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Report 100837

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Samples:

Eight rock samples, as detailed below, were submitted by Robert Boyd, President and CEO of Endurance Gold Corp., with a request for petrographic study.

N.	*ID1*	Lithology
1	478704	Hornfelsed siltstone and Albite-quartz-monazite-zircon-pyrite vein.
2	478706	Fenite
3	478707	Fenite
4	478708	Brecciated Fenite and siltstone
5	478711	Silicified brecciated mudstone(?)
6	478712	Silicfied fenite(?)
7	478713	Brecciated siltstone and quartz-sericite-hematite cataclasite
8	478714	Brecciated siltstone and quartz-rich cataclasite

Summary:

The samples originated from the same source area as the samples already undergone petrographic analysis and are described in the reports 100896 and 100742.

The samples represent a cataclastic margin of sedimentary rock (1, 4, 5, 7 and 8) with local evidence of contact metamorphism (sample 1). The infill material of the veins crosscutting the sedimentary rocks is generally composed of quartz with various amounts of albite, monazite, zircon, pyrite (generally substituted by hematite), sericite and possibly annabergite.
Samples 2, 3, 4, and 6 represent a locally silicified (sample 6) and brecciated (sample 4)

fenite.

Trace amounts of monazite and zircon are recognized in sample 1. Zircon may also be present in sample 6. In the rest of the samples the very fine-grained nature of most of the pseudomorphosed material does not allow the recognition of the mineralogy that may be accountable for the high values of REE.

The highest values of Nickel appears to be related to the periphery of the alteration zone. Hematite is the most common opaque mineral with trace amounts of pyrite in samples 5, 6 and 7.

The high values of Nickel (from 7.0 - 15.8% in samples 5 through 8) and the absence of opaque minerals leads to the conclusion that the nickel is likely contained in the unidentified, very fine-grained transparent mineral with high refractive indices. It has a dark grey colour in plane-polarized transmitted light and a reflectance of about 10 in plane-polarized reflected light. This mineral should be determined by X-ray diffractometry as it is irresolvable by the microscope.

Respectfully submitted

F. Colombo, Ph.D., P.Geo.

Sample: 478704

Hornfelsed siltstone

Albite-quartz-monazite-zircon-pyrite vein.

The sample consists of a layered hornfelsed siltstone crosscut by quartz-albite veins.

The siltstone displays a well-defined bedding with lighter bands of clay-rich material and submillimetric bands with coarser-grained quartz, albite, white mica and chlorite.

The veins crosscut the bedding at a low angle (~15°) and are composed of albite, quartz and trace amounts of monazite and pyrite. The edges of the veins are characterized by tabular to columnar crystals of albite oriented perpendicularly to the vein walls.

mineral	***modal %***	***main size range (mm)***
Hornfelsed (?) siltstone	60	<0.04
clay	35 - 37	
quartz	8 - 10	
white mica	3 - 5	
chlorite	1	
veins	***40***	
albite	30 - 33	up to 0.4
quartz	5 - 7	up to 0.4
hematite	2 - 4	~0.1
pyrite	1	
monazite	1	
zircon?	tr	
fluorite	tr	

The **siltstone** shows a planar parallel bedding defined by lighter clay-rich layers (~1 mm thick) and light-brown plurimillimetric layers containing very fine-grained minerals, among which quartz, white mica,and chlorite are locally recognized. Quartz is the only mineral that reaches 0.1 mm in size and it occurs as subrounded to subangular clasts dispersed in finer-grained matrix. The lighter layers are characterized by amoeboid to rounded domains up to 0.1-0.2 mm with an increased amount of very fine-grained (less than 0.002 mm) clay minerals, possibly produced during a contact metamorphic event.

Vein

Albite crystallizes perpendicularly to the vein walls as tabular to columnar subhedral crystals up to 0.4 mm in length. Within the rest of the vein randomly oriented, subhedral tabular to amoeboid crystals of up to 0.5 mm in length occur interlobated with quartz.

Quartz occurs rarely within interstitial domains, and is probably infilling irregular cavities

among albite crystals. Within the quartz, cubic crystals (up to 0.04 mm) of fluorite are recognized by their low refractive indices. Quartz is preferentially associated with the occurrence of skeletal crystals of monazite and zircon, all ranging in size from 0.1 to 0.2 mm. Quartz also occurs in the interstices of polycrystalline aggregates of an unidentified mineral with high refractive indices and high birefringence, which reaches 0.4 mm in size.

Pyrite is partially replaced by hematite and goethite(?). A few relicts of pyrite display cubic habits. Limonitic materials generally occur along fractures and originate at the oxidized pyrite crystals.

Sample: 478706

Fenite

The sample is dominated by replacement structures with idioblastic, tabular plagiocalse (albite) and interstitial cryptocrystalline aggregates occuring as an “intergranular-like” microstructure. There are rare interstitial domains containing quartz. Pseudomorphs of very fine-grained white mica, (possibly replacing nepheline?) and are unevenly distributed within the sample.

mineral	*modal %*		*main size range (mm)*
K-feldspar	35	-	up to 2.5
albite	25	-	up to 2.5
(nepheline?): white mica	13	-	up to 0.1
cryptocrystalline material	10		<0.002
kaolinite	7		<0.002
quartz	4		
hematite-limonite	3		
zircon	1		
pyrite	tr		

The **K-feldspar** occupies interstitial positions with respect to the sericite-rich pseudomorphs. K-feldspar is xenoblastic and intergrown with **plagioclase** laths. Both feldspars were possibly crystallized during a high temperature metasomatic event. When they are idioblastic or subidioblastic they can reach 2-2.5 mm in length. The feldspathic domain is locally substituted by a very fine-grained aggregate of clay (kaolinite?).

Subrounded to amoeboid **pseudomorphs**, possibly after nepheline, up to 2.5-3 mm are made up of **white mica** (sericite), which is is very fine-grained, generally smaller than 0.002 mm in size, with rare flakes reaching 0.1 mm.

Quartz possibly crystallized during the late stage of the alteration event. It occurs as quartz-rich, irregular domains, occasionally displaying polygonal crystal habits and, in few instances, are mantled by hematite. Quartz occurrences are more abundant within the clay altered patches of the sample.

Within the feldspars there are abundant, fine-grained (less than 0.02 mm) inclusions of xenoblastic grains of an unknown mineral with high refractive indices. The same cryptocrystalline aggregate occupying the interstices among feldspar laths, described above, forms irregular feldspar-free domains possibly representing pseudomorphs.

Sample: 478707

Fenite

Three domains with different compositions are recognized within this sample:

The first domain, in the upper left corner of the thin section, is mostly composed of hematite with rare relicts of pyrite. Pseudomorphs of sericite, up to 0.5 mm, are dispersed within this oxidized domain.

A second domain is made up of acicular crystals, completely pseudomorphed and substituted by quartz, and smaller amoeboid to subhedral pseudomorphs of sericite, immersed in a very fine-grained matrix of clay.

The rest of the rock is made up of randomly oriented, coarse-grained, subhedral, tabular K-feldspar and an interstitial, cryptocrystalline aggregate irresolvable by the microscope. Different amount of hematite and limonitic material subdivide the coarser part of the sample in two different subdomains.

mineral	*modal %*		*main size range (mm)*
K-feldspar	50	-	up to 4
cryptocrystalline material	20	-	up to 3 mm
white mica	12	-	<0.002
albite	12		up to 4
hematite-limonite	10		up to 0.2
kaolinite	5		<0.002
zircon	1		~0.01
pyrite	tr		~0.01

K-feldspar is subhedral and reaches 4 mm in length. Most of the tabular crystals display an overgrowth edge of albite. The K-feldspar is moderately altered by a dusty dispersion of irresolvable minerals (possibly clay). The K-feldspar contains abundant inclusions of hematite. The intergranular spaces between the feldspathic laths are, in most instances, occupied by a cryptocrystalline aggregate, which, in the lower part of the section, hosts hematite and limonitic material, and gives the subdomain a brownish appearance.

The sample contains abundant **cavities** rimmed by sericite, hematite and cryptocrystalline material. Minor clay (kaolinite?) is also observed in an interstitial position between K-feldspar laths.

Pyrite is rare, skeletal and rimmed by hematite indicating that pyrite is at least one of the possible sources of the locally abundant hematitic and limonitic material in this sample.

Sample: 478708

Brecciated Fenite and siltstone

The sample consists of layered siltstone interbedded with sandstone (2 mm thick). Quartz is an abundant constituent of both the siltstone and sandstone, other constituents could not be recognized because of their very fine grain-size.

The sedimentary rock is crosscut by a breccia with rounded lithic fragments, mostly made up of tabular euhedral albite, chlorite and an interstitial microcrystalline material. The matrix of the lithic fragments displays the same composition as the fragments but the albite is xenoblastic and locally cataclastic.

mineral	*modal %*	*main size range (mm)*
fenite	***70***	
albite	50 - 55	0.1-1.4
chlorite	5 - 7	up to 0.1
cryptocrystalline material	3 - 5	<0.002
hematite	8 - 10	up to 4
(pyrite): hematite	1	up to 0.8
pyrite	tr	up to 0.02
turmaline	tr	
apatite	tr	
siltstone	***30***	

Albite is generally euhedral and forms tabular crystals from 0.1 to 0.4 mm in length with rare phenocrysts up to 1.5 mm. Albite is randomly oriented and the interstices of the tabular crystals are occupied by chlorite and a microcrystalline aggregate irresolvable by the microscope. Albite is generally fresh and contains only very rare and very fine-grained dispersions of white mica. Where the size of the albite increases, also the microcrystalline aggregate increases in abundance.

Hematite is possibly associated with the cataclastic matrix of the breccia and mostly crystallized after the deformation as agglomerated lamellae with a very high aspect ratio (1:10 or higher) as irregular thin (0.1-0.2 mm thick) veinlets and as a replacement of a possibly octahedral mineral .

Very fine-grained (up to 0.02 mm) euhedral **pyrite** are observed as inclusions within the platy crystals of hematite and as skeletal fragments within the goethite replaced octahedra.

Sample: 478711

Silicified brecciated mudstone(?)

The sample represents a very fine-grained, intensely silicified and brecciated lithology (mudstone?). Quartz constitutes most of the rock fragments, their fringes and the infill of the breccia. Hematite and limonitic material are associated with quartz within the infill and locally define triangular microstructures.

mineral	*modal %*	*main size range (mm)*
quartz	75 - 80	0.01-0.2
hematite+limonite	15 - 20	up to 0.5
pyrite	tr	0.07
mudstone rock fragments	***10***	

Quartz grain-size varies from 0.01 mm in the very fine-grained silicified portion of the rock, to 0.04 mm in the matrix, which contains more abundant hematitic and limonitic infill and up to 0.2 mm within cavities, triangular infill structures and vein-like domains, which are partially to completely infilled by quartz. In its finer grain size quartz occurs as amoeboid equigranular aggregates. In its coarser variety it displays locally idioblastic face terminations, particularly noticeable where the crystals are projecting towards the centre of the partially filled cavity. Some syntaxial vein-like microstructures show the quartz assuming prismatic to columnar shapes with lengths up to 0.4 mm elongated perpendicularly to the vein walls. Coarser quartz crystals are generally associated with irregular to interstitial **limonitic** to **hematitic** aggregates indicating that the hematite-rich infill possibly occurred during the latest phases of the quartz crystallization and therefore at the very end of the brecciation process.

Only one xenoblastic relict of **pyrite** (0.07 mm) is observed and is found within a coarse quartz-hematite-rich domain.

Cavities, up to 2 mm, are present within the sample along with a limited number of small rock fragments, from submillimetric to centimetric in size. These fragments have a negligible degree of silicification and are interpreted to be fragmented mudstone, however no mineral phases are recognized due to their extremely fine grain size.

Sample: 478712

Silicfied fenite(?)

The sample is dominated by replacement microstructures with local patches of xenoblastic K-feldspar. Most of the sample was moderately to intensely altered by sericite and minor chlorite, and was later brecciated and crosscut by quartz-rich veins and veinlets. It contains abundant amoeboid microcrystalline aggregates.

mineral	*modal %*	*main size range (mm)*
K-feldspar	40 - 45	up yo 1 mm
quartz	20 - 25	up to 0.5
HR microgranular mineral	15 - 18	0.002-0.004
white mica	10 - 12	<0.002 up to 0.2
limonite	5 - 7	
chlorite	5 - 6	~0.1
Bi(?)	tr	
pyrite	tr	0.15
apatite	tr	

The fenite is constituted by a xenoblastic aggregate of relict K-feldspar, patchy aggregates ov very fine-grained white mica and fine grained (0.002-0.004 mm) transparent, high relief crystals not resolved by the microscope. Aggregates of a microcrystalline phase form amoeboid shapes up to 0.7 mm, possibly representing pseudomorphs. In one instance, a grain of the high relief material is observed with a lozenge shaped habit and with two cleavages at 120° to one another suggesting that carbonate is a possible candidate for the phase that is otherwise irresolvable by optical microscopy.

The fenite is locally brecciated and subangular clasts are immersed in a very fine-grained quartz aggregate. Along one of the fractures the quartz aggregate's grain size reaches 0.4-0.5 mm in size and the crystals are elongated perpendicularly to the fracture walls. Possibly acicular relicts of aegirine are constituted by a dispersion of high relief fine grained crystals.

Quartz partially infills the fractures. Xenoblastic crystals (0.1-0.2 mm in size) are observed at the border between the quartz and open space . These crystals have high relief and either have a very low birefringence or are isotropic (Bi?).

Sample: 478713

Brecciated siltstone and quartz-sericite-hematite cataclasite

The sample is composed of a siltstone with 1.5-2 mm thick beds of fine sandstone. The sedimentary rock is fractured, fragmented and infilled by a cataclastic aggregate of quartz fragments, intensely silicified and locally sericitized rock, sericite, angular fragments of sedimentary rock and a later infill of quartz, fluorite, very minor native copper grains and hematite, which is possibly replacing pyrite.

mineral	*modal %*	*main size range (mm)*
cataclasite	***55***	
quartz	40 - 50	up to 0.2
white mica	4 - 6	up to 0.1
hematite	4 - 6	up to 0.1
Fine-grained HR mineral	4 4	<0.001
fluorite	1 - 2	~0.4
pyrite	tr	~0.01
siltstone-fine sandstone	***45***	

Quartz occurs within the cataclastic portion of the rock as xenoblastic grains up to 0.1 mm in size with a strong undulose extinction, as possible clasts disrupted by the fragments of sedimentary rock, and as very fine-grained aggregates, locally associated with white mica flakes within fragments of a strongly silicified rock. Quartz also occurs as a late infill material as coarser grains (0.15-0.2 mm) and hosting fluorite skeletal grains (up to 0.4 mm).

White mica (sericite) is associated with very fine-grained quartz within the fragments of silicified rock and occurs as a minor constituent within the sedimentary rock. It is also dispersed within the cataclastic matrix as irregular flakes up to 0.1 mm in size and displays undulose extinction.

Hematite is preferentially hosted within the very fine-grained silicified and sericitized rock fragments and at their fringes as fine-grained dispersions of amoeboid to sub-angular grains up to 0.1 mm in size.

Chlorite forms clusters (up to 2 mm) of randomly oriented flakes (up to 0.2 mm) preferentially observed within the cataclasite at the edge of the sedimentary rock. Chlorite is interpreted to be crystallized after the end of the brittle deformation event.

The fractured **sedimentary rock** consists of a layered sequence of siltstone and minor fine sandstone with sub-angular to sub-rounded quartz clasts reaching 0.15 mm in size. The rock is differentially permeated by sericite (rare flakes up to 0.1 mm) and hematite (up to 0.1 mm). Hematite can constitute up to 40% of the 2 mm thick sandstone layers. Sub-angular fragments of the sedimentary rock are enclosed within the cataclastic matrix, are fractured and their fractures are mostly infilled by polygonal to amoeboid quartz.

Sample: 478714

Brecciated siltstone and quartz-rich cataclasite

The siltstone is fractured and infilled by quartz-rich material. The sedimentary structures were possibly destroyed by the recrystallization of the clays and by quartz alteration. Some quartz clasts (up to 0.3 mm) are showing a rounded to subrounded shape and are possibly the only relicts of the sedimentary origin of this sample. Locally abundant dispersions of a fine-grained mineral with high refractive indices and grey colours in plane-polarized transmitted light confirm the presence of an intense alteration pre-dating cataclasis. The siltstone is fractured and infilled by a network of veins of quartz a clay-eaarthy mineral, white micaa and fine grained unrisolved mineral with high relief.

mineral	*modal %*	*main size range (mm)*
siltstone-fine sandstone	***55***	
cataclasite	***44***	
quartz	32 - 35	up to 0.3
clay earthy mineral (annabergite?)	5 - 7	up to 0.1
white mica	3 - 4	0.02
fine granied HR mineral	2 - 3	up to 0.03

Quartz is the main constituent of the matrix of the cataclasite. It occurs as interlobate to amoeboid grains, generally with undulose extinction and ranging from 0.01 to 0.3 mm in size. Quartz infills the fractures resulting from the brittle deformation of the sedimentary rock. Within some of the wider fractures the infill quartz is associated with xenoblastic aggregates, up to 0.2 mm in size, with earthy, clay-like textures and uniformly indistinguishable crystals. The clay-like minerals preferentially occur as a coating on the sedimentary rock fragments and in the median zone of the quartz-rich veins. In a few cases they assume reddish-brownish colours in plane-polarized transmitted light (annabergite?). In a few instances quartz is elongated perpendicularly to the wall of the fractures.

An unknown, very fine-grained (<0.001mm), dark grey, transparent, mineral with a reflectance of greater than 10 is dispersed within the sedimentary rock as xenoblastic crystals up to 0.03 mm in size.

Glossary of microstructural terms

Aspect ratio: Ratio of length to width of crystals and grains.

Cataclastic microstructure: Microstructure of rocks (cataclasites) formed by brittle deformation, involving fracturing of grains and relative movement of fragments.

Fenite: Fenites are high temperature metasomatic rocks composed mainly of K-Na-feldspars (perthiteor antiperthite), albite, nepheline, alkaline pyroxenes (aegirine, aegirine-diopside, aegirineaugite), alkaline amphiboles (arfvedsonite, riebeckite, hastingsite, richterite); subordinate minerals include biotite-phlogopite micas, magnetite and ilmenite and the most common accessories are titanite and apatite. In some cases fenites contain calcite. Fenites are related to alkaline-ultramafic magmatic complexes and may replace a wide range of rocks including ultramafic rocks and carbonatites formed in the early magmatic stages, as well as acid host rocks such as granite-gneisses and more rarely sandstones. The fenitisation process occurs in exocontact aureoles of nepheline syenites. Fenites are formed mainly or completely during the magmatic stage by silica-undersaturated alkaline magmatic fluids. The width of fenitisation aureoles may reach several kilometres.

Interlobate: Structure composed of crystals with irregular, lobate grain boundaries.

Interstitial: Describes the microstructure formed by the crystallization of fine-grained minerals within angular cavities or interspace fillings between coarser minerals.

Metasomatism, allochemical metamorphism: Change of bulk chemical composition of a rock during metamorphism.

Pleochroism: Pleochroism is the change in colour evident as the mineral is rotated under plane-polarized light. The primary cause of pleochroism in minerals is due to adsorption of particular wavelengths of light. This selective adsorption of certain wavelengths of light causes the transmitted light to appear coloured. This colour is a function of the thickness and the particular chemical and crystallographic nature of the mineral.

Pseudomorph: A mineral or aggregate of minerals replacing an older mineral grain or crystal, preserving the original size and shape of the replaced mineral.

Syntaxial veins: Veins with elongate crystals (columnar or fibrous) crystals projecting from the walls of the vein and growing towards the centre. Typically these crystals nucleate heterogeneously on minerals of the wall-rocks, so that generally the fibres are closely related to minerals in the wall-rocks, for example, quartz veins in sandstones and calcite veins in limestones or marbles.

Xenoblastic: Describes a structure of irregular grains showing no crystal-face boundaries in a metamorphic rock.

References

The microstructural definitions are mostly taken from:

Passchier C.W. And Trouw R.A.J., 1998, Microtectonics, Springer, 289 pp.

Vernon R.H., 2004, A practical guide to rock microstructure. Cambridge University Press, 594 pp.

The definition of fenite is quoted from:

Zharikov, V.A., Pertsev, N.N., Rusinov, V.L., Callegari, E., and Fettes, D.J., 2007, 9. Metasomatism and metasomatic rocks., Recommendations by the IUGS Subcommission on the Systematics of Metamorphic Rocks: Web version 01.02.07.

List of Figures - Report 100837:

Figure	ID1	Lithology
0		Offcuts and thin sections
1	478704	Hornfelsed siltstone and Albite-quartz-monazite-zircon-pyrite vein.
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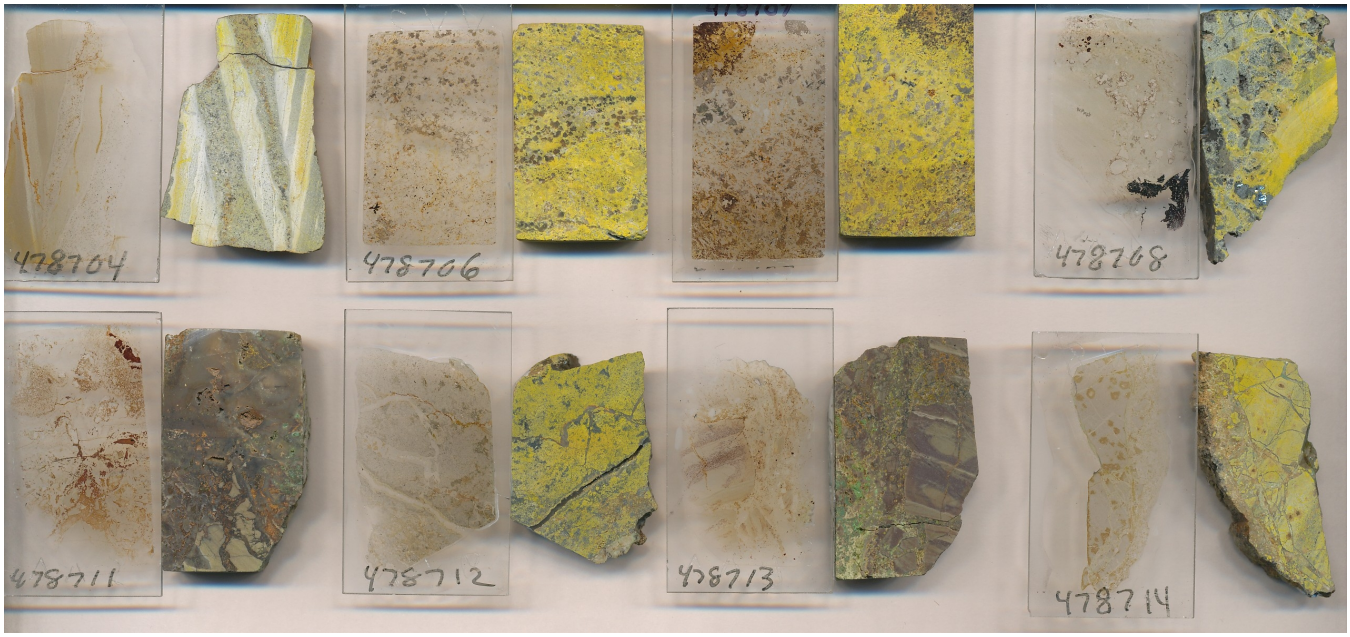

Figure 0: Offcuts and thin sections.

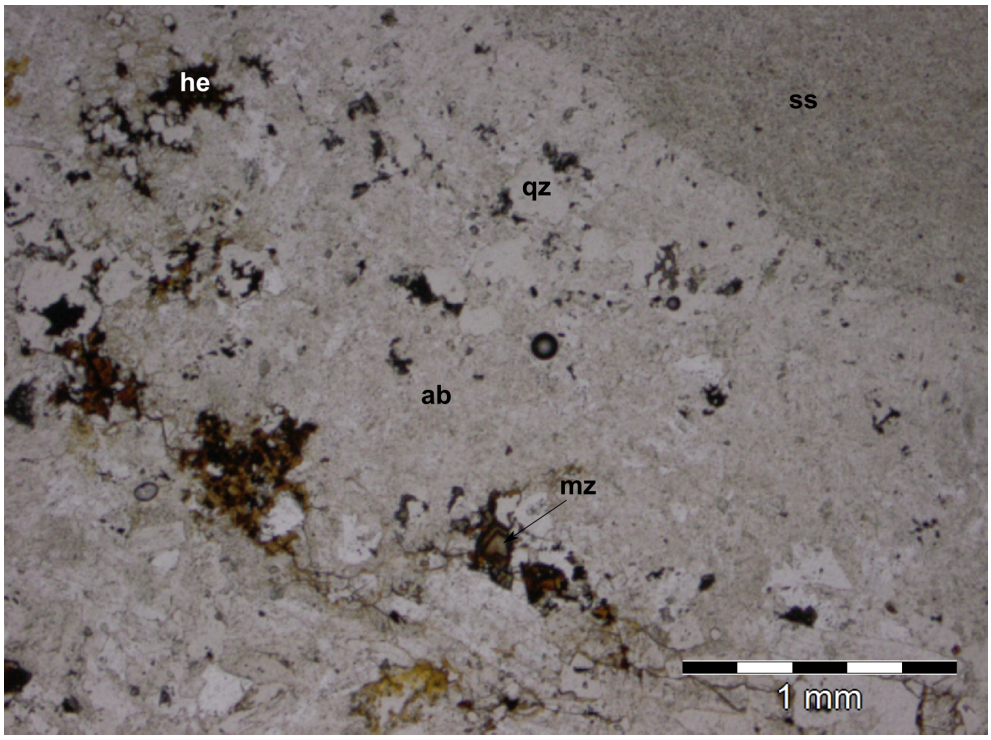

Figure 1: Photomicrograph showing the siltstone (ss) in the upper right portion of the figure, infilled by albite (ab)-quartz (qz)-monazite (mz)-zircon-pyrite-vein. Plane polarized transmitted light.

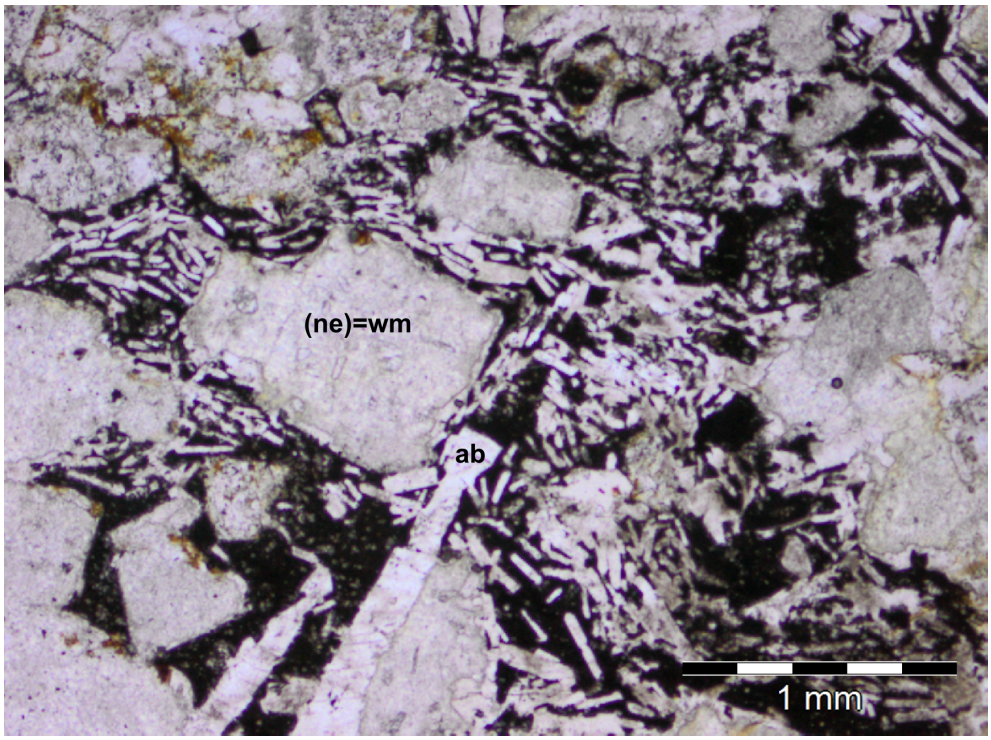

Figure 2: Photomicrograph showing pseudomporphs of white mica (wm) after possibly nepheline (ne), euhedral albite (ab) and interstitial cryptocrystalline material. Plane polarized transmitted light.

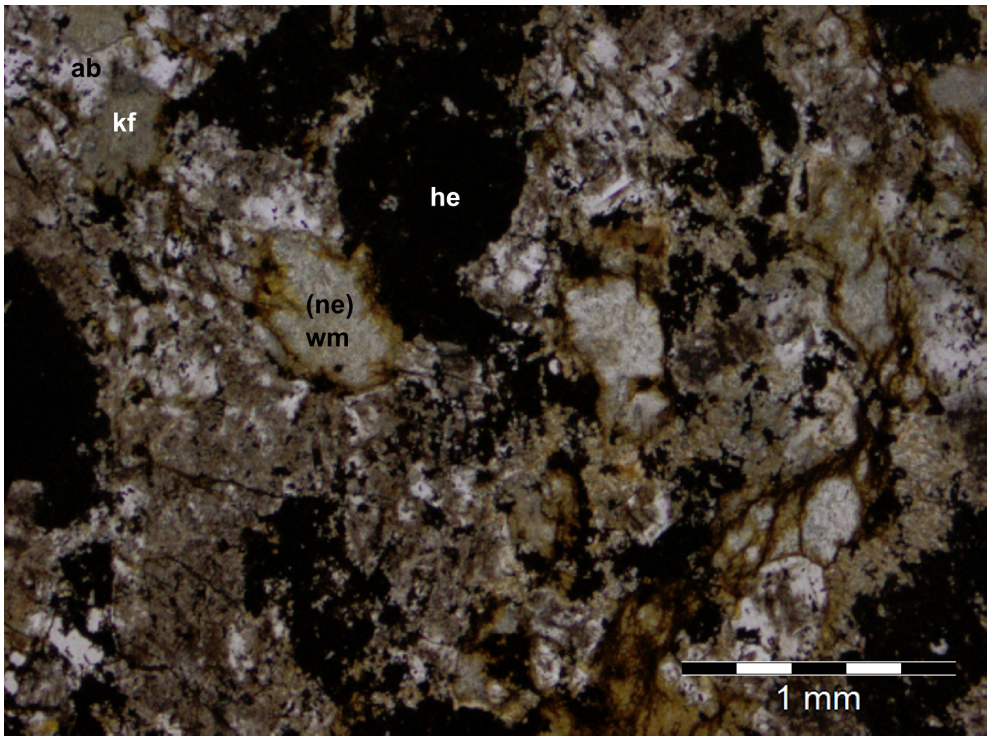

Figure 3: Photomicrograph showing irregular domains of hematite (he), pseudomporphs of white mica (wm) after possibly nepheline (ne), albite (ab) and K-feldspar (kf). Plane polarized transmitted light.

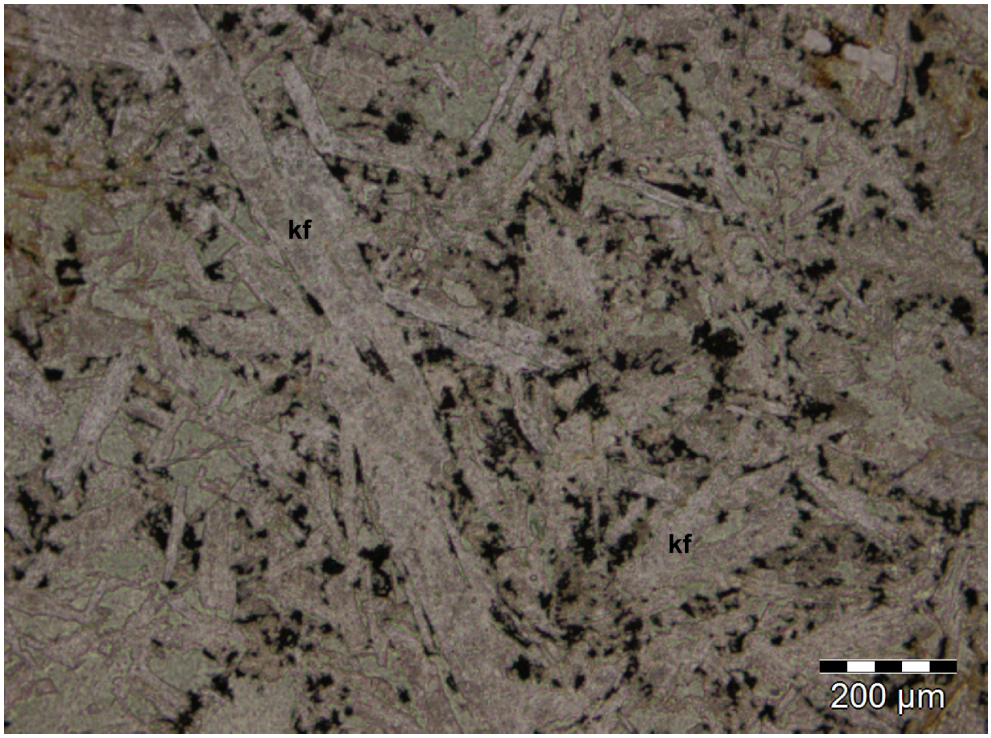

Figure 4: Photomicrograph showing euhedral K-feldspar (kf) and interstitial very fine grained minerals. Plane polarized transmitted light.

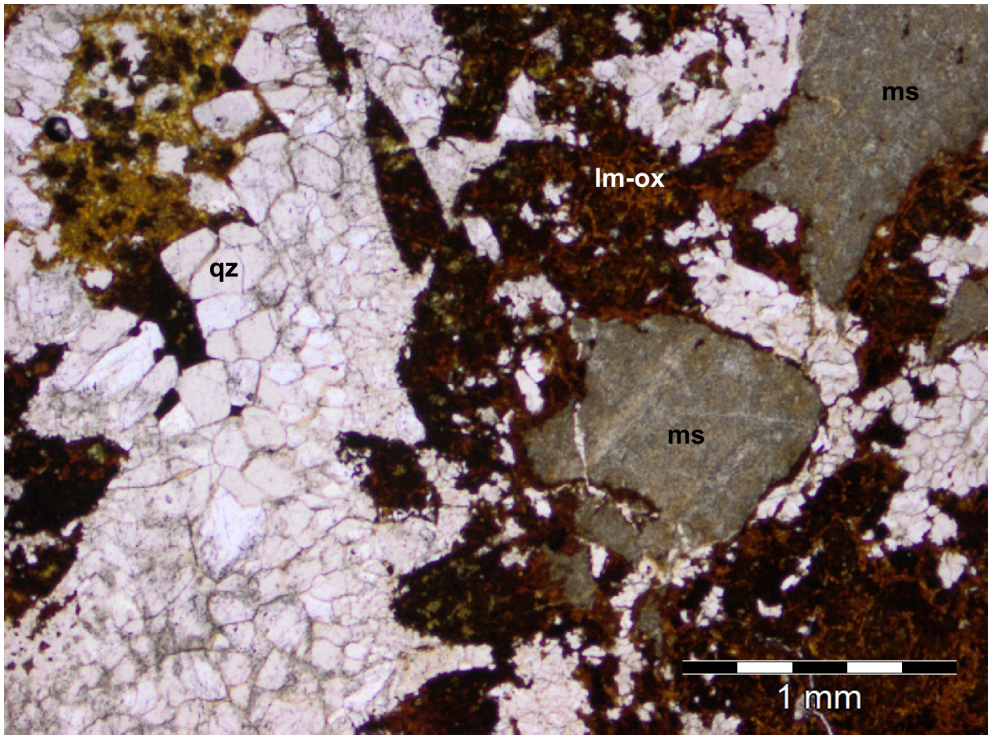

Figure 5: Photomicrograph showing fragments of mudstone (ms) and limonitic and oxidized material (lm-ox) infilled by quartz (qz). Plane polarized transmitted light.

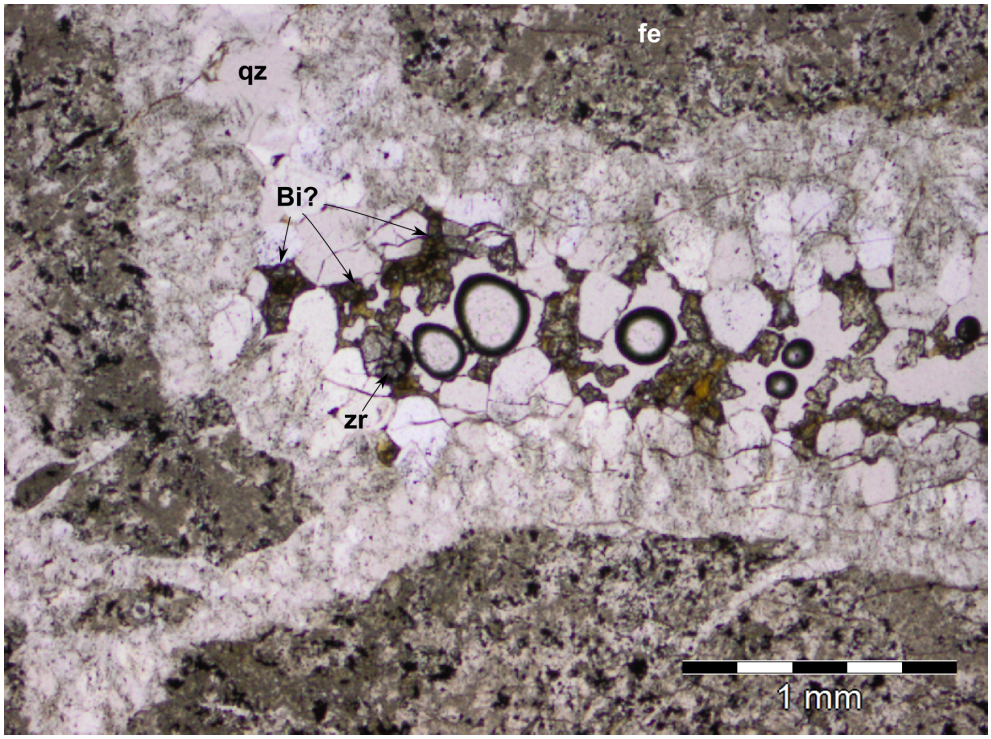

Figure 6: Photomicrograph showing the fenite (fn) crosscut by quartz (qz)-zircon (zr) and possibly bismuth (Bi?). Plane polarized transmitted light.

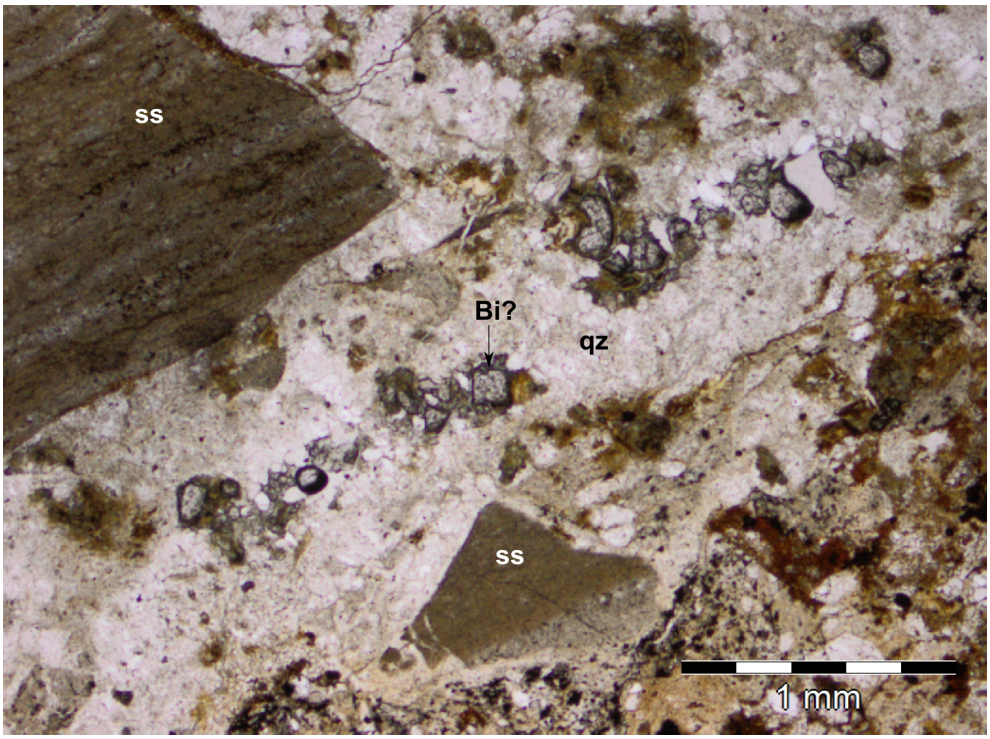

Figure 7: Photomicrograph showing the fragments of siltstone (ss) infilled by quartz (qz) and possibly bismuth (Bi?). Plane polarized transmitted light.

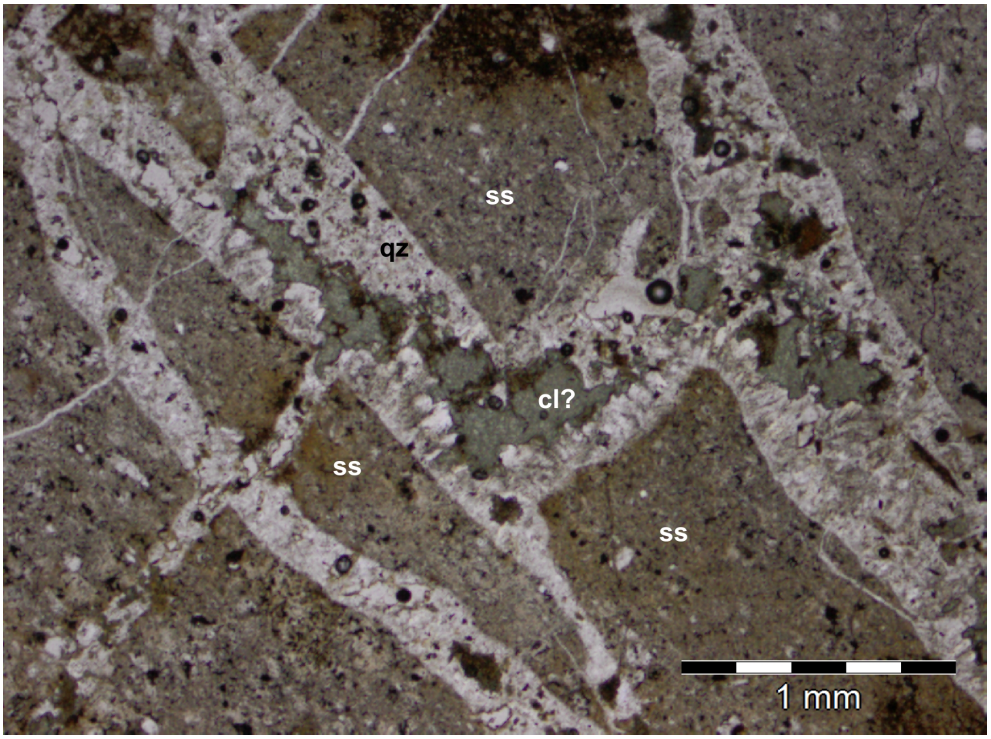

Figure 8: Photomicrograph showing the siltstone (ss) crosscut by veins of quartz (qz) and clay-earthy mineral (cl?) occupying the median zone of some of the veins. Plane polarized transmitted light.