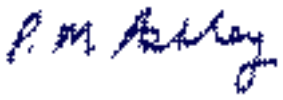
PETROGRAPHIC REPORT ON NINE DRILL CORE SAMPLES FROM THE ROSEBERY MINE AREA, TASMANIA

For

MMG Rosebery Mine

Reference: Email from Sam Maloney 22-1-14. Sample receipt 3-2-14.



P.M. Ashley (MAusIMM, FSEG)
Paul Ashley Petrographic and Geological Services
37 Bishop Crescent
Armidale
NSW 2350
Phone: 02 6772 8293, 0422 750 742, email: papags47@une.edu.au

ABN 59 334 039 958

May, 2014

Report #875

SUMMARY

A suite of nine drill core samples from the Rosebery mine area, Tasmania, was submitted for petrographic preparation, description and interpretation. The samples were from drill hole WSP17 and were labelled 1392750-1392758. Polished thin sections (PTS) were prepared from each sample as most appeared to contain some sulphide mineralisation. Subsequently, PTS were examined microscopically in transmitted and reflected light. Representative photomicrographs of textures and mineralogical relationships were taken. Each sample was measured for magnetic susceptibility and a couple of samples were tested with dilute HCl to check carbonate speciation.

Summary descriptions of each sample are listed following:

1392750 PTS

Summary: Coarse felsic tuff, of lithic-vitric-crystal type and perhaps originally of rhyodacite composition. Relict pyroclastic texture is moderately well preserved, despite strong pervasive alteration and local mineralisation and veining. Fragments in the tuff include glassy, porphyritic and ignimbritic types, with phenocrystal grains of quartz, plagioclase and K-feldspar. The matrix component is subordinate and included finer grained vitric and lithic material. Apart from relict quartz phenocrysts and perhaps K-feldspar, the rock was replaced by dominant fine to medium grained (commonly finely granular) albite, K-feldspar and quartz, with minor chlorite and sericite, although the latter two phases are locally abundant. There is also a minor amount of sulphide minerals, a little carbonate and trace titanite. Sulphides are irregularly distributed and commonly intergrown with quartz, Pyrrhotite is the most widely dispersed, but sphalerite is the most abundant, forming a local semi-massive aggregate. Small amounts of galena and pyrite are associated with sphalerite and pyrrhotite, and uncommon arsenopyrite and chalcopyrite form composites with pyrrhotite.

1392751 PTS

Summary: Coarse vitric-lithic-crystal felsic tuff, perhaps originally of rhyodacite composition, with overprinting strong hydrothermal alteration, and development of carbonate- and pyrrhotite-rich replacement and veinlike aggregates. Relict coarse pyroclastic texture is moderately well preserved and indicates that fragments were dominated by glassy and sparsely porphyritic felsic volcanic rock, with local flow foliation, perlitic cracking and possible ignimbritic texture. Phenocrystal phases were dominated by plagioclase and quartz, but some fragments contain a little K-feldspar and there are vestiges of altered biotite. The rock underwent strong recrystallisation of former glassy and minor matrix material, likely due to hydrothermal alteration, but also could involve an element of later-imposed metamorphism that has also led to local development of a weak foliation. Much of the finer grained component of the rock was replaced by quartz, albite and K-feldspar, with minor, but patchily abundant sericite and carbonate, a little chlorite and trace titanite and pyrrhotite. In a few places, there are recrystallised irregular to veinlike masses rich in carbonate and these locally merge into a large sulphide-rich mass that is intergrown with subordinate quartz. There are also a few thin veins rich in albite. The sulphide-rich mass contains abundant recrystallised pyrrhotite, with minor arsenopyrite and sphalerite, plus a trace of chalcopyrite.

1392752 PTS

Summary: Complex felsic volcanic rock that is considered most likely to represent a body of sparsely porphyritic, originally glassy groundmass rhyodacite that could have been intrusive into masses of crystal-lithic-vitric felsic tuff and vitriclastic-dominated felsic tuff. Relict textures are moderately well preserved. The tuff components and rhyodacite host a few phenocrystal grains of quartz and altered plagioclase, with pervasive alteration having been

imposed. This has resulted in replacement of the different textural domains by fine grained quartz and alkali feldspars, and subordinate sericite, with a little carbonate and pyrrhotite and traces of allanite and leucoxene-rutile. A few irregular carbonate veins occur and these grade locally into thinner feldspar-rich veining. It is possible that the rock was metamorphosed to low grade following alteration, with development of a weak foliation.

1392753 PTS

Summary: The sample contains two texturally and compositionally distinct domains. There are separate masses of altered, partly recrystallised porphyritic rhyodacite that retain relict quartz phenocrysts, altered plagioclase phenocrysts and a few smaller altered biotite phenocrysts. These occurred in a possibly largely glassy groundmass that could have been coherent, or may represent former vitriclastic material (the former is favoured). The rhyodacite masses have sharp, commonly irregular contacts against a finely recrystallised rock that is interpreted as originally being a cherty tuff (of felsic derivation). The latter rock is compositionally homogeneous. Hydrothermal alteration and probable low grade metamorphism were imposed, with the rhyodacite showing groundmass replacement by fine grained quartz, feldspars and subordinate sericite, minor chlorite, and trace carbonate, leucoxene-rutile and pyrrhotite. Plagioclase phenocrysts were replaced by albite and sericite, and biotite by chlorite. The cherty tuff was recrystallised to very fine quartz and sericite, with local carbonate, a little pyrrhotite and trace leucoxene-rutile. Several stylolites formed, mainly in the cherty tuff, showing concentrations of leucoxene-rutile and trace pyrrhotite and sphalerite.

1392754 PTS

Summary: Three compositionally and texturally distinct zones occur in the sample. A central sheared and crudely banded zone contains abundant fine to medium grained recrystallised carbonate (calcite) and sphalerite, with minor quartz and a little chlorite, pyrite, pyrrhotite, galena and albite. This zone might represent an original veinlike concentration. On one side of the sphalerite-carbonate zone, there is a domain with moderately well preserved relict texture indicating that it is an altered, rather coarse, lithic-vitric-crystal felsic tuff. This rock is little-deformed and has a strong alteration assemblage of quartz-sericite-K-feldspar, with minor carbonate, chlorite and albite, and trace sphalerite, pyrite and rutile. On the other side of the sphalerite-carbonate zone, there is a merger into a strongly foliated and altered domain of chlorite-sericite-carbonate, hosting a few obliquely dispersed carbonate veins. This domain has a few relict phenocrystal grains of quartz and could represent a former felsic tuff.

1392755 PTS

Summary: Coarse matrix-supported felsic volcanic breccia with scattered angular to sub-rounded clasts of variably porphyritic, fine grained felsic volcanic rock (ranging from almost aphyric) to more conspicuously phenocryst-bearing) in a generally fine grained matrix that is dominated by vitriclastic material. In the latter, there are local zones with coarser vitriclasts (including pseudomorphed glass shard material) and a few phenocrystal grains of quartz. The clasts have local flow foliation and relict perlitic cracking in groundmass material, that would have probably been glassy. Phenocrysts in the porphyritic clasts are dominated by quartz, with minor feldspars and trace biotite. The rock has experience strong pervasive alteration, perhaps due to both hydrothermal and low grade metamorphic processes. The replacement assemblage is dominated by fine grained sericite and quartz, with some clasts being particularly sericite-rich. There is also subordinate carbonate and chlorite, with trace pyrrhotite, pyrite and rutile. Several irregular to veinlike masses of recrystallised carbonate occur and the rock has a sericite-defined foliation in places.

1392756 PTS

Summary: Dominant fine grained tuffaceous, fine grained siltstone (epiclastic), containing a few isolated detrital lithic fragments and individual volcanic phenocrystal mineral grains (quartz, plagioclase), plus a little dispersed carbonaceous material and a few possible

recrystallised radiolarians. Larger lithic fragments in the tuffaceous siltstone include porphyritic rhyodacite (phenocrysts of quartz, altered feldspar and trace biotite in a fine grained, possibly formerly glassy, groundmass) and a single mass of medium grained altered microdiorite. All components of the rock were subject to pervasive propylitic alteration, but with local quartz-rich replacement aggregates having formed locally. Fine grained sericite and quartz, with subordinate chlorite and minor pyrrhotite and carbonate prevail in the tuffaceous siltstone, whereas in the rhyodacite, replacement was by quartz, sericite, K-feldspar, albite and minor chlorite, and in the microdiorite fragment, by albite, chlorite and pyrrhotite. The quartz-rich alteration aggregates are finely recrystallised and also contain carbonate and pyrrhotite. A weak to moderate foliation is evident in the tuffaceous siltstone, defined by preferred orientation of layer silicates and pyrrhotite aggregates.

1392757 PTS

Summary: Felsic pyroclastic or epiclastic rock, containing sparsely scattered relict quartz and altered feldspar phenocrystal grains, as well as altered volcanic lithic grains in a fine grained matrix that has experienced strong hydrothermal alteration as well as low grade metamorphic and penetrative deformation effects. The rock has a strong foliation and interpreted hydrothermal components are entirely recrystallised. The latter are commonly found in a compositionally banded distribution, perhaps reflecting in part, original compositional layering. The main alteration minerals are sericite and carbonate (calcite), with minor quartz, chlorite and trace pyrrhotite and rutile. There is a major foliation-parallel band of recrystallised, semi-massive pyrrhotite and sphalerite, intergrown with subordinate quartz, minor carbonate and chlorite, and containing a little galena and trace pyrite and arsenopyrite. The sulphide-rich band is interpreted as a vein-like mass emplaced concordantly with the foliation.

1392758 PTS

Summary: Epiclastic sedimentary rock, with likely felsic volcanic detritus, including sparse lithics, feldspar (altered) and quartz grains in a fine grained matrix (containing trace graphite), showing strong pervasive alteration and a large sulphide-rich mass that is considered to be the product of hydrothermal replacement. The host rock has been replaced by assemblages that range from being rich in carbonate, quartz, chlorite or sericite (with gradations, and also containing a little disseminated pyrrhotite and sphalerite) and shows a generally weak foliation. The sulphide-rich mass is dominated by strongly disseminated to semi-massive, recrystallised pyrrhotite and sphalerite, intergrown with abundant carbonate. In places, there are local concentrations of quartz, arsenopyrite and pyrite, with a little chlorite, galena, chalcopyrite and marcasite.

Interpretation and comment

The sample suite is composed of felsic pyroclastic and probably related epiclastic rocks, ranging from coarse breccias to fine grained siltstone, and assumed to be representative of the Cambrian Mount Read Volcanics. There were overprinting effects of hydrothermal alteration, sulphide mineralisation, probable low grade metamorphism and related penetrative deformation. Sulphide-rich masses have epigenetic relationships with host rocks and have differing mineralogical relationships compared to typical volcanic-associated massive sulphide deposits.

In the sample suite, relict textures are commonly moderately well preserved and there is some preservation of primary mineralogy (e.g. relict phenocrystal quartz, and indications of former phenocrysts of feldspars and biotite), although there is clearly a range into textural domains where primary characteristics were destroyed by the overprinting processes. Interpreted coarsely fragmental felsic lithic-vitric-crystal tuff occurs in samples 1392750 and 1392751, in parts of 1392752 and 1392754. These rocks are largely clast-supported. There could be a gradation into rocks with large fragments, but having a matrix-supported texture in samples 1392753-8, with the amount of fine grained matrix increasing downhole. Possible primary compositional layering could be preserved in 1392757. In 1392752 and possibly 1392753, there are equivocal relationships between what appears to be coherent porphyritic rhyodacite and crystal-lithic-vitric and finer grained vitriclastic-dominated felsic tuffs. It could be interpreted that rhyodacite might be intrusive into the tuff matrix (perhaps forming a type of peperite), but alternatively, the observed rhyodacite masses (on the scale of a thin section) might simply be portions of larger fragments (enclosed by depositional processes in a tuff matrix). In samples 1392756-8, it is apparent that these matrix-supported rocks have a large, fine grained matrix component that is interpreted as being largely sedimentary in character, but probably composed significantly of volcaniclastic (especially former vitriclastic) detritus. Texturally, the matrix material is considered to be epiclastic siltstone and its sedimentary nature is further implied by the presence of traces of interpreted matured organic material (now graphitic) in 1392756 and 1392758.

Fragmental material in the coarse pyroclastic samples (clast-supported tuff, and breccia) includes interpreted porphyritic rhyodacite (with a former glassy groundmass and sparse phenocrysts of quartz, feldspars and uncommon biotite) and near-aphyric, flow foliated coherent and pyroclastic felsic rocks that could include ignimbritic material. There are also isolated discrete phenocrystal mineral grains, e.g., quartz and feldspar. Lithic detritus in the more matrix-dominated samples appears to be of the same type, although in 1392756, a single clast of altered microdiorite is recognised. In several samples, the interstitial matrix material is clearly vitriclastic, with glass shard texture being locally preserved (e.g. in 1392752, 1392755, 1392757).

The primary rocks have all been overprinted by subsequent processes. Hydrothermal alteration was imposed, resulting in pervasive replacement of primary mineralogy and the formation of irregular and veinlike replacement masses. It is possible that there were two alteration events, one early, e.g. with temporal affinities to the deposition of the volcaniclastic host rocks, and one later, perhaps related to imposed deformation and related low grade metamorphism. The alteration effects vary, depending somewhat on compositions of the protolith materials, with a range from assemblages rich in feldspars (albite, K-feldspar) plus quartz in some of the coarse pyroclastic rocks and in large clasts of felsic volcanic rock (e.g. 1392750-2), grading

through to those locally rich in quartz, and more commonly in carbonate (calcite), sericite and locally chlorite (e.g. in 1392755, 1392757, 1392758) in the matrix-supported (epiclastic siltstone) examples. It is likely that small amounts of Ti-bearing minerals (rutile, titanite) could have formed during early alteration, as well as minor disseminated sulphides (mostly pyrrhotite). There is no textural evidence for the coeval deposition of massive (or semi-massive) or temporally-related stockwork vein sulphides with the volcaniclastic host rocks. The alteration assemblages observed can be broadly classified as ranging from propylitic to possibly phyllic, to feldspathic and local silicification.

There is difficulty in distinguishing between interpreted early hydrothermal alteration and effects of later imposed metamorphism as the mineral assemblages can be similar, especially assemblages such as sericite-chlorite-carbonate-quartz. However, it is more likely that assemblages with significant carbonate, or locally abundant quartz, or sulphides, are likely to represent hydrothermal introduction of components (e.g. CO_2, S and metals) and also the local mobility of silica and alkalies. Assuming that low grade regional metamorphism was imposed, e.g. coeval with formation of a foliation in the altered rocks, then the mineral assemblages are consistent with metamorphism having achieved chlorite grade of the greenschist facies. There is no (preserved) evidence of any overprinting of the deformation fabric (foliation defined by preferred orientation of sericite, carbonate and pyrrhotite aggregates, and locally, chlorite, plus local development of thin stylolites) by any later thermal event (e.g. growth of metamorphic biotite).

Several of the samples contain irregular to veinlike masses rich in sulphide minerals that are commonly intergrown with substantial amounts of carbonate, locally abundant quartz, and in places, a little chlorite and feldspars. There are also a few other types of discrete veining including thin feldspar ± quartz types in 1392750-1 and minor carbonate-rich types. The latter include possible tension gash fillings, with all being strongly recrystallised (i.e. pre- to syn-tectonic). The sulphide-rich masses are conspicuous in 1392750, 1392751, 1392754, 1392757 and 1392758. In places they are irregular and have sharp contacts against enclosing host rock, and elsewhere, they can be veinlike and enclosed co-planar with foliation in the host rock. None of the sulphide-rich masses appear to have enclosed relict material from the host rocks (e.g. recognisable relict quartz phenocrystal grains or altered lithic clasts) and therefore they could be considered as products of total replacement of host rock, or hydrothermal infill. The contents of these masses are commonly banded, sheared and thoroughly recrystallised and therefore they might represent the product of syn-tectonic emplacement.

The sulphide-rich masses commonly contain abundant pyrrhotite and/or sphalerite (pyrrhotite-rich in 1392751 and sphalerite-rich in 1392754), locally

arranged in crudely banded form, and in places containing minor galena, pyrite, arsenopyrite and generally only a little chalcopyrite. In contrast to typical massive (or semi-massive) volcanic-associated sulphides, pyrite is an uncommon mineral (and can be locally intergrown with marcasite, suggesting that in part it could be a retrograde alteration product after pyrrhotite). Similarly, pyrrhotite is commonly abundant, a characteristic atypical of most VAMS systems. Galena and chalcopyrite are only trace to minor constituents, but arsenopyrite can be locally conspicuous (e.g. in 1392758), again characteristics that are not shared with most VAMS systems. Consequently, it is speculated that the majority of the sulphide mineralisation in the sample suite could be of later-imposed, epigenetic type, mostly introduced as replacement and foliation-parallel masses. The later process might have been syn-tectonic, but there remains the possibility of the mineralisation being derived ultimately from a VAMS source, but hydrothermally remobilised.

Individual sample descriptions

1392750 PTS

Summary: Coarse felsic tuff, of lithic-vitric-crystal type and perhaps originally of rhyodacite composition. Relict pyroclastic texture is moderately well preserved, despite strong pervasive alteration and local mineralisation and veining. Fragments in the tuff include glassy, porphyritic and ignimbritic types, with phenocrystal grains of quartz, plagioclase and K-feldspar. The matrix component is subordinate and included finer grained vitric and lithic material. Apart from relict quartz phenocrysts and perhaps K-feldspar, the rock was replaced by dominant fine to medium grained (commonly finely granular) albite, K-feldspar and quartz, with minor chlorite and sericite, although the latter two phases are locally abundant. There is also a minor amount of sulphide minerals, a little carbonate and trace titanite. Sulphides are irregularly distributed and commonly intergrown with quartz, Pyrrhotite is the most widely dispersed, but sphalerite is the most abundant, forming a local semi-massive aggregate. Small amounts of galena and pyrite are associated with sphalerite and pyrrhotite, and uncommon arsenopyrite and chalcopyrite form composites with pyrrhotite.

Handspecimen: The drill core sample is composed of a grey, apparently coarsely fragmental texture, altered felsic volcanic rock. Irregular fragments (?lithic material) up to 1 cm across and a few feldspar and quartz phenocrystal grains are evident (Fig. 1). It is likely that the rock is strongly replaced by finer grained feldspar and quartz, with apparent green-grey chlorite and slightly yellowish-brown sericite. There are a couple of brown aggregates of sphalerite (Fig. 1) and a little pyrrhotite disseminated elsewhere. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units.

Fig. 1: Drill core sample showing pale grey, altered, coarse lithic-vitric-crystal felsic tuff, with dark brown sphalerite-rich aggregate. The rock was replaced by fine to medium grained quartz, albite, K-feldspar, minor sericite, chlorite and sulphides, of which sphalerite and pyrrhotite are the dominant species, with a little associated galena and pyrite.

Petrographic description

a) Primary rock characteristics: In the section, relict coarsely fragmental texture is moderately well preserved. The rock has a clast-supported texture, with abundant angular to sub-

rounded altered lithic and vitric fragments up to several millimetres across, along with a few phenocrystal grains of quartz, plagioclase and K-feldspar, up to 3 mm across (Fig. 2). The fragments include those that are porphyritic (quartz- and feldspar-phyric), with a fine grained quartzofeldspathic groundmass, and those that were originally glassy (e.g. with relict perlitic cracking) and flow-foliated (perhaps ignimbritic) (Fig. 2). The rock had a subordinate tuffaceous matrix component, perhaps of finer grained vitric and lithic material. The relict textural and mineralogical characteristics indicate that the protolith was a coarsely fragmental felsic pyroclastic, e.g. lithic-vitric-crystal felsic tuff, perhaps of rhyodacitic composition.

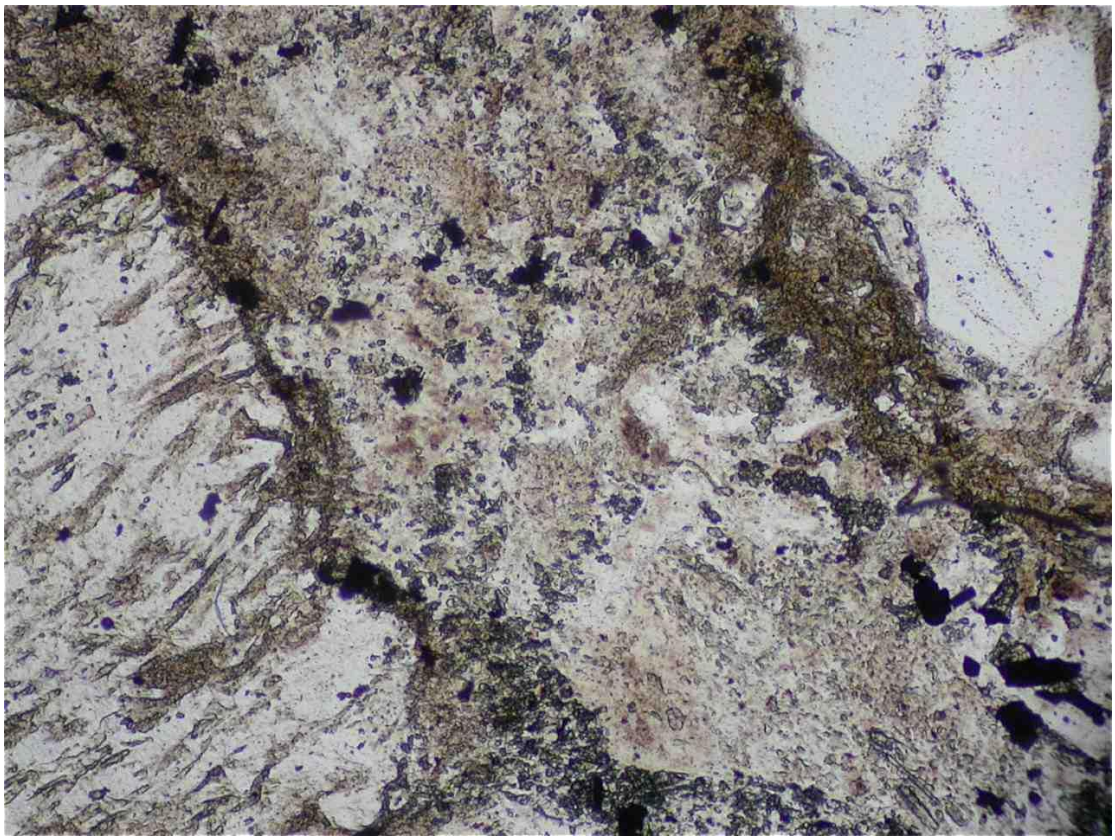


Fig. 2: Altered felsic tuff showing former ignimbritic lithic fragment (left), an altered plagioclase grain (lower right) and relict quartz phenocryst (upper right) in a altered, finer grained matrix. The rock was replaced by abundant finer grained feldspars and quartz, but in the matrix, there is significant chlorite and sericite (darker brown, greenish and grey shades). Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: The interpreted pyroclastic rock was strongly affected by hydrothermal alteration. Some of the recrystallisation might also be implied to result from subsequently imposed metamorphism. Lithic and vitric fragments, and much of the matrix, were replaced by generally fine grained (locally medium grained) K-feldspar, albite and quartz, with commonly minor chlorite and sericite, but with the latter two phases commonly being more abundant in the altered matrix (Fig. 2). Original phenocrystal plagioclase grains show variable replacement by albite or K-feldspar, as well as fine flecking by sericite. A small amount of disseminated sulphides, a little carbonate and trace titanite are irregularly distributed. There is one large, apparently replacement mass of sulphide and quartz ~1 cm across and the rock is also cut by several sub-planar to irregular veins up to 0.5 mm wide, with these being dominated by albite, or locally, quartz and K-feldspar. The overall alteration could be considered as of feldspathic type, but gradational to propylitic.

c) Mineralisation: The altered rock contains minor, irregularly distributed sulphides. There are sparse aggregates of pyrrhotite up to 1.5 mm across, with a few of these having small

composites with arsenopyrite (up to 0.2 mm) and rare chalcopyrite. There is a single large sulphide-rich aggregate (~1 cm across), where dominant semi-massive sphalerite (a moderate-Fe variety) is intergrown with quartz, patchily distributed pyrrhotite and minor galena and pyrite (Fig. 3). A trace of fine grained marcasite is associated with pyrite in this aggregate. Textures suggest that most pyrite was paragenetically earlier than sphalerite and galena.

Mineral Mode (by volume): quartz 30%, K-feldspar and plagioclase (mostly albite) each 25%, chlorite and sericite each 5%, sphalerite 4%, pyrrhotite 2%, carbonate, galena and pyrite each 1% and traces of titanite, marcasite, chalcopyrite and arsenopyrite.

Interpretation and comment: It is interpreted that the sample represents a pervasively altered (and possibly low grade metamorphosed) lithic-vitric-crystal felsic tuff and perhaps originally of rhyodacite composition. Relict coarse pyroclastic texture is moderately well preserved. Fragments in the tuff include glassy, porphyritic and ignimbritic types, with phenocrystal grains of quartz, plagioclase and K-feldspar. The matrix component is subordinate and included finer grained vitric and lithic material. Apart from relict quartz phenocrysts and perhaps K-feldspar, the rock was replaced by albite, K-feldspar and quartz, with minor chlorite and sericite, although the latter two phases are locally abundant. There is also a minor amount of sulphide minerals, a little carbonate and trace titanite. Sulphides are irregularly distributed and commonly intergrown with quartz. Sphalerite is the most abundant sulphide, forming a local semi-massive aggregate, with associated pyrrhotite, galena and pyrite, but elsewhere, pyrrhotite is sparsely distributed and associated with traces of arsenopyrite and chalcopyrite.

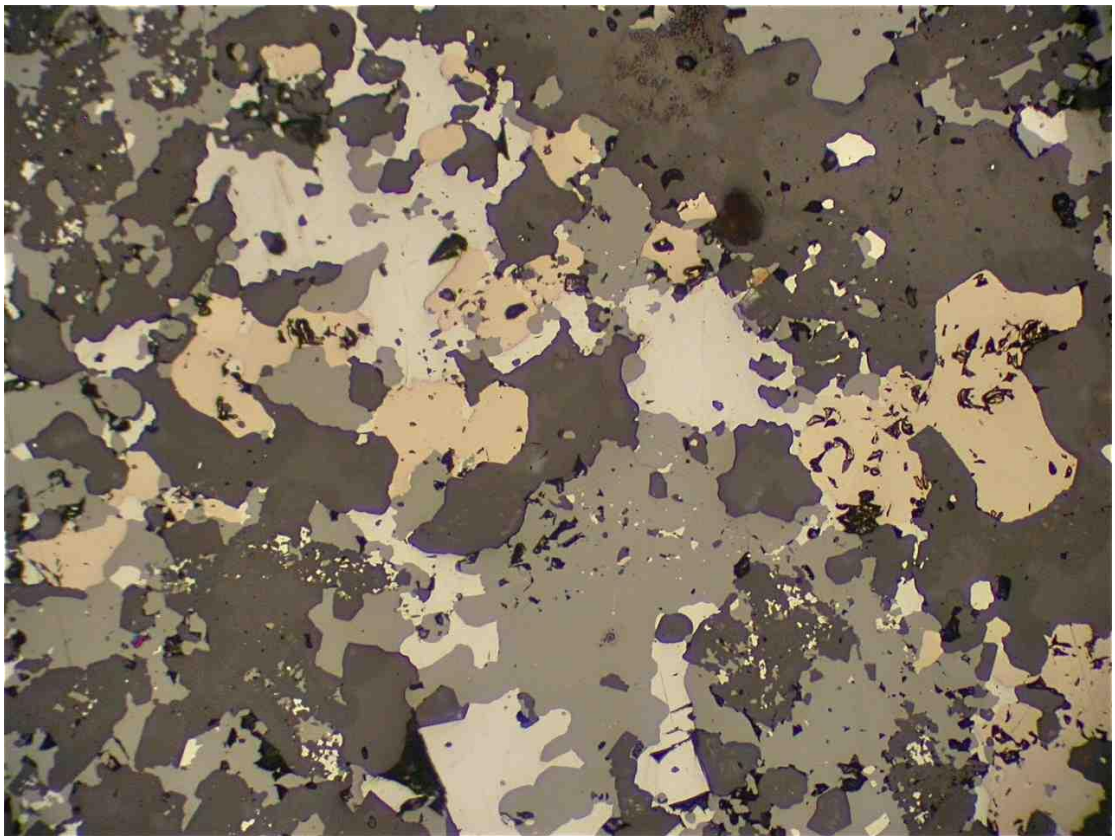


Fig. 3: Portion of a sulphide-quartz replacement aggregate, showing intergrown sphalerite (mid grey), pyrrhotite (pale creamy brown) and galena (silvery grey) in quartz gangue (dark grey). Plane polarised reflected light, field of view 1 mm across.

1392751 PTS

Summary: Coarse vitric-lithic-crystal felsic tuff, perhaps originally of rhyodacite composition, with overprinting strong hydrothermal alteration, and development of carbonate- and pyrrhotite-rich replacement and veinlike aggregates. Relict coarse pyroclastic texture is moderately well preserved and indicates that fragments were dominated by glassy and sparsely porphyritic felsic volcanic rock, with local flow foliation, perlitic cracking and possible ignimbritic texture. Phenocrystal phases were dominated by plagioclase and quartz, but some fragments contain a little K-feldspar and there are vestiges of altered biotite. The rock underwent strong recrystallisation of former glassy and minor matrix material, likely due to hydrothermal alteration, but also could involve an element of later-imposed metamorphism that has also led to local development of a weak foliation. Much of the finer grained component of the rock was replaced by quartz, albite and K-feldspar, with minor, but patchily abundant sericite and carbonate, a little chlorite and trace titanite and pyrrhotite. In a few places, there are recrystallised irregular to veinlike masses rich in carbonate and these locally merge into a large sulphide-rich mass that is intergrown with subordinate quartz. There are also a few thin veins rich in albite. The sulphide-rich mass contains abundant recrystallised pyrrhotite, with minor arsenopyrite and sphalerite, plus a trace of chalcopyrite.

Handspecimen: The drill core sample is composed of an altered and probably metamorphosed coarsely fragmental felsic volcanic rock. There are scattered irregular to elongate grey fragments up to 5 cm across enclosed in a pale grey matrix that appears to be rich in finely recrystallised quartz, feldspar and patchy carbonate (Fig. 4). There is a single large (several centimetre) replacement aggregate rich in pyrrhotite (Fig. 4). The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, despite the presence of pyrrhotite, suggesting that pyrrhotite is of the non-magnetic, hexagonal type.

Fig. 4: Drill core sample illustrating the relict coarse fragmental texture of the protolith, with paler grey interstitial zones being rich in recrystallised quartz, feldspars and carbonate. The brown-bronze elongate mass towards the top of the image is a pyrrhotite-rich sulphide mass.

Petrographic description

a) Primary rock characteristics: In the section, relict coarsely fragmental texture is moderately well preserved. The rock has a clast-supported texture, with abundant angular altered lithic and vitric fragments up to centimetres across, along with a few phenocrystal grains of quartz (up to 2 mm) and plagioclase (up to 3.5 mm). The fragments include those that are porphyritic (quartz- and feldspar-phyric), with a fine grained quartzofeldspathic groundmass, and those that were originally glassy (e.g. with relict perlitic cracking) and flow-foliated (perhaps ignimbritic) (Fig. 5). There is little apparent matrix, perhaps due to alteration and recrystallisation, but if it does occur it is likely to be of fine vitriclastic character. The relict textural and mineralogical characteristics indicate that the protolith was a coarse felsic pyroclastic, e.g. vitric-lithic-vitric-crystal felsic tuff, perhaps of rhyodacitic composition.

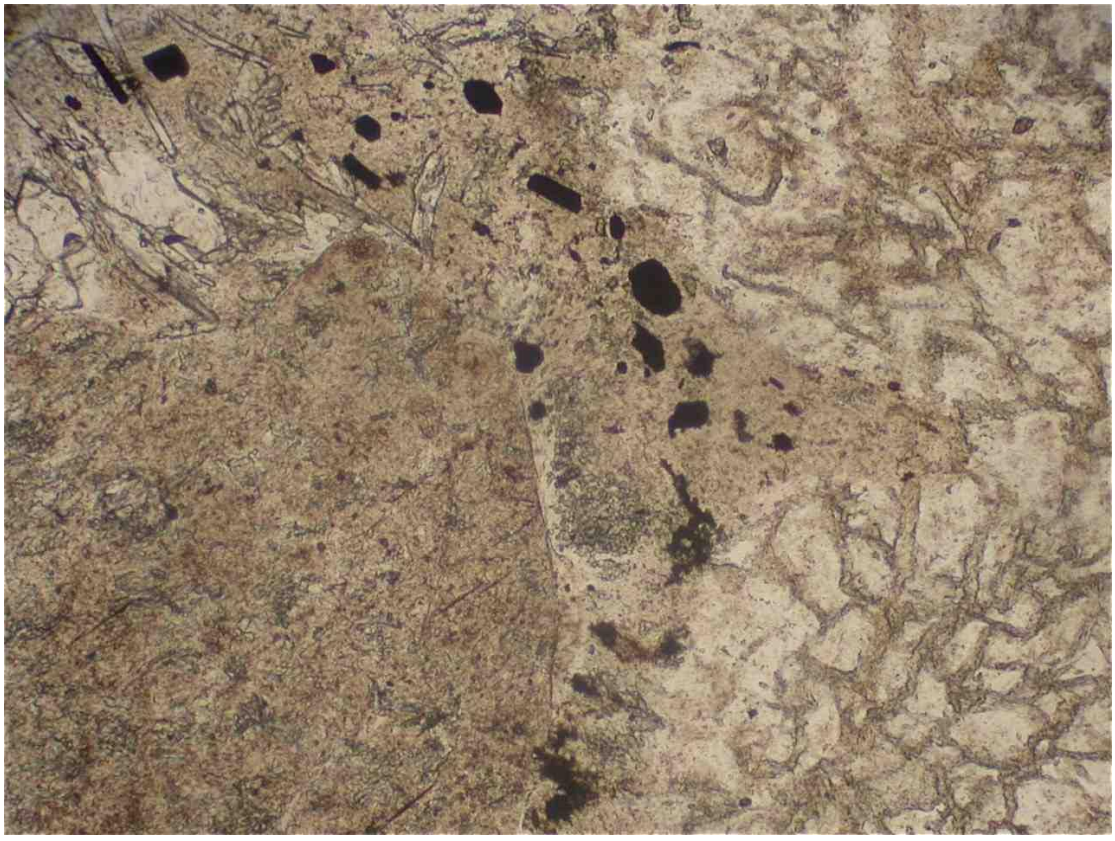


Fig. 5: Altered coarse felsic tuff with a turbid, partly sericitised phenocrystal grain of plagioclase (lower left), portion of a former glassy fragment to right, and development of a carbonate aggregate at upper left. The small black grains are pyrrhotite. Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: The protolith was overprinted by hydrothermal alteration, but some recrystallisation effects, and local indications of a foliation, could also be due to subsequently imposed metamorphism. Vitric and lithic fragments, and any matrix material, were replaced by fine grained albite, quartz and K-feldspar, with commonly minor sericite and carbonate (as prismatic and irregular porphyroblasts), a little chlorite and trace titanite and pyrrhotite (Fig. 5). In places, sericite is abundant, perhaps having preferentially replaced some fragments. Phenocrystal grains of plagioclase are commonly replaced by fine grained sericite (Fig. 5), as well as by albite and K-feldspar. The rock displays several irregular to veinlike masses of fine to medium grained (locally coarse) recrystallised carbonate and in one zone, there is a gradation into a major sulphide-rich replacement mass a few centimetres across. The rock also has a few thin (up to 0.3 mm wide) irregular veins of albite ± quartz ± K-feldspar, perhaps locally overprinted by carbonate. The sulphide-rich mass is elongate in the

plane of the weak foliation (also defined by preferred orientation of carbonate and sericite) and is rich in recrystallised, fine grained pyrrhotite. This mineral is intermediate with medium grained quartz, minor sericite, chlorite, albite, arsenopyrite, sphalerite and trace chalcopyrite (Fig. 6). The overall alteration in the sample is of feldspathic type, but gradational to propylitic.

c) Mineralisation: A major sulphide-rich aggregate about 4 cm long occurs, but elsewhere in the sample, there is only a trace of pyrrhotite. The sulphide-rich mass is constituted mainly from finely recrystallised pyrrhotite, with irregularly distributed minor arsenopyrite (grains to 0.5 mm), patchy sphalerite and a trace of chalcopyrite (Fig. 6).

Mineral Mode (by volume): quartz, plagioclase (mostly albite) and pyrrhotite each 20%, K-feldspar and carbonate each 15%, sericite 7%, chlorite, arsenopyrite and sphalerite each 1% and traces of titanite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample is an altered and locally sulphide-mineralised, coarse vitric-lithic-crystal felsic tuff. Relict coarse pyroclastic texture is moderately well preserved indicating fragments were dominated by glassy and sparsely porphyritic felsic volcanic rock, with local flow foliation, perlitic cracking and possible ignimbritic texture. Phenocrystal phases were dominated by plagioclase and quartz. The rock underwent strong recrystallisation of former glassy and minor matrix material, likely due to hydrothermal alteration, but also could involve an element of later-imposed metamorphism that has also caused development of a weak foliation. The rock was largely replaced by quartz, albite and K-feldspar, with minor, but patchily abundant sericite and carbonate, a little chlorite and trace titanite and pyrrhotite. In a few places, there are recrystallised irregular to veinlike masses rich in carbonate and these locally merge into a large sulphide-rich mass that contains abundant recrystallised pyrrhotite, with minor arsenopyrite and sphalerite, plus a trace of chalcopyrite, intergrown with quartz.

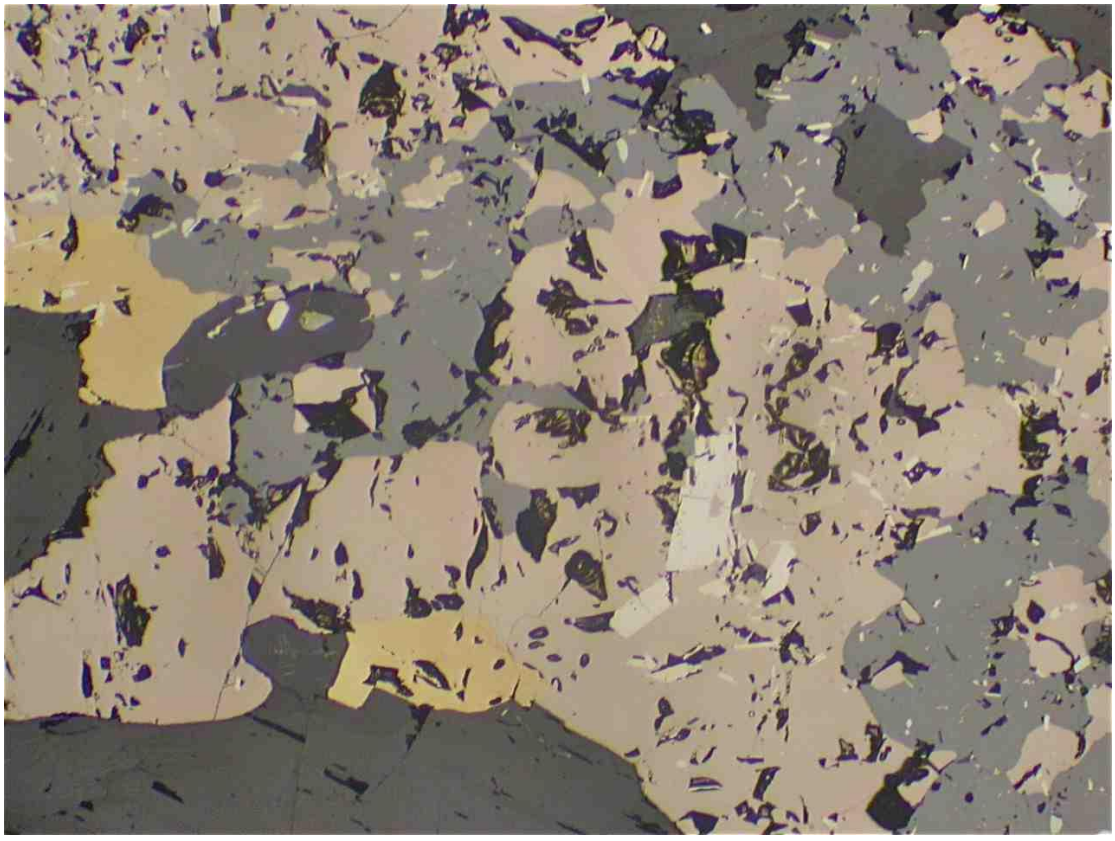


Fig. 6: Portion of the sulphide-rich aggregate, showing dominant pyrrhotite (pale brown), intergrown with sphalerite (mid grey), chalcopyrite (yeloow), arsenopyrite (white) and gangue quartz (dark grey). Plane polarised reflected light, field of view 1 mm across.

1392752 PTS

Summary: Complex felsic volcanic rock that is considered most likely to represent a body of sparsely porphyritic, originally glassy groundmass rhyodacite that could have been intrusive into masses of crystal-lithic-vitric felsic tuff and vitriclastic-dominated felsic tuff. Relict textures are moderately well preserved. The tuff components and rhyodacite host a few phenocrystal grains of quartz and altered plagioclase, with pervasive alteration having been imposed. This has resulted in replacement of the different textural domains by fine grained quartz and alkali feldspars, and subordinate sericite, with a little carbonate and pyrrhotite and traces of allanite and leucoxene-rutile. A few irregular carbonate veins occur and these grade locally into thinner feldspar-rich veining. It is possible that the rock was metamorphosed to low grade following alteration, with development of a weak foliation.

Handspecimen: The drill core sample is composed mostly of a dark grey altered porphyritic, fine grained felsic igneous rock containing a few quartz and feldspar phenocrysts in a fine grained groundmass (Fig. 7) This rock type has sharp, but in detail, rather irregular contacts against paler grey domains of apparent finely fragments and locally weakly flow foliated (?ignimbritic) felsic volcanic rock. The contact relations are not diagnostic on the handspecimen scale as to timing relations, although it could be speculated that the dark grey porphyritic rock is intrusive into the other textural domains (Fig. 7) Pervasive alteration has probably occurred, with replacement by fine grained feldspar, quartz and subordinate sericite (more abundant in the apparent pyroclastic domains), and a trace of fine grained pyrrhotite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units.

Fig. 7: Drill core sample showing different textural domains. The darker grey domain at top is a porphyritic fine grained felsic igneous rock of rhyodacitic character. The paler grey domains include possible vitriclastic felsic tuff and a crystal-lithic-vitric felsic tuff, all of which show pervasive alteration and replacement by fine grained quartz, feldspars and sericite, with a little pyrrhotite and carbonate. The thin whitish veins at right are carbonate.

Petrographic description

a) Primary rock characteristics: In the section, relict textural features are moderately well preserved and there is preservation of relict phenocrystal quartz. There are three textural domains recognised. The most voluminous is an apparently coherent, sparsely porphyritic felsic igneous rock, with a few phenocrysts of quartz and altered plagioclase (up to ~2.5 mm) in what was originally a glassy groundmass (but with a few small microphenocrysts of feldspar and rare zircon). Former glassy material is devitrified and has possible relict perlitic

cracking. This rock type could have been of rhyodacite composition and has sharp and relatively intricate contacts against the other two textural types and could be speculated to be intrusive (or maybe has a peperitic relationship). The dominant rock of the remaining two is a relatively fine grained crystal-lithic-vitric tuff, with altered plagioclase and rare phenocrystal grains of quartz, in a finer, weakly foliated tuffaceous matrix, and the minority rock type is a medium grained vitric tuff, with some preservation of glass shard texture and uncommon phenocrystal quartz and altered plagioclase (Figs 8, 9). Another alternative interpretation of the sample is that it represents a coarse breccia, with the three different texture types being tightly packed and there being no matrix (on the scale of the section).

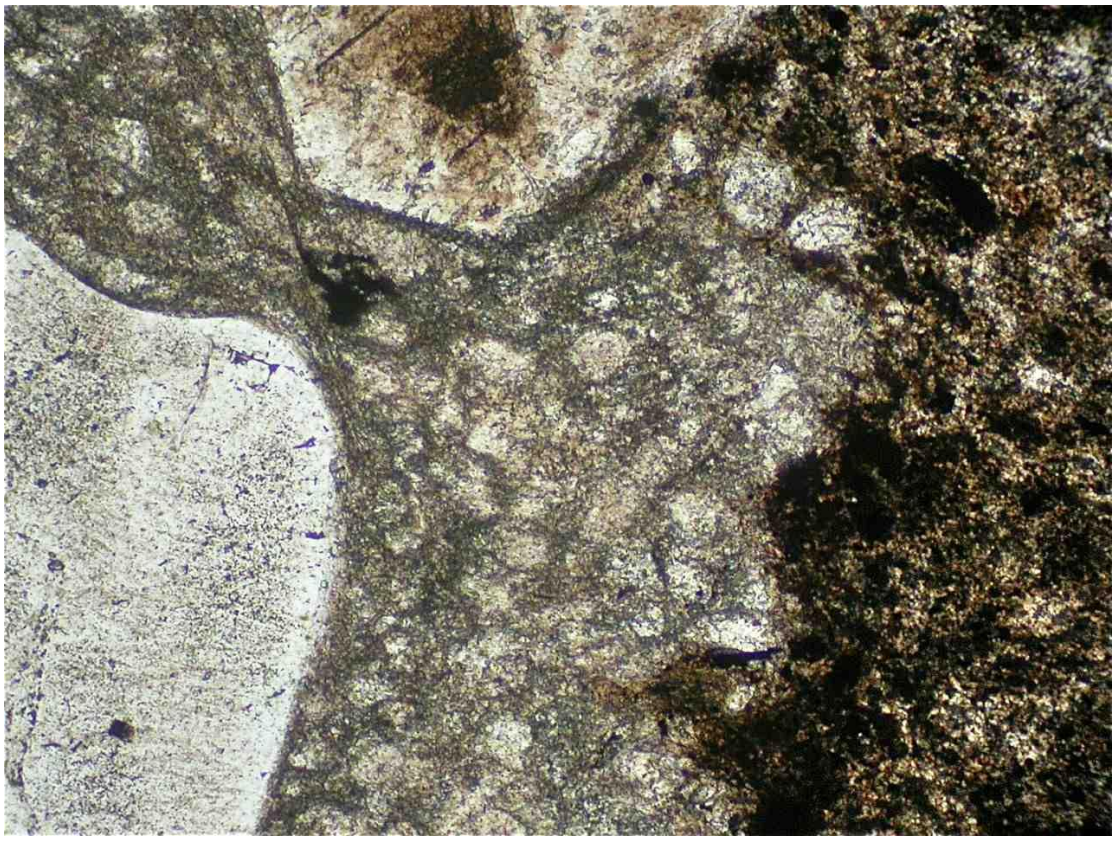


Fig. 8: Porphyritic, glassy groundmass rhyodacite at left, showing quartz phenocryst (rounded) and albitised plagioclase phenocryst (turbid, top), plus devitrified groundmass showing strong sericite alteration, abutting dark, altered tuffaceous rock at right. The latter is altered, with the pigmentation due to very small inclusions of pyrrhotite. Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: Each of the three texturally different felsic rock types has been pervasive altered, probably by an initial hydrothermal process, but also possibly by imposed metamorphism that has also led to the development of a weak foliation. Plagioclase phenocrystal grains are replaced by albite and variable amounts of sericite and trace carbonate. Much of the groundmass/matrix components were replaced by fine grained quartz, albite and K-feldspar, with variable amounts of sericite (more common in the crystal-lithic-vitric tuff and the altered glassy groundmass of the rhyodacite), a little carbonate and pyrrhotite and traces of leucoxene-rutile and allanite. Overall, the alteration is feldspathic, but grades to a type that may be transitional between phyllic and propylitic. In one part of the rock, there are a few irregular recrystallised carbonate-rich veins up to 2 mm wide, with an apparent gradation locally into thin veinlets of albite ± quartz ± carbonate.

c) Mineralisation: In most of the sample, there is a trace of sparsely disseminated pyrrhotite, with aggregates <0.3 mm across. However, in places, mostly in the altered crystal-lithic-vitric

tuff, pyrrhotite is more abundant and can form semi-massive aggregates up to 2 mm across. Associated with pyrrhotite are rare small aggregates of pyrite ± marcasite, sphalerite, and a single grain of arsenopyrite in composite with pyrrhotite.

Mineral Mode (by volume): quartz and plagioclase (mostly albite) each 30%, K-feldspar 20%, sericite 16%, carbonate 2%, pyrrhotite 1% and traces of zircon, allanite, leucoxene-rutile, pyrite, marcasite, sphalerite and arsenopyrite.

Interpretation and comment: It is interpreted that the sample represents a felsic volcanic rock with three differing textural domains. Relict textures are moderately well preserved. There is a body of sparsely porphyritic, originally glassy groundmass rhyodacite that could have been intrusive into masses of crystal-lithic-vitric felsic tuff and vitriclastic-dominated felsic tuff. The tuff components and rhyodacite host a few phenocrystal grains of quartz and altered plagioclase. Alternatively, the rock could represent a coarse breccia with three texturally differing clast types and no intervening matrix. Pervasive hydrothermal alteration was imposed as well as possibly overprinting metamorphic effects, including local development of foliation. The imposed effects caused replacement of the different textural domains by fine grained quartz and alkali feldspars, sericite, with a little carbonate and pyrrhotite, and traces of allanite and leucoxene-rutile. A few irregular carbonate veins occur and these grade locally into thinner feldspar-rich veining.

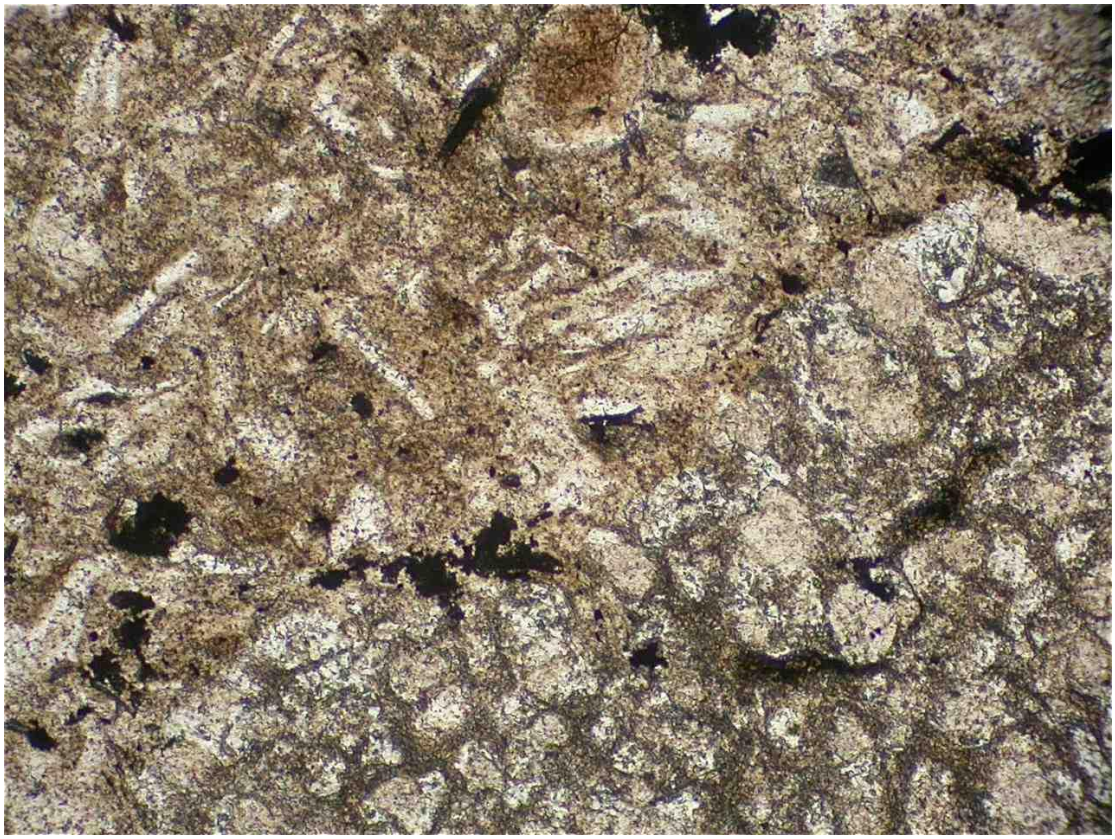


Fig. 9: Zone of altered vitriclastic tuff (upper left), with relict glass shard texture, abutting coherent rhyodacite (lower right). The latter had a largely glassy groundmass that was devitrified and developed strong replacement by sericite (turbid, greenish tint). The dark aggregates in the sample include leucoxene-rutile and at top, pyrrhotite. Plane polarised transmitted light, field of view 2 mm across.

1392753 PTS

Summary: The sample contains two texturally and compositionally distinct domains. There are separate masses of altered, partly recrystallised porphyritic rhyodacite that retain relict quartz phenocrysts, altered plagioclase phenocrysts and a few smaller altered biotite phenocrysts. These occurred in a possibly largely glassy groundmass that could have been coherent, or may represent former vitriclastic material (the former is favoured). The rhyodacite masses have sharp, commonly irregular contacts against a finely recrystallised rock that is interpreted as originally being a cherty tuff (of felsic derivation). The latter rock is compositionally homogeneous. Hydrothermal alteration and probable low grade metamorphism were imposed, with the rhyodacite showing groundmass replacement by fine grained quartz, feldspars and subordinate sericite, minor chlorite, and trace carbonate, leucoxene-rutile and pyrrhotite. Plagioclase phenocrysts were replaced by albite and sericite, and biotite by chlorite. The cherty tuff was recrystallised to very fine quartz and sericite, with local carbonate, a little pyrrhotite and trace leucoxene-rutile. Several stylolites formed, mainly in the cherty tuff, showing concentrations of leucoxene-rutile and trace pyrrhotite and sphalerite.

Handspecimen: The drill core sample is composed of differing textural and compositional domains. There are a few porphyritic zones up to several centimetres across, with these ranging from khaki-grey to dark grey in colour (Fig. 10). They contain quartz and feldspar phenocrysts in a fine grained groundmass. The porphyritic masses appear to be enclosed by fine grained grey rock, appearing to be of tuffaceous or cherty character (Fig. 10). Contacts between the two domain types are sharp and in places irregular. A few white to pale creamy brown carbonate veins are apparent. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units.

Fig. 10: Drill core sample showing different textural domains. The khaki-grey domains near centre and the dark grey domain at right are texturally and compositionally similar, being possibly coherent porphyritic rhyodacite (with plagioclase and quartz phenocrysts). The fine grained grey material is interpreted as cherty tuff. Relations between the two remain equivocal, i.e. the rhyodacite masses could be intrusive into the cherty tuff, or alternatively, the rhyodacite masses could be large lithic fragments enclosed in the fine cherty tuff. The thin discontinuous whitish veins are carbonate.

Petrographic description

a) Primary rock characteristics: In the section, relict texture is moderately well preserved and it is evident that there are two textural and compositional domains, each up to several

centimetres across and showing a sharp and commonly irregular contact (Fig. 11). There are three main zones of a porphyritic fine grained felsic igneous rock, and an intervening zone of very fine grained, homogeneous rock, which from its composition (mainly quartz and subordinate sericite, plus minor carbonate) is considered to represent an altered tuffaceous cherty rock. The porphyritic rock contains a few relict quartz phenocrysts and altered plagioclase phenocrysts up to 2.5 mm across (Fig. 11) and uncommon altered biotite phenocrysts up to 1 mm across in a fine grained groundmass. Apart from a few microphenocrysts, the latter could have originally been glassy and of quartzofeldspathic composition. Although the rock appears to be coherent, it is possible that the groundmass might have originally been vitriclastic. This rock type could be of porphyritic rhyodacite character.

Fig. 11: The left-hand half of the image shows the altered porphyritic rhyodacite (with relict quartz phenocryst) and a sharp contact against the fine grained, rather granular texture cherty tuff at right (darker). The cherty tuff is composed of dominant quartz, with minor sericite and a couple of small, prismatic carbonate porphyroblasts (pale brown). Transmitted light, crossed polars, field of view 2 mm across.

b) Alteration and structure: In the porphyritic rhyodacite, original plagioclase phenocrysts were replaced by albite and sericite, with former biotite phenocrysts being replaced by chlorite. The groundmass was replaced by finely inequigraniular quartz, albite and K-feldspar, commonly with rather abundant sericite, with minor chlorite and traces of carbonate, leucoxene-rutile and pyrrhotite. It is interpreted that the fine tuffaceous chert was replaced by very finely granular quartz, with generally minor sericite, patchily development (but mostly minor) prismatic porphyroblastic carbonate (Fig. 11), a little pyrrhotite and traces of leucoxene-rutile. A few thin stylolitic aggregates occur, mainly in the tuffaceous chert. In places they are composed of sericite, with small concentrations of leucoxene-rutile, and trace pyrrhotite and sphalerite (Fig. 12). A coupe of irregular to veinlike aggregates of recrystallised carbonate up to 2 mm across occur, mainly in the tuffaceous chert, but elsewhere, there are a few thin veins of quartz and/or carbonate + trace pyrrhotite.

c) Mineralisation: A little pyrrhotite occurs in the sample, mostly in the tuffaceous chert, in aggregates up to 1 mm across. A trace of chalcopyrite occurs in a composite with pyrrhotite in this situation. In the porphyritic rhyodacite, there are traces of pyrrhotite and pyrite. Trace pyrrhotite and sphalerite are observed as part of stylolities (Fig. 12).

Mineral Mode (by volume): quartz 40%, plagioclase (mostly albite) 25%, K-feldspar 15%, sericite 13%, carbonate 4%, chlorite 2%, pyrrhotite 1% and traces of leucoxene-rutile, pyrite, chalcopyrite and sphalerite.

Interpretation and comment: It is interpreted that the sample hosts two texturally and compositionally distinct domains, but of which were overprinted by pervasive alteration. There are separate masses of porphyritic rhyodacite that retain relict quartz phenocrysts, altered plagioclase phenocrysts and a few smaller altered biotite phenocrysts that occurred in a possibly largely glassy groundmass. Rhyodacite masses have sharp, commonly irregular contacts against a finely recrystallised rock that is interpreted as a compositionally homogeneous cherty tuff (of felsic derivation). Hydrothermal alteration and probable low grade metamorphism were imposed, with the rhyodacite showing groundmass replacement by fine grained quartz, feldspars and subordinate sericite, minor chlorite, and trace carbonate, leucoxene-rutile and pyrrhotite. Plagioclase phenocrysts were replaced by albite and sericite, and biotite by chlorite. The cherty tuff was recrystallised to very fine quartz and sericite, with local carbonate, a little pyrrhotite and trace leucoxene-rutile. Several stylolites formed, mainly in the cherty tuff, showing concentrations of leucoxene-rutile and trace pyrrhotite and sphalerite.

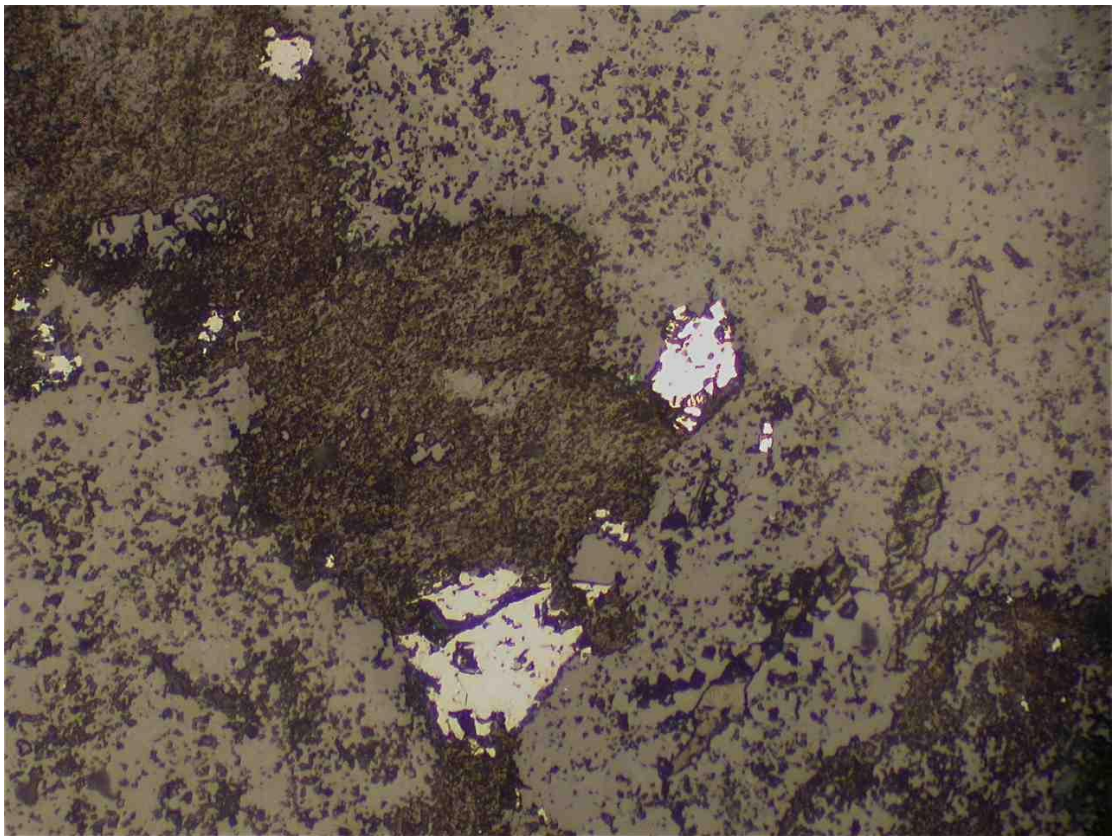


Fig. 12: Part of a stylolitic concentration of sericite (dark) containing a small aggregate of sphalerite (pale grey, lower), pyrrhotite (bright silvery pink, near centre) and rutile (upper left). Plane polarised reflected light, field of view 1 mm across.

1392754 PTS

Summary: Three compositionally and texturally distinct zones occur in the sample. A central sheared and crudely banded zone contains abundant fine to medium grained recrystallised carbonate (calcite) and sphalerite, with minor quartz and a little chlorite, pyrite, pyrrhotite, galena and albite. This zone might represent an original veinlike concentration. On one side of the sphalerite-carbonate zone, there is a domain with moderately well preserved relict texture indicating that it is an altered, rather coarse, lithic-vitric-crystal felsic tuff. This rock is little-deformed and has a strong alteration assemblage of quartz-sericite-K-feldspar, with minor carbonate, chlorite and albite, and trace sphalerite, pyrite and rutile. On the other side of the sphalerite-carbonate zone, there is a merger into a strongly foliated and altered domain of chlorite-sericite-carbonate, hosting a few obliquely dispersed carbonate veins. This domain has a few relict phenocrystal grains of quartz and could represent a former felsic tuff.

Handspecimen: The drill core sample contains a thinly banded, apparently sheared zone up to 2.5 cm wide containing abundant brown sphalerite and pale grey carbonate that is at ~40° to the core axis (Fig. 13)> On one side of the sphalerite-carbonate mass, there is a dark grey, altered domain of coarsely fragmental texture felsic volcanic rock, with lithic clasts up to 1 cm across and a few feldspar and quartz phenocrystal grains. On the other side of the sphalerite-carbonate mass, there is a fine grained, foliated grey rock, with sparse deformed lithic fragments and rare quartz phenocrystal grains. This rock type could represent a deformed and altered felsic pyroclastic and appears to be rich in sericite, chlorite and carbonate, with several foliation-parallel and obliquely cross-cutting whitish carbonate veins (Fig. 13). The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Fig. 13: Drill core sample illustrating the crudely banded domain of brown sphalerite and pale grey carbonate (calcite) at ~40° to the core axis. On the left-hand side of the sphalerite-carbonate zone is a strongly foliated domain of highly altered felsic tuff, now replaced by chlorite, sericite and carbonate, and containing several tension gash type carbonate veins. On the right-hand side of the sphalerite-carbonate zone is a small domain of altered coarse lithic-vitric-crystal felsic tuff that has considerable preservation of relict texture.

Petrographic description

a) Primary rock characteristics: In the section, there are three textural and compositional domains. These are: (a) A central zone dominated by foliated and recrystallised texture sphalerite and carbonate, with minor quartz and a little chlorite, albite, pyrite, pyrrhotite and galena. This zone has no relict texture due to deformation and recrystallisatiomn and it could possibly represent a vein assemblage. (b) On one side of the sphalerite-carbonate zone, there is a domain with moderately well preserved relict coarsely fragmental pyroclastic texture (Fig. 14). In this domain, there are scattered altered lithic fragments up to 1 cm across of porphyritic felsic volcanic similar to that in 1392752-3 that have quartz and plagioclase phenocrysts in a glassy or pumiceous groundmass, along with individual grains of quartz and plagioclase, and rare apatite in a fine grained matrix of possible former vitriclastic material. This rock is interpreted as a lithic-vitric-crystal felsic tuff. (c) On the other side of the sphalerite-carbonate zone, there is a strongly foliated domain with no relict texture apart from a few relict phenocrystal grains of quartz up to 1 mm and "ghosted" small remnants of former plagioclase and lithic grains. This domain is speculated to have been a type of felsic tuff.

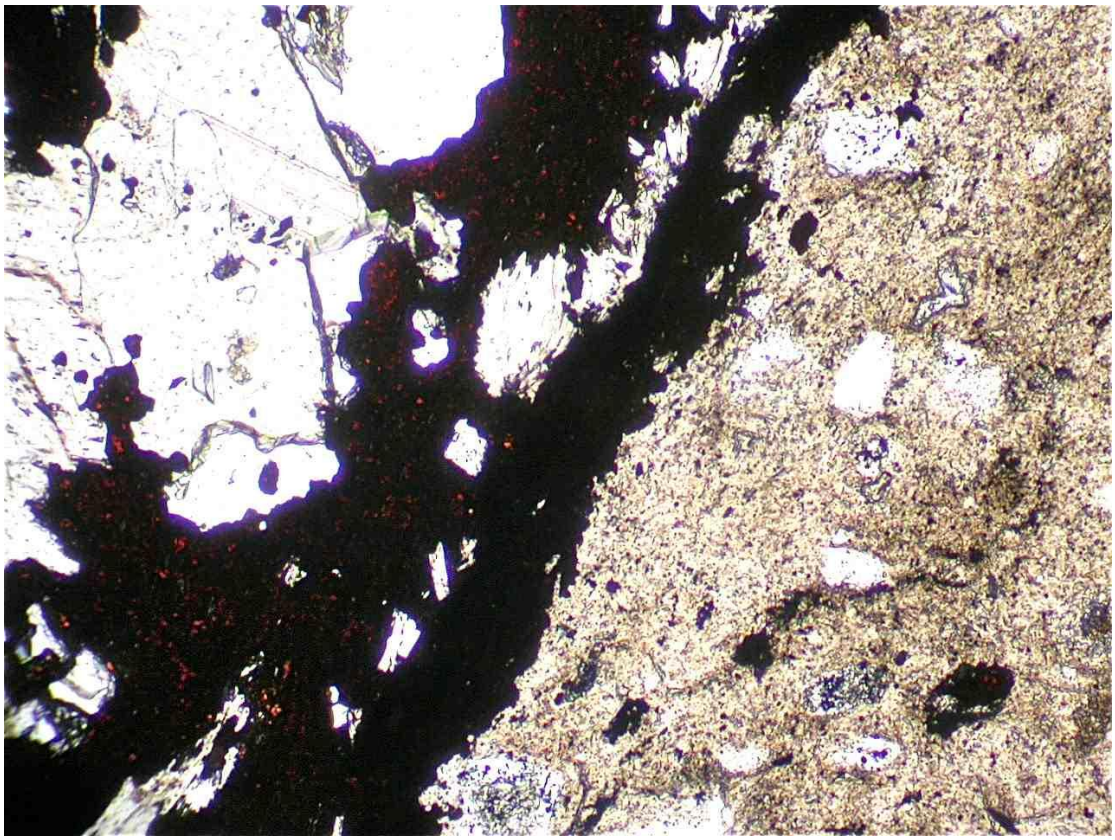


Fig. 14: Sharp contact between altered lithic-vitric-crystal felsic tuff (right) and the veinlike zone of sphalerite (dark brown to black) and carbonate (clear) with a little quartz and chlorite (left). Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: The interpreted felsic pyroclastic rocks bordering the sphalerite-carbonate zone are strongly hydrothermally altered and variably deformed. In the zone with better preservation of relict texture, an alteration assemblage was imposed that had later incipient development of foliation, and replacement by abundant fine grained quartz and sericite, patchy K-feldspar, minor carbonate, chlorite and albite and traces of sphalerite, pyrite, pyrrhotite and rutile. In the strongly foliated zone, fine to medium grained chlorite is abundant, with intercalated zones of sericite and carbonate, and trace sphalerite, pyrite and galena. Preferred orientation of chlorite and sericite defines the foliation and there is a considerable amount of recrystallised carbonate veining oblique to the foliation and defining

a secondary foliation. The sphalerite-carbonate zone is ~2.5 cm wide and contains crudely banded fine to medium grained sphalerite and carbonate, with minor patchy recrystallised quartz (aggregates up to a few millimetres, locally intergrown with albite), chlorite (near the margins of the zone) and a little pyrrhotite, pyrite and galena (Figs 14, 15). Carbonate and sphalerite aggregates in this zone commonly show weak to moderate foliation.

c) Mineralisation: In the sphalerite-carbonate zone, there is abundant, fine to medium grained, moderate-Fe sphalerite, intergrown with carbonate and quartz. A little galena, in aggregates up to 0.5 mm across are intergrown with sphalerite and there are irregularly distributed porphyroblasts of pyrite up to 0.5 mm across (Fig. 15) and prismatic pyrrhotite up to 0.5 mm long. In the altered felsic pyroclastic domains, there are traces of disseminated pyrite and sphalerite.

Mineral Mode (by volume): carbonate (calcite) 40%, sphalerite 16%, quartz and chlorite each 15%, K-feldspar and sericite each 5%, albite, pyrite, pyrrhotite and galena each 1% and traces of rutile and apatite.

Interpretation and comment: It is interpreted that the sample has three compositionally and texturally distinct zones. A central zone contains abundant fine to medium grained recrystallised carbonate (calcite) and sphalerite, showing crude banding and foliation. This zone might represent an original veinlike concentration. On one side of the sphalerite-carbonate zone, there is a domain with moderately well preserved relict texture indicating that it is an altered, rather coarse, lithic-vitric-crystal felsic tuff. This rock is little-deformed and has a strong alteration assemblage of quartz-sericite-K-feldspar, with minor carbonate, chlorite and albite, and trace sphalerite, pyrite and rutile. On the other side of the sphalerite-carbonate zone, there is a merger into a strongly foliated and altered domain of chlorite-sericite-carbonate, hosting a few obliquely dispersed carbonate veins. This domain has a few relict phenocrystal grains of quartz and could represent a former felsic tuff. The strongly mineralised central zone contains abundant moderate-Fe sphalerite, with a little intergrown galena and small, porphyroblastic grains of pyrrhotite and pyrite.

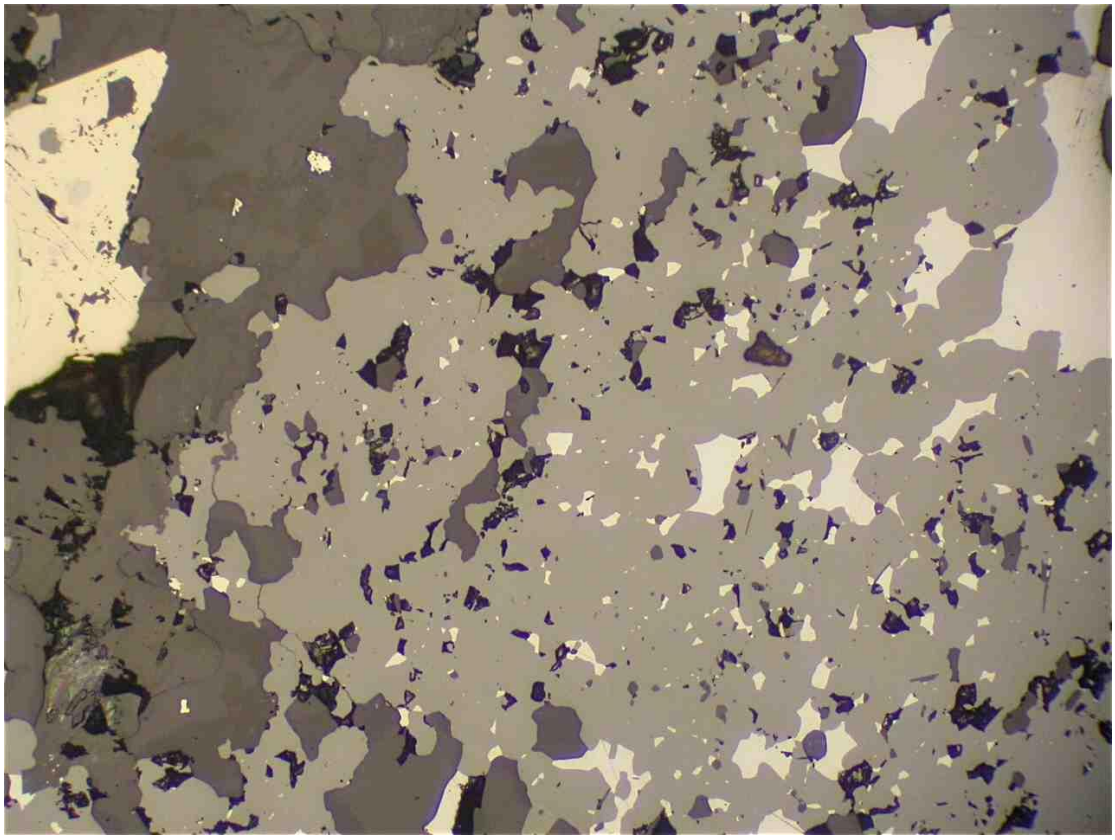


Fig. 15: Semi-massive sphalerite in the central sphalerite-carbonate domain, showing intergrwn with minor galena (silvery grey), carbonate (dark grey) and at left, portion of a pyrite porphyroblast. Plane polarised reflected light, field of view 1 mm across.

1392755 PTS

Summary: Coarse matrix-supported felsic volcanic breccia with scattered angular to sub-rounded clasts of variably porphyritic, fine grained felsic volcanic rock (ranging from almost aphyric) to more conspicuously phenocryst-bearing) in a generally fine grained matrix that is dominated by vitriclastic material. In the latter, there are local zones with coarser vitriclasts (including pseudomorphed glass shard material) and a few phenocrystal grains of quartz. The clasts have local flow foliation and relict perlitic cracking in groundmass material, which would have probably been glassy. Phenocrysts in the porphyritic clasts are dominated by quartz, with minor feldspars and trace biotite. The rock has experience strong pervasive alteration, perhaps due to both hydrothermal and low grade metamorphic processes. The replacement assemblage is dominated by fine grained sericite and quartz, with some clasts being particularly sericite-rich. There is also subordinate carbonate and chlorite, with trace pyrrhotite, pyrite and rutile. Several irregular to veinlike masses of recrystallised carbonate occur and the rock has a sericite-defined foliation in places.

Handspecimen: The drill core sample is composed of a coarse, matrix-supported felsic volcanic breccia. Angular to sub-rounded volcanic clasts are up to several centimetres across and occur in a grey, fine grained, altered tuffaceous matrix (Fig. 16). There are two main types of volcanic clast – one is pale grey, largely aphyric and weakly flow banded, and the other is porphyritic, with quartz and feldspar phenocrysts in a fine grained groundmass (Fig. 16). There are a few medium grained carbonate-rich aggregates that might represent disrupted veins. A single aggregate of pyrrhotite a few millimetres across is prominent. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units.

Fig. 16: Drill core sample showing coarse, matrix-supported breccia texture. The clasts are composed of coherent felsic volcanic rock, with a range of textures from almost aphyric to more strongly porphyritic (e.g. at left), with the clasts enclosed in a grey matrix of fine grained vitriclastic-dominated material. The rock is pervasively altered, with an assemblage of sericite-quartz (-carbonate-chlorite) having formed.

Petrographic description

a) Primary rock characteristics: In the section, relict pyroclastic texture is moderately well preserved. It is apparent that the rock is rather coarse and displays a matrix-supported texture. There are scattered angular to sub-rounded clasts up to several centimetres across, enclosed in a generally fine grained matrix. The latter is mostly composed of fine vitriclastic material, but in places this grades into somewhat coarser vitriclasts (e.g. glass shard texture)

(Fig. 17) and also contains a few relict phenocrystal grains of quartz and small, felsic volcanic lithics. The clasts are dominated by fine grained, sparsely porphyritic felsic volcanic rock, with textural variations depending on the amounts of phenocrysts (quartz and uncommon feldspars up to 2.5 mm across, plus rare biotite), presence of flow foliation and perlitic cracking (Fig. 18). Textural characteristics of the groundmass component of the clasts implies that it was glassy to aphanitic and of quartzofeldspathic composition. From the relict characteristics, the rock is interpreted as a coarse lithic-vitric-crystal tuff, with the clast size indicating the alternative terminology of a volcanic breccia.

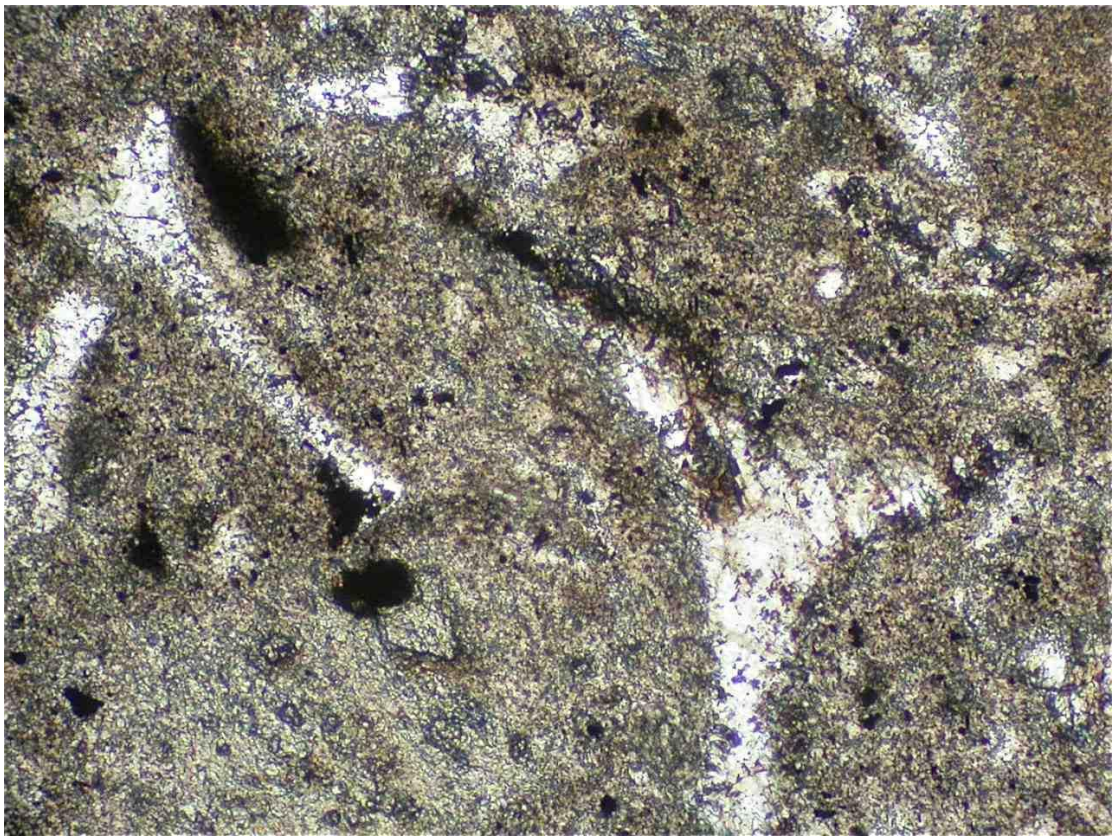


Fig. 17: A zone within the vitriclastic matrix that is somewhat coarser and displays relict glass shard texture. The rock is strongly altered to sericite and quartz, with minor chlorite, and the black grains being pyrrhotite. Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: Pervasive alteration was imposed, along with effects of penetrative deformation and local veining. The alteration assemblage is dominated by fine grained sericite and quartz, with patchy (generally minor) chlorite in the vitriclastic matrix (Fig. 17), along with a little porphyroblastic carbonate and traces of pyrrhotite, pyrite and rutile. Most original feldspar was destroyed by alteration. Some of the volcanic clasts are particularly rich in alteration-derived sericite. Irregularly distributed medium grained recrystallised aggregates of carbonate up to several millimetres across occur, with many of these being veinlike. The alteration assemblage is consistent with propylitic type and could be due to hydrothermal and low grade metamorphic processes. A weak to moderate foliation is commonly apparent, especially in the sericite-dominated zones.

c) Mineralisation: The alteration assemblage contains a little irregularly distributed pyrrhotite in aggregates up to 0.5 mm across (Fig. 17). There are also rare fine grained pyrite aggregates up to 1 mm across.

Mineral Mode (by volume): sericite 50%, quartz 25%, carbonate 15%, chlorite 8%, K-feldspar 1% and traces of rutile, pyrrhotite and pyrite.

Interpretation and comment: It is interpreted that the sample represents a felsic volcanic breccia with a matrix-supported texture and containing scattered angular to sub-rounded clasts of variably porphyritic, fine grained felsic volcanic rock in a generally fine grained vitriclastic matrix. In the latter, there are local zones with coarser vitriclasts (including pseudomorphed glass shard material) and a few phenocrystal grains of quartz. The clasts have local flow foliation and relict perlitic cracking in groundmass material, that would have probably been glassy. Phenocrysts in the porphyritic clasts are dominated by quartz, with minor feldspars and trace biotite. Strong pervasive alteration was imposed, perhaps due to both hydrothermal and low grade metamorphic processes, and leading to replacement by fine grained sericite and quartz, with some clasts being particularly sericite-rich. There is also subordinate carbonate and chlorite, with trace pyrrhotite, pyrite and rutile. Several irregular to veinlike masses of recrystallised carbonate occur and the rock has a sericite-defined foliation in places.

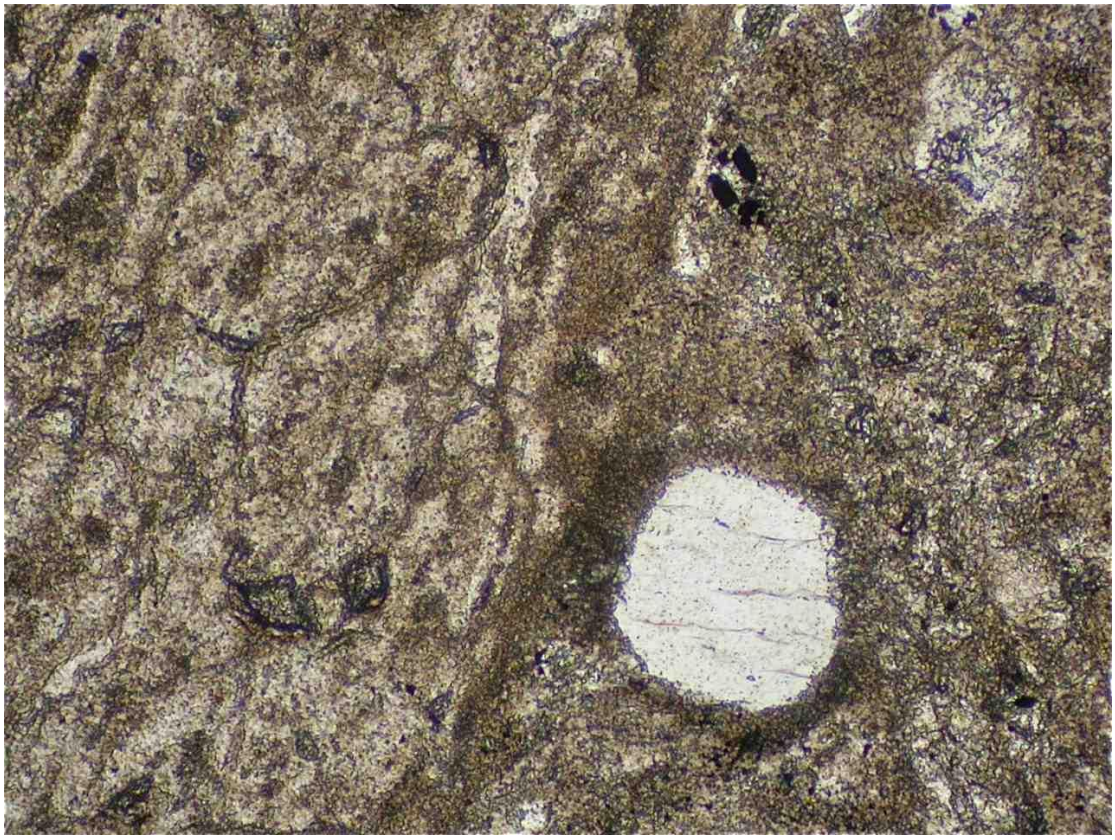


Fig. 18: Portion of a weakly flow-foliated aphyric felsic volcanic clast (left) abutting the altered fine grained vitriclastic matrix (right) that also has a microphenocrystal grains of quartz and altered feldspar (upper right). There is pervasive sericite-quartz alteration throughout. Plane polarised transmitted light, field of view 2 mm across.

1392756 PTS

Summary: Dominant fine grained tuffaceous, fine grained siltstone (epiclastic), containing a few isolated detrital lithic fragments and individual volcanic phenocrystal mineral grains (quartz, plagioclase), plus a little dispersed carbonaceous material and a few possible recrystallised radiolarians. Larger lithic fragments in the tuffaceous siltstone include porphyritic rhyodacite (phenocrysts of quartz, altered feldspar and trace biotite in a fine grained, possibly formerly glassy, groundmass) and a single mass of medium grained altered microdiorite. All components of the rock were subject to pervasive propylitic alteration, but with local quartz-rich replacement aggregates having formed locally. Fine grained sericite and quartz, with subordinate chlorite and minor pyrrhotite and carbonate prevail in the tuffaceous siltstone, whereas in the rhyodacite, replacement was by quartz, sericite, K-feldspar, albite and minor chlorite, and in the microdiorite fragment, by albite, chlorite and pyrrhotite. The quartz-rich alteration aggregates are finely recrystallised and also contain carbonate and pyrrhotite. A weak to moderate foliation is evident in the tuffaceous siltstone, defined by preferred orientation of layer silicates and pyrrhotite aggregates.

Handspecimen: The drill core sample is dominantly composed of fine grained, weakly to moderately foliated, dark grey tuffaceous or sedimentary (e.g. shale-siltstone, maybe epiclastic) rock, containing a few irregular khaki-grey clasts, the largest of which is several centimetres across and composed of porphyritic, fine grained felsic volcanic rock (Fig. 19). The fragments contain phenocrysts of quartz and feldspar in a fine grained, altered groundmass. Smaller clasts could be of similar type, although some appear to be dominated by fine grained, pale grey quartz. The dark grey rock could contain abundant sericite, quartz and chlorite and be pigmented by finely dispersed carbonaceous material and finely disseminated pyrrhotite. Foliation in the rock is at a low angle to the core axis. The sample is moderately magnetic, with susceptibility up to 160 x 10^{-5} SI units.

Fig. 19: Drill core sample containing dark grey fine grained tuffaceous siltstone (epiclastic), with dark colour due to dispersed pyrrhotite and graphite, and with a couple of large, khaki-grey fragments of porphyritic felsic volcanic rock (e.g. rhyodacite). The latter has alteration to quartz, sericite, K-feldspar and albite, with minor chlorite, whereas the host tuffaceous siltstone is dominated by foliated sericite and quartz, plus subordinate chlorite and minor pyrrhotite and carbonate.

Petrographic description

a) Primary rock characteristics: In the section, relict texture is moderately well preserved. The majority of the rock (~70% of the section) is composed of a weakly to moderately foliated,

generally fine grained rock that has relict characteristics indicating that it is probably an epiclastic, e.g. siltstone with abundant vitriclastic and locally lithic and mineral grain detritus. In a few places, it can be discerned that there are small pseudomorphed glass shard structures, along with a few small individual grains of quartz, feldspar and small, altered lithic grains (Figs 20, 21). The interpreted tuffaceous siltstone has a few ovoid aggregates up to 1 mm across that contain a little dispersed carbonaceous material (along with pyrrhotite and rutile) and hence they are darkly pigmented ((Fig. 20). There are also rare spheroidal aggregates up to 0.3 mm across of finely recrystallised quartz that are interpreted as former radiolarians. Hosted in the tuffaceous siltstone, there is a large (>5 cm) clast of porphyritic, fine grained felsic volcanic rock (and a couple of smaller ones of similar character), as well as a single clast about 8 mm across of a medium grained, plagioclase-rich igneous rock, e.g. microdiorite, and a few irregular quartz-rich masses. The latter are probably hydrothermal replacive aggregates, but could be in part overprinting earlier lithic clasts. The porphyritic felsic volcanic clasts have scattered quartz and feldspar phenocrysts, and pseudomorphs after rare biotite phenocrysts in a fine grained quartzofeldspathic groundmass that might have once been partly glassy, but has now been recrystallised and hosts abundant small K-feldspar spheroids (Fig. 21).

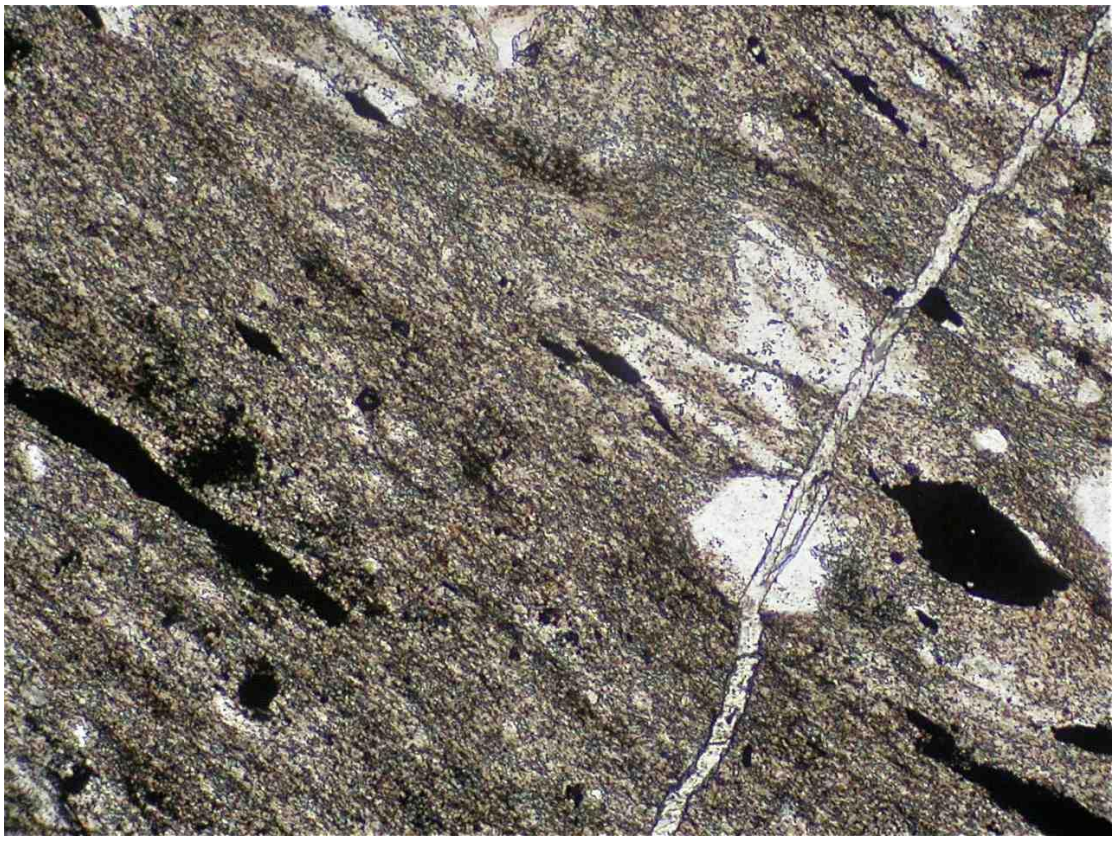


Fig. 20: Interpreted tuffaceous siltstone, with small clastic grains of quartz and feldspar (right). The rock was replaced by a foliated assemblage of sericite and quartz, with minor chlorite and pyrrhotite (black). The dark pigmentation in places is due to finely dispersed graphitic material. Note the thin carbonate vein cutting the foliation at a high angle. Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: Pervasive alteration has occurred throughout, with patchy intense quartz replacement zones up to several millimetres across and development of a foliation (Fig. 20). The tuffaceous siltstone was replaced by fine grained sericite and quartz, with subordinate chlorite, minor disseminated pyrrhotite and carbonate, and traces of graphite, rutile, pyrite and chalcopyrite. The rhyodacite clasts show strong alteration to fine grained quartz, sericite and K-feldspar, with plagioclase phenocrysts being replaced by albite,

K-feldspar, sericite and carbonate, and biotite by chlorite and sericite, along with trace pyrite and rutile. The microdiorite clast was replaced by albite, chlorite and pyrrhotite. The quartz-rich aggregates show fine grained recrystallised texture and also have minor carbonate and pyrrhotite. Foliation in the rock is defined by preferred orientation of sericite and chlorite, along with elongation of pyrrhotite aggregates. A couple of elongated carbonate "pressure shadows" have formed adjacent to lithic clasts. Alteration in the sample is essentially of propylitic type, although in part is it likely due to low grade metamorphism.

c) Mineralisation: The sample contains disseminated pyrrhotite in the tuffaceous siltstone and locally prominently in the quartz-rich replacement aggregates and the altered microdiorite clast. Pyrrhotite masses are commonly elongate in the plane of the foliation, up to 2 mm long and locally form composites with pyrite. Elsewhere, there are traces of pyrite and rare chalcopyrite (attached to pyrrhotite).

Mineral Mode (by volume): sericite 40%, quartz 25%, K-feldspar 15%, chlorite 10%, albite 5%, carbonate and pyrrhotite each 2% and traces of carbonaceous material (graphite), rutile, pyrite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample is an epiclastic sedimentary rock, being a rather fine grained tuffaceous siltstone containing a few isolated detrital lithic fragments and individual volcanic phenocrystal mineral grains (quartz, plagioclase), plus a little dispersed carbonaceous material and possible recrystallised radiolarians. Larger lithic fragments include porphyritic rhyodacite (quartz- and feldspar-phyric) and a single mass of medium grained altered microdiorite. All components of the rock were subject to pervasive propylitic alteration, but with local quartz-rich replacement aggregates having formed locally. Fine grained sericite and quartz, with subordinate chlorite and minor pyrrhotite and carbonate are dominant in the tuffaceous siltstone, whereas in the rhyodacite, replacement was by quartz, sericite, K-feldspar, albite and minor chlorite, and in the microdiorite fragment, by albite, chlorite and pyrrhotite. The quartz-rich alteration aggregates are finely recrystallised and also contain carbonate and pyrrhotite. A weak to moderate foliation is evident in the tuffaceous siltstone, defined by preferred orientation of layer silicates and pyrrhotite aggregates.

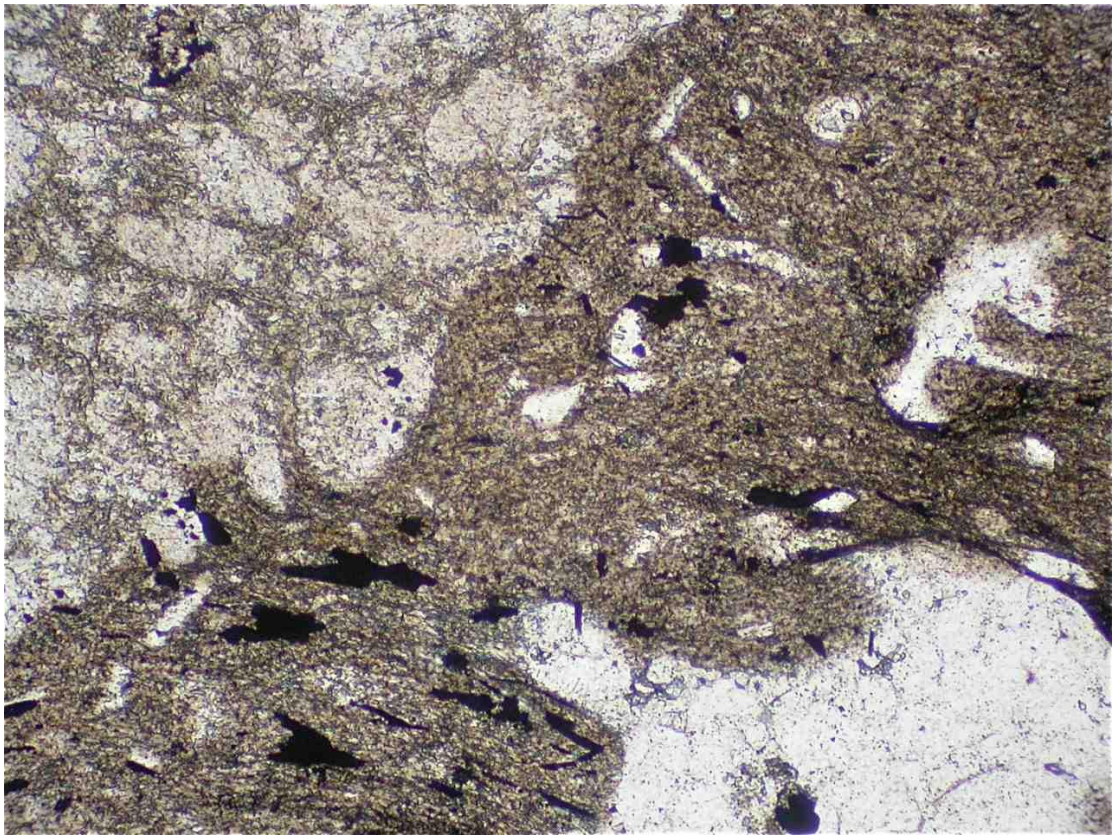


Fig. 21: Portion of rhyodacite clast (left, with diffuse aggregates of K-feldspar), abutting turbid, fine grained altered tuffaceous siltstone. Note altered vitriclastic fragments and a relict volcanic phenocrystal quartz grain in the siltstone. The small black aggregates are pyrrhotite. Plane polarised transmitted light, field of view 2 mm across.

1392757 PTS

Summary: Felsic pyroclastic or epiclastic rock, containing sparsely scattered relict quartz and altered feldspar phenocrystal grains, as well as altered volcanic lithic grains in a fine grained matrix that has experienced strong hydrothermal alteration as well as low grade metamorphic and penetrative deformation effects. The rock has a strong foliation and interpreted hydrothermal components are entirely recrystallised. The latter are commonly found in a compositionally banded distribution, perhaps reflecting in part, original compositional layering. The main alteration minerals are sericite and carbonate (calcite), with minor quartz, chlorite and trace pyrrhotite and rutile. There is a major foliation-parallel band of recrystallised, semi-massive pyrrhotite and sphalerite, intergrown with subordinate quartz, minor carbonate and chlorite, and containing a little galena and trace pyrite and arsenopyrite. The sulphide-rich band is interpreted as a vein-like mass emplaced concordantly with the foliation.

Handspecimen: The drill core sample displays a compositionally banded, foliated, strongly altered rock, with banding and co-planar foliation being at ~20° to the core axis (Fig. 22). A prominent band of fine grained sulphides up to 2 cm wide ranges from pyrrhotite- to sphalerite-rich and is enclosed by altered host rock bands that range from pale grey to darker grey and pale khaki-grey (Fig. 22). The pale grey bands are carbonate-rich, which when treated with dilute HCl, gave a strong reaction, indicating that it is calcite. The other bands have relict clastic texture, with sparsely scattered relict quartz and altered feldspar and lithic grains in a fine grained altered matrix, probably rich in sericite (Fig. 22). These compositional domains could represent former pyroclastic or epiclastic material. The sample is strongly magnetic in the pyrrhotite-rich zone, with susceptibility up to 1800 x 10^{-5} SI units.

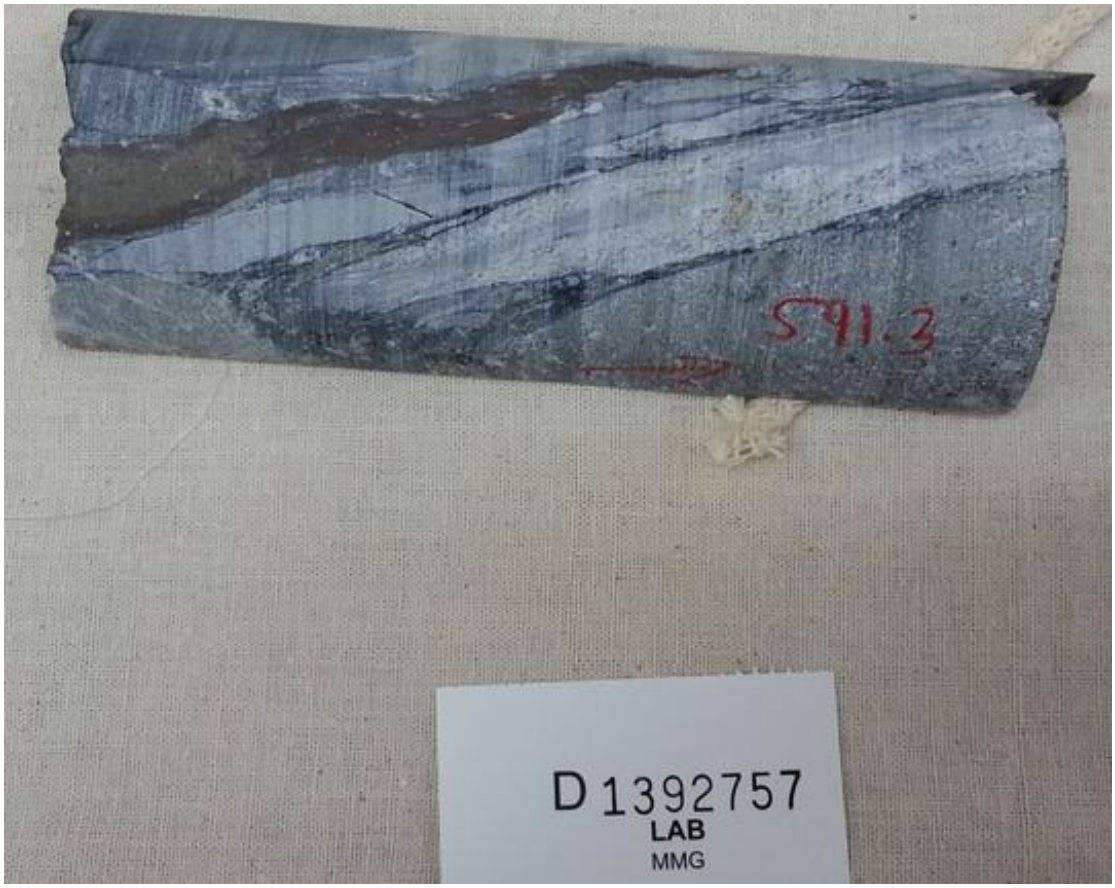


Fig. 22: Drill core sample showing foliated, compositionally banded, strongly altered rock, some of which has relict grains of quartz, feldspar and volcanic lithics in a fine grained matrix. Pale grey-white bands are dominated by recrystallised hydrothermal carbonate

(calcite) and the pale grey-khaki domains have abundant sericite alteration. The dark band represents a sheared, foliation-parallel vein-like mass of pyrrhotite, sphalerite and minor quartz and carbonate.

Petrographic description

a) Primary rock characteristics: In the section, relict texture is commonly largely destroyed due to imposition of alteration and deformation, but there are banded domains in which relict clastic texture is poorly to moderately preserved. It is possible that the rock preserves some form of primary compositional layering, based on differences in amounts of clastic grains versus fine grained matrix. Apart from a band containing abundant sulphides, the remainder of the rock is considered to represent a type of felsic pyroclastic or epiclastic, with varying (generally small) amounts of clastic grains (including relict volcanic phenocrystal quartz and altered feldspar up to 1.5 mm, and volcanic lithic grains up to a few millimetres) in a dominant fine grained matrix (Fig. 23). It is speculated that the matrix could have included fine vitriclastic material.

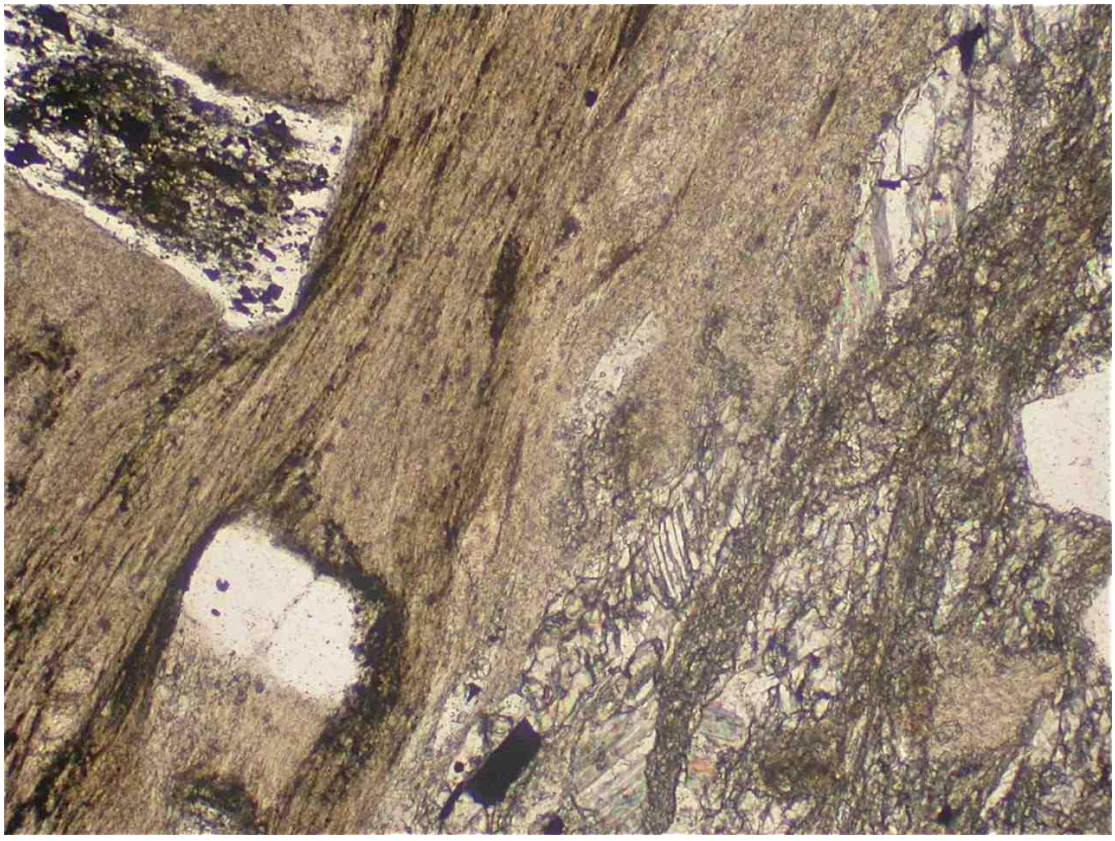


Fig. 23: Interpreted altered felsic pyroclastic or epiclastic rock, with preserved altered feldspar at upper left and a couple of relict quartz grains. The foliated, altered matrix is sericite-rich at left and carbonate-rich at right. Plane polarised transmitted light, field of view 2 mm across.

b) Alteration and structure: The interpreted pyroclastic or epiclastic rock was strongly hydrothermally altered, subject to penetrative deformation and probably, coeval low grade metamorphism. It was replaced by a compositionally banded assemblage that ranges from fine grained sericite-rich to fine to medium grained carbonate-rich (Fig. 23), with the sericite-rich zones also containing minor chlorite and local quartz. Former phenocrystal feldspars were replaced by albite and/or K-feldspar ± carbonate and sericite, and lithic grains were replaced by assemblages that include abundant quartz (± albite, K-feldspar, sericite, carbonate, pyrrhotite). In the sericite-rich zones, there is commonly a little pyrrhotite (and trace pyrite, chalcopyrite, arsenopyrite) and locally, thin, highly contorted stylolitic

aggregates of rutile ± pyrrhotite. Foliation in the altered rock is defined by sericite preferred orientation, as well as by elongation of carbonate aggregates. A prominent sulphide-rich mass up to 2 cm wide occurs concordantly with the foliation and compositional banding. It contains semi-massive, recrystallised pyrrhotite and sphalerite, commonly intergrown with subordinate quartz, minor carbonate and a little chlorite, galena and trace pyrite and arsenopyrite (Fig. 24). The sulphide-rich band does not contain any relict material from enclosing host rock and is therefore considered more likely to represent a veinlike mass, e.g. remobilised material emplaced along the foliation. A few recrystallised veinlike carbonate masses up to 0.5 mm wide occur oblique to the foliation and could represent tension gash fillings.

c) Mineralisation: Away from the sulphide-rich band, the altered host rock contains a little irregularly distributed pyrrhotite and trace pyrite, chalcopyrite and arsenopyrite. The sulphide-rich band is composed of crudely layered, semi-massive pyrrhotite, grading to sphalerite-rich, in places accompanied by a little galena (aggregates up to 2 mm) and trace pyrite and arsenopyrite (Fig. 24). Sphalerite and pyrrhotite have fine to medium grained recrystallised texture.

Mineral Mode (by volume): sericite 25%, carbonate (calcite) 20%, quartz and pyrrhotite each 15%, sphalerite 11%, K-feldspar and chlorite each 5%, albite 2%, galena 1% and traces of rutile, pyrite, arsenopyrite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample represents a deformed, altered and mineralised felsic pyroclastic or epiclastic rock. Patchily preserved relict texture indicates that there are scattered relict quartz and altered feldspar phenocrystal grains, as well as altered volcanic lithic grains in a fine grained matrix. The rock has a strong foliation and interpreted hydrothermal components are entirely recrystallised. The latter are commonly found in a compositionally banded distribution. The main alteration minerals are sericite and carbonate (calcite), with minor quartz, chlorite and trace pyrrhotite and rutile. There is a major foliation-parallel band of recrystallised, semi-massive pyrrhotite and sphalerite, intergrown with subordinate quartz, minor carbonate and chlorite, and containing a little galena and trace pyrite and arsenopyrite. The sulphide-rich band is interpreted as a vein-like mass emplaced concordantly with the foliation.

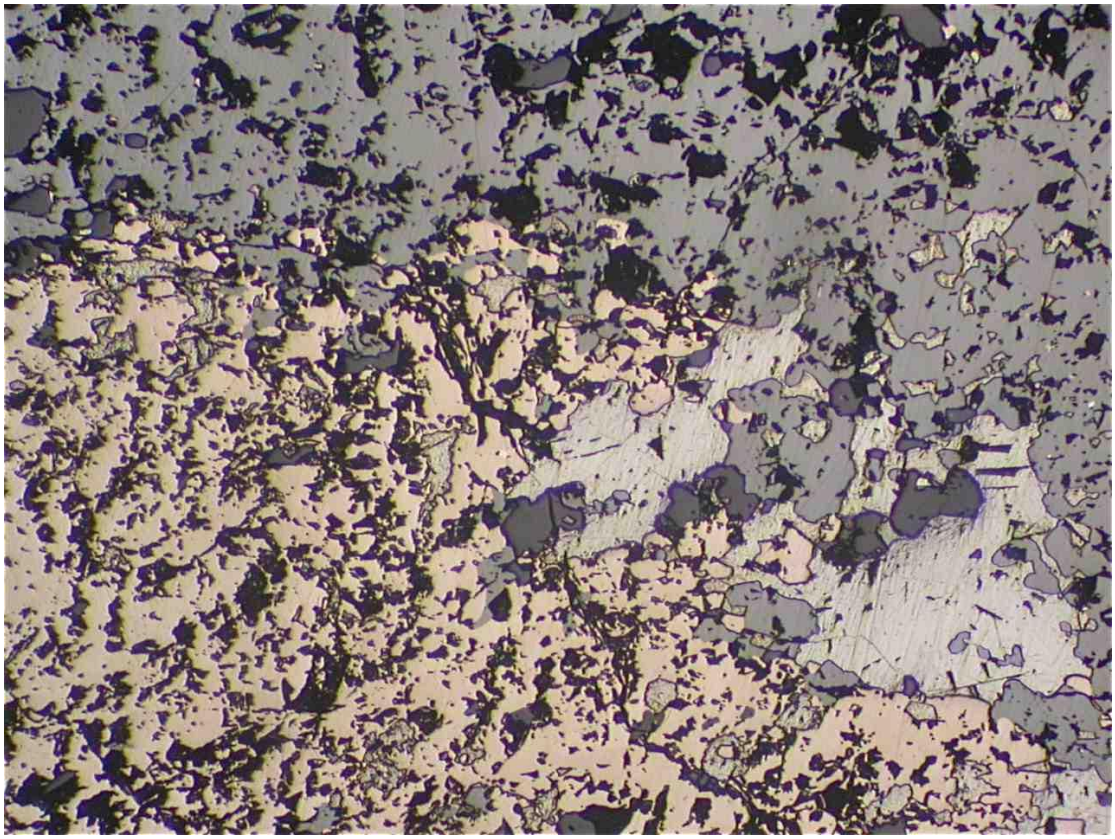


Fig. 24: Rather poorly polished zone of essentially massive sulphides in the sulphide-rich band. Abundant sphalerite (mid grey) and pyrrhotite (pale brown) are intergrown with minor galena (silvery grey). Plane polarised reflected light, field of view 2 mm across.

1392758 PTS

Summary: Epiclastic sedimentary rock, e.g. siltstone, with likely felsic volcanic detritus, including sparse lithics, feldspar (altered) and quartz grains in a fine grained matrix (containing trace graphite), showing strong pervasive alteration and a large sulphide-rich mass that is considered to be the product of hydrothermal replacement. The host rock has been replaced by assemblages that range from being rich in carbonate, quartz, chlorite or sericite (with gradations, and also containing a little disseminated pyrrhotite and sphalerite) and shows a generally weak foliation. The sulphide-rich mass is dominated by strongly disseminated to semi-massive, recrystallised pyrrhotite and sphalerite, intergrown with abundant carbonate. In places, there are local concentrations of quartz, arsenopyrite and pyrite, with a little chlorite, galena, chalcopyrite and marcasite.

Handspecimen: The drill core sample is composed of a rather coarsely fragmental clastic rock, with scattered sub-rounded to angular fragments up to several centimetres across of pale yellowish-grey, altered fine grained porphyritic felsic volcanic rock in a matrix of fine grained, dark grey rock that appears to be of sedimentary type, e.g. siltstone, maybe pigmented by finely dispersed carbonaceous material. The latter compositional zone is closely associated with a large ovoid mass rich in sulphides (mainly pyrrhotite and sphalerite) up to several centimetres across (Fig. 25). Alteration in the host rock varies from sericite-rich (in the volcanic fragments) to zones with chlorite, quartz and carbonate. A weak foliation is apparent at a low angle to the core axis (Fig. 25). The sample is strongly magnetic in the pyrrhotite-rich zone, with susceptibility up to 1240 x 10^{-5} SI units. It is important to note that the polished thin section was taken across the sulphide-rich zone and adjacent fine grained rock and did not intersect many of the large altered volcanic fragments.

Fig. 25: Drill core sample containing large ovoid sulphide-rich aggregate (dominated by pyrrhotite and sphalerite) hosted within a pale to dark grey mass of altered epiclastic sedimentary rock (felsic volcanic detritus), which elsewhere contains scattered large fragments of altered porphyritic felsic volcanic rock. The host rock has strong alteration to fine grained carbonate (commonly porphyroblastic), chlorite, sericite and quartz, plus disseminated sulphides, and is typically weakly foliated.

Petrographic description

a) Primary rock characteristics: In the section, much of the sample has no recognised relict texture due to apparently intense hydrothermal replacement, especially in association with the mass that is rich in sulphides and carbonate. Away from this zone, there are domains with moderate preservation of relict clastic texture. It appears that the host rock was mostly fine grained, e.g. epiclastic siltstone, but with a few included altered lithic fragments (up to 6 mm across and possibly including largely aphyric felsic volcanic material), plus a few grains of altered feldspar up to 2 mm across and relict quartz up to 1 mm across (Fig. 26). Clearly, the texture of this rock is matrix-supported.

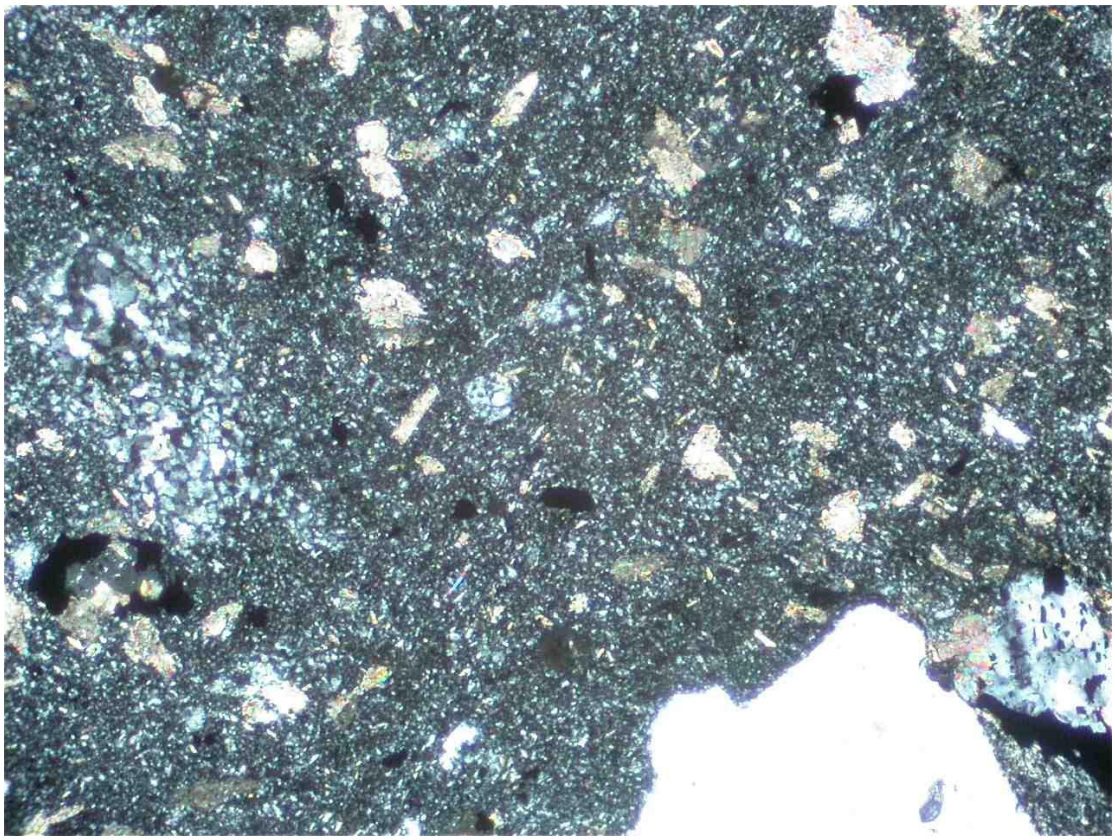


Fig. 26: Interpreted fine grained epiclastic siltstone containing a diffuse, quartz-altered lithic grain at left and a relict phenocrystal grain of quartz at lower right. The matrix was replaced by fine grained chlorite and quartz, with minor sericite, small porphyroblasts of carbonate (pale creamy brown) and a few grains of pyrrhotite (black). Transmitted light, crossed polars, field of view 2 mm across.

b) Alteration and structure: The interpreted epiclastic rock was strongly hydrothermally altered, with large zones of probable hydrothermal replacement, as well as development of a weak foliation. Where some vestiges of relict texture are preserved, the rock is replaced by varying amounts of fine grained chlorite, sericite, carbonate and quartz, with patchy carbonate commonly occurring as porphyroblasts (Fig. 26) and with these being locally aligned in the plane of the foliation. Lithic clasts were commonly replaced by fine grained quartz, and original detrital feldspar by albite ± carbonate. A little pyrrhotite and sphalerite are irregularly distributed and there are small concentrations of rutile in places, mostly in thin stylolitic masses adjacent to interpreted sulphide-rich replacement aggregates. In the stylolites, there is also a little dispersed graphite. The sulphide-rich masses are up to several centimetres across and also occurs as veinlike protuberances into the altered host rock. Sulphides are dominated by pyrrhotite and sphalerite, typically recrystallised into fine to medium grained aggregates that show intergrowth with abundant carbonate, locally common quartz and a little chlorite. Crude banding is common in the sulphide masses and this appears to be locally folded. There are no recognised remnants of the host rock in the

sulphide-rich zones and hence the latter are considered to be the product of total hydrothermal replacement.

c) Mineralisation: The altered host rock contains minor, irregularly distributed sulphides, mostly pyrrhotite and sphalerite, with a trace of galena. Mineralisation in the sample mostly occurs in a large irregular to ovoid sulphide-rich mass up to 7 cm across, where sulphides are intergrown with abundant fine to medium grained carbonate and subordinate quartz. There is a range from strongly disseminated to semi-massive sulphides, and with a gradation between pyrrhotite-rich and sphalerite-rich zones. Minor galena tends to be concentrated into sphalerite-rich zones (Fig. 27), with disseminated to locally abundant fine to medium grained arsenopyrite occurring throughout and pyrite mostly occurring with pyrrhotite (Fig. 28). Pyrite occurs in a subhedral, medium grained form, as well as in anhedral fine grained aggregates, in places associated with a trace of marcasite (Fig. 28). A little chalcopyrite occurs with pyrrhotite, but also occurs as discrete masses in adjacent altered host rock.

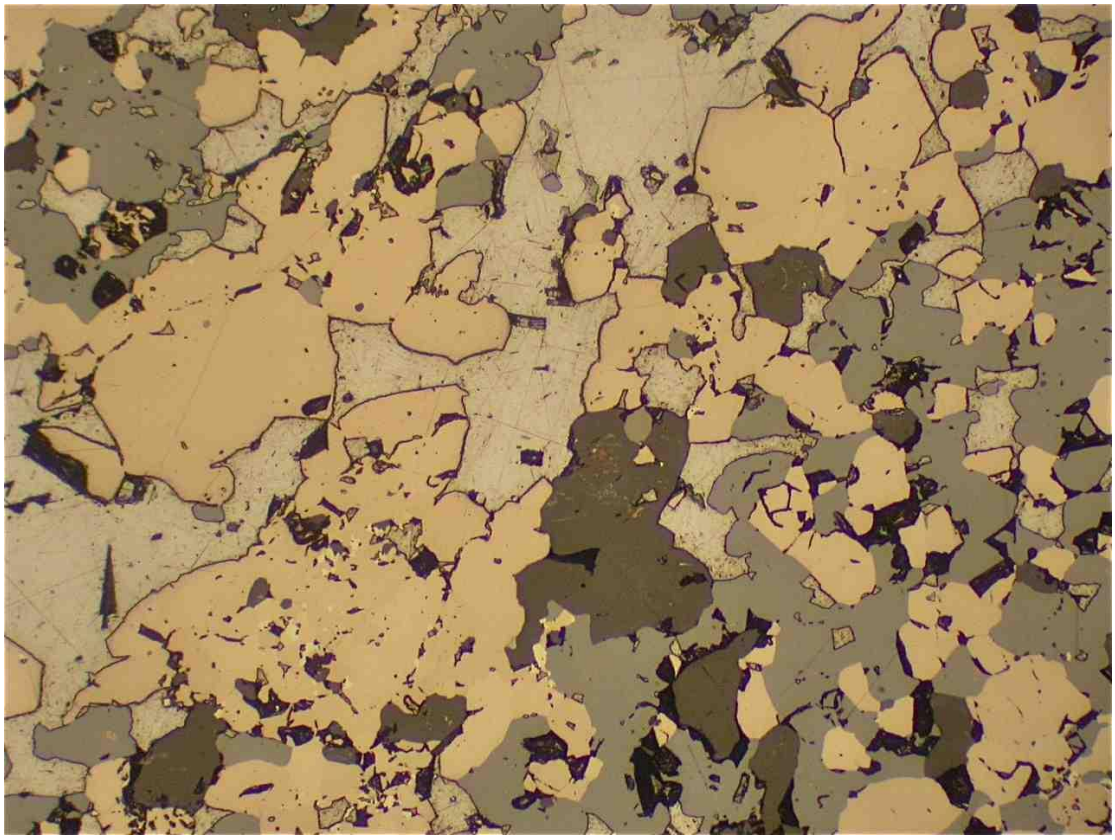


Fig. 27: Zone with abundant pyrrhotite (pale brown) intergrown with galena (silvery grey) and sphalerite (mid grey). The dark grey grains are carbonate. Plane polarised reflected light, field of view 1 mm across.

Mineral Mode (by volume): carbonate 30%, pyrrhotite and sphalerite each 15%, quartz, chlorite and sericite each 10%, albite 3%, arsenopyrite and pyrite each 2%, galena and chalcopyrite each 1% and traces of carbonaceous material (graphite), rutile and marcasite.

Interpretation and comment: It is interpreted that the sample is an altered and mineralised epiclastic sedimentary rock, e.g. siltstone, with felsic volcanic detritus, including sparse lithics, feldspar (altered) and quartz grains in a fine grained matrix (containing trace graphite), resulting in a matrix-supported texture. Pervasive strong pervasive alteration has occurred, along with emplacement of a large sulphide-rich mass, considered to be the product of hydrothermal replacement. The alteration assemblages range from being rich in carbonate, quartz, chlorite or sericite (with gradations, and also containing a little

disseminated pyrrhotite and sphalerite) and shows a generally weak foliation. The sulphide-rich mass is dominated by strongly disseminated to semi-massive, recrystallised pyrrhotite and sphalerite, intergrown with abundant carbonate. In places, there are local concentrations of quartz, arsenopyrite and pyrite, with a little chlorite, galena, chalcopyrite and marcasite.

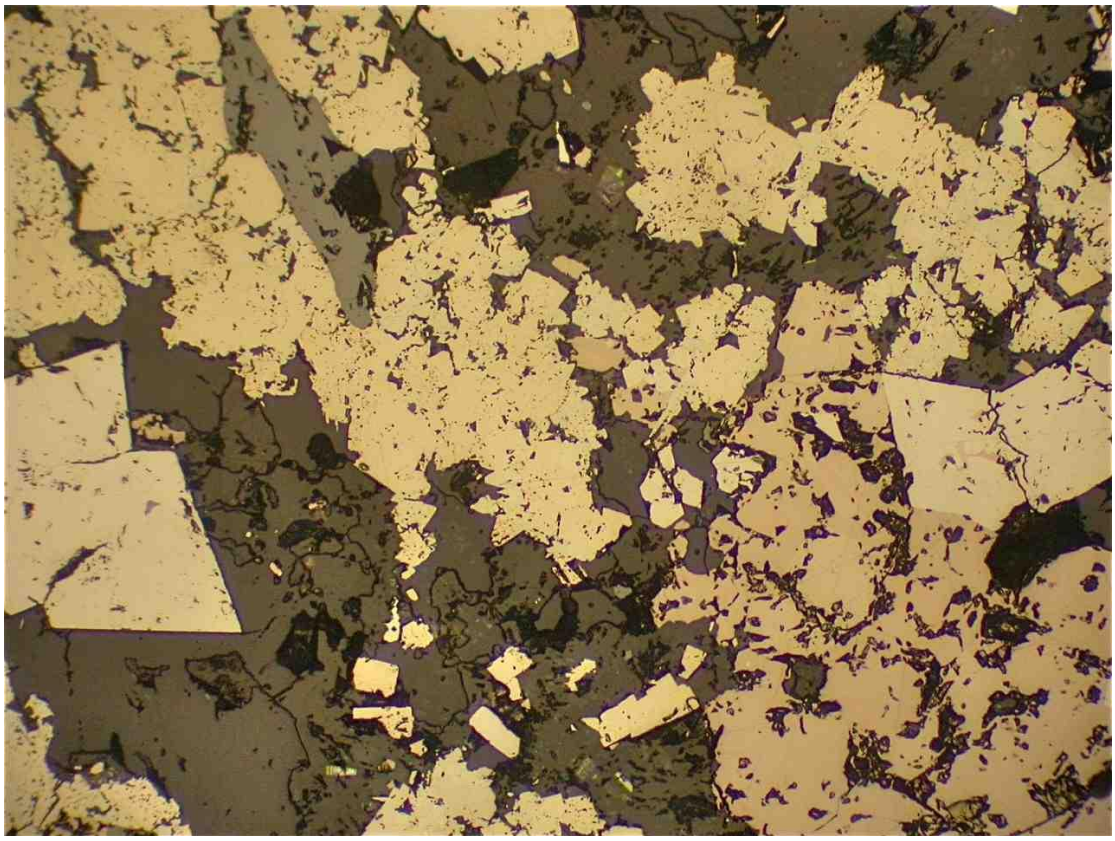


Fig. 28: Portion of the sulphide-rich aggregate containing abundant pyrrhotite (pale brown, lower right), fine grained pyrite (pale creamy) as well as a few subhedra of arsenopyrite (whitish) and a single grain of sphalerite (mid grey, upper left). The dark gangue material is mostly carbonate. Plane polarised reflected light, field of view 2 mm across.