:Monazite
3:Zircon

Figure 1-2.9a: Horton Group sample 2349A site 23.



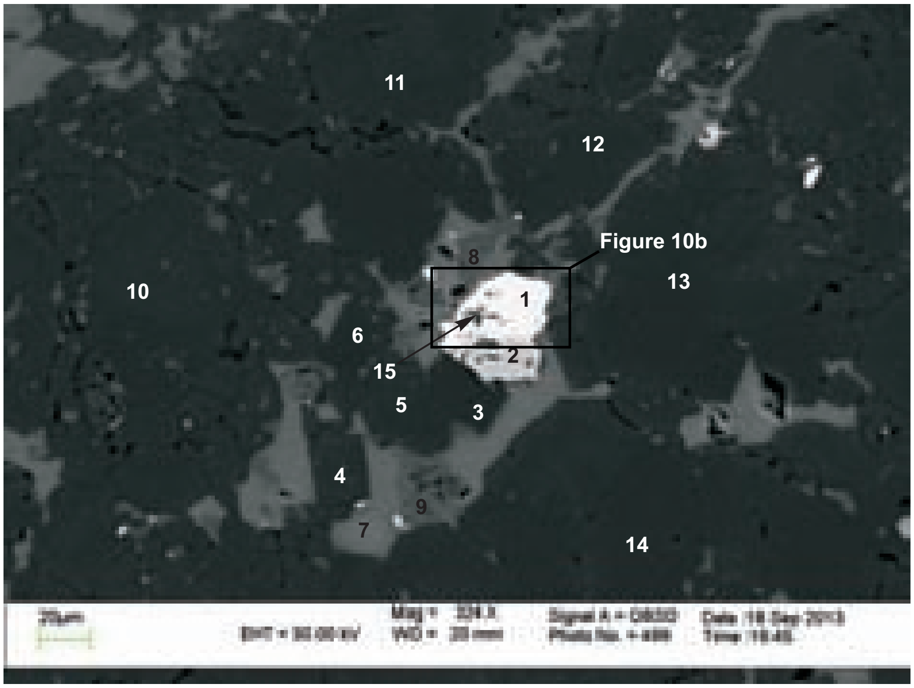
1:Quartz
2:Muscovite
3:Albite
4:Quartz
5:Quartz
6:Quartz

Figure 1-2.9b: Horton group sample 2349A site 25; monazite, probably of hydrothermal origin as suggested by sharp, euhedral crystal outlines that cut detrital quartz (positions A&B).



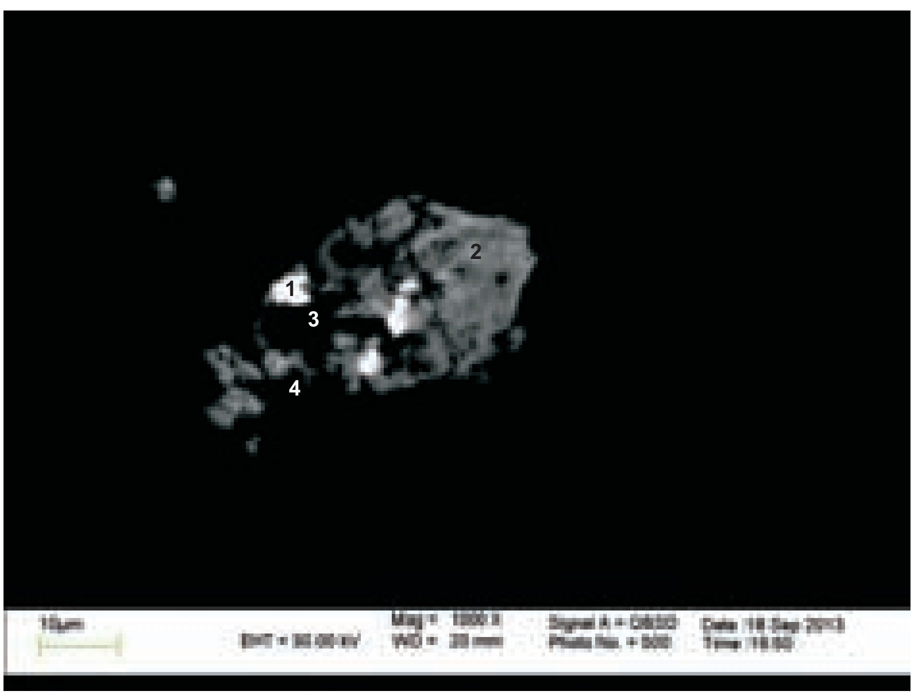
1:Quartz(+Monazite)
2:Quartz(+Monazite)
3:Monazite
4:Monazite

Figure 1-2.9c: Horton group sample 2349A site 24; monazite contains inclusion of quartz (analyses 1&2)



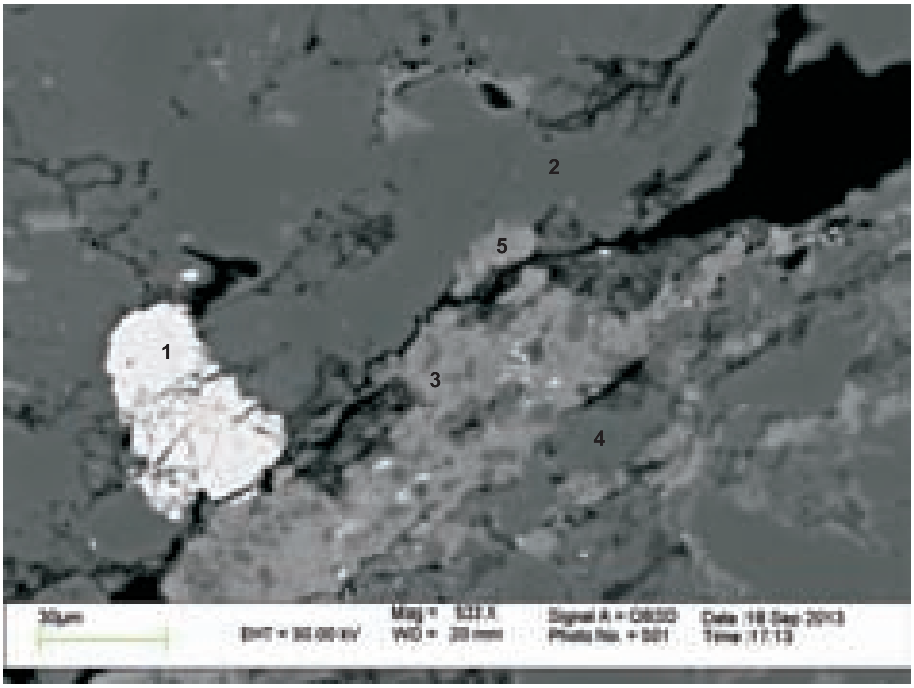
1:Zircon
2:TiO_2
3:Quartz
4:Albite
5:Albite
6:Quartz
7:Mn-calcite
8:Muscovite
9:Muscovite
10:Albite
11:Albite
12:Albite
13:Albite
14:Quartz
15:Mix

Figure 1-2.10a: Horton Group 2349A site 26.



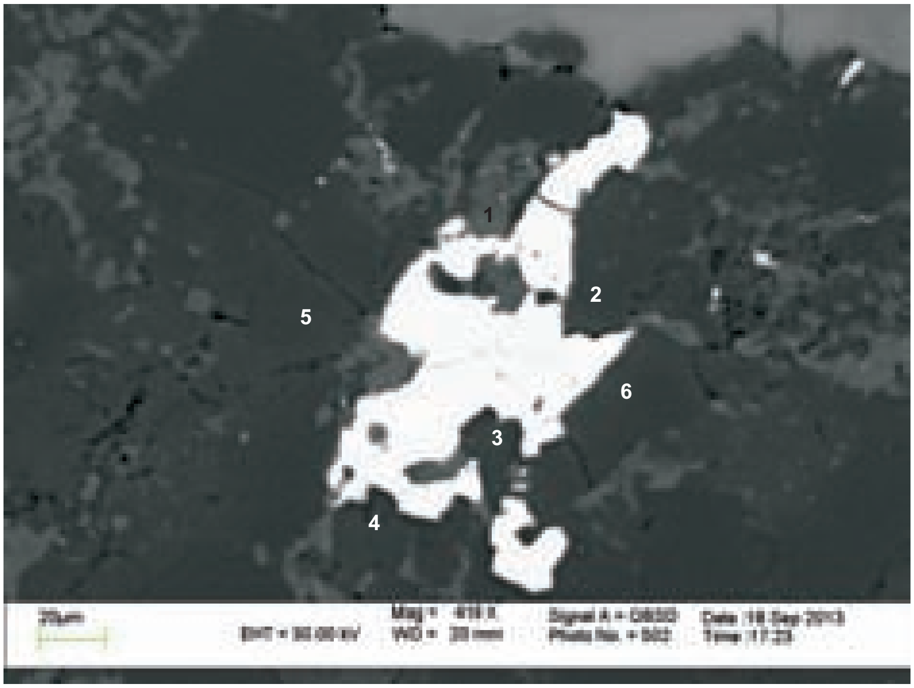
1:Thorite
2:Zircon
3:Mix(Quartz+others)
4:Mix(Zircon+others)

Figure 1-2.10b: Horton Group 2349A site 27.



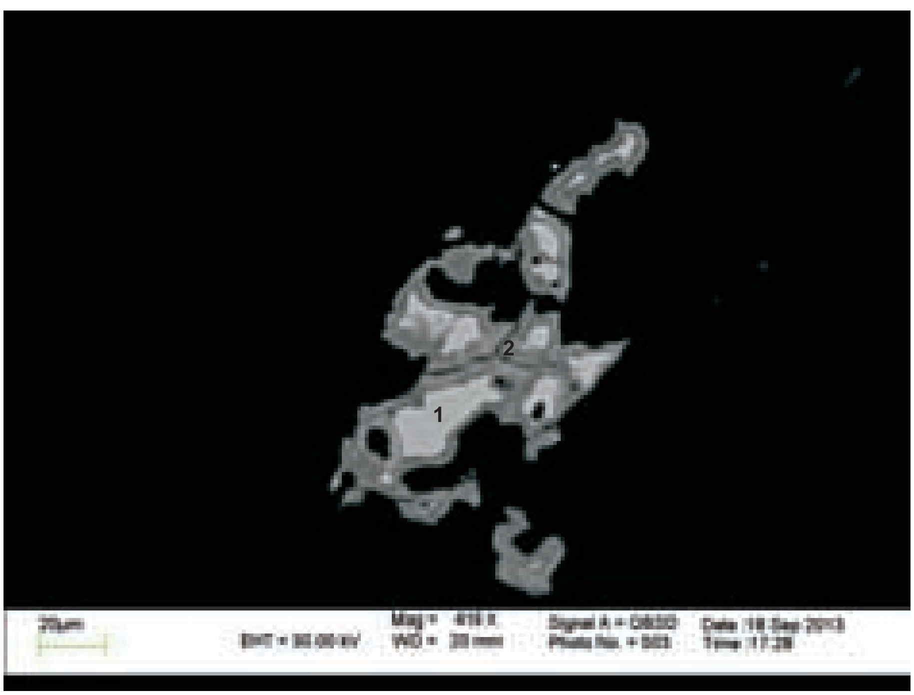
1:TiO_2
2:Quartz
3:Calcite(+others)
4:Albite
5:Calcite(+others)

Figure 1-2.11: Horton group sample 2349A site 30



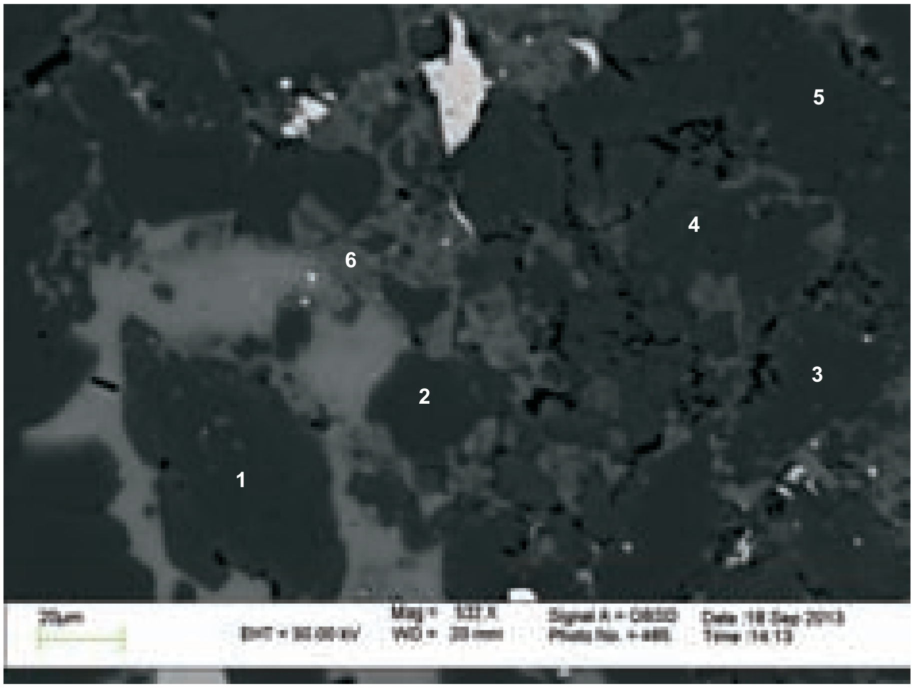
1:Biotite
2:Albite
3:Albite
4:Albite
5:Albite
6:Albite

Figure 1-2.12a: Horton Group sample 2349A site 31.



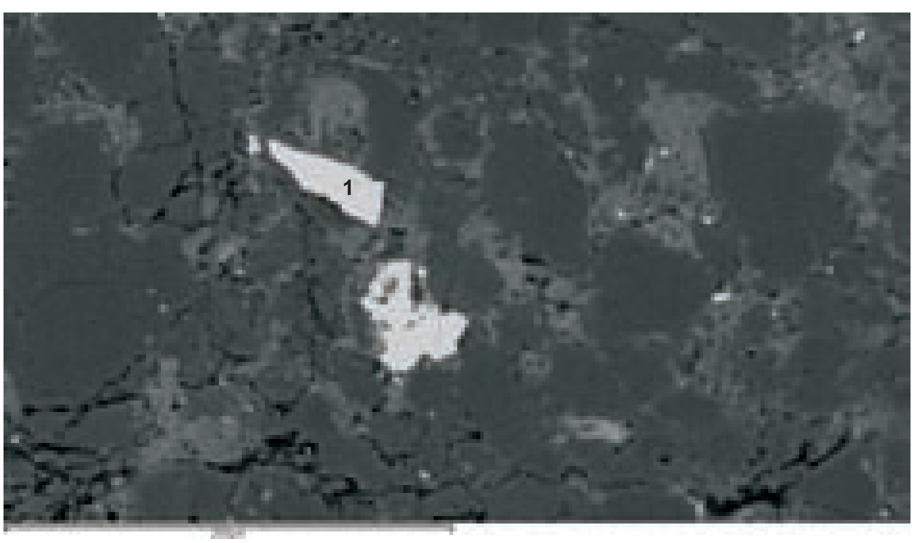
1:Pyrite
2:Fe-oxide

Figure 1-2.12b: Horton Group sample 2349A site 32; partially oxidized pyrite.



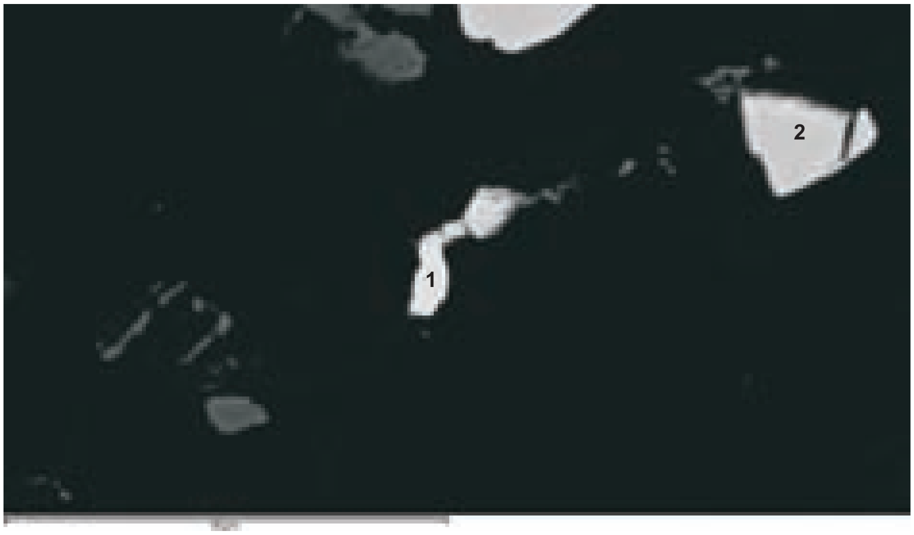
1:Albite
2:Quartz
3:Quartz
4:Albite
5:Quartz
6:Muscovite

Figure 1-2.13: Horton Group sample 2349A site 2.



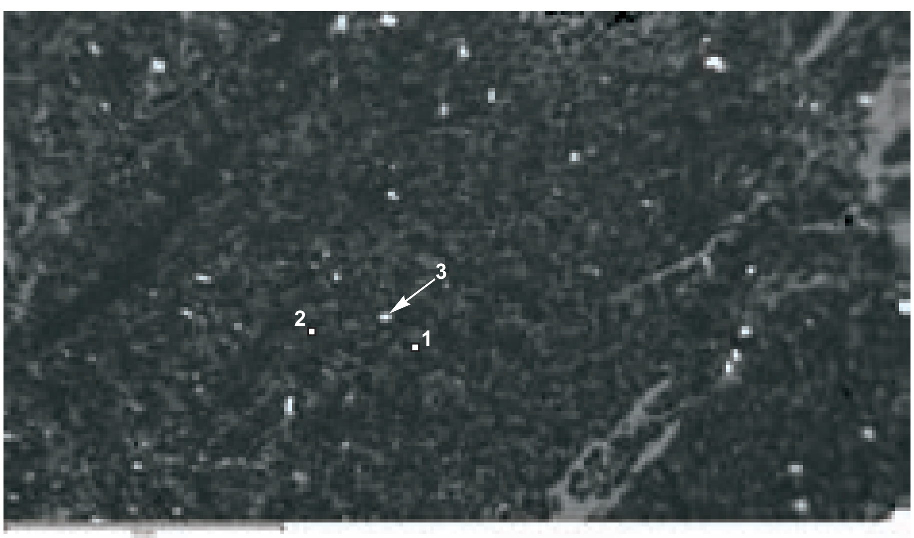
1:Zircon

Figure 1-2.14: Horton Group sample 2349A site 8.



1:Thorite
2:Zircon

Figure 1-2.15: Horton Group sample 2349A site 28.



1:Zircon
2:Quartz
3:Zircon

Figure 1-2.16: Horton Group sample 2349A site 29.

Table 1-2: EDS analyses of sample 2349A from Horton Group

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl
2349A	1	1	Fluorapatite							47.28			44.77		7.94	
2349A	1	2	Fluorapatite							47.99			44.25		7.59	0.18
2349A	1	3	TiO_2	2.57	95.21	1.00	0.53					0.41				0.26
2349A	1	4	Zircon	31.92												
2349A	1	5	Calcite					0.72		55.29						
2349A	1	6	Albite	68.58		19.18				0.39	11.85					
2349A	1	7	Quartz	99.99												
2349A	1	8	Quartz	99.99												
2349A	1	9	Quartz	99.99												
2349A	1	10	Quartz	99.99												
2349A	1	11	Albite	67.51		20.58				0.22	11.06	0.64				
2349A	2	1	Albite	68.88		18.95				0.41	11.77					
2349A	2	2	Quartz	99.99												
2349A	2	3	Quartz	96.80		2.25						0.95				
2349A	2	4	Albite	72.99		16.36				0.28	10.39					
2349A	2	5	Quartz	99.99												
2349A	2	6	Muscovite	52.17	0.45	32.33	1.99		1.79		0.40	10.84				
2349A	3	1	Quartz	99.99												
2349A	3	2	Calcite					0.74		55.27						
2349A	4	1	Monazite	2.99						1.90			36.66	1.55		
2349A	7	1	Quartz	99.99												
2349A	7	2	Quartz	98.85		0.77						0.36				
2349A	7	3	Calcite					0.38		55.62						
2349A	7	4	Mn-calcite					1.12		54.88						
2349A	8	1	Zircon	31.98												
2349A	9	1	Thorite	28.02	0.67	5.86	6.96			2.97	0.86	2.08	3.60			
2349A	10	1	Quartz	99.73												0.27
2349A	10	2	Albite	67.28		17.61	0.37			3.90	10.69	0.14				
2349A	10	3	Albite	68.67		18.22	0.55			2.00	10.12	0.45				
2349A	10	4	Mix	51.75		14.80	1.05	0.25		20.13	11.78	0.23				
2349A	10	5	TiO_2	5.05	90.41	2.19	0.58			0.88		0.69				0.19
2349A	11	1	Pyrite				28.10			0.24				71.67		
2349A	11	2	Albite	65.89		18.76	0.26			3.20	11.66	0.22				
2349A	11	3	Quartz	99.99												
2349A	11	4	Calcite				0.84	4.43		94.31						0.42
2349A	11	4	Calcite				0.47	2.48		52.81						0.24
2349A	14	1	Zircon	33.33	0.35	0.70				0.18						
2349A	14	2	Zircon	30.50		0.83	0.60			0.81						0.30
2349A	14	3	Muscovite(+others)	63.92	0.33	24.81	1.53		1.39		0.69	7.31				
2349A	16	1	Thorite	21.82			1.04			2.34			1.72		3.91	
2349A	16	2	Thorite	21.01		1.87	1.09			2.24	0.59		3.12		1.56	
2349A	16	3	TiO_2	0.96	98.35		0.49									0.20
2349A	16	4	Zircon	32.28			0.33									
2349A	16	5	Zircon	31.57												
2349A	16	6	Muscovite	52.45	0.53	33.09	1.45		1.74			10.72				
2349A	19	1	Xenotime										17.67			
2349A	20	1	Musovite	55.02	0.60	33.31	1.22					9.83				
2349A	20	2	Quartz	99.99												
2349A	20	3	Zircon	32.09		1.63				0.50		0.31				
2349A	20	4	TiO_2		98.82		0.40			0.24						

Sample	Site	Pos.	Mineral	Sc_2O_3	Cr_2O_3	CoO	NiO	Y_2O_3	ZrO_2	Ag_2O	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total	Actual Total
2349A	1	1	Fluorapatite																				99.99	158.36
2349A	1	2	Fluorapatite																				100.01	148.64
2349A	1	3	TiO_2																				99.98	130.39
2349A	1	4	Zircon						66.96									1.13					100.01	150.58
2349A	1	5	Calcite																				56.00	65.50
2349A	1	6	Albite																				100.00	141.70
2349A	1	7	Quartz																				99.99	142.71
2349A	1	8	Quartz																				99.99	144.01
2349A	1	9	Quartz																				99.99	143.71
2349A	1	10	Quartz																				99.99	146.45
2349A	1	11	Albite																				100.01	148.86
2349A	2	1	Albite																				100.01	144.72
2349A	2	2	Quartz																				99.99	147.78
2349A	2	3	Quartz																				100.00	148.56
2349A	2	4	Albite																				100.02	147.84
2349A	2	5	Quartz																				99.99	148.97
2349A	2	6	Muscovite																				99.97	136.27
2349A	3	1	Quartz																				99.99	125.66
2349A	3	2	Calcite																				56.00	52.11
2349A	4	1	Monazite							1.55	13.32	30.99	11.02										99.98	117.18
2349A	7	1	Quartz																				99.99	150.32
2349A	7	2	Quartz																				99.98	148.07
2349A	7	3	Calcite																				56.00	67.28
2349A	7	4	Mn-calcite																				56.00	66.20
2349A	8	1	Zircon						68.03														100.01	156.10
2349A	9	1	Thorite					2.15												46.82			99.99	107.94
2349A	10	1	Quartz																				100.00	144.27
2349A	10	2	Albite																				99.99	147.72
2349A	10	3	Albite																				100.01	131.92
2349A	10	4	Mix																				99.99	145.71
2349A	10	5	TiO_2																				99.99	129.62
2349A	11	1	Pyrite																				100.01	269.84
2349A	11	2	Albite																				99.99	145.56
2349A	11	3	Quartz																				99.99	145.66
2349A	11	4	Calcite																				100.00	69.81
2349A	11	4	Calcite																				56.00	69.81
2349A	14	1	Zircon						64.05									1.40					100.01	151.01
2349A	14	2	Zircon	0.51				2.01	63.34									1.12					100.02	132.85
2349A	14	3	Muscovite(+others)																				99.98	141.04
2349A	16	1	Thorite					1.66												62.59	4.93		100.01	126.43
2349A	16	2	Thorite					2.49												61.92	4.10		99.99	118.04
2349A	16	3	TiO_2																				100.00	125.22
2349A	16	4	Zircon						66.26									1.13					100.00	129.53
2349A	16	5	Zircon						67.50									0.92					99.99	144.50
2349A	16	6	Muscovite																				99.98	135.58
2349A	19	1	Xenotime					18.10						1.08	2.15	1.93	2.04					57.08	100.05	261.80
2349A	20	1	Musovite																				99.98	134.41
2349A	20	2	Quartz																				99.99	142.24
2349A	20	3	Zircon						63.96									1.51					100.00	151.61
2349A	20	4	TiO_2		0.54																		100.00	124.19

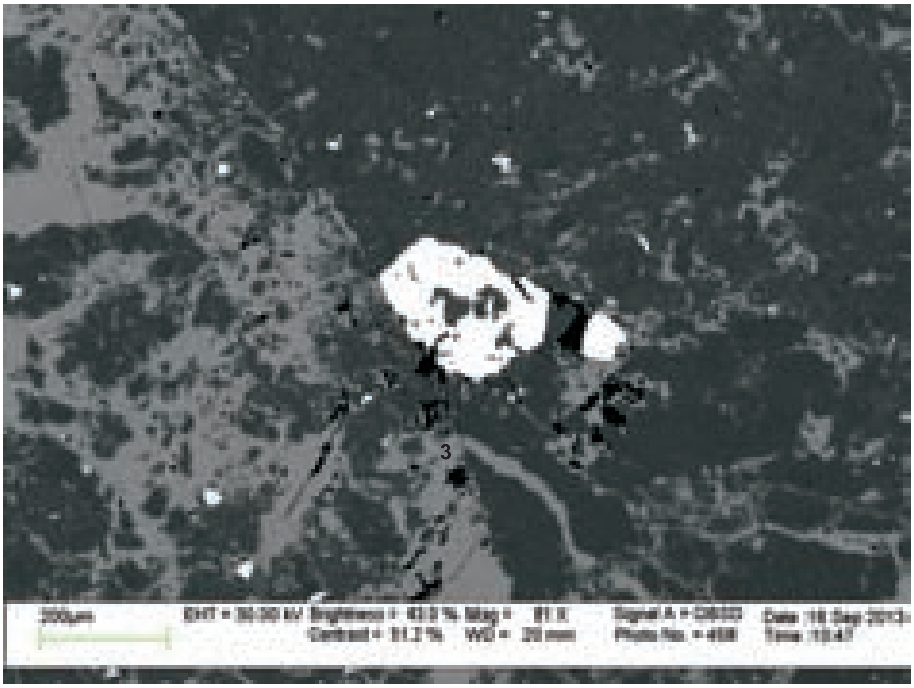
Table 1-2: EDS analyses of sample 2349A from Horton Group

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	Cr_2O_3	CoO	NiO	Y_2O_3	ZrO_2	Ag_2O	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total	Actual Total
2349A	20	5	Musovite	56.97	0.55	29.87	1.58		1.33		0.63	9.06																								99.99	135.77
2349A	21	1	Monazite	2.37		1.30	3.71			11.36			30.57	1.30									1.37	12.39	26.02	9.61										100.00	108.40
2349A	21	2	Monazite(+others)	1.39			0.46			1.74			37.24	0.92									1.54	14.98	30.43	11.28										99.98	120.13
2349A	21	3	Monazite	21.18		6.27	4.94			0.87	5.10		20.16										0.79	10.57	22.01	8.09										99.98	133.82
2349A	21	4	Monazite	3.94		1.13				0.81			36.64											14.29	29.00	10.78							3.39			99.98	127.64
2349A	21	5	Mix(calcite+others)	34.89		3.38	0.37	0.94		58.68	1.73																									99.99	90.36
2349A	21	6	Albite	68.63		19.08				0.42	11.88																									100.01	144.67
2349A	21	7	Albite	68.90		19.08					12.00																									99.98	143.10
2349A	21	8	Quartz	98.60		1.00					0.39																									99.99	142.83
2349A	21	9	Quartz	99.99																																99.99	142.64
2349A	22	1	Mix(Quartz +Monazite)	66.12			0.37			0.24			6.99											6.76	14.01	5.54										100.03	152.72
2349A	22	2	Mix(Quartz +Monazite)	69.87		0.87	1.76			0.36			6.26											5.14	11.47	4.27										100.00	139.46
2349A	23	1	Zircon	55.19		0.70	0.31															43.04									0.77					100.01	144.11
2349A	23	2	Monazite	8.34		0.85	14.37			0.97			27.86	1.05										10.32	21.32	8.56							6.34			99.98	123.49
2349A	23	3	Zircon	27.27		0.36																54.41									1.08					83.12	151.96
2349A	24	1	Quartz (+ monazite)	88.78									2.64											2.31	4.66	1.60										99.99	135.38
2349A	24	2	Quartz (+ monazite)	78.42			0.26			0.27			5.75											3.84	8.54	2.93										100.01	131.46
2349A	24	3	Monazite	5.90						1.22			35.77	1.05									1.25	14.50	29.55	10.77										100.01	128.15
2349A	24	4	Monazite	2.10						0.64			35.45											14.91	30.31	11.41							5.18			100.00	126.36
2349A	25	1	Quartz	99.99																																99.99	144.14
2349A	25	2	Muscovite	58.01	0.37	28.70	1.38		1.64		0.40	9.49																								99.99	138.33
2349A	25	3	Albite(+Quartz)	71.43		17.29				0.55	10.73																									100.00	152.41
2349A	25	4	Quartz	99.99																																99.99	142.92
2349A	25	5	Quartz	99.99																																99.99	143.65
2349A	25	6	Quartz	96.78																				0.84	1.73	0.64										99.99	150.08
2349A	26	1	Zircon	30.12		0.87	5.44			0.87											2.86	58.35									1.49					100.00	132.87
2349A	26	2	TiO_2	0.94	97.75		0.41			0.91																										100.01	125.12
2349A	26	3	Quartz	99.99																																99.99	145.66
2349A	26	4	Albite	68.60		19.18				1.11	11.11																									100.00	143.28
2349A	26	5	Albite	70.40		18.05				0.48	11.07																									100.00	144.78
2349A	26	6	Quartz	99.99																																99.99	143.75
2349A	26	7	Mn-calcite					0.67		54.35				0.98																						56.00	66.16
2349A	26	8	Muscovite	52.13	0.57	30.10	3.54		2.49			11.18																								100.01	133.01
2349A	26	9	Muscovite	51.38	0.57	30.23	3.00		2.57	1.72		10.54																								100.01	134.44
2349A	26	10	Albite	67.73		19.58	0.24			0.70	11.76																									100.01	142.37
2349A	26	11	Albite	74.40		14.93				0.42	10.02	0.24																								100.01	147.77
2349A	26	12	Albite	68.18		19.35				0.52	11.96																									100.01	146.14
2349A	26	13	Albite	79.32		12.34				0.39	7.94																									99.99	161.29
2349A	26	14	Quartz	99.99																																99.99	148.01
2349A	26	15	Mix	35.36	30.09	17.91	2.02		2.80	0.50		5.47										5.82														99.97	149.35
2349A	27	1	Thorite	27.40	0.38	0.96	3.92			8.83	0.54										2.95	23.84											31.20			100.02	126.69
2349A	27	2	Zircon	30.44		0.83	1.48			0.88											2.24	62.57									1.56					100.00	134.99
2349A	27	3	Mix(quartz+others)	66.59	0.25	9.43	1.98		0.66	0.59		2.65										17.33	0.52													100.00	129.62
2349A	27	4	Mix(zircon+others)	39.45	15.80	2.14	1.05			2.25		0.54									3.24	34.77	0.75													99.99	129.22
2349A	28	1	Thorite	25.58		1.95	1.27			2.55		1.25	2.91								2.95												61.54			100.00	116.90
2349A	28	2	Zircon	32.02																		66.88									1.10					100.00	153.46
2349A	29	1	Zircon	31.60			0.96															66.41									1.04					100.01	140.86
2349A	29	2	Quartz	90.55		1.38				0.67		0.49										6.89														99.98	136.49
2349A	29	3	Zircon	43.19																		54.82									1.99					100.00	173.09

Table 1-2: EDS analyses of sample 2349A from Horton Group

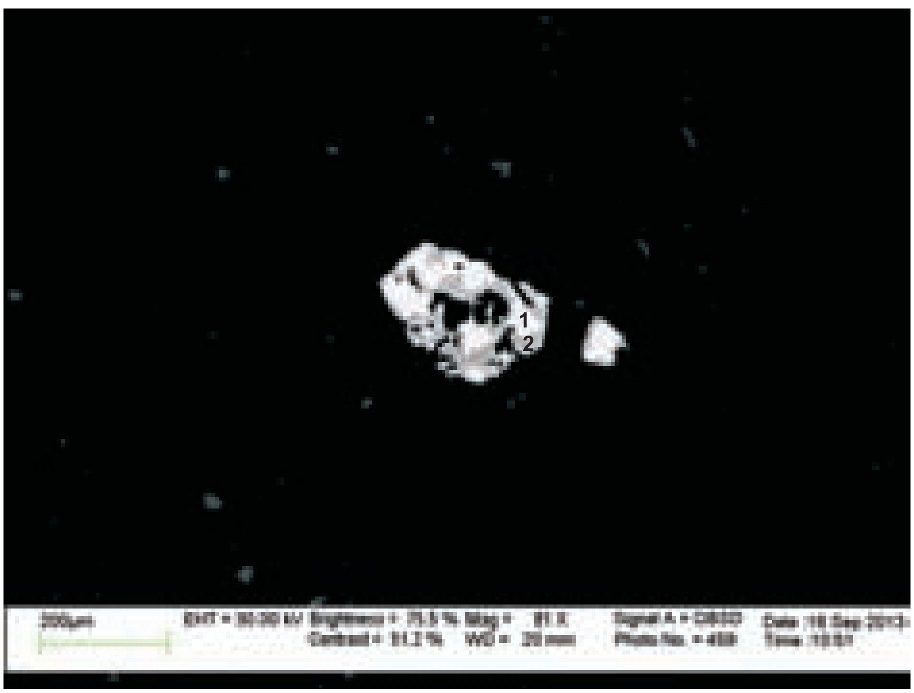
Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	Cr_2O_3	CoO	NiO	Y_2O_3	ZrO_2	Ag_2O	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total	Actual Total
2349A	30	1	TiO_2	0.47	98.85		0.41									0.26																				99.99	118.31
2349A	30	2	Quartz	99.99																																99.99	138.43
2349A	30	3	Calcite(+others)	14.33		5.37	0.96	0.53	0.73	75.19	2.62	0.25																								99.98	76.40
2349A	30	4	Albite	69.35		18.82					11.84																									100.01	140.75
2349A	30	5	Calcite(+others)	21.22		4.99		0.75		69.39	3.64																									99.99	80.46
2349A	31	1	Biotite	55.11		29.50	3.50		2.17			9.72																								100.00	127.41
2349A	31	2	Albite	68.09	0.45	18.80	0.28			0.25	12.12																									99.99	143.41
2349A	31	3	Albite	67.41		19.67	0.37			1.12	11.45																									100.02	139.42
2349A	31	4	Albite	68.01		19.48	0.28			0.73	11.37	0.14																								100.01	138.11
2349A	31	5	Albite	67.56		19.56	0.54			0.81	11.55																									100.02	137.88
2349A	31	6	Albite	67.98		19.42	0.27			0.55	11.78																									100.00	142.40
2349A	32	1	Pyrite				27.60							72.12						0.29																100.01	258.29
2349A	32	2	Fe-oxide	5.37			90.59			1.13				2.02						0.88																99.99	93.03

Appendix 1-3: BSE images and EDS mineral analyses of sample 2349B (subarkosic arenite)



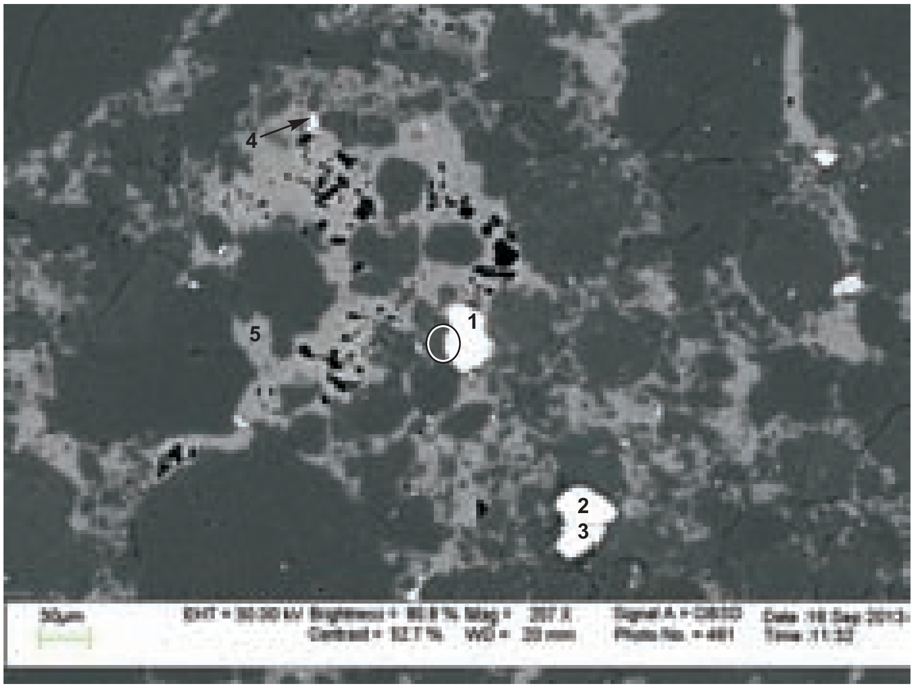
3: Calcite

Figure 1-3.1a: Horton group sample 2349B site 7; pyrite partially oxidized in dissolution void.



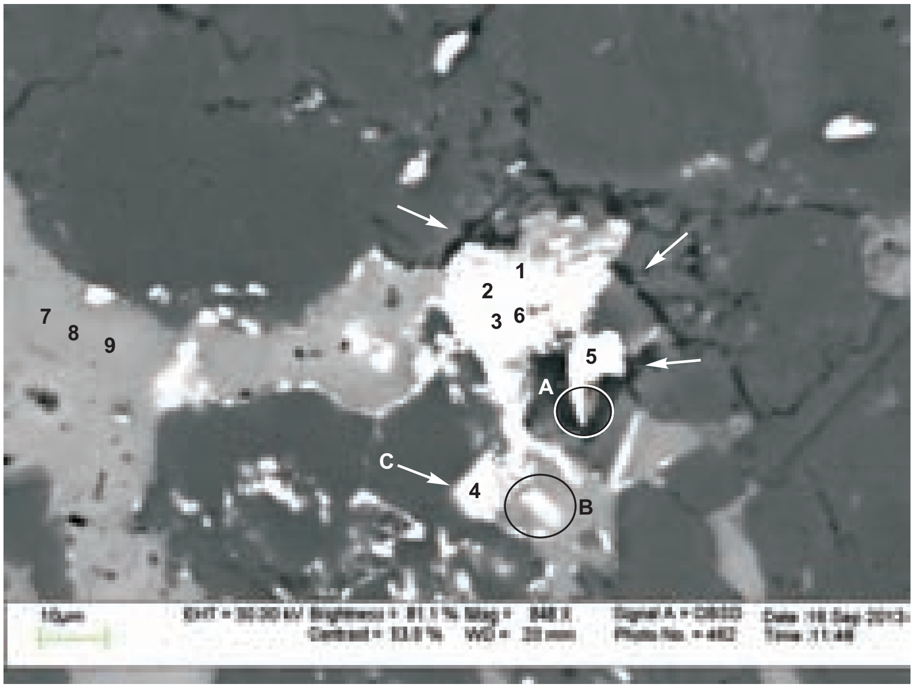
1:Pyrite
2:Fe-oxide

Figure 1-3.1b: Horton group sample 2349B site 7; pyrite partially oxidized in dissolution void.



1:Xenotime
2:Zircon
3:Zircon
4:TiO_2
5:Calcite

Figure 1-3.2: Horton group sample 2349B site 10; xenotime, possibly of hydrothermal origin as grain appears to cut detrital quartz (circle).

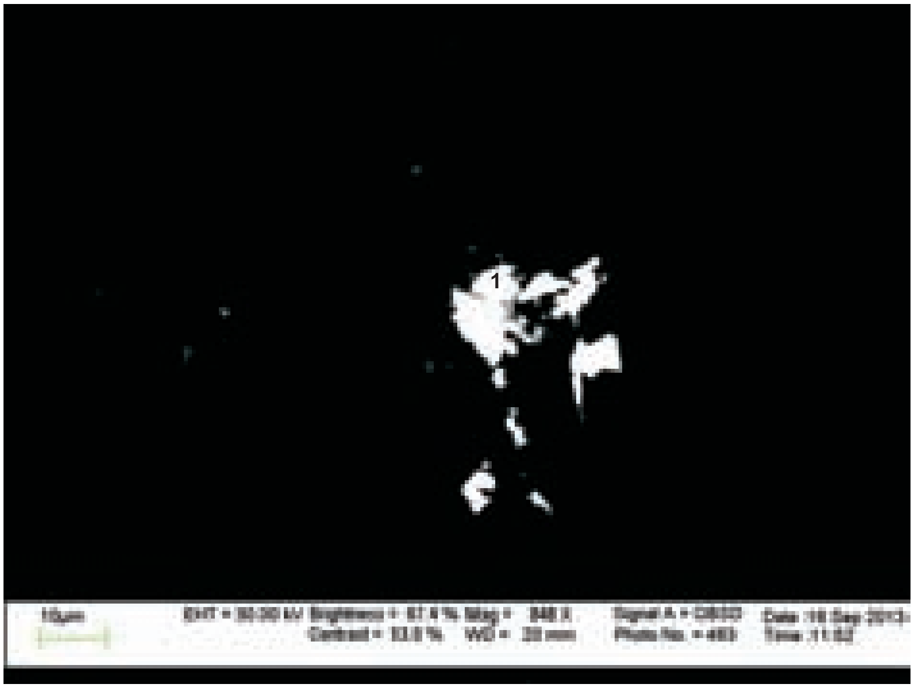


1:Thorite
2:Thorite
3:Thorite
4:Monazite(+others)
5:Thorite
6:Thorite replacing zircon
7:Calcite
8:Calcite
9:Calcite

Figure 1-3.3a: Horton group sample 2349B site 13; thorite occuring at the intersection of fractures (white arrows). It is also filling voids (position A) and floating in cement (position B), which further suggests a hydrothermal origin. Monazite (analysis 4) also appears to be of hydrothermal origin, as it can be seen cutting detrital quartz (position C)

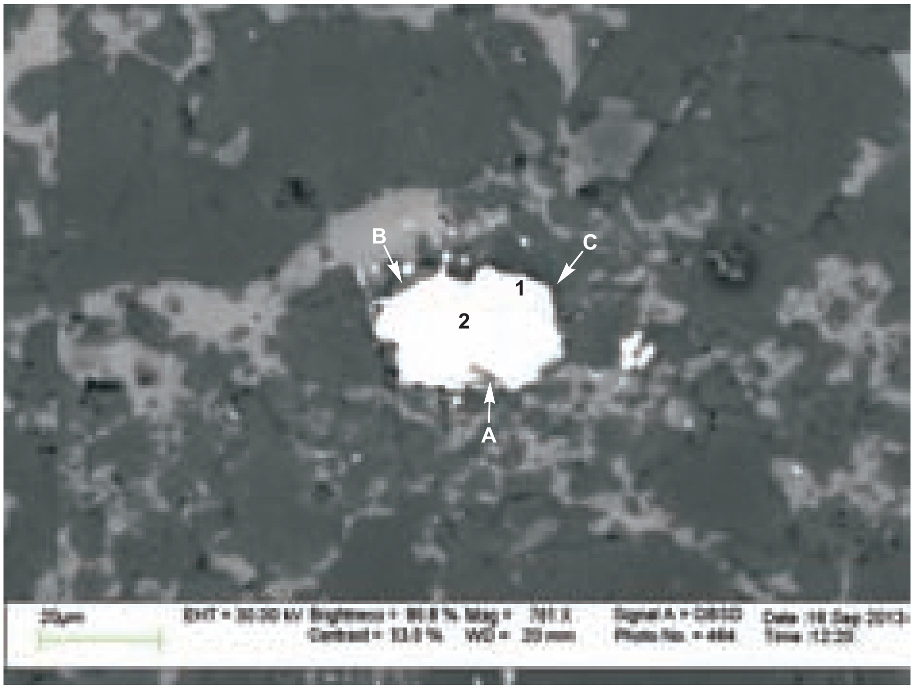
1:Thorite
2:Thorite
3:Thorite
4:Monazite(+others)
5:Thorite
6:Thorite replacing zircon

Figure 1-3.3b: Horton group sample 2349B site 13; darker BSE image of figure 3a. Thorite (as distinguished by similar brightness) floating in calcite cement (B). Thorite has almost completely replaced zircon (analysis 6).



1: Thorite

Figure 1-3.3c: Horton Group sample 2349B site 12.



1:Xenotime
2:Xenotime

Figure 1-3.4a: Horton Group sample 2349B site 14; xenotime, possibly hydrothermal as it appears to cut quartz (position C). Sharp euhedral edges are seen in contact with what appears to be calcite cement (positions A&B).

1:Xenotime
2:Thorite(+others)?

Figure 1-3.4b: Horton Group sample 2349B site 15.

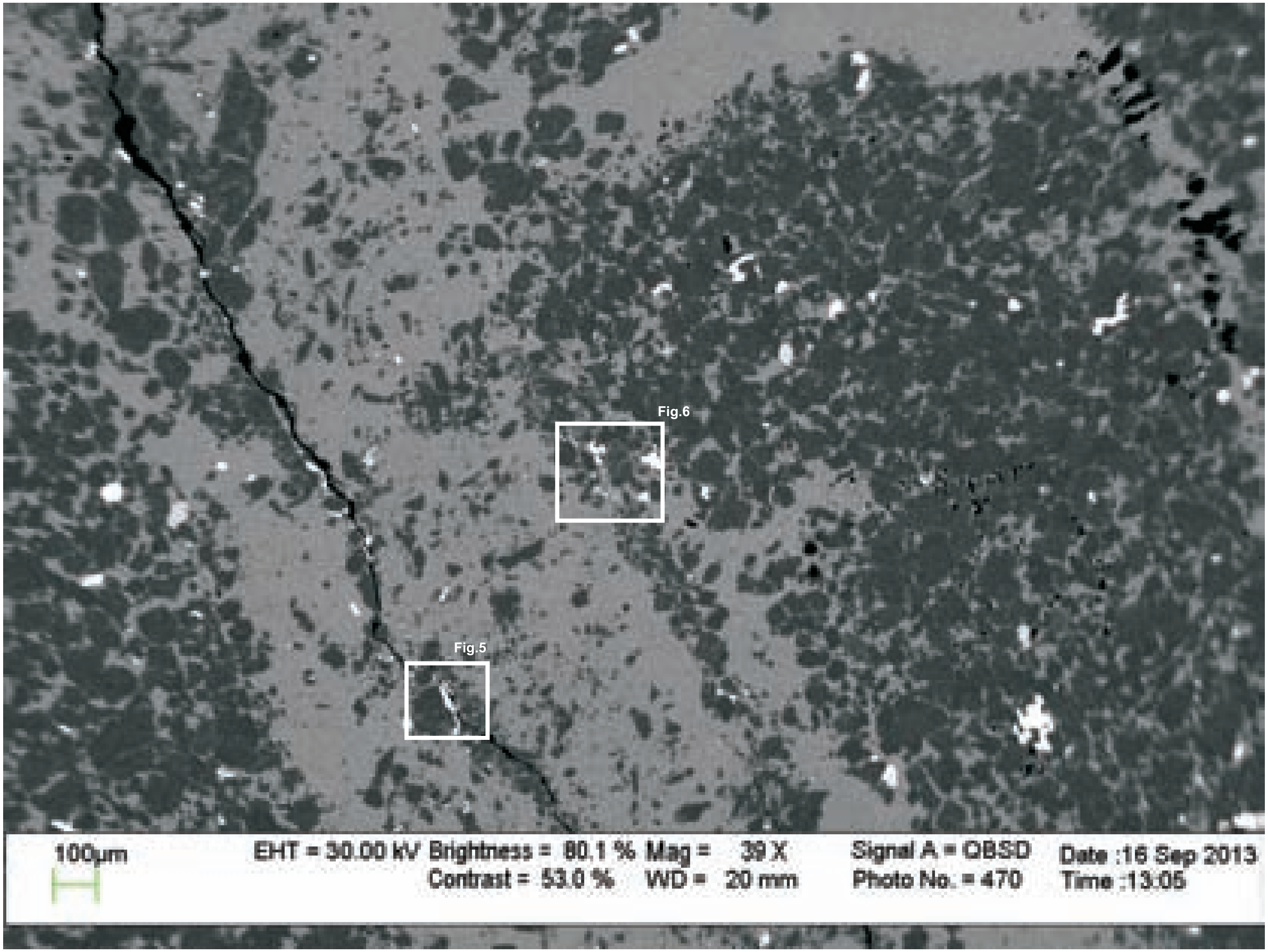
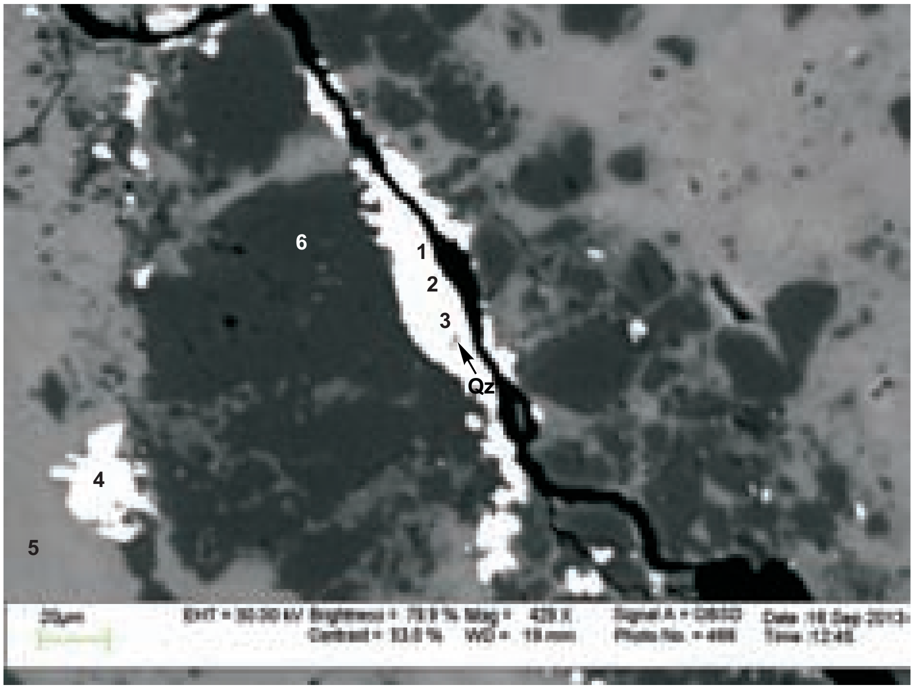
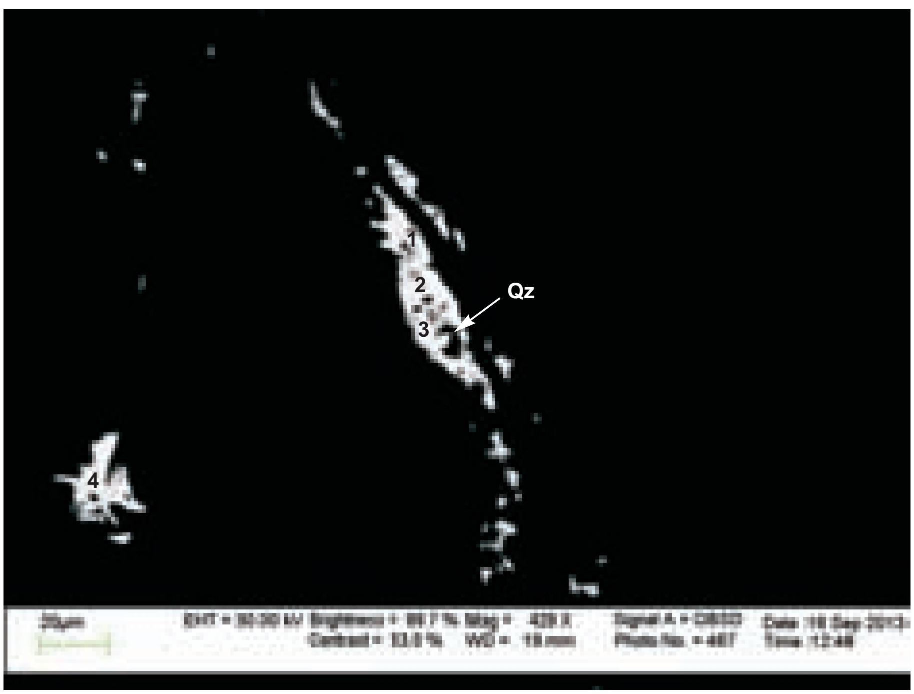


Fig.6
Fig.5
100µm
EHT = 30.00 kV Brightness = 80.1 % Mag = 39 X
Contrast = 53.0 % WD = 20 mm
Signal A = QBSD
Photo No. = 470
Date :16 Sep 2013
Time :13:05



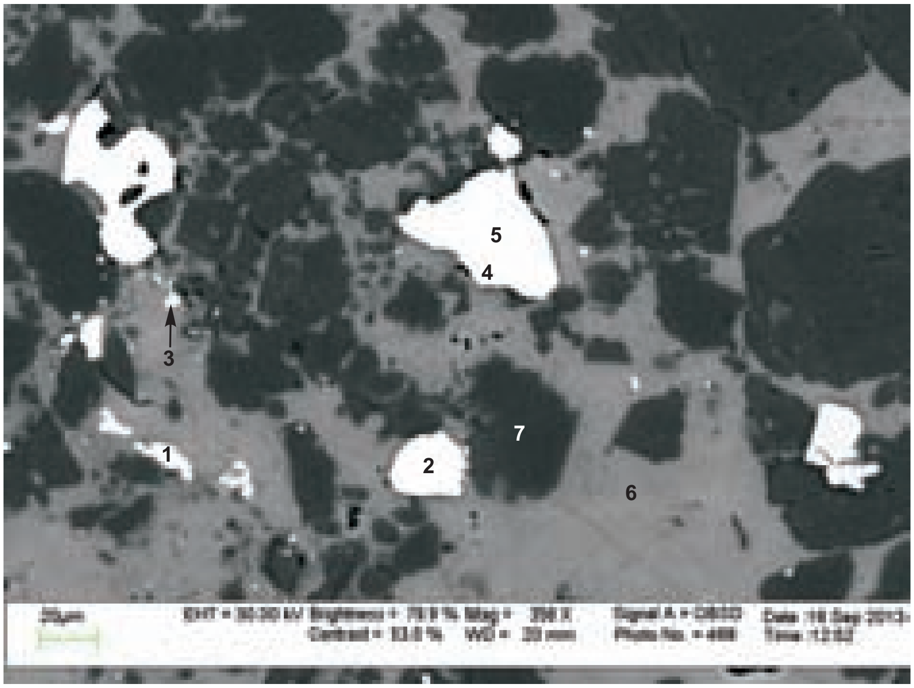
1:Synchysite-Ce
2:Synchysite-Ce
3:Synchysite-Ce
4:Synchysite-Ce
5:Calcite
6:Quartz

Figure 1-3.5a:Horton group sample 2349B site 16; synchysite-Ce precipitated in fracture, which was later reopened.



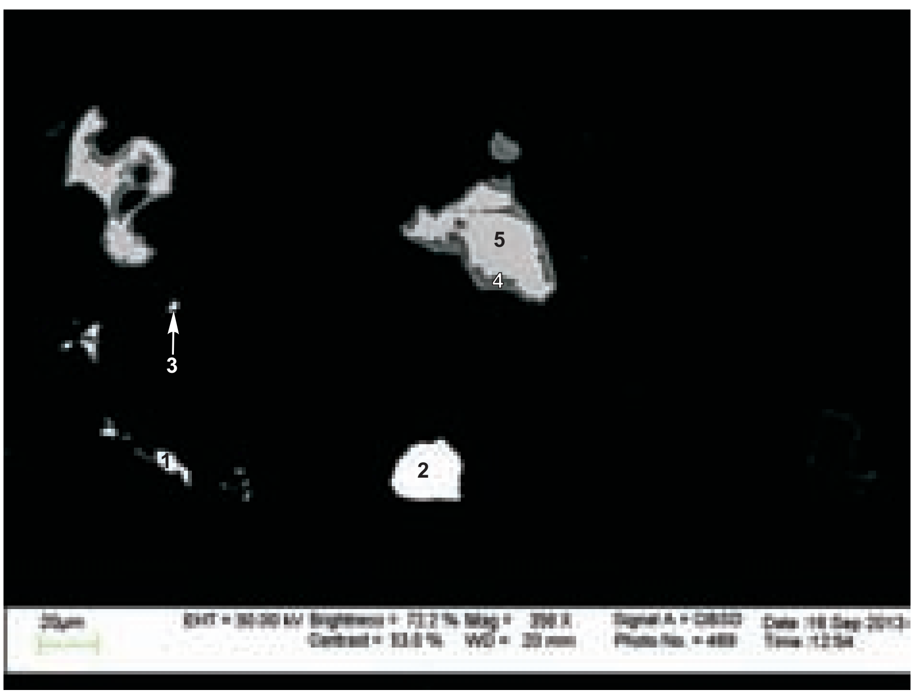
1:Synchysite-Ce
2:Synchysite-Ce
3:Synchysite-Ce
4:Synchysite-Ce

Figure 1-3.5b:Horton group sample 2349B site 16; darker BSE image of figure 5a. Synchysite-Ce precipitated in fracture, which was later reopened.



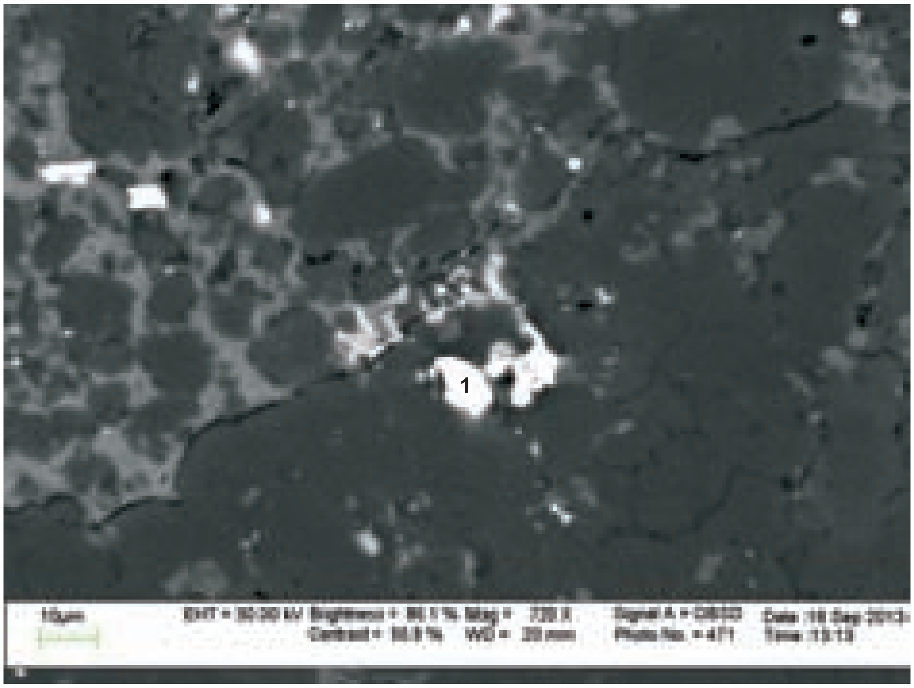
1:Synchysite-Ce
2:Xenotime
3:Mix(Thorite+Calcite)
4:Fe-oxide(+others)
5:Pyrite
6:Calcite
7:Quartz

Figure 1-3.6a: Horton group sample 2349B site 17; partly oxidized (analysis 4) pyrite (analysis 5).



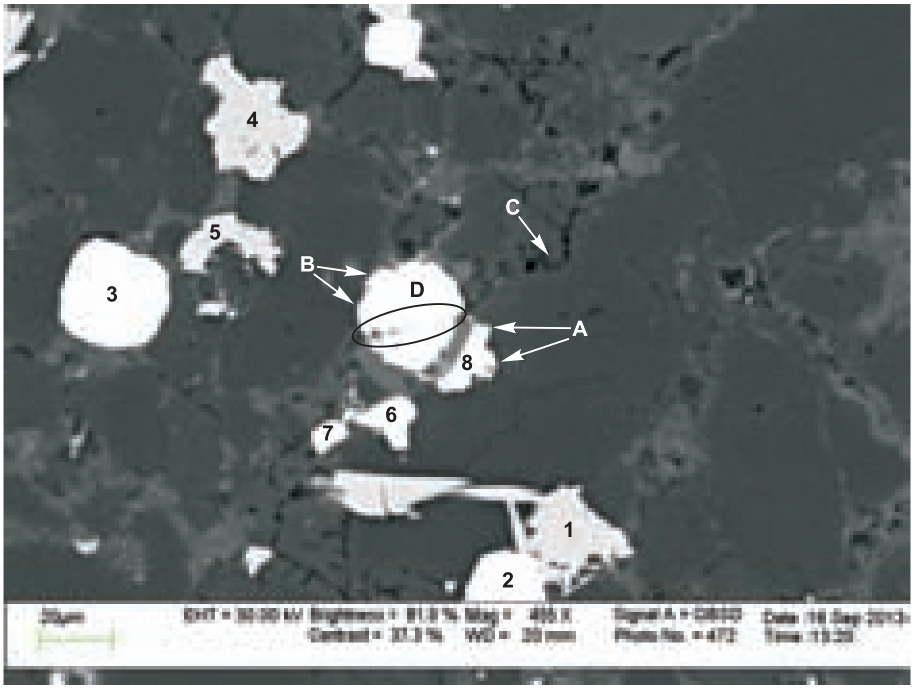
1:Synchysite-Ce
2:Xenotime
3:Mix(Thorite+Calcite)
4:Fe-oxide(+others)
5:Pyrite
6:Calcite
7:Quartz

Figure 1-3.6b: Horton group sample 2349B site 17; darker BSE image of figure 6a. Partly oxidized (analysis 4) pyrite (analysis 5).



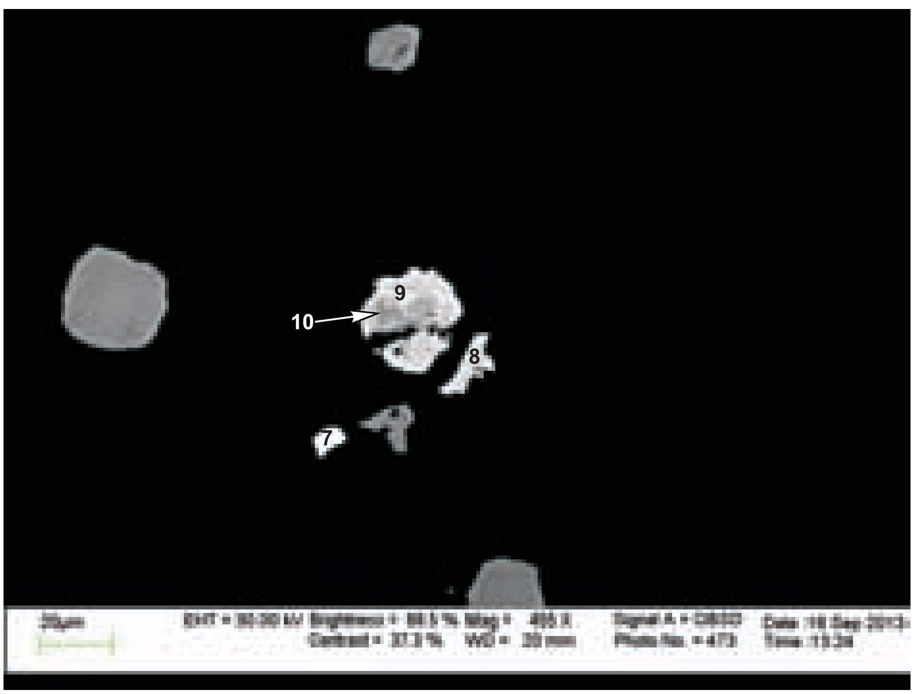
1:Thorite

Figure 1-3.7: Horton group sample 2349B site 18.



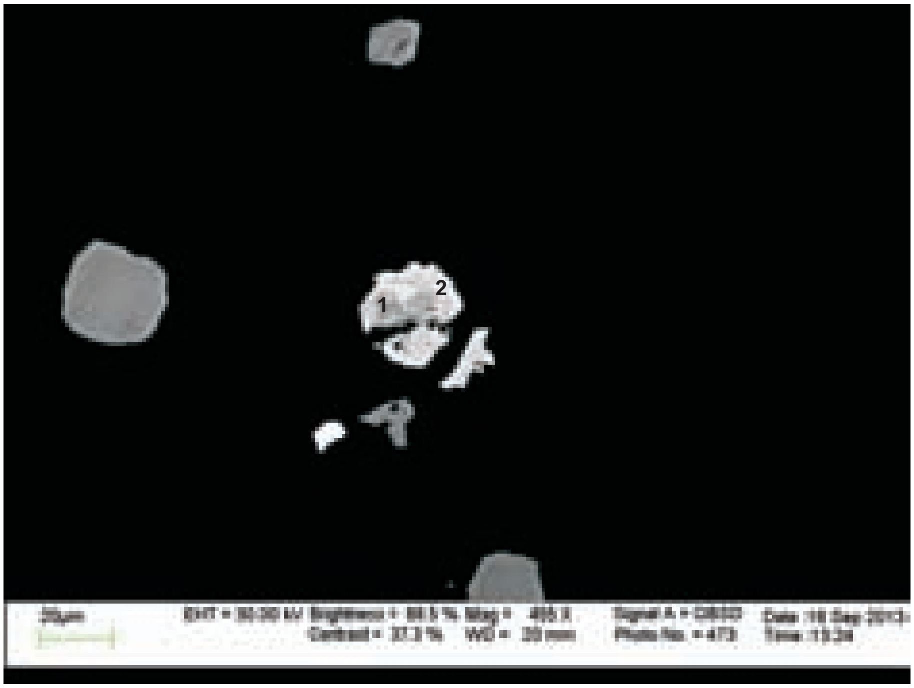
1:TiO_2
3:Zircon
3:Zircon
4:TiO_2
5:TiO_2
6:Zircon
7:Thorite
8:Xenotime
9:Xenotime
10:Xenotime

Figure 1-3.8a: Horton group sample 2349B 19. Xenotime, likely hydrothermal as it appears to cut detrital quartz (positions A&B).Xenotime appears to be cut by later fracture (C,D)



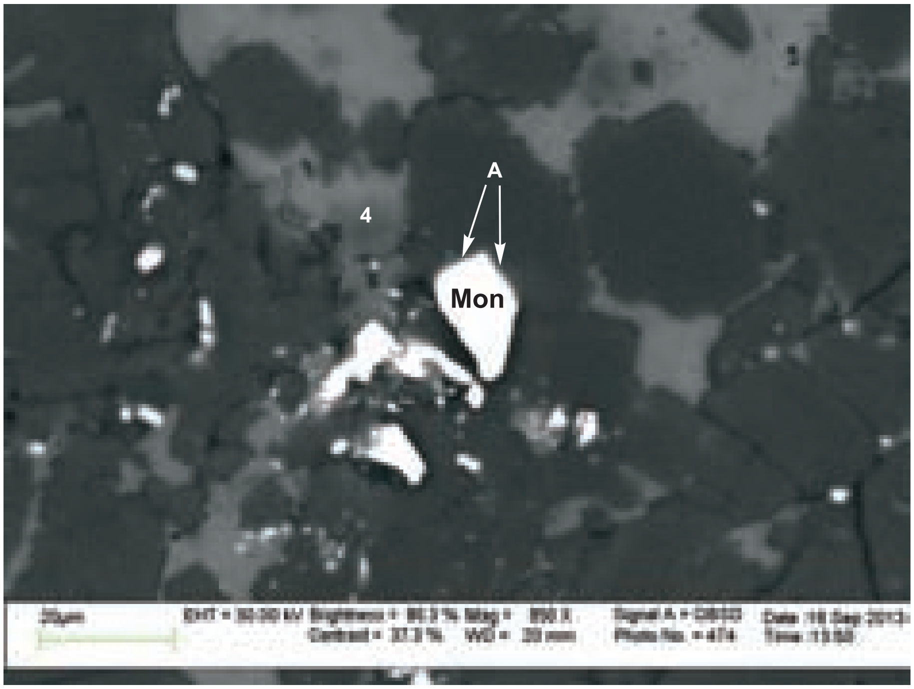
7:Thorite
8:Xenotime
9:Xenotime (+zircon)
10:Zircon(+Xenotime)

Figure 1-3.8b: Horton group sample 2349B site 19; darker BSE image of figure 8a. Xenotime contains patches of heterogeneously mixed zircon (analysis 10). The two minerals are known to exhibit solid solution with each other.



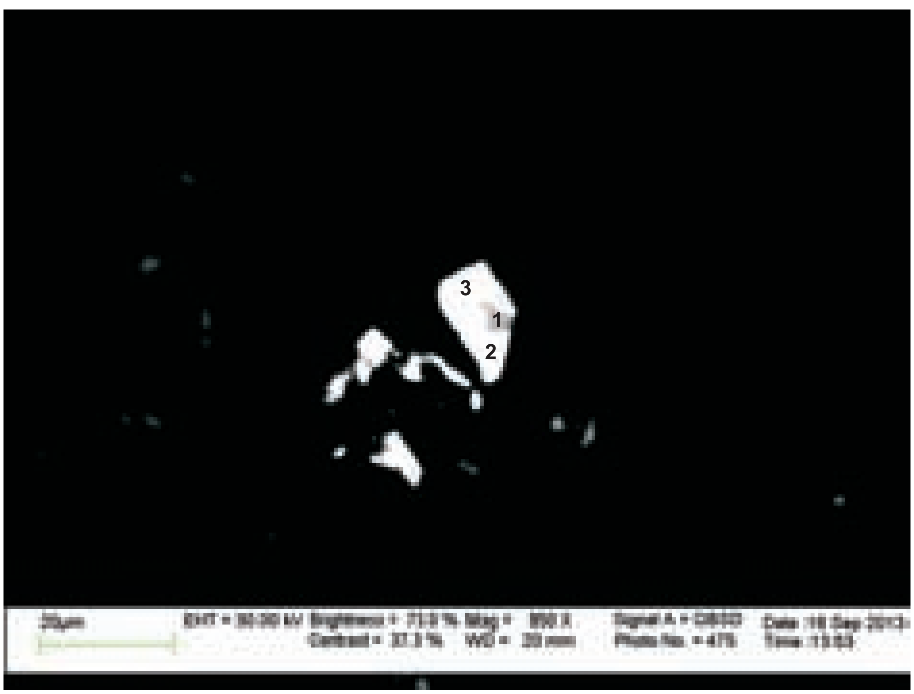
1:Zircon(+Xenotime)
2:Xenotime

Figure 1-3.8c: Horton Group quartzite sample 2349B site 20.



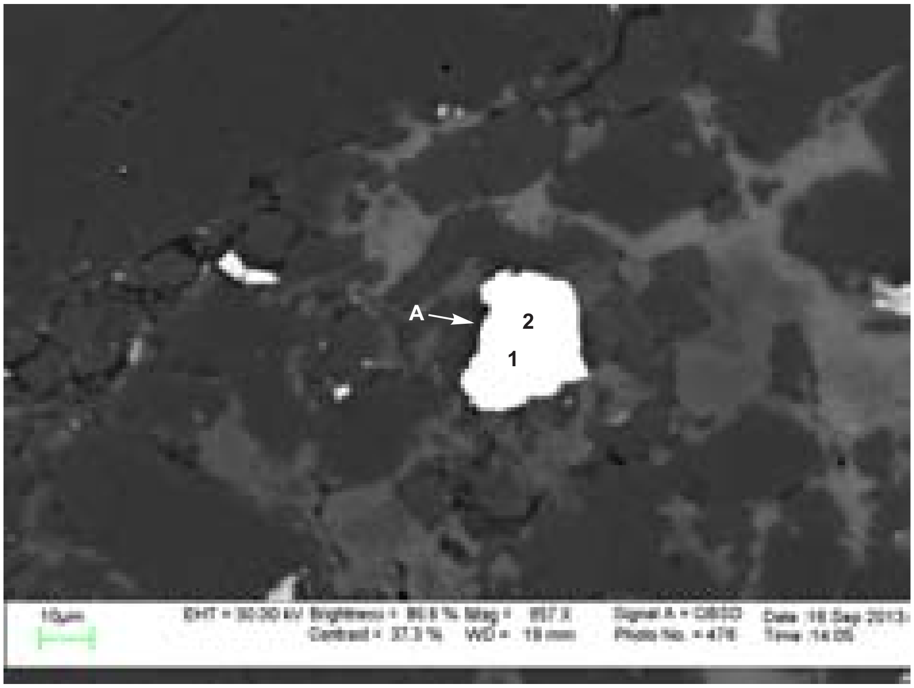
4:Calcite(+others)

Figure 1-3.9a: Horton group sample 2349B site 22. Monazite, likely of hydrothermal origin as euhedral grain edges (position A) appear to cut detrital quartz.



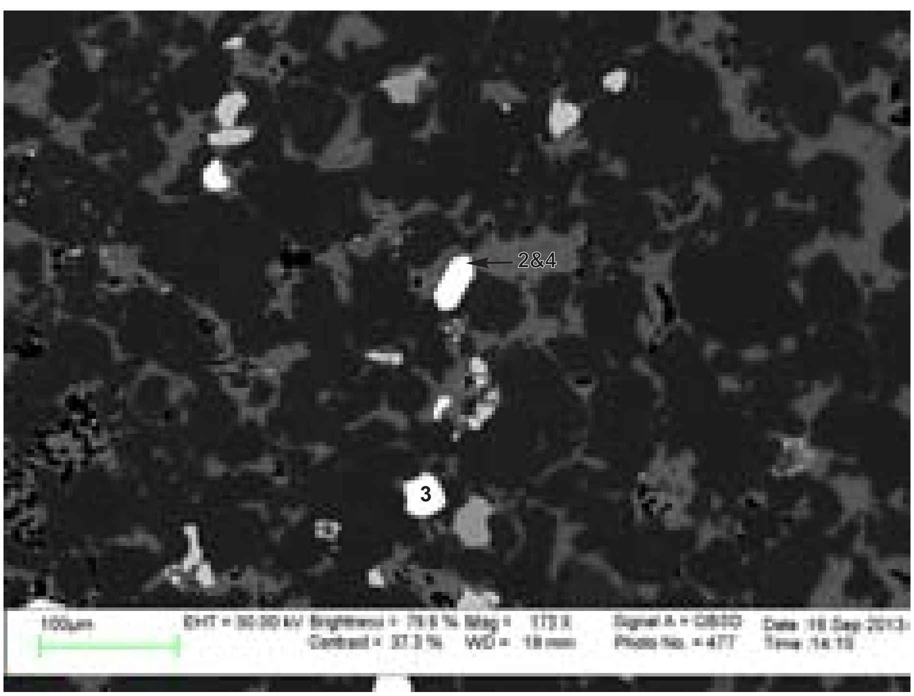
1:Fe-oxide(+others)
2:Monazite
3:Monazite

Figure 1-3.9b: Horton group sample 2349B site 22; darker BSE image of figure 9a. Monazite partially replaced(?) by Fe-oxide (analysis 1)



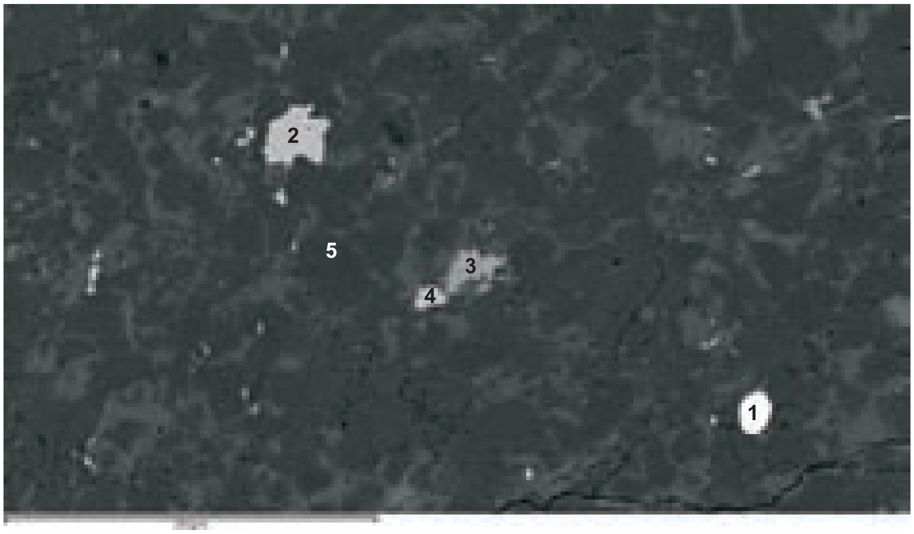
1:Xenotime
2:Xenotime

Figure 1-3.10: Horton group sample 2349B site 23; xenotime, likely hydrothermal as it appears to fill dissolution void (position A).



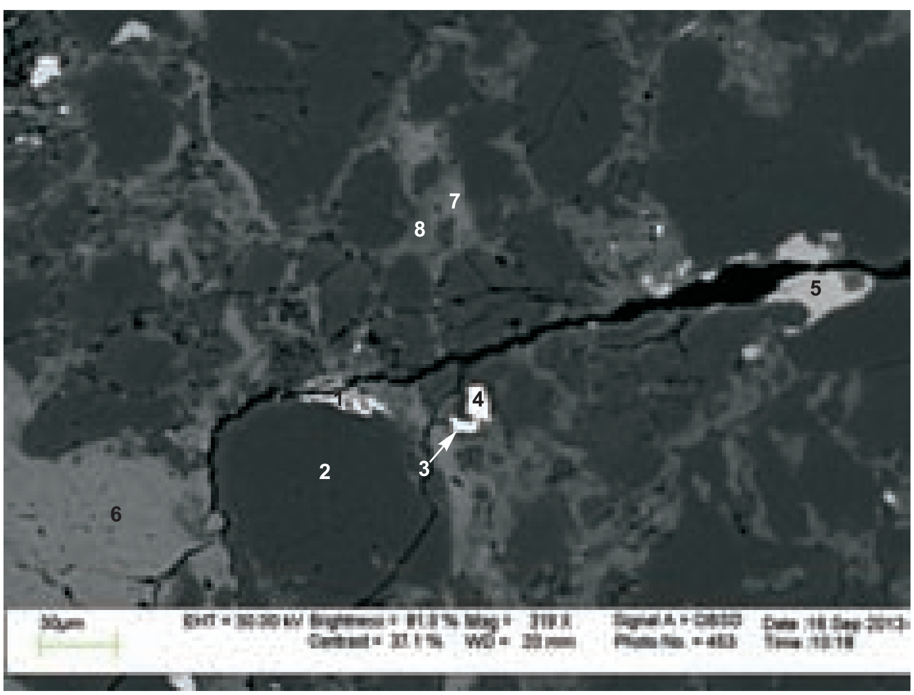
1:Zircon (missing spot)
2:Zircon
3:Zircon
4:Zircon

Figure 1-3.11: Horton group sample 2349B site 24; hydrothermal zircon.



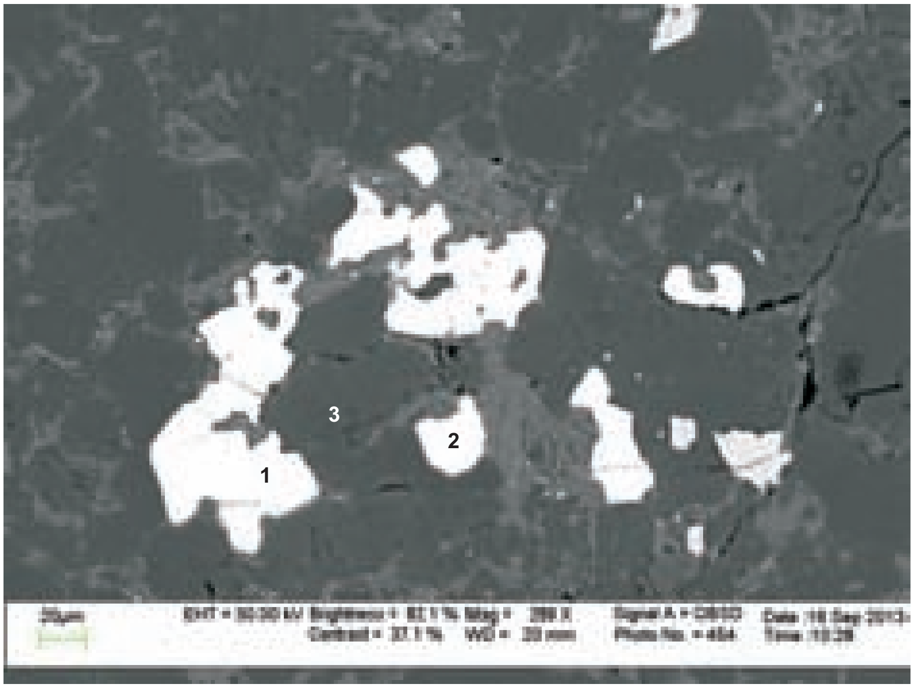
1:Zircon
2:TiO2
3:Fluorapatite
4:Rutile
5:Quartz
6:Biotite

Figure 1-3.12: Horton Group sample 2349B site 3.



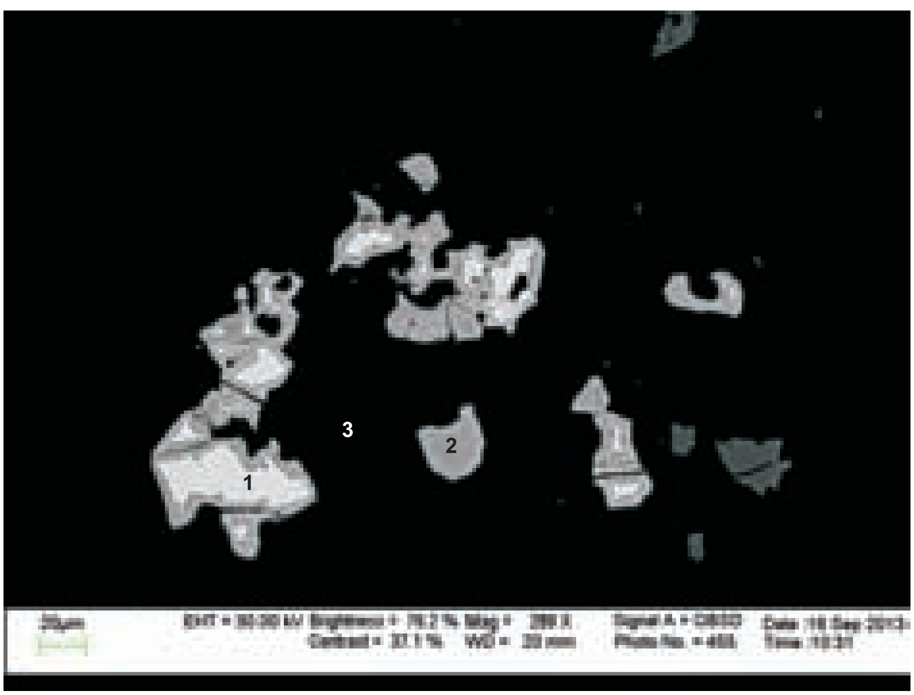
1:TiO2(+others)
2:Quartz
3:Zircon
4:Zircon
5:Fluorapatite
6:Calcite
7:Calcite
8:Biotite

Figure 1-3.13: Horton Group sample 2349B site 4; detrital fluorapatite (analysis 5) cut by later fracture.



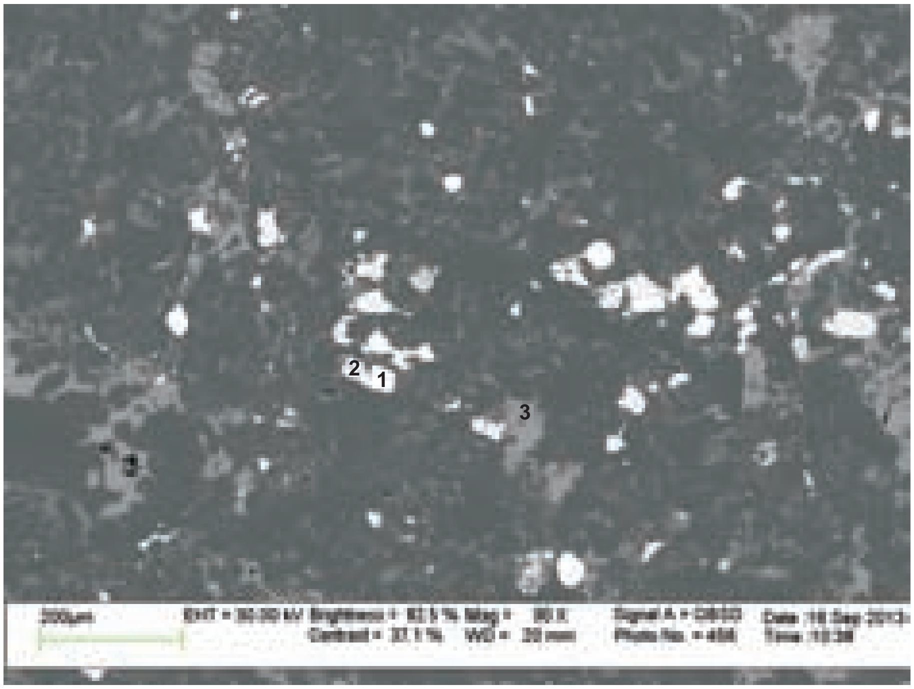
1:Pyrite
2:Fe-oxide
3:Quartz

Figure 1-3.14a: Horton Group sample 2349B site 5; partially oxidized pyrite.



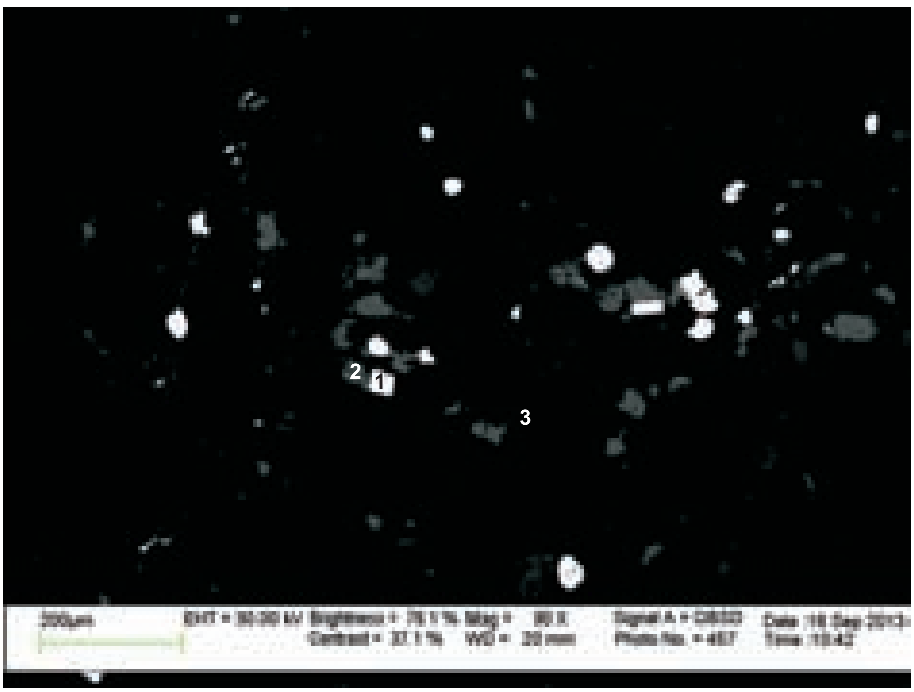
1:Pyrite
2:Fe-oxide
3:Quartz

Figure 1-3.14b:Horton Group sample 2349B site 5; darker BSE image of figure 14a. Partially oxidized (analysis 3) pyrite (analysis 1).



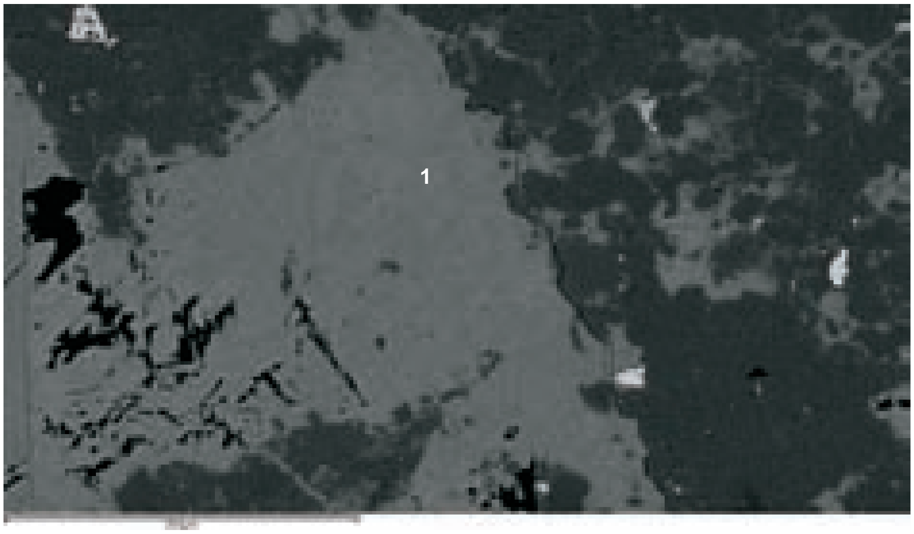
1:Zircon
2:Rutile
3:Calcite(+others)

Figure 1-3.15a: Horton Group sample 2349B site 6



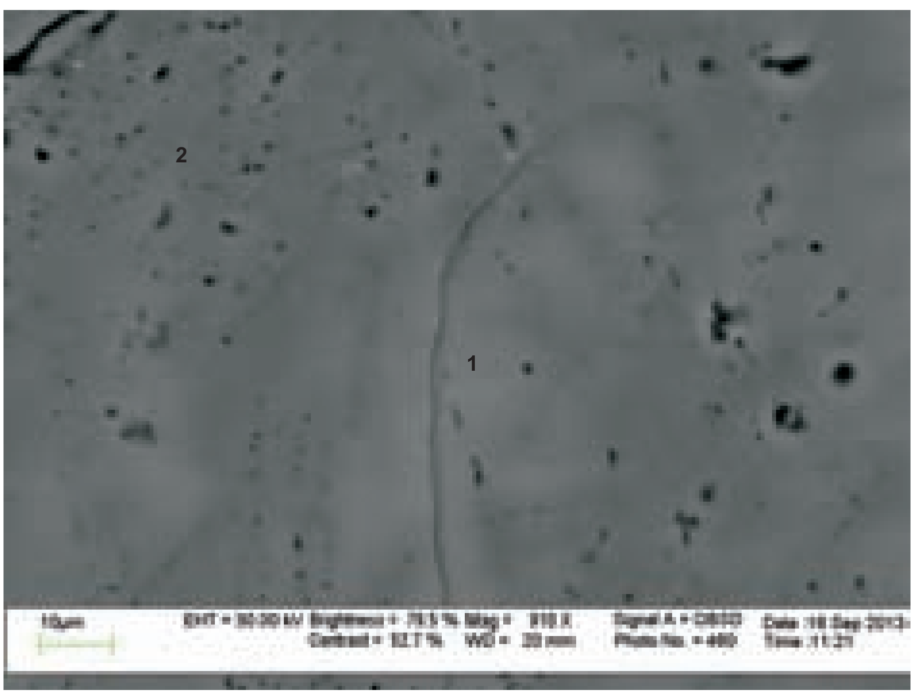
1:Zircon
2:Rutile
3:Calcite(+others)

Figure 1-3.15b: Horton Group sample 2349B site 6



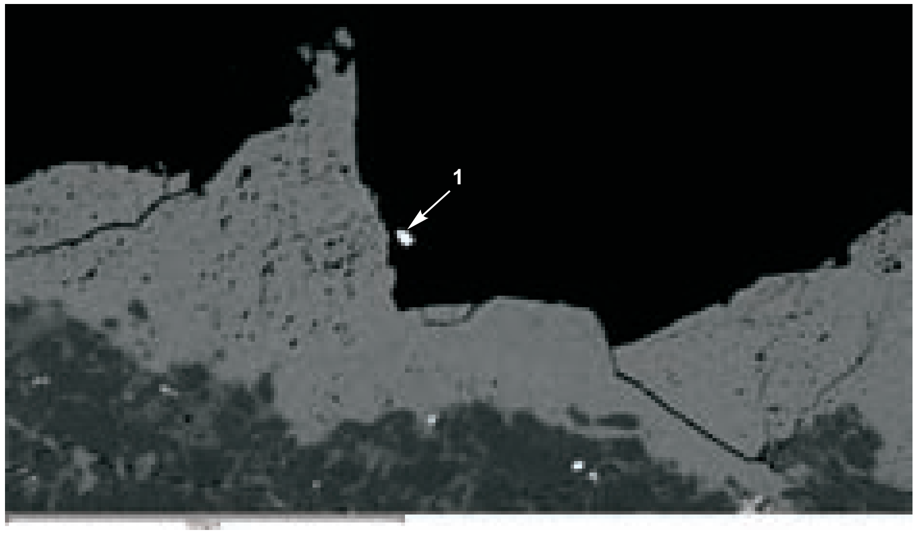
1:Calcite

Figure 1-3.16:Horton Group sample 2349B site 8.



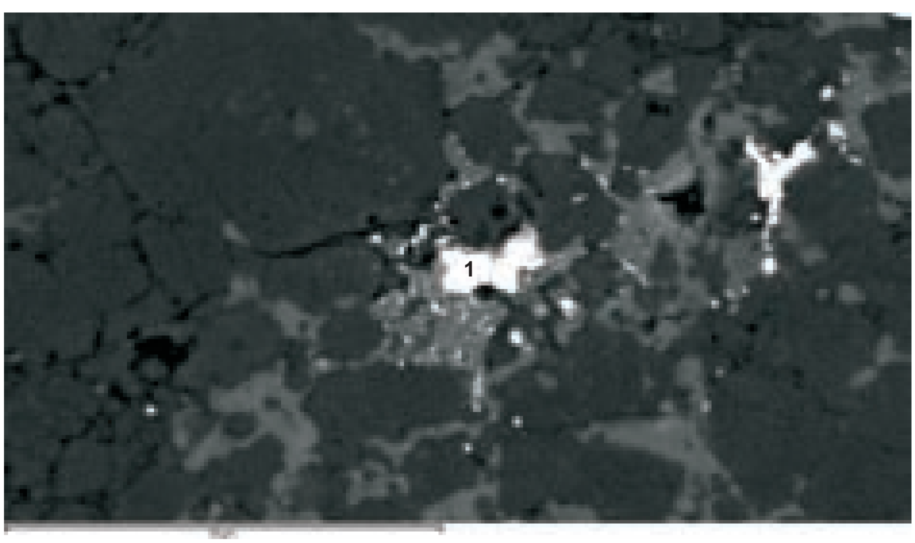
1:Calcite
2:Calcite

Figure 1-3.17:Horton Group sample 2349B site 9.



1:Barite

Figure 1-3.18: Horton Group sample 2349B site 11.



1:Thorite

Figure 1-3.19: Horton Group sample 2349B site 21.

Table 1-3: EDS analyses of sample 2349B from Horton Group

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	CoO	Y_2O_3	ZrO_2	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Tm_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total	Actual Total
2349B	3	1	Zircon	31.79																67.12											1.10					100.01	83.07
2349B	3	2	TiO2		99.62												0.39																			100.01	66.33
2349B	3	3	Fluorapatite							48.68			44.94		6.15	0.23																				100.00	78.76
2349B	3	4	TiO2		98.47		0.58			0.25						0.70																				100.00	65.72
2349B	3	5	Quartz	99.99																																99.99	77.05
2349B	3	6	Muscovite	54.12	0.95	29.19	2.66		2.49			10.58																								99.99	71.61
2349B	4	1	TiO2(+others)	15.47	80.78	1.87	0.44			0.85		0.60																								100.01	72.98
2349B	4	2	Quartz	99.99																																99.99	77.82
2349B	4	3	Zircon	35.79		3.12	0.28			2.90		0.96								55.69											1.25					99.99	80.63
2349B	4	4	Zircon	35.79		0.96														63.26																100.01	80.05
2349B	4	5	Fluorapatite							47.74			44.41		7.32	0.54																				100.01	80.96
2349B	4	6	Calcite				0.40	1.53		54.07																										56.00	35.77
2349B	4	7	Calcite(+others)	9.28	1.62	5.06	1.09	1.27		78.80		2.89																								100.01	38.16
2349B	4	8	Muscovite	54.10	1.08	33.14	0.91		0.61		0.75	9.38																								99.97	75.15
2349B	5	1	Pyrite				27.72							72.29																						100.01	142.92
2349B	5	2	Fe-oxide(+Pyrite)	2.97			87.27			0.43				9.34																						100.01	53.76
2349B	5	3	Quartz	88.82		9.03						2.14																								99.99	93.44
2349B	6	1	Zircon	31.81																68.19																100.00	78.22
2349B	6	2	TiO2	0.79	98.40		0.35										0.45																			99.99	66.11
2349B	6	3	Calcite(+others)	4.39		2.51		2.66		89.74		0.70																								100.00	37.37
2349B	7	1	Pyrite				27.97							72.04																						100.01	146.05
2349B	7	2	Fe-oxide	4.43			94.87			0.70																										100.00	50.31
2349B	7	3	Calcite				0.60	1.97		53.43																										56.00	36.41
2349B	8	1	Calcite				0.43	1.52		54.03																										56.00	36.09
2349B	9	1	Calcite				0.55	1.52	0.41	53.52																										56.00	35.55
2349B	9	2	Calcite				0.40	1.48		52.11					2.00																					56.00	37.20
2349B	10	1	Xenotime*										17.58						17.41							1.64	2.67	1.61		1.48				0.56	57.05	100.00	149.13
2349B	10	2	Zircon	31.51		0.74				0.69										65.85											1.21					100.00	77.11
2349B	10	3	Zircon	34.46		1.27				0.56										62.46											1.26					100.01	74.97
2349B	10	4	TiO2	7.68	86.51					5.34							0.48																			100.01	65.10
2349B	10	5	Calcite				0.37	1.66		53.98																										56.00	36.04
2349B	11	1	Barite*											20.98								37.25													41.81	100.04	128.09
2349B	12	1	Thorite	18.25		1.40	7.20			4.16			3.46						3.15														58.88	3.51		100.01	68.12
2349B	13	1	Thorite	18.85		1.40	5.78			4.72			3.23						2.49														60.03	3.52		100.02	68.30
2349B	13	2	Thorite	16.30		0.89	7.33			3.29	0.97		4.06						2.08														65.09			100.01	63.33
2349B	13	3	Thorite	20.28		0.68	15.15			2.60			3.64						2.72														54.95			100.02	70.76
2349B	13	4	Monazite-Ce(+others)	15.81		0.81	2.79			1.37			30.43								1.85		12.19	25.17	9.59											100.01	80.04
2349B	13	5	Thorite	34.14		3.16	4.91	0.41		3.82	1.00		2.61			0.26																	49.68			99.99	67.01
2349B	13	6	Thorite	33.97	0.38	1.08	14.78			7.64			2.29						1.94	5.40													32.49			99.97	62.08
2349B	13	7	Calcite					0.99		55.01																										56.00	41.72
2349B	13	8	Calcite					0.90		55.11																										56.00	38.14
2349B	13	9	Calcite					1.32		54.68																										56.00	37.59
2349B	14	1	Xenotime (+Fe)	9.11			13.35			5.36			35.88					1.53	29.62							1.75				3.42						100.02	57.60
2349B	14	2	Xenotime*	0.88						0.11			17.83						17.03							0.86	2.25	2.17		2.78				0.68	55.40	99.99	153.59
2349B	15	1	Xenotime	12.26			1.53			1.92	0.77		39.25						34.37							1.99		4.13		3.80						100.02	62.53
2349B	15	2	Thorite(+others)?	45.56	1.70	6.42	7.32			22.19	2.63									4.93													9.24			99.99	66.87
2349B	16	1	Synchysite-Ce	5.17		1.87				17.71					10.08				2.68				10.10	20.26	8.13											76.00	56.16
2349B	16	2	Synchysite-Ce	1.88		0.89				19.14		0.33			9.90				2.58				11.00	22.22	8.05											76.00	52.77
2349B	16	3	Synchysite-Ce	1.58						19.99					10.03				3.44				10.95	21.76	8.25											76.00	53.53
2349B	16	4	Synchysite-Ce	1.17			0.52			19.74					9.86				3.35				10.58	21.66	8.24	0.90										76.00	53.13
2349B	16	5	Calcite				0.50	1.61		53.88																										56.00	40.25
2349B	16	6	Quartz	99.81												0.19																				100.00	87.65

* If we consider B_2O_3 as an analytical artifact

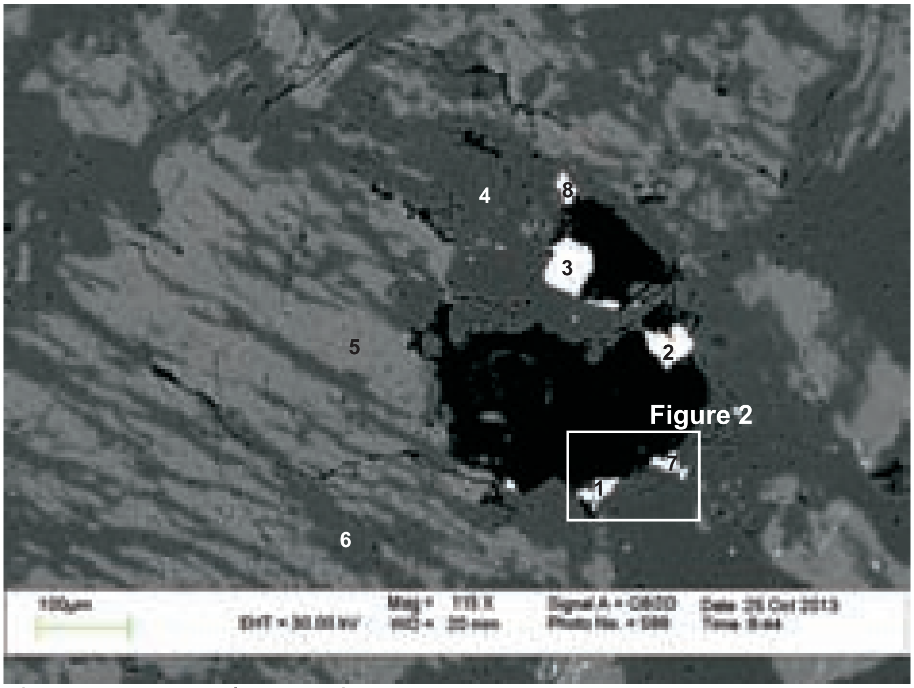
Table 1-3: EDS analyses of sample 2349B from Horton Group

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	CoO	Y_2O_3	ZrO_2	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Tm_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total	Actual Total
2349B	17	1	Synchysite-Ce	2.27			2.06			23.73					11.48				1.80				9.66	18.04	6.94											76.00	54.47
2349B	17	2	Xenotime*							0.14			18.22						18.15							1.39	2.81	1.76		1.22					56.34	100.03	164.44
2349B	17	3	Mix(Thorite+Calcite)	14.53		2.70	7.78	0.58		34.17	1.46		4.47						4.36														29.96			100.01	69.93
2349B	17	4	Fe-oxide(+others)	13.80			75.21			8.56				2.45																						100.02	60.05
2349B	17	5	Pyrite				27.72							72.29																						100.01	162.65
2349B	17	6	Calcite				0.45	1.37		54.17																										56.00	41.15
2349B	17	7	Quartz	99.79						0.21																										100.00	86.86
2349B	18	1	Thorite	24.60			1.71			2.28			1.90																				69.51			100.00	71.57
2349B	19	1	TiO2	0.81	98.33		0.64									0.21																				99.99	75.33
2349B	19	2	Zircon	31.70																68.30																100.00	87.70
2349B	19	3	Zircon	32.15																67.84																99.99	86.27
2349B	19	4	TiO2		100.00																															100.00	74.36
2349B	19	5	TiO2	1.67	96.95	0.68	0.45					0.26																								100.01	74.89
2349B	19	6	Zircon	33.03																65.85											1.13					100.01	90.88
2349B	19	7	Thorite	22.76			0.95			2.22			1.26		2.13																		65.32	5.36		100.00	75.75
2349B	19	8	Xenotime*				0.33			0.14			17.14						16.52							1.15	2.58	1.60		1.39					59.17	100.02	175.53
2349B	19	9	Xenotime*	1.41						0.20			17.23						16.68							1.16	2.35	1.86		2.37				1.08	55.69	100.03	160.82
2349B	19	10	Zircon(+Xenotime)	10.85			2.79			2.90			31.14					1.42	26.98	15.20	1.40					1.64				2.89				2.81		100.02	61.10
2349B	20	1	Zircon(+Xenotime)	12.26			1.31			2.97			27.34					0.95	22.99	19.47	1.69					1.41	3.42			3.28				2.93		100.02	63.86
2349B	20	2	Xenotime							0.49			46.68					1.35	35.69							2.65	5.72			4.05		1.16		2.21		100.00	67.62
2349B	21	1	Thorite	20.88		2.12	2.83			8.40	0.98		3.32																				58.14	3.33		100.00	70.41
2349B	22	1	Fe-oxide(+others)	9.26		1.02	64.39			0.80			7.42										4.48	8.82	3.83											100.02	64.01
2349B	22	2	Monazite	8.94		1.63				1.96			35.10	1.57							1.70		12.85	26.45	9.79											99.99	81.87
2349B	22	3	Monazite	2.22			0.41			1.39			36.69	1.15							1.51		14.90	30.28	11.47											100.02	74.73
2349B	22	4	Calcite(+others)	14.93		12.45	2.97	1.79	3.37	64.49																										100.00	48.29
2349B	23	1	Xenotime	3.85									46.54					1.55	35.74							3.19	6.09			3.03						99.99	74.23
2349B	23	2	Xenotime*										16.27						16.56							0.98	2.47	1.76		1.36					60.65	100.05	191.15
2349B	24	1	Zircon	32.99																64.97											2.04					100.00	89.81
2349B	24	2	Zircon	31.81																67.03											1.17					100.01	91.53
2349B	24	3	Zircon	32.22			0.30													65.55											1.95					100.02	90.87
2349B	24	4	Zircon	31.92																66.80											1.30					100.02	92.06

* If we consider B_2O_3 as an analytical artifact

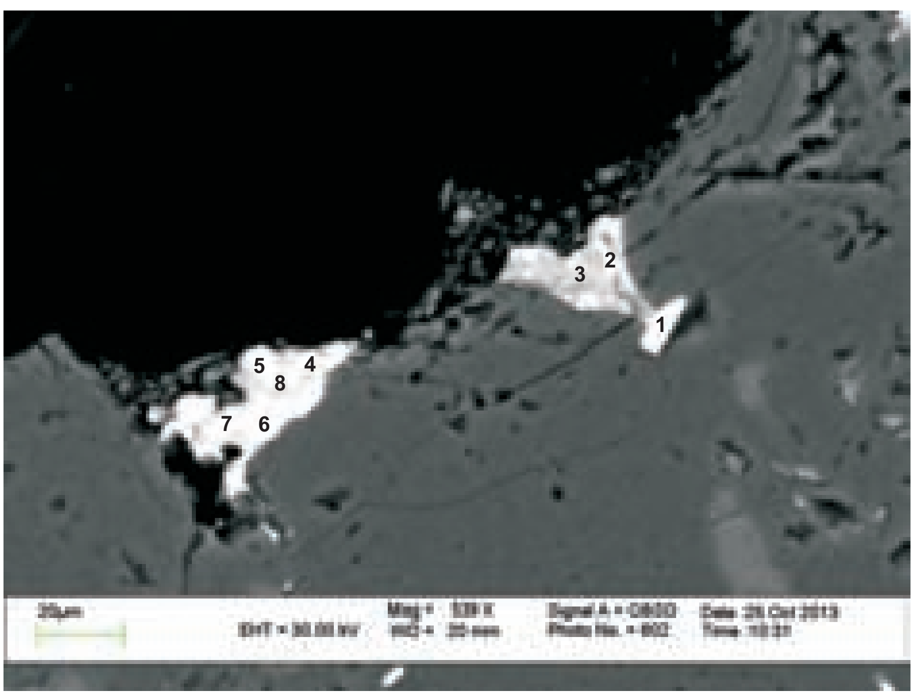
Appendix 2: BSE images and EDS mineral analyses of Granites and fractures

Appendix 2-1: BSE images and EDS mineral analyses of sample 9873



1:Fe-oxide(+others)
2:Fe-oxide(+others)
3:Fe-oxide(+others)
4:Albite
5:K-feldspar
6:Albite
7:Fe-oxide(+others)
8:Ilmenite

Figure 2-1.1: Sample 9873 site 3;



1:Fe-oxide
2:Fe-oxide(+others)
3:Fe-oxide(+others)
4:Fe-oxide(+others)
5:Fe-oxide(+others)
6:Fe-oxide(+others)
7:Fe-oxide(+others)
8:Fe-oxide(+others)

Figure 2-1.2: Sample 9873 site 4; analyses of Fe-oxide with lesser amount of Nb, Ti, & Ca. Likely a mixture of Fe-oxide phase and, either aeschynite-euxenite or polycrase.

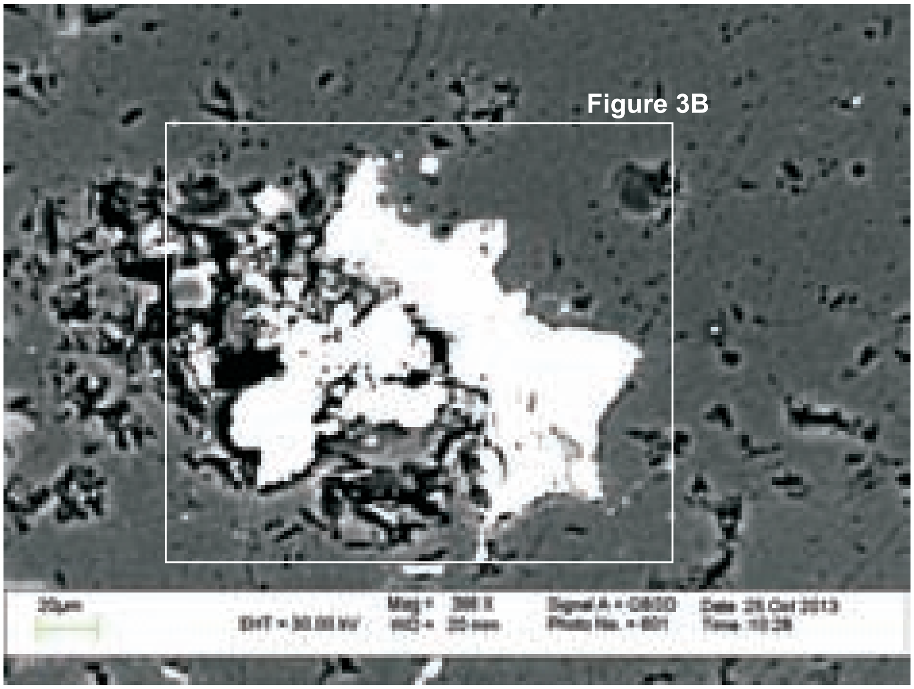
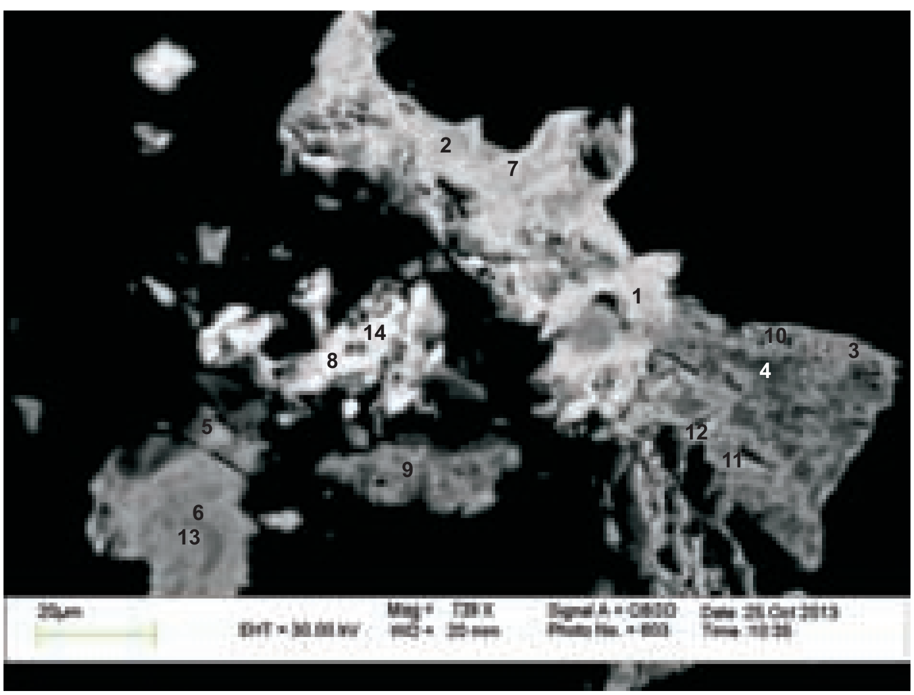
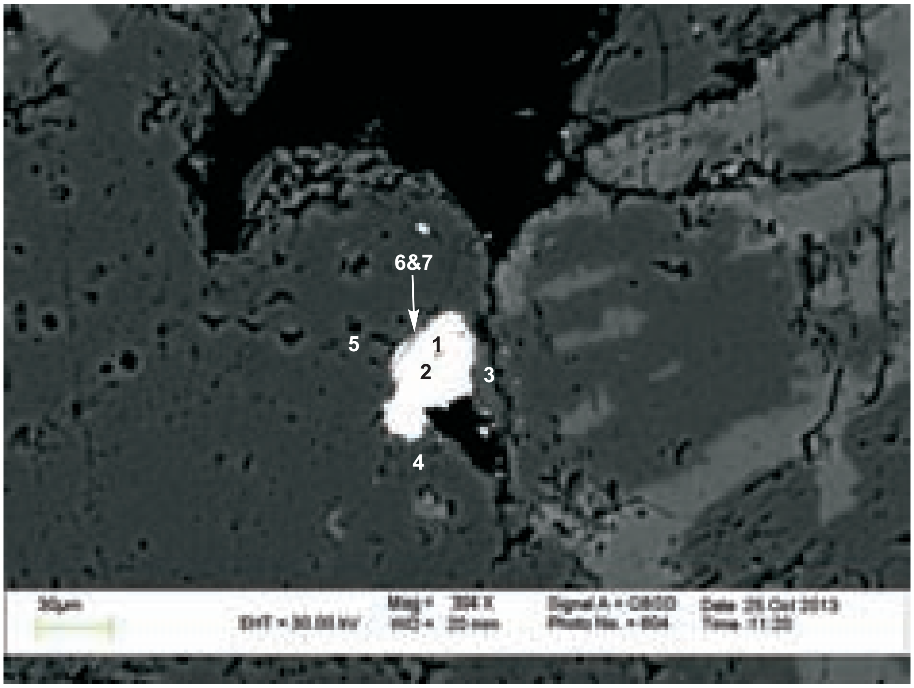


Figure 2-1.3a: Sample 9873 site 5; dissolution voids developing in proximity to primary ilmenite and zircon grains (figure 3B).



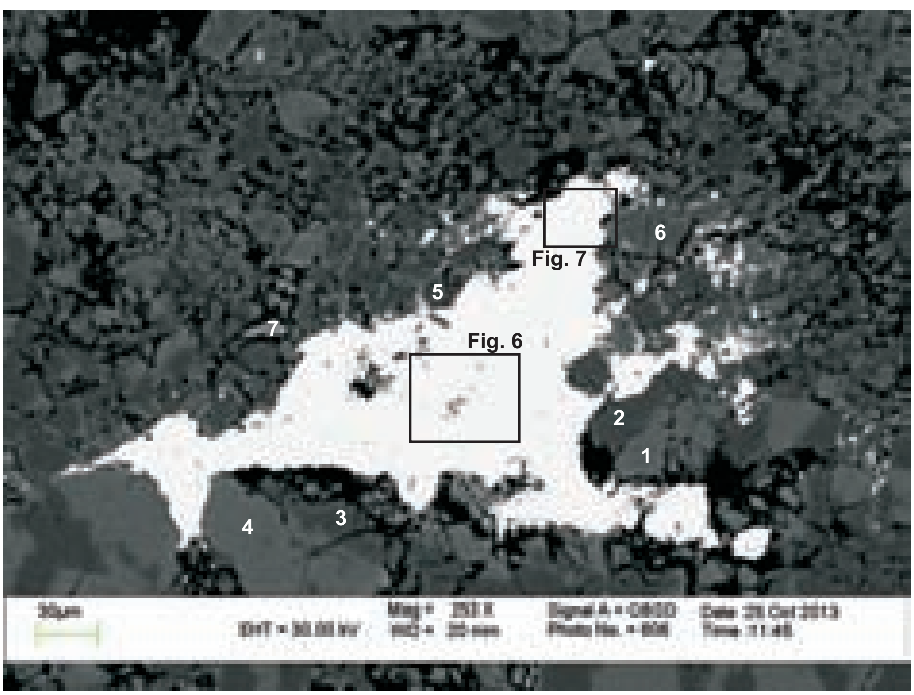
1:Zircon
2:Zircon
3:Mix(Fe-oxide+Ilmenite)
4:Ilmenite
5:Mix(Fe-oxide+Ilmenite)
6:Fe-oxide(+others)
7:Zircon
8:Aeschynite-euxenite
9:Fe-oxide(+others)
10:Mix(Fe-oxide + Quartz)
11:Fe-oxide(+others)
12:Mix
13:Fe-oxide(+others)
14:Aeschynite-euxenite

Figure 2-1.3b: Sample 9873 site 5; ilmenite (analysis 4)and zircon (analyses 1,2,&7) grains in contact. Ilmenite (analysis 4) is partially replaced by Fe-oxide (analyses 3&5). Zircon is enriched in Fe (all zircon analyses) and Y (analysis 7). Aeschynite-euxenite (analyses 8&14) has precipitated in dissolution void.



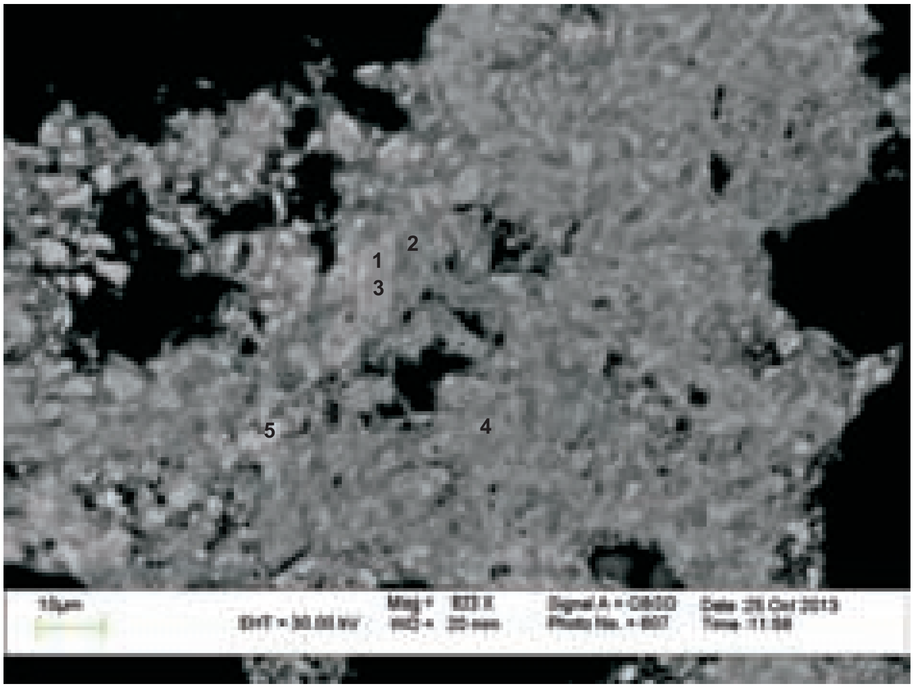
1:Pyrochlore
2:Pyrochlore
3:Quartz
4:Quartz
5:Quartz
6:Chlorite(+pyro)
7:Chlorite(+pyro)

Figure 2-1.4: sample 9873 site 7; pyrochlore precipitates along fracture. Pyrochlore is itself fractured and infilled by chlorite (analyses 6&7).



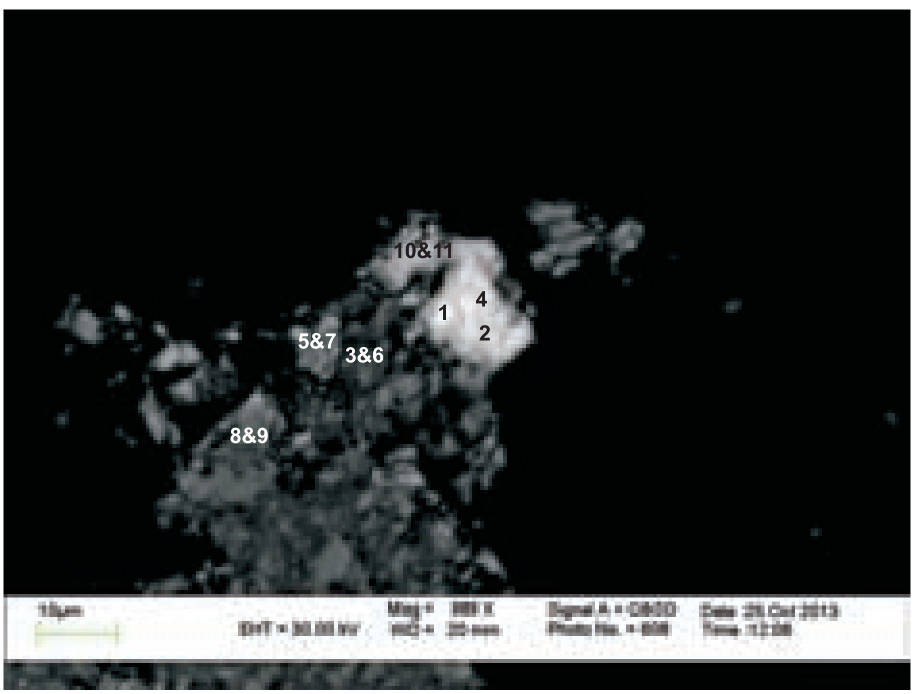
1:K-feldpsar
2:Albite
3:Albite
4:K-feldspar
5:Albite
6:Mix(Albite+other)
7:K-feldspar

Figure 2-1.5: sample 9873 site 9; zircon possibly filling voids in dissolved feldspar. However, it is difficult to evaluate whether zircon is hydrothermal or highly dissolved itself (figures 6&7).



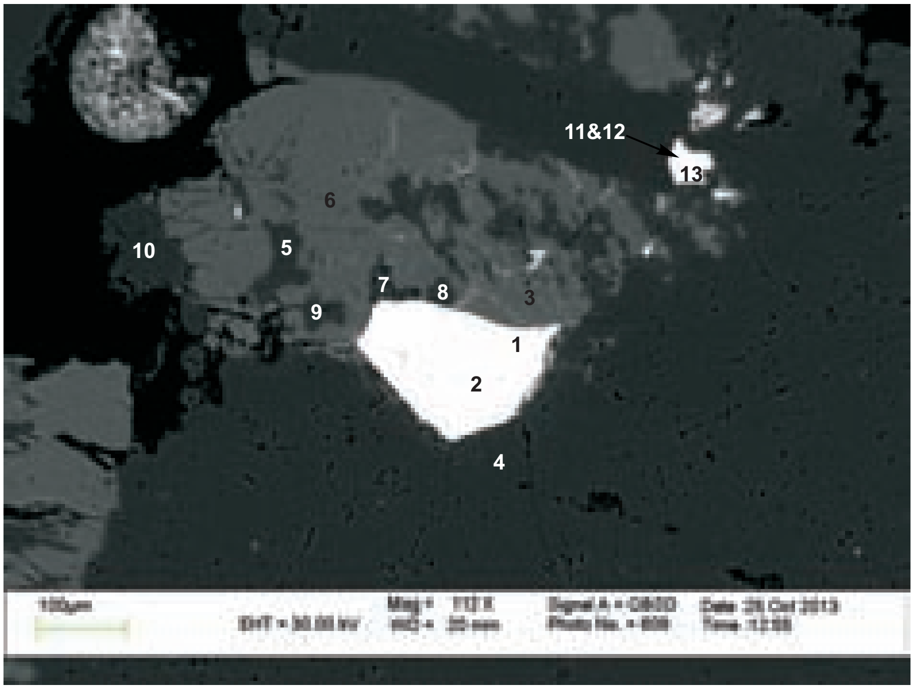
1:Zircon
2:Zircon
3:Zircon
4:Zircon
5:Thorite(+Zircon)

Figure 2-1.6: sample 9873 site 10; zircon is enriched in Y and Yb (analysis 2) and contains patches of thorite (analysis 5).



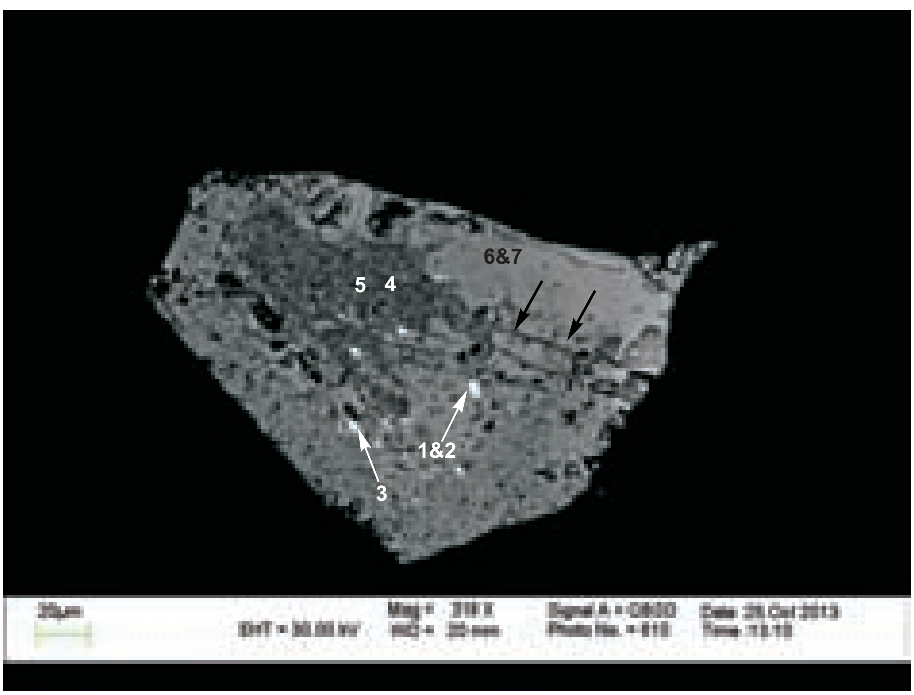
1:Thorite(+Zircon)
2:Mix(Thorite+Zircon)
3:Zircon
4:Mix(Thorite+Zircon)
5:Zircon
6:Zircon
7:Zircon
8:Zircon
9:Zircon
10:Mix(Thorite+Zircon)
11:Mix(Thorite+Zircon)

Figure 2-1.7: sample 9873 site 11; zircon analyses are enriched in Y and Yb (analyses 3&6) . The zircon shows a high degree of fracturing and dissolution. Analysis 1, 2, 4, 10 & 11 are mixtures of zircon and thorite suggesting that zircon may be partially altered to thorite.



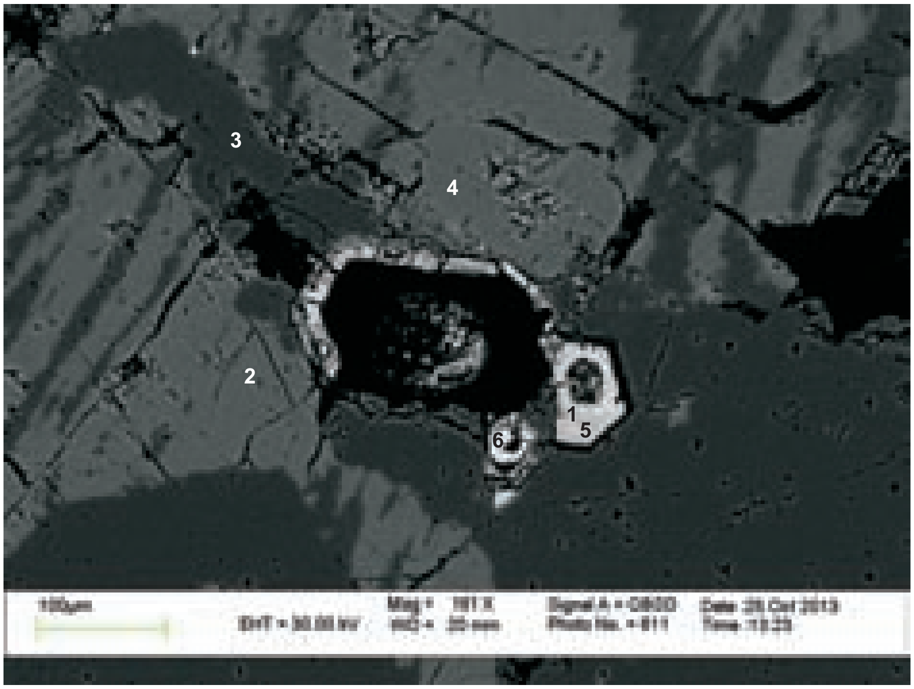
1:Zircon
2:Zircon
3:K-feldspar
4:Quartz
5:Albite
6:K-feldspar
7:Albite(+Fe)
8:Albite
9:Albite
10:Quartz
11:Fe-oxide(+other)
12:Fe-oxide(+other)
13:Mix

Figure 2-1.8: sample 9873 site 12; zircon formed at boundary between feldspar and quartz grains



1:Thorite+Zircon
2:Thorite+Zircon
3:Zircon
4:Zircon
5:Zircon
6:Zircon
7:Zircon

Figure 2-1.9: sample 9873 site 13; zircon is enriched in Y (analyses 4&5) and contains inclusions of thorite (bright spots), that are probably hydrothermally derived. Enrichment in Y appears to be of a secondary origin as darker areas (those corresponding to Y enrichment) can be seen cross-cutting zircon (dark arrows) and show ragged texture. One possibility is that these ragged zones contain crystallites of Y-bearing minerals, which formed during hydrothermal alteration of the primary zircon.



1:Mix(Fe-oxide + others)
2:K-feldspar
3:Albite
4:K-feldspar
5:Mix(Fe-oxide + others)
6:Mix(Fe-oxide + others)

Figure 2-1.10: sample 9873 site 14; skeletal rim of dissolved mineral. The mineral relics now consist of Fe-oxides, Nb-minerals and others.

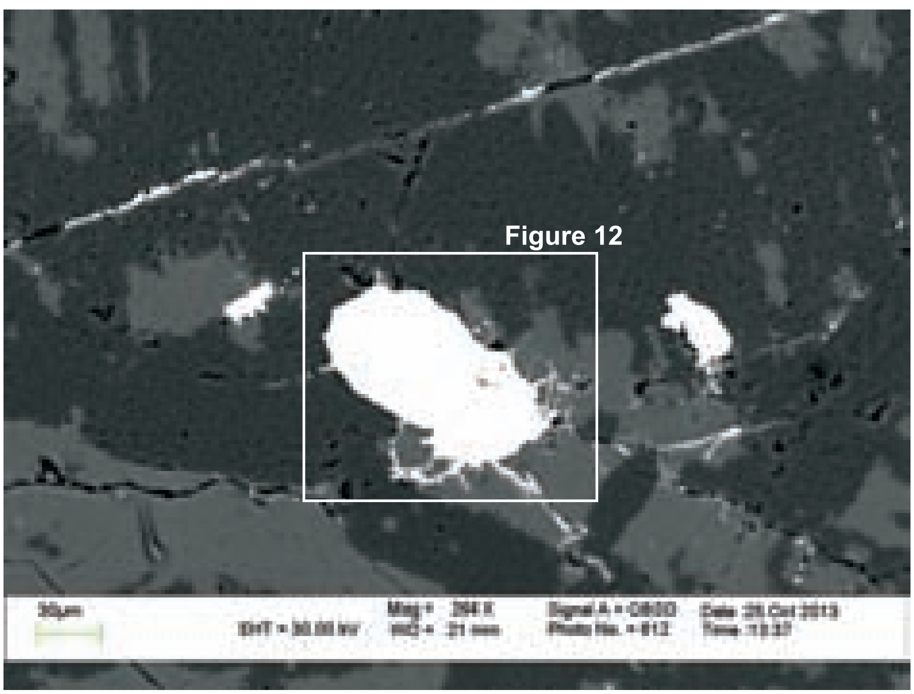
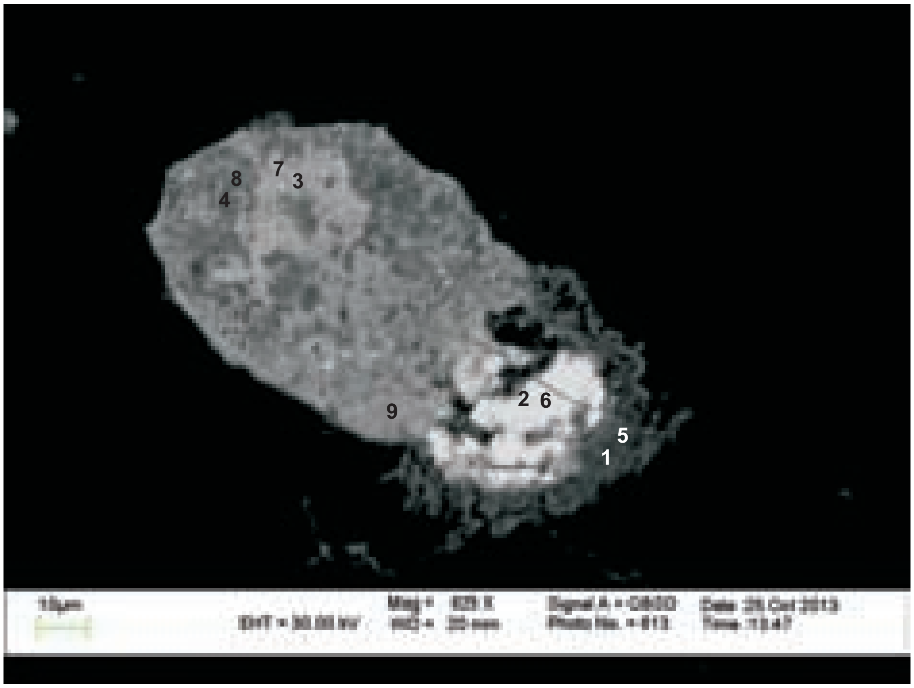
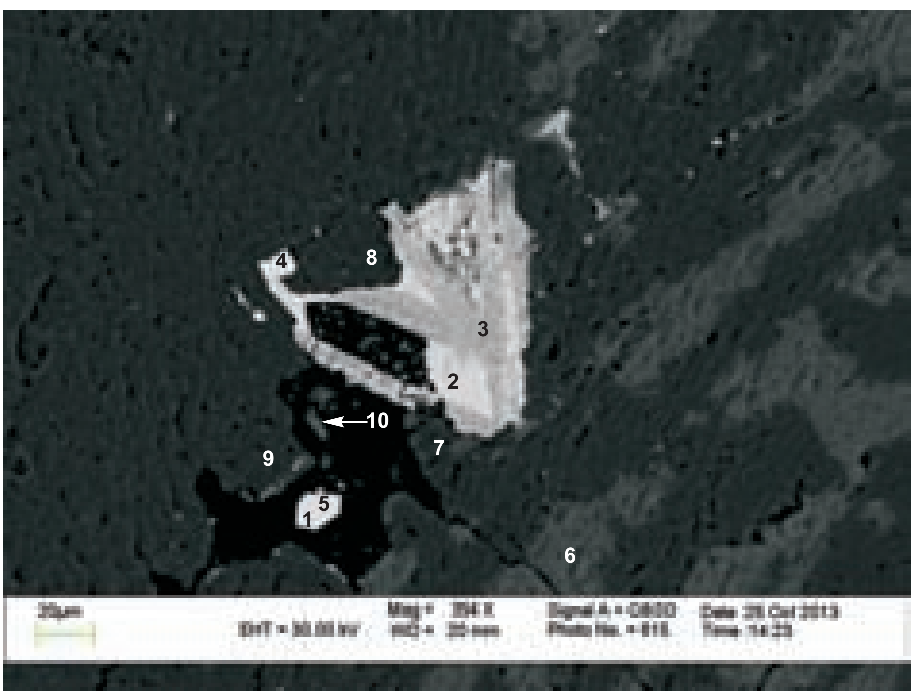


Figure 2-1.11: sample 9873 site 16.



1:Fe-oxide(+other)
2:Thorite
3:Zircon
4:Zircon
5:Mix(Fe-oxide+feldspar)
6:Mix(Thorite+Fe-oxide)
7:Zircon
8:Zircon
9:Zircon

Figure 2-1.12: sample 9873 site 16; probably a composite crystal of zircon (analyses 7,8,&9) and thorite (analysis 2) with both minerals highly affected by hydrothermal activity (analyses 1,5,&6).



1:Aeschynite-euxenite
2:Fe-oxide(+other)
3:TiO_2
4:bad analysis
5:Aeschynite-euxenite
6:Alkali feldspar
7:bad analysis
8:bad analysis
9:Albite
10:bad analysis

Figure 2-1.13: sample 9873 site 21; Ti-magnetite (analysis 2) alters to TiO_2 (analysis 3).

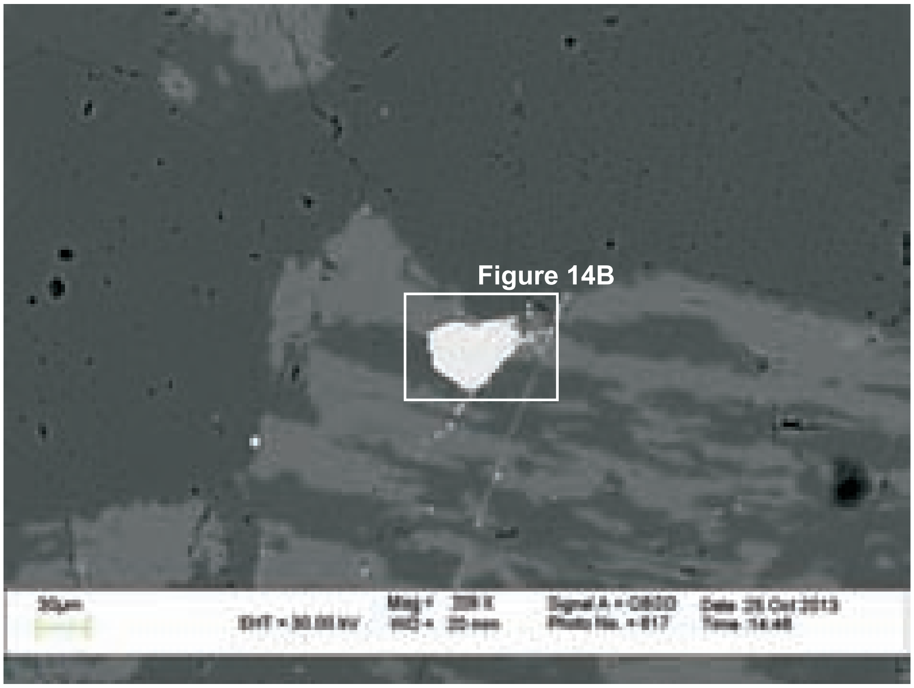
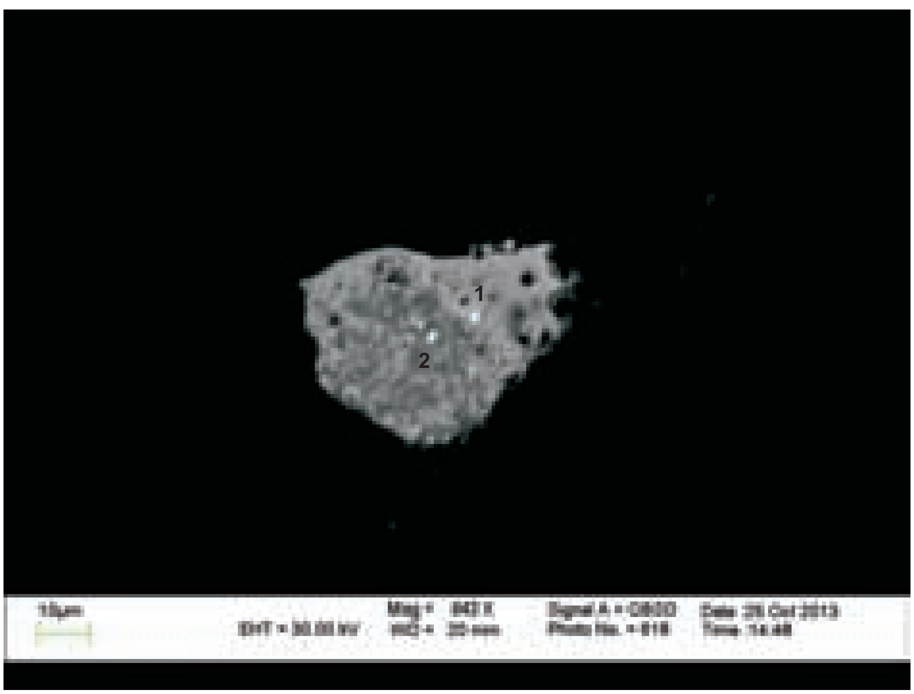
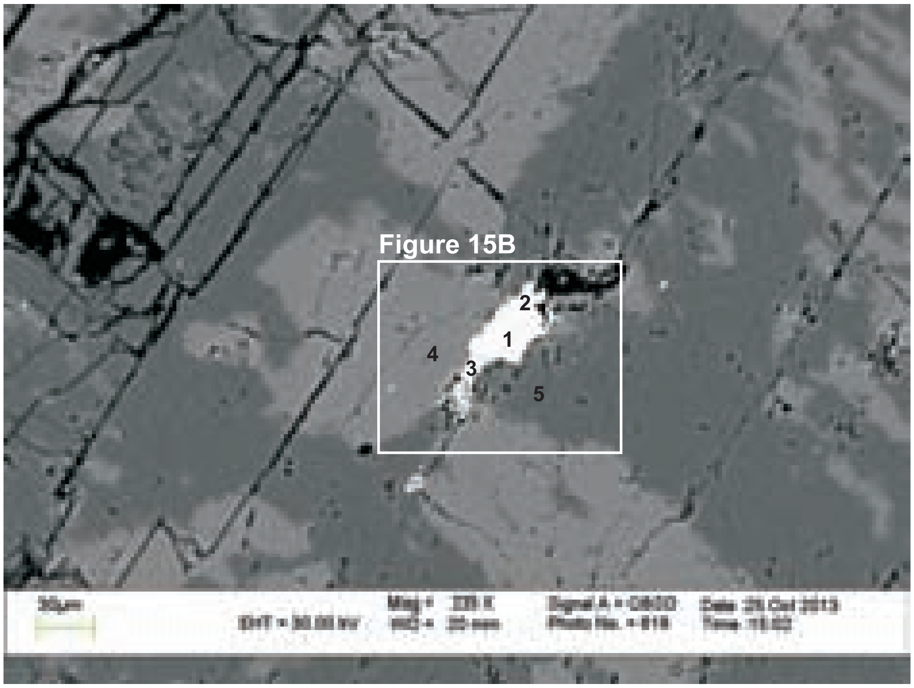


Figure 2-1.14A: sample 9873 site 22



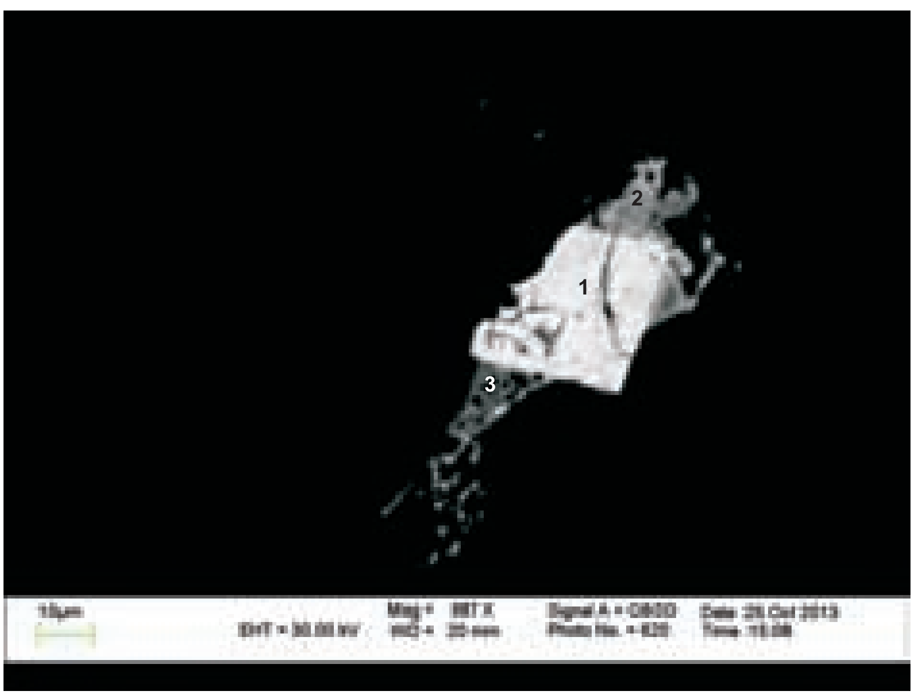
1:Zircon
2:Zircon

Figure 2-1.14B: sample 9873 site 22; zircon inclusion in perthite crystal (Figure 14A).



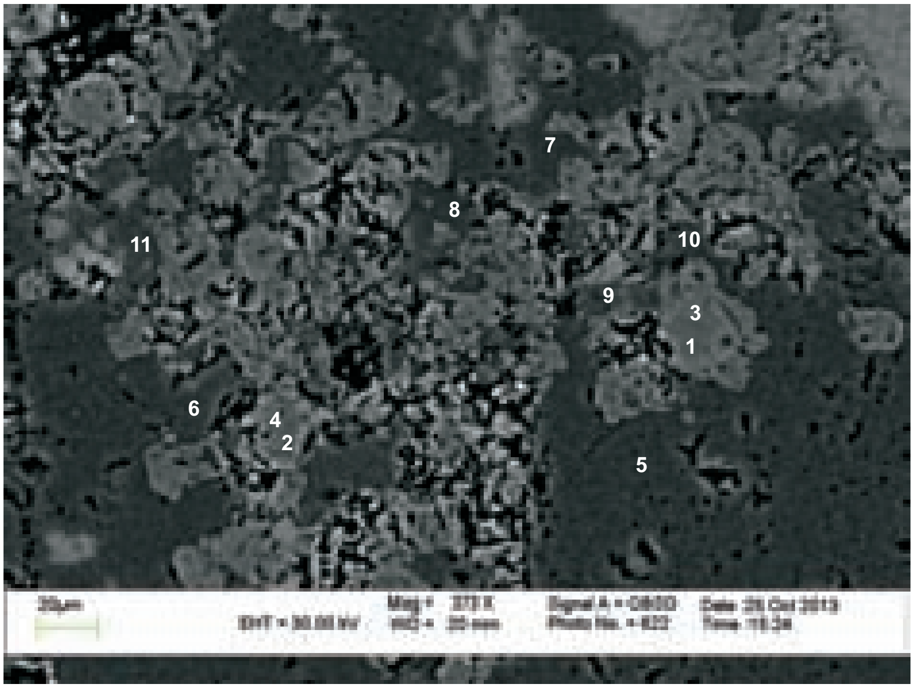
1:Xenotime
2:Fe-oxide(+others)
3:Fe-oxide(+others)
4:K-feldspar
5:Albite

Figure 2-1.15A: sample 9873 site 23; xenotime and Fe-oxide precipitate along feldspar cleavage. Xenotime contains 10% HREE’s, and postdates Fe-oxide (figure 15B).



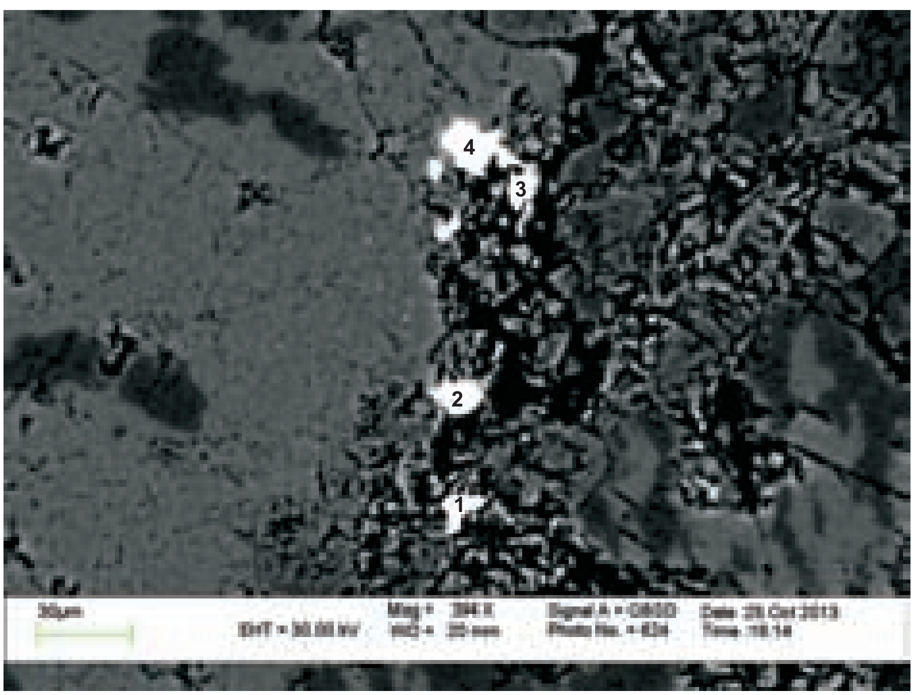
1:Xenotime
2:Fe-oxide(+others)
3:Fe-oxide(+others)

Figure 2-1.15B: sample 9873 site 23



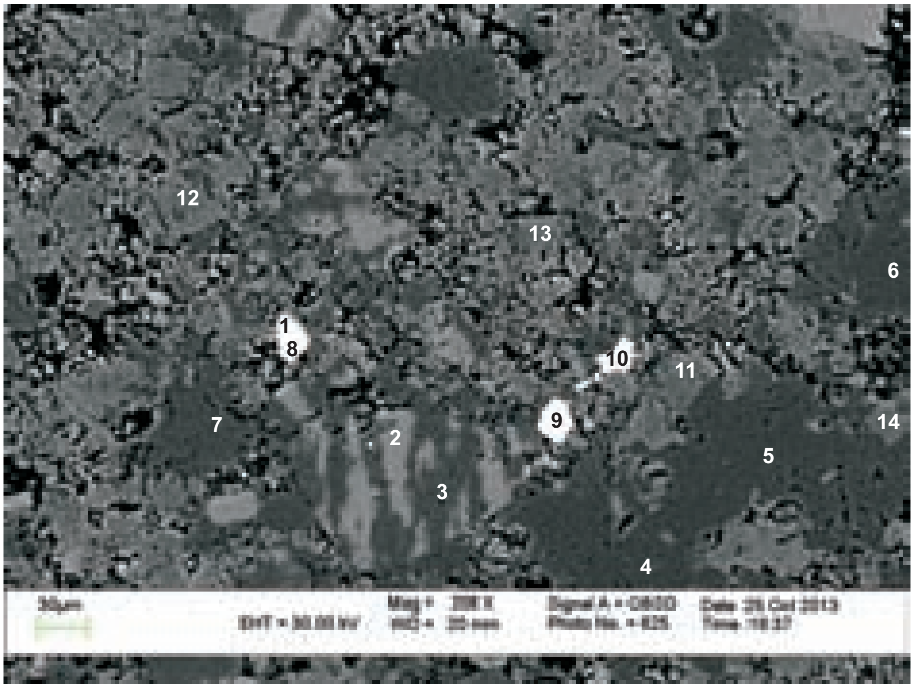
1:Tourmaline
2:Tourmaline
3:Tourmaline
4:Tourmaline
5:Quartz
6:Albite
7:Quartz
8:Quartz
9:K-feldspar
10:K-feldspar
11:K-feldspar

Figure 2-1.16: sample 9873 site 26; tourmaline (analyses 1,2,3&4) filling dissolution voids.



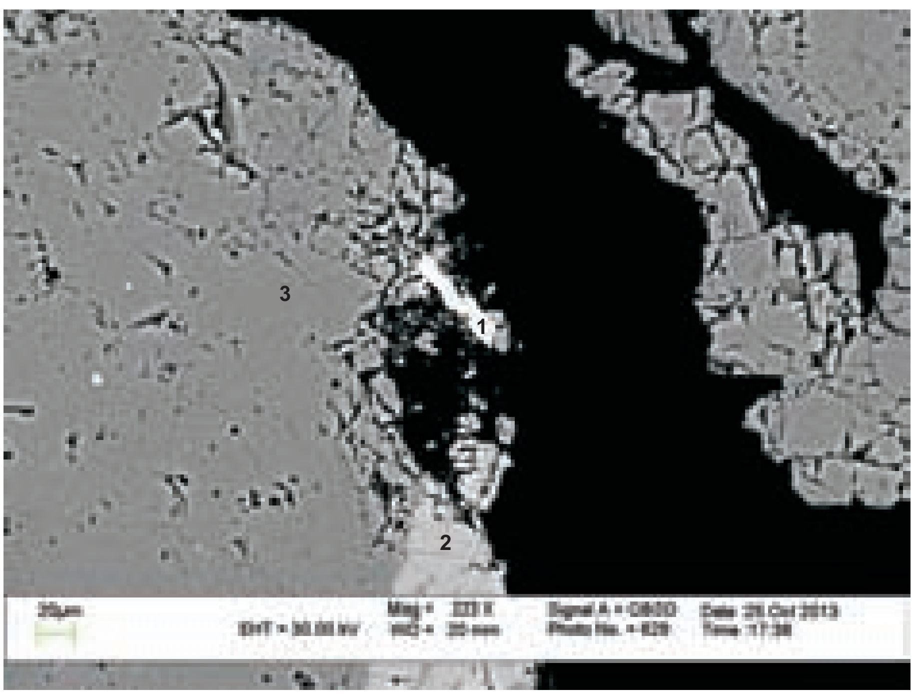
1:Zircon
2:Pyrochlore
3:Pyrochlore
4:Pyrochlore

Figure 2-1.17: sample 9873 site 28; pyrochlore filling dissolution voids.



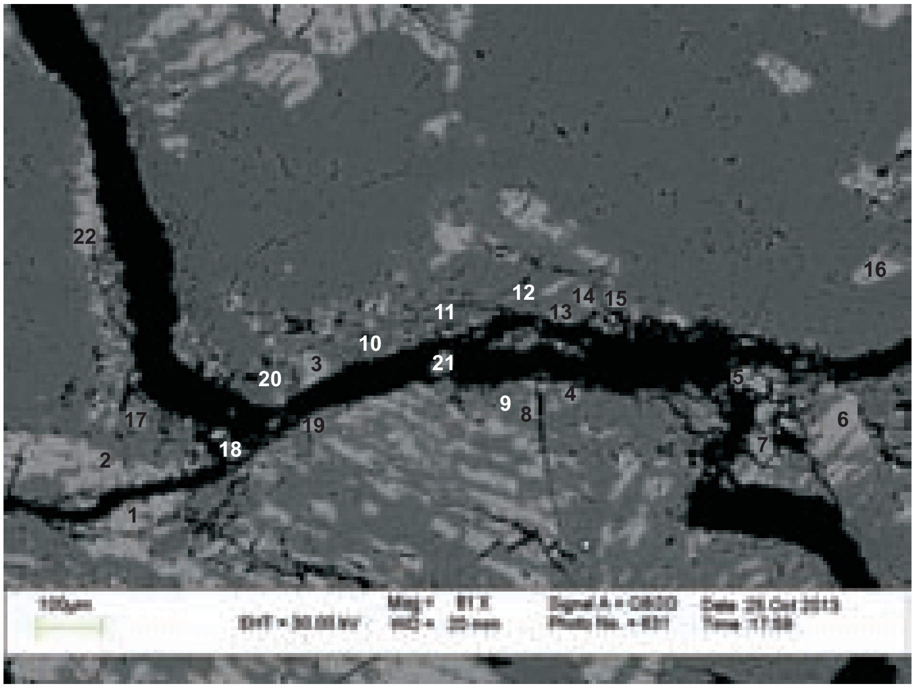
1:Zircon
2:K-feldspar
3:Albite
4:Quartz
5:Quartz
6:Quartz
7:Albite
8:Zircon
9:Zircon
10:Zircon
11:Tourmaline
12:Tourmaline
13:Tourmaline
14:Tourmaline

Figure 1-3.18: sample 9873 site 31; primary feldspar (2,3,&7) and tourmaline (analyses 11-14) are heavily fractured, whereas zircon seems to postdate the fracturing.



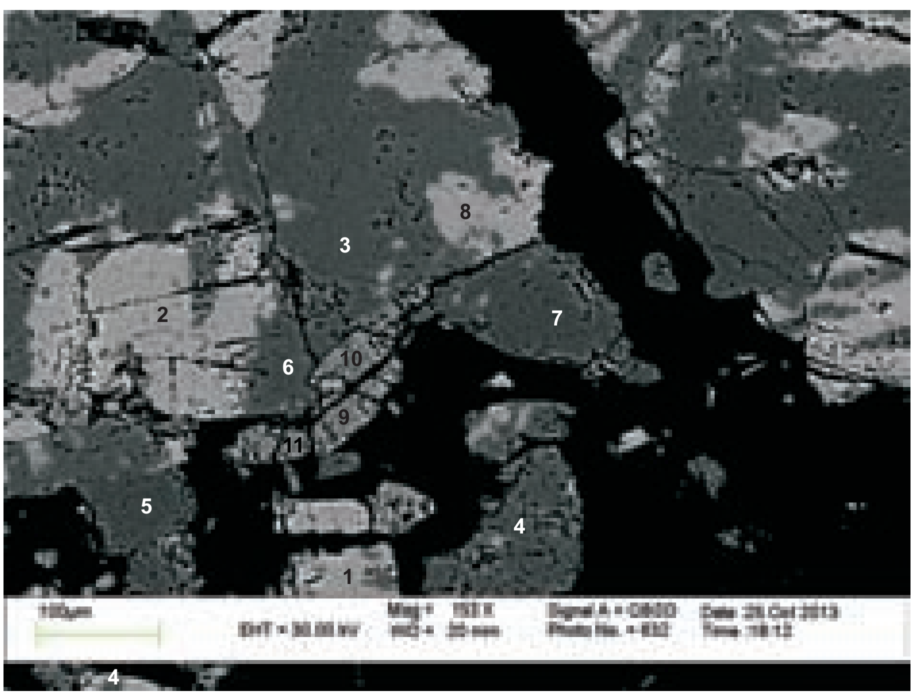
1:Fe-oxide(+others)
2:K-feldspar
3:Quartz

Figure 1-3.19: sample 9873 site 35; magnetite precipitates in fracture



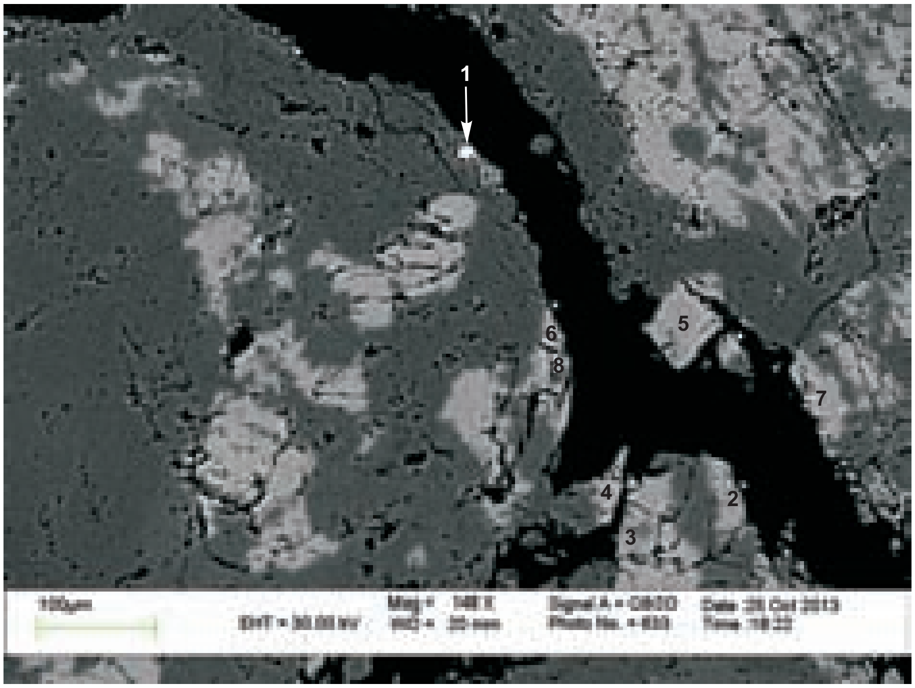
1:K-feldspar
2:K-feldspar
3:K-feldspar
4:K-feldspar
5:K-feldspar
6:K-feldspar
7:K-feldspar
8:K-feldspar
9:Albite
10:Albite
11:Albite
12:Albite
13:K-feldspar
14:K-feldspar
15:K-feldspar
16:K-feldspar
17:Alkali feldspar
18:Albite
19:K-feldspar
20:Quartz
21:K-feldspar
22:K-feldspar

Figure 1-3.20: sample 9873 site 38; fractures devoid of mineral precipitation.



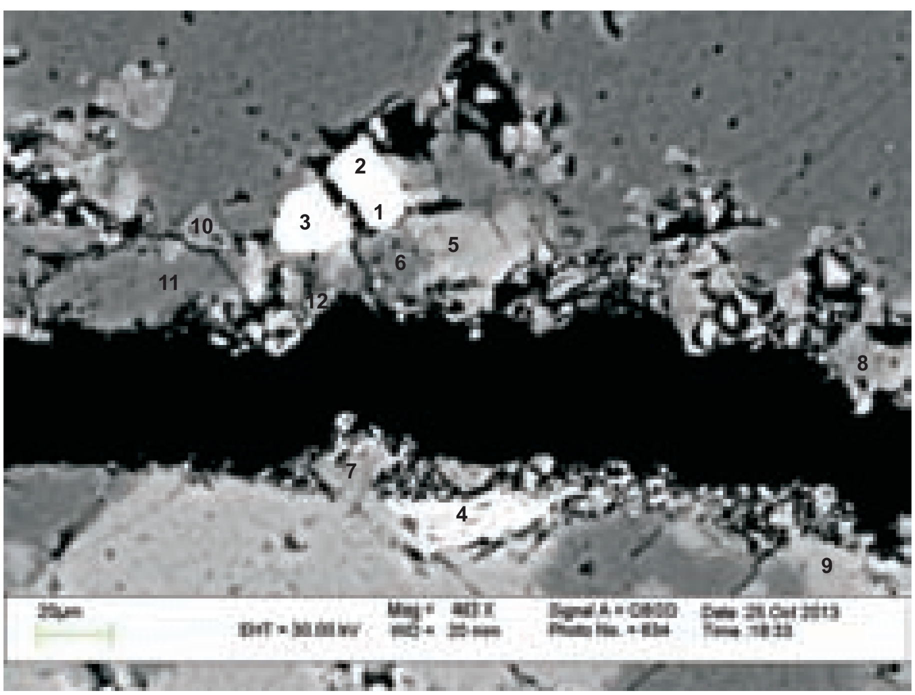
1:K-feldspar
2:K-feldspar
3:Albite
4:Albite
5:Quartz
6:Albite
7:Quartz
8:K-feldspar
9:Tourmaline
10:Tourmaline
11:Tourmaline

Figure 1-3.21: sample 9873 site 40; tourmaline (analyses 9-11) is cut by later fractures.



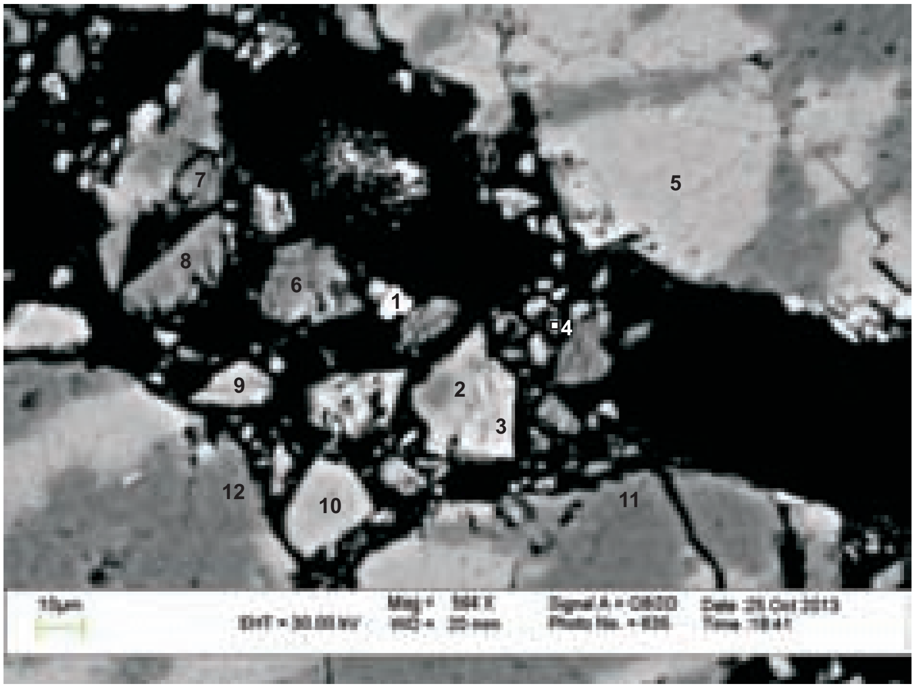
1:Thorite(+others)
2:K-feldpsar
3:K-feldpsar
4:K-feldpsar
5:K-feldpsar
6:K-feldpsar
7:K-feldpsar
8:K-feldpsar

Figure 1-3.22: sample 9873 site 41; fracture devoid of mineral precipitation, although thorite(analysis 1) seems to postdate fracturing.



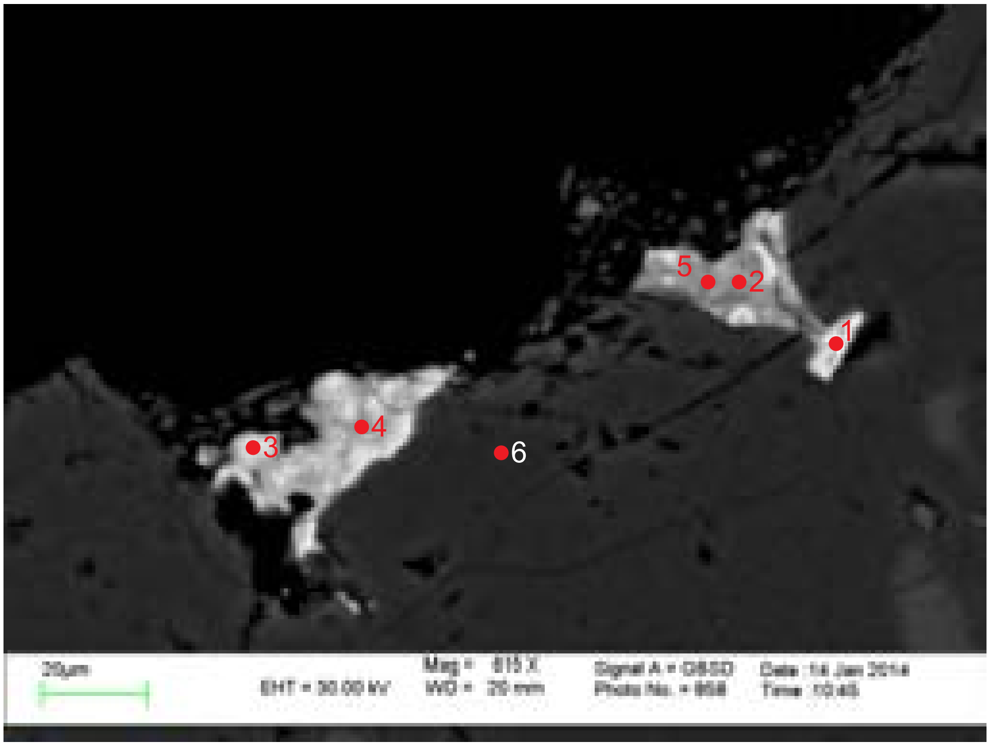
1:Zircon
2:Zircon
3:Zircon
4:Fe-chlorite
5:K-feldspar
6:Albite
7:Tourmaline
8:Tourmaline
9:K-feldspar
10:Tourmaline
11:Albite
12:Mix

Figure 1-3.23: sample 9873 site 42; zircon (analyses 1&2) enriched in Y(6-7%) and Yb (2%) and seems to fill porosity (analysis 2). Fracture is devoid of mineral precipitation.



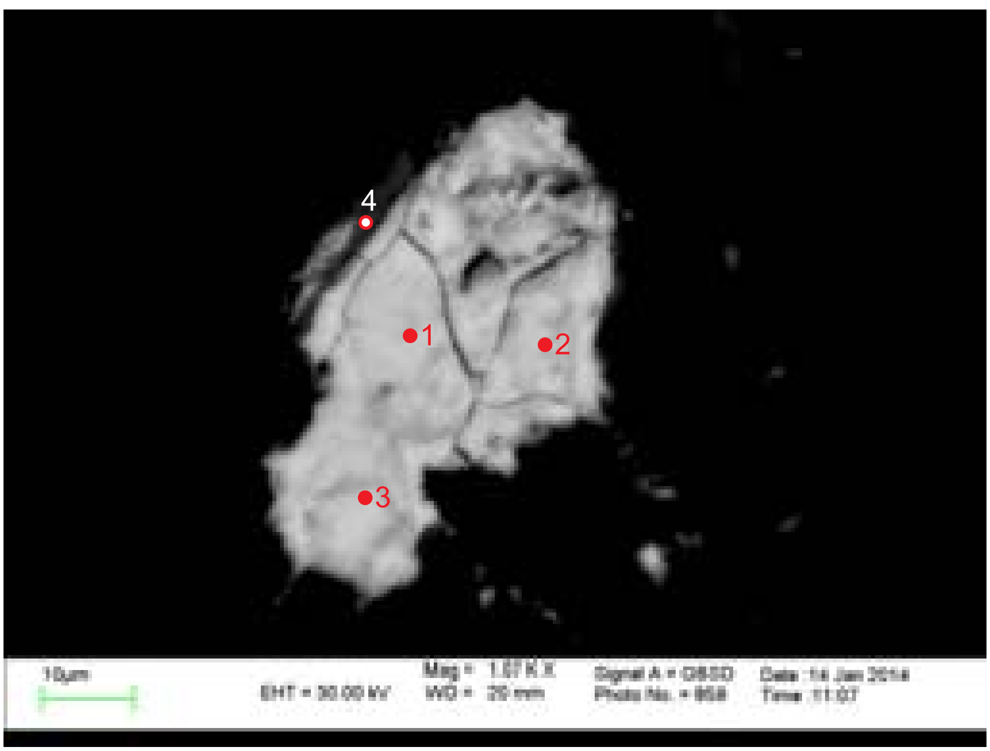
1:Xenotime(+others)
2:Mix
3:Mix
4:Quartz
5:K-feldspar
6:Albite
7:Alkali feldspar
8:Albite
9:Alkali feldspar
10:K-feldspar
11:Albite
12:Mix

Figure 1-3.24: sample 9873 site 44; highly fractured area.



1:Fe-oxide (+others)
2:Fe-oxide (+others)
3:Fe-oxide (+others)
4:Fe-oxide (+others)
5:Fe-oxide (+others)
6:Quartz

Figures 2-1.25: Sample 9873 site 1(EDS analysis b); the void wall is lined by mixtures of Fe-oxide and pyrochlore.



1:Pyrochlore
2:Pyrochlore
3:Pyrochlore
4:Chlorite/biotite

Figures 2-1.25: Sample 9873 site 2(EDS analysis b). Pyrochlore is fractured and infilled by later chlorite (analysis 4).

Table 2-1A: EDS analyses of sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	CoO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9873	3	1	Fe-oxide(+others)	11.51	1.38	5.76	70.36			0.38										10.6													99.99	113.56
9873	3	2	Fe-oxide(+SiO2)	1.8			98.21																										100.01	107.79
9873	3	3	Fe-oxide(+others)	1.63		0.93	97.44																										100	102.96
9873	3	4	Albite	72.69		16.42	0.49			0.42	9.77	0.22																					100.01	147.25
9873	3	5	K-feldspar	66.44		17.89					0.80	14.86																					99.99	146.56
9873	3	6	Albite	69.37		18.46					12.17																						100.00	147.82
9873	3	7	Fe-oxide(+others)	11.06	1.28	8.77	67.72			0.41				0.41						10.34													99.99	105.34
9873	3	8	Ilmenite	3.12	53.24	1.36	42.27																										99.99	117.58
9873	4	1	Fe-oxide(+SiO2)	6.33			93.68																										100.01	105.13
9873	4	2	Fe-oxide(+others)	27.53	0.93	5.14	57.85							0.32						8.21													99.98	108.68
9873	4	3	Fe-oxide(+others)	11.23	0.92	12.13	65.26			0.49				0.44						9.53													100.00	93.63
9873	4	4	Fe-oxide(+others)	9.71	1.57	9.66	67.58			0.45										11.04													100.01	98.53
9873	4	5	Fe-oxide(+others)	9.41	1.43	8.26	69.12			0.67										11.09													99.98	99.56
9873	4	6	Fe-oxide(+others)	7.02	1.52	6.71	73.09			0.43										11.23													100.00	109.86
9873	4	7	Fe-oxide(+others)	8.69	1.47	7.99	70.50			0.49										10.86													100.00	106.18
9873	4	8	Fe-oxide(+others)	10.70	1.47	7.31	69.06			0.35										11.13													100.02	106.00
9873	5	1	Zircon	29.41	0.60		9.74												58.62								1.62						99.99	152.72
9873	5	2	Zircon	32.88			3.78												61.43								1.90						99.99	130.70
9873	5	3	Mixture (Fe-oxide + Ilmenite)	2.05	33.16	0.66	63.45				0.69																						100.01	117.69
9873	5	4	Ilmenite	2.42	43.40	0.70	53.47																										99.99	115.90
9873	5	5	Mixture (Fe-oxide + Ilmenite)	7.06	49.27	4.88	30.77	0.67		0.21	0.92									6.21													99.99	119.66
9873	5	6	Fe-oxide(+others)	4.32	4.72	3.63	75.92			0.28										10.07	1.04												99.98	107.97
9873	5	7	Zircon	30.25	0.58	0.81	9.44											1.51	55.49								1.90						99.98	142.48
9873	5	8	Aeschynite-Euxenite	10.18	15.36	8.79	7.11			1.40					0.95			7.81		33.87								2.04		12.49			100.00	98.37
9873	5	9	Fe-oxide(+others)	2.80	0.73	2.34	94.11																										99.98	103.20
9873	5	10	Mix (Fe-oxide + Qz)	39.62	6.89		53.49																										100.00	141.51
9873	5	11	Fe-oxide(+others)	1.88	7.17	0.83	87.88													2.22													99.98	110.64
9873	5	12	Mix	5.86	18.77	4.02	54.74			0.39								1.96		10.71	0									3.56			100.01	112.22
9873	5	13	Fe-oxide(+others)	4.94	4.97	4.21	73.78													10.83	1.27												100.00	108.48
9873	5	14	Aeschynite-Euxenite	11.04	16.65	7.84	7.81			1.16								6.62		31.57	0				1.77			2.08		11.63	1.84		100.01	109.07
9873	7	1	Pyrochlore	9.95	20.30	3.95	4.97			1.58					0.92			9.79		35.93								2.30		10.32			100.01	104.09
9873	7	2	Pyrochlore	9.22	18.40	4.52	5.04			1.36					0.69			8.24	3.42	34.28								2.26		10.01	2.60		100.04	118.38
9873	7	3	Quartz	99.99																													99.99	158.71
9873	7	4	Quartz	99.99																													99.99	149.32
9873	7	5	Quartz	99.99																													99.99	157.06
9873	7	6	Chlorite (+pyro)	49.80	2.15	16.51	18.08		7.18	0.29		1.04								4.94													99.99	131.09
9873	7	7	Chlorite (+pyro)	44.41	3.47	16.76	18.31		7.28	0.32		0.87								7.27	1.32												100.01	126.30
9873	9	1	K-feldspar	66.25		17.99					0.43	15.33																					100.00	169.72
9873	9	2	Albite	69.20		18.76	0.21				11.85																						100.02	178.59
9873	9	3	Albite	68.90		18.99					11.86	0.24																					99.99	174.21
9873	9	4	K-feldspar	66.66		17.84					0.44	15.04																					99.98	167.06

* If we consider B_2O_3 as an analytical artifact

Table 2-1A: EDS analyses of sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	CoO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9873	9	5	Albite	68.86		18.91	0.73				11.49																						99.99	165.42
9873	9	6	Mix(Albite + other)	45.03	0.32	35.09	9.58		6.70	0.43	2.84																						99.99	149.39
9873	9	7	K-feldspar	67.04		18.29					0.98	13.68																					99.99	172.55
9873	10	1	Zircon	31.90			0.35												65.76								2.00						100.01	175.79
9873	10	2	Zircon	31.23			1.05											4.11	58.25							1.46	2.00			1.87			99.97	153.18
9873	10	3	Zircon	31.96			0.57												65.28								2.19						100.00	167.78
9873	10	4	Zircon	31.49			2.46			0.35					0.31			4.13	58.25							1.24	1.77						100.00	147.82
9873	10	5	Thorite(+Zircon)	28.00	0.50	3.59	1.62			0.36					0.51			7.23	38.61							1.99				17.58			99.99	122.96
9873	11	1	Thorite(+Zircon)	24.02	0.63	2.74	3.94			0.70								7.24	22.36							1.76				36.62			100.01	140.97
9873	11	2	Mix(Thorite+Zircon)	21.52		3.21	4.59			0.50								7.56	24.38						1.43	1.71				35.09			99.99	130.51
9873	11	3	Zircon	31.02			1.16			0.39								7.24	54.84		1.51					1.56	2.25						99.97	139.07
9873	11	4	Mix(Thorite+Zircon)	22.97	0.57	3.63	4.13			0.42					0.51			7.40	25.15							1.96				33.26			100.00	128.71
9873	11	5	Zircon	32.71		0.53													62.66								4.08						99.98	173.14
9873	11	6	Zircon	30.57		1.47	1.08			0.43								4.65	56.19							1.47	2.34			1.81			100.01	150.75
9873	11	7	Zircon	32.39		0.36	0.30												63.23								3.73						100.01	182.19
9873	11	8	Zircon	31.70			0.69	0.23										1.28	63.77								2.30						99.97	172.63
9873	11	9	Zircon	32.05		0.36	0.68												64.43								2.46						99.98	171.99
9873	11	10	Mix(Thorite+Zircon)	27.62	0.50		2.05			0.45					0.56			8.53	31.68							2.32	1.59			24.70			100.00	130.24
9873	11	11	Mix(Thorite+Zircon)	27.77	0.47	4.88	2.34			0.45					0.43			7.42	32.00							2.08	1.39			20.79			100.02	130.76
9873	12	1	Zircon	32.60															62.88								4.52						100.00	163.99
9873	12	2	Zircon	32.07			0.58												64.46								2.89						100.00	159.97
9873	12	3	K-feldspar	66.46		17.86	0.62				0.58	14.48																					100.00	164.91
9873	12	4	Quartz	99.62			0.37																										99.99	164.33
9873	12	5	Albite	68.65		18.82					12.07	0.47																					100.01	164.77
9873	12	6	K-feldspar	66.66		17.84	0.33				0.50	14.68																					100.01	156.28
9873	12	7	Albite(+Fe)	67.15	0.47	19.27	2.97				9.91	0.20																					99.97	120.07
9873	12	8	Albite	68.41		18.76	0.14			0.15	12.39	0.14																					99.99	171.29
9873	12	9	Albite	69.22		19.10					11.46	0.23																					100.01	142.47
9873	12	10	Quartz	99.99																													99.99	157.04
9873	12	11	Fe-oxide(+others)	5.50	5.69	5.95	73.43													9.44													100.01	115.01
9873	12	12	Fe-oxide(+others)	6.80	5.82	5.69	71.72													8.78	1.19												100.00	116.49
9873	12	13	Mix	22.12	4.64	6.24	56.50				1.89									7.27										1.37			100.03	131.49
9873	13	1	Thorite+Zircon	27.30			1.43			0.57								2.17	43.23								1.98			19.54	3.77		99.99	157.33
9873	13	2	Thorite+Zircon	28.60			2.42			0.28								1.38	50.55		0						2.51			11.82	2.44		100.00	156.95
9873	13	3	Zircon	31.90		2.02	1.13					0.43							54.88		4.35						2.44				2.86		100.01	149.20
9873	13	4	Zircon	28.67	1.02		9.34			0.56								3.81	52.30		1.30					1.06	1.95						100.01	134.98
9873	13	5	Zircon	29.07	0.78	0.85	7.99			0.25								2.63	55.69		1.15						1.58						99.99	135.88
9873	13	6	Zircon	32.41															63.50								4.10						100.01	165.39
9873	13	7	Zircon	32.64															63.03								4.34						100.01	162.31
9873	14	1	Mix(Fe-oxide + others)	13.33	5.84	20.07	49.21			0.27	0.97			0.37						8.81	1.15												100.02	103.86
9873	14	2	K-feldspar	67.00		17.74					0.61	14.66																					100.01	154.84
9873	14	3	Albite	68.71		18.88	0.18				12.24																						100.01	158.81

* If we consider B_2O_3 as an analytical artifact

Table 2-1A: EDS analyses of sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	CoO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9873	14	4	K-feldspar	66.72		17.97					0.51	14.79																					99.99	152.73
9873	14	5	Mix(Fe-oxide + others)	13.84	5.62	21.47	48.33							0.41						9.24	1.10												100.01	99.50
9873	14	6	Mix(Fe-oxide + others)	17.88	4.99	19.25	47.54							3.47						6.87													100.00	38.12
9873	16	1	Fe-oxide(+others)	5.22	3.02	3.61	82.19					0.45								4.74	0.81												100.04	106.93
9873	16	2	Thorite	18.29		5.97	8.77			0.46	0.84							1.94		10.33										53.38			99.98	107.81
9873	16	3	Zircon	28.86		0.43	0.98												51.92								1.42			2.15	1.54		87.30	130.84
9873	16	4	Zircon	32.26			0.40											1.57	60.48		1.46						1.79				2.04		100.00	154.39
9873	16	5	Mix(Fe-oxide + feldspar)	31.60	1.80	10.75	47.75				4.22	3.67		0.20																			99.99	127.30
9873	16	6	Mix(Thorite + Fe-oxide)	9.60	1.90	4.88	61.21													5.79										16.60			99.98	108.14
9873	16	7	Zircon	30.89		0.77	7.68			0.24									59.00								1.40						99.98	138.17
9873	16	8	Zircon	32.75			0.53												61.41		1.77						1.42				2.11		99.99	144.00
9873	16	9	Zircon	27.49		3.91	16.60			0.34	0.67							2.04	32.72		0						1.62			13.54	1.07		100.00	117.41
9873	21	1	Aeschynite-Euxenite*	3.34	3.90		2.50			0.62								3.68		13.69	1.10										1.01	70.22	100.06	270.21
9873	21	2	Fe-oxide(+others)	6.76	9.47	3.89	68.42													11.46													100.00	109.03
9873	21	3	TiO_2	2.14	67.02	1.13	25.68													4.05													100.02	122.64
9873	21	4	bad analysis	66.06		17.99	1.33			0.18	12.90		1.54																				100.00	150.72
9873	21	5	Aeschynite-Euxenite	20.09	4.47	29.99	5.27	0.94		1.51	1.00			0.83				4.22		26.24	2.12	3.33											100.01	66.67
9873	21	6	Alkali feldspar	67.06		18.27					6.96	7.70																					99.99	168.55
9873	21	7	bad analysis	30.50	47.66	10.11	3.15				1.94	3.93								2.72													100.01	152.82
9873	21	8	bad analysis	2.01	93.16	1.00	3.83																										100.00	119.79
9873	21	9	Albite	77.93		11.05	1.30			0.80	6.16			2.75																			99.99	51.29
9873	21	10	bad analysis	67.43	0.28	2.82	0.24	0.23	4.86	4.46	17.22	0.24		2.20																			99.98	88.82
9873	22	1	Zircon	33.37		1.38	0.94					0.61							60.50								1.97			1.23			100.00	159.39
9873	22	2	Zircon	31.51			3.05												62.10								1.36				1.99		100.01	146.26
9873	23	1	Xenotime	6.78									46.65					29.67	4.35				1.42	3.51	3.30	10.00							100.00	124.31
9873	23	2	Fe-oxide(+others)	5.65	10.16	3.12	69.74	0.32		0.35										9.14	1.51												99.99	113.61
9873	23	3	Fe-oxide(+others)	9.58	5.27	7.27	61.42			0.43	1.17	0.35								13.59	0.90												99.98	110.99
9873	23	4	K-feldspar	67.19		17.95					0.81	14.03																					99.98	177.83
9873	23	5	Albite	68.71		18.99				0.20	12.09																						99.99	182.08
9873	26	1	Tourmaline	38.95	0.37	29.57	7.56		5.72	0.39	2.46																						85.00	156.00
9873	26	2	Tourmaline	39.09	0.19	30.66	7.33		5.33	0.25	2.17																						85.00	151.54
9873	26	3	Tourmaline	39.20	0.45	29.20	7.45		5.71	0.48	2.26	0.25																					85.00	156.02
9873	26	4	Tourmaline	38.84	0.45	29.68	7.45		5.70	0.35	2.52																						85.00	154.37
9873	26	5	Quartz	99.99																													99.99	182.56
9873	26	6	Albite	68.56		18.56					11.81	1.06																					99.99	187.83
9873	26	7	Quartz	93.40		4.16	1.89		0.55																								100.00	180.51
9873	26	8	Quartz	91.56		5.84	1.24		0.66		0.71																						100.01	167.39
9873	26	9	K-feldspar	67.51		18.71	0.35				10.69	2.76																					100.02	189.22
9873	26	10	K-feldspar	66.40		19.14	0.40				10.73	3.34																					100.01	184.56
9873	26	11	K-feldspar	67.81		19.07	0.36			0.24	12.12	0.40																					100.00	183.50
9873	28	1	Zircon	31.72		1.47	0.50											1.31	62.97								2.02						99.99	181.34
9873	28	2	Pyrochlore	12.98	19.03	8.71	4.72			0.91	1.25							4.78	3.26	29.64								1.84		9.76	3.12		100.00	140.44

* If we consider B_2O_3 as an analytical artifact

Table 2-1A: EDS analyses of sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	CoO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9873	28	3	Pyrochlore	28.60	10.03	17.80	7.28		2.30	1.20	1.23			0.37				4.06		18.70										6.10	2.32		99.99	88.87
9873	28	4	Pyrochlore	11.53	21.20	6.65	4.85			0.98							0.73	4.99	3.13	30.26								2.15		9.68	3.85		100.00	136.93
9873	31	1	Zircon	31.02		2.36	0.40											2.12	62.81								1.27						99.98	174.90
9873	31	2	K-feldspar	66.10		18.18	0.78				0.53	14.39																					99.98	186.00
9873	31	3	Albite	68.90		19.08					11.26	0.76																					100.00	191.26
9873	31	4	Quartz	98.45		1.53																										99.98	183.05
9873	31	5	Quartz	99.99																												99.99	192.01
9873	31	6	Quartz	99.99																												99.99	193.53
9873	31	7	Albite	68.56		19.08					12.36																						100.00	191.91
9873	31	8	Zircon	32.54		1.51	0.35											1.59	62.65								1.34						99.98	188.79
9873	31	9	Zircon	32.39		0.70	0.27												65.37								1.27						100.00	185.17
9873	31	10	Zircon	33.88		3.21	0.66				0.86							1.80	58.11								1.45						99.97	154.83
9873	31	11	Touramline	39.15		31.42	6.66		5.46	0.18	2.15																						85.00	163.49
9873	31	12	Touramline	39.62		31.38	6.17		5.68	0	2.15																						85.00	156.98
9873	31	13	Touramline	39.24	0.17	30.34	6.95		5.78	0.25	2.27																						85.00	156.72
9873	31	14	Touramline	39.35		31.38	6.90		5.12	0.12	2.13																						85.00	169.56
9873	35	1	Fe-oxide(+others)	11.00		1.47	87.53																									100.00	114.12
9873	35	2	K-feldspar	66.83		18.16					0.65	14.36																					100.00	164.02
9873	35	3	Quartz	99.99																												99.99	164.48
9873	38	1	K-feldspar	66.79		17.89					0.75	14.56																					99.99	171.44
9873	38	2	K-feldspar	67.41		18.46					2.20	11.94																					100.01	168.50
9873	38	3	K-feldspar	66.87		17.89						15.24																					100.00	173.14
9873	38	4	K-feldspar	66.42		18.54	0.26				0.57	14.24																					100.03	186.04
9873	38	5	K-feldspar	67.11		16.53	0.54					15.82																					100.00	140.27
9873	38	6	K-feldspar	67.06		17.86					0.53	14.55																					100.00	202.95
9873	38	7	K-feldspar	67.19		18.22						14.24		0.34																			99.99	159.46
9873	38	8	K-feldspar	66.53		18.18					0.59	14.70																					100.00	183.71
9873	38	9	Albite	68.37		19.03	0.30			0.28	12.04																						100.02	198.42
9873	38	10	Albite	69.46		18.61					11.49	0.45																					100.01	174.07
9873	38	11	Albite	67.83		18.73					10.41	3.04																					100.01	186.85
9873	38	12	Albite	68.30		19.67	0.28				11.74																						99.99	198.24
9873	38	13	K-feldspar	67.45		18.01						14.55																					100.01	188.18
9873	38	14	K-feldspar	67.58		18.39					1.97	12.07																					100.01	190.71
9873	38	15	K-feldspar	75.51		13.30	0.28					10.91																					100.00	186.28
9873	38	16	K-feldspar	66.89		18.31					1.23	13.58																					100.01	201.73
9873	38	17	Alkali feldspar	67.88		18.27					8.49	5.36																					100.00	182.43
9873	38	18	Albite	68.63		18.74					11.22	1.41																					100.00	182.64
9873	38	19	K-feldspar	67.21		17.80						15.00																					100.01	174.89
9873	38	20	Quartz	99.99																												99.99	177.42
9873	38	21	K-feldspar	66.85		18.12					0.80	14.23																					100.00	187.04
9873	38	22	K-feldspar	66.40		18.18					1.04	14.39																					100.01	156.63
9873	40	1	K-feldspar	66.02		18.14					1.05	14.77																					99.98	180.53
9873	40	2	K-feldspar	66.91		17.97						15.10																					99.98	174.94
9873	40	3	Albite	69.12		18.95					11.95																						100.02	183.85

* If we consider B_2O_3 as an analytical artifact

Table 2-1A: EDS analyses of sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cl	CoO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9873	40	4	Albite	69.40		18.97					11.65																						100.02	189.48
9873	40	5	Quartz	99.99																													99.99	177.38
9873	40	6	Albite	68.82		19.27					11.92																						100.01	185.27
9873	40	7	Quartz	99.99																													99.99	186.15
9873	40	8	K-feldspar	66.68		18.10					0.57	14.64																					99.99	182.80
9873	40	9	Tourmaline	38.90		31.14	7.82		4.88		2.28																						85.00	156.87
9873	40	10	Tourmaline	39.11		30.10	7.43		6.02	0.20	2.12																						85.00	156.42
9873	40	11	Tourmaline	39.35		29.84	8.08		5.23	0.25	2.27																						85.00	154.26
9873	41	1	Thorite(+others)	32.11	5.29	7.22	35.66							1.11																18.63			100.02	87.28
9873	41	2	K-feldspar	66.46		18.91	0.22				2.51	11.89																					99.99	190.51
9873	41	3	K-feldspar	67.02		18.18					0.81	14.00																					100.01	189.10
9873	41	4	K-feldspar	67.09		18.01						14.89																					99.99	163.97
9873	41	5	K-feldspar	66.49		17.95					0.67	14.89																					100.00	185.90
9873	41	6	K-feldspar	66.25		18.03					1.42	14.32																					100.02	174.14
9873	41	7	K-feldspar	66.72		17.78	0.54					14.94																					99.98	192.80
9873	41	8	K-feldspar	67.32		18.12					1.78	12.43		0.35																			100.00	158.64
9873	42	1	Zircon	31.38			2.34				0.86							5.88	56.10		1.33					2.10							99.99	119.68
9873	42	2	Zircon	30.48			4.54			0.63	0.51				0.52			6.96	51.20		1.48					1.95	1.71						99.98	115.16
9873	42	3	Zircon	30.76			3.16			0.45		0.29						1.79	61.99								1.54						99.98	147.98
9873	42	4	Fe-Chlorite	33.26		26.66	31.79	0.17	7.61					0.16		0.35																	100.00	150.48
9873	42	5	K-feldspar	67.09		17.93						14.98																					100.00	183.89
9873	42	6	Albite	68.78		18.74	0.27			0.22	12.00																						100.01	195.55
9873	42	7	Tourmaline	39.41		30.35	7.63		5.10	0.29	2.24																						85.00	154.25
9873	42	8	Tourmaline	40.59		30.29	6.48		5.20	0.25	2.20																						85.00	169.82
9873	42	9	K-feldspar	66.96		18.14						14.90																					100.00	185.21
9873	42	10	Tourmaline	41.57		29.67	7.06		4.65		2.07																						85.00	163.59
9873	42	11	Albite	69.63		18.76					11.62																						100.01	185.30
9873	42	12	Mix	59.96		25.66	3.63		2.92	0.34	6.35	0.88		0.27																			100.01	156.71
9873	44	1	Xenotime(+others)	38.14		14.46	2.07		1.13		5.30	1.04	17.92	6.45	0.67			12.85															100.03	143.27
9873	44	2	Mix	55.64		26.55	5.06		1.39		0.32	10.85		0.20																			100.01	37.27
9873	44	3	Mix	61.59	0.30	22.54	5.47		2.52		2.02	4.49		1.06																			99.99	186.66
9873	44	4	Quartz	95.79		2.68	0.63		0.55			0.20		0.14																			99.99	119.50
9873	44	5	K-feldspar	66.81		17.89					0.61	14.70																					100.01	183.85
9873	44	6	Albite	69.01		18.78	0.26				11.39	0.54																					99.98	191.76
9873	44	7	Alkali feldspar	64.15		18.46	1.18		0.78		9.65	4.31		1.46																			99.99	189.30
9873	44	8	Albite	69.44		18.71	0.13				11.38	0.34																					100.00	108.96
9873	44	9	Alkali feldspar	62.85		19.88	2.30		0.51		4.99	8.62		0.85																			100.00	180.87
9873	44	10	K-feldspar	63.60		18.97	1.93				0.40	14.65		0.46																			100.01	126.95
9873	44	11	Albite	71.86		17.23	0.17			0.17	10.58																						100.01	134.45
9873	44	12	Mix	58.27		24.49	5.58		2.4	0.5	3.75	0.95		4.04																			99.98	203.51

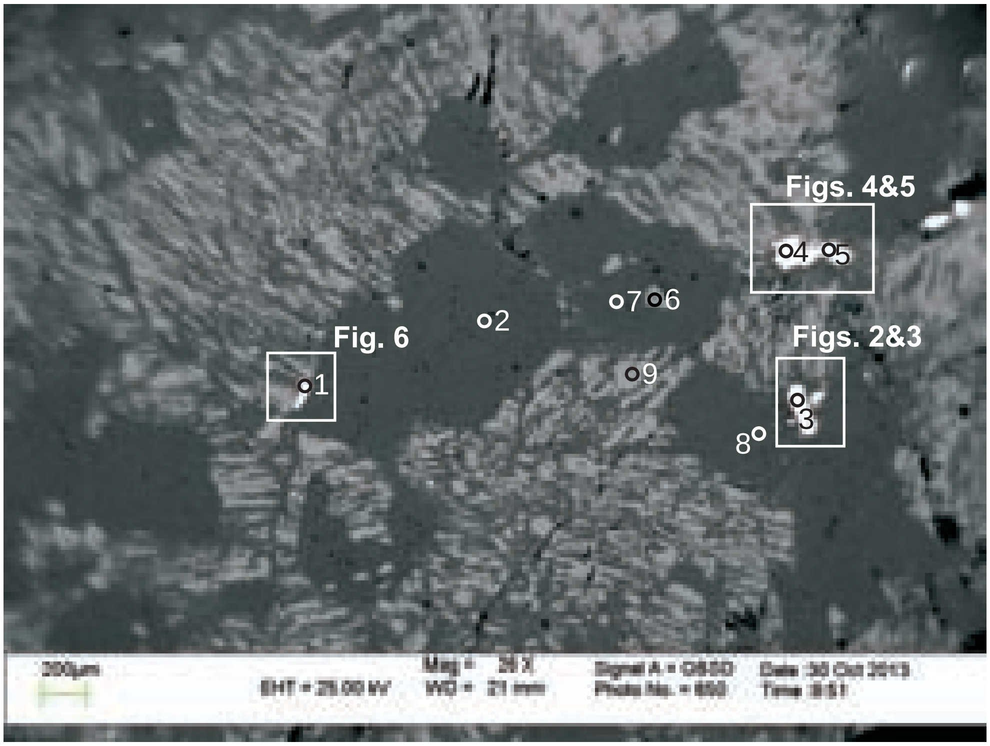
* If we consider B_2O_3 as an analytical artifact

Table 2-1B: EDS analyses from sample 9873

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MgO	CaO	K_2O	F	Cl	CoO	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Er_2O_3	Yb_2O_3	Ta_2O_5	ThO_2	UO_3	B_2O_3	Total
9873	1	1	Fe-oxide (+others)	7.36		0.89	91.75																	100
9873	1	2	Fe-oxide (+others)	9.69	1.03	11.68	67.67		0.36			0.27				9.3								100
9873	1	3	Fe-oxide (+others)	7.85	1.4	5.82	74.04		0.43							10.46								100
9873	1	4	Fe-oxide (+others)	7.44	1.43	9.28	70.99		0.28							10.59								100.01
9873	1	5	Fe-oxide (+others)	14.65	0.87	10.51	63.45		0.5			0.49				9.53								100
9873	1	6	Quartz	99.81			0.18																	99.99
9873	2	1	Pyrochlore	10.44	17.26	3.44	4.76		1.33		3.89			8.51	3.09	32.13		2.12		2.21	10.81			99.99
9873	2	2	Pyrochlore*	3.55	10.83	1.8	2.89		0.48		1.48			4.45		14.21		1.02		1.1	4.11		54.15	100.07
9873	2	3	Pyrochlore	9.97	21.53		4.81		1.67				0.92	10.74		35.32			1.56	2.5	8.3	2.73		100.05
9873	2	4	Chlorite (+pyro)	34.4	2.839	14.92	16.46	7.02	0.3	0.37				1.08		6.409	1.22							85

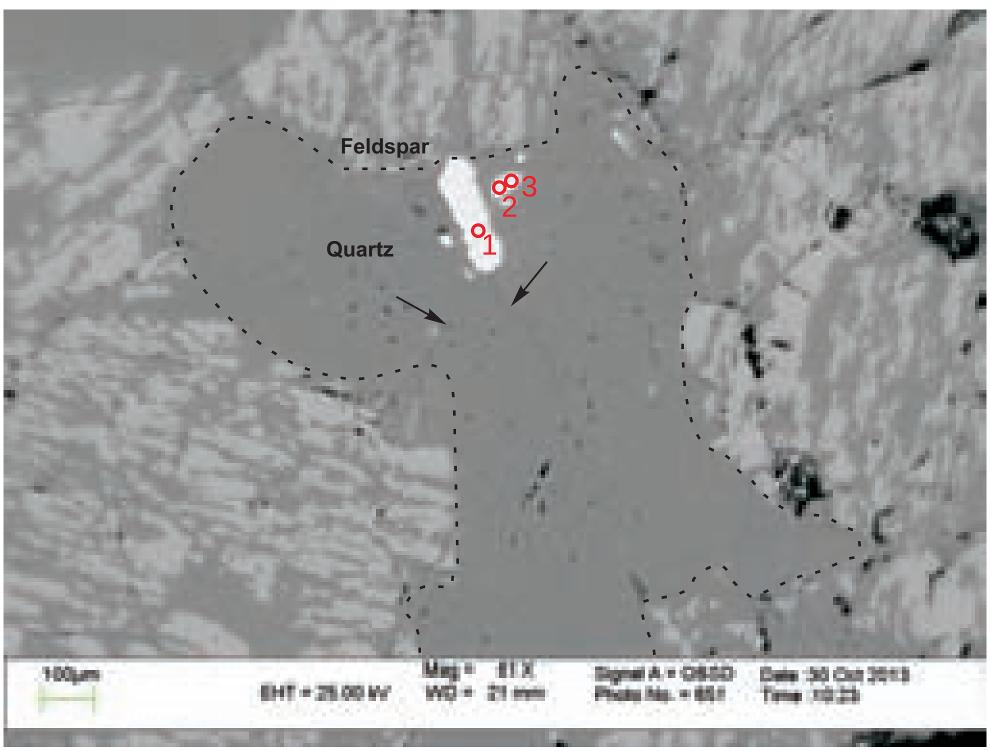
* If we consider B_2O_3 as an analytical artifact

Appendix 2-2: BSE images and EDS mineral analyses of sample 9874



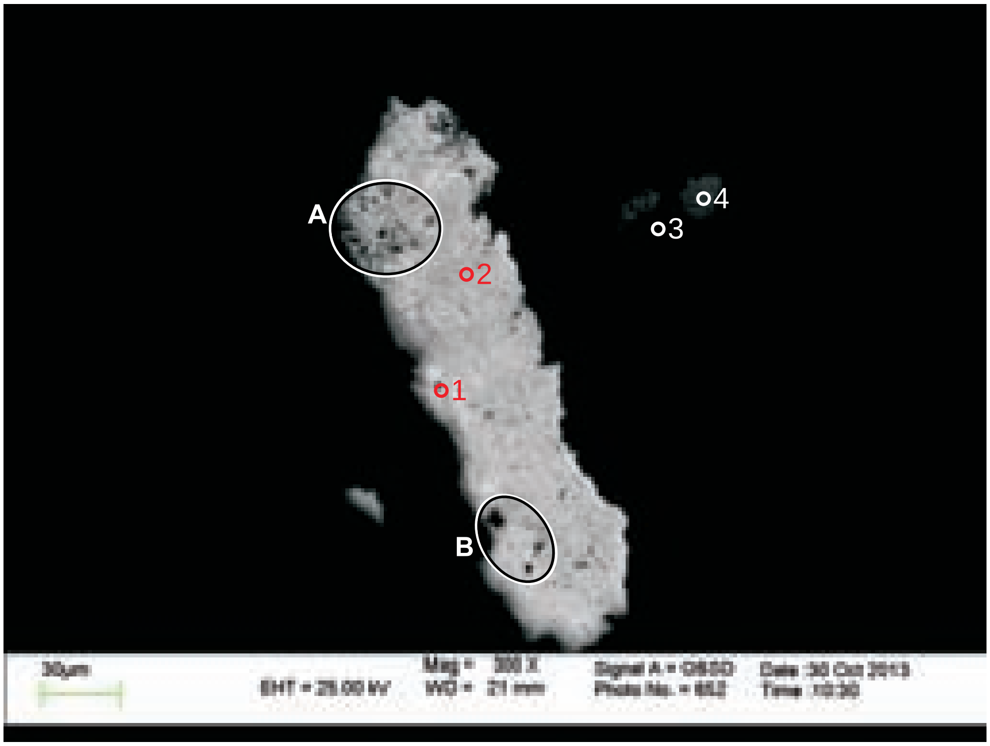
1: Zircon
2:Quartz
3:Zircon
4:Zircon (+others)
5:Zircon (+others)
6:K-feldspar
7:Quartz
8:Quartz
9:K-feldspar

Figure 2-2.1: Sample 9874 site 1; zircon (analyses 3&5) with Y (2-4%) and Fe (all zircon analyses,2-3%).



1:Zircon
2:Fe-oxide(+other)
3:Fe-oxide(+other)

Figure 2-2.2: Sample 9874 site 2; zircon inclusion (analysis 1) in quartz with Fe, Y, and Yb. Fractures are indicated by arrows, as well as grain boundary between quartz and feldspar.



1:Zircon
2:Zircon
3:Fe-oxide(+other)
4:Fe-oxide(+other)

Figure 2-2.3: Sample 9874 site 3; darker BSE image of figure 2. Morphology, inhomogeneities, in addition to corrosion (position A) and dissolution (position B) suggest that this is a magmatic zircon probably affected by hydrothermal activity. Darker areas (analysis 2) corresponds to zircon enriched in Y and Fe, whereas lighter areas correspond to more pure zircon compositions. The former probably represents the magmatic zircon and the latter the result of hydrothermal activity.

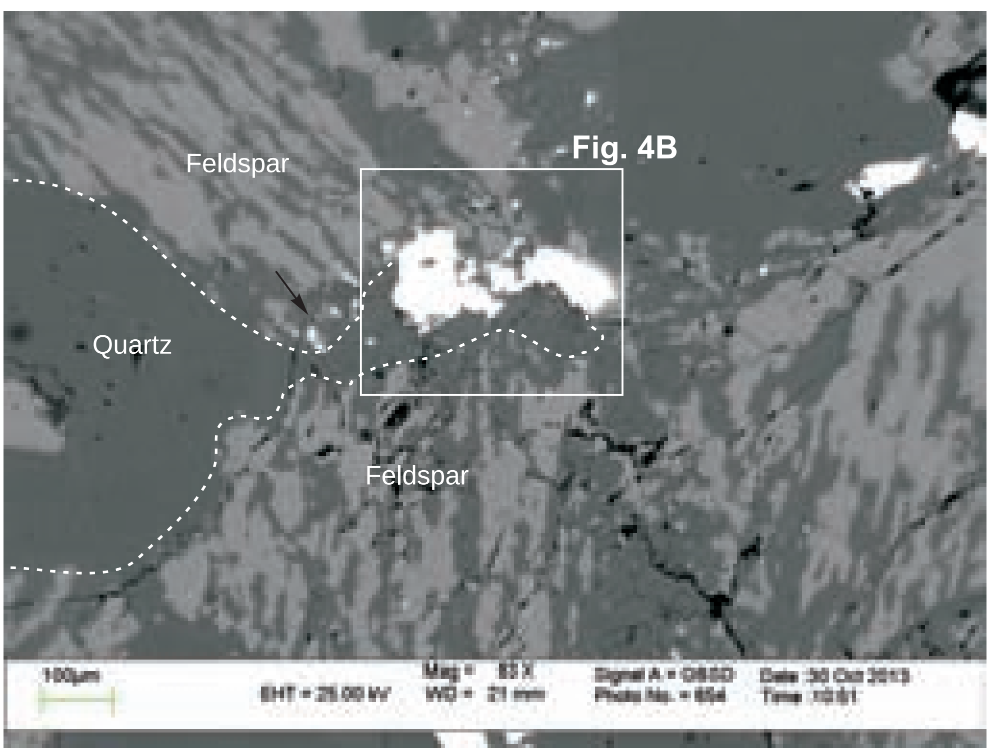
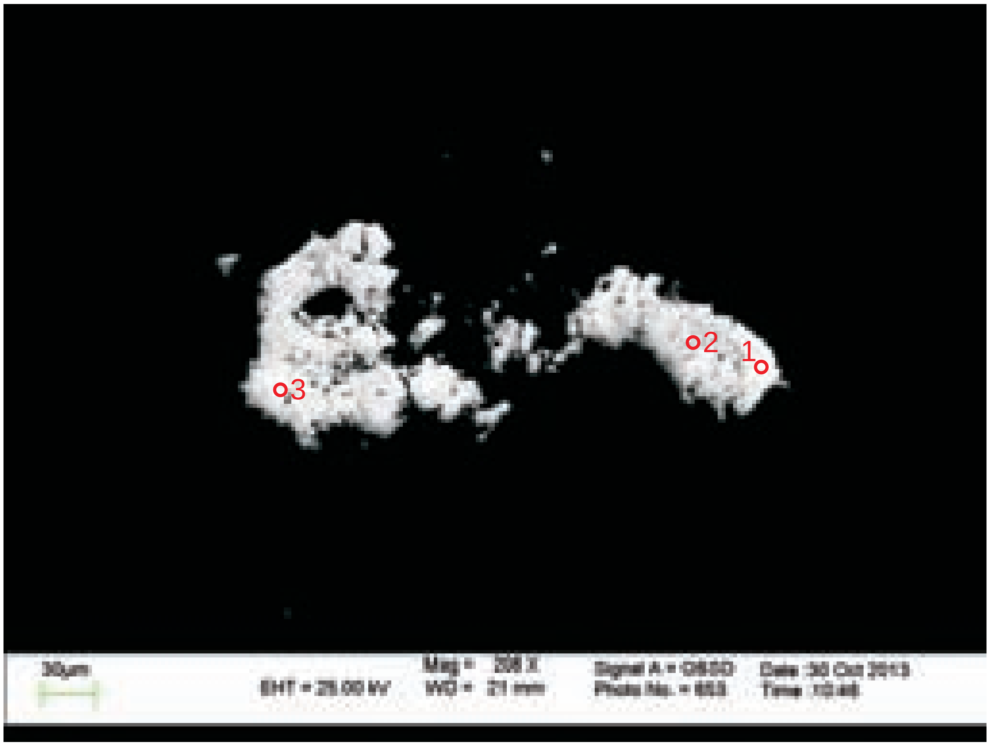
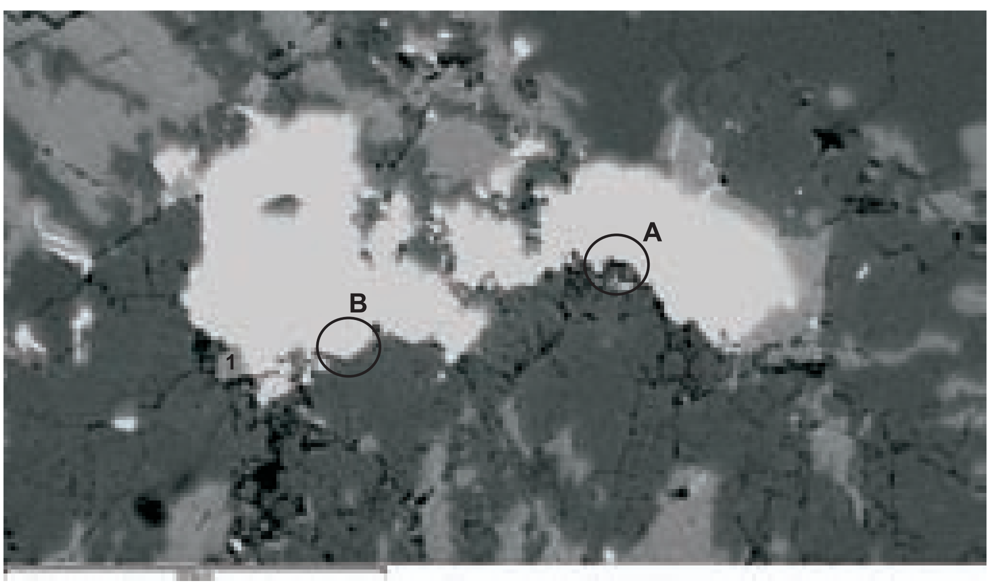


Figure 2-2.4A: Sample 9874 site 4. Zircon (figure 4B) precipitated along grain boundary. Zircon seems to be later than the fractures (arrow) that cut both quartz and K-feldspar.



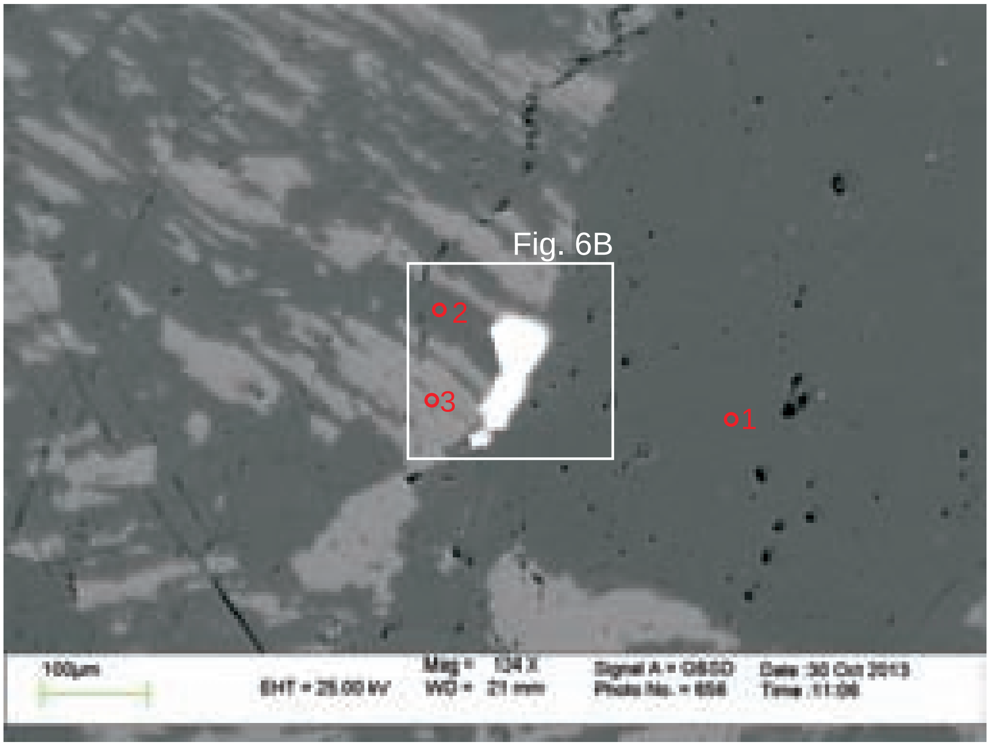
1:Zircon
2:Zircon
3:Zircon

Figure 2-2.4B: Sample 9874 site 4; zircon with little enrichment in Fe (<1%).



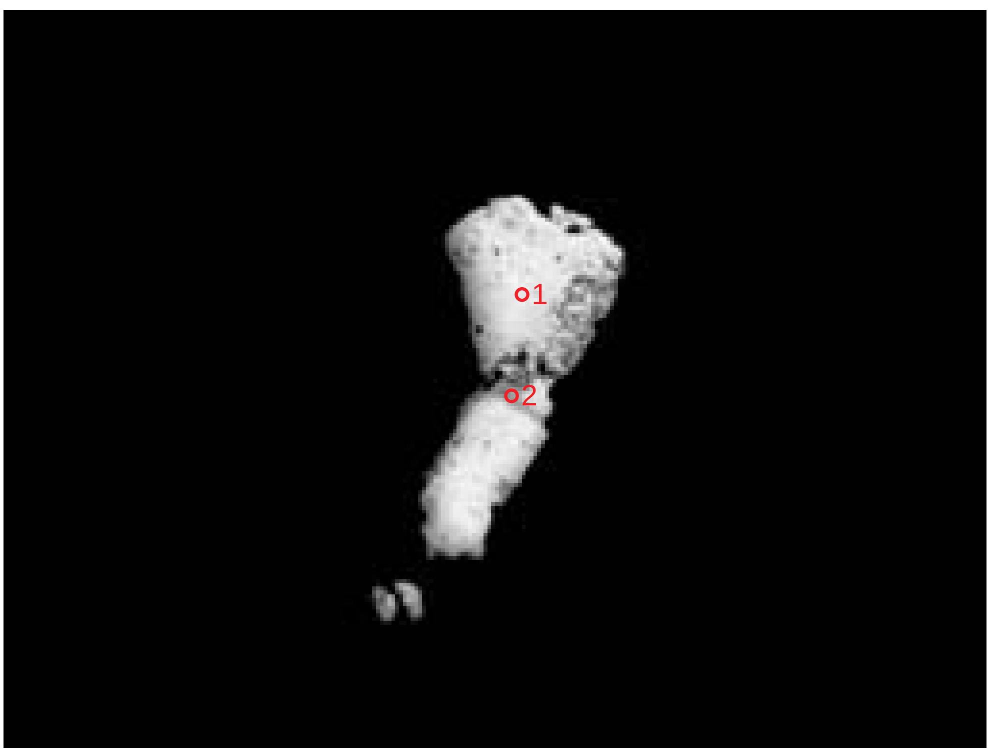
1: K-feldspar (+Fe)

Figure 2-2.5: Sample 9874 site 5; same grain as figure 4; all fractures are older than zircon and thus these zircon grains are considered hydrothermally derived. Positions A and B also support this consideration.



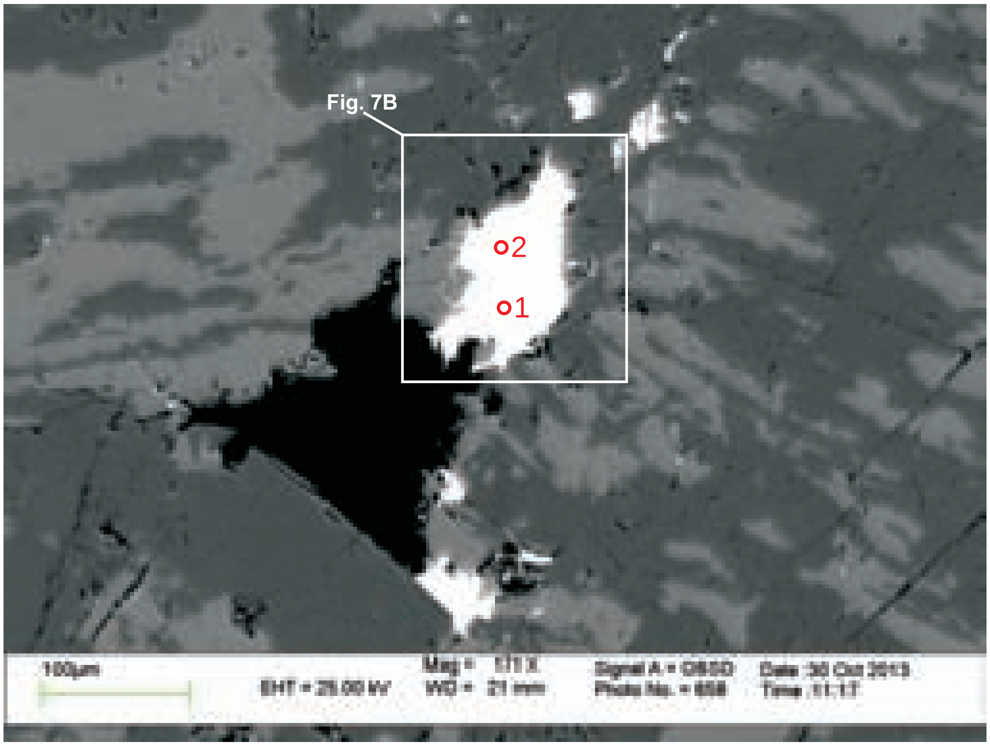
1:Quartz
2:Albite
3:K-feldspar

Figure 2-2.6A: Sample 9874 site 7. Late zircon forms along the grain boundary between quartz and feldspar.



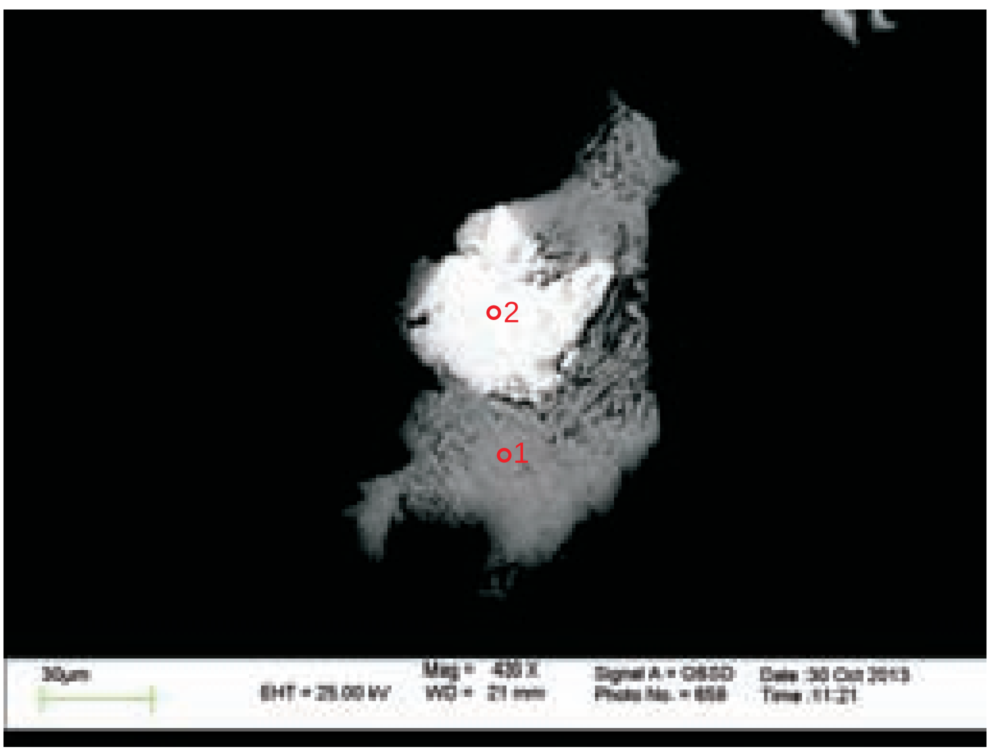
1:Zircon
2:Fe-oxide(+Zircon)

Figure 2-2.6B: Sample 9874 site 6. Fe-oxide (analysis 2) rims zircon (analysis 1) along grain boundary (figure 6A).



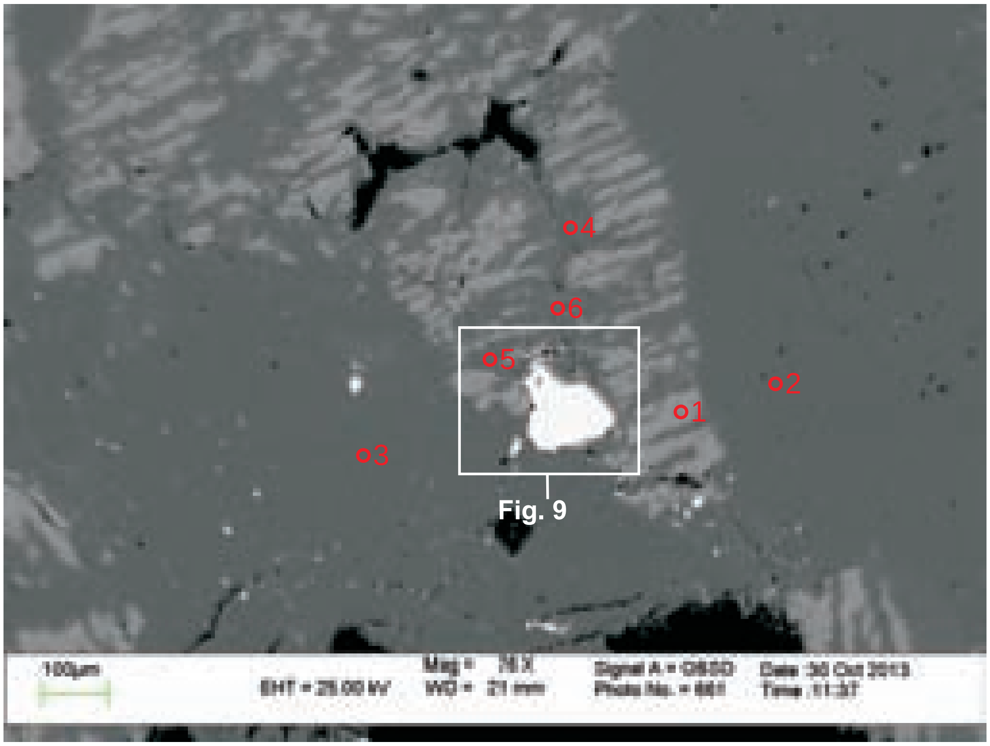
1:Fe-oxide (+other)
2:Zircon

Figure 2-2.7A: Sample 9874 site 8.



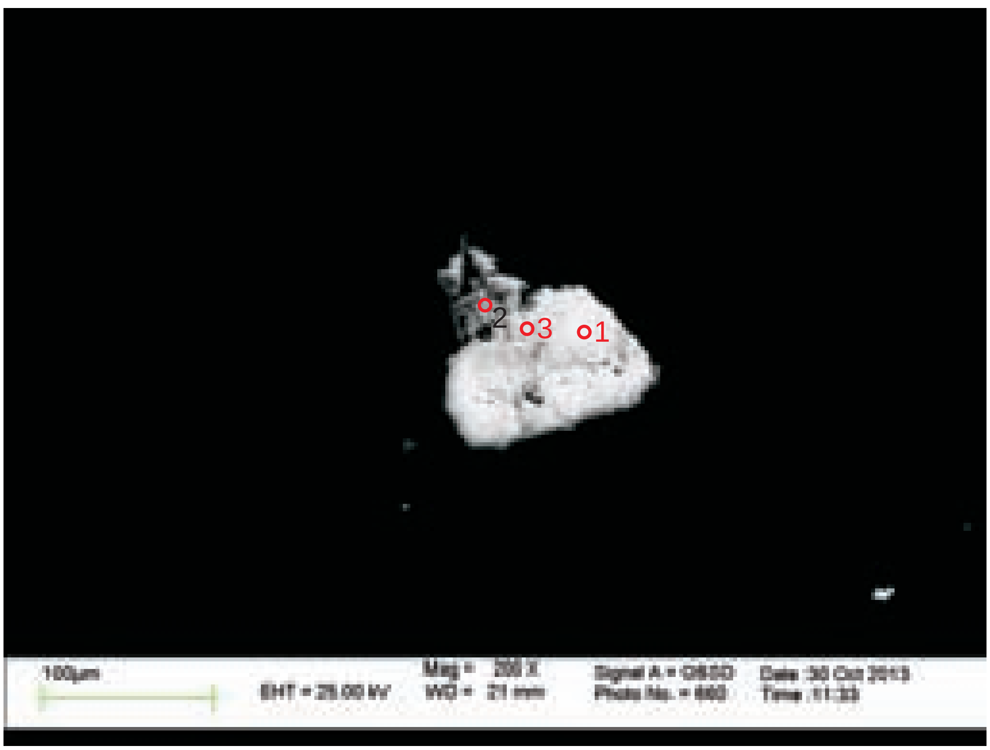
1:Fe-oxide(+other)
2:Zircon

Figure 2-2.7B: Sample 9874 site 8; darker BSE image of figure 7A. Fe-oxideand zircon precipitated in dissolution void. It seems that zircon postdates magnetite.



1:K-feldspar
2:Quartz
3:Quartz
4:Albite
5:Albite
6:Albite

Figure 2-2.8: Sample 9874 site 10; zircon (figure 9) forming between feldspar (analyses 1,4,5,&6) and quartz (analyses 2&3) grains.



1:Zircon
2:Zircon
3:Zircon

Figure 2-2.9: Sample 9874 site 9; zircon (analysis 1) contains Y (7-9%, analyses 2&3) and Yb (approx. 2%, analyses 2&3). Analysis 2 contains 8% Fe, and analysis 3 contains 3% F. The morphology of the crystals and their chemical compositions suggest that a magmatic zircon has probably been affected by later hydrothermal activity.

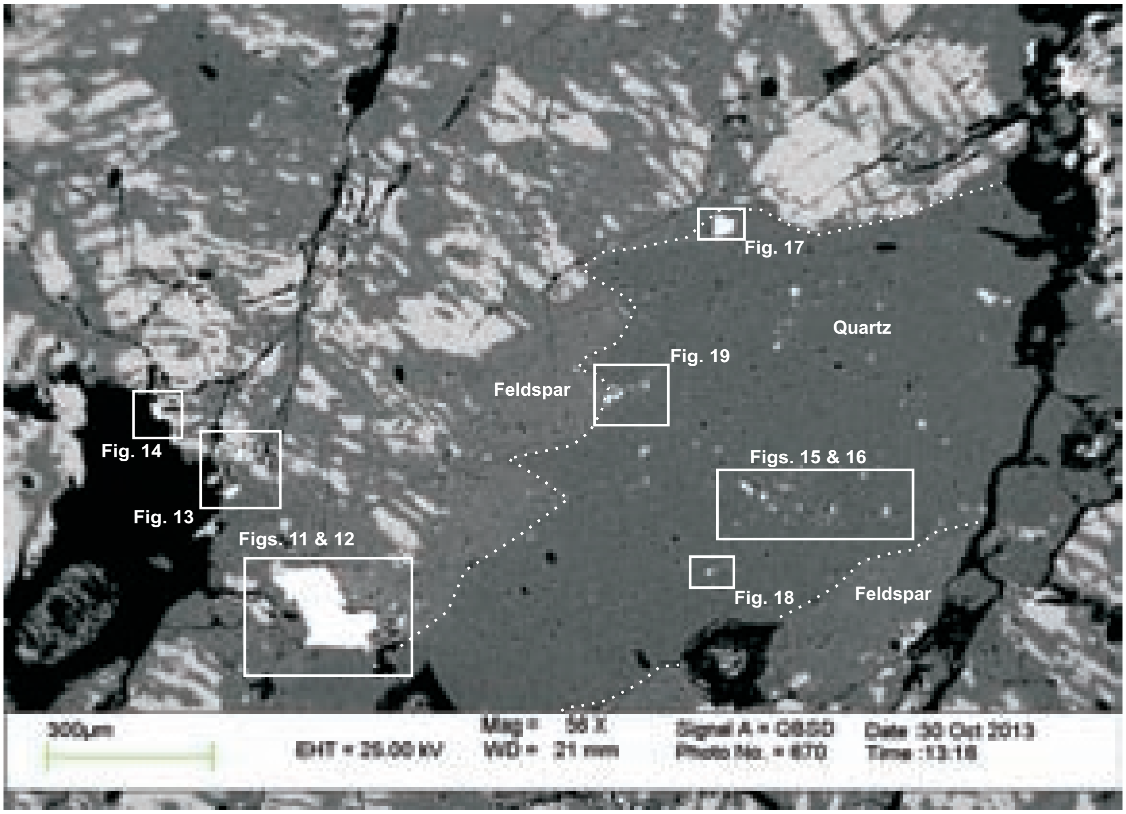
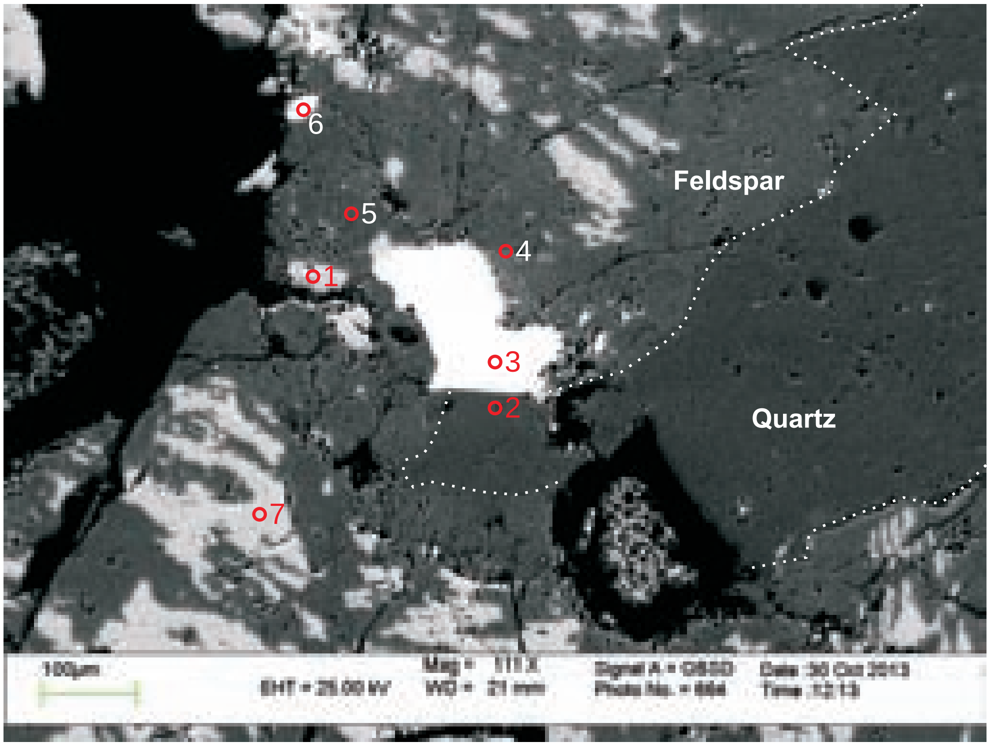
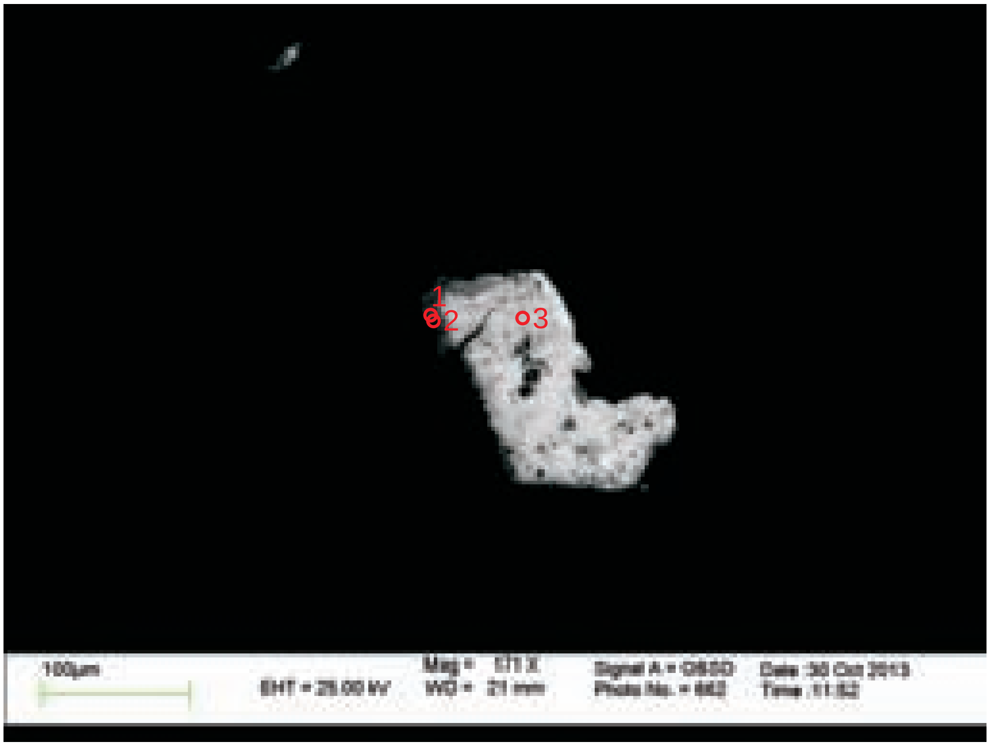


Figure 2-2.10: BSE SEM image of 9874. Figures 11 & 12 are located near magmatic zircon. Figures 13 & 14 are located partly within large void. Figures 15 - 18 are located within partially dissolved quartz grain(s). Figure 19 is located at the boundary between quartz and feldspar.



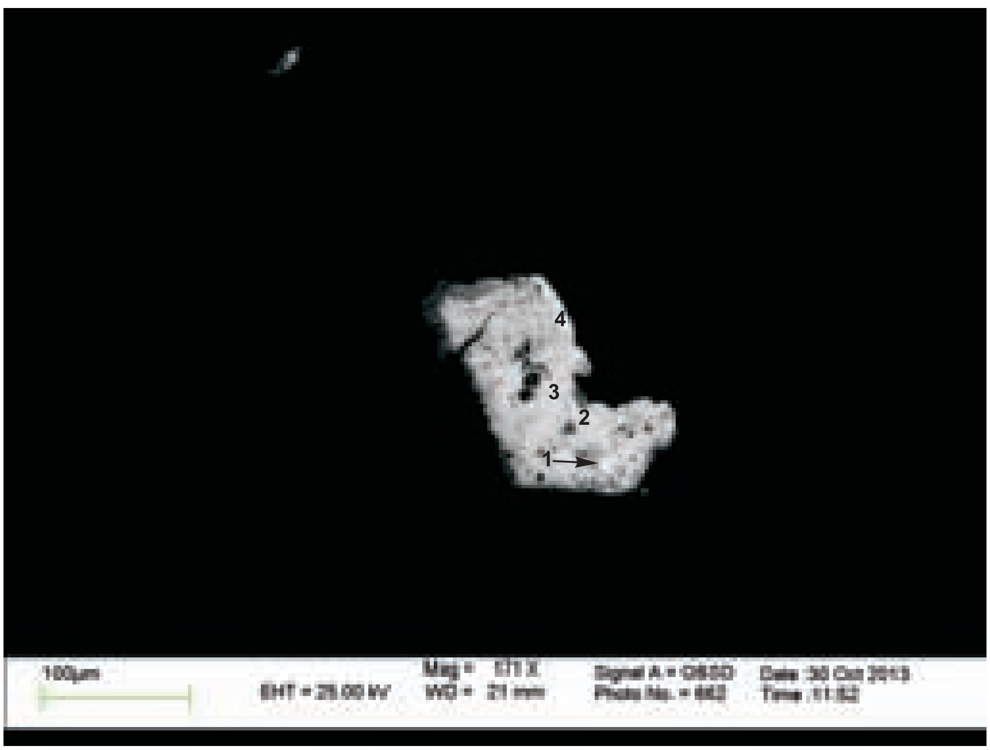
1:K-feldpsar
2:Quartz
3:Zircon
4:Albite
5:Albite
6:bad analysis
7:K-feldspar

Figure 2-2.11: Sample 9874 site 12



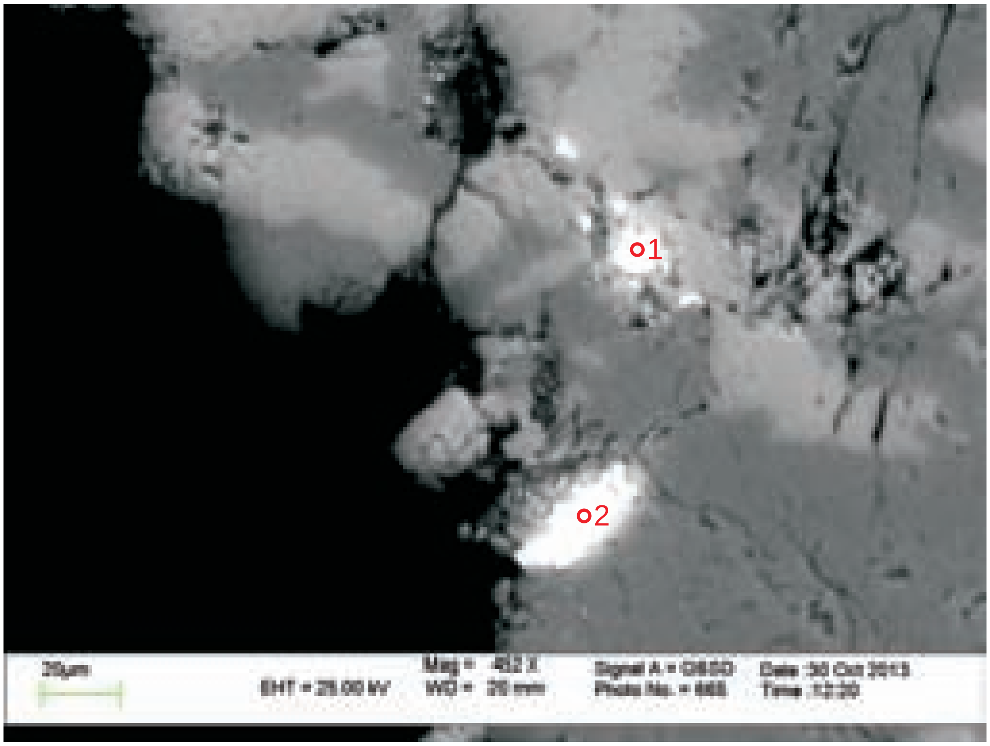
1:Fe-oxide (+others)
2:Fe-oxide (+others)
3: Zircon

Figure 2-2.12A: Sample 9874 site 11; magmatic zircon with Fe-oxide overgrowth (analyses 1&2), is cut by fracture and contains dissolution voids. Zircon contains Y (~6.5%) and Yb(~1%).



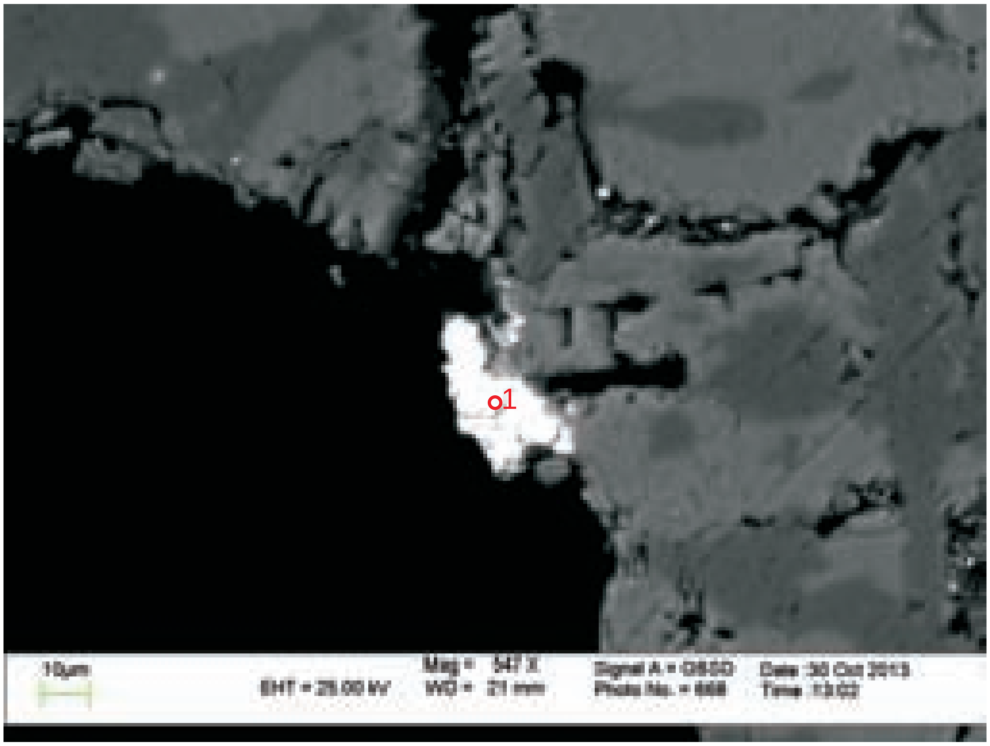
1:Aeschynite-euxenite(+zi
2:Zircon
3:Zircon
4:Zircon

Figure 2-2.12B: Sample 9874 site 13; the magmatic zircon seems to be inhomogeneous with variable compositions and patches of aeschynite-euxenite (analysis 1) as if it may have been affected by both dissolution and recrystallization.



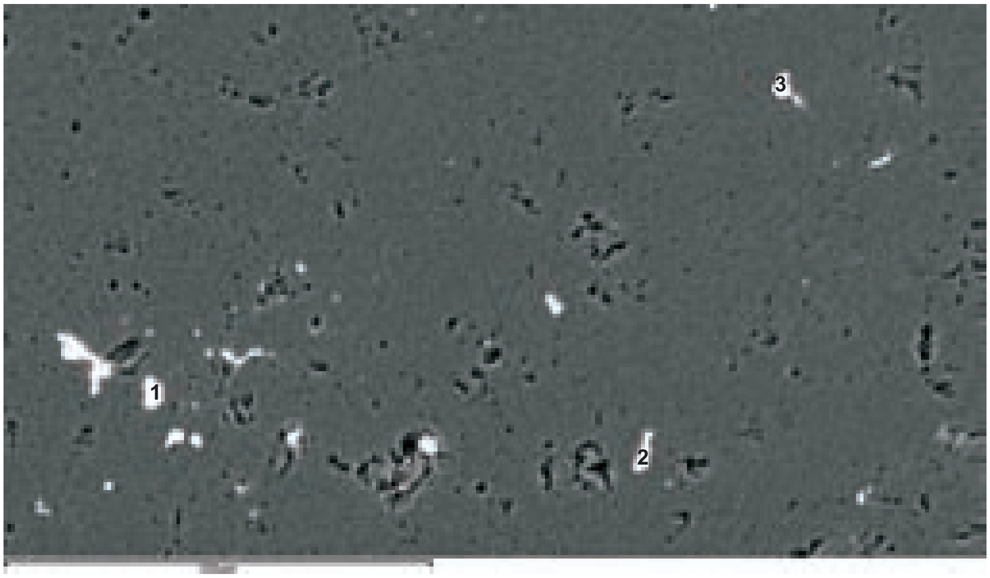
1:Samarskite-Y (+others)
2:Samarskite-Y

Figure 2-2.13: Sample 9874 site 15



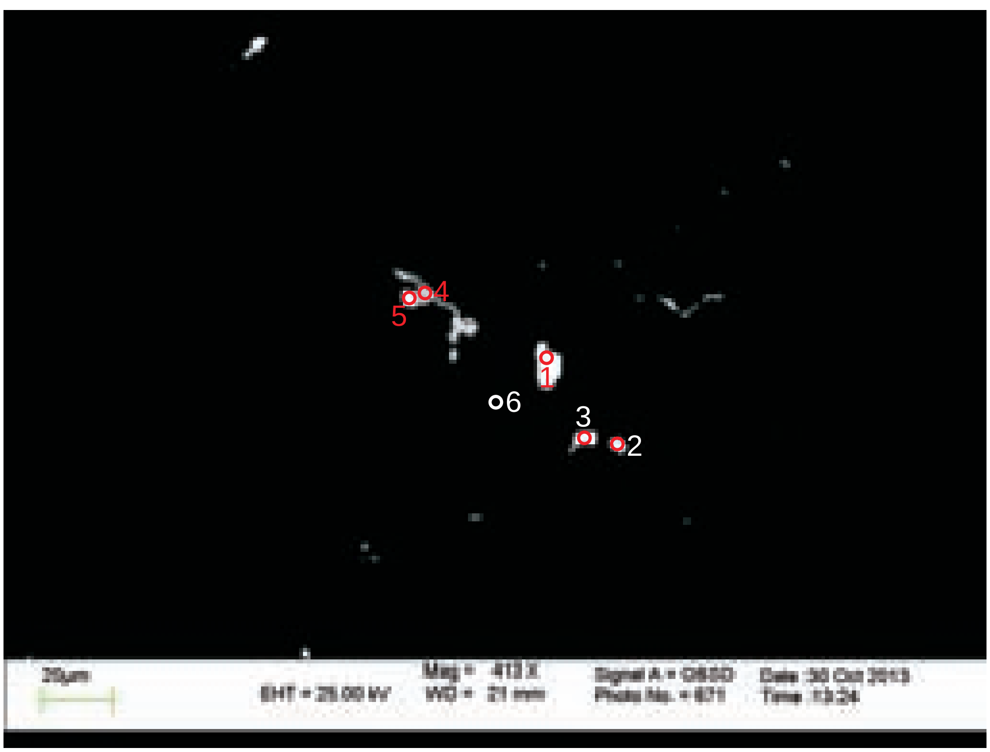
1:Samarskite-Y

Figure 2-2.14: Sample 9874 site 16; samarskite-Y(figure 10) precipitates on a void wall.



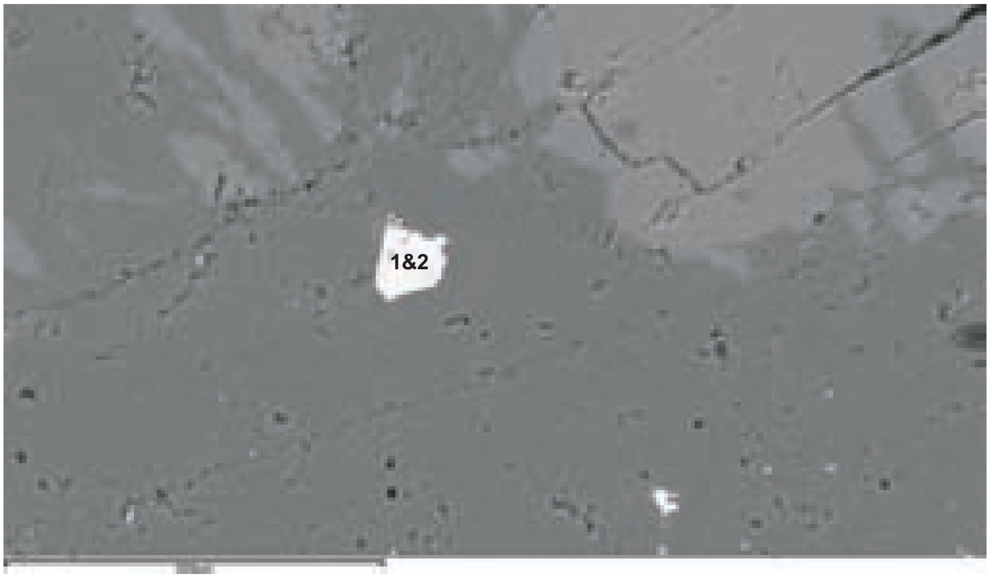
1:Samarskite-Y
2:Samarskite-Y
3:Samarskite-Y

Figure 2-2.15: Sample 9874 Site 17; quartz grains with dissolution voids. Some of the voids host samarskite-Y



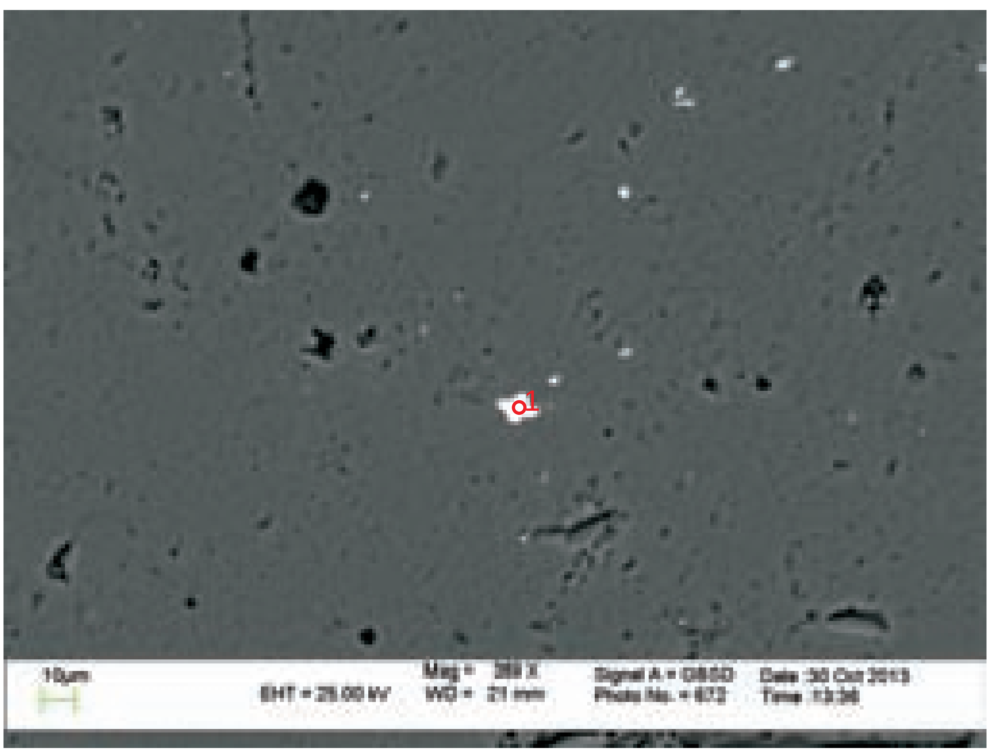
1:Samarskite-Y
2:Samarskite-Y (+Quartz)
3:Samarskite-Y (+Quartz)
4:Pyrochlore
5:Mix (Quartz + Samarskite-Y)
6:Quartz

Figure 2-2.16: Sample 9874 Site 19; Samarskite-Y (analyses 1-3) in contact with pyrochlore (analysis 4). Samarskite-Y contains up to 7 wt. % HREE’s (analysis 1). Samarskite-Y is enclosed by quartz (analysis 6 & fig. 10,) with numerous dissolution voids suggesting a hydrothermal origin for samarskite-Y.



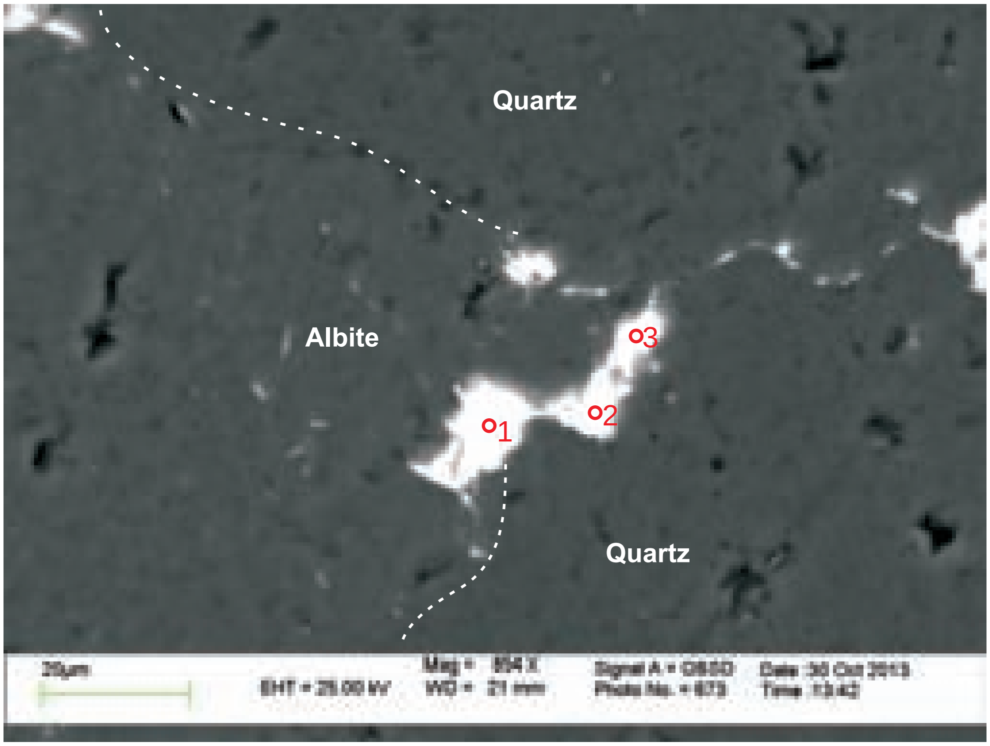
1:Fe-oxide(+silicate)
2:Fe-oxide(+silicate)

Figure 2-2.17: Sample 9874 Site 18; Fe-oxide in quartz with dissolution voids.



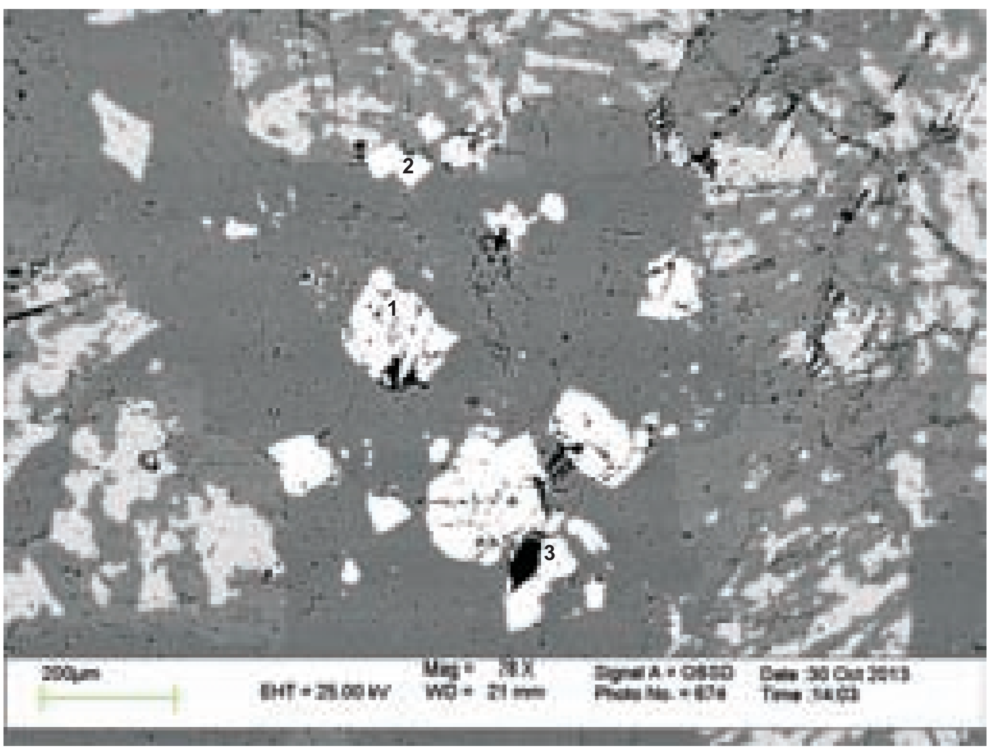
1: Mix (quartz
+ samarskite-Y)

Figure 2-2.18: Sample 9874 Site 20; samarskite-Y in quartz with dissolution voids.



1:Samarskite-Y
2:Samarskite-Y
3:Mix (Samarskite-Y
+ Quartz
+ Fe-oxide)

Figure 2-2.19: Sample 9874 Site 21; Samarskite-Y occurs along grain boundary between quartz and albite both with dissolution voids.



1:Fe-oxide
2:Zircon
3:Fe-oxide (+silicate)

Figure 2-2.20: Sample 9874 Site 22; quartz with dissolution voids that probably hosted the Fe-oxide and zircon grains.

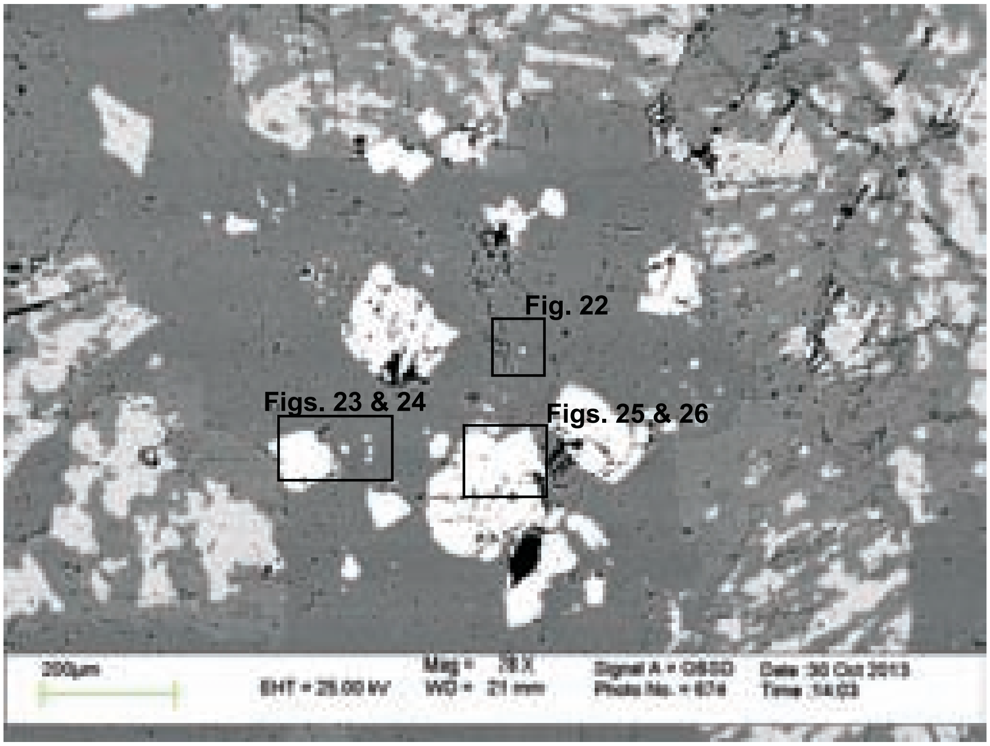
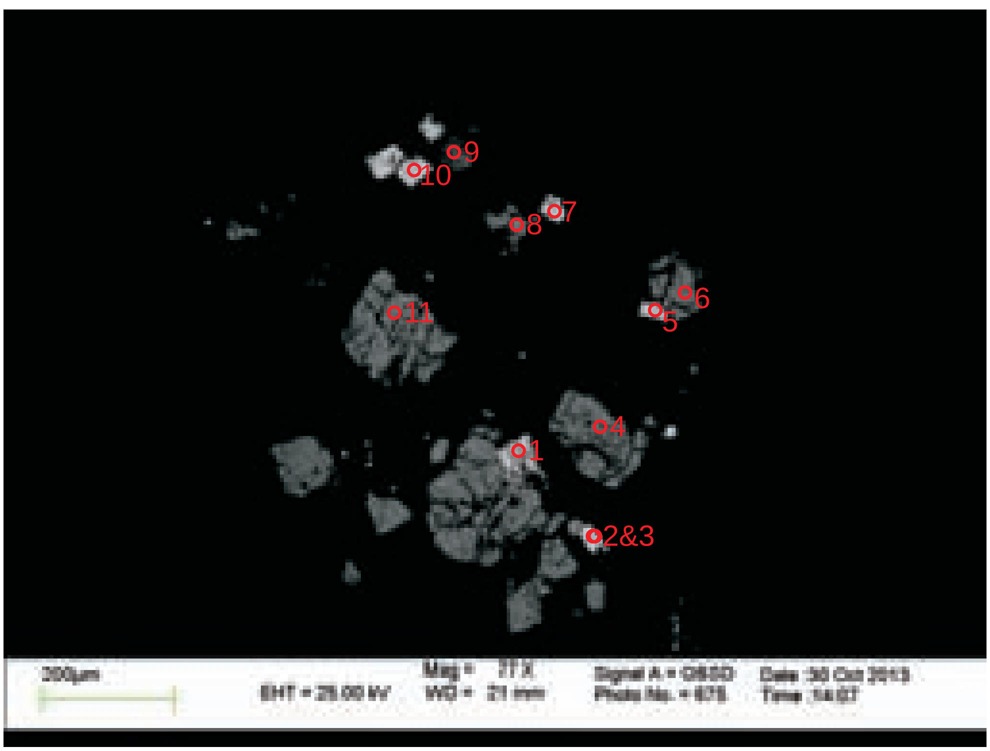
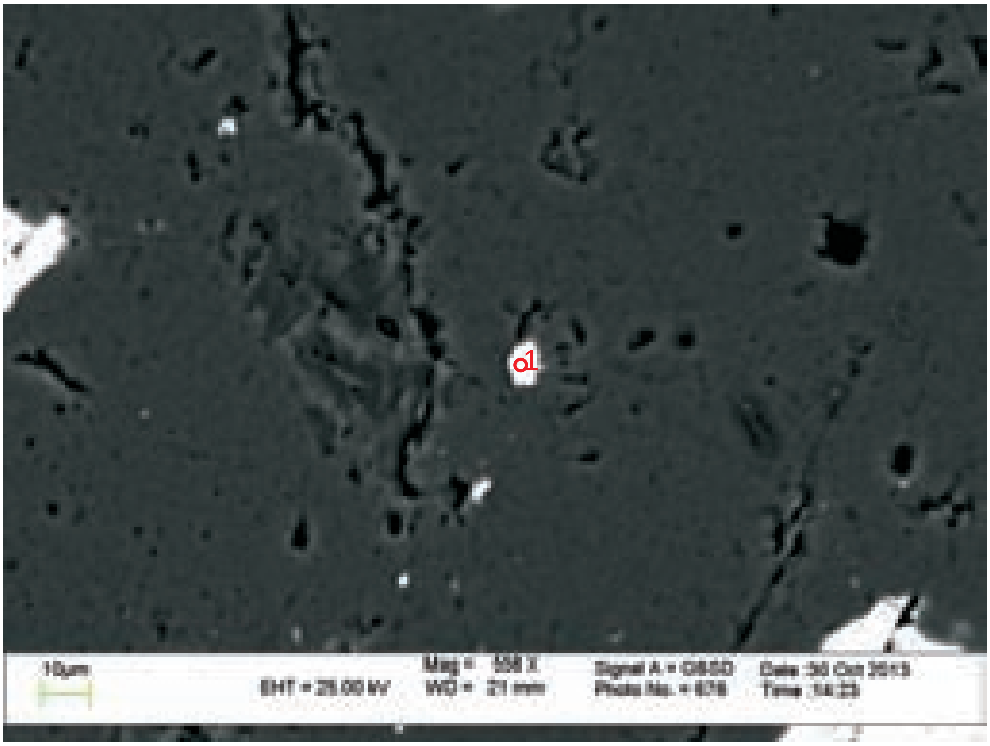


Figure 2-2.21A: Sample 9874 Site 23;



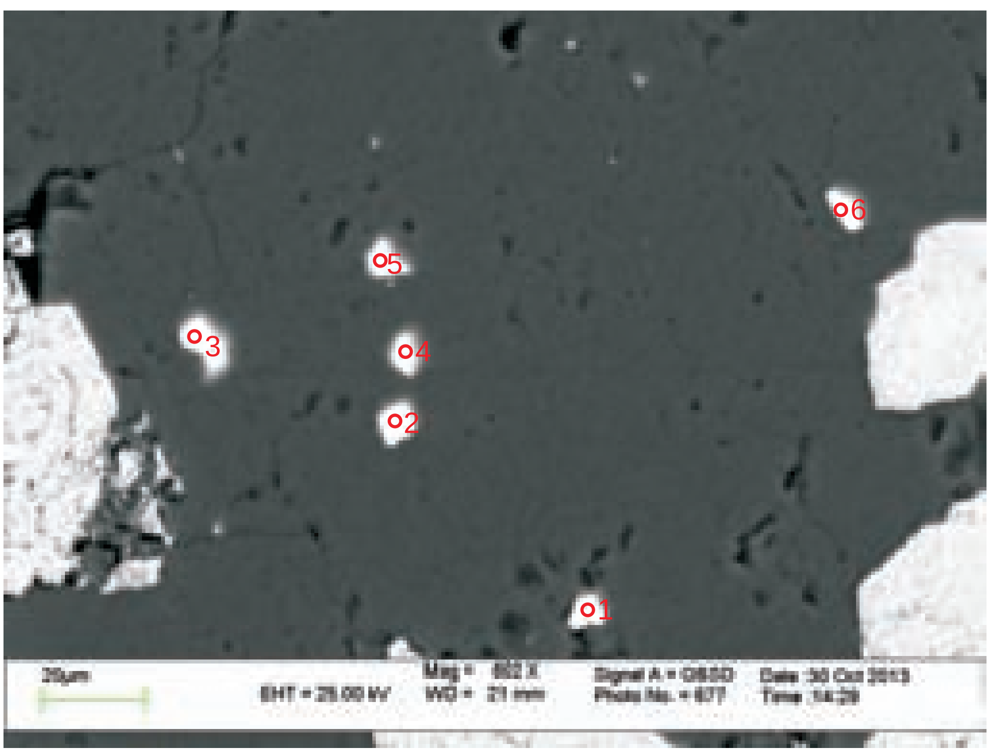
1:Zircon
2:Zircon (+Fe)
3:Zircon
4:Fe-oxide(+silicate)
5:Mix (Quartz + zircon)
6:Mix (Quartz + Fe-oxide)
7:Zircon
8:Fe-oxide(+silicate)
9:Fe-oxide(+silicate)
10:Zircon
11:Fe-oxide(+silicate)

Figure 2-2.21B: Sample 9874 Site 23; dark BSE image of figure 20 and 21A. Quartz with dissolution voids that probably hosted the Fe-oxide and zircon grains. It seems that the Fe-oxides show some dissolution predating zircon grains.



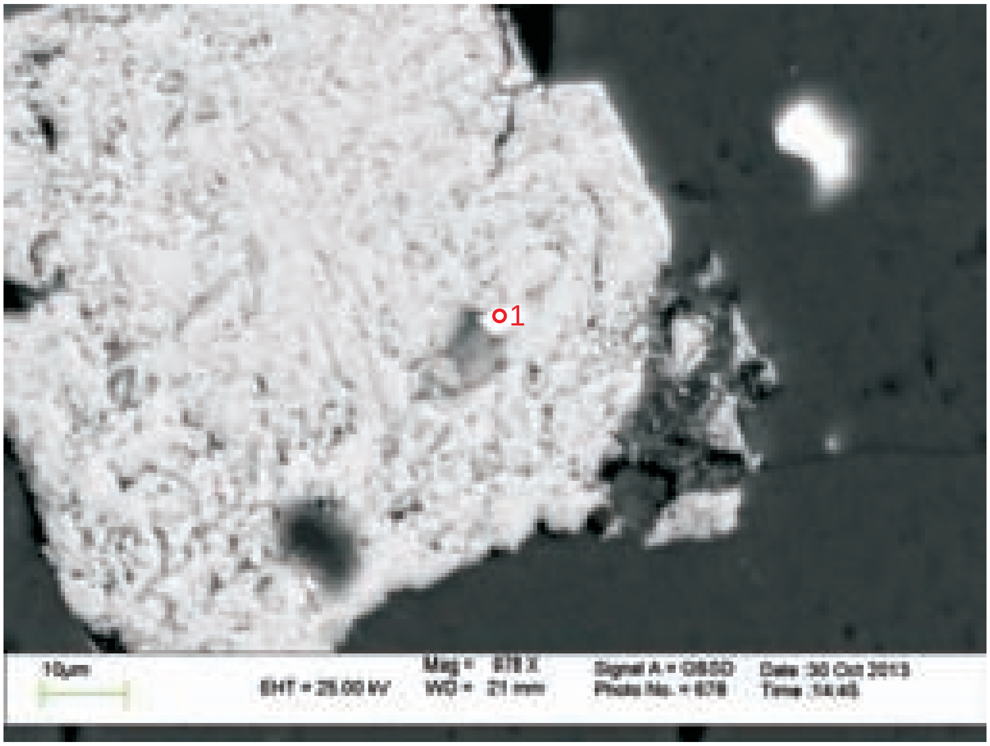
1:Samarskite-Y

Figure 2-2.22: Sample 9874 Site 24; samarskite-Y with ~7 wt.% HREE’s.



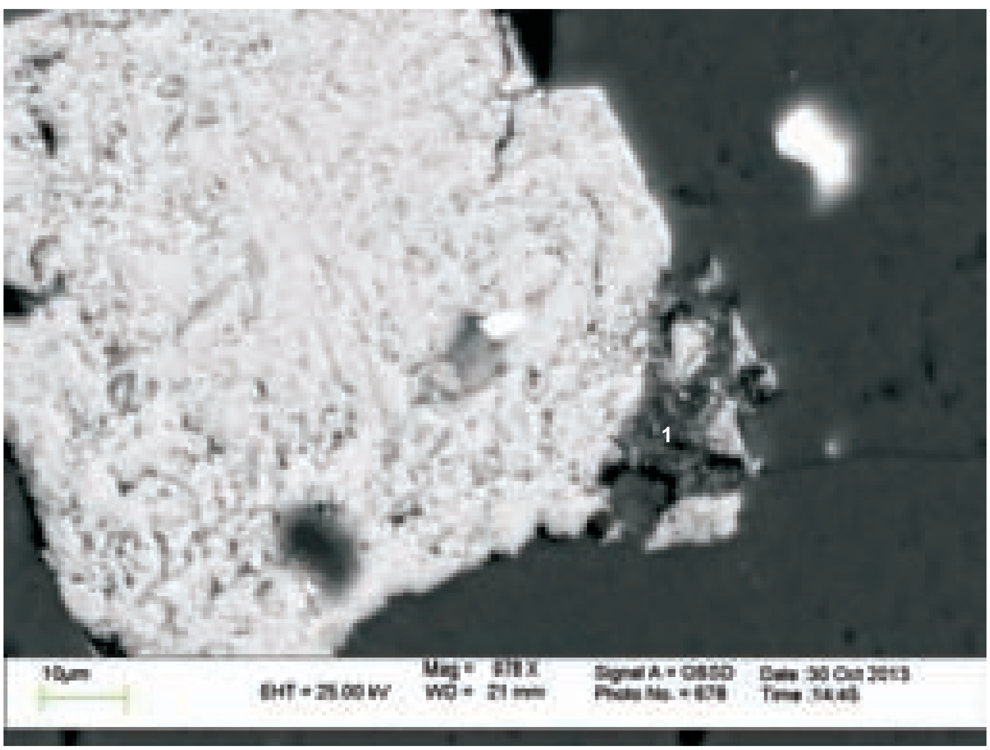
1:Samarskite-Y
2:Pyrochlore
3:Aeschynite-euxenite
4:Aeschynite-euxenite
5:Pyrochlore
6:Samarskite-Y

Figure 2-2.23: Sample 9874 Site 25; Nb-Y minerals filling dissolution voids in quartz (e.g. analysis 1).



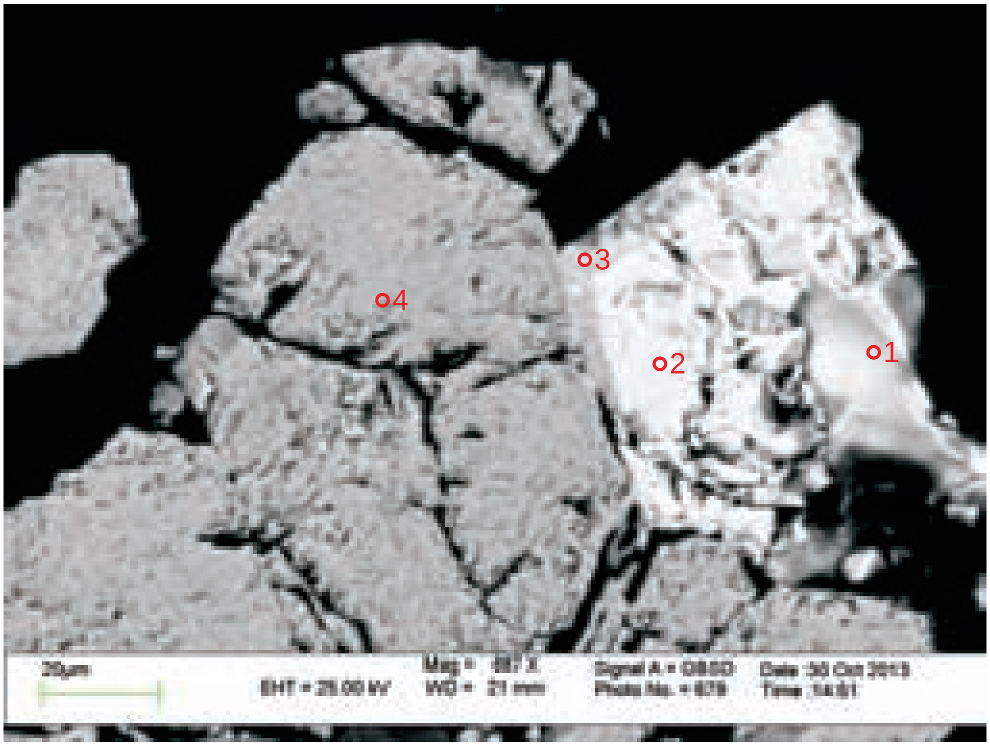
1:Samarskite-Y(+others)

Figure 2-2.24A: Sample 9874 site 26; samarskite-Y filling dissolution void in Fe-oxide grain.



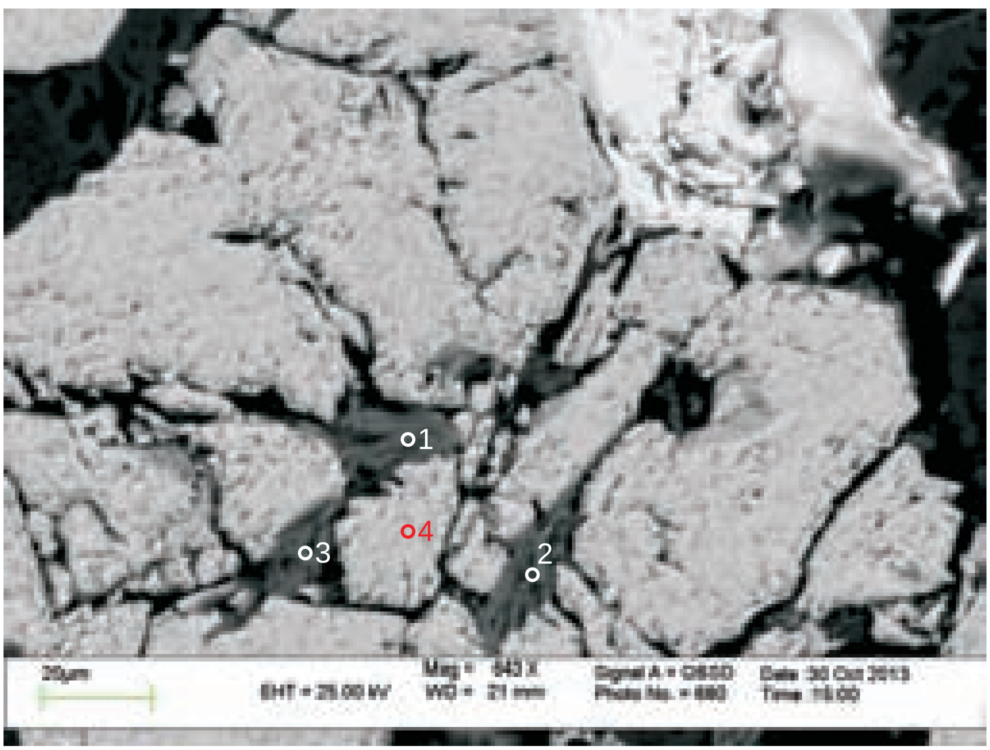
1: Mix(Quartz+Fe-oxide)

Figure 2-2.24B: Sample 9874 site 27



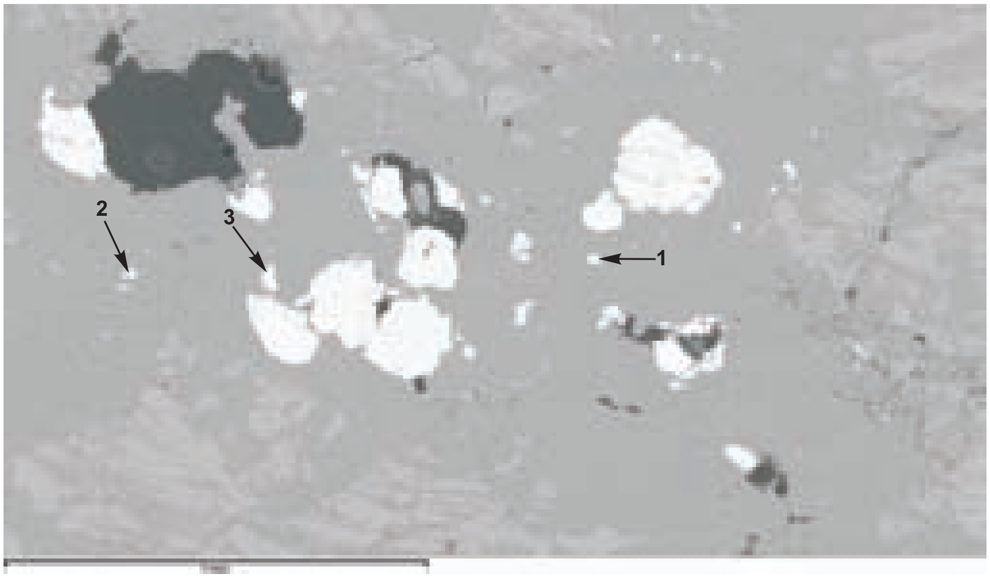
1:Zircon
2:Zircon
3:Zircon
4:Fe-oxide

Figure 2-2.25: Sample 9874 site 28; subhedral grain of zoned zircon showing interlocking texture with Fe-oxide. Both minerals are strongly fractured and zircon is partially dissolved and recrystallized.



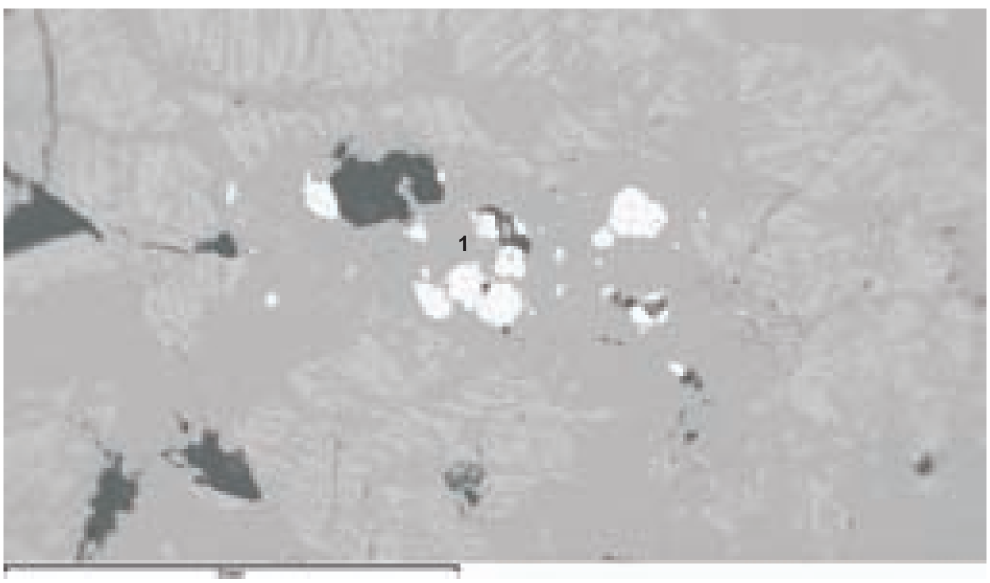
1:Biotite altering to Chlorite
2:Chlorite
3:Chlorite
4:Fe-oxide(+silicate)

Figure 2-2.26: Sample 9874 site 29; biotite grain, partially chloritized (analysis 1), and chlorite (analyses 2&3) filling fractures in magnetite.



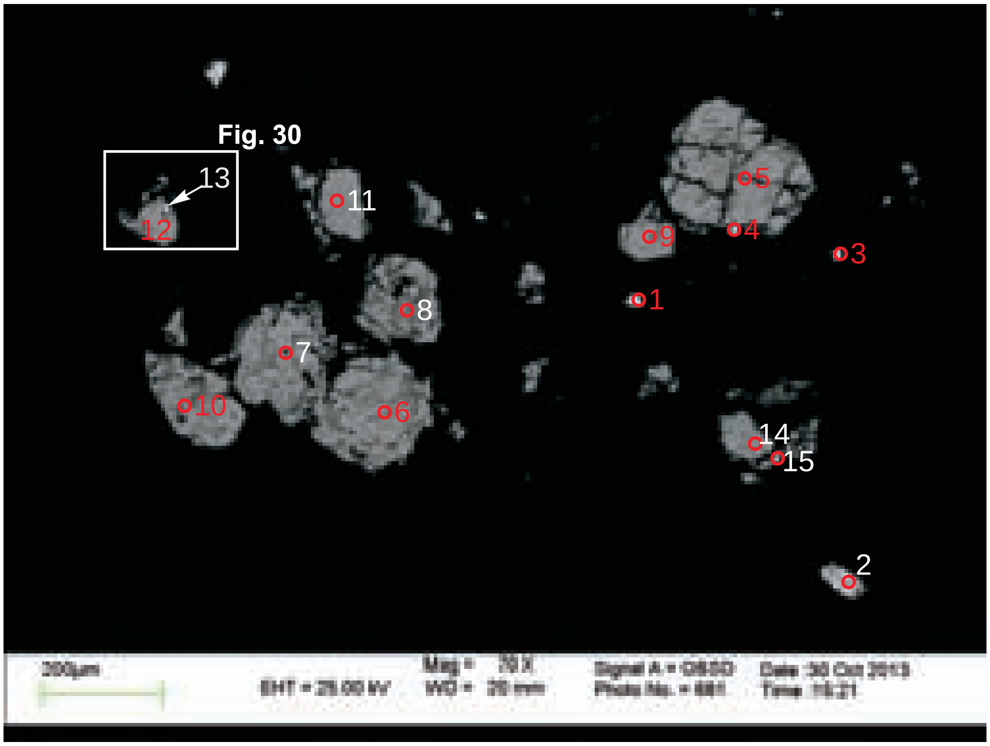
1: Zircon
2: Mix (Fe-oxide + Quartz)
3: Mix (Fe-oxide + Quartz)

Figure 2-2.27: Sample 9874 site 30



1: Quartz

Figure 2-2.28: Sample 9874 site 31



1:Zircon
2:Mix (Fe-oxide + zircon)
3:Zircon
4:Zircon
5:Fe-oxide
6:Fe-oxide
7:Mix (Fe-oxide +others)
8:Fe-oxide
9:Fe-oxide
10:Fe-oxide
11:Fe-oxide
12:Fe-oxide
13:Samarskite-Y
14:Fe-oxide
15:Mix

Figure 2-2.29: Sample 9874 site 32; analyses of various crystals of zircon, Fe-oxide and samarskite-Y.

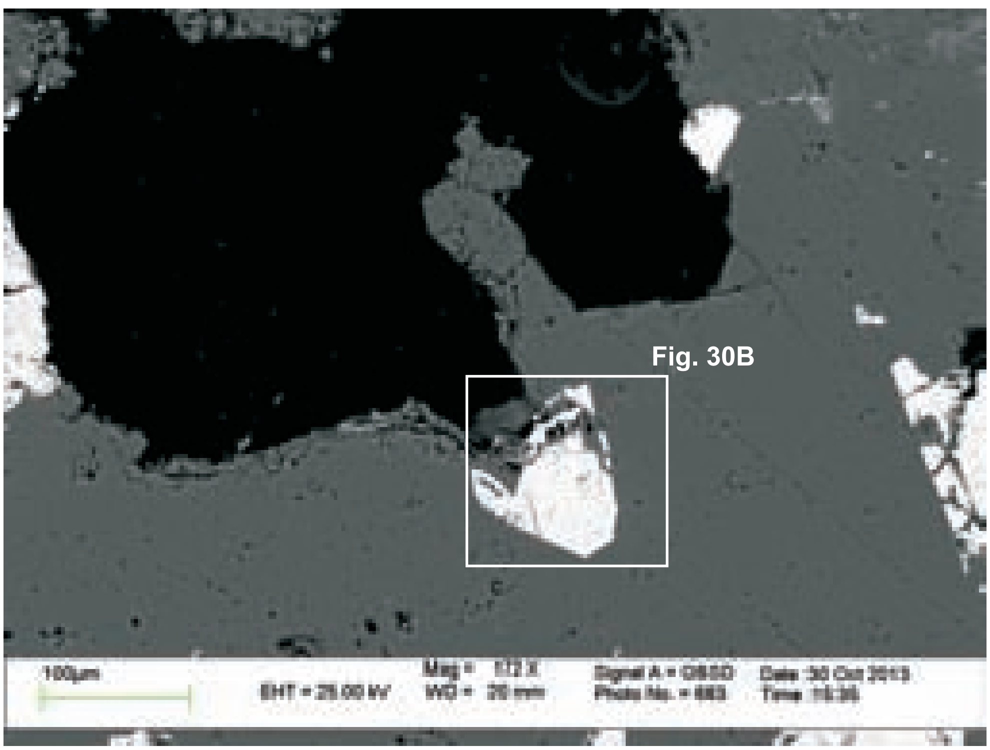
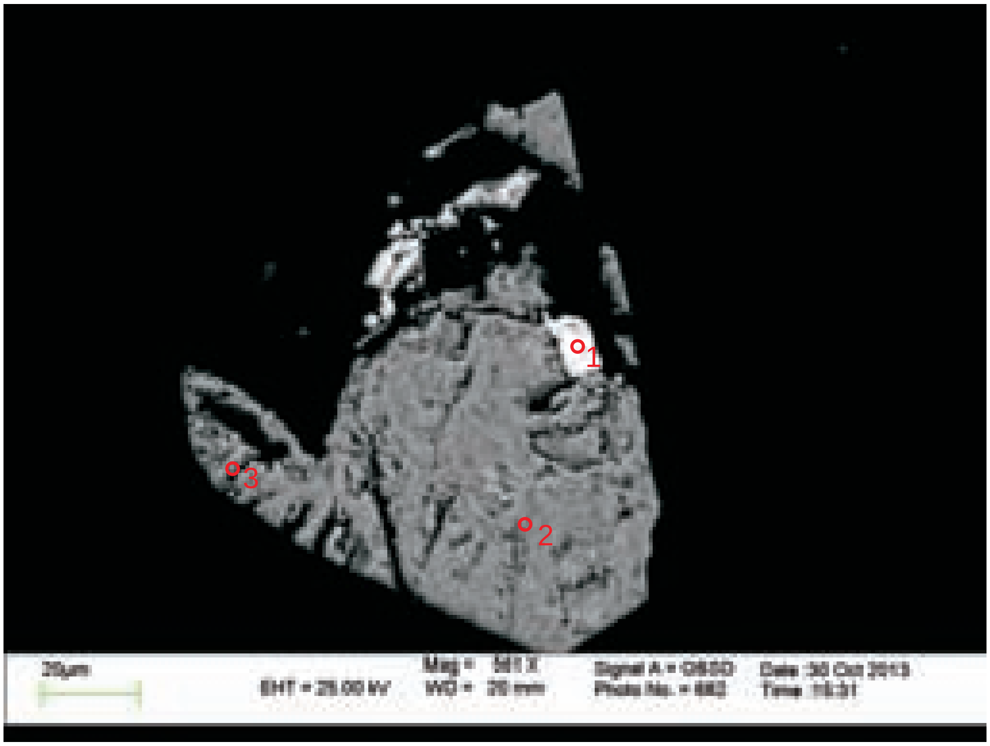
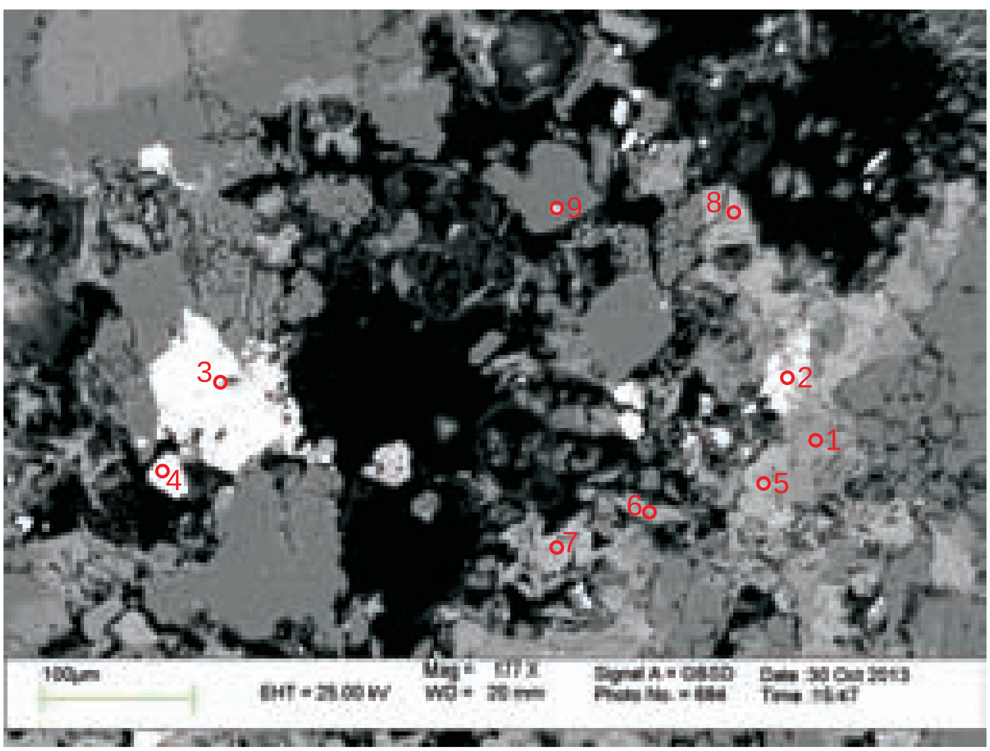


Figure 2-2.30A: Sample 9874.



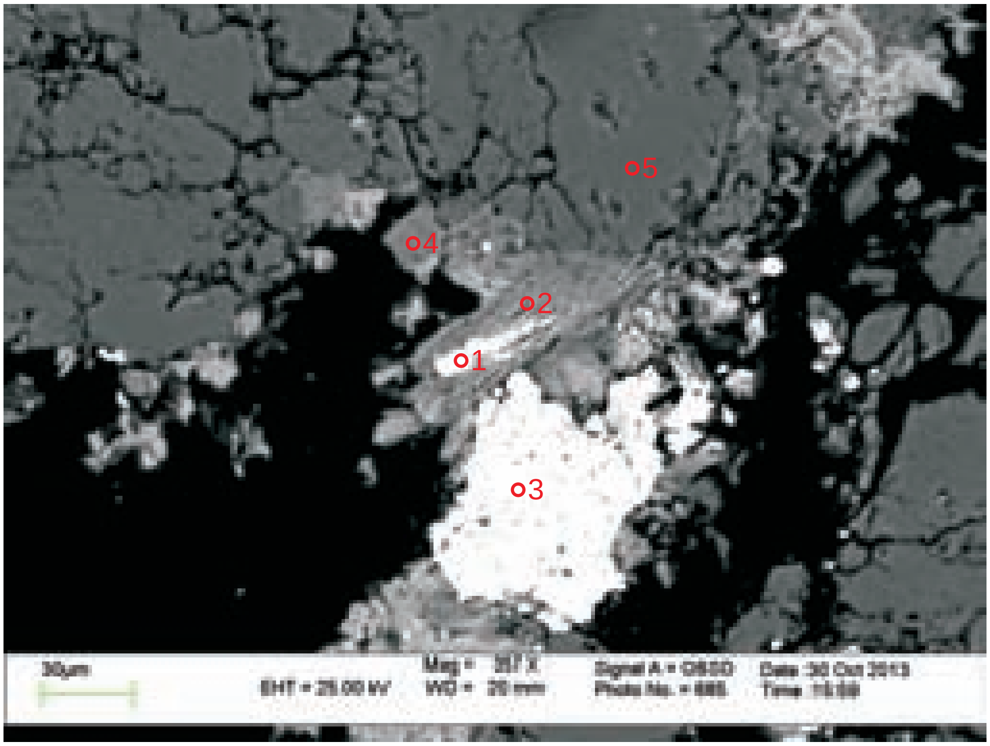
1:Nb-Y phase
2:Fe-oxide(+silicate)
3:Fe-oxide(+silicate)

Figure 2-2.30: Sample 9874 site 33; Nb-Y phase precipitates in space created by dissolution of Fe-oxide grain.



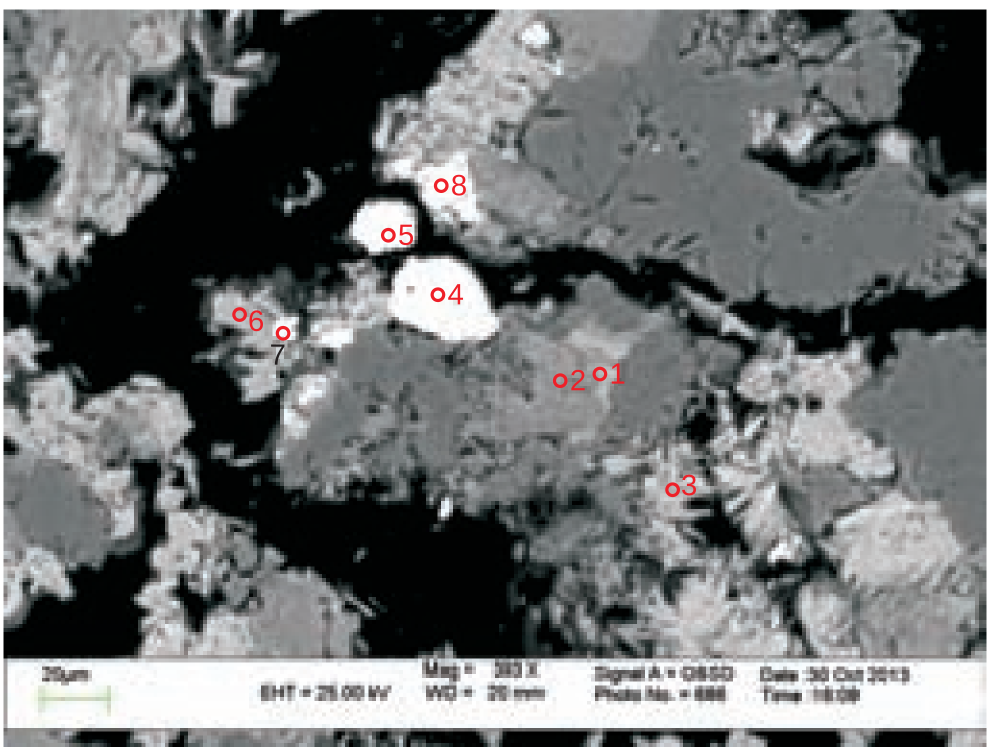
1:Muscovite
2:Zircon
3:Zircon
4:Zircon
5:Chlorite
6:Chlorite
7:Ilmenite (+others)
8:Chlorite
9:Mix (Fe-oxide+quartz)

Figure 2-2.31: Sample 9874 site 34



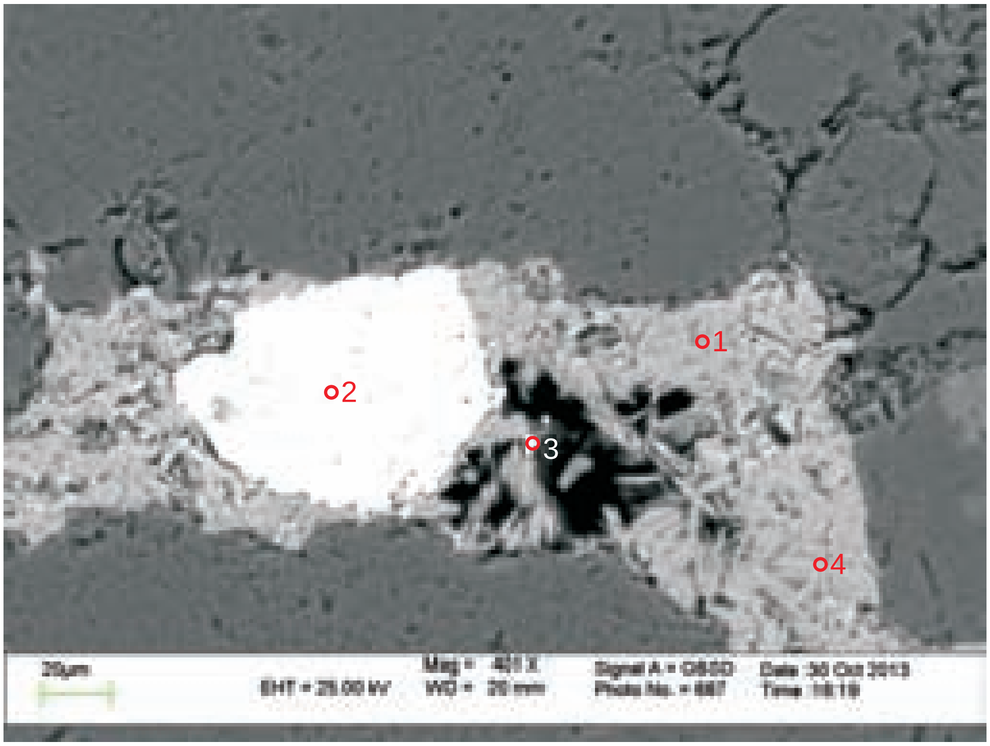
1: Zircon
2: Muscovite
3: Zircon
4: K-feldspar
5: Albite

Figure 2-2.32: Sample 9874 site 35



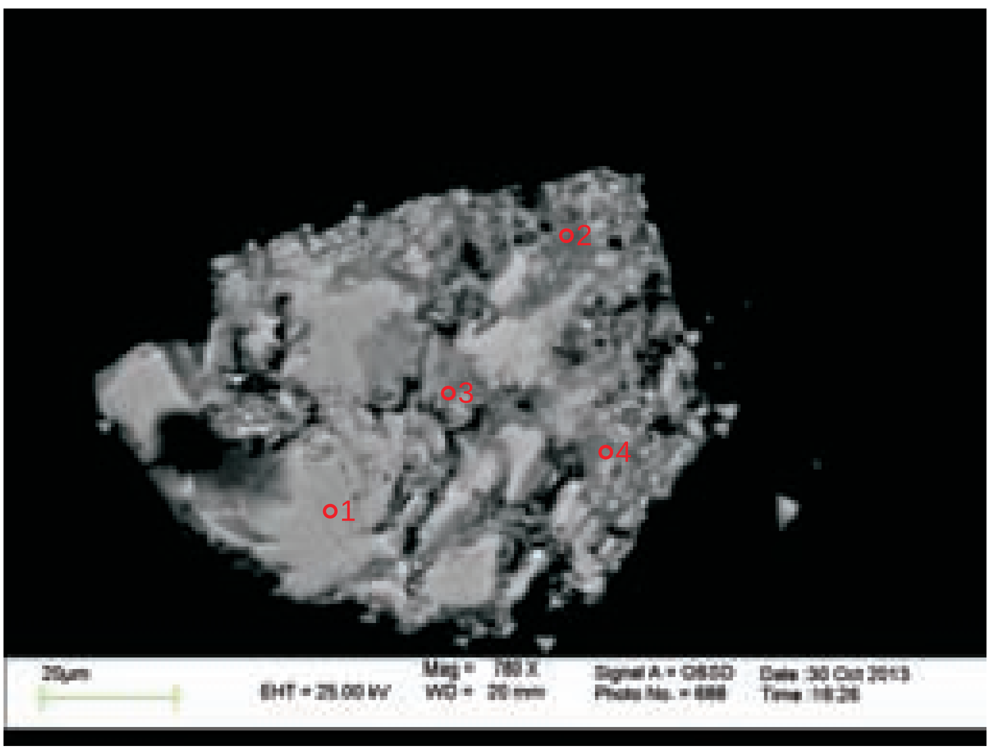
1: Muscovite altering to Chlorite
2: Muscovite
3: Chlorite
4: Zircon
5: Zircon
6: Chlorite
7: Zircon
8: Zircon

Figure 2-2.33: Sample 9874 site 36; hydrothermal zircon (analyses 4,5,&8).



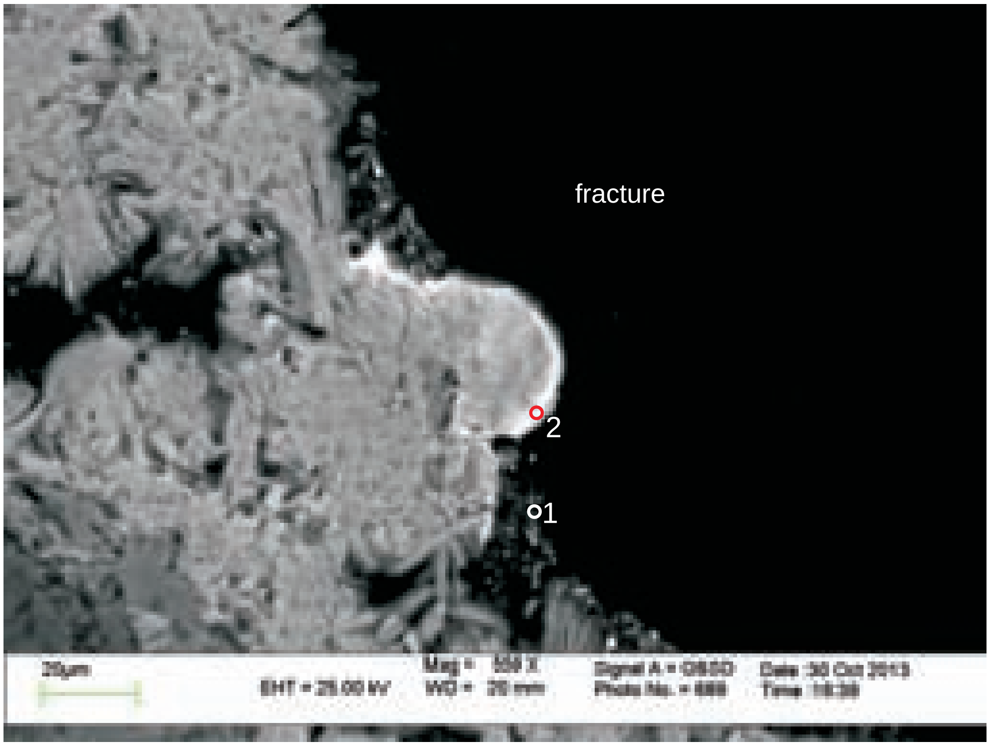
1: Chlorite
2: Zircon
3: Zircon
4: Chlorite

Figure 2-2.34: Sample 9874 site 37; zircon predates chlorite in pore. Zircon from analysis 2 contains Y (~ 4 wt. %).



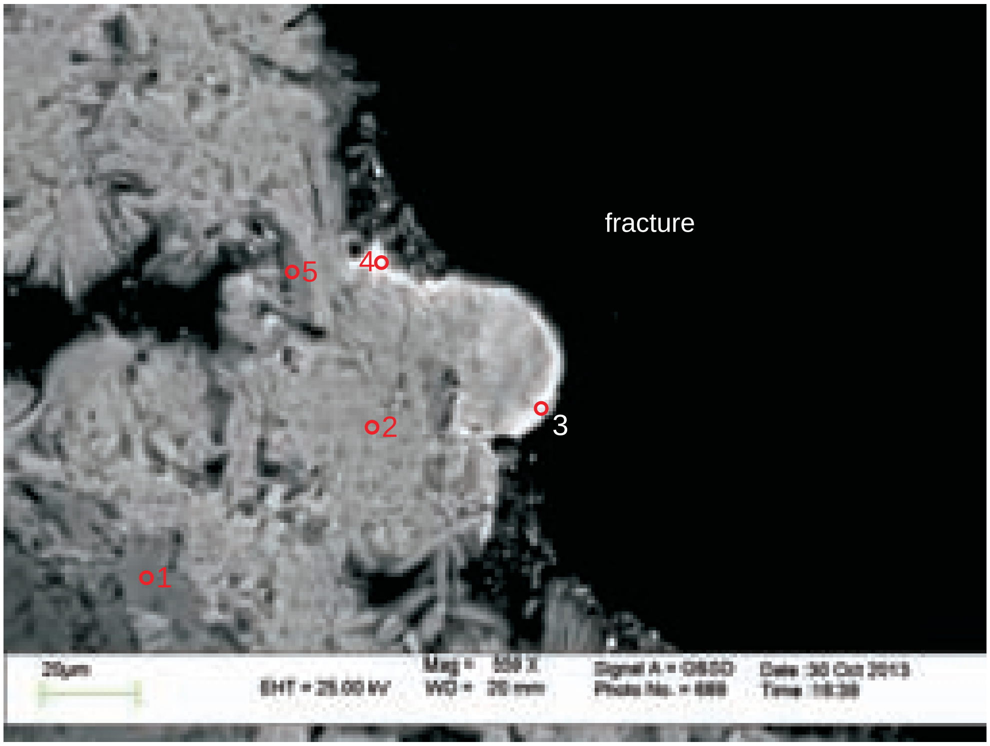
1: Zircon
2: Zircon
3: Zircon
4: Mix (Zircon + Fe-oxide)

Figure 2-2.35: Sample 9874 site 38; same magmatic zircon grain from figure 34, fractured and with dissolution voids. Some zircon assemblages (analyses 3&4) contain Y, whereas others (analyses 1&2) do not. This suggests partial recrystallization of the original magmatic zircon.



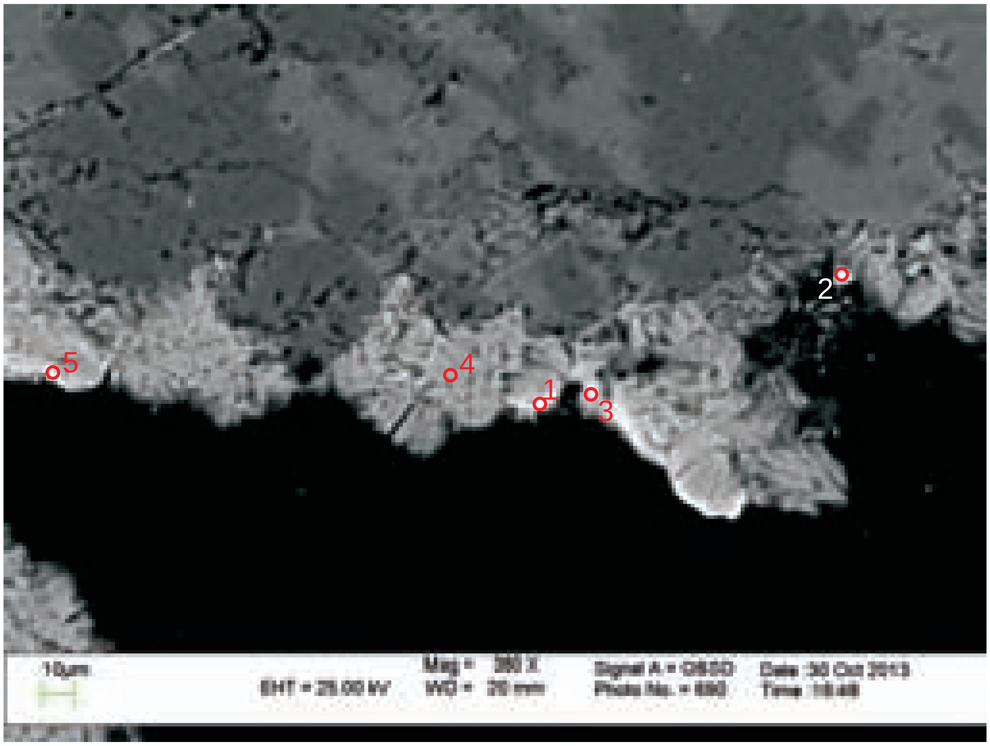
1:Fe-oxide
2:Cerianite (+ Chlorite)

Figure 2-2.36: Sample 9874 site 39; cerianite precipitates on fracture wall with chlorite grain.



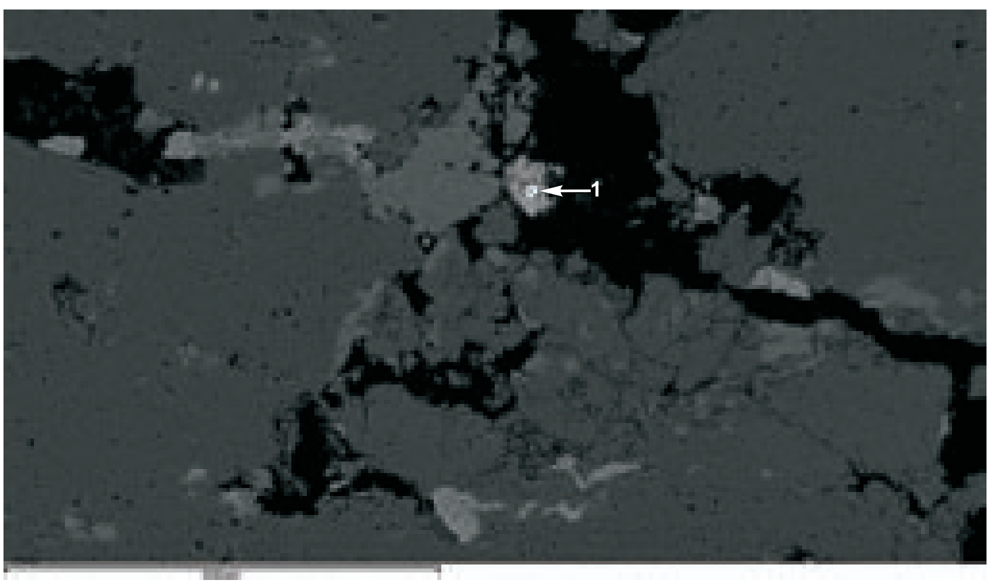
1:K-feldspar
2:Chlorite
3:Cerianite (+chlorite)
4:Cerianite (+chlorite)
5:Chlorite

Figure 2-2.37: Sample 9874 site 40; cerianite precipitates on fracture wall with chlorite.



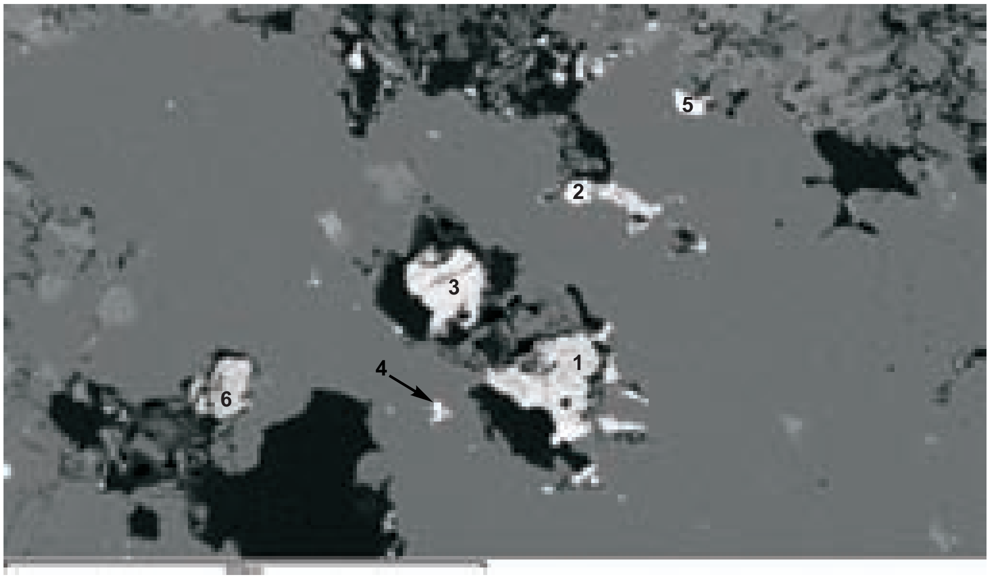
1:Cerianite (+chlorite)
2:Fe-oxide
3:Cerianite (+chlorite)
4:Chlorite
5:Cerianite (+chlorite)

Figure 2-2.38: Sample 9874 site 41; cerianite, chlorite, and Fe-oxide all line the wall of a fracture.



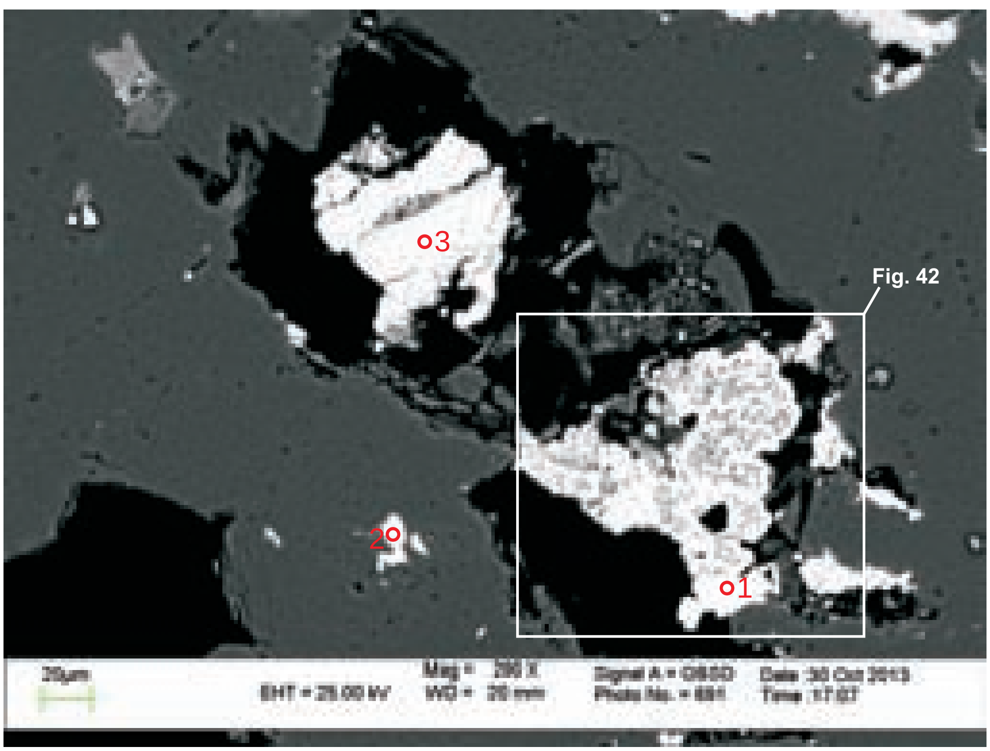
1:Fe-oxide(+silicate)

Figure 2-2.39: Sample 9874 site 42



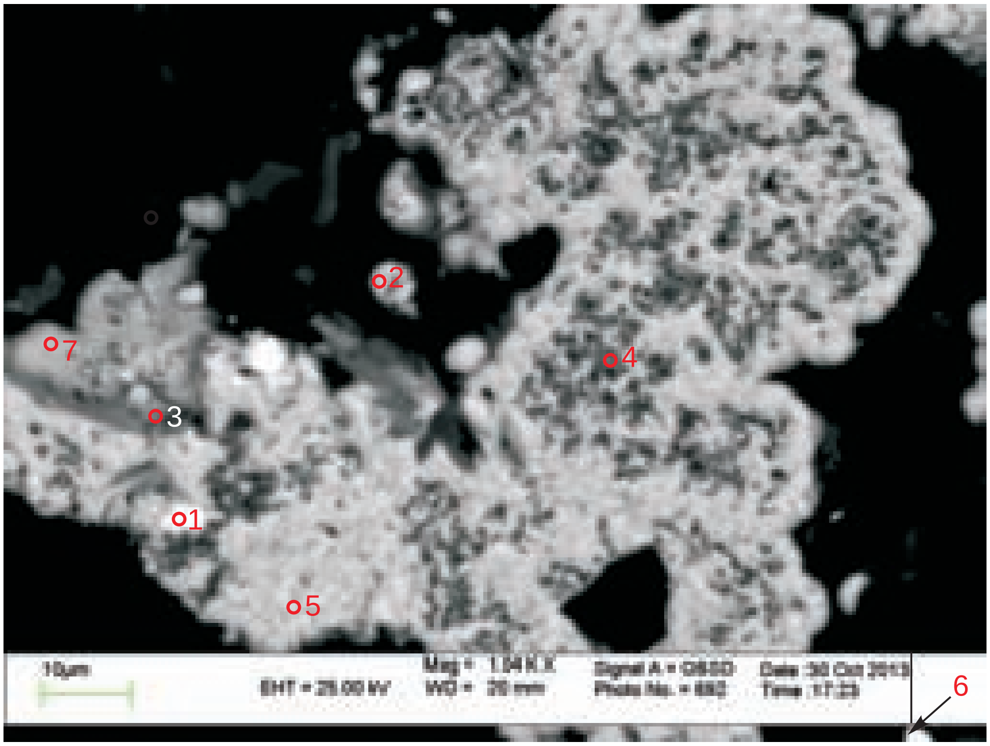
1:Fe-oxide (+others)
2:Zircon (+others)
3:Fe-oxide(+others)
4:Aeschynite-euxenite
5:Zircon
6:Fe-oxide(+others)

Figure 2-2.40: Sample 9874 site 43; Fe-oxide (analyses 1,3,&6), and zircon (analysis 2) fill porosity. Aeschynite-euxenite may also fill dissolution void.



1:Zircon
2:Aeschynite-euxenite
3:Fe-oxide (+others)

Figure 2-2.41: Sample 9874 site 44; aeschynite-euxenite (analysis 1) fills dissolution void.



1:Nb-Y phase (in Fe-oxide)
2:bad analysis
3:Fe-oxide (+others)
4:TiO_2(+Fe-oxide)
5:Fe-oxide(+others)
6:Zircon
7:Fe-oxide(+others)

Figure 2-2.42: Sample 9874 site 45; same as figure 41. Ilmenite enriched in Nb (analysis 4). Grain contains inclusion of samarskite-Y(analysis 1). Anhedral grain of Fe-oxide (analyses 3,5,7) exhibits high degree of corrosion and dissolution and contains patches of samarskite-Y(analysis 1) and TiO2(analysis 4).

Table 2-2: EDS anlyses of sample 9874

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	BaO	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9874	1	1	Zircon	31.17		0.42	2.48														63.92									2						99.99	133.67
9874	1	2	Quartz	99.86			0.14																													100	167.86
9874	1	3	Zircon	33.86			2.7			0.34										3.91	56.3								0.87	2.03						100.01	186.13
9874	1	4	Zircon(+others)	37.5		4.04	3.36					1.42									51.67									2.02						100.01	196.94
9874	1	5	Zircon(+others)	34.8		3.74	1.88				0.39	2.43								2.12	52.45									2.17						99.98	199.83
9874	1	6	K-feldspar	66.1		17.72					0.4	14.85	0.92																							99.99	196.19
9874	1	7	Quartz	99.99																																99.99	191.95
9874	1	8	Quartz	98.57			0.15				0.24		0.89	0.14																						99.99	214.05
9874	1	9	K-feldspar	66.55		17.76					0.54	15.15																								100	192.63
9874	2	1	Zircon	30.98			1.99			0.28										3.42	60.41								0.83	2.09						100	163.68
9874	2	2	Fe-oxide(+other)	5.03		1.63	93.36																													100.02	111.03
9874	2	3	Fe-oxide(+other)	2.57		1.11	96.31																													99.99	125.66
9874	3	1	Zircon	34.93		1.02	1.18														58.62									4.25						100	169.6
9874	3	2	Zircon	30.61			3.72			0.42	0.53									5.25	57.35									2.12						100	154.96
9874	3	3	Fe-oxide(+other)	4.77		2.02	92.41		0.78																											99.98	113.69
9874	3	4	Fe-oxide(+other)	3.66		1.17	95.17																													100	127.78
9874	4	1	Zircon	32.11		0.32	0.3														63.85									3.42						100	177.84
9874	4	2	Zircon	32.3		0.49	0.57														64.04									2.61						100.01	173.15
9874	4	3	Zircon	32.17		0.47	0.93														63.03									3.41						100.01	172.94
9874	5	1	Kfs(+Fe)	52.84		30.91	5.02		0.68		0.66	9.6		0.3																						100.01	155.07
9874	6	1	Zircon	31.38			1.38														65.16									2.09						100.01	180.42
9874	6	2	Fe-oxide(+zircon)	14.87		1.57	61.04														22.52															100	149.15
9874	7	1	Quartz	99.99																																99.99	181.23
9874	7	2	Albite	69.22		18.67					12.12																									100.01	181.84
9874	7	3	K-feldspar	66.55		17.86					0.73	14.88																								100.02	178.78
9874	8	1	Fe-oxide(+other)	2.48		2.66	94.84																													99.98	126.66
9874	8	2	Zircon	31.66			1.22														64.03									3.10						100.01	177.78
9874	9	1	Zircon	32.17			0.49														64.97									2.36						99.99	171.61
9874	9	2	Zircon	28.56		6.73	8.08					0.36								7.26	44.29		1.19						1.73	1.79						99.99	128.47
9874	9	3	Zircon	30.18			1.80			0.25			3.09		0.55					8.95	51.05								1.84	2.28						99.99	136.58
9874	10	1	K-feldspar	67.28		18.03					2.58	12.11																								100	180.72
9874	10	2	Quartz	99.99																																99.99	187.82
9874	10	3	Quartz	99.99																																99.99	164.74
9874	10	4	Albite	68.90		18.78	0.30				12.04																									100.02	179.76
9874	10	5	Albite	68.71		18.76					11.45	1.06																								99.98	173.98
9874	10	6	Albite	68.39		19.18	0.53			0.27	11.63																									100	173.99
9874	11	1	Fe-oxide (+others)	10.05	3.55	3.08	75.92														7.39															99.99	114.32
9874	11	2	Fe-oxide (+others)	12.28	3.25	4.08	72.26				1.79										6.32															99.98	117.48
9874	11	3	Zircon	30.74			3.72			0.56										6.49	54.42								1.28	2.78						99.99	158.48
9874	12	1	K-feldpsar	66.55		18.05					0.58	14.83																								100.01	173.48
9874	12	2	Quartz	99.99																																99.99	177
9874	12	3	Zircon	32.52		0.47	0.81														63.24									2.96						100	166.68
9874	12	4	Albite	69.07		18.99				0.67	11.27																									100	179.43
9874	12	5	Albite	68.92		18.9	0.23			0.24	11.72																									100.01	180.97
9874	12	6	bad analysis	18.57	2.49	12.7	6.2			1.86	2.75	0.79							1.44			37.39	3.8		1.79						2.66			7.56		100	108.65
9874	12	7	K-feldpsar	66.83		17.91					0.49	14.77																								100	169.4
9874	13	1	Aeschynite-euxenite (+Zircon)	20.09	6.97		2.1			0.92					0.5					11.53	31.18	23.95	1.36							1.4						100	150.42
9874	13	2	Zircon	32.05			0.33														63.83									3.79						100	180.55
9874	13	3	Zircon	32.34																	64.65									3.01						100	177.02
9874	13	4	Zircon	32.71		0.43	0.5														59.79									6.58						100.01	172.51
9874	15	1	Samarskite (+others)	29.59	4.59	11.66	6.81			1.15	0.82	5.4		0.26						9.21		28.01	2.51													100.01	133.56
9874	15	2	Samarskite-Y	14.08	2.25	9.43	5.3			1.54	2.21	0.52		0.18						7.48	5.15	33.32			1.42						1.78	4.05	5.19	6.13		100.03	144.54
9874	16	1	Samarskite-Y	9.22	3.29	9.16	9.33			1.85	0.97		2.34	0.68						5.44		36.59			2.13							4.83	5.66	8.5		99.99	103.36
9874	17	1	Samarskite-Y*	2.82						0.43										11.72		17.32							1.04						66.68	100.01	196.03
9874	17	2	Samarskite-Y	23.62			3.37			0.92										26.99		39.91					2.43		2.77							100.01	79.3
9874	17	3	Samarskite-Y	23.92						0.63										28.77		41.94					2.4		2.35							100.01	84.06
9874	18	1	Fe-oxide(+Quartz)	1.24			98.75																													99.99	60.42
9874	18	2	Fe-oxide(+Quartz)	3.68		0.93	95.39																													100	62.86

* If we consider B_2O_3 as an analytical artifact

Table 2-2: EDS anlyses of sample 9874

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	BaO	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9874	19	1	Samarskite-Y	3.72						1.29										31.32		51.18	1.76			1.18	2.69	2.07	3.22		1.56					99.99	82.36
9874	19	2	Samarskite-Y (+Quartz)	27.17						0.29										26.26		39.74					2.04	2.08	2.41							99.99	85.89
9874	19	3	Samarskite-Y (+Quartz)	42.61			0.69			0.67					0.64					21.78		30.48							1.82		1.28					99.97	84.86
9874	19	4	Mix(Quartz + Samarskite-Y)	50.21	0.47	3.91	2.07			0.32			2.32							3.94		34.25			1.01						1.51					100.01	73.89
9874	19	5	Mix(Quartz + Samarskite-Y)	67.77		0.6	4.81			0.32										5.54		19.97						0.99								100	85.66
9874	19	6	Quartz	99.99																																99.99	86.92
9874	20	1	Mix(Quartz + Samarskite-Y)	61.07			0.51			0.45					0.33					17.55		17.47					1.08		1.51							99.97	86.9
9874	21	1	Samarskite-Y*	4.11		1.59	4.32			0.48			2.43						0.63	4.58		19.41			0.68									1.63	60.14	100	156.85
9874	21	2	Samarskite-Y*	7.08		1.36	2.43			0.43	0.58		1.18							4.33		17.14			0.57									1.06	63.84	100	177.08
9874	21	3	Mix (Samarskite-Y +Quartz + Fe-oxide)	23.75		2.85	23.68			0.9	0.7									9.97		36.09												2.07		100.01	70.9
9874	22	1	Fe-oxide				100																													100	62.06
9874	22	2	Zircon	32.09																	67.9															99.99	84.05
9874	22	3	Fe-oxide (+silicate)	2.52			97.48																													100	64.23
9874	23	1	Zircon	33.14			1.16														65.7															100	33.63
9874	23	2	Zircon (+Fe)	28.11			14.56														57.31															99.98	90.7
9874	23	3	Zircon	32.17			0.42														66.09									1.3						99.98	93.33
9874	23	4	Fe-oxide (+silicate)	2.08		1.06	96.88																													100.02	64.16
9874	23	5	Mix (quartz + zircon)	79.79			0.99														18.41									0.79						99.98	100.14
9874	23	6	Mix (quartz + Fe-oxide)	55.34			44.65																													99.99	100.51
9874	23	7	Zircon	32.22			0.3														66.27									1.21						100	92
9874	23	8	Fe-oxide(+silicate)	1.71	1.23		97.07																													100.01	64.32
9874	23	9	Fe-oxide(+silicate)	1.11		0.79	98.09																													99.99	60.91
9874	23	10	Zircon	32.24																	66.55									1.19						99.98	91.95
9874	23	11	Fe-oxide(+silicate)	1.58		0.74	97.67																													99.99	62.06
9874	24	1	Samarskite-Y	5.11						0.55										32.69		51.46				1.44	2.66	2.7	3.4							100.01	85.89
9874	25	1	Samarskite-Y*	9.26	0.22		1.12			0.2					0.47					11.91		18.74							1.4						56.72	100.04	159.77
9874	25	2	Pyrochlore*	16.02	11.14	1.02	3.46			0.49										4.98		14.16	1.15								1.25				46.35	100.02	138.44
9874	25	3	Aeschynite-euxenite*	7.47	9.87		4.68			0.53	0.51									7.16		18.6									1.21		1.71		48.25	99.99	109.88
9874	25	4	Aeschynite-euxenite	23.3	13.74		7.81			0.99	0.86									11.96		37.06	2.37								1.89					99.98	65.89
9874	25	5	Pyrochlore	22.08	17.45		6.47			1.13					0.85					11.93		35.19	3.02								1.87					99.99	69.98
9874	25	6	Samarskite-Y*	17.52	0.17		1.3			0.32			1.18		0.32					6.46		11.89							0.75						60.14	100.05	191.01
9874	26	1	Samarskite-Y*	4.26	9.42	1.93	8.32		0.76	0.46		0.58								5.5		12.46	0.49												55.82	100	156.15
9874	27	1	Mix (Quartz+Fe-oxide)	45.37		5.06	44.55	0.35			1.36	2.04		1.27																						100	52.2
9874	28	1	Zircon	32.26			0.44														66.01									1.3						100.01	106.47
9874	28	2	Zircon	31.9			0.76														65.73									1.62						100.01	91.4
9874	28	3	Zircon	28.22		2.53	3.22						2.35							8.1	51.99								1.8	1.79						100	74.73
9874	28	4	Fe-oxide	0.79	2.2		97.01																													100	62.63
9874	29	1	Biotite/Chlorite	42.31	0.58	25.87	21.6		4.69			4.08					0.30	0.56																		99.99	79.42
9874	29	2	Chlorite	30.9145	1.5045	22.1765	24.582		4.4115		0.289	0.289					0.34	0.5015																		85	70.97
9874	29	3	Chlorite	30.9825	0.2125	21.9045	22.253		7.735		0.323	0.6715					0.37	0.527																		85	77.36
9874	29	4	Fe-oxide(+silicate)	1.97	2.15	0.6	95.29																													100.01	63.23
9874	30	1	Zircon	30.4			7.08														61.07									1.44						99.99	99.86
9874	30	2	Mix (Fe-oxide + Quartz)	78.68			21.33																													100.01	85.73
9874	30	3	Mix (Fe-oxide + Quartz)	20.41		0.94	78.64																													99.99	68.05
9874	31	1	Quartz	99.99																																99.99	95.77
9874	32	1	Zircon	33.84			0.37														64.35									1.42						99.98	99.92
9874	32	2	Mix (Fe-oxide + zircon)	11.98	3.2	1.19	66.43														17.18															99.98	69.43
9874	32	3	Zircon	45.2			2.95														51.86															100.01	101
9874	32	4	Zircon	32.58			3.46														60.62									3.34						100	88.31
9874	32	5	Fe-oxide	1.63			98.38																													100.01	69.53
9874	32	6	Fe-oxide	1.93	3.02		95.05																													100	66.09
9874	32	7	Mix (Fe-oxide + others)	10.48	1.08		80.53			1.44										6.45																99.98	54.19
9874	32	8	Fe-oxide		0.88		99.11																													99.99	56.99
9874	32	9	Fe-oxide		0.55		99.45																													100	69.99

* If we consider B_2O_3 as an analytical artifact

Table 2-2: EDS anlyses of sample 9874

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	BaO	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9874	32	10	Fe-oxide		3.97		96.02																													99.99	58.54
9874	32	11	Fe-oxide		4.25		95.75																													100	64.26
9874	32	12	Fe-oxide	1.48	0.85		97.68																													100.01	59.49
9874	32	13	Samarskite-Y	7.47	0.9		13.52			1.51					1.88					23.46		51.28														100.02	55.05
9874	32	14	Fe-oxide	1.33	2.55		96.11																													99.99	72.79
9874	32	15	Mix	34.38			1.29														61.79									2.56						100.02	87.56
9874	33	1	Samarskite-Y*	2.01			2.03			0.31			1.08							5.89	1.24	9.78			0.33			1.11	0.95					0.49	74.79	100.01	220.33
9874	33	2	Fe-oxide(+silicate)	1.67		0.93	97.41																													100.01	69.01
9874	33	3	Fe-oxide(+silicate)	2.44		1.19	96.37																													100	67.43
9874	34	1	Muscovite	51.55		28.97	7.62		0.9			10.41		0.54																						99.99	96.44
9874	34	2	Zircon	33.29		3.8	4.03		0.91												57.98															100.01	72.6
9874	34	3	Zircon	33.18			0.81							0.9							65.1															99.99	49.19
9874	34	4	Zircon	31.64																	68.36															100	97.31
9874	34	5	Chlorite	30.039		19.992	27.3275		7.157									0.4845																		85	78.77
9874	34	6	Chlorite	33.439		16.932	24.1485		8.8485	0.3315								1.3005																		85	72.28
9874	34	7	Ilmenite (+others)	10.18	31.58	11.21	43.84	2.52						0.66																						99.99	51.4
9874	34	8	Chlorite	30.855		19.193	25.2705		8.4405									1.241																		85	84.5
9874	34	9	Mix(Fe-oxide+quartz)	49.8			50.2																													100	93.93
9874	35	1	Zircon	31.98		0.93	0.63														64.03									2.44						100.01	95.04
9874	35	2	Muscovite	55.62		28.21	4.71		1.53			9.95																								100.02	79.26
9874	35	3	Zircon	31.51																	66.7									1.79						100	101.61
9874	35	4	K-feldspar	66.76		17.72	0.39					15.13																								100	100.47
9874	35	5	Albite	68.43		19.14				0.7	11.57			0.18																						100.02	103.84
9874	36	1	Muscovite/chlorite	38.55		24.02	27		8.41			2.02																								100	86.83
9874	36	2	Muscovite	52.32		30.02	5.63		1.13			10.65		0.25																						100	92.45
9874	36	3	Chlorite	33.0905		18.02	24.208		8.9335			0.255						0.4845																		85	80.84
9874	36	4	Zircon	31.92			0.37														65.85									1.86						100	100.6
9874	36	5	Zircon	32.07		0.49	0.71														64.45									2.29						100.01	96.9
9874	36	6	Chlorite	32.4785		16.9915	23.205		6.8765	0.3315		0.5185					0.59	4.012																		85	78.33
9874	36	7	Zircon	31.23		3.57	7.29		0.73												55.87									1.31						100	75.47
9874	36	8	Zircon	33.07			0.84														63.35									2.74						100	60.54
9874	37	1	Chlorite	30.4895		17.493	28.3135	0.2635	8.1005									0.3485																		85	87.98
9874	37	2	Zircon	30.18		1.44	1.65			0.32			2.42							4.19	57.84									1.95						99.99	72.58
9874	37	3	Zircon	32.97		1.4	2.88		0.6												60.77									1.36						99.98	110.11
9874	37	4	Chlorite	29.053		18.4875	29.801	0.272	6.9105									0.476																		85	84.3
9874	38	1	Zircon	31.87			0.33														66.49									1.3						99.99	105.99
9874	38	2	Zircon	30.78		1.28	4.22			0.28		0.26	3.66								57.77									1.72						99.97	96.13
9874	38	3	Zircon	30.7			2.75			0.45			2.25							5.51	56.14								0.98	1.23						100.01	94.99
9874	38	4	Mix (Zircon + Fe-oxide)	26.18		0.91	19.75			0.28										3.98	47.09									1.8						99.99	89.96
9874	39	1	Fe-oxide(+others)	5.05		0.76	92.46	0.84			0.78			0.12																						100.01	65.32
9874	39	2	Cerianite (+chlorite)	30.63		17.44	15.4	9.33	1.82	0.77		0.34		0.49		0.42	1.46	0.59							21.3											99.99	64.94
9874	40	1	K-feldspar	65.72		17.57	0.8					14.71	1.2																							100	103.19
9874	40	2	Chlorite	31.382		16.32	26.8855		8.891	0.2635								1.258																		85	83.35
9874	40	3	Cerianite (+chlorite)	26.68		17.89	15.95	10.88	1.82	0.78		0.29		0.49	1.48	0.69	1.78	0.82							20.44											99.99	66.01
9874	40	4	Cerianite (+chlorite)	20.6		16.16	12.88	6.08		0.84	1.36			0.53	1.68		1.06								38.8											99.99	59.97
9874	40	5	Chlorite	32.708		16.7875	24.99		9.061		0.8925							0.561																		85	94.37
9874	41	1	Cerianite (+chlorite)	31.83		16.5	14.4	2.94	1.54	0.7		0.72					0.58								30.78											99.99	76.91
9874	41	2	Fe-oxide	13.67		1.68	83.02	0.49			0.89			0.25																						100	93.37
9874	41	3	Cerianite (+chlorite)	11.34		16.7	5.97	10.74		0.91			10.77	0.34	2.86		1.55								38.8											99.98	68.71
9874	41	4	Chlorite	29.24		18.258	30.3365		6.9105									0.2635																		85	85.48
9874	41	5	Cerianite (+Chlorite)	30.1		18.63	13.65	3.56	2.29	0.56		0.77		1.37			0.84								28.24											100.01	56.36
9874	42	1	Fe-oxide (+others)	15.83		1.02	82.15	0.99																												99.99	82.93
9874	43	1	Fe-oxide(+other)	3.25	6.01	3.65	78.48	0.75														7.88														100.02	69.48
9874	43	2	Zircon (+others)	23.87	6.17	1.4	28.07														40.5															100.01	94.92
9874	43	3	Fe-oxide(+others)	4.94	5.17	2.36	83.25	0.59														3.68														99.99	76.1
9874	43	4	Aeschynite-euxenite	28.88	0.75		0.76			1.72										17.08		44.42					2.07		2.16					2.16		100	94.84
9874	43	5	Zircon	32.05			0.64														65.08									2.23						100	111.11
9874	43	6	Fe-oxide(+others)	3.12	8.02	3.8	74.4															10.64														99.98	61.51
9874	44	1	Zircon	32			0.94						1.6								64									1.46						100	108.3
9874	44	2	Aeschynite-euxenite	28.17			0.58			2.01					0.48					15.61		44.95		1.94					1.78		1.75			2.75		100.02	90.44

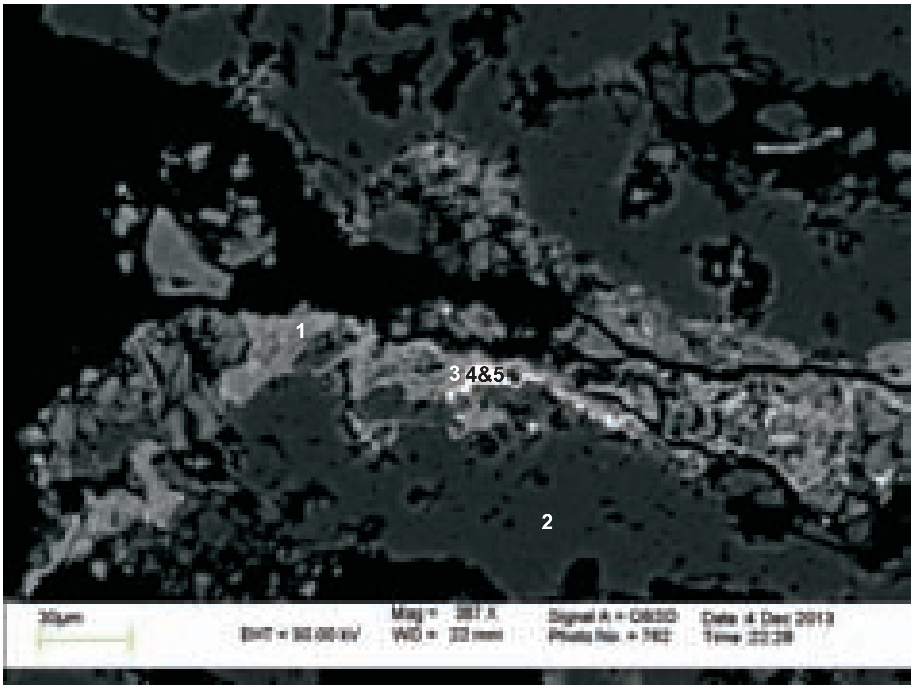
* If we consider B_2O_3 as an analytical artifact

Table 2-2: EDS anlyses of sample 9874

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	BaO	Ce_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9874	44	3	Fe-oxide(+silicate)	4.88	6.42	2.38	81.86	0.88														3.56														99.98	76.54
9874	45	1	Nb-Y phase (in Fe-oxide)	5.2	9.01	2.78	52.6	0.84		0.43				0.37						8.8		19.97														100	68.56
9874	45	2	Bad Analysis	0.06			0.28													0.17		0.27			0.01										99.24	100.03	7701.14
9874	45	3	Fe-oxide(+others)	12.54	2.29	2.95	77.68		0.53		0.96			0.26								2.82														100.03	66.12
9874	45	4	TiO2(+Fe-oxide)	2.67	20	3.46	63.53	3.15						0.58								6.62														100.01	63.88
9874	45	5	Fe-oxide(+others)	5.22	3.9	3.17	82.68															5.04														100.01	74.73
9874	45	6	Zircon	35.64		4.44	2.97		0.5												55.22									1.24						100.01	114.5
9874	45	7	Fe-oxide(+others)	6.76	1.53	1.64	87.78															2.29														100	63.24

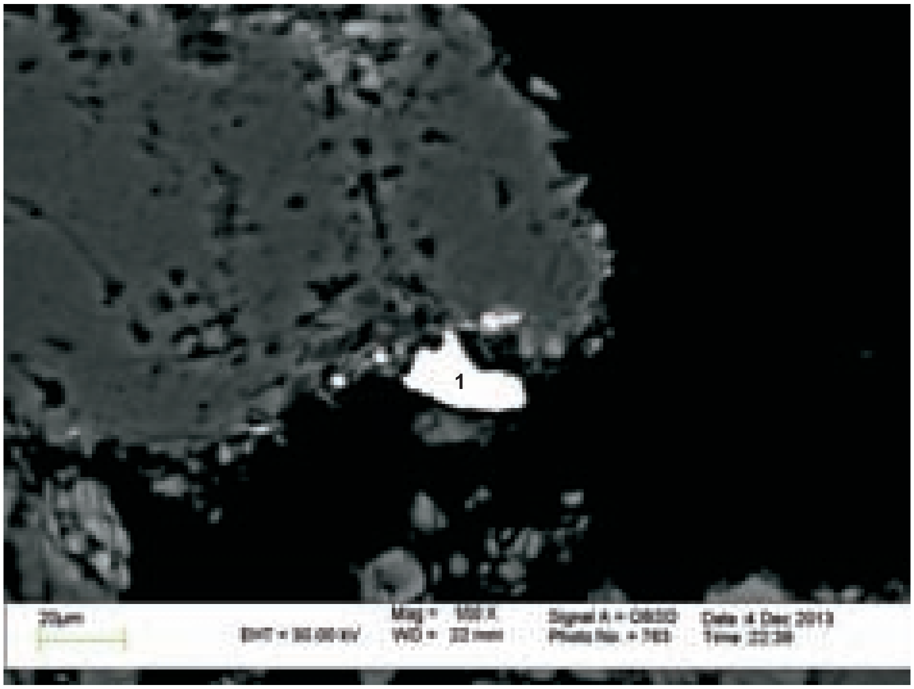
* If we consider B_2O_3 as an analytical artifact

Appendix 2-3: BSE images and EDS mineral analyses of sample 9876



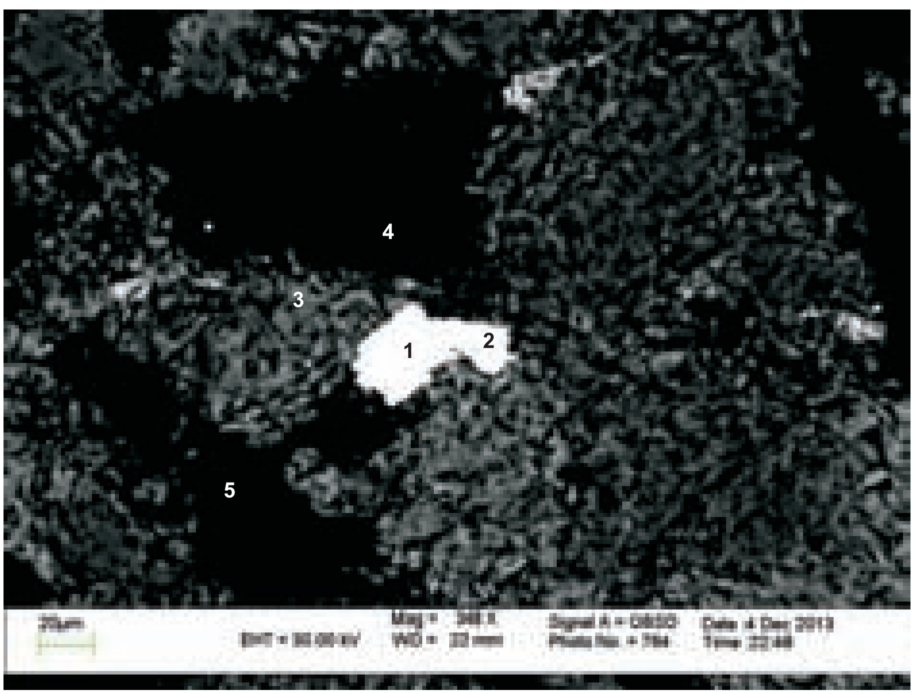
1:Chlorite/Muscovite
2:Quartz
3:Chlorite/Muscovite
4:Aeschynite-euxenite
5:Aeschynite-euxenite

Figure 2-3.1: Sample 9876 site 8



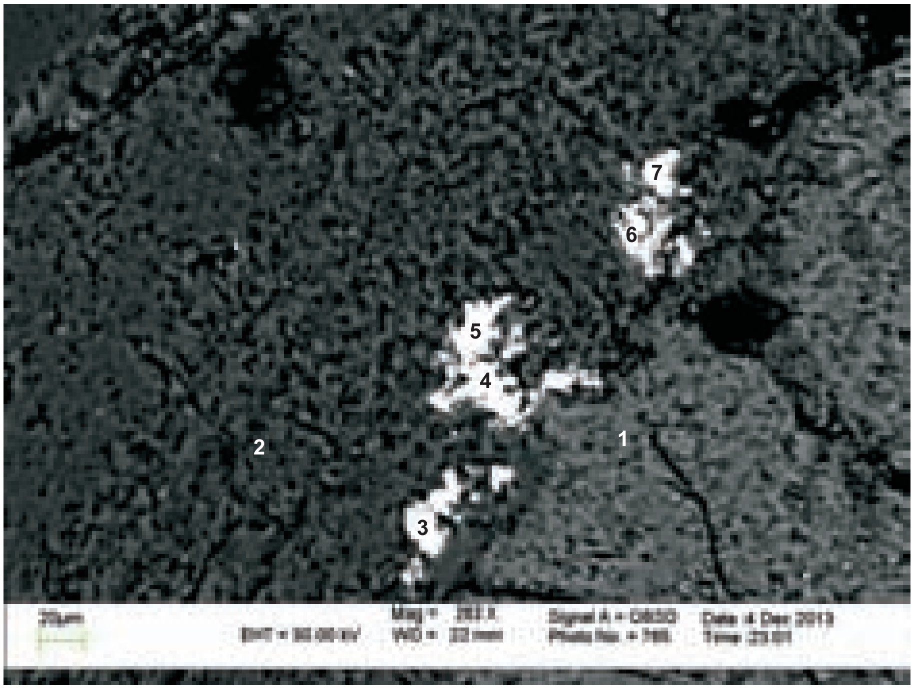
1:Fe-oxide

Figure 2-3.2: Sample 9876 site 9



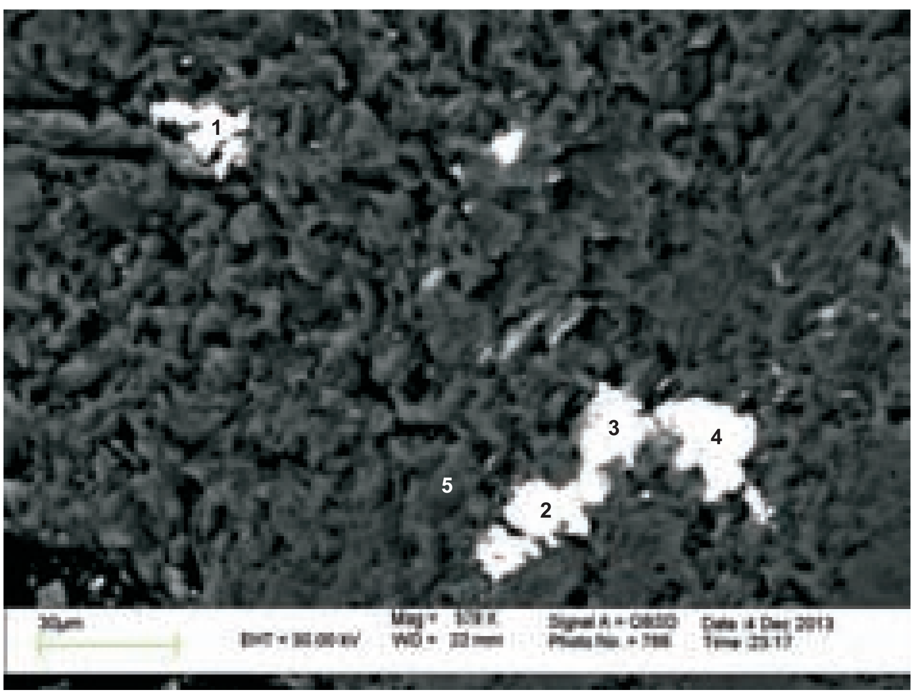
1:Aeschynite-euxenite
2:Aeschynite-euxenite
3:Alkali feldspar
4:hole
5:hole

Figure 2-3.3: Sample 9876 site 11



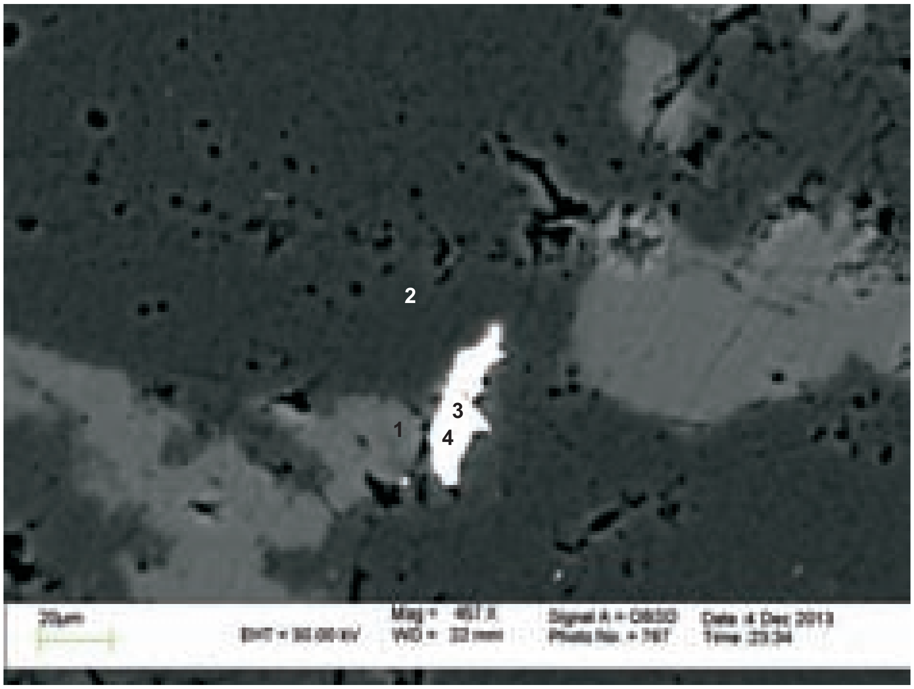
1:K-feldspar
2:Albite
3:Fe-hingganite-Y
4:Fe-hingganite-Y
5:Fe-hingganite-Y
6:Fe-hingganite-Y
7:Fe-hingganite-Y

Figure 2-3.4: Sample 9876 site 13: hingganite fills porosity.



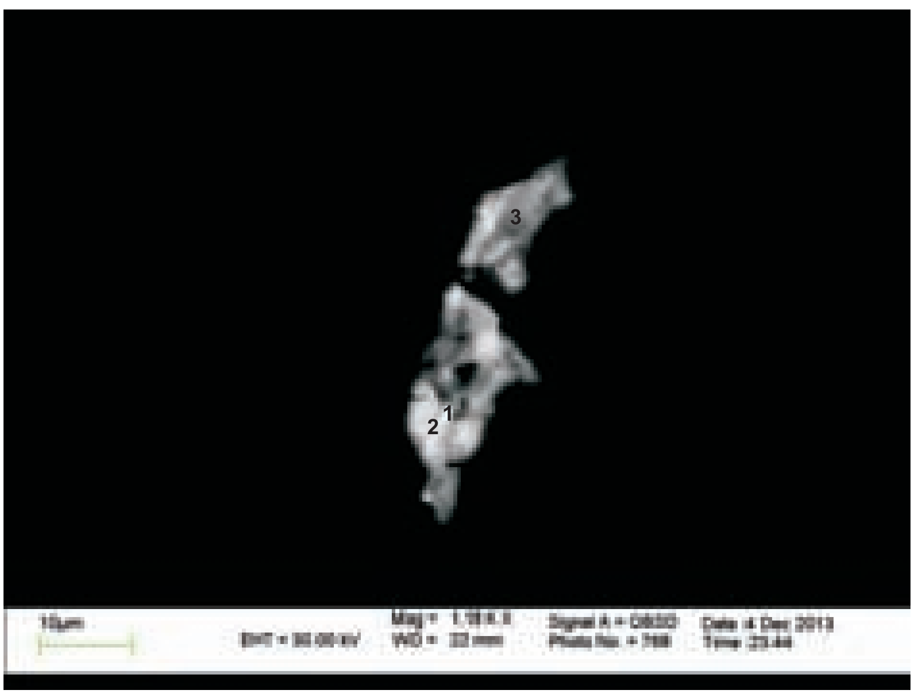
1:Aeschynite-euxenite (+others)
2:Fe-hingganite-Y
3:Fe-hingganite-Y
4:Fe-hingganite-Y
5:Albite

Figure 2-3.5: Sample 9876 site 14; hingganite (analyses 2-4) and aeschynite-euxenite (analysis 1) fill porosity.



1:K-feldspar
2:Quartz
3:Aeschynite-euxenite (+others)
4:Aeschynite-euxenite (+others)

Figure 2-3.6: Sample 9876 site 16; aeschynite-euxenite fills dissolution void.



1:Aeschynite-euxenite (+others)
2:mix
3:Aeschynite-euxenite (+others)

Figure 2-3.7: Sample 9876 site 17; higher magnification than figure 6.

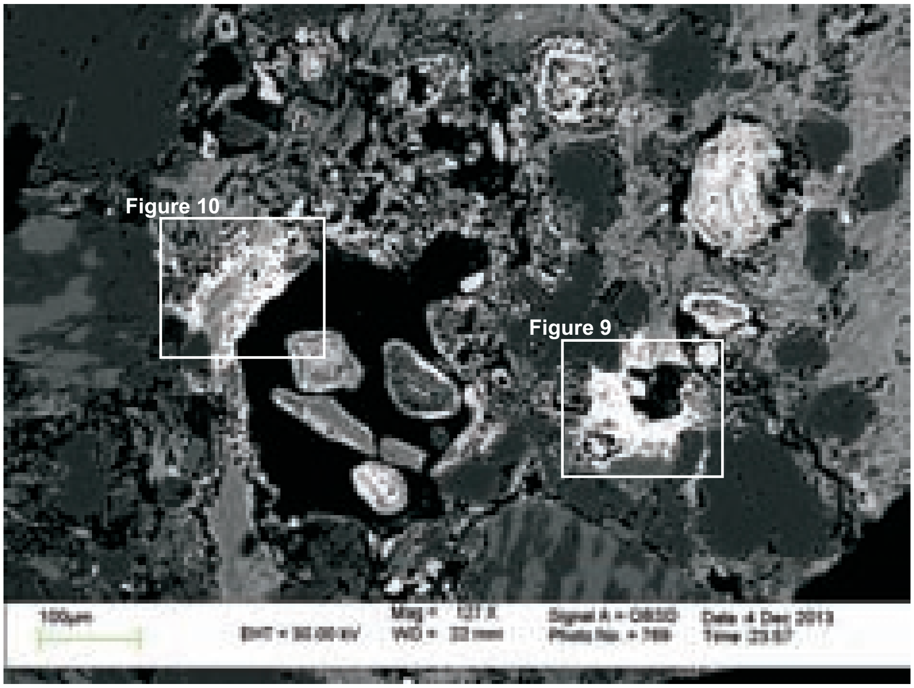
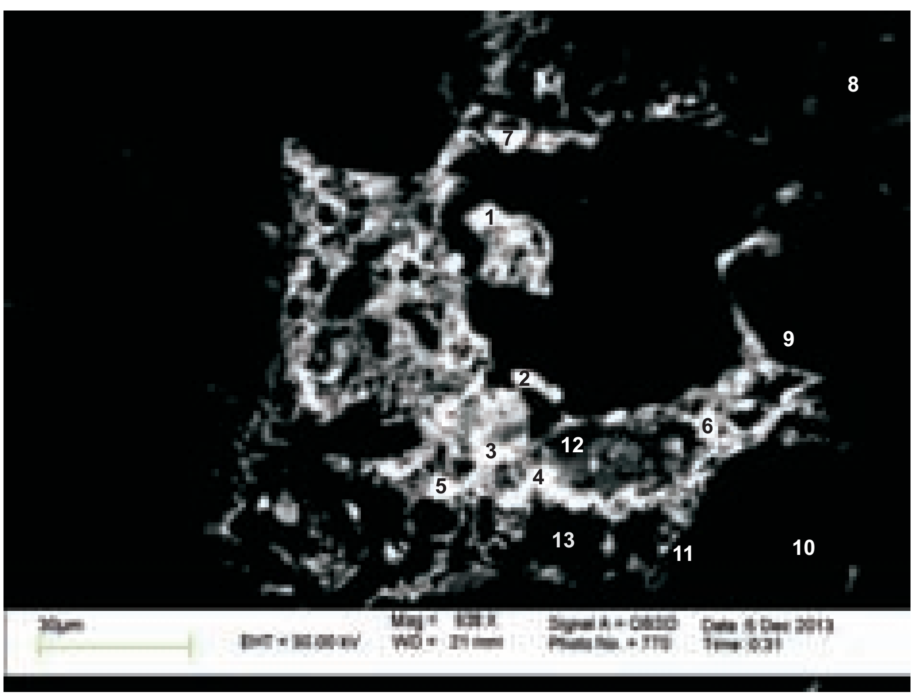
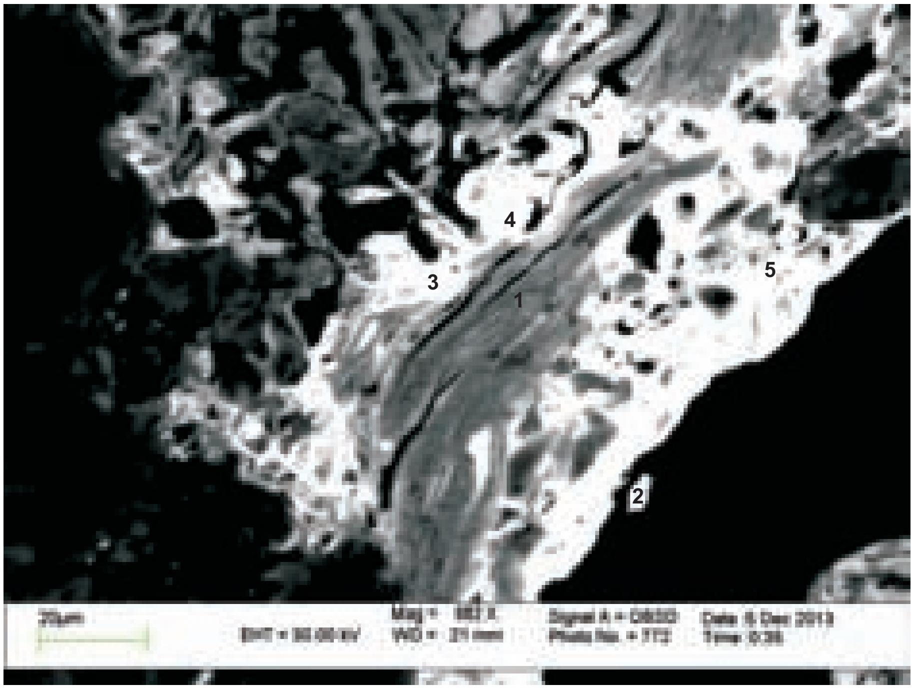


Figure 2-3.8: Sample 9876



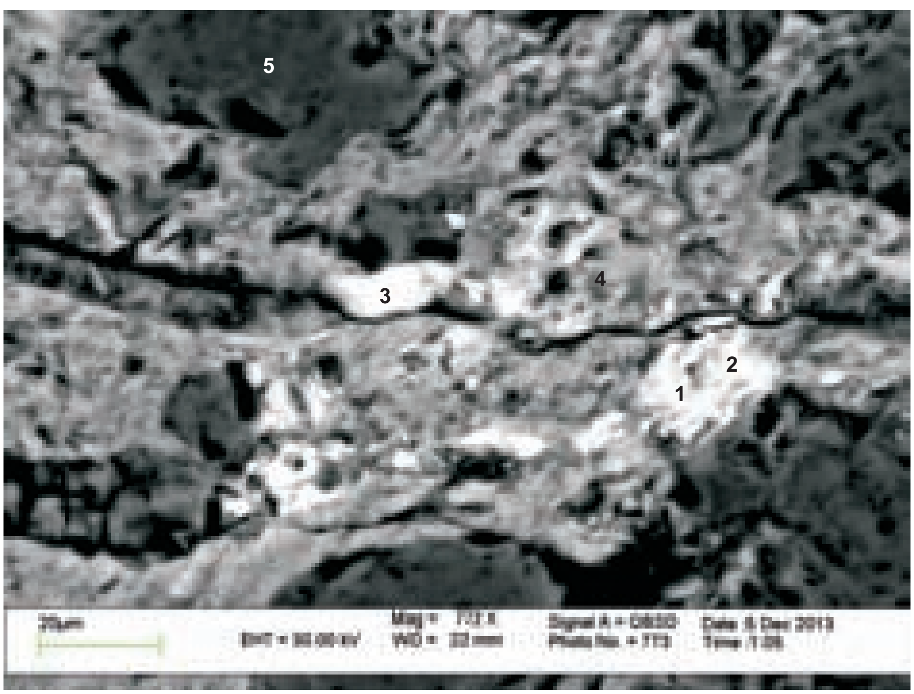
1:cerianite(+others)
2:cerianite(+others)
3:cerianite(+others)
4:cerianite(+others)
5:cerianite(+others)
6:cerianite(+others)
7:cerianite(+others)
8:Fe-oxide(+others)
9:Chlorite
10:Albite
11:K-feldspar
12:Mix
13:Chlorite

Figure 2-3.9:Sample 9876 site 19; cerianite (brighter spots) together with Fe-oxides, chlorite and probably an aluminum-phosphate mineral phase rim a void.



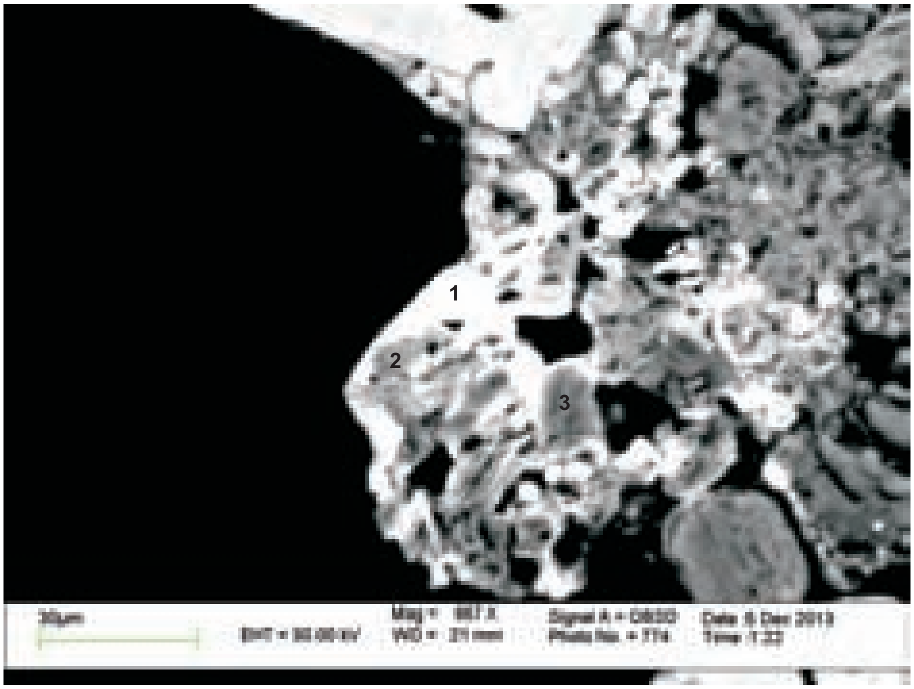
1:Chlorite
2:Mix
3:Cerianite
4:Cerianite
5:Cerianite

Figure 10: Sample 9876 site 20; cerianite rims chlorite and precipitates along cleavage planes of chlorite.



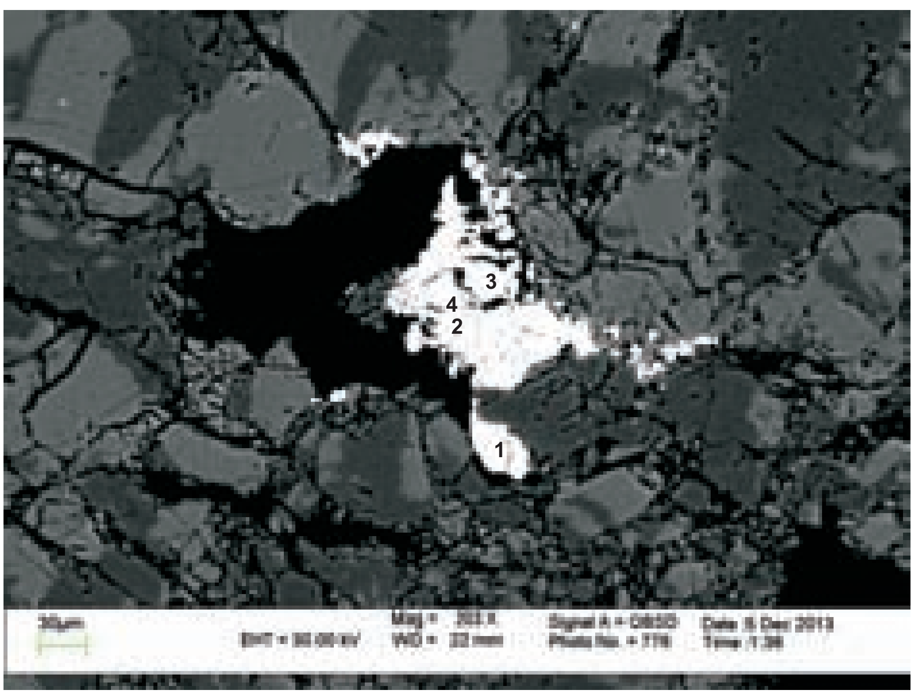
1:TiO2
2:TiO2
3:Mix(Cerianite+mica)
4:Chlorite
5:Quartz

Figure 11: Sample 9876 site 22; the latest mineral includes cerianite and TiO2 minerals.



1:Cerianite
2:Muscovite
3:Muscovite

Figure 12: Sample 9876 site 24; cerianite rims chlorite and precipitates along its cleavage planes.



1:Aeschynite-euxenite
2:Aeschynite-euxenite
3:Aeschynite-euxenite
4:Aeschynite-euxenite

Figure 13: Sample 9876 site 29; aeschynite-euxenite fills porosity.

Table 2-3: EDS analyses of sample 9876

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	SnO_2	Ce_2O_3	Nd_2O_3	Gd_2O_3	Er_2O_3	Yb_2O_3	Ta_2O_5	ThO_2	UO_3	Total	Total
9876	8	1	Chlorite replacing muscovite	33.59	0.62	24.83	21.34	0.25	19.14			0.25																							100.02	65.07
9876	8	2	Quartz	99.99																															99.99	76.33
9876	8	3	Chlorite replacing muscovite	38.18	1.97	24.21	20.98	0.22	12.93			1.51																							100	67.31
9876	8	4	aeschynite-euxenite (+others)	23.19	7.21	8.09	10.3		1.38	0.9		0.55										6.41	2.77	33.32	2.52									3.34	99.98	52.82
9876	8	5	aeschynite-euxenite (+others)	25.69	6.91	6.88	8.62			1.08												7.8		34.82									4.85	3.35	100	56.78
9876	9	1	Fe-oxide			1.36	89.76												3.63							1.61									99.98	82.99
9876	11	1	aeschynite-euxenite	5.07	13.28	3.29	8.01			2.1							1.41					13.75	3.2	38.72	3.33			1.55				2.78		3.5	99.99	37.98
9876	11	2	aeschynite-euxenite	5.9	10.71	3.89	7.29			1.9												11.66		44.96						2.69		1.65	5.92	3.41	99.98	49.95
9876	11	3	Alkali Feldspar	68.82		18.74	0.32				6.13	5.97																							99.98	87.66
9876	11	4	hole	12.73												87.27																			100	1.72
9876	11	5	hole	20.43		7.77						4.76				67.06																			100.02	3
9876	13	1	K-feldspar	65.95		17.74					0.66	15.65																							100	77.93
9876	13	2	albite	67.47		19.37	0.41			0.57	12.16																								99.98	87.37
9876	13	3	Fe-hingganite-Y	45.95			14.02			1.79							1.41					34.18							2.65						100	48.14
9876	13	4	Fe-hingganite-Y	42.44			13.37			1.74	1.07											34.8							3.34	3.25					100.01	45.22
9876	13	5	Fe-hingganite-Y	44.58			14.33			2.15						0.43						31.85							3.47	3.18					99.99	44.97
9876	13	6	Fe-hingganite-Y	46.46			11.5			1.87	1.33					0.4						32.88							2.92	2.62					99.98	40.03
9876	13	7	Fe-hingganite-Y	40.84			15			1.74	1.46					0.37						34.77							2.71	3.1					99.99	43.26
9876	14	1	aeschynite-euxenite (+others)	25.35	0.92	10.49	1.75			1.27	2.86					0.4	0.56					11.54		35.51			0.83				1.46		5.18	1.9	100.02	56.97
9876	14	2	Fe-hingganite-Y	41.65			14.9			1.93						0.39						31.6					1.19	1.31	1.57	3.1	2.36				100	48.41
9876	14	3	Fe-hingganite-Y	39.43			18.17			3.72	1.33											28.79						1.32	1.94	2.94	2.37				100.01	48.45
9876	14	4	Fe-hingganite-Y	40.24			14.15			2.49						0.37						33.02						1.63	1.68	3.7	2.72				100	45.01
9876	14	5	Albite	69.2		19.16					11.65																								100.01	73.37
9876	16	1	K-feldspar	66.59		17.86					0.51	15.06																							100.02	75.28
9876	16	2	Quartz	99.99																															99.99	77.57
9876	16	3	aeschynite-euxenite	14.08	5.5	6.35	7.71			1.48							1.18					12.54		38.6							1.94		7.82	2.82	100.02	44.06
9876	16	4	aeschynite-euxenite	16.75	3.94	9.52	5.16			1.5	2.02	0.51										10		38.22	4.18		1.21			2.17	1.43			3.38	99.99	58.09
9876	17	1	aeschynite-euxenite	14.05	4.05	8.96	4.98			1.47	1.55	0.58										10.64		39.24				0.71		1.99	1.58		7.56	2.64	100	57.39
9876	17	2	mix	59.92	0.75	17.52	1.6				9.64	1.59										1.07		7.11	0.83										100.03	66.91
9876	17	3	aeschynite-euxenite	30.18	6.81	4.29	5.08			1.51												7.98		33.39			1.11					2.59	4.37	2.69	100	63.91
9876	19	1	cerianite(+others)	7.66		11.7	40.16	3.25					3.53	1.22													32.46								99.98	59.64
9876	19	2	cerianite(+others)	11.23	0.57	10.98	34.01	3.54				0.58	3.23	1.6		0.46								3.86			29.93								99.99	57.1
9876	19	3	cerianite(+others)	15.49	0.55	12.4	27.7	1.47				1.94	3.55	0.95										3.63			32.32								100	60.73
9876	19	4	cerianite(+others)	11.19	0.4	11.94	28.25	2.94				0.92	3.76	1.52													39.09								100.01	55.06
9876	19	5	cerianite(+others)	4.09		11.41	28.66	3.96				0.29	4.06	1.4		0.31											45.81								99.99	55.96
9876	19	6	cerianite(+others)	6.33	1.33	10.39	39.34	4.08					3.62														34.91								100	59.61
9876	19	7	cerianite(+others)	7.85	0.55	8.96	38.72	2.03				0.31	3.3			0.28								3.99			34								99.99	57.27
9876	19	8	Fe-oxide (+others)	9.75	1.1	9.45	71.71									0.37								7.62											100	50.3
9876	19	9	Chlorite	36.28		25.26	25.22	0.31	12.93																										100	69.58
9876	19	10	Albite	68.45		18.93	0.4			0.42	11.8																								100	86.43
9876	19	11	K-feldspar (+others)	51.21		31.29	3.71		2.55			10.55															0.68								99.99	76.79
9876	19	12	mix	5.01		14.53	42.67	3.73				0.43	2.73			0.77											30.14								100.01	46.93
9876	19	13	Chlorite	33.84		24.26	21.09	1.02	13.55			0.59								0.44							5.21								100	69.91
9876	20	1	Chlorite	34.63		23.26	20.69	1.32	15.72											0.37							4.02								100.01	69.07
9876	20	2	bad analysis	15.27			7.41									38.89		10.79			27.63														99.99	4.02
9876	20	3	Cerianite(+others)	10.8	0.53	10.47	33.02	2.66	2.92				2.61	1.1										2.37			33.5								99.98	63.29
9876	20	4	Cerianite(+others)	6.8	0.72	8.28	32.66	3.27					3.46	1.87										4.38			38.57								100.01	60.45
9876	20	5	Cerianite(+others)	25.93	0.4	19.69	19.88	2.53	0.91			3.06	1.56														26.04								100	70.4
9876	22	1	TiO_2	1.09	98.13		0.77																												99.99	65.78

Table 2-3: EDS analyses of sample 9876

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	SnO_2	Ce_2O_3	Nd_2O_3	Gd_2O_3	Er_2O_3	Yb_2O_3	Ta_2O_5	ThO_2	UO_3	Total	Total
9876	22	2	TiO_2	0.71	97.93	0.43	0.93																												100	65.99
9876	22	3	mix (cerianite + mica)	38.31	0.33	18.08	7.29	1.86	2.49			3.48	3.19	0.6													24.38								100.01	66.69
9876	22	4	Chlorite	34.8	0.3	25.66	24.38	0.3	14.34			0.2																							99.98	73.86
9876	22	5	Quartz	99.77			0.22																												99.99	79.97
9876	24	1	Cerianite	5.07	0.53	6.63	43.32	3.47					2.89											3.22			34.87								100	61.04
9876	24	2	Muscovite	49.14	0.22	29.76	3.5	2.36	1.97			8.37			1.35												3.33								100	74.88
9876	24	3	Muscovite	49.84	0.32	31.88	3.55	0.15	2.12		0.28	10.18															1.68								100	77.74
9876	29	1	aeschynite-euxenite	7.44	2.19	7.01	3.07			1.51							0.99					13.01	4.43	43.29			1.62				2.05	2.04	8.68	2.67	100	52.94
9876	29	2	aeschynite-euxenite	11.44	2.14	7.01	2.69			0.92						0.56						11.28	5.65	40.87			1.42			2.34	1.75		8.98	2.91	99.96	51.8
9876	29	3	aeschynite-euxenite	7.83	2.2	7.01	2.86			1.16												12.55	5.07	43.67			1.25			2.74	1.96		8.84	2.88	100.02	55.12
9876	29	4	aeschynite-euxenite	8.83	2.47	6.31	3.16			0.92						1.33	1.13					11.95	4.66	41.76							2.06	1.99	9.7	3.71	99.98	39.23

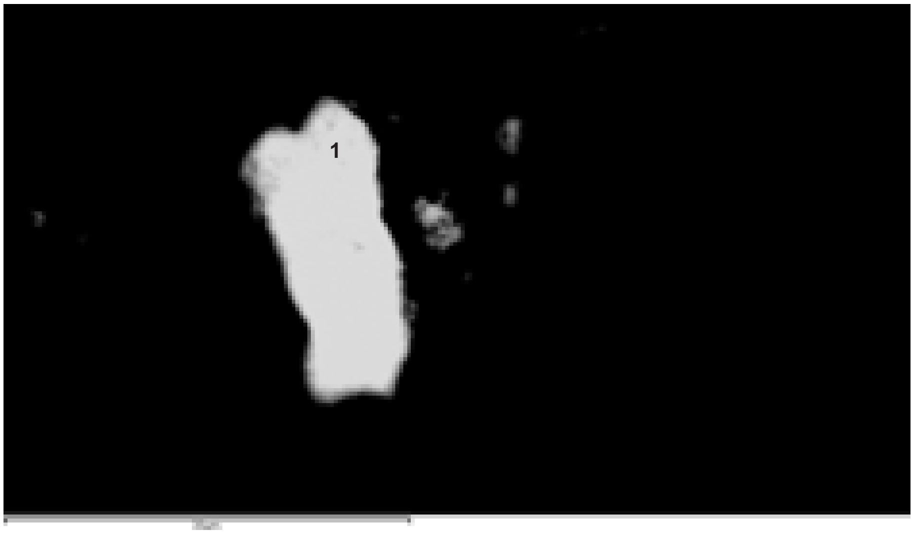
Appendix 2-4: BSE images and EDS mineral analyses of sample 9878B

1:Pyrochlore

Figure 2-4.1: Sample 9878B site 2.

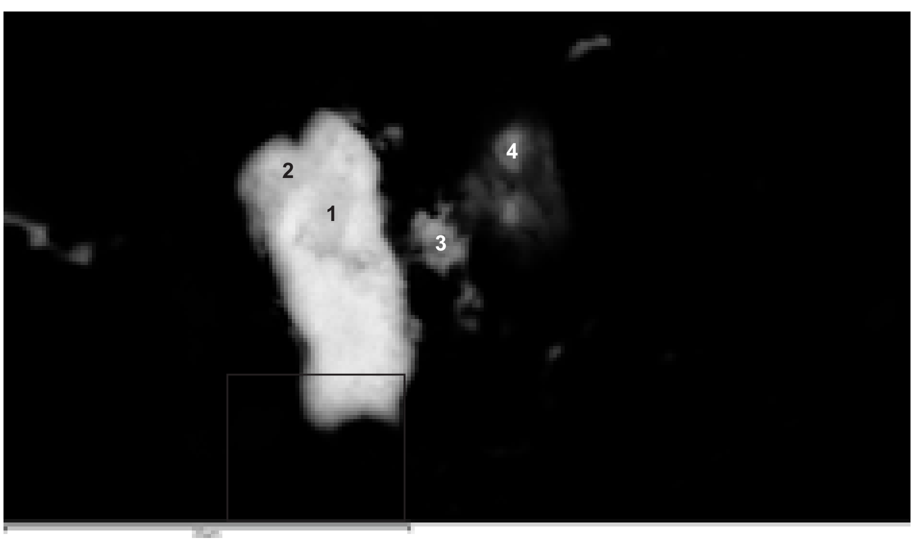
1:Pyrochlore
2:Aeschynite-euxenite

Figure 2-4.2: Sample 9878B site 3; contact between pyrochlore (analysis 1) and aeschynite-euxenite (analysis 2).



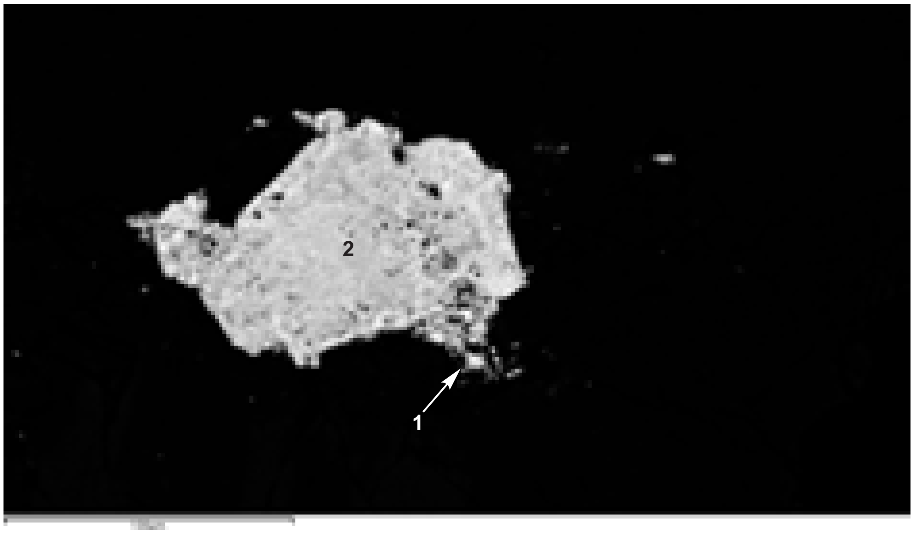
1:Aeschynite-euxenite

Figure 2-4.3: Sample 9878B site 4.



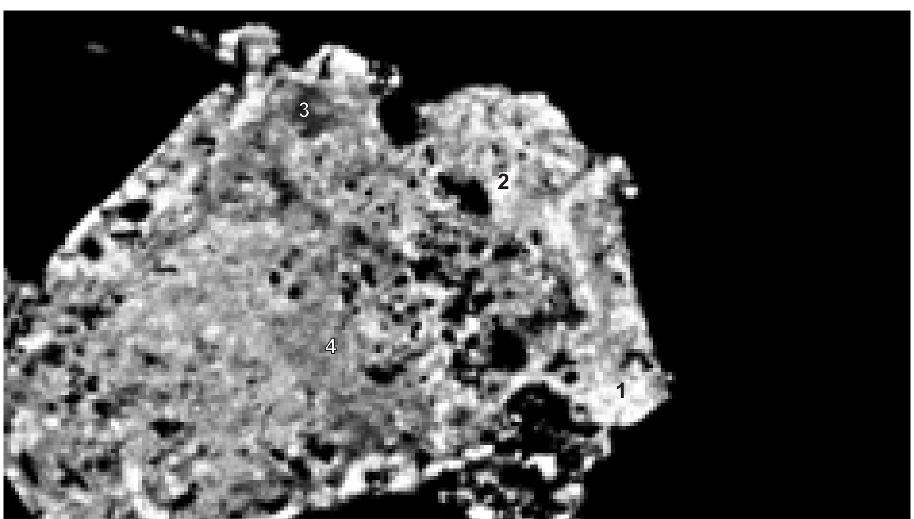
1:Aeschynite-euxenite
2:Mix(Quartz+aes-eux)
3:Mix
4:Mix

Figure 2-4.4: Sample 9878B site 5.



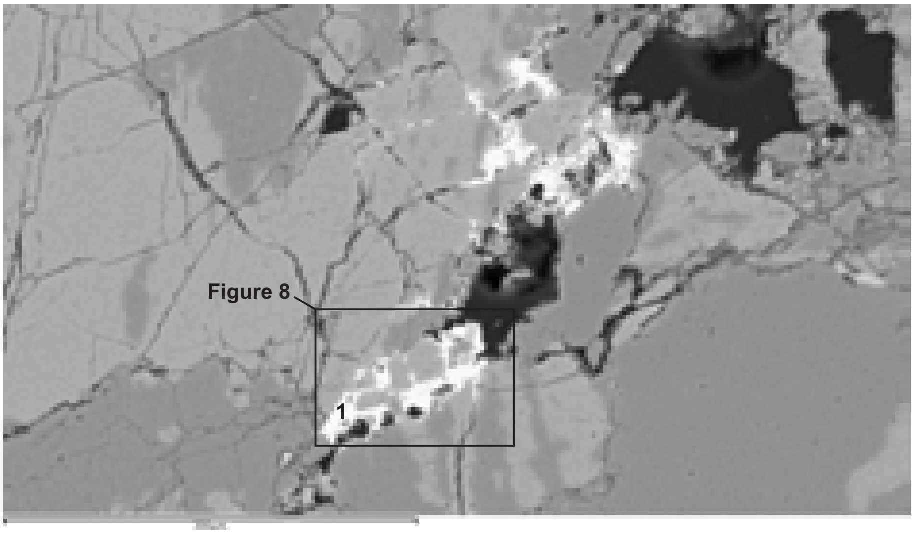
1:Zircon-Hingganite-Y
2:Zircon-Hingganite-Y

Figure 2-4.5: Sample 9878B site 6; zircon mixed with hingganite-Y.



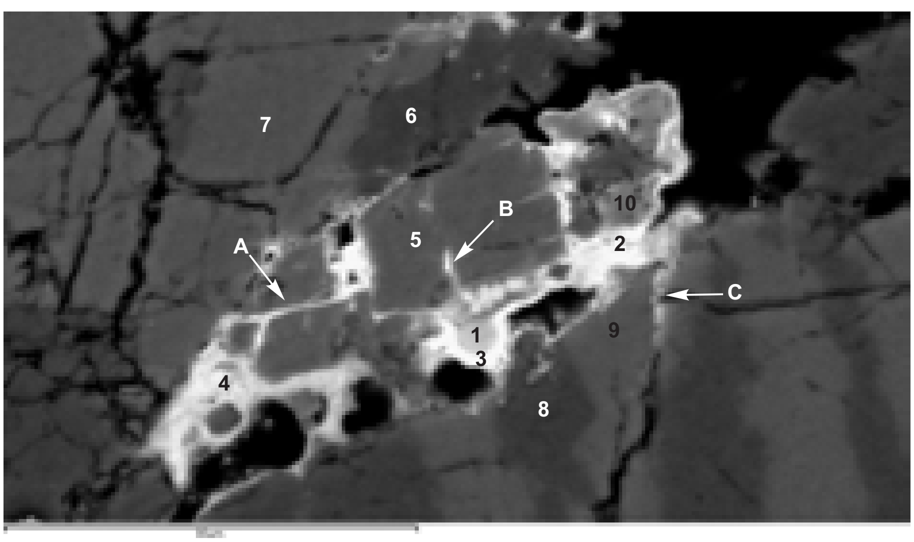
1:Zircon-Hingganite-Y
2:Zircon-Hingganite-Y
3:Zircon-Hingganite-Y
4:Zircon-Hingganite-Y

Figure 2-4.6: Sample 9878B site 7; higher magnification of figure 5. Darker areas correspond to zircon analyses enriched in Y (analyses 3&4), whereas brighter areas correspond to more pure zircon analyses (analyses 1&2). Based on the heterogeneous texture it is possible that the analyses are a mixture of zircon and hingganite-Y crystallites.



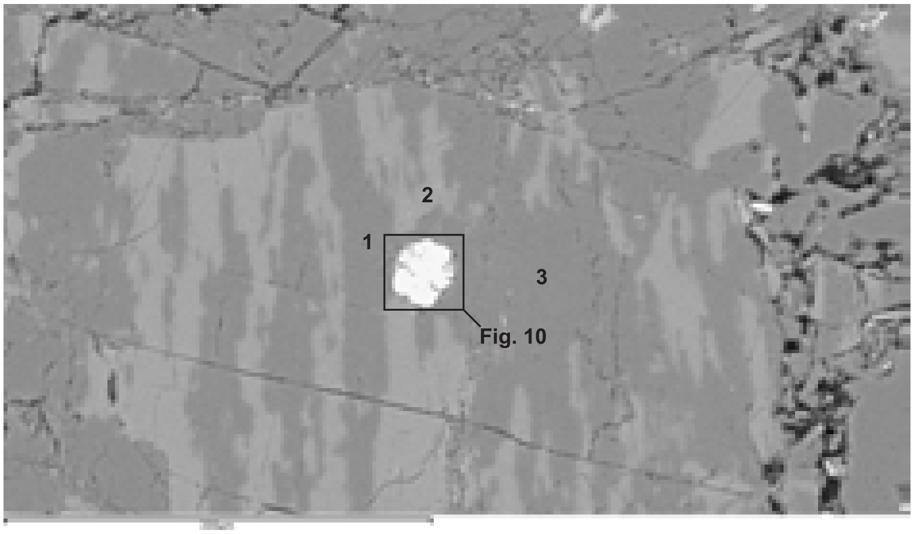
1:Ce-phase(+others)

Figure 2-4.7: Sample 9878B site 8; Ce-phase (bright spots, analysis 1) - likely either cerianite (Ce-oxide), cerite, or manganian androsite (Ce-silicates), but difficult to determine from analysis.



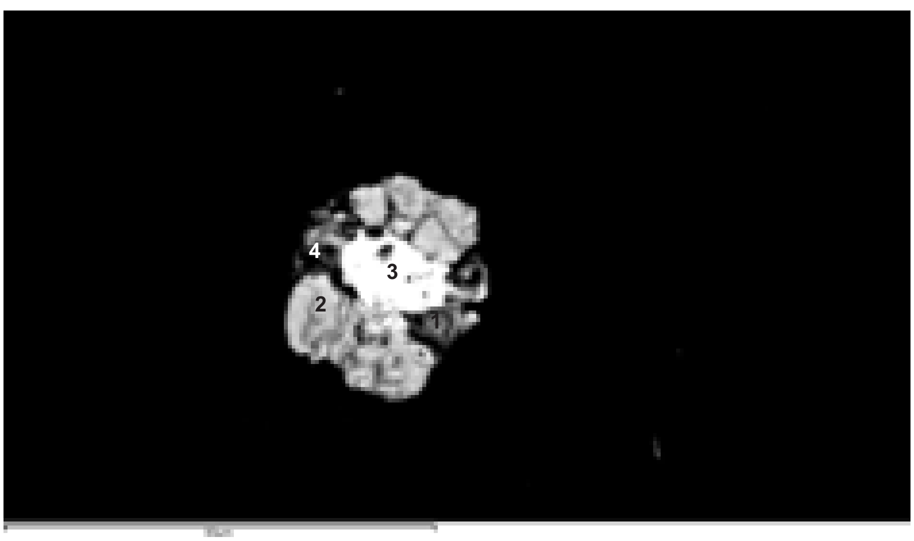
1:Ce-phase(+others)
2:Ce-phase(+others)
3:Ce-phase(+others)
4:Ce-phase(+others)
5:K-feldspar
6:Albite
7:K-feldspar
8:Albite
9:K-feldspar
10:Alkali feldspar

Figure 2-4.8: Sample 9878B site 9; Ce-phase rimming primary feldspar and filling fractures (position A,B,&C)



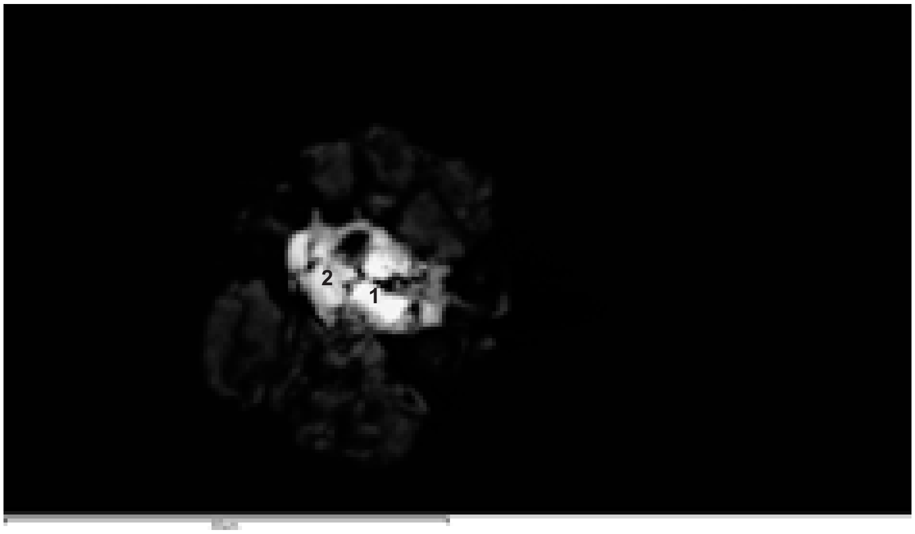
1:Albite
2:K-feldspar
3:Albite

Figure 2-4.9a: Sample 9878B site 13.



1:Mix
2:Fe-oxide
3:Thorite
4:Fe-oxide

Figure 2-4.9b: Sample 9878B site 11; hydrothermal thorite filling pores of a partially dissolved primary Fe-oxide.

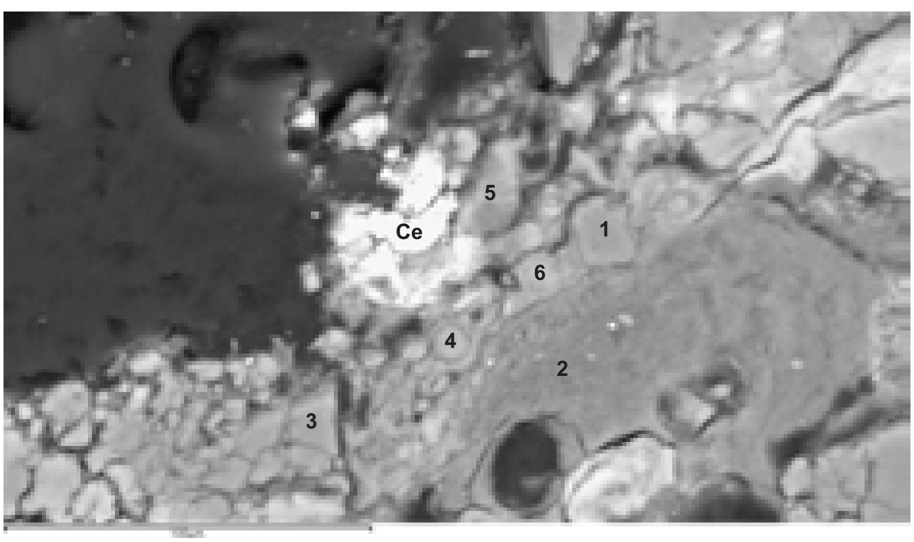


1:Thorite
2:Thorite

Figure 2-4.9c: Sample 9878B site 12.

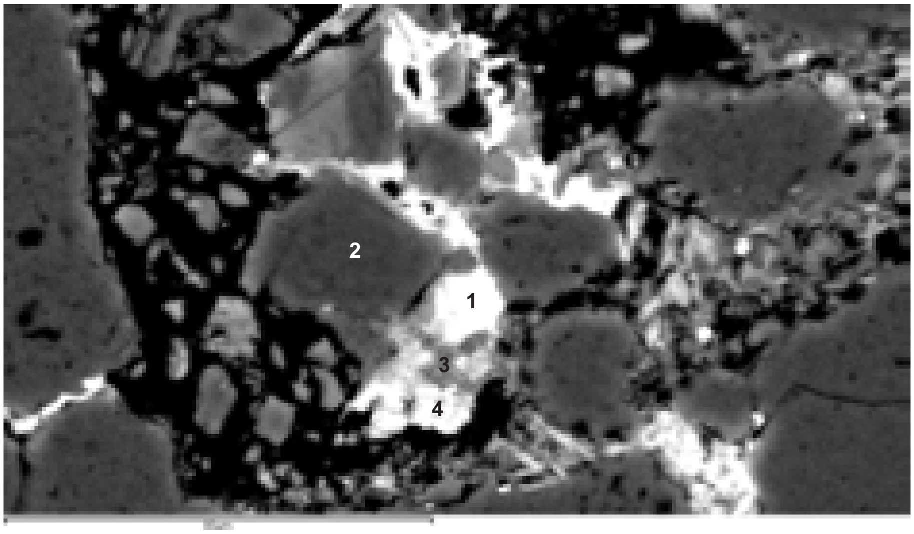
1:Ce-phase(+others)
2:Ce-phase(+others)
3:Ce-phase(+others)
4:Ce-phase(+others)

Figure 2-5.10a: Sample 9878B site 14.



1:Quartz
2:Muscovite/chlorite
3:Albite
4:Mix
5:Albite
6:Mix

Figure 2-5.10b: Sample 9878B site 17; same BSE image as figure 10a. Ce-phase seems to postdate albite (analysis 5).



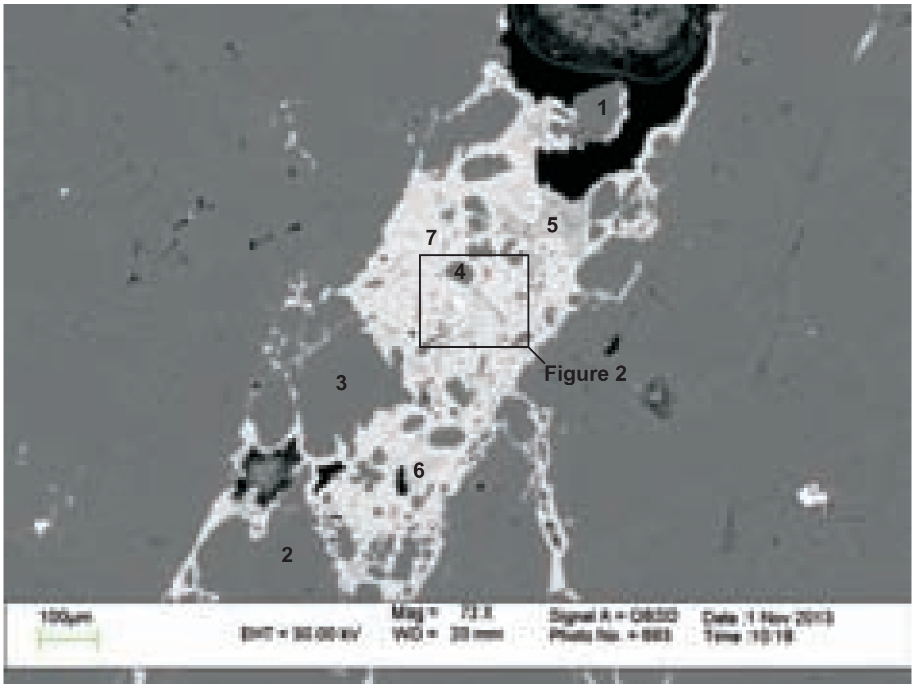
1:Ce-phase(+others)
2:Quartz
3:Mix
4:Ce-phase(+others)

Figure 2-5.11: Sample 9878 site 18; Ce-phase (analyses 1&4) seems to have partially replaced quartz (analyses 2&3).

Table 2-4: EDS analyses of Sample 9878B.

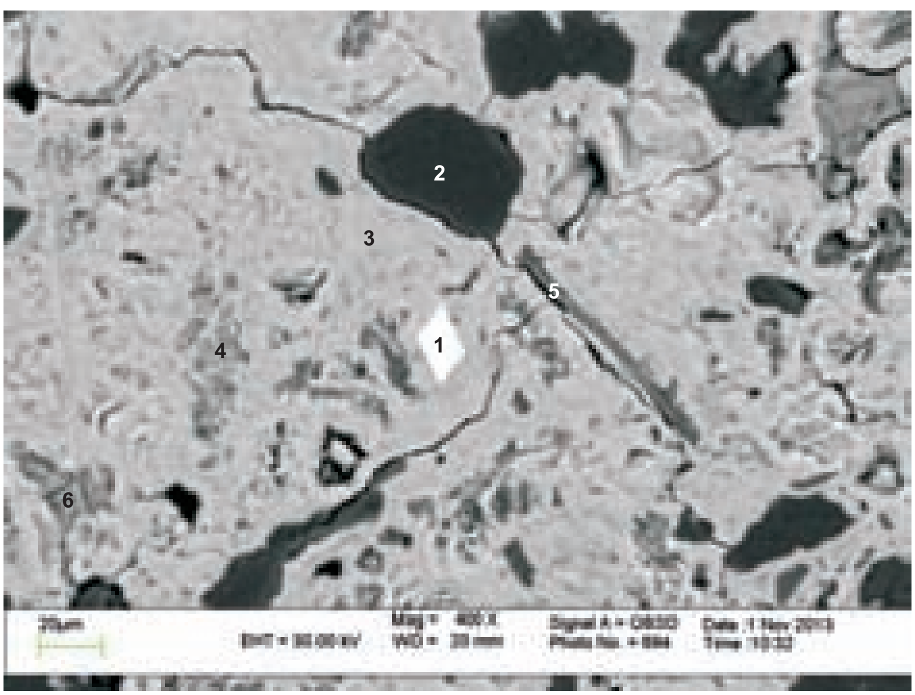
Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	CoO	NiO	CuO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	Ag_2O	Ce_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O_5	PbO	ThO_2	UO_3	Total
9878B	2	1	Pyrochlore	15.44	26.97	3.78	6.19														7.87		29.74	5.35					4.64				99.98
9878B	3	1	Pyrochlore	11.53	24.29	3.5	6.19			0.97											6.93	3.9	28.52	4.05		1.93	1.45		2.89			3.85	100
9878B	3	2	Aeschynite-euxenite	12.26	19.62	4.69	7.51			1.37											7.2	3.98	31.39								7.4	4.6	100.02
9878B	4	1	Aeschynite-euxenite	21.01	15.63	4.36	6.36			1.18											6.44	4.26	29.14	3.88		1.69	1.45					4.63	100.03
9878B	5	1	Aeschynite-euxenite	12.69	19.08	4.33	7.29			1.4											7.57		30.6				1.5		2.7	1.11	6.92	4.79	99.98
9878B	5	2	Mix(Quartz+aes-eux)	73.78	4.67	1.25	1.75			0.38						0.24					1.84	1.82	11.72	1.14								1.42	100.01
9878B	5	3	Mix	11.02	5.89	4.82	70.22				2.84					0.36							4.88										100.03
9878B	5	4	Mix	28.69	1.47	10.3	51.63			0.35	4.13					0.22			0.36				2.88										100.03
9878B	6	1	Zircon-Hingganite-Y	32.84		2.06	1.12														3.87	55.72					1.63	2.77					100.01
9878B	6	2	Zircon-Hingganite-Y	30.23			8.93			0.87											6.64	49.05					2.31	1.97					100
9878B	7	1	Zircon-Hingganite-Y	34.85			0.55														1.08	60.53						2.98					99.99
9878B	7	2	Zircon-Hingganite-Y	31.25		0.4	1.72														1.31	61.47		1.16				2.68					99.99
9878B	7	3	Zircon-Hingganite-Y	30.08		2.31	3.05			0.29							0.47				7.25	52.67					1.94	1.96					100.02
9878B	7	4	Zircon-Hingganite-Y	29.67			8.98			0.69											5.82	51.53					1.47	1.84					100
9878B	8	1	Ce-phase(+others)	41.09		20.03	5.49	2.36	1.94		3.9	2.16							0.65						22.37								99.99
9878B	9	1	Ce-phase(+others)	11.85		21.31	4.62	19.16		0.49		1.58	1.31				2.47		1.97						35.27								100.03
9878B	9	2	Ce-phase(+others)	49.86		17.14	0.63	5.73			0.43	12.72				0.23	0.83		0.69						11.7								99.96
9878B	9	3	Ce-phase(+others)	27.98		20.33	3.59	9.39		0.32	1.23	1.46	1.37			0.51	1.36		1.11						31.32								99.97
9878B	9	4	Ce-phase(+others)	33.88	0.38	19.97	6.79	3.05	1.86		1.48	3.26				0.27			0.59						28.44								99.97
9878B	9	5	K-feldspar	65.8		17.74	0.4				0.43	15.61																					99.98
9878B	9	6	Albite	69.16		18.76	0.19				11.63	0.25																					99.99
9878B	9	7	K-feldspar	66.27		17.88	0.14				0.62	15.1																					100.01
9878B	9	8	Albite	68.73		18.88	0.46				11.68	0.28																					100.03
9878B	9	9	K-feldspar	66.66		17.72					0.34	15.27																					99.99
9878B	9	10	Alkali feldspar (+others)	61.5		18.54	0.41	2.18			2.22	8.7					0.39		0.28						5.77								99.99
9878B	11	1	Mix	9.95	0.47	11.47	67.08			0.46			1.47			0.54				1.44			2.83								4.3		100.01
9878B	11	2	Fe-oxide	7.53		2.44	89.44											0.6															100.01
9878B	11	3	Thorite	17.46		4.7	14.61			0.69			4.93		2.37						4.79										50.46		100.01
9878B	11	4	Mix	9.84	0.68	11.49	66.28			1.04			1.17			0.34				1.31			2.65								5.2		100
9878B	12	1	Thorite	17.93			11.26			0.76			5.36		2.74	0.33					5.5										56.14		100.02
9878B	12	2	Thorite	19.51		6.18	21.92			0.73			4.51								3.94										43.22		100.01
9878B	13	1	Albite	69.01		18.8	0.24				11.96																						100.01
9878B	13	2	K-feldspar	67.09		17.65						15.29																					100.03
9878B	13	3	Albite	68.6		19.2				0.24	11.96																						100
9878B	14	1	Ce-phase(+others)	12.49		27.98	1.94	23.92			2.24		2.5				2.8		2.54						23.58								99.99
9878B	14	2	Ce-phase(+others)	17.84		26.32	5.61	20.98		0.43	1.07	1.45	1.79	0.87			2.4		1.92						19.33								100.01
9878B	14	3	Ce-phase(+others)	15.49		27.66	1.8	22.43		0.49	1.63	0.31	1.76	0.9		0.35	2.75		2.3						22.14								100.01
9878B	14	4	Ce-phase(+others)	13.03		28	3.15	22.05		0.5	0.94	0.84	1.95	0.7		0.35	2.52		2.3						22.69					0.97			99.99
9878B	17	1	Quartz	99.99																													99.99
9878B	17	2	Muscovite/Chlorite	50.81	0.72	27.53	11.1		3.9			4.73				1.22																	100.01
9878B	17	3	Albite	68.6		19.05					12.36																						100.01
9878B	17	4	Mix	22.08		29.46	42.22					1.3	1.65	2.32		0.98																	100.01
9878B	17	5	Albite	68.45		18.74	0.3				12.51																						100
9878B	17	6	Mix	26.78		28.68	38.66			0.5		2.61		2.02		0.74																	99.99
9878B	18	1	Ce-phase(+others)	13.58		21.47	5.22	17.91					2.04				2.17		2.53						35.08								100
9878B	18	2	Quartz	99.79								0.2																					99.99
9878B	18	3	Mix	52.6		18.59	14.24	3.72			6.15	1.69							0.49						2.51								99.99
9878B	18	4	Ce-phase(+others)	42.04		19.31	3.89	8.75			5.95	1.72				0.4	1.21		1.08						15.65								100

Appendix 2-5: BSE images and EDS mineral analyses of sample 9877



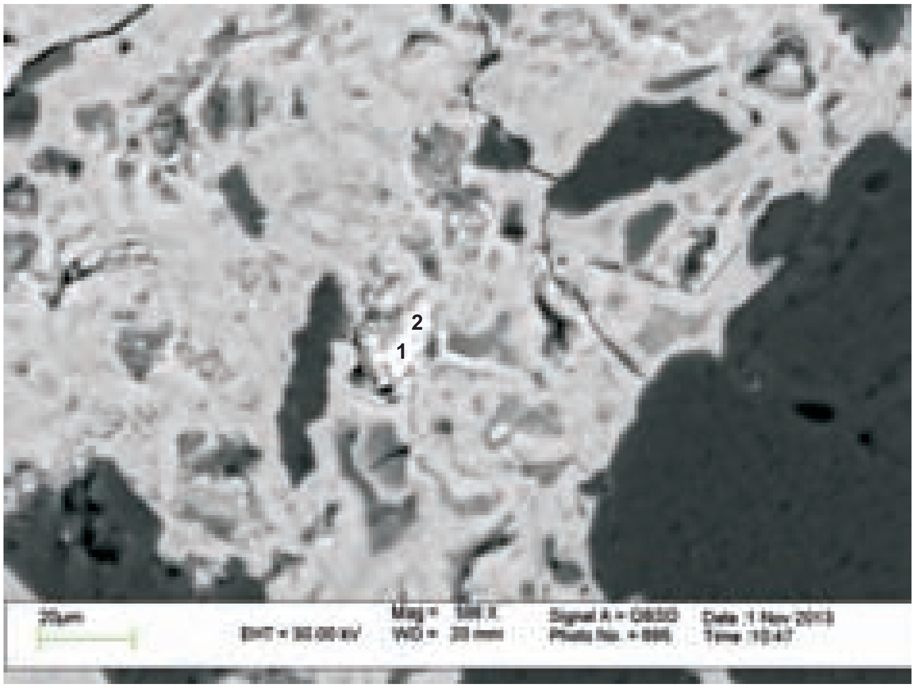
1:Quartz
2:Quartz
3:Quartz
4:Quartz
5:Mix(Fe-oxide+Py+Ccp+Chl+Al)
6:Mix(Fe-oxide+Py+Ccp+Chl+Al)
7:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.1: sample 9877 site 1; granite. Fe-oxide mixture precipitated in fractured zone.



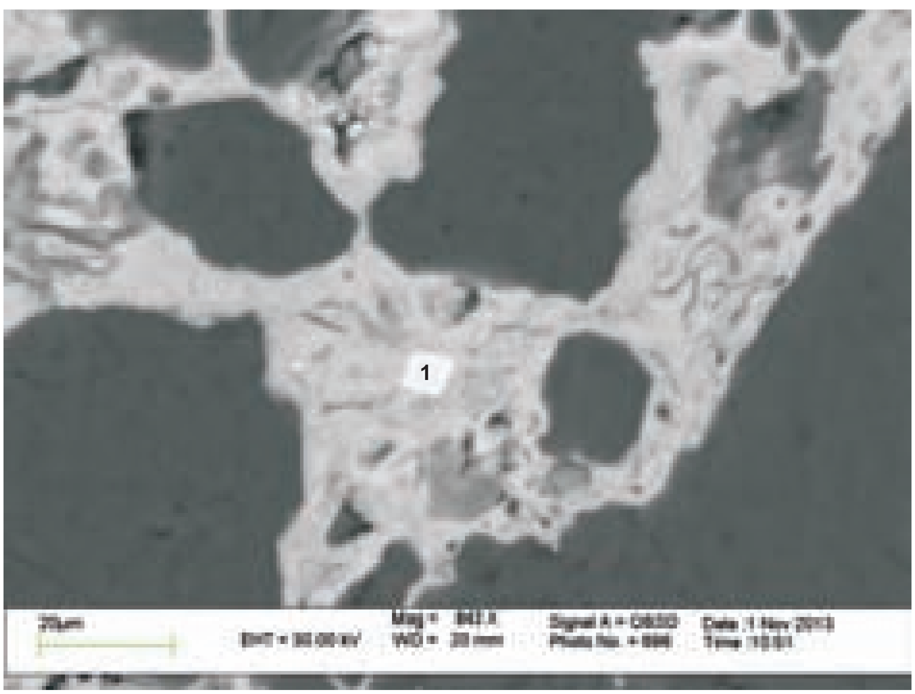
1:Xenotime
2:Quartz
3:Mix (Fe-oxide+Ccp+Cu+Chl)
4:Mix(Fe-oxide+Ccp+Chl+Al
5:Chlorite (detrital)
6:Mix(Fe-oxide+Py+Ccp+Chl+Al)

Figure 2-5.2: Sample 9877 site 2; granite. Higher magnification of figure 1. Xenotime may be the latest phase to precipitate in fracture or it may have precipitated at the same time as the Fe-oxide mixture. The chlorite seems to be detrital.



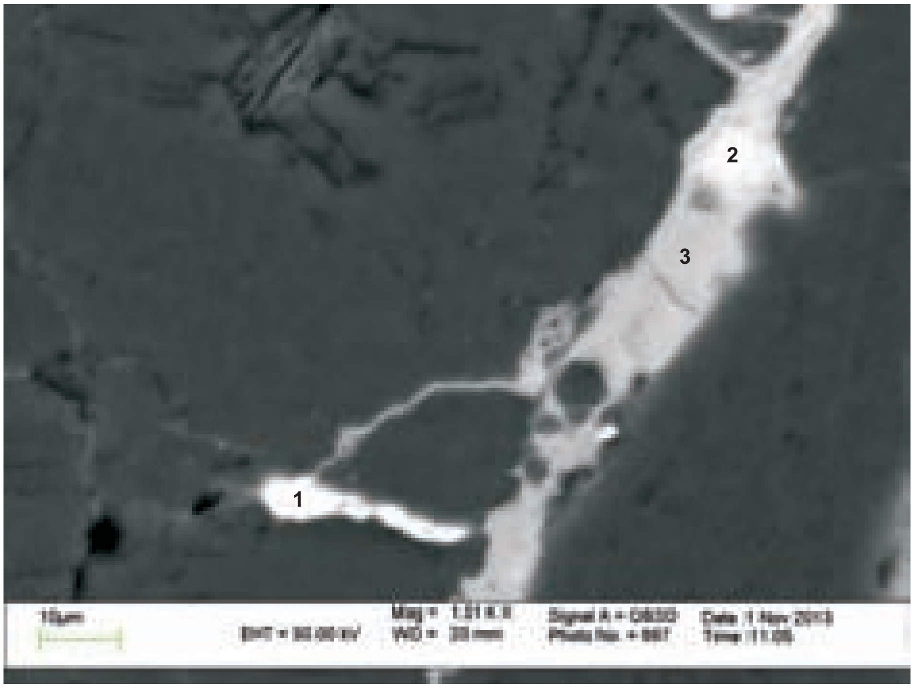
1: Y-phase
2: Y-phase

Figure 2-5.3: Sample 9877 site 3; granite. Y-rich phase (likely xenotime) in fracture; either later than or synchronous with precipitation of Fe-oxide mixture.



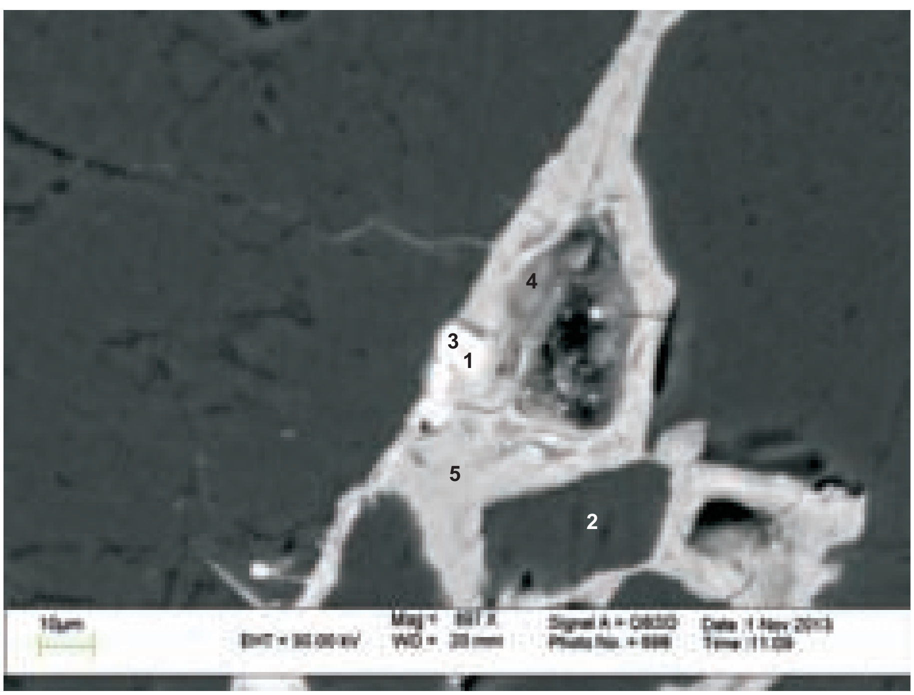
1: Xenotime

Figure 2-5.4: Sample 9877 site 4; granite. Xenotime in fracture; either later than or synchronous with precipitation of Fe-oxide



1:Zircon
2:Nb-Ti-rich phase
3:Aeschynite-euxenite

Figure 2-5.5: Sample 9877 site 5; granite.



1:Aeschynite-euxenite
2:Albite
3:Aeschynite-euxenite
4:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
5:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.6: Sample 9877 site 6; granite. Aeschynite-euxenite postdates Fe-oxide mixture.

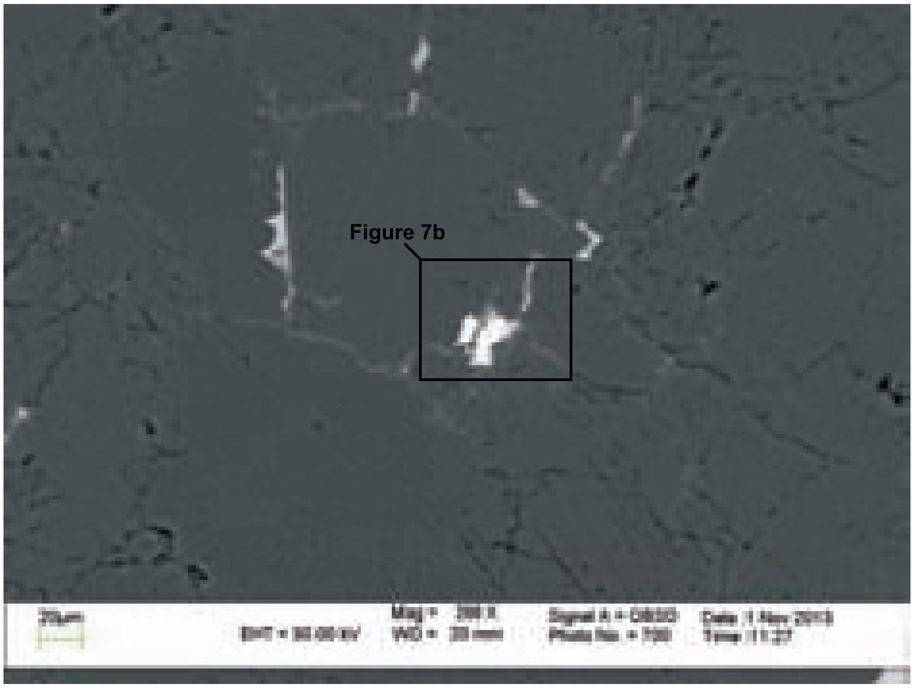
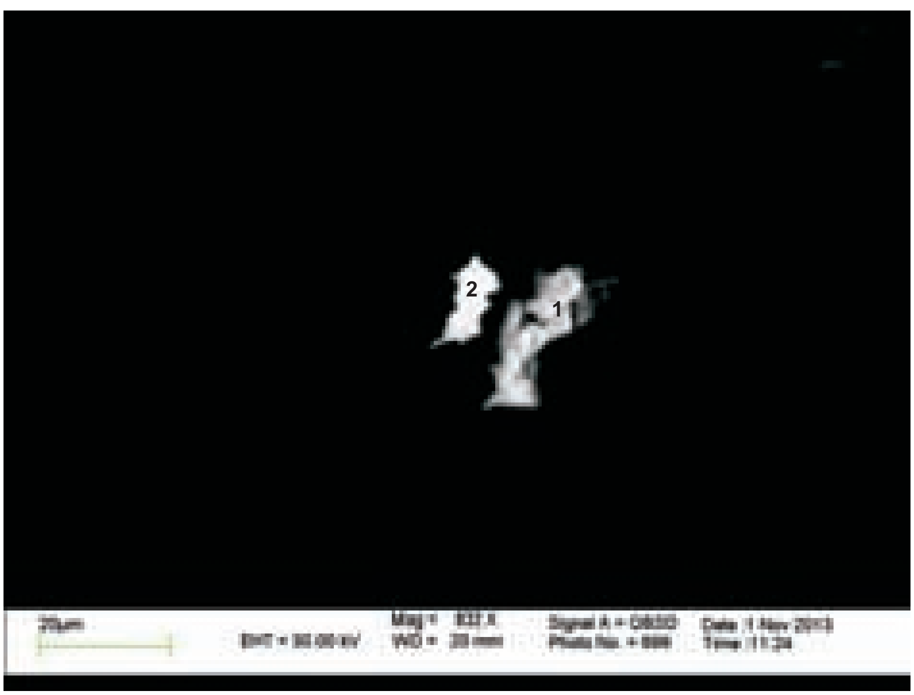


Figure 2-5.7a: Sample 9877; granite.

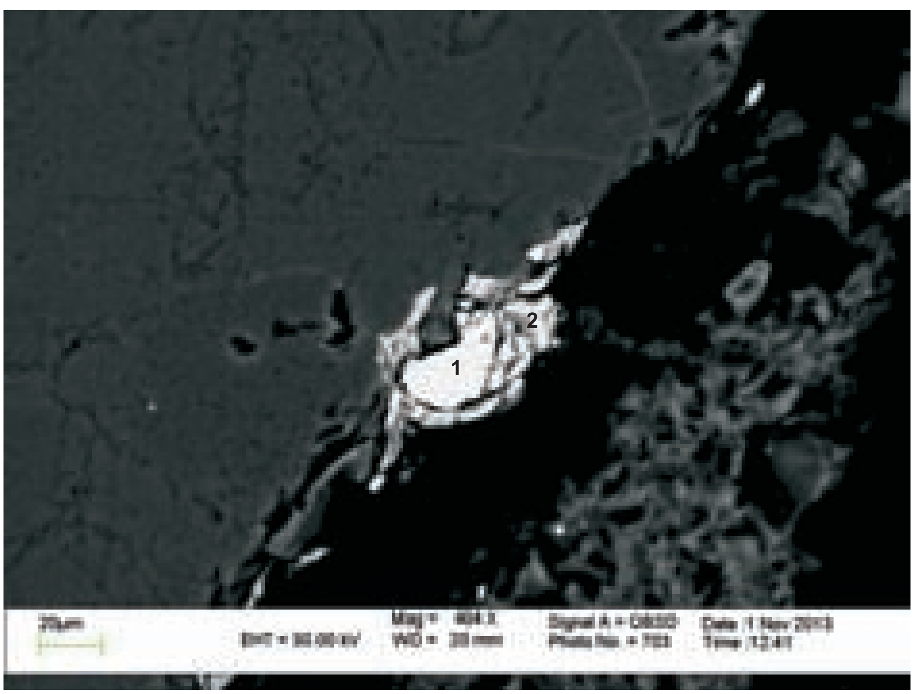


1: Zircon
2: Xenotime

Figure 2-5.7b: Sample 9877 site 7; granite. High magnification of figure 7a. Zircon and xenotime precipitating in fracture.

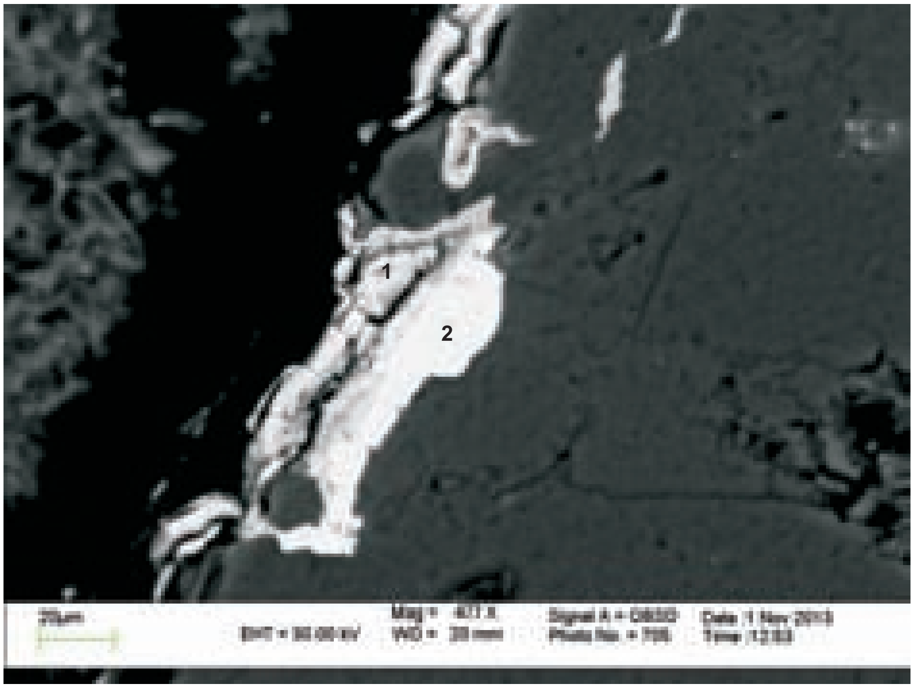
1:Mix(Fe-oxide+Ccp+Chl+Al)
2:Mix(Fe-oxide+Ccp+Cu+Chl)
3:Mix(Fe-oxide+Ccp+Cu+Chl)
4:Mix(Fe-oxide+Ccp+Cu+Chl)
5:Mix(Fe-oxide+Ccp+Cu+Chl)
6:Mix(Fe-oxide+Ccp+Cu+Chl)
7:Mix(Fe-oxide+Ccp+Cu+Chl)
8:Mix(Fe-oxide+Py+Ccp+Chl+Al)

Figure 2-5.8: Sample 9877 site 10; granite. It seems that the Fe-oxide phase leaves considerable porosity (possibly volume reduction from a previous phase).



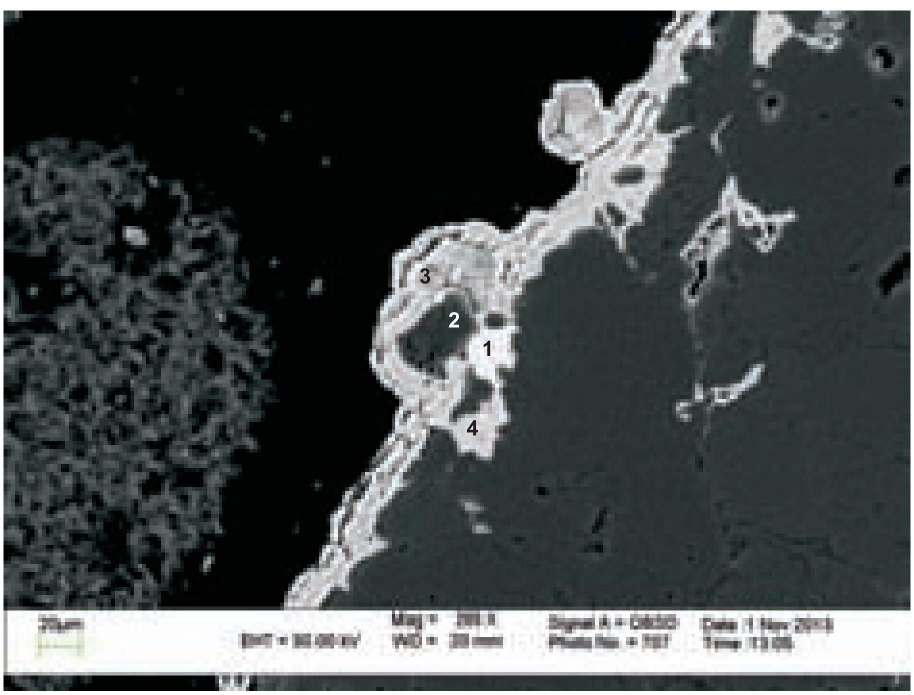
1: Xenotime
2: Mix(Fe-oxide+Ccp+Cu+Chl+Al)

Figure 2-5.9: Sample 9877 site 11; granite. Xenotime precipitates along fracture and seems to be engulfed by the Fe-oxide phase.



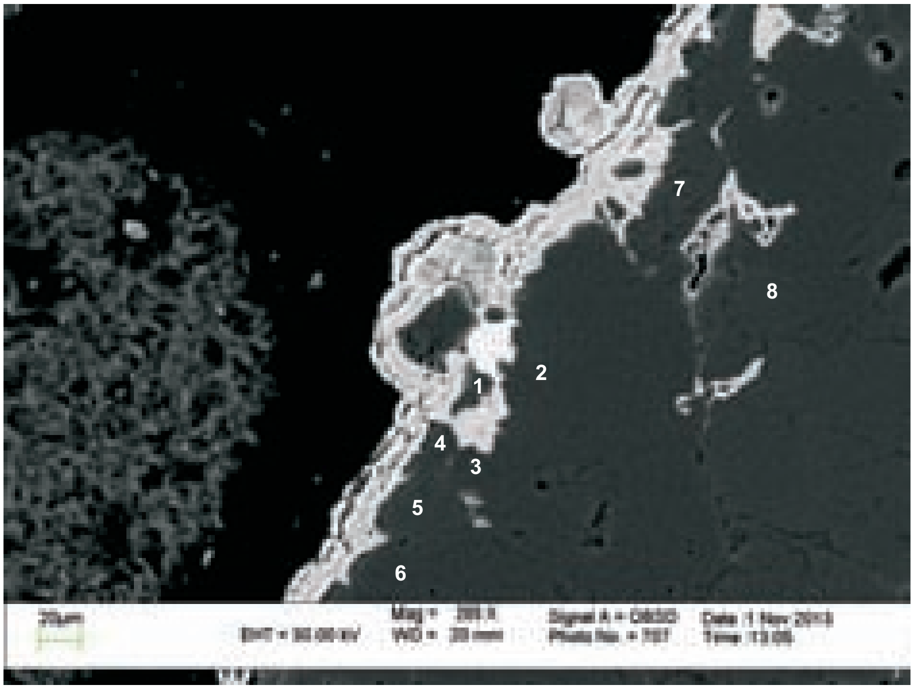
1:Mix (Fe-oxide+Ccp+Cu+Chl+Al)
2: Xenotime

Figure 2-5.10: Sample 9877 site 12; granite. Xenotime probably precipitated along fracture.



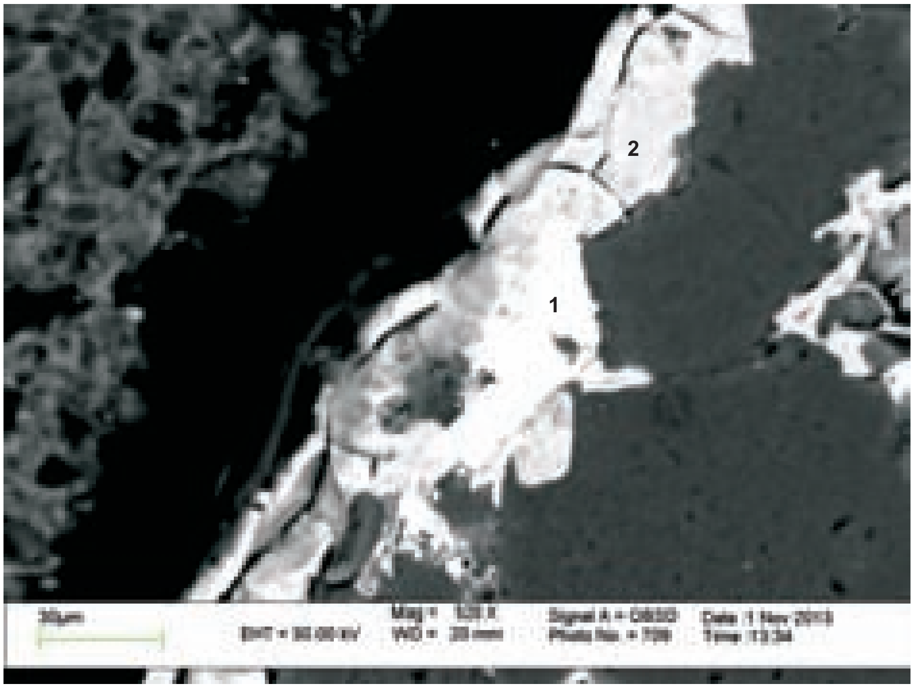
1: Xenotime
2: Quartz
3:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
4: Mix(Fe-oxide+Ccp+Cu+Chl)

Figure 2-5.11a: Sample 9877 site 13; granite. The Fe-oxide phase seems to precipitate concentrically along a probable fracture.



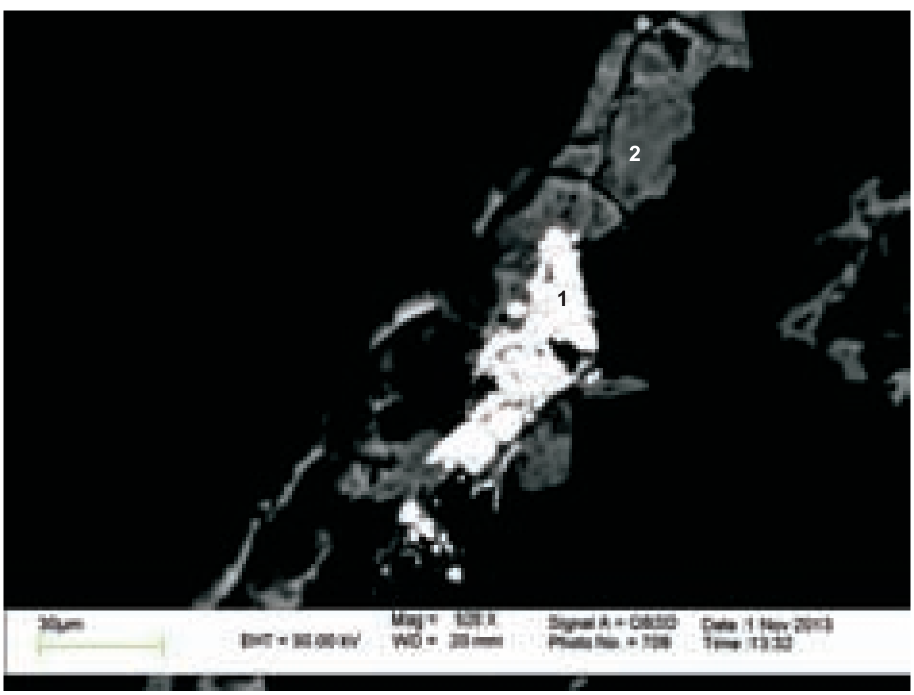
1:Mix(Quartz+Fe-oxide)
2:Quartz
3:Quartz
4:Quartz
5:K-felspar
6:Quartz
7:Albite
8:Albite

Figure 2-5.11b: Sample 9877 site 14; granite.



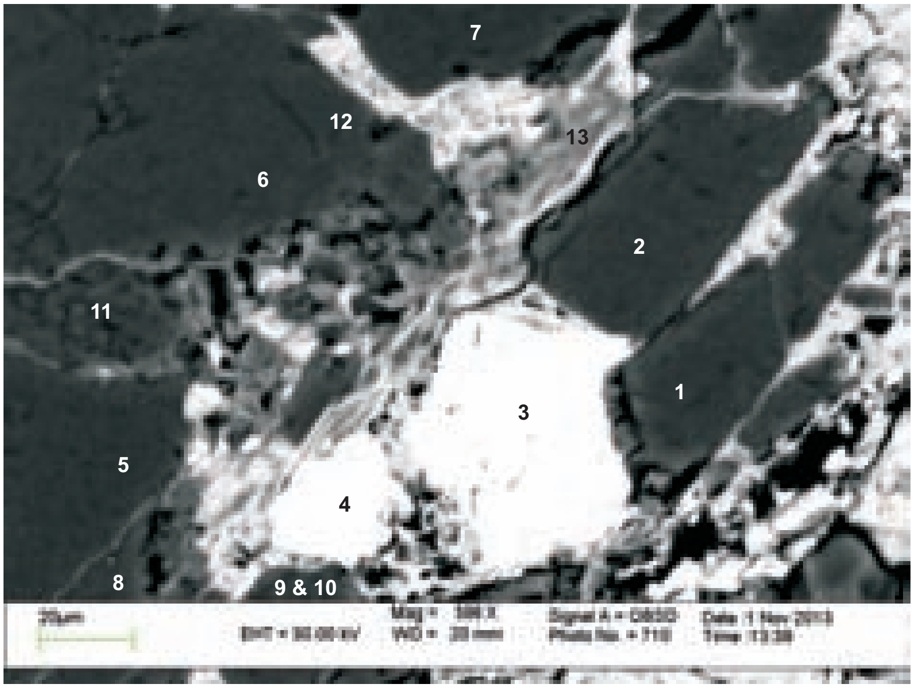
1:Xenotime
2:Mix(Fe-oxide+Ccp+Cu+Chl)

Figure 2-5.12a: Sample 9877 site 15; granite. Xenotime postdates the Fe-oxide phase and both have precipitated along fracture.



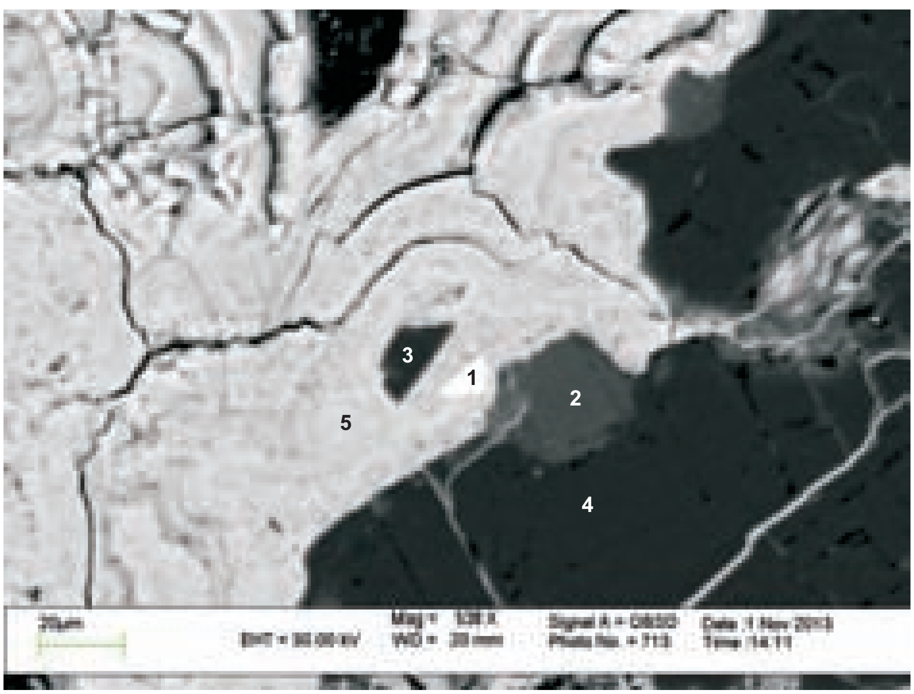
1:Xenotime
2:Mix(Fe-oxide+Ccp+Cu+Chl)

Figure 2-5.12b: Sample 9877 site 15; granite. Darker BSE image of figure 12a. Xenotime postdates the Fe-oxide phase and both have precipitated along fracture.



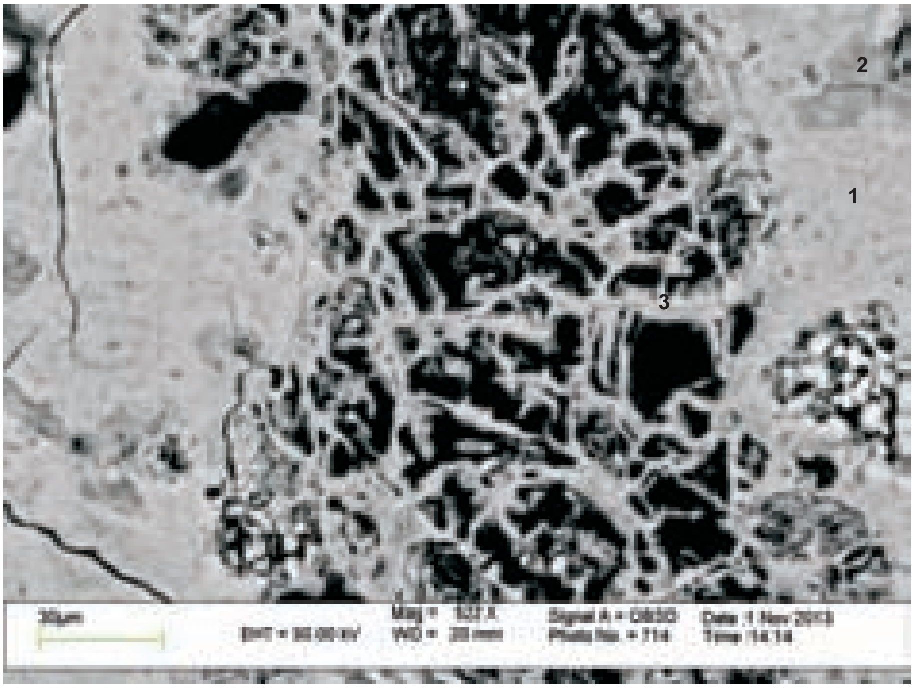
1: Albite
2: Albite
3: Xenotime
4: Xenotime
5: Quartz
6: Albite
7: Quartz
8: Albite
9: Albite
10: Albite
11: Albite(+chlorite)
12: Albite
13: Chlorite

Figure 2-5.13: Sample 9877 site 16; granite. Xenotime and chlorite precipitated in fracture.



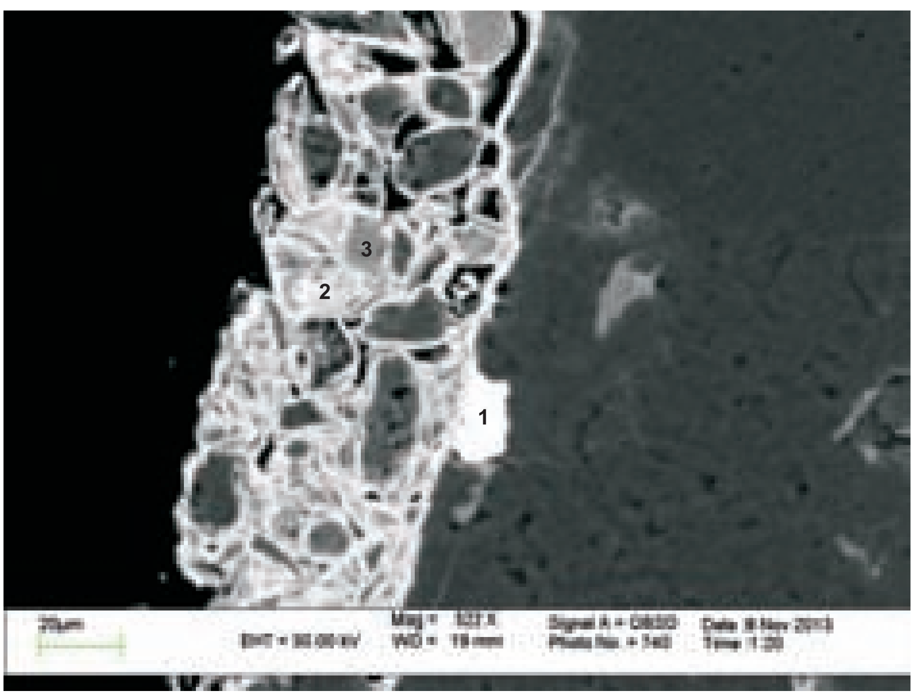
1:Xenotime
2:K-feldspar
3:Albite
4:Albite
5: Mix(Fe-oxide+Ccp+Cu +Chl+Qz)

Figure 2-5.14: Sample 9877 site 17; granite. The Fe-oxide phase (analysis 5) seems to precipitate concentrically around minerals of the granite (analyses 2&3).



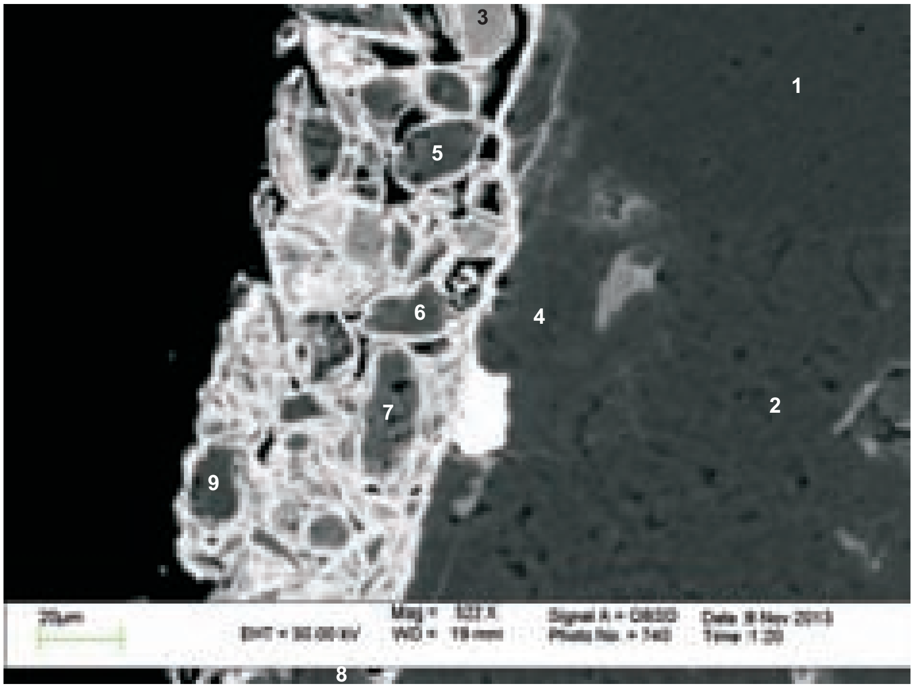
1:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
2:Mix(Fe-oxide+Py+Ccp+Chl+Al)
3:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.15: Sample 9877 site 18; granite. This location illustrates an early stage in the Fe-oxide precipitation.



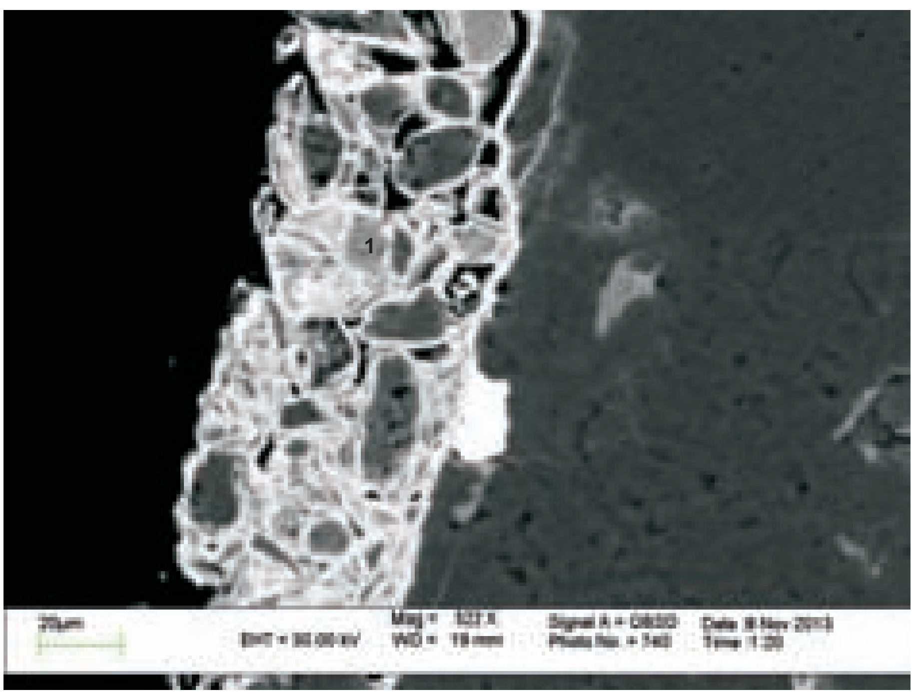
1: Xenotime
2: Mix(Fe-oxide+Ccp+Cu+Chl)
3:Epidote

Figure 2-5.16a: Sample 9877 site 19; Horton Group. Xenotime appears to fill one of several voids in the Horton hornfels. The Fe-oxide mixture seems to coat all the grains in the breccia.



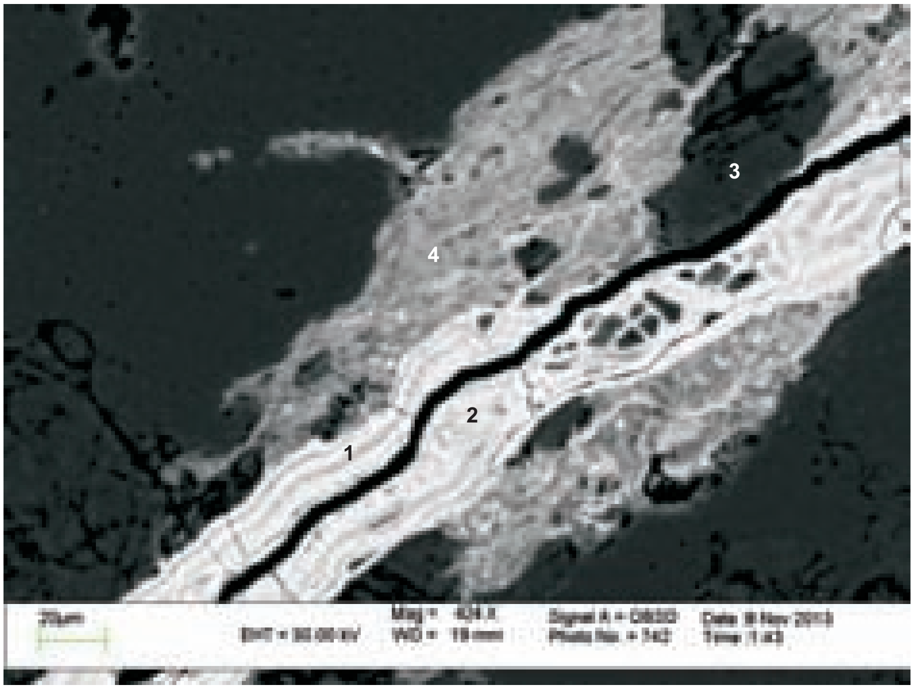
1:Quartz
2:Albite
3:Biotite
4:Albite
5:Albite
6:Albite
7:Muscovite
8:Quartz
9:Quartz

Figure 2-5.16b: Sample 9877 site 20; Horton Group. The fracture is within Horton hornfels which is presumably metasomatized (albite). Fragments, presumably breccia, from the metasomatized hornfels are coated by the Fe-oxide phase.



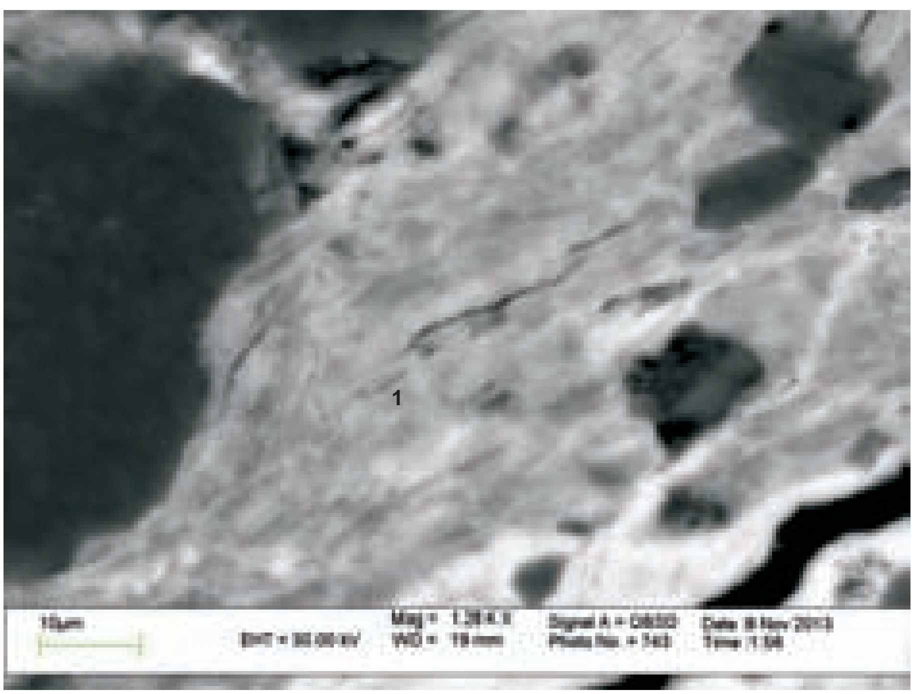
1:Epidote

Figure 2-5.16c: Sample 9877 site 21; Horton Group.



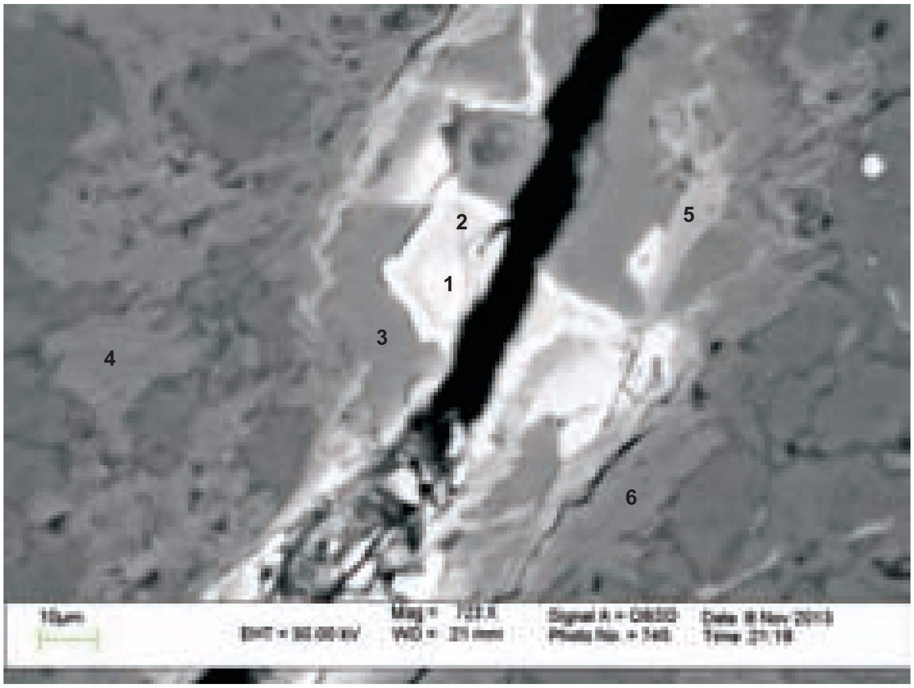
1:Mix(Fe-oxide+Ccp+Chl+Al-P)
2: Mix(Fe-oxide+Ccp+Cu+Chl)
3: Albite
4: Mix (Chlorite + TiO2)

Figure 2-5.17: Sample 9877 site 22; Horton Group. Fe-oxide phase in successive zones and is cut by later barren fracture.



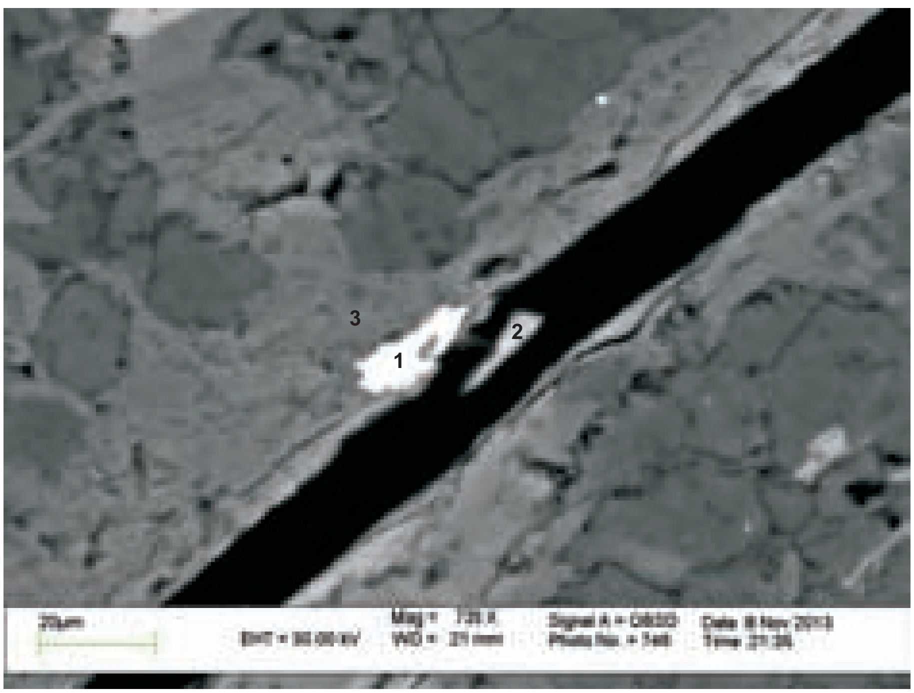
1: Chlorite + TiO_2(?)

Figure 2-5.18: Sample 9877 site 23; Horton Group; the TiO2 phase seems to occur in the form of crystallites.



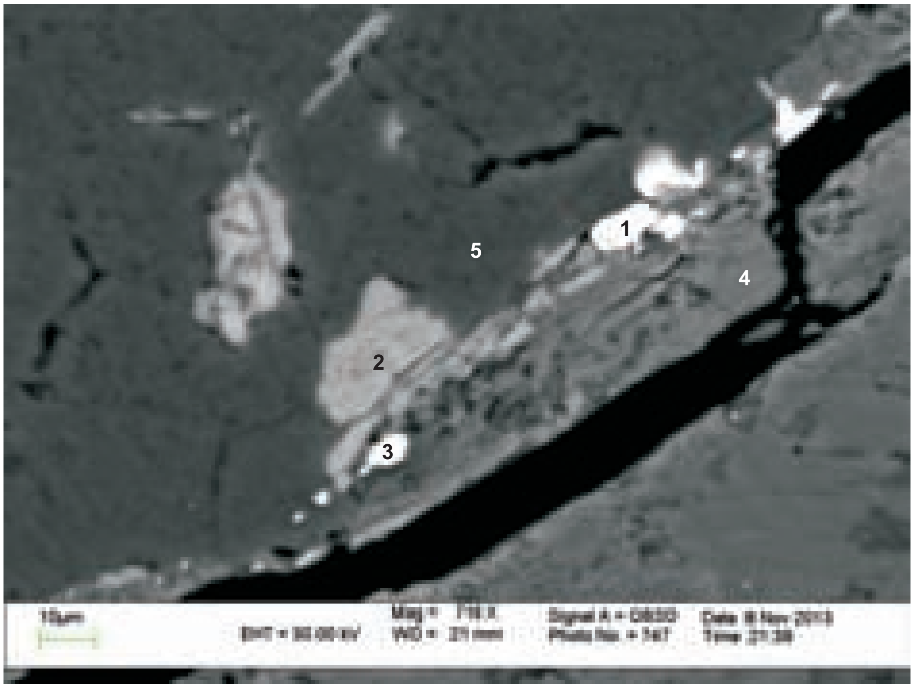
1:Mix(Fe-oxide+Py+CcpChl+Al-P)
2:Mix(Fe-oxide+Py+Ccp+Chl +Al-P)
3:K-feldspar
4:Muscovite
5:Chlorite
6:Muscovite

Figure 2-5.19: Sample 9877 site 25; Horton Group. Fe-oxide phase (analyses 1&2) cut by later barren fracture.



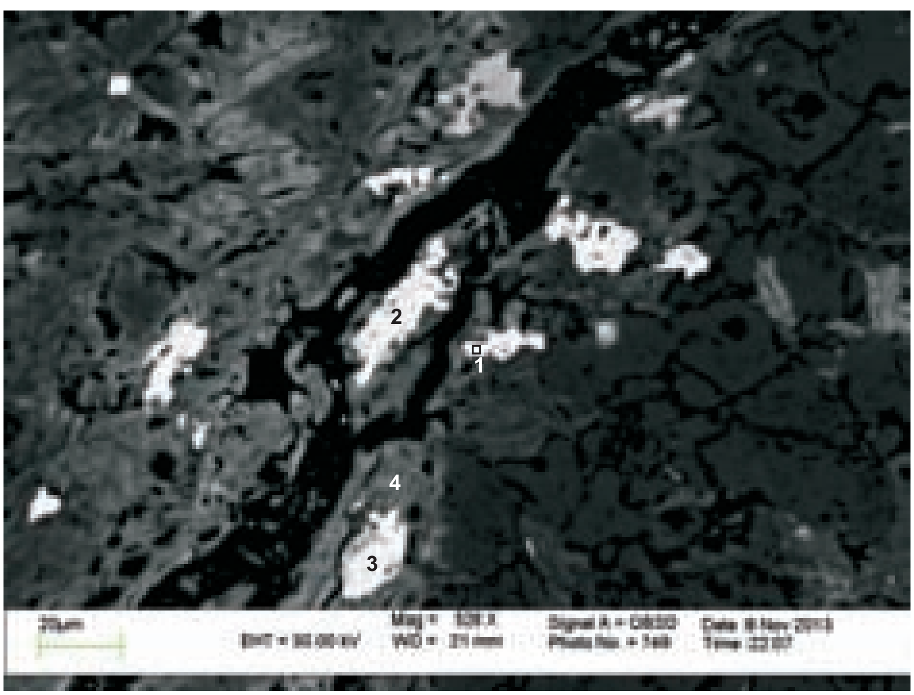
1:Ilmenite
2:Chlorite/Muscovite (+Chalcopyrite)
3:Muscovite

Figure 2-5.20: Sample 9877 site 26; Horton Group.



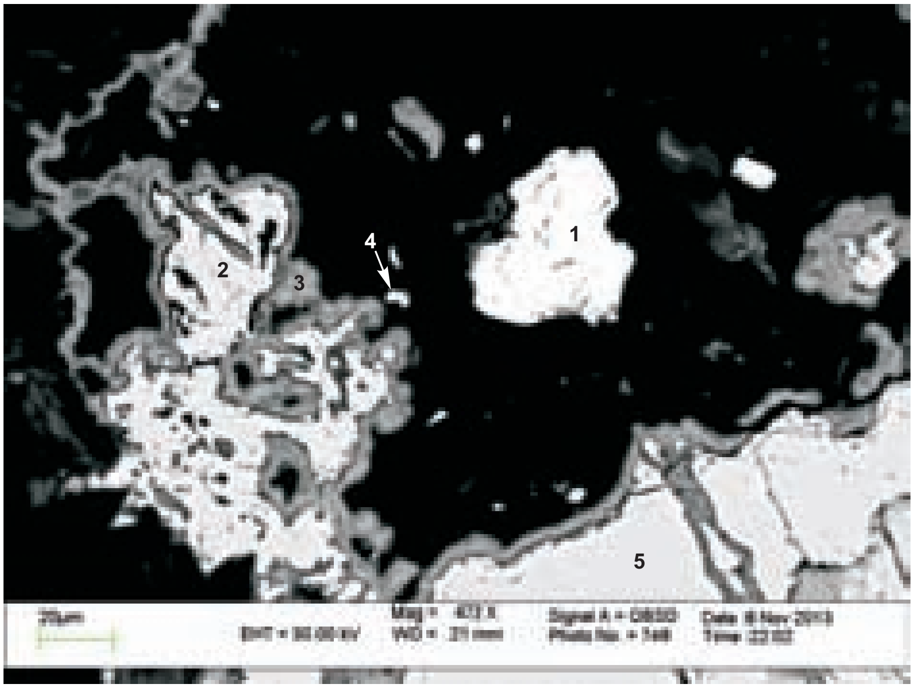
1:Ilmenite
2:Biotite
3:Ilmenite(+others)
4:K-feldspar
5:Quartz

Figure 2-5.21: Sample 9877 site 27; Horton Group.



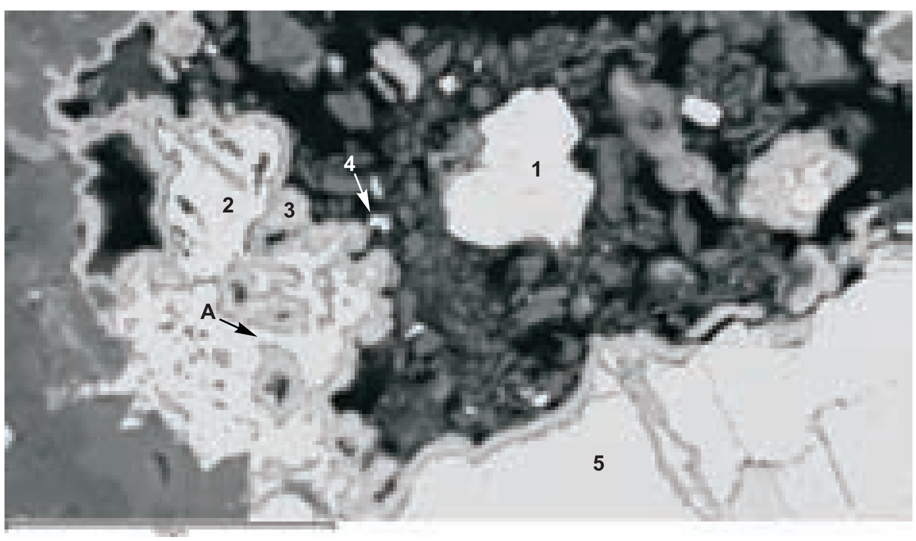
1:Molybdenite
2:Ilmenite
3:Ilmenite
4:Biotite/chlorite

Figure 2-5.22: Sample 9877 site 28.



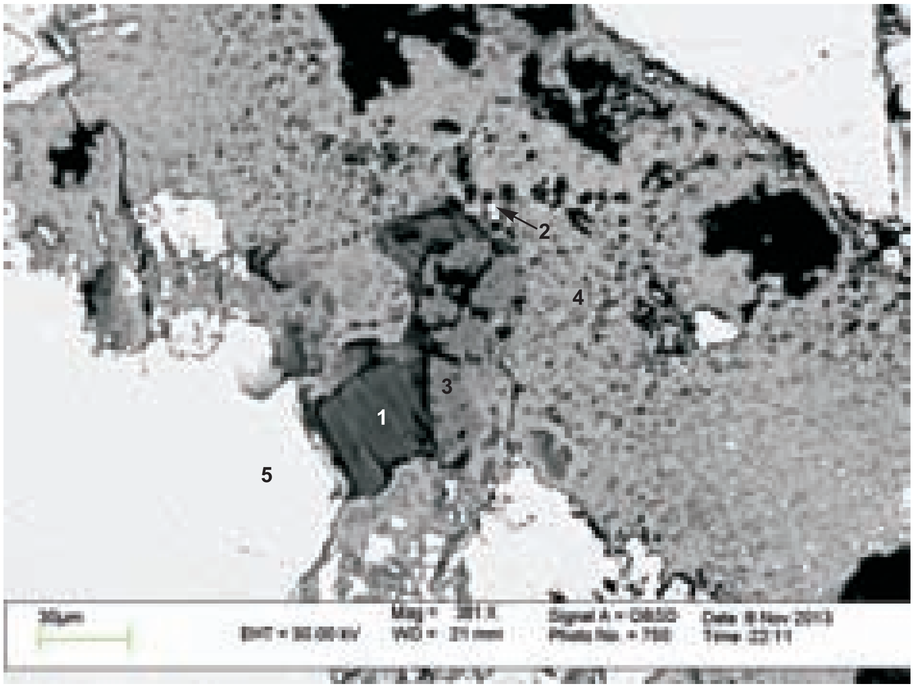
1:Chalcopyrite
2:Pyrite
3:Mix(Fe-oxide+Py+Chl
+AlPO4+Qz)
4:Chalcopyrite
5:Pyrite

Figure 2-5.23a: Sample 9877 site 29; Horton Group. Pyrite is rimmed by the Fe-oxide phase with a narrow dissolution zone between the two.



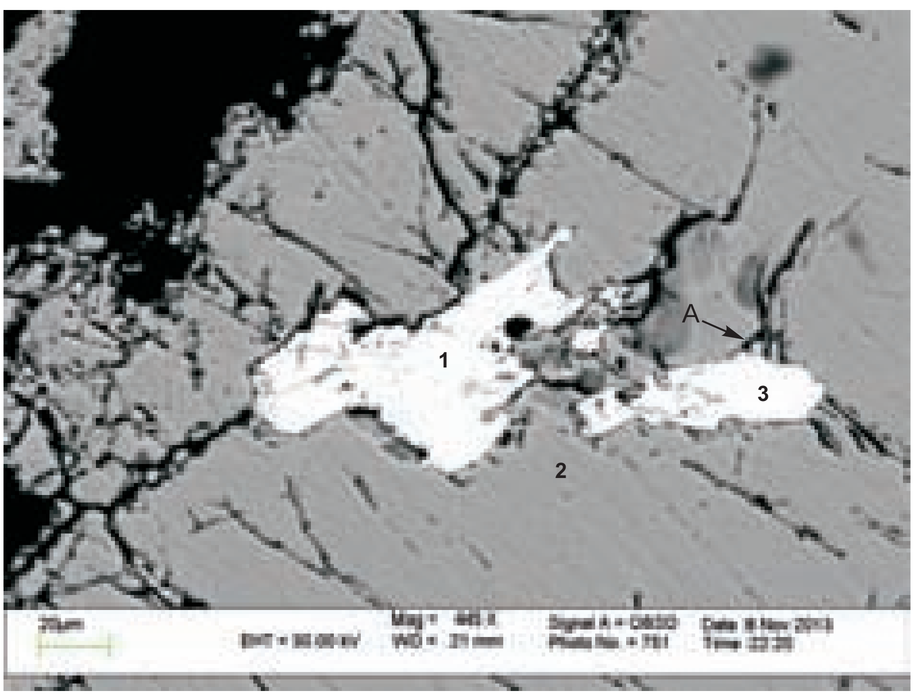
1:Chalcopyrite
2:Pyrite
3:Mix(Fe-oxide+Py+Chl+Al-P)
4:Chalcopyrite
5:Pyrite

Figure 2-5.23b: Sample 9877 site 29; Horton Group. Brighter BSE image of figure 23a. Scattered chalcopyrite grains (analyses 1&4). Pyrite grains are generally rimmed by an Fe-oxide phase and it shows replacive textures (position A).



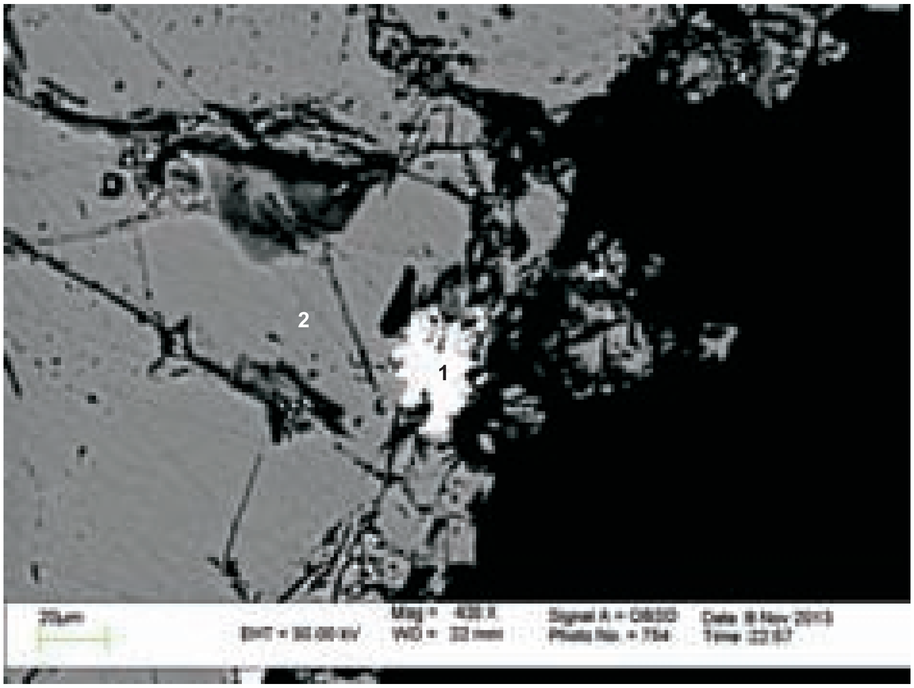
1:Biotite
2:Pyrite
3:TiO_2
4:Mix(Fe-oxide+Py+Ccp+Chl
+Qz+Al-P+Ti)
5:Pyrite

Figure 2-5.24: Sample 9877 site 30; Horton Group. Secondary biotite (analysis 1), pyrite (analysis 2&5) and TiO2 (analysis 3) precipitated in fracture.



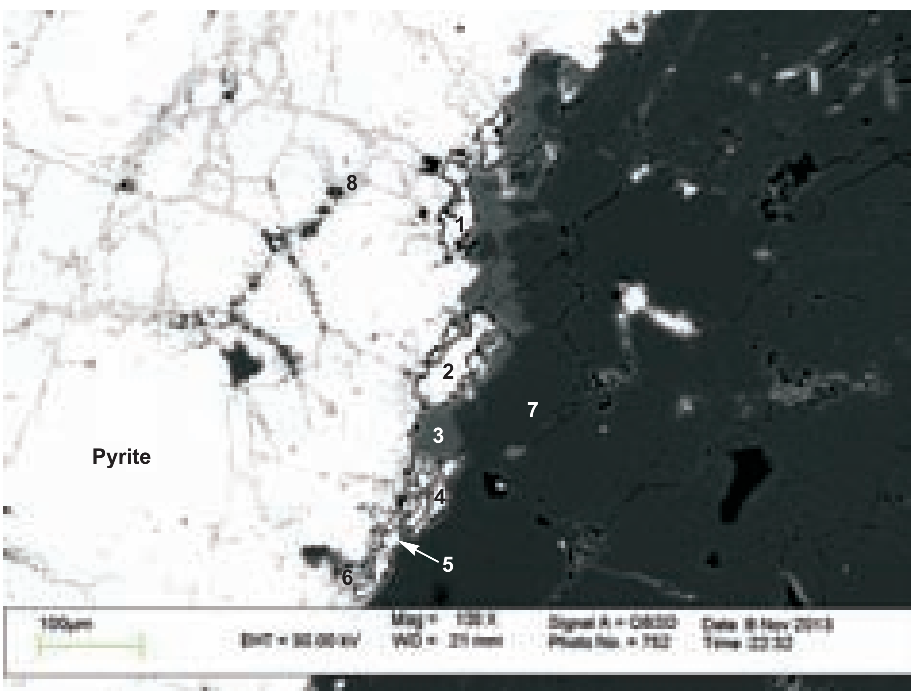
1:Xenotime
2:Pyrite
3:Xenotime

Figure 2-5.25: Sample 9877 site 31; Horton Group. Xenotime fills porosity in fracture. It seems to postdate pyrite, because it precipitates over fractures cutting pyrite (position A).



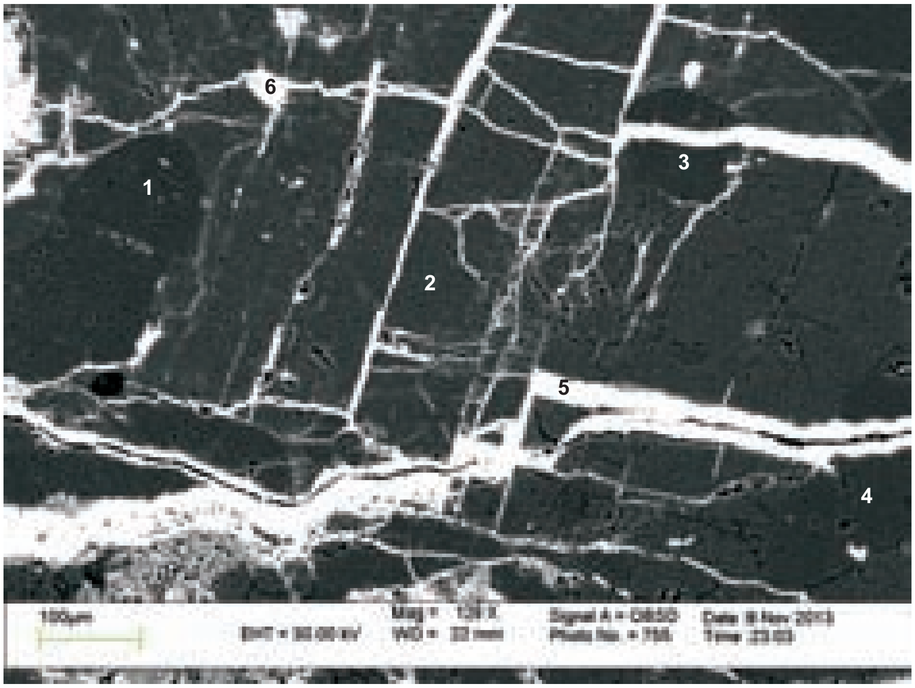
1: Xenotime
2: Pyrite

Figure 2-5.26: Sample 9877 site 32; Horton Group. Xenotime postdates pyrite.



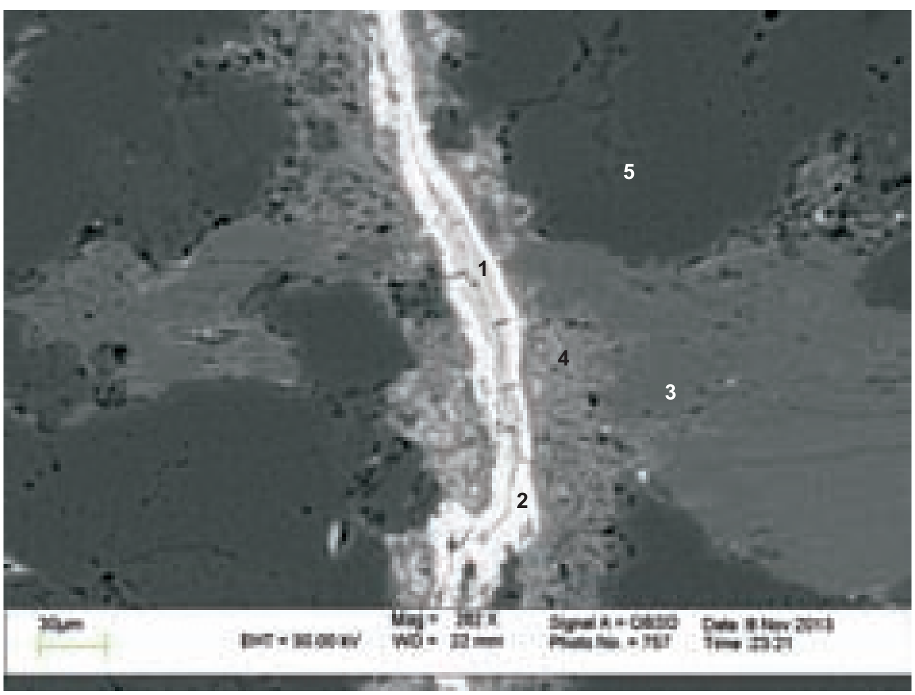
1:Chalcopyrite
2:Chalcopyrite
3:K-feldspar
4:Chalcopyrite
5:Chalcopyrite
6:Mix(Fe-oxide+Py+Chl+Al-P+Qz)
7:Albite
8:Mix(Fe-oxide+Py+Ccp+Chl +Qz+Al-P)

Figure 2-5.27: Sample 9877 site 35; Horton Group. Pyrite with a rim of chalcopyrite (analyses 1,2,4&5) and K-feldspar (analysis 3).



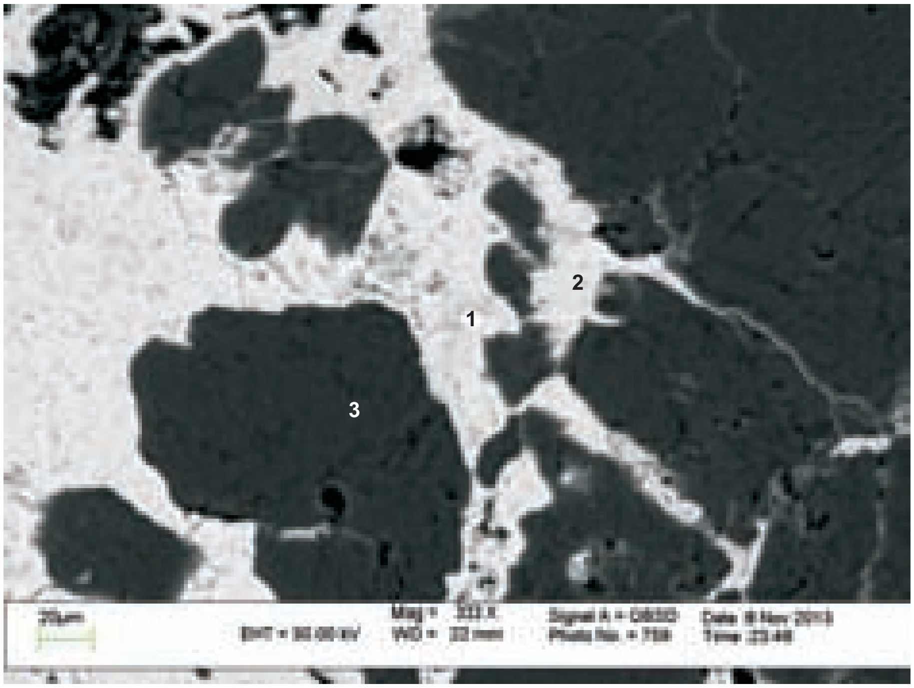
1:Quartz
2:Albite
3:Quartz
4:Quartz
5:Mix
6:Chlorite

Figure 2-5.28: Sample 9877 site 37; Horton Group and granite contact. Fe-oxide mix precipitated along feldspar cleavages and fractures.



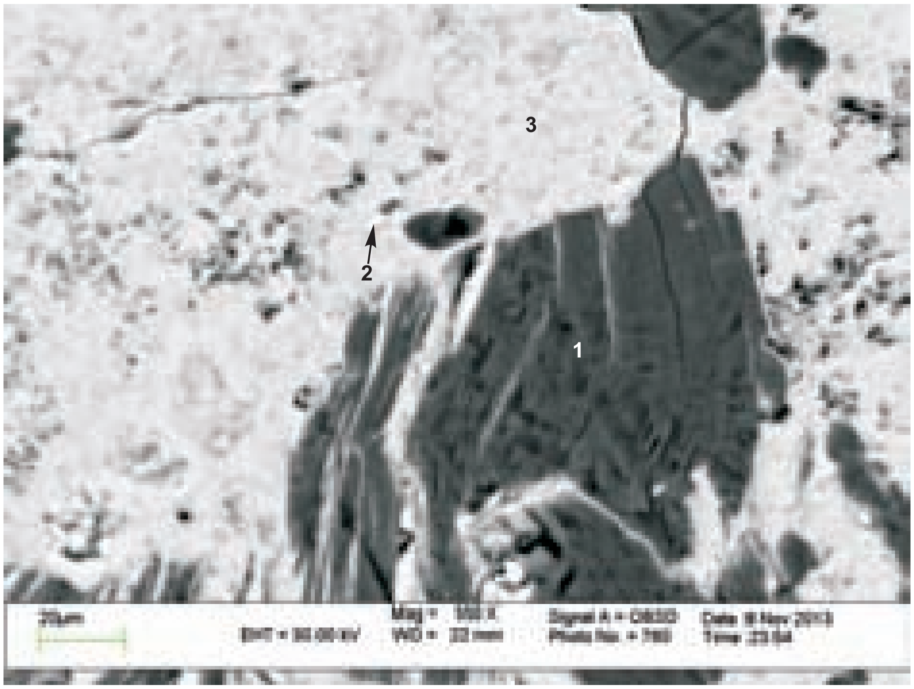
1:Mix(Fe-oxide+Py+Ccp+Chl+Al)
2:Mix(Fe-oxide+Ccp+Cu+Chl)
3:Muscovite
4:Chlorite
5:Albite

Figure 2-5.29: Sample 9877 site 39; granite. A mixture of Fe-oxide, chlorite and probably pyrite precipitated along fractures.



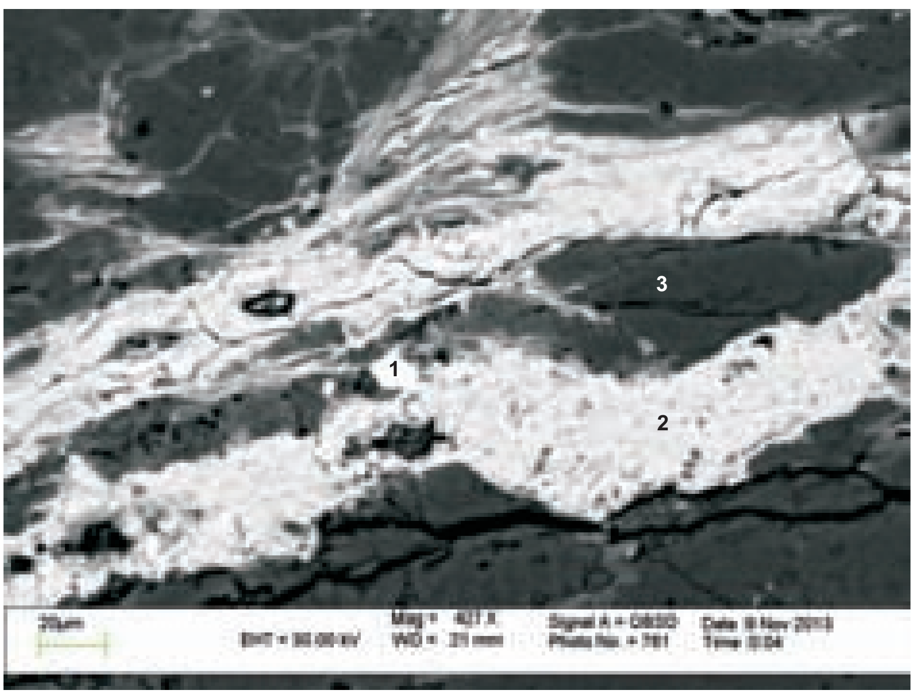
1:Xenotime
2:Mix (Fe-oxide+Py+Ccp+Chl+Qz)
3:Albite

Figure 2-5.30: Sample 9877 site 41; granite. Xenotime postdates Fe-oxide mixture.



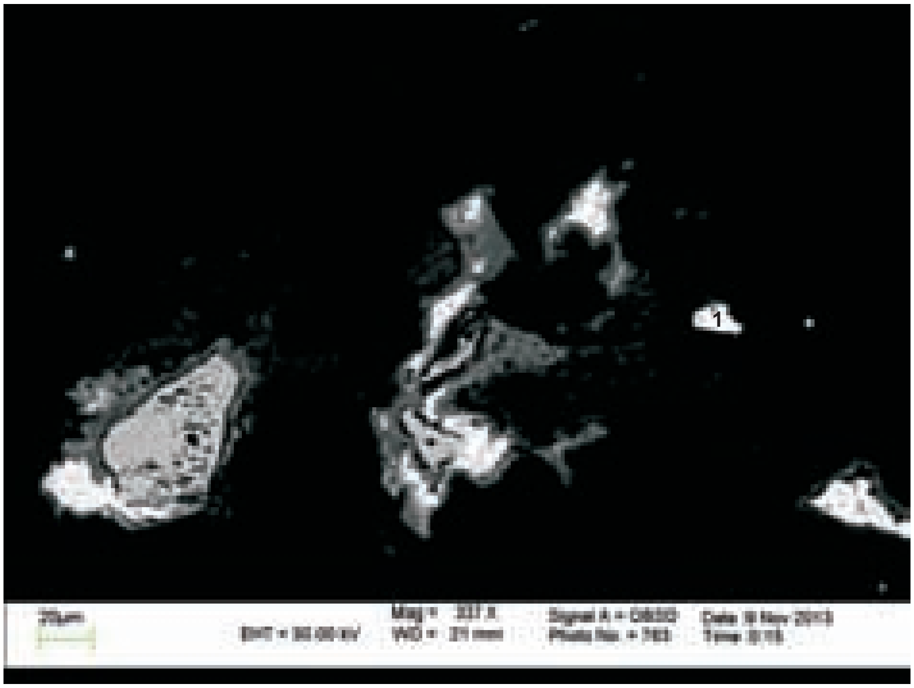
1:Muscovite
2:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
3:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.31: Sample 9877 site 43; granite. The mixture of Fe-oxide, chlorite, and pyrite has precipitated along the muscovite cleavage planes.



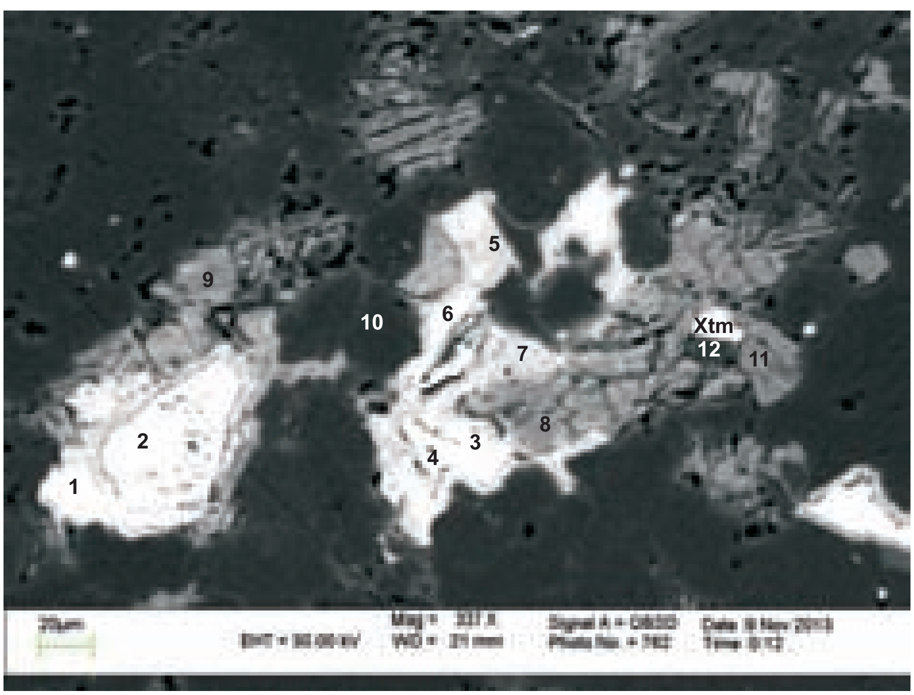
1:Zircon
2:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
3:Albite

Figure 2-5.32: Sample 9877 site 44; Horton Group and granite contact. The same mixture of Fe-oxide, chlorite, and pyrite precipitated along irregular fractures.



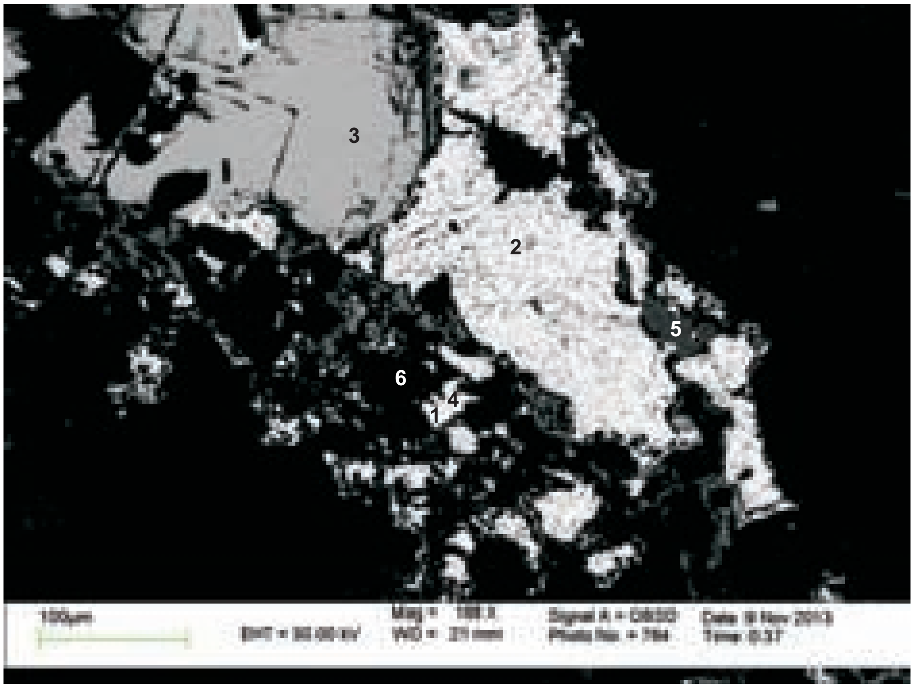
1:Xenotime

Figure 2-5.33: Sample 9877 site 45.



1:Chalcopyrite
2:Pyrite
3:Chalcopyrite
4:Pyrite
5:Mix(Fe-oxide+Ccp+Chl+Qz +Al-P)
6:Chalcopyrite
7:Mix(Fe-oxide+Ccp+Cu+Chl +Qz+Al-P)
8:Biotite
9:Biotite/Chlorite
10:Albite
11:Chlorite/Biotite
12:Quartz

Figure 2-5.34: Sample 9877 site 46; brighter BSE image of figure 33. Scattered grains of chalcopyrite and pyrite. Chalcopyrite (analysis 1) seems to postdate pyrite (analysis 2).



1:Xenotime
2:Chalcopyrite
3:Pyrite
4:Pyrite
5:TiO2
6:Muscovite(+others)

Figure 2-5.35: Sample 9877 site 47; Horton Group. Scattered grains of chalcopyrite, pyrite, and TiO2.

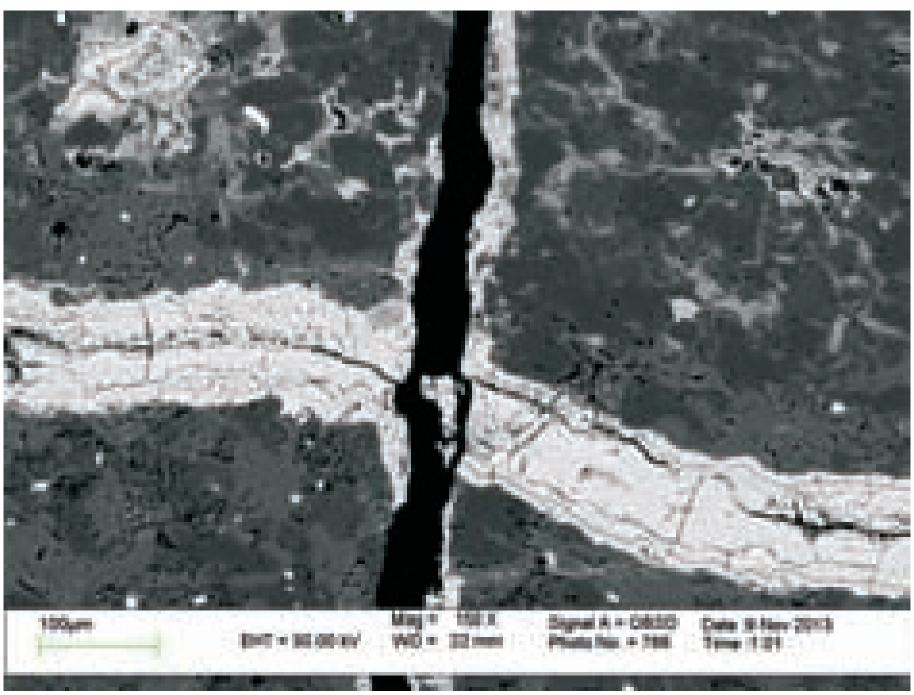
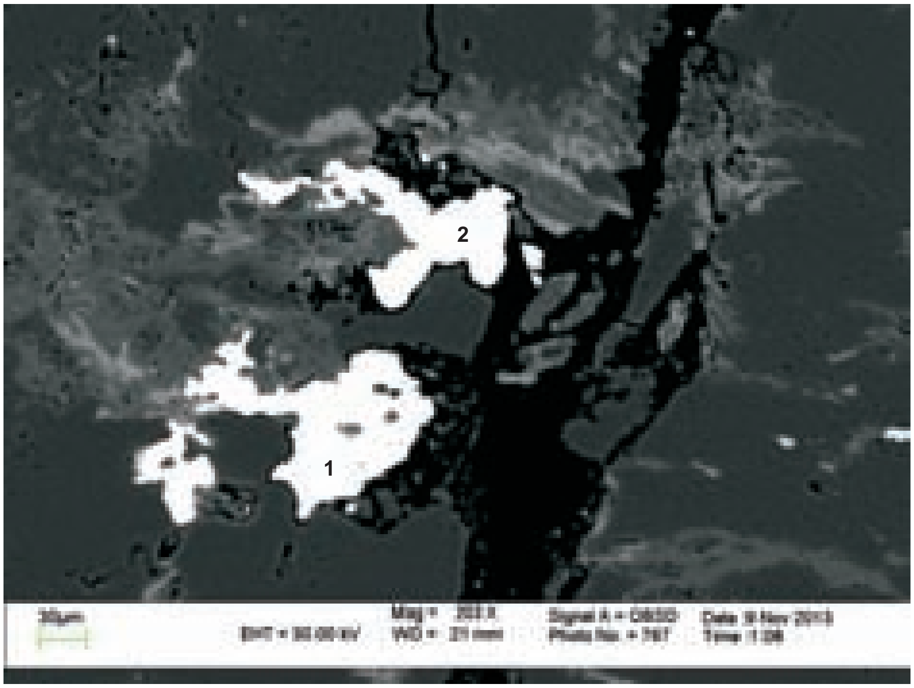
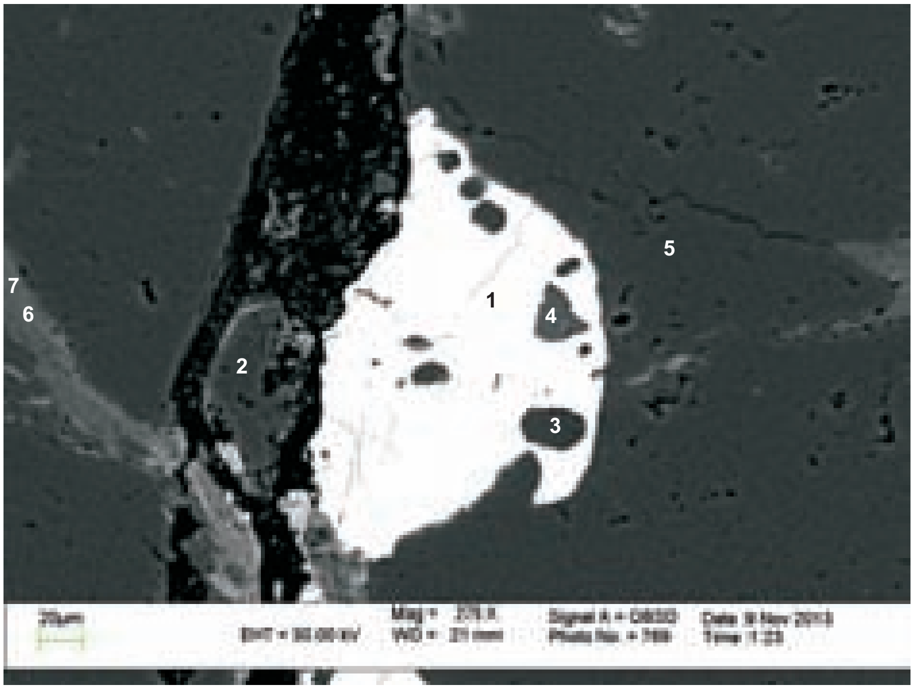


Figure 2-5.36: Sample 9877; Horton Group. Vein filled with Fe-oxide mixture cut by later fracture.



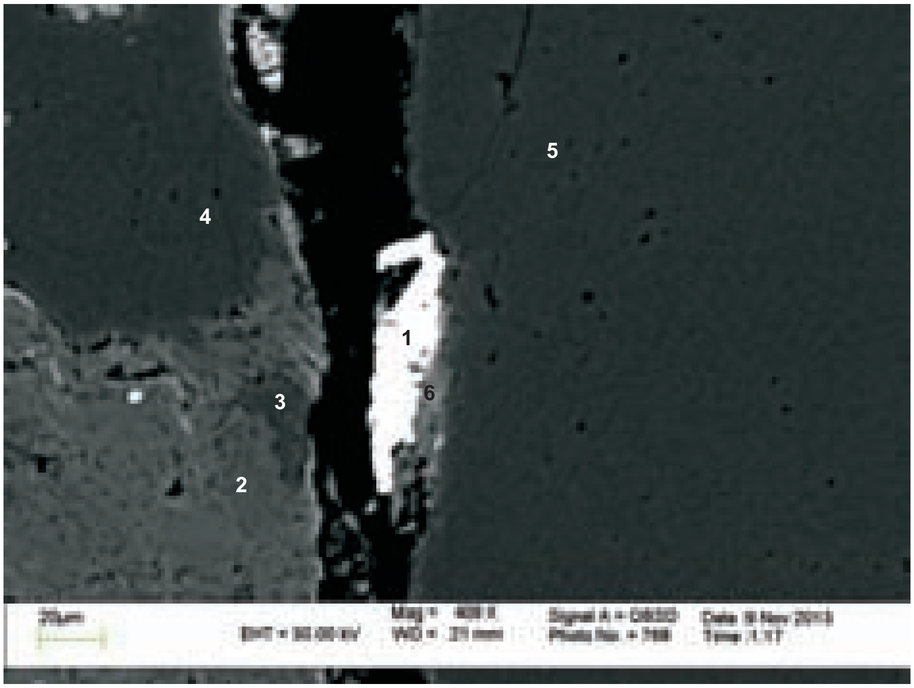
1:Chalcopyrite
2:Chalcopyrite

Figure 2-5.37: Sample 9877 site 50; Horton Group. Chalcopyrite fills porosity.



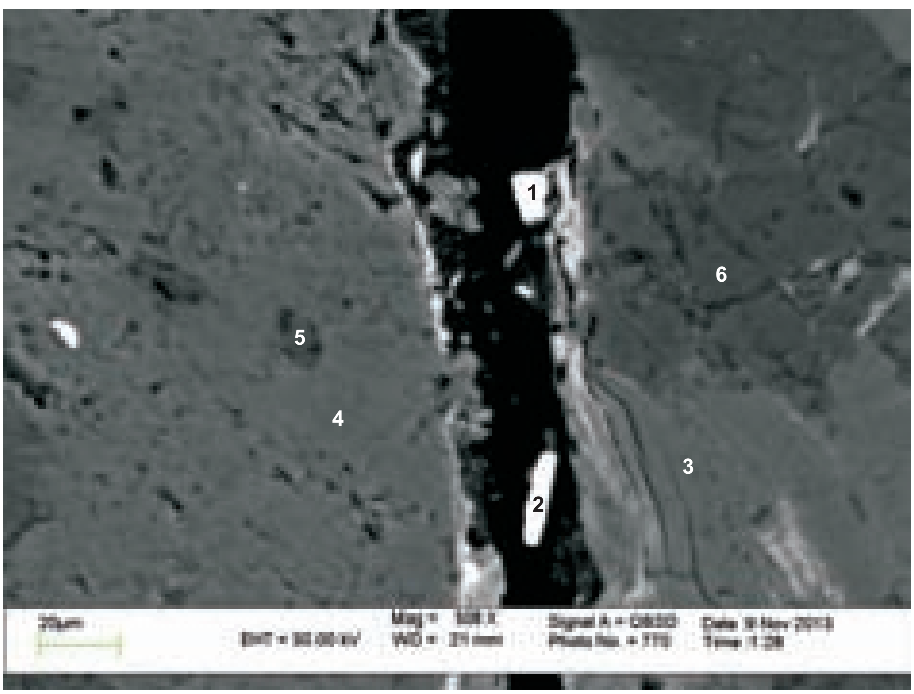
1:Pyrite
2:Quartz
3:Quartz
4:Muscovite
5:Quartz
6:Muscovite
7:Muscovite

Figure 2-5.38: Sample 9877 site 51; Horton Group. Fracture cuts muscovite in the country rock (analyses 6&7) and is partly filled by quartz with overgrowths (analysis 2) and pyrite (analysis 1) that contains quartz (analysis 3) and muscovite (analysis 4) fragments. The pyrite is cut by later fractures.



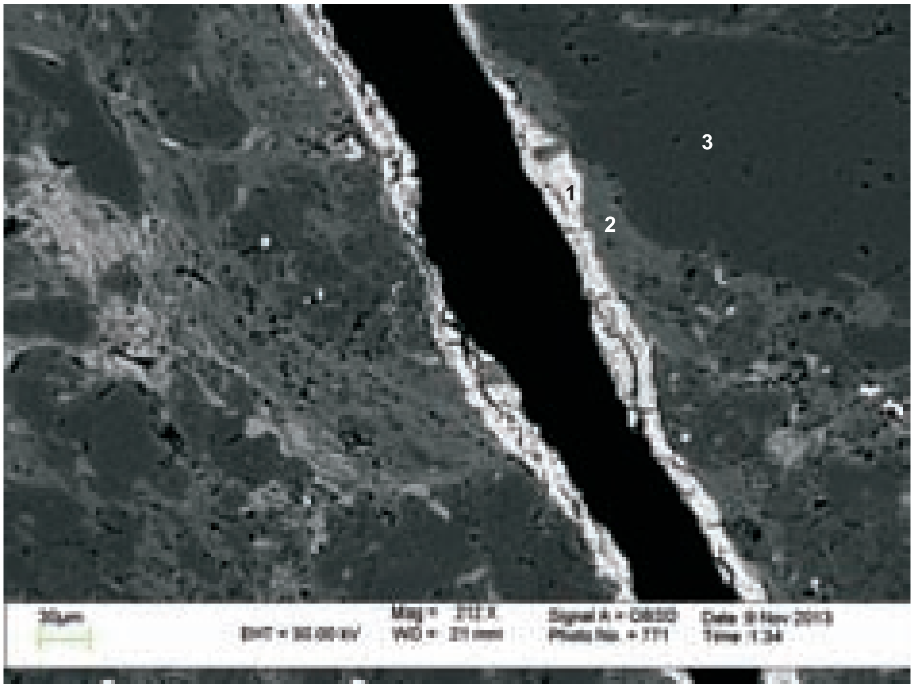
1:Barite
2:Muscovite
3:Quartz
4:Quartz
5:Quartz
6:Muscovite/Chlorite

Figure 2-5.39: Sample 9877 site 53; Horton Group. Barite has precipitated in late fracture



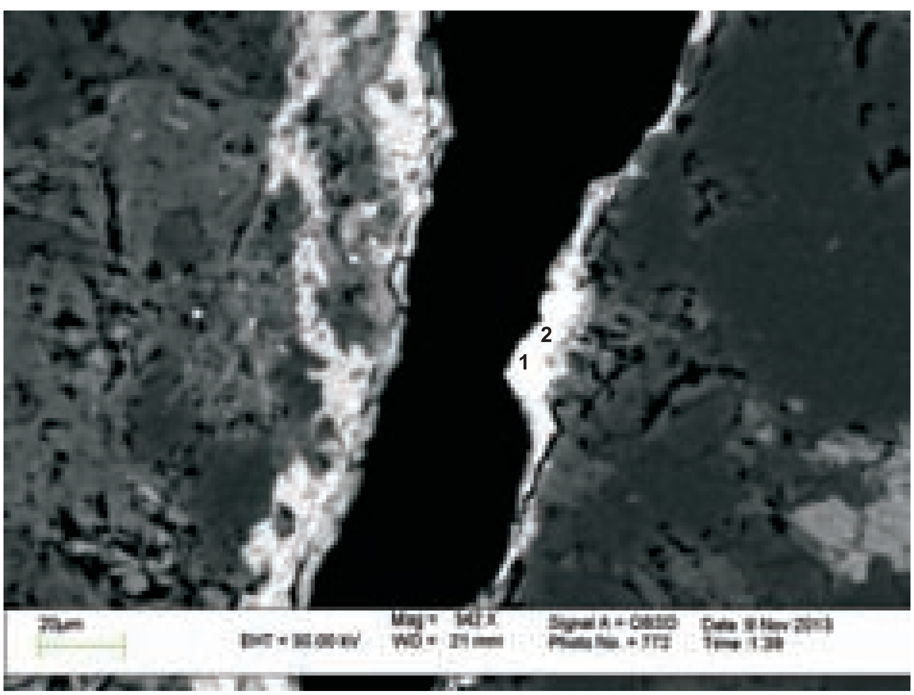
1:Barite
2:Barite
3:Muscovite
4:Muscovite
5:Quartz
6:Albite

Figure 2-5.40: Sample 9877 site 55; Horton Group. Barite has precipitated in late fracture.



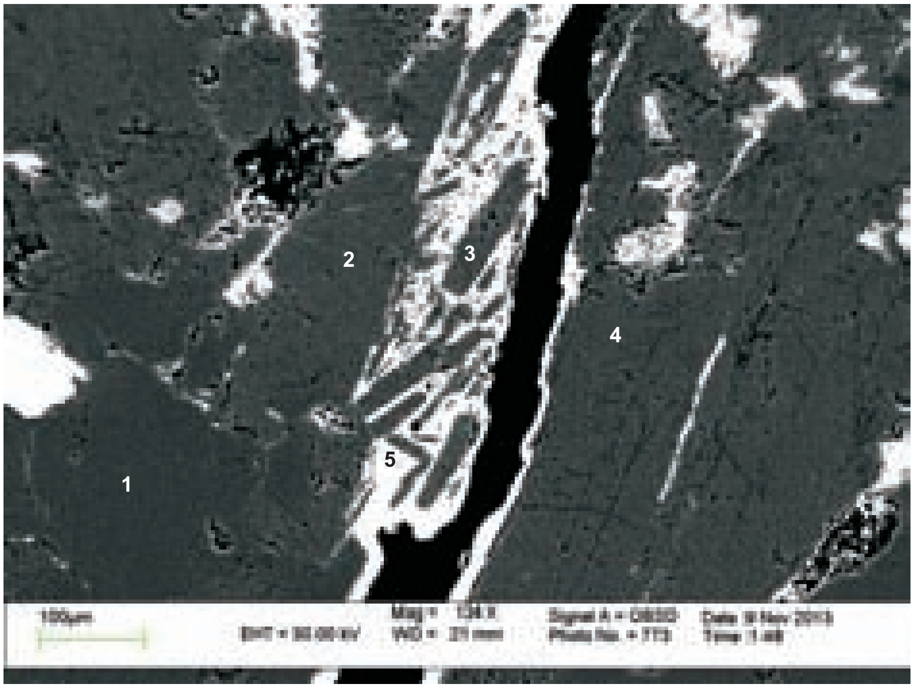
1:Mix(Fe-oxide+Ccp+Chl+Al-P)
2:Muscovite
3:Quartz

Figure 2-5.41: Sample 9877 site 56; Horton Group. Fe-oxide mixture (analysis 1) cut by late fracture reopening.



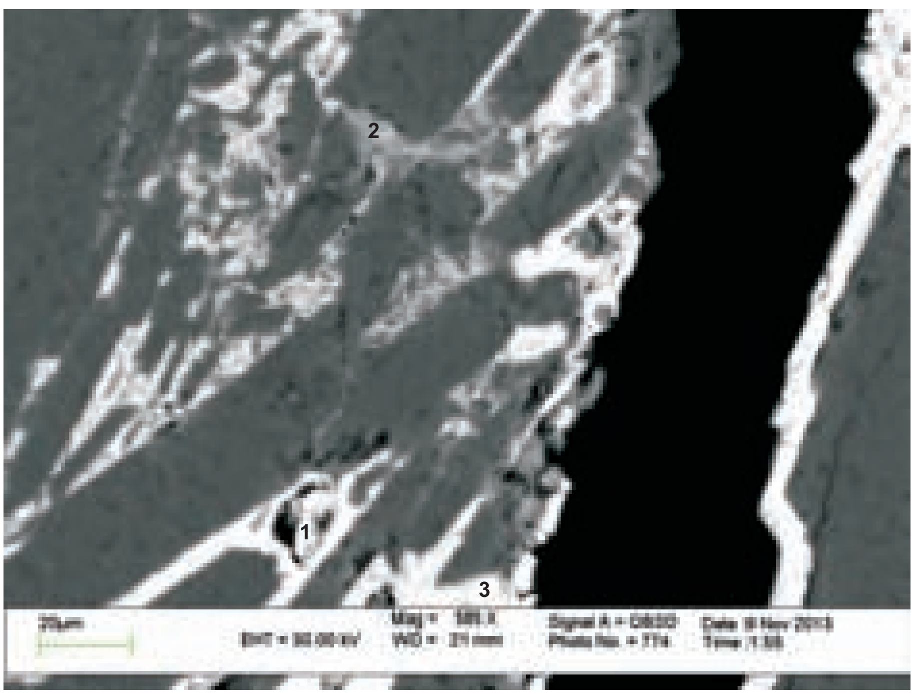
1:Barite
2:Barite

Figure 2-5.42: Sample 57 site 57; Horton Group. Barite has precipitated in fracture.



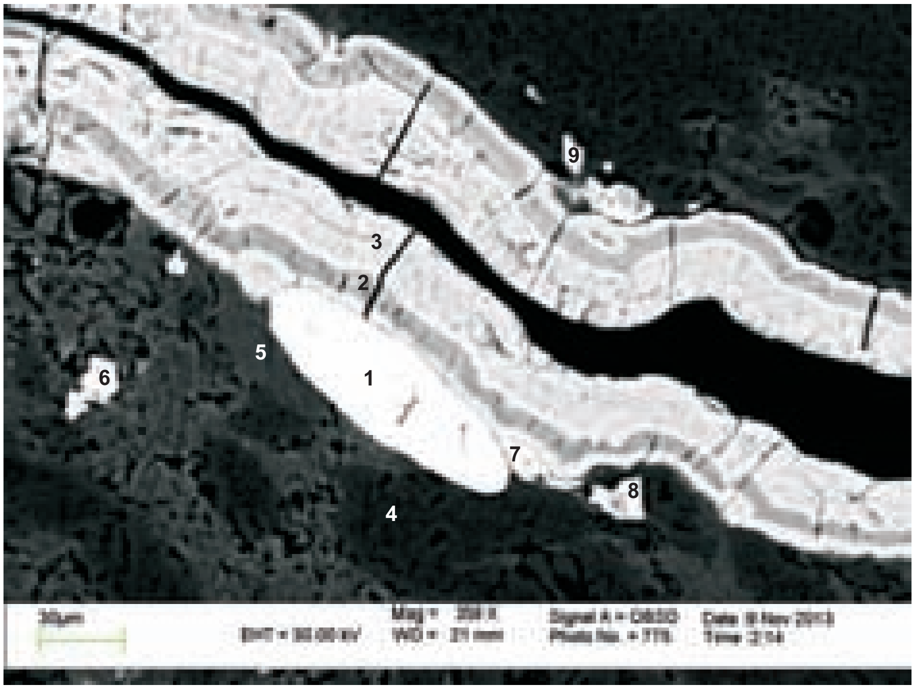
1:Quartz
2:Albite
3:Albite
4:Albite
5:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.43a: Sample 9877 site 59; contact between Horton Group and granite. Albite is rimmed by Fe-oxide mixture along fracture.



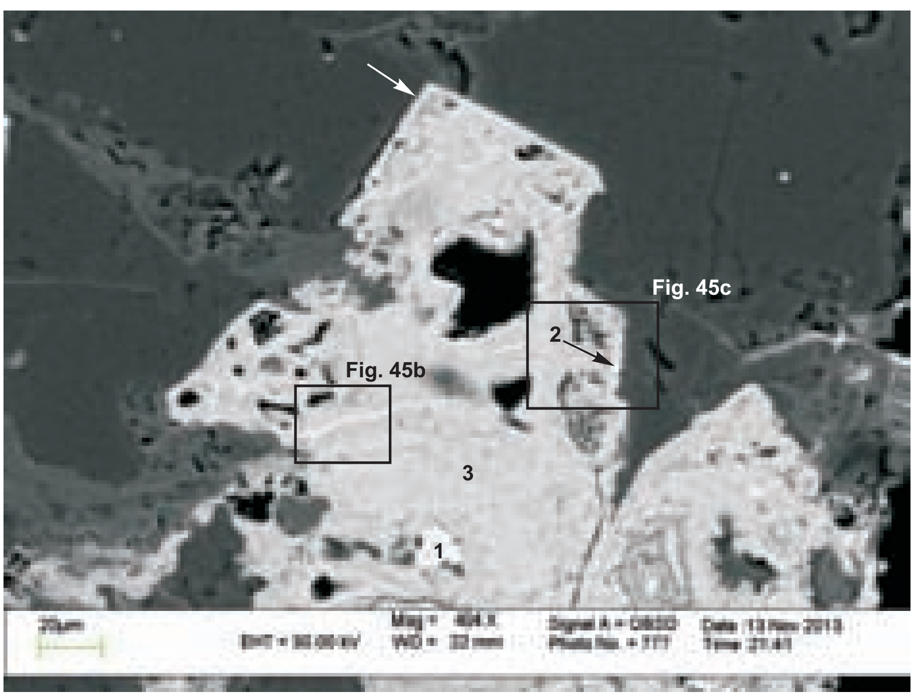
1:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
2:Chlorite
3:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)

Figure 2-5.43b: Sample 9877 site 60; contact between Horton Group and granite. Higher magnification of figure 43a.



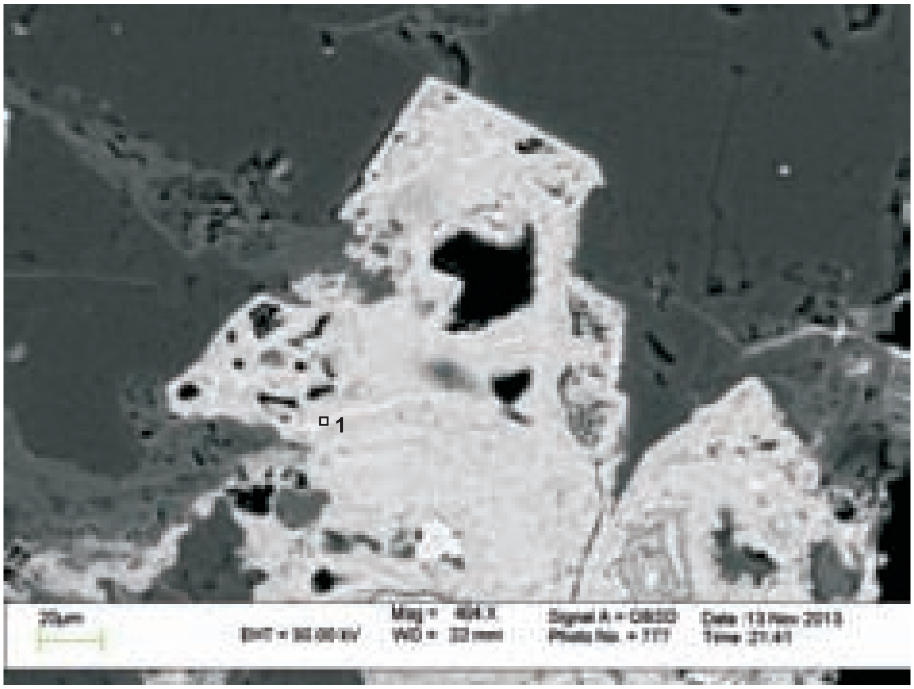
1:Zircon
2:Mix(Fe-oxide+Py+Ccp+Chl+Al-P)
3:Mix(Fe-oxide+Ccp+Cu+Chl+Qz)
4:Quartz
5:Biotite
6:Ilmenite
7:Ilmenite
8:Ilmenite
9:Ilmenite

Figure 2-5.44: Sample 9877 site 63; Horton Group. Zircon postdated by later Fe-oxide mixture in fracture with cooling cracks. Fracture filled with successive zones of Fe-oxide and chalcopyrite intermixed with chlorite and phosphate.



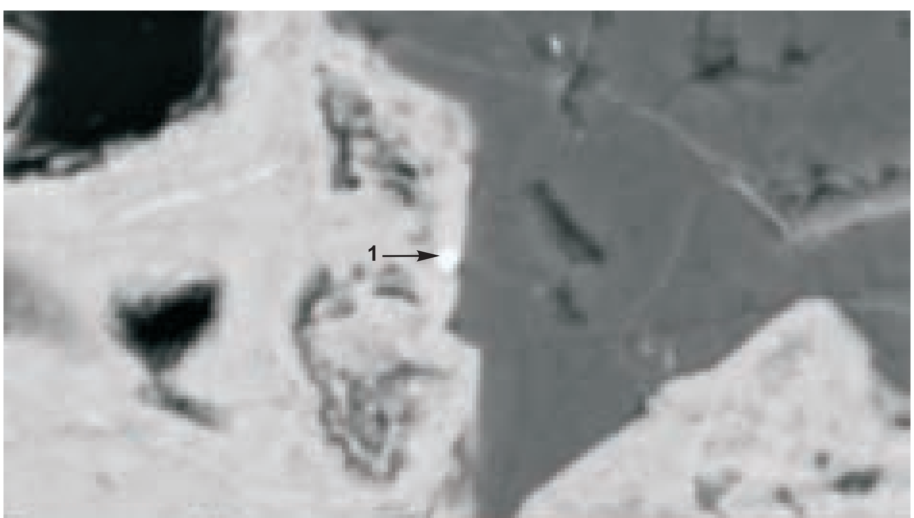
1:Ilmenite
2:Mix(REE+others)
3:Mix(Fe-oxide+Ccp+Cu+Qz)

Figure 2-5.45a: Sample 9877 site 65; Fe-oxide mixture with cubic habit, likely magnetite and pyrite, (white arrow). This is postdated by ilmenite (analysis 1) filling porosity within the Fe-oxide mixture, and a REE bearing phase (analysis 2 & figure 45c). It is probably an original pyrite crystal pseudomorphed by Fe-oxide mixture.



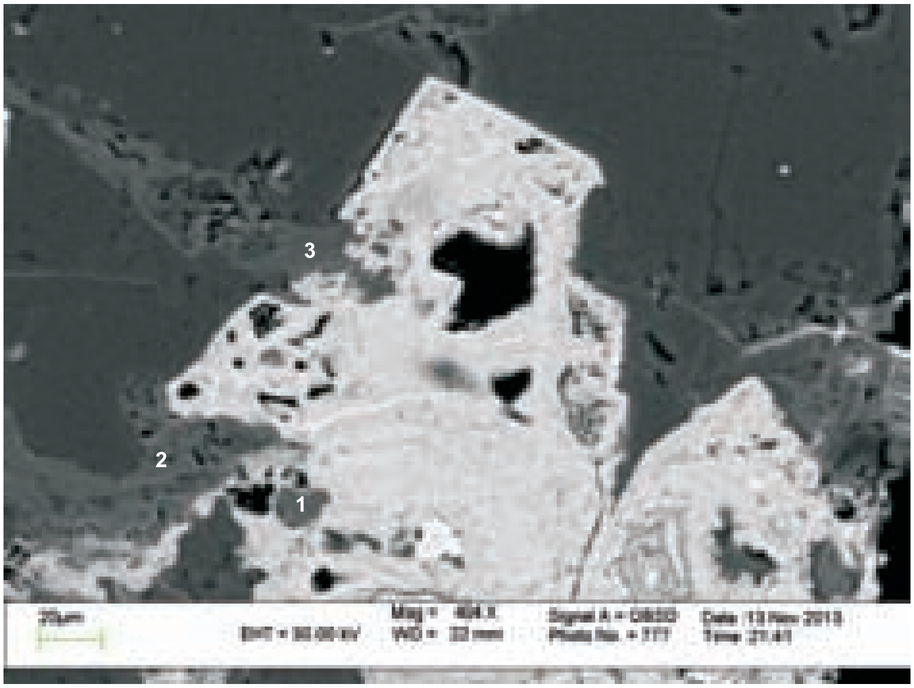
1:Mix(Fe-oxide+Ccp+Chl+Qz)

Figure 2-5.45b: Sample 9877 site 66; brighter spots contain more Fe and Al, and less Si than darker areas. Brighter areas appear to crosscut darker areas.



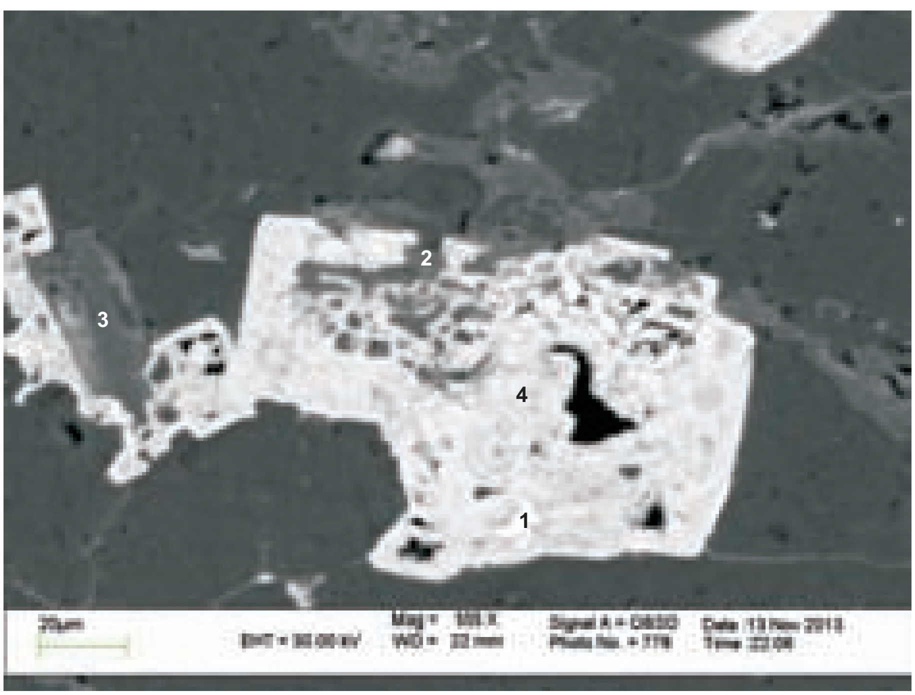
1:Monazite?(+others)

Figure 2-5.45c: Sample 9877 site 67.



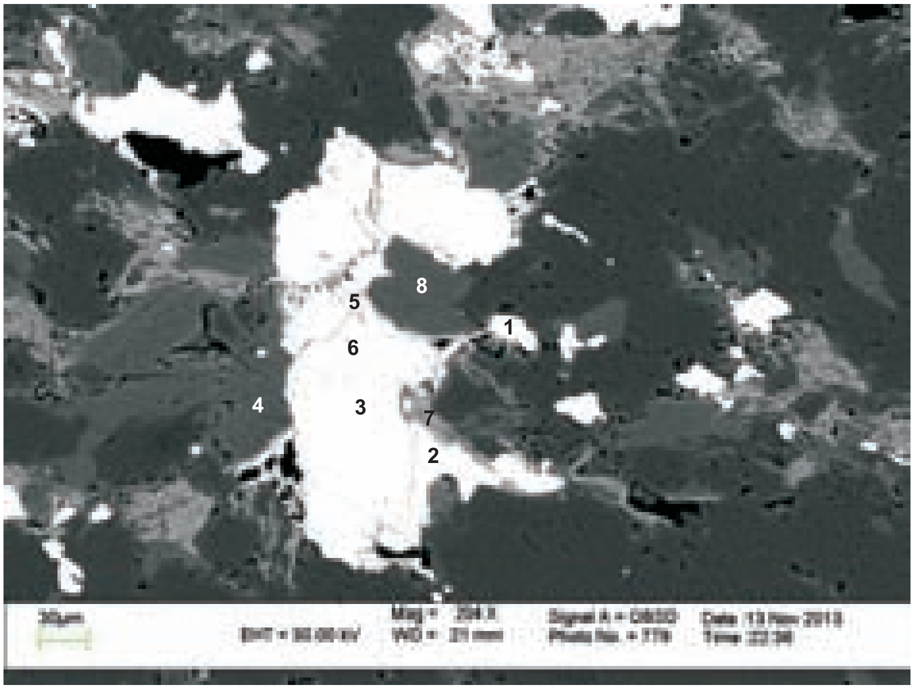
1:Muscovite
2:Muscovite
3:Muscovite

Figure 2-5.45d: Sample 9877 site 68



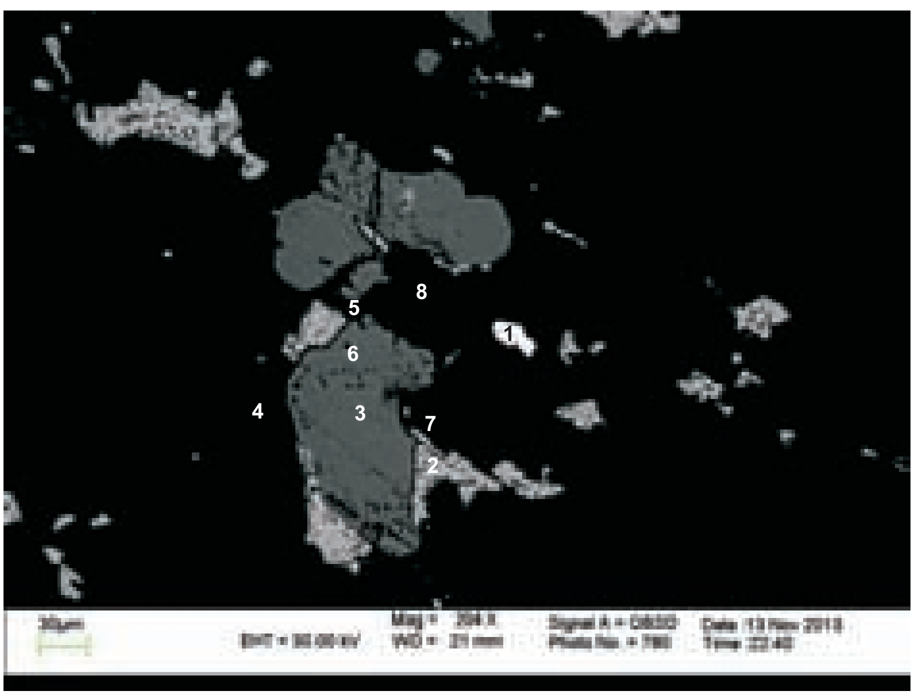
1:Contamination (Cr and Ni)
2:Mix(Muscovite+others)
3:Muscovite
4:Mix(Fe-oxide+Ccp+Cu+Chl+Al-P

Figure 2-5.46: Sample 9877 site 69; muscovite (analyses 2&3) replaced by later Fe-oxide bearing phase (analysis 4).



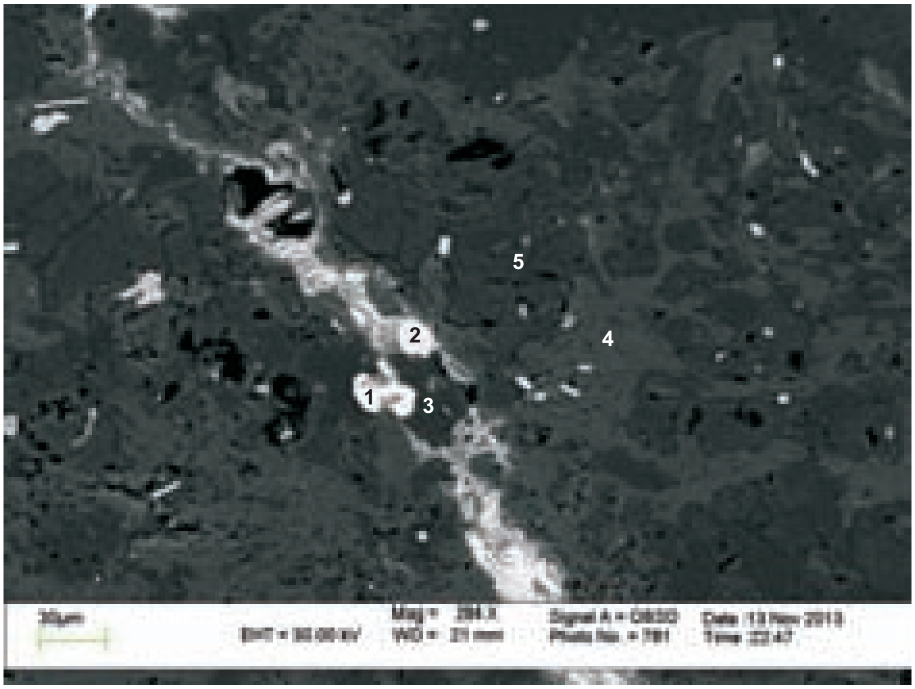
1:Barite
2:Chalcopyrite
3:Pyrite
4:Muscovite
5:Mix(Fe-oxide+Ccp
+Chl+Al-P)
6:Bad analysis
7:Biotite
8:Muscovite

Figure 2-5.47a: Sample 9877 site 71; bright BSE image. Pyrite replaces muscovite (analyses 4&8) and biotite (analysis 7). Pyrite is in turn rimmed by chalcopyrite (analysis 2). Barite (analysis 1) fills porosity.



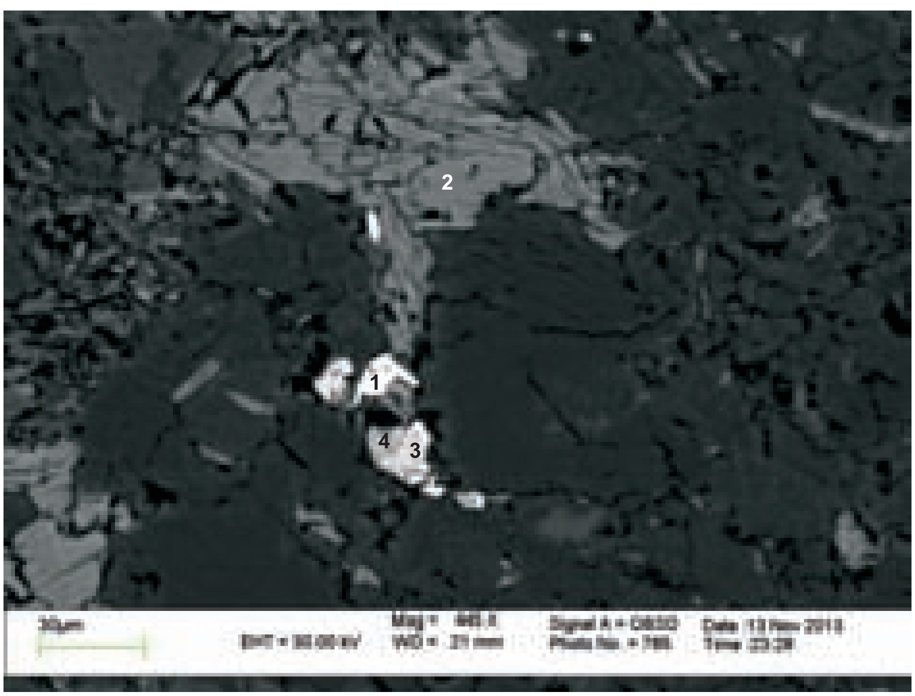
1:Barite
2:Chalcopyrite
3:Pyrite
4:Muscovite
5:Mix(Fe-oxide+Ccp
+Chl+Al-P)
6:Bad analysis
7:Biotite
8:Muscovite

Figure 2-5.47b: Sample 9877 site 71; darker BSE image of figure 47a.



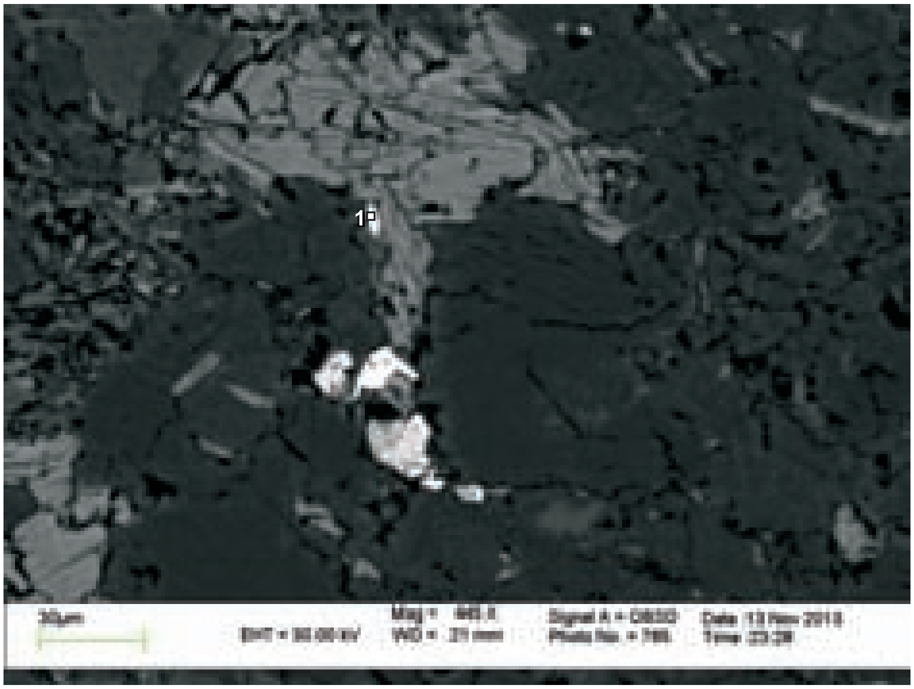
1:Covellite
2:Pyrite
3:Quartz
4:Muscovite
5:Albite

Figure 2-5.48: Sample 9877 site 73; pyrite (analysis 2) and covellite (analysis 1) precipitated in fracture.



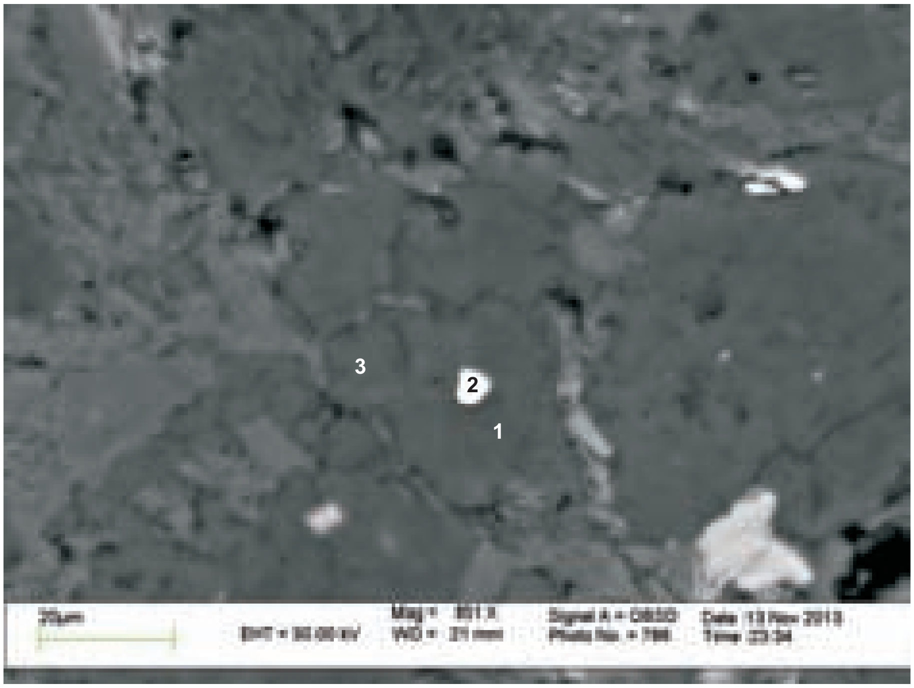
1:Molybdenite
2:Biotite
3:Ilmenite
4:TiO_2

Figure 2-5.49a: Sample 9877 site 79; molybdenite (analysis 1) engulfing biotite (analysis 2) and TiO_2 (analysis 3) engulfing ilmenite (analysis 4).



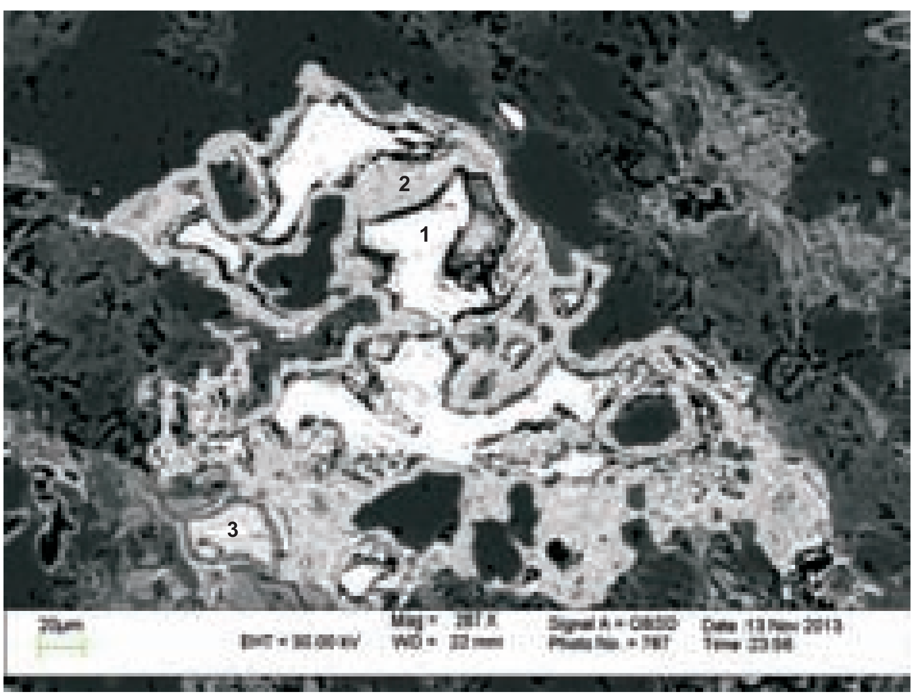
1:Zircon

Figure 2-5.49b: Sample 9877 site 80



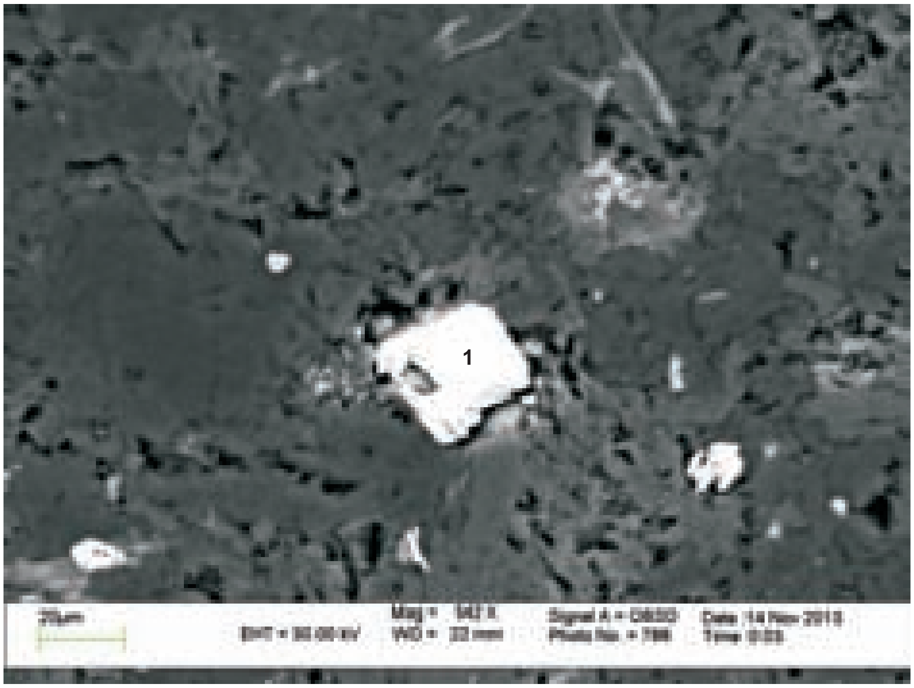
1:Albite
2:Albite
3:Monazite

Figure 2-5.50: Sample 9877 site 82; detrital (?) monazite.



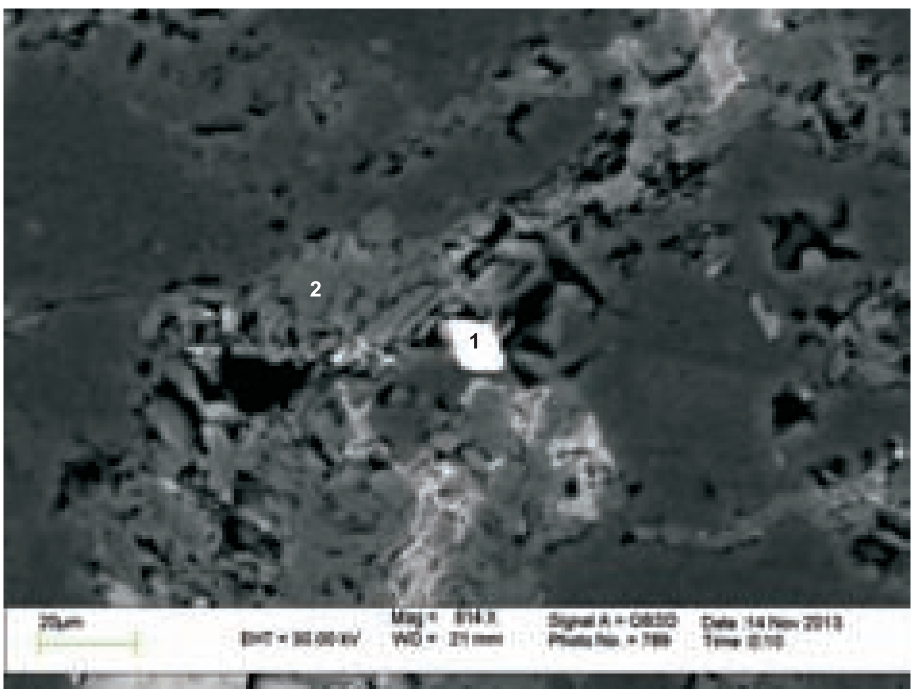
1:Pyrite
2:Mix(Fe-oxide+Py
+Ccp+Chl+Al-P)
3:Pyrite

Figure 2-5.51: Sample 9877 site 84; pyrite with irregular rims of Fe-oxide mixture (analysis 2), with a dissolution zone between the two.



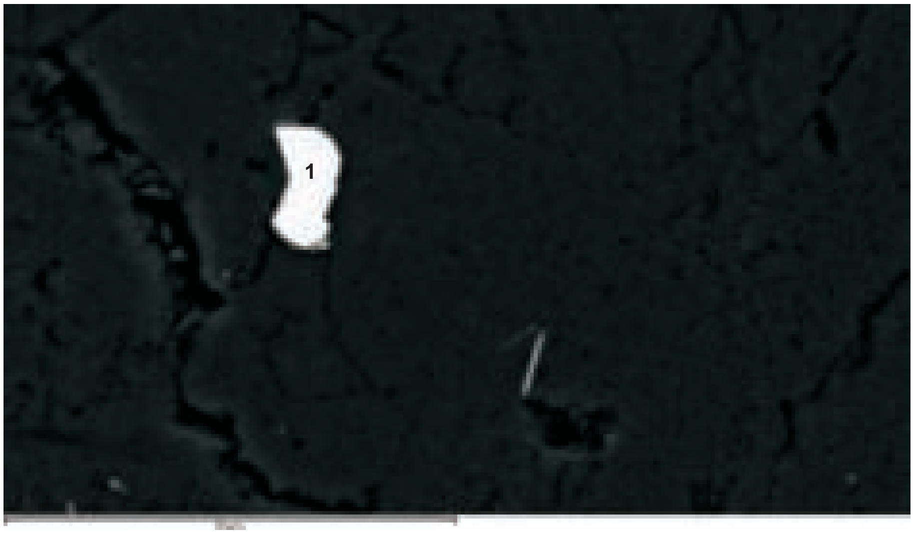
1:Zircon

Figure 2-5.52: Sample 9877 site 86; zircon fills porosity in muscovite.



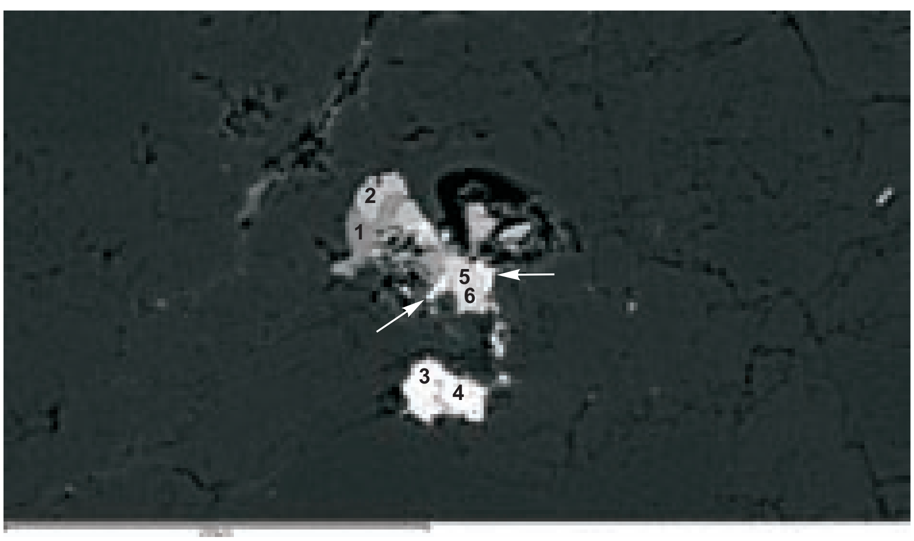
1:Xenotime
2:Muscovite

Figure 2-5.53: Sample 9877 site 87; xenotime fills porosity in muscovite.



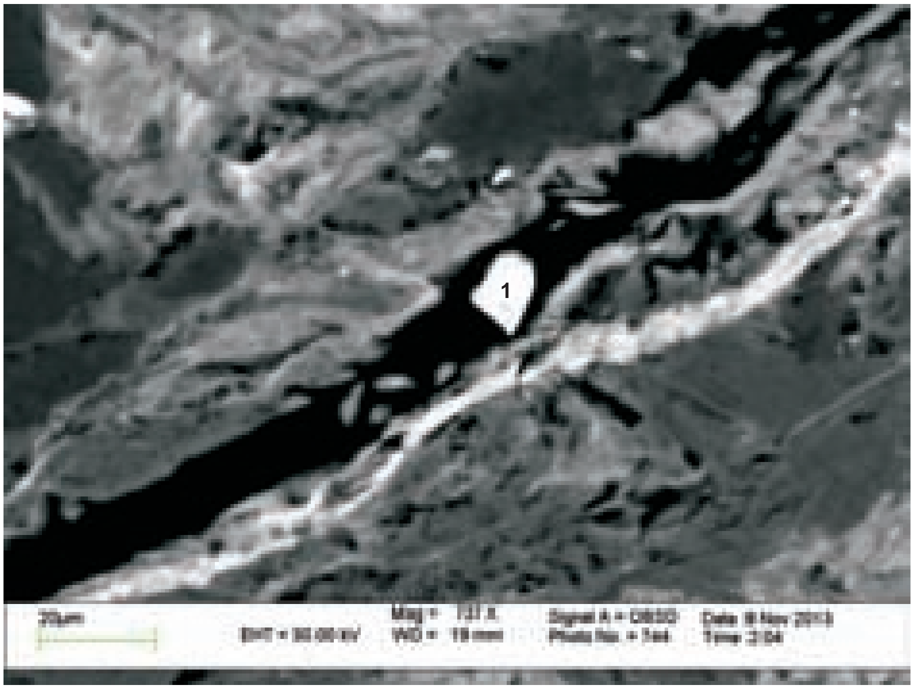
1: Pyrochlore

Figure 2-5.54: Sample 9877 site 98;



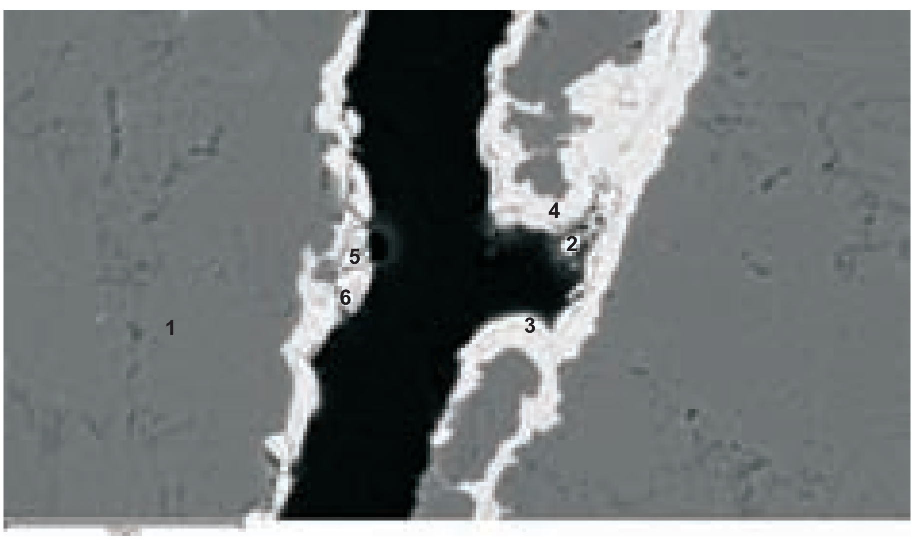
1: TiO_2
2:Ilmenite
3:Aeschynite-euxenite
4:Aeschynite-euxenite
5:Pyrochlore
6:Pyrochlore

Figure 2-5.55: Sample 9877 site 114; TiO_2 (analysis 1) engulfing ilmenite (analysis 2). Pyrochlore (analyses 5&6) likely has been replaced by aeschynite-euxenite (analyses 3&4, arrows).



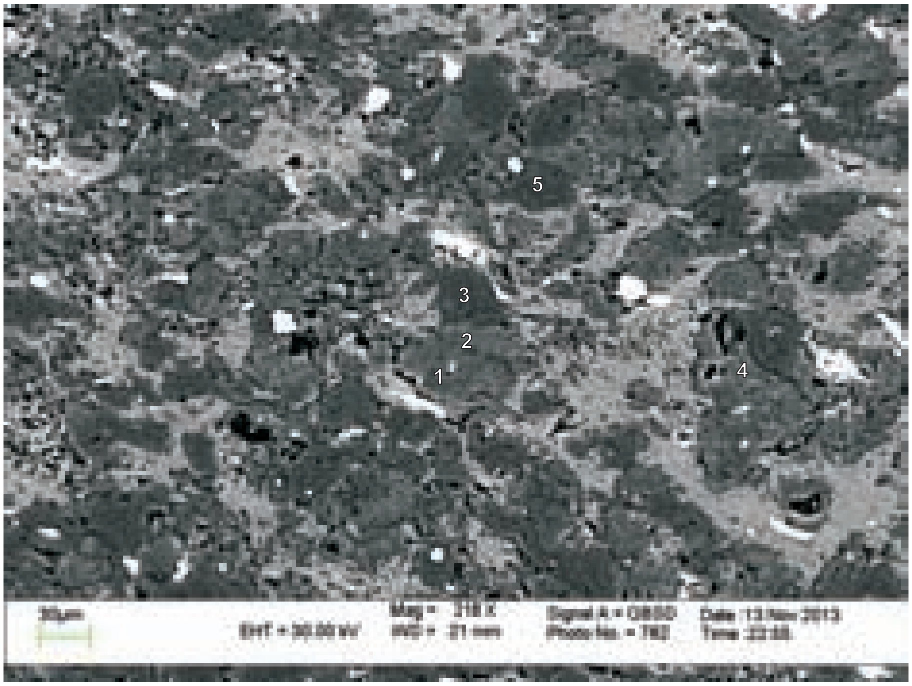
1:Ti-magnetite

Figure 2-5.56: Sample 9877 site 24; Horton Group. Fragment of Ti-magnetite grain in fracture.



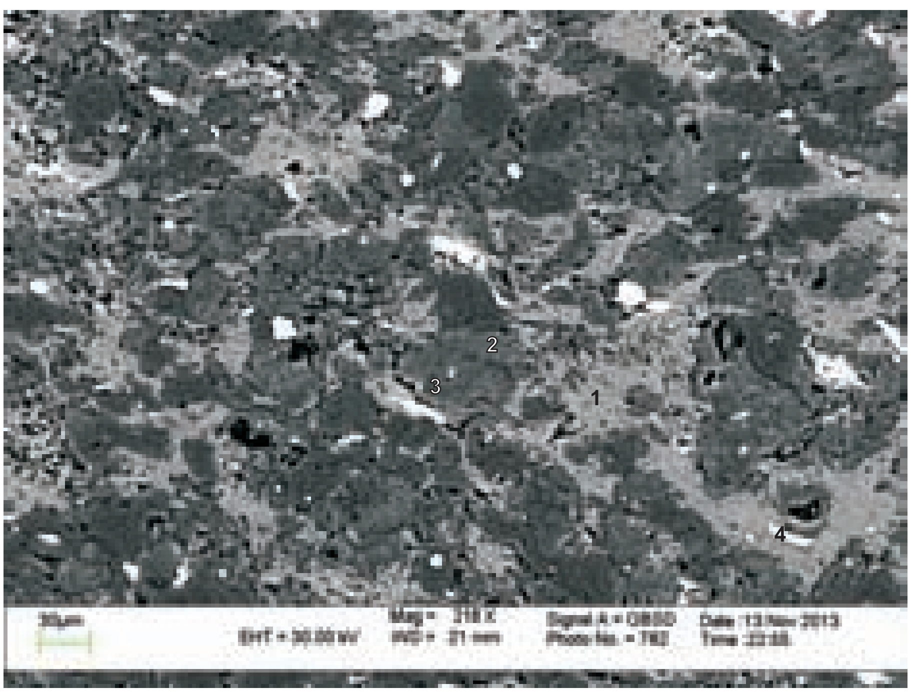
1:bad analysis
2:Mix(Fe-oxide+Ccp +Cu+Chl+Qz)
3:Mix(Fe-oxide+Ccp +Cu+Chl)
4:Mix(Fe-oxide+Ccp +Cu+Chl)
5:Mix(Fe-oxide+Cu+Chl+Qz)
6:Mix(Fe-oxide+Ccp +Cu+Chl)

Figure 2-5.57: Sample 9877 site 61; Fe-oxide mixture lining a fracture.



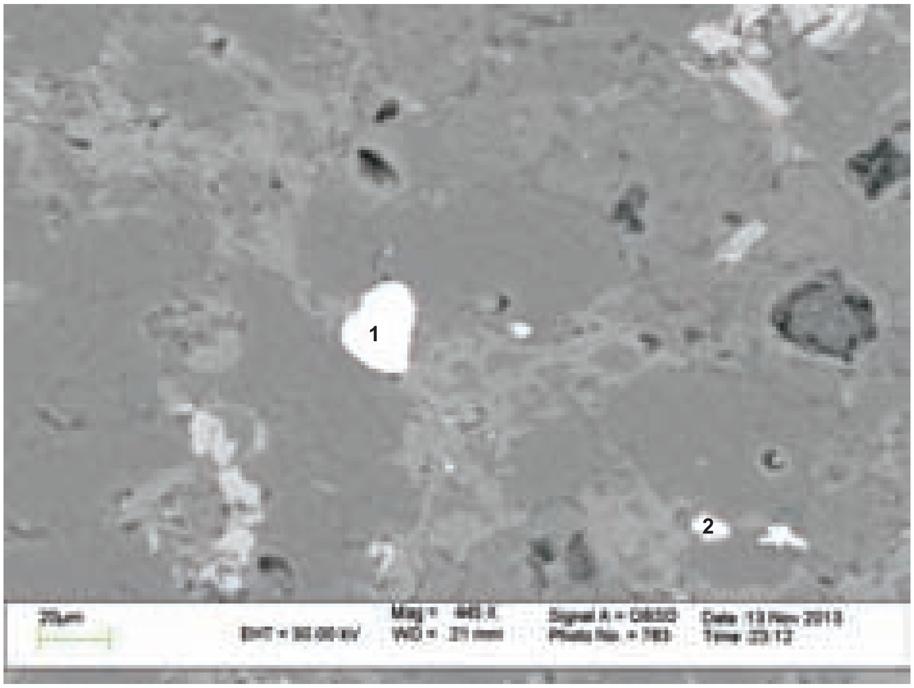
1:Albite
2:Albite
3:Quartz
4:Plagioclase
5:Quartz

Figure 2-5.58: Sample 9877 site 74; Horton Group.



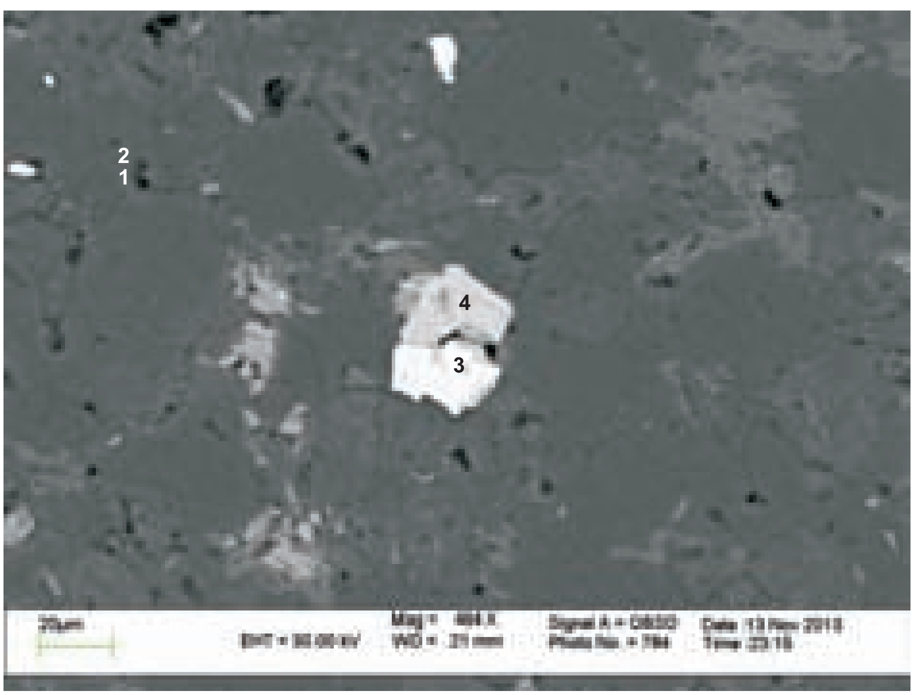
1:Muscovite
2:Albite
3:Albite
4:Ilmenite

Figure 2-5.59: Sample 9877 site 75; Horton Group.



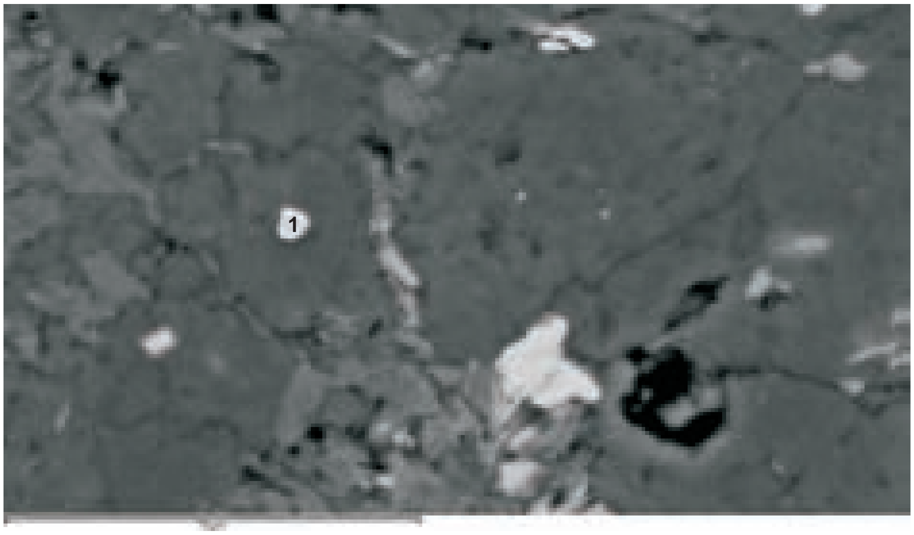
1:Zircon
2:Ilmenite

Figure 2-5.60: Sample 9877 site 76.



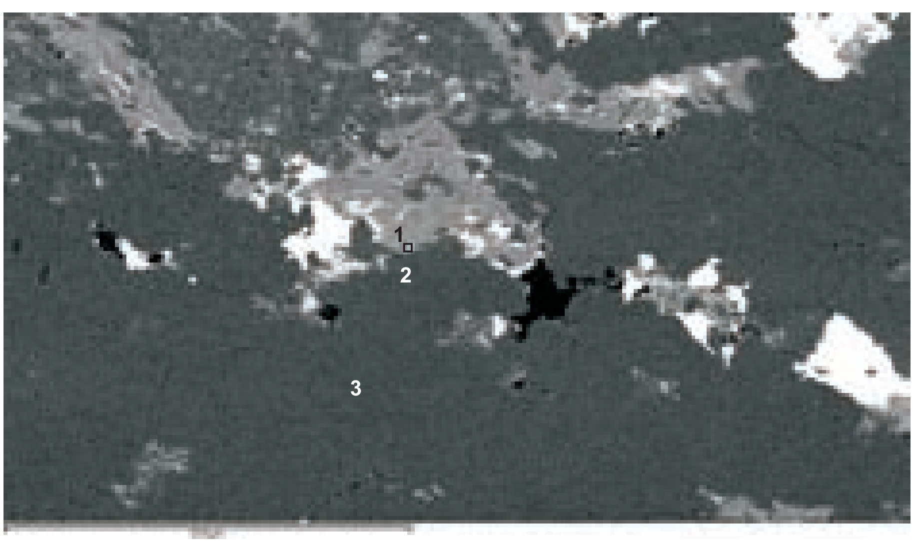
1:bad analysis
2:bad analysis
3:Ilmenite
4:TiO_2

Figure 2-5.61: Sample 9877 site 77; ilmenite (analysis 3) partly replaced by TiO_2(analysis 4).



1:Monazite?(+others)

Figure 2-5.62: Sample 9877 site 81; a primary monazite inclusion in albite.

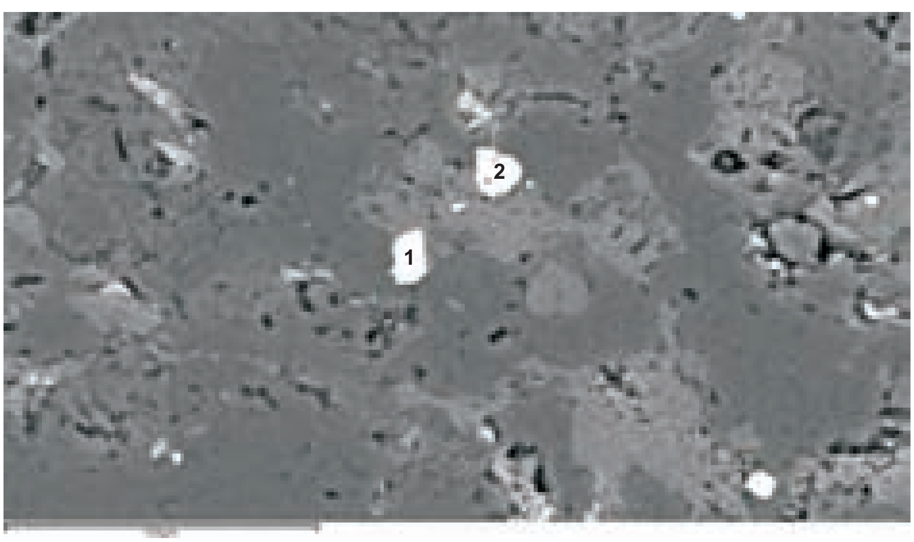


1:Barite (+quartz)
2:Zircon
3:Quartz

Figure 2-5.63: Sample 9877 site 83.

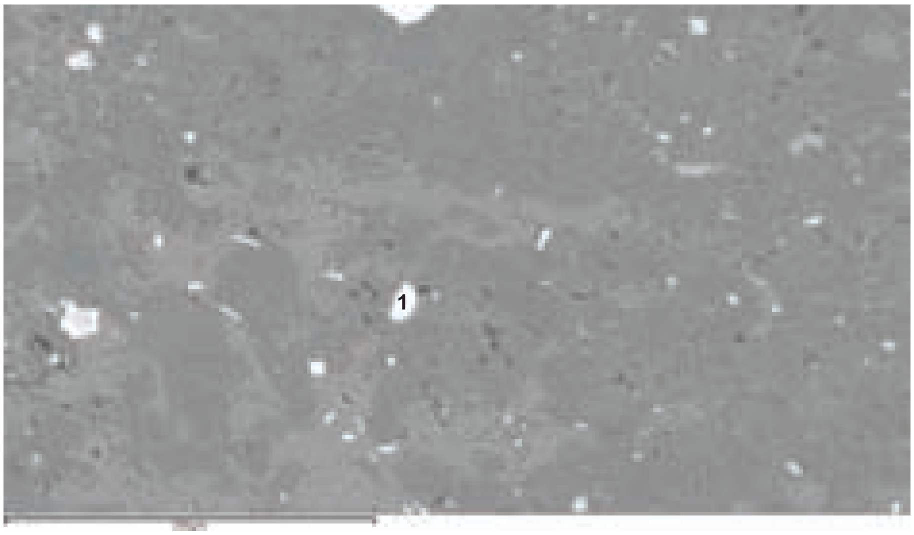
1:Zircon

Figure 2-5.64: Sample 9877 site 85; zircon grain, probably primary.



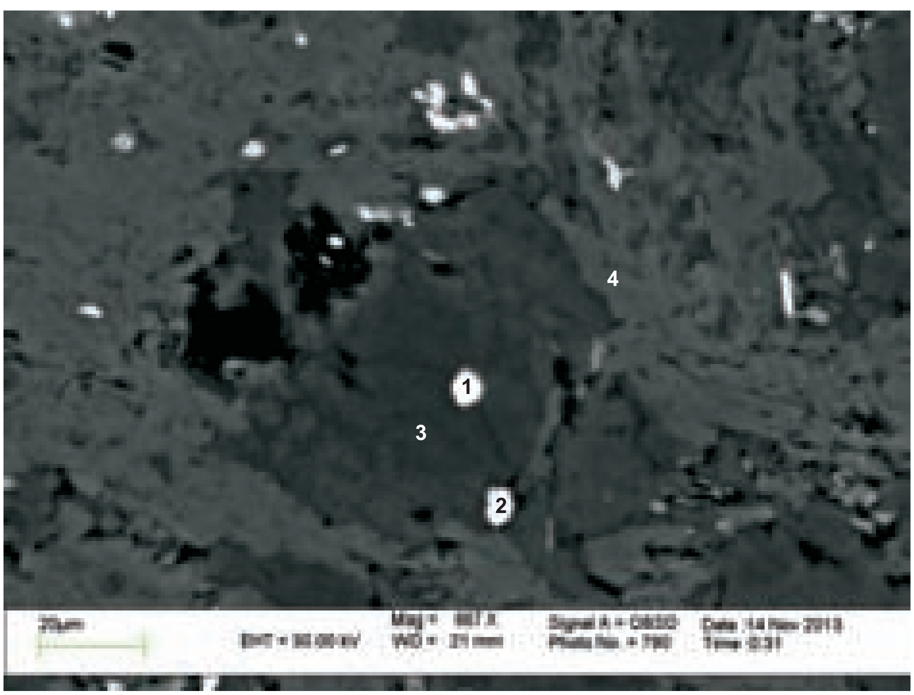
1:Zircon
2:Ilmenite

Figure 2-5.65: Sample 9877 site 88; zircon and ilmenite, probably filling pores.



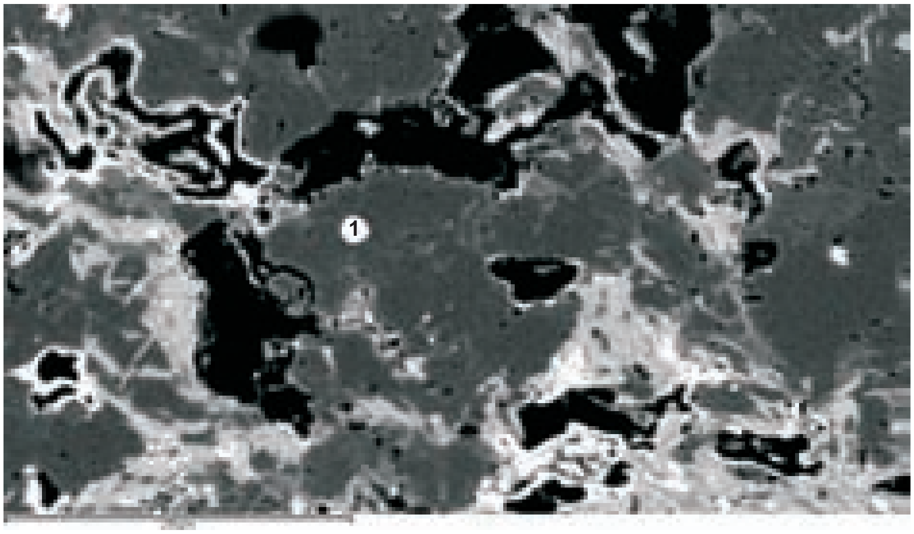
1:Zircon

Figure 2-5.66: Sample 9877 site 89



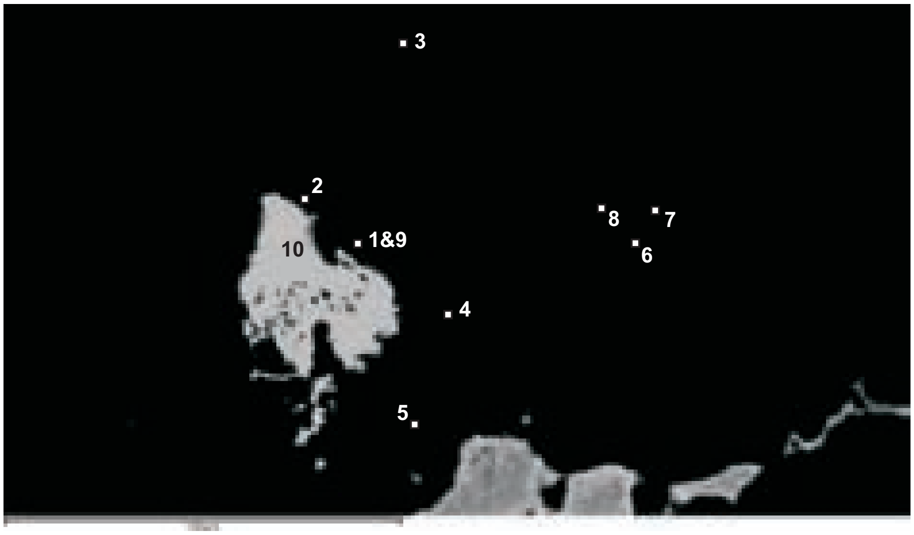
1:Monazite(+albite)
2:Ilmenite
3:Albite
4:Muscovite

Figure 2-5.67: Sample 9877 site 91; Horton Group. Monazite-Ce (analysis 1) and ilmenite fill porosity in detrital albite grain.



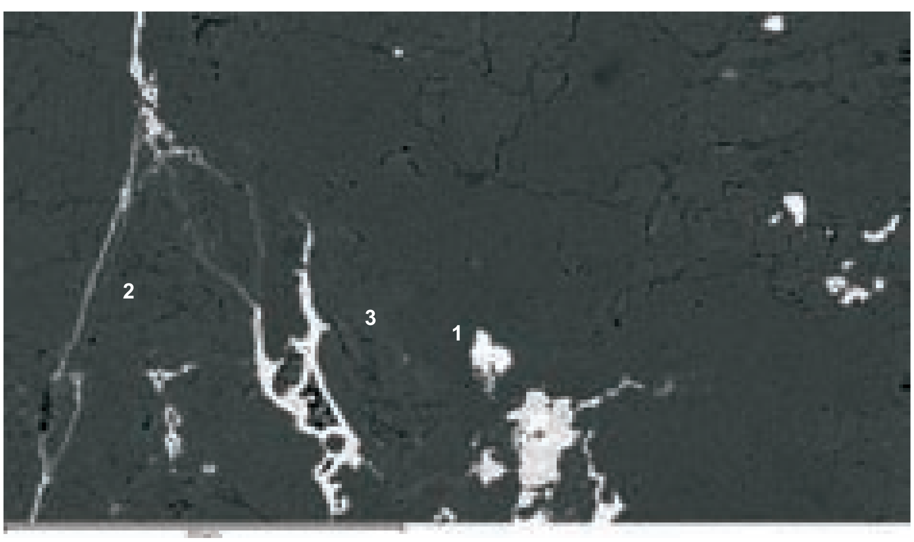
1:Chalcopyrite

Figure 2-5.68: Sample 9877 site 92



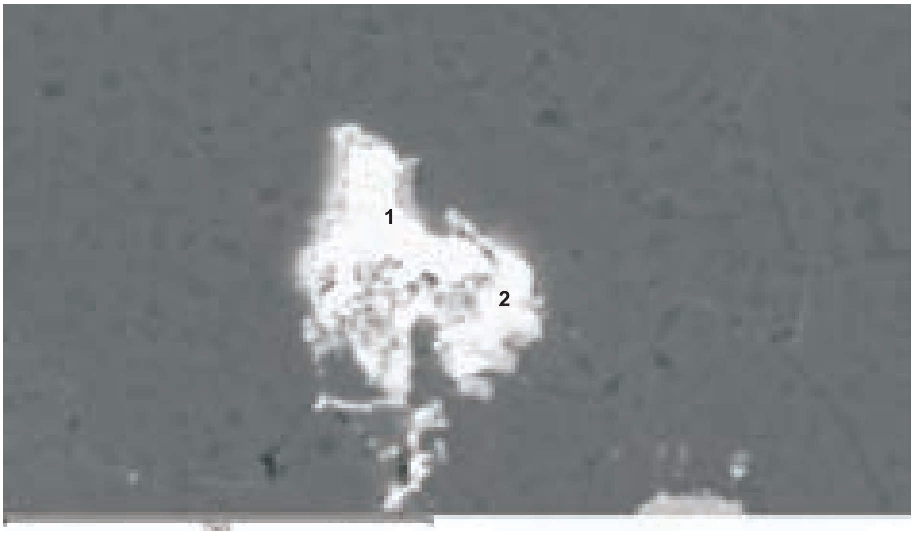
1:Zircon
2:Zircon
3:Pyrite
4:Pyrite
5:Pyrite
6:Zircon
7:Zircon
8:Fe-oxide(+Zrn & Ccp)
9:Zircon
10:Aeschynite-euxenite

Figure 2-5.69: Sample 9877 site 93



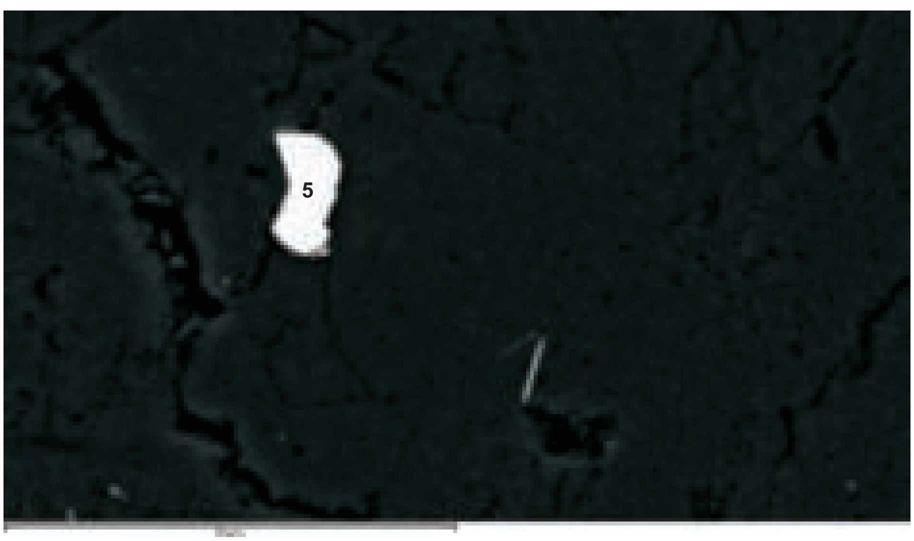
1:Quartz
2:Albite
3:Albite

Figure 2-5.70: Sample 9877 site 94



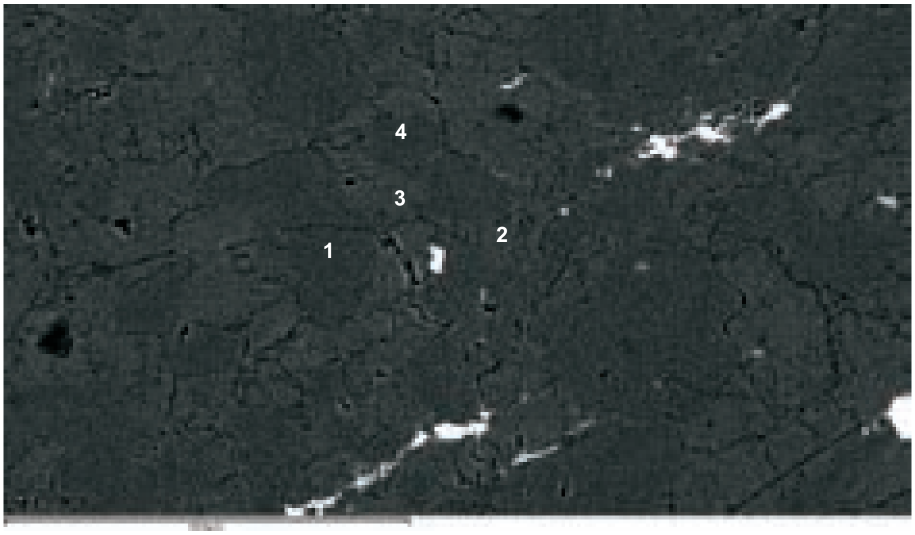
1:Samarskite-Y
2:Pyrochlore
3:Mix

Figure 2-5.71: Sample 9877 site 95; pyrochlore (analysis 2) partly replaced by samarskite-Y (analysis 1).



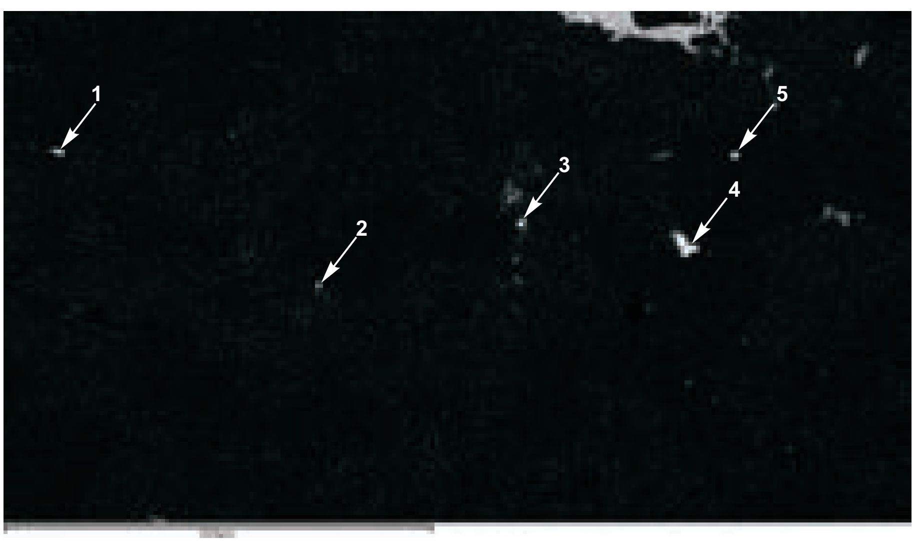
5:Pyrochlore

Figure 2-5.72: Sample 9877 site 96; pyrochlore grain (analysis 5) probably filling dissolution void.



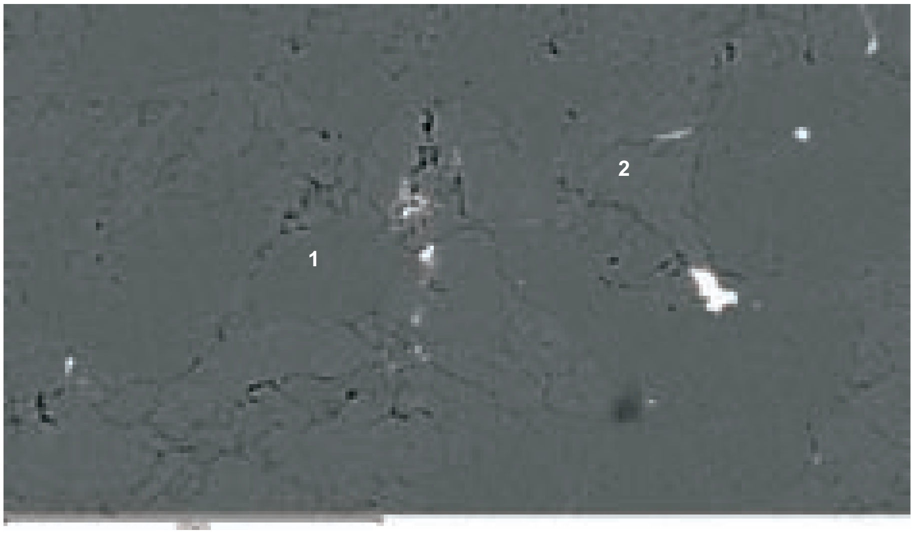
1:Quartz
2:Albite
3:Albite
4:Quartz

Figure 2-5.73: Sample 9877 site 97.



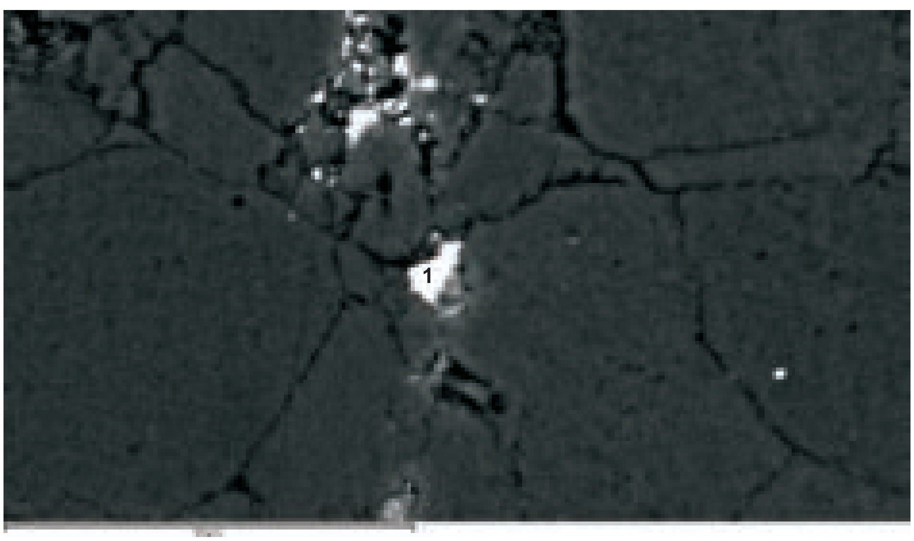
1:Zircon
2:Xenotime
3:Pyrochlore
4:Pyrochlore
5:Thorite

Figure 2-5.74: Sample 9877 site 99



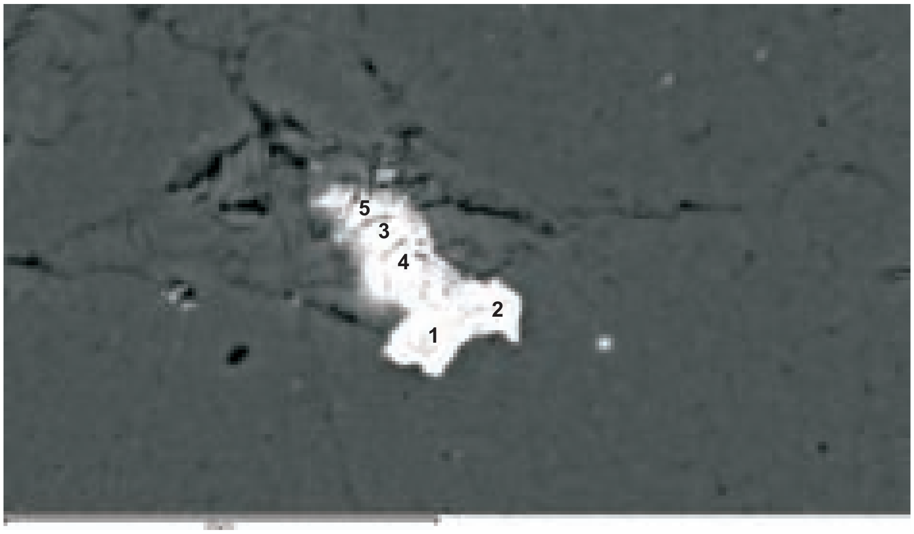
1:Quartz
2:Albite

Figure 2-5.75: Sample 9877 site 100.



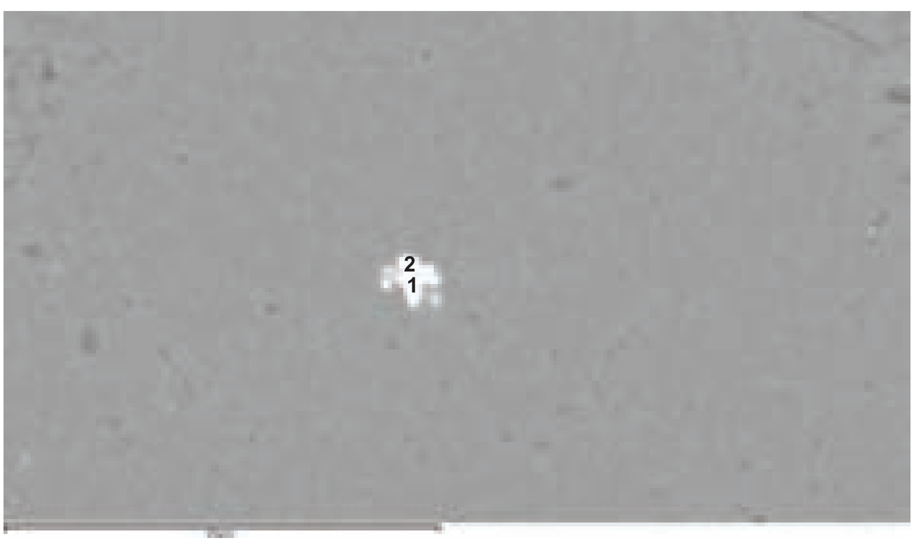
1:Mix(Aeschynite-euxenite
+others)

Figure 2-5.76: Sample 9877 site 101; aeschynite-euxenite (analysis 1) filling porosity.



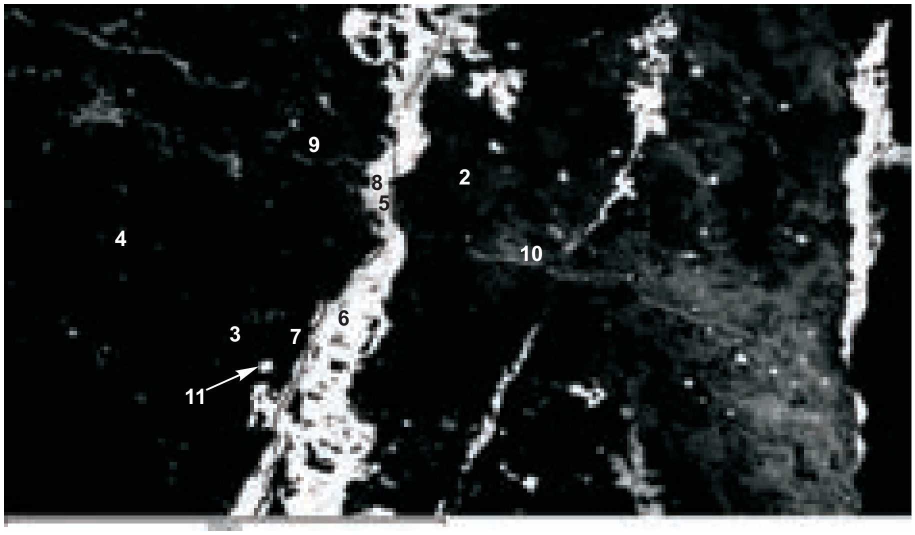
1:Mix(Ilmenite+others)
2:Ilmenite
3:Pyrochlore
4:Aeschynite-euxenite
5:Aeschynite-euxenite

Figure 2-5.77: Sample 9877 site 102; ilmenite, probably attacked by REE-bearing fluids, is partially converted to pyrochlore (analysis 3) and aeschynite-euxenite (analysis 4&5). All minerals have about the same TiO_2 composition, suggesting that Ti was relatively immobile.



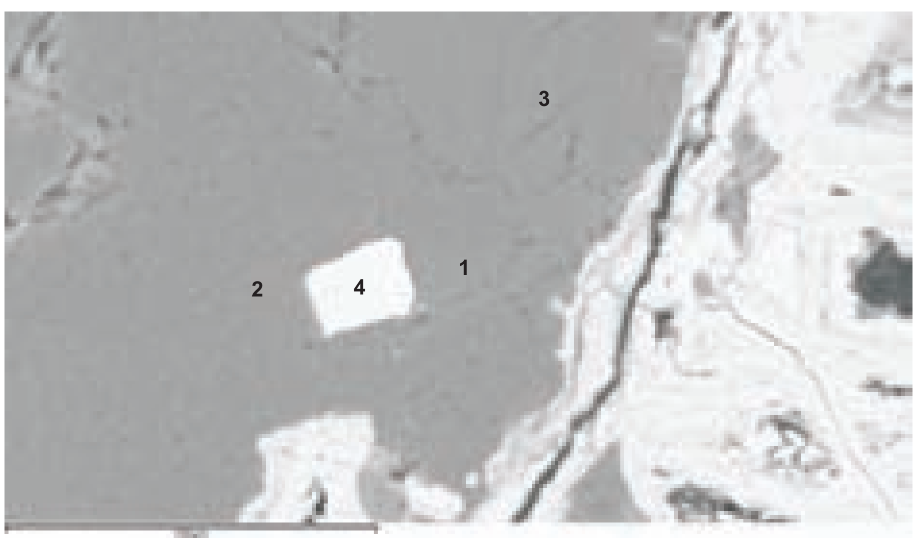
1:Thorite-xenotime(+Qz)
2:Thorite-xenotime(+Qz)

Figure 2-5.78: Sample 9877 site 103.



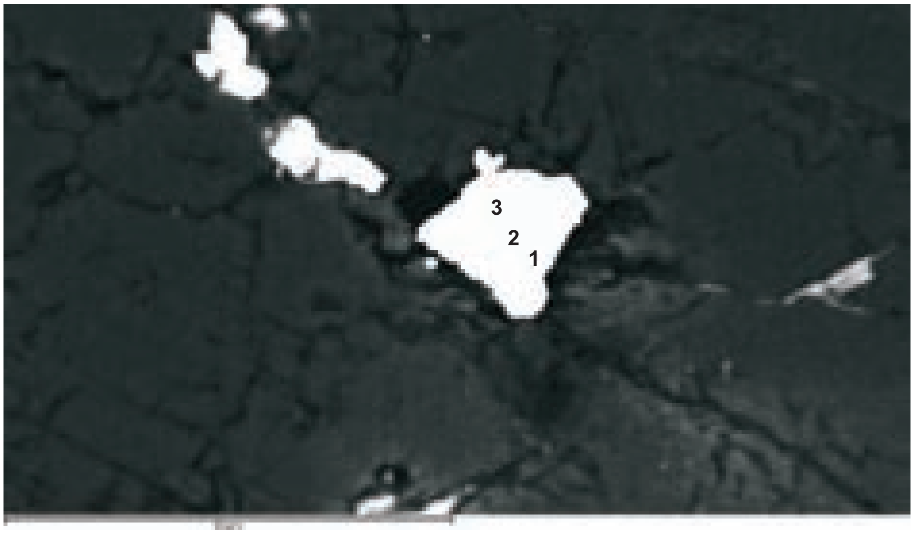
1:Zircon
2:Zircon
3:Quartz
4:Zircon(+others)
5:Zircon
6:Ilmenite
7:Bad analysis
8:Zircon
9:Pyrite
10:Pyrite
11:Samarskite-Y

Figure 2-5.79: Sample 9877 site 104.



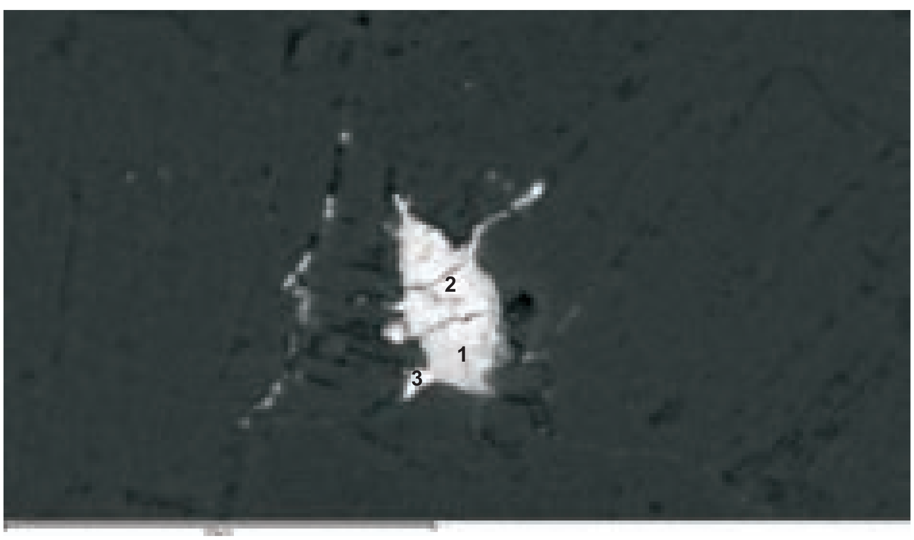
1:Quartz
2:Quartz
3:Albite
4:Nb-rich phase

Figure 2-5.80: Sample 9877 site 105.



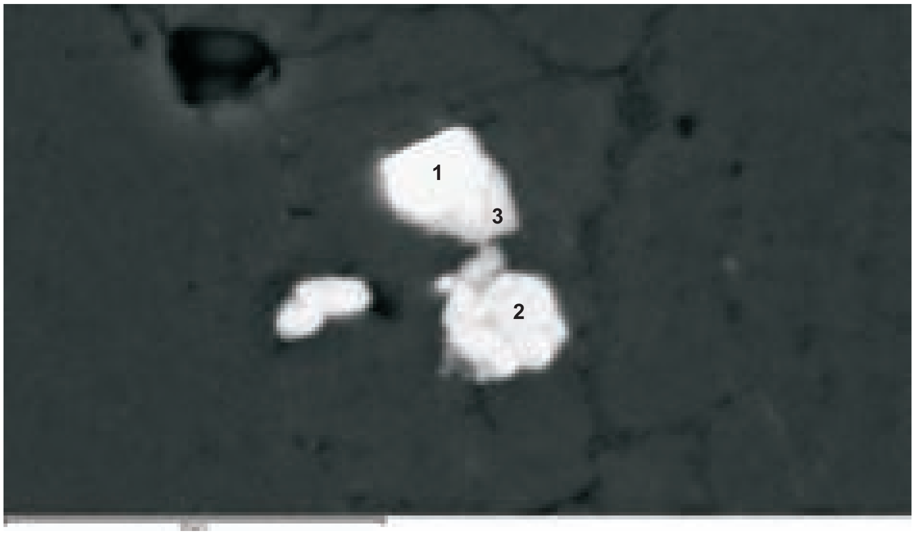
1:Aeschynite-euxenite
2:Pyrochlore
3:Pyrochlore

Figure 2-5.81: Sample 9877 site 107.



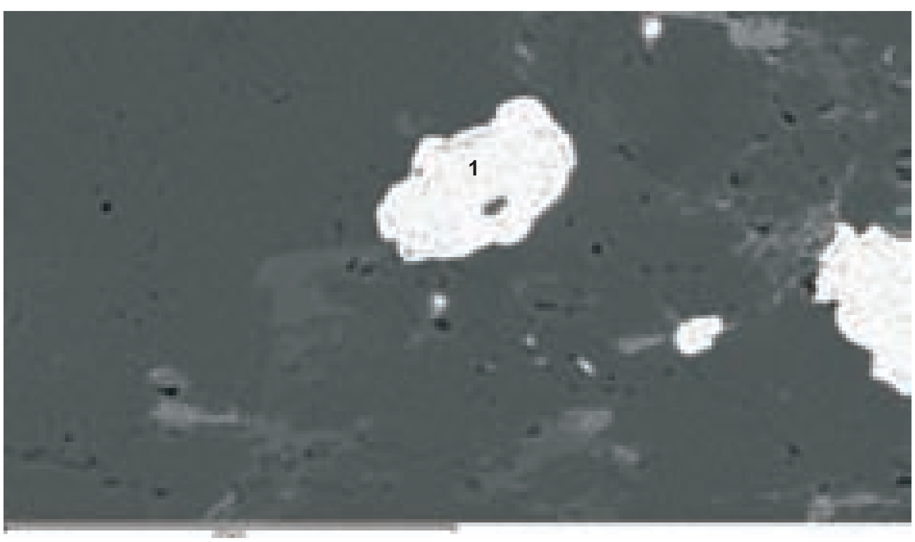
1:Pyrochlore
2:Pyrochlore
3:Samarskite-Y

Figure 2-5.82: Sample 9877 site 109.



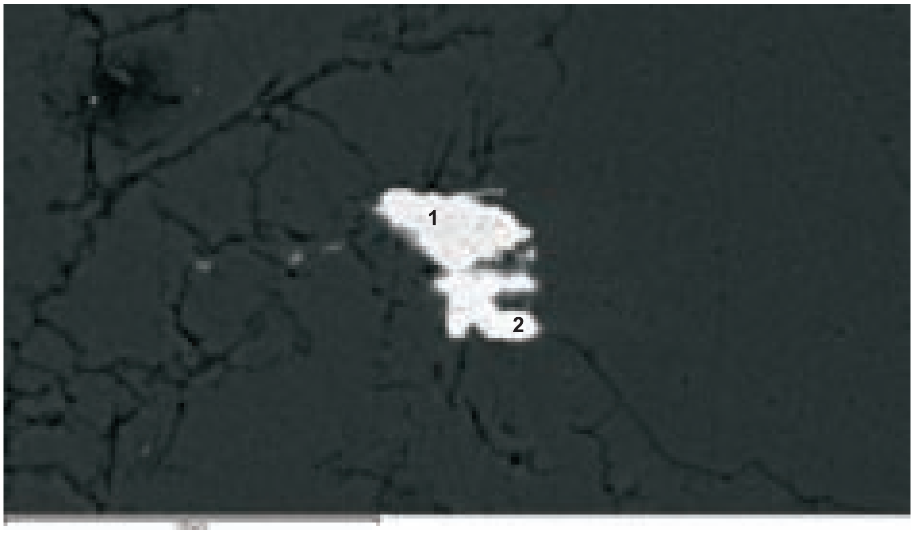
1:Aeschynite-euxenite
2:Zircon
3:Pyrochlore?

Figure 2-5.83: Sample 9877 site 111.



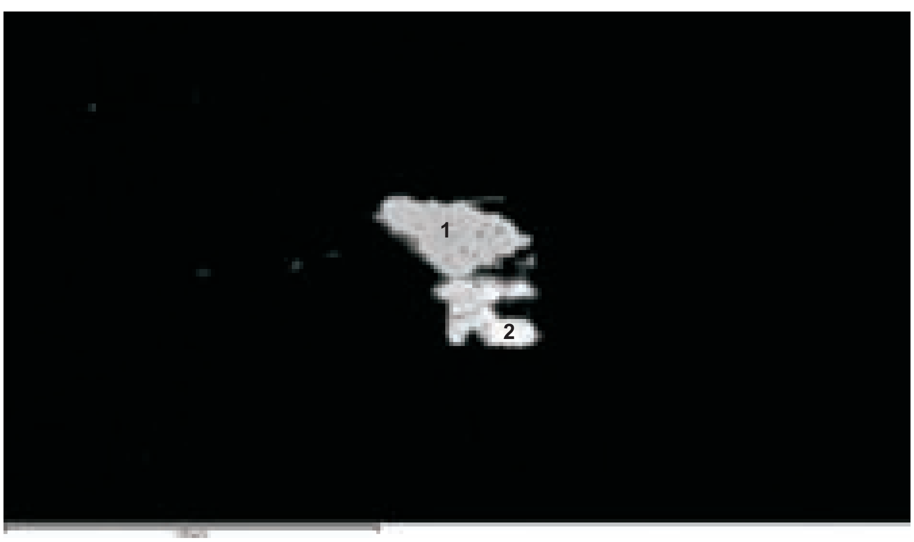
1:Chalcopyrite

Figure 2-5.84: Sample 9877 site 112.



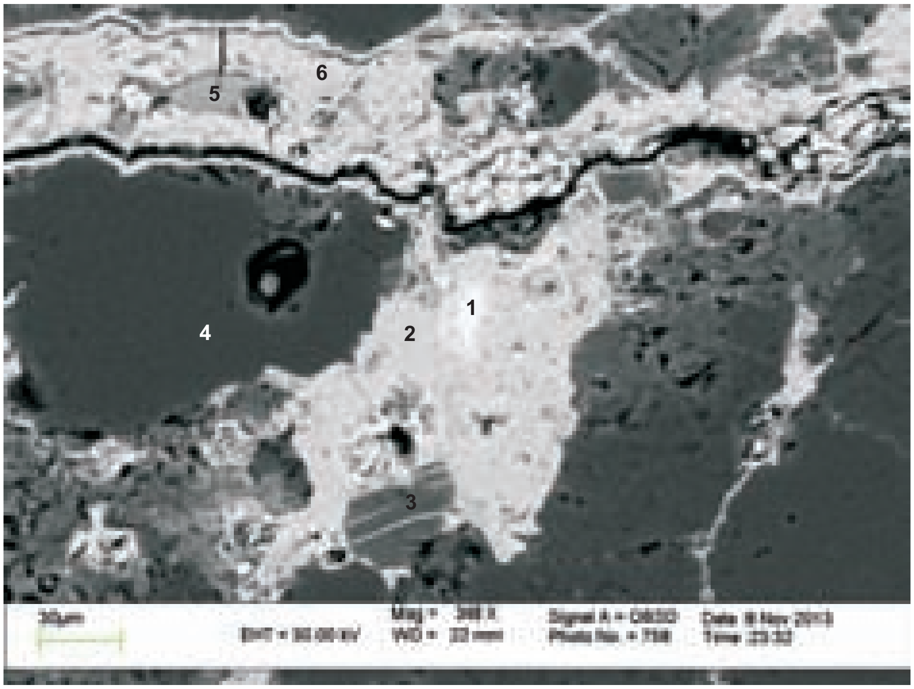
1:Zircon
2:Samarskite-Y

Figure 2-5.84a: Sample 9877 site 116; zircon and samarskite-Y filling porosity.



1:Zircon
2:Samarskite-Y

Figure 2-5.84b: Sample 9877 site 116; darker BSE image of figure 84a. Zircon and samarskite-Y filling porosity.



1:Pyrite
2:Mix(Fe-oxide+Py+Ccp+Chl+Qz)
3:K-feldspar(+others)
4:Quartz
5:Mix(Fe-oxide+Py+Ccp+Chl+Al-P)
6:Mix(Fe-oxide+Ccp+Cu+Chl+Al-P)

Figure 2-5.85: Sample 9877 site 40; granite. Pyrite inclusion or relic (analysis 1) in Fe-oxide mixture (analysis 2).

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	1	1	Quartz	99.99																																									99.99	132.61
9877	1	2	Quartz	99.99																																									99.99	121.74
9877	1	3	Quartz	99.77			0.23																																						100.00	126.06
9877	1	4	Quartz	99.41			0.58																																						99.99	131.86
9877	1	5	Mix(Fe-oxide+Py +Ccp+Chl+Al)	4.98		9.39	74.22							10.49								0.90																							99.98	85.41
9877	1	6	Mix(Fe-oxide+Py +Ccp+Chl+Al)	7.02		9.83	71.54							10.66								0.95																							100.00	85.05
9877	1	7	Mix(Fe-oxide+ Ccp+Cu+Chl)	9.46		5.10	79.66							3.60								2.17																							99.99	88.59
9877	2	1	Xenotime*				1.22						17.55												17.96										1.71	1.61	1.94		0.20					57.82	100.01	269.27
9877	2	2	Quartz	99.45			0.54																																						99.99	138.28
9877	2	3	Mix (Fe-oxide+Ccp+Cu+Chl)	7.51		4.88	80.24							4.37								3.00																							100.00	90.52
9877	2	4	Mix(Fe-oxide+Ccp+Chl+Al)	7.12		10.34	76.25							4.37								1.93																							100.01	86.25
9877	2	5	Chlorite	22.49		17.48	32.44		11.31					0.78								0.50																							85.00	118.17
9877	2	6	Mix(Fe-oxide+Py +Ccp+Chl+Al)	8.19		11.11	74.38							5.17								1.15																							100.00	85.45
9877	3	1	Y-phase	33.07			27.56			1.93				1.17											29.62											3.13	3.50								99.98	89.79
9877	3	2	Y-phase	26.63		2.63	35.91			1.65				1.97								0.85			24.83											2.56	2.98								100.01	93.74
9877	4	1	Xenotime*				3.68						17.05												18.30									0.56		1.70	1.38							57.37	100.04	259.21
9877	5	1	Zircon	32.73		2.53	4.76				1.33															56.49												2.16							100.00	141.49
9877	5	2	Aeschynite-euxenite	8.17	28.84	3.40	24.25			0.64					5.15							0.73			1.91	1.97	17.61															7.32			99.99	106.77
9877	5	3	Mix(Fe-oxide+Ccp+Cu +Chl+Qz)	9.26		4.84	78.36							4.69								2.83																							99.98	95.23
9877	6	1	Aeschynite-euxenite	8.66	38.12	3.72	22.17			0.71												0.55			2.31		19.63		1.66														2.48		100.01	105.79
9877	6	2	Albite	67.58		19.20	1.11			0.92	11.19																																		100.00	146.24
9877	6	3	Aeschynite-euxenite	12.07	31.41	4.72	23.21			0.81	0.86											0.75			2.91		18.10															3.45	1.71		100.00	107.11
9877	6	4	Mix(Fe-oxide+Ccp+Cu+Chl+Qz)	11.32		1.70	82.97				1.09			0.95								1.97																							100.00	76.21
9877	6	5	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	10.18		5.12	76.94							4.74								3.00																							99.98	98.74
9877	7	1	Zircon	31.40	0.27	1.49	5.21				0.88														1.60	57.46												1.67							99.98	142.28
9877	7	2	Xenotime*	2.76			0.51				0.51		11.87												12.65									0.59	1.64	1.20	1.06							67.26	100.05	388.58
9877	9	1	Albite	68.24		19.76				0.45	11.55																																		100.00	135.37
9877	9	2	Quartz	99.99																																									99.99	136.22
9877	9	3	Albite	69.14		19.37				0.45	11.06																																		100.02	136.75
9877	9	4	Quartz	99.99																																									99.99	139.54
9877	9	5	Quartz	99.99																																									99.99	150.58
9877	9	6	Quartz	99.99																																									99.99	130.00
9877	10	1	Mix(Fe-oxide+Ccp+Chl+Al)	6.01		9.45	78.68							4.02								1.84																							100.00	123.00
9877	10	2	Mix(Fe-oxide+Ccp+Cu+Chl)	7.74		5.42	79.66							4.22								2.94																							99.98	132.73
9877	10	3	Mix(Fe-oxide+Ccp+Cu+Chl)	9.48		7.24	76.31							4.37								2.62																							100.02	135.47
9877	10	4	Mix(Fe-oxide+Ccp+Cu+Chl)	6.31		3.80	83.67							3.47								2.72																							99.97	129.87
9877	10	5	Mix(Fe-oxide+Ccp+Cu+Chl)	7.57		5.39	80.01							4.25								2.80																							100.02	132.51
9877	10	6	Mix(Fe-oxide+Ccp+Cu+Chl)	2.74		1.55	92.54							0.85								2.33																							100.01	98.68
9877	10	7	Mix(Fe-oxide+Ccp+Cu+Chl)	7.40		5.73	79.62							4.59								2.65																							99.99	130.06
9877	10	8	Mix(Fe-oxide+Py+Ccp +Chl+Al)	8.69		11.34	73.47							5.19								1.33																							100.02	126.91
9877	11	1	Xenotime	5.07			1.39						47.85												32.70				1.57					1.69	4.13	2.98	2.62								100.00	195.24
9877	11	2	Mix(Fe-oxide+Ccp+Cu +Chl+Al)	10.01		9.94	73.83							3.30								2.90																							99.98	137.75
9877	12	1	Mix(Fe-oxide+Ccp+Cu +Chl+Al)	9.37		8.58	76.03							2.87								3.17																							100.02	134.01
9877	12	2	Xenotime*	1.48			0.41						17.00												19.60									1.01	2.39	1.73	1.59					0.83		53.99	100.03	358.04

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	13	1	Xenotime*	3.29			3.59						17.53												18.49									0.47		1.64	1.49							53.53	100.03	339.31
9877	13	2	Quartz	99.39			0.62																																						100.01	201.63
9877	13	3	Mix(Fe-oxide+Ccp+Cu +Chl+Qz)	8.86		4.12	81.81				0.82			1.55								2.87																							100.03	117.28
9877	13	4	Mix(Fe-oxide+Ccp+Cu+Chl)	8.47		4.97	79.21							4.54								2.80																							99.99	132.51
9877	14	1	Qz(+Fe-oxide)	87.60			12.40																																						100.00	220.60
9877	14	2	Quartz	99.99																																									99.99	203.67
9877	14	3	Quartz	99.60			0.39																																						99.99	200.69
9877	14	4	Quartz	99.54			0.46																																						100.00	201.76
9877	14	5	K-feldspar	69.35		18.97					11.69																																		100.01	193.43
9877	14	6	Quartz	99.67			0.33																																						100.00	199.13
9877	14	7	Albite	68.90		19.12	0.33			0.32	11.32																																		99.99	201.35
9877	14	8	Albite	69.12		19.14					11.73																																		99.99	199.06
9877	15	1	Xenotime*				1.29						18.58												20.46									0.51		1.88	1.81							55.50	100.03	334.84
9877	15	2	Mix(Fe-oxide+Ccp+Cu+Chl)	8.26		6.63	76.85							4.89								3.37																							100.00	137.78
9877	16	1	Albite	69.05		18.91	0.37			0.34	11.32																																		99.99	198.67
9877	16	2	Albite	68.52		19.25	0.35			0.55	11.32																																		99.99	199.90
9877	16	3	Xenotime*										18.33												19.66				0.41					0.95	2.05	1.73	1.86							55.05	100.04	361.11
9877	16	4	Xenotime*				0.62						17.51												18.70									0.81	2.46	1.70	1.70							56.56	100.06	374.66
9877	16	5	Quartz	99.99																																									99.99	198.00
9877	16	6	Albite	68.92		18.88				0.39	11.81																																		100.00	198.24
9877	16	7	Quartz	99.99																																									99.99	201.08
9877	16	8	Albite	68.78		19.10	0.64				11.49																																		100.01	197.65
9877	16	9	Albite	68.95		18.52	0.75			0.69	11.11																																		100.02	196.42
9877	16	10	Albite	68.50		19.14	0.39			0.48	11.49																																		100.00	200.63
9877	16	11	Albite (+chlorite)	66.64		19.42	1.94			0.99	10.45	0.43				0.12																													99.99	179.88
9877	16	12	Albite	68.71		18.93	0.54			0.36	11.45																																		99.99	190.46
9877	16	13	Chlorite	32.95		19.85	25.12		5.83			0.35										0.88																							85.00	163.20
9877	17	1	Xenotime*				1.76						18.19												19.33												1.73		0.40					58.62	100.03	366.10
9877	17	2	K-feldpsar	65.97		17.72	0.54					15.77																																	100.00	198.48
9877	17	3	Albite	65.20		18.48	4.36			0.39	11.45	0.12																																	100.00	208.67
9877	17	4	Albite	68.84		19.01	0.33			0.34	11.47																																		99.99	200.44
9877	17	5	Mix(Fe-oxide+Ccp+Cu+ Chl+Qz)	11.72		4.55	80.60							2.07								1.08																							100.02	137.49
9877	18	1	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	11.36		4.57	80.74							2.10								1.24																							100.01	140.25
9877	18	2	Mix(Fe-oxide+Py +Ccp+Chl+Al)	6.20		7.52	76.66							8.24								1.40																							100.02	136.38
9877	18	3	Mix(Fe-oxide+Ccp+Cu+ Chl+Qz)	8.98		4.65	81.01							2.95		0.21						2.20																							100.00	130.35
9877	19	1	Xenotime*				1.52						19.39												18.68									0.96	2.44	1.76	1.41		0.20					53.66	100.02	228.51
9877	19	2	Mix(Fe-oxide+Ccp+Cu+Chl)	7.02		4.91	81.63							4.15								2.32																							100.03	81.59
9877	19	3	Epidote	40.41		24.28	10.68			24.40								0.23																											100.00	115.33
9877	20	1	Quartz	99.99																																									99.99	132.07
9877	20	2	Albite	69.14		19.14				0.39	11.32																																		99.99	129.53
9877	20	3	Biotite	40.79	1.35	15.80	20.38		10.74			8.66				1.66						0.59																							99.97	120.68
9877	20	4	Albite	67.47		20.26	1.14			0.81	10.31																																		99.99	124.23
9877	20	5	Albite	63.68		18.40	5.70			0.46	11.58	0.18																																	100.00	146.34
9877	20	6	Albite	65.46		20.16	3.00			1.34	10.04																																		100.00	131.00
9877	20	7	Muscovite	54.38	0.43	30.82	2.52		1.53			10.32																																	100.00	127.27
9877	20	8	Quartz	93.16		0.49	6.34																																						99.99	140.60

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl
9877	20	9	Quartz	99.19			0.81									
9877	21	1	Epidote	40.60		24.04	10.30	0.17		24.67						
9877	22	1	Mix(Fe-oxide+Ccp+ Chl+Al-P)	5.65		6.46	78.64						0.82	5.87		
9877	22	2	Mix(Fe-oxide+Ccp+Cu+Chl)	6.80		5.16	79.45							5.42		
9877	22	3	Albite	67.43		19.14	0.77			0.55	10.84				1.26	
9877	22	4	Mix (Chlorite + TiO2)	28.13	3.52	17.78	42.93		3.78			0.37	0.94	1.02		
9877	23	1	Chlorite + TiO2(?)	30.95	1.47	18.90	39.73		5.24			0.73	0.60	1.00		
9877	24	1	Ti-magnetite	1.58	7.07	5.14	84.15	0.23	0.91							
9877	25	1	Mix(Fe-oxide+Py+Ccp Chl+Al-P)	5.43		5.78	72.33					0.64	8.11	6.19		
9877	25	2	Mix(Fe-oxide+Py +Ccp+Chl+Al-P)	5.22		6.16	68.63						9.49	9.51		
9877	25	3	K-feldspar	66.17		17.95	0.49					15.39				
9877	25	4	Muscovite	51.40	0.35	33.63	1.84		1.39		0.39	10.99				
9877	25	5	Chlorite	31.76		19.75	23.46		8.85			1.16				
9877	25	6	Muscovite	51.58	0.37	34.24	1.78		1.38			10.67				
9877	26	1	Ilmenite(+others)	1.33	64.57	0.93	31.81	1.12				0.25				
9877	26	2	Chlorite /Muscovite(+Ccp)	27.75		17.97	37.51		1.28			2.65	0.87	7.89		0.92
9877	26	3	Muscovite	51.62	0.22	34.07	1.54		1.23		0.39	10.93				
9877	27	1	Ilmenite	5.50	52.83	1.19	38.12	1.87				0.51				
9877	27	2	Biotite	40.52	1.25	16.70	19.31		11.44			9.21				1.56
9877	27	3	Ilmenite(+others)	19.64	41.85	4.95	29.64	1.95	0.73			1.25				
9877	27	4	K-feldspar	66.51		17.10	1.22					14.78		0.37		
9877	27	5	Quartz	99.99												
9877	28	1	Molybdenite	10.63	1.07	6.97	5.60		1.66			1.30		37.98		
9877	28	2	Ilmenite	1.28	52.99	0.60	43.35	1.77								
9877	28	3	Ilmenite	1.01	53.48	0.53	43.35	1.63								
9877	28	4	Bioite/Chlorite	42.81	0.87	20.46	23.88		8.29			2.81				0.57
9877	29	1	Chalcopyrite	0.34			21.79							55.29		
9877	29	2	Pyrite				26.21							69.47	4.32	
9877	29	3	Mix(Fe-oxide+Py +Chl+Al-P)	12.15		6.80	76.83						2.73	1.50		
9877	29	4	Chalcopyrite	6.72		2.31	18.58							51.79		
9877	29	5	Pyrite				27.35							72.66		
9877	30	1	Biotite	39.90	1.47	14.81	21.47		11.46			9.19				1.72
9877	30	2	Pyrite	1.07	0.27	0.91	38.25					0.14	0.34	58.66		
9877	30	3	TiO_2	0.94	97.20		1.29					0.57				
9877	30	4	Mix(Fe-oxide+Py+Ccp +Chl+Qz+Al-P+Ti)	9.39	0.52	3.25	79.52						2.68	3.80		
9877	30	5	Pyrite				27.57							72.44		
9877	31	1	Xenotime*				0.37						17.48			
9877	31	2	Pyrite	0.19			27.63							72.19		
9877	31	3	Xenotime				1.48						44.22	1.27	1.88	
9877	32	1	Xenotime				1.51			0.28			44.55			
9877	32	2	Pyrite				27.17							72.84		
9877	35	1	Chalcopyrite				22.04							54.89		
9877	35	2	Chalcopyrite	1.88			23.27							51.09		
9877	35	3	K-feldpar	65.29		17.69	1.03					14.98		1.02		
9877	35	4	Chalcopyrite	5.60			21.63							50.54		
9877	35	5	Chalcopyrite	4.68			22.63							51.19		

Sample	Site	Pos.	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	20	9																													100.00	136.91
9877	21	1		0.23																											100.01	120.88
9877	22	1						2.55																							99.99	86.65
9877	22	2						3.17																							100.00	89.00
9877	22	3																													99.99	128.13
9877	22	4						1.53																							100.00	99.47
9877	23	1						1.40																							100.02	105.35
9877	24	1		0.89																											99.97	111.13
9877	25	1						1.50																							99.98	43.85
9877	25	2						1.00																							100.01	44.70
9877	25	3																													100.00	67.43
9877	25	4																													99.99	63.40
9877	25	5																													85.00	62.40
9877	25	6																													100.02	66.81
9877	26	1																													100.01	60.13
9877	26	2						3.18																							100.02	47.19
9877	26	3																													100.00	66.88
9877	27	1																													100.02	60.13
9877	27	2																													99.99	47.19
9877	27	3																													100.01	66.88
9877	27	4																													99.98	111.71
9877	27	5																													99.99	63.42
9877	28	1												34.81																	100.02	63.07
9877	28	2																													99.99	64.50
9877	28	3																													100.00	118.79
9877	28	4						0.31																							100.00	143.62
9877	29	1						22.58																							100.00	50.08
9877	29	2																													100.00	99.56
9877	29	3																													100.01	140.75
9877	29	4						20.59																							99.99	69.91
9877	29	5																													100.01	94.74
9877	30	1																													100.02	63.14
9877	30	2						0.36																							100.00	51.21
9877	30	3																													100.00	143.18
9877	30	4						0.88																							100.04	148.30
9877	30	5																													100.01	135.80
9877	31	1									18.07									0.62	1.95	1.70	1.74		0.21					57.85	99.99	64.09
9877	31	2																													100.01	61.11
9877	31	3									37.99									1.67	4.27	3.78	3.43								99.99	147.20
9877	32	1									38.94									1.98	5.00	3.72	4.02								100.00	117.42
9877	32	2																													100.01	119.64
9877	35	1						23.08																							100.01	73.69
9877	35	2						23.76																							100.00	93.54
9877	35	3																													100.01	83.40
9877	35	4						22.23																							100.00	50.05
9877	35	5						21.51																							100.01	76.06

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	35	6	Mix(Fe-oxide+Py+ Chl+Al-P+Qz)	16.66		7.31	70.07						2.27	3.70																															100.01	48.29
9877	35	7	Albite	68.80		19.37				0.35	11.50																																		100.02	57.02
9877	35	8	Mix(Fe-oxide+Py +Ccp+Chl+Qz+Al-P)	7.66		3.51	80.96						1.58	5.22								1.05																							99.98	67.11
9877	37	1	Quartz	99.99																																									99.99	78.69
9877	37	2	Albite	68.58		19.12	0.35			0.41	11.55																																		100.01	80.82
9877	37	3	Quartz	99.47			0.26									0.27																													100.00	49.28
9877	37	4	Quartz	99.99																																									99.99	54.17
9877	37	5	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	9.11		4.91	78.45							4.52								3.02																							100.01	56.77
9877	37	6	Chlorite	31.67		17.31	30.05		4.22			0.90										0.83																							85.00	65.49
9877	39	1	Mix(Fe-oxide+Py +Ccp+Chl+Al)	7.02		10.30	70.36							11.34								0.98																							100.00	68.92
9877	39	2	Mix(Fe-oxide+ Ccp+Cu+Chl)	8.77		7.18	76.87							4.02				0.46				2.69																							99.99	62.50
9877	39	3	Muscovite	50.74		35.37	2.17		0.78		0.57	10.38																																	100.01	81.05
9877	39	4	Chlorite	35.55	0.44	20.89	18.50		6.87			1.62				0.47						0.66																							85.00	138.04
9877	39	5	Albite	79.00		12.38	0.40			0.63	7.58																																		99.99	49.81
9877	40	1	Pyrite				27.84							72.17																															100.01	68.57
9877	40	2	Mix(Fe-oxide+Py+Ccp +Chl+Qz)	13.03		6.39	78.01							1.87								0.73																							100.03	74.15
9877	40	3	K-feldspar (+others)?	50.49	0.20	33.20	4.18		1.44			10.49																																	100.00	45.03
9877	40	4	Quartz	99.19		0.38	0.30					0.13																																	100.00	49.88
9877	40	5	Mix(Fe-oxide+Py+Ccp +Chl+Al-P)	8.83		8.86	72.43						1.37	7.82								0.69																							100.00	56.70
9877	40	6	Mix(Fe-oxide+Ccp+Cu+Chl+ Al-P)	8.75		5.10	78.18						3.19	2.80								2.00																							100.02	48.41
9877	41	1	Xenotime	3.23			14.42						38.13							1.36					38.29												4.57								100.00	73.98
9877	41	2	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	11.12		5.76	80.13							1.92								1.06																							99.99	76.46
9877	41	3	Albite	68.13		19.27	0.41			0.43	11.76																																		100.00	71.01
9877	43	1	Muscovite	50.55		35.20	3.24				0.67	10.35																																	100.01	61.43
9877	43	2	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	10.70		5.08	80.91							2.05								1.26																							100.00	56.92
9877	43	3	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	9.90		2.42	85.22	0.57						1.00					0.31			0.58																							100.00	50.80
9877	44	1	Zircon	28.09		5.40	19.17			0.34															3.51	41.96			1.55																100.02	76.97
9877	44	2	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	12.90		4.14	80.68							1.25								1.04																							100.01	64.77
9877	44	3	Albite	68.50		19.14	0.72			0.43	11.22																																		100.01	110.86
9877	45	1	Xenotime				1.90						48.12												38.13									1.50	4.75	3.33	2.27								100.00	137.12
9877	46	1	Chalcopyrite	0.39			22.18							54.14								23.30																							100.01	108.32
9877	46	2	Pyrite	0.21			27.31							72.49																															100.01	135.16
9877	46	3	Chalcopyrite				24.53							50.74								24.74																							100.01	49.54
9877	46	4	Pyrite	0.26			28.11							71.64																															100.01	107.20
9877	46	5	Mix(Fe-oxide+Ccp+Chl+Qz +Al-P)	13.58		5.61	71.70						4.38	3.22								1.53																							100.02	59.50
9877	46	6	Chalcopyrite	1.24			24.89							51.44								22.42																							99.99	70.31
9877	46	7	Mix(Fe-oxide+Ccp+Cu+Chl+ Qz+Al-P)	11.64		4.76	63.11						1.88	11.61								7.00																							100.00	65.21
9877	46	8	Biotite	38.81	0.40	18.20	23.71		10.30			7.19				1.07						0.33																							100.01	75.67
9877	46	9	Bioite/Chlorite	39.02	0.83	16.95	25.19		9.83			5.67	0.66	0.55		0.92						0.38																							100.00	69.40
9877	46	10	Albite	67.83		19.46	0.57			0.85	11.30																																		100.01	78.25

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	46	11	Chlorite/Biotite	41.14	0.43	18.59	23.61		9.45			4.87				1.07						0.85																							100.01	61.27
9877	46	12	Quartz	96.29			0.87						1.49												1.36																				100.01	109.72
9877	47	1	Xenotime				0.87						46.45							1.53		0.60			40.15									1.95	4.65		3.26		0.55						100.01	139.67
9877	47	2	Chalcopyrite	0.24		0.25	24.04							50.79								24.69																							100.01	118.97
9877	47	3	Pyrite	0.15			27.45							72.39																															99.99	68.83
9877	47	4	Pyrite	0.24			21.88							54.69								23.20																							100.01	71.42
9877	47	5	TiO_2	1.41	96.68	0.49	0.60			0.32												0.49																							99.99	70.52
9877	47	6	Muscovite (+others)	51.94	0.43	26.98	8.61		3.20			8.24				0.18						0.43																							100.01	120.10
9877	50	1	Chalcopyrite	0.49			22.53							53.06								23.91																							99.99	146.70
9877	50	2	Chalcopyrite	0.36			21.15							55.19								23.32																							100.02	80.35
9877	51	1	Pyrite	0.30			29.15							70.42								0.14																							100.01	84.86
9877	51	2	Quartz	99.99																																									99.99	76.24
9877	51	3	Quartz	99.99																																									99.99	86.14
9877	51	4	Muscovite	52.60		35.05	1.52					10.83																																	100.00	73.58
9877	51	5	Quartz	97.83		1.72						0.43																																	99.98	74.37
9877	51	6	Muscovite	51.85		33.37	2.87		1.64			10.26																																	99.99	114.61
9877	51	7	Muscovite	51.98	0.33	32.63	2.21		1.89		0.38	10.56																																	99.98	75.45
9877	53	1	Barite*	1.80		0.53								20.50																36.06														41.17	100.06	79.79
9877	53	2	Muscovite	51.15	0.47	34.92	0.96		1.01		0.77	10.72																																	100.00	80.75
9877	53	3	Quartz	99.99																																									99.99	83.49
9877	53	4	Quartz	99.99																																									99.99	69.28
9877	53	5	Quartz	99.99																																									99.99	144.28
9877	53	6	Muscovite /Chlorite	51.06	0.35	18.71	21.59		5.39			2.46										0.44																							100.00	75.19
9877	55	1	Barite*	0.53		0.45								17.43																31.98														49.60	99.99	76.82
9877	55	2	Barite	3.55		1.32	0.59							37.73																56.81															100.00	76.50
9877	55	3	Muscovite	51.58	0.62	34.88	1.08		1.19			10.65																																	100.00	79.25
9877	55	4	Muscovite	48.92	0.58	35.16	0.98		1.03		0.63	10.18			2.53																														100.01	84.49
9877	55	5	Quartz	97.74		1.59						0.66																																	99.99	57.16
9877	55	6	Albite	68.43		19.33				0.39	11.85																																		100.00	76.10
9877	56	1	Mix(Fe-oxide+Ccp+Chl+ Al-P)	9.56		8.60	69.91					0.48	6.51	3.32								1.60																							99.98	83.84
9877	56	2	Muscovite	52.50	0.53	32.50	2.46		1.48			10.54																																	100.01	175.66
9877	56	3	Quartz	99.99																																									99.99	67.97
9877	57	1	Barite*	0.41			0.39							14.86																24.31														60.07	100.04	50.24
9877	57	2	Barite	4.09		2.97	20.37						3.28	25.57																43.75															100.03	70.14
9877	59	1	Quartz	99.99																																									99.99	77.39
9877	59	2	Albite	69.29		18.74				0.36	11.61																																		100.00	79.06
9877	59	3	Albite	68.86		18.61	0.67			0.25	11.62																																		100.01	49.92
9877	59	4	Albite	68.88		19.37				0.45	11.31																																		100.01	48.72
9877	59	5	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	10.31		4.42	78.22							3.82								3.23																							100.00	61.68
9877	60	1	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	16.47		8.90	69.30							2.62								2.70																							99.99	54.88
9877	60	2	Chlorite?	41.65		23.41	26.72		3.53		1.81	1.96										0.91																							99.99	78.53
9877	60	3	Mix(Fe-oxide+Ccp+ Cu+Chl+Qz)	13.76		7.16	71.76				2.18			2.80								2.34																							100.00	48.63
9877	61	1	bad analysis	35.60			0.64																			61.04												2.72							100.00	48.51
9877	61	2	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	15.42		6.80	72.83							2.20								2.75																							100.00	50.27
9877	61	3	Mix(Fe-oxide+Ccp +Cu+Chl)	11.08		7.82	75.56							2.67								2.85																							99.98	38.27

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	61	4	Mix(Fe-oxide+Ccp +Cu+Chl)	8.64		5.86	79.39							3.50								2.62																							100.01	46.36
9877	61	5	Mix(Fe-oxide+Cu +Chl+Qz)	6.59		2.32	88.29															2.82																							100.02	78.33
9877	61	6	Mix(Fe-oxide+Ccp +Cu+Chl)	9.37		5.37	80.06							1.90								3.30																							100.00	51.07
9877	63	1	Zircon	31.85			0.57																			66.74												0.84							100.00	49.50
9877	63	2	Mix(Fe-oxide+Py +Ccp+Chl+Al-P)	5.71		9.41	70.16						2.38	11.29								1.03																							99.98	77.25
9877	63	3	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	6.95		3.38	82.85							4.05								2.77																							100.00	73.02
9877	63	4	Quartz	99.99																																									99.99	63.38
9877	63	5	Biotite	54.16	0.48	31.63	1.79		1.36			10.31							0.26																										99.99	66.95
9877	63	6	Ilmenite	1.09	52.43		44.98	1.50																																					100.00	66.64
9877	63	7	Ilmenite	1.07	61.92	0.45	34.90	1.65																																					99.99	70.45
9877	63	8	Ilmenite	2.31	55.83		40.41	1.45																																					100.00	43.94
9877	63	9	Ilmenite	6.14	48.27	2.44	41.51	1.39				0.25																																	100.00	47.63
9877	65	1	Ilmenite	1.13	49.52		47.48	1.61				0.24																																	99.98	36.25
9877	65	2	Mix(REE + others)	33.01		1.89	41.12						8.75	2.05								1.01							1.00		3.14	5.58	2.44												99.99	37.23
9877	65	3	Mix(Fe-oxide+Ccp +Cu+Qz)	11.59			85.49							1.77								1.14																							99.99	53.13
9877	66	1	Mix(Fe-oxide+Ccp +Chl+Qz)	5.31		1.66	88.51							3.10								1.44																							100.02	55.54
9877	67	1	Monazite? (+others)	20.73		2.29	38.66			0.35			14.46	1.82								1.15									5.52	9.38	3.32									2.32			100.00	55.27
9877	68	1	Muscovite	50.36	0.37	31.67	4.85		1.48		0.36	10.93																																	100.02	56.24
9877	68	2	Muscovite	52.50	0.35	31.52	3.69		1.21		0.42	10.30																																	99.99	43.35
9877	68	3	Muscovite	54.49	0.28	30.48	2.59		1.74		0.44	9.97																																	99.99	61.76
9877	69	1	Contamination (Cr and Ni)	7.57		1.27	77.81	0.63						0.75					7.64		3.93	0.41																							100.01	54.05
9877	69	2	Mix(Muscovite + others)	46.96	0.22	26.98	17.07		1.36			7.17										0.25																							100.01	39.21
9877	69	3	Muscovite	51.55		34.07	1.93		1.08		0.82	10.55																																	100.00	116.30
9877	69	4	Mix(Fe-oxide+Ccp+Cu+Chl +Al-P)	6.91		3.85	84.84						1.33	1.95								1.11																							99.99	84.53
9877	70	1	Pyrite				27.84							72.17																															100.01	125.89
9877	71	1	Barite	4.51		0.76	0.82							39.38																54.54															100.01	147.23
9877	71	2	Chalcopyrite	0.36		0.32	21.41							55.19								22.72																							100.00	73.14
9877	71	3	Pyrite				27.87							72.14																															100.01	52.53
9877	71	4	Muscovite	49.35	0.33	35.26	1.38		0.90		0.62	10.66			1.52																														100.02	13654.56
9877	71	5	Mix(Fe-oxide+Ccp +Chl+Al-P)	7.12		4.82	78.31						3.41	4.34								1.98																							99.98	73.35
9877	71	6	Bad analysis																									99.99																	99.99	75.47
9877	71	7	Biotite	39.15	0.23	19.61	21.25		9.77			8.20				1.02						0.76																							99.99	86.68
9877	71	8	Muscovite	49.33	0.23	34.60	1.36		1.16		0.63	10.30			2.40																														100.01	112.69
9877	73	1	Covellite				1.90							52.04								46.07																							100.01	78.16
9877	73	2	Pyrite				27.80							72.22																															100.02	70.82
9877	73	3	Quartz	96.76		0.62	0.66					0.43		1.55																															100.02	74.45
9877	73	4	Muscovite	51.79		33.41	1.74		1.63		0.67	10.78																																	100.02	77.33
9877	73	5	Albite	67.04		20.75				1.74	10.22	0.25																																	100.00	76.00
9877	74	1	Albite	65.72		20.10				1.55	10.26				2.38																														100.01	75.98
9877	74	2	Albite	66.87		20.46				1.26	10.58	0.83																																	100.00	79.26
9877	74	3	Quartz	99.99																																									99.99	76.63

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	74	4	Plagioclase	64.22		22.52				3.90	9.34																																		99.98	71.88
9877	74	5	Quartz	98.90		0.85				0.25																																			100.00	74.47
9877	75	1	Muscovite	52.00	0.40	32.97	1.98		1.66			10.99																																	100.00	78.16
9877	75	2	Albite	66.81		20.75				2.24	10.21																																		100.01	74.41
9877	75	3	Albite	66.12		19.73				1.57	10.12				2.47																														100.01	72.16
9877	75	4	Ilmenite	7.96	47.79	6.07	34.64	1.86			1.08	0.59																																	99.99	64.93
9877	76	1	Zircon	32.52																						65.57												1.91							100.00	62.82
9877	76	2	Ilmenite	9.37	51.59	1.13	35.60	1.81				0.51																																	100.01	66.34
9877	77	1	Ilmenite?		55.80		43.33	0.88																																					100.01	63.44
9877	77	2	TiO_2?		100.00																																								100.00	66.01
9877	77	3	Ilmenite	1.75	54.73	0.64	41.91	0.96																																					99.99	76.13
9877	77	4	TiO_2	1.39	98.62																																								100.01	140.51
9877	79	1	Molybdenite	4.04		1.74	0.66		0.41					48.77	1.71													42.68																	100.01	64.41
9877	79	2	Bioite	40.07	1.30	16.50	20.57		10.61			9.43				1.51																													99.99	67.73
9877	79	3	Ilmenite	1.86	55.76	0.94	40.06	1.38																																					100.00	75.70
9877	79	4	TiO_2	1.78	96.35	1.11	0.77																																						100.01	79.44
9877	80	1	Zircon	33.37	0.67	5.71	4.07		2.21			2.14				0.36	0.38									51.10																			100.01	77.73
9877	81	1	Monazite? (+others)	23.40		8.88				0.92	3.55		28.44																		8.66	18.39	7.76												100.00	80.79
9877	82	1	Albite	68.35		19.29				0.92	11.42																																		99.98	78.40
9877	82	2	Albite	65.37		21.64	0.31			2.60	9.59	0.49																																	100.00	98.34
9877	82	3	Monazite (+others)	22.93		8.94	0.39			0.91	3.63	0.28	26.12												1.57				1.13		8.21	18.05	7.86												100.02	76.34
9877	83	1	Barite (+quartz)	27.34		1.27	0.54							30.74																40.13															100.02	68.96
9877	83	2	Zircon	31.36																						68.63																			99.99	128.26
9877	83	3	Quartz	99.41												0.59																													100.00	46.98
9877	84	1	Pyrite				28.19							71.82																															100.01	122.39
9877	84	2	Mix(Fe-oxide+Py+Ccp +Chl+Al-P)	10.93		6.29	75.52						3.51	2.95								0.81																							100.01	92.23
9877	84	3	Pyrite				28.96							71.04																															100.00	73.77
9877	85	1	Zircon	31.94																						68.07																			100.01	62.83
9877	86	1	Zircon	31.79																						67.12												1.08							99.99	66.62
9877	87	1	Xenotime	3.57			0.77						45.14												36.88									1.51	4.33	3.88	3.92								100.00	74.60
9877	87	2	Muscovite	51.32	0.37	31.56	3.99		2.16			10.60																																	100.00	72.68
9877	88	1	Zircon	32.43																						66.36												1.19							99.98	53.16
9877	88	2	Ilmenite	7.68	53.19		37.89	1.24																																					100.00	128.56
9877	89	1	Zircon	34.40		2.29					1.71															61.61																			100.01	90.99
9877	91	1	Monazite (+albite)	21.78		8.33	0.35			0.53	5.78		25.02																		10.03	20.58	7.62												100.02	79.43
9877	91	2	Ilmenite	10.03	47.42	5.44	33.02	1.32		0.32	1.81	0.64																																	100.00	74.67
9877	91	3	Albite	69.12		19.10				0.27	11.50																																		99.99	139.09
9877	91	4	Muscovite	51.23	0.52	33.43	1.80		1.44		0.42	10.83							0.32																										99.99	49.39
9877	92	1	Chalcopyrite	1.07			21.57							53.69								23.67																							100.00	50.62
9877	93	1	Zircon	30.61			4.84																			64.54																			99.99	103.43
9877	93	2	Zircon	30.16			3.94																			65.92																			100.02	81.23
9877	93	3	Pyrite	1.09			31.70							67.22																															100.01	90.59
9877	93	4	Pyrite				33.58							66.42																															100.00	52.79
9877	93	5	Pyrite	1.69			34.04							64.27																															100.00	53.22
9877	93	6	Zircon	34.08																						65.92																			100.00	44.42

* If we consider B_2O_3 as an analytical artifact

Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	93	7	Zircon	31.66			3.55																			62.77												2.03							100.01	52.37
9877	93	8	Fe-oxide(+Zrn & Ccp)	29.03			50.13							2.77								3.22				14.83																			99.98	44.87
9877	93	9	Zircon	32.26			4.62																			63.12																			100.00	54.36
9877	93	10	Aeschynite-euxenite	4.39																2.10					23.81		58.75								3.25		7.71								100.01	48.80
9877	94	1	Quartz	99.99																																									99.99	54.25
9877	94	2	Albite	69.22		18.82				0.36	11.59																																		99.99	105.21
9877	94	3	Albite	69.29		19.07					11.28	0.35																																	99.99	42.02
9877	95	1	Samarskite-Y*	1.71	0.18															0.70					11.21		13.19								0.95		3.22						0.42	68.42	100.00	41.36
9877	95	2	Pyrochlore	18.48	1.83	4.38	6.20			0.42						0.36						0.71		0.75			61.00															5.87			100.00	47.07
9877	95	3	Mix(Fe-oxide+Ccp +Cu+Chl+Qz)	27.19	11.78	3.84	53.22							2.20								1.78																							100.01	46.91
9877	96	1	zircon(misplaced analysis?)	35.75		2.42	1.21				1.09															57.35												2.17							99.99	51.10
9877	96	2	zircon(misplaced analysis?)	33.69		1.63																				62.96												1.72							100.00	68.11
9877	96	3	Rutile(misplaced analysis?)	1.90	95.81	0.68	1.61																																						100.00	40.85
9877	96	4	zircon(misplaced analysis?)	36.07		2.48	1.40																			60.06																			100.01	50.08
9877	96	5	Pyrochlore	3.76	35.01																				20.98		31.00		3.16														6.09		100.00	52.57
9877	97	1	Quartz	99.99																																									99.99	50.90
9877	97	2	Albite	69.40		19.27				0.27	11.06																																		100.00	50.78
9877	97	3	Albite	69.03		19.16				0.43	11.37																																		99.99	41.20
9877	97	4	Quartz	99.99																																									99.99	43.27
9877	98	1	Pyrochlore	1.16	31.56		0.75																		17.44		23.68							1.80	3.56	2.57	5.16		3.13	5.45		3.76			100.02	46.69
9877	99	1	Zircon	54.72																						45.28																			100.00	32.54
9877	99	2	Xenotime	25.73		6.65	1.96				4.76		29.72							0.84					25.81										1.87		2.66								100.00	31.90
9877	99	3	Pyrochlore	20.49	14.66	7.26	9.96			1.89	3.44														7.81		29.88															4.60			99.99	48.74
9877	99	4	pyrochlore	12.19	28.76	3.08	4.10			1.51															7.70		21.82												2.38			10.03	8.44		100.01	50.34
9877	99	5	Thorite	63.92		1.61	3.85			0.97			2.91																			6.08										20.68			100.02	54.29
9877	100	1	Quartz	99.99																																									99.99	74.34
9877	100	2	Albite	68.52		19.14				0.29	12.05																																		100.00	44.52
9877	101	1	Mix (Aeschynite-euxenite +others)	5.54	8.39		2.41			1.06	0.66									0.74					5.83		15.51		0.67					0.81										58.43	100.05	44.76
9877	102	1	Mix(Ilmenite+others)	3.32	66.97		24.55	1.83																			3.35																		100.02	35.96
9877	102	2	Ilmenite	5.56	49.76	0.72	41.22	2.72																																					99.98	36.32
9877	102	3	Pyrochlore	8.34	30.18		2.26			2.46										0.75					12.59		25.61		5.99														11.81		99.99	38.20
9877	102	4	Aeschynite-euxenite	14.35	22.02	4.31	6.37			0.83	1.21				3.61	0.50						0.76			3.57	3.97	22.76												2.34			9.62	3.80		100.02	46.60
9877	102	5	Aeschynite-euxenite	27.94	20.88	7.54	6.43			0.91	1.74				3.42							0.73				3.00	18.91															6.98	1.50		99.98	49.09
9877	103	1	Thorite-xenotime(+Qz)	52.90		1.38	1.35			0.94			2.47												3.05						1.60	4.50	1.27									30.52			99.98	46.97
9877	103	2	Thorite-xenotime(+Qz)	56.41		1.47	1.27			0.99			2.70												2.29						2.20	3.63	1.33									27.70			99.99	47.12
9877	104	1	Zircon	31.62		0.93	1.20																			66.27																			100.02	43.21
9877	104	2	Zircon	34.10																						65.89																			99.99	44.86
9877	104	3	Quartz	92.14			0.54			3.25																					1.27	2.82													100.02	47.70
9877	104	4	Zircon (+others)	46.57		10.62	3.05				6.36															33.39																			99.99	42.54
9877	104	5	Zircon	31.34		0.98	1.24																			62.38												1.56				2.50			100.00	44.96
9877	104	6	Ilmenite	3.85	50.23	1.63	41.82	2.48																																					100.01	48.70
9877	104	7	Bad analysis	2.78	40.85		14.38	1.17															40.82																						100.00	73.91
9877	104	8	Zircon	31.72																						68.28																			100.00	74.55
9877	104	9	Pyrite				31.93							68.07																															100.00	38.63
9877	104	10	Pyrite				32.54							67.47																															100.01	49.91
9877	104	11	Samarskite-Y	10.08	3.27		3.72			4.48															10.52		61.17		6.77																100.01	49.54
9877	105	1	Quartz	99.99																																									99.99	50.07

* If we consider B_2O_3 as an analytical artifact

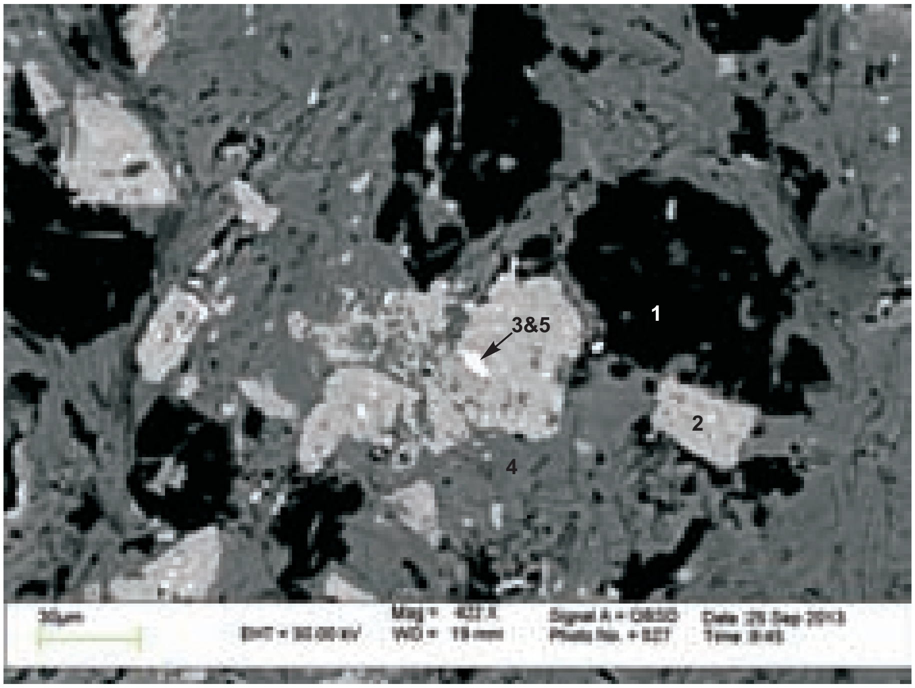
Table 2-5A: EDS of sample 9877 from the contact between Granite and Horton Group country rock.

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Sc_2O_3	V_2O_5	Cr_2O_3	CoO	NiO	CuO	ZnO	As_2O_3	Y_2O_3	ZrO_2	Nb_2O_5	MoO_3	Ag_2O	BaO	La_2O_3	Ce_2O_3	Nd_2O_3	Gd_2O_3	Dy_2O_3	Er_2O_3	Yb_2O_3	HfO_2	Ta_2O5	WO_3	PbO	ThO_2	UO_3	B_2O_3	Total	Actual Total
9877	105	2	Quartz	99.99																																									99.99	63.03
9877	105	3	Albite	68.75		19.10				0.46	11.68																																		99.99	34.90
9877	105	4	Nb-rich phase	2.42	1.58		2.17			2.48															4.70		32.00															4.71		49.96	100.02	38.80
9877	107	1	Aeschynite-euxenite	3.36	5.77					1.51										1.18					19.27		57.12		1.35					1.63	2.98		2.99						2.82		99.98	92.40
9877	107	2	Pyrochlore	6.48	7.24		1.43			5.19										0.67					8.46		60.95		2.30			1.50					2.08						3.69		99.99	69.09
9877	107	3	Pyrochlore*	0.56	10.83		0.53													0.45					7.61		13.29							0.81								1.75	0.70	63.52	100.05	39.27
9877	109	1	Pyrochlore*	2.82	0.25	1.61	2.25			0.13					1.70							0.35		0.36		1.05	15.91															2.40		71.22	100.05	107.62
9877	109	2	Pyrochlore*	3.02	0.23	1.45	2.10			0.13												0.21		0.41		0.65	15.52															1.89		74.41	100.02	50.47
9877	109	3	Samarskite-Y*	10.25	0.23	3.23	2.80	0.25		0.49	1.89											0.16					17.48		0.33			0.29									0.78		0.47	61.36	100.01	37.86
9877	111	1	Aeschynite?	13.82	2.57	2.36	3.64			0.90	0.81													1.29			59.80					2.32							1.86			5.96	4.69		100.02	43.34
9877	111	2	Zircon	32.75																						64.39												2.85							99.99	88.25
9877	111	3	Pyrochlore?	36.90	0.85	8.73	3.64			0.60	3.64				3.21							0.44		1.29		3.74	30.01												1.50			5.46			100.01	88.25
9877	112	1	Chalcopyrite			0.74	23.08							52.39								23.80																							100.01	48.28
9877	114	1	TiO_2	2.89	92.91	0.77	1.04			0.25																	2.15																		100.01	75.53
9877	114	2	Ilmenite	1.63	52.18		44.77	1.45																																					100.03	39.64
9877	114	3	Aeschynite-euxenite*	1.60	10.46		1.25			0.98										0.38					6.29		10.67		0.88										0.68				4.10	62.75	100.04	33.74
9877	114	4	Aeschynite-euxenite	2.82	0.58					0.38															24.77		54.43							1.59	4.14	4.17	4.83						2.31		100.02	60.82
9877	114	5	Pyrochlore*	4.75	3.47	2.74	4.26			0.39					3.60												29.33		1.51												0.99		1.08	47.90	100.02	115.72
9877	114	6	Pyrochlore	8.30	7.04	5.25	7.82			0.78												0.98		0.96			59.54		3.53										3.05				2.75		100.00	39.64
9877	116	1	Zircon	32.54																						64.01												3.44							99.99	
9877	116	2	Samarskite-Y*	1.93	0.37					0.17															11.44		16.49							0.80	1.78	1.38	1.62		1.65				0.70	61.72	100.05	

* If we consider B_2O_3 as an analytical artifact

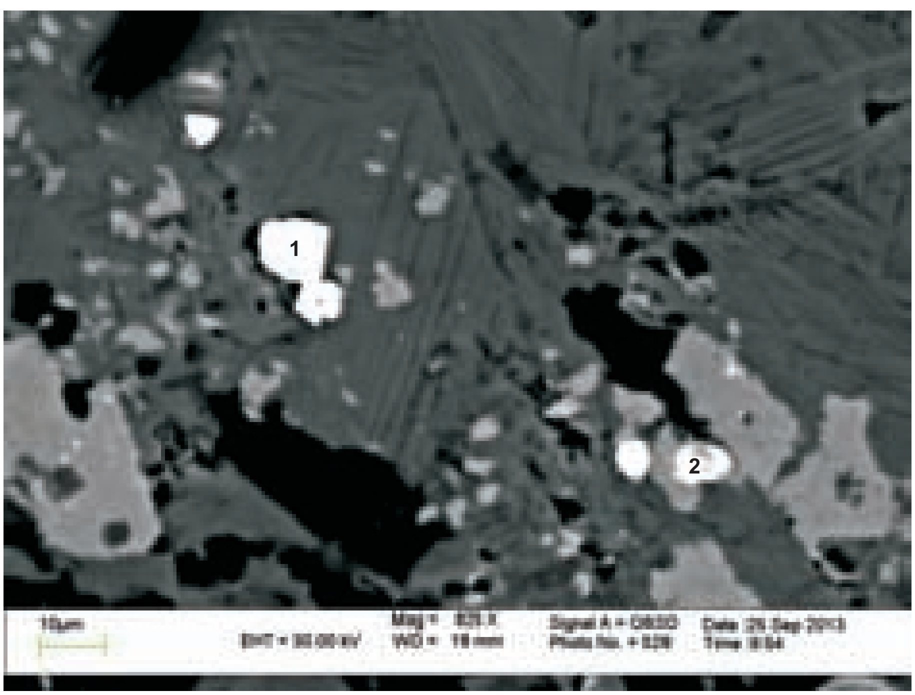
Appendix 3: BSE images and EDS mineral analyses of Lamprophyres

Appendix 3-1: BSE images and EDS mineral analyses of sample 1159



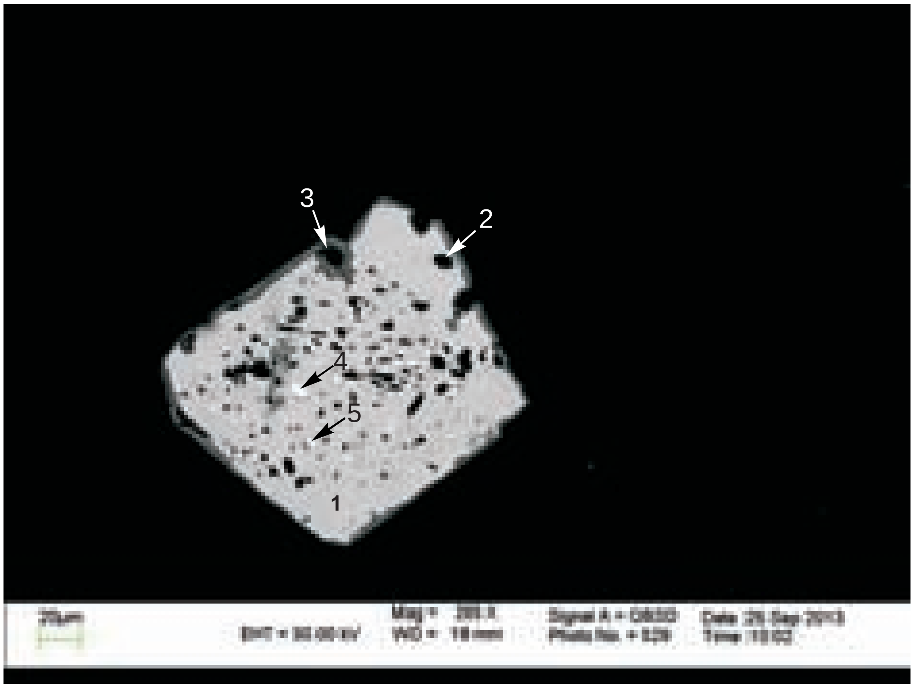
1:Albite
2:Titanite(+others)
3:Mix?
4:Biotite
5:Mix?

Figure 3-1.1: Lamprophyre dyke sample 1159 site 1; primary biotite, albite and titanite.



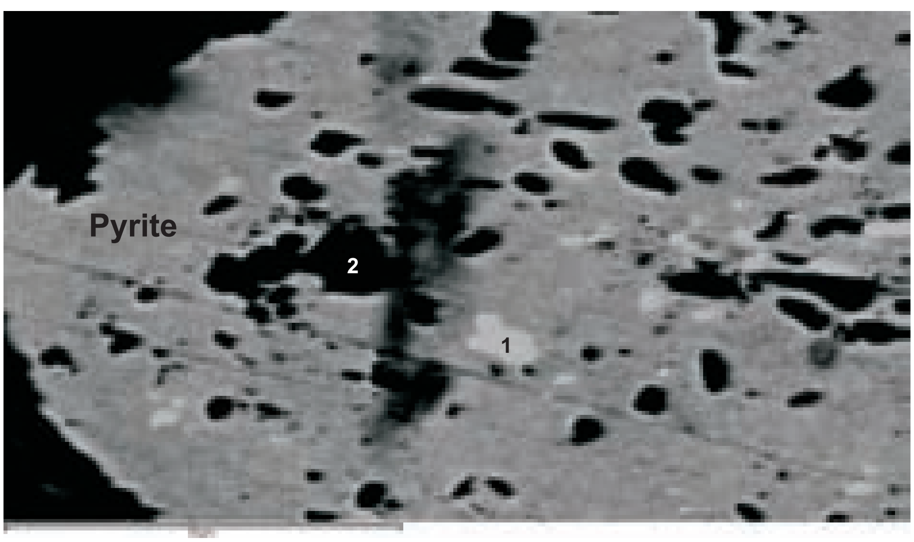
1:Magnetite(+others)
2:Mix?

Figure 3-1.2: Lamprophyre dyke sample 1159 site 2; magnetite possibly of secondary origin.



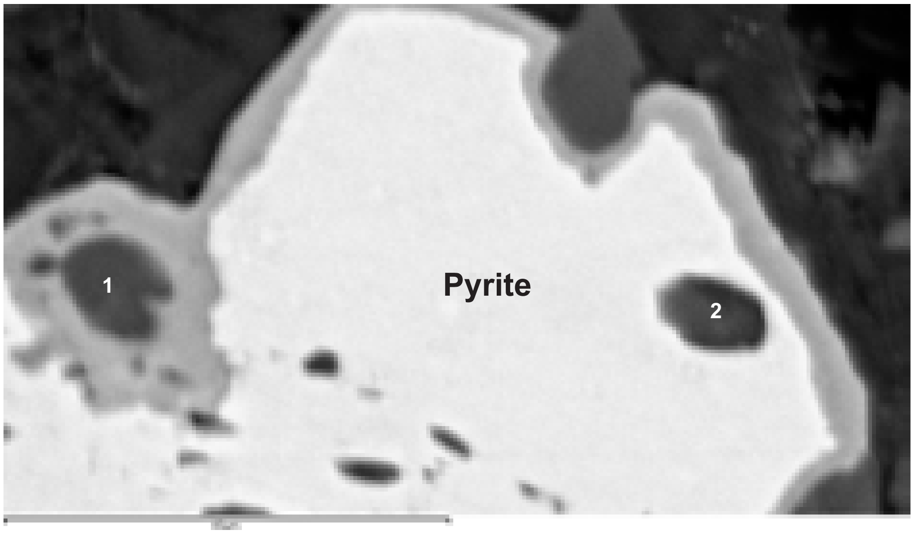
1:Pyrite
2:Pyrite
3:Mix(titanite+pyrite)
4:Pyrite
5:Pyrite

Figure 3-1.3a: Lamprophyre dyke sample 1159 site 3; pyrite (analysis 1) with inclusions of titanite (analyses 3) as well galena (figure 3b, analysis 1).



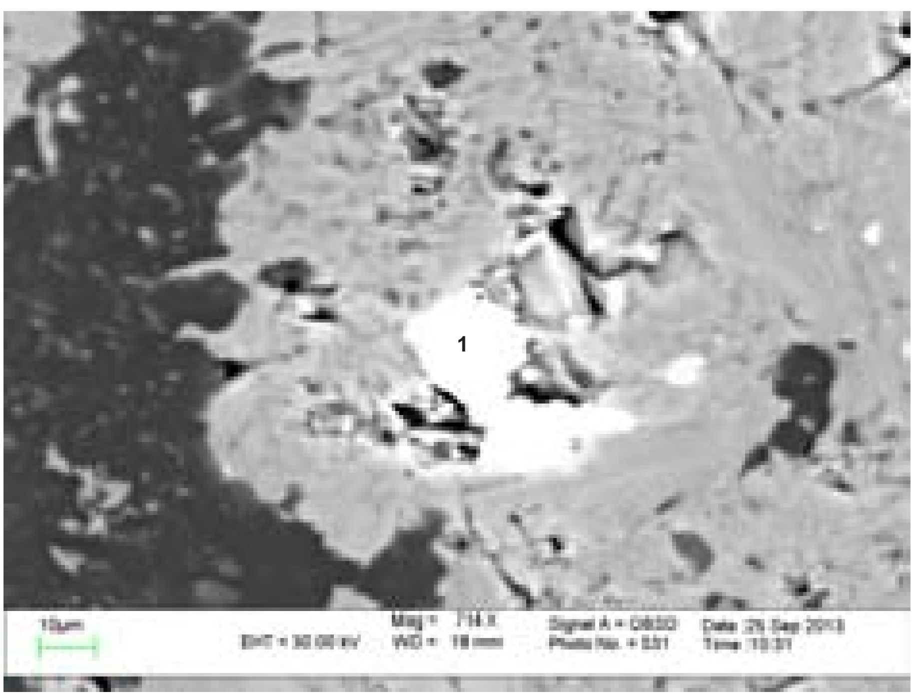
1:Galena (+others)
2:Mix (pyrite+titanite)

Figure 3-1.3b: Lamprophyre dyke sample 1159 site 4; higher magnification of figure 3a. Galena (analysis 1) and titanite (analysis 2) inclusions in pyrite.



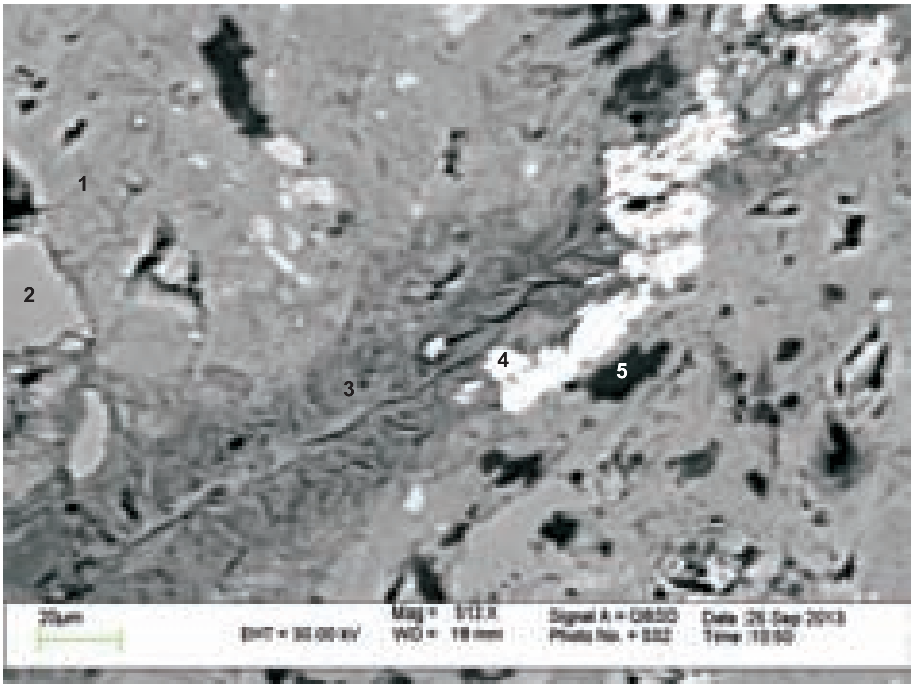
1:Titanite(+Fe-oxide)
2:Titanite(+pyrite)

Figure 3-1.3c: Lamprophyre dyke sample 1159 site 5; higher magnification of figure 3a; pyrite



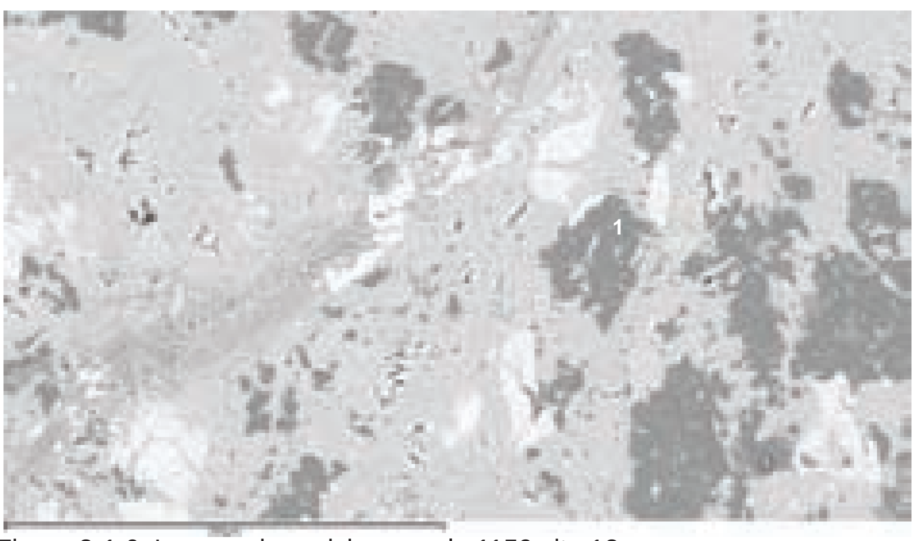
1:Contamination from the polishing of the thin section

Figure 3-1.4: Lamprophyre dyke sample 1159 site 7.



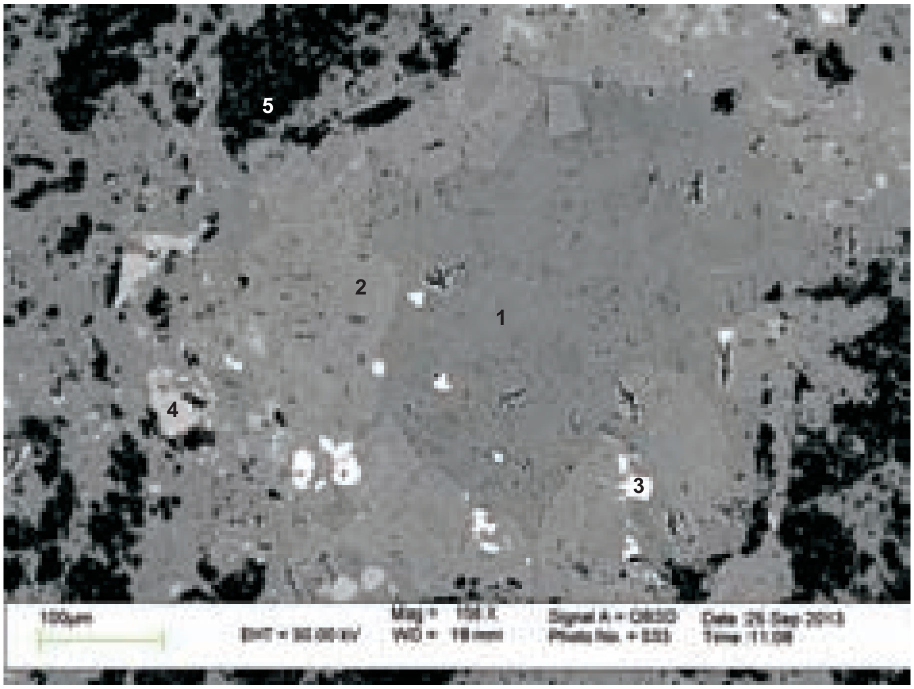
1:Biotite
2:Epidote
3:Chlorite
4:Magnetite(+others)
5:Albite

Figure 3-1.5: Lamprophyre dyke sample 1159 site 11; chlorite (analysis 3) and magnetite (analysis 4) precipitated along fracture. Component minerals include biotite, albite, and epidote.



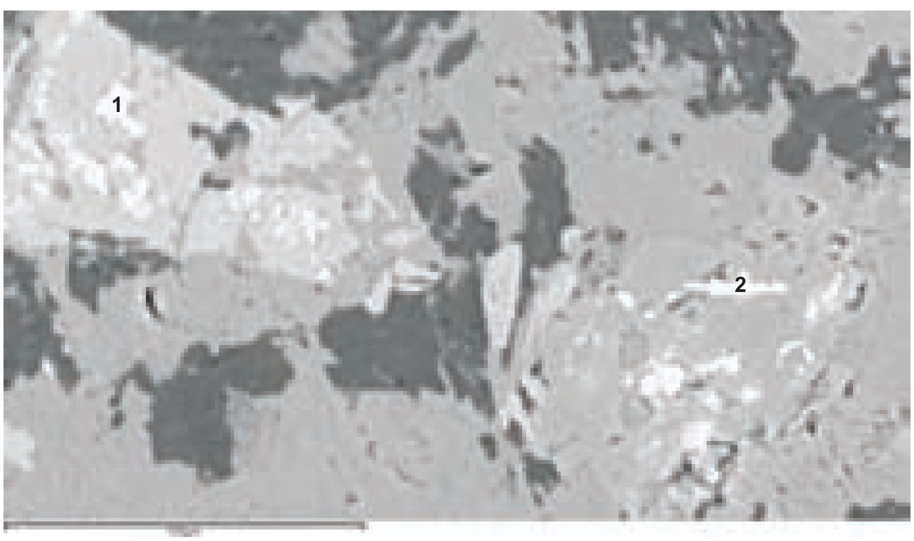
1:Albite

Figure 3-1.6: Lamprophyre dyke sample 1159 site 12.



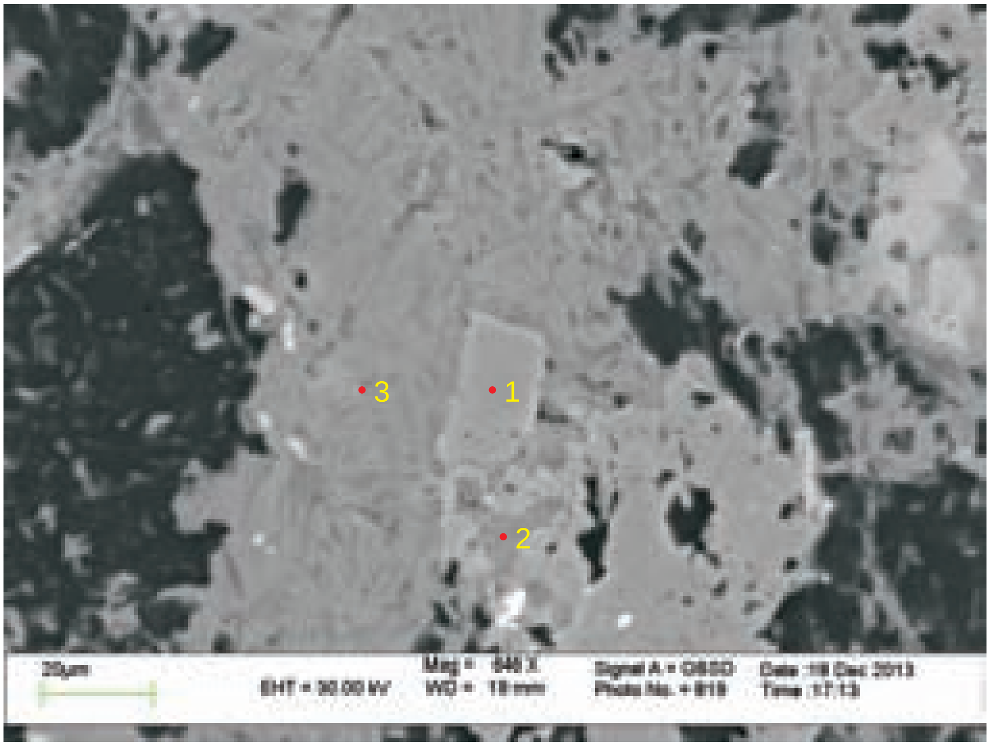
1:Biotite
2:Epidote
3:Magnetite
4:Titanite
5:Albite

Figure 3-1.7: Lamprophyre dyke sample 1159 site 13; component minerals include biotite, albite, epidote, magnetite, and titanite.



1:Magnetite
2:bad analysis

Figure 3-1.8: Lamprophyre dyke sample 1159 site 6.



1	Epidote
2	Biotite
3	Biotite

Figure 3-1.9: Sample 1159b, site of interest 2. Biotite with inclusions of epidote.

Table 3-1A: EDS anlyses from sample 1159

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	Cl	Cr_2O_3	ZnO	PbO	Total	Actual Total
L1159	1	1	Albite	66.51		20.75	0.75			0.24	10.06	1.69							100	207.73
L1159	1	2	Titanite(+others)	34.01	33.41	2.76	3.32			25.35	0.58	0.33			0.23				99.99	188.33
L1159	1	3	Mix?	41.67	5.67	14.23	14.09		11.77	3.93		8.61							99.97	178.13
L1159	1	4	Biotite	42.93	2.5	15.48	14.68		13.88	1.15		9.38							100	189.84
L1159	1	5	Mix?	40.94	10.03	12.43	11.37		10.3	7.89		7.02							99.98	186.94
L1159	2	1	Magnetite(+others)	16.86	0.57	7.75	63.44		7.91			2.9				0.6			100.03	190.71
L1159	2	2	Mix?	42.51	9.26	11.9	14.13		7.58	8.33	1.98	4.3							99.99	199.84
L1159	3	1	Pyrite	0.9		0.47	26.58				0.55	0.31		71.19					100	374.8
L1159	3	2	Pyrite	3.32	2.62	0.36	23.94			2.59	0.58			66.57					99.98	349.96
L1159	3	3	Mix(Pyrite+Titanite)	22.7	11.03	2.15	51.9			9.91				2.35					100.04	163.18
L1159	3	4	Pyrite				26.66							73.34					100	365.54
L1159	3	5	Pyrite	0.24			26.71				0.49	0.11		72.46					100.01	369.93
L1159	4	1	Galena (+other)				10.87				2.33	1.81		49.09				35.9	100	254.29
L1159	4	2	Mix(Pyrite+Titanite)	19.66		3.21	17.51		7.91	7.71	1.07		6.19	36.76					100.02	285.21
L1159	5	1	Titanite	34.72	31.94	2.34	6.12			24.88									100	182.98
L1159	5	2	Titanite(+Pyrite)	29.8	27.16	2	4.79			21.87	3.2			11.19					100.01	206.76
L1159	6	1	Magnetite	1.05	1.15		97.07			0.73									100	144.18
L1159	6	2	Bad analysis	30.4		12.7	35.94		2.01	8.3		0.37						10.29	100.01	167.69
L1159	7	1	Contamination	6.5		1.66	4.28											87.55	99.99	83.17
L1159	8	1	Contamination	1.84		1.08	1.89					0.24					94.95		100	192.49
L1159	9	1	Contamination				3.82											96.18	100	82.53
L1159	10	1	Contamination	26.83		7.92	4.84		2.95	1.32	1.6	2.04			2.23			50.3	100.03	107.95
L1159	11	1	Biotite	42.96	1.32	17.02	15.84		13.8			9.06							100	201.9
L1159	11	2	Epidote	42.27		24.24	11.03	0.41		22.04									99.99	193.11
L1160	11	3	Chlorite	34.26		13.78	19.24	0.45	16.36	0.442		0.47							85	165.44
L1159	11	4	Magnetite(+others)	23.15	1.13	9.39	57.87		6.86	0.69		0.89							99.98	167.04
L1159	11	5	Albite	67.02		19.16	0.9			0.45	11.89	0.55							99.97	219.97
L1159	12	1	Albite	67.56		19.44	0.21			0.43	12.12	0.23							99.99	220.89
L1159	13	1	Biotite	44.15	0.92	15.8	14.95		14.54			9.62							99.98	196.78
L1159	13	2	Epidote	42.06		24.28	15	0.32	2.24	16.1									100	188.35
L1159	13	3	Magnetite	4.75		2.17	89.89		1.67	0.45		1.07							100	152.11
L1159	13	4	Titanite	35.98	33.31	2.06	1.7		0.48	26.14		0.33							100	186.81
L1159	13	5	Albite	66.4		20.33	0.82		0.55	0.39	10.22	1.29							100	216.12

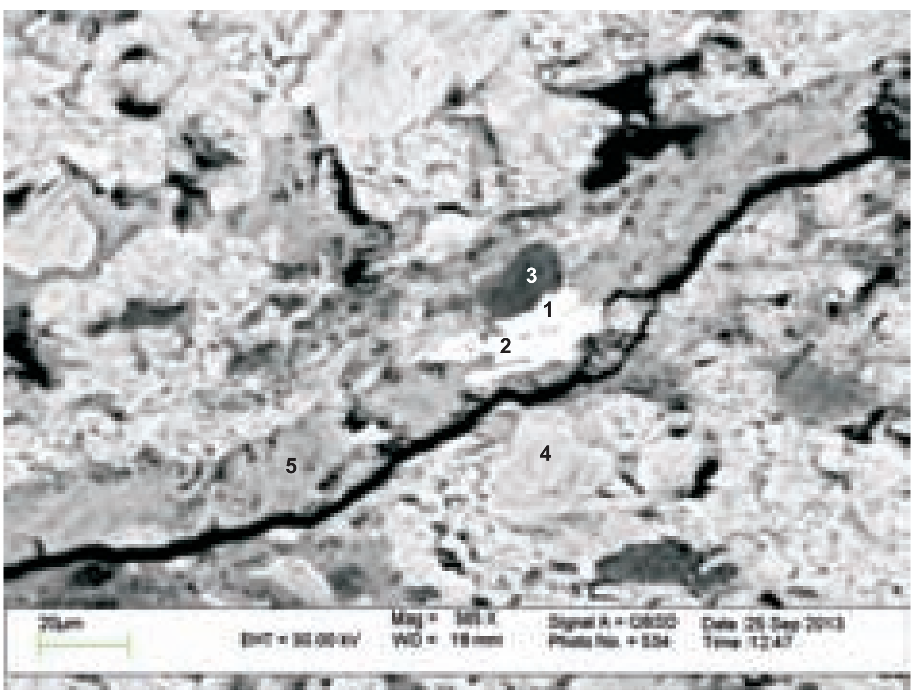
Table 3-1B: EDS analyses of sample 1159

Sample	Site	Position	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O	Cl	Total
1159	1	1	Biotite	41.84	1.38	15.85	16.85		12.44	2.74	8.64	0.23	99.97
1159	2	1	Epidote	41.33		23.56	11.85	0.36		22.92			100.02
1159	2	2	Biotite	42.04	0.92	15.49	17.53		12.54	2.03	8.94	0.5	99.99
1159	2	3	Biotite	41.69	1.38	15.65	17.92		13.23		9.83	0.31	100.01

Appendix 3-2: BSE images and EDS mineral analyses of sample C2226

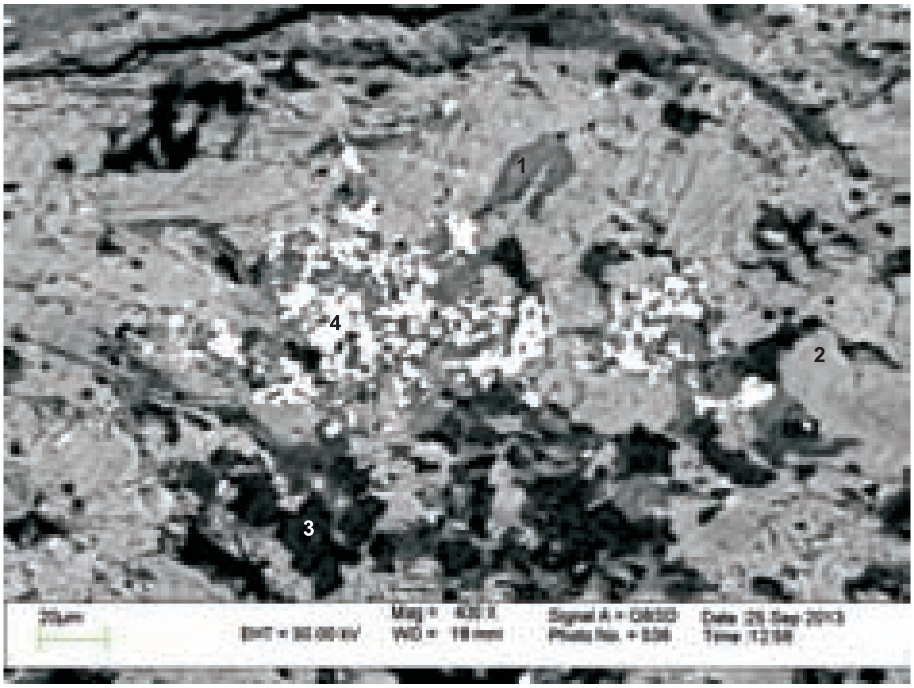
1:Synchysite-Ce(+Calcite)
2:Synchysite-Ce(+Calcite)

Figure 3-2.1: Lamprophyre dyke sample C2226 site 1; veinlets of synchysite-Ce



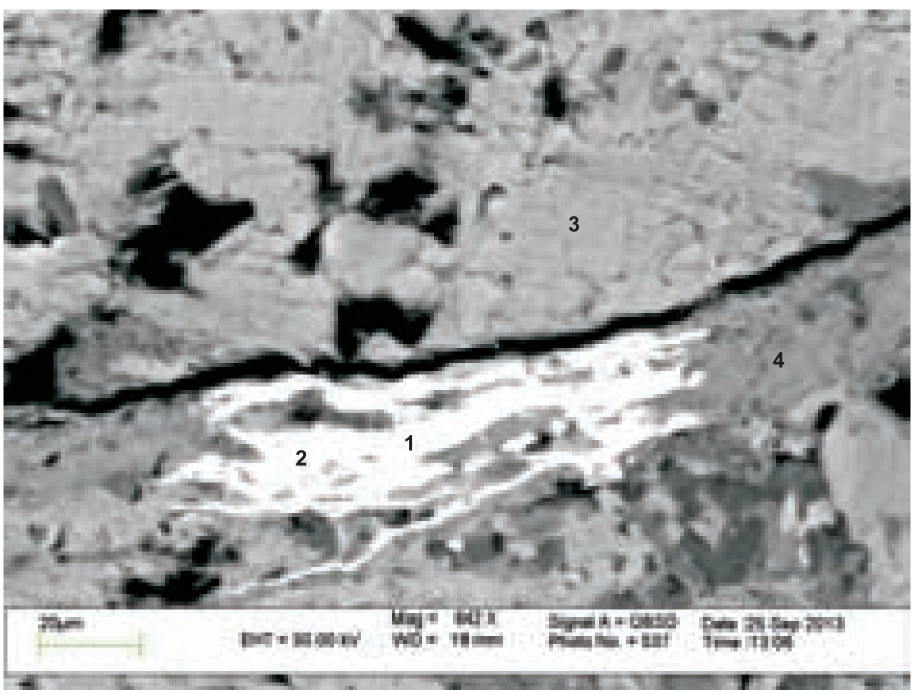
1:Synchysite-Ce(+others)
2:Synchysite-Ce(+others)
3:Albite
4:Biotite
5:Calcite

Figure 3-2.2: Lamprophyre dyke sample C2226 site 2; synchysite-Ce precipitated in calcite vein. Vein reopened by subsequent fracturing.



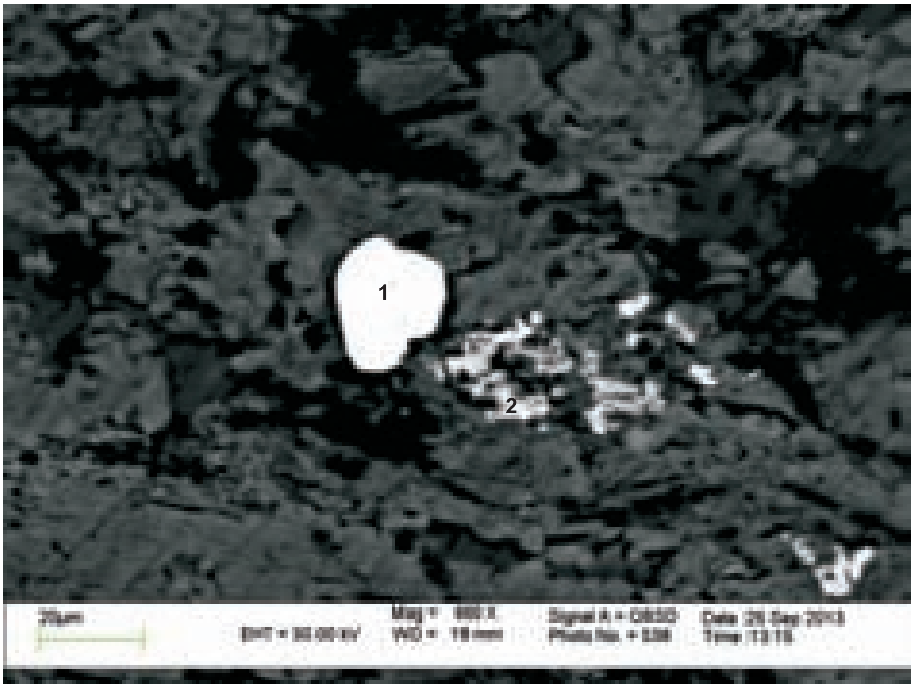
1:Calcite
2:Biotite
3:Albite
4:Ilmenite

Figure 3-2.3: Lamprophyre dyke sample C2226 site 3; skeletal crystals of ilmenite.



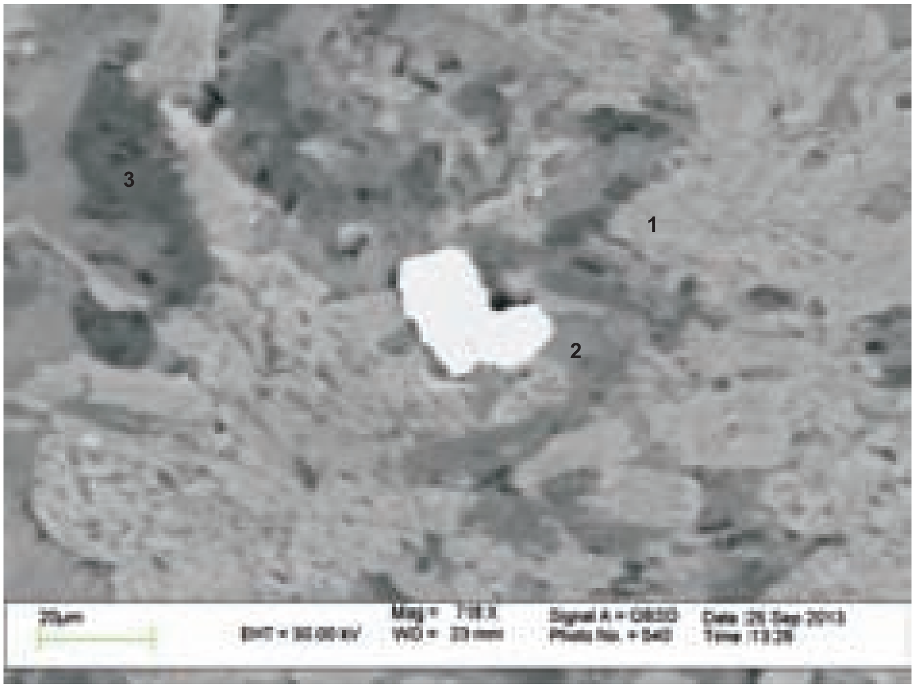
1:Synchysite-Ce(+others)
2:Synchysite-Ce(+others)
3:Biotite
4:Calcite

Figure 3-2.4:Lamprophyre dyke sample C2226 site 4; synchysite-Ce precipitated in calcite vein. Vein reopened by later fracturing.



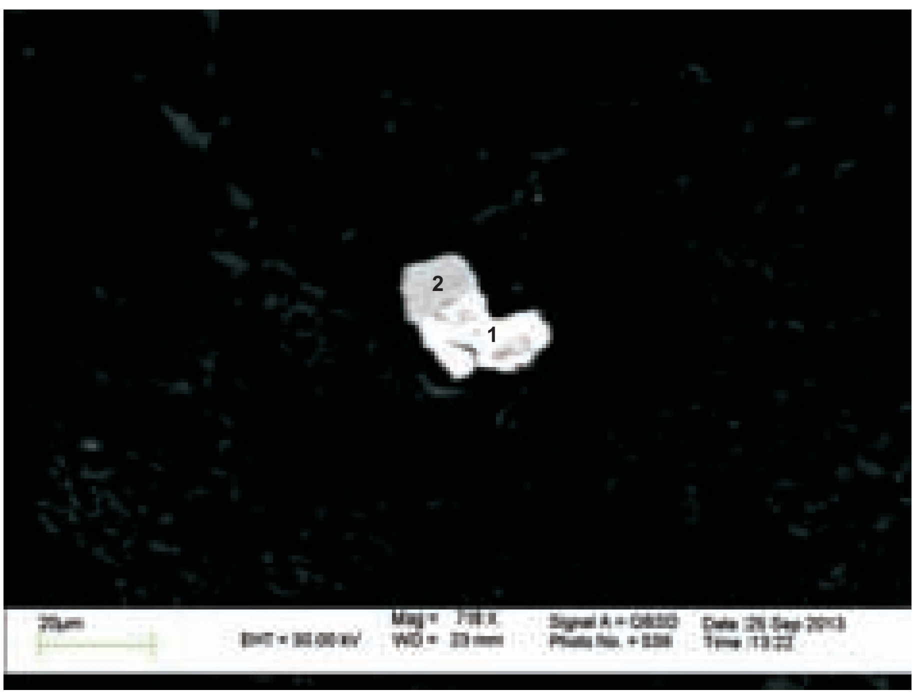
1: Pyrite
2: Ilmenite

Figure 3-2.5: Lamprophyre Dyke sample C2226 site 5; small dispersed crystals of ilmenite (analysis 2) and pyrite (analysis 1).



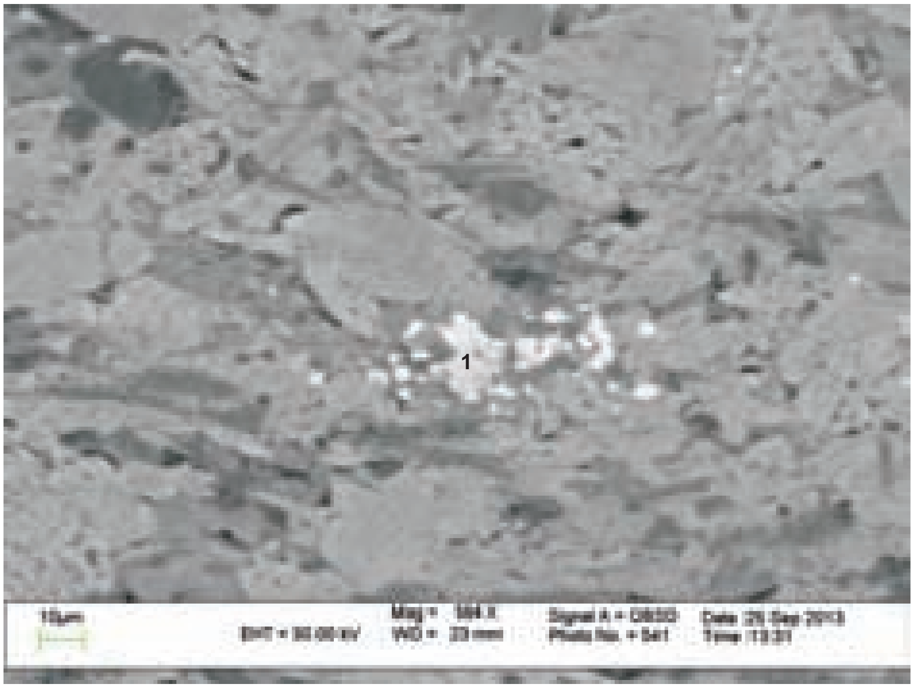
1:Biotite
2:Calcite
3:Albite

Figure 3-2.6a: Lamprophyre dyke sample C2226 site 7; component minerals include biotite, albite, calcite, pyrite and xenotime.



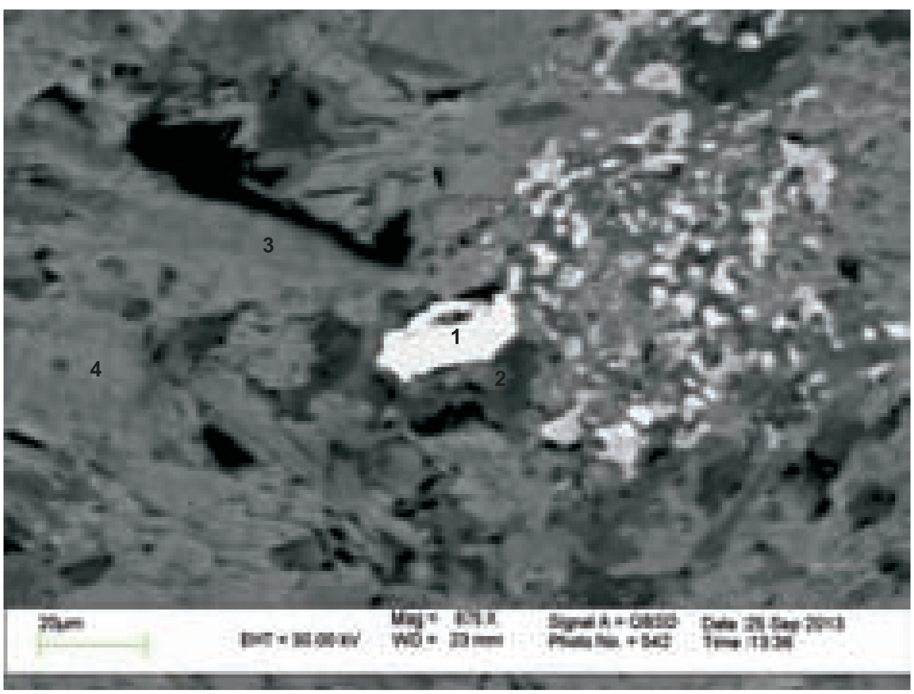
1:Xenotime
2:Pyrite

Figure 3-2.6b: Lamprophyre dyke sample C2226 site 6; brighter BSE image of figure 6a. Xenotime appears to replace earlier pyrite.



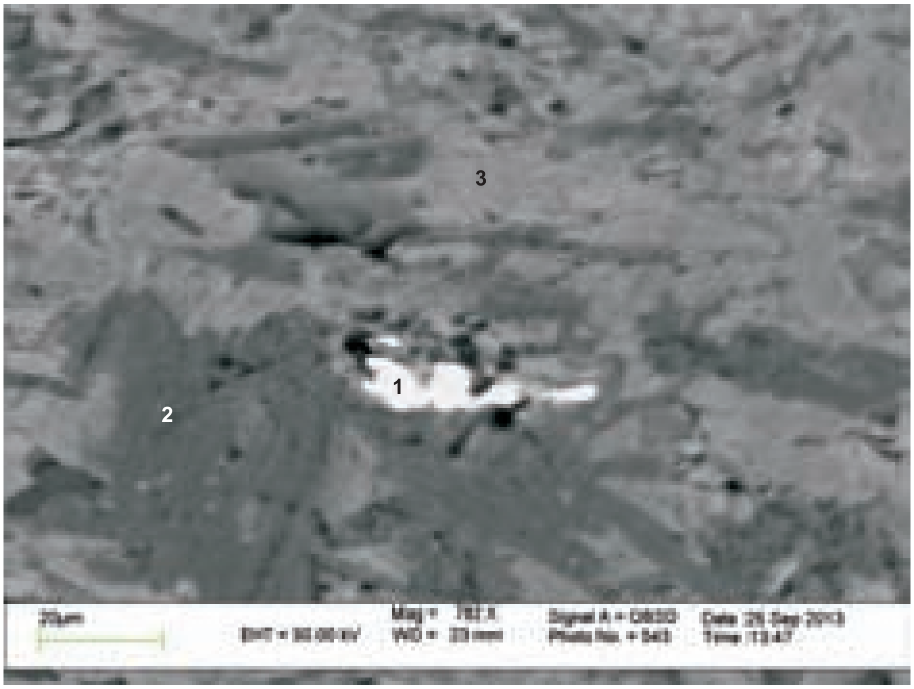
1:TiO_2

Figure 3-2.7: Lamprophyre dyke sample sample C2226 site 8; small dispersed crystals of TiO_2.



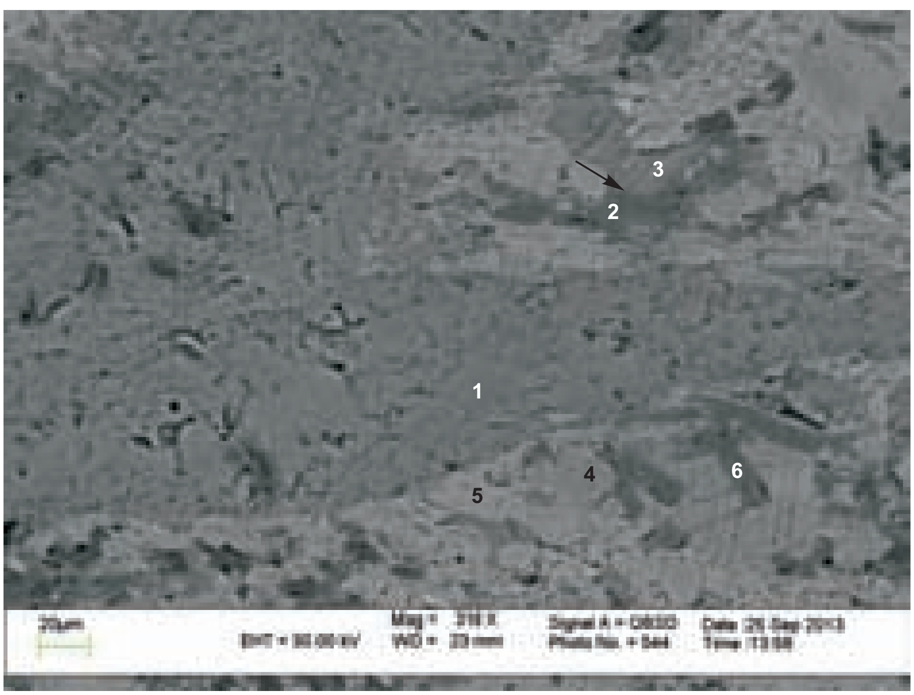
1:Xenotime
2:Albite (+Biotite)
3:Biotite
4:Biotite

Figure 3-2.8: Lamprophyre dyke sample C2226 site 10; xenotime (analysis 1) appears to postdate albite (analyses 2) and biotite (analysis 3-4).



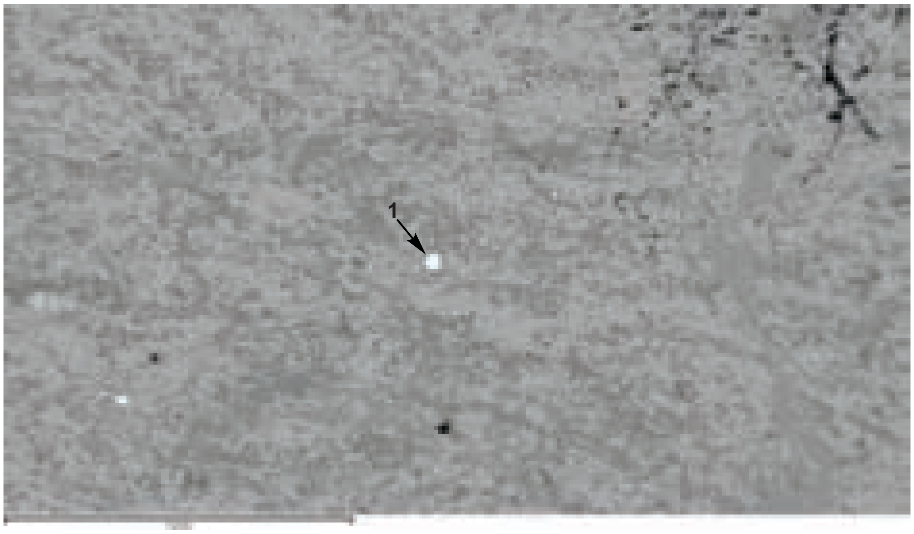
1:Synchysite-Ce(+others)
2:Bad analysis
3:Biotite

Figure 3-2.9: Lamprophyre dyke sample C2226 site 12; synchysite-Ce precipitated in dissolution void.



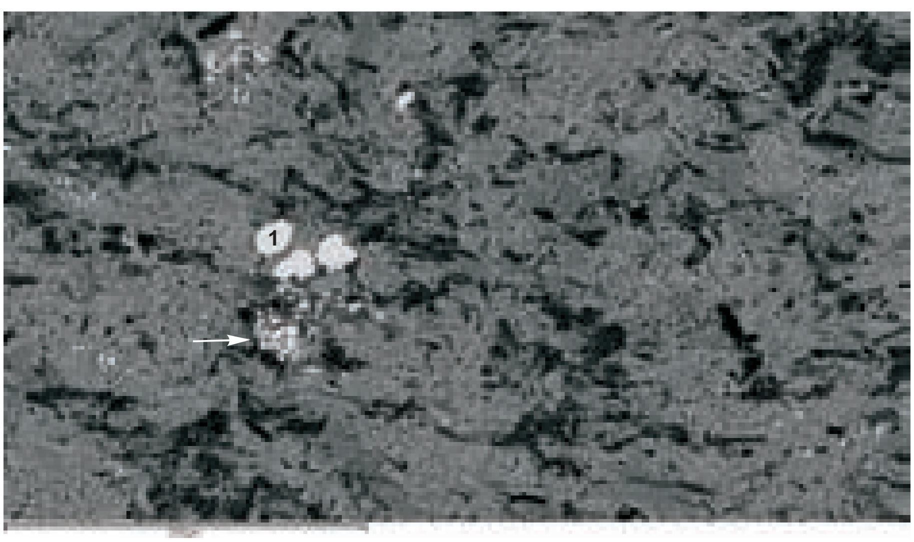
1:Calcite
2:Muscovite (+Calcite & Biotite)
3:Calcite
4:Biotite
5:Biotite
6:Muscovite

Figure 3-2.10: Lamprophyre dyke sample C2226 site 15; late laths of muscovite (analysis 6) and possible composite vein of muscovite and calcite (arrow).



1:Pyrite

Figure 3-2.11: Lamprophyre dyke sample C2226 site 11; accessory pyrite.



1:Pyrite

Figure 3-2.12: Lamprophyre dyke sample C2226 site 13; accessory pyrite in close spatial association with dispersed minerals (arrow, possibly TiO_2).

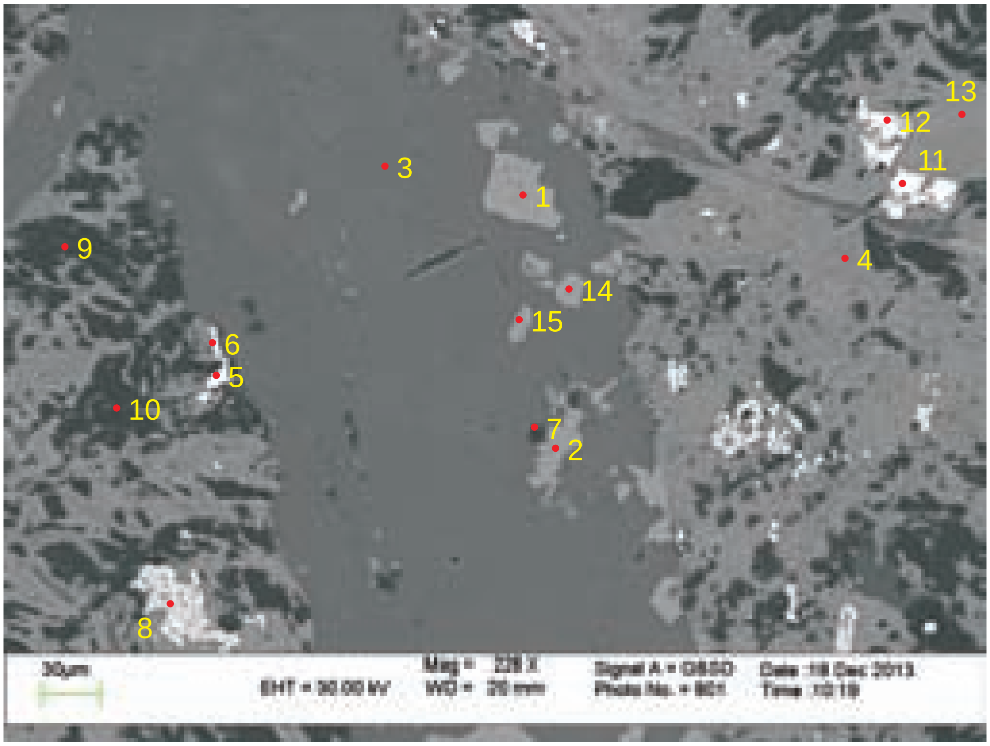
Table 3-2: EDS analyses from sample C2226

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	CoO	As_2O_3	Y_2O_3	La_2O_3	Ce_2O_3	Nd_2O_3	Sm_2O_3	Gd_2O_3	Dy_2O_3	Yb_2O_3	Total	Actual Total
C2226	1	1	Synchysite-Ce (+Calcite)	4.70		2.55	2.66		1.51	39.03		0.36		0.74	5.02	0.65				4.21	10.65	3.93					76.00	80.02
C2226	1	2	Synchysite-Ce (+Calcite)	4.14		1.89				27.04		0.33			10.93				2.56	7.01	15.09	7.00					76.00	109.40
C2226	2	1	Synchysite-Ce (+others)	12.89		4.10				17.51	1.36	0.23			8.31				2.80	6.36	12.45	6.52	1.60	1.85			76.00	164.46
C2226	2	2	Synchysite-Ce (+others)	13.79		6.51	0.52			19.68	1.67	1.44			4.72				2.44	6.04	12.37	5.54		1.27			76.00	153.06
C2226	2	3	Albite	68.86		19.05				0.59	11.24	0.26															100.00	213.63
C2226	2	4	Biotite	40.54	1.75	16.91	18.46		11.57			9.94				0.84											100.01	202.55
C2226	2	5	Calcite	1.78		0.59	1.35	1.57	1.17	49.22						0.33											56.00	94.08
C2226	3	1	Calcite	0.68			1.20	1.16	1.08	51.89																	56.00	99.46
C2226	3	2	Biotite	40.13	1.68	16.53	19.40		11.38			9.88				0.99											99.99	202.51
C2226	3	3	Albite	67.75		19.39	0.30			1.26	11.15	0.16															100.01	218.30
C2226	3	4	Ilmenite	1.67	53.44	0.83	38.27	1.25		4.55																	100.01	182.44
C2226	4	1	Synchysite-Ce (+others)	12.02	1.73	7.24	1.26		1.16	14.66		1.47			6.82				1.85	6.86	13.26	6.63		1.06			76.00	159.53
C2226	4	2	Synchysite-Ce (+others)	10.60		4.51	3.42		3.37	19.93		1.97			6.47	0.30			1.89	5.58	12.27	4.78		0.91			76.00	128.35
C2226	4	3	Biotite	40.41	1.05	17.10	18.82		11.51			10.06				1.07											100.02	201.37
C2226	4	4	Calcite	1.78		0.70	1.05	1.24	0.57	50.33						0.34											56.00	91.51
C2226	5	1	Pyrite	0.30			27.02							70.79			1.37	0.53									100.01	406.53
C2226	5	2	Ilmenite	3.38	57.56	1.66	30.57	1.32	1.19	3.67		0.66															100.01	185.33
C2226	6	1	Xenotime	3.72						0.74			44.02				0.99		39.09					3.40	5.50	2.54	100.00	57.41
C2226	6	2	Pyrite				26.40			0.22				71.87			1.51										100.00	130.40
C2226	7	1	Biotite	41.18	1.17	16.97	18.06		12.10			9.76				0.76											100.00	66.91
C2226	7	2	Calcite	4.80		3.01	1.58	0.43	1.18	43.78		1.23															56.01	37.94
C2226	7	3	Albite	67.81		19.01	0.42			1.19	11.57																100.00	74.23
C2226	8	1	TiO_2	3.36	89.71		3.34			2.17		1.41															99.99	56.92
C2226	10	1	Xenotime	4.39			0.89			0.57			44.11				1.39		38.47					2.39	4.92	2.88	100.01	55.82
C2226	10	2	Albite (+Biotite)	65.01		19.03	2.47		2.82	0.97	8.32	1.37															99.99	70.42
C2226	10	3	Biotite	41.67	1.32	18.03	15.73		13.02			10.24															100.01	63.80
C2226	10	4	Biotite	41.52	1.38	18.31	16.61		12.09			9.44				0.63											99.98	66.38
C2226	11	1	Pyrite				26.48							72.09			1.45										100.02	129.26
C2226	12	1	Synchysite-Ce (+others)	11.06		6.67	3.04		2.54	22.47		0.88			9.25				2.51	8.96	17.39	9.30	2.89	3.04			100.00	49.68
C2226	12	1	Synchysite-Ce (+others)	8.41		5.07	2.31		1.93	17.08		0.67			7.03				1.91	6.81	13.22	7.07	2.20	2.31			76.00	49.68
C2226	12	2	bad analysis	55.62		25.64	3.10		1.43		6.51	7.71															100.01	67.70
C2226	12	3	Biotite	41.07	1.38	17.69	17.52		12.25			9.41				0.66											99.98	68.88
C2226	13	1	Pyrite				26.71							72.79				0.50									100.00	117.40

Table 3-2: EDS analyses from sample C2226

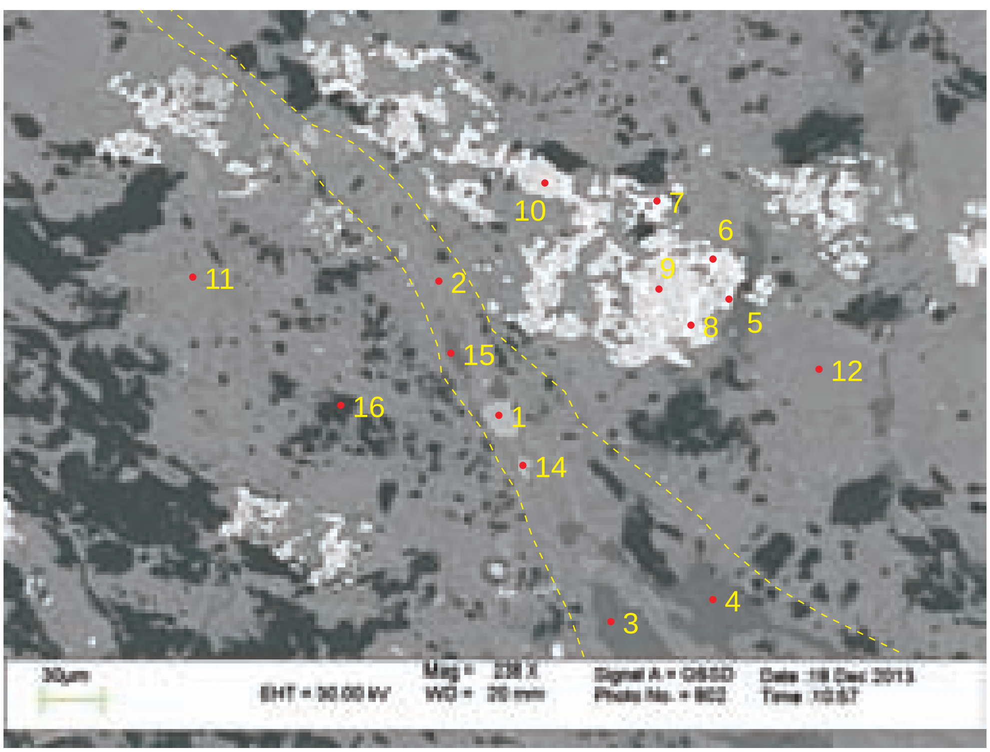
Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	CoO	As_2O_3	Y_2O_3	La_2O_3	Ce_2O_3	Nd_2O_3	Sm_2O_3	Gd_2O_3	Dy_2O_3	Yb_2O_3	Total	Actual Total
C2226	15	1	Calcite					0.55		55.08						0.37											56.00	31.01
C2226	15	2	Muscovite (+Calcite & Biotite)	46.36	0.48	28.32	5.33		3.50	6.69		9.32															100.00	63.68
C2226	15	3	Calcite				1.13	0.93		97.48		0.46															100.00	30.95
C2226	15	4	Biotite	41.82	1.35	18.18	15.45		13.18			10.01															99.99	63.44
C2226	15	5	Biotite	40.49	1.17	16.93	19.64		11.26			9.15				1.34											99.98	63.43
C2226	15	6	Muscovite	51.88		30.91	3.09		2.92			11.20															100.00	64.44

Appendix 3-3: BSE images and EDS mineral analyses of sample 7106



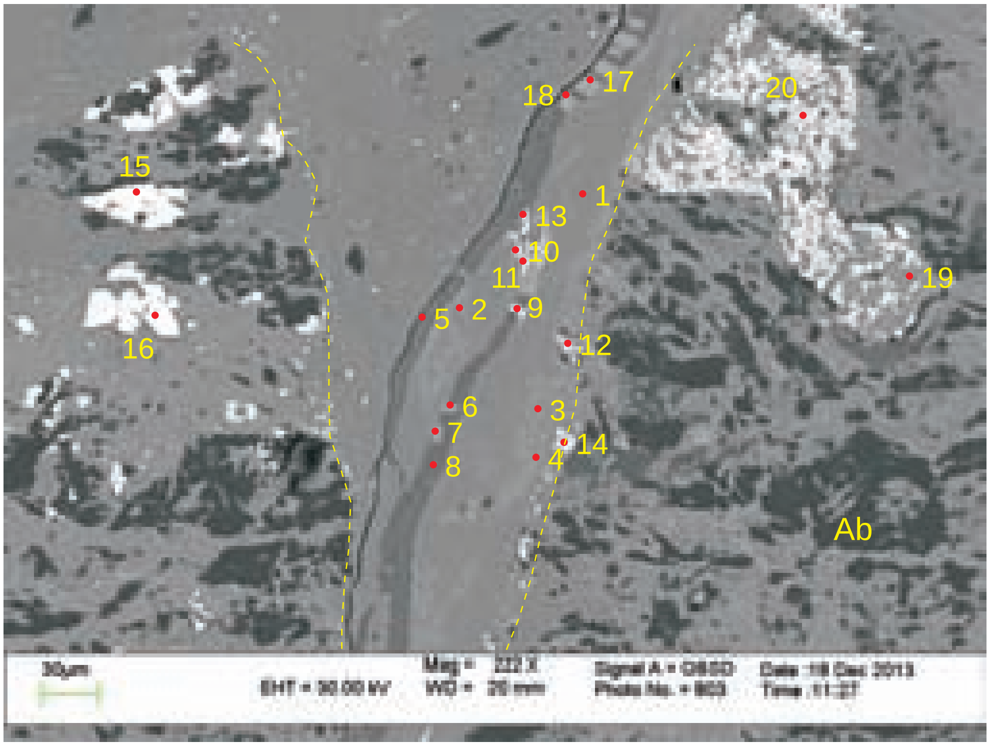
1:Fluorite
2:Fluorite
3:Calcite
4:Biotite
5:Synchysite
6:Synchysite
7:Quartz
8:Ilmenite
9:Albite
10:Albite
11:Magnetite
12:Magnetite
13:Biotite
14:Fluorite
15:Fluorite

Figure 3-3.1: Sample 7106 site 1; calcite vein with fluorite (analyses 1,2,14 and 15) and synchysite-(Ce) at the margin (analyses 5&6). Minerals in the host lamprophyre include: albite (analyses 9&10), magnetite (analyses 11&12) and biotite (4,7). Biotite is probably secondary.



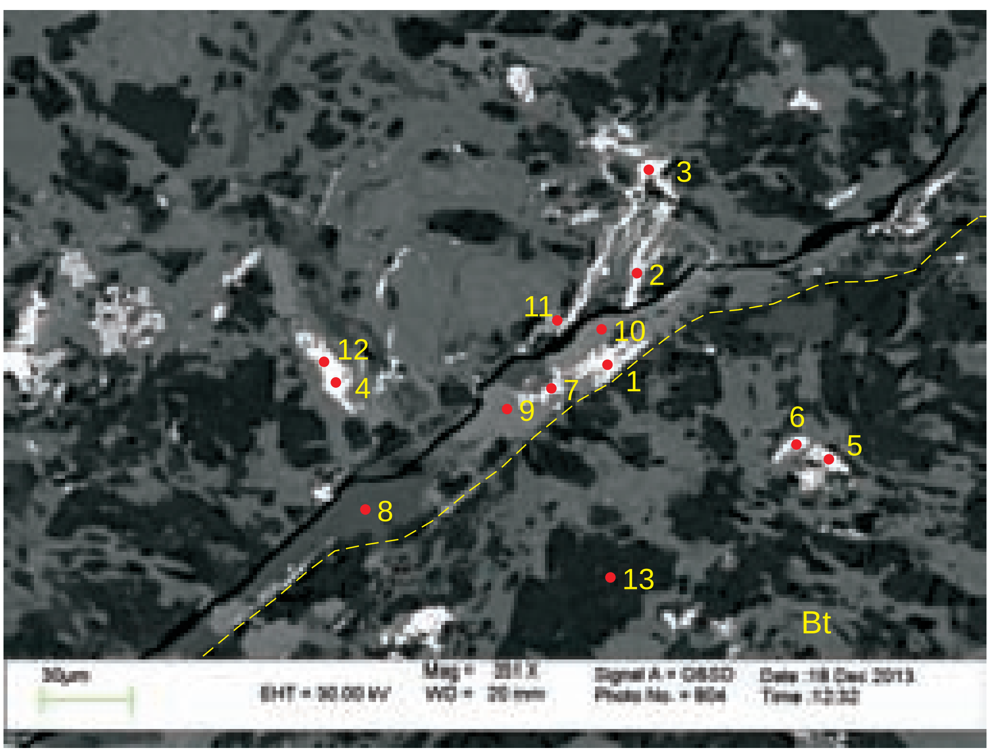
1:TiO_2
2:Chlorite
3:Calcite
4:Calcite
5:Magnetite
6:Magnetite
7:Magnetite
8:Ilmenite
9:Ilmenite
10:Ilmenite
11:Biotite
12:Biotite
13:Albite
14:TiO_2
15:Calcite
16:Quartz

Figure 3-3.2: Sample 7106 site 2; fracture cutting biotite filled with chlorite (analysis 2), TiO_2(analysis 1), and calcite (analyses 3&4). Magnetite present in the host-rock shows exsolution lamellae of ilmenite.



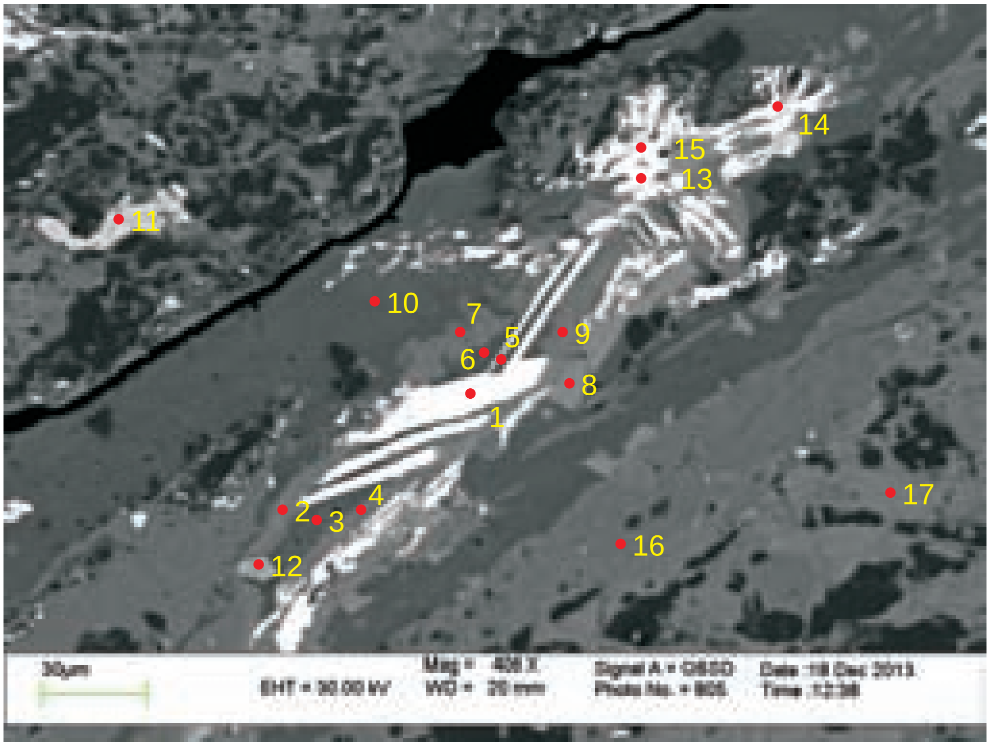
1:Chlorite
2:Chlorite
3:Chlorite
4:Chlorite
5:Calcite
6:Fluorite
7:Fluorite
8:Calcite
9:Synchysite
10:Synchysite
11:Synchysite
12:Ilmenite
13:Synchysite
14:Ilmenite
15:Synchysite
16:Magnetite
17:Fluorite
18:Fluorite
19:Biotite
20:Ilmenite

Figure 3-3.3: Sample 7106 site 3; chlorite-filled vein cut by younger calcite veinlets (analyses 8&5) that contain synchysite-Ce. Magmatic biotite (analysis 19) exsolves ilmenite. Synchysite-Ce crystals in the host-rock (analysis 15).



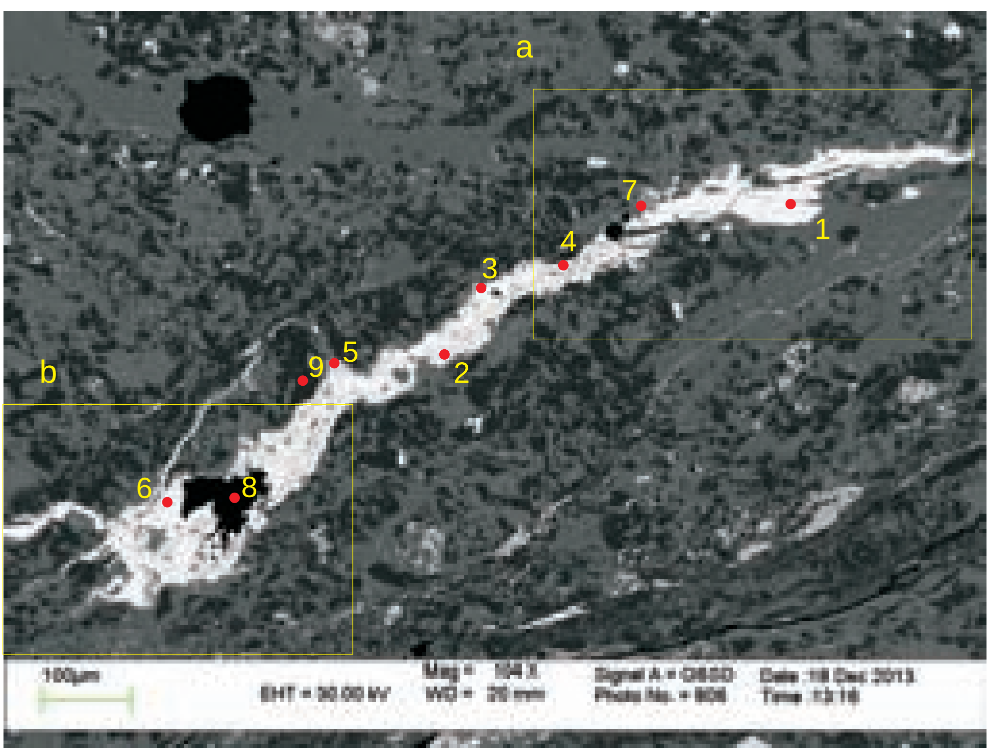
1:Synchysite
2:Synchysite
3:Synchysite
4:Synchysite
5:Synchysite
6:Chlorite-mixture
7:Synchysite
8:Calcite
9:Fluorite
10:Fluorite
11:Ilmenite
12:Synchysite
13:Albite

Figure 3-3.4: Sample 7106 site 4; a calcite-fluorite fracture with synchysite-Ce (analysis 2) cut by a younger barren veinlet. Synchysite appears younger than the calcite (analysis 8) and the fluorite (analyses 8&10).



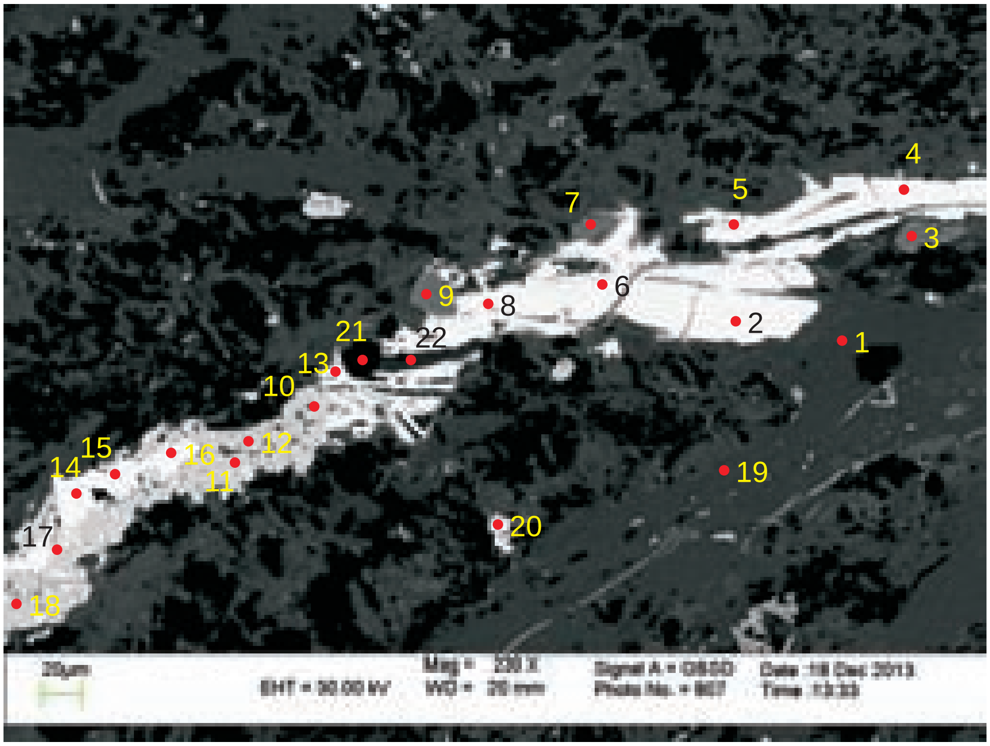
1:Synchysite
2:Chlorite
3:Calcite
4:Chlorite
5:Calcite
6:Calcite
7:mixture
8:Fluorite
9:Chlorite
10:Calcite
11:Ilmenite
12:TiO_2
13:Synchysite
14:Synchysite
15:Synchysite
16:Chlorite
17:Biotite

Figure 3-3.5: Sample 7106 site 5; composite fracture through which different types of fluids have circulated. Partially filled by chlorite (analyses 2,4,&9) that has been penetrated and cut by calcite (analyses 3,5,6&10). Fluorite (analysis 8) and subhedral TiO_2 (analysis 12) post-date the chlorite but not the calcite. Synchysite-Ce (brightest phase) has straight crystal outlines against calcite and fluorite suggesting that it post-dates both minerals.



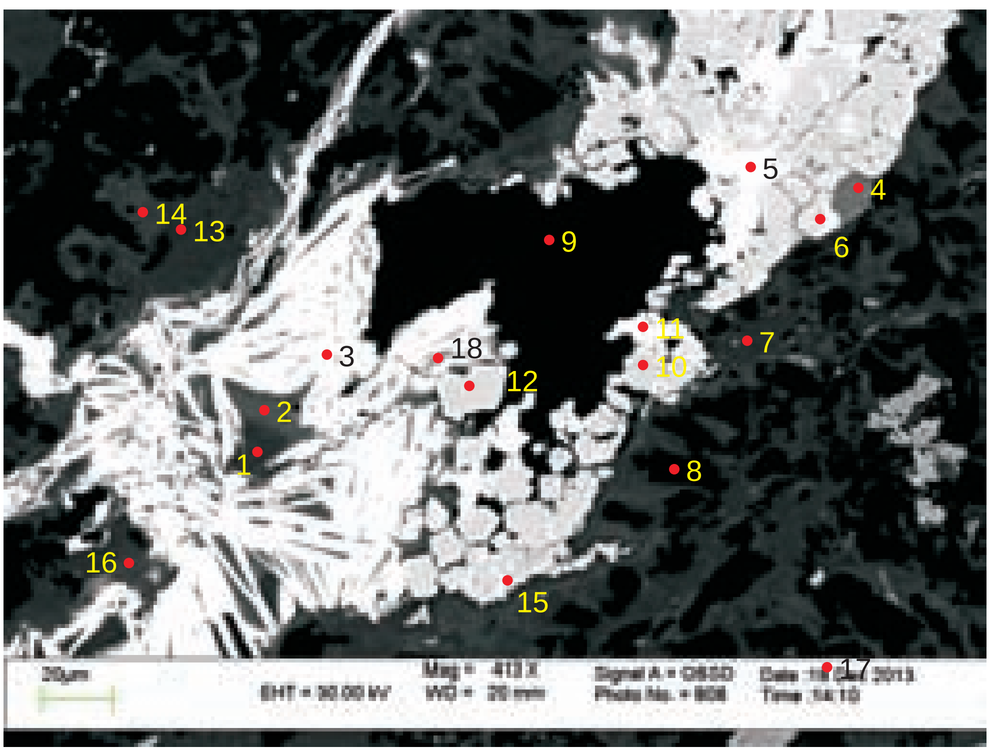
1:Synchysite
2:Pyrite
3:Barite
4:Pyrite
5:Pyrite
6:Synchysite
7:TiO_2
8:hole
9:Albite

Figure 3-3.6: Sample 7106, site of interest 6. Large vein that is marginally filled by synchysite-Ce (a & b), whereas the central part is filled by pyrite and younger barite.



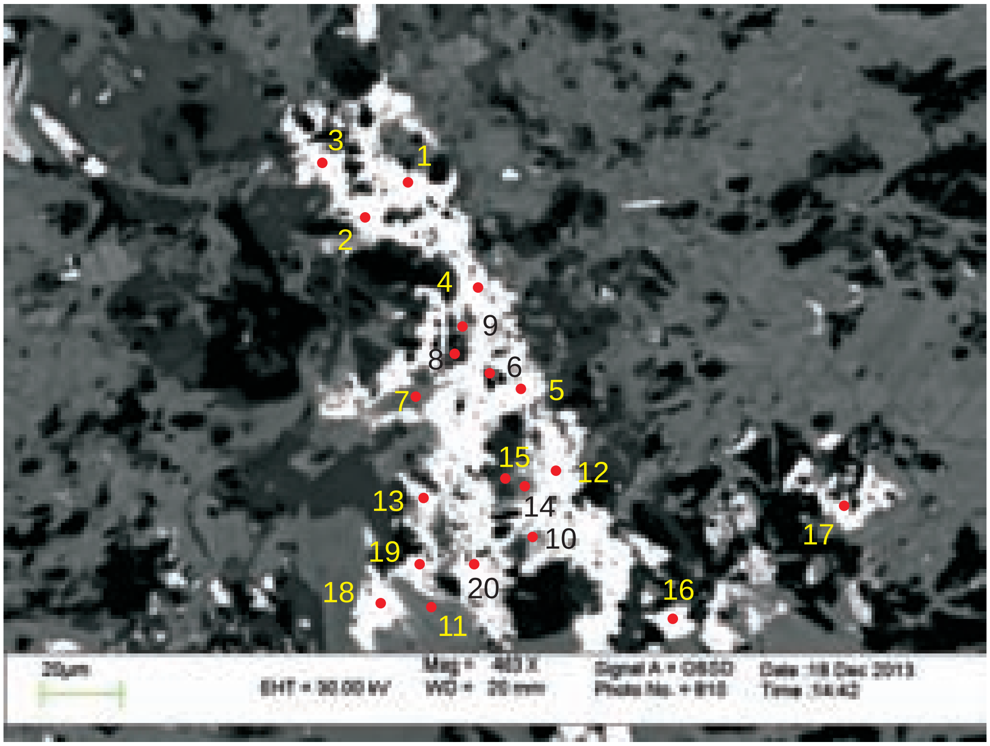
1:Chlorite
2:Synchysite
3:TiO_2
4:Synchysite
5:Synchysite
6:Synchysite
7:TiO_2
8:Synchysite
9:TiO_2
10:Pyrite
11:Pyrite
12:Pyrite
13:Synchysite
14:Barite
15:Barite
16:Barite
17:Pyrite
18:Pyrite
19:Chlorite
20:Synchysite
21:hole
22:Calcite

Figure 3-3.7: Sample 7106 site 7 (a in Fig. 6); pyrite-filled fracture (analyses 10,11,12,14&18) with younger barite (analyses 14,15,&16) penetrating and engulfing pyrite. Synchysite-Ce (analyses 2,4,5,6,8,&13) fills fractures in pyrite, therefore seems to post-date them. Calcite (analysis 22) appears synchronous with synchysite, whereas rutile (analyses 3,7,&9) is a later phase.



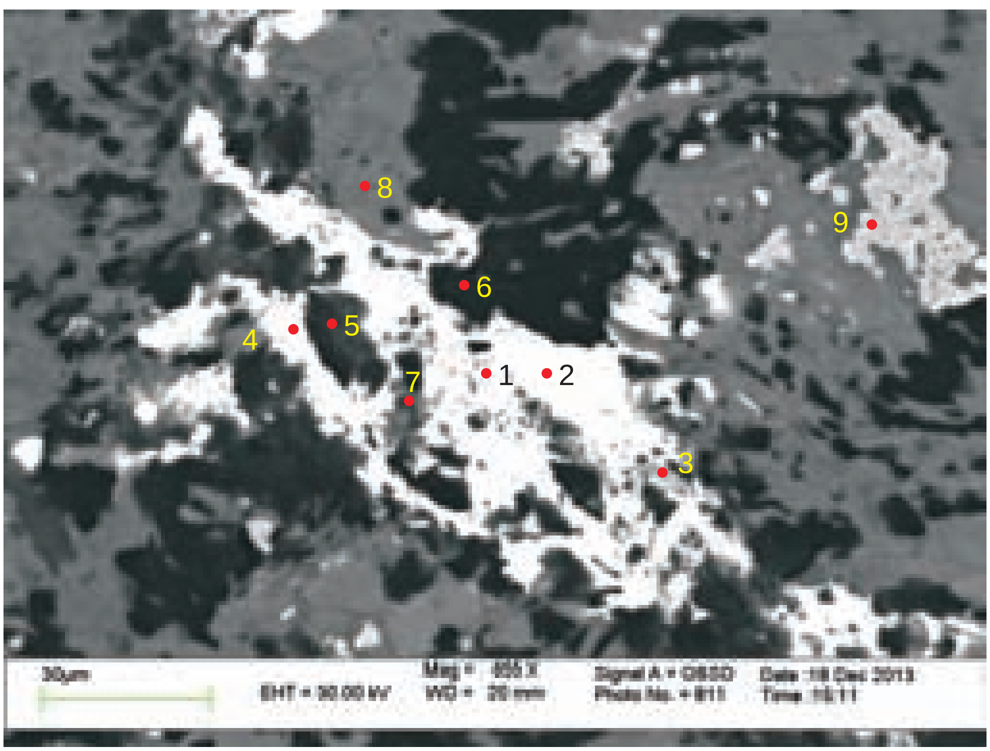
1:Chlorite
2:Fluorite
3:Synchysite
4:TiO_2
5:Barite
6:Pyrite
7:Chlorite
8:Quartz
9:hole
10:Pyrite
11:Barite
12:Pyrite
13:Chlorite
14:Biotite
15:Pyrite
16:Chlorite
17:mixture
18:Fluorite

Figure 3-3.8: Sample 7106 site 8 (b in Fig 6); pyrite-filled fracture with younger barite (analyses 5&11) penetrating pyrite (analyses 6&10). In this part of the fracture, pyrite (analysis 12) seems to post-date synchysite (analyses 3). Chlorite (analyses 1,7,13,&16) is cut by synchysite and pyrite and is the oldest phase in this fracture. TiO_2 (analysis 4) is the youngest, presenting straight crystal outlines against pyrite.



1:Synchysite
2:Synchysite
3:Synchysite
4:Synchysite
5:Synchysite
6:Albite
7:Biotite
8:K-feldspar
9:mixture
10:Biotite
11:Biotite
12:Synchysite
13:Synchysite
14:Biotite
15:K-feldspar
16:Synchysite
17:Synchysite
18:Synchysite
19:Synchysite
20:Synchysite

Figure 3-3.9: Sample 7106 site 9; the upper part of a fracture that is filled with synchysite-Ce (bright phase).



1:mixture
2:Synchysite
3:mixture
4:Synchysite
5:K-feldspar
6:Albite
7:mixture
8:Biotite
9:Ilmenite

Figure 3-3.10: Sample 7106 site 10; lower part of the same fracture as in Fig. 9. Synchysite-Ce (bright phase) cuts through the major rock-forming minerals of the host rock (biotite and feldspar). preserved.

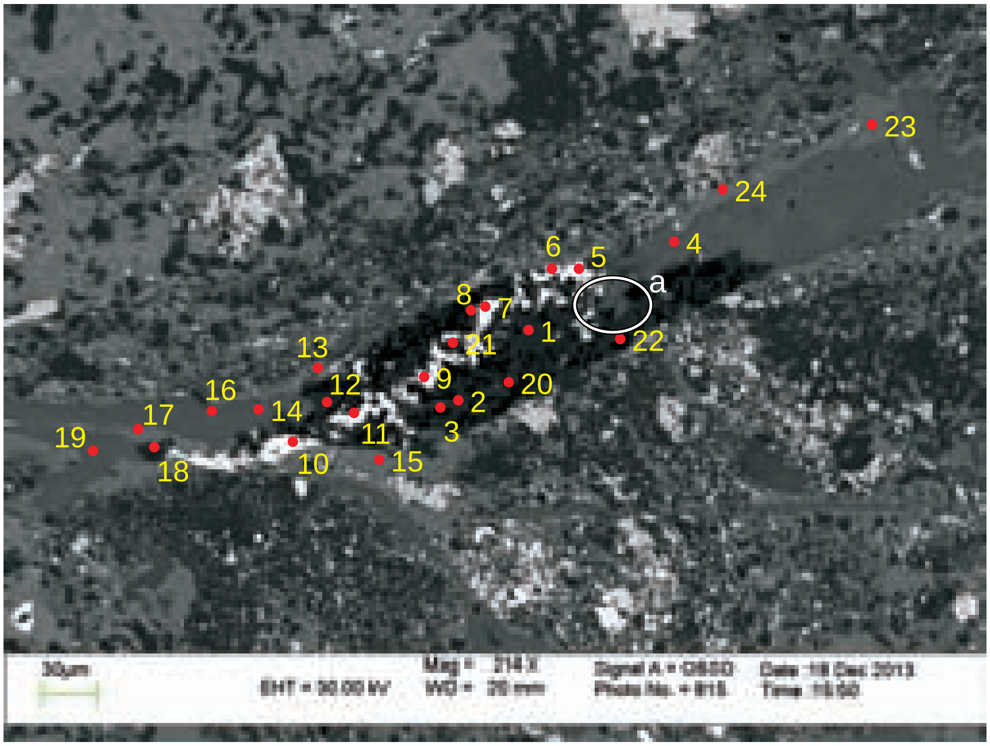


Figure 3-3.11: Sample 7106 site 11; composite fracture with paragenetic sequence: albite➔chlorite➔ calcite & synchysite. The oldest phase is porous and cut by later chlorite (analyses 13&15) and calcite (position a). Chlorite (analyses 23&24) is on margins of later calcite vein (analysis 4). Synchysite (bright phase) cuts chlorite (analysis 15) and fills porosity in albite.

1:Albite
2:Albite
3:Albite
4:Calcite+chl
5:Synchysite
6:Synchysite
7:Synchysite
8:Albite
9:Synchysite
10:Synchysite
11:Synchysite
12:Albite
13:Chlorite
14:Calcite
15:Chlorite
16:Calcite
17:Chlorite
18:mixture
19:Calcite
20:Albite
21:Albite
22:Albite
23:Chlorite
24:Chlorite

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	1	1	Fluorite				0.10			44.77					55.13															100.00
7106	1	2	Fluorite	0.41		0.23				45.57					53.80															100.01
7106	1	3	Calcite				0.25	0.87		53.18					1.70															56.00
7106	1	4	Biotite	38.66	1.32	18.46	24.12	0.19	10.63			6.31				0.31														100.00
7106	1	5	Synchysite	9.12		3.55	3.25		0.88	14.93		0.86			8.36					1.24			8.25	17.94		6.68	0.94			76.00
7106	1	6	Synchysite	21.82		8.25	4.70		3.49	7.54	1.92	1.40			6.42	0.17				0.93			4.67	10.67		4.05				76.00
7106	1	7	Quartz	87.02		0.38	0.89	0.15		11.53																				99.97
7106	1	8	Ilmenite	2.99	60.17	0.76	33.95	0.87		0.85		0.43																		100.02
7106	1	9	Albite	66.08		19.33	1.40			0.84	11.16	1.18																		99.99
7106	1	10	Albite	67.13	0.30	19.33	0.53			1.05	11.49	0.17																		100.00
7106	1	11	Magnetite	0.56			98.60					0.25					0.60													100.01
7106	1	12	Magnetite	6.61	0.32	2.89	84.11		2.32			1.12				0.20	2.44													100.01
7106	1	13	Biotite	38.21	1.77	17.59	22.89	0.19	10.18			7.83				0.77	0.58													100.01
7106	1	14	Fluorite							44.97					55.04															100.01
7106	1	15	Fluorite							44.69					55.31															100.00
7106	2	1	TiO_2	0.56	98.13		1.12			0.21																				100.02
7106	2	2	Chlorite	27.34	0.24	19.90	29.33	0.57	7.11									0.51												85.00
7106	2	3	Calcite				0.98	3.01		51.55						0.46														56.00
7106	2	4	Calcite	1.43		0.86	2.03	2.26	0.48	48.82						0.12														56.00
7106	2	5	Magnetite	3.55	7.77	0.47	71.55			16.64																				99.98
7106	2	6	Magnetite	0.71	8.77		90.52																							100.00
7106	2	7	Magnetite	1.01	8.01	0.70	90.27																							99.99
7106	2	8	Ilmenite	0.58	38.97	0.43	57.93	1.38		0.70																				99.99
7106	2	9	Ilmenite	0.68	54.66		40.09	2.35		2.21																				99.99
7106	2	10	Ilmenite	0.83	48.09		47.10	2.26		1.74																				100.02
7106	2	11	Biotite	39.87	1.97	15.99	21.48		11.06			8.72				0.92														100.01
7106	2	12	Biotite	38.78	0.85	16.87	24.71	0.25	11.13			6.16				0.97		0.26												99.98
7106	2	13	Albite	68.43		19.20	0.23			0.48	11.66																			100.00
7106	2	14	TiO_2	3.66	87.11	2.48	5.31		0.99	0.46																				100.01
7106	2	15	Calcite	2.77		1.83	6.51	2.08	1.11	41.71																				56.00
7106	2	16	Quartz	98.85			0.84					0.31																		100.00
7106	3	1	Chlorite	27.71		19.82	25.96	0.19	11.32																					85.00
7106	3	2	Chlorite	27.31		20.48	28.55	0.49	7.28	0.26								0.60												85.00
7106	3	3	Chlorite	27.84		20.33	28.68	0.53	7.09									0.52												85.00
7106	3	4	Chlorite	27.36		20.27	29.21	0.53	7.11									0.53												85.00
7106	3	5	Calcite	0.90		0.72	2.18	2.82	0.86	48.54																				56.00

* assuming B_2O_3 is an analytical artifact

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	3	6	Fluorite	0.32		0.28	0.67	0.15	0.28	48.23					50.07															100.00
7106	3	7	Fluorite	0.62		0.42	1.00	0.13		44.05					53.80															100.02
7106	3	8	Calcite	0.96		0.50	1.58	2.12	0.95	49.90																				56.00
7106	3	9	Synchysite	3.94		2.47	5.60		1.70	33.02					6.16					1.32			5.92	12.01		3.88				76.00
7106	3	10	Synchysite	14.63		11.32	13.35		6.62	12.58					4.58								3.42	7.03		2.46				76.00
7106	3	11	Synchysite	9.90		7.70	8.97		4.64	13.98					13.03					0.79			4.68	9.03		3.30				76.00
7106	3	12	Ilmenite	12.98	42.97	3.87	34.54	1.21	1.79	0.92		0.77	0.96																	100.01
7106	3	13	Synchysite	17.64		12.55	15.09		7.14	9.26					2.04					0.81			3.12	6.09		2.25				76.00
7106	3	14	Ilmenite	4.09	57.05	1.61	35.01	1.28	0.46			0.53																		100.03
7106	3	15	Synchysite	5.51		2.53	1.57			17.92					9.93					1.71			9.34	19.18		7.30	1.03			76.00
7106	3	16	Magnetite	1.26			97.91					0.82																		99.99
7106	3	17	Fluorite				0.51	0.10		45.36					54.02															99.99
7106	3	18	Fluorite	0.94		0.60	1.71	0.46	0.41	47.06					48.81															99.99
7106	3	19	Biotite	38.89	3.10	15.87	22.56	0.18	9.73			8.47				1.22														100.02
7106	3	20	Ilmenite	7.57	48.82	0.89	39.86	1.82		0.73		0.31																		100.00
7106	4	1	Synchysite	10.31		5.10	5.09		1.51	13.19	1.24				10.65					1.07			7.27	15.22		5.37				76.00
7106	4	2	Synchysite	16.54	3.08	7.58	9.74		4.55	8.34		0.15			6.07								5.27	10.65		4.00				76.00
7106	4	3	Synchysite	11.57		5.72	7.75		3.15	10.84					7.83					1.08			7.29	15.00		5.76				76.00
7106	4	4	Synchysite	4.62		2.70	4.13		1.51	21.97		0.27			10.10					1.33			7.53	15.81		6.03				76.00
7106	4	5	Synchysite	13.97		6.48	3.12			13.41	1.67				8.50								7.14	15.23		5.76	0.73			76.00
7106	4	6	Chlorite	23.88		14.31	13.13		8.89	6.20		0.20											4.62	9.95		3.82				85.00
7106	4	7	Synchysite	5.68	1.59	2.76	4.71		1.22	19.11					22.53								5.05	9.67		3.68				76.00
7106	4	8	Calcite				0.60	1.44		53.96																				56.00
7106	4	9	Fluorite				0.18			45.10					54.72															100.00
7106	4	10	Fluorite	2.33	0.18	0.53	0.72			42.07					54.17															100.00
7106	4	11	Ilmenite	18.91	28.04	6.54	36.01	0.92	3.30	3.11														3.19						100.02
7106	4	12	Synchysite	4.08		2.21	2.55		1.22	18.03		0.43			9.46					1.30			9.35	19.05		7.26	1.08			76.00
7106	4	13	Albite	68.01		19.35	0.37			0.94	11.32																			99.99
7106	5	1	Synchysite							21.12					10.15					2.72			10.60	22.19		8.19	1.03			76.00
7106	5	2	Chlorite	27.31		18.89	27.61	0.52	8.59	1.73								0.36												85.00
7106	5	3	Calcite	1.10		0.83	1.18	2.94	0.66	46.64					2.64															56.00
7106	5	4	Chlorite	25.68		18.05	25.97	0.54	8.23	6.25								0.31												85.00
7106	5	5	Calcite				0.32	0.62		43.25					2.89								2.42	4.65		1.85				56.00
7106	5	6	Calcite	1.05		0.70	2.17	1.91	0.51	49.66																				56.00
7106	5	7	mixture	28.26		18.18	27.49	0.53	10.55	15.01																				100.02
7106	5	8	Fluorite	0.45		0.25	0.24			44.68					54.39															100.01

* assuming B_2O_3 is an analytical artifact

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	5	9	Chlorite	27.40		19.61	27.45	0.49	7.28	2.35								0.42												85.00
7106	5	10	Calcite				0.82	3.01	0.58	51.58																				56.00
7106	5	11	Ilmenite	3.34	56.86	1.76	35.38	1.77	0.70			0.19																		100.00
7106	5	12	TiO_2	1.86	87.39	1.06	3.59		0.50	5.61																				100.01
7106	5	13	Synchysite	4.96		3.15	3.08		1.57	16.67					9.36					2.03			9.04	18.54		6.67	0.93			76.00
7106	5	14	Synchysite	15.70		9.25	11.58		5.52	6.75					6.68								5.48	11.13		3.89				76.00
7106	5	15	Synchysite	9.38		1.95	2.68		0.77	17.12					9.06					1.73			8.49	17.37		6.41	1.04			76.00
7106	5	16	Chlorite	31.06	0.17	17.80	22.95	0.16	10.43			2.02				0.22														85.00
7106	5	17	Biotite	36.62	0.75	18.59	27.05	0.32	9.80			5.41				1.22		0.24												100.00
7106	6	1	Synchysite							21.02					10.47					2.24			10.86	22.01		8.37	1.04			76.00
7106	6	2	Pyrite	0.19			27.41				0.26			71.87					0.29											100.02
7106	6	3	Barite				0.42			0.55				38.35								60.67								99.99
7106	6	4	Pyrite	0.34			27.88							71.79																100.01
7106	6	5	Pyrite	0.13			27.57							72.29																99.99
7106	6	6	Synchysite							21.23					15.99					3.12			9.03	17.83		7.55	1.24			76.00
7106	6	7	TiO_2	1.09	95.70	0.72	1.92			0.59																				100.02
7106	6	8	hole				15.49									84.51														100.00
7106	6	9	Albite	67.47		19.63	0.42			0.92	11.45	0.12																		100.01
7106	7	1	Chlorite	27.22		20.08	25.08	0.14	11.77			0.59				0.13														85.00
7106	7	2	Synchysite							20.41					10.00					2.54			11.13	22.53		8.11	1.28			76.00
7106	7	3	TiO_2	0.60	97.75		1.30			0.36																				100.01
7106	7	4	Synchysite							20.54					10.21					2.36			11.20	22.31		8.29	1.10			76.00
7106	7	5	Synchysite	1.41		0.95	0.45			26.01					12.24					1.69			8.51	17.21		6.55	0.97			76.00
7106	7	6	Synchysite							20.35					16.74					2.53			9.23	18.76		7.36	1.03			76.00
7106	7	7	TiO_2	0.71	97.76	0.34	0.86			0.32																				99.99
7106	7	8	Synchysite							24.98					12.97					3.29			8.72	17.88		7.20	0.97			76.00
7106	7	9	TiO_2	0.60	98.28		0.64			0.50																				100.02
7106	7	10	Pyrite				27.92							72.09																100.01
7106	7	11	Pyrite				27.75							72.24																99.99
7106	7	12	Pyrite	0.26			27.88							71.87																100.01
7106	7	13	Synchysite	0.83			5.32			20.52					9.97					3.34			9.42	19.02		7.58				76.00
7106	7	14	Barite	1.01		0.64	0.99			0.38	0.42			36.41								60.19								100.04
7106	7	15	Barite	1.03		0.76	3.52			0.48				36.51								57.72								100.02
7106	7	16	Barite	0.79			0.98			0.27				37.86								60.13								100.03
7106	7	17	Pyrite	0.41			27.50							70.92								1.17								100.00
7106	7	18	Pyrite				27.66							72.34																100.00

* assuming B_2O_3 is an analytical artifact

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	7	19	Chlorite	27.46		20.09	25.50	0.16	11.50			0.29																		85.00
7106	7	20	Synchysite	7.14		2.83	1.34			20.01					14.82								7.80	15.84		6.24				76.00
7106	7	21	hole	9.22			7.81			13.50						46.57					22.91									100.01
7106	7	22	Calcite				0.38	1.96		50.92					1.93									0.82						56.00
7106	8	1	Chlorite	29.58		15.06	24.25	0.22	13.22	1.90														0.77						85.00
7106	8	2	Fluorite	0.36		0.32	0.13			44.77					54.41															99.99
7106	8	3	Synchysite	2.75		2.30	1.19		1.47	21.01					10.72					2.36			8.76	17.26		7.11	1.09			76.00
7106	8	4	TiO_2	1.67	94.45	0.51	2.69							0.67																99.99
7106	8	5	Barite*				1.08			0.38				23.80								39.31							35.46	100.03
7106	8	6	Pyrite	0.43			27.93							70.04														1.61		100.01
7106	8	7	Chlorite	28.93		19.14	24.58		10.37		1.58	0.26				0.13														85.00
7106	8	8	Quartz	98.62		0.36	0.54		0.25			0.22																		99.99
7106	8	9	hole													100.00														100.00
7106	8	10	Pyrite	0.13			27.57							72.32																100.02
7106	8	11	Barite	0.94		0.77	3.24			0.81				40.00								54.22								99.98
7106	8	12	Pyrite	0.15			27.39			0.10				72.37																100.01
7106	8	13	Chlorite	27.66		19.95	25.30		11.71			0.26				0.14														85.00
7106	8	14	Biotite	38.91	1.08	17.38	24.28	0.25	10.99			6.36				0.75														100.00
7106	8	15	Pyrite	3.12		1.91	28.77		0.90					64.90					0.40											100.00
7106	8	16	Chlorite	29.21	0.36	18.44	26.27	0.42	7.74	0.31		1.60				0.26		0.43												85.00
7106	8	17	mixture	41.63		14.27	6.32		1.56	15.32	8.26	0.67	11.98																	100.01
7106	8	18	Fluorite				0.72			35.02				0.65	48.74					0.85			3.74	7.06		3.23				100.01
7106	9	1	Synchysite	8.66	2.71	3.60	4.67		1.38	7.58		0.30			9.31								10.23	20.27		7.27				76.00
7106	9	2	Synchysite	10.39	2.52	5.40	5.47		2.78	5.97		0.46			8.78								9.58	18.38		6.25				76.00
7106	9	3	Synchysite	12.19		5.02	2.86		1.38	4.54		0.68			9.92					1.55			9.10	20.88		7.87				76.00
7106	9	4	Synchysite	19.61	4.84	7.41	7.43		2.90	3.30	2.24	0.27			7.01									13.07	2.34	4.77	0.81			76.00
7106	9	5	Synchysite	11.46	5.15	5.15	8.29		1.99	5.03		0.31			10.07								7.62	15.27		5.68				76.00
7106	9	6	Albite	56.05		16.00	1.42			3.36	9.76	0.63			2.69								2.25	5.66		2.18				100.00
7106	9	7	Chlorite	35.35	1.73	14.55	15.39		8.84	0.92	0.39	4.67				0.65								1.85		0.67				85.00
7106	9	8	K-feldspar	58.51	0.37	17.14	1.81		0.45	1.15	6.04	7.75			0.83								1.60	3.17		1.18				100.00
7106	9	9	mixture	49.61	0.97	15.10	1.67		0.51	2.63	4.99	4.25			1.91								4.56	9.91		3.92				100.03
7106	9	10	Chlorite	30.33	2.38	13.22	10.80		6.83	0.95	2.58	3.05				0.38							3.92	7.82		2.75				85.00
7106	9	11	Biotite	38.61	1.25	18.56	24.43	0.21	10.73			5.46				0.76														100.01
7106	9	12	Synchysite	14.80	3.11	8.63	10.15		4.04	2.90		0.36			6.04								6.90	14.23		4.86				76.00
7106	9	13	Synchysite	17.07		8.17	7.07		4.12	5.69		1.03			7.50	0.20							6.12	13.98		5.05				76.00
7106	9	14	Biotite	36.43	1.93	15.72	16.88		9.70	0.84	0.66	5.93				0.72							3.05	6.07		2.06				99.99

* assuming B_2O_3 is an analytical artifact

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	9	15	K-feldspar	49.69	1.98	17.35	10.57		4.26	0.84	7.21	4.50				0.19								2.46		0.94				99.99
7106	9	16	Synchysite	5.27		1.92				18.77					9.55					1.25			9.85	20.54		7.49	1.35			76.00
7106	9	17	Synchysite	21.25		7.01	4.01			10.66	2.76	0.42			8.78					1.00			5.12	10.72		4.28				76.00
7106	9	18	Synchysite	17.20		6.57	0.68		0.71	12.18	4.07	0.22			4.69								7.36	15.75		5.88	0.71			76.00
7106	9	19	Synchysite	10.73		6.25	3.56		3.01	9.52		0.36			7.40					1.29			8.34	18.29		6.51	0.74			76.00
7106	9	20	Synchysite	9.39		4.20	2.63		1.54	7.99		0.40			10.40								9.22	21.49		7.77	0.99			76.00
7106	10	1	mixture	33.99	12.93	4.27	6.95		0.83	2.95	2.22				11.70									16.67		6.28	1.21			100.00
7106	10	2	Synchysite	3.78		1.85	2.21			13.37					10.15					1.17			11.15	24.08		8.22				76.00
7106	10	3	mixture	35.51	1.40	2.57	3.60		1.36	19.73		0.35	20.69		7.29									5.48		2.01				99.99
7106	10	4	Synchysite	11.56		3.86	0.36			9.29	1.42	0.87			9.49					1.29			9.23	20.06		7.69	0.87			76.00
7106	10	5	K-feldspar	65.91	0.27	18.52	0.63			0.53	6.93	6.70												0.53						100.02
7106	10	6	Albite	67.60		19.50	0.51			1.04	11.12	0.20																		99.97
7106	10	7	mixture	51.49	0.77	16.70	10.82		5.02	0.81	3.99	4.72				0.31							1.45	2.99		0.90				99.97
7106	10	8	Chlorite	35.10	1.34	13.69	17.39		8.95			7.41				1.14														85.00
7106	10	9	Ilmenite	6.20	51.59	2.10	36.39	1.05	0.90	0.21		1.58																		100.02
7106	11	1	Albite	69.18		18.80					12.01																			99.99
7106	11	2	Albite	68.97		18.84	0.14				12.07																			100.02
7106	11	3	Albite	68.80		22.22	1.72		1.89	0.46	4.06	0.86																		100.01
7106	11	4	Calcite	1.16		0.49	1.66	1.27	0.45	50.97																				56.00
7106	11	5	Synchysite	8.50		2.61	0.31			20.64	1.97				10.45					1.79			7.33	15.41		6.22	0.77			76.00
7106	11	6	Synchysite	18.11	2.07	5.41	3.47		0.53	10.89	3.15				8.63								6.14	12.45		5.12				76.00
7106	11	7	Synchysite	5.64		1.85				18.52					10.52					2.26			9.53	19.18		7.33	1.15			76.00
7106	11	8	Albite	67.47		18.71	0.24			0.84	11.90	0.13												0.70						99.99
7106	11	9	Synchysite	9.69		3.36				16.41	1.54				9.22					1.79			8.77	17.18		6.82	1.25			76.00
7106	11	10	Synchysite	11.49		7.84	11.08		4.51	11.87					5.75					0.99			5.71	11.64		4.32	0.79			76.00
7106	11	11	Synchysite	11.93		3.97	0.58			15.45	1.17				9.85					2.14			8.06	15.98		6.06	0.81			76.00
7106	11	12	Albite	68.15		18.59	0.21			1.30	11.76																			100.01
7106	11	13	Chlorite	33.11	0.78	17.70	22.18	0.19	10.00	0.13		0.75				0.16														85.00
7106	11	14	Calcite				0.66	0.81		52.09				2.45																56.00
7106	11	15	Chlorite	27.90		19.47	25.46	0.21	11.56			0.29				0.14														85.00
7106	11	16	Calcite	0.42			0.41	0.72		53.96				0.49																56.00
7106	11	17	Chlorite	26.02		17.09	22.47	0.30	10.94	8.19																				85.00
7106	11	18	mixture	57.27		17.80	1.30	0.17	1.09	14.36	7.77	0.26																		100.02
7106	11	19	Calcite				0.68	1.21		54.12																				56.00
7106	11	20	Albite	67.66		21.75	2.57		2.34	0.62	4.02	1.05																		100.01
7106	11	21	Albite	68.58		18.97	0.33			0.28	11.84																			100.00

* assuming B_2O_3 is an analytical artifact

Table 3-3: EDS analyses from sample 7106

Sample	Site	Pos.	Mineral	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	SO_3	F	Cl	Cr_2O_3	ZnO	As_2O_3	Y_2O_3	SnO_2	BaO	La_2O_3	Ce_2O_3	Pr_2O_3	Nd_2O_3	Gd_2O_3	PbO	B_2O_3	Total
7106	11	22	Albite	68.22		21.05	1.74		1.94	0.52	5.72	0.82																		100.01
7106	11	23	Chlorite	29.16	1.46	17.33	24.13	0.27	11.52	0.90		0.20																		85.00
7106	11	24	Chlorite	28.70	0.72	18.73	24.99	0.19	11.16	0.35		0.19																		85.00

* assuming B_2O_3 is an analytical artifact

Appendix 4: Sample 9877

Steps to identify the mineral phases present in a fine-grained mixture of hydrothermal paragenesis, from EDS mineral analyses, that filled dissolution voids of various sizes, coated grains in breccia of fracture zones, or coated magmatic minerals.

1.) The major component of mixture was an Fe-oxyhydroxide phase (nomenclature after Bau, 1999) that we abbreviated to "Fe-oxide" throughout the thesis.

2.) CuO was balanced with SO_3, assuming a composition of chalcopyrite. Leftover SO_3 was assumed to be part of pyrite. The still leftover CuO was assumed to be part of additional Cu mineral (e.g. chalcocite, copper oxide, native copper). Elsewhere in the sample, chalcopyrite engulfs pyrite.

3.) Al_2O_3 was balanced with SiO_2, assuming a chlorite composition based on pure analysis found elsewhere in the sample. Leftover SiO_2 was assumed to be free silica (e.g. quartz).

4.) Still leftover Al_2O_3 was assumed to be part of an aluminum-phosphate, if P_2O_5 was detected. No CaO was detected to suggest that apatite group minerals were present. If no P_2O_5 was detected, leftover Al_2O_3 was assumed to be part of some other Al mineral.

Paragenesis: Fe-oxide + pyrite + chalcopyrite + aluminum-phosphate + chlorite + quartz. This is a common mineral association in mineralized areas.

Appendix 5

Tentative steps to identify Nb-Ti-Y-REE minerals

Chemistries of minerals in question, most resemble those of the pyrochlore supergroup, aeschynite group, euxenite group, samarskite group, and fergusonite group (table 1). The proportion of B-site to A-site cations were calculated (figure 1) using compositional constraints from the literature (table 1). Calculated B:A ratios were then compared to those of the literature to identify species.

A number of issues arise using this method. Firstly, the pyrochlore supergroup minerals have crystallographic vacancies in their A-site, allowing the B:A site ratios to range from 1-6.67, as observed in hydrothermal specimens (Lumpkin, 1995). Secondly, some elements appear in both the A-site and the B-site of crystals; Fe in euxenite and aeschynite; Ti in Samarskite. Calculations assumed Fe and Ti to be in the A- and B-sites, respectively. This is turn may have led to an over-calculation of B:A ratios in samarskite and an under-calculation in euxenite and aeschynite.

Due to both the semi-quantitative nature of EDS analyses and the uncertainty in cation sites, ABO_4 type minerals included B:A ratios ranging from 0.9 - 1.4. Likewise, AB_2O_6 type-minerals included B:A ratios ranging from 1.4 - 2.2. Analyses with B:A ratios greater than 2.2 were considered pyrochlore (Figure 1). ABO_4-type minerals are either samarskite or fergusonite. Fergusonite was excluded based on the presence of Fe,Ti, Ca, U, or Th. Otherwise these two minerals could not be distinguished. AB_2O_6-type minerals are either aeschynite or euxenite. However, these two minerals are polymorphs, and hence, can not be distinguished by EDS data alone. Analysis with B:A ratios less than 0.9 appear to be a result of contamination from surrounding grain that contains Fe - which was incorporated into the analysis.

Table 5.1: Chemical compositions of Nb-Ti-Y-REE minerals.

	Pyrochlore Supergroup (isometric)	**Aeschnyite Group (othorhomibc, Pbnm)**	**Euxenite Group (orhorhombic, Pcan)**	**Samarskite Group (monoclinic)**	**Fergusonite Group (monoclinic & tetragonal)**
Formula	$A_{2-m}B_2X_{6-w}Y_{1-n}$•p(H_2O)	AB_2O_6		ABO4	ABO4
A-site	Y, REE's, Sc, Na, Ca, Mn, Fe^{2+}, Sr, Sb, Cs, Ba, Pb, Bi, Th, U	REE's, Fe^{2+}, Mn, Ca, Th, U, Pb		Y, REE, Ca, Th, U, Fe^{2+}, Ti	Y, REE's
B-site	Nb, Ta, Ti, Al, Fe^{3+}, Zr, Sn, W	Nb, Ta, Ti, Fe^{3+}		Ta, Nb, Ti	Nb, Ta
Vacancies	m=0-1.7, w=0-0.7, n=0-1, p=0-2	-		-	-
B:A site ratio	1-6.67	2		1	1
References	(Lumpkin, 1995)	(Ewing, 1976)		(Warner & Ewing, 1993)	(Ercit,2005)

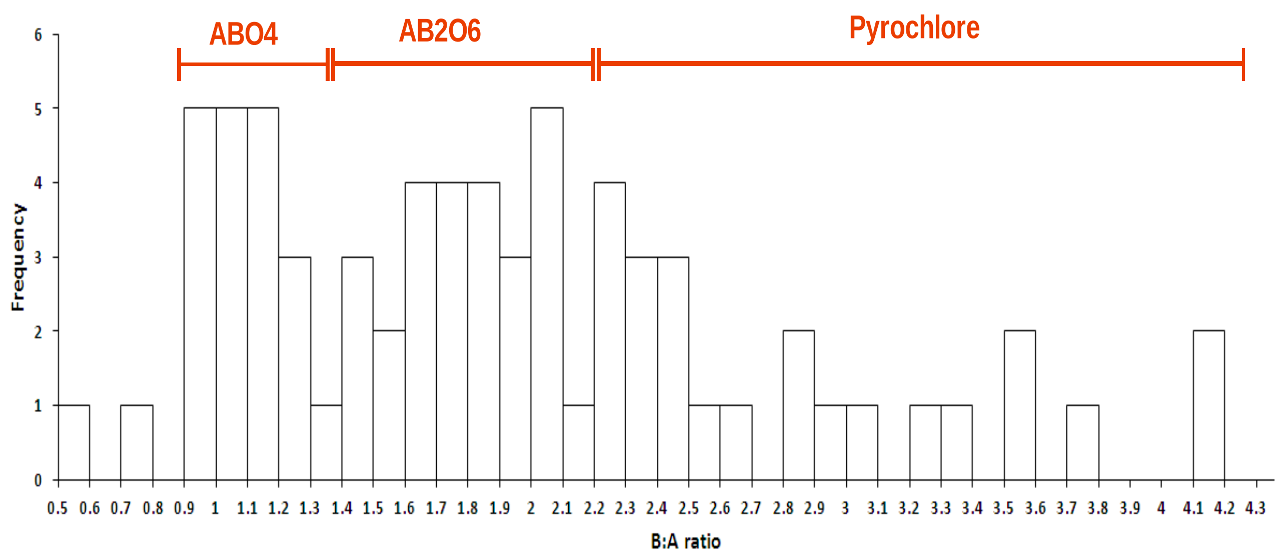


Figure 5.1: Ratios of B:A-sites calculated from EDS analysis of Nb-Ti-Y-REE minerals. Assumed mineral group, based off ratio, are superimposed at the top.