PETROGRAPHIC REPORT ON FIFTY-TWO DRILL CORE SAMPLES FROM THE THURSDAY'S GOSSAN PROSPECT, WESTERN VICTORIA

For

Stavely Minerals

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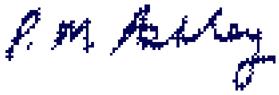

Introduction

A suite of fifty-two drill core samples from the Thursday's Gossan prospect in the Cambrian age Stavely Belt in western Victoria was submitted for petrographic preparation, description and interpretation. Samples were from drill holes STRC005D (12 samples), STRC007D (8), STRC008D (14) and SMD012 (18) and were from downhole depths ranging from 56.9 m to 348.1 m. Most samples were fresh, but possible imposed supergene alteration effects occur in some of the shallower samples (e.g. clay alteration). A priority batch of 27 samples were prepared at Australian Petrographics in Queanbeyan into 22 polished thin sections (PTS) and 5 standard thin sections (TS). The remaining batch of 25 samples was prepared at Petrographic International in Brisbane into 7 PTS and 18 TS. Subsequently, PTS were examined microscopically in transmitted and reflected light, and TS in transmitted and oblique reflected light. Two sample offcuts were tested with hydrofluoric acid and sodium cobaltinitrite to check for the presence of K-feldspar. All samples were measured for magnetic susceptibility and representative photomicrographs of textural and mineralogical characteristics were taken of each sample.

Handspecimen photos of each sample were provided, along with multi-element geochemical data from the intervals where the samples were derived. The geochemical data provides valuable information to corroborate with mineralogical deductions, and to give better confirmation on protolith types where primary characteristics are variably overprinted by hydrothermal alteration.

The purpose of the petrographic work was to identify the primary rock types, the nature of alteration, mineralisation and veining. Many of the samples contain significant sulphide mineralisation and a few also host an unusual fine grained bright green mineral, considered to be Cr-bearing and with such samples correlating with anomalously high Cr, Ni and Co values.

Summary descriptions of the samples are listed following:

STRC005D

STRC005D 129.4 m PTS

Summary: Strongly hydrothermally altered porphyritic dacite, with moderate preservation of primary texture. The original rock contained scattered blocky feldspar phenocrysts (prpbably plagioclase) and less common ferromagnesian (perhaps hornblende, with a little biotite) and quartz phenocrysts, along with a few microphenocrysts of FeTi oxide and rare zircon. These phases occurred in a fine grained quartzofeldspathic groundmass. The rock was replaced by a fine grained phyllic assemblage, with feldspar and ferromagnesian phenocrysts being replaced by sericite ± pyrite ± chalcopyrite ± quartz, and FeTi oxide by rutile ± pyrite. The groundmass was replaced by fine grained inequigranular quartz and subordinate sericite.

Disseminated pyrite grains are locally associated with minor paragenetically later chalcopyrite, with the sulphides being most common at altered phenocryst sites.

STRC005D 134.7 m PTS

Summary: Pyrite-quartz rock, representing the product of hydrothermal infill (e.g. of a vein) and/or intense hydrothermal replacement of a protolith, or which there are no relict textural characteristics preserved. Within pyrite, there are a few pseudomorphic aggregates that could be after former chromite grains, and together with the fact that the rock also contains a little Cr-sericite (fuchsite) and anomalous assay values of Cr, Ni and Co, implies that there was an ultramafic protolith, or that components were leached from an adjacent ultramafic rock. Disseminated to massive pyrite also hosts a few small aggregates of chalcopyrite. Interstitial quartz masses are medium grained and host a few small aggregates of fine grained fuchsite. Interpreted former chromite grains were replaced by fine grained, red-coloured ?Cr-bearing corundum ± fuchsite or by eskolaite ± chalcopyrite.

STRC005D 136.4 m PTS

Summary: Pyrite-quartz-sericite (fuchsite) rock, considered to represent the product of intense hydrothermal alteration of a former ultramafic to mafic composition igneous rock. There are no preserved relict textural attributes, but within medium to coarse grained pyrite, there are uncommon small relict grains of FeCr spinel, interpreted to have been inherited from the protolith. Pyrite ranges from strongly disseminated to massive and also contains traces of included and interstitial chalcopyrite. Scattered throughout are aggregates of fine to medium grained quartz and fine grained green sericite (fuchsite), with these phases also hosting rare very fine grained aggregates of ?eskolaite.

STRC005D 143.0 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and local infill of a protolith whose original nature is obscure, but speculated to have possibly been of mafic igneous type. No relict textures or minerals are preserved from a protolith, but there are traces of rutile and pale green sericite (e.g. Cr-bearing fuchsite). The rock is dominated by fine to medium grained quartz, commonly with textures showing affinities with those formed in an epithermal environment. Quartz contains several cavities, along with abundantly disseminated fine to rather coarse pyrite. Apart from trace rutile and fuchsite, there is also a trace of chalcopyrite and anhydrite contained within quartz. A variety of small mineral inclusions occur in pyrite, including chalcopyrite and less common bornite, hematite, ?tennantite, ?sphalerite and anhydrite. The mineral assemblage appears to have formed under relatively oxidising conditions.

STRC005D 146.6 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic to mafic igneous type. No relict textures or minerals are preserved from a protolith, but there are traces of Ni sulphides and in handspecimen, pale green sericite (e.g. Cr-bearing fuchsite). The rock is dominated by fine to coarse grained quartz, commonly with textures showing affinities to those characteristic of an epithermal environment. Disseminated to semi-massive pyrite occurs in quartz, along with minor aggregates of chalcopyrite, and locally, faint pigmentation by ultrafine hematite. Chalcopyrite contains a few small inclusions of ?tennantite, bornite, millerite and gersdorffite, and pyrite commonly hosts chalcopyrite, along with rare bornite and ?tennantite. The mineral assemblage appears to have formed under relatively oxidising conditions.

STRC005D 150.5 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic type. No relict textures or minerals are preserved from a protolith, but there are small amounts of green Cr-bearing sericite (fuchsite) and traces of eskolaite, supporting an ultramafic affinity. The rock is dominated by medium grained quartz, with inequigranular and locally zoned and cavity fill textures. Disseminated to semi-massive pyrite occurs throughout, commonly with minor amounts of interstitial and included bornite, chalcopyrite and trace ?tennantite. There are also a few discrete aggregates of bornite and chalcopyrite. Sparsely scattered interstitial to quartz and pyrite are irregular to elongate aggregates of fine grained fuchsite and closely associated with some of these are small aggregates of fine grained eskolaite. The mineral assemblage is consistent with silicic-phyllic alteration and mineralisation of high sulphidation affinity.

STRC005D 151.9 m PTS

Summary: Hydrothermal quartz-sulphide rock with a few elongate to irregular, strongly altered and disaggregated fragments of serpentinite host rock. The latter were replaced by talc, and locally by chlorite, with local quartz, chalcopyrite and pyrite. Traces of chromite occur in these fragments and have also been liberated into the hydrothermal quartz-sulphide matrix. The latter could represent hydrothermal infill as well as the product of complete hydrothermal replacement (except for relict chromite). Quartz is fine to medium grained and locally hosts a few cavities and there is a little interstitial chlorite and traces of ultrafine hematite. Strongly disseminated sulphides are dominated by fine to medium grained pyrite, with subordinate chalcopyrite and traces of gersdorffite and millerite. Pyrite hosts small inclusions of chalcopyrite and rare ?tennantite and chromite. Gersdorffite is associated with chalcopyrite and locally rims pyrite, and shows some replacement by millerite. The serpentinite host rock was subject to silicic alteration and mineralisation under relatively oxidising conditions.

STRC005D 153.5 m TS

Summary: Medium to coarse grained granitic rock, considered most likely to have originally been of granodiorite to tonalite type. It formerly contained abundant quartz and feldspar (probably mostly plagioclase), a small amount of ferromagnesian material and traces of FeTi oxide and zircon. The rock was subject to deformation, causing strain, recrystallisation and local foliation development in quartz, and pervasive strong hydrothermal alteration of transitional propylitic-argillic type. Alteration led to all feldspar, ferromagnesian material and FeTi oxide being destroyed and the formation of an assemblage of fine grained sericite, chlorite, quartz, clay (maybe kaolinite) and trace leucoxene-rutile. A single, largely unstrained vein of medium to coarse grained quartz occurs, also hosting a little chlorite and sericite.

STRC005D 154.4 m PTS

Summary: Chlorite-quartz-talc-hematite-pyrite-chalcopyrite rock showing a weak foliation in places and representing the product of intense hydrothermal replacement of a former ultramafic rock, e.g. serpentinite. There are sparse scattered relict chromite grains, verifying the ultramafic protolith and in the talc-rich domains, speculative relict texture suggestive of a serpentinite precursor. There are diffuse and intergradational domains rich in chlorite, quartz or talc, with all having disseminated to locally semi-massive bladed texture hematite, as well as sulphides. Pyrite is dominant and is paragenetically earlier than commonly associated chalcopyrite, which also shows slight marginal replacement by digenite (maybe an incipient deep supergene effect). A single grain of electrum is observed in chalcopyrite. Alteration and mineralisation of the protolith took place under relatively oxidising conditions.

STRC005D 162.5 m TS

Summary: Strongly altered fine grained porphyritic mafic igneous rock, most likely an olivine basalt originally. Relict texture is moderately preserved and indicates that the rock had rather sparsely scattered phenocrysts of olivine (in places with tiny FeCr spinel inclusions) and possible microphenocrysts of plagioclase in a fine grained, felted texture groundmass, evidently rich in small plagioclase laths and with likely interstitial ferromagnesian material and a little FeTi oxide. The rock experienced low grade alteration and was replaced by abundant fine grained chlorite, subordinate amounts of a clay phase (perhaps smectite), quartz, a little leucoxene and trace pyrite. A few small amygdules occur, filled by quartz ± chlorite.

STRC005D 168.0 m PTS

Summary: Strongly altered breccia containing angular to sub-rounded fragments and exhibiting a matrix- to clast-supported texture. Fragments included former fine grained sedimentary types (e.g. siltstone, cherty argillite), fine grained, possibly porphyritic mafic rock (e.g. basaltic) and disaggregated vein quartz material. These occur in a matrix of smaller fragments (mostly quartz) that has been strongly replaced, along with lithic fragments, by a hydrothermal assemblage dominated by fine grained chlorite and quartz, and with disseminated grains and irregular aggregates of pyrite and subordinate chalcopyrite. Traces of rutile have also formed in altered mafic rock and siltstone. Sulphide aggregates are patchily abundant and range from medium to coare pyrite, to composites of chalcopyrite and pyrite.

STRC005D 175.3 m TS

Summary: Porphyritic dacite with strong pervasive propylitic alteration, but moderately well preserved relict texture. There are sparse relict quartz phenocrysts, but all former feldspar (probably plagioclase) and ferromagnesian (mostly hornblende) phenocrysts are altered, as is all of the former quartzofeldspathic groundmass. Feldspar phenocrysts were replaced by sericite and chlorite, with a little quartz and trace pyrite, and ferromagnesian phenocrysts were mostly replaced by chlorite, with a little sericite and leucoxene-rutile. Small amounts of igneous FeTi oxide and apatite were present, but the former is totally altered to leucoxene-rutile. Groundmass replacement is dominated by granular quartz, with subordinate sericite and minor chlorite.

STRC007D

STRC007D 101.15 m TS

Summary: Porphyritic hornblende-quartz microdiorite, with pervasive moderate to strong propylitic alteration. Relict texture is moderately well preserved, indicating that the rock had a crowded porphyritic texture with abundant plagioclase phenocrysts and less common ferromagnesian phenocrysts (probably hornblende) enclosed in a groundmass component of fine to medium grained plagioclase and subordinate quartz, with a little ferromagnesian material and FeTi oxide. Alteration led to partial albitisation of plagioclase and development of considerable chlorite, minor epidote, sericite, carbonate and leucoxene-rutile. A prominent vein cuts the rock, containing carbonate (ankerite) and bordering epidote.

STRC007D 125.1 m TS

Summary: Strongly porphyritic hornblende microdiorite with poor to moderate preservation of primary texture and strongly overprinting alteration of largely propylitic type. The original rock contained rather abundant phenocrysts of plagioclase and ferromagnesian material (probably hornblende), set in a fine to medium grained groundmass that was feldspathic (again probably plagioclase) with minor ferromagnesian material, and a little quartz and FeTi oxide. A pervasive alteration assemblage of sericite, chlorite, locally common albite, minor quartz and leucoxene-rutile, plus a trace of pyrite developed, but there is a more altered zone with a greater proportion of chlorite and little/no remnant feldspar, with this bordering on to a local narrow zone with strong sericite alteration.

STRC007D 132.5 m TS

Summary: Porphyritic hornblende dacite with strong pervasive argillic alteration. The rock has well preserved relict texture, but all former feldspar phenocrysts (e.g. plagioclase), ferromagnesian phenocrysts (hornblende and possible minor biotite) and FeTi oxide grains are altered, although uncommon quartz phenocrysts are retained. The phenocrystal grains occurred in a fine grained quartzofeldspathic groundmass. The alteration assemblage is fine grained with abundant sericite, clay (e.g. kaolinite) and chlorite, and finely granular quartz in the groundmass. Ferromagnesian phenocrysts are chloritised and feldspar phenocrysts altered to sericite, with minor clay and chlorite. There is strong clay development in the groundmass. A little leucoxene-rutile has formed as part of the alteration, along with traces of pyrite and chalcopyrite. A couple of thin clay-rich veins cut the altered rock.

STRC007D 168.8 m TS

Summary: Strongly porphyritic hornblende-quartz microdiorite, displaying moderate preservation of relict texture, but with a strong pervasive overprint of propylitic alteration. The rock formerly contained abundant plagioclase phenocrysts and less common phenocrysts of a ferromagnesian phase (probably hornblende) in a fine to medium grained groundmass of feldspar, with minor quartz and ferromagnesian material, and a little disseminated FeTi oxide. The imposed alteration assemblage is dominated by fine grained sericite and chlorite, with significant fine grained quartz being developed in the groundmass. A little leucoxene-rutile occurs throughout and in one small part of the sample, traces of pyrite, chalcopyrite and hematite occur, mainly at former ferromagnesian sites. The only observed variation between the different coloured alteration zones is that the pale zone contains less chlorite.

STRC007D 191.1 m PTS

Summary: Strongly hydrothermally altered porphyritic intermediate igneous rock, considered most likely to have been a hornblende-quartz microdiorite. Relict texture is poorly to moderately preserved, with indications of rather abundant feldspar phenocrysts (e.g. plagioclase), less common ferromagnesian phenocrysts (e.g. hornblende) and a few quartz microphenocrysts in a fine to medium grained quartzofeldspathic groundmass. It is possible that the igneous rock sustained early mild potassic alteration to develop minor hydrothermal biotite, with this alteration evolving into (or overprinted by) pervasive alteration to sericite, quartz, minor chlorite and pyrite. There was an early phase of thin pyrite-rich veinlet emplacement, followed by emplacement of a network of veins containing quartz and pyrite, in places with significant chalcopyrite.

STRC007D 204.7 m PTS

Summary: Porphyritic dacite displaying strong phyllic hydrothermal alteration as well as a major vein and a few smaller subsidiary veins. The rock has moderately well preserved primary texture indicating that it originally contained scattered feldspar (e.g. plagioclase) and less common ferromagnesian phenocrysts, as well as a few quartz phenocrysts, set in a fine grained quartzofeldspathic groundmass. The alteration assemblage is dominated by fine grained sericite and quartz, with minor disseminated pyrite and chalcopyrite, mostly at former phenocryst sites, and a trace of rutile. A major vein contains massive sulphides: dominant pyrite and chalcopyrite, and subordinate, paragenetically later marcasite. Smaller veins also have pyrite and chalcopyrite, along with quartz. In the major vein, chalcopyrite hosts rare small grains of Cu-Bi minerals (emplectite, wittichenite), as well as traces of stannite and bismuth. Chalcopyrite locally shows slight replacement by digenite.

STRC007D 291.5 m TS

Summary: Medium to coarse grained leucocratic tonalite with a sharp contact against medium grained biotite microtonalite, with both rock types showing effects of imposed penetrative deformation, strong propylitic alteration and minor veining. The leucocratic tonalite is dominated by plagioclase and quartz, with a little biotite and K-feldspar. Microtonalite contained abundant plagioclase, quartz and biotite, with no textural evidence that the former abundant biotite was of hydrothermal derivation. Deformation led to strain and recrystallisation of quartz, fracturing of plagioclase and in the microtonalite, development of a weak, biotite-defined foliation. Pervasive alteration caused considerable replacement of igneous feldspar, initially by albite, but with subsequently abundant fine grained chlorite. Biotite was largely altered to chlorite and the rock has traces of sericite, leucoxene and pyrite. A couple of small, discontinuous quartz veins occur, along with several shear-controlled thin veins of chlorite and local sericite.

STRC007D 292.5 m TS

Summary: Medium grained biotite microtonalite containing a domain of coarser, leucocratic tonalite (relations between the two are not resolved), and with both rock types showing effects of deformation (e.g. strain and part recrystallisation of quartz), strong hydrothermal alteration and local veining. The microtonalite had a medium grained igneous assemblage of quartz, plagioclase and biotite, with a little FeTi oxide. The coarser, leucocratic tonalite had a similar assemblage, but much less biotite. Some plagioclase is retained in this rock type, but overall in both rock types, plagioclase and biotite are replaced, mostly by chlorite. In the microtonalite, there is also a little leucoxene-rutile and trace pyrite. The microtonalite hosts a couple of quartz (-chlorite) veins, with some association with sheared zones containing abundant chlorite. There is no evidence in the sample for the development of any hydrothermal biotite.

STRC008D

STRC008D 94.1 m PTS

Summary: Pervasively altered and veined, strongly porphyritic hornblende-quartz microdiorite. Relict texture is moderately well preserved, indicating that the original rock contained abundant plagioclase phenocrysts and less abundant ferromagnesian (e.g. hornblende) phenocrysts, hosted in a subordinate amount of finer groundmass material dominated by plagioclase, but with minor quartz and ferromagnesian material. It is suspected that the rock experienced early mild hydrothermal alteration associated with vein emplacement. This alteration could be of Na-Ca-Fe type, resulting in development of albite, actinolite and minor magnetite, with the associated veins being sub-planar, sub-parallel, quartz-rich, but also with minor magnetite and trace actinolite. The rock (and veins) were subsequently subject to very low grade metamorphism, forming a pervasive "propylitic-like" alteration assemblage that includes prehnite, pumpellyite, chlorite, sericite, epidote and clay (from plagioclase), chlorite from actinolite, and hematite from magnetite. A few epidote-rich patches occur and thin veining by epidote, carbonate or chlorite overprints the rock and quartz-rich veins.

STRC008D 117.5 m TS

Summary: Strongly altered hornblende-quartz microdiorite that has moderate retention of a crowded porphyritic texture. The rock originally contained abundant plagioclase and ferromagnesian (probably hornblende) phenocrysts in a fine to medium grained groundmass with abundant feldspar, subordinate quartz and ferromagnesian material, and a little disseminated FeTi oxide. The rock was affected by propylitic alteration, forming a fine grained assemblage of sericite and chlorite, minor quartz and leucoxene-rutile. All original feldspar, ferromagnesian material and FeTi oxide was destroyed. The altered rock hosts several sub-parallel quartz-rich veins that also contain a little chlorite, pyrite and chalcopyrite, and show indications of recrystallisation.

STRC008D 131.9 m TS

Summary: Porphyritic microdiorite or microtonalite, showing poor to moderate preservation of relict texture, and with intense alteration to an argillic assemblage. The rock originally contained abundant blocky feldspar phenocrysts (probably plagioclase) and scattered smaller phenocrysts of a ferromagnesian phase (e.g. hornblende) and a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material, with a little FeTi oxide. The rock was replaced by abundant clay phases (probably illite-smectite > kaolinite) and chlorite, but with local patchy quartz aggregates. A couple of clay veins cut the altered rock.

STRC008D 150.1 m TS

Summary: Intensely altered porphyritic hornblende dacite (or microtonalite). There is moderate preservation of relict texture, indicating that the rock originally contained abundant feldspar (e.g. plagioclase) phenocrysts and prismatic ferromagnesian phenocrysts (e.g. hornblende) in an inequigranular, fine to medium grained groundmass of feldspar, quartz and minor ferromagnesian material. Argillic alteration was imposed, with replacement of feldspar and ferromagnesian material and development of an assemblage of fine grained sericite, clay (e.g. kaolinite and illite-smectite), minor chlorite, quartz and pyrite, and a trace of leucoxene-rutile.

STRC008D 157.1 m PTS

Summary: Sulphide-rich hydrothermal breccia displaying a clast- to matrix-supported texture. Breccia fragments are dominated by fine to medium grained hydrothermal quartz, with minor sericite in places, disseminated pyrite and a trace of rutile. There are no diagnostic textures from a protolith, but it is speculated that it could have been of felsic to intermediate igneous type. The intensely altered fragments are veined and infilled by initial veins and irregular masses rich in sericite, and subsequently by abundant sulphides in places accompanied by quartz. Sulphides range from disseminated to massive and include paragenetically early pyrite, with abundant chalcopyrite and bornite, minor tennantite and traces of stannite and covellite. Bornite and chalcopyrite are typically intergrown.

STRC008D 168.5 m TS

Summary: Strongly propylitically altered porphyritic hornblende-quartz microdiorite. The rock has moderate preservation of primary texture, indicative that it originally contained rather abundant phenocrysts of feldspar (assumed to have been plagioclase) and a prismatic ferromagnesian phase (e.g. hornblende). The phenocrysts occurred in a fine to medium grained groundmass of feldspar and subordinate quartz and ferromagnesian material, and a little FeTi oxide. Pervasive alteration led to development of an assemblage of fine grained sericite, chlorite and minor quartz (in the groundmass), plus a little leucoxene and traces of pyrite and chalcopyrite. A single thin vein occurs, containing quartz, minor chlorite and traces of clay and chalcopyrite.

STRC008D 170.05 m PTS

Summary: Strongly porphyritic hornblende-quartz microdiorite with intense phyllic alteration grading sharply into a zone that contains chlorite as part of the alteration assemblage (i.e. propylitic alteration). The rock has moderately preserved relict texture indicating that it contained abundant feldspar (probably plagioclase) phenocrysts and less common prismatic ferromagnesian (e.g. hornblende) phenocrysts in a fine to medium grained groundmass with abundant feldspar and subordinate ferromagnesian material and quartz. Much of the rock has phyllic alteration, with replacement by a sericite-rich assemblage, plus subordinate quartz, a little disseminated chalcopyrite and pyrite, and a trace of rutile. A minority portion of the sample shows a sharp gradation into an alteration assemblage that has significant chlorite (as well as abundant sericite), mostly at ferromagnesian sites. There is no evidence for more than one rock type to have been present.

STRC008D 185.45 m PTS

Summary: Pyrite-quartz veining within an intensely altered porphyritic igneous rock, perhaps originally of felsic to intermediate composition. There are a few pseudomorphs after possible feldspar phenocrysts, but generally, the host rock has little preserved texture and is composed of fine to medium grained quartz, subordinate sericite, a little disseminated pyrite and trace rutile. Vein material is dominated by medium to coarse pyrite, commonly fractured, and with interstitial quartz and local sericite aggregates. A tiny trace of chalcopyrite occurs within pyrite.

STRC008D 188.5 m PTS

Summary: Intensely phyllic altered porphyritic quartz microdiorite, with a few veins. Due to the pervasive alteration, the rock only has poor to moderate preservation of original texture, but it can be deduced that it formerly contained abundant feldspar (probably plagioclase) phenocrysts, with a small amount of ferromagnesian material (e.g. hornblende) and a few quartz microphenocrysts. A finer grained groundmass component was relatively minor. Feldspar and ferromagnesian material was replaced by fine grained sericite and subordinate quartz, with significant disseminated pyrite and chalcopyrite being formed, along with a trace of rutile. A couple of pyrite (-quartz-chalcopyrite) veins were emplaced and appear to have preceded emplacement of a couple of quartz-rich veins that also contain minor pyrite, chalcopyrite and sericite.

STRC008D 223.4 m PTS

Summary: Intensely phyllic altered fine grained rock, possibly a matrix-supported siltstone. It preserves a few possoble small relict detrital quartz grains and a trace of zircon in a completely hydrothermally replaced matrix, now altered to sericite, quartz, minor disseminated pyrite and traces of chalcopyrite and rutile. Within the altered rock are sparsely scattered fine grained quartz-rich aggregates, with a little hematite pigmentation and trace associated rutile, chalcopyrite and pyrite. These are of metasomatic growth origin and do not represent replaced phenocrysts. The sample is cut by a single vein of pyrite, with minor associated quartz, chalcopyrite and trace galena, and subsequently by a network of quartz-rich veins that also host a few aggregates of pyrite and chalcopyrite. Textures indicate that chalcopyrite and galena are paragenetically later than pyrite.

STRC008D 238.1 m PTS

Summary: Fine grained siltstone, containing a few small relict detrital quartz grains and local possible bedding phenomena, showing pervasive replacement by a fine grained alteration assemblage of sericite, quartz, local chlorite, minor disseminated pyrite and trace rutile. The altered rock is cut by a couple of sulphide-rich veins containing medium to coarse grained pyrite, interstitial quartz and chlorite, and paragenetically later chalcopyrite, a little sphalerite and trace galena. Apparently later quartz veining also occurs and this also contains a little chalcopyrite.

STRC008D 339.8 m TS

Summary: Former medium to coarse grained granitoid, perhaps of granodiorite-tonalite type, with effects of imposed deformation, strong hydrothermal alteration and minor veining. Relict texture is poorly preserved, but it can be deduced that the original rock contained significant quartz and feldspar, with minor ferromagnesian material, a little FeTi oxide and trace apatite. Penetrative deformation effects caused strain and part recrystallisation of relict quartz, and all former feldspar, ferromagnesian material and FeTi oxide were replaced, mainly by fine grained chlorite, plus subordinate sericite and quartz and a little leucoxene-rutile at FeTi oxide and ferromagnesian sites. A few irregular veinlike masses of medium grained quartz were emplaced, along with a couple of narrow, shear veins of sericite.

STRC008D 340.7 m PTS

Summary: The sample possibly represents a former medium grained, leucocratic, rather plagioclase-rich granitoid (e.g. of tonalitic type) that was brecciated and invaded by abundant quartz infill. Remnants of the host rock were cataclasised, with shattering of plagioclase and strain and recrystallisation of quartz. Further alteration was imposed, with minor development of chlorite and sericite, plus traces of rutile, galena and pyrite in the host rock and infill by locally prismatic quartz, patchily abundant fine grained chlorite, local graphite and small amounts of chalcedonic quartz. Graphite, chlorite and minor sericite can be concentrated into stylolitic aggregates. Textures imply that graphite has formed hydrothermally, e.g. by mobilisation of carbonaceous material from a sedimentary source or by precipitation from hydrothermal fluids containing CO_2 and CH_4.

STRC008D 348.1 m TS

Summary: Medium to coarse grained leucocratic diorite, with effects of imposed deformation and pervaisce strong sodic alteration. The igneous rock contained abundant plagioclase and probably a subordinate amount of a ferromagnesian phase (e.g. hornblende) and trace FeTi oxide. The protolith underwent mild cataclasis and weak foliation development, as well as being strongly replaced by an assemblage of albite, subordinate chlorite, minor titanite and a little sericite. There is no evidence for the former presence of igneous quartz, or that any quartz formed hydrothermally. Minor veining occurred in the rock, now converted to an albitite, with veins containing chlorite and a little titanite.

SMD012

SMD012 56.9 m TS

Summary: Strongly porphyritic hornblende-quartz microdiorite, with strong argillic alteration. Relict texture is moderately preserved, indicating that the rock originally had prominent feldspar (probably plagioclase) phenocrysts, as well as smaller ferromagnesian (e.g. hornblende) phenocrysts in a fine to medium grained groundmass that was feldspar-rich, with minor quartz, ferromagnesian material and FeTi oxide. Pervasive alteration led to replacement of the igneous rock by fine grained clay (e.g. illite-smectite), sericite and chlorite, with minor quartz (in the groundmass) and a little leucoxene-rutile and pyrite. Uncommon thin veins with quartz and/or chlorite also occur.

SMD012 59.3 m TS

Summary: Fine grained, matrix-supported siltstone, perhaps of epiclastic type, with strong argillic alteration and an array of thin, intersecting veins. There is some preservation of sparse small relict quartz grains and it is possible that the rock also had small feldspar and lithic grains in a fine grained matrix (possibly with some vitriclastic material). The rock was pervasively replaced by a fine grained alteration assemblage of clay (e.g. illite-smectite), chlorite, quartz and sericite, with a little leucoxene-rutile and trace pyrite. Apparently earlier veins contain sericite, or quartz ± clay (kaolinite) and trace pyrite, and appear to be cut by thin chlorite-rich veins.

SMD012 82.4 m TS

Summary: Intensely hydrothermally silicified ultramafic rock (e.g. serpentinised peridotite) retaining sparse grains of relict chromite, but otherwise represented by an assemblage of abundant fine to medium grained quartz, patchy disseminated grains and aggregates of chlorite and pyrite, and irregular zones of hematite pigmentation. A few discontinuous quartz veins occur and the rock appears to have been partly affected by supergene alteration, leading to local degradation of chlorite to a clay (smectite) phase and the production of a few voids.

SMD012 88.3 m PTS

Summary: Intensely hydrothermally altered and veined ultramafic rock, perhaps a type of pyroxenite. Relict texture is poorly to moderately preserved, but suggests that the original rock contained abundant, rather coarse grained pyroxene and possibly minor amounts of other silicates, including plagioclase and olivine. The rock retains sparse small grains of chromite, although many are partly altered. The hydrothermal process has converted the protolith to an assemblage dominated by fine to medium grained quartz and fine grained chlorite, with minor, irregularly distributed sulphides that include pyrite, chalcopyrite and a little violarite. Relict chromite is variably replaced by a lower-Fe spinel phase and trace violarite. Several veins occur, dominated by quartz and sulphides, but commonly with chlorite selvedges. Chalcopyrite is the dominant vein sulphide, but pyrite is locally common and a little sphalerite occurs with chalcopyrite.

SMD012 95.4 m PTS

Summary: Talc-rich rock representing an alteration product of an ultramafic composition protolith. Ultimately the latter could have been a type of peridotite, but it could have been serpentinised prior to being replaced by fine to medium grained talc. There are a few possible pseudomorphs after original pyroxene grains and the rock retains sparsely scattered relict chromite. A little quartz forms aggregates within talc and there is a minor amount of finely disseminated pyrite and chalcopyrite.

SMD012 98.4 m TS

Summary: Strongly altered porphyritic hornblende dacite. The sample has moderately well preserved relict texture, indicating that the protolith contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), along with a few smaller phenocrystal grains of quartz and FeTi oxide, set in a fine grained quartzofeldspathic groundmass. Pervasive argillic alteration was imposed, with replacement of primary phases (except quartz) by fine grained sericite (mainly concentrated at feldspar phenocryst sites), chlorite (mostly at ferromagnesian sites), quartz and a clay phase (maybe illite-smectite), as well as a little leucoxene-rutile and trace chalcopyrite and pyrite. A single quartz vein occurs in the altered rock.

SMD012 102.9 m TS

Summary: Porphyritic hornblende microtonalite or dacite, with imposed strong propylitic alteration. Relict texture is moderately well preserved, indicating that the rock contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), along with a few smaller phenocrystal grains of quartz and FeTi oxide, hosted in a fine grained quartzofeldspathic groundmass. Imposed alteration caused replacement of feldspar, dominantly by sericite, and ferromagnesian material mostly by chlorite. Small amounts of pyrite and trace chalcopyrite occur, mostly at altered ferromagnesian sites. A couple of thin quartz-rich veins cut the altered rock.

SMD012 109.8 m PTS

Summary: Fine grained clastic rock, perhaps originally a siltstone or felsic tuff/epiclastic, overprinted by intense phyllic alteration. There is little recognised relict texture and the protolith was thoroughly replaced by fine grained sericite and quartz, disseminated pyrite and traces of chalcopyrite and rutile. Scattered throughout are small, irregular, discontinuous veinlets of pyrite, with a little associated quartz and paragenetically later chalcopyrite and trace marcasite. Pyrite contains rare tiny bornite inclusions.

SMD012 132.0 m PTS

Summary: Former fine grained siltstone or tuff, with very strong pervasive alteration to fine grained quartz and sericite (or pyrophyllite), with minor disseminated pyrite, small aggregates of fine grained clay (e.g. kaolinite) and trace rutile and an alunite-like phase (maybe svanbergite). The rock also contains a few metasomatic aggregates, some of veinlike form, of quartz, with local sericite, a little pyrite and trace rutile and chalcopyrite. Alteration is of phyllic or advanced argillic type, depending on the identity of the layer silicate phase.

SMD012 160.4 m TS

Summary: Medium to coarse grained lithic sandstone, grading into conglomerate and displaying strong propylitic alteration. Lithic grains are commonly fine grained and some could represent altered sedimentary material (e.g. siltstone), whereas others have relict porphyritic texture and could have originally been of felsic to intermediate volcanic type. Overall relict texture is poorly preserved due to the strong alteration, which has caused replacement of the protolith, forming patchy domains rich in chlorite, locally in quartz, and elsewhere in quartz + sericite, plus variable chlorite. Disseminated pyrite, a little chalcopyrite and trace leucoxene-rutile occur throughout, but sulphides tend to be more abundant in association with chlorite and/or quartz-rich aggregates.

SMD012 163.4 m PTS

Summary: Coarse, clast-supported breccia, with the majority of fragments probably being of fine grained clastic sedimentary type (e.g. cherty argillite, siltstone), but with possible quartz-phyric felsic volcanic material and at least one large fragment of possible altered mafic igneous rock. There are also a few isolated discrete quartz grains. Little matrix is recognised and interstitial sites are strongly altered. The rock has sustained strong propylitic alteration, with the interpreted sedimentary and ?felsic volcanic fragments being replaced by fine grained quartz, with minor sericite, chlorite, pyrite and trace rutile and chalcopyrite. Chlorite-rich aggregates occur at possible mafic igneous and interstitial sites and these also display considerable hydrothermal quartz, abundant pyrite, minor chalcopyrite and traces of rutile and marcasite (associated with chalcopyrite). At these sites, pyrite also hosts a few tiny inclusions of chalcopyrite, bornite and galena.

SMD012 166.0 m PTS

Summary: Intensely silicified ultramafic rock (e.g. serpentinite), retaining a few grains of relict chromite. The rock is dominated by fine grained quartz, but with disseminated pyrite, a little chlorite and trace chalcopyrite and it contains scattered irregular to veinlike aggregates of pyrite, quartz, minor chlorite, and in places, a little chalcopyrite and talc. Pyrite hosts a few small inclusions of chromite, chalcopyrite and rare hematite and magnetite.

SMD012 180.9 m PTS

Summary: Pyrite-chalcopyrite-fuchsite-quartz rock, representing the product of intense hydrothermal replacement and/or infill of an ultramafic protolith. Semi-massive pyrite-chalcopyrite aggregates have associated interstitial masses of fine grained fuchsite, with patchy quartz. Fuchsite hosts sparse, very fine grained aggregates of a phase that could be Cr-bearing corundum. In sulphide aggregates, fine to medium grained pyrite appears to be enclosed and replaced by chalcopyrite, with the latter hosting uncommon small grains of bornite and tennantite, rare stannite and a trace of replacive covellite.

SMD012 181.6 m PTS

Summary: Intensely hydrothermally altered, originally coarse grained ultramafic rock, perhaps of pyroxenite type. Vestiges of relict texture suggest that the protolith was dominated by coarse prismatic to blocky ferromagnesian material (e.g. pyroxene, but could have included amphibole), and there are sparse small relict grains of chromite. The silicate material was totally replaced by fine grained quartz and chlorite, with disseminated and veinlet pyrite and subordinate chalcopyrite. In places, chromite occurs as inclusions in sulphides, and textures indicate that chalcopyrite is paragenetically later than pyrite.

SMD012 181.9 m PTS

Summary: Intensely hydrothermally silicified ultramafic rock, with disseminated to semi-massive sulphides, minor chlorite and a trace of relict chromite. The last mineral attests to the ultramafic protolith, perhaps of peridotite type. There was replacement by abundant fine to medium grained, inequigranular quartz that also hosts a few cavities and locally, a little hematite pigmentation. Sparse chlorite occurs interstitial to quartz and in a few larger irregular to elongate aggregates. Pyrite is the dominant sulphide, in places having zonal growth texture and hosting a few small inclusions of hematite and chalcopyrite. Pyrite also forms a few composites with chalcopyrite, but the latter also forms a few large discrete aggregates, some of which show slight marginal replacement by digenite, maybe reflecting incipient deep supergene oxidation.

SMD012 183.5 m TS

Summary: Intensely altered porphyritic olivine basalt. Relict texture is moderately preserved, with scattered pseudomorphs after former small olivine phenocrysts in a fine grained groundmass. At former olivine sites, there are sparsely scattered tiny relict grains of FeCr spinel. The groundmass may have been composed of feldspar, ferromagnesian material and disseminated FeTi oxide. Alteration is interpreted as argillic type, with replacement of phenocrysts by quartz and minor chlorite and clay (could include illite-smectite, kaolinite), and replacement of the groundmass by clay phases, chlorite, quartz and leucoxene-rutile.

SMD012 184.0 m PTS

Summary: Porphyritic hornblende-quartz microdiorite with strong propylitic alteration. Relict texture is moderately preserved, showing that the rock originally contained scattered blocky feldspar (presumably plagioclase) phenocrysts as well as a prismatic ferromagnesian phase (e.g. hornblende) set in a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material. Pervasive alteration led to replacement of feldspar and ferromagnesian material and development of an assemblage of fine grained sericite, chlorite, quartz, disseminated pyrite and trace chalcopyrite and rutile. A couple of sub-planar veins cut the altered rock and contain quartz, with minor pyrite and chalcopyrite.

SMD012 192.4 m TS

Summary: Strongly altered porphyritic olivine basalt with moderately well preserved relict texture. It is apparent that the rock originally contained scattered phenocrysts of blocky feldspar (e.g. plagioclase) and blocky to prismatic ferromagnesian phases that are interpreted to have included olivine and pyroxene (and less likely, hornblende). At interpreted olivine sites, there are scattered tiny relict inclusions of FeCr spinel. The phenocryst phases occurred in a fine grained crystalline groundmass with abundant ferromagnesian material, feldspar and minor disseminated FeTi oxide. Alteration is of propylitic-argillic type, causing replacement by fine grained chlorite (abundant at former ferromagnesian sites), sericite and clay (abundant at feldspar sites and in the groundmass), minor quartz and leucoxene-rutile. A couple of thin quartz veins occur locally.

Interpretation and comment

Samples in the suite represent a diverse group of rocks that have varying protoliths, a range of alteration types, and minor to locally abundant veining and sulphide mineralisation, including a few samples with evidently local high Cu grades.

Primary rock types

Six major primary rock type associations are recognised in the suite, with the distinctions being made based on varying degrees of preservation of primary textures and minerals, and geochemical composition.

A few samples are interpreted as having sedimentary (clastic) protoliths. The following samples could have had fine grained siltstone (or possibly tuffaceous/epiclastic) protoliths: STRC008D/223.4 m, STRC008D/238.1 m, SMD012/59.3 m, SMD012/109.8 m, SMD012/132.0 m. The rocks locally have small relict ?detrital quartz grains and possible diffuse bedding laminations are locally observed. Sample SMD012/160.4 m is considered as a medium to coarse lithic sandstone, grading to lithic conglomerate, containing fine grained sedimentary and porphyritic volcanic detrital material. Samples STRC005D/168.0 m and SMD012/163.4 m are interpreted as coarse breccias, containing fine grained sedimentary and mafic igneous lithic fragments, as well as isolated quartz grains. Whether the breccias represent coarse clastic sedimentary rocks, or have formed by some other process, e.g. hydrothermal brecciation, remains unclear.

Several samples have ultramafic composition protoliths, or at least have had their bulk composition influenced by ultramafic rocks (e.g. immediately adjacent). These samples are STRC005D/134.7 m, STRC005D/136.4 m, STRC005D/143.0 m, STRC005D/146.6 m, STRC005D/150.5 m, STRC005D/151.9 m, STRC005D/154.4 m, SMD012/82.4 m, SMD012/88.3 m, SMD012/95.4 m, SMD012/166.0 m, SMD012/180.9 m, SMD012/181.6 m and SMD012/181.9 m. The evidence for these having an ultramafic protolith, or at least a nearby ultramafic influence is from their geochemical composition (i.e. anomalously high Cr, Ni and Co contents, and in places, high Mg), presence of relict chromite (in many) and presence of other Cr-bearing minerals and locally, Ni sulphide minerals. The characteristics of relict chromite in some samples is typical of that found in peridotites and their serpentinised equivalents, but relict textures in SMD012/88.3 m and SMD012/181.6 m could imply that rather than these representing olivine-rich protoliths that they might have been types of pyroxenites.

Likely mafic igneous protoliths are proposed for three samples, with these being STRC005D/162.5 m, SMD012/183.5 m and SMD012/192.4 m. It is interpreted that the protoliths were porphyritic basalt, with pseudomorphs after former olivine phenocrysts being prominent (and having tiny relict inclusions of FeCr spinel) and also locally containing pseudomorphs after former plagioclase and pyroxene phenocrysts. These rocks also have somewhat elevated concentrations of Cr, Ni, Ti, V and Sc.

A few samples appear to have had relatively coarse grained granitoid protoliths, with these typically being rather deformed and subsequently altered, such that their primary characteristics are partly obscured. These samples (STRC005D/153.9 m, STRC007D/291.5 m, STRC007D/292.5 m, STRC008D/339.8 m, STRC008D/340.7 m, STRC008D/348.1 m) are inferred to have been of leucocratic tonalite and diorite composition, maybe containing abundant plagioclase and variable amounts of quartz and ferromagnesian material (apparently mostly biotite). Weak foliation, along with cataclastic and strain textures, are locally present in these rocks.

A large population of samples in the suite are interpreted as originally being porphyritic hornblende-quartz microdiorite, typically containing phenocrysts of plagioclase and hornblende (based on relict texture) and having a fine to medium grained groundmass, formerly with abundant feldspar, lesser quartz and ferromagnesian material, and minor FeTi oxide. These samples include STRC007D/101.15 m, STRC007D/125.1 m, STRC007D/168.8 m, STRC007D/191.1 m, STRC008D/94.1 m, STRC008D/117.5 m, STRC008D/150.1 m, STRC008D/168.5 m, STRC008D/170.05 m, STRC008D/188.5 m, SMD012/56.9 m and SMD012/184.0 m. Another group of samples is interpreted to have been compositionally similar, but evidently more felsic, typically having a lower proportion of former ferromagnesian material (including original hornblende phenocrysts) and a higher proportion of feldspar and quartz, including sparse quartz phenocrysts. These rocks are interpreted as porphyritic dacite and include STRC005D/129.4 m, STRC005D/175.3 m, STRC007D/132.5 m, STRC007D/204.7 m, STRC008D/150.1 m, SMD012/98.4 m and SMD012/102.9 m. Two other samples (STRC008D/157.1 m and STRC008D/185.45 m) are intensely altered and have obliteration of most primary features, but are inferred to have had felsic to intermediate igneous protoliths, based on low concentrations of Cr, Ni and V.

The intermediate to felsic composition igneous rocks are largely of tonalitic/dacitic to dioritic composition and form a low-K suite. There is little indication for any significant primary K-feldspar to have occurred, although groundmasses in the microdiorite and dacite examples are all altered and any prior K-feldspar could have been destroyed. Although biotite has crystallised in some rocks (e.g. the coarser, leucocratic tonalites), the dominant ferromagnesian phase appears to have been hornblende. The relationship of the mafic and ultramafic igneous rocks to the more felsic igneous rocks is not resolved from the samples in the suite, e.g. whether the more felsic composition rocks are intrusive into the mafic-ultramafic rocks, or whether the relationship is tectonic.

Alteration

All samples in the suite are pervasively altered, with a few being the product of intense hydrothermal replacement (± hydrothermal infill) such that almost all primary characteristics of protolith material were destroyed. On the scale of petrographic sections, there is little evidence for any fracture (or vein) controlled alteration (i.e. it is pervasive). Based on alteration mineral assemblages, the dominant types of alteration recognised are propylitic, argillic and phyllic, with intergradations between these types. However, in ultramafic host rocks, the alteration assemblages do not conform to regularly recognised types and tend to be variants of sulphide- and quartz-rich alterations. Only one sample (STRC007D/191.1 m) has any indication of an initial phase of potassic alteration, with minor biotite apparently developed, but subsequently retrogressively overprinted by phyllic-propylitic alteration. If hydrothermal biotite did develop in other rocks, then later-imposed retrograde alteration must have destroyed any evidence. Another sample (STRC008D/94.1 m) has an indication of early alteration that has developed an assemblage of albite, actinolite and magnetite, with associated veining of quartz, with minor magnetite. This could be viewed as being of Na-Ca-Fe alteration type, but again retrogressively overprinted by propylitic or very low grade metamorphic effects. It could be speculated that the sample SMD012/132.0 m might have advanced argillic alteration, but the presence of possible pyrophyllite (rather than sericite) is not confirmed. This sample does, however, contain a clay mineral phase (e.g. kaolinite) and traces of an alunite-type phase (?svanbergite). Sample STRC008D/157.1 m shows evidence of hydrothermal brecciation, destruction of primary characteristics and alteration to a sulphide-rich silicic-phyllic assemblage.

Samples that have an ultramafic protolith (or whose present composition was influenced by an ultramafic component) have been replaced by alteration assemblages that do not conform well to those in quartzofeldspathic composition rocks. Alteration assemblages range from sulphide-rich (dominant pyrite) to quartz-rich (silicification) to those with considerable talc (e.g. SMD012/95.4), chlorite, fuchsite (Cr-bearing sericite) and hematite (e.g. STRC005D/154.4 m). There are also trace mineral subtleties developed in a few of these rocks. In STRC005D/134.7 m, STRC005D/136.4 m, STRC005D/150.5 m and SMD012/180.9 m, there are small amounts of possible eskolaite (Cr_2O_3) and/or possible Cr-bearing corundum, maybe developed from the breakdown of original Cr-bearing silicate (e.g. pyroxene) or chromite under extreme conditions. Also, samples STRC005D/146.6 m, STRC005D/151.9 m and SMD012/88.3 m contain traces of Ni-bearing sulphides (e.g. gersdorffite, millerite, violarite).

In the "normal" igneous and sedimentary rock compositions in the suite, typical propylitic assemblages contain chlorite, commonly with sericite and quartz, and with a small amount of leucoxene-rutile and pyrite. Some of these assemblages also contain albite (maybe in part residual from igneous protoliths) but the presence of this phase, together with minerals including actinolite, prehnite, pumpellyite and titanite, might reflect the overprint of very low grade regional metamorphism (e.g. STRC008D/94.1 m, STRC008D/348.1 m), rather than a hydrothermal effect. Several samples with propylitic-like assemblages evidently grade into argillic alteration, with the presence of minor to significant amounts of clay phases (could include kaolinite and illite-smectite) and decreases in amounts of chlorite and sericite. There are also gradations from propylitic to phyllic alteration, as the amount of chlorite decreases and sericite increases (e.g. STRC007D/125.1 m). Typical phyllic alteration has an assemblage of sericite, quartz and pyrite, with a little leucoxene-rutile, and in places, chalcopyrite.

In drill hole SMD012, it is possible that a few of the samples from shallower depths downhole (<100 m) have a slight supergene alteration overprint, reflected in strong clay development, e.g. possible illite-smectite in SMD012/56.9 m, SMD012/59.3 m and SMD012/98.4 m, and smectite in SMD012/82.4 m. A few other samples also show slight supergene replacement of hypogene chalcopyrite by thin rims of digenite (e.g. in STRC005D/154.4 m).

Veining (and local breccia fill)

Minor to abundant veining occurs in at least half of the samples in the suite and breccia infill by hydrothermal minerals has taken place in a few samples (e.g. STRC005D/168.0 m, STRC008D/157.1 m, SMD012/163.4 m). Some samples of altered ultramafic rocks could have a large hydrothermal infill component (of sulphides, quartz and fuchsite) and include cavity fill textures and open voids, with some analogies to “epithermal” characteristics.

The most common vein and breccia fill type is one that contains varying proportions of quartz and sulphides. These veins range from <1 mm to a few centimetres in width and are most typical of rocks in which phyllic alteration prevails, but they are also present in some rocks with propylitic alteration as well as altered ultramafics. Quartz and sulphide infill can be commonly accompanied by sericite and/or chlorite, and although the sulphide component is generally dominated by pyrite, chalcopyrite can be locally abundant and with significant bornite or marcasite occurring in a few samples. An unusual type of hydrothermal infill occurs in sample STRC008D/340.7 m, where brecciated leucocratic tonalite has infill of quartz, chlorite and locally abundant graphite. In the absence of an adjacent metasedimentary source of carbon, the graphite could have been deposited hydrothermally by reaction between CO_2 and CH_4. Other vein types are minor and narrow, and include those with quartz, chlorite, sericite, and a clay phase. In altered microdiorite samples STRC007D/101.15 m and STRC008D/94.1 m, minor veining by epidote occurs, with ankeritic carbonate accompanying in the former sample.

Mineralisation

The majority of samples in the suite contain sulphide minerals, with amounts ranging from traces through to largely massive aggregates that represent either hydrothermal infill and/or near-total replacement of protolith material. The more sulphide-rich rocks mostly have sulphides as part of hydrothermal infill (of veins and local breccia zones), but there are situations where sulphides are strongly disseminated as part of pervasive alteration and probably (in some ultramafic rocks) as near-total replacement.

Many of the interpreted ultramafic protoliths contain abundant sulphides, ranging from a few % to >60% and this suggests that such composition materials in this hydrothermal environment have provided an excellent mineralisation host, e.g. by providing a large geochemical contrast. Be that as it may, there are locally high total sulphide concentrations (e.g. in the range 10-35% sulphides) in some of the strongly altered and veined microdiorite, dacite and sedimentary host rocks.

Pyrite is commonly the major sulphide mineral and is present up to 30-60% in a few samples (e.g. STRC005D/134.7 m, STRC005D/136.4 m, STRC008D/185.45 m, SMD012/180.9 m), with several other samples with >10% pyrite. The mineral is commonly fine to medium grained, locally coarser, paragenetically earlier than associated chalcopyrite (-bornite), but it can also contain scattered tiny inclusions of chalcopyrite, bornite, tennantite, galena, hematite and relict chromite in some ultramafic rocks. Chalcopyrite is generally significantly subordinate in amount to pyrite, but in a few samples, it is abundant (in range 5-30%) and occurs in similar or greater amounts to pyrite (e.g. STRC007D/204.7 m, STRC008D/157.1 m, SMD012/180.9 m). As mentioned, chalcopyrite is paragenetically later than pyrite and might replace the latter. Chalcopyrite can also be closely intergrown with bornite and be associated with generally trace amounts of marcasite, tennantite (rarely up to 1%), galena, sphalerite and rare stannite. Bornite mostly occurs as a trace sulphide, but it is locally common to the percent level (e.g. STRC005D/150.5 m, STRC008D/157.1 m) and it can be closely associated with tennantite and rare tiny grains of covellite (apparently not of supergene origin). Marcasite occurs as a trace to minor phase in a few samples, mostly associated with chalcopyrite. There is no evidence that marcasite has replaced prior pyrrhotite. A few samples with ultramafic protoliths (STRC005D/146.6 m, STRC005D/151.9, SMD012/88.3 m) contain traces of Ni-bearing sulphides (gersdorffite, millerite, violarite) associated with chalcopyrite and pyrite. As mentioned above, traces of stannite are found with chalcopyrite in a few samples and in STRC007D/204.7 m, tiny traces of Bi minerals (wittichenite, emplectite, bismuth) are recognised and a single grain of electrum occurs in chalcopyrite in STRC005D/154.4 m.

Relict chromite occurs in several of the altered ultramafic protoliths, hosted in sulphides and in various silicate gangue phases. The possible phases eskolaite and Cr-bearing corundum also occur in a few of the ultramafic-influenced samples and could have formed under extreme hydrothermal conditions, e.g. low pH, moderate T and high fS_2 and fO_2, by the breakdown of Cr-bearing silicates or chromite, e.g. by a reaction such as:

$Fe(Cr, Al)_2O_4$ + fluid with S, Cu, K, etc ==> $(Cr,Al)_2O_3$ + pyrite, chalcopyrite, fuchsite

Magnetite is absent as an alteration or vein mineral in almost all samples and it has really only been recognised in an appreciable amount in STRC008D/94.1 m (estimated 5%). Although generally only a trace phase, hematite is much more common than magnetite, as a pigmentation in quartz and as tiny inclusions in pyrite. However, in STRC005D/154.4 m, there is an estimated 20% hematite, associated with pyrite and chalcopyrite.

Comments

The mineral assemblage in some of the sulphide-rich hydrothermal fillings and replacements clearly has analogies to those in high-sulphidation systems.

This is manifest in the assemblage of pyrite-chalcopyrite-bornite, with locally associated tennantite and trace covellite, as well as adjacent, commonly intense alteration of phyllic to silicic type. It is possible that advanced argillic alteration could occur locally, but potential pyrophyllite was not able to be distinguished from sericite optically. Similarly, no alunite was recognised. This type of mineralisation clearly occurred under rather oxidising conditions, given the presence of bornite (-hematite-covellite).

The alteration-mineralisation assemblages have other interesting and perhaps location-specific characteristics. Clearly, ultramafic rocks have influenced sulphide deposition from hydrothermal fluids, as well as contributing to the presence of small amounts of Cr-bearing minerals (not including relict chromite) and Ni-bearing sulphides. In contrast, the presence of tiny traces of stannite and Bi-bearing minerals could imply the involvement of a hydrothermal fluid from an evolved granitic source.

For the alteration-mineralisation system as a whole, the actual cause/source of hydrothermal fluid flux through the varied host rocks remains obscure. It could be speculated that the relatively abundant porphyritic microdiorite and dacite might have had a role in the process as such rocks could represent high crustal level intrusives. They also locally host strong phyllic (-silicic) alteration and associated mineralisation. On the other hand, there is little (or no) evidence for an event of early potassic (or sodic-potassic, calcic-potassic) alteration and associated early veining (e.g. quartz ± biotite, K-feldspar, magnetite, chalcopyrite, bornite, pyrite, molybdenite, etc) that might be expected to be associated with a porphyry system. Perhaps evidence of such early alteration and veining has been largely obscured by later-imposed alteration and veining, or alternatively it did not develop and the observed high level porphyritic intrusive rocks (microdiorite, dacite) might represent passive hosts, with the system being driven from a presently unexposed (not intersected) intrusive source.

Individual sample descriptions

STRC005D 129.4 m PTS

Summary: Strongly hydrothermally altered porphyritic dacite, with moderate preservation of primary texture. The original rock contained scattered blocky feldspar phenocrysts (prpbably plagioclase) and less common ferromagnesian (perhaps hornblende, with a little biotite) and quartz phenocrysts, along with a few microphenocrysts of FeTi oxide and rare zircon. These phases occurred in a fine grained quartzofeldspathic groundmass. The rock was replaced by a fine grained phyllic assemblage, with feldspar and ferromagnesian phenocrysts being replaced by sericite ± pyrite ± chalcopyrite ± quartz, and FeTi oxide by rutile ± pyrite. The groundmass was replaced by fine grained inequigranular quartz and subordinate sericite. Disseminated pyrite grains are locally associated with minor paragenetically later chalcopyrite, with the sulphides being most common at altered phenocryst sites.

Handspecimen: The drill core sample is composed of a massive, strongly hydrothermally altered, porphyritic fine grained felsic igneous rock. It contains scattered creamy to pale grey pseudomorphic aggregates after former feldspar and ferromagnesian phenocrysts, as well as retaining a couple of relict pale grey quartz phenocrysts, set in a fine grained pale creamy-grey altered groundmass (Fig. 1). The latter was probably of quartzofeldspathic composition by was completely altered, along with most phenocrysts, by fine grained sericite, quartz and minor disseminated pyrite, forming aggregates up to 2 mm across (Fig. 1). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 1: Cut drill core of sample showing relict porphyritic texture and replacement by a fine grained quartz-sericite-pyrite assemblage.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately preserved, despite strong pervasive alteration. There are a few relict quartz phenocrysts up to 2.5 mm across and scattered pseudomorphs after former blocky feldspar phenocrysts (e.g. plagioclase) up to 5 mm long, and after elongate ferromagnesian phenocrysts (probably mostly hornblende, but could include a little biotite) up to 3 mm long (Fig. 2). There are also a few altered microphenocrysts of FeTi oxide, with which are associated rare relict grains of zircon. All the above phases occur in a fine grained altered groundmass, interpreted to have been of quartzofeldspathic composition. From the relict characteristics, the original rock is interpreted as a porphyritic dacite, assuming that plagioclase was the dominant igneous feldspar.

b) Alteration and structure: The original porphyritic igneous rock was strongly and pervasively hydrothermally altered and all original phases (except quartz and zircon) were replaced (Fig. 2). Feldspar phenocrysts were altered to aggregates of fine grained sericite ± pyrite, chalcopyrite and quartz (Figs 2, 3). Ferromagnesian phenocrysts were also replaced by sericite, with local pyrite, chalcopyrite and trace rutile, and FeTi oxide was replaced by rutile ± pyrite. In the groundmass, there was total replacement by finely inequigranular quartz, subordinate sericite and a trace of pyrite, chalcopyrite and rutile. A couple of diffuse, veinlike concentrations of pyrite ± chalcopyrite ± sericite ± quartz (fibre texture about pyrite) occur and there is a single thin, discontinuous veinlet of sericite + chalcopyrite. The alteration assemblage conforms to phyllic type.

c) Mineralisation: The rock contains minor disseminated pyrite and lesser chalcopyrite throughout, but mostly concentrated at altered phenocryst sites (Fig. 3). Anhedral to subhedral pyrite grains are up to 2 mm across and less common chalcopyrite is up to 0.6 mm across, generally associated with paragenetically earlier pyrite, but locally forming discrete grains (Fig. 3). Rare small inclusions of chalcopyrite and rutile are observed in pyrite.

Mineral Mode (by volume): quartz 50%, sericite 43%, pyrite 6%, chalcopyrite 1% and traces of rutile and zircon.

Interpretation and comment: It is interpreted that the sample represents a strongly phyllic altered porphyritic dacite. There is moderate preservation of primary texture indicating that the rock formerly contained scattered blocky feldspar phenocrysts (prpbably plagioclase) and less common ferromagnesian (perhaps hornblende, with a little biotite) and quartz phenocrysts, along with a few microphenocrysts of FeTi oxide and rare zircon, hosted in a fine grained quartzofeldspathic groundmass. The rock was replaced by fine grained sericite and quartz, with minor pyrite, a little chalcopyrite and trace rutile. Disseminated pyrite grains are locally associated with minor paragenetically later chalcopyrite, with the sulphides being most common at altered phenocryst sites.

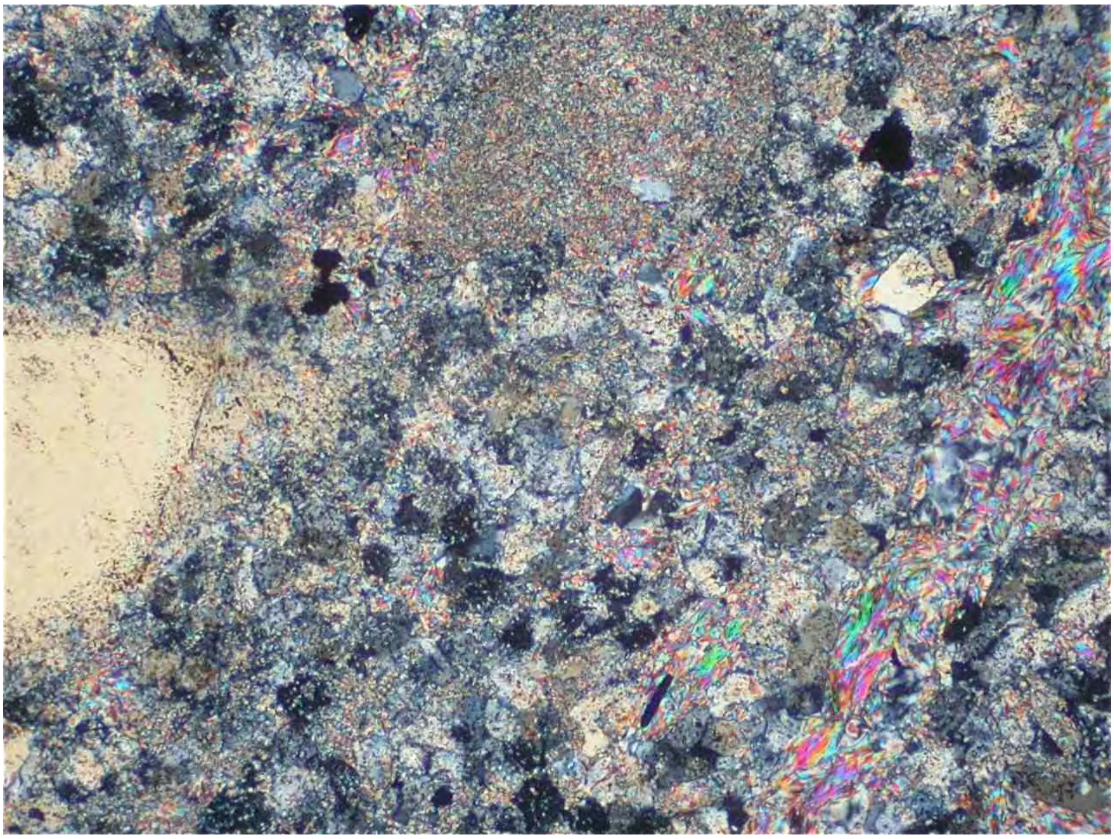

Fig. 2: Relict porphyritic texture in altered dacite, showing a relict quartz phenocryst at left, an elongate pseudomorph at right after a former ferromagnesian phenocryst and a pseudomorph at upper centre after a former feldspar phenocryst. The rock was replaced by sericite and finely inequigranular quartz. Transmitted light, crossed polarisers, field of view 2 mm across.

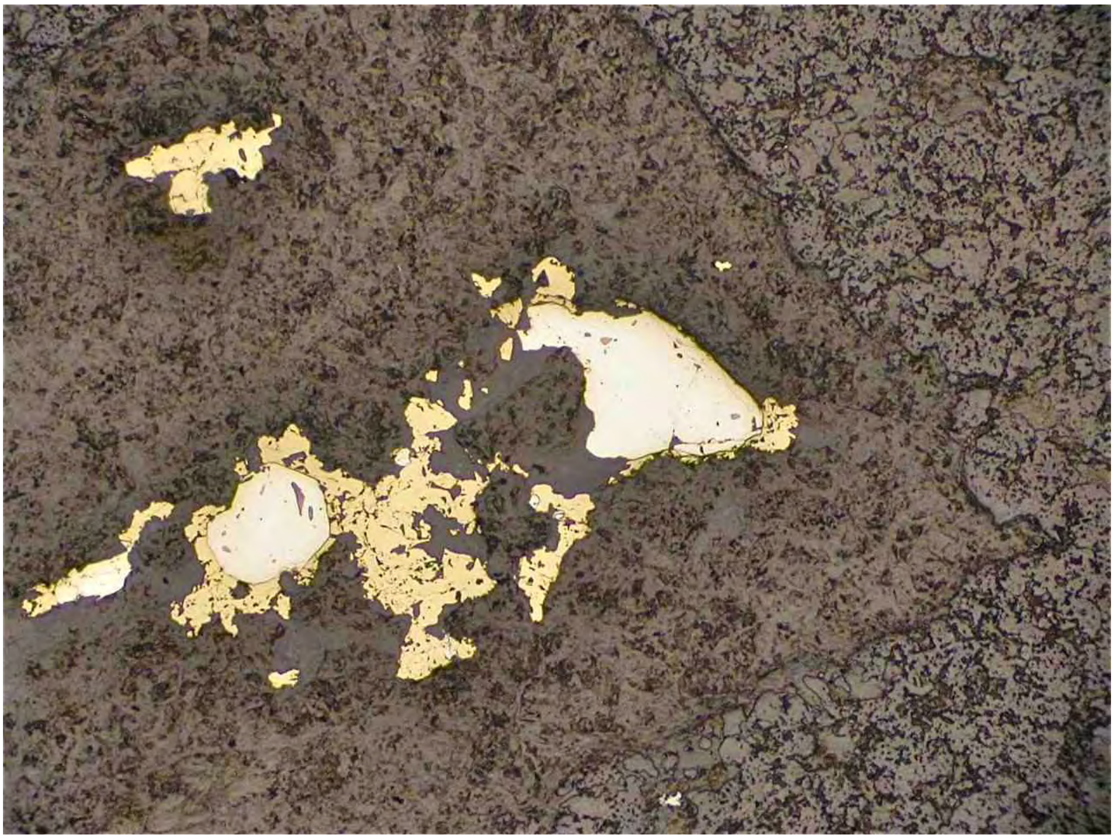

Fig. 3: Small aggregate of pyrite (pale creamy) and chalcopyrite (yellow) hosted in a sericite pseudomorph after a blocky feldspar phenocryst. Plane polarised reflected light, field of view 2 mm across.

STRC005D 134.7 m PTS

Summary: Pyrite-quartz rock, representing the product of hydrothermal infill (e.g. of a vein) and/or intense hydrothermal replacement of a protolith, or which there are no relict textural characteristics preserved. Within pyrite, there are a few pseudomorphic aggregates that could be after former chromite grains, and together with the fact that the rock also contains a little Cr-sericite (fuchsite) and anomalous assay values of Cr, Ni and Co, implies that there was an ultramafic protolith, or that components were leached from an adjacent ultramafic rock. Disseminated to massive pyrite also hosts a few small aggregates of chalcopyrite. Interstitial quartz masses are medium grained and host a few small aggregates of fine grained fuchsite. Interpreted former chromite grains were replaced by fine grained, red-coloured ?Cr-bearing corundum ± fuchsite or by eskolaite ± chalcopyrite.

Handspecimen: The drill core sample is composed of a hydrothermal pyrite-quartz rock. It contains abundant medium to coarse grained disseminated to massive pyrite, with interstitial white to grey quartz (Fig. 4). A trace of green, fine grained sericite (maybe fuchsite) occurs in quartz and it is possible that there are traces of chalcopyrite hosted in pyrite. No relict texture from a protolith is recognised. The rock is cut by a couple of sub-planar, narrow quartz veins at a moderate to low angle to the core axis. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

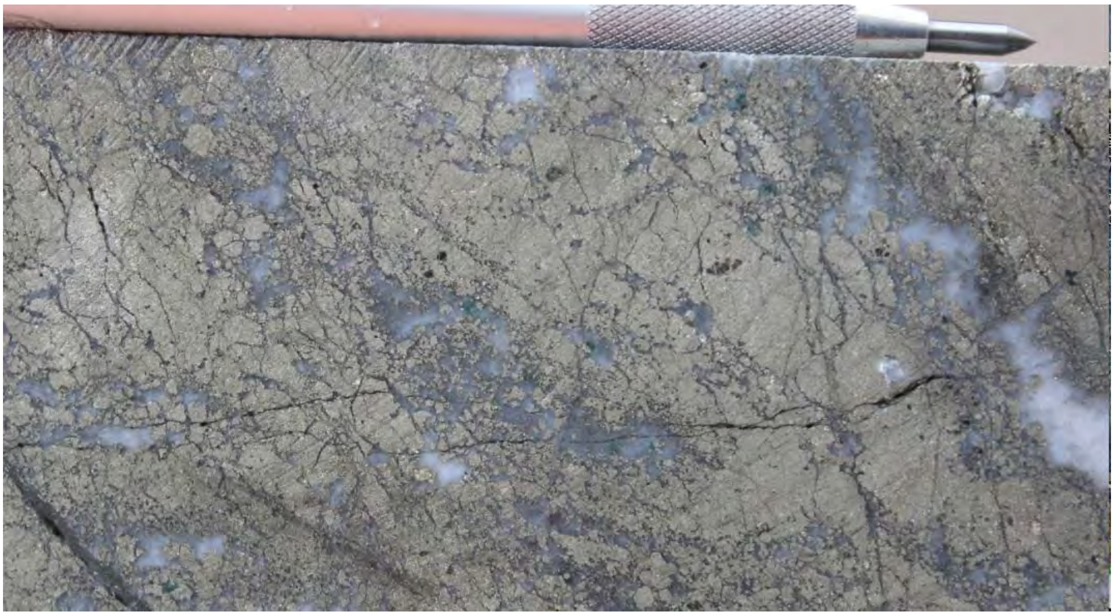

Fig. 4: Cut drill core of sample exhibiting largely massive pyrite, with patchy interstitial white to grey quartz. Near centre is a tiny green aggregate of fuchsite.

Petrographic description

a) Primary rock characteristics: In the section, the rock is dominated by pyrite and quartz, and no definite relict textures are recognised after a protolith. A few pseudomorphic aggregates up to 1.5 mm across are speculated to be after original fractured chromite grains, based on their shape and alteration assemblage that could include Cr-bearing corundum and eskolaite (Figs 5, 6). Elsewhere in the rock, there are a few small aggregates of Cr-bearing sericite (fuchsite) and these mineralogical attributes, together with high assay values of Cr, Ni and Co, indiate that the sample is either the product of intense hydrothermal replacement of an ultramafic protolith and/or that components were mobilised from an adjacent ultramafic rock.

b) Alteration and structure: The sample contains abundant pyrite, ranging from disseminated (in quartz) to massive aggregates up to a few centimetres across, with pyrite grainsize being up to 1-2 mm. Patchily abundant medium grained, inequigranular quartz occurs interstitial to pyrite, in places forming semi-continuous aggregates and with quartz being up to 1.5 mm grainsize and commonly exhibiting growth zoning texture. Within quartz-rich domains are a few small aggregates (up to 1 mm) of fine grained, pale green sericite (fuchsite). Within pyrite are uncommon small aggregates of chalcopyrite (up to 0.5 mm) and a few pseudomorphic aggregates up to 1.5 mm across that could be after original chromite (Fig. 5). These also occur rarely in quartz. The pseudomorphic aggregates contain one or the other of a) fine grained reddish, granular ?Cr-bearing corundum ± fuchsite, or b) fine grained (up to 30 μm) blocky-prismatic eskolaite ± chalcopyrite (Figs 5, 6). The occurrence of ?Cr-bearing corundum is similar to that in sample SMD012/180.9 m. The replacement of primary chromite under the influence of intense hydrothermal alteration could occur as follows:

$$Fe(Cr,Al,Fe)_2O_4 + \text{fluid (S, Cu)} \text{ ----> } (Al, Cr)_2O_3 \text{ or } Cr_2O_3 \pm \text{fuchsite} \pm FeS_2, CuFeS_2.$$

c) Mineralisation: The rock contains abundant disseminated to massive pyrite commonly as aggregates of interlocking grains up to 1-2 mm. Pyrite hosts uncommon small aggregates of chalcopyrite up to 0.5 mm across and rare pseudomorphic aggregates after former chromite, now replaced by fine grained aggregates of ?Cr-bearing corundum ± fuchsite or eskolaite ± chalcopyrite (Figs 5, 6).

Mineral Mode (by volume): pyrite 55%, quartz 43%, Cr-sericite (fuchsite) 1% and traces of chalcopyrite, ?Cr-corundum and eskolaite.

Interpretation and comment: It is interpreted that the sample is a hydrothermal pyrite-quartz rock. It could be the product of hydrothermal infill (e.g. of a vein) and/or intense hydrothermal replacement of a protolith, or which there are no relict textural characteristics preserved. Disseminated to massive pyrite contains a few small aggregates of chalcopyrite and pseudomorphic aggregates that could be after former chromite grains, and together with the fact that the rock also contains a little Cr-sericite (fuchsite) and anomalous assay values of Cr, Ni and Co, implies that there was an ultramafic protolith, or that components were leached from an adjacent ultramafic rock. Interstitial quartz masses contain a few small aggregates of fine grained fuchsite. Interpreted former chromite grains were replaced by fine grained, red-coloured ?Cr-bearing corundum ± fuchsite or by eskolaite ± chalcopyrite.

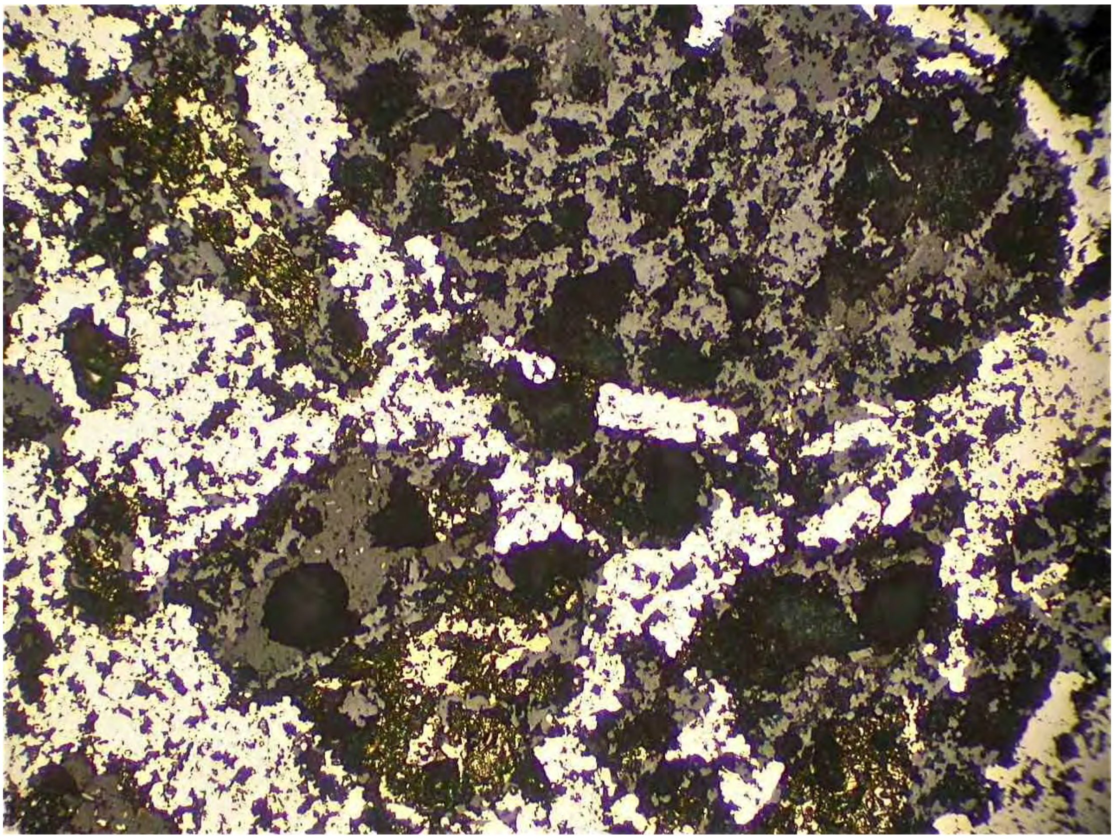

Fig. 5: Poorly polished mid-grey aggregates of ?Cr-bearing corundum, veined and surrounded by pyrite (pale creamy) and a couple of grains of chalcopyrite (yellow). Plane polarised reflected light, field of view 1 mm across.

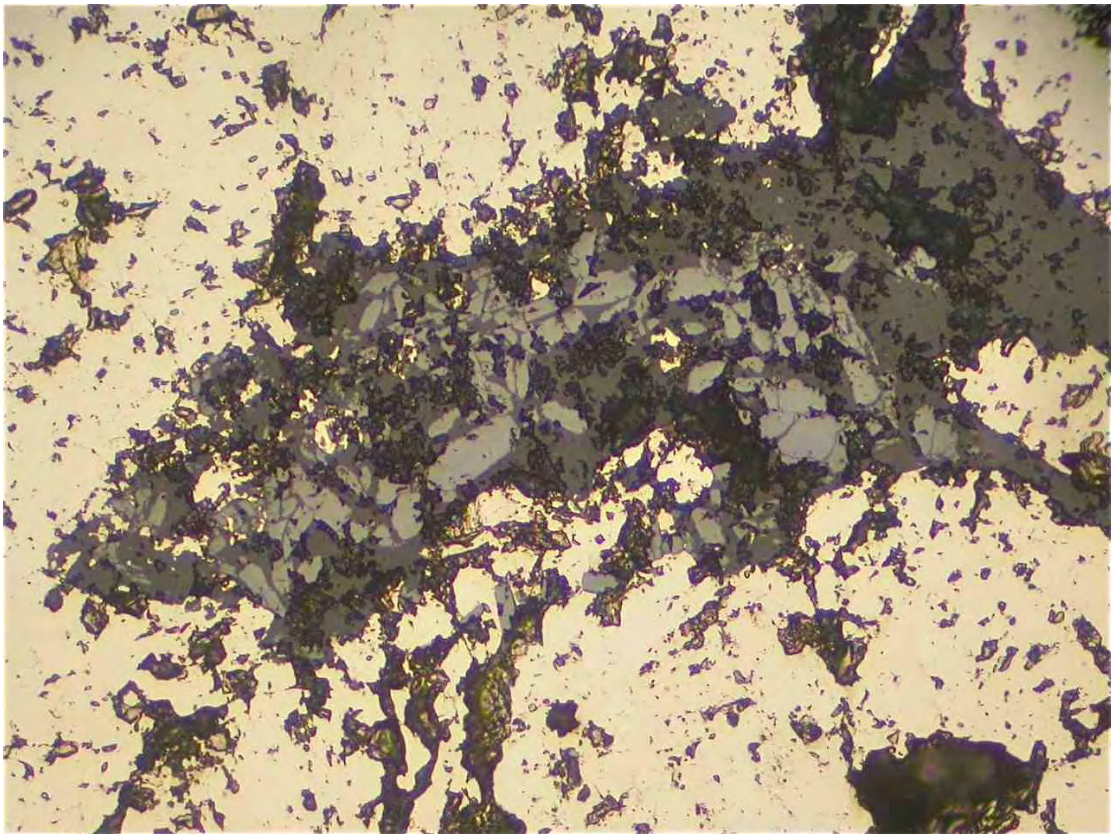

Fig. 6: Small aggregate of eskolaite (mid-grey) surrounded by pyrite (pale creamy). Plane polarised reflected light, field of view 0.5 mm across.

STRC005D 136.4 m PTS

Summary: Pyrite-quartz-sericite (fuchsite) rock, considered to represent the product of intense hydrothermal alteration of a former ultramafic to mafic composition igneous rock. There are no preserved relict textural attributes, but within medium to coarse grained pyrite, there are uncommon small relict grains of FeCr spinel, interpreted to have been inherited from the protolith. Pyrite ranges from strongly disseminated to massive and also contains traces of included and interstitial chalcopyrite. Scattered throughout are aggregates of fine to medium grained quartz and fine grained green sericite (fuchsite), with these phases also hosting rare very fine grained aggregates of ?eskolaite.

Handspecimen: The drill core sample is composed of semi-massive to massive, medium to coarse grained pyrite, with a subordinate proportion of interstitial silicates (Fig. 7). The latter include aggregates of fine grained, mid-green sericite (probably the Cr-bearing type, fuchsite) and pale grey quartz (Fig. 7). No relict texture after protolith material is recognised. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 7: Cut drill core sample showing largely massive, locally fractured pyrite, with scattered interstitial aggregates of fine grained green sericite (fuchsite).

Petrographic description

a) Primary rock characteristics: In the section, no definite relict textures from a protolith are recognised and the rock is regarded as the product of total replacement and reconstitution, now dominated by pyrite, subordinate quartz and pale green sericite (fuchsite). However, within pyrite are sparse, tiny (up to 50 µm) subhedral inclusions of interpreted FeCr spinel (chromite) (Fig. 8) and these could have been inherited from an original ultramafic to mafic igneous protolith.

b) Alteration and structure: It is possible that a former igneous protolith of ultramafic to mafic composition was intensely hydrothermally altered and reconstituted, with only uncommon tiny grains of FeCr spinel being preserved. The protolith was replaced by dominant medium to coarse grained pyrite, ranging from strongly disseminated to massive, interlocking grains that are up to 3 mm across. Pyrite encloses rare small inclusions of chalcopyrite, FeCr spinel and silicates (Fig. 8). Interstitial to pyrite are patchily abundant masses of fine to medium grained, inequigranular quartz (individual grains up to 1 mm) and fine grained pale green sericite (fuchsite) (Fig. 9). Aggregates of either phase can dominate and are up to several millimetres across, with small aggregates of a very fine grained prismatic phase tentatively identified as eskolaite being locally included (Fig. 9). It could be interpreted that the rock represents the product of intense phyllic alteration imposed on an ultramafic-mafic protolith.

c) Mineralisation: The sample contains abundant medium to coarse grained pyrite, with it being strongly disseminated to massive and anhedral grains being up to 3 mm across and interlocking in massive zones. Pyrite contains uncommon small (up to 50 μm) inclusions of chalcopyrite and FeCr spinel (Fig. 8) and there are a few grains of chalcopyrite up to 0.1 mm across interstitial to pyrite.

<u>Mineral Mode (by volume)</u>: pyrite 60%, quartz 25%, sericite (fuchsite) 15% and traces of ?eskolaite, FeCr spinel (chromite) and chalcopyrite.

<u>Interpretation and comment</u>: It is interpreted that the sample is an intensely hydrothermally altered ultramafic-mafic igneous rock, now replaced by an assemblage of pyrite, quartz and sericite (most likely Cr-bearing fuchsite). There are no preserved relict textural attributes, but within medium to coarse grained pyrite, there are uncommon small relict grains of FeCr spinel, interpreted to have been inherited from the protolith. Pyrite ranges from strongly disseminated to massive and it also contains traces of included and interstitial chalcopyrite. Interstitial to pyrite are scattered aggregates of quartz and green sericite (fuchsite), with these phases also hosting rare small aggregates of ?eskolaite.

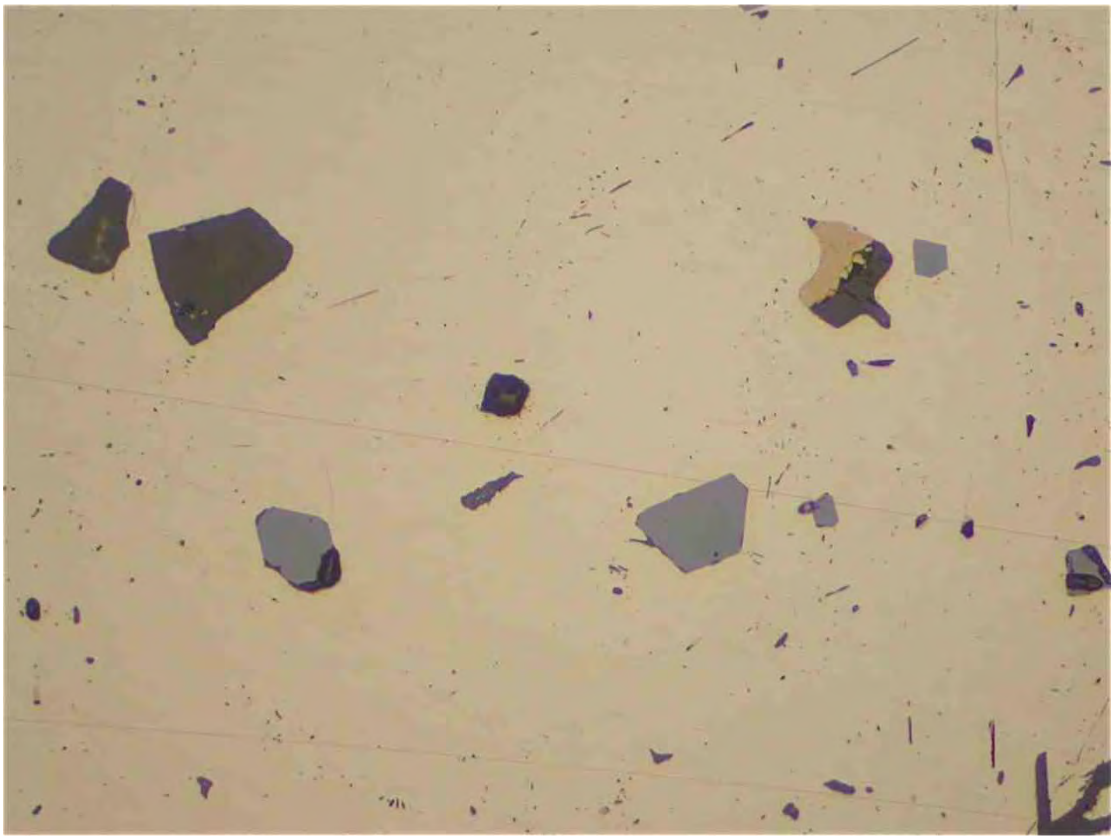

Fig. 8: Medium grey grains of subhedral FeCr spinel (chromite) and a single grain of chalcopyrite (yellow, upper right) hosted within a large pyrite grain. Plane polarised reflected light, field of view 0.5 mm across.

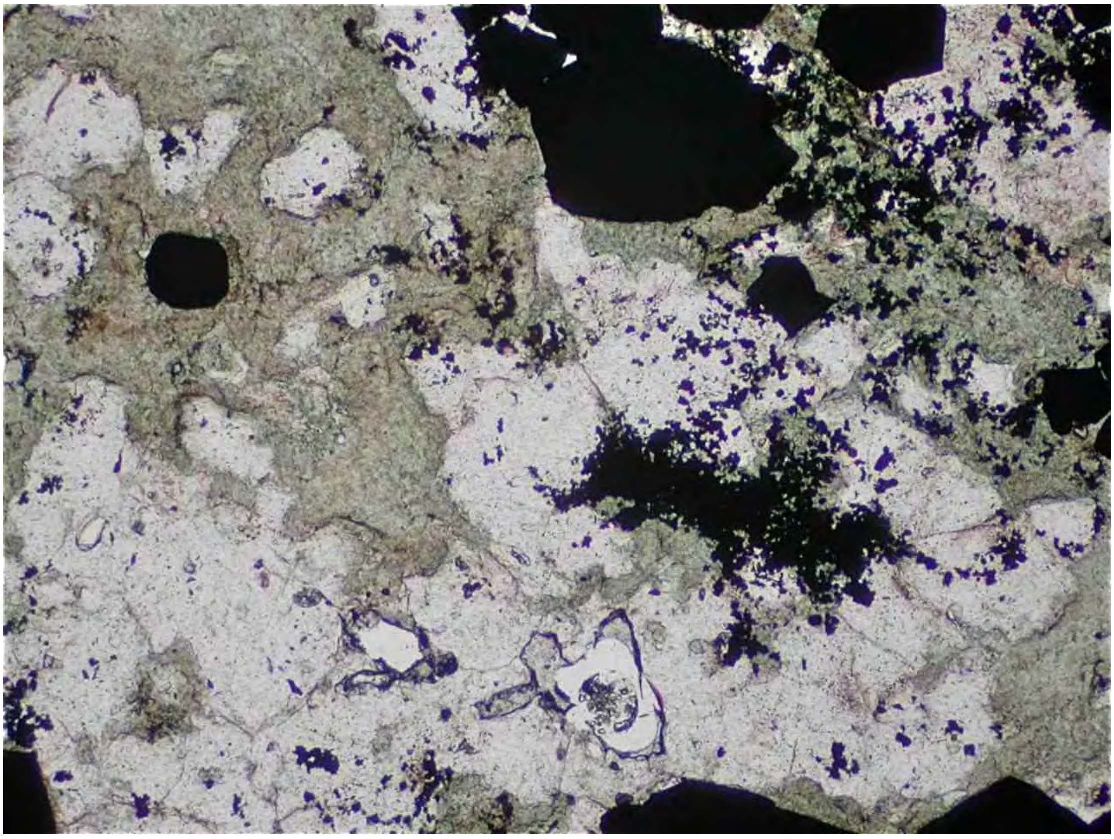

Fig. 9: Aggregate of pale green fine grained sericite (fuchsite) and quartz (clear) hosting a few grains of pyrite (larger black grains). The fine grained ragged black aggregate just right of centre is composed of ?eskolaite. Plane polarised transmitted light, field of view 2 mm across.

STRC005D 143.0 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and local infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic igneous type. No relict textures or minerals are preserved from a protolith, but there are traces of rutile and pale green sericite (e.g. Cr-bearing fuchsite). The rock is dominated by fine to medium grained quartz, commonly with textures showing affinities with those formed in an epithermal environment. Quartz contains several cavities, along with abundantly disseminated fine to rather coarse pyrite. Apart from trace rutile and fuchsite, there is also a trace of chalcopyrite and anhydrite contained within quartz. A variety of small mineral inclusions occur in pyrite, including chalcopyrite and less common bornite, hematite, ?tennantite, ?sphalerite and anhydrite. The mineral assemblage appears to have formed under relatively oxidising conditions.

Handspecimen: The drill core sample is composed of massive, quartz-pyrite rock, perhaps representing the product of intense hydrothermal replacement of protolith material. No relict texture from a protolith is recognised. Pale grey, fine to medium grained quartz hosts strongly disseminated pyrite that forms aggregates up to several millimetres across and there are a couple of small pale green ?fuchsite aggregates (Fig. 10). Several irregular cavities up to 5 mm across are present in quartz (Fig. 10). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 10: Cut drill core sample of quartz-pyrite rock, being the product of intense hydrothermal alteration and local infill. Note local quartz-rich domains and a few small cavities.

Petrographic description

a) Primary rock characteristics: In the section, no definite relict texture or minerals are recognised and the rock is considered to be the product of total hydrothermal replacement, as well as probable hydrothermal infill. It is now dominated by quartz and pyrite, but it does contain traces of finely disseminated rutile and a couple of small aggregates of pale green sericite (fuchsite). The presence of anomalously high geochemical values of Cr and Ni, and trace Cr-bearing mica could imply that if the rock is derived from intense alteration of a protolith, then the latter might have been of ultramafic igneous type.

b) Alteration and structure: A speculative protolith was intensely hydrothermally altered and probably partly dissolved, forming void space, leading to hydrothermal replacement and infill occurring. The resulting product is dominated by fine to medium grained, inequigranular quartz, locally with growth zoning, sub-radiating and cavity fill texture (Fig. 11). These textures resemble those formed in the epithermal environment. Strongly disseminated pyrite occurs in quartz, forming aggregates up to 4 mm across (Fig. 11), as well as a couple of small (<0.2 mm) discrete grains of chalcopyrite, several fine grained aggregates of rutile and a couple of aggregates up to 0.3 mm across of pale green sericite (fuchsite) and rare tiny grains of anhydrite. Tiny scattered mineral inclusions are common in pyrite, with chalcopyrite being the most abundant and up to 0.1 mm across and accompanied by rarer grains of bornite, hematite, ?tennantite, ?sphalerite and anhydrite (Fig. 12). The alteration assemblage is viewed as being of intense "silica-pyrite" type (i.e. silicification), forming under relatively oxidising conditions.

c) Mineralisation: The sample contains strongly disseminated pyrite throughout, in anhedral grains and aggregates up to 4 mm across. A trace of chalcopyrite occurs as discrete grains up to 0.2 mm across hosted in quartz, but other grains of chalcopyrite are more typically associated with pyrite, either as small interstitial grains up to 0.2 mm across, or as inclusions in pyrite. The latter are accompanied by less common small inclusions of bornite, hematite, ?tennantite, ?sphalerite and anhydrite (Fig. 12). The mineral assemblage has some affinity with that developed in high sulphidation systems.

Mineral Mode (by volume): quartz 80%, pyrite 19% and traces of rutile, sericite (fuchsite), chalcopyrite, bornite, hematite, ?tennantite, ?sphalerite and anhydrite.

Interpretation and comment: It is interpreted that the sample represents the product of intense hydrothermal replacement and local infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic igneous type. The rock is dominated by quartz (in places with textures resembling those formed in an epithermal environment) and disseminated pyrite. There are also traces of rutile and pale green sericite (fuchsite), chalcopyrite and anhydrite contained within quartz. A variety of small mineral inclusions occur in pyrite, including chalcopyrite and less common bornite, hematite, ?tennantite, ?sphalerite and anhydrite. The mineral assemblage appears to have formed under relatively oxidising conditions and has similarity to that in high sulphidation systems.

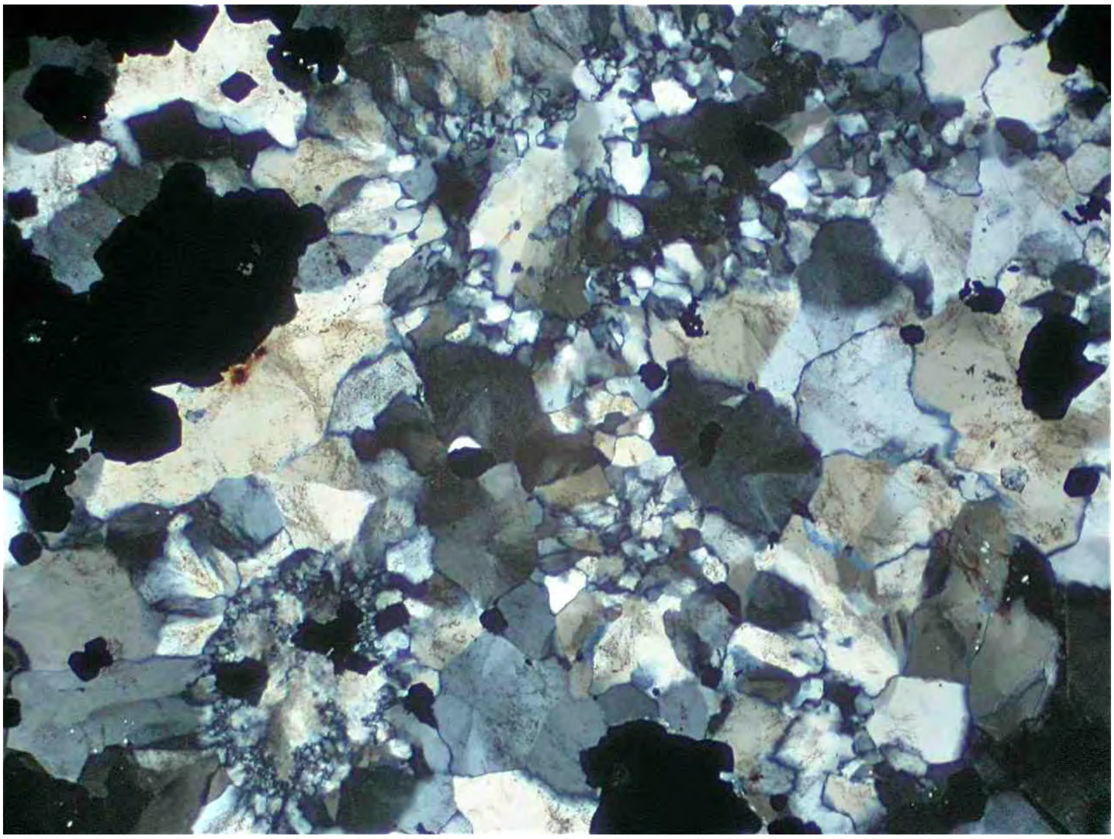

Fig. 11: Typical texture of hydrothermal quartz, with local sub-radiating growth. Black grains are pyrite. Transmitted light, crossed polarisers, field of view 2 mm across.

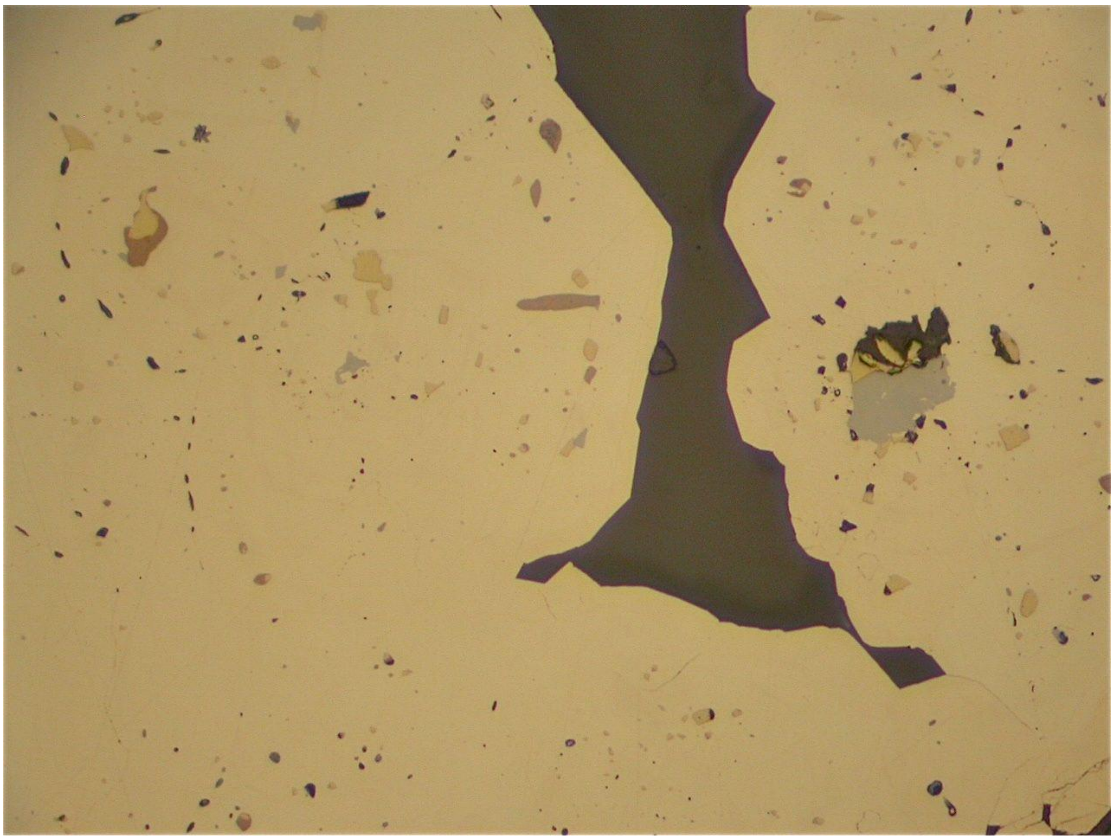

Fig. 12: Pyrite hosting small inclusions that include chalcopyrite (yellow), bornite (brown) and ?tennantite (pale grey). Dark grey mass is quartz. Plane polarised reflected light, field of view 0.5 mm across.

STRC005D 146.6 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic to mafic igneous type. No relict textures or minerals are preserved from a protolith, but there are traces of Ni sulphides and in handspecimen, pale green sericite (e.g. Cr-bearing fuchsite). The rock is dominated by fine to coarse grained quartz, commonly with textures showing affinities to those characteristic of an epithermal environment. Disseminated to semi-massive pyrite occurs in quartz, along with minor aggregates of chalcopyrite, and locally, faint pigmentation by ultrafine hematite. Chalcopyrite contains a few small inclusions of ?tennantite, bornite, millerite and gersdorffite, and pyrite commonly hosts chalcopyrite, along with rare bornite and ?tennantite. The mineral assemblage appears to have formed under relatively oxidising conditions.

Handspecimen: The drill core sample is composed of a rather heterogeneous quartz-pyrite rock, representing the product of intense hydrothermal replacement and locally, vein infill. Quartz is fine to medium grained and commonly contains irregular to elongate cavities up to 2 cm long (Fig. 13). Veinlike quartz-rich masses up to a few centimetres wide are intercalated with irregular to veinlike masses of fine to medium grained pyrite up to a few centimetres across, with crude banding being at a moderate to high angle to the core axis (Fig. 13). Part of the sample shows strongly disseminated pyrite hosted in quartz with the latter variably impregnated by fine grained green sericite (fuchsite) (Fig. 13). In other quartz-rich domains, there is a little dark red-brown pigmentation due to included ultrafine hematite (Fig. 13). A few irregular to elongate aggregates of chalcopyrite up to 3 mm across occur in the quartz-rich domains, adjacent to pyrite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

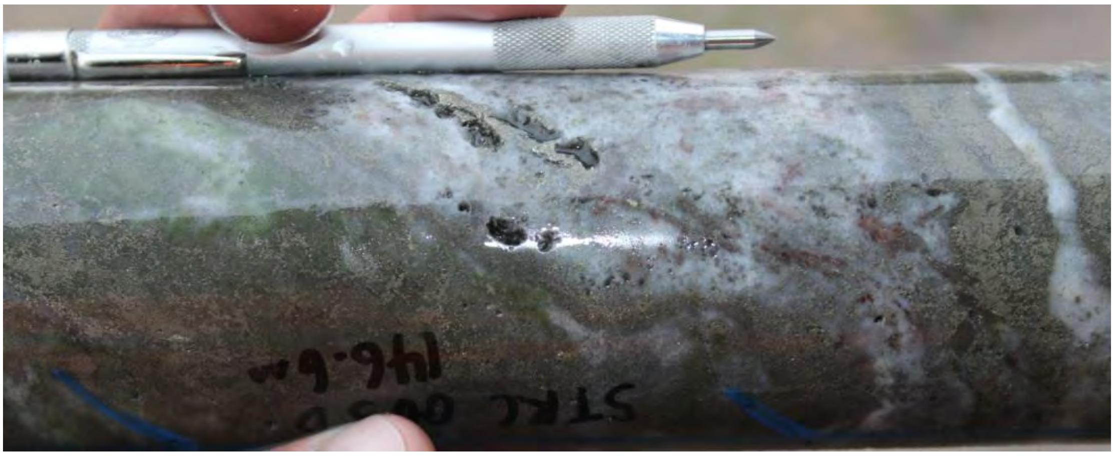

Fig. 13: Drill core sample of quartz-pyrite rock showing local green colouration at left due to minor amounts of fuchsite occurring, and intercalation of quartz-rich and pyrite-rich, locally veinlike domains. Local red-brown pigmentation in quartz is due to ultrafine hematite.

Petrographic description

a) Primary rock characteristics: In the section, no relict textures or minerals from a protolith are recognised and the rock could be the product of hydrothermal infill as well as complete replacement of protolith material. The fact that there are traces of Ni-bearing sulphides in the sample (see below) and traces of fuchsite in the handspecimen could imply that adjacent host rock was of ultramafic-mafic igneous type.

b) Alteration and structure: It is speculated that protolith material was intensely hydrothermally altered and probably dissolved, causing complete replacement as well as considerable hydrothermal infill to occur. The rock is now dominated by fine grained to locally rather coarse grained (up to 2.5 mm) inequigranular quartz, commonly showing growth zoning, sub-radiating and cavity fill textures (Fig. 14), characteristic of formation in the epithermal environment. Quartz hosts minor disseminated, through to semi-massive aggregates up to 2 cm wide of pyrite (Fig. 14) as well as a few irregular to elongate aggregates of chalcopyrite, and in places, faint pigmentation by ultrafine hematite. Within chalcopyrite, there are included grains of pyrite, ?tennantite and rarer bornite, millerite and in one aggregate, several grains of gersdorffite (Fig. 15). Pyrite commonly contains inclusions of, and small interstitial masses of, chalcopyrite, as well as rare bornite and ?tennantite.

c) Mineralisation: The sample contains disseminated to locally semi-massive aggregates of fine to medium grained, anhedral pyrite. Within pyrite, there are locally common inclusions and small interstitial masses of chalcopyrite (up to 0.3 mm across) as well as rare small inclusions of bornite and ?tennantite. Quartz-rich zones also contains irregular scattered aggregates of chalcopyrite up to 3 mm across, commonly including paragenetically earlier grains of pyrite, but also having uncommon intergrowths with ?tennantite (up to 0.2 mm), rare bornite, millerite and in one aggregate, a few grains of gersdorffite (Fig. 15). The Ni sulphide phases are up to 0.1 mm across. The mineral assemblage has some affinity with that developed in high sulphidation systems and evidently formed under relatively oxidising conditions.

Mineral Mode (by volume): quartz 75%, pyrite 23%, chalcopyrite 2% and traces of bornite, hematite, ?tennantite, millerite and gersdorffite.

Interpretation and comment: It is interpreted that the sample is a quartz-pyrite rock that could be the result of intense hydrothermal replacement and infill of a protolith this is speculated to possibly be of ultramafic to mafic igneous type. Traces of Ni sulphides and pale green sericite (e.g. Cr-bearing fuchsite) are supportive of this concept. The rock is dominated by hydrothermal quartz, commonly with textures suggestive of formation in the epithermal environment. Disseminated to semi-massive pyrite occurs in quartz, together with minor chalcopyrite, and locally, faint pigmentation by ultrafine hematite. Chalcopyrite contains a few small inclusions of ?tennantite, bornite, millerite and gersdorffite, and pyrite commonly hosts chalcopyrite, along with rare bornite and ?tennantite. The mineral assemblage appears to have formed under relatively oxidising conditions and has some affinities to those in high sulphidation systems.

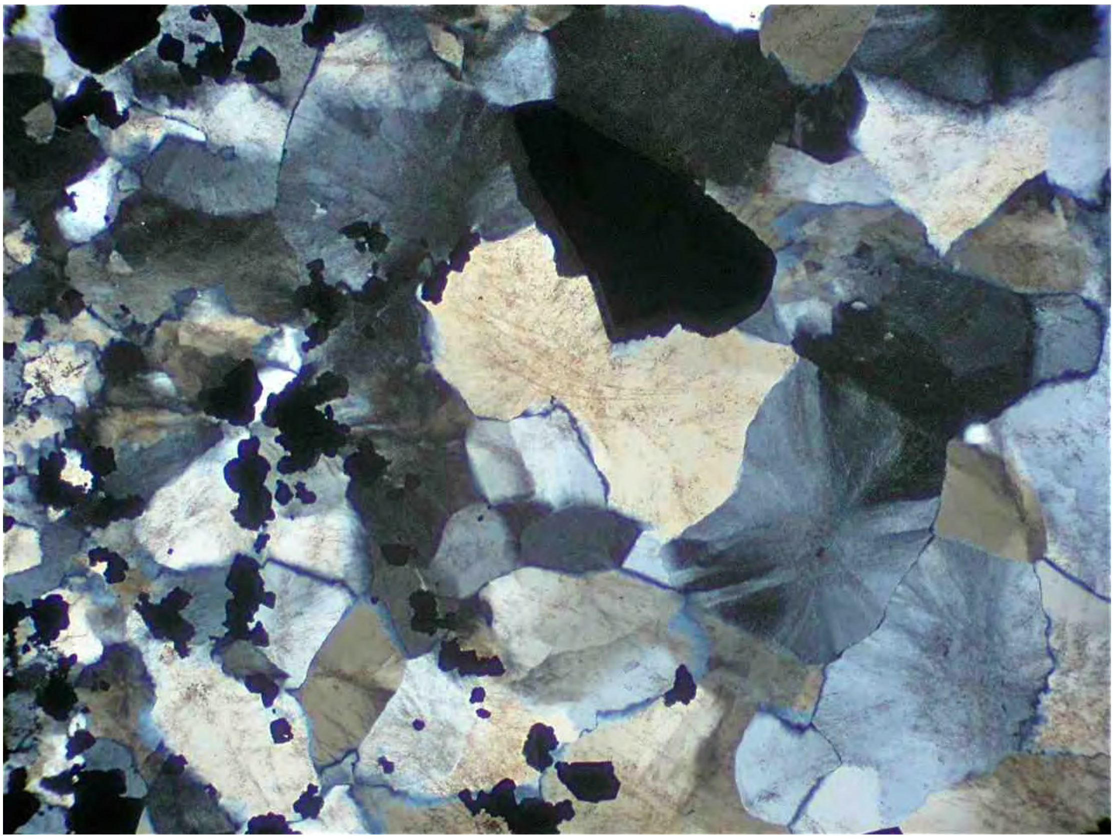

Fig. 14: Characteristic textures of hydrothermal quartz, with local sub-radiating growth in cavity infill. Black grains are pyrite. Transmitted light, crossed polarisers, field of view 2 mm across.

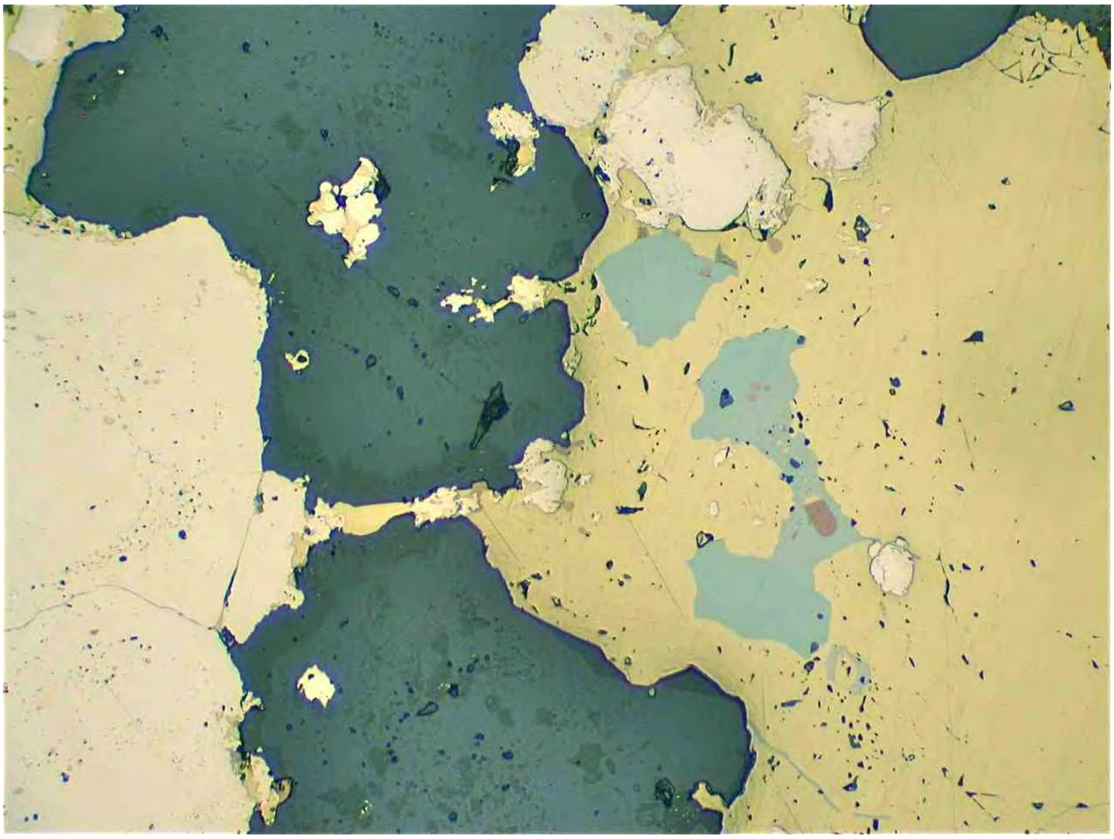

Fig. 15: Composite aggregate of pyrite (pale creamy) and chalcopyrite (yellow) adjacent to quartz (dark grey). Chalcopyrite contains small inclusions of ?tennantite (pale blue-grey) and bornite (pink-brown) is mostly associated with ?tennantite. Plane polarised reflected light, field of view 0.5 mm across.

STRC005D 150.5 m PTS

Summary: Quartz-pyrite rock representing the product of intense hydrothermal replacement and infill of a protolith whose original nature is obscure, but speculated to have possibly been of ultramafic type. No relict textures or minerals are preserved from a protolith, but there are small amounts of green Cr-bearing sericite (fuchsite) and traces of eskolaite, supporting an ultramafic affinity. The rock is dominated by medium grained quartz, with inequigranular and locally zoned and cavity fill textures. Disseminated to semi-massive pyrite occurs throughout, commonly with minor amounts of interstitial and included bornite, chalcopyrite and trace ?tennantite. There are also a few discrete aggregates of bornite and chalcopyrite. Sparsely scattered interstitial to quartz and pyrite are irregular to elongate aggregates of fine grained fuchsite and closely associated with some of these are small aggregates of fine grained eskolaite. The mineral assemblage is consistent with silicic-phyllic alteration and mineralisation of high sulphidation affinity.

Handspecimen: The drill core sample is composed of a crudely banded quartz-pyrite rock, with diffuse, somewhat irregular layering on a scale of up to 2 cm, defined by differences in amounts of fine to medium grained quartz and pyrite, and oriented at ~30° to the core axis (Fig. 16) Many quartz-rich domains contain greenish colouration due to minor dispersed Cr-bearing sericite (fuchsite) and there are also cavities up to several millimetres across (Fig. 16). A few aggregates of bornite ± chalcopyrite up to 1-2 mm across occur in quartz-rich domains. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 16: Drill core sample showing crudely banded quartz-pyrite rock, with minor green colouration in quartz-rich domains due to small aggregates of Cr-bearing sericite (fuchsite). Note scattered cavities in quartz-rich domains.

Petrographic description

a) Primary rock characteristics: In the section, there are no recognised remnants of protolith material and the sample is regarded as the product of hydrothermal infill as well as probable total hydrothermal replacement. The fact that there are small amounts of Cr-bearing phases in the alteration assemblage (fuchsite, eskolaite) imply that the adjacent protolith material was of ultramafic type.

b) Alteration and structure: The sample represents a totally reconstituted assemblage, dominated by hydrothermal quartz and a subordinate amount of sulphides. Quartz is medium grained (up to 1 mm), inequigranular and locally shows zoned growth and cavity fill textures.

Sparsely scattered, interstitial to quartz and sulphides are irregular to elongate aggregates up to 4 mm across of fine grained green fuchsite, and in these aggregates and adjacent quartz, there are a few aggregates up to 1 mm across of fine grained eskolaite (Figs 17, 18). Pyrite is the dominant sulphide, forming anhedral masses up to 3 mm across, but it is commonly intergrown with minor to locally abundant aggregates of bornite ± chalcopyrite ± trace ?tennantite (Fig. 19), as well as containing sparse tiny inclusions of bornite, chalcopyrite and eskolaite. There are also several discrete irregular aggregates up to 3 mm across of bornite and chalcopyrite (and trace ?tennantite), in places attached to pyrite (Fig. 20). If there was some initial ultramafic protolith, it is evident that this was subject to intense silicic (-phyllic) hydrothermal alteration and diffuse quartz-sulphide veining.

c) Mineralisation: The sample contains relatively abundant sulphides, dominated by disseminated to semi-massive, fine to medium grained pyrite, forming anhedral aggregates up to 6 mm across. In places, pyrite hosts minor to locally common interstitial bornite ± chalcopyrite, as well as tiny inclusions of bornite, chalcopyrite and eskolaite. There are a few aggregates adjacent to pyrite that contain bornite + chalcopyrite ± ?tennantite aggregates up to 2 mm across (Figs 19, 20), and discrete bornite-chalcopyrite aggregates up to 3 mm across, with bornite and chalcopyrite commonly showing trellis texture intergrowths (Fig. 20). Sparsely scattered in fuchsite aggregates and adjacent quartz (and rarely in pyrite) are aggregates up to 1 mm across of finely prismatic eskolaite, also locally attached to chalcopyrite (Figs 17, 18). Textures indicate that bornite-chalcopyrite-?tennantite are paragenetically later than pyrite and eskolaite.

Mineral Mode (by volume): quartz 80%, pyrite 15%, fuchsite and bornite each 2%, chalcopyrite 1% and traces of ?tennantite and eskolaite.

Interpretation and comment: It is interpreted that the sample represents a hydrothermal quartz-pyrite rock having formed by intense hydrothermal replacement and infill of a protolith that is speculated to have been of ultramafic type. No relict textures or minerals are preserved from a protolith, but there are small amounts of green Cr-bearing sericite (fuchsite) and traces of eskolaite, supporting an ultramafic affinity. Medium grained quartz dominates, with disseminated to semi-massive pyrite occurs throughout, commonly with minor amounts of interstitial and included bornite, chalcopyrite and trace ?tennantite. There are also a few discrete aggregates of bornite and chalcopyrite. Interstitial to quartz and sulphides are sparse aggregates of fuchsite with closely associated small fine grained aggregates of eskolaite. The mineral assemblage is consistent with silicic-phyllic alteration and mineralisation of high sulphidation affinity.

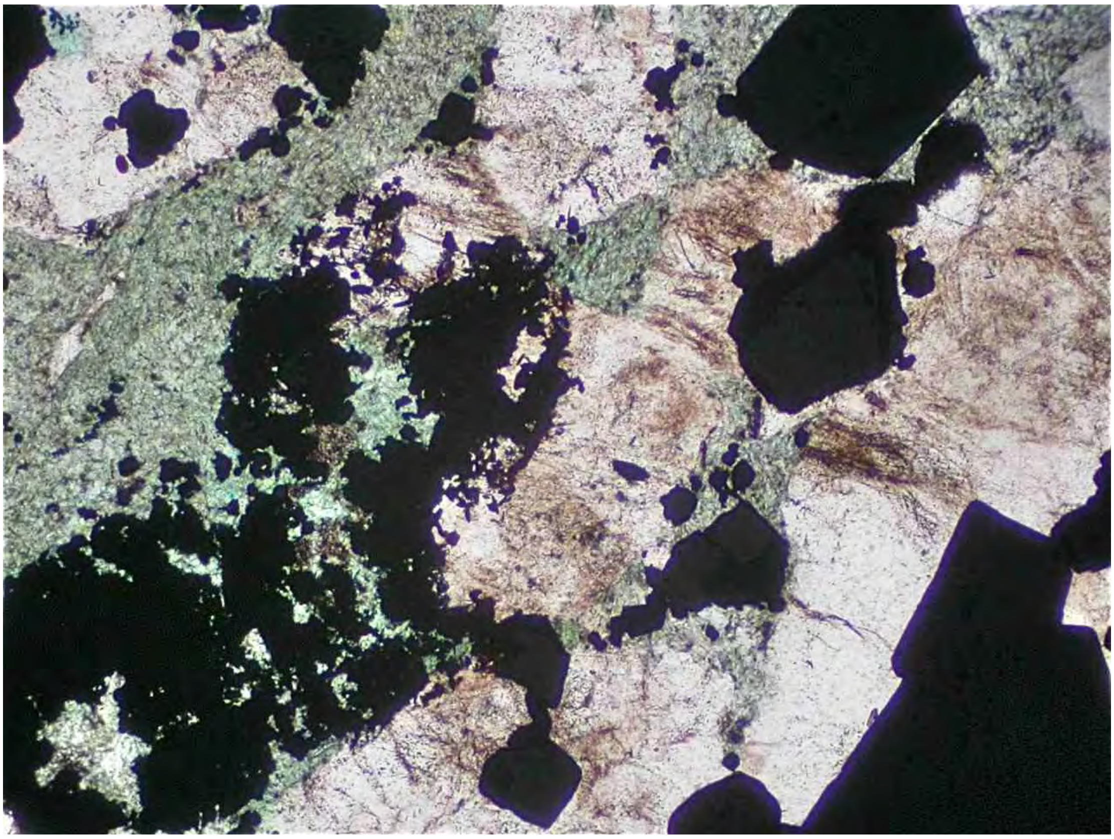

Fig. 17: Pale green fuchsite aggregates interstitial to quartz and pyrite (larger black masses). The fine grained black aggregate closely associated with fuchsite contains considerable eskolaite. Plane polarised transmitted light, field of view 2 mm across.

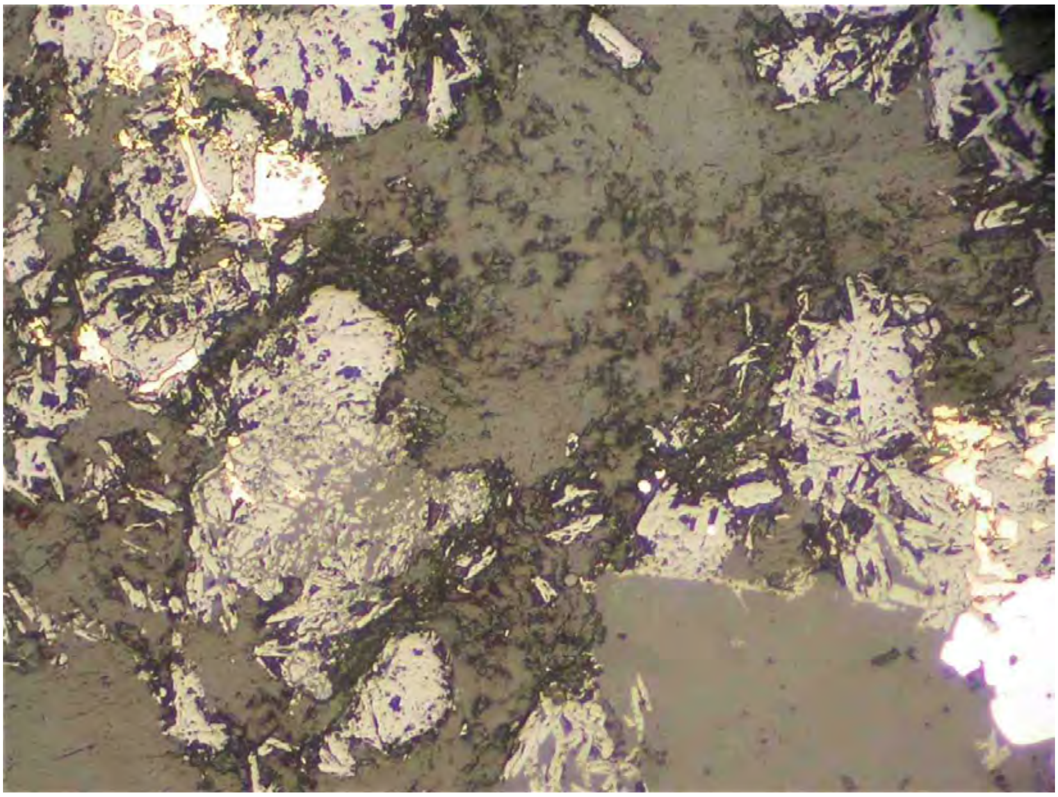

Fig. 18: Aggregates of fine grained prismatic eskolaite (pale grey), hosted in fuchsite (grey-green) and associated with small aggregates of pyrite and chalcopyrite (white to pale yellow). Plane polarised reflected light, field of view 0.5 mm across.

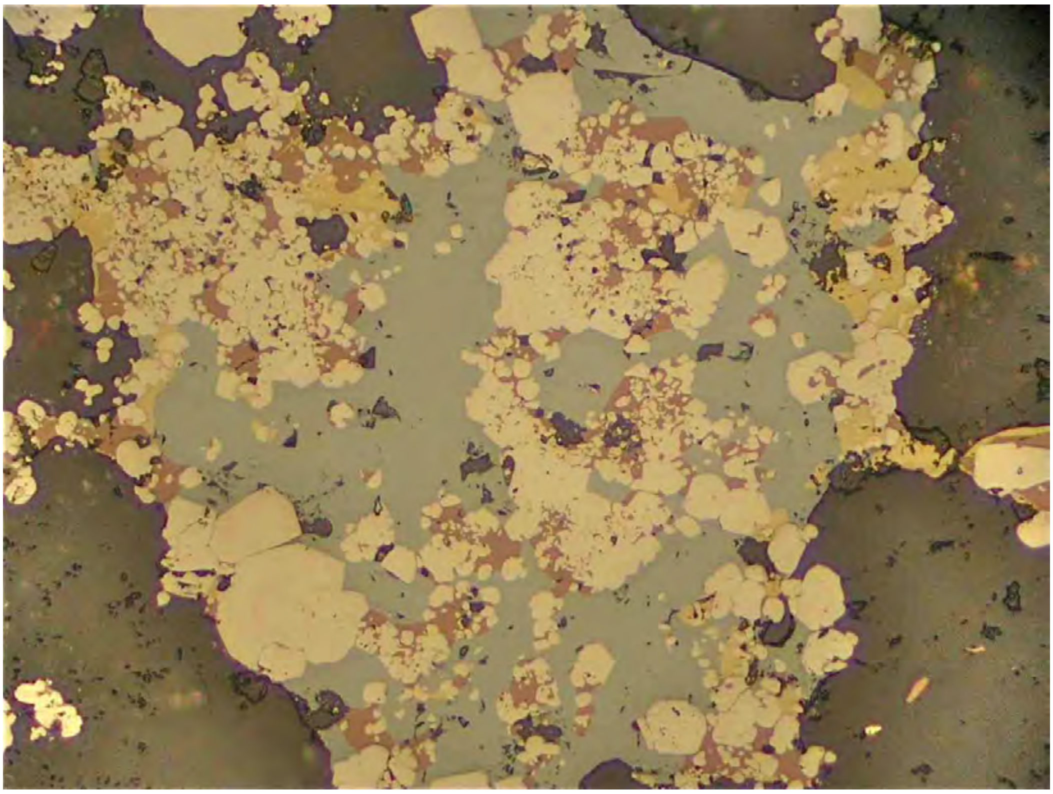

Fig. 19: Composite aggregate of pyrite (pale creamy), ?tennantite (pale grey), bornite (pink-brown) and chalcopyrite (yellow) in quartz (dark grey). Plane polarised reflected light, field of view 0.5 mm across.

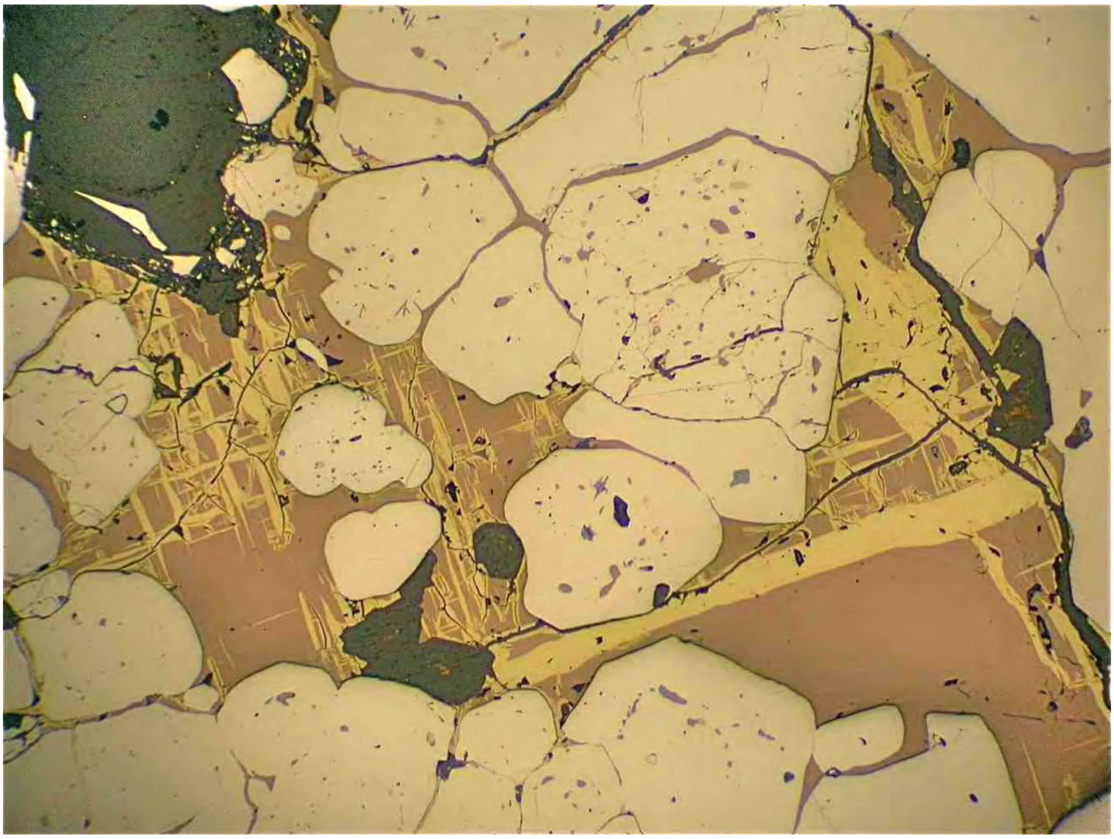

Fig. 20: Trellis texture intergrowth between bornite and chalcopyrite, interstitial to paragenetically earlier pyrite. Plane polarised reflected light, field of view 1 mm across.

STRC005D 151.9 m PTS

Summary: Hydrothermal quartz-sulphide rock with a few elongate to irregular, strongly altered and disaggregated fragments of serpentinite host rock. The latter were replaced by talc, and locally by chlorite, with local quartz, chalcopyrite and pyrite. Traces of chromite occur in these fragments and have also been liberated into the hydrothermal quartz-sulphide matrix. The latter could represent hydrothermal infill as well as the product of complete hydrothermal replacement (except for relict chromite). Quartz is fine to medium grained and locally hosts a few cavities and there is a little interstitial chlorite and traces of ultrafine hematite. Strongly disseminated sulphides are dominated by fine to medium grained pyrite, with subordinate chalcopyrite and traces of gersdorffite and millerite. Pyrite hosts small inclusions of chalcopyrite and rare ?tennantite and chromite. Gersdorffite is associated with chalcopyrite and locally rims pyrite, and shows some replacement by millerite. The serpentinite host rock was subject to silicic alteration and mineralisation under relatively oxidising conditions.

Handspecimen: The drill core sample is composed of a crudely banded, fine to medium grained quartz-sulphide rock. Pale grey quartz commonly hosts disseminated pyrite and minor chalcopyrite, but there are also some better-defined quartz-rich irregular veins up to 4 mm wide, in places hosting cavities. Veining and banding are at a moderate angle to the core axis (Fig. 21). No definite relict texture from a protolith is recognised, but there are a couple of elongate pale creamy aggregates containing fine grained layer silicate and which might represent altered protolith, that are oriented co-planar with the diffuse quartz veining (Fig. 21). These aggregates locally contain chalcopyrite and one has a little fine grained hematite as red-brown pigmentation. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 21: Drill core sample showing crudely banded quartz-sulphide rock, with a couple of elongate, creamy coloured aggregates that are rich in talc and represent altered ultramafic protolith. A little red-brown hematite pigmentation is associated with one of these aggregates. Pale grey anastomosing quartz-rich domains and intercalated with sulphides that include major pyrite and subordinate chalcopyrite.

Petrographic description

a) Primary rock characteristics: In the section, the rock is dominated by hydrothermal quartz and sulphides, but there are a few elongate, variably disaggregated masses of strongly hydrothermally altered rock, totalling ~5% of the sample. No relict textures are preserved in the quartz-sulphide aggregate, but there are a few relict, commonly fractured, grains of chromite up to 1.5 mm across (Fig. 22). In the altered rock masses, which are to 2 cm long, there are also a couple of small, relict chromite grains, along with locally preserved texture suggesting that the protolith was a weakly schistose serpentinite containing a few pseudomorphs after former pyroxene grains up to 0.6 mm across (Fig. 23). Mostly, however, the interpreted altered serpentinite entities are variably disaggregated, with no preserved primary characteristics except rare chromite.

b) Alteration and structure: It is interpreted that an original serpentinised ultramafic rock (e.g. peridotite), containing sparse relict chromite grains, was intensely hydrothermally altered, disaggregated and veined. More coherent rock masses, up to 2 cm across, were replaced by fine grained talc, or, in a couple of masses, by near-colourless chlorite, in places accompanied by fine grained quartz, chalcopyrite and pyrite (Fig. 23). Where more disaggregated, the altered host rock fragments merge into a hydrothermal matrix dominated by fine to medium grained, inequigranular quartz (grainsize up to 0.8 mm) and sulphides that constitute most of the sample. Quartz locally hosts a few cavities and there is also a little interstitial fine grained chlorite and a couple of aggregates of ultrafine hematite. Although sulphides are generally strongly disseminated in quartz-rich zones, they also occur in the talc- and chlorite-bearing altered host rock, and locally associated with chromite, e.g. in fractures (Fig. 22). Sulphides in the rock are dominated by pyrite, with subordinate chalcopyrite (in composites with pyrite or as discrete masses) (Fig. 24) and there are traces of gersdorffite, millierite and ?tennantite. The serpentinite host rock was subject to silicic alteration and sulphide mineralisation under relatively oxidising conditions.

c) Mineralisation: The sample contains strongly disseminated sulphides, hosted mainly in quartz, but with a small amount in the talc- and chlorite-altered host rock, and also locally filling fractures in relict chromite that forms grains up to 1.5 mm across (Fig. 22). Pyrite is the most common sulphide mineral, forming anhedral individual grains up to 2.5 mm across, as well as abundant composites with chalcopyrite (Fig. 24) and with rare gersdorffite. Chalcopyrite forms small inclusions in pyrite, along with rare small grains of ?tennantite and chromite. Chalcopyrite also forms discrete masses and is paragenetically later than pyrite. It hosts rare grains of gersdorffite up to 0.3 mm across, with the latter commonly showing variable replacement by millerite (Fig. 25).

Mineral Mode (by volume): quartz 82%, pyrite 8%, talc 5%, chalcopyrite 3%, chlorite 1% and traces of chromite, hematite, gersdorffite and millerite.

Interpretation and comment: It is interpreted that the sample is a hydrothermal quartz-sulphide rock containing a few altered and disaggregated fragments of serpentinite host rock that were replaced by talc, and locally by chlorite, minor quartz, chalcopyrite and pyrite. Traces of chromite occur in these fragments and have also been liberated into the hydrothermal quartz-sulphide matrix that could represent hydrothermal infill as well as the product of complete hydrothermal replacement (except for relict chromite). Quartz is inequigranular with a few cavities, a little interstitial chlorite and traces of ultrafine hematite. Strongly disseminated sulphides are dominated by pyrite, with subordinate chalcopyrite and traces of gersdorffite and millerite. Pyrite hosts small inclusions of chalcopyrite and rare ?tennantite and chromite. Gersdorffite is associated with chalcopyrite and locally rims pyrite, and shows some replacement by millerite. The serpentinite host rock was subject to silicic alteration and mineralisation under relatively oxidising conditions.

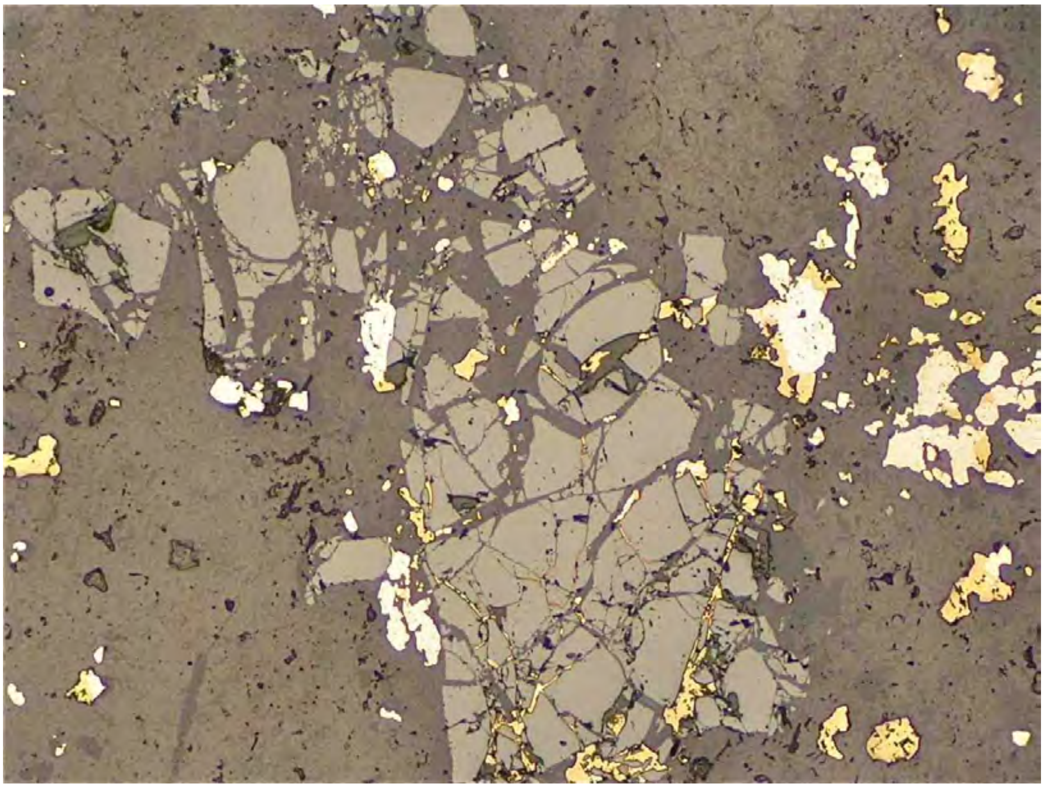

Fig. 22: Fractured relict chromite grain (pale grey) hosted in quartz and with a little disseminated pyrite (whitish) and chalcopyrite (yellow). Note sulphides in fractures in chromite. Plane polarised reflected light, field of view 2 mm across.

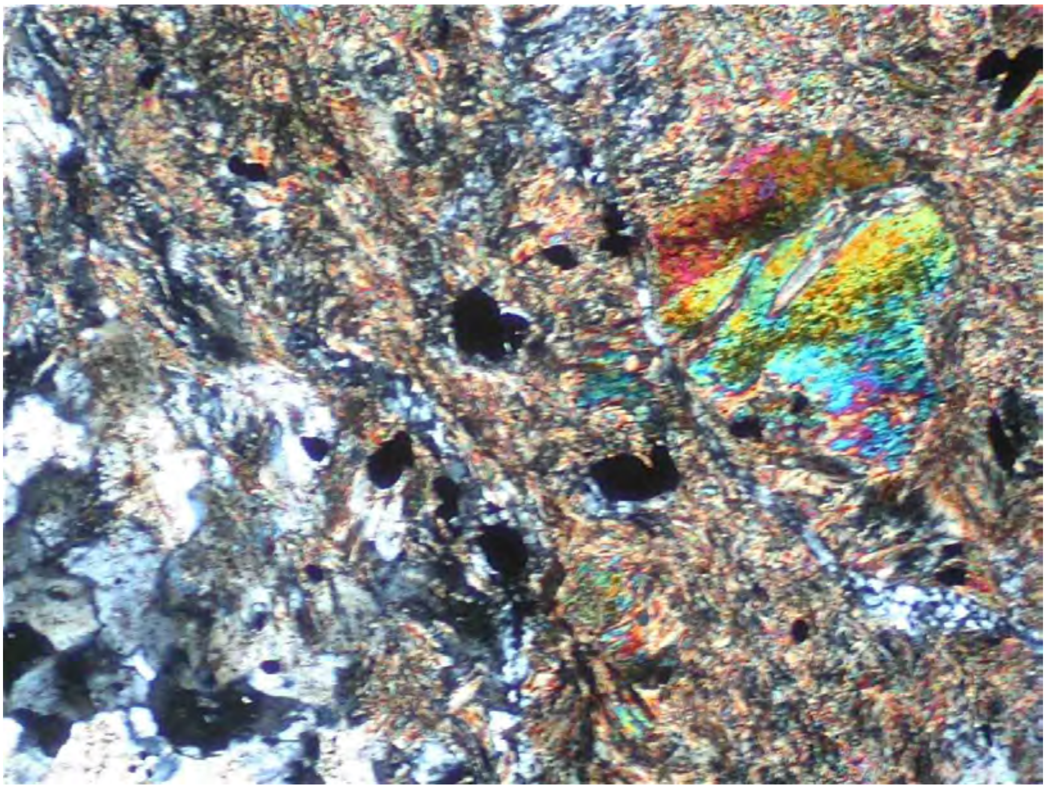

Fig. 23: Altered serpentinite, replaced by talc (bright colours) plus a little quartz and sulphides (black), and merging into quartz-rich hydrothermal matrix as lower left. Note larger talc pseudomorph after former pyroxene grain. Transmitted light, crossed polarisers, field of view 2 mm across.

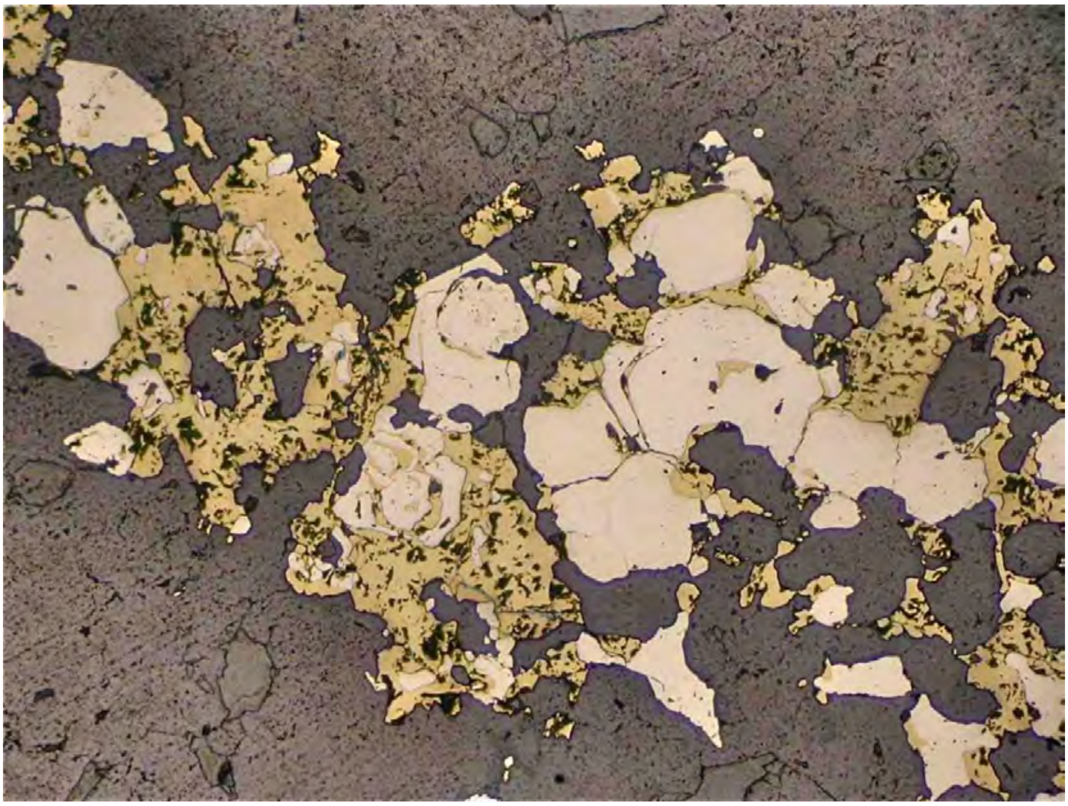

Fig. 24: Elongate aggregate of pyrite (pale creamy) and paragenetically later chalcopyrite (yellow) in quartz (dark grey). Plane polarised reflected light, field of view 2 mm across.

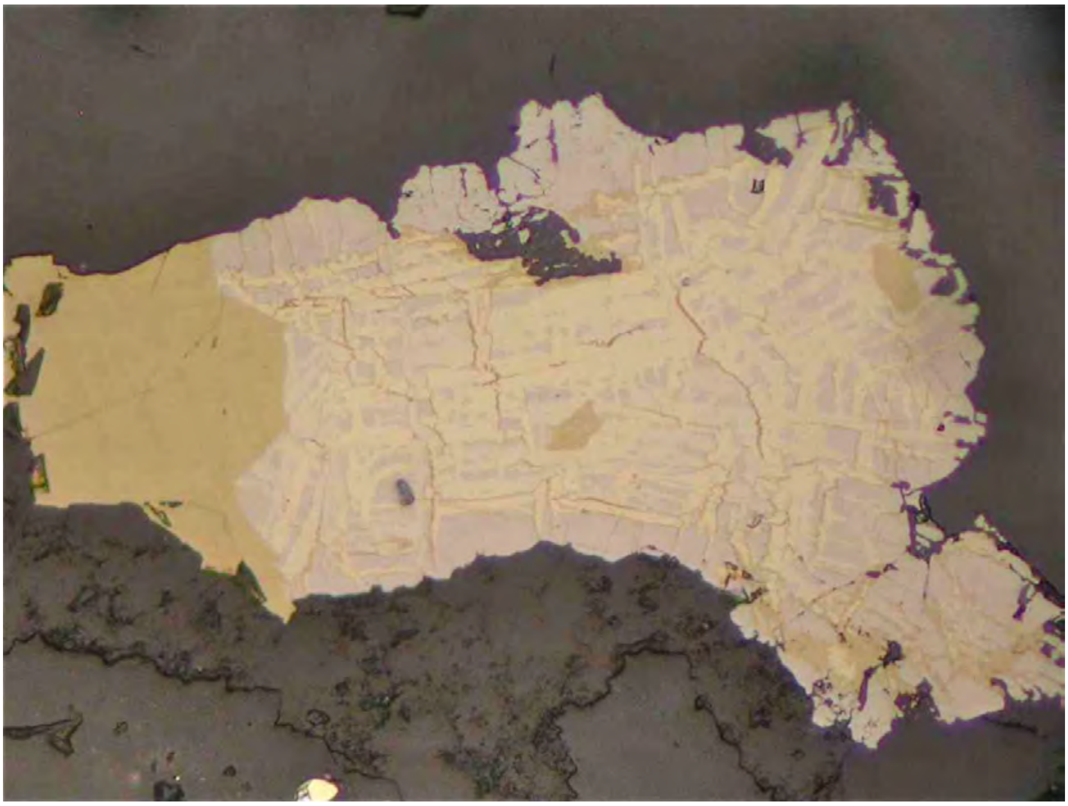

Fig. 25: Composite aggregate of chalcopyrite (yellow) and gersdorffite (pale pinkish) with the latter showing replacement by network texture millerite (pale lemon yellow). Plane polarised reflected light, field of view 0.25 mm across.

STRC005D 153.5 m TS

Summary: Medium to coarse grained granitic rock, considered most likely to have originally been of granodiorite to tonalite type. It formerly contained abundant quartz and feldspar (probably mostly plagioclase), a small amount of ferromagnesian material and traces of FeTi oxide and zircon. The rock was subject to deformation, causing strain, recrystallisation and local foliation development in quartz, and pervasive strong hydrothermal alteration of transitional propylitic-argillic type. Alteration led to all feldspar, ferromagnesian material and FeTi oxide being destroyed and the formation of an assemblage of fine grained sericite, chlorite, quartz, clay (maybe kaolinite) and trace leucoxene-rutile. A single, largely unstrained vein of medium to coarse grained quartz occurs, also hosting a little chlorite and sericite.

Handspecimen: The drill core sample is composed of a massive, strongly altered, medium to coarse grained granitic rock, evidently originally containing abundant feldspar, quartz and ferromagnesian material (Fig. 26). It has a speckled white/grey-green/pale yellow-green appearance and probably has pervasive alteration to sericite and chlorite (Fig. 26). A single sub-planar vein up to 3 mm wide occurs (Fig. 26), containing pale grey quartz, and being at a low angle to the core axis. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

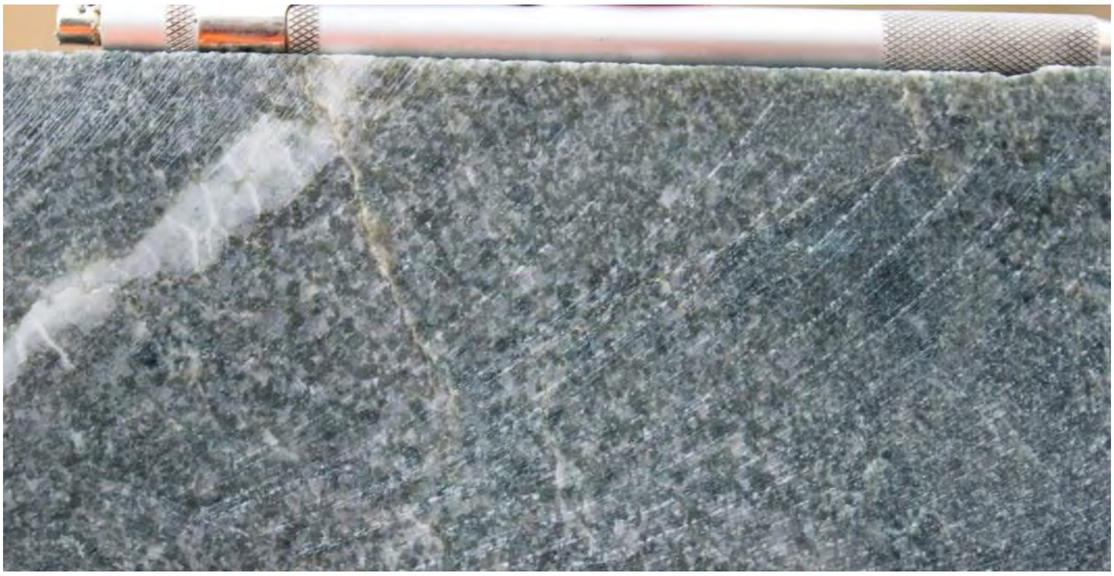

Fig. 26: Drill core sample of strongly altered granodiorite/tonalite with an alteration assemblage of sericite, quartz, chlorite and clay. The altered rock hosts a single quartz vein.

Petrographic description

a) Primary rock characteristics: In the section, it is apparent that an original medium to coarse grained granitic rock is strongly altered and deformed, such that relict texture is poorly to moderately preserved. Relict texture indicates that the rock originally contained abundant blocky feldspar (grains up to 3-4 mm) interlocking with abundant quartz (Fig. 27). It is likely that there was a small amount of ferromagnesian material, traces of FeTi oxide and zircon. Although all original feldspar is altered, the blocky pseudomorphic shapes are considered to indicate that plagioclase was the dominant feldspar type and thus the rock was mostly likely of granodiorite/tonalite composition.

b) Alteration and structure: Very strong hydrothermal alteration was imposed, causing all feldspar, ferromagnesian material and FeTi oxide to be destroyed. Original igneous quartz, although preserved (along with trace zircon), is deformed, showing strain and recrystallisation phenomena, and development of a weak foliation. Feldspars were altered to fine grained aggregates of sericite, quartz, minor chlorite and a fine grained, low-birefringent clay phase (maybe kaolinite) (Fig. 27). Ferromagnesian material was replaced by chlorite, sericite and trace leucoxene-rutile, and FeTi oxide was replaced by leucoxene-rutile. The altered rock is cut by a single sub-planar quartz-rich vein up to 5 mm wide that contains little-strained, medium to coarse quartz (grains up to 2.5 mm long) and small interstitial patches of fine grained quartz, chlorite and sericite. The alteration in the sample is considered to be consistent with transitional propylitic to argillic type.

c) Mineralisation: No sulphide minerals were observed.

Mineral Mode (by volume): quartz 50%, sericite 30%, chlorite and clay each 10% and traces of leucoxene-rutile and zircon.

Interpretation and comment: It is interpreted that the sample represents a strongly hydrothermally altered granitic tock, perhaps of granodiorite-tonalite type. Relict texture is poorly to moderately preserved but it can be deduced that there was formerly abundant quartz and feldspar (probably mostly plagioclase), a small amount of ferromagnesian material and traces of FeTi oxide and zircon. The rock deformed, causing strain, recrystallisation and local foliation development in quartz. Alteration is of transitional propylitic-argillic type, causing all feldspar, ferromagnesian material and FeTi oxide to be destroye, with formation of an assemblage of sericite, chlorite, quartz, clay (maybe kaolinite) and trace leucoxene-rutile. A single, largely unstrained vein of medium to coarse grained quartz occurs, also hosting a little chlorite and sericite.

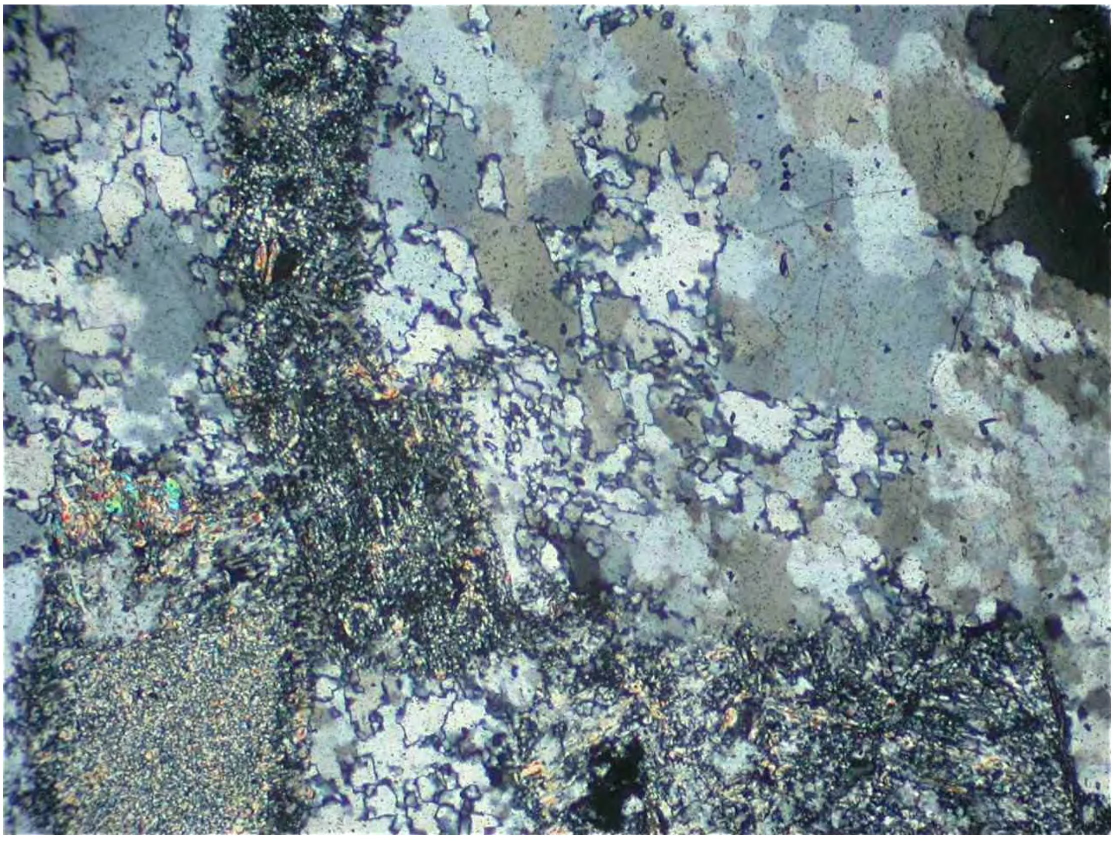

Fig. 27: Pseudomorphs after former blocky feldspar grains, replaced by fine grained sericite and clay, adjacent to strained and recrystallised quartz. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC005D 154.4 m PTS

Summary: Chlorite-quartz-talc-hematite-pyrite-chalcopyrite rock showing a weak foliation in places and representing the product of intense hydrothermal replacement of a former ultramafic rock, e.g. serpentinite. There are sparse scattered relict chromite grains, verifying the ultramafic protolith and in the talc-rich domains, speculative relict texture suggestive of a serpentinite precursor. There are diffuse and intergradational domains rich in chlorite, quartz or talc, with all having disseminated to locally semi-massive bladed texture hematite, as well as sulphides. Pyrite is dominant and is paragenetically earlier than commonly associated chalcopyrite, which also shows slight marginal replacement by digenite (maybe an incipient deep supergene effect). A single grain of electrum is observed in chalcopyrite. Alteration and mineralisation of the protolith took place under relatively oxidising conditions.

Handspecimen: The drill core sample is composed of a rather heterogeneous, fine to medium grained and weakly foliated assemblage that includes quartz, pale coloured layer silicates, patchy dark reddish and locally grey crystalline (specular) hematite, and a zone with strongly disseminated to semi-massive sulphides (appear to be pyrite and chalcopyrite) (Fig. 28). Quartz-rich zones contain scattered small cavities. No relict textures from a protolith are recognised. The sample is moderately magnetic, with susceptibility up to 140 x 10^{-5} SI.

Fig. 28: Drill core sample showing dark reddish pigmentation by abundant hematite in a rock that contains pale coloured quartz, chlorite and talc and towards the top of the sample, dark coloured and yellow sulphides (pyrite and chalcopyrite).

Petrographic description

a) Primary rock characteristics: In the section, there is little recognisable relict texture from a protolith, but sparsely scattered throughout are isolated and variably fractured relict chromite grains up to 0.7 mm across (Fig. 29). These could indicate an ultramafic protolith. It can be speculated that locally there are relict schistose textures and small pseudomorphs after former pyroxene grains, similar to what is typical of serpentinites (Fig. 30).

b) Alteration and structure: It is interpreted that the protolith was an ultramafic rock, e.g. serpentinite, mainly based on the presence of sparsely scattered relict chromite (Fig. 29). Apart from chromite, the original rock was totally reconstituted and replaced by a fine to medium grained, locally weakly foliated aggregates that range from being rich in near-colourless (Mg-rich) chlorite, or in quartz, or in talc (Fig. 30). There is some gradation between each of these three types and irregularly scattered throughout are disseminated to semi-massive aggregates of fine to medium grained, typically bladed texture hematite (grains up to 0.5 mm long) and disseminated to semi-massive sulphides (mostly pyrite and chalcopyrite) forming aggregates up to several millimetres across (Figs 29, 30, 31). Sulphides and hematite are locally intergrown. Essentially, the original interpreted ultramafic rock was replaced by a hydrothermal chlorite-quartz-talc-hematite-pyrite-chalcopyrite assemblage, evidently with introduction of silica, S, Fe and Cu, and under relatively oxidising conditions. Chalcopyrite shows minor replacement by digenite (Figs 31, 32) and this could indicate incipient deep supergene alteration.

c) Mineralisation: The sample retains sparse relict grains of chromite up to 0.7 mm across (Figs 29, 31), inherited from an ultramafic protolith. Subsequently, there was strong hydrothermal replacement, forming disseminated to semu-massive bladed texture hematite, as well as disseminated to semi-massive pyrite and chalcopyrite (Figs 29, 31, 32). Pyrite is the more abundant major sulphide, forming anhedral grains up to 2 mm across and hosting a few small inclusions of chalcopyrite and rare hematite, ?tennantite and chromite. Pyrite is commonly closely associated with paragenetically later chalcopyrite (i.e. chalcopyrite encloses pyrite and invades along fractures) (Figs 31, 32). Chalcopyrite forms masses up to 3 mm across and in one aggregate, a single elongate grain of electrum (~25 μm long) is present (Fig. 32). Chalcopyrite also shows minor rim replacement by digenite (Figs 31, 32).

<u>Mineral Mode (by volume)</u>: chlorite 30%, quartz 22%, hematite 20%, pyrite 15%, talc 8%, chalcopyrite 5% and traces of chromite, digenite, electrum and ?tennantite.

<u>Interpretation and comment</u>: It is interpreted that the sample represents an intensely altered ultramafic rock (e.g. serpentinite) replaced by a weakly foliated assemblage of chlorite-quartz-talc-hematite-pyrite-chalcopyrite. There are sparse scattered relict chromite grains, verifying the ultramafic protolith. Diffuse and intergradational domains rich in chlorite, quartz or talc occur, with all having disseminated to locally semi-massive bladed texture hematite, as well as sulphides, of which pyrite is dominant. It is paragenetically earlier than commonly associated chalcopyrite, which also shows slight marginal replacement by digenite (maybe an incipient deep supergene effect). A single grain of electrum is observed in chalcopyrite. Alteration and mineralisation of the protolith took place under relatively oxidising conditions, with hydrothermal introduction of silica, S, Fe and Cu.

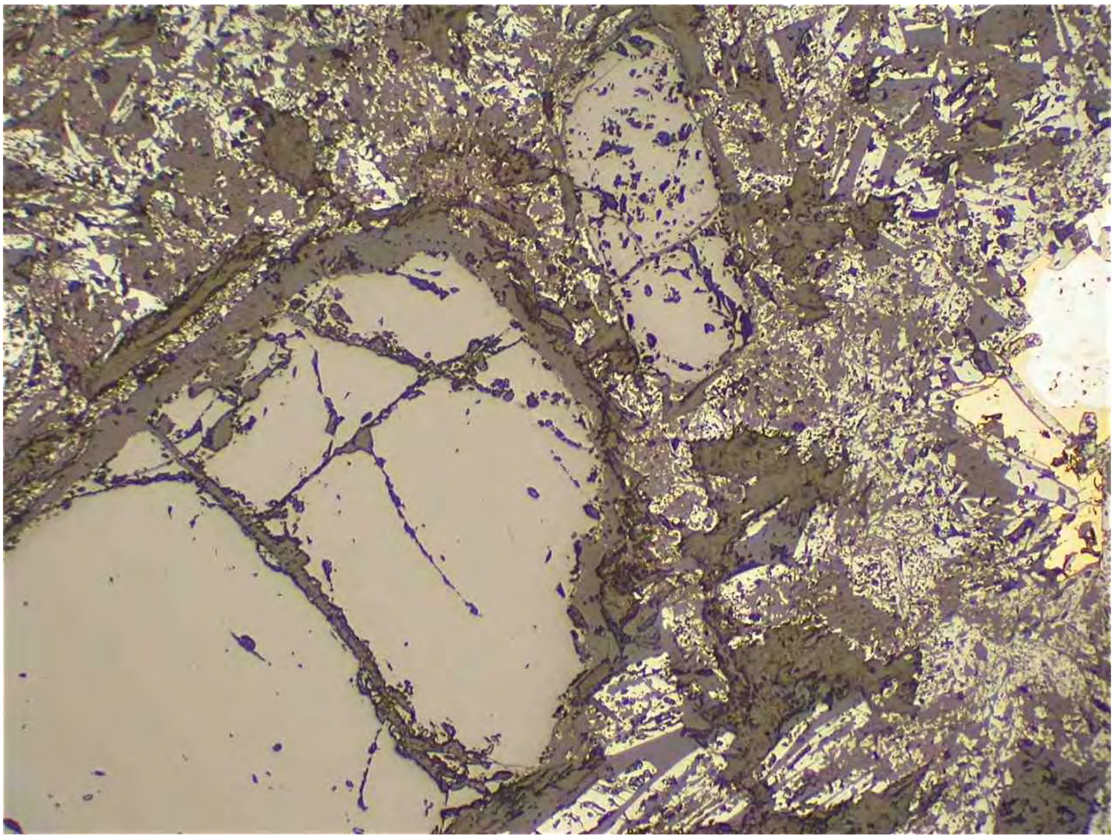

Fig. 29: Fractured relict chromite grains (pale grey) hosted in fine grained chlorite and small blady grains of hematite (paler grey than chromite). At right is a small composite of chalcopyrite and pyrite. Plane polarised reflected light, field of view 1 mm across.

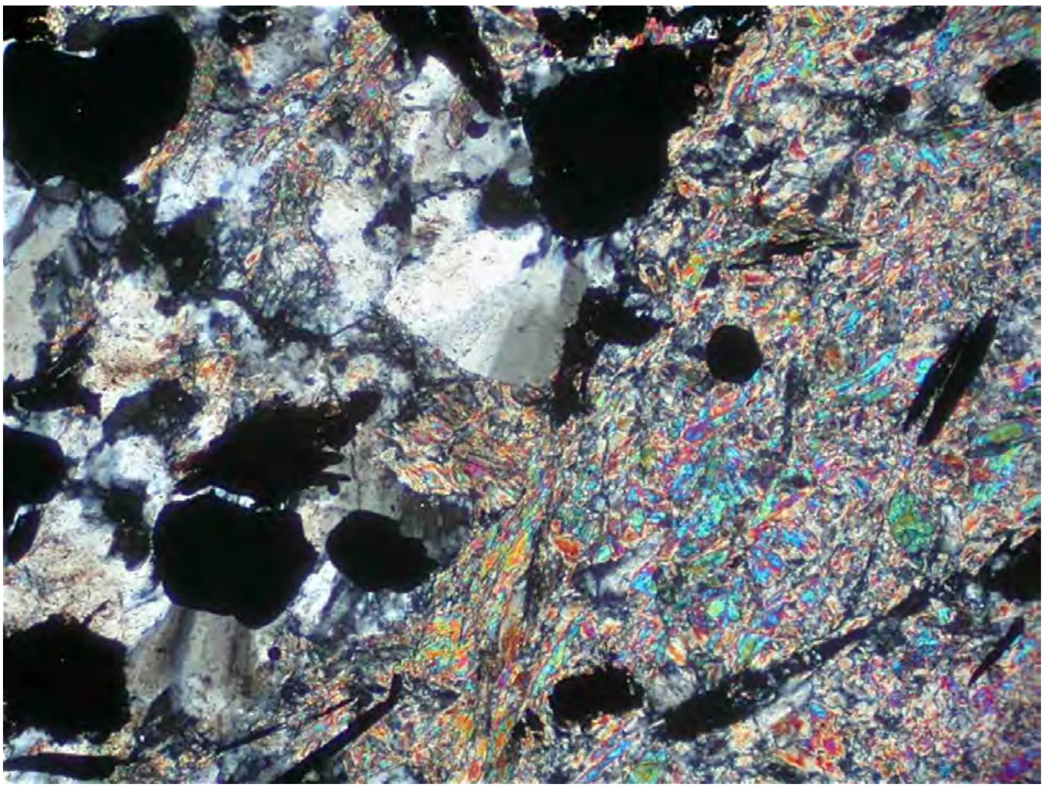

Fig. 30: Talc-rich domain (right) containing a few bladed hematite grains (black) and bordering on to a quartz-rich domain (left) hosting grains of sulphides (black). Transmitted light, crossed polarisers, field of view 2 mm across.

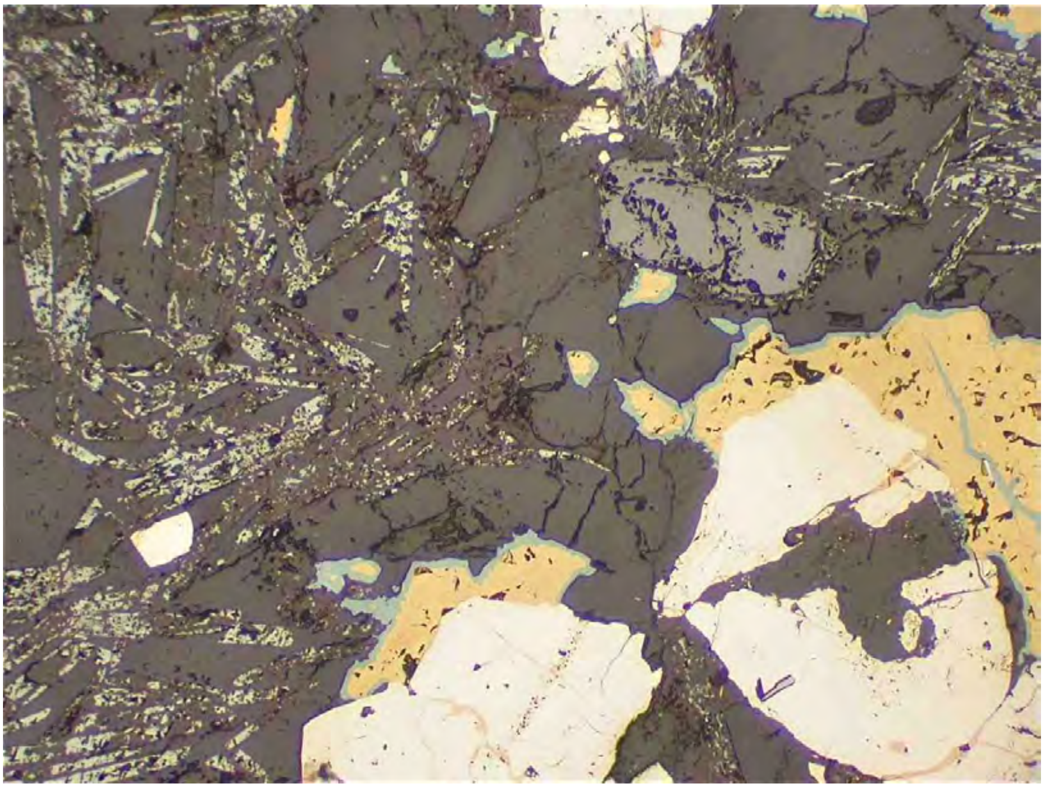

Fig. 31: Composite aggregate of pyrite (pale creamy) and paragenetically later chalcopyrite (yellow) in quartz and chlorite (dark grey), hosting scattered small bladed hematite grains (pale grey). Chalcopyrite shows slight rim replacement to bluish digenite. Note relict chromite grain above chalcopyrite. Plane polarised reflected light, field of view 1 mm across.

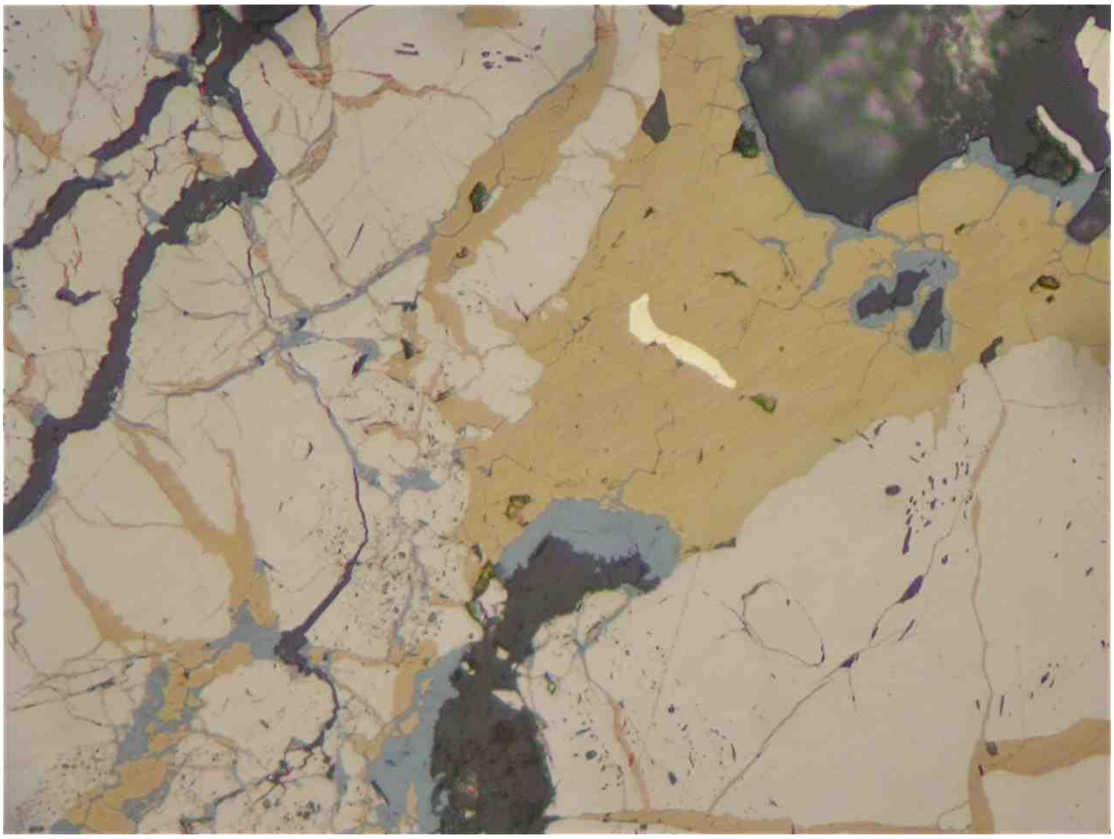

Fig. 32: Elongate electrum grain (creamy white) hosted in chalcopyrite that shows minor replacement by bluish digenite. Chalcopyrite is paragenetically later than associated fractured pyrite (pale creamy). Plane polarised reflected light, field of view 0.25 mm across.

STRC005D 162.5 m TS

Summary: Strongly altered fine grained porphyritic mafic igneous rock, most likely an olivine basalt originally. Relict texture is moderately preserved and indicates that the rock had rather sparsely scattered phenocrysts of olivine (in places with tiny FeCr spinel inclusions) and possible microphenocrysts of plagioclase in a fine grained, felted texture groundmass, evidently rich in small plagioclase laths and with likely interstitial ferromagnesian material and a little FeTi oxide. The rock experienced low grade alteration and was replaced by abundant fine grained chlorite, subordinate amounts of a clay phase (perhaps smectite), quartz, a little leucoxene and trace pyrite. A few small amygdules occur, filled by quartz ± chlorite.

Handspecimen: The drill core sample is composed of a massive, fine grained khaki-grey altered igneous rock, perhaps of mafic composition. Small darker grey-green chlorite aggregates occur, maybe reflecting sites of former ferromagnesian phenocrysts up to 1 mm across (Fig. 33). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 33: Drill core sample of altered fine grained basaltic rock. Small darker aggregates are chlorite-rich and have replaced former olivine grains. The remainder of the rock has a chlorite-clay-quartz alteration assemblage.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately preserved, but the rock is strongly altered and almost all igneous minerals are replaced (Fig. 34). The rock contains pseudomorphic aggregates up to 1.5 mm across after a former ferromagnesian phase, with the relict shapes and presence of preserved tiny inclusions of FeCr spinel (up to 50 μm) implying that the phenocrysts were originally olivine (Fig. 34). It is possible that the rock also contained sparse tabular microphenocrysts of feldspar (e.g. plagioclase) and a few small amygdules (up to 0.6 mm across). These components were set in a fine grained groundmass with a felted, locally sub-trachytic relict texture (Fig. 34). The groundmass is interpreted to have contained abundant small plagioclase laths, with interstitial ferromagnesian material and/or glass, and a little finely disseminated FeTi oxide. From the preserved primary characteristics, the original rock is interpreted as a porphyritic olivine basalt and this conforms to the fact that the sample interval has relatively high Cr and Ni assay values.

b) Alteration and structure: Strong pervasive low grade alteration was imposed. Former phenocrysts were replaced by fine grained chlorite, near-colourless clay (maybe a smectite phase) and minor quartz and trace pyrite, with the groundmass being replaced alos by chlorite, clay, minor quartz and finely dispersed leucoxene (Fig. 34). Amygdules are filled by finely granular quartz and local chlorite. The alteration assemblage is of propylitic-argillic type and could be the result of very low grade metamorphism, but evidently with considerable transfer of primary components, e.g. loss of Ca and Na.

c) Mineralisation: At former olivine phenocrystal sites, there are uncommon tiny grains of relict FeCr spinel (Fig. 34). A trace of fine grained pyrite has formed at some phenocryst sites as part of the alteration.

Mineral Mode (by volume): chlorite 60%, clay 25%, quartz 14%, leucoxene 1% and traces of FeCr spinel and pyrite.

Interpretation and comment: It is interpreted that the sample is a former porphyritic olivine basalt that has experienced strong pervasive alteration of propylitic-argillic type. Relict texture is moderately preserved and indicates that the rock had scattered phenocrysts of olivine (containing tiny FeCr spinel inclusions) and possible microphenocrysts of plagioclase in a fine grained, felted texture groundmass, evidently rich in small plagioclase laths and with likely interstitial ferromagnesian material and a little FeTi oxide. Imposed alteration caused formation of abundant fine grained chlorite, subordinate amounts of a clay phase (perhaps smectite), quartz, a little leucoxene and trace pyrite. A few small amygdules occur, filled by quartz ± chlorite.

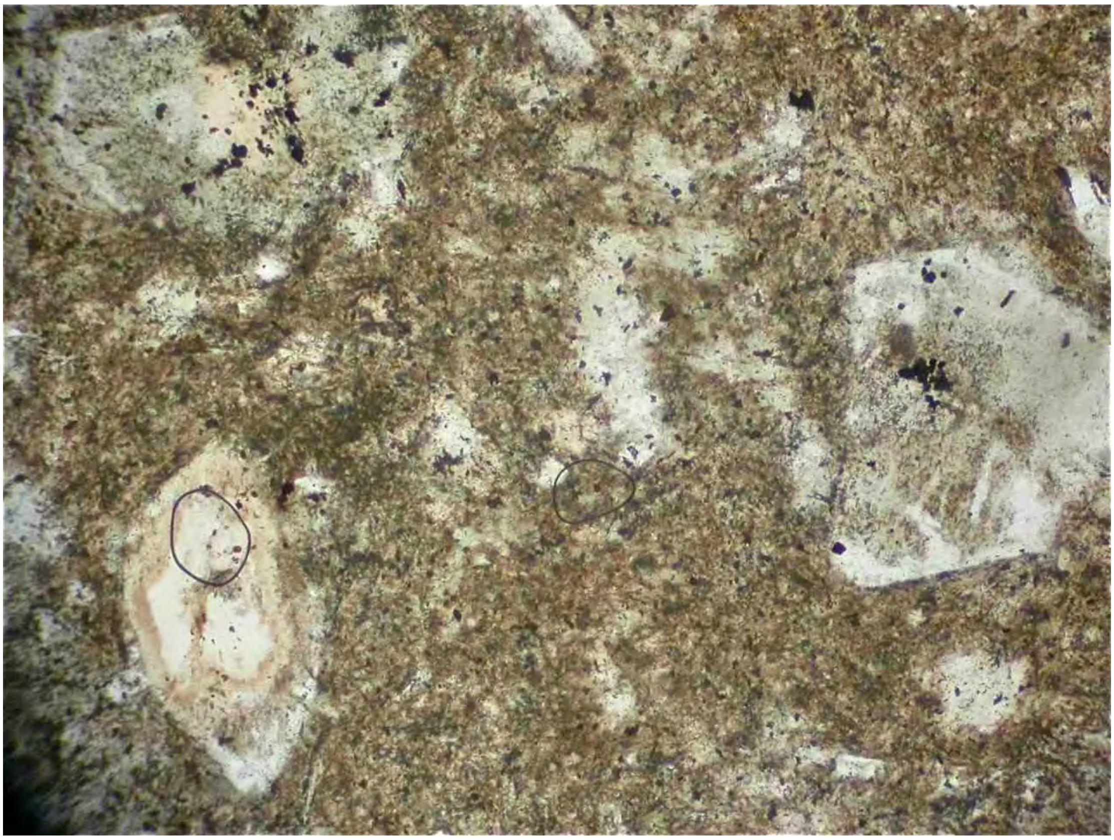

Fig. 34: Relict porphyritic texture in altered basalt, showing pseudomorphs after former olivine grains (with tiny black inclusions of FeCr spinel) and a fine grained groundmass. The alteration

assemblage is dominated by chlorite and subordinate clay, with minor quartz. Plane polarised transmitted light, field of view 2 mm across.

STRC005D 168.0 m PTS

Summary: Strongly altered breccia containing angular to sub-rounded fragments and exhibiting a matrix- to clast-supported texture. Fragments included former fine grained sedimentary types (e.g. siltstone, cherty argillite), fine grained, possibly porphyritic mafic rock (e.g. basaltic) and disaggregated vein quartz material. These occur in a matrix of smaller fragments (mostly quartz) that has been strongly replaced, along with lithic fragments, by a hydrothermal assemblage dominated by fine grained chlorite and quartz, and with disseminated grains and irregular aggregates of pyrite and subordinate chalcopyrite. Traces of rutile have also formed in altered mafic rock and siltstone. Sulphide aggregates are patchily abundant and range from medium to coarse pyrite, to composites of chalcopyrite and pyrite.

Handspecimen: The drill core sample is composed of a type of coarse, grey-green altered breccia, with the texture ranging from matrix- to clast-supported (Fig. 35). Fragments are up to several centimetres across and are angular to sub-rounded. Many are fine grained and could include sedimentary protoliths (e.g. siltstone), but there are also a few whitish fragments of coarse grained quartz and dark, chlorite-rich altered types (?mafic igneous). In zones where the texture is matrix-supported, there is infill by fine grained chlorite and quartz, plus patchily abundant sulphides, including aggregates rich in pyrite up to 2 cm across and less common chalcopyrite (Fig. 35). It is apparent that lithic fragments have chlorite alteration and that there is abundant chlorite in association with sulphide aggregates. The sample is very weakly magnetic, with susceptibility up to 30 x 10^{-5} SI.

Fig. 35: Drill core sample of strongly altered breccia containing angular to sub-rounded fragments of fine grained sedimentary rock (e.g. siltstone, cherty argillite), mafic rock (maybe basaltic) and quartz (disaggregated vein material). The breccia was overprinted by development of fine grained chlorite and quartz, with disseminated grains and larger aggregates of pyrite and subordinate chalcopyrite.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the sample is a matrix-supported breccia (Fig. 36). There are a couple of larger angular fragments (up to 3.5 cm across) of altered fine grained sedimentary protolith (e.g. siltstone) and smaller fragments (up to 1 cm) of fine grained quartz-rich sedimentary material (e.g. chert, cherty argillite) and altered mafic igneous rock (Fig. 36). The latter was probably fine grained and in places could have a relict sparsely porphyritic texture, but generally all original characteristics are destroyed. It is speculated that these fragments might have been of basaltic type. The rock also contains abundant angular to sub-rounded quartz fragments up to 5 mm across. Many of these are single grains, but others are composites of fine to medium grained quartz, commonly deformed. It is considered that the quartz fragments represent disaggregated former vein material. The nature of the breccia is speculative (on the scale of the section) and there are no diagnostic criteria to choose between it being of sedimentary type, or as a result of tectonic and/or hydrothermal processes.

b) Alteration and structure: Lithic fragments in the breccia are strongly altered and the breccia matrix is largely the product of imposed alteration (Fig. 36). Interpreted siltstone fragments were replaced by fine grained chlorite and quartz, with a little disseminated pyrite and trace rutile. Interpreted basaltic fragments were replaced by abundant chlorite, minor to abundant pyrite, local chalcopyrite and a trace of rutile. In the breccia matrix, abundant small quartz fragments are enclosed by fine grained quartz and/or chlorite, with disseminated to semi-massive sulphide aggregates typically associated with more chlorite-rich patches (Fig. 37). Most larger sulphide aggregates contain medium to coarse pyrite, but there are several smaller aggregates (up to 2.5 mm) with abundant chalcopyrite (Fig. 37).

c) Mineralisation: The sample contains patchily abundant sulphides, as part of the alteration and mostly replacing breccia matrix and altered mafic fragments, although there is a small amount of disseminated pyrite in altered siltstone fragments. Pyrite is the dominant sulphide, ranging from fine grained, to medium to coarse grained in larger aggregates (up to 1 cm across). Some smaller aggregates have considerable chalcopyrite (up to 2.5 mm across), typically forming composites with pyrite (Fig. 37). There is a close association between sulphide aggregates and strong chlorite development.

Mineral Mode (by volume): quartz 50%, chlorite 35%, pyrite 12%, chalcopyrite 3% and a trace of rutile.

Interpretation and comment: It is interpreted that the sample represents a strongly altered heterolithic breccia. It contains angular to sub-rounded fragments and has a matrix- to clast-supported texture. Fragments include altered siltstone, cherty argillite, porphyritic mafic rock (e.g. basaltic) and disaggregated vein quartz material. These occur in a matrix of smaller fragments (mostly quartz) that has been strongly replaced, along with lithic fragments, by a hydrothermal assemblage of chlorite and quartz, and disseminated grains and aggregates of pyrite and subordinate chalcopyrite. Traces of rutile have also formed in altered mafic rock and siltstone. Sulphide aggregates are patchily abundant and range from medium to coare pyrite, to composites of chalcopyrite and pyrite.

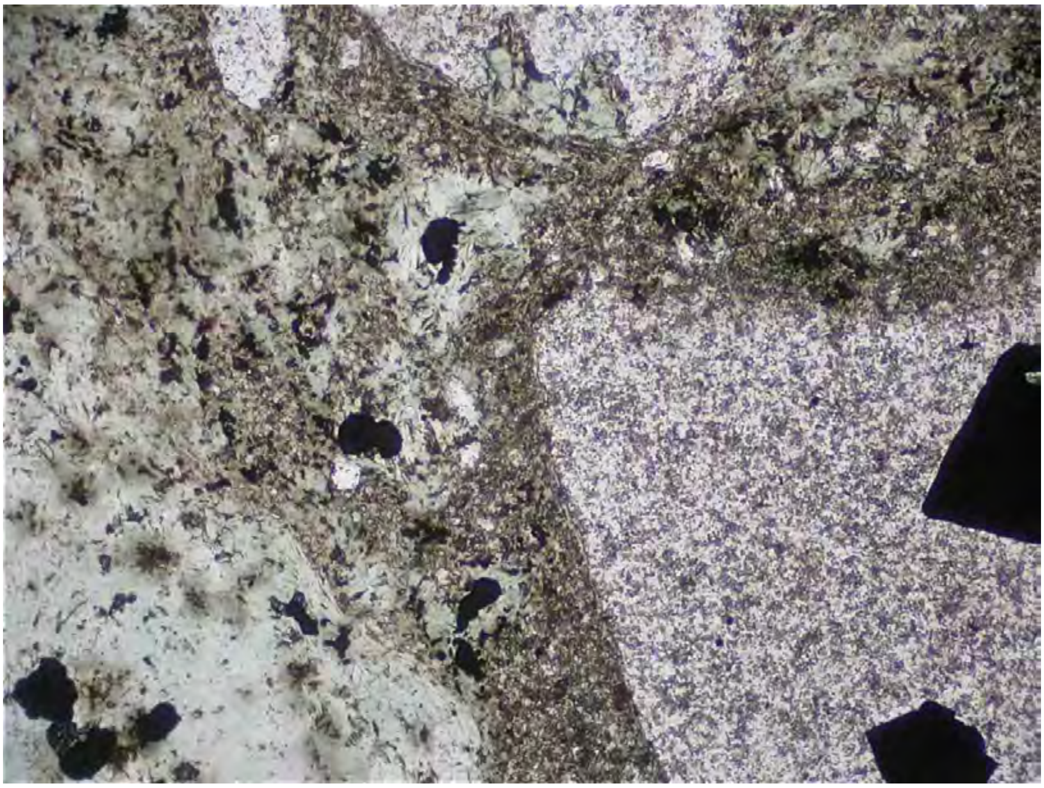

Fig. 36: Altered breccia containing fragments of cherty argillite (right), altered mafic rock (lower left) and a few small quartz grains. Alteration of the breccia matrix and fragments is to fine grained chlorite and quartz, with the black grains being pyrite. Plane polarised transmitted light, field of view 2 mm across.

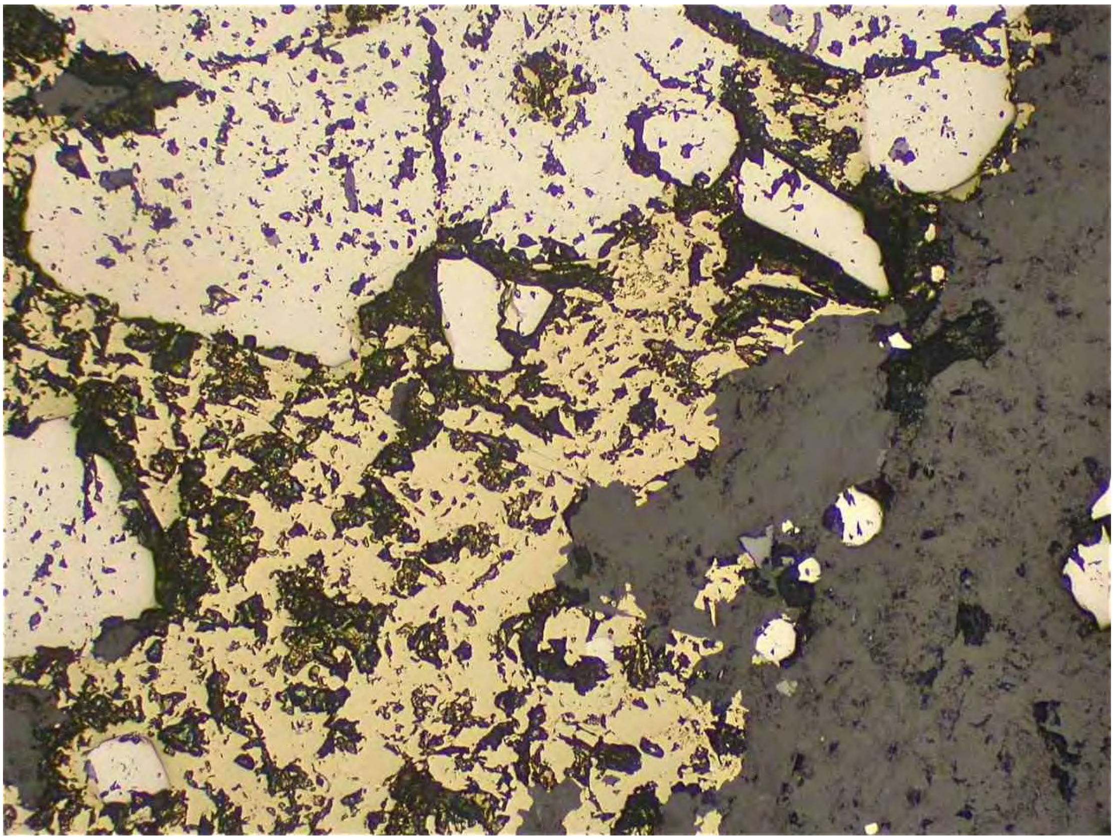

Fig. 37: Portion of a sulphide aggregate showing medium grained pyrite (pale creamy) and interstitial chalcopyrite (yellow), adjacent to chlorite-rich breccia matrix at right. Plane polarised reflected light, field of view 1 mm across.

STRC005D 175.3 m TS

Summary: Porphyritic dacite with strong pervasive propylitic alteration, but moderately well preserved relict texture. There are sparse relict quartz phenocrysts, but all former feldspar (probably plagioclase) and ferromagnesian (mostly hornblende) phenocrysts are altered, as is all of the former quartzofeldspathic groundmass. Feldspar phenocrysts were replaced by sericite and chlorite, with a little quartz and trace pyrite, and ferromagnesian phenocrysts were mostly replaced by chlorite, with a little sericite and leucoxene-rutile. Small amounts of igneous FeTi oxide and apatite were present, but the former is totally altered to leucoxene-rutile. Groundmass replacement is dominated by granular quartz, with subordinate sericite and minor chlorite.

Handspecimen: The drill core sample is composed of a strongly altered, pale grey-green igneous rock, with moderately well preserved relict porphyritic texture manifest as scattered dark grey-green altered phenocrysts that could include former feldspar and ferromagnesian phases (Fig. 38). Pseudomorphs after phenocrysts are blocky to elongate in shape and up to 7 mm across (Fig. 38). There are also uncommon relict white quartz phenocrysts up to 3 mm across, with the phenocrysts having been enclosed in a fine grained groundmass of probable quartzofeldspathic type (Fig. 38), but replaced by sericite, quartz and minor chlorite, with a trace of pyrite. Altered phenocrysts are represented by chlorite-rich aggregates (Fig. 38), with trace pyrite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 38: Drill core sample of altered porphyritic dacite, showing pseudomorphs after phenocrysts of feldspar (plagioclase) and ferromagnesian material, replaced by chlorite and sericite, in groundmass that is replaced by dominant quartz and sericite.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is moderately well preserved (Figs 39, 40). There are a few relict quartz phenocrysts up to 3.5 mm across (Fig. 39), but other silicate phenocryst types are all altered. Pseudomorphic shapes after former blocky feldspar grains (e.g. plagioclase) are up to 7 mm across and there are also abundant pseudomorphs after former ferromagnesian grains up to 4.5 mm long (Fig. 39). Relict shapes infer that most of the original ferromagnesian grains were hornblende (Figs 39, 40), but some smaller grains could have been biotite. The rock also contained a few microphenocrysts of FeTi oxide up to 0.8 mm (now altered) and blocky apatite up to 0.4 mm. Apatite and rare zircon are locally included at altered ferromagnesian and feldspar sites. The original groundmass was probably fine grained and of quartzofeldspathic composition, but is completely altered and recrystallised (Fig. 40). It is estimated to have comprised ~50% of the rock. The preserved primary characteristics suggest that the sample represents an altered porphyritic hornblende dacite.

b) Alteration and structure: The igneous rock was strongly hydrothermally altered and apart from quartz phenocrysts and traces of apatite and zircon, all other phases were replaced. Feldspar phenocrysts were replaced by fine grained sericite, commonly accompanied by very pale green to colourless chlorite, a little quartz and trace pyrite (Figs 39, 40). Ferromagnesian material was replaced by chlorite (Figs 39, 40), with local seriite and trace leucoxene-rutile, and igneous FeTi oxide was replaced by leucoxene-rutile. In the groundmass, there was replacement by abundant granular quartz (up to 0.3 mm), subordinate sericite, minor chlorite and trace leucoxene-rutile. The alteration assemblage is consistent with propylitic type.

c) Mineralisation: Sparse grains of pyrite up to 0.7 mm across have formed as part of the alteration and are mostly observed at altered feldspar phenocryst sites.

<u>Mineral Mode (by volume)</u>: quartz 45%, sericite 35%, chlorite 19% and traces of pyrite, leucoxene-rutile, apatite and zircon.

<u>Interpretation and comment</u>: It is interpreted that the sample is a strongly propylitically altered porphyritic dacite. It has moderately well preserved relict texture and contains sparse relict quartz phenocrysts, but all former feldspar (probably plagioclase) and ferromagnesian (mostly hornblende) phenocrysts are altered, as is all of the former quartzofeldspathic groundmass. Feldspar phenocrysts were replaced by sericite and chlorite, with a little quartz and trace pyrite, and ferromagnesian phenocrysts were replaced by chlorite, with a little sericite and leucoxene-rutile. Small amounts of igneous FeTi oxide and apatite were present, but the former is totally altered to leucoxene-rutile. Groundmass replacement is dominated by granular quartz, with subordinate sericite and minor chlorite.

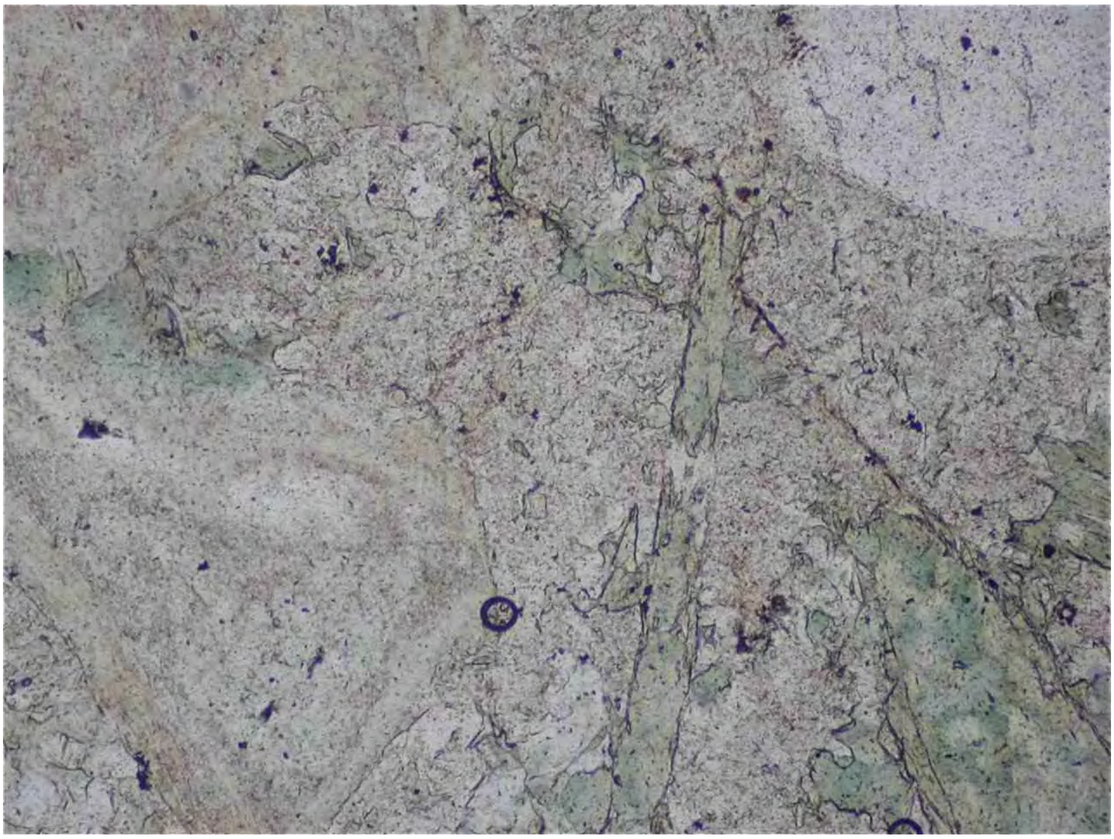

Fig. 39: Altered porphyritic dacite showing a relict quartz phenocryst (upper right), part of an altered feldspar phenocryst (left, replaced by sericite and very pale green chlorite) and prismatic hornblende grains replaced by pale green chlorite. The pale grey groundmass is dominated by quartz and sericite. Plane polarised transmitted light, field of view 2 mm across.

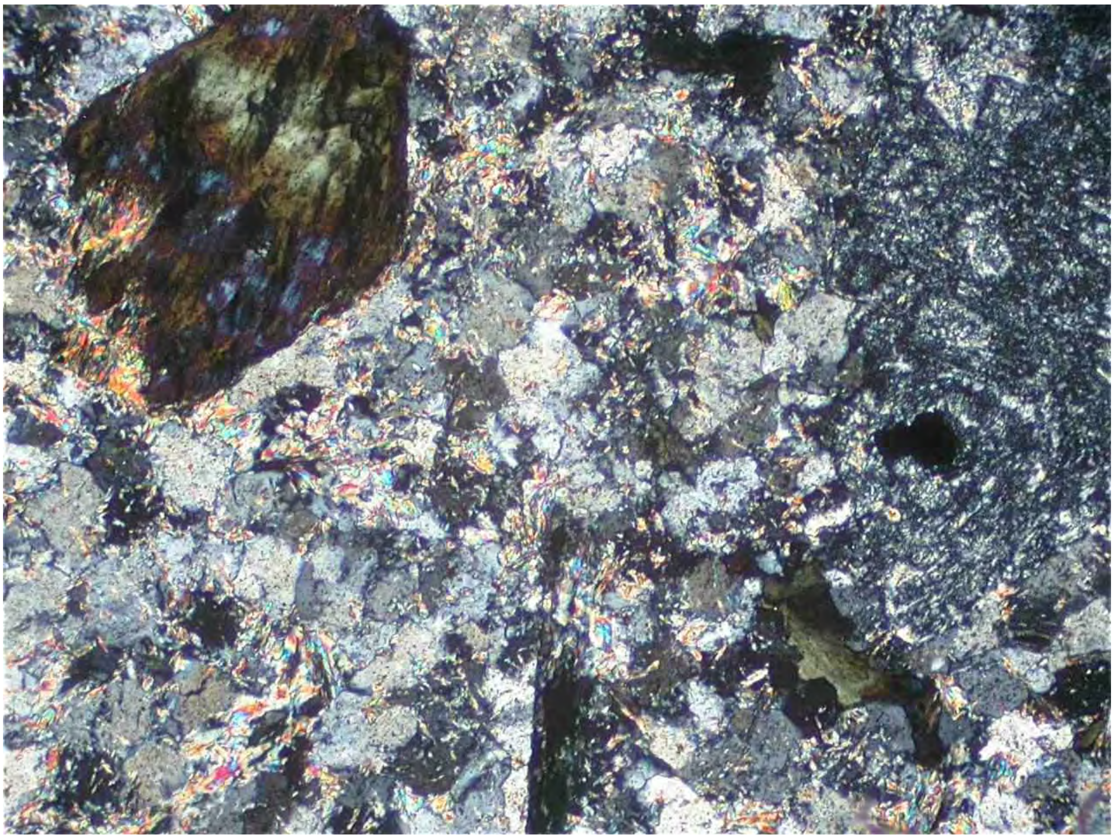

Fig. 40: Replacement of the groundmass by granular quartz and minor sericite. Note altered feldspar phenocryst at right and a chlorite pseudomorph after a former hornblende grain at upper left. Transmitted light, crossed polarisers, field of view 2 mm across.

<u>STRC007D 101.15 m TS</u>

Summary: Porphyritic hornblende-quartz microdiorite, with pervasive moderate to strong propylitic alteration. Relict texture is moderately well preserved, indicating that the rock had a crowded porphyritic texture with abundant plagioclase phenocrysts and less common ferromagnesian phenocrysts (probably hornblende) enclosed in a groundmass component of fine to medium grained plagioclase and subordinate quartz, with a little ferromagnesian material and FeTi oxide. Alteration led to partial albitisation of plagioclase and development of considerable chlorite, minor epidote, sericite, carbonate and leucoxene-rutile. A prominent vein cuts the rock, containing carbonate (ankerite) and bordering epidote.

Handspecimen: The drill core sample is composed of a porphyritic, medium grained igneous rock of possible intermediate to felsic composition, and showing pervasive alteration. It has a speckled appearance, with coour ranging from pale creamy, pale green, darker grey-green and yellow-green. It evidently contains considerable feldspar, with lesser ferromagnesian material. There are a few feldspar phenocrysts (maybe plagioclase) up to 4 mm across (Fig. 41). The rock appears to have development of chlorite and minor epidote, and is cut by a single sub-planar vein up to 2 mm wide at a low angle to the core axis (Fig. 41). The vein contains pale brown carbonate and epidote. Testing of the section offcut with dilute HCl did not give any reaction on carbonate, suggesting that it could be ankerite. The sample is strongly magnetic, with susceptibility up to 1630 x 10^{-5} SI, indicating that there is a little disseminated magnetite.

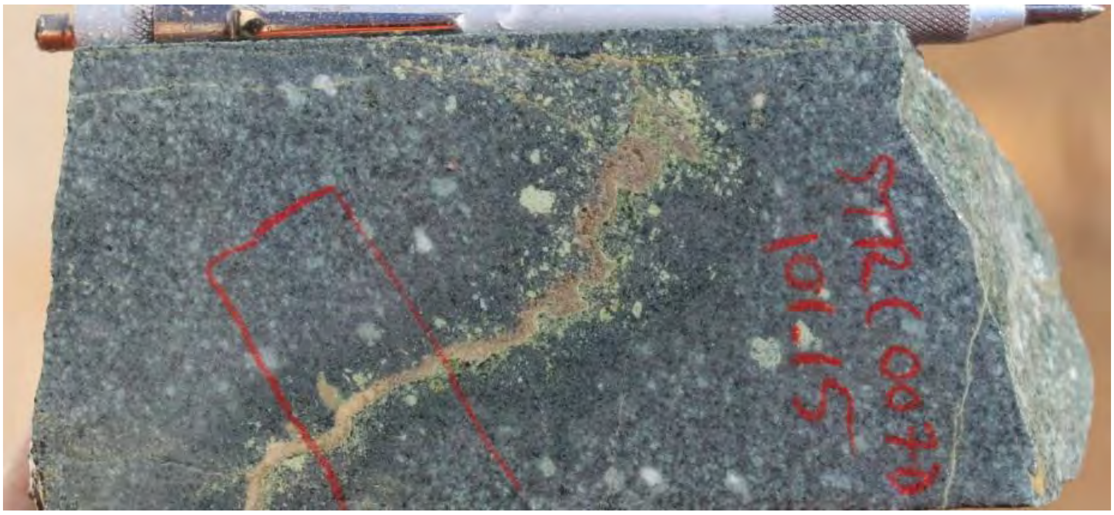

Fig. 41: Drill core sample of altered porphyritic microdiorite showing a few larger plagioclase phenocrysts and pervasive alteration to grey-green chlorite. The vein cutting the sample contains pale brown carbonate (ankerite) and fringing epidote.

Petrographic description

a) Primary rock characteristics: In the section, relict crowded porphyritic texture is moderately well preserved (Fig. 42). There are abundant blocky plagioclase phenocrysts up to 4 mm across, although most are <2 mm, with these being variably altered (Fig. 42). Plagioclase is accompanied by less common pseudomorphs after a former prismatic ferromagnesian phase (e.g. hornblende) up to 1.5 mm long (Fig. 42). The phenocrysts occurred in a fine to medium grained, inequigranular texture groundmass containing abundant plagioclase and subordinate intergrown quartz (grains up to 0.8 mm), with minor altered ferromagnesian material and a little disseminated FeTi oxide (e.g. titanomagnetite) (Fig. 42). From the relict characteristics, the rock is interpreted as an altered porphyritic hornblende microdiorite.

b) Alteration and structure: The igneous rock had moderate to strong and pervasive alteration effects imposed. Plagioclase is partly albitised and also finely flecked by chlorite, sericite, carbonate and a little epidote (Fig. 42). Adjacent to a major vein, plagioclase is more strongly replaced by epidote or carbonate. All ferromagnesian material was replaced by chlorite, with a little carbonate and leucoxene-rutile, and igneous FeTi oxide is partly replaced by leucoxene-rutile. The altered rock is cut by a single thin, sub-planar carbonate vein and also by a sub-parallel, major vein, up to 3 mm wide, containing fine to medium grained carbonate (ankerite) and bordering epidote. The alteration assemblage in the rock is consistent with propylitic type.

c) Mineralisation: No sulphides are observed. The rock retains a little finely disseminated igneous FeTi oxide (titanomagnetite) in grains that are <0.1 mm.

Mineral Mode (by volume): plagioclase (includes albite) 70%, chlorite 11%, quartz 7%, carbonate 6%, epidote 3%, sericite, FeTi oxide and leucoxene-rutile each 1%.

Interpretation and comment: It is interpreted that the sample represents a strongly porphyritic hornblende-quartz microdiorite, showing moderate to strong alteration of propylitic type. Relict texture is moderately well preserved, and it is apparent that the rock contained abundant plagioclase phenocrysts and less common ferromagnesian phenocrysts (probably hornblende) enclosed in a groundmass of fine to medium grained plagioclase and subordinate quartz, with a little ferromagnesian material and FeTi oxide. Alteration caused partial albitisation of plagioclase and development of considerable chlorite, minor epidote, sericite, carbonate and leucoxene-rutile. A prominent vein cuts the rock, containing carbonate (ankerite) and bordering epidote.

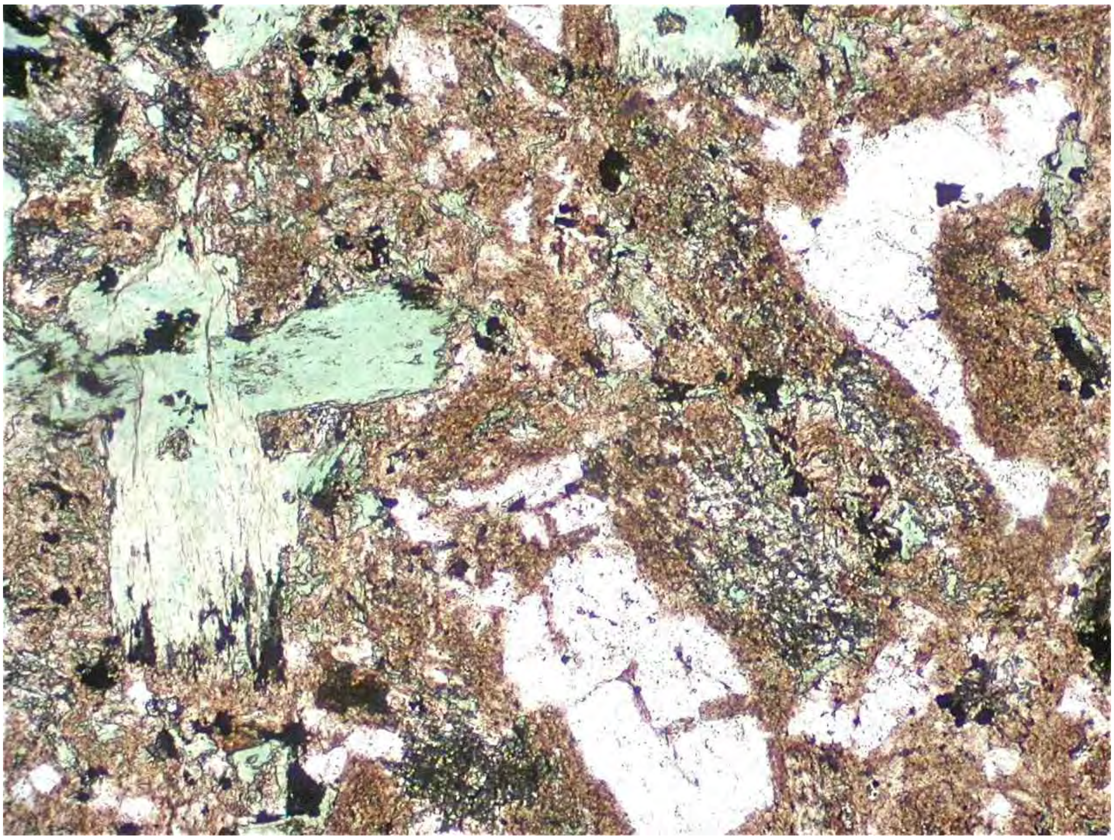

Fig. 42: Blocky plagioclase phenocryst (near centre), replaced by turbid albite (pale brown), chlorite and epidote, with nearby chloritised hornblende grains (left) in a groundmass of

quartz (clear) and turbid altered plagioclase. Small black grains include titanomagnetite and leucoxene-rutile. Plane polarised transmitted light, field of view 2 mm across.

STRC007D 125.1 m TS

Summary: Strongly porphyritic hornblende microdiorite with poor to moderate preservation of primary texture and strongly overprinting alteration of largely propylitic type. The original rock contained rather abundant phenocrysts of plagioclase and ferromagnesian material (probably hornblende), set in a fine to medium grained groundmass that was feldspathic (again probably plagioclase) with minor ferromagnesian material, and a little quartz and FeTi oxide. A pervasive alteration assemblage of sericite, chlorite, locally common albite, minor quartz and leucoxene-rutile, plus a trace of pyrite developed, but there is a more altered zone with a greater proportion of chlorite and little/no remnant feldspar, with this bordering on to a local narrow zone with strong sericite alteration.

Handspecimen: The drill core sample is mostly composed of a pale creamy-grey speckled porphyritic intermediate to felsic igneous rock. It has sparse altered feldspar phenocrysts up to a few millimetres across and abundant, smaller dark green-grey ferromagnesian phenocrysts (e.g. former hornblende) in a finer grained feldspathic groundmass (Fig. 43). A zone of grey-green chlorite alteration cuts across the rock at ~30° to the core axis, with primary texture being partly obliterated in this zone due to development of abundant chlorite (Fig. 43). The chloritic zone appears to border on to a narrow ?sheared band with pale brown-cream sericite alteration (Fig. 43). A trace of fine grained pyrite occurs as part of the pervasive alteration. The sample is very weakly magnetic, with susceptibility up to 30 x 10^{-5} SI.

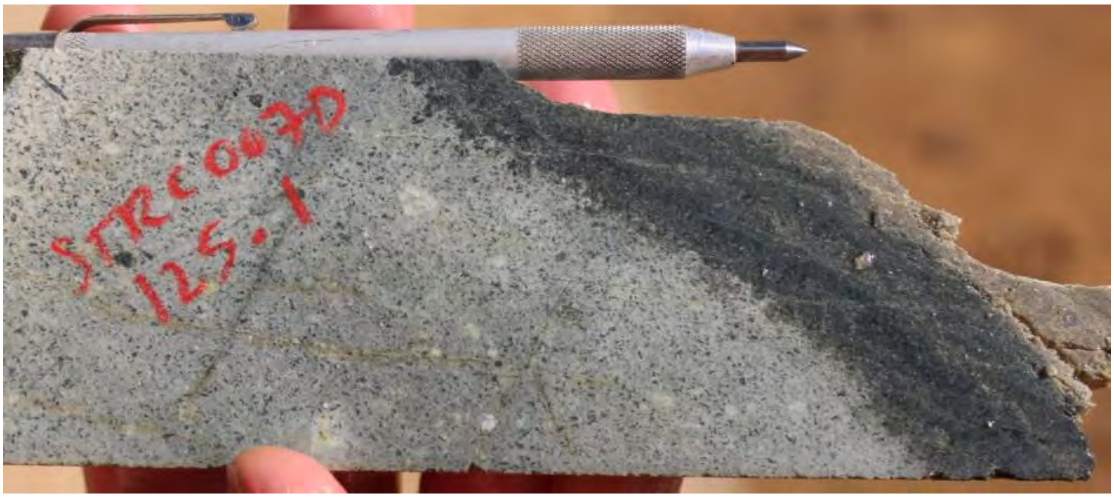

Fig. 43: Drill core sample showing pale coloured domain of sericite (-chlorite)-altered porphyritic microdiorite, with this grading sharply into a more strongly chlorite-altered zone at right. The thin pale brown mass at far right is a strongly sericite-altered zone.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is poorly to moderately preserved (Fig. 44). It is evident that the original rock contained abundant blocky feldspar (probably plagioclase) phenocrysts up to 2.5 mm across, as well as ferromagnesian phenocrysts up to 3 mm long (Fig. 44). Pseudomorphs after the latter are commonly prismatic in form, implying that the original mineral was hornblende. The phenocrystal phases occurred in a fine to medium grained, inequigranular groundmass with abundant feldspar (probably plagioclase), with minor ferromagnesian material, interstitial quartz and a little FeTi oxide. From the preserved primary characteristics, the original rock is interpreted as a porphyritic hornblende microdiorite.

b) Alteration and structure: The original igneous rock experienced strong pervasive hydrothermal alteration, with one part being apparently more affected than the remainder. Much of the original feldspar was replaced, along with all original ferromagnesian material and interpreted FeTi oxide. In the part of the sample that appears to be less altered (the paler creamy-grey domain in handspecimen), there is some preservation of relict plagioclase (but maybe partly albitised), although much is replaced by fine grained sericite and minor chlorite and quartz. In the more altered zone (the darker grey-green domain in handspecimen), all original feldspar appears to be altered to sericite and chlorite and minor quartz (Fig. 44). Throughout the sample, ferromagnesian material is replaced by chlorite (Fig. 44), with a little leucoxene-rutile, local quartz and trace pyrite. FeTi oxide was replaced by leucoxene-rutile and in the groundmass, minor fine to medium grained quartz has developed throughout, along with sericite, chlorite, a little leucoxene-rutile and trace pyrite. The slightly less altered domain grades into the more altered domain with development of more chlorite and disappearance of any remnant feldspar. The more strongly chloritised zone is bordered by a narrow rind up to 1 mm wide with strong sericite alteration. Overall, alteration is interpreted to be largely of propylitic type and there is no evidence for the prior existence of an earlier phase of epidote-magnetite alteration.

c) Mineralisation: A trace of sparsely disseminated pyrite occurs as part of the pervasive alteration. Most aggregates are <0.2 mm across, but there is a single pyrite aggregate ~1 mm across.

Mineral Mode (by volume): sericite 45%, chlorite 30%, plagioclase (including albite) 13%, quartz 10%, leucoxene-rutile 2% and a trace of pyrite.

Interpretation and comment: It is interpreted that the sample represents a strongly hydrothermally altered, porphyritic hornblende microdiorite. It has poor to moderate preservation of primary texture but it can be ascertained that there were phenocrysts of plagioclase and ferromagnesian material (probably hornblende), set in a fine to medium grained groundmass that was feldspathic, with minor ferromagnesian material, and a little quartz and FeTi oxide. Alteration of strong propylitic type was imposed, forming sericite, chlorite, locally common albite, minor quartz and leucoxene-rutile, plus a trace of pyrite. , There is also a more altered zone with a greater proportion of chlorite and little/no remnant feldspar, with this bordering on to a local narrow zone with strong sericite alteration.

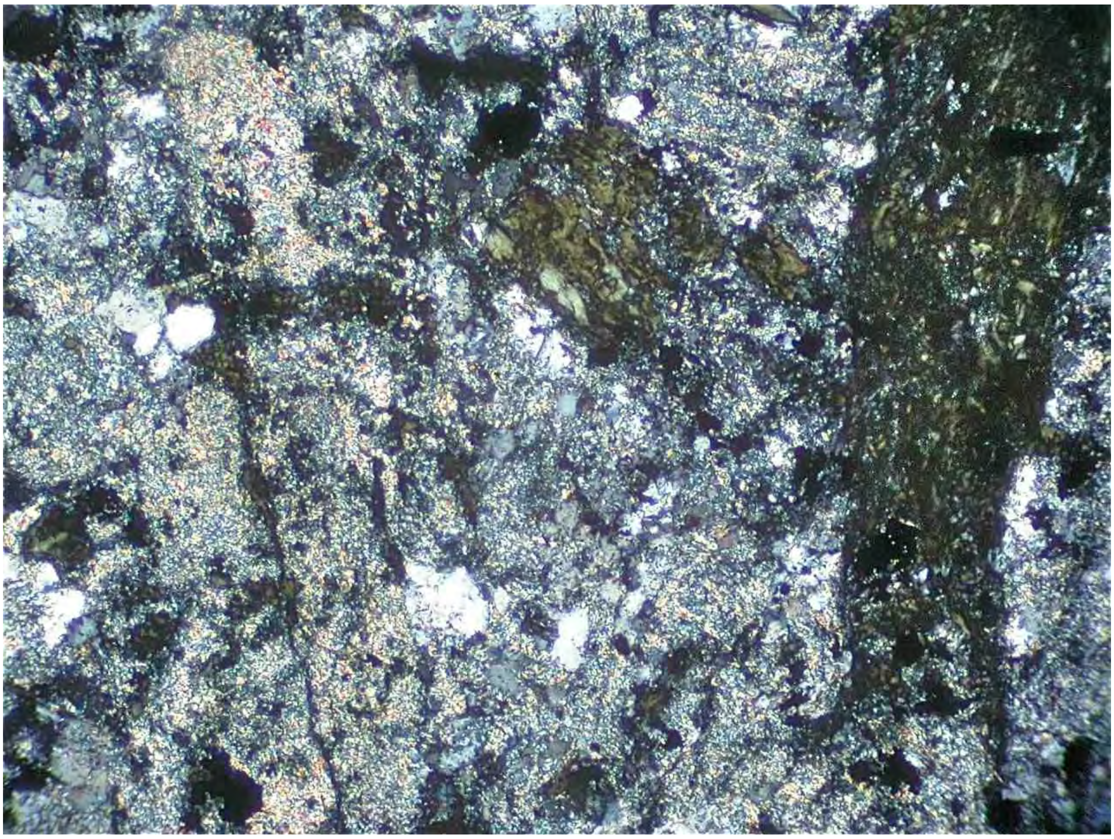

Fig. 44: Relict porphyritic texture in strongly altered microdiorite, showing a couple of chlorite-altered prismatic hornblende phenocrysts (dark khaki) and at left a sericite-dominated pseudomorph after a former blocky plagioclase phenocryst. Note minor quartz in altered groundmass. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC007D 132.5 m TS

Summary: Porphyritic hornblende dacite with strong pervasive argillic alteration. The rock has well preserved relict texture, but all former feldspar phenocrysts (e.g. plagioclase), ferromagnesian phenocrysts (hornblende and possible minor biotite) and FeTi oxide grains are altered, although uncommon quartz phenocrysts are retained. The phenocrystal grains occurred in a fine grained quartzofeldspathic groundmass. The alteration assemblage is fine grained with abundant sericite, clay (e.g. kaolinite) and chlorite, and finely granular quartz in the groundmass. Ferromagnesian phenocrysts are chloritised and feldspar phenocrysts altered to sericite, with minor clay and chlorite. There is strong clay development in the groundmass. A little leucoxene-rutile has formed as part of the alteration, along with traces of pyrite and chalcopyrite. A couple of thin clay-rich veins cut the altered rock.

Handspecimen: The drill core sample is composed of a strongly altered, strongly porphyritic felsic igneous rock, with rather abundantly scattered phenocrysts in a fine grained groundmass (Fig. 45). Phenocrysts include a few relict quartz grains up to 2 mm across and more common altered pale creamy-brown feldspar up to 6 mm across (probably plagioclase originally) and dark grey-green altered prismatic ferromagnesian material up to 4 mm long (probably hornblende) (Fig. 45). Feldspar phenocrysts are altered to sericite and/or clay, and ferromagnesian phenocrysts to chlorite. The pale creamy-grey groundmass could have been of quartzofeldspathic composition and has strong replacement by clay and quartz. A trace of fine grained pyrite occurs as part of the pervasive alteration. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI. Testing of the section offcut with sodium cobaltinitrite did not reveal the presence of K-feldspar.

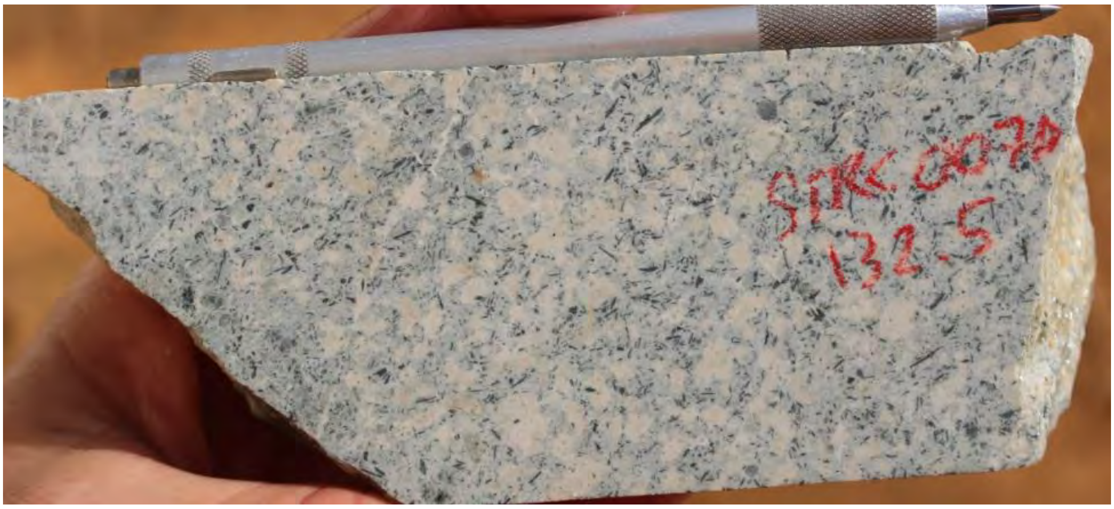

Fig. 45: Drill core sample showing strongly and pervasively altered porphyritic hornblende dacite. Former plagioclase phenocrysts (pale creamy) are mostly altered to sericite and prismatic hornblende phenocrysts to chlorite. The fine grained groundmass has considerable replacement by clay and quartz.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is well preserved. There are a few relict quartz phenocrysts up to 2.5 mm across, but more abundant, former phenocrysts of feldspar (probably plagioclase) and ferromagnesian material are entirely altered (Fig. 46). Feldspar phenocrysts were blocky and up to 5 mm across and ferromagnesian phenocrysts were mostly prismatic, up to 4 mm long and from relict shapes, were probably mostly hornblende (Fig. 46). It is likely, however, that there were also a few smaller biotite phenocrysts. The rock also contained a few microphenocrysts of FeTi oxide up to 0.7 mm across. Phenocrystal phases occurred in a fine grained (typically <0.1 mm) quartzofeldspathic composition groundmass, e.g. with abundant alkali feldspar and quartz, and minor ferromagnesian material and trace FeTi oxide and apatite. From the preserved primary characteristics, the original rock is interpreted as a porphyritic hornblende dacite.

b) Alteration and structure: Strong pervasive hydrothermal alteration was imposed on the igneous rock and all primary minerals except quartz and rare apatite were replaced. Feldspar phenocrysts were altered to fine grained sericite, commonly with minor low-birefringent clay (e.g. kaolinite) and chlorite, and all ferromagnesian material was replaced by chlorite, with traces of leucoxene-rutile, pyrite and chalcopyrite (Fig. 46). Igneous FeTi oxide was replaced by leucoxene-rutile and in the groundmass, there was total replacement by finely granular quartz, abundant interstitial clay and a little chlorite, sericite, leucoxene-rutile and rare pyrite (Fig. 46). The altered rock is cut by a couple of thin (<0.3 mm) sub-planar veins of fine grained clay ± sericite ± quartz. The observed alteration assemblage in the sample is consistent with argillic type.

c) Mineralisation: As part of the alteration assemblage, there are sparse aggregates of pyrite and chalcopyrite, generally <0.3 mm across, associated with altered ferromagnesian and FeTi oxide sites, and in the groundmass. One ferromagnesian phenocryst site has a couple of aggregates of chalcopyrite and pyrite up to 1 mm across enclosed in chlorite.

Mineral Mode (by volume): sericite 35%, quartz and clay (e.g. kaolinite) each 25%, chlorite 13%, leucoxene-rutile 1% and traces of apatite, chalcopyrite and pyrite.

Interpretation and comment: It is interpreted that the sample is a strongly argillically altered porphyritic hornblende dacite. Relict texture is well preserved despite alteration. There are a few relict quartz phenocrysts, but all former feldspar phenocrysts (e.g. plagioclase) were replaced by sericite, clay (kaolinite) and chlorite, and ferromagnesian phenocrysts (hornblende and possible minor biotite) by chlorite. Igneous FeTi oxide grains were replaced by leucoxene-rutile. The phenocrystal grains occurred in a fine grained quartzofeldspathic groundmass. There is strong clay-quartz development in the groundmass. Traces of pyrite and chalcopyrite are found as part of the alteration assemblage and a couple of thin clay-rich veins cut the altered rock.

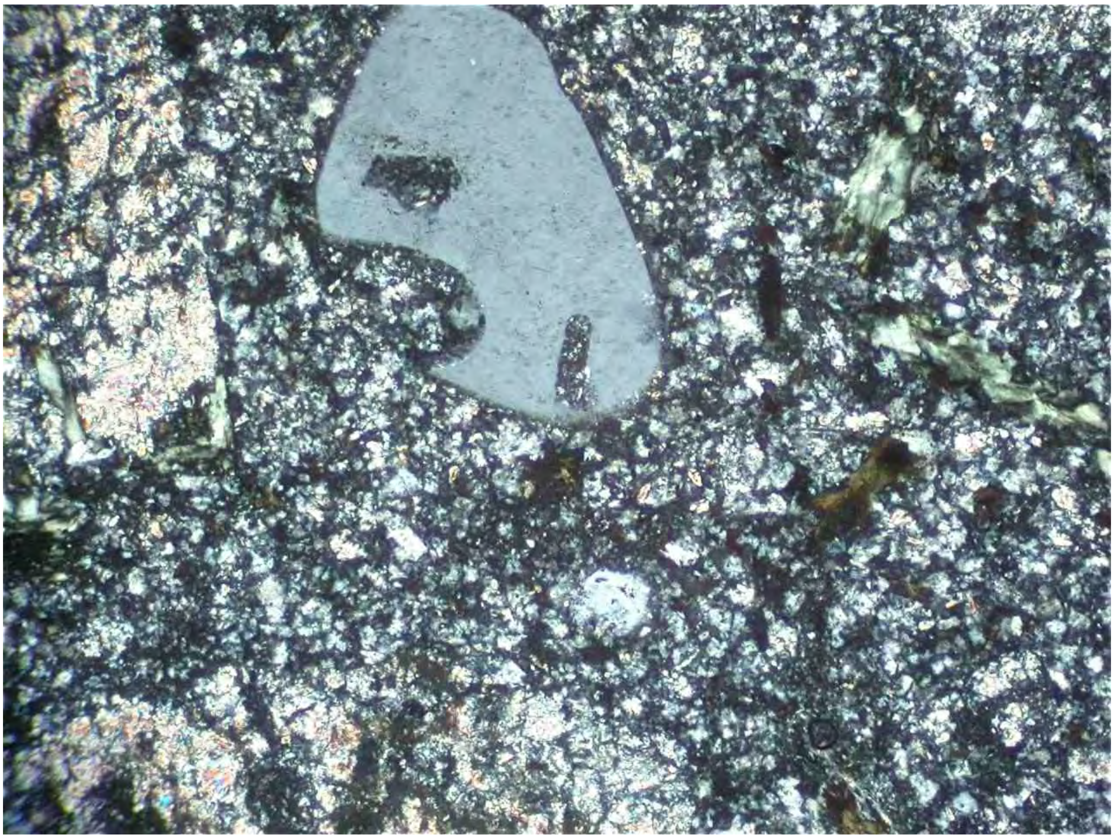

Fig. 46: Relict porphyritic texture in strongly altered dacite, showing a relict quartz phenocryst (upper), a couple of sericitised feldspar phenocrysts (left) and small, chloritised hornblende grains (right) in a finely granular quartz-clay altered groundmass. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC007D 168.8 m TS

Summary: Strongly porphyritic hornblende-quartz microdiorite, displaying moderate preservation of relict texture, but with a strong pervasive overprint of propylitic alteration. The rock formerly contained abundant plagioclase phenocrysts and less common phenocrysts of a ferromagnesian phase (probably hornblende) in a fine to medium grained groundmass of feldspar, with minor quartz and ferromagnesian material, and a little disseminated FeTi oxide. The imposed alteration assemblage is dominated by fine grained sericite and chlorite, with significant fine grained quartz being developed in the groundmass. A little leucoxene-rutile occurs throughout and in one small part of the sample, traces of pyrite, chalcopyrite and hematite occur, mainly at former ferromagnesian sites. The only observed variation between the different coloured alteration zones is that the pale zone contains less chlorite.

Handspecimen: The drill core sample is composed of a strongly altered, porphyritic intermediate to felsic igneous rock, with scattered phenocrysts up to 4 mm across in a fine to medium grained groundmass. The majority of the rock is grey-green in colour, but there is a relatively sharp change to a whitish zone, with the boundary being at ~20° to the core axis (Fig. 47). The rock originally contained feldspar and probable ferromagnesian phenocrysts, but pervasive alteration led to strong replacement by fine grained chlorite and sericite/clay. The whitish zone evidently contains more sericite/clay and less chlorite (Fig. 47). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 47: Drill core sample of altered porphyritic microdiorite, displaying grey-green alteration zone (higher proportion of chlorite, relative to sericite) and a rather sharp contact against a paler, more sericitic alteration zone. The narrow vein at left was not intersected in the section.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately preserved (Fig. 48). The rock originally contained abundant blocky feldspar (probably plagioclase) phenocrysts, up to 4 mm across, as well as less common ferromagnesian phenocrysts up to 4 mm across (most <2 mm) (Fig. 48). Pseudomorphic shapes of the latter infer that the phase was hornblende. The phenocrystal phases formed ~50% of the rock and were enclosed in a fine to medium grained, inequigranular groundmass that contained abundant feldspar, lesser quartz (up to 0.8 mm) and ferromagnesian material, and a little disseminated FeTi oxide. The preserved textural and mineralogical attributes of the rock indicate that it was a strongly porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: Strong pervasive hydrothermal alteration was imposed on the igneous rock. All feldspar was replaced by fine grained sericite and minor chlorite, but with significant fine grained quartz also being formed in the groundmass (Fig. 48). Former ferromagnesian material was mostly replaced by chlorite (Fig. 48), but there is local minor sericite, as well as a little leucoxene-rutile, and in a small part of the sample, traces of pyrite, chalcopyrite and hematite. Original igneous FeTi oxide was replaced by leucoxene-rutile (Fig. 48). The only difference between the grey-green and whitish domains in handspecimen is that the latter alteration zone appears to contain less chlorite (and hence is a paler colour). The alteration assemblage in the sample is consistent with propylitic type.

c) Mineralisation: Generally, no sulphides occur, but in a small portion of the sample (in the pale zone), altered ferromagnesian sites and adjacent groundmass have traces of fine grained pyrite, chalcopyrite and hematite.

<u>Mineral Mode (by volume)</u>: sericite 60%, chlorite 25%, quartz 14%, leucoxene-rutile 1% and traces of hematite, chalcopyrite and pyrite.

<u>Interpretation and comment</u>: It is interpreted that the sample represents a strongly propylitically altered, porphyritic hornblende-quartz microdiorite. The rock has moderate preservation of relict texture, indicating that it contained abundant plagioclase phenocrysts and less common phenocrysts of a ferromagnesian phase (probably hornblende) in a fine to medium grained groundmass of feldspar, with minor quartz and ferromagnesian material, and a little disseminated FeTi oxide. The alteration assemblage is dominated by sericite and chlorite, with significant quartz being developed in the groundmass. A little leucoxene-rutile occurs throughout and in one small part of the sample, traces of pyrite, chalcopyrite and hematite occur, mainly at former ferromagnesian sites. The only observed variation between the different coloured alteration zones is that the pale zone contains less chlorite.

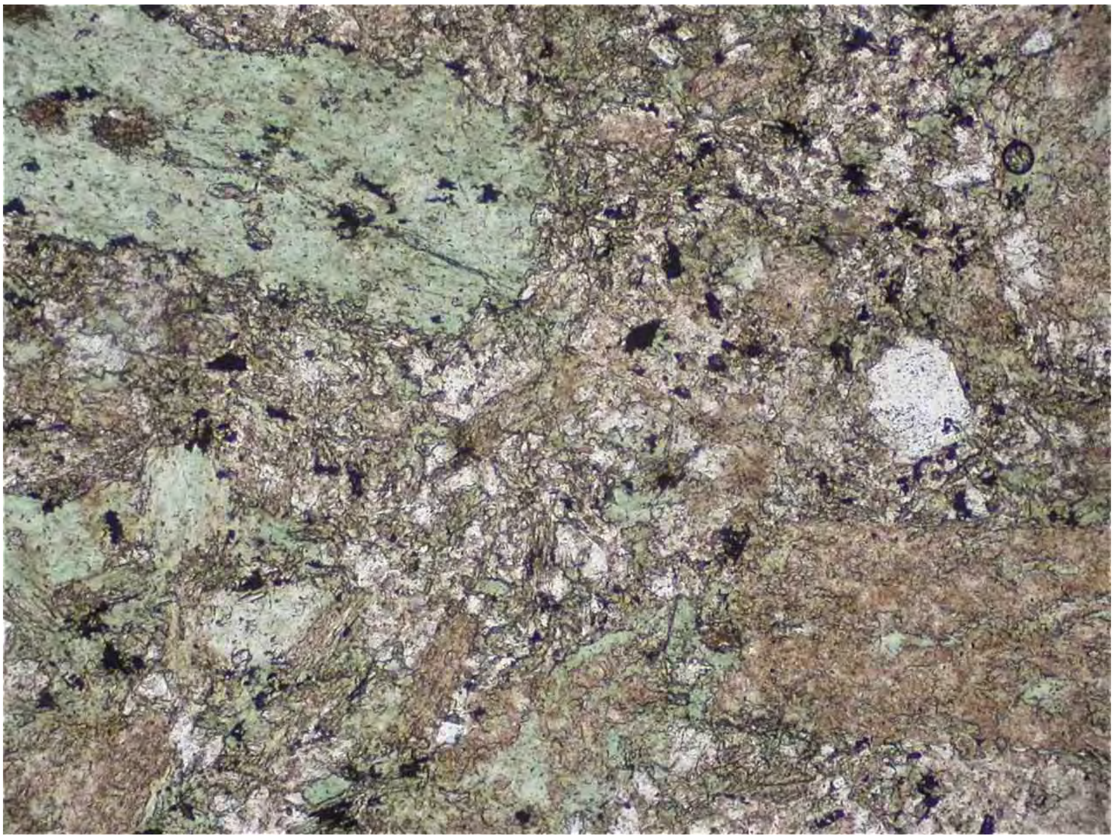

Fig. 48: Chlorite-replaced hornblende prism at upper left, and a sericite (-chlorite)-replaced plagioclase phenocryst at lower right, with the remainder of the rock being altered groundmass, originally with abundant feldspar, lesser quartz and ferromagnesian material and FeTi oxide, now replaced by leucoxene-rutile (small black grains). Plane polarised transmitted light, field of view 2 mm across.

STRC007D 191.1 m PTS

Summary: Strongly hydrothermally altered porphyritic intermediate igneous rock, considered most likely to have been a hornblende-quartz microdiorite. Relict texture is poorly to moderately preserved, with indications of rather abundant feldspar phenocrysts (e.g. plagioclase), less common ferromagnesian phenocrysts (e.g. hornblende) and a few quartz microphenocrysts in a fine to medium grained quartzofeldspathic groundmass. It is possible that the igneous rock sustained early mild potassic alteration to develop minor hydrothermal biotite, with this alteration evolving into (or overprinted by) pervasive alteration to sericite, quartz, minor chlorite and pyrite. There was an early phase of thin pyrite-rich veinlet emplacement, followed by emplacement of a network of veins containing quartz and pyrite, in places with significant chalcopyrite.

Handspecimen: The drill core sample is composed of a strongly altered, grey-green rock that in places appears to have a poorly preserved relict porphyritic texture, e.g. altered feldspar phenocrysts up to a few millimetres across. Otherwise, the rock has primary textural destruction due to strong replacement by fine grained sericite, subordinate chlorite and finely disseminated pyrite (Fig. 49). Darker grey-brown zones in the might contain hydrothermal biotite. A network of sub-planar, locally intersecting veins up to 3 mm wide cuts the altered rock, with veins ranging from pyrite-rich to those containing abundant quartz and locally, pyrite and chalcopyrite (Fig. 49). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 49: Drill core sample containing strongly altered porphyritic intermediate rock (e.g. originally quartz microdiorite), with possible early hydrothermal biotite alteration (darker grey-brown zones) overprinted by sericite-quartz (-chlorite-pyrite) alteration and cut by a few veins ranging from quartz-rich to quartz-pyrite-chalcopyrite and pyrite-rich.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is poorly to moderately preserved (Fig. 50). There are rather abundant pseudomorphs after former blocky feldspar phenocrysts (e.g. plagioclase) up to 6 mm across, as well as after less common elongate, prismatic ferromagnesian phenocrysts up to 3 .5 mm long (mostly <1 mm) (Fig. 50). Relict shapes of the latter imply that they were originally hornblende. The phenocrystal phases, including a few small relict microphenocrysts of quartz, occur in a fine to medium grained groundmass that probably consisted of feldspar with lesser ferromagnesian material and quartz. From the remnant texture and inferences about primary mineralogy, the original rock is interpreted as a porphyritic hornblende-quartz microdiorite. There is no evidence that the rock was originally a sandstone.

b) Alteration and structure: The original igneous rock was strongly hydrothermally altered and cut by a network of sub-planar to anastomosing veins. There are relict textural indications that minor hydrothermal biotite (i.e. potassic alteration) initially developed at ferromagnesian sites and in the groundmass. Alteration then evolved to a strongly pervasive retrograde type that overprinted any biotite and was dominated by fine grained sericite (at feldspar sites and in the groundmass), quartz (in the groundmass) and chlorite (mainly at ferromagnesian sites), with minor disseminated pyrite and a trace of rutile (Fig. 50). There was an initial event of thin veining (up to 0.3 mm wide) dominated by pyrite, but locally with quartz, sericite and trace chalcopyrite. These small veins appear to be cut by less common, but more prominent, sub-planar veins up to 3 mm wide containing fine to medium grained quartz (locally deformed and with fibre growth texture), with commonly abundant pyrite and in places, considerable chalcopyrite (Fig. 51). The pervasive alteration that could have been imposed on earlier mild potassic (biotite) alteration is interpreted as being of transitional phyllic-propylitic type.

c) Mineralisation: The sample contains considerable sulphides, largely hosted in veins, although there is minor disseminated pyrite, with individual grains up to 0.3 mm, as part of the pervasive alteration. Apparently early veins are pyrite-rich, with trace chalcopyrite, but later quartz-rich veins commonly contain abundant pyrite, overprinted by paragenetically later chalcopyrite forming aggregates up to 2 mm across (Fig. 51).

Mineral Mode (by volume): sericite 50%, quartz 32%, pyrite and chlorite each 8%, chalcopyrite 2% and a trace of rutile.

Interpretation and comment: It is interpreted that the sample is a porphyritic hornblende-quartz microdiorite that experienced initial mild potassic alteration forming minor hydrothermal biotite, subsequently overprinted by strong pervasive alteration of transitional phyllic-propylitic type and two generations of sulphide-bearing veins. Relict texture is poorly to moderately preserved, with indications that the rock contained feldspar phenocrysts (e.g. plagioclase), less common ferromagnesian phenocrysts (e.g. hornblende) and a few quartz microphenocrysts in a fine to medium grained quartzofeldspathic groundmass. The strong pervasive alteration formed sericite, quartz, minor chlorite and pyrite. An early phase of thin pyrite-rich veinlets were emplaced, followed by a network of veins containing quartz and pyrite, in places with significant chalcopyrite.

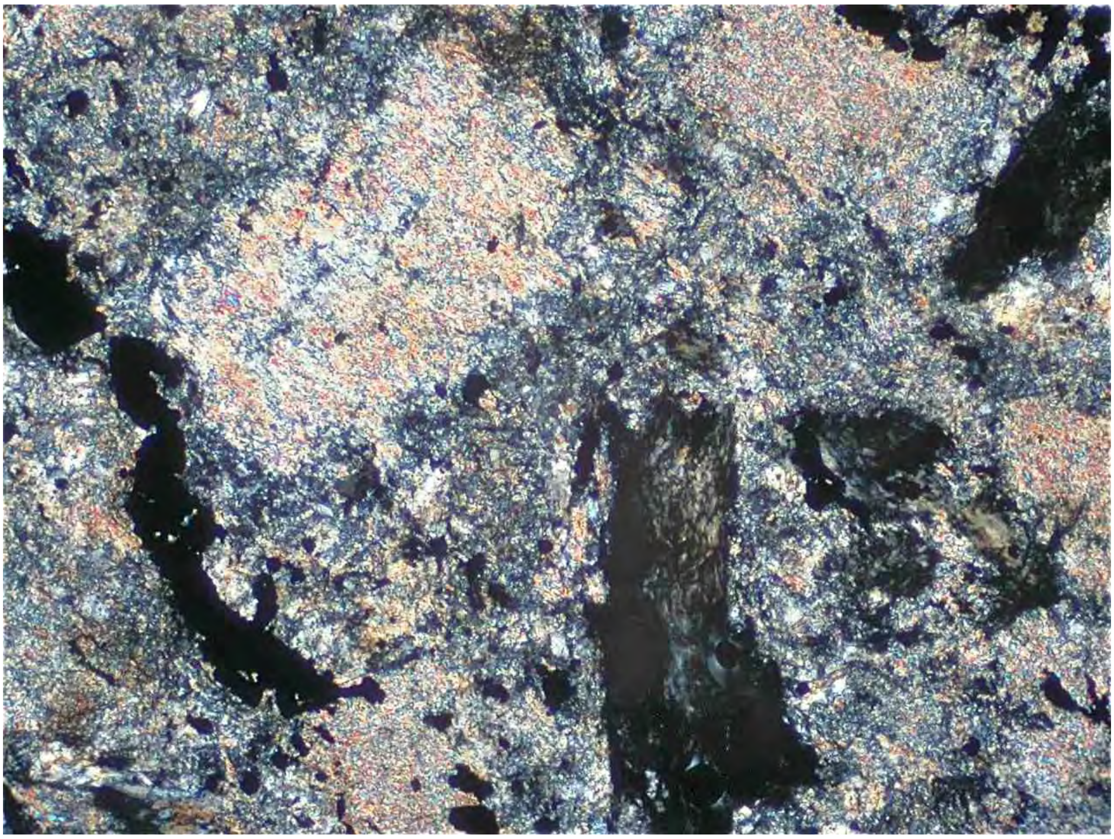

Fig. 50: Relict porphyritic texture with a few former feldspar phenocrysts replaced by fine grained sericite and a couple of ferromagnesian phenocrysts (dark) mainly replaced by chlorite. The black aggregate at left is a pyrite veinlet. Transmitted light, crossed polarisers, field of view 2 mm across.

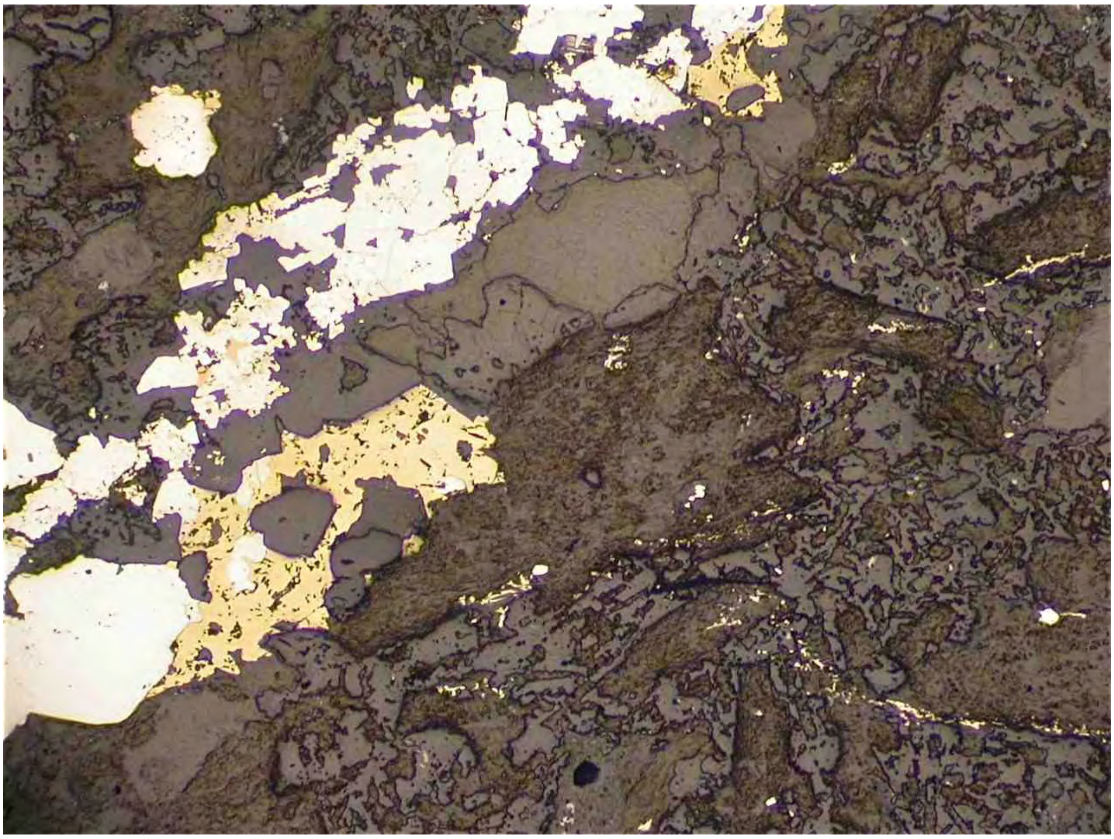

Fig. 51: Part of a quartz-pyrite-chalcopyrite vein cutting altered host rock that also displays a few small disseminated pyrite grains and very thin pyrite veinlets. Plane polarised reflected light, field of view 2 mm across.

<u>STRC007D 204.7 m PTS</u>

<u>Summary</u>: Porphyritic dacite displaying strong phyllic hydrothermal alteration as well as a major vein and a few smaller subsidiary veins. The rock has moderately well preserved primary texture indicating that it originally contained scattered feldspar (e.g. plagioclase) and less common ferromagnesian phenocrysts, as well as a few quartz phenocrysts, set in a fine grained quartzofeldspathic groundmass. The alteration assemblage is dominated by fine grained sericite and quartz, with minor disseminated pyrite and chalcopyrite, mostly at former phenocryst sites, and a trace of rutile. A major vein contains massive sulphides: dominant pyrite and chalcopyrite, and subordinate, paragenetically later marcasite. Smaller veins also have pyrite and chalcopyrite, along with quartz. In the major vein, chalcopyrite hosts rare small grains of Cu-Bi minerals (emplectite, wittichenite), as well as traces of stannite and bismuth. Chalcopyrite locally shows slight replacement by digenite.

<u>Handspecimen</u>: The drill core sample is composed of a strongly hydrothermally altered, porphyritic felsic igneous rock, with scattered altered phenocrysts of feldspar and ferromagnesian phases, and a few of relict quartz, set in a fine grained altered, pale creamy-grey groundmass (Fig. 52). Apart from relict quartz, the rock appears to be replaced by fine grained sericite and quartz, with minor disseminated pyrite (Fig. 52). A major sub-planar sulphide vein up to 2 cm wide cuts the rock at a moderate angle to the core axis, and is accompanied by a couple of narrow, subsidiary veins (Fig. 52). Veining contains pyrite and chalcopyrite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

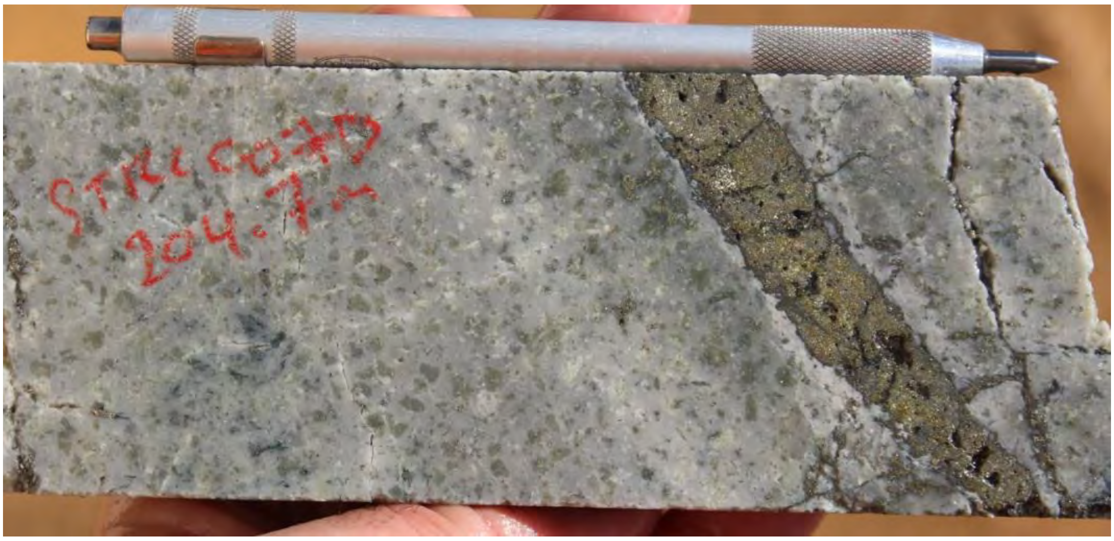

Fig. 52: Drill core sample showing a prominent sub-planar pyrite-chalcopyrite-marcasite vein cutting strongly phyllic altered porphyritic dacite. Original feldspar and ferromagnesian phenocrysts were sericitised and the groundmass replaced by quartz and sericite.

<u>Petrographic description</u>

a) Primary rock characteristics: In the section, about a third of the sample constitutes sulphide-rich vein filling, with the remainder being strongly altered host rock. The latter has moderately well preserved relict porphyritic texture, despite the strong alteration. There are a few relict quartz phenocrysts up to 3 mm across and pseudomorphs after former blocky feldspar (e.g. plagioclase) phenocrysts up to 4 mm across, and also after former ferromagnesian phenocrysts (Fig. 53). The latter commonly have prismatic form and are up to 3 mm long and could represent former hornblende (Fig. 53), but some smaller pseudomorphs appear to have been derived from original biotite. The rock also contains a few altered microphenocrysts of FeTi oxide. Phenocrystal phases were set in a fine grained groundmass that occupied at least 60% of the rock and which was probably largely of quartzofeldspathic composition. The relict characteristics of the rock suggest it represents a former porphyritic dacite.

b) Alteration and structure: Strong pervasive alteration was imposed on the igneous rock and sulphide-rich veining emplaced. Alteration is of phyllic type, with replacement of feldspar phenocrysts by fine grained sericite and in places, pyrite, chalcopyrite and quartz (Fig. 53). Former ferromagnesian grains were replaced by sericite and small amounts of pyrite, chalcopyrite and rutile, and igneous FeTi oxide was replaced by rutile ± sericite. In the groundmass, there was replacement by finely granular quartz and subordinate sericite (Fig. 53). A major sub-planar vein, up to 2 cm wide was emplaced, along with a few narrower (up to 2 mm) subsidiary veins. The large vein is dominated by massive sulphides (pyrite, chalcopyrite, marcasite) (Fig. 54) and smaller veins are similar, but contain local quartz and little or no marcasite.

c) Mineralisation: The rock contains rather abundant sulphides, mostly concentrated into the veins, but there is locally significant disseminated sulphides, mainly at altered phenocryst sites. At the latter, there is fine to medium grained pyrite and minor chalcopyrite, but adjacent to the main vein, pyrite-chalcopyrite aggregates commonly contain minor marcasite, encrusting pyrite and chalcopyrite. In the main vein, massive, fine to medium grained chalcopyrite and pyrite occur, commonly encrusted and veined by finely inequigranular marcasite (Fig. 54). Chalcopyrite hosts uncommon small (up to 0.1 mm) inclusions of trace sulphides, with these tentatively identified as the CuBi sulphides emplectite and wittichenite, and stannite, with a tiny trace of bismuth hosted in wittichenite. Chalcopyrite also shows slight marginal replacement by digenite, perhaps reflecting incipient deep supergene oxidation.

<u>Mineral Mode (by volume)</u>: quartz 35%, sericite 30%, pyrite and chalcopyrite each 15%, marcasite 5% and traces of rutile, emplectite, wittichenite, bismuth, stannite and digenite.

<u>Interpretation and comment</u>: It is interpreted that the sample represents a strongly phyllic altered and sulphide-veined porphyitic dacite. Primary texture is moderately well preserved primary texture indicating that the rock contained scattered feldspar (e.g. plagioclase) and less common ferromagnesian phenocrysts, as well as a few quartz phenocrysts, set in a fine grained quartzofeldspathic groundmass. The alteration assemblage is dominated by sericite and quartz, with minor disseminated pyrite and chalcopyrite, and a trace of rutile. A major vein contains massive pyrite and chalcopyrite, and subordinate, paragenetically later marcasite. Smaller veins also have pyrite and chalcopyrite, along with quartz. In the major vein, chalcopyrite hosts rare small grains of Cu-Bi minerals (emplectite, wittichenite), as well as traces of stannite and bismuth. Chalcopyrite locally shows slight replacement by digenite.

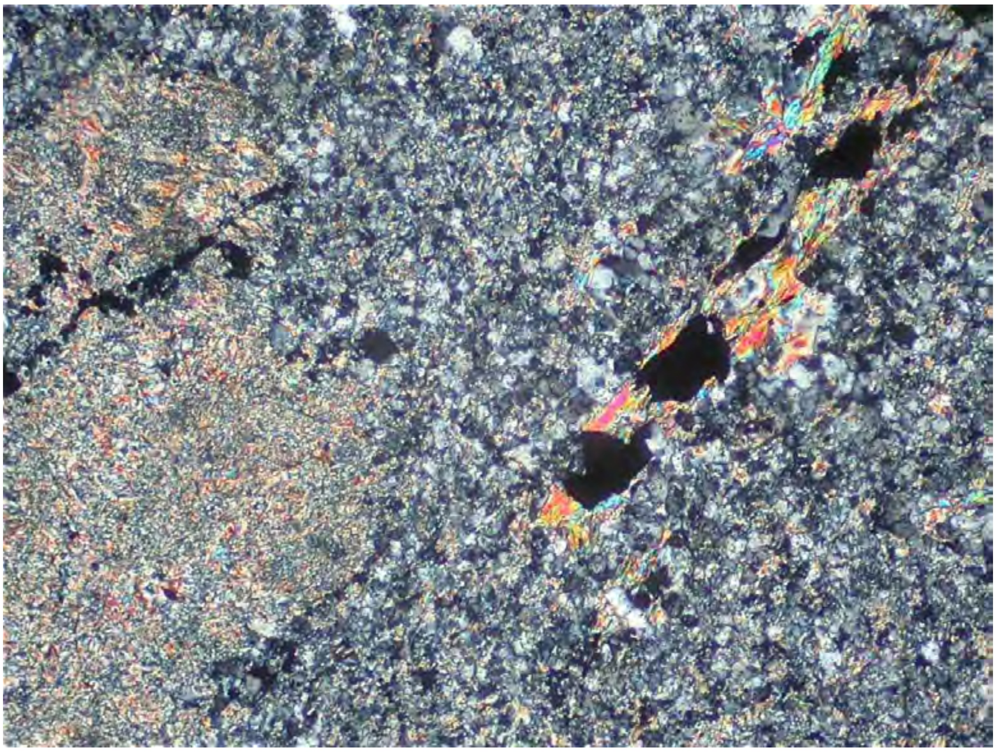

Fig. 53: Relict porphyritic texture in altered dacite, with a sericite pseudomorph after a feldspar phenocryst at left, and a sericite-sulphide pseudomorph after a hornblende phenocryst at right. The fine grained altered groundmass contains quartz and sericite. Transmitted light, crossed polarisers, field of view 2 mm across.

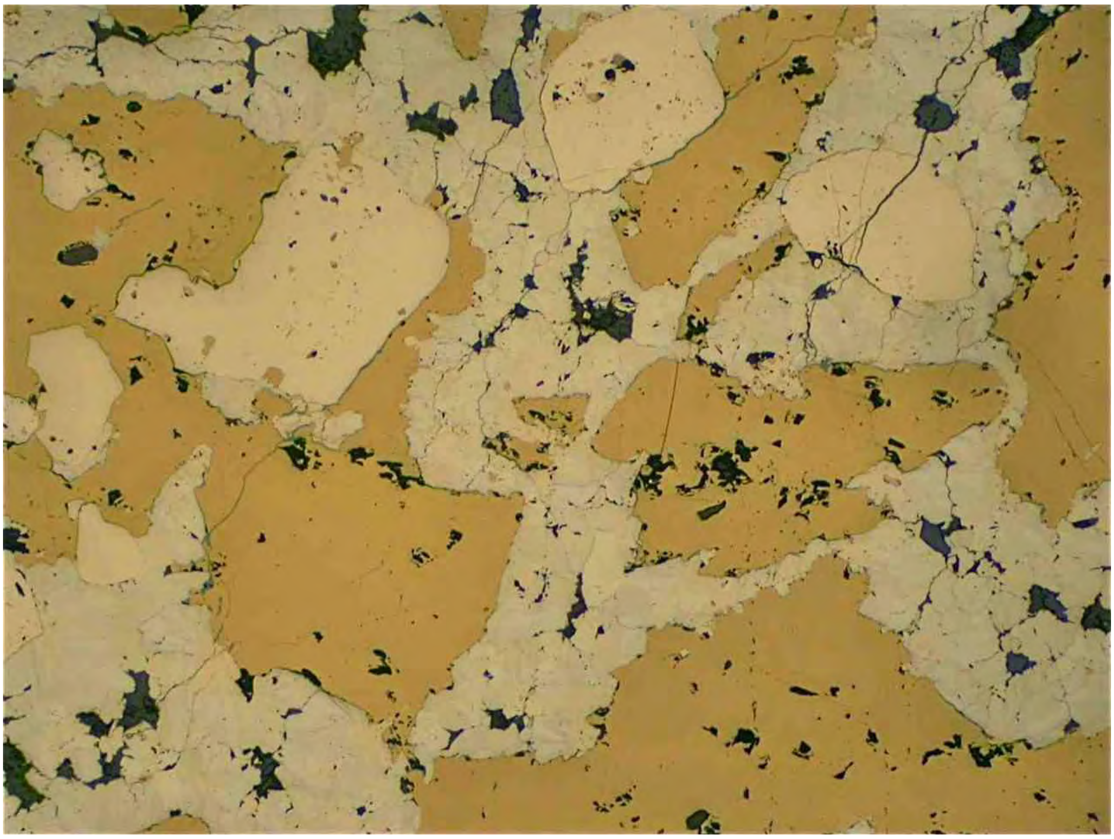

Fig. 54: Part of the major, massive sulphide vein, displaying a few grains of pyrite (pale creamy) hosted in chalcopyrite (yellow), and with encrustation and veinlets of marcasite (slightly bluish-cream). Plane polarised reflected light, field of view 2 mm across.

STRC007D 291.5 m TS

Summary: Medium to coarse grained leucocratic tonalite with a sharp contact against medium grained biotite microtonalite, with both rock types showing effects of imposed penetrative deformation, strong propylitic alteration and minor veining. The leucocratic tonalite is dominated by plagioclase and quartz, with a little biotite and K-feldspar. Microtonalite contained abundant plagioclase, quartz and biotite, with no textural evidence that the former abundant biotite was of hydrothermal derivation. Deformation led to strain and recrystallisation of quartz, fracturing of plagioclase and in the microtonalite, development of a weak, biotite-defined foliation. Pervasive alteration caused considerable replacement of igneous feldspar, initially by albite, but with subsequently abundant fine grained chlorite. Biotite was largely altered to chlorite and the rock has traces of sericite, leucoxene and pyrite. A couple of small, discontinuous quartz veins occur, along with several shear-controlled thin veins of chlorite and local sericite.

Handspecimen: The drill core sample has a relatively sharp, but irregular contact between a pale grey, medium to coarse grained granitic rock and a darker, brownish-grey and finer grained, possibly intermediate igneous rock that occupies the majority of the sample (Fig. 55). The contact between the two is approximately normal to the core axis. The darker rock appears to have contained considerable biotite, but now probably chloritised. A trace of pyrite is observed in this rock type. Adjacent to the contact zone, a discontinuous, sub-planar milky quartz vein up to 1 cm wide occurs, at a moderate angle to the core axis (Fig. 55). The darker rock is very weakly magnetic, with susceptibility up to 40 x 10^{-5} SI, whereas the leucocratic rock is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

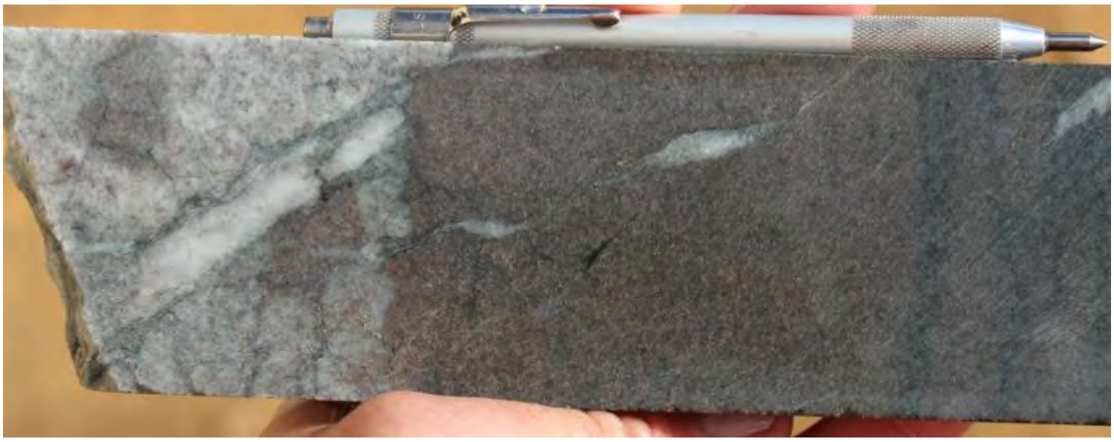

Fig. 55: Drill core sample displaying a relatively sharp contact between pale-coloured leucocratic tonalite at left and dark microtonalite at right. The latter originally contained significant igneous biotite, now largely chloritised. Minor quartz veining cuts the sample.

Petrographic description

a) Primary rock characteristics: In the section, the sample has a relatively sharp contact between a strongly altered, leucocratic, medium to coarse grained granitic rock, and a strongly altered, medium grained igneous rock of evidently less felsic composition. Primary textures in the two different rock types are moderately preserved (Figs 56, 57). The leucocratic rock contains abundant blocky plagioclase up to 3 mm across and interstitial quartz, a little biotite and K-feldspar, and traces of apatite and FeTi oxide (Fig. 56). From the preserved texture and mineralogy, this rock type is interpreted as a leucocratic tonalite. The medium grained rock evidently contained abundant flaky biotite (up to 1 mm grainsize and commonly in elongate bundles; Fig. 57), intergrown with abundant feldspar (probably plagioclase) and quartz, and a trace of apatite. It is interpreted that this rock represents a biotite microtonalite.

There is no diagnostic indication as to the temporal relation between the two rock types. Original biotite in the microtonalite is considered to be of igneous crystallisation, based on textural relationships, and was unlikely to be hydrothermal.

b) Alteration and structure: Both rock types were subject to imposed deformation and strong pervasive hydrothermal alteration. There are significant strain and recrystallisation effects apparent in quartz, fracturing of plagioclase and foliation development in biotite (in the microtonalite; Fig. 57). Imposed alteration led to variable replacement of plagioclase by albite, but generally, stronger overprinting of feldspar, particularly in the microtonalite, by fine grained, very pale green chlorite and trace sericite, with almost all biotite being replaced by chlorite, plus trace sericite, leucoxene and pyrite (Fig. 57). Rare igneous FeTi oxide in the leucocratic tonalite was replaced by leucoxene and pyrite. A couple of discontinuous quartz veins up to 0.5 mm wide occur, largely parallel to the foliation. Also, the rock contains several shear-controlled veins, up to 1 mm wide, largely co-planar with foliation, that contain chlorite and locally, sericite. The observed alteration assemblage is viewed as being of propylitic type.

c) Mineralisation: As part of the alteration, the sample contains a few isolated grains of pyrite up to 0.2 mm across, mostly associated with altered biotite sites (Fig. 57).

Mineral Mode (by volume): chlorite 50%, quartz 30%, plagioclase (includes albite) 18%, sericite and K-feldspar each 1% and traces of apatite, leucoxene, biotite and pyrite.

Interpretation and comment: It is interpreted that the sample has a contact between leucocratic tonalite and medium grained biotite microtonalite, with both rock types having imposed penetrative deformation, strong propylitic alteration and minor veining. The leucocratic tonalite contains plagioclase and quartz, with a little biotite and K-feldspar. Microtonalite contained abundant plagioclase, quartz and biotite, with no textural evidence that the former abundant biotite was of hydrothermal derivation. Deformation caused strain and recrystallisation of quartz, fracturing of plagioclase and in the microtonalite, development of a weak, biotite-defined foliation. Strong propylitic alteration caused considerable replacement of igneous feldspar, initially by albite, but with subsequently abundant chlorite. Biotite was largely altered to chlorite and the rock has traces of sericite, leucoxene and pyrite. A couple of small, discontinuous quartz veins occur, along with several shear-controlled thin veins of chlorite and local sericite.

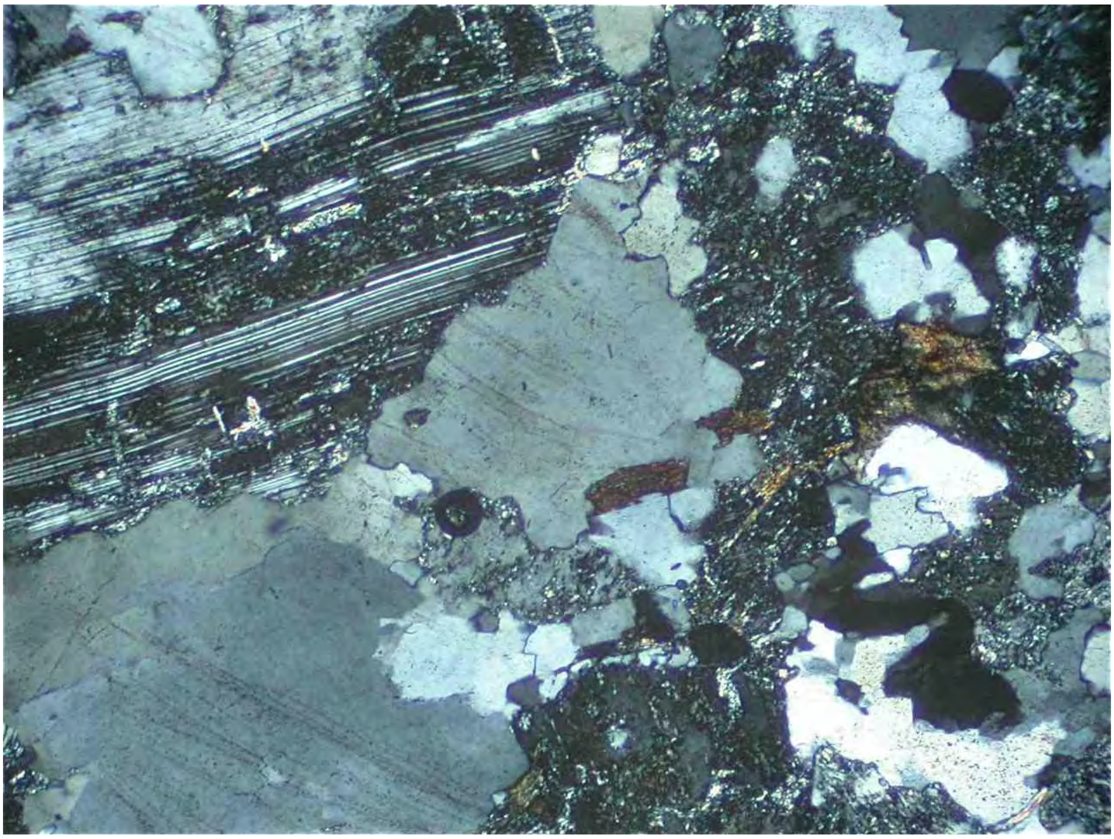

Fig. 56: Leucocratic tonalite with strained and recrystallised quartz and a large relict plagioclase grain. At right is chloritised feldspar (dark grey) and a couple of grains of largely altered biotite (brownish). Transmitted light, crossed polarisers, field of view 2 mm across.

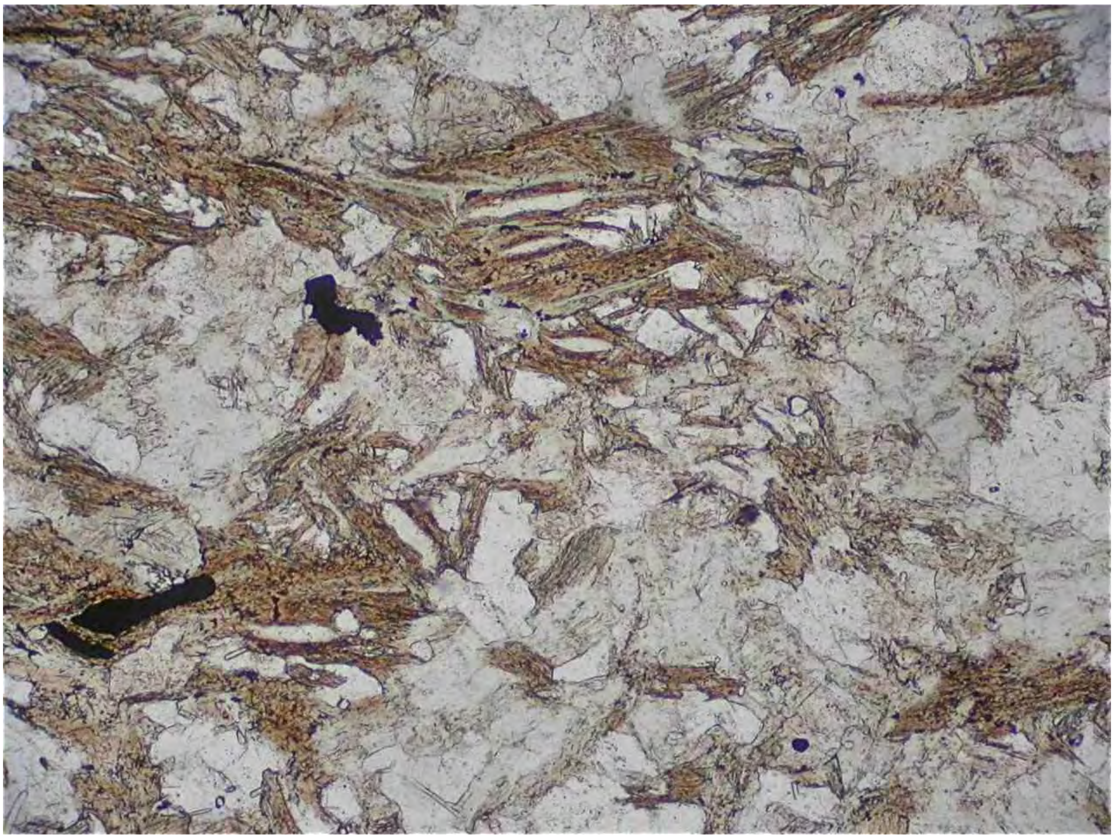

Fig. 57: Altered microtonalite showing weakly foliated aggregates of largely chloritised biotite (brownish), associated with quartz and chloritised feldspar. Small black grains are pyrite. Plane polarised transmitted light, field of view 2 mm across.

STRC007D 292.5 m TS

Summary: Medium grained biotite microtonalite containing a domain of coarser, leucocratic tonalite (relations between the two are not resolved), and with both rock types showing effects of deformation (e.g. strain and part recrystallisation of quartz), strong hydrothermal alteration and local veining. The microtonalite had a medium grained igneous assemblage of quartz, plagioclase and biotite, with a little FeTi oxide. The coarser, leucocratic tonalite had a similar assemblage, but much less biotite. Some plagioclase is retained in this rock type, but overall in both rock types, plagioclase and biotite are replaced, mostly by chlorite. In the microtonalite, there is also a little leucoxene-rutile and trace pyrite. The microtonalite hosts a couple of quartz (-chlorite) veins, with some association with sheared zones containing abundant chlorite. There is no evidence in the sample for the development of any hydrothermal biotite.

Handspecimen: The drill core sample is composed of a strongly altered, dark grey-green, medium grained igneous rock, probably of intermediate composition, but at one end of the interval, there is a zone a few centimetres wide of a speckled white, pale grey and grey-green, medium to coarse grained altered igneous rock, evidently of more felsic composition (Fig. 58). The latter contains abundant white feldspar, plus quartz and altered ferromagnesian material, whereas the more abundant, medium grained rock type probably contained more abundant ferromagnesian material and less feldspar and quartz (Fig. 58). The medium grained rock is cut by a couple of narrow shear zones rich in chlorite and these appear to be associated with the occurrence of a sub-planar quartz vein up to 4 mm wide that occurs at a low angle to the core axis. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 58: Drill core sample showing strongly altered, grey-green microtonalite and pale zone of coarser, leucocratic tonalite. The latter rock type has some retention of plagioclase, but elsehwere in the sample, there is pervasive, strong chlorite alteration. The fracture at right follows a chloritic shear zone.

Petrographic description

a) Primary rock characteristics: In the section, two different rock types occur, with relatively sharp contacts. There is no diagnostic criterion for timing relations between the two. The more abundant rock type in the section corresponds to the pale felsic type in handspecimen and it has moderate preservation of relict medium to coarse grained granitic texture. It was evidently dominated by interlocking grains of quartz and blocky plagioclase up to 4 mm across, with a few flakes of biotite up to 1 mm across and a trace of apatite (Fig. 59). This rock type is interpreted as a leucocratic tonalite. The other rock type also has moderate preservation of relict texture and was apparently medium grained (up to 2 mm), formerly with abundant feldspar (probably plagioclase), quartz and biotite, and with a little FeTi oxide and trace apatite. This rock type is interpreted a biotite microtonalite. Both rock types are similar to those present in STRC007D/291.5 m.

b) Alteration and structure: Both rock types were subject to imposed deformation and strong pervasive hydrothermal alteration, with local veining. There are significant strain and recrystallisation effects apparent in quartz, and foliation development in the microtonalite. In the leucocratic tonalite, there is some preservation of plagioclase (Fig. 59), although it could be albitised. Elsehwere in this rock type, and in the microtonalite, original igneous feldspar and biotite are altered and replaced by fine grained chlorite (Fig. 60). At biotite and FeTi oxide sites, minor leucoxene-rutile has also developed, and trace pyrite is part of the alteration assemblage in the microtonalite. In domains of the latter, a couple of sub-parallel quartz-rich veins were emplaced (Fig. 60). These are up to 2 mm wide, with medium grained quartz and minor screens of chlorite. The wider of these veins appears to be controlled by a chlorite-rich shear zone (Fig. 60). Alteration in this sample is similar to that observed in STRC007D/291.5 m. There is no evidence for the development of any hydrothermal biotite

c) Mineralisation: As part of the alteration, the microtonalite has developed a trace of pyrite, forming aggregates up to 0.2 mm across.

<u>Mineral Mode (by volume)</u>: quartz 50%, chlorite 40%, plagioclase (includes albite) 9%, leucoxene 1% and traces of apatite and pyrite.

<u>Interpretation and comment</u>: It is interpreted that the sample is a biotite microtonalite containing a domain of coarser, leucocratic tonalite (relations between the two are unresolved), and with both rock types showing effects of deformation, strong hydrothermal alteration and veining. The microtonalite had a medium grained assemblage of quartz, plagioclase and biotite, with a little FeTi oxide. The coarser, leucocratic tonalite had a similar assemblage, but with much less biotite. Some plagioclase is retained in this rock type, but overall in both rock types, plagioclase and biotite are replaced, mostly by chlorite, with a little leucoxene-rutile and trace pyrite occurring in the microtonalite. A couple of quartz (-chlorite) veins occur in the microtonalite, locally hosted in sheared zone with abundant chlorite. There is no evidence in the sample for the development of any hydrothermal biotite.

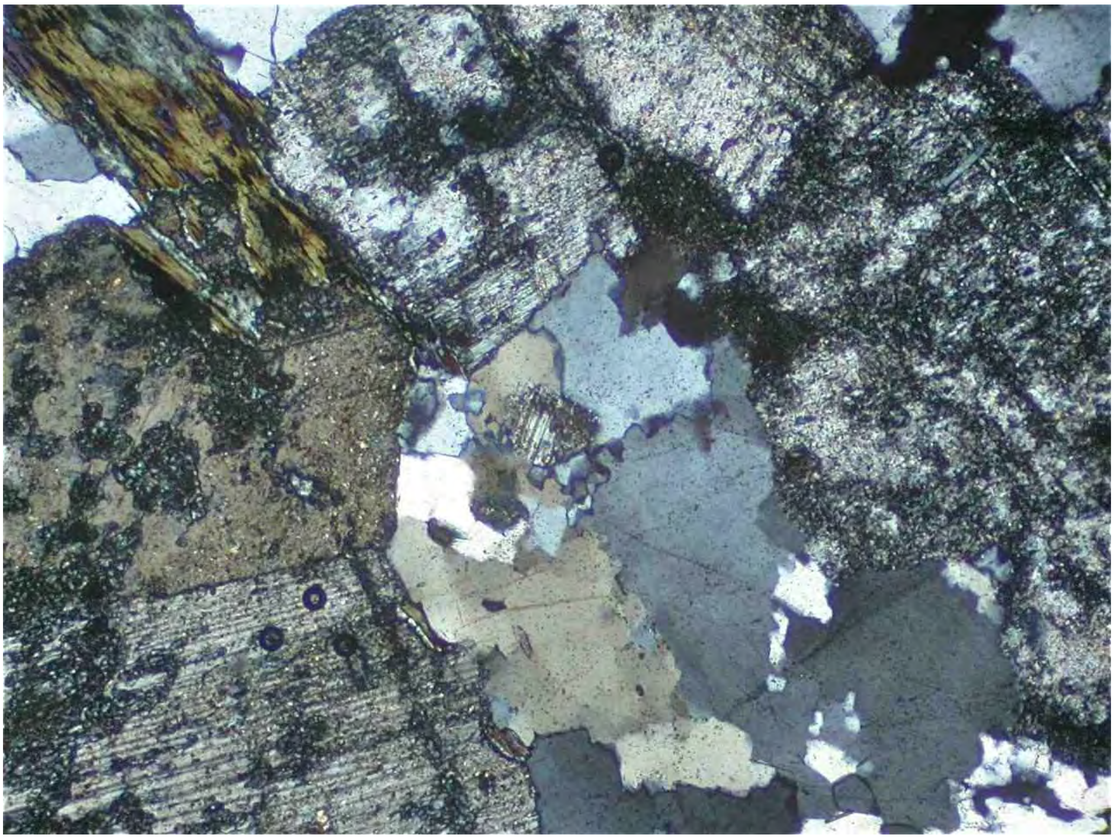

Fig. 59: Leucocratic tonalite containing relict plagioclase, partly replaced by fine grained chlorite (darker grey). Note strain and recrystallisation textures in quartz. At upper left is a chloritised biotite grain. Transmitted light, crossed polarisers, field of view 2 mm across.

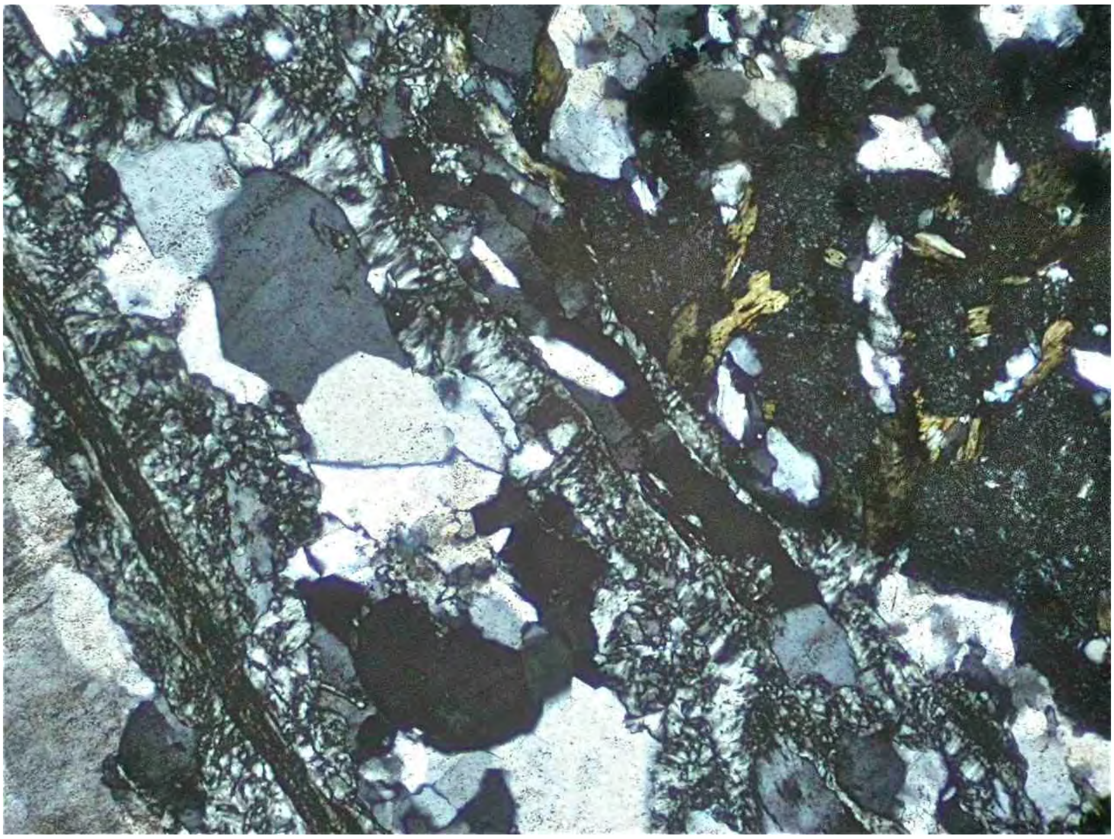

Fig. 60: Very strongly altered microtonalite at right, containing abundant chlorite (dark grey and khaki), bordering on to a sheared, chlorite-rich zone at left that hosts medium grained quartz veining. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 94.1 m PTS

Summary: Pervasively altered and veined, strongly porphyritic hornblende-quartz microdiorite. Relict texture is moderately well preserved, indicating that the original rock contained abundant plagioclase phenocrysts and less abundant ferromagnesian (e.g. hornblende) phenocrysts, hosted in a subordinate amount of finer groundmass material dominated by plagioclase, but with minor quartz and ferromagnesian material. It is suspected that the rock experienced early mild hydrothermal alteration associated with vein emplacement. This alteration could be of Na-Ca-Fe type, resulting in development of albite, actinolite and minor magnetite, with the associated veins being sub-planar, sub-parallel, quartz-rich, but also with minor magnetite and trace actinolite. The rock (and veins) were subsequently subject to very low grade metamorphism, forming a pervasive "propylitic-like" alteration assemblage that includes prehnite, pumpellyite, chlorite, sericite, epidote and clay (from plagioclase), chlorite from actinolite, and hematite from magnetite. A few epidote-rich patches occur and thin veining by epidote, carbonate or chlorite overprints the rock and quartz-rich veins.

Handspecimen: The drill core sample is composed of grey-green, porphyritic, fine to medium grained intermediate igneous rock (e.g. microdiorite), with scattered plagioclase phenocrysts up to 5 mm across and abundant smaller grains of plagioclase and altered ferromagnesian material (Fig. 61). Pervasive alteration could have led to development of considerable chlorite (e.g. from original ferromagnesian material) and a little disseminated magnetite and epidote. The rock is cut by a sub-parallel array of quartz-rich veins up to 3 mm wide approximately normal to the core axis (Fig. 61). In and adjacent to some veins, there is a little dark grey fine grained magnetite. Testing of the section offcut with sodium cobaltinitrite did not reveal the presence of K-feldspar. The sample is strongly magnetic, with susceptibility up to 7620 x 10^{-5} SI, due to the presence of magnetite.

Fig. 61: Drill core sample of porphyritic microdiorite showing a few large plagioclase phenocrysts and the grey-green colour due to replacement of primary minerals by phases including chlorite, actinolite, epidote, prehnite and pumpellyite. An array of sub-parallel quartz-rich veins with a little associated magnetite cuts the sample.

Petrographic description

a) Primary rock characteristics: In the section, relict crowded porphyritic texture is moderately well preserved (Fig. 62). There are a few large (up to 5 mm) blocky plagioclase phenocrysts, but most are <2 mm across (Fig. 62). Smaller prismatic ferromagnesian phenocrysts (likely to have been hornblende) were up to 2 mm long, with these phases being enclosed by a subordinate amount of fine to medium grained groundmass material dominated by plagioclase, but also containing quartz, ferromagnesian material and a little magnetite (Fig. 62). From the preserved characteristics, the rock is interpreted as a porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: The igneous rock experienced rather strong pervasive alteration and emplacement of several veins. Apart from relict quartz and minor retention of primary plagioclase and magnetite, most of the igneous assemblage was altered. There appears to have been a mild initial alteration event accompanying emplacement of quartz-rich veining. It is interpreted that original hornblende was replaced by actinolite and minor magnetite, and that there was some albitisation of plagioclase (Fig. 62). Associated veining up to 3 mm wide forms a sub-parallel array of sub-planar aggregates of fine to medium grained, inequigranular quartz, with minor magnetite (Fig. 63) and trace actinolite, pyrite and chalcopyrite. Subsequently, the rock was affected by imposed very low grade metamorphism, resulting in development of a retrograde assemblage. Plagioclase was variably replaced by fine grained associations that include prehnite, pumpellyite, chlorite, sericite, epidote and a clay phase, with a few epidote-rich patches developing. Alteration-derived actinolite was commonly replaced by chlorite and trace carbonate, and magnetite by hematite (Fig. 62). Quartz-rich veins may have also been overprinted by retrogression, with development of minor carbonate infill and trace epidote and pumpellyite. Quartz-rich veining is also cut by rare thin veins of epidote ± carbonate, and the rock also has a couple of thin chlorite veins. The alteration assemblages in the sample are viewed as reflecting early mild Na-Ca-Fe alteration, overprinted by a "propylitic-like" assemblage due to very low grade metamorphism.

c) Mineralisation: Minor hydrothermal magnetite formed with the early alteration and quartz-rich veining. Grains are up to 0.2 mm across and are concentrated in and about the quartz-rich veins (Fig. 63), but they also occur in the host rock. There has been local retrograde replacement of magnetite by hematite. One quartz-rich vein contains a tiny trace of pyrite and chalcopyrite.

Mineral Mode (by volume): plagioclase (includes albite) 50%, quartz and chlorite each 15%, magnetite and prehnite each 5%, actinolite 3%, epidote and pumpellyite each 2%, sericite, carbonate and clay each 1% and traces of hematite, pyrite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample represents a porphyritic hornblende-quartz microdiorite that has pervasive alteration and an array of sub-parallel veins. Relict texture is moderately well preserved, with the rock containing abundant plagioclase phenocrysts and less common ferromagnesian (e.g. hornblende) phenocrysts, hosted in a finer groundmass of plagioclase, minor quartz and ferromagnesian material. The rock could have experienced early mild hydrothermal alteration of Na-Ca-Fe type, resulting in development of albite, actinolite and minor magnetite, associated with quartz-rich veining that contains minor magnetite and trace actinolite. The rock was subsequently subject to very low grade metamorphism, forming a pervasive "propylitic-like" alteration assemblage that includes prehnite, pumpellyite, chlorite, sericite, epidote and clay (from plagioclase), chlorite from actinolite, and hematite from magnetite. A few epidote-rich patches occur and thin veining by epidote, carbonate or chlorite overprints the rock and quartz-rich veins.

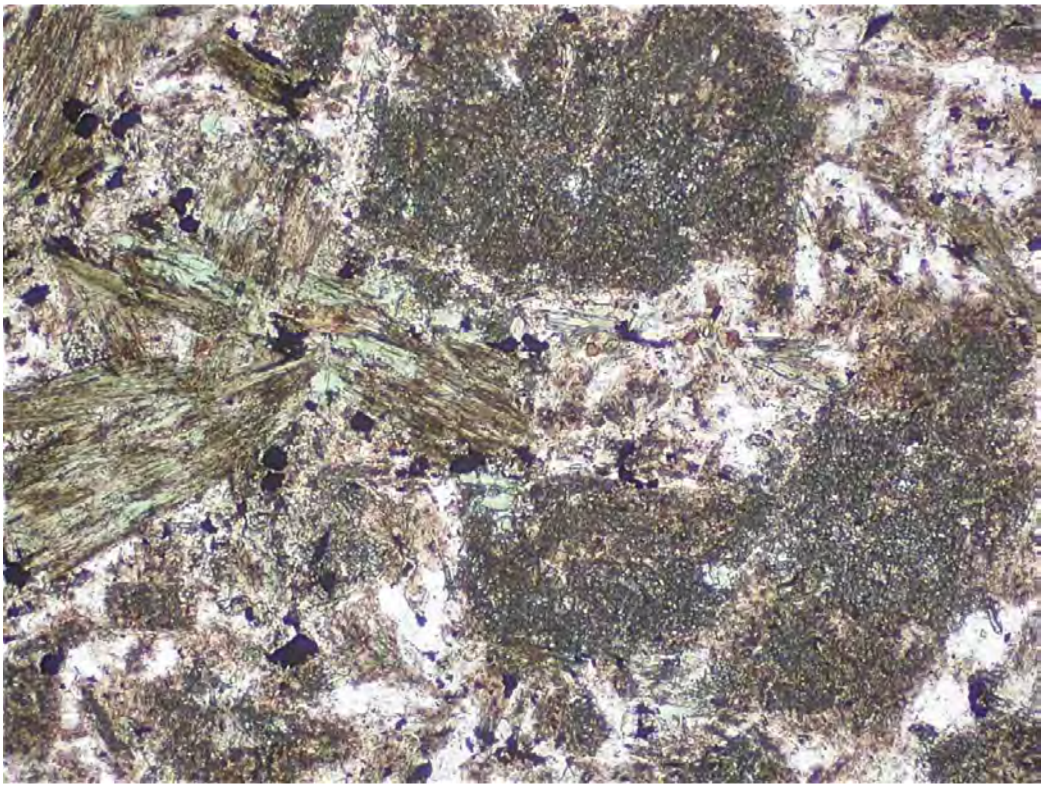

Fig. 62: Relict porphyritic texture in microdiorite showing altered plagioclase phenocrysts (turbid due to fine grained alteration minerals) and altered hornblende (mostly replaced by green chlorite). The groundmass contains minor quartz (clear) and the small black grains are magnetite. Plane polarised transmitted light, field of view 2 mm across.

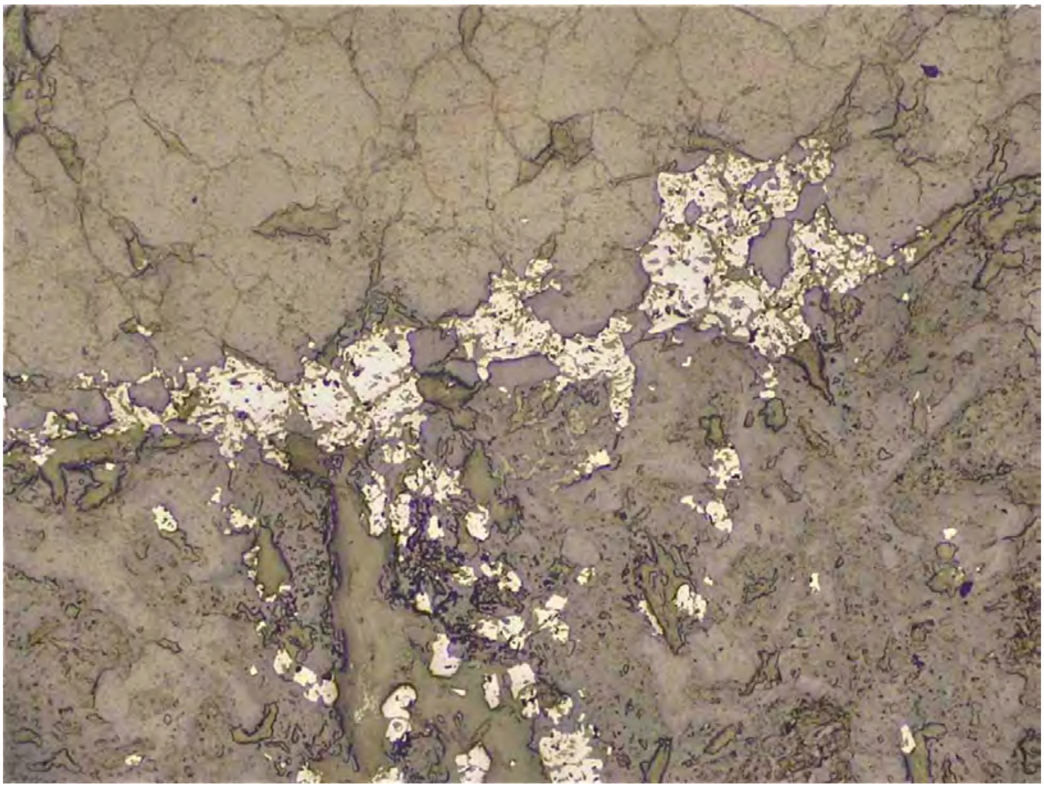

Fig. 63: Margin of a quartz-rich vein showing concentration of magnetite (pale grey). Altered host rock also contains minor magnetite. Plane polarised reflected light, field of view 2 mm across.

<u>STRC008D 117.5 m TS</u>

Summary: Strongly altered hornblende-quartz microdiorite that has moderate retention of a crowded porphyritic texture. The rock originally contained abundant plagioclase and ferromagnesian (probably hornblende) phenocrysts in a fine to medium grained groundmass with abundant feldspar, subordinate quartz and ferromagnesian material, and a little disseminated FeTi oxide. The rock was affected by propylitic alteration, forming a fine grained assemblage of sericite and chlorite, minor quartz and leucoxene-rutile. All original feldspar, ferromagnesian material and FeTi oxide was destroyed. The altered rock hosts several sub-parallel quartz-rich veins that also contain a little chlorite, pyrite and chalcopyrite, and show indications of recrystallisation.

Handspecimen: The drill core sample is composed of a strongly altered porphyritic igneous rock of probable intermediate to felsic igneous composition. It is grey-green to pale green, with the paler domain being sharply defined against quartz-rich veins (Fig. 64). The differences in colour could reflect variations in the alteration assemblage, e.g. in amounts of chlorite versus sericite. The original rock contained scattered phenocrysts up to 5 mm across (e.g. of feldspar, ferromagnesians), now totally altered. Phenocrysts occurred in a finer grained groundmass. Several sub-parallel quartz-rch veins cut the altered rock, at moderate angles to the core axis (Fig. 64). Veins are up to 8 mm wide and locally contain traces of chalcopyrite and pyrite. The sample is very weakly magnetic, with susceptibility up to 40 x 10^{-5} SI.

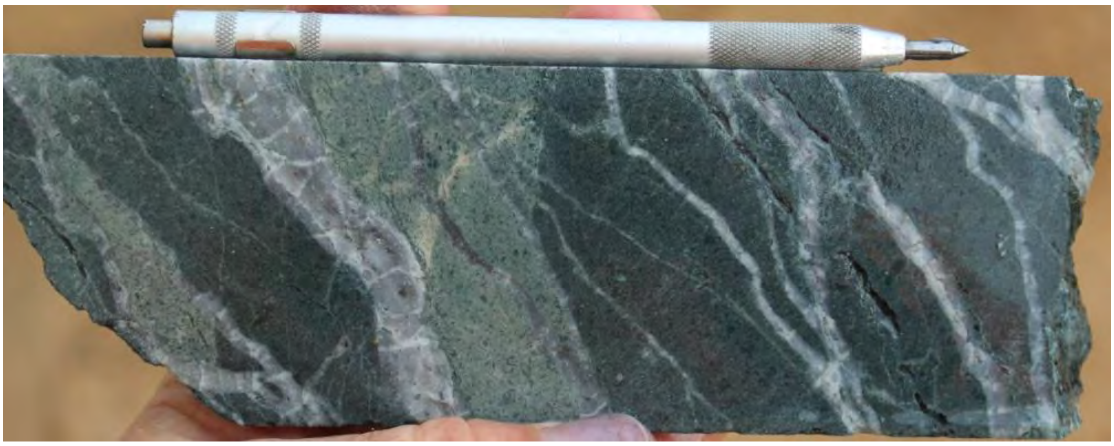

Fig. 64: Drill core sample of altered porphyritic microdiorite that has been invaded by a sub-parallel array of quartz-rich veins. The host rock has strong chlorite-sericite alteration, with colour variations possibly due to differences in amounts of these phases.

Petrographic description

a) Primary rock characteristics: In the section, relict crowded porphyritic texture is moderately preserved (Fig. 65). The rock originally contained abundant blocky feldspar phenocrysts (probably plagioclase) up to 3.5 mm across (mostly <2 mm) as well as scattered ferromagnesian phenocrysts up to 2 mm long (Fig. 65). Relict shapes of the latter imply that they were formerly hornblende. Phenocrystal phases occurred in an inequigranular, fine to medium grained groundmass that contained abundant feldspar, subordinate quartz and ferromagnesian material, and a little disseminated FeTi oxide. There is no primary textural or mineralogical difference across the sample corresponding to the colour variation in handspecimen. From the preserved characteristics, the rock is interpreted as a porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: Strong pervasive alteration and considerable veining were imposed on the igneous rock. All former feldspar was replaced by fine grained sericite, with minor chlorite and quartz (the last mostly in the groundmass), and former ferromagnesian material was replaced by chlorite, with a little leucoxene-rutile and quartz (Figs 65, 66). Igneous FeTi oxide was completely replaced by leucoxene-rutile (Fig. 65). The alteration assemblage is consistent with propylitic type. Despite the colour variation evident in handspecimen, there is little difference in the alteration assemblage in the host rock. It is possible that paler coloured zones contain less chlorite. A few thin veins of chlorite ± quartz were emplaced and these appear to be cut by an array of prominent, sub-parallel quartz-rich veins up to 4 mm wide (Fig. 66). In the latter veins, quartz is inequigranular, fine to medium grained and appears to be recrystallised. Quartz is accompanied in places by a little chlorite, chalcopyrite and pyrite.

c) Mineralisation: In the quartz-rich veins, there are small individual grains and sparse ragged aggregates up to 1 mm across of chalcopyrite and pyrite, grown interstitially to quartz. No sulphides are recognised in the altered host rock.

Mineral Mode (by volume): sericite and chlorite each 35%, quartz 29%, leucoxene-rutile 1% and traces of pyrite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample is a porphyritic hornblende-quartz microdiorite, affected by strong propylitic alteration and cut by several quartz-rich veins. The rock originally had abundant plagioclase and ferromagnesian (probably hornblende) phenocrysts in a fine to medium grained groundmass of feldspar, subordinate quartz and ferromagnesian material, and a little disseminated FeTi oxide. Imposed alteration destroyed most primary minerals and formed an assemblage of sericite and chlorite, minor quartz and leucoxene-rutile. Several sub-parallel quartz-rich veins occur with these also hosting a little chlorite, pyrite and chalcopyrite, and showing indications of recrystallisation.

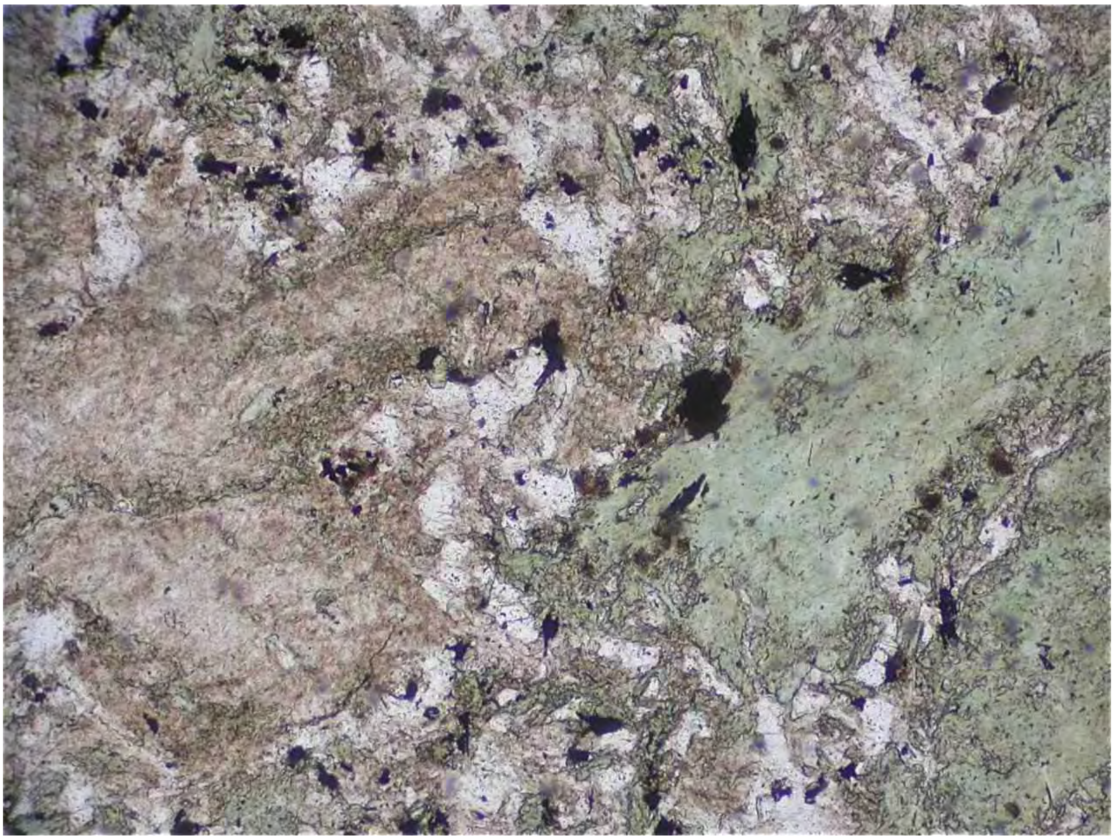

Fig. 65: Moderately preserved relict porphyritic texture in microdiorite, with altered plagioclase phenocrysts (turbid due to fine grained sericite) and altered hornblende (mostly replaced by green chlorite). The groundmass contains altered feldspar and quartz (clear) and the small black grains are leucoxene-rutile. Plane polarised transmitted light, field of view 2 mm across.

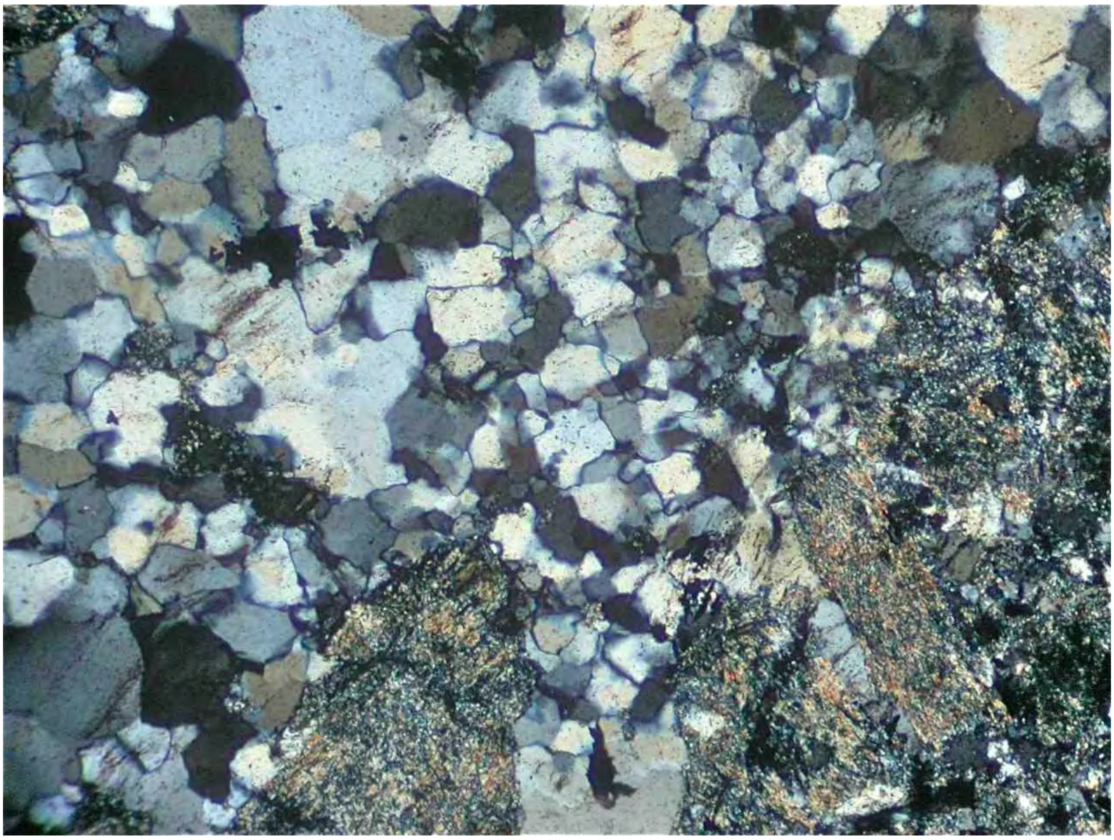

Fig. 66: Intersecting veins containing granular, probably recrystallised quartz, with adjacent strongly sericitised porphyritic microdiorite (lower right). Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 131.9 m TS

Summary: Porphyritic microdiorite or microtonalite, showing poor to moderate preservation of relict texture, and with intense alteration to an argillic assemblage. The rock originally contained abundant blocky feldspar phenocrysts (probably plagioclase) and scattered smaller phenocrysts of a ferromagnesian phase (e.g. hornblende) and a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material, with a little FeTi oxide. The rock was replaced by abundant clay phases (probably illite-smectite > kaolinite) and chlorite, but with local patchy quartz aggregates. A couple of clay veins cut the altered rock.

Handspecimen: The drill core sample is composed of a rather soft and crumbly, strongly clay altered igneous rock, retaining a moderately preserved relict porphyritic texture (Fig. 67). It is creamy-white to grey-green in colour, and it evidently contained scattered feldspar phenocrysts up to a few millimetres across, along with smaller ferromagnesian phenocrysts, enclosed in a finer grained groundmass (Fig. 67). The main alteration phase appears to be a clay mineral, but minor chlorite also occurs and the rock hosts a couple of thin, sub-planar veins with clay and/or chlorite (Fig. 67). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

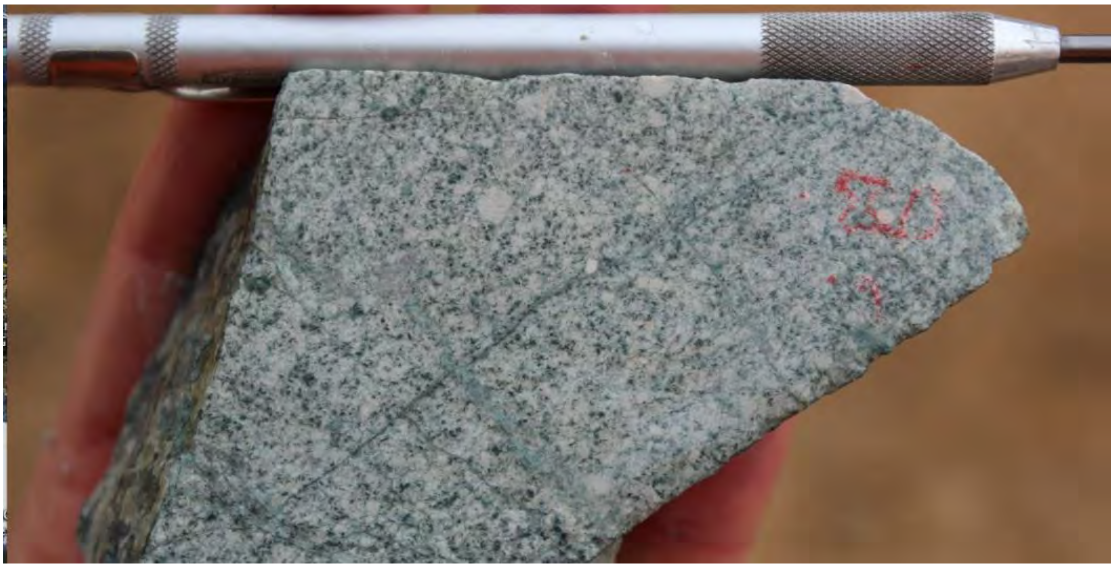

Fig. 67: Drill core sample of porphyritic microdiorite or microtonalite showing strong alteration to pale coloured clay and grey-green chlorite (mainly at former ferromagnesian sites).

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is poorly to moderately preserved (Fig. 68). The rock originally contained abundant blocky feldspar phenocrysts (probably plagioclase) up to 2.5 mm across and less common, smaller ferromagnesian phenocrysts (Fig. 68). The latter have some retention of original prismatic form and could represent sites of former hornblende. The phenocrystal phases appear to have occurred in a fine to medium grained groundmass composed of feldspar, quartz and ferromagnesian material, with minor disseminated FeTi oxide. From the preserved characteristics, the original rock is tentatively interpreted as a porphyritic quartz microdiorite or microtonalite.

b) Alteration and structure: Intense hydrothermal alteration of argillic type was imposed. Original feldspar was replaced by fine grained aggregates of clay phases (could include illite-smectite, as well as low-birefringent kaolinite) and minor quartz, with ferromagnesian material being replaced by chlorite and a little leucoxene-rutile (Fig. 68). In places, patchy fine to medium grained quartz aggregates have invaded the rock ("quartz flooding") and the altered groundmass contains considerable fine grained quartz (Fig. 68), along with the clay phases, chlorite and disseminated aggregates of leucoxene-rutile up to 0.2 mm across, representing former FeTi oxide sites. A couple of sub-planar clay veins (illite-smectite) up to 0.2 mm wide cut the altered rock.

c) Mineralisation: No sulphide minerals are observed in the sample.

Mineral Mode (by volume): clay phases (illite-smectite > kaolinite) 60%, chlorite 20%, quartz 19%, leucoxene-rutile 1%.

Interpretation and comment: It is interpreted that the sample represents an intensely altered porphyritic microdiorite or microtonalite. It has poor to moderate preservation of relict texture, indicating the former presence of abundant blocky feldspar phenocrysts (probably plagioclase) and scattered smaller phenocrysts of a ferromagnesian phase (e.g. hornblende) and a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material, with a little FeTi oxide. The rock was subject to argillic alteration, leading to replacement by abundant clay phases (probably illite-smectite > kaolinite) and chlorite, and with local patchy quartz aggregates. A couple of clay veins cut the altered rock.

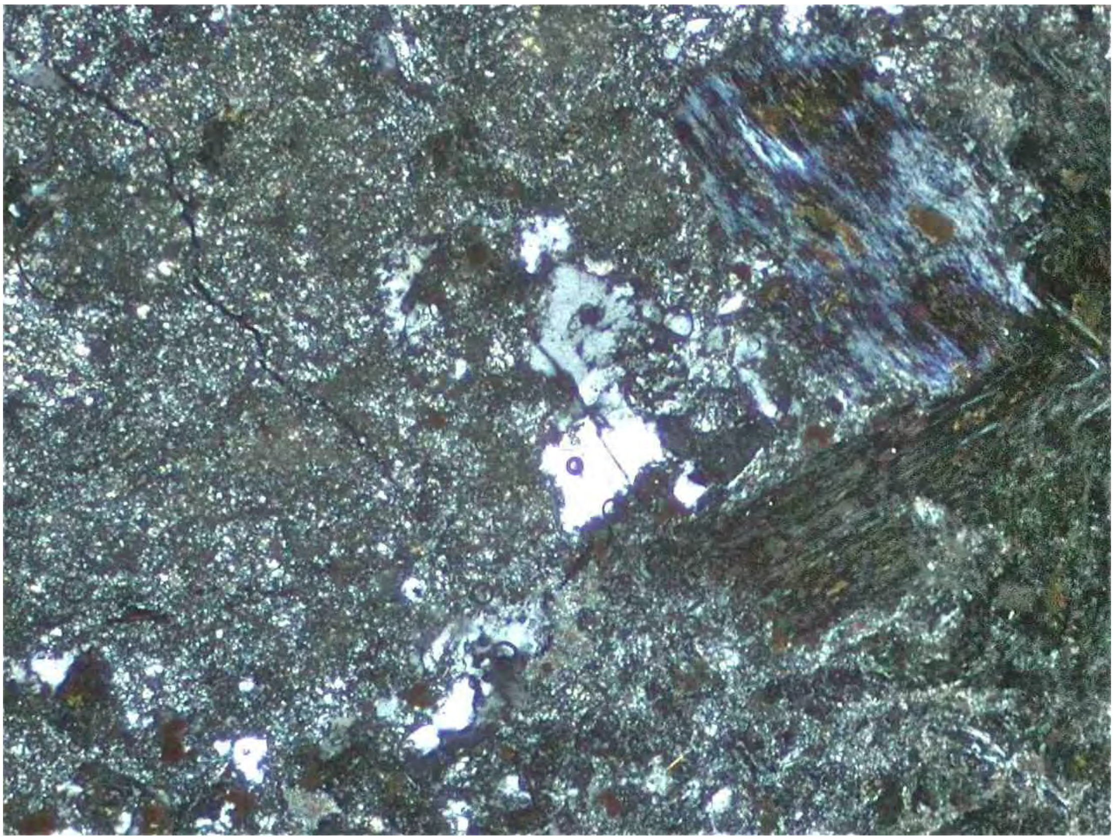

Fig. 68: Intensely altered microdiorite/microtonalite showing vague pseudomorphs at left after plagioclase phenocrysts (now represented by fine grained clay aggregates) and chlorite-replaced hornblende grains at right. Locally abundant quartz has formed interstitially. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 150.1 m TS

Summary: Intensely altered porphyritic hornblende dacite (or microtonalite). There is moderate preservation of relict texture, indicating that the rock originally contained abundant feldspar (e.g. plagioclase) phenocrysts and prismatic ferromagnesian phenocrysts (e.g. hornblende) in an inequigranular, fine to medium grained groundmass of feldspar, quartz and minor ferromagnesian material. Argillic alteration was imposed, with replacement of feldspar and ferromagnesian material and development of an assemblage of fine grained sericite, clay (e.g. kaolinite and illite-smectite), minor chlorite, quartz and pyrite, and a trace of leucoxene-rutile.

Handspecimen: The drill core sample is composed of a massive, creamy to pale grey, strongly altered porphyritic igneous rock, probably of original felsic to intermediate composition. There are scattered pseudomorphs after former blocky feldspar (e.g. plagioclase) phenocrysts up to 8 mm across and there are also grey-green pseudomorphs after a former prismatic ferromagnesian phase (e.g. hornblende) up to 5 mm long (Fig. 69). The original groundmass was fine grained and perhaps of quartzofeldspathic composition. Pervasive alteration appears to be dominated by fine grained clay/sericite, with minor chlorite at ferromagnesian sites, and a trace of disseminated pyrite (Fig. 69). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 69: Drill core sample of porphyritic dacite or microtonalite showing relict texture and altered phenocrysts of plagioclase (whitish) and altered phenocrysts of hornblende (dark grey-green) in a finer grained groundmass. The rock has pervasive strong argillic alteration, with replacement by sericite, clay, chlorite, quartz and minor pyrite.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is moderately preserved (Fig. 70). The rock originally contained scattered blocky feldspar phenocrysts (e.g. plagioclase) up to 4 mm across (mostly <2 mm) as well as a prismatic ferromagnesian phase (e.g. hornblende) up to 5 mm long (mostly <2 mm) (Fig. 70). A few clusters of feldspar and ferromagnesian grains originally occurred. There are also a couple of microphenocrysts of quartz up to 0.6 mm across. These phases were set in a fine to medium grained, inequigranular groundmass with abundant feldspar and quartz, minor ferromagnesian material and a trace of FeTi oxide. From the preserved characteristics, the original rock is interpreted as a porphyritic hornblende dacite (gradational to microtonalite).

b) Alteration and structure: Intense hydrothermal alteration was imposed on the igneous protolith. Feldspar phenocrysts and groundmass feldspar were replaced by fine grained sericite and varying amounts of clay phases (including low-birefringent kaolinite and probable illite-smectite) (Fig. 70). Ferromagnesian material was replaced by sericite and/or clay and/or chlorite, plus a trace of leucoxene-rutile (Fig. 70). Igneous FeTi oxide was replaced by leucoxene-rutile. Although some of the quartz in the groundmass could be of primary igneous origin, some could have also been developed by alteration. Scattered throughout, as part of the alteration assemblage, are individual grains and aggregates of pyrite (Fig. 70). The alteration characteristics are consistent with argillic type.

c) Mineralisation: As part of the alteration assemblage, there are individual grains and aggregates of pyrite up to 0.3 mm across (Fig. 70).

Mineral Mode (by volume): sericite 35%, clay phases (kaolinite > illite-smectite) 30%, quartz 25%, chlorite 8%, pyrite 2% and a trace of leucoxene-rutile.

Interpretation and comment: It is interpreted that the sample is a porphyritic hornblende dacite (or microtonalite) that has undergone intense argillic alteration. Relict texture is moderately preserved and shows that the rock originally contained abundant feldspar (e.g. plagioclase) phenocrysts and prismatic ferromagnesian phenocrysts (e.g. hornblende) in an inequigranular, fine to medium grained groundmass of feldspar, quartz and minor ferromagnesian material. Alteration caused replacement of feldspar and ferromagnesian material and formed an assemblage of fine grained sericite, clay (e.g. kaolinite and illite-smectite), minor chlorite, quartz and pyrite, and a trace of leucoxene-rutile.

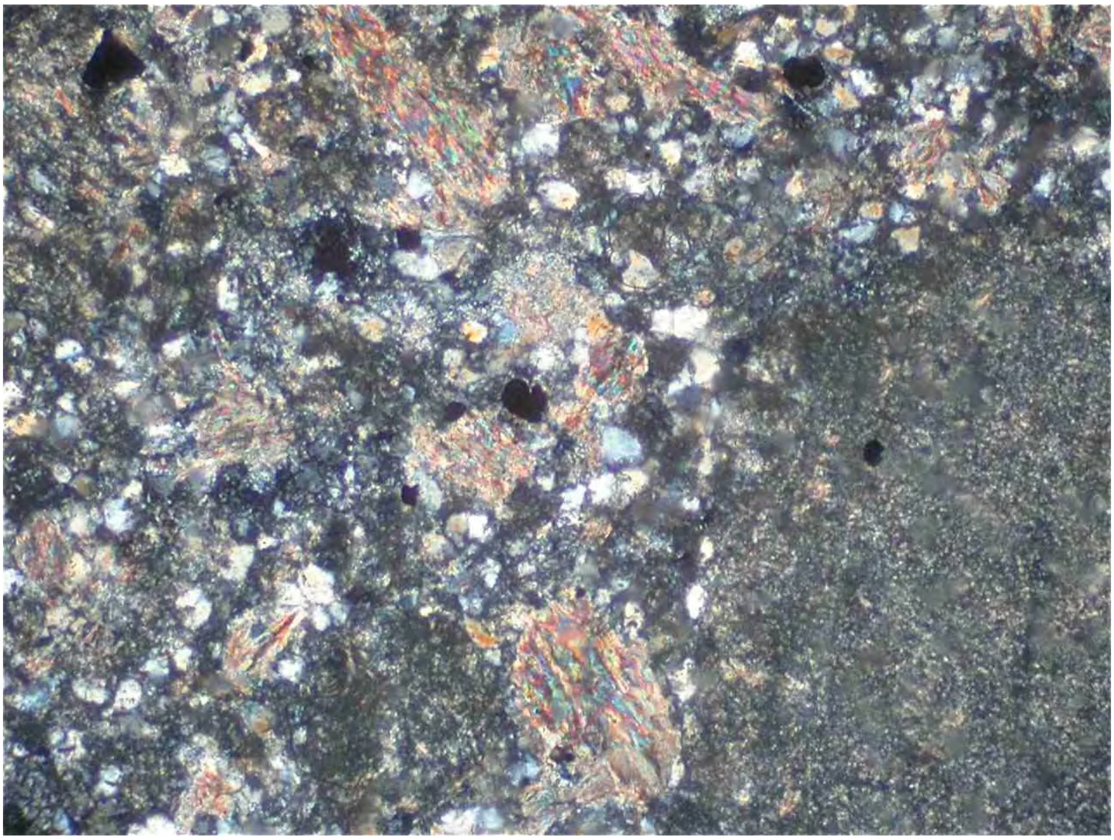

Fig. 70: Feldspar phenocryst at right, replaced by clay, and smaller ferromagnesian phenocrysts replaced by sericite, hosted in a fine grained groundmass containing dominated clay and quartz. Small black grains are pyrite. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 157.1 m PTS

Summary: Sulphide-rich hydrothermal breccia displaying a clast- to matrix-supported texture. Breccia fragments are dominated by fine to medium grained hydrothermal quartz, with minor sericite in places, disseminated pyrite and a trace of rutile. There are no diagnostic textures from a protolith, but it is speculated that it could have been of felsic to intermediate igneous type. The intensely altered fragments are veined and infilled by initial veins and irregular masses rich in sericite, and subsequently by abundant sulphides in places accompanied by quartz. Sulphides range from disseminated to massive and include paragenetically early pyrite, with abundant chalcopyrite and bornite, minor tennantite and traces of stannite and covellite. Bornite and chalcopyrite are typically intergrown.

Handspecimen: The drill core sample represents a zone of sulphide-rich breccia. A pale grey, fine to medium grained quartz-rich rock forms angular fragments up to 1-2 cm across, with the texture of the breccia ranging from clast- to matrix-supported (Fig. 71). Interstitial to the quartz-rich fragments and also occurring as diffuse veins, are abundant sulphides, ranging from zones that are pyrite-rich, to chalcopyrite-rich and bornite-rich (Fig. 71). There are also a few whitish aggregates of fine grained layer silicates (e.g. clay/sericite). In places, massive to slightly banded sulphide aggregates are up to 2-3 cm across. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

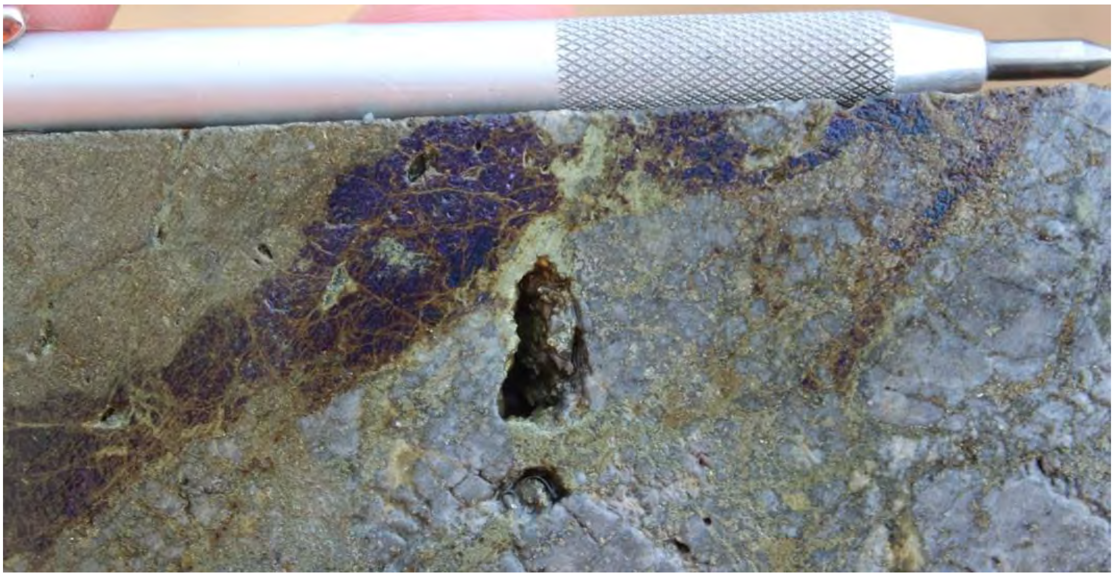

Fig. 71: Drill core sample of sulphide-rich hydrothermal breccia. Pale grey quartz-rich breccia fragments are veined and infilled by pyrite, chalcopyrite and bornite, as well as minor sericite and quartz.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the sample is a sulphide-rich hydrothermal breccia, with breccia infill and veins constituting about a third of the rock. The remainder represents breccia fragments that are up to 3 cm across and commonly veined by sulphides. Fragments are dominated by fine to medium grained, inequigranular quartz and essentially no relict textures after a protolith are recognised. There are a few aggregates of fine grained sericite that could be speculated to be pseudomorphous after former feldspar and/or ferromagnesian grains and the alteration assemblage in the quartz-rich zones also contains a trace of rutile, suggesting that the breccia fragments at least in part represent intensely hydrothermally replaced host rock, rather that being entirely hydrothermal infill material. Perhaps some of the breccia fragments originally had a felsic to intermediate igneous protolith, but there could be a significant hydrothermal infill component.

b) Alteration and structure: A speculative igneous protolith was intensely hydrothermally altered and brecciated with fragments being replaced by fine to medium grained, inequigranular quartz, minor patchy sericite, disseminated pyrite and trace rutile, with probably coeval veining and breccia infilling. It is apparent that there was an early hydrothermal infill phase of fine grained sericite, forming veins and elongate masses up to a few millimetres across in quartz-rich zones (Fig. 72). The sericite-rich aggregates locally contain pyrite and minor amounts of chalcopyrite and bornite. They appear to be cut and overprinted, along with associated quartz-rich zones, by strongly disseminated to massive sulphide aggregates, in places accompanied by fine to medium grained quartz (Fig. 72). Many of the sulphide-rich aggregates are up to 1-3 cm across and contain patchily abundant pyrite, abundant chalcopyrite and bornite (commonly intergrown), minor tennantite (in chalcopyrite and bornite) and traces of stannite and covellite (Figs 73, 74). The mineral assemblage in the breccia fragments suggests that alteration is transitional between phyllic and silicic types.

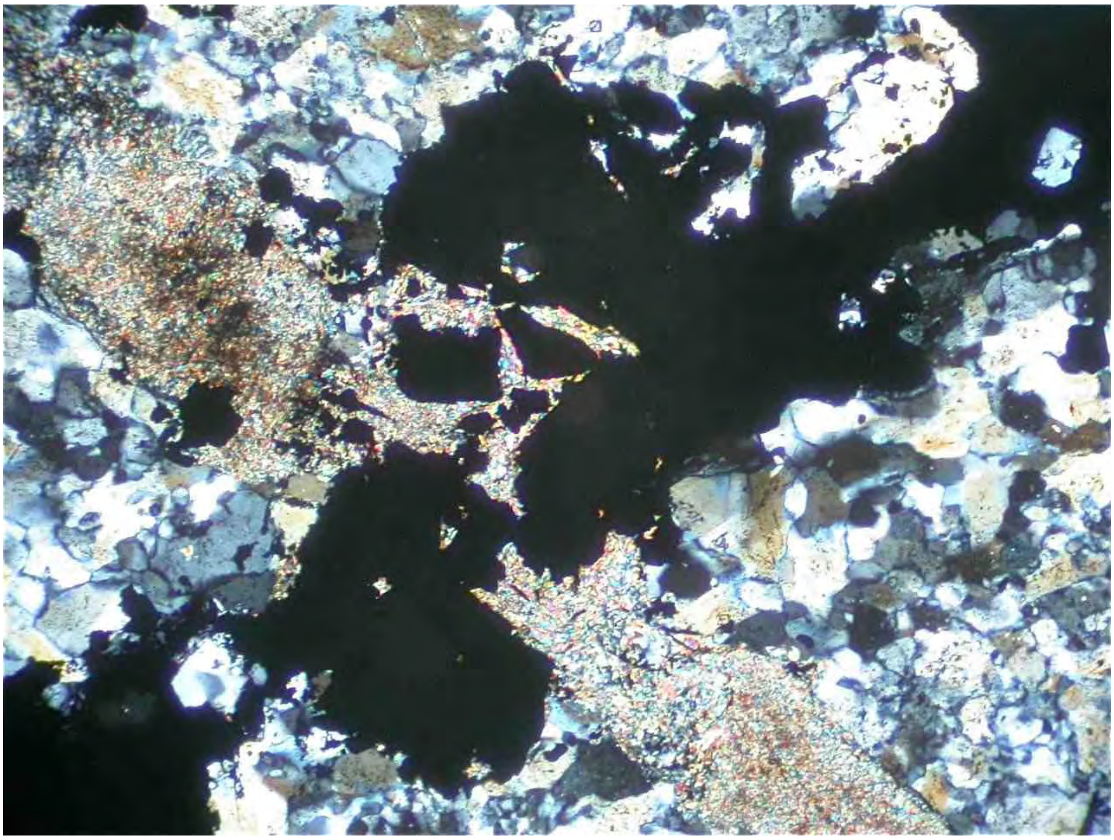

Fig. 72: Sulphide-rich diffuse vein (black) cutting fine grained sericite vein that has in turn cut quartz-replaced breccia fragment. Transmitted light, crossed polarisers, field of view 2 mm across.

c) Mineralisation: The sample contains abundant sulphides, mostly as interstitial in fill in breccia interstices and veins, but there are also disseminated sulphides in altered breccia fragments. Pyrite is locally abundant, with individual anhedral to subhedral grains up to 2 mm across, locally showing zoning and having a few inclusions of chalcopyrite, bornite and tennantite. Pyrite is paragenetically earlier and is invaded and replaced by abundant chalcopyrite and bornite, forming masses up to 1 cm across (Fig. 73). There is considerable intergrowth between bornite and chalcopyrite (e.g. trellis texture), with textures indicating in places that chalcopyrite has replaced bornite. Similarly, scattered masses of tennantite (up to 1 mm across) appear to be paragenetically earlier than, and replaced by, chalcopyrite. A trace of stannite (grains up to 0.1 mm) occurs in chalcopyrite, in association with bornite and tennantite (Fig. 74). Traces of covellite occur sparsely in the breccia, being a late stage phase, perhaps reflecting incipient deep supergene oxidation).

Mineral Mode (by volume): quartz 60%, chalcopyrite 15%, pyrite 10%, bornite 9%, tennantite 1% and traces of rutile, stannite and covellite.

Interpretation and comment: It is interpreted that the sample is a sulphide-rich hydrothermal breccia with fragments dominated by hydrothermal quartz, minor sericite, disseminated pyrite and a trace of rutile. There are no diagnostic textures from a protolith, but it is speculated that it could have been of felsic to intermediate igneous type. Breccia fragments are veined and infilled by initial sericite-rich veins and irregular masses, and subsequently by abundant sulphides in places accompanied by quartz. Sulphides range from disseminated to massive and include paragenetically early pyrite, with abundant chalcopyrite and bornite, minor tennantite and traces of stannite and covellite. Bornite and chalcopyrite are typically intergrown.

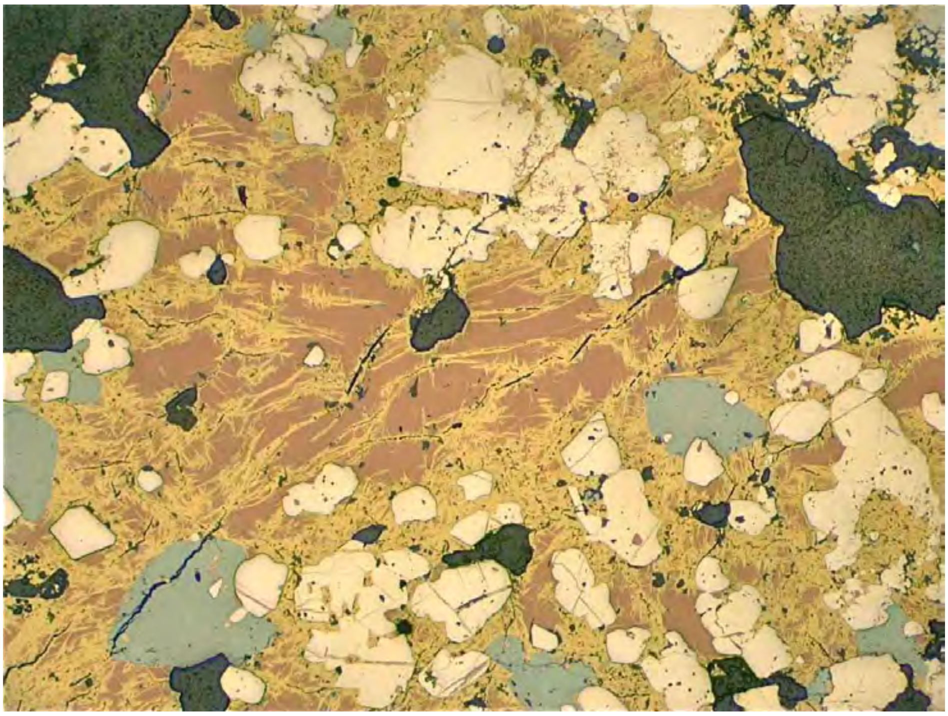

Fig. 73: Sulphide-rich breccia infill zone, showing paragenetically early strongly disseminated pyrite (pale creamy), intergrown chalcopyrite (yellow) and bornite (pink-brown) and a few grains of tennantite (pale grey). Plane polarised reflected light, field of view 2 mm across.

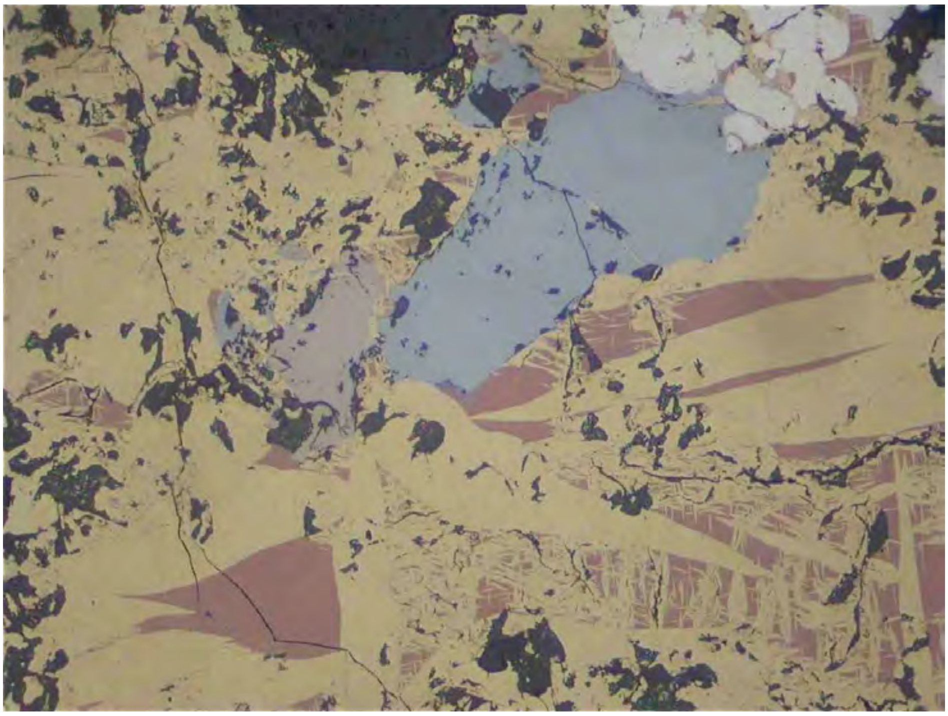

Fig. 74: Intergrown chalcopyrite and bornite (local trellis texture) hosting grains of pyrite (pale creamy, upper right), tennantite (pale grey) and stannite (pale brown-grey). Plane polarised reflected light, field of view 0.5 mm across.

STRC008D 168.5 m TS

Summary: Strongly propylitically altered porphyritic hornblende-quartz microdiorite. The rock has moderate preservation of primary texture, indicative that it originally contained rather abundant phenocrysts of feldspar (assumed to have been plagioclase) and a prismatic ferromagnesian phase (e.g. hornblende). The phenocrysts occurred in a fine to medium grained groundmass of feldspar and subordinate quartz and ferromagnesian material, and a little FeTi oxide. Pervasive alteration led to development of an assemblage of fine grained sericite, chlorite and minor quartz (in the groundmass), plus a little leucoxene and traces of pyrite and chalcopyrite. A single thin vein occurs, containing quartz, minor chlorite and traces of clay and chalcopyrite.

Handspecimen: The drill core sample represents a zone of a massive, strongly altered, porphyritic intermediate to felsic igneous rock. There are abundant grey-green pseudomorphs after former phenocryst phases up to a few millimetres across (Fig. 75). These could have included feldspar and ferromagnesian material and are set in a finer grained groundmass that is pale greenish-cream in colour and was perhaps originally of quartzofeldspathic composition (Fig. 75). The rock has evidently been pervasively altered, with development of fine grained sericite and chlorite, plus a trace of disseminated pyrite. A single thin quartz vein is also observed. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

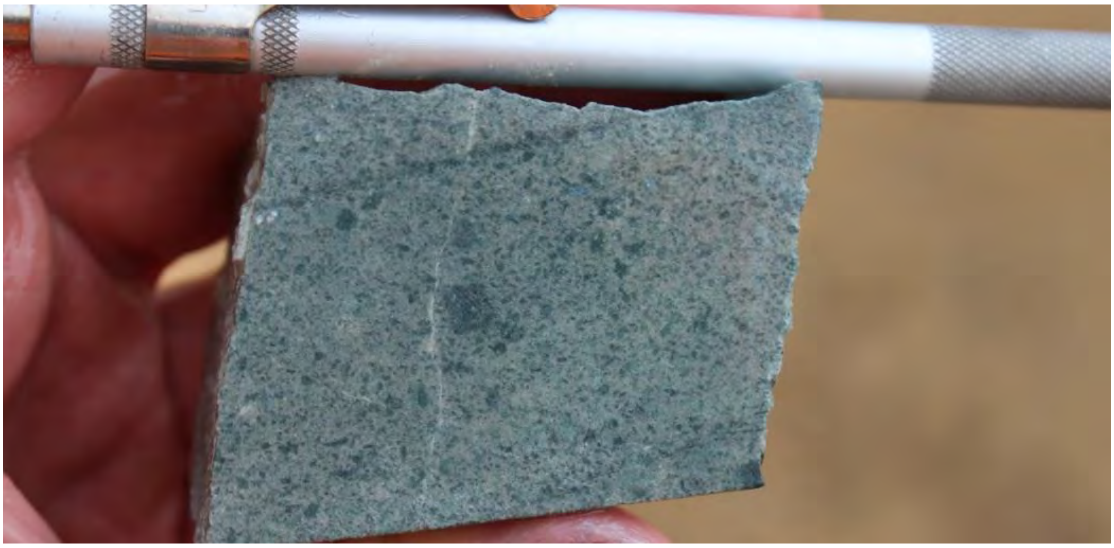

Fig. 75: Drill core sample altered microdiorite showing grey-green pseudomorphs after former feldspar and ferromagnesian phenocrysts in a paler coloured groundmass. The rock has pervasive sericite-chlorite (-quartz) alteration.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is moderately preserved (Fig. 76). There are scattered pseudomorphs after former blocky feldspar (e.g. plagioclase) phenocrysts up to 4 mm across and also after a prismatic ferromagnesian phase (e.g. hornblende) up to 1.5 mm long (Fig. 76). The original phenocryst phases occurred in a fine to medium grained, inequigranular texture groundmass composed of abundant feldspar and subordinate ferromagnesian material and quartz, and a little FeTi oxide. From the preserved primary characteristics, the rock is interpreted as a porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: Strong pervasive hydrothermal alteration of propylitic type was imposed and apart from quartz, all primary minerals were altered. Feldspar phenocrysts were replaced by fine grained aggregates of sericite, with a little chlorite and traces of pyrite and chalcopyrite (Fig. 76). Ferromagnesian material was replaced by chlorite, with traces of leucoxene, pyrite and chalcopyrite, and FeTi oxide was replaced by leucoxene (Fig. 76). Groundmass material was replaced by sericite, chlorite, quartz, a little leucoxene and traces of pyrite and chalcopyrite. The altered rock is cut by a single sub-planar vein, up to 0.2 mm wide, containing quartz, minor chlorite and traces of low-birefringent clay (e.g. kaolinite) and chalcopyrite.

c) Mineralisation: As part of the pervasive alteration, sparse aggregates of pyrite and chalcopyrite up to 0.3 mm across developed, within the groundmass and at altered phenocryst sites.

Mineral Mode (by volume): sericite 55%, chlorite 30%, quartz 13%, leucoxene 1% and traces of clay (kaolinite), pyrite and chalcopyrite.

Interpretation and comment: It is interpreted that the sample represents a porphyritic hornblende-quartz microdiorite with strong propylitic alteration. Primary texture is moderately preserved, showing that it originally contained phenocrysts of feldspar (assumed to have been plagioclase) and a prismatic ferromagnesian phase (e.g. hornblende). Phenocrysts were set in a finer grained groundmass of feldspar and subordinate quartz and ferromagnesian material, and a little FeTi oxide. Pervasive alteration caused development of an assemblage of fine grained sericite, chlorite and minor quartz (in the groundmass), plus a little leucoxene and traces of pyrite and chalcopyrite. The altered rock is cut by a single thin quartz-rich vein.

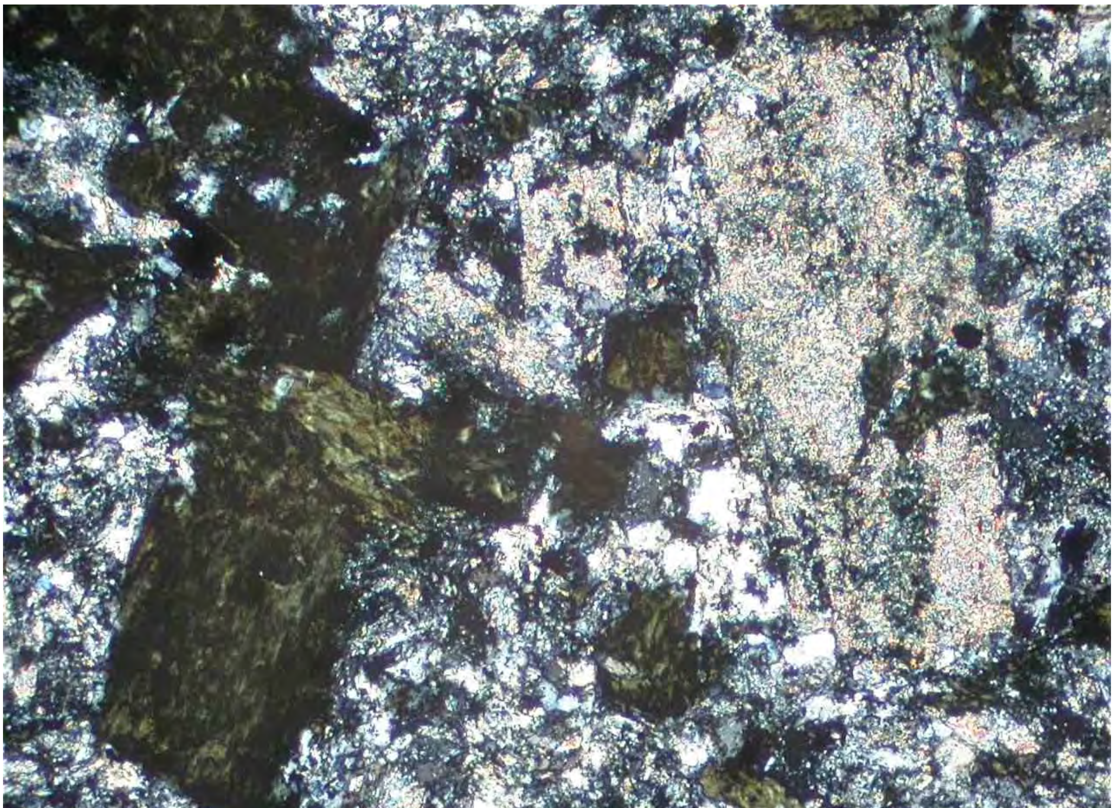

Fig. 76: Strongly altered porphyritic microdiorite with a sericite-rich pseudomorph after a plagioclase phenocryst at right and a couple of chlorite pseudomorphs after former hornblende grains at left. The finer grained groundmass is altered to sericite, quartz and chlorite. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 170.05 m PTS

Summary: Strongly porphyritic hornblende-quartz microdiorite with intense phyllic alteration grading sharply into a zone that contains chlorite as part of the alteration assemblage (i.e. propylitic alteration). The rock has moderately preserved relict texture indicating that it contained abundant feldspar (probably plagioclase) phenocrysts and less common prismatic ferromagnesian (e.g. hornblende) phenocrysts in a fine to medium grained groundmass with abundant feldspar and subordinate ferromagnesian material and quartz. Much of the rock has phyllic alteration, with replacement by a sericite-rich assemblage, plus subordinate quartz, a little disseminated chalcopyrite and pyrite, and a trace of rutile. A minority portion of the sample shows a sharp gradation into an alteration assemblage that has significant chlorite (as well as abundant sericite), mostly at ferromagnesian sites. There is no evidence for more than one rock type to have been present.

Handspecimen: The drill core sample is composed of a strongly altered, massive porphyritic felsic to intermediate igneous rock. It ranges from creamy to grey-green in colour and is fine to medium grained (Fig. 77). Pseudomorphs after former phenocryst phases (probably mostly feldspar, but could include ferromagnesian material) are up to a few millimetres across and are hosted in a finer grained groundmass. The rock has evidently been strongly replaced by fine grained sericite, but in the grey-green domain, chlorite is also present (Fig. 77). A little disseminated pyrite (aggregates up to 2 mm) and chalcopyrite occur throughout. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 77: Drill core sample of altered porphyritic microdiorite displaying a colour change corresponding to a strong phyllic alteration zone (pale creamy) abutting against a zone that contains significant chlorite in the alteration assemblage (grey-green).

Petrographic description

a) Primary rock characteristics: In the section, relict crowded porphyritic texture is moderately preserved, with the rock originally containing at least 50-60% phenocryst phases, dominated by blocky feldspar (e.g. plagioclase) up to 3.5 mm across (Fig. 78). There were also less common phenocrysts of a prismatic ferromagnesian phase (e.g. hornblende) up to 2.5 mm long (Fig. 78). The phenocrystal phases occurred in a subordinate groundmas component, comprising fine to medium grained feldspar, minor quartz and ferromagnesian material, and a trace of FeTi oxide. The preserved primary characteristics indicate that the rock was originally a porphyritic hornblende-quartz microdiorite. There is no evidence for a primary textural or mineralogical change across the sample (i.e. only one rock type occurs).

b) Alteration and structure: The original igneous rock was intensely altered and apart from minor primary quartz, all igneous minerals were replaced. There is an evident mineralogical difference across the sample reflecting the colour variation in handspecimen. In most of the rock there was replacement of feldspar and ferromagnesian components by fine grained sericite, and a subordinate amount of fine grained quartz in the groundmass, along with a little disseminated chalcopyrite and pyrite, and a trace of rutile. Locally, a little chlorite occurs at ferromagnesian sites, but in part of the section, corresponding to the grey-green domain in handspecimen, chlorite is more abundant at former ferromagnesian sites (Fig. 78). Sulphides are sparsely scattered throughout, with a few individual grains and aggregates of pyrite, as well as disseminated chalcopyrite, locally forming composites with pyrite (Fig. 79). Alteration in the sample is largely of phyllic type, but there is a sharp gradation to propylitic type where chlorite becomes more apparent.

c) Mineralisation: As part of the pervasive alteration, minor disseminated pyrite and chalcopyrite have developed throughout. Pyrite forms small individual grains and medium grained aggregates up to 2.5 mm across, locally with attached, paragenetically later, chalcopyrite (Fig. 79). There are also scattered discrete aggregates of chalcopyrite up to 0.5 mm across, commonly at altered phenocryst sites. A tiny grain of galena has been observed included in chalcopyrite.

Mineral Mode (by volume): sericite 65%, quartz 28%, chlorite 3%, pyrite and chalcopyrite each 2% and traces of rutile and galena.

Interpretation and comment: It is interpreted that the sample is a strongly altered, crowded porphyritic texture hornblende-quartz microdiorite. Relict texture is moderately preserved indicating that the rock contained abundant feldspar (probably plagioclase) phenocrysts and less common prismatic ferromagnesian (e.g. hornblende) phenocrysts in a fine to medium grained groundmass with abundant feldspar and subordinate ferromagnesian material and quartz. Much of the rock has phyllic alteration, with replacement by a sericite-rich assemblage, plus subordinate quartz, a little disseminated chalcopyrite and pyrite, and a trace of rutile. There is a sharp gradation into a minority portion of the sample that has an alteration assemblage with significant chlorite (as well as abundant sericite), mostly at ferromagnesian sites. There is no evidence for more than one rock type to have been present.

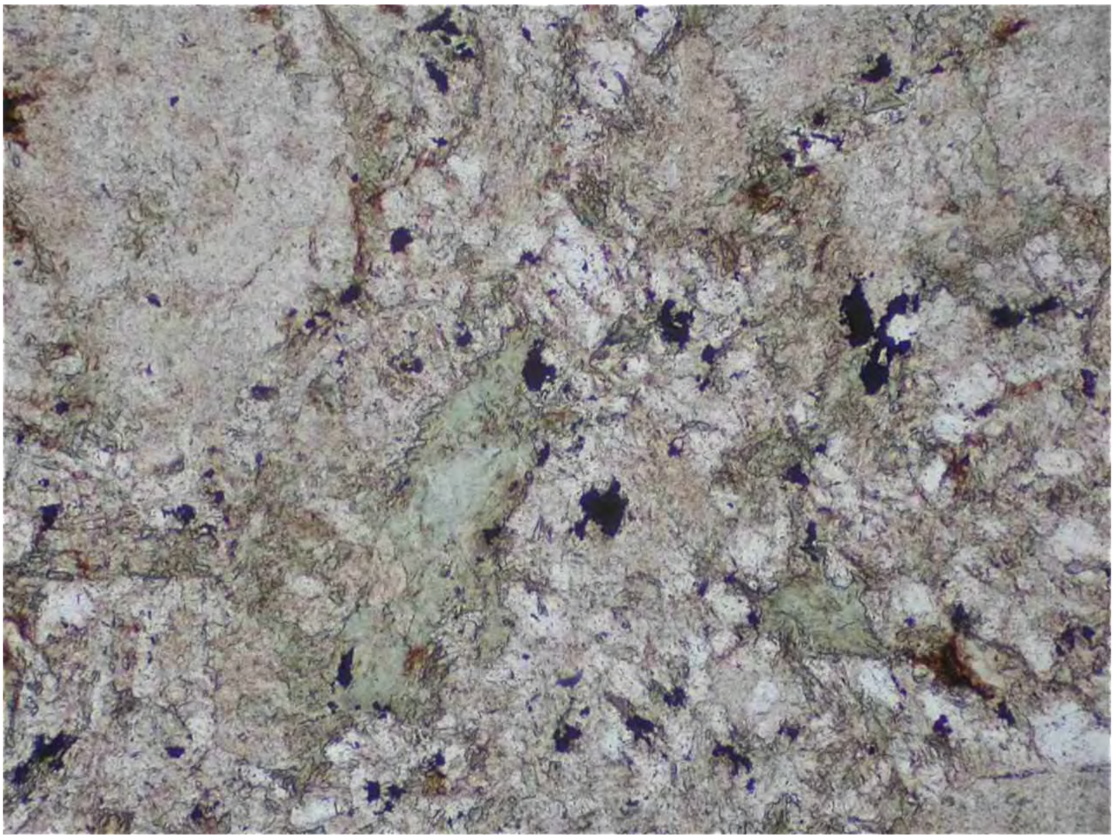

Fig. 78: Portion of the porphyritic microdiorite that has significant chlorite in the alteration assemblage. Note the relict porphyritic texture, with pseudomorphs after former blocky plagioclase phenocrysts, now replaced by sericite, and the greenish chlorite aggregates after former ferromagnesian grains. Small black aggregates include rutile and chalcopyrite. Plane polarised transmitted light, field of view 2 mm across.

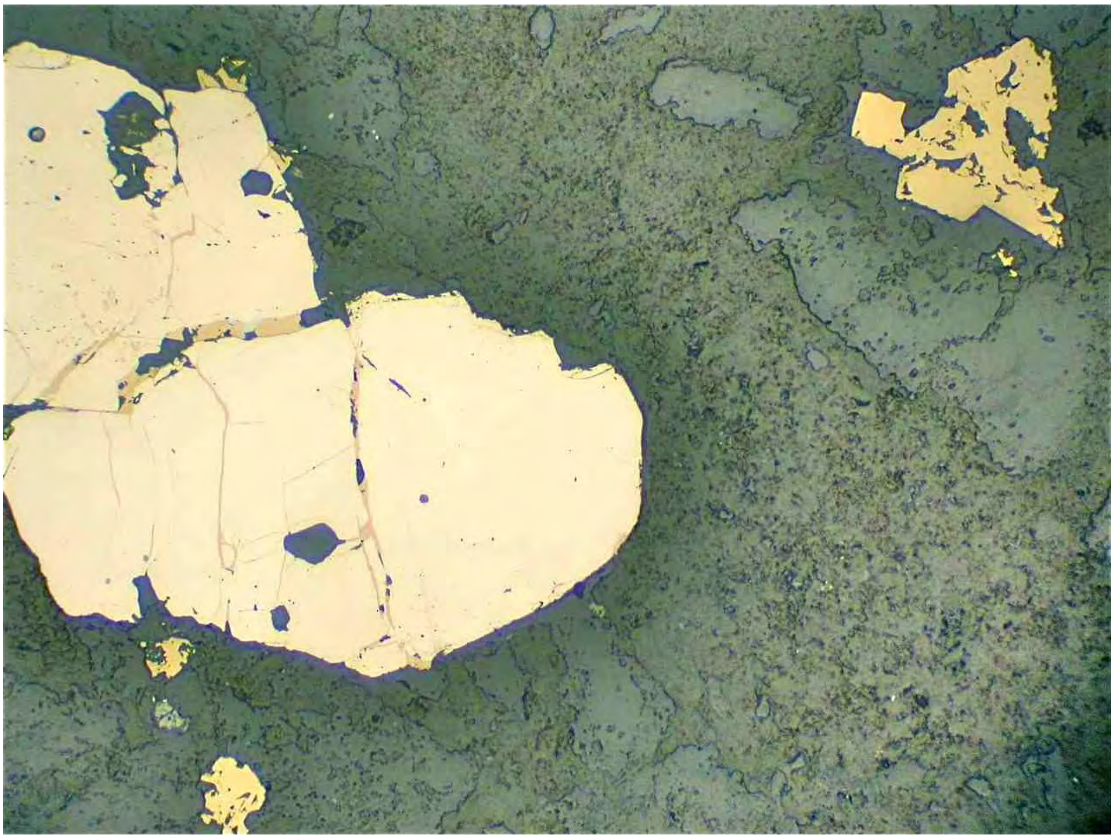

Fig. 79: Fractured pyrite grains (pale creamy) at left with infilling by chalcopyrite, plus a couple of small, discrete aggregates of chalcopyrite (yellow). Sulphides mostly hosted in fine grained sericite. Plane polarised reflected light, field of view 1 mm across.

STRC008D 185.45 m PTS

Summary: Pyrite-quartz veining within an intensely altered porphyritic igneous rock, perhaps originally of felsic to intermediate composition. There are a few pseudomorphs after possible feldspar phenocrysts, but generally, the host rock has little preserved texture and is composed of fine to medium grained quartz, subordinate sericite, a little disseminated pyrite and trace rutile. Vein material is dominated by medium to coarse pyrite, commonly fractured, and with interstitial quartz and local sericite aggregates. A tiny trace of chalcopyrite occurs within pyrite.

Handspecimen: The drill core sample displays veins at least 4 cm wide at a low angle to the core axis, containing medium to coarse grained pyrite and pale grey quartz, occurring within pale creamy-grey, strongly hydrothermally altered, medium grained igneous rock (Fig. 80). The latter might have been of granitic type, but is strongly replaced by sericite, quartz and minor pyrite (Fig. 80). In the veins, pyrite grains are up to 4 mm across and are commonly fractured, with quartz occurring interstitially. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 80: Drill core sample showing rather coarse pyrite-quartz vein (lower left) abutting against pale coloured, strongly phyllic altered igneous host rock (upper right).

Petrographic description

a) Primary rock characteristics: In the section, ~50% of the sample represents vein infill and the remainder is intensely hydrothermally altered host rock. In much of the latter, no relict texture is recognised due to hydrothermal reconstitution. In places, however, there are a few pseudomorphic aggregates up to 1.5 mm across that tend to have rectangular outlines and may be after former feldspar phenocrysts (Fig. 81). There are other, smaller pseudomorphic aggregates that could be speculated to be after former ferromagnesian grains. From these textural vestiges, it is proposed that the protolith was a porphyritic intermediate to felsic type, similar to many other samples in the suite.

b) Alteration and structure: The protolith was intensely hydrothermally altered and cut by pyrite-quartz veining The alteration assemblage is of phyllic type, being composed of inequigranular, fine to medium grained quartz, subordinate sericite (some in pseudomorphs), plus a little disseminated pyrite and trace rutile (Fig. 81). Vein fillings are up to 2.5 cm wide and display medium to coarse grained pyrite (in places strongly fractured) (Fig. 82), with interstitial quartz and a couple of elongate patches of sericite. Some of the infill quartz has strain phenomena, including syn-tectonic fibre growth texture. Rare tiny grains of chalcopyrite occur in pyrite.

c) Mineralisation: The altered host rock contains a little disseminated pyrite. Vein infill has disseminated to semi-massive, medium to coarse pyrite, with individual grains up to 4 mm across and showing fracturing and shattering in places (Fig. 82). Rare tiny grains of chalcopyrite (up to 20 µm) occur in pyrite.

Mineral Mode (by volume): quartz 50%, pyrite 35%, sericite 15% and traces of rutile and chalcopyrite.

Interpretation and comment: It is interpreted that the sample is an intensely phyllic altered porphyritic intermediate to felsic igneous rock hosting pyrite-quartz veining. The igneous rock was replaced by quartz and sericite, with a little pyrite and trace rutile, largely destroying most primary texture. Vein material is dominated by medium to coarse pyrite, commonly fractured, and with interstitial quartz and local sericite aggregates. A tiny trace of chalcopyrite occurs within pyrite.

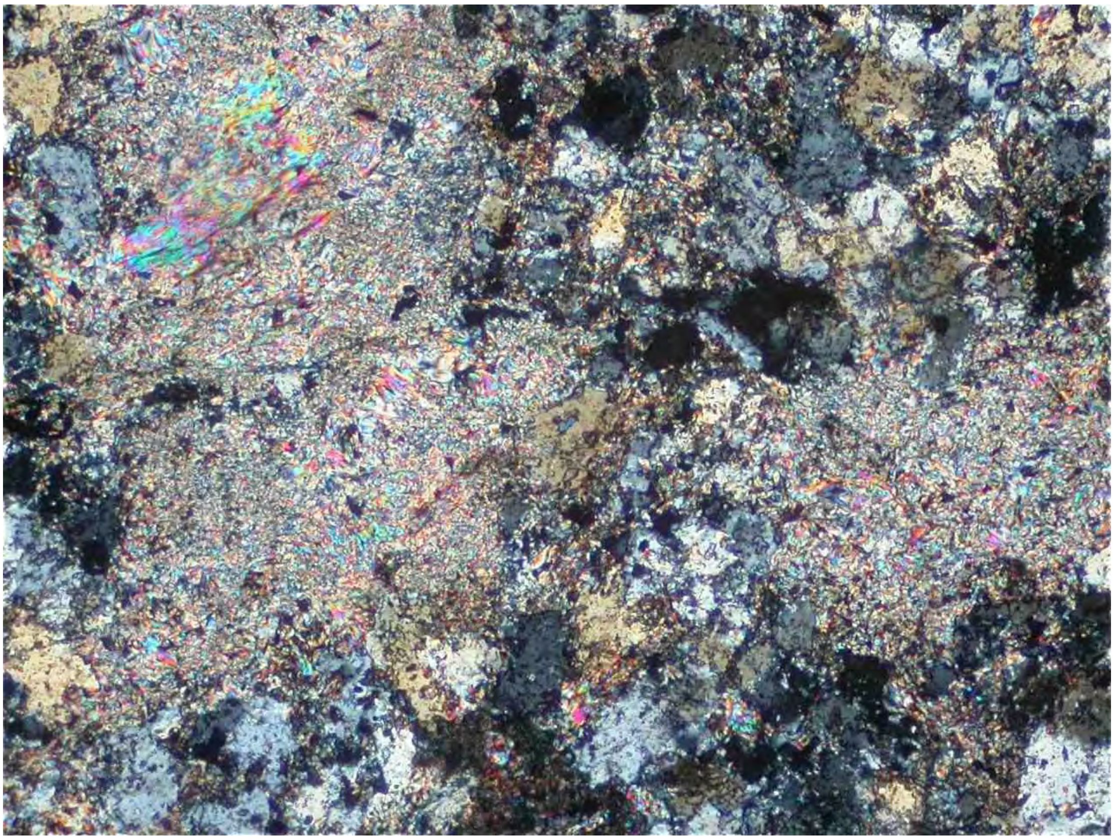

Fig. 81: Pseudomorphic aggregates of sericite, perhaps after former feldspar phenocrysts, enclosed by an alteration aggregate of quartz, sericite and minor pyrite (black). Transmitted light, crossed polarisers, field of view 2 mm across.

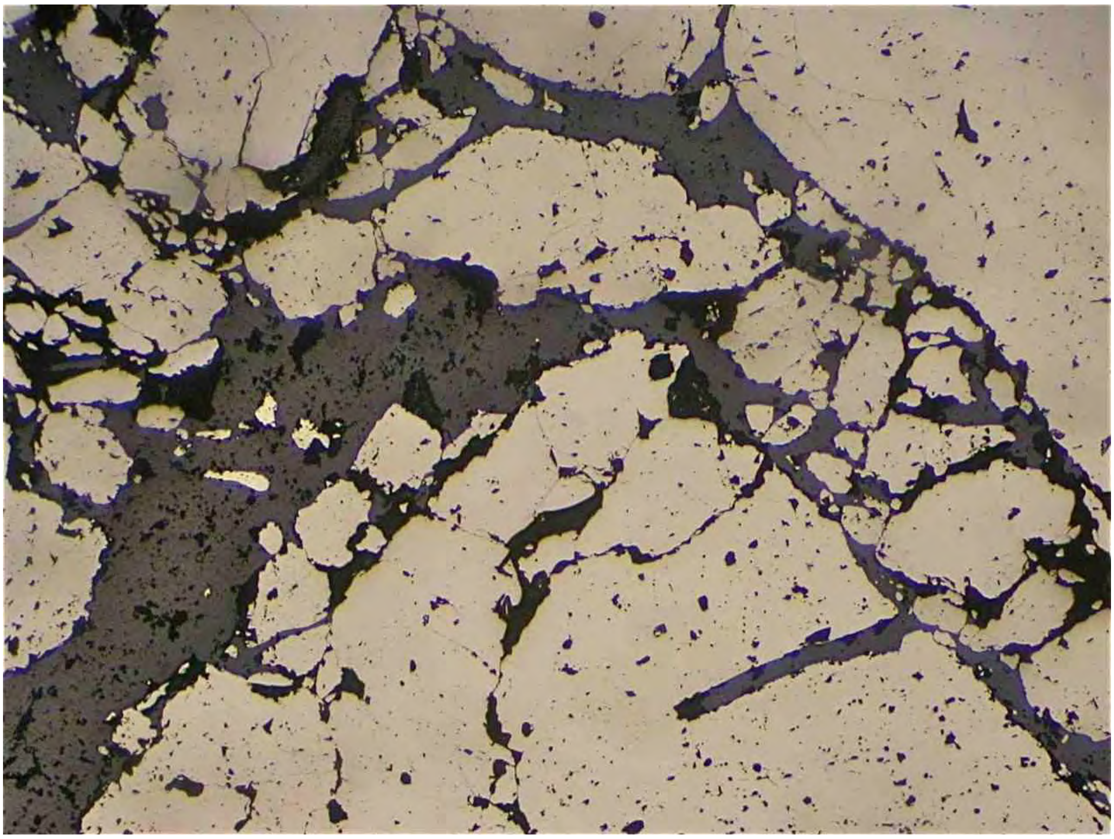

Fig. 82: Fractured pyrite grains (pale creamy) with interstitial quartz (dark grey) as part of a vein infill assemblage. Plane polarised reflected light, field of view 2 mm across.

STRC008D 188.5 m PTS

Summary: Intensely phyllic altered porphyritic quartz microdiorite, with a few veins. Due to the pervasive alteration, the rock only has poor to moderate preservation of original texture, but it can be deduced that it formerly contained abundant feldspar (probably plagioclase) phenocrysts, with a small amount of ferromagnesian material (e.g. hornblende) and a few quartz microphenocrysts. A finer grained groundmass component was relatively minor. Feldspar and ferromagnesian material was replaced by fine grained sericite and subordinate quartz, with significant disseminated pyrite and chalcopyrite being formed, along with a trace of rutile. A couple of pyrite (-quartz-chalcopyrite) veins were emplaced and appear to have preceded emplacement of a couple of quartz-rich veins that also contain minor pyrite, chalcopyrite and sericite.

Handspecimen: The drill core sample is composed of a pale grey, largely massive, fine to medium grained and strongly hydrothermally altered rock, apparently of porphyritic type and possibly of former felsic to intermediate composition. Rather diffuse pseudomorphs after abundant former feldspar phenocrysts are up to 3 mm across (Fig. 83). The rock was replaced by fine grained quartz, sericite and disseminated pyrite and chalcopyrite and cut by a couple of sub-planar veins up to 2 mm wide containing quartz and/or sulphides, generally occurring at a low angle to the core axis (Fig. 83). The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI.

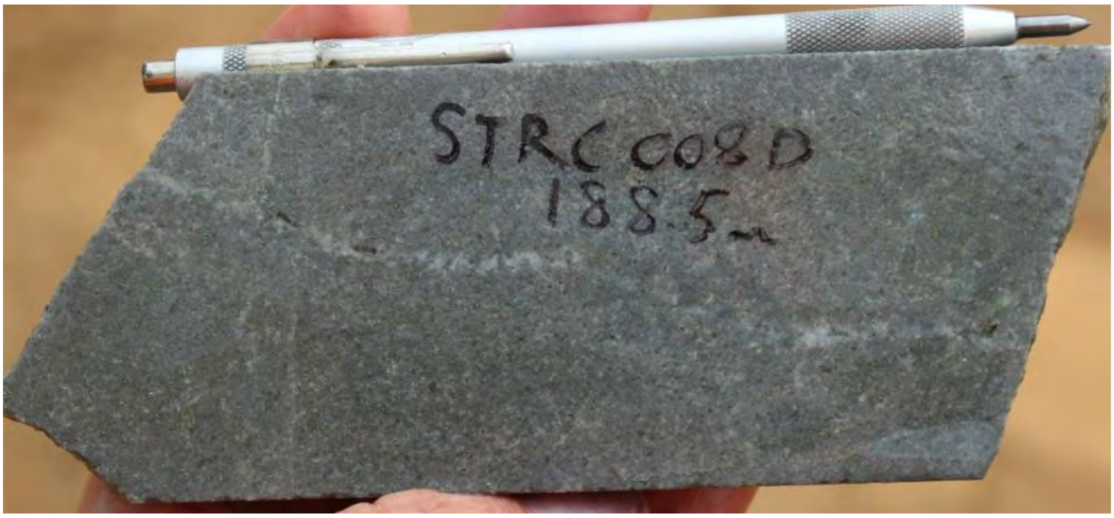

Fig. 83: Drill core sample of intensely phyllic altered microdiorite hosting a couple of thin quartz-rich veins. The rock has a pervasive alteration assemblage of sericite, quartz, pyrite and chalcopyrite.

Petrographic description

a) Primary rock characteristics: In the section, relict crowded porphyritic texture is poorly to moderately preserved (Fig. 84). The rock originally contained abundant blocky feldspar (probably plagioclase) phenocrysts, up to 4 mm across (Fig. 84), with a minor amount of prismatic ferromagnesian material (perhaps hornblende) that locally formed phenocrysts up to 3 mm long. There are also a few quartz microphenocrysts up to 0.8 mm across and interstitial to the phenocrysts, the rock would have contained a subordinate fine to medium grained groundmass component (maybe 30% of the rock) that was dominated by feldspar, with minor quartz and ferromagnesian material, and a trace of FeTi oxide. From the preserved primary characteristics, the rock is interpreted as an altered porphyritic quartz microdiorite.

b) Alteration and structure: Intense hydrothermal alteration was imposed on the igneous rock and a few veins emplaced. All former feldspar was replaced by fine grained aggregates of sericite, with local quartz and sulphides (Fig. 84). Ferromagnesian grains were also entirely replaced by sericite, local quartz and sulphides and a trace of rutile, and FeTi oxide was replaced by rutile. Scattered patches of quartz and sulphides, up to 2.5 mm across, formed throughout, with sulphide aggregates replacing groundmass and phenocryst sites (Fig. 85). A couple of sub-planar, discontinuous veins up to 1 mm wide contain pyrite and minor quartz and chalcopyrite were emplaced and they appear to pre-date emplacement of a couple of quartz-rich veins. One of the latter is prominent, up to 2.5 mm wide, and contains medium grained quartz, with minor pyrite, interstitial chalcopyrite and a trace of sericite. The observed alteration assemblage is consistent with phyllic type.

c) Mineralisation: The rock contains rather abundant disseminated sulphides, as part of the pervasive alteration and also in veins (Figs 84, 85). Pyrite forms individual anhedral grains and aggregates up to 1.5 mm across, commonly forming composites with chalcopyrite that are up to several millimetres across (Fig. 85). Textures indicate that chalcopyrite is paragenetically later than pyrite. Chalcopyrite also forms individual ragged aggregates up to 1.5 mm across.

Mineral Mode (by volume): sericite 70%, quartz 20%, pyrite and chalcopyrite each 5% and a trace of rutile.

Interpretation and comment: It is interpreted that the sample represents a former porphyritic quartz microdiorite that was subjected to intense phyllic alteration and emplacement of a few veins. The rock has poor to moderate preservation of original texture, but it can be deduced that it formerly contained abundant feldspar (probably plagioclase) phenocrysts, with a small amount of ferromagnesian material (e.g. hornblende), a few quartz microphenocrysts, all set in a subordinate amount of finer grained groundmass. Alteration caused feldspar and ferromagnesian material to be replaced by sericite and subordinate quartz, with significant disseminated pyrite and chalcopyrite, and a trace of rutile. A couple of pyrite (-quartz-chalcopyrite) veins were emplaced and appear to have preceded emplacement of a couple of quartz-rich veins that also contain minor pyrite, chalcopyrite and sericite.

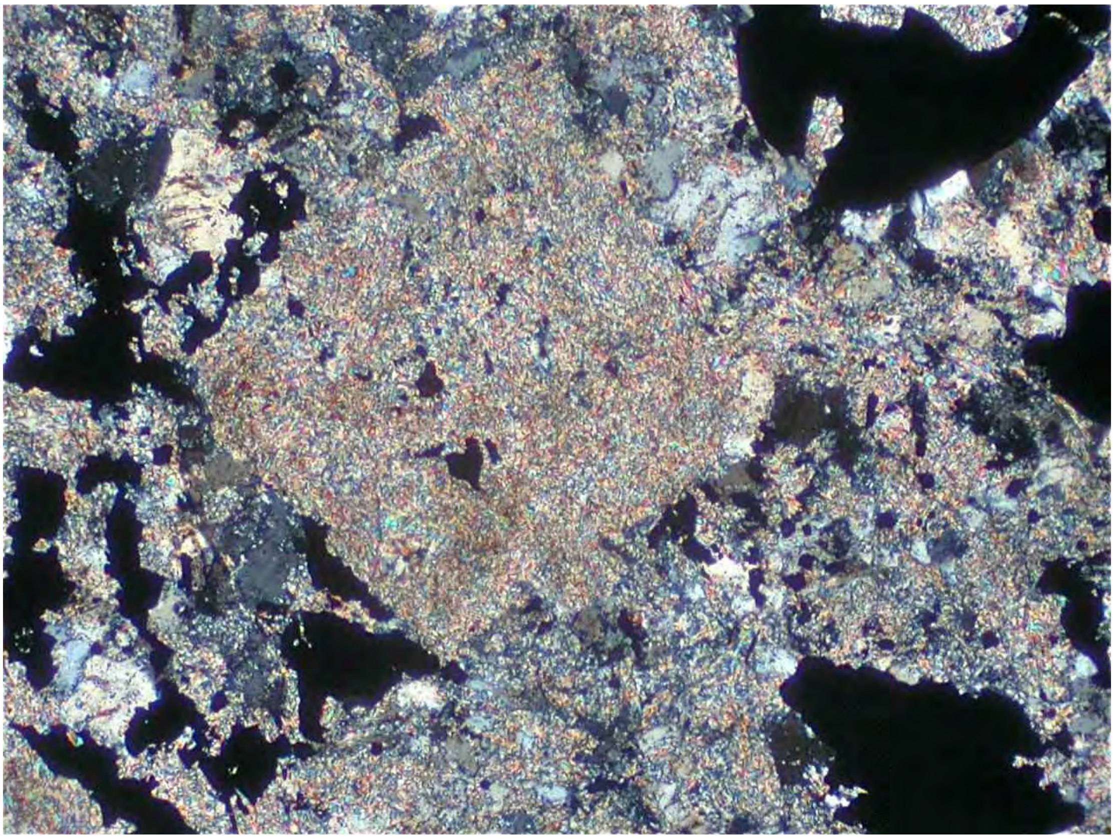

Fig. 84: Sericite pseudomorph after a former feldspar phenocryst, enclosed in an alteration assemblage of sericite, quartz and sulphides (black). Transmitted light, crossed polarisers, field of view 2 mm across.

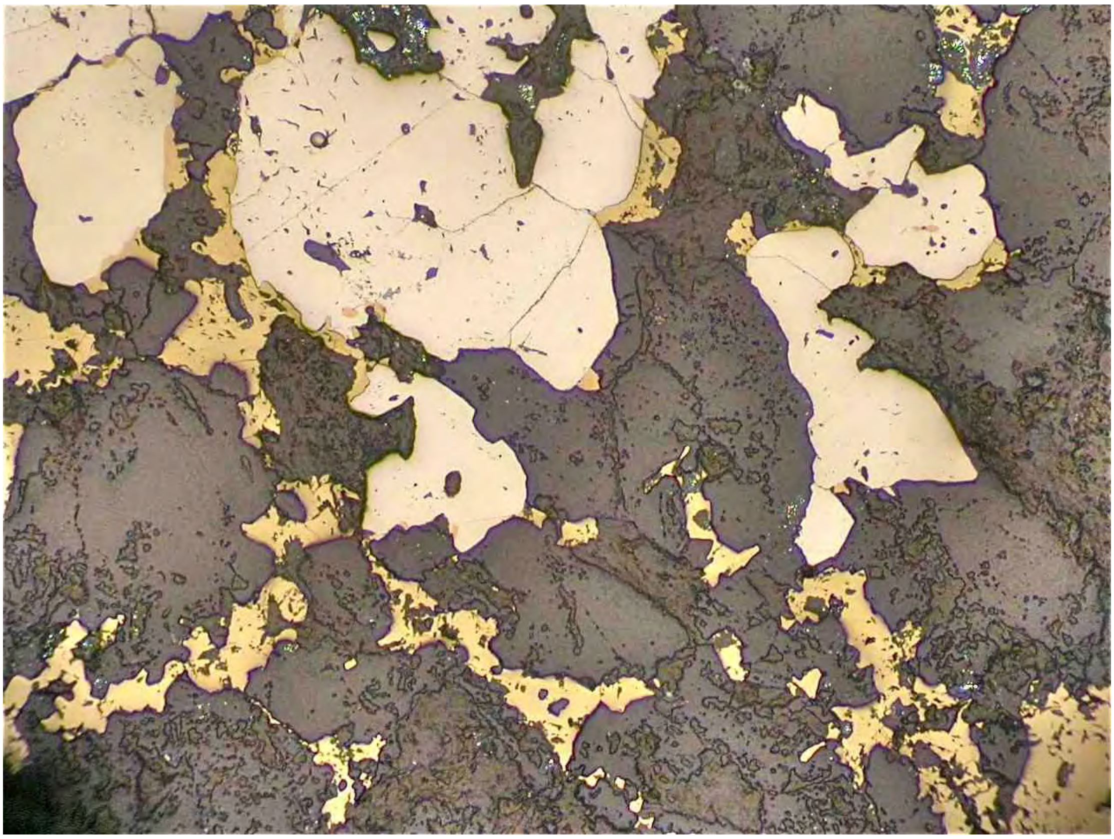

Fig. 85: Portion of an aggregate of pyrite (pale creamy) and paragenetically later chalcopyrite (yellow) hosted in sericite-quartz-altered microdiorite. Plane polarised reflected light, field of view 2 mm across.

STRC008D 223.4 m PTS

Summary: Intensely phyllic altered fine grained rock, possibly a matrix-supported siltstone. It preserves a few possoble small relict detrital quartz grains and a trace of zircon in a completely hydrothermally replaced matrix, now altered to sericite, quartz, minor disseminated pyrite and traces of chalcopyrite and rutile. Within the altered rock are sparsely scattered fine grained quartz-rich aggregates, with a little hematite pigmentation and trace associated rutile, chalcopyrite and pyrite. These are of metasomatic growth origin and do not represent replaced phenocrysts. The sample is cut by a single vein of pyrite, with minor associated quartz, chalcopyrite and trace galena, and subsequently by a network of quartz-rich veins that also host a few aggregates of pyrite and chalcopyrite. Textures indicate that chalcopyrite and galena are paragenetically later than pyrite.

Handspecimen: The drill core sample is composed of a strongly altered, fine grained whitish rock containing an irregular network of pale grey quartz-rich veins up to several millimetres wide and at least one prominent pyrite-rich vein up to 3 mm wide at ~60° to the core axis (Fig. 86). It is possible that the quartz-rich veining (that also contains minor pyrite and chalcopyrite) cuts the pyrite-rich vein (Fig. 86). The host rock has no recognised relict texture and appears to be rich in clay/sericite, with minor disseminated pyrite and a few sub-spheroidal dark reddish-brown aggregates up to 4 mm across that appear to be quartz-rich and pigmented by hematite (Fig. 86). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 86: Drill core sample of intensely phyllic altered fine grained rock, possibly originally siltstone, showing a few dark reddish-brown "spots" of hematite-pigmented quartz, a dark pyrite-rich vein and apparently later, pale grey quartz-rich veins.

Petrographic description

a) Primary rock characteristics: In the section, no definite relict texture is recognised and the rock is largely the product of strong hydrothermal replacement and associated veining. However, there are sparsely scattered, small (up to 0.2 mm) sub-rounded quartz grains and rare zircon that are speculated to represent original detrital grains. These are distributed in a totally recrystallised fine grained matrix (Fig. 87). Consequently, it is tentatively proposed that the original rock was a fine grained siltstone, with a matrix-supported texture.

b) Alteration and structure: It is interpreted that the protolith was very strongly hydrothermally altered, with associated emplacement of several veins. The replacement assemblage is dominated by fine grained sericite and quartz, with minor disseminated pyrite (porphyroblastic aggregates up to 2 mm) and traces of rutile and chalcopyrite (Fig. 87). Sparsely scattered are ovoid to spheroidal fine grained quartz-rich aggregates up to 4 mm across, in places containing ultrafine hematite disting (Fig. 88), with a little associated rutile, chalcopyrite and pyrite. These aggregates do not represent replaced quartz phenocrysts (or any other former phenocryst phase) and are regarded as being of metasomatic growth origin. The altered rock is cut by a single sub-planar vein up to 3 mm wide that contains abundant medium grained pyrite, with minor interstitial quartz, a little chalcopyrite and trace galena. This vein appears to pre-date the emplacement of a network of quartz-rich veins up to 4 mm wide, with the latter containing medium grained quartz, a few pyrite aggregates and a little chalcopyrite (Fig. 89). Alteration in the sample is consistent with phyllic type.

c) Mineralisation: The sample contains locally significant sulphides. In the altered host rock, there are disseminated, fine to medium grained porphyroblastic aggregates of pyrite up to 2 mm across, with a trace of chalcopyrite (e.g. in quartz-rich aggregates). The pyrite-rich vein contains abundant medium to coarse pyrite (up to 2.5 mm), with a little interstitial chalcopyrite and trace galena, mainly filling fractures in pyrite. A few aggregates of chalcopyrite up to 1.5 mm across occur in association with pyrite in the quartz-rich veins (Fig. 89). Textures indicate that chalcopyrite and galena are paragenetically later than pyrite.

Mineral Mode (by volume): quartz 60%, sericite 30%, pyrite 8%, chalcopyrite 1% and traces of rutile, hematite, galena and zircon.

Interpretation and comment: It is interpreted that the sample is a strongly phyllic altered fine grained rock, possibly originally a matrix-supported siltstone. It was replaced by fine grained sericite and quartz, and shows development of possibly metasomatic growth aggregates of fine grained quartz, with a little hematite pigmentation and traces of rutile, chalcopyrite and pyrite. The sample is cut by a single vein of pyrite, with minor associated quartz, chalcopyrite and trace galena, and subsequently by a network of quartz-rich veins that also host a few aggregates of pyrite and chalcopyrite. Textures indicate that chalcopyrite and galena are paragenetically later than pyrite.

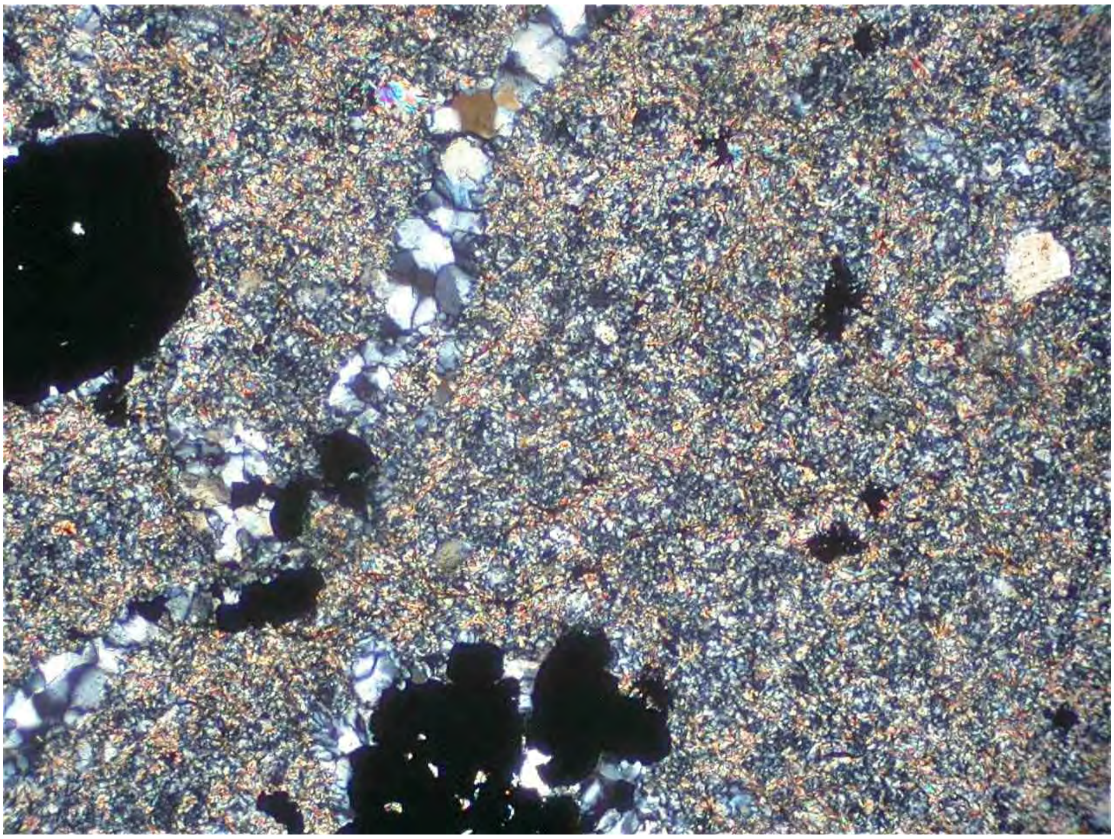

Fig. 87: Fine grained ?siltstone host rock (note possible relict detrital quartz grain at upper right) replaced by sericite, quartz and porphyroblastic pyrite (black) and cut by a narrow quartz vein. Transmitted light, crossed polarisers, field of view 2 mm across.

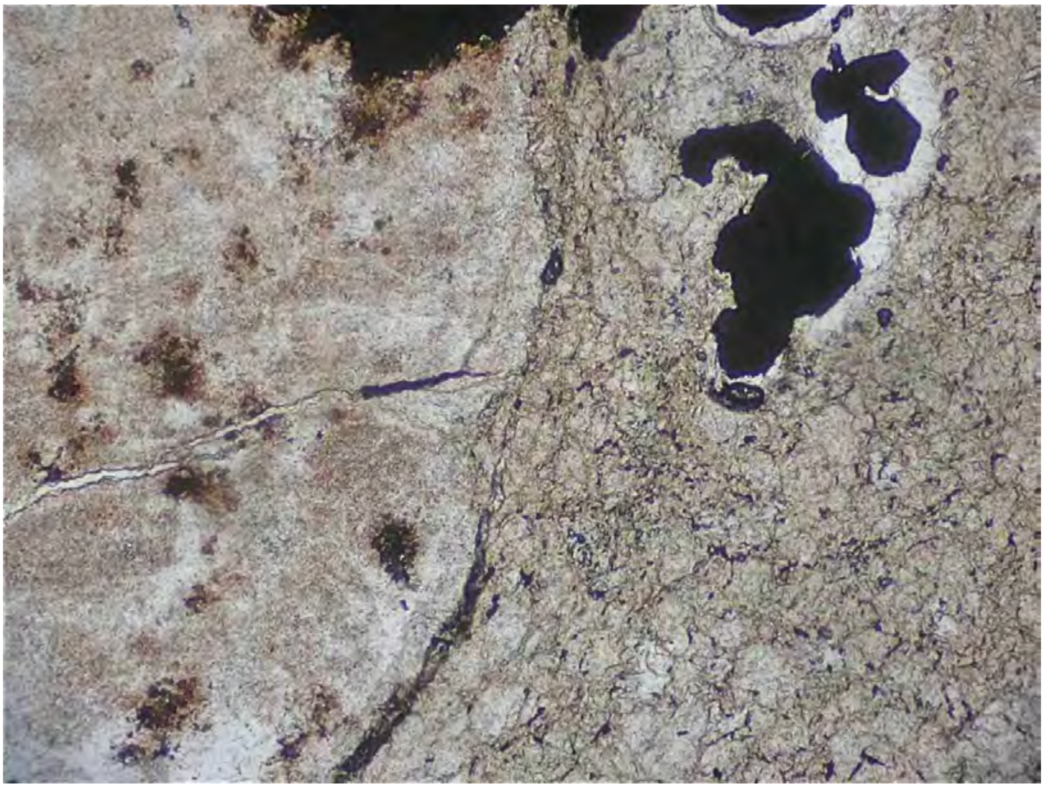

Fig. 88: Portion of a fine grained quartz-rich metasomatic replacment aggregate at left (note brownish hematite pigmentation) in sericite-quartz-altered rock contain a few aggregates of pyrite (black). Plane polarised transmitted light, field of view 2 mm across.

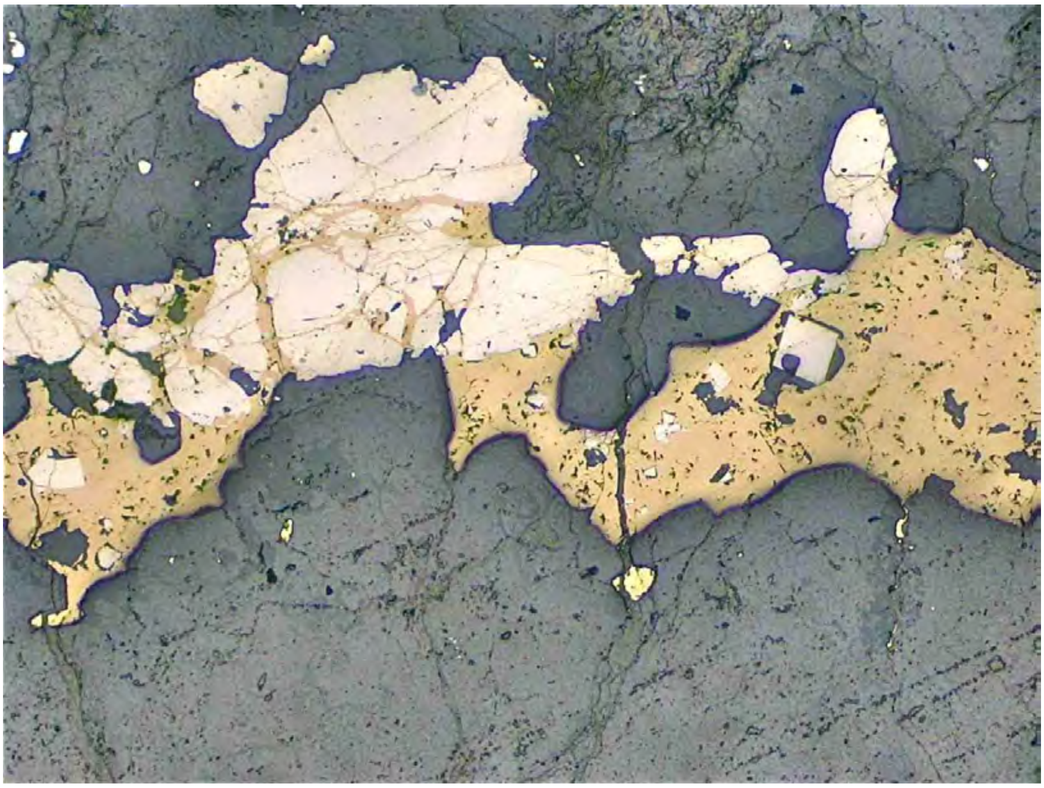

Fig. 89: Portion of a quartz-rich vein containing an aggregate of pyrite (pale creamy) and paragenetically later chalcopyrite (yellow). Plane polarised reflected light, field of view 2 mm across.

STRC008D 238.1 m PTS

Summary: Fine grained siltstone, containing a few small relict detrital quartz grains and local possible bedding phenomena, showing pervasive replacement by a fine grained alteration assemblage of sericite, quartz, local chlorite, minor disseminated pyrite and trace rutile. The altered rock is cut by a couple of sulphide-rich veins containing medium to coarse grained pyrite, interstitial quartz and chlorite, and paragenetically later chalcopyrite, a little sphalerite and trace galena. Apparently later quartz veining also occurs and this also contains a little chalcopyrite.

Handspecimen: The drill core sample is composed of a strongly sulphide veined, altered fine grained, grey-green rock, perhaps representing a fine clastic sedimentary type, e.g. siltstone. The host rock is evidently relatively quartz-rich, but is likely to also contain considerable sericite and chlorite, and a little disseminated pyrite (Fig. 90). Sulphide-rich veins are up to 3 cm wide and occur at ~60° to the core axis. They contain abundant medium to coarse grained pyrite, subordinate quartz and chalcopyrite, and in places are bordered by darker grey-green chlorite alteration selvedges up to 2 mm wide (Fig. 90). Locally in these veins there are elongate aggregates of fine grained grey sulphides, e.g. sphalerite and galena. The sample also hosts quartz-rich veining up to 4 mm wide and locally containing chalcopyrite, apparently cutting the sulphide-rich veining (Fig. 90). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

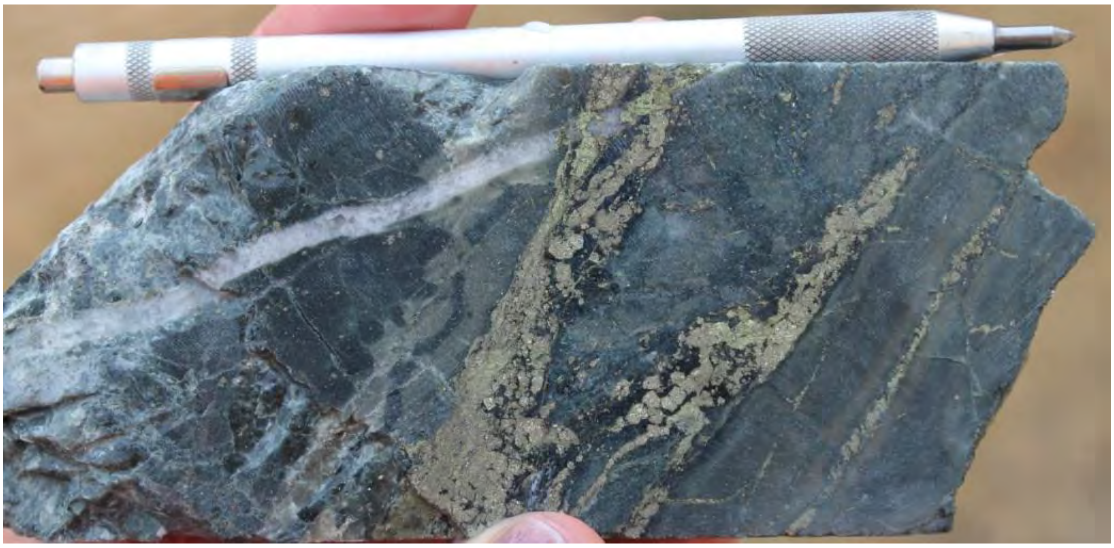

Fig. 90: Drill core sample of fine grained sedimentary rock (e.g. siltstone), with strong alteration to sericite, chlorite and quartz, and with sulphide-rich veining (pyrite, chalcopyrite, minor quartz, chlorite and sphalerite) and an apparently later quartz-rich vein.

Petrographic description

a) Primary rock characteristics: In the section, about 40% of the sample represents vein infill and the remainder is strongly altered host rock. The latter was evidently fine grained and contained a few apparent relict detrital quartz grains up to 0.2 mm across, as well as a couple of possible irregular bedding laminations. Much of the rock, however, is strongly altered and finely recrystallised (Fig. 91) and could represent the matrix in a fine grained clastic sedimentary rock type, e.g. siltstone. The original rock may have had a tuffaceous component, i.e. epiclastic.

b) Alteration and structure: The protolith experienced strong hydrothermal alteration and considerable veining (Fig. 91). There was fine recrystallisation of the host rock to quartz and sericite, but with patchy development of significant chlorite, disseminated pyrite and trace rutile. Immediately adjacent to the sulphide-rich veins, strong chlorite alteration is evident, locally with considerable associated quartz and minor chalcopyrite and pyrite. Two types of veining were emplaced. An apparently earlier type, up to 2 cm wide and bordered by chlorite and/or quartz, contains abundant pyrite and chalcopyrite, with infill chlorite and quartz, and a few aggregates of sphalerite and trace associated galena (Fig. 92). A later vein type appears to transect the sulphide-rich veining and is up to 4 mm wide and dominated by medium to coarse grained inequigranular quartz (Fig. 91), with local chalcopyrite and trace galena. No obvious alteration occurs about the quartz-rich veining. In the sulphide-rich veining, pyrite is commonly fractured and invaded by paragenetically later chalcopyrite, sphalerite and trace galena (Fig. 92). It is possible that the latter veining event actually introduced the base metal sulphides, which overprint the earlier pyrite-rich aggregates (Fig. 92).

c) Mineralisation: In the altered host rock, there is minor disseminated pyrite, forming anhedral to subhedral grains up to 1 mm across (Fig. 91). Most sulphides occur in the veins, with earlier, sulphide-rich veins containing abundant medium to coarse grained (up to 4 mm) anhedral to subhedral pyrite. In places, pyrite is fractured and invaded by locally abundant chalcopyrite and minor sphalerite (aggregates up to 2 mm) and a trace of associated galena (Fig. 92). Later quartz-rich veining also has aggregates of chalcopyrite up to 3 mm across with a trace of associated galena. In the sulphide-rich veining, chalcopyrite (-sphalerite-galena) masses are paragenetically later than pyrite (Fig. 92).

Mineral Mode (by volume): quartz 55%, pyrite and sericite each 15%, chlorite 10%, chalcopyrite 5% and traces of rutile, sphalerite and galena.

Interpretation and comment: It is interpreted that the sample represents a strongly veined and altered, fine grained siltstone. There are a few small relict detrital quartz grains and local possible bedding phenomena in the host rock, which has been replaced by fine grained sericite, quartz, chlorite, minor disseminated pyrite and trace rutile. The altered rock is cut by a couple of sulphide-rich veins containing medium to coarse grained pyrite, interstitial quartz and chlorite, and paragenetically later chalcopyrite, a little sphalerite and trace galena. Apparently later quartz veining also occurs and this also contains a little chalcopyrite.

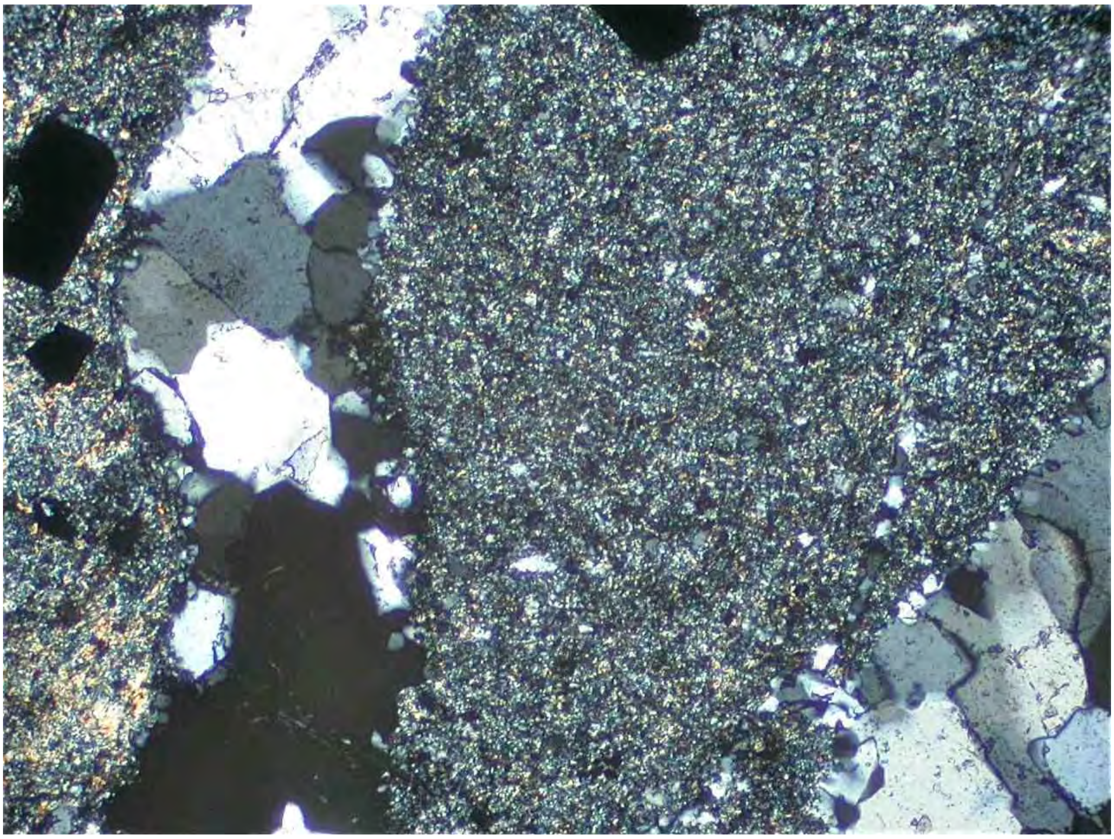

Fig. 91: Fine grained siltstone replaced by sericite, quartz and minor chlorite and pyrite (black) and cut by a couple of quartz-rich veins. Transmitted light, crossed polarisers, field of view 2 mm across.

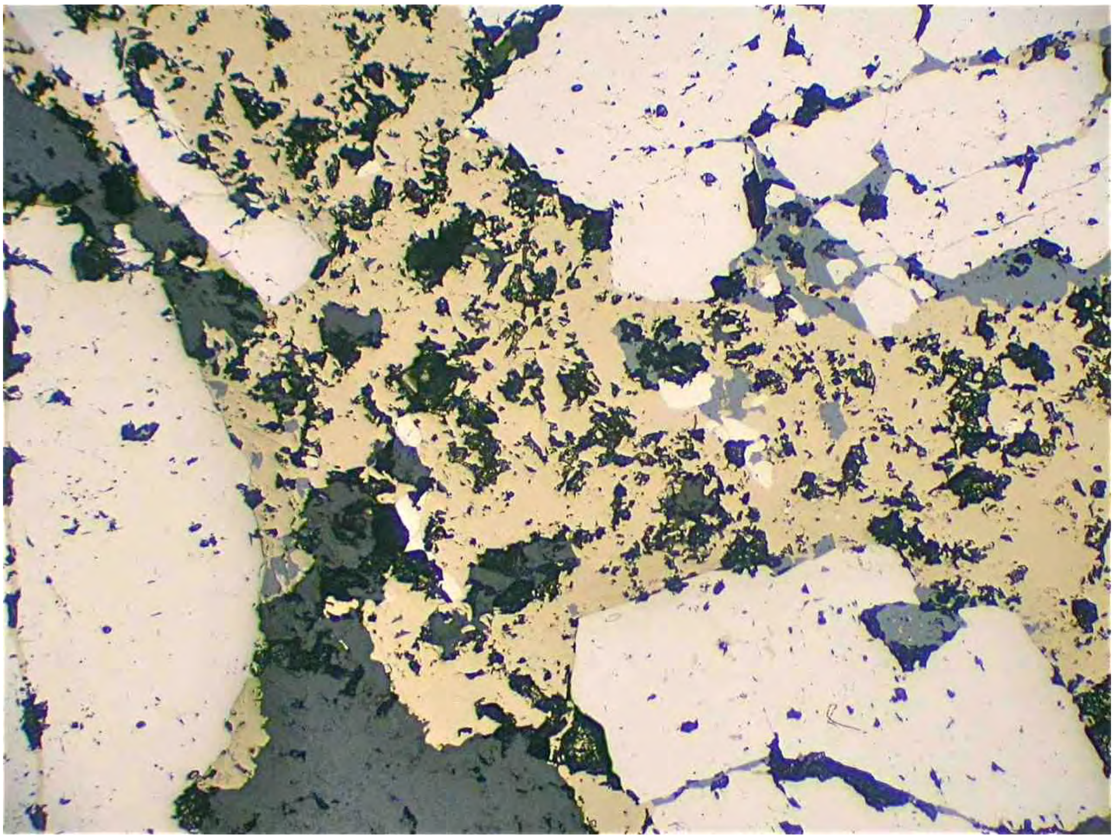

Fig. 92: Paragenetically early pyrite (pale creamy) invaded by chalcopyrite (yellow) and a little sphalerite (mid grey at right). Plane polarised reflected light, field of view 1 mm across.

<u>STRC008D 339.8 m TS</u>

Summary: Former medium to coarse grained granitoid, perhaps of granodiorite-tonalite type, with effects of imposed deformation, strong hydrothermal alteration and minor veining. Relict texture is poorly preserved, but it can be deduced that the original rock contained significant quartz and feldspar, with minor ferromagnesian material, a little FeTi oxide and trace apatite. Penetrative deformation effects caused strain and part recrystallisation of relict quartz, and all former feldspar, ferromagnesian material and FeTi oxide were replaced, mainly by fine grained chlorite, plus subordinate sericite and quartz and a little leucoxene-rutile at FeTi oxide and ferromagnesian sites. A few irregular veinlike masses of medium grained quartz were emplaced, along with a couple of narrow, shear veins of sericite.

Handspecimen: The drill core sample is composed of a relatively massive, dark grey-green to paler grey and buff-coloured, strongly altered granitic rock. It evidently contains considerable quartz, but all original feldspar and ferromagnesian material was replaced by dark chlorite and paler-coloured sericite (Fig. 93). The rock is cut by a few quartz-rich veins up to 5 mm wide (Fig. 93). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 93: Drill core sample of granitoid rock showing patchy alteration to dark grey-green chlorite and paler, buff-coloured sericite, and cut by a few pale grey quartz veins.

Petrographic description

a) Primary rock characteristics: In the section, relict texture from a protolith is poorly preserved as a result of strong alteration and deformation effects. There are scattered anhedral, medium to coarse grained quartz masses up to a few millimetres across that are interpreted as remnants of original igneous quartz and these appear to have been intergrown with formerly abundant feldspar and less common ferromagnesian material (Fig. 94). In places, there are vague pseudomorphs after former blocky feldspar and after former prismatic or flaky ferromagnesian grains (e.g. hornblende, biotite) (Fig. 94). The rock also contains sparsely scattered grains of FeTi oxide (now altered) and a few grains of relict apatite up to 0.3 mm across. From the inferred primary texture and mineralogy, the protolith is interpreted as a medium to coarse granitoid, perhaps of granodiorite-tonalite type.

b) Alteration and structure: The igneous protolith was subject to penetrative deformation, strong hydrothermal alteration and emplacement of a few veins. Original quartz shows effects of strain and local recrystallisation (Fig. 94). All interpreted former feldspar and ferromagnesian material was replaced by varying amounts of fine grained, very pale green chlorite, subordinate sericite (although locally abundant), finely granular quartz and at former ferromagnesian sites, a trace of leucoxene-rutile (Fig. 94). All original FeTi oxide was replaced by leucoxene-rutile aggregates. A few irregular, veinlike aggregates of medium grained quartz up to 4 mm across were emplaced, with these being cut by local thin shear veinlets of sericite up to 0.2 mm wide. The altered rock also contains a single thin stylolitic veinlet of leucoxene-rutile. The observed alteration assemblage in the sample is considered to be of propylitic type.

c) Mineralisation: No sulphide minerals are observed.

Mineral Mode (by volume): quartz 50%, chlorite 35%, sericite 14%, leucoxene-rutile 1% and a trace of apatite.

Interpretation and comment: It is interpreted that the sample represents a strongly altered, deformed and veined granitoid, perhaps formerly of granodiorite-tonalite type. Relict texture is poorly preserved, but the rock formerly contained quartz and feldspar, with minor ferromagnesian material, a little FeTi oxide and trace apatite. Penetrative deformation effects caused strain and part recrystallisation of relict quartz. Original feldspar, ferromagnesian material and FeTi oxide were completely altered, to fine grained chlorite, subordinate sericite and quartz and a little leucoxene-rutile at FeTi oxide and ferromagnesian sites. A few irregular veinlike masses of medium grained quartz were emplaced, along with a couple of narrow, shear veins of sericite.

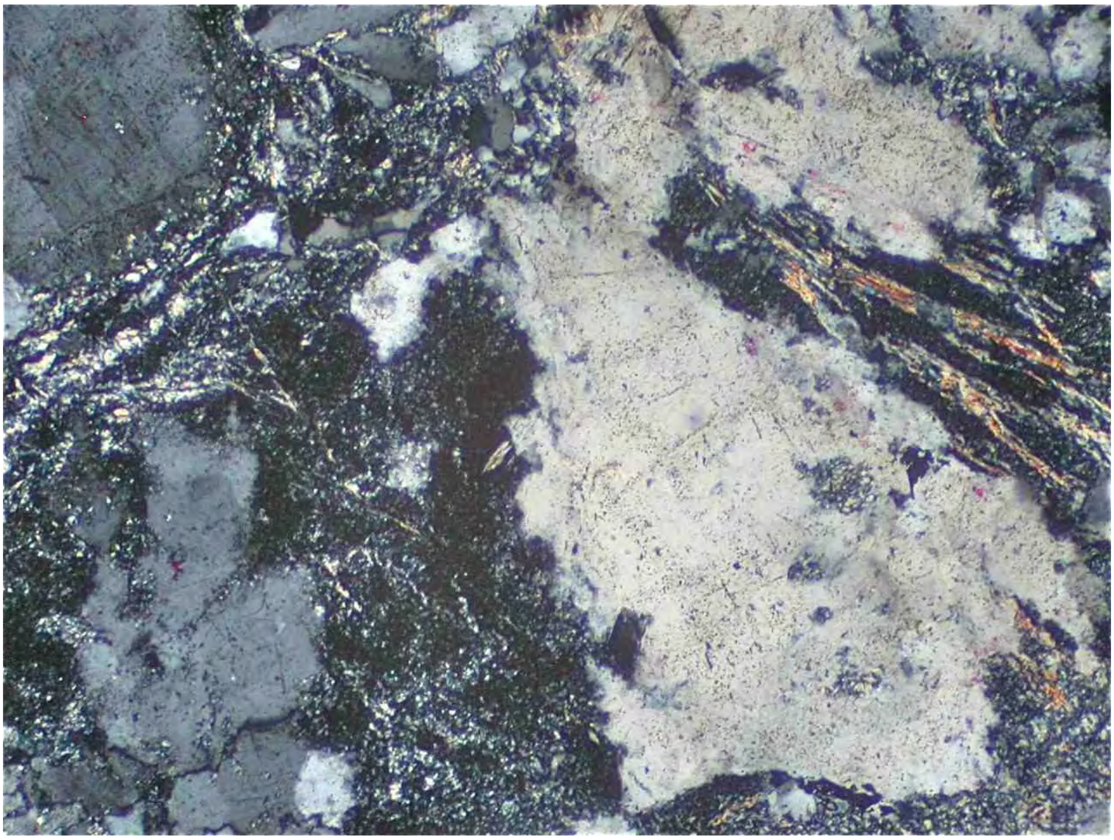

Fig. 94: Relict quartz (slightly strained) adjacent to possible pseudomorphs of blocky feldspar (left) and elongate ferromagnesian material (right). The alteration assemblage contains fine grained chlorite (dark), with minor quartz and sericite. Transmitted light, crossed polarisers, field of view 2 mm across.

STRC008D 340.7 m PTS

Summary: The sample possibly represents a former medium grained, leucocratic, rather plagioclase-rich granitoid (e.g. of tonalitic type) that was brecciated and invaded by abundant quartz infill. Remnants of the host rock were cataclasised, with shattering of plagioclase and strain and recrystallisation of quartz. Further alteration was imposed, with minor development of chlorite and sericite, plus traces of rutile, galena and pyrite in the host rock and infill by locally prismatic quartz, patchily abundant fine grained chlorite, local graphite and small amounts of chalcedonic quartz. Graphite, chlorite and minor sericite can be concentrated into stylolitic aggregates. Textures imply that graphite has formed hydrothermally, e.g. by mobilisation of carbonaceous material from a sedimentary source or by precipitation from hydrothermal fluids containing CO_2 and CH_4.

Handspecimen: The drill core sample is composed of a pale grey, defomed medium grained granitoid, probably with significant alteration in the form of quartz flooding (silicification) (Fig. 95). The rock hosts a network of fracture-controlled diffuse dark grey to slightly brownish veins, and a couple of bettter-defined black veins up to 2-3 mm wide (Fig. 95), with the latter locally appearing stylolitic. The black material does not appear to include fine grained sulphides and could be carbonaceous in character. A few late fracture surfaces are thinly coated by whitish fine grained clay. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

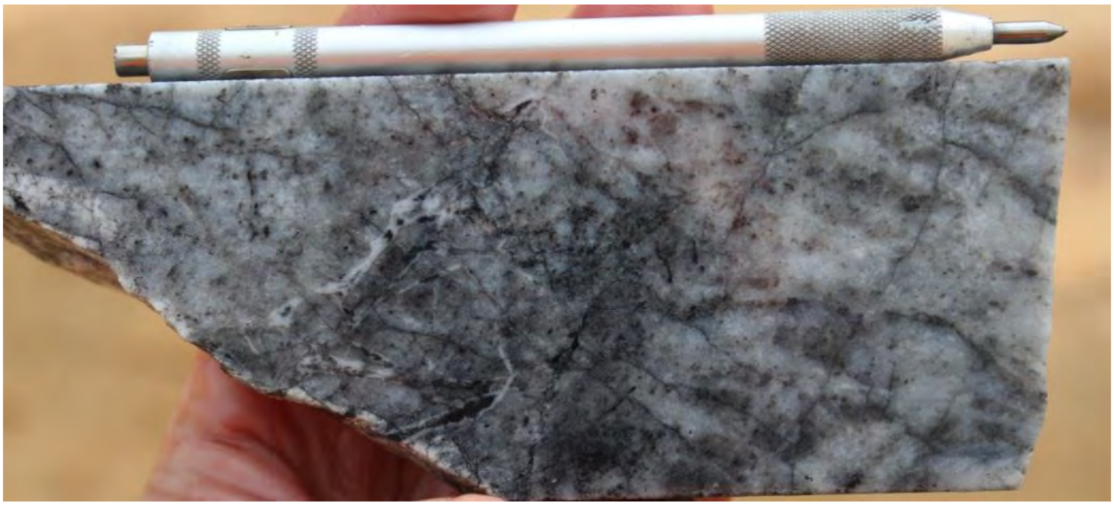

Fig. 95: Drill core sample of deformed and quartz-flooded granitoid rock containing a diffuse network of fractures, commonly hosting veinlets of chlorite (locally brownish colour) and black graphitic material.

Petrographic description

a) Primary rock characteristics: In the section, relict texture from a protolith is poorly preserved. There are local domains up to several millimetres across having indications that the protolith was originally of medium grained, and quartz-feldspar-rich, e.g. a type of granitoid containing abundant plagioclase (up to 1.5 mm), subordinate quartz, a little K-feldspar intergrown micrographically with quartz, ferromagnesian material and traces of FeTi oxide and zircon. This assemblage could infer that the protolith was of leucocratic tonalitic type.

b) Alteration and structure: The original rock was evidently brecciated and invaded by abundant hydrothermal quartz as breccia infill and network vein masses up to several millimetres across. Remnants of the host rock are up to a few millimetres across and commonly show cataclastic texture with fracturing of plagioclase and strain and recrystallisation of quartz (Fig. 96). Apart from invasion by quartz, host rock remnants also have minor development if interstitial fine grained pale green to pale brown chlorite, sericite and traces of rutile and rare tiny grains of pyrite and galena. Some quartz infill is also deformed, but wider zones tend to be little-strained and have medium grained inequigranular and prismatic grains up to 2 mm across, in places projecting into irregular to veinlike zones that are filled by fine grained pale brown chlorite (aggregates up to several millimetres across) that in turn host a few tiny veinlets of chalcedonic quartz. Some of this later infill also includes finely granular quartz, and in part of the sample, locally abundant aggregates of fine grained graphite (Fig. 97). The latter is concentrated into veinlike (including stylolitic) masses up to 1 mm across. The textural setting of graphite implies that it is of hydrothermal derivation, e.g. possibly mobilised from an original sedimentary source or from precipitation from hydrothermal fluids containing CO_2 and CH_4. It is possible that the brown colour in chlorite is due to slight carbonaceous pigmentation. The rock is also cut by a couple of thin (<0.2 mm) stylolitic aggregates of sericite.

c) Mineralisation: Tiny grains of pyrite (<25 μm) and a single grain of galena (~0.2 mm) are observed in the sample, probably formed during the deformation and alteration process.

<u>Mineral Mode (by volume)</u>: quartz 65%, plagioclase (might include albite) 25%, chlorite 6%, graphite 2%, sericite 1% and traces of rutile, zircon, K-feldspar, pyrite and galena.

<u>Interpretation and comment</u>: It is interpreted that the sample is a former medium grained, leucocratic, rather plagioclase-rich granitoid (e.g. of tonalitic type) that experienced brecciated and invasion by abundant quartz (silicification). Host rock remnants show cataclastic texture, with shattering of plagioclase and strain and recrystallisation of quartz. Further alteration was imposed, with minor development of chlorite and sericite, plus traces of rutile, galena and pyrite in the host rock and infill by locally prismatic quartz, patchily abundant fine grained chlorite, local graphite and small amounts of chalcedonic quartz. Graphite, chlorite and minor sericite can be concentrated into stylolitic aggregates. Textures imply that graphite has formed hydrothermally, e.g. by mobilisation of carbonaceous material from a sedimentary source or by precipitation from hydrothermal fluids containing CO_2 and CH_4.

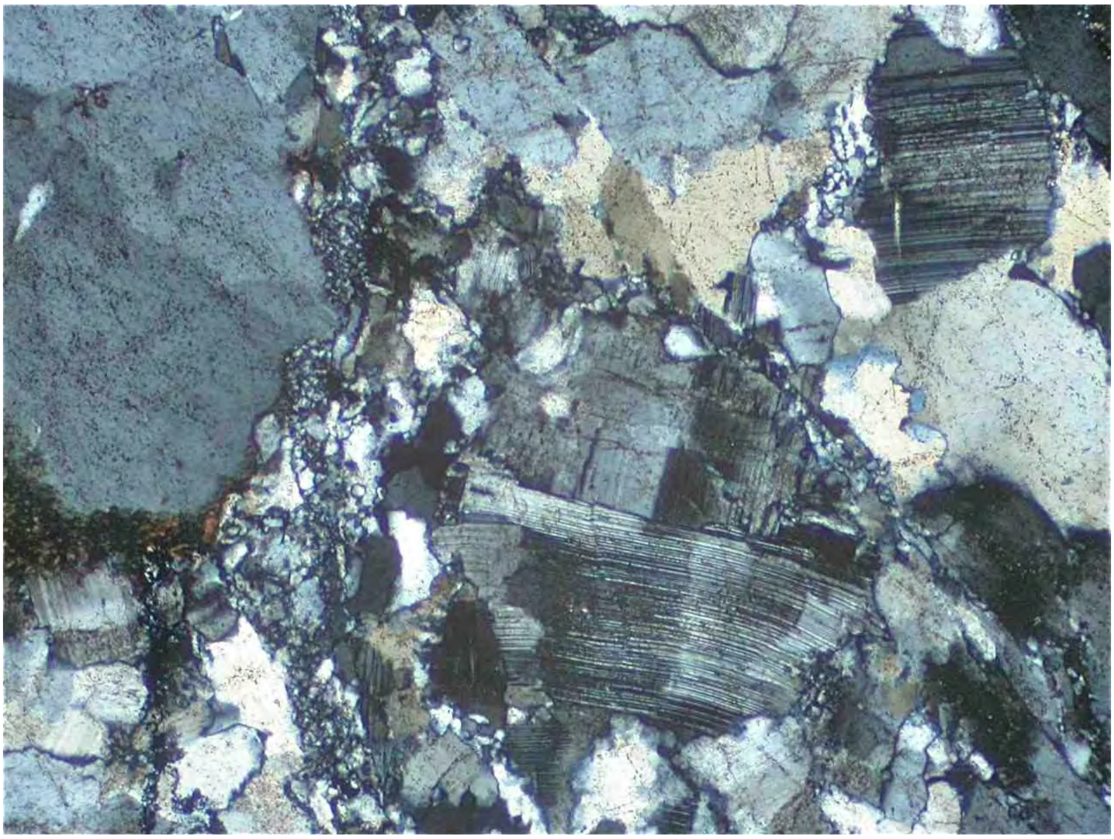

Fig. 96: Strongly deformed tonalitic granitoid showing strained and partly recrystallised quartz and plagioclase. The dark brown aggregate at left is chlorite. Transmitted light, crossed polarisers, field of view 2 mm across.

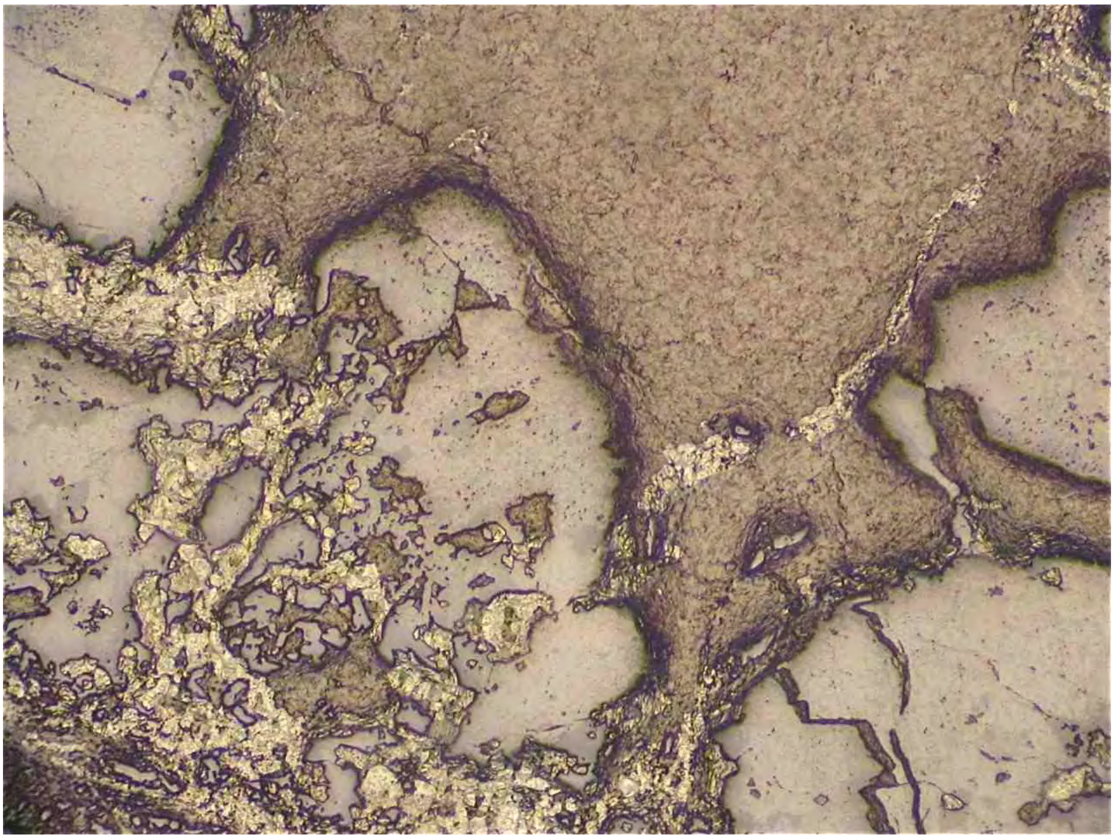

Fig. 97: Zone of hydrothermal quartz infill (high relief) adjacent to an interstitial chlorite mass (low relief) that also hosts fine grained graphite (pale grey). Plane polarised reflected light, field of view 2 mm across.

STRC008D 348.1 m TS

Summary: Medium to coarse grained leucocratic diorite, with effects of imposed deformation and pervasive strong sodic alteration. The igneous rock contained abundant plagioclase and probably a subordinate amount of a ferromagnesian phase (e.g. hornblende) and trace FeTi oxide. The protolith underwent mild cataclasis and weak foliation development, as well as being strongly replaced by an assemblage of albite, subordinate chlorite, minor titanite and a little sericite. There is no evidence for the former presence of igneous quartz, or that any quartz formed hydrothermally. Minor veining occurred in the rock, now converted to an albitite, with veins containing chlorite and a little titanite.

Handspecimen: The drill core sample is composed of an altered and mildly deformed, medium to coarse grained feldspar-rich igneous rock. It is dominated by white to pale grey feldspar (e.g. plagioclase), with grainsize up to a few millimetres (Fig. 98). A minor amount of ferromagnesian material was formerly present, but it is altered to grey-green chlorite. In places, a weak foliation is apparent, at a moderate angle to the core axis, and the rock is cut by several sub-planar veins of dark grey-green chlorite up to 2 mm wide, at varying orientations (Fig. 98). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 98: Drill core sample of altered leucocratic diorite, containing abundant albitised plagioclase, minor chlorite and an array of chlorite veins.

Petrographic description

a) Primary rock characteristics: In the section, it is apparent that the original rock contained abundant plagioclase, and probably minor interstitial ferromagnesian material, based on moderate preservation of original texture. However, primary igneous minerals are completely altered. The rock contained abundant blocky to tabular plagioclase grains up to 4 mm across, and maybe up to 10% of interstitial ferromagnesian material. There are local elongate pseudomorphic aggregates after the latter, up to 2 mm long, inferring that the ferromagnesian phase could have been hornblende. The rock also contained traces of disseminated FeTi oxide. Large plagioclase grains appear to be partly enclosed by a subordinate volume of fine to medium grained, inequigranular plagioclase (Fig. 99). There is no evidence that the original igneous rock contained interstitial quartz. Consequently, it is tentatively interpreted that the protolith was originally a leucocratic diorite.

b) Alteration and structure: It is interpreted that the original rock experienced deformation and strong pervasive alteration, along with emplacement of a few veins. Textures imply that mild cataclasis was imposed, causing fracturing and granulation of plagioclase, as well as the development of a weak foliation, typically defined by chlorite aggregates anastomosing about larger remnant plagioclase (Figs 99, 100). Pervasive alteration caused plagioclase to be replaced by albite, with slight flecking throughout by sericite, patchy development of fine grained aggregates of near-colourless chlorite, and a trace of pale green actinolite. Original ferromagnesian material was replaced by chlorite and minor titanite, and FeTi oxide by leucoxene-rutile ± titanite. Several anastomosing to sub-planar veins cut the rock, with some being co-planar with the weak foliation, and others oblique (Figs 99, 100). Veins are up to 1 mm wide and contain fine grained, weakly foliated, near-colourless chlorite and a little titanite. Essentially, the imposed alteration has converted the protolith into an albitite, accompanied by gain of Na and loss of Ca (K, Fe).

c) Mineralisation: No sulphide minerals are observed in the sample.

Mineral Mode (by volume): plagioclase (albite) 80%, chlorite 17%, titanite 2%, sericite 1% and traces of leucoxene-rutile and actinolite.

Interpretation and comment: It is interpreted that the sample represents a former leucocratic diorite, subsequently converted to albitite. It formerly contained abundant plagioclase and minor ferromagnesian material (e.g. hornblende) and trace FeTi oxide. The protolith experienced mild cataclasis and weak foliation development, as well as being strongly replaced by albite, subordinate chlorite, minor titanite and a little sericite. There is no evidence for the former presence of igneous quartz, or that any quartz formed hydrothermally. Minor veining by chlorite and a little titanite also occurred.

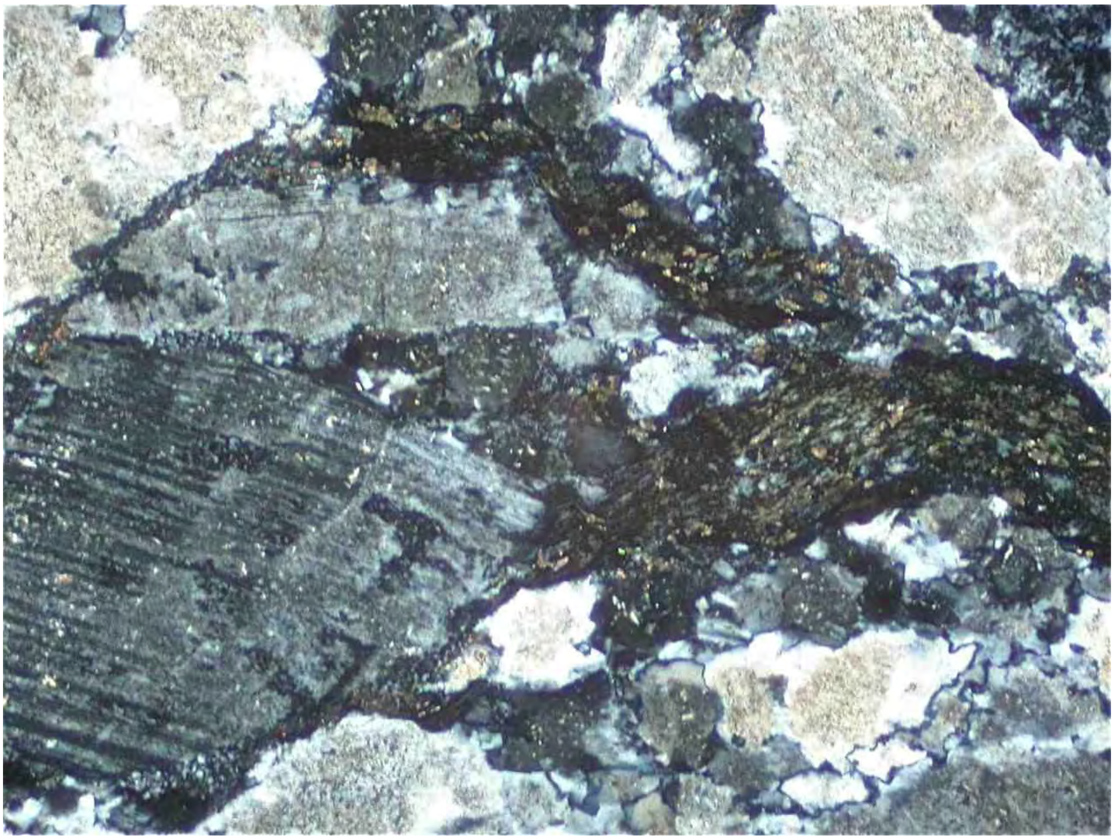

Fig. 99: Deformed plagioclase-rich rock, showing fracturing and granulation of plagioclase (now albitised), and development of a weak foliation, expressed by the elongate, chlorite-rich aggregates (dark) that also contain a little disseminated titanite. Transmitted light, crossed polarisers, field of view 2 mm across.

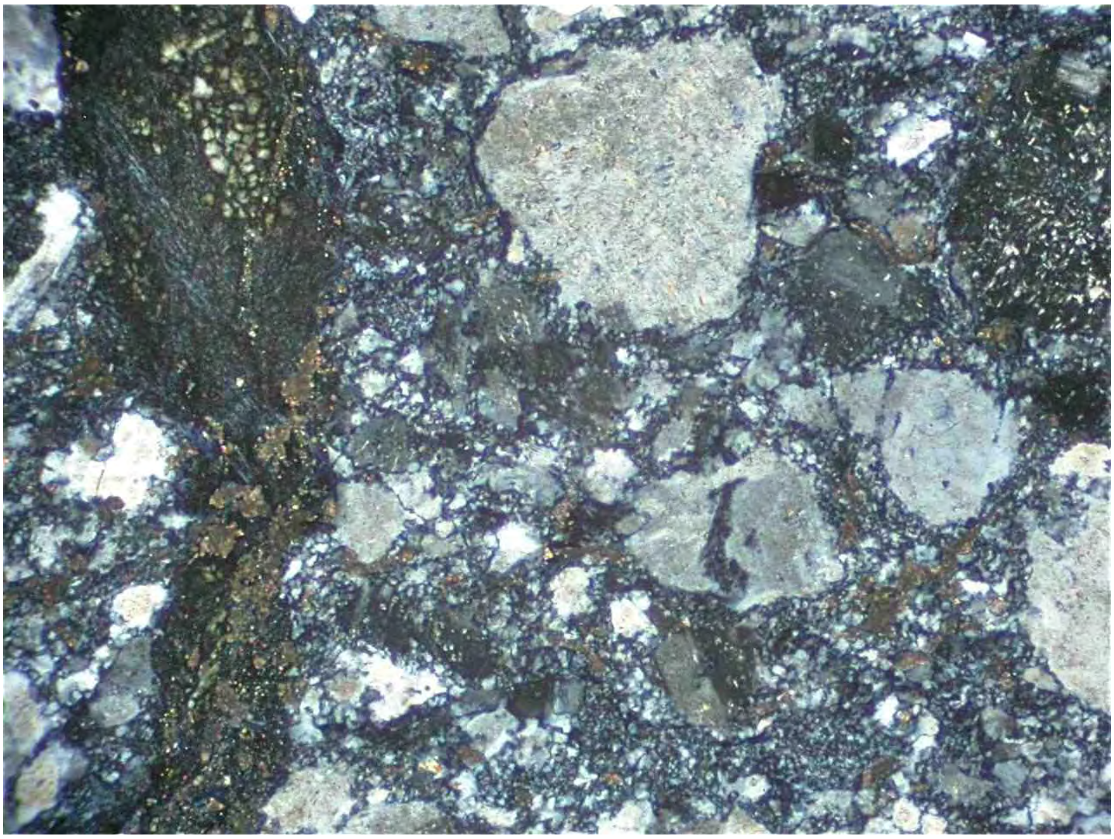

Fig. 100: Cataclastic zone, showing granulated plagioclase (now albitised). At left is a vein of chlorite (dark) and minor titanite aggregates (pale brown-grey). Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 56.9 m TS

Summary: Strongly porphyritic hornblende-quartz microdiorite, with strong argillic alteration. Relict texture is moderately preserved, indicating that the rock originally had prominent feldspar (probably plagioclase) phenocrysts, as well as smaller ferromagnesian (e.g. hornblende) phenocrysts in a fine to medium grained groundmass that was feldspar-rich, with minor quartz, ferromagnesian material and FeTi oxide. Pervasive alteration led to replacement of the igneous rock by fine grained clay (e.g. illite-smectite), sericite and chlorite, with minor quartz (in the groundmass) and a little leucoxene-rutile and pyrite. Uncommon thin veins with quartz and/or chlorite also occur.

Handspecimen: The drill core sample is composed of a pale grey-green, strongly altered, porphyritic intermediate to felsic igneous rock. It displays white, altered feldspar phenocrysts up to 5 mm across and smaller, grey-green altered ferromagnesian phenocrysts (e.g. originally hornblende) in a finer grained, probably feldspathic composition groundmass (Fig. 101). Pervasive alteration has developed considerable fine grained clay/sericite and subordinate chlorite (Fig. 101). A few sub-planar, clay-lined fractures occur at varying angles to the core axis. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 101: Drill core sample of porphyritic microdiorite showing altered feldspar and ferromagnesian phenocrysts. The rock has sustained strong argillic alteration, with replacement by fine grained clay, sericite and chlorite.

Petrographic description

a) Primary rock characteristics: In the section, relict strongly porphyritic texture is moderately preserved (Fig. 102). There are pseudomorphs after scattered blocky to tabular feldspar phenocrysts (probably plagioclase) up to 5 mm across and less common pseudomorphs after a prismatic ferromagnesian phase (e.g. hornblende) up to 3 mm long (Fig. 102). The phenocrystal phases occurred in a fine to medium grained, inequigranular groundmass that contained abundant feldspar, and with minor quartz, ferromagnesian material and a little disseminated FeTi oxide (Fig. 102). From the preserved characteristics, the original rock is interpreted as a porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: The igneous protolith was subject to strong pervasive alteration, with only igneous quartz being preserved. Feldspar phenocrysts were replaced by fine grained sericite, accompanied in places by chlorite and a clay phase (e.g. illite-smectite) (Fig. 102).

Former ferromagnesian material was replaced by chlorite, with local clay and leucoxene-rutile, and FeTi oxide was replaced by leucoxene-rutile (Fig. 102). Groundmass material shows replacement by fine grained turbid clay (Fig. 102), minor granular quartz and chlorite. Irregularly scattered throughout, but mostly at former phenocryst sites, is a little fine grained pyrite. The alteration assemblage is interpreted as being of argillic type. A single quartz-chlorite vein up to 0.4 mm wide occurs along part of an edge of the section, and elsewhere in the rock, there are a couple of thin, discontinuous chlorite veins.

c) Mineralisation: A little fine grained pyrite is irregularly distributed, tending more common at altered phenocryst sites.

Mineral Mode (by volume): clay (e.g. illite-smectite) 45%, sericite 30%, chlorite 15%, quartz 8%, leucoxene-rutile and pyrite each 1%.

Interpretation and comment: It is interpreted that the sample is a strongly argillically-altered, porphyritic hornblende-quartz microdiorite. There is moderate preservation of relict texture, indicating that the rock originally had feldspar (probably plagioclase) phenocrysts, and smaller ferromagnesian (e.g. hornblende) phenocrysts in a finer grained groundmass that was feldspar-rich, with minor quartz, ferromagnesian material and FeTi oxide. Pervasive alteration caused replacement of the igneous rock by fine grained clay (e.g. illite-smectite), sericite and chlorite, with minor quartz (in the groundmass) and a little leucoxene-rutile and pyrite. Uncommon thin veins with quartz and/or chlorite also occur.

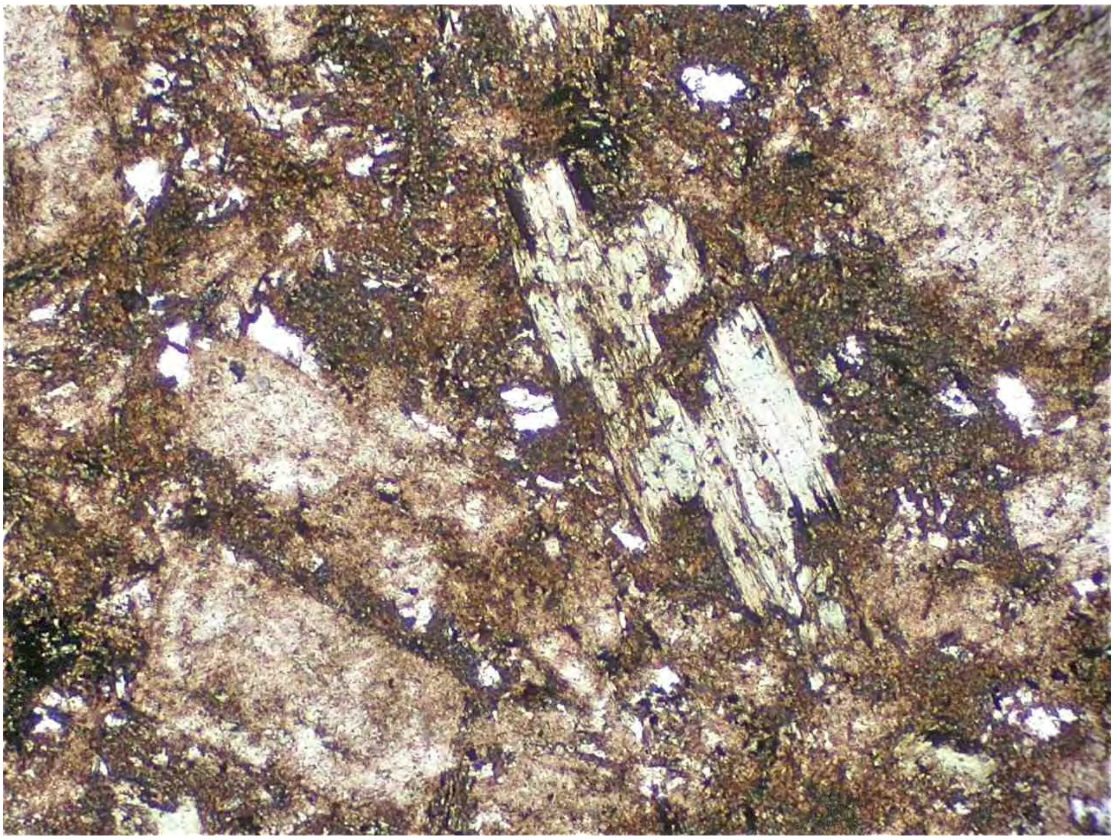

Fig. 102: Relict porphyritic texture in altered microdiorite, showing blocky-shaped pseudomorphs after former feldspar phenocrysts (now mostly fine grained sericite), very pale green chlorite-altered hornblende, and a turbid, clay-altered groundmass. The small black grains include leucoxene-rutile and pyrite. Plane polarised transmitted light, field of view 2 mm across.

SMD012 59.3 m TS

Summary: Fine grained, matrix-supported siltstone, perhaps of epiclastic type, with strong argillic alteration and an array of thin, intersecting veins. There is some preservation of sparse small relict quartz grains and it is possible that the rock also had small feldspar and lithic grains in a fine grained matrix (possibly with some vitriclastic material). The rock was pervasively replaced by a fine grained alteration assemblage of clay (e.g. illite-smectite), chlorite, quartz and sericite, with a little leucoxene-rutile and trace pyrite. Apparently earlier veins contain sericite, or quartz ± clay (kaolinite) and trace pyrite, and appear to be cut by thin chlorite-rich veins.

Handspecimen: The drill core sample is composed of a fine grained, pale creamy-grey rock, containing veinlike and diffuse darker grey-green zones. The sample could represent an altered fine grained clastic sedimentary (siltstone) or tuffaceous protlith and evidently has strongly developed clay/sericite, with the darker zones probably containing significant chlorite (Fig. 103). An array of thin, intersecting veins is apparent, with veins containing fine grained chlorite, clay/sericite and quartz (Fig. 103). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

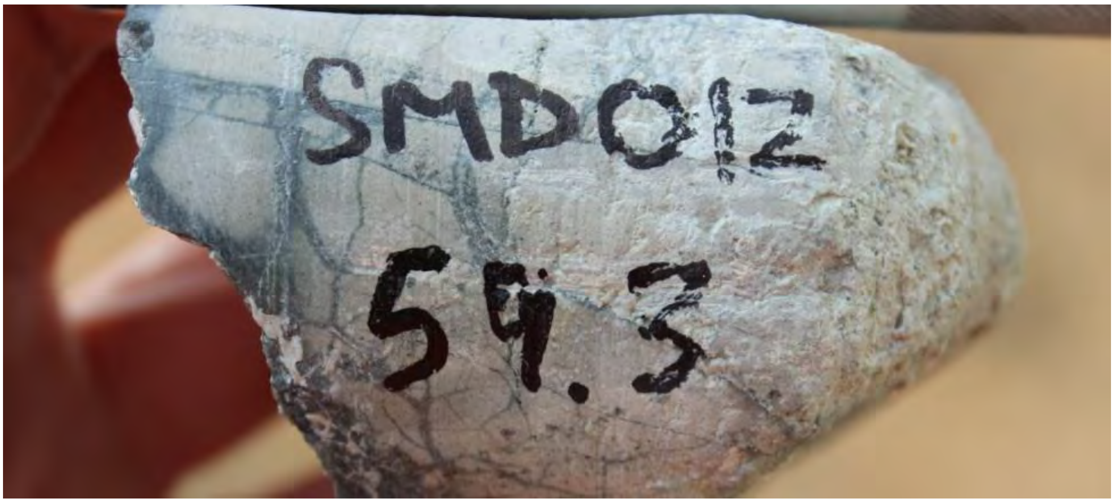

Fig. 103: Drill core sample of strongly argillic altered fine grained siltstone, with an intersecting array of veins that appear to be chlorite-rich. The siltstone has been altered to clay, quartz, sericite and chlorite.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the protolith was fine grained and had a dominantly matrix-supported texture (Fig. 104). There are sparsely scattered relict quartz grains up to 0.2 mm across and it can also be speculated that there were also other grains, including feldspar and fine grained lithics, though now completely altered. These small grains were set in a fine grained matrix that is now altered and recrystallised (Fig. 104). The matrix could be further speculated to have had a vitriclastic (tuffaceous) component. From the vestiges of relict texture, it is tentatively implied that the protolith was a fine grained siltstone, maybe of epiclastic character and with a significant provenance from a felsic volcanic source.

b) Alteration and structure: The original fine grained clastic (or epiclastic) rock was strongly hydrothermally altered and cut by an aeeay of thin veins (Fig. 104). Small ?feldspar and/or lithic grains were replaced by fine grained sericite and/or quartz, and the matrix was replaced by fine grained quartz, a clay phase (e.g. illite-smectite), sericite, chlorite, a little leucoxene-rutile and trace pyrite. The veins are sub-planar to anastomosing and up to 0.4 mm wide, commonly intersecting (Fig. 104). Relationships are not consistent, but generally there are early veins of fine grained sericite, and or fine grained quartz ± clay (e.g. kaolinite) ± pyrite, cut by sub-planar chlorite veins that have traces of leucoxene-rutile and pyrite. Some of the earlier veins have narrow, diffuse alteration selvedges of clay and chlorite. Overall, the alteration and vein assemblage is consistent with argillic type.

c) Mineralisation: A trace of fine grained pyrite occurs in some of the narrow veins and as part of the pervasive alteration assemblage.

Mineral Mode (by volume): quartz and clay phases (e.g. illite-smectite > kaolinite) each 30%, chlorite 25%, sericite 14%, leucoxene-rutile 1% and a trace of pyrite.

Interpretation and comment: It is interpreted that the sample represents a strongly argillically altered, matrix-supported siltstone, perhaps of epiclastic type. There is some preservation of sparse small relict quartz grains and it is possible that the rock also had small feldspar and lithic grains in a fine grained matrix (possibly with some vitriclastic material). The rock was pervasively replaced by a fine grained alteration assemblage of clay (e.g. illite-smectite), chlorite, quartz and sericite, with a little leucoxene-rutile and trace pyrite. An array of thin, intersecting veins cuts the altered rock, with apparently earlier veins containing sericite, or quartz ± clay (kaolinite) and trace pyrite, and cut by thin chlorite-rich veins.

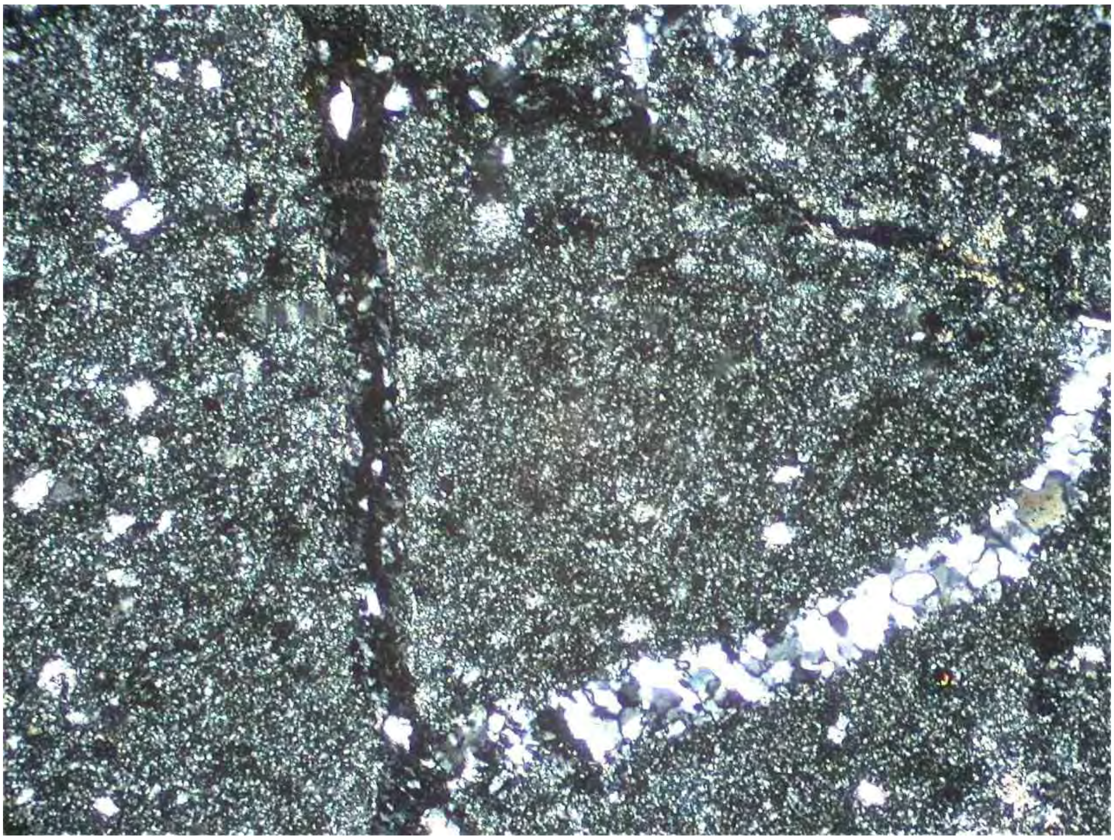

Fig. 104: Altered epiclastic siltstone with sparse small relict quartz grains. The matrix was replaced by fine grained clay, chlorite, quartz and sericite, and cut by thin veins of quartz and apparently later veins of chlorite (dark). Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 82.4 m TS

Summary: Intensely hydrothermally silicified ultramafic rock (e.g. serpentinised peridotite) retaining sparse grains of relict chromite, but otherwise represented by an assemblage of abundant fine to medium grained quartz, patchy disseminated grains and aggregates of chlorite and pyrite, and irregular zones of hematite pigmentation. A few discontinuous quartz veins occur and the rock appears to have been partly affected by supergene alteration, leading to local degradation of chlorite to a clay (smectite) phase and the production of a few voids.

Handspecimen: The drill core sample is composed of a grey, fine to medium grained quartz-rich rock, probably representing a strongly hydrothermally altered (silicified) protolith. It has scattered patches of dark reddish hematite pigmentation and irregularly distributed pyrite as disseminations and semi-massive aggregates up to several millimetres across (Fig. 105). No definite relict texture from a protolith is recognised. Some supergene alteration effects are apparent, with leaching out of pyrite in places and formation of a few irregular cavities, as well as paler coloured zones with possible clay development (Fig. 105). The sample is moderately magnetic, with susceptibility up to 230 x 10^{-5} SI.

Fig. 105: Drill core sample of silicified ultramafic rock. The protolith was replaced by fine to medium grained quartz, minor chlorite, irregularly distributed pyrite and local patches of dark reddish hematite pigmentation. Some supergene alteration was also imposed, causing leaching of pyrite and formation of cavities and pale coloured clay.

Petrographic description

a) Primary rock characteristics: In the section, no definite relict texture is recognised in most of the sample. There are, however, sparsely scattered relict grains of fractured chromite up to 1 mm across (Fig. 106) and the presence of this phase indicates that the protolith must have been of ultramafic type, e.g. ultimately a peridotite. Such a rock was probably serpentinised and in places it can be speculated that vague relict texture typical of serpentinite is locally preserved. In addition, these zones have a little finely disseminated magnetite, a typical alteration product present in serpentinite. The fact that the sample interval contains anomalously high values of Cr, Ni and Cr attests to an ultramafic composition protolith.

b) Alteration and structure: An interpreted ultramafic protolith (e.g. serpentinised peridotite) experienced intense hydrothermal alteration, but relict chromite grains are preserved (Fig.

106). Much of the rock was replaced by fine to medium grained, inequigranular quartz, but in places there are minor disseminations, grading to semi-massive aggregates up to several millimetres across of fine grained chlorite, and of pyrite (Figs 106, 107). Irregularly scattered throughout are diffuse zones of dusty hematite pigmentation, associated with pyrite (rather than chlorite) (Fig. 106). Zones with hematite and pyrite also locally contain fine grained magnetite, with the latter possibly inherited from a serpentinite precursor. Textures suggest that magnetite is locally replaced by hematite and pyrite. A few discontinuous veins of fine to medium grained quartz up to 1 mm wide occur in the sample (Fig. 107). In parts of the section, there is evidence of supergene alteration, with this having led to partial dissolution of pyrite and the formation of irregular voids, and the degradation of chlorite to fine grained pale orange-brown clay, probably a smectite phase.

c) Mineralisation: The altered rock contains several relict grains of fractured chromite up to 1 mm across (Fig. 106). As part of the intense alteration, minor disseminated, through to local semi-massive aggregates of fine to medium grained pyrite developed (Figs 106, 107). Individual pyrite grains are up to 0.4 mm across. Pyrite-bearing zones also commonly have dusty hematite pigmentation (Fig. 106).

Mineral Mode (by volume): quartz 85%, chlorite 6%, pyrite 5%, clay (smectite) 2%, chromite and hematite each 1% and a trace of magnetite.

Interpretation and comment: It is interpreted that the sample is a former ultramafic rock, e.g. serpentinised peridotite, which experienced intense hydrothermal silicification. Generally, primary texture was destroyed, but sparse grains of relict chromite are retained. The protolith was replaced by abundant fine to medium grained quartz, patchy disseminated grains and aggregates of chlorite and pyrite, and irregular zones of hematite pigmentation. A few discontinuous quartz veins occur and the rock appears to have been partly affected by supergene alteration, leading to local degradation of chlorite to a clay (smectite) phase and the production of a few voids.

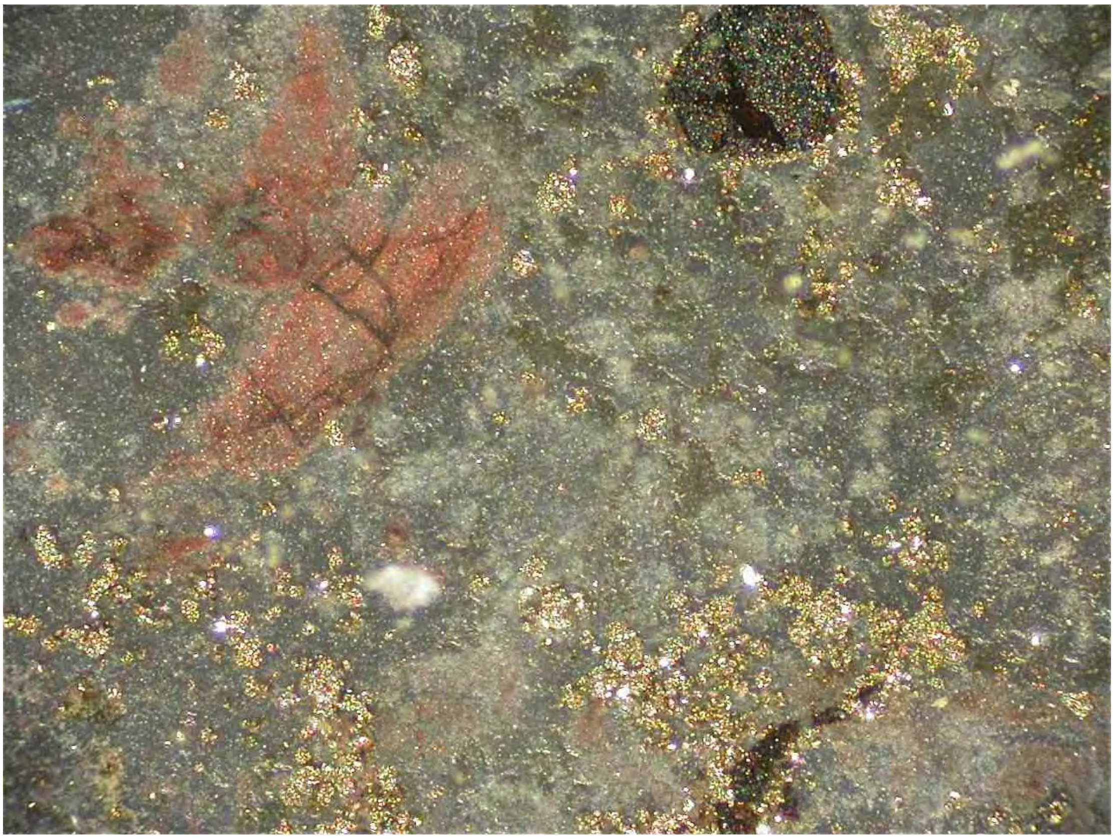

Fig. 106: Relict chromite grains (dark brown-black) within an aggregate of fine to medium grained quartz, disseminated pyrite and patchy reddish hematite dusting. Plane polarised oblique reflected light, field of view 2 mm across.

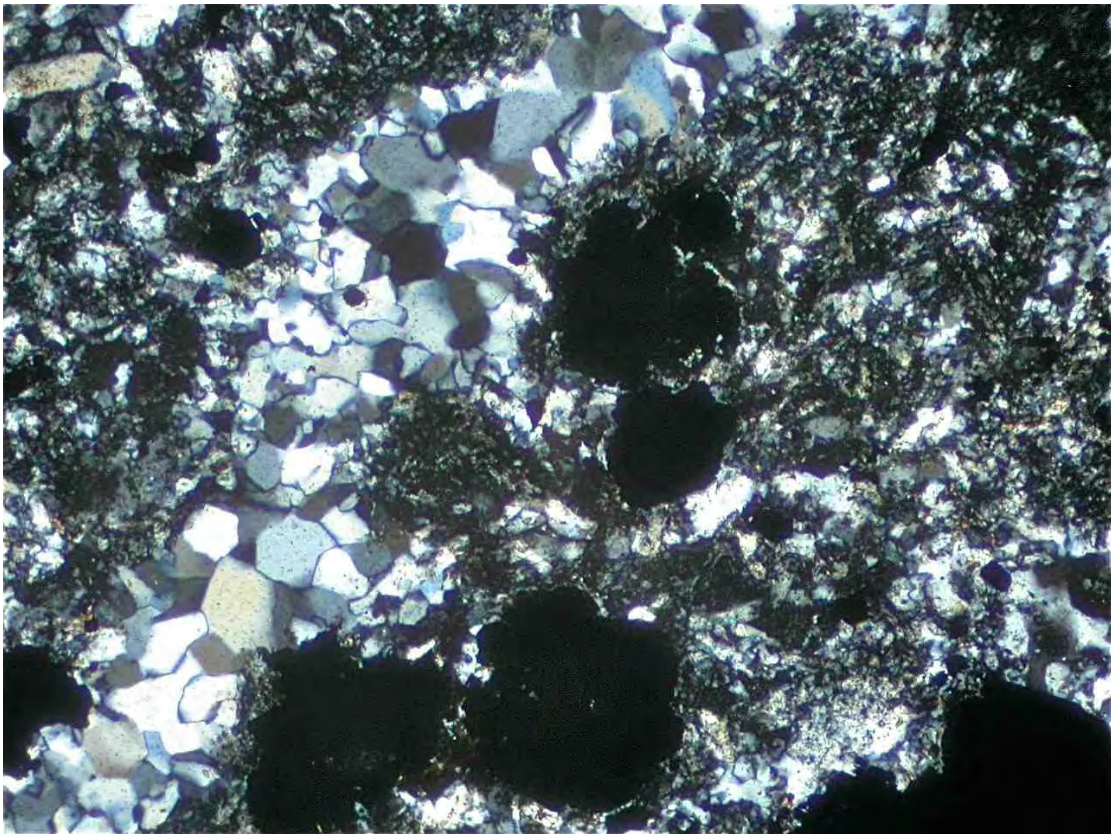

Fig. 107: Quartz vein within a zone of intense replacement of the protolith by granular fine grained quartz, chlorite (dark khaki-grey) and pyrite (black). Transmitted light, crossed polarisers, field of view 2 mm across.

<u>SMD012 88.3 m PTS</u>

Summary: Intensely hydrothermally altered and veined ultramafic rock, perhaps a type of pyroxenite. Relict texture is poorly to moderately preserved, but suggests that the original rock contained abundant, rather coarse grained pyroxene and possibly minor amounts of other silicates, including plagioclase and olivine. The rock retains sparse small grains of chromite, although many are partly altered. The hydrothermal process has converted the protolith to an assemblage dominated by fine to medium grained quartz and fine grained chlorite, with minor, irregularly distributed sulphides that include pyrite, chalcopyrite and a little violarite. Relict chromite is variably replaced by a lower-Fe spinel phase and trace violarite. Several veins occur, dominated by quartz and sulphides, but commonly with chlorite selvedges. Chalcopyrite is the dominant vein sulphide, but pyrite is locally common and a little sphalerite occurs with chalcopyrite.

Handspecimen: The drill core sample is composed of a grey-green, strongly altered fine grained rock, varying from darker to lighter. No definite relict texture is recognised, but it is speculated that possible coarse cumulate texture might occur. The rock now contains abundant chlorite, but with paler coloured zones also containing considerable quartz (Fig. 108). A little disseminated pyrite and chalcopyrite occur throughout and the rock is cut by a few sub-parallel, sub-planar veins at ~70° to the core axis. The veins contain chalcopyrite, quartz and a little pyrite (Fig. 108). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 108: Drill core sample of altered ultramafic rock, now dominated by quartz and chlorite and containinf a couple of sulphide-rich veins (left hand side of sample).

Petrographic description

a) Primary rock characteristics: In the section, relict texture is poorly to moderately preserved, suggesting that the original rock was dominated by medium to coarse grained blocky to prismatic ferromagnesian material (e.g. pyroxene), with grains up to several millimetres (Fig. 109). Other possible silicates might have been present, e.g. plagioclase and olivine, and sparsely scattered throughout the rock are small (up to 0.2 mm) relict chromite grains (Fig. 110). The inferred primary mineralogy indicates that the rock was originally ultramafic, e.g. a type of pyroxenite.

b) Alteration and structure: The interpreted ultramafic protolith was intensely hydrothermally altered and veined, and only relict chromite is inherited from the protolith, albeit commonly partly altered (Fig. 110). Original silicate phases were replaced by fine to medium grained quartz and variable amounts of fine grained chlorite (locally massive aggregates to several millimetres), with irregularly distributed minor sulphides. The latter include pyrite, chalcopyrite and violarite, each occurring discretely (e.g. pyrite aggregates up to 2.5 mm) and in composites (Fig. 111). Chromite is partly to completely replaced by a lower-reflectivity spinel phase and trace violarite (Fig. 110), perhaps due to Fe abstraction during alteration. The altered rock is cut by several veins. Most form a sub-parallel array of sub-planar veins up to 3 mm wide, but there are a couple of other narrow, discontinuous, anastomosing types. Veins contain medium grained quartz and locally abundant sulphides, commonly associated with a chlorite-rich selvedge. Sulphides are dominated by chalcopyrite, but there is locally abundant pyrite, and a little sphalerite associated with chalcopyrite (Fig. 112). The alteration assemblage and veining imply that the protolith has experienced intense quartz-chlorite-sulphide alteration, with hydrothermal introduction of silica, S, Cu (and Zn) and loss of Mg.

c) Mineralisation: The rock contains sparse small relict chromite grains, commonly with zonal texture due to part alteration to a lower-Fe spinel and trace violarite (Fig. 110). Irregularly scattered as part of the alteration assemblage are individual grains and aggregates of sulphides, including pyrite, chalcopyrite and fine grained violarite, locally forming composites (Fig. 111). Veins host considerable sulphides, ranging from disseminated to semi-massive, with dominant chalcopyrite, locally common pyrite (paragenetically early) and a little sphalerite associated with chalcopyrite (Fig. 112).

Mineral Mode (by volume): quartz 50%, chlorite 40%, chalcopyrite 6%, pyrite 3% and traces of chromite (and alteration products), violarite and sphalerite.

Interpretation and comment: It is interpreted that the sample represents a former ultramafic rock (e.g. pyroxenite) that has experienced intense quartz-chlorite-sulphide alteration and associated veining. Relict texture is poorly to moderately preserved, but suggests that the original rock contained abundant, rather coarse grained pyroxene and possibly minor plagioclase and olivine. Sparse small grains of chromite are locally retained. Hydrothermal alteration converted the protolith to quartz and chlorite, with minor, irregularly distributed pyrite, chalcopyrite and a little violarite. Relict chromite is variably replaced by a lower-Fe spinel phase and trace violarite. Several veins occur, dominated by quartz and sulphides, but commonly with chlorite selvedges. Chalcopyrite is the dominant vein sulphide, but pyrite is locally common and a little sphalerite occurs with chalcopyrite.

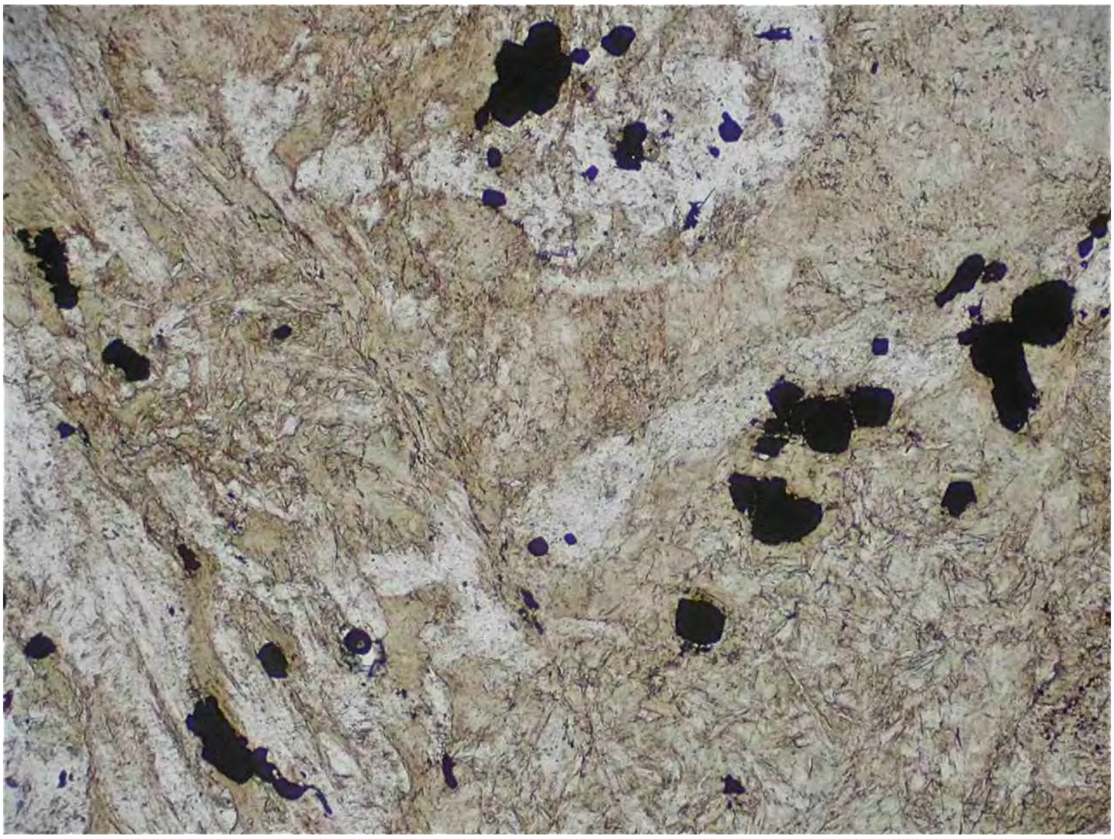

Fig. 109: Interpreted former ultramafic rock (e.g. pyroxenite) with alteration to pale khaki chlorite and quartz (clear). Small black grains include relict chromite as well as disseminated sulphides. Plane polarised transmitted light, field of view 2 mm across.

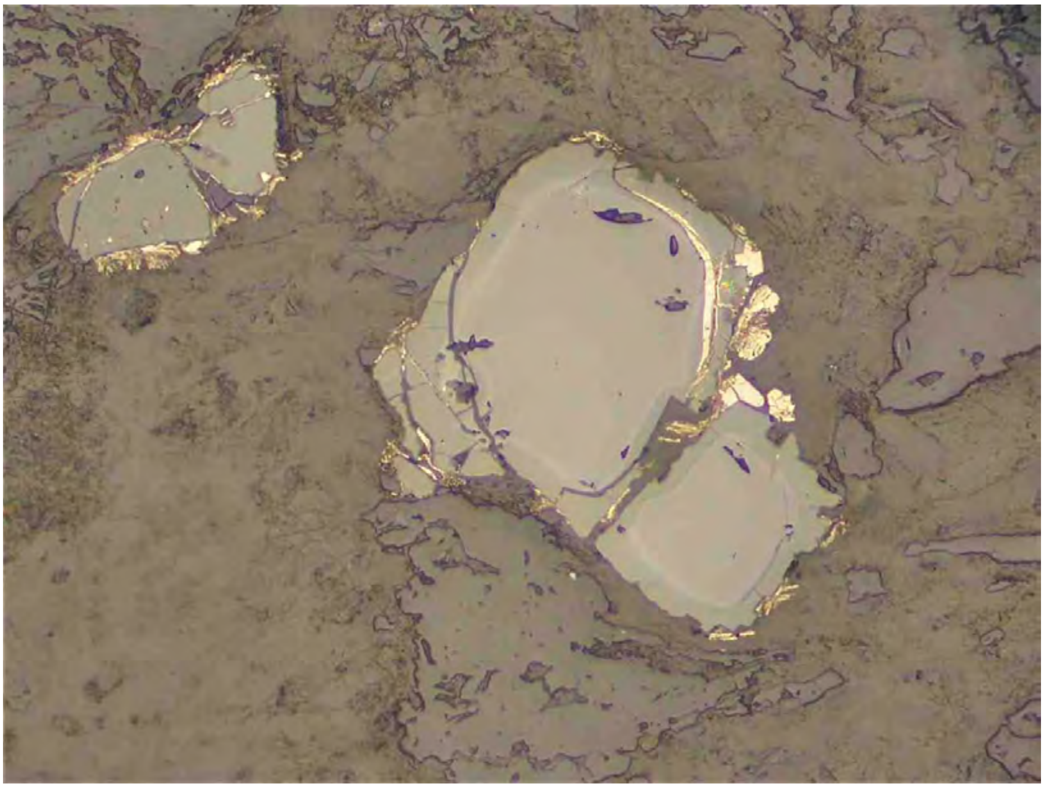

Fig. 110: Relict chromite grains showing zonal texture due to alteration and formation of a lower-Fe spinel phase at margins, accompanied by traces of violarite (creamy). Plane polarised reflected light, field of view 0.5 mm across.

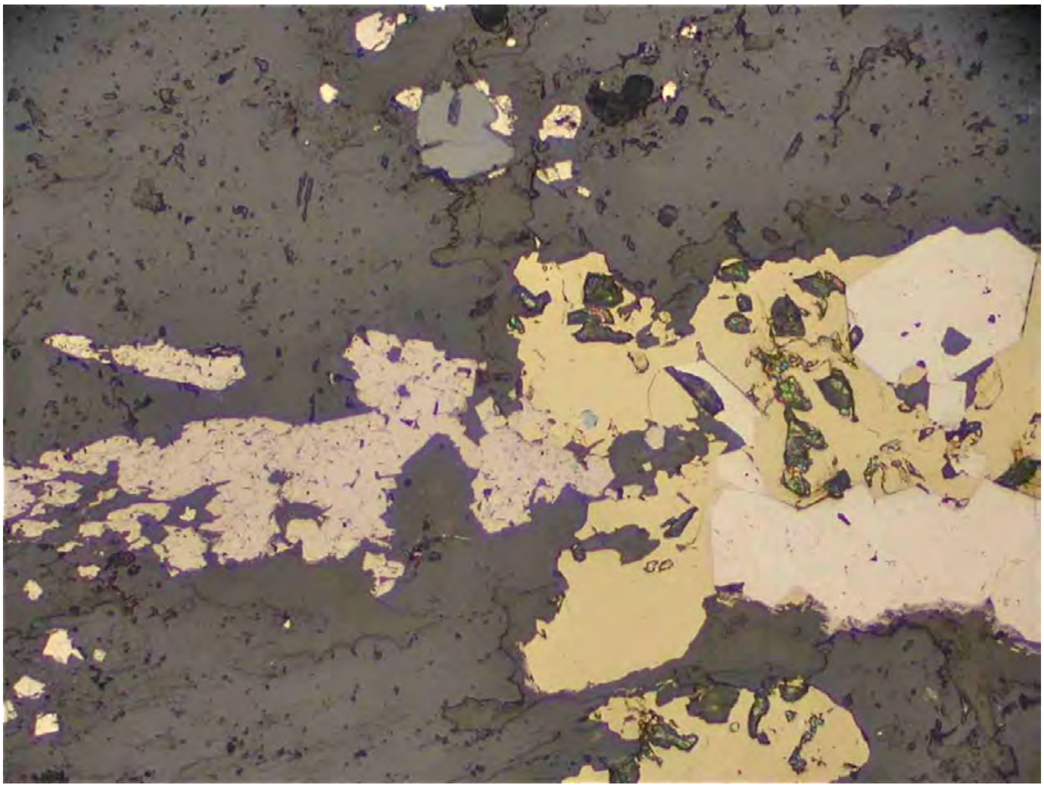

Fig. 111: Small composite aggregate of pyrite (pale creamy), chalcopyrite (yellow) and violarite (slightly pinkish cream at left). Note small relict chromite grain (mid grey) at upper centre. Plane polarised reflected light, field of view 0.5 mm across.

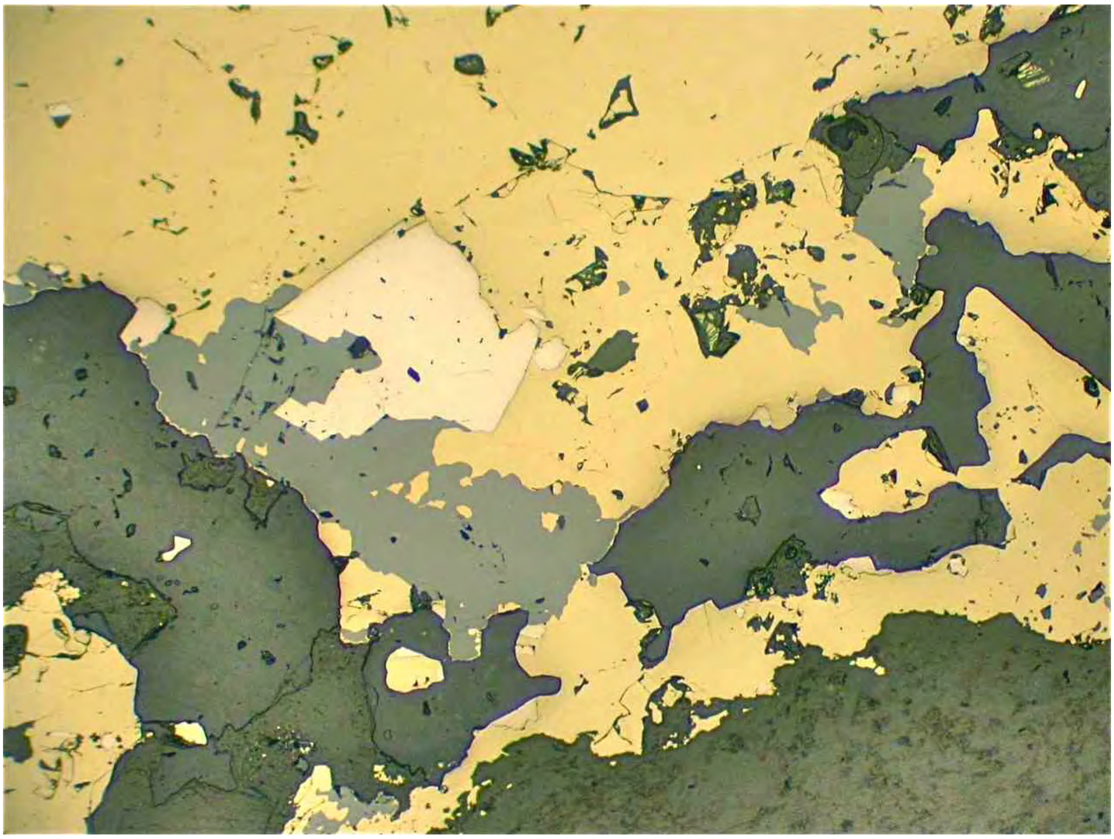

Fig. 112: Sulphide-rich portion of vein assemblage, with chalcopyrite (yellow) hosting pyrite (creamy) and sphalerite (mid grey), adjacent to chlorite and quartz. Plane polarised reflected light, field of view 1 mm across.

SMD012 95.4 m PTS

Summary: Talc-rich rock representing an alteration product of an ultramafic composition protolith. Ultimately the latter could have been a type of peridotite, but it could have been serpentinised prior to being replaced by fine to medium grained talc. There are a few possible pseudomorphs after original pyroxene grains and the rock retains sparsely scattered relict chromite. A little quartz forms aggregates within talc and there is a minor amount of finely disseminated pyrite and chalcopyrite.

Handspecimen: The drill core sample is composed of a whitish, fine grained talc-rich rock, containing sparse black grains up to 0.5 mm across of probable relict chromite (Fig. 113). The presence of chromite indicates that the sample most likely represents an altered ultramafic. A few small grains of pyrite are also apparent. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 113: Drill core sample of altered ultramafic rock, composed dominantly of very soft, fine grained talc. Disseminated small black grains are chromite.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the sample is a talc-rich rock, containing sparsely scattered relict subhedral grains of chromite up to 1 mm across (Figs 114, 115). The presence of chromite confirms that the protolith was of ultramafic type. In places, talc masses up to 2 mm across appear to be pseudomorphs, e.g. after former pyroxene grains up to 2 mm across (or their serpentinised equivelant, i.e. "bastite" pseudomorphs). Apart from chromite, the remainder of the rock does not have any recognised relict texture (e.g. after "mesh texture" after former olivine). The protolith was ultimately a peridotite, but it could have been serpentinised prior to replacement by talc.

b) Alteration and structure: An ultramafic protolith could have been initially serpentinised, then subsequently replaced (except for relict chromite) by fine to medium grained talc, forming flaky and decussate aggregates (Fig. 114). Sparse aggregates of fine grained quartz occur within talc, along with a little fine grained disseminated pyrite and chalcopyrite (Fig. 115). Alteration of the protolith has involved hydrothermal addition of silica, S and Cu.

c) Mineralisation: The rock contains sparse relict subhedral chromite grains up to 1 mm across (Figs 114, 115), with these being locally fractured. As part of the pervasive alteration, small aggregates and individual grains of pyrite (up to 0.3 mm) and chalcopyrite (up to 0.1 mm) are irregularly distributed, hosted in talc (Fig. 115).

Mineral Mode (by volume): talc 95%, chromite 2%, quartz, chalcopyrite and pyrite each 1%.

Interpretation and comment: It is interpreted that the sample is a former ultramafic rock (e.g. peridotite or serpentinised equivalant) that has been altered to form a talc-rich rock. Talc is fine to medium grained and outlines a few possible pseudomorphs after original pyroxene grains. Sparsely scattered relict chromite occurs throughout attesting to the ultramafic protolith. A little quartz forms aggregates within talc and there is a minor amount of finely disseminated pyrite and chalcopyrite.

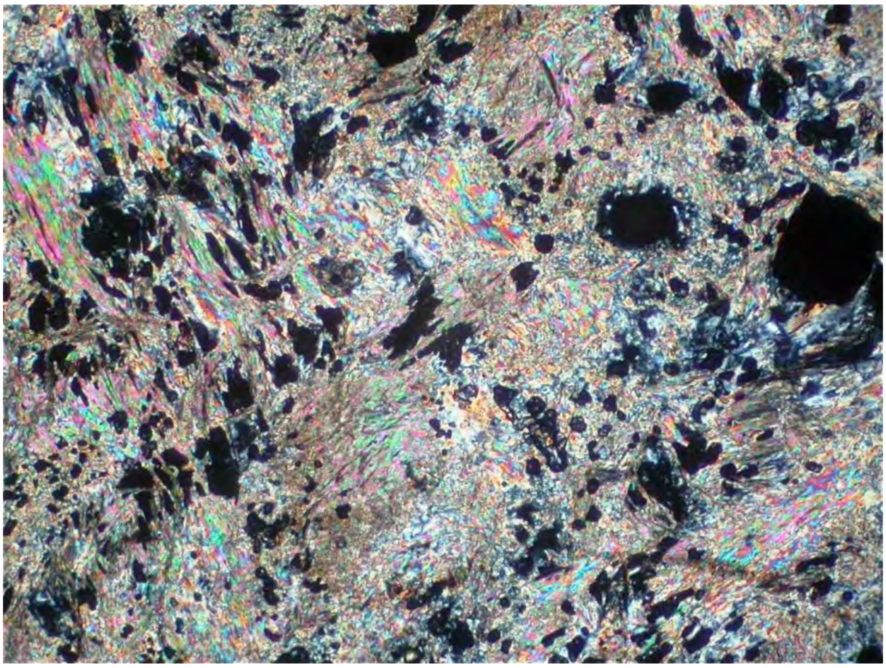

Fig. 114: Talc aggregate, with slightly coarser flaky mass at left being possibly pseudomorphous after a former pyroxene grain. Sub-rounded black grains at right are relict chromite. Most of the other black masses in the image are holes in the section (due to the softness of talc). Transmitted light, crossed polarisers, field of view 2 mm across.

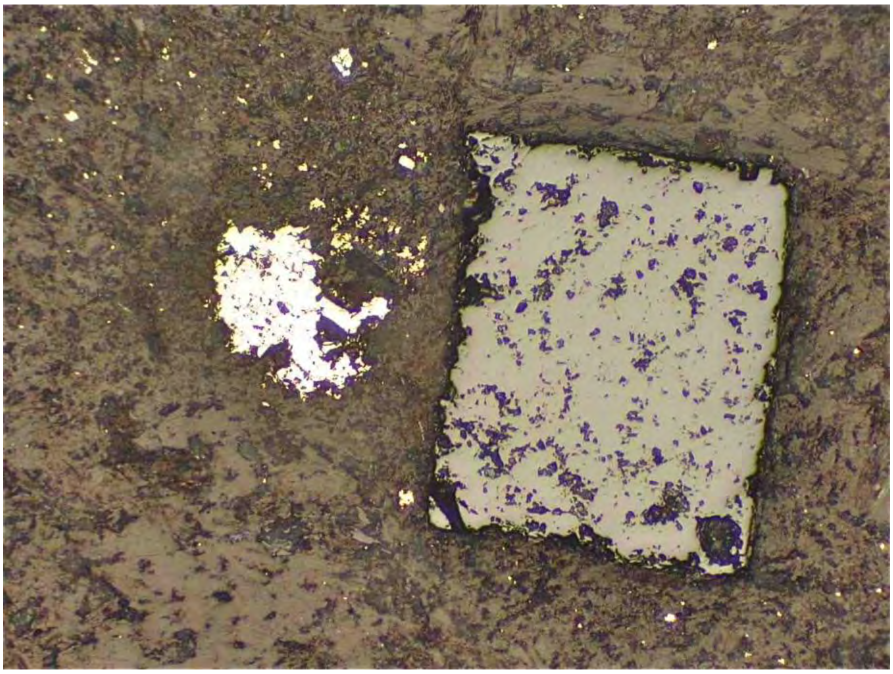

Fig. 115: Subhedral relict chromite grain (pale grey) in talc, with an adjacent small aggregate of pyrite (whitish) and finely disseminated yellow grains of chalcopyrite. Plane polarised reflected light, field of view 1 mm across.

SMD012 98.4 m TS

Summary: Strongly altered porphyritic hornblende dacite. The sample has moderately well preserved relict texture, indicating that the protolith contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), along with a few smaller phenocrystal grains of quartz and FeTi oxide, set in a fine grained quartzofeldspathic groundmass. Pervasive argillic alteration was imposed, with replacement of primary phases (except quartz) by fine grained sericite (mainly concentrated at feldspar phenocryst sites), chlorite (mostly at ferromagnesian sites), quartz and a clay phase (maybe illite-smectite), as well as a little leucoxene-rutile and trace chalcopyrite and pyrite. A single quartz vein occurs in the altered rock.

Handspecimen: The drill core sample is composed of a strongly altered, massive, porphyritic felsic to intermediate composition igneous rock. It has scattered whitish, altered feldspar phenocrysts up to 5 mm across, and greenish pseudomorphs after a former prismatic ferromagnesian phenocryst phase (e.g. hornblende) up to 4 mm long, set in a fine grained, creamy coloured altered groundmass, probably originally of quartzofeldspathic composition (Fig. 116). It is likely that the rock has alteration to fine grained clay/sericite and minor chlorite developed at ferromagnesian sites (Fig. 116). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 116: Drill core sample of strongly altered porphyritic dacite. It originally contained phenocrysts of plagioclase and hornblende in a fine grained quartzofeldspathic groundmass. Alteration is of argillic type and includes sericite, clay, quartz and chlorite.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately well preserved, despite strong hydrothermal alteration (Fig. 117). The rock originally contained scattered blocky feldspar phenocrysts (e.g. plagioclase) up to 5 mm across, with less common prismatic ferromagnesian phenocrysts up to 4 mm long (relict shapes suggest that they were hornblende) and uncommon small phenocrysts of quartz (up to 1.5 mm) and FeTi oxide (up to 0.8 mm) (Fig. 117). A trace of relict zircon occurs at altered ferromagnesian sites. The phenocrystal phases occurred in a fine grained groundmass, probably of original quartzofeldspathic composition. The relict characteristics of the rock indicate that it was originally a porphyritic hornblende dacite.

b) Alteration and structure: The igneous rock experienced strong pervasive hydrothermal alteration and emplacement of a single vein. Former feldspar phenocrysts were replaced by fine grained sericite, locally with a little clay (e.g. illite-smectite) and chlorite (Fig. 117). All ferromagnesian material was replaced by chlorite (Fig. 117), with local sericite, a little leucoxene-rutile and traces of chalcopyrite and pyrite. Igneous FeTi oxide was replaced by leucoxene-rutile and in the groundmass there was strong replacement by finely granular quartz, clay, minor sericite and chlorite, and trace pyrite. The alteration assemblage is interpreted as being of argillic type. The vein is sub-planar, up to 1.5 mm wide, and contains medium grained quartz.

c) Mineralisation: As part of the alteration assemblage, the rock contains traces of disseminated pyrite and chalcopyrite, mostly at altered ferromagnesian sites, forming aggregates up to 0.3 mm across.

Mineral Mode (by volume): quartz and sericite each 30%, clay (maybe illite-sericite) 25%, chlorite 14%, leucoxene-rutile 1% and traces of chalcopyrite, pyrite and zircon.

Interpretation and comment: It is interpreted that the sample represents a porphyritic hornblende dacite that has experienced strong argillic alteration. Relict texture is moderately well preserved, indicating that the rock formerly contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), along with a few smaller phenocrystal grains of quartz and FeTi oxide, enclosed by a fine grained quartzofeldspathic groundmass. Alteration caused replacement by sericite (mainly concentrated at feldspar phenocryst sites), chlorite (mostly at ferromagnesian sites), quartz and a clay phase (maybe illite-smectite), as well as a little leucoxene-rutile and trace chalcopyrite and pyrite. A single quartz vein occurs in the altered rock.

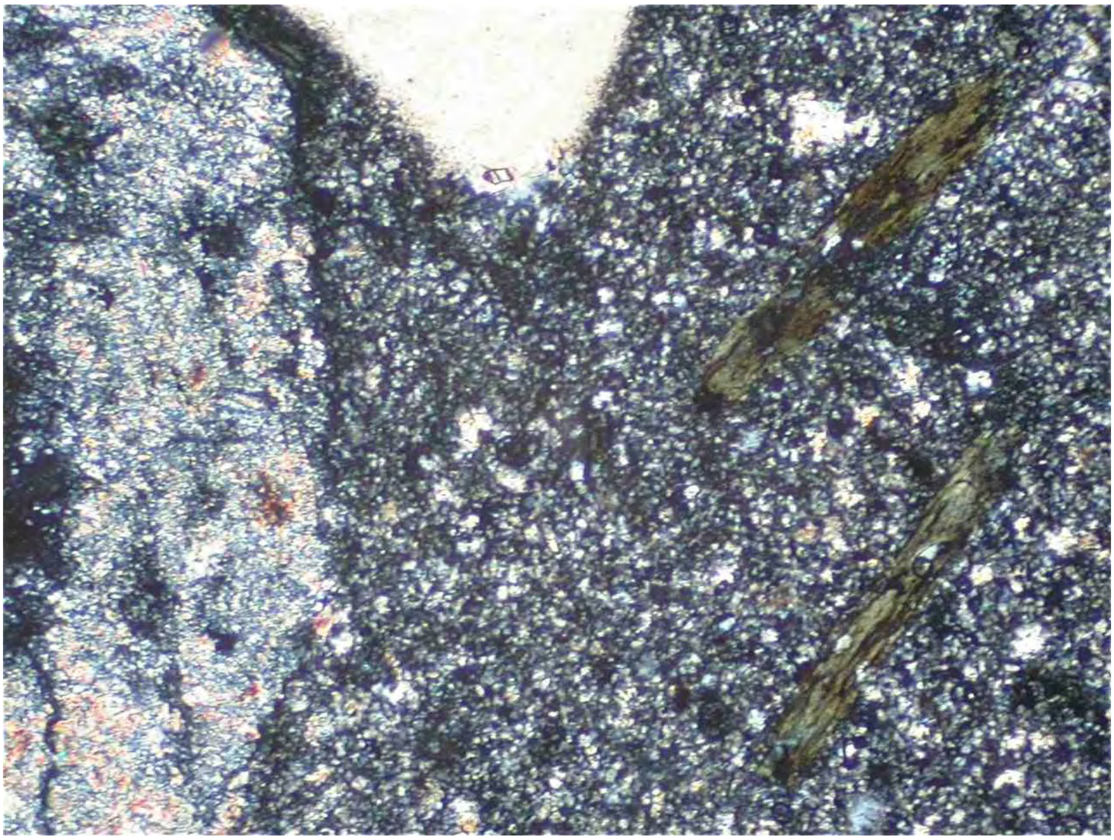

Fig. 117: Relict porphyritic texture in altered dacite, showing a sericite-replaced plagioclase phenocryst at left, a couple of chlorite pseudomorphs (khaki) after former hornblende phenocrysts, part of a relict quartz phenocryst (top) and a fine grained groundmass, replaced mostly by quartz and clay. Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 102.9 m TS

Summary: Porphyritic hornblende microtonalite or dacite, with imposed strong propylitic alteration. Relict texture is moderately well preserved, indicating that the rock contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), along with a few smaller phenocrystal grains of quartz and FeTi oxide, hosted in a fine grained quartzofeldspathic groundmass. Imposed alteration caused replacement of feldspar, dominantly by sericite, and ferromagnesian material mostly by chlorite. Small amounts of pyrite and trace chalcopyrite occur, mostly at altered ferromagnesian sites. A couple of thin quartz-rich veins cut the altered rock.

Handspecimen: The drill core sample is composed of a strongly altered, pale grey-green, porphyritic felsic to intermediate composition igneous rock (Fig. 118). It contains scattered creamy to pale grey, altered blocky feldspar phenocrysts up to 6 mm across, as well as dark greenish-grey pseudomorphs after a former prismatic ferromagnesian phenocryst phase (e.g. hornblende) up to 4 mm long. The phenocrystal phases occur in a fine grained, altered groundmass, probably originally of quartzofeldspathic composition. The rock has pervasive alteration to fine grained sericite/clay, lesser chlorite and a little disseminated pyrite, mainly at ferromagnesian sites. A couple of sub-planar quartz veins up to 1 mm wide cut the altered rock, which is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 118: Drill core sample of strongly altered porphyritic dacite or microtonalite. It originally contained phenocrysts of plagioclase and hornblende in a fine grained quartzofeldspathic groundmass. Alteration is of propylitic type and includes sericite, quartz, chlorite and a little pyrite and chalcopyrite. A couple of thin quartz veins are apparent.

Petrographic description

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately well preserved (Fig. 119). There are scattered pseudomorphs after fomer blocky feldspar phenocrysts (probably plagioclase) up to 6 mm across and pseudomorphs after a former prismatic ferromagnesian phase (e.g. hornblende) up to 3.5 mm long (Fig. 119). The rock retains uncommon quartz phenocrysts up to 1.5 mm across and there are a few altered microphenocrysts of FeTi oxide up to 0.4 mm across. The phenocrystal phases occurred in a fine grained, microgranular texture groundmass, probably of quartzofeldspathic composition (Fig. 119). From the relict characteristics, the primary rock indicate is interpreted as a porphyritic hornblende microtonalite or dacite.

b) Alteration and structure: The igneous rock was subject to strong, pervasive hydrothermal alteration. All former feldspar was replaced by fine grained sericite, with a little chlorite and pyrite, and all ferromagnesian material was replaced by chlorite, in places accompanied by a little sericite, quartz, leucoxene-rutile, pyrite and chalcopyrite (Fig. 119). Igneous FeTi oxide was replaced by leucoxene-rutile and in the groundmass there was replacement and recrystallisation to finely granular quartz, interstitial sericite and a little chlorite and pyrite (Fig. 119). The altered rock is cut by a couple of sub-planar veins up to 0.5 mm wide, containing quartz and a little sericite and chlorite. The alteration assemblage in the sample is consistent with propylitic type.

c) Mineralisation: The rock contains a little disseminated pyrite and trace chalcopyrite as part of the alteration assemblage, most commonly occurring at altered ferromagnesian sites (Fig. 119). Largest pyrite grains are up to 0.8 mm across.

Mineral Mode (by volume): quartz and sericite each 45%, chlorite 9%, pyrite 1% and traces of leucoxene-rutile and chalcopyrite.

Interpretation and comment: It is interpreted that the sample is a strongly propylitically altered porphyritic hornblende microtonalite or dacite. There is moderately well preserved relict texture, indicating that the rock contained scattered phenocrysts of feldspar (probably plagioclase) and a prismatic ferromagnesian phase (probably hornblende), as well as a few smaller phenocrystal grains of quartz and FeTi oxide, hosted in a fine grained quartzofeldspathic groundmass. Alteration led to replacement of feldspar, dominantly by sericite, and ferromagnesian material mostly by chlorite. Small amounts of pyrite and trace chalcopyrite occur, mostly at altered ferromagnesian sites. A couple of thin quartz-rich veins cut the altered rock.

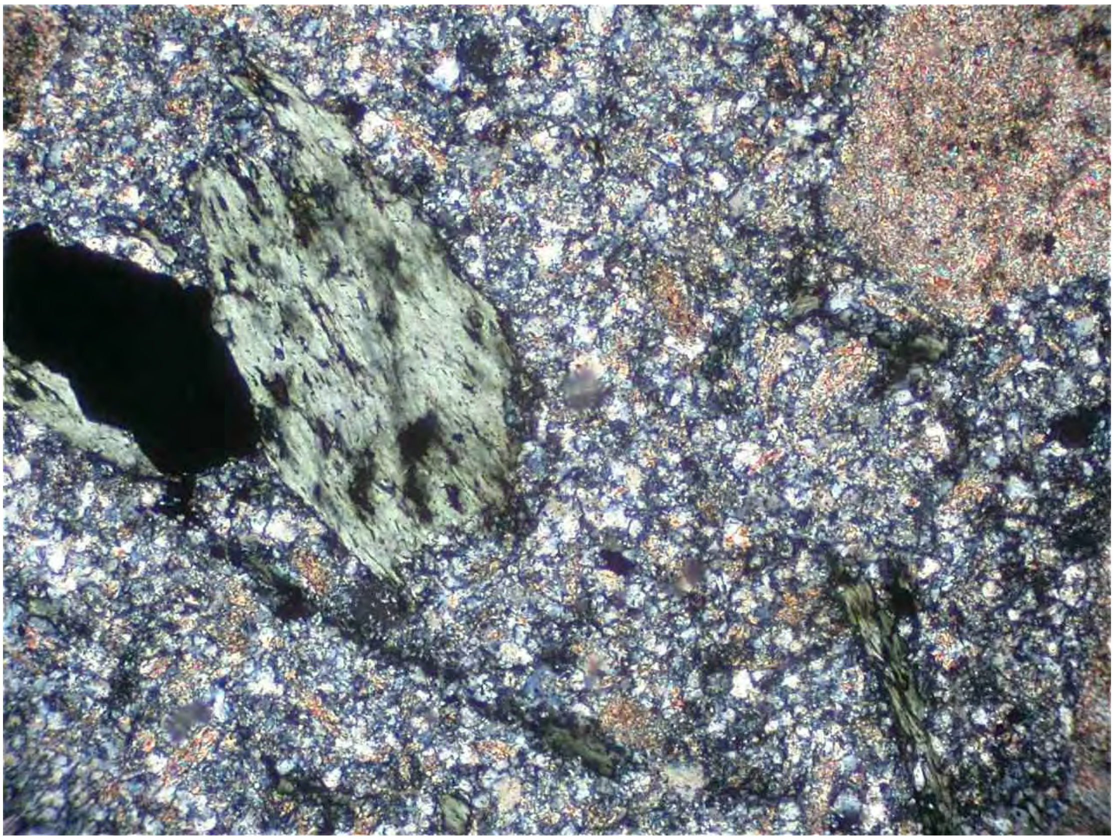

Fig. 119: Chlorite-replaced hornblende phenocryst at left, with associated pyrite aggregate (black) and portion of a sericite-replaced feldspar phenocryst at upper right. The original groundmass was replaced by finely granular quartz and interstitial sericite and chlorite. Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 109.8 m PTS

Summary: Fine grained clastic rock, perhaps originally a siltstone or felsic tuff/epiclastic, overprinted by intense phyllic alteration. There is little recognised relict texture and the protolith was thoroughly replaced by fine grained sericite and quartz, disseminated pyrite and traces of chalcopyrite and rutile. Scattered throughout are small, irregular, discontinuous veinlets of pyrite, with a little associated quartz and paragenetically later chalcopyrite and trace marcasite. Pyrite contains rare tiny bornite inclusions.

Handspecimen: The drill core sample is composed of a very strongly altered, fine grained rock, now dominated by whitish clay/sericite, and disseminated and veinlet pyrite (Fig. 120). Scattered pale grey, fine grained quartz-rich aggregates up to a few millimetres across occur in places, locally associated with pyrite. A trace of chalcopyrite is also evident in aggregates with pyrite, which are up to a few millimetres across. No diagnostic relict texture is apparent in the sample, which is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 120: Drill core sample of strongly altered fine grained clastic sedimentary or epiclastic rock, replaced by sericite and quartz, with disseminated and veinlet pyrite. A little chalcopyrite occurs with veinlet pyrite.

Petrographic description

a) Primary rock characteristics: In the section, there is no diagnostic relict texture, although it is likely that the protolith was fine grained. It is speculated that there are a few possible relict quartz grains up to 0.1 mm across and a trace of zircon, which could have originally been detrital grains. The alteration assemblage contains abundant fine grained sericite and quartz and this could be consistent with the protolith being of former pelitic-psammopelite sedimentary composition (shale-siltstone), or a similar type of felsic tuffaceous rock (e.g. epiclastic siltstone).

b) Alteration and structure: Protolith material was intensely hydrothermally altered and replaced by a phyllic assemblage with abundant fine grained sericite and quartz (Fig. 121). Within this, there are variations to somewhat more quartz-rich zones (up to a few millimetres across) as well as disseminated pyrite (aggregates up to 2 mm across), with traces of chalcopyrite (in pyrite aggregates) and rutile (Fig. 121). Some of the pyrite aggregates have “pressure shadows” of finely granular and fibre-texture quartz (Fig. 121). The altered rock also hosts several small, irregular, discontinuous veinlets up to 0.6 mm wide containing pyrite and chalcopyrite, minor quartz, and a trace of marcasite associated with chalcopyrite (Fig. 122).

c) Mineralisation: Significant sulphides occur in the altered rock, with disseminated aggregates of pyrite up to 2 mm across, in places containing a trace of associated chalcopyrite, and irregular, discontinuous veinlets up to 0.6 mm wide with fine to medium grained pyrite, paragenetically later chalcopyrite and a trace of fine grained marcasite (Fig. 122). In these veinlets, pyrite hosts rare tiny inclusions of bornite (up to 20 µm across).

Mineral Mode (by volume): quartz and sericite each 45%, pyrite 8%, chalcopyrite 2% and traces of rutile, zircon, marcasite and bornite.

Interpretation and comment: It is interpreted that the sample represents an intensely phyllic altered fine grained clastic or epiclastic rock (siltstone or felsic tuff). There is little recognised relict texture, with replacement of the protolith by fine grained sericite and quartz, disseminated pyrite and traces of chalcopyrite and rutile. Scattered throughout are small, irregular, discontinuous veinlets of pyrite, with a little associated quartz and paragenetically later chalcopyrite and trace marcasite. Pyrite contains rare tiny bornite inclusions.

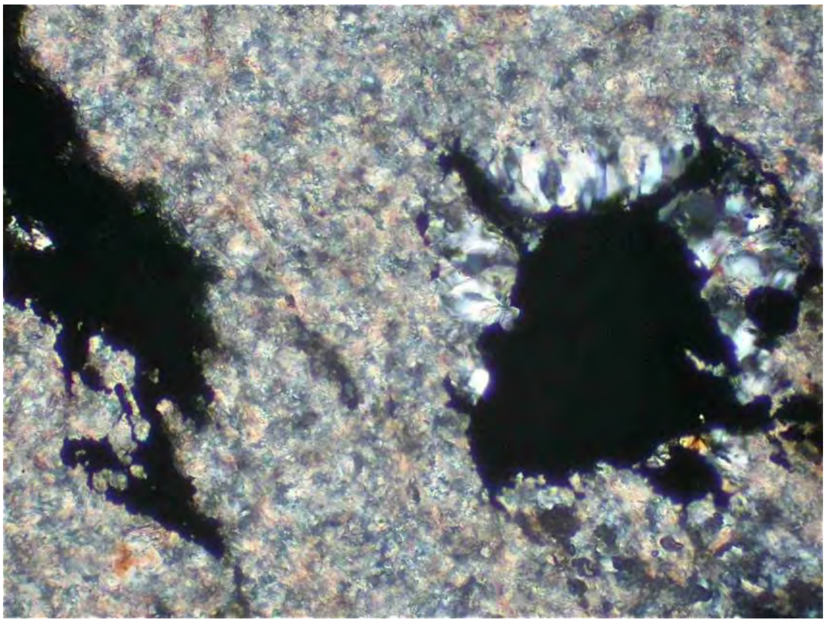

Fig. 121: Pyrite aggregate (right) showing local development of fringing "pressure shadow" quartz, hosting in a fine grained sericite-quartz aggregate. At left is part of a veinlet of chalcopyrite and pyrite. Transmitted light, crossed polarisers, field of view 1 mm across.

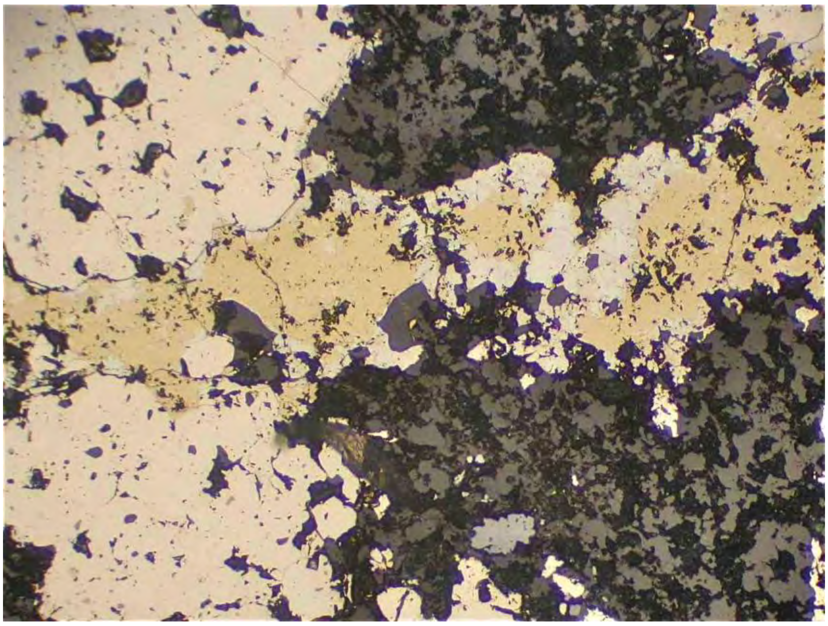

Fig. 122: Small chalcopyrite vein cutting an aggregate of pyrite (left) and quartz-sericite (dark grey). A little marcasite (slightly paler than pyrite) is associated with chalcopyrite. Plane polarised reflected light, field of view 1 mm across.

SMD012 132.0 m PTS

Summary: Former fine grained siltstone or tuff, with very strong pervasive alteration to fine grained quartz and sericite (or pyrophyllite), with minor disseminated pyrite, small aggregates of fine grained clay (e.g. kaolinite) and trace rutile and an alunite-like phase (maybe svanbergite). The rock also contains a few metasomatic aggregates, some of veinlike form, of quartz, with local sericite, a little pyrite and trace rutile and chalcopyrite. Alteration is of phyllic or advanced argillic type, depending on the identity of the layer silicate phase.

Handspecimen: The drill core sample is composed of a pale grey, fine grained, strongly altered rock, probably with an alteration assemblage of quartz and clay/sericite, as well as minor disseminated pyrite (aggregates up to 5 mm across) (Fig. 123). There are also a few diffuse veins up to 2 mm wide containing quartz and local pyrite, and which have scattered cavities (Fig. 123). No definite relict texture is recognised and it is speculated that the original rock was a fine grained clastic sedimentary or felsic pyroclastic type (e.g. siltstone or tuff). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 123: Drill core sample of strongly altered rock, possibly a tuff or tuffaceous siltstone, with replacement by fine grained quartz and sericite or pyrophyllite. Small dark aggregates are mostly pyrite, and there are a few small cavities.

Petrographic description

a) Primary rock characteristics: In the section, most of the sample has no recognised relict texture due to strong alteration. It is likely that the protolith was fine grained and there are sparsely scattered relict quartz grains up to 0.2 mm across and a few possible pseudomorphs after former blocky feldspar grains up to 1.5 mm across, and after FeTi oxide grains up to 0.3 mm across. Rare tiny grains of relict zircon are also recognised. It is speculated that the bulk rock composition could have been of quartzofeldspathic type and that originally the rock was a felsic composition tuff or derived epiclastic (e.g. tuffaceous siltstone).

b) Alteration and structure: Intense hydrothermal alteration was imposed on the protolith, with pervasive replacement and development of scattered irregular to veinlike metasomatic aggregates (Fig. 124). Most of the rock was replaced by a fine grained sericite-like mineral and quartz, with sparsely scattered anhedral porphyroblastic pyrite aggregates up to 2 mm across, scattered small interstitial aggregates of a fine grained, low-birefringent clay phase (e.g. kaolinite) and a little rutile. There are also a few aggregates up to 0.8 mm across of an alunite-like phase (perhaps svanbergite, given the anomalous Sr value in the rock) that is intergrown with quartz and clay (Fig. 125). The irregular to veinlike aggregates are up to 1.5 mm wide and contain fine to medium grained quartz, patchy sericite, a few grains of pyrite and traces of rutile and chalcopyrite (Fig. 124). In places, these aggregates host a few small cavities up to 1 mm across. The identity of the fine grained, near-colourless layer silicate phase (sericite-like) is not resolved. The fact that the bulk rock sample has low K could imply that this mineral is not sericite, but pyrophyllite. The presence of this mineral, together with kaolinite and possible svanbergite is consistent with advanced argillic alteration, rather than phyllic alteration.

c) Mineralisation: The sample contains irregularly distributed pyrite grains and aggregates up to 2 mm across as part of the alteration. A little pyrite occurs in the veinlike aggregates (Fig. 124), and in these there is also a tiny trace of chalcopyrite.

Mineral Mode (by volume): quartz 50%, layer silicate phase (sericite or pyrophyllite) 40%, clay (kaolinite) 5%, pyrite 4% and traces of rutile, zircon, chalcopyrite and ?svanbergite.

Interpretation and comment: It is interpreted that the sample represents a very strongly hydrothermally altered fine grained siltstone or tuff. Alteration could be of phyllic or advaned argillic type, depending on the identity of a fine grained layer silicate phase (sericite or pyrophyllite) that is accompanied by abundant fine grained quartz, minor disseminated pyrite, small aggregates of clay (e.g. kaolinite) and trace rutile and an alunite-like phase (maybe svanbergite). The rock also contains a few metasomatic aggregates, some of veinlike form, of quartz, with local sericite, a little pyrite and trace rutile and chalcopyrite. Alteration is of phyllic or advanced argillic type, depending on the identity of the layer silicate phase.

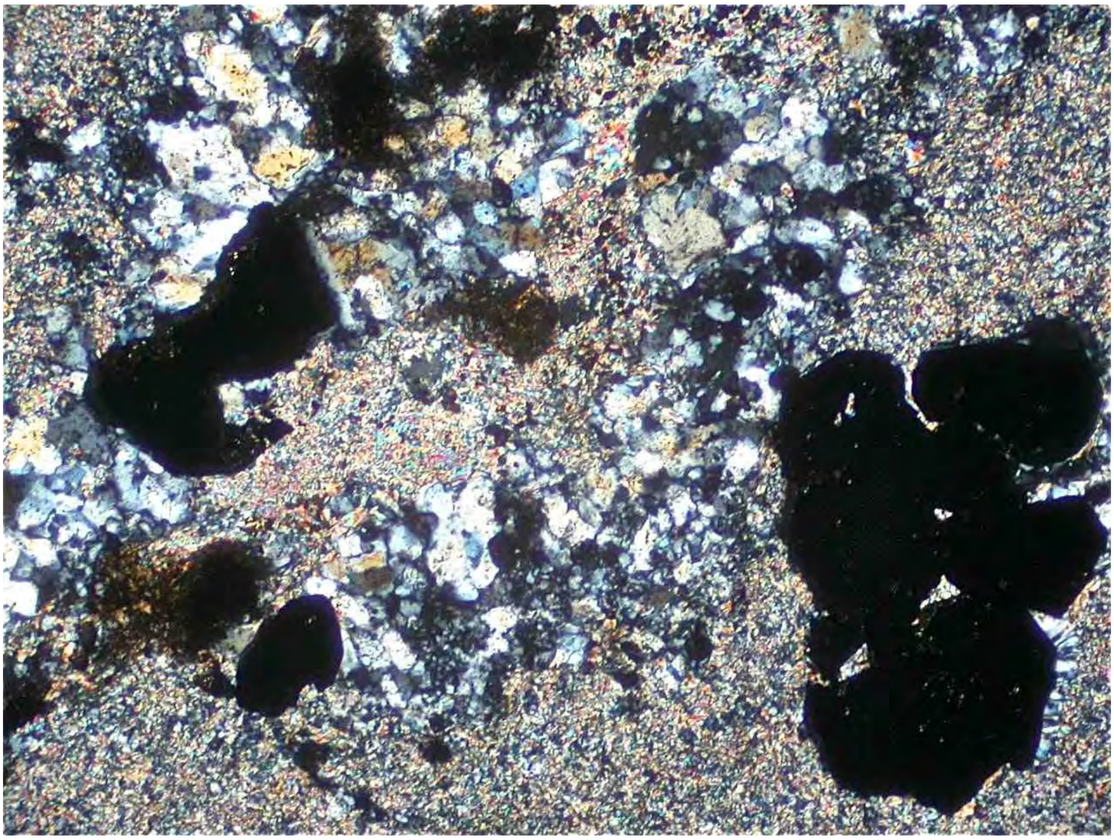

Fig. 124: Quartz-rich veining and minor associated pyrite (black) cutting very strongly altered rock composed of sericite/pyrophyllite and quartz. Transmitted light, crossed polarisers, field of view 2 mm across.

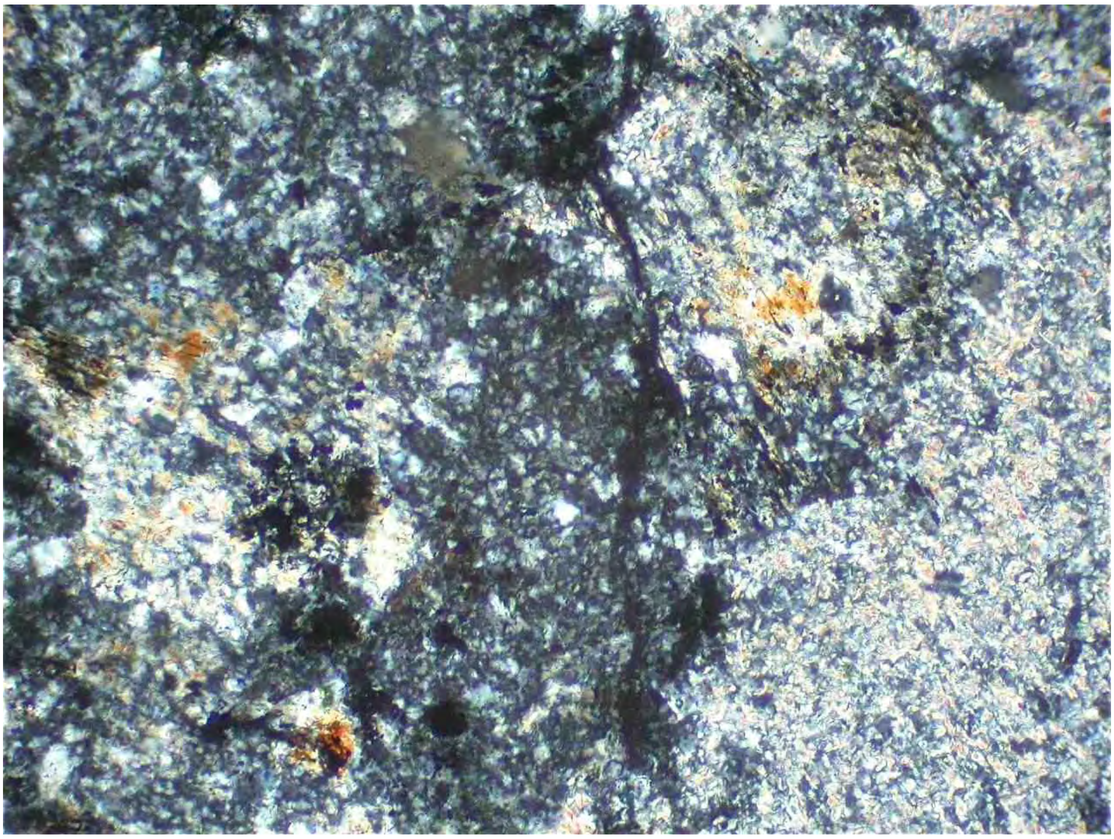

Fig. 125: Small aggregates of ?svanbergite (yellow tints) intergrown with quartz and low-birefringent clay (grey) adjacent to sericite/pyrophyllite aggregate at right. Transmitted light, crossed polarisers, field of view 1 mm across.

<u>SMD012 160.4 m TS</u>

<u>Summary</u>: Medium to coarse grained lithic sandstone, grading into conglomerate and displaying strong propylitic alteration. Lithic grains are commonly fine grained and some could represent altered sedimentary material (e.g. siltstone), whereas others have relict porphyritic texture and could have originally been of felsic to intermediate volcanic type. Overall relict texture is poorly preserved due to the strong alteration, which has caused replacement of the protolith, forming patchy domains rich in chlorite, locally in quartz, and elsewhere in quartz + sericite, plus variable chlorite. Disseminated pyrite, a little chalcopyrite and trace leucoxene-rutile occur throughout, but sulphides tend to be more abundant in association with chlorite and/or quartz-rich aggregates.

<u>Handspecimen</u>: The drill core sample is composed of a grey-green coarse sandstone, grading to conglomerate and showing strong, pervasive alteration. Larger detrital grains are commonly well-defined and dominated by fine grained lithic and quartz-rich types. In the coarser, conglomeratic zone, lithic grains are up to 2.5 cm across, but elsewhere, they are mostly <5 mm (Fig. 126). Diffuse bedding lamination occurs, oriented at ~60° to the core axis, defined by differences in detrital grain size (Fig. 126). Lithic grains could include fine sedimentary as well as volcanic material (possible porphyritic texture). Imposed alteration has likely caused replacement by sericite, chlorite and quartz, with minor disseminated pyrite, grading locally into semi-massive aggregates (Fig. 126). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

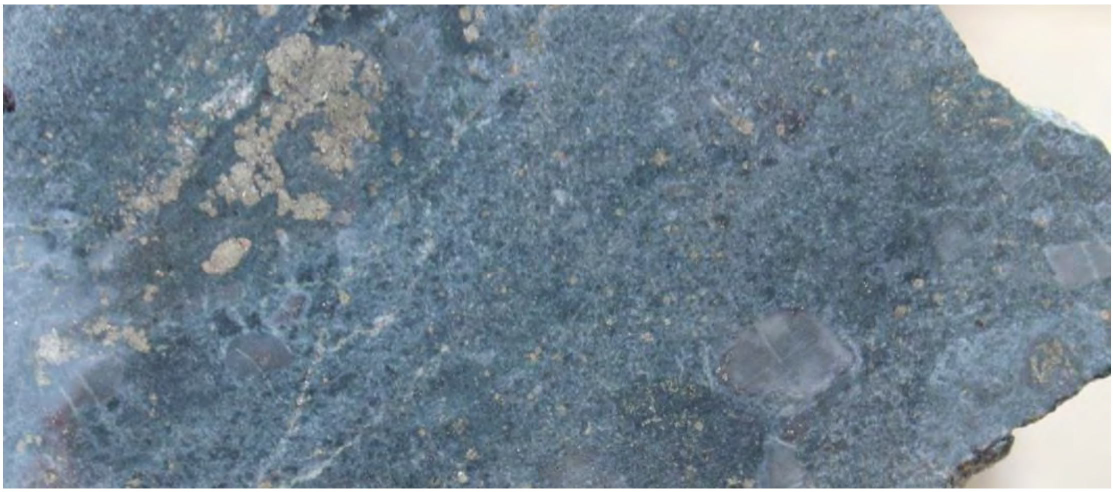

Fig. 126: Drill core sample of altered lithic sandstone, grading to conglomerate, showing generally diffuse large detrital grains of fine grained lithics (may include sedimentary and volcanic types). The rock has strong alteration to chlorite, sericite and quartz, with scattered aggregates of individual grains of pyrite.

<u>Petrographic description</u>

a) Primary rock characteristics: In the section, relict texture is poorly preserved and only diffuse oitlines after scattered lithic fragments up to 2 cm across are recognised. Within some fragments, possible relict porphyritic texture (feldspar-phyric) occurs and there are a few individual grains of quartz (former volcanic phenocrysts) up to 0.5 mm, along with possible altered feldspar grains (Fig. 127). Some lithic fragments are fine grained and recrystallised, and rich in quartz and sericite and/or chlorite, with possible relict detrital quartz grains; these fragments are tentatively interpreted as originally being fine grained siltstone. Overall, it appears that the rock had fine grained sedimentary and intermediate to felsic volcanic detritus, with larger grains enclosed in a sandy texture matrix. It is therefore tentatively suggested that the rock was a lithic-dominated conglomerate, grading to sandstone.

b) Alteration and structure: Strong pervasive hydrothermal alteration was imposed, and apart from the few relict quartz grains, all other primary components were replaced. Sites with former feldspar tend to have abundant fine grained sericite aggregates (Fig. 127), and these occur in domains rich in fine grained quartz, and in chlorite. Elsewhere, there are many diffuse domains up to 2 cm across rich in chlorite and locally with abundant fine to medium grained quartz, commonly associated with significant sulphide masses up to 6 mm across (Fig. 128). Minor disseminated sulphides occur throughout the rock, along with traces of finely disseminated leucoxene-rutile. The alteration assemblage is interpreted to be of propylitic type.

c) Mineralisation: Minor disseminated sulphides, grading to local semi-massive agrgegates up to 6 mm across, occur irregularly in the sample, but are most common in chlorite- and quartz-rich domains (Fig. 128). Medium to coarse grained, anhedral to subhedral pyrite is common, with individual grains up to 3.5 mm across, and locally forming composite aggregates with chalcopyrite. There are also sparse discrete aggregates of the latter up to 0.8 mm across.

Mineral Mode (by volume): chlorite 40%, sericite 30%, quartz 25%, pyrite 4%, chalcopyrite 1% and a trace of leucoxene-rutile.

Interpretation and comment: It is interpreted that the sample is a strongly altered lithic sandstone, grading into conglomerate. Lithic grains are fine grained and could represent altered sedimentary material (e.g. siltstone) and porphyritic felsic to intermediate volcanic rock. Relict texture is generally poorly preserved due to the strong propylitic alteration, which has caused replacement, forming patchy domains rich in chlorite, locally in quartz, and elsewhere in quartz + sericite, plus variable chlorite. Disseminated pyrite, a little chalcopyrite and trace leucoxene-rutile occur throughout, but sulphides tend to be more abundant in association with chlorite and/or quartz-rich aggregates.

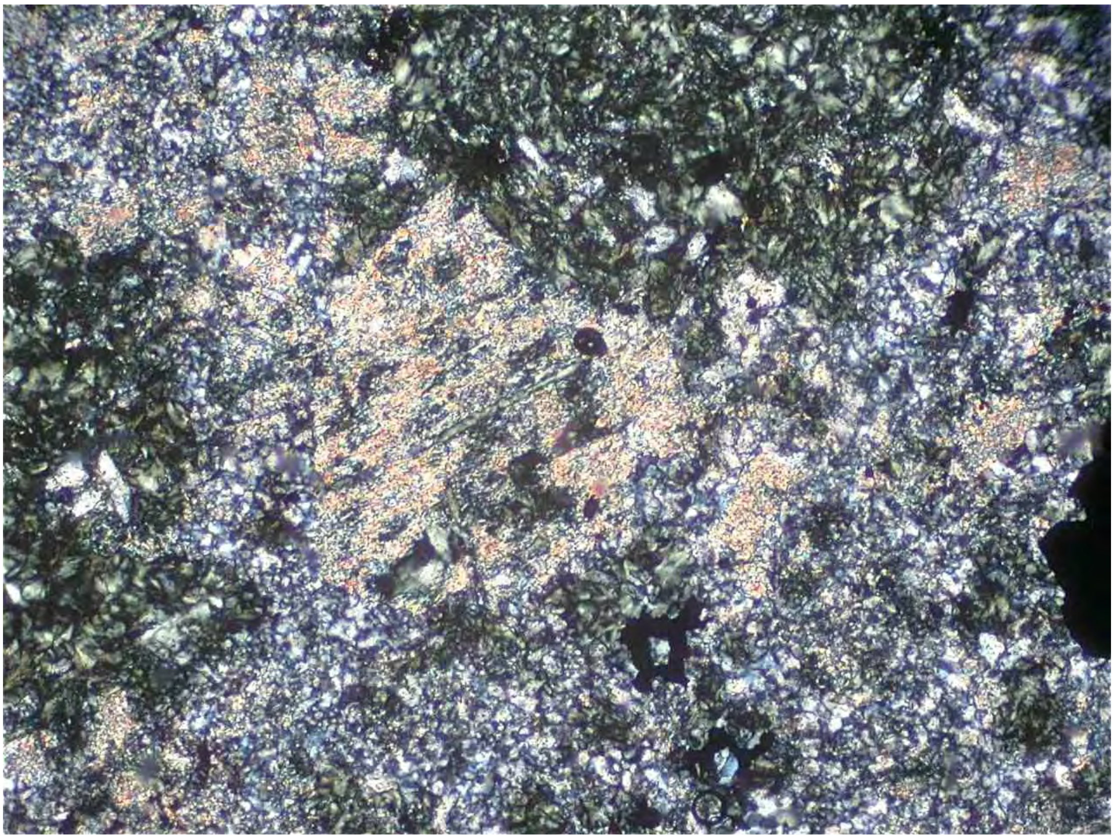

Fig. 127: Sericite-rich aggregates, possibly after former feldspar grains, with nearby chlorite-rich aggregates (dark khaki-grey) in an altered matrix rich in quartz. Black grains are pyrite. Transmitted light, crossed polarisers, field of view 2 mm across.

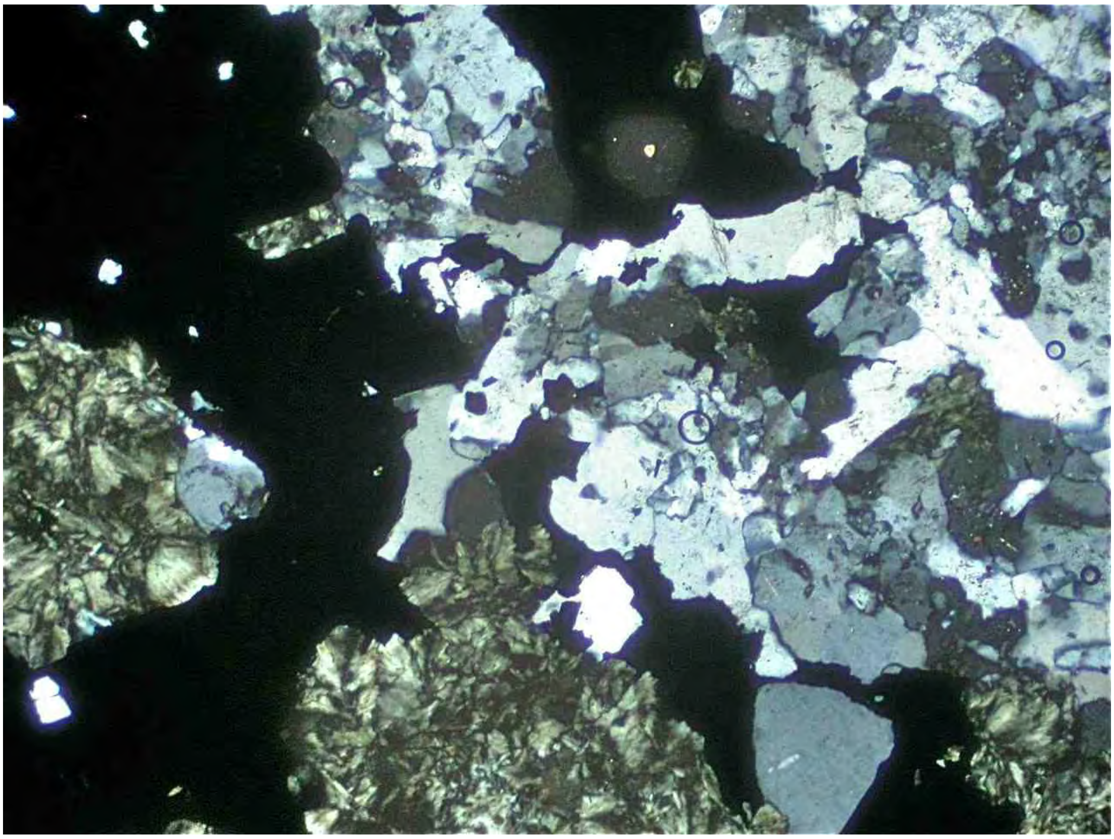

Fig. 128: Chlorite aggregates (khaki) associated with black masses of pyrite + chalcopyrite and adjacent fine to medium grained inequigranular quartz. Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 163.4 m PTS

Summary: Coarse, clast-supported breccia, with the majority of fragments probably being of fine grained clastic sedimentary type (e.g. cherty argillite, siltstone), but with possible quartz-phyric felsic volcanic material and at least one large fragment of possible altered mafic igneous rock. There are also a few isolated discrete quartz grains. Little matrix is recognised and interstitial sites are strongly altered. The rock has sustained strong propylitic alteration, with the interpreted sedimentary and ?felsic volcanic fragments being replaced by fine grained quartz, with minor sericite, chlorite, pyrite and trace rutile and chalcopyrite. Chlorite-rich aggregates occur at possible mafic igneous and interstitial sites and these also display considerable hydrothermal quartz, abundant pyrite, minor chalcopyrite and traces of rutile and marcasite (associated with chalcopyrite). At these sites, pyrite also hosts a few tiny inclusions of chalcopyrite, bornite and galena.

Handspecimen: The drill core sample is composed of clast-supported breccia containing angular to sub-rounded fine grained fragments up to 2.5 cm across (Fig. 129). Most clasts appear to be of fine grained sedimentary type (e.g. siltstone, cherty argillite) and range from whitish to green-grey. There are a couple of darker greenish fragments, evidently containing abundant chlorite and pyrite, and minor chalcopyrite (Fig. 129). Other fragments are relatively quartz-rich, probably with minor chlorite and/or sericite, and minor disseminated pyrite. Interstitial to the breccia fragments is a small volume of grey-green matrix, probably rich in chlorite and with disseminated pyrite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 129: Drill core sample of coarse, clast-supported breccia. Most fragments are of fine grained sedimentary type (e.g. cherty argillite, siltstone), but the darker, chlorite-sulphide-altered types might represent former mafic igneous material.

Petrographic description

a) Primary rock characteristics: In the section, relict texture is poorly to moderately preserved. It is evident that there are abundant angular to sub-rounded altered lithic fragments, up to 2.5 cm across, forming a clast-supported texture. However, internal characteristics of fragments are largely obliterated due to imposed alteration. The majority of fragments appear to have been of fine grained, quartz-rich sedimentary type, e.g. cherty argillite and siltstone, but there are a few with isolated quartz grains up to 0.5 mm across in a fine grained matrix (Fig. 130) and these could be interpreted as former quartz-phyric fine grained felsic volcanic material, or a matrix-supported clastic sedimentary rock, e.g. siltstone with larger detrital quartz grains. There are also a couple of fine grained quartzite fragments and several individual quartz grains up to 1 mm across. A single large fragment (~2.5 cm across) with no recognised relict texture also occurs, with it now composed of abundant chlorite and pyrite, lesser quartz and chalcopyrite, and a little disseminated rutile. The presence of rutile aggregates (up to 0.4 mm across, possibly having replaced earlier FeTi oxide) and abundant chlorite in this fragment could imply that the protolith was of mafic igneous type. Little matrix is recognised in the rock; it could have included small fragments as well as isolated quartz grains, but is now strongly altered.

b) Alteration and structure: The coarse breccia was subject to strong hydrothermal alteration of propylitic type, with effects being most apparent in the interpreted mafic igneous composition fragment and interstitial to other fragments. Here, there was replacement by abundant pale green chlorite, commonly accompanied by sulphides, fine to medium grained quartz and a trace of rutile. In other fragments, there was fine grained recrystallisation and replacement by quart, locally common sericite and/or chlorite, disseminated pyrite and trace rutile and chalcopyrite (Fig. 130). In chlorite-rich zones, sulphides are dominated by medium grained pyrite, but there is also locally common chalcopyrite and traces of marcasite associated with the latter (Fig. 131).

c) Mineralisation: Chlorite-rich domains in the rock commonly contain disseminated to locally semi-massive medium grained pyrite, in places in association with abundant, paragenetically later chalcopyrite (Fig. 131). Traces of fine grained marcasite occur with chalcopyrite and pyrite in these masses locally contains small inclusions of chalcopyrite and rare bornite and galena (<20 μm across). Disseminated pyrite and trace chalcopyrite also occur elsewhere as part of the alteration assemblage.

<u>Mineral Mode (by volume)</u>: chlorite and quartz each 40%, sericite 10%, pyrite 8%, chalcopyrite 2% and traces of rutile, marcasite, bornite and galena.

<u>Interpretation and comment</u>: It is interpreted that the sample represents a clast-supported breccia. Fragments are mostly of fine grained clastic sedimentary type (e.g. cherty argillite, siltstone), but there are possible quartz-phyric felsic volcanic fragments and at least one large fragment of altered mafic igneous rock, and a few isolated discrete quartz grains. Little matrix is recognised and interstitial sites are strongly altered. Strong propylitic alteration was imposed, with the interpreted sedimentary and ?felsic volcanic fragments being replaced by fine grained quartz, with minor sericite, chlorite, pyrite and trace rutile and chalcopyrite. Chlorite-rich aggregates occur at possible mafic igneous and interstitial sites and these also display considerable hydrothermal quartz, abundant pyrite, minor chalcopyrite and traces of rutile and marcasite (associated with chalcopyrite). At these sites, pyrite also hosts a few tiny inclusions of chalcopyrite, bornite and galena.

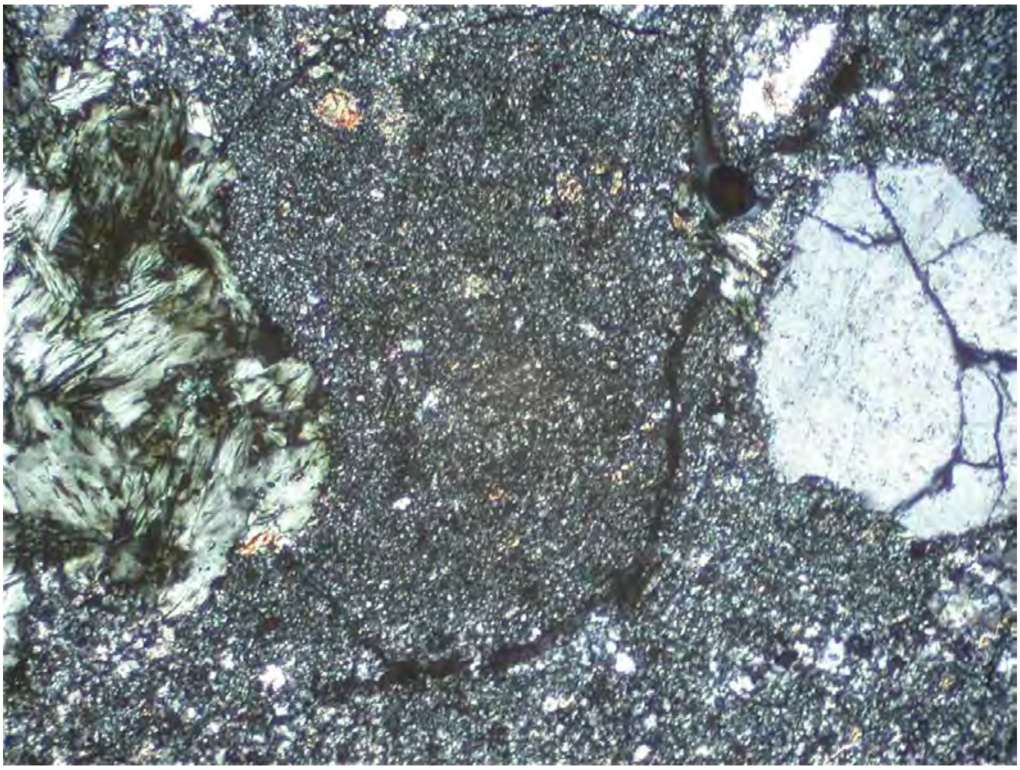

Fig. 130: Isolated quartz grain and a chlorite-rich aggregate (left) in association with fine grained quartz-rich sedimentary clastic material (?cherty argillite) that also contains minor chlorite and sericite. Transmitted light, crossed polarisers, field of view 2 mm across.

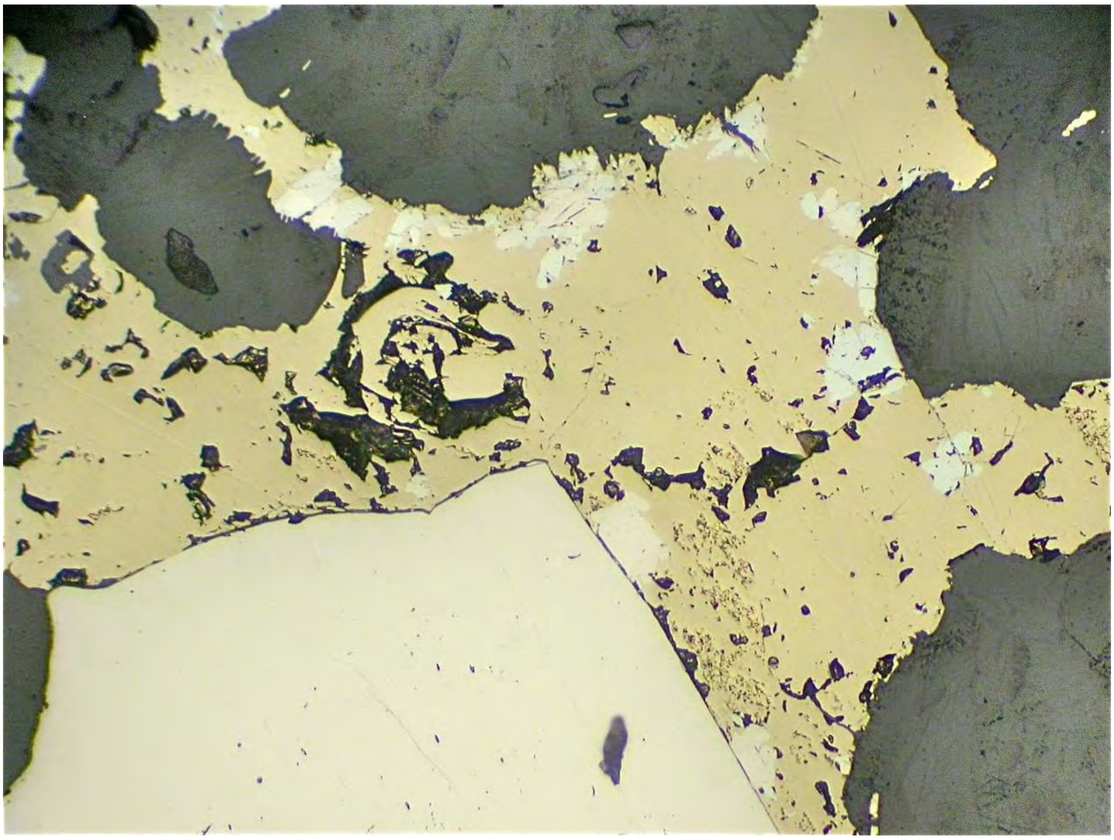

Fig. 131: Sulphide aggregate in chlorite matrix (dark grey). A subhedral grain of pyrite (pale creamy) borders on to a chalcopyrite mass (yellow) that also contains small grains of marcasite and pyrite. Plane polarised reflected light, field of view 1 mm across.

SMD012 166.0 m PTS

Summary: Intensely silicified ultramafic rock (e.g. serpentinite), retaining a few grains of relict chromite. The rock is dominated by fine grained quartz, but with disseminated pyrite, a little chlorite and trace chalcopyrite and it contains scattered irregular to veinlike aggregates of pyrite, quartz, minor chlorite, and in places, a little chalcopyrite and talc. Pyrite hosts a few small inclusions of chromite, chalcopyrite and rare hematite and magnetite.

Handspecimen: The drill core sample is composed of a grey, fine grained quartz-rich rock, perhaps representing the product of intense hydrothermal alteration (silicification). Several irregular cavities up to 1.5 cm across occur and the rock contains scattered aggregates of pyrite up to 6 mm across and a trace of disseminated and veinlet chalcopyrite (Fig. 132). A couple of diffuse, pale grey quartz veins up to 3 mm wide occur and fine grained quartz hosts rare black oxide grains up to 1 mm across and a trace of reddish hematite pigmentation. No obvious relict textures are recognised in the sample, which is weakly magnetic, with susceptibility up to 90 x 10^{-5} SI.

Fig. 132: Drill core sample of strongly silicified rock with grey fine grained quartz, scattered pyrite aggregates and a few cavities.

Petrographic description

a) Primary rock characteristics: In the section, no definite relict texture from a protolith is recognised. However, there are a few relict subhedral chromite grains up to 1 mm across (Fig. 133) and these indicate that the protolith must have been of ultramafic type (e.g. ultimately a peridotite). In a few places, a vagie relict foliation is apparent, but overall the rock is the product of intense hydrothermal replacement.

b) Alteration and structure: It is interpreted that an ultramafic composition protolith (e.g. serpentinised peridotite) experienced intense hydrothermal alteration, with replacement by dominantly finely granular quartz, accompanied by aggregates of pyrite, a little chlorite and trace chalcopyrite. Commonly, there are scattered, slightly coarser quartz aggregates. The rock contains scattered irregular to veinlike masses up to several millimetres across of medium to coarse grained pyrite and quartz, with minor chlorite (Fig. 134). In one veinliek aggregate, there is locally abundant chalcopyrite, and in another, a little fine grained talc is associated with chlorite. Pyrite has a few inclusions of chromite and chalcopyrite, and rare hematite and magnetite. The alteration assemblage is consistent with being of silicic type.

c) Mineralisation: A few grains of relict chromite (commonly subhedral and locally fractured) up to 1 mm across are preserved (Fig. 133). The sample contains disseminated pyrite, more concentrated into irregular to veinlike agrgegates up to several millimetres across, where pyrite is medium to coarse grained (up to 3 mm) and has a few inclusions of chromite, chalcopyrite and rare hematite and magnetite. A trace of chalcopyrite is disseminated in quartz, locally in composites with pyrite (Fig. 133) and there is a single veinlike aggregate of chalcopyrite and pyrite ~2.5 mm wide. Texturally, chalcopyrite is paragenetically later than pyrite.

Mineral Mode (by volume): quartz 85%, pyrite 8%, chlorite 5%, chalcopyrite 1% and traces of chromite, talc, hematite and magnetite.

Interpretation and comment: It is interpreted that the sample is an intensely silicified ultramafic (e.g. serpentinised peridotite). It retains a few relict grains of chromite, but otherwise has been replaced by fine grained quartz, disseminated pyrite, a little chlorite and trace chalcopyrite. The rock also contains scattered irregular to veinlike aggregates of pyrite, quartz, minor chlorite, and in places, a little chalcopyrite and talc. Pyrite hosts a few small inclusions of chromite, chalcopyrite and rare hematite and magnetite.

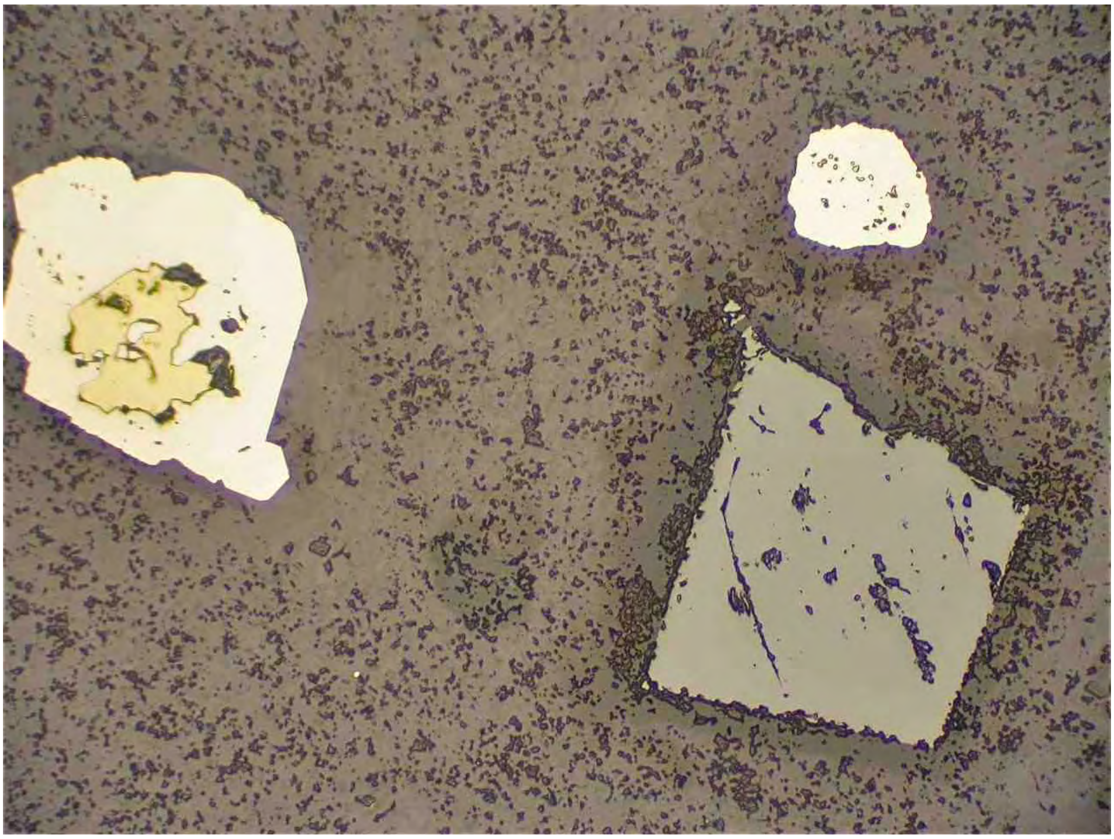

Fig. 133: Subhedral relict chromite grain (pale grey) hosted in fine grained quartz that contains pyrite (pale creamy) grains, with the one at left being in a composite with chalcopyrite (yellow). Plane polarised reflected light, field of view 1 mm across.

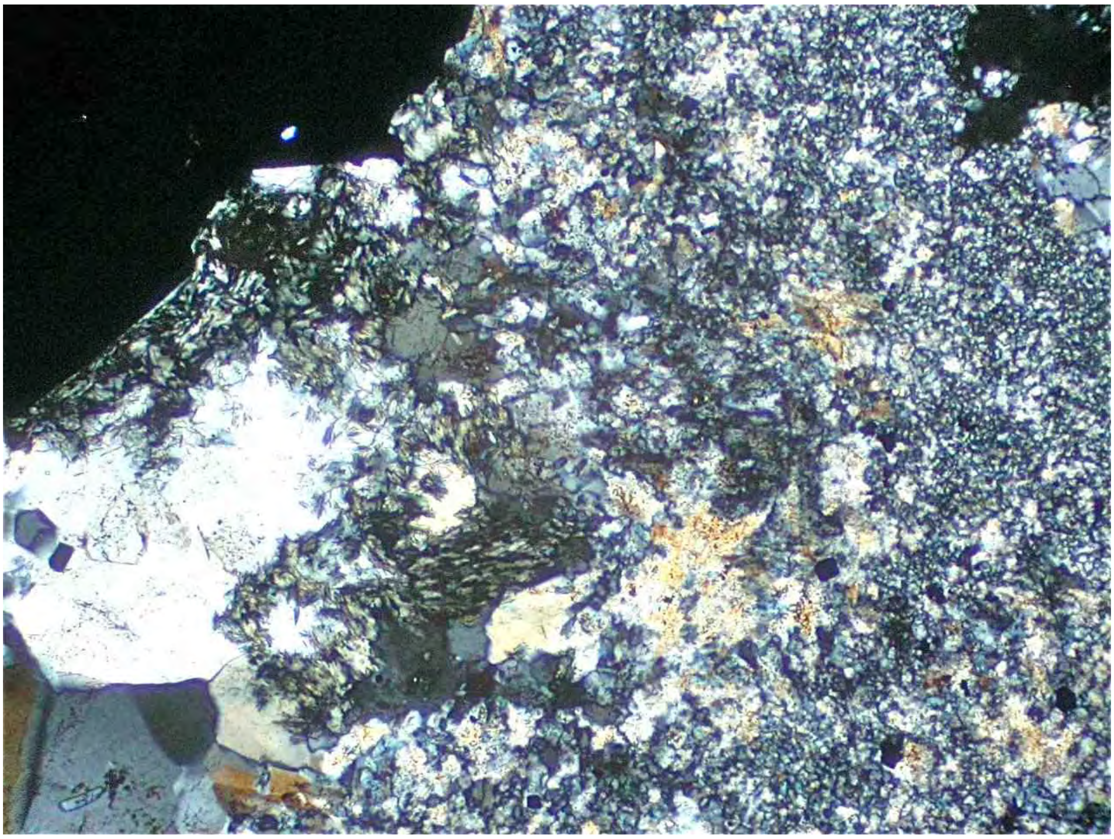

Fig. 134: Fine grained quartz, representing silicified host rock (right) adjoining an aggregate of medium grained quartz, pyrite (black) and minor khaki-grey chlorite at left. Transmitted light, crossed polarisers, field of view 2 mm across.

SMD012 180.9 m PTS

Summary: Pyrite-chalcopyrite-fuchsite-quartz rock, representing the product of intense hydrothermal replacement and/or infill of an ultramafic protolith. Semi-massive pyrite-chalcopyrite aggregates have associated interstitial masses of fine grained fuchsite, with patchy quartz. Fuchsite hosts sparse, very fine grained aggregates of a phase that could be Cr-bearing corundum. In sulphide aggregates, fine to medium grained pyrite appears to be enclosed and replaced by chalcopyrite, with the latter hosting uncommon small grains of bornite and tennantite, rare stannite and a trace of replacive covellite.

Handspecimen: The drill core sample is composed of semi-massive, fine to medium grained sulphides, with intergrown pyrite and chalcopyrite (Fig. 135). The rock also contains interstitial aggregates up to a few millimetres across of a fine grained green layer silicate phase (e.g. fuchsite) (Fig. 135). Abundant irregular cavities up to 2 cm across are dispersed throughout (Fig. 135). No relict texture from a protolith is recognised. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 135: Drill core sample of semi-massive pyrite and chalcopyrite, showing rather cavernous texture and green aggregates of fine grained fuchsite that are interstitial to sulphides.

Petrographic description

a) Primary rock characteristics: In the section, no relict texture from a protolith is recognised and the sample could be the product of intense hydrothermal replacement and/or infill. The fact that the rock contains high values of Cr, Ni and Co, as well as considerable fine grained fuchsite (Cr-bearing sericite), implies that an ultramafic rock was either a protolith, or supplied some hydrothermally mobilised components.

b) Alteration and structure: The rock contains abundant, semi-continuous sulphide aggregates up to 1.5 cm across, with interstitial masses up to several millimetres across that are dominated by fine grained pale green fuchsite and which in places are associated with aggregates of fine to medium grained quartz up to 3 mm across (Fig. 136). Within fuchsite aggregates are small irregular to elongate aggregates up to 0.2 mm across of a very fine grained (~20 µm) translucent, red-brown oxide phase, speculated to be Cr-bearing corundum (Fig. 136). Sulphide aggregates are dominated by pyrite and chalcopyrite, with the latter generally enclosing pyrite (and probably replacing it) (Fig. 137). Within chalcopyrite are uncommon small grains of bornite and tennantite (Fig. 137), rare tiny grains of stannite and a couple of aggregates of covellite that could have replaced chalcopyrite and bornite. Assuming an ultramafic composition rock was either protolith or adjacent, it appears to have had major hydrothermal addition of Fe, Cu and S (as well as K) and loss of silica and Mg.

c) Mineralisation: The sample contains abundant sulphides. Aggregates of pyrite and chalcopyrite are up to 1.5 mm across, with largest pyrite grains up to ~1 mm and typically surrounded and probably replaced by chalcopyrite (Fig. 137). Pyrite hosts a few small inclusions of bornite and chalcopyrite. Sparse grains of bornite (up to 0.3 mm), tennantite (up to 0.1 mm) and rare stannite occur in chalcopyrite (Fig. 137), and a couple of small aggregates of covellite could have replaced chalcopyrite and bornite.

Mineral Mode (by volume): pyrite and chalcopyrite each 30%, fuchsite 25%, quartz 14% and traces of bornite, tennantite, stannite, covellite and ?corundum.

Interpretation and comment: It is interpreted that the sample represents a pyrite-chalcopyrite-fuchsite-quartz rock, being the product of intense hydrothermal replacement and/or infill of an ultramafic protolith. It contains semi-massive pyrite-chalcopyrite aggregates with interstitial masses of fuchsite and patchy quartz. Fuchsite hosts very fine grained aggregates of a phase speculated to be Cr-bearing corundum. In sulphide aggregates, pyrite is enclosed and apparently replaced by chalcopyrite, with the latter hosting uncommon small grains of bornite and tennantite, rare stannite and a trace of replacive covellite.

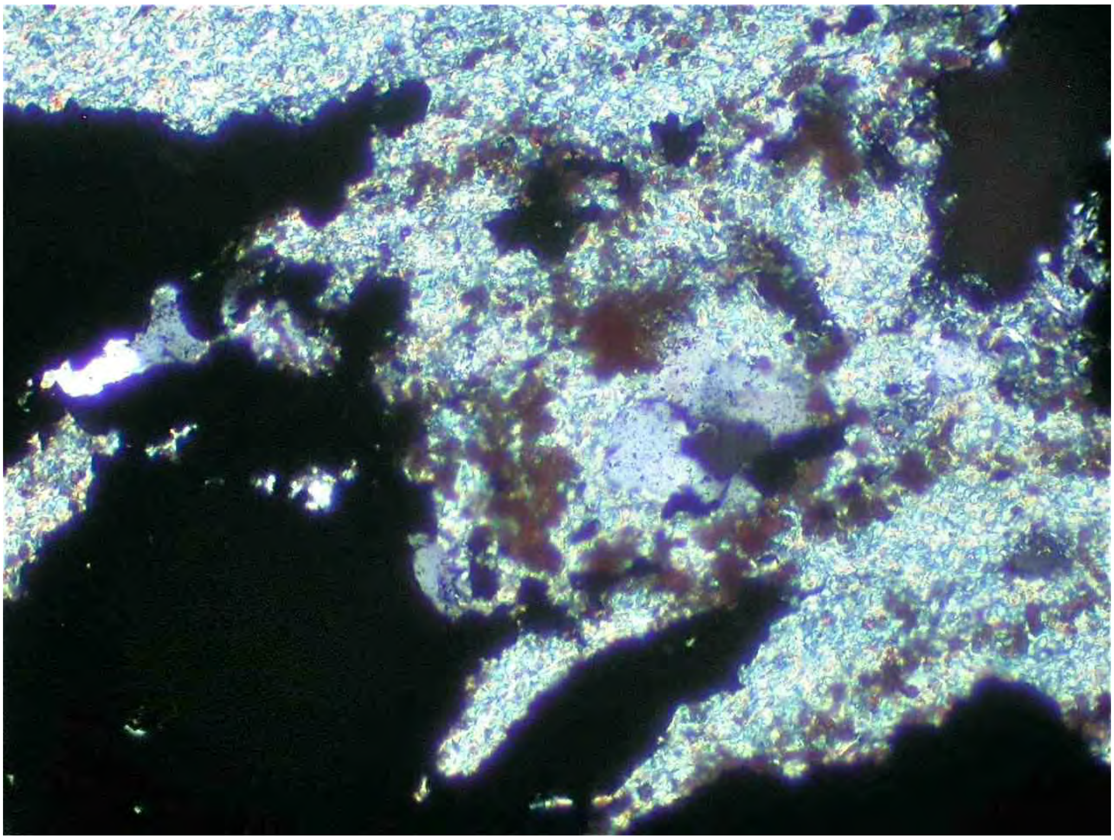

Fig. 136: Fine grained pale greenish fuchsite and a couple of grains of associated quartz (pale grey) containing very fine aggregates of dark reddish-brown ?Cr-bearing corundum. Black material is chalcopyrite and pyrite. Transmitted light, crossed polarisers, field of view 1 mm across.

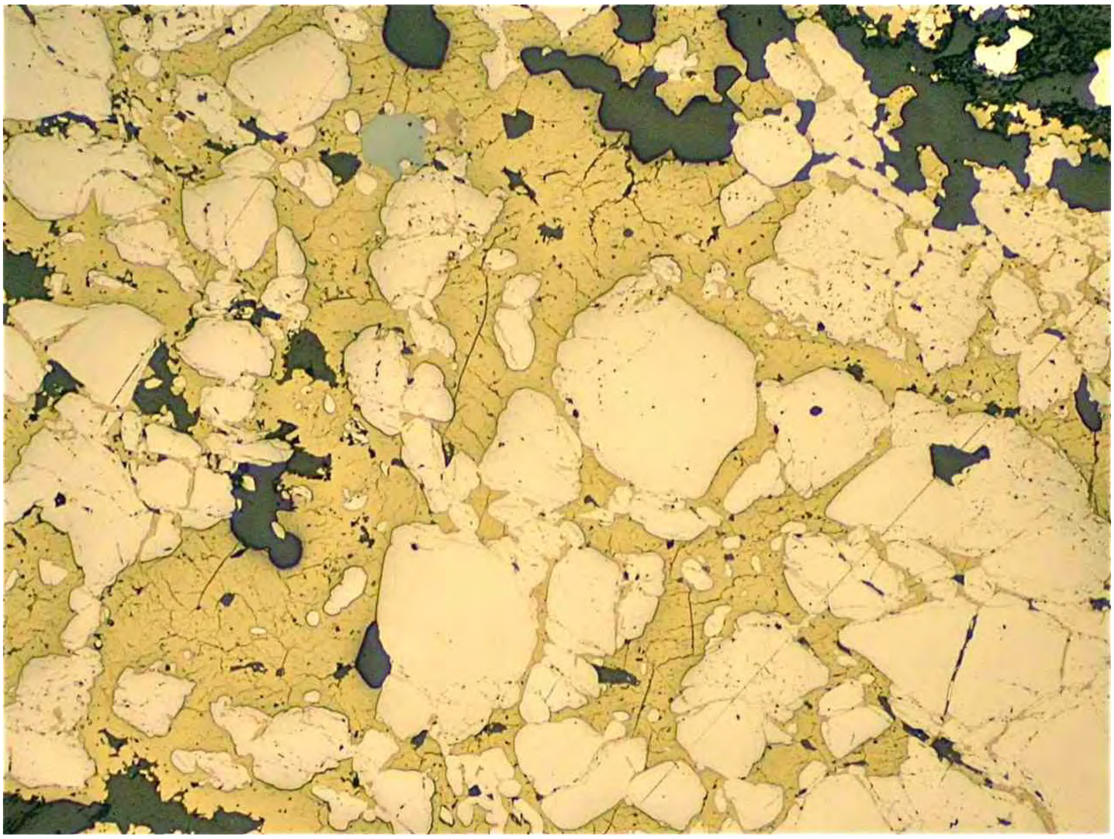

Fig. 137: Portion of a largely massive sulphide aggregate, with pyrite (pale creamy) being paragenetically earlier than abundant chalcopyrite (yellow). At upper left is a small grain of tennantite (pale grey) and a nearby tiny grain of brownish bornite. Plane polarised reflected light, field of view 2 mm across.

SMD012 181.6 m PTS

Summary: Intensely hydrothermally altered, originally coarse grained ultramafic rock, perhaps of pyroxenite type. Vestiges of relict texture suggest that the protolith was dominated by coarse prismatic to blocky ferromagnesian material (e.g. pyroxene, but could have included amphibole), and there are sparse small relict grains of chromite. The silicate material was totally replaced by fine grained quartz and chlorite, with disseminated and veinlet pyrite and subordinate chalcopyrite. In places, chromite occurs as inclusions in sulphides, and textures indicate that chalcopyrite is paragenetically later than pyrite.

Handspecimen: The drill core sample is composed of a massive, dark grey-green, strongly altered rock. It appears to have been of medium to coarse grained, perhaps mafic, igneous type, and has been strongly replced by fine grained chlorite and quartz, as well as minor disseminated and veinlet sulphides, evidently including pyrite and chalcopyrite (Fig. 138). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 138: Drill core sample of strongly altered ultramafic rock, perhaps originally of pyroxenite type, and now consisting of rather fine grained quartz and chlorite, with disseminated and veinlet pyrite and chalcopyrite.

Petrographic description

a) Primary rock characteristics: In the section, it is apparent that the protolith is intensely hydrothermally altered, but there are vestiges of relict texture indicating that there was a formerly abundant coarse prismatic to blocky silicate phase, with grainsize up to several millimetres (Fig. 139). The relict shapes of the pseudomorphs imply that this phase was pyroxene, although amphibole is also a possibility. Sparsely scattered within the pseudomorphs after the interpreted ferromagnesian phase are small (up to 0.1 mm) relict grains of chromite (Fig. 140). The fact that the rock contains high values of Cr, Ni and Co, as well as relict chromite, indicates that the protolith was of ultramafic composition and it could be inferred that it was a type of pyroxenite. The sample is similar to that in SMD012/88.3 m.

b) Alteration and structure: Intense hydrothermal alteration was imposed, but relict chromite is preserved (Fig. 140). All former silicate material was replaced, in part pseudomorphically, by fine grained quartz (mostly <0.3 mm) and pale green chlorite, and with disseminated and veinlet pyrite and chalcopyrite (Fig. 139). Veinlets of sulphides are dominated by pyrite, are anastomosing to sub-planar and up to 0.2 mm wide. Disseminated sulphides occur in aggregates up to 1.5 mm across, and include discrete grains of pyrite and chalcopyrite, as well as abundant composites (Fig. 140).

c) Mineralisation: A small amount of relict chromite is observed in the sample, as isolated grains up to 0.1 mm and in small clusters, in places variably enclosed in sulphides (Fig. 140). As part of the pervasive alteration, the rock developed disseminated and veinlet pyrite and chalcopyrite. Veinlets are dominated by pyrite, but chalcopyrite is relatively common, along with pyrite, as part of the disseminations, locally forming composite aggregates up to 1.5 mm across (Fig. 140).

Mineral Mode (by volume): quartz 55%, chlorite 37%, pyrite 6%, chalcopyrite 2% and a trace of chromite.

Interpretation and comment: It is interpreted that the sample is a former coarse grained ultramafic rock, perhaps of pyroxenite type that has experienced intense hydrothermal alteration. Remnants of relict texture imply that the protolith was dominated by coarse prismatic to blocky ferromagnesian material (e.g. pyroxene, but could have included amphibole), and there are sparse small relict grains of chromite. There was total hydrothermal replacement of silicate material by fine grained quartz and chlorite, with disseminated and veinlet pyrite and subordinate chalcopyrite. In places, chromite occurs as inclusions in sulphides, and textures indicate that chalcopyrite is paragenetically later than pyrite.

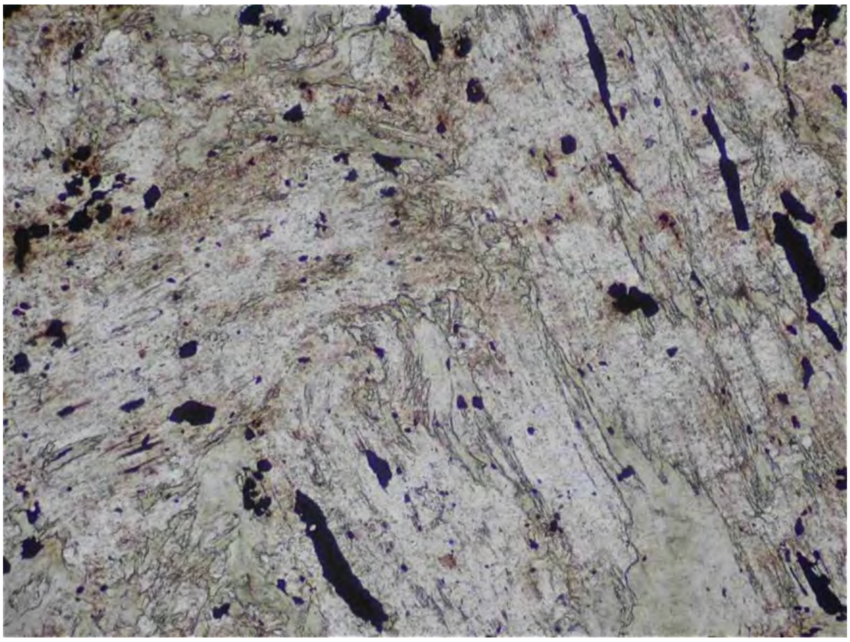

Fig. 139: Pseudomorphic texture in fine grained quartz and pale green chlorite aggregates after former interpreted ferromagnesian grains (e.g. pyroxene). Black grains and aggregates are mostly pyrite. Plane polarised transmitted light, field of view 2 mm across.

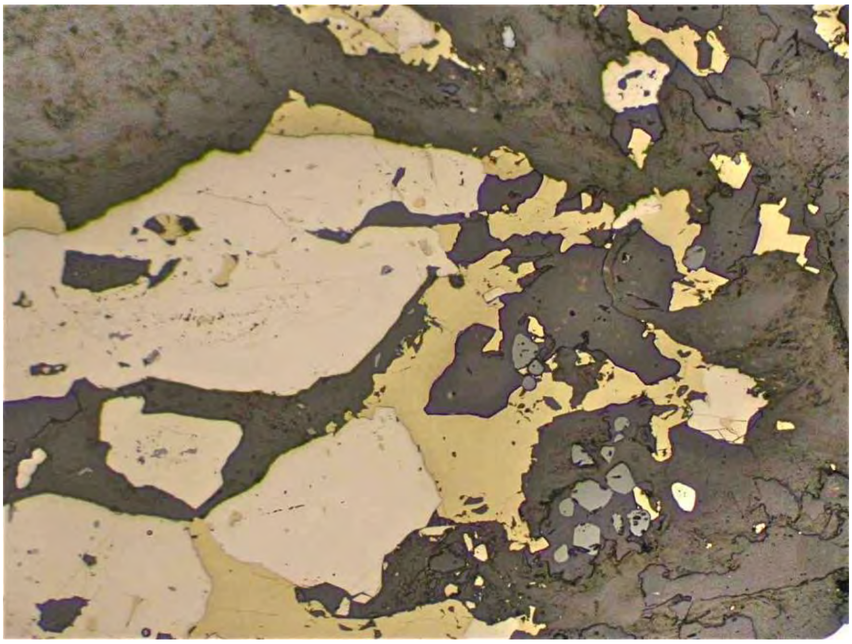

Fig. 140: Composite aggregate of pyrite (pale creamy) and paragenetically later chalcopyrite (yellow) hosted in chlorite (dark). The small, mid grey grains towards lower right are relict chromite. Plane polarised reflected light, field of view 1 mm across.

SMD012 181.9 m PTS

Summary: Intensely hydrothermally silicified ultramafic rock, with disseminated to semi-massive sulphides, minor chlorite and a trace of relict chromite. The last mineral attests to the ultramafic protolith, perhaps of peridotite type. There was replacement by abundant fine to medium grained, inequigranular quartz that also hosts a few cavities and locally, a little hematite pigmentation. Sparse chlorite occurs interstitial to quartz and in a few larger irregular to elongate aggregates. Pyrite is the dominant sulphide, in places having zonal growth texture and hosting a few small inclusions of hematite and chalcopyrite. Pyrite also forms a few composites with chalcopyrite, but the latter also forms a few large discrete aggregates, some of which show slight marginal replacement by digenite, maybe reflecting incipient deep supergene oxidation.

Handspecimen: The drill core sample is dominated by pale grey, rather vuggy, fine to medium grained quartz, containing disseminated to semi-massive sulphide aggregates (Fig. 141). The latter are up to a few millimetres across and are mostly pyrite, although minor chalcopyrite-rich aggregates are observed. In places, quartz has a reddish colour due to fine hematite dusting and quartz also hosts irregular cavities up to 2 cm across, some of which have a lining of crystalline quartz (Fig. 141). The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 141: Drill core sample of strongly altered ultramafic rock, replaced by vuggy quartz and disseminated to semi-massive pyrite and minor chalcopyrite. Local reddish colour is due to hematite pigmentation of quartz.

Petrographic description

a) Primary rock characteristics: In the section, no definite relict texture from a protolith is apparent. However, there are a few relict chromite grains up to 0.8 mm across (Fig. 142) and this phase, together with the fact that the sample contains high values of Cr, Ni and Co, indicate that the protolith was of ultramafic type. Notably, the chromite in this sample differes from that in nearby sample SMD012/181.6 m in that grains are larger and probably of different composition, likely being lower in Fe and higher in Cr and/or Al (translucent dark orange-brown versus opaque). From this observation, it is suspected that the ultimate protolith was of peridotite type.

b) Alteration and structure: The protolith was intensely hydrothermally altered and mostly replaced by fine to medium grained inequigranular quartz and disseminated to semi-massive sulphides, with local disseminated grains and irregular to elongate aggregates of pale green chlorite (Fig. 143). Relict chromite occurs in quartz and is locally partly enclosed by pyrite (Fig. 142). Small irregular patches of ultrafine hematite lead to reddish pigmentation of quartz and the latter also hosts several cavities up to a few millimetres across that are locally lined by medium grained, terminated quartz grains. Disseminated to semi-massive sulphides are dominated by fine to medium grained pyrite, but there are a few discrete chalcopyrite-dominated aggregates, as well as composites of chalcopyrite and pyrite (Fig. 144). A few chalcopyrite aggregates show slight marginal replacement by digenite (Fig. 144), maybe reflecting a deep supergene oxidation effect.

c) Mineralisation: The sample contains a few grains of relict chromite up to 0.8 mm across, in places partly enclosed by pyrite (Fig. 142). Disseminated to semi-massive pyrite is rather abundant, with largest aggregates up to several millimetres and individual grains up to 1 mm across. Pyrite aggregates locally show zonal growth texture and the mineral hosts a few small inclusions of chalcopyrite and hematite. Pyrite also forms a few small composites with chalcopyrite, with the latter being paragenetically later and occurring marginal to, and filling fractures in pyrite. The sample also has a few discrete irregular chalcopyrite-dominated aggregates up to 4 mm across, some of which have narrow rims of digenite that could reflect the imposition of incipient supergene oxidation (Fig. 144).

Mineral Mode (by volume): quartz 75%, pyrite 19%, chalcopyrite 3%, chlorite 2% and traces of chromite, hematite and digenite.

Interpretation and comment: It is interpreted that the sample represents an intensely silicified and mineralised ultramafic rock. It retains a trace of relict chromite. The protolith was replaced by abundant quartz that also hosts a few cavities and locally, a little hematite pigmentation. Sparse chlorite occurs interstitial to quartz and in a few larger irregular to elongate aggregates. Pyrite is the dominant sulphide, in places having zonal growth texture and hosting a few small inclusions of hematite and chalcopyrite. Pyrite also forms composites with chalcopyrite, with the latter also forming a few larger aggregates, some of which show slight marginal replacement by digenite, maybe reflecting incipient deep supergene oxidation.

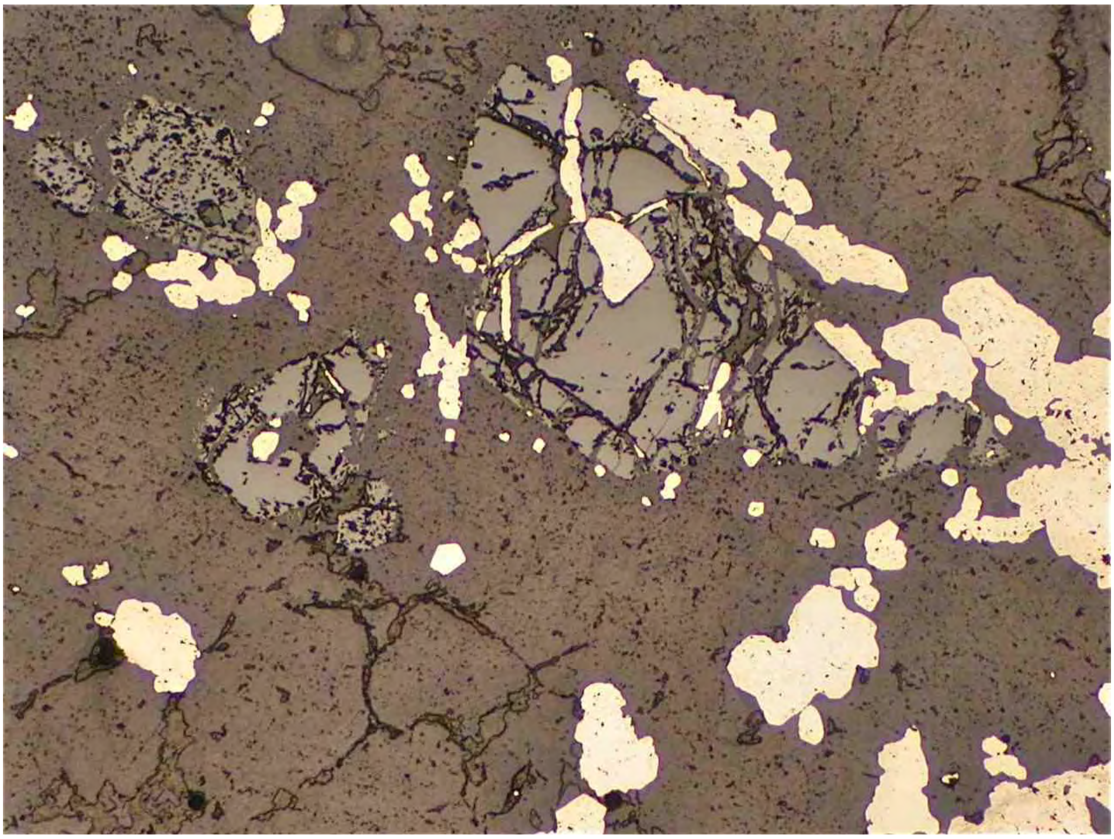

Fig. 142: Relict fractured grains of chromite (pale grey) hosted in quartz and with minor associated pyrite (pale creamy) partly infilling fractures. Plane polarised reflected light, field of view 2 mm across.

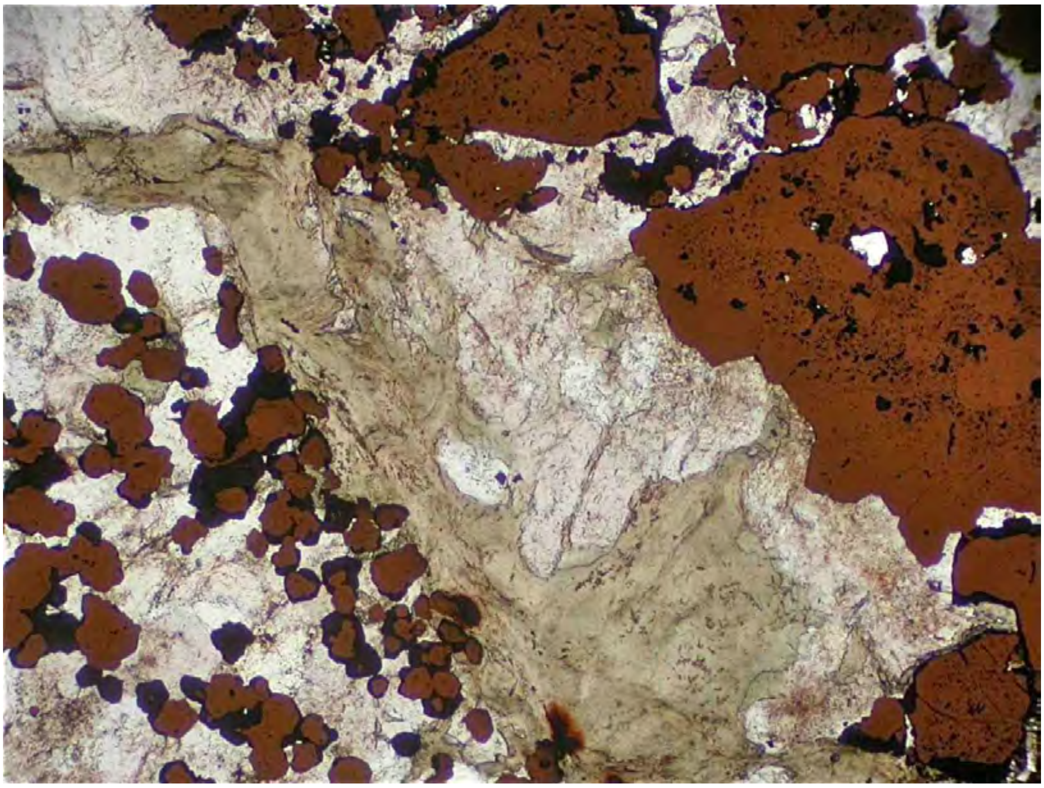

Fig. 143: Disseminated and semi-massive pyrite (dark orange) adjacent to an elongate chlorite aggregate (pale khaki) and quartz. Plane polarised transmitted and reflected light, field of view 2 mm across.

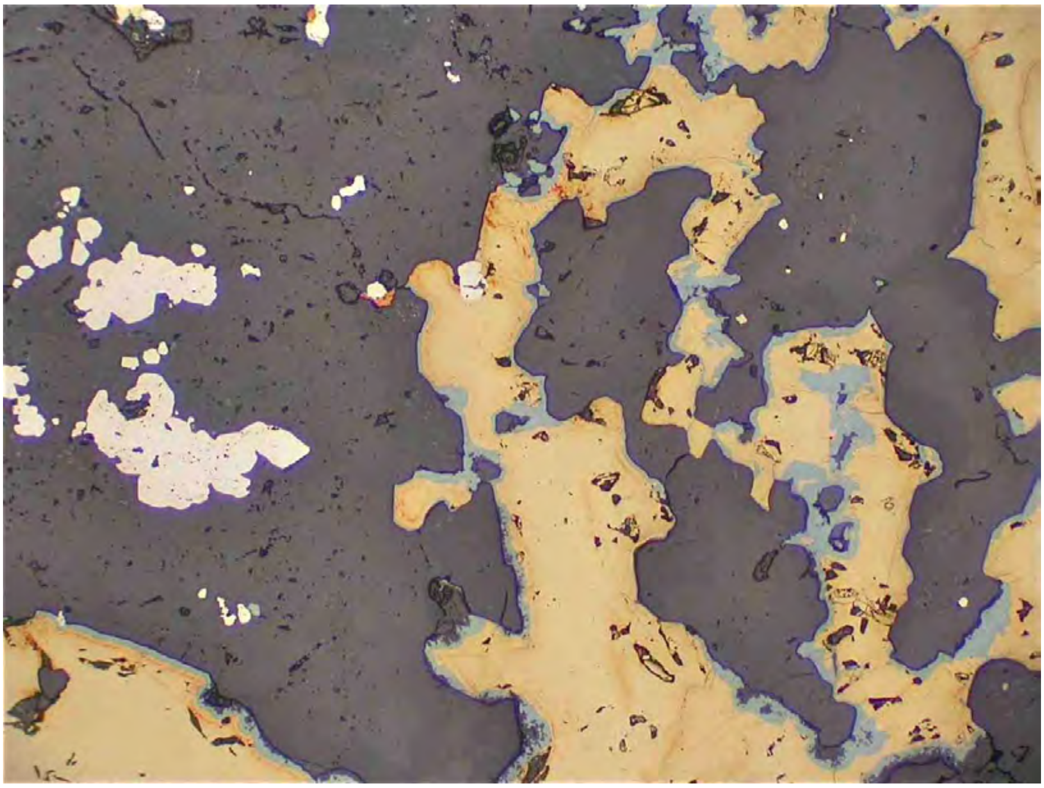

Fig. 144: Chalcopyrite (yellow) aggregate in quartz, with an adjacent small aggregate of pyrite (pale creamy at left), and with chalcopyrite showing slight marginal replacement by pale grey-blue digenite. Plane polarised reflected light, field of view 1 mm across.

SMD012 183.5 m TS

Summary: Intensely altered porphyritic olivine basalt. Relict texture is moderately preserved, with scattered pseudomorphs after former small olivine phenocrysts in a fine grained groundmass. At former olivine sites, there are sparsely scattered tiny relict grains of FeCr spinel. The groundmass may have been composed of feldspar, ferromagnesian material and disseminated FeTi oxide. Alteration is interpreted as argillic type, with replacement of phenocrysts by quartz and minor chlorite and clay (could include illite-smectite, kaolinite), and replacement of the groundmass by clay phases, chlorite, quartz and leucoxene-rutile.

Handspecimen: The drill core sample is dominated by a massive, khaki-grey, strongly altered fine grained rock (Fig. 145), locally with possible porphyritic texture and speculated to have been of mafic composition. Phenocrysts appear to be sparse and altered to whitish quartz, whereas the remainder of the rock could have strong replacement by clay and chlorite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

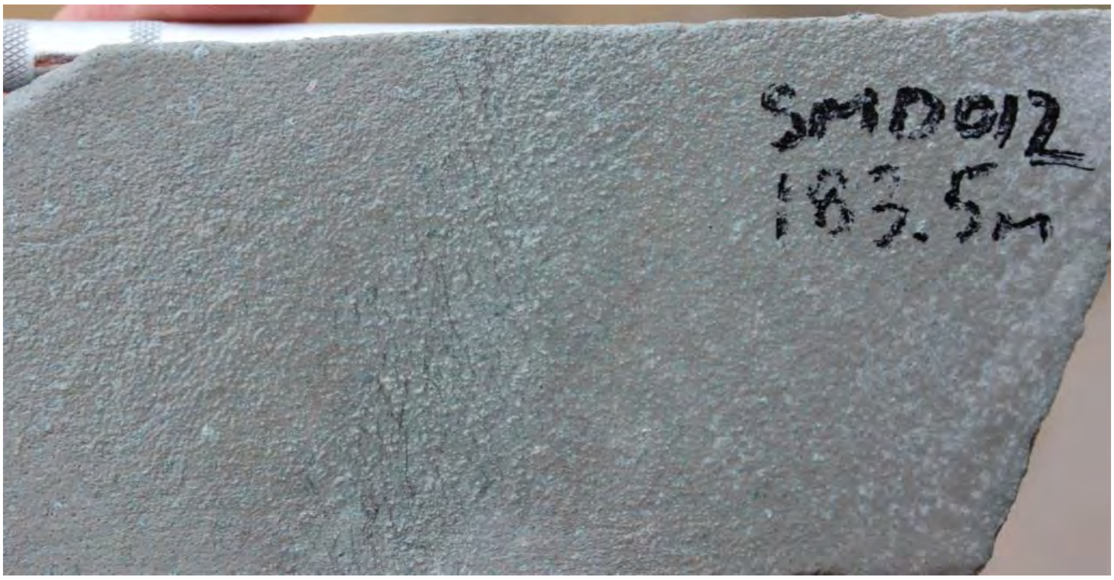

Fig. 145: Drill core sample of strongly altered, fine grained mafic igneous rock (porphyritic olivine basalt originally), with a replacement assemblage of clay, chlorite and quartz.

Petrographic description

a) Primary rock characteristics: In the section, it is apparent that the original rock is very strongly altered, but relict porphyritic texture is moderately preserved (Fig. 146). There are scattered pseudomorphs after a prismatic to diamond shaped phenocryst phase, up to 2 mm long (Fig. 146). The pseudomorphic shapes do not resemble those after feldspars, but are considered most likely to be after former olivine. Further evidence for this is the fact that many pseudomorphic sites also host tiny relict grains of dark brown FeCr spinel up to 20 µm across (Fig. 146), a phase typically found in olivine phenocrysts in basaltic rocks. The remainder of the sample, estimated at ~75%, represents altered fine grained groundmass, speculated to have contained abundant feldspar (e.g. plagioclase), ferromagnesian material and minor disseminated FeTi oxide. From these relict characteristics, the original rock is inferred to have been a porphyritic olivine basalt.

b) Alteration and structure: The igneous rock experienced very strong pervasive alteration and only the tiny grains of FeCr spinel that were hosted in former olivine are preserved. The phenocrysts were replaced by aggregates of fine grained quartz (Fig. 146), with lesser amounts of chlorite and a brownish clay phase. The groundmass was replaced by the clay phase, as well as chlorite, generally minor quartz (although there are local fine grained aggregates, in places with tiny associated grains of carbonate) and disseminated leucoxene-rutile. The clay phase could include illite-smectite as well as kaolinite. It is considered that the alteration assemblage is consistent with argillic type.

c) Mineralisation: No sulphide minerals are observed. There are tiny relict grains of FeCr spinel up to 20 µm across, clustered at altere olivine phenocryst sites (Fig. 146).

Mineral Mode (by volume): clay phases 40%, chlorite 35%, quartz 23%, leucoxene-rutile 2% and traces of FeCr spinel and carbonate.

Interpretation and comment: It is interpreted that the sample is a former porphyritic olivine basalt that has undergone very strong argillic alteration. Relict texture is moderately preserved, with pseudomorphs after former small olivine phenocrysts in a fine grianed groundmass. At former olivine sites, there are sparse tiny relict grains of FeCr spinel. The groundmass may have been composed of feldspar, ferromagnesian material and disseminated FeTi oxide. Alteration led to replacement of phenocrysts by quartz and minor chlorite and clay (could include illite-smectite, kaolinite), and replacement of the groundmass by clay phases, chlorite, quartz and leucoxene-rutile.

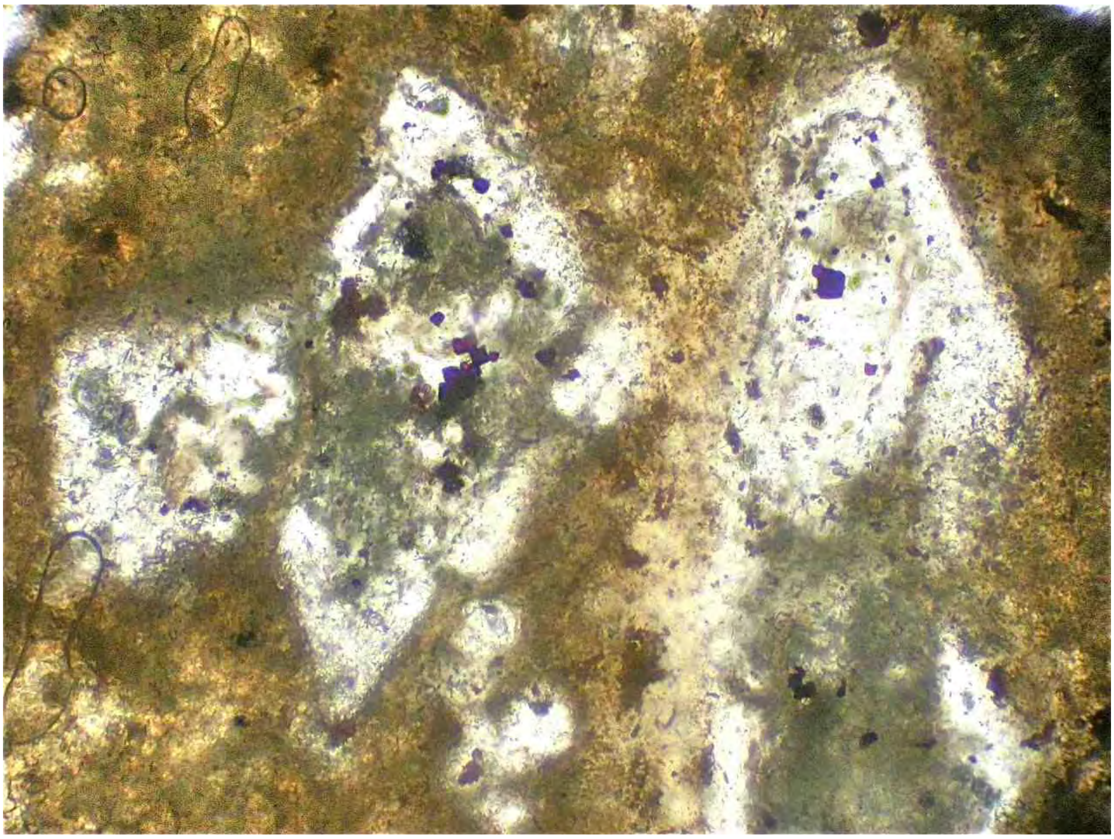

Fig. 146: Pseudomorphic aggregates of quartz and turbid clay, interpreted to be after former olivine phenocrysts, and hosting tiny dark brown relict grains of FeCr spinel. Surrounding groundmass is altered to fine grained clay and chlorite. Plane polarised transmitted light, field of view 1 mm across.

SMD012 184.0 m PTS

Summary: Porphyritic hornblende-quartz microdiorite with strong propylitic alteration. Relict texture is moderately preserved, showing that the rock originally contained scattered blocky feldspar (presumably plagioclase) phenocrysts as well as a prismatic ferromagnesian phase (e.g. hornblende) set in a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material. Pervasive alteration led to replacement of feldspar and ferromagnesian material and development of an assemblage of fine grained sericite, chlorite, quartz, disseminated pyrite and trace chalcopyrite and rutile. A couple of sub-planar veins cut the altered rock and contain quartz, with minor pyrite and chalcopyrite.

Handspecimen: The drill core sample is composed of a largely massive, grey-green rock, with a moderately preserved relict porphyritic texture (Fig. 147). It contained scattered, slightly darker colour altered phenocrysts of probable former feldspar and ferromagnesian phases up to several millimetres across in a finer grained altered groundmass, assumed to have originally been of quartzofeldspathic composition. The rock exhibits pervasive strong alteration to fine grained sericite, chlorite and quartz, with minor disseminated pyrite, and is cut by a couple of sub-planar veins up to 1.5 mm wide at a moderate angle to the core axis (Fig. 147). Veins contain quartz and pyrite, with trace chalcopyrite. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

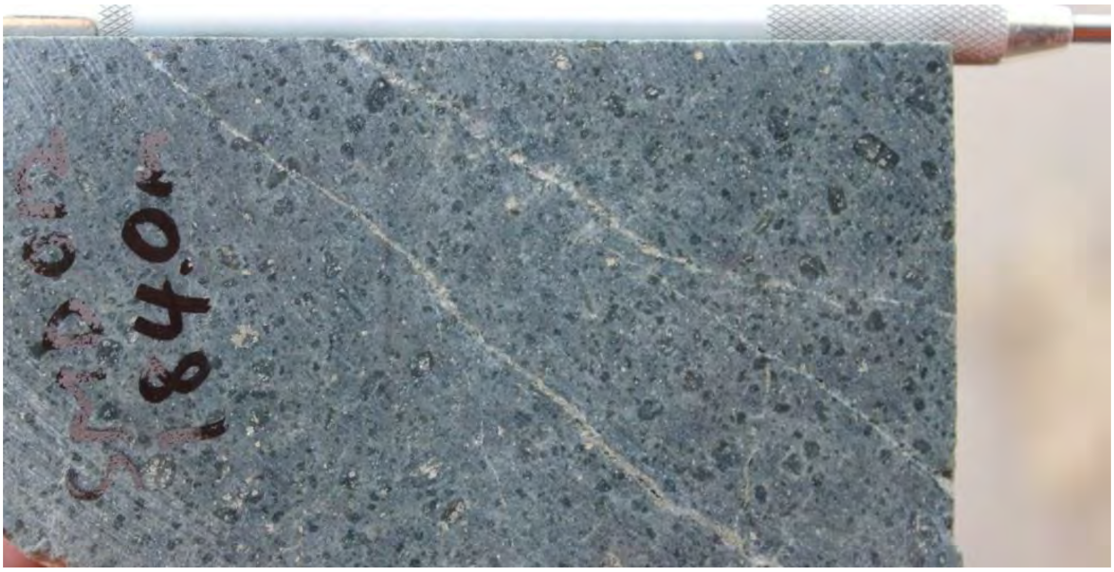

Fig. 147: Drill core sample of strongly altered, porphyritic microdiorite, showing relict texture and pseudomorphs after former feldspar and ferromagnesian phenocrysts in a former quartzofeldspathic groundmass. A couple of thin, sub-planar quartz-rich veins occur.

Petrographic description

a) Primary rock characteristics: In the section, it is apparent that the rock is very strongly altered, but relict texture is moderately preserved. Originally, the rock contained scattered blocky feldspar phenocrysts (most likely plagioclase) up to 5 mm across (mostly <3 mm) as well as phenocrysts of an elongate, prismatic ferromagnesian phase (e.g. hornblende) up to 6 mm long (mostly <2 mm) set in a fine to medium grained, inequigranular groundmass (Fig. 148). The groundmass probably contained abundant feldspar and subordinate quartz, plus minor ferromagnesian material and a trace of FeTi oxide. From the relict texture and inference on primary mineralogy, the rock is interpreted as a former porphyritic hornblende-quartz microdiorite.

b) Alteration and structure: Strong pervasive alteration was imposed on the igneous protolith. Feldspar phenocrysts were replaced by fine grained aggregates of sericite, locally accompanied by chlorite, quartz and pyrite, with all former ferromagnesian material being replaced by chlorite, with a little associated quartz, pyrite and trace rutile (Fig. 148). In the groundmass, several irregular patches of medium grained quartz (± chlorite) occur, but mostly, there was replacement by quartz, interstitial sericite, minor chlorite, disseminated pyrite and traces of chalcopyrite and rutile. The alteration in the sample is consistent with propylitic type. A couple of sub-planar veins up to 1.5 mm wide cut the altered rock. These contain medium grained quartz and minor pyrite and chalcopyrite.

c) Mineralisation: As part of the pervasive alteration, minor disseminated pyrite has formed throughout, with a trace of associated chalcopyrite. Veins also contain minor pyrite and chalcopyrite, with aggregates of the latter up to 1 mm long. Largest pyrite grains are up to 0.6 mm across.

Mineral Mode (by volume): sericite 50%, chlorite 25%, quartz 20%, pyrite 4%, chalcopyrite 1% and a trace of rutile.

Interpretation and comment: It is interpreted that the sample represents a strongly propylitically altered, porphyritic hornblende-quartz microdiorite. There is moderate preservation of relict texture, demonstrating that the rock originally contained blocky feldspar (presumably plagioclase) and prismatic ferromagnesian (e.g. hornblende) phenocrysts set in a fine to medium grained groundmass of feldspar, quartz and ferromagnesian material. Alteration caused replacement of feldspar and ferromagnesian material and development of an assemblage of fine grained sericite, chlorite, quartz, disseminated pyrite and trace chalcopyrite and rutile. A couple of sub-planar veins cut the altered rock and contain quartz, with minor pyrite and chalcopyrite.

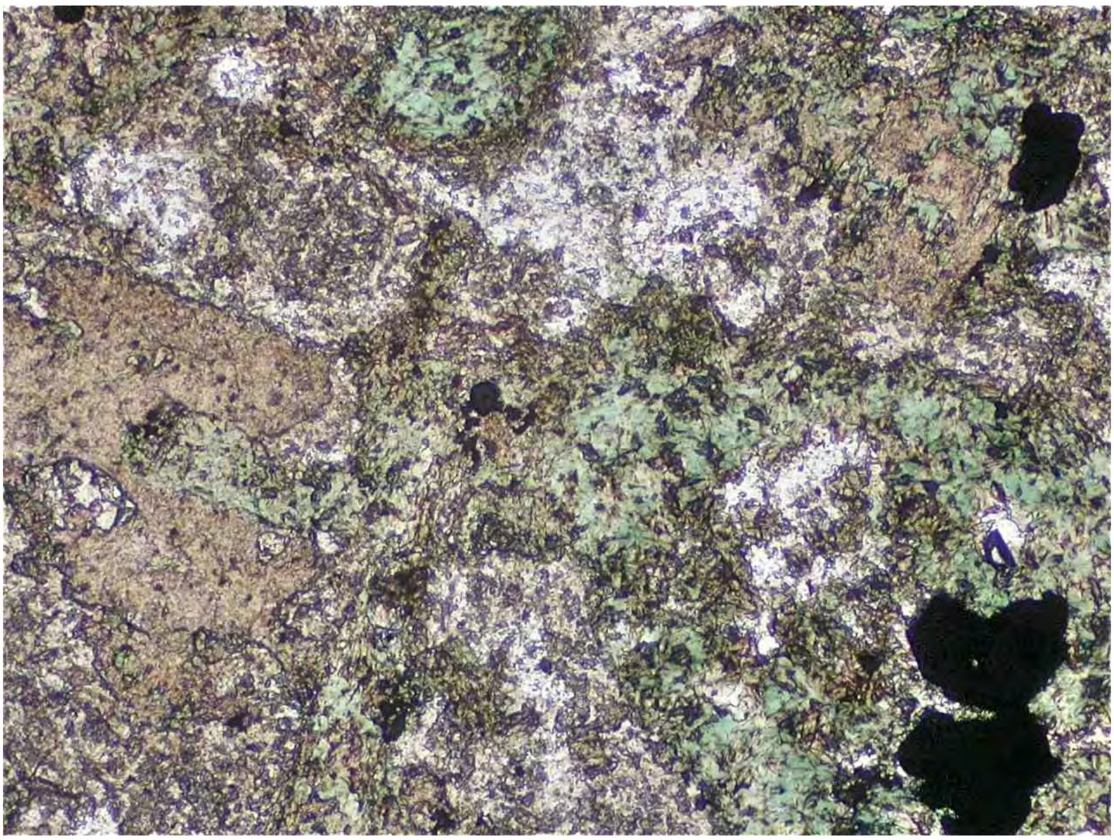

Fig. 148: Pseudomorphic aggregates of sericite after feldspar phenocrysts (left and upper right) and an aggregate of green chlorite, with minor quartz and pyrite (black) after a former hornblende phenocryst (lower right), with the altered groundmass containing considerable quartz and sericite. Plane polarised transmitted light, field of view 2 mm across.

<u>**SMD012 192.4 m TS**</u>

<u>Summary</u>: Strongly altered porphyritic olivine basalt with moderately well preserved relict texture. It is apparent that the rock originally contained scattered phenocrysts of blocky feldspar (e.g. plagioclase) and blocky to prismatic ferromagnesian phases that are interpreted to have included olivine and pyroxene (and less likely, hornblende). At interpreted olivine sites, there are scattered tiny relict inclusions of FeCr spinel. The phenocryst phases occurred in a fine grained crystalline groundmass with abundant ferromagnesian material, feldspar and minor disseminated FeTi oxide. Alteration is of propylitic-argillic type, causing replacement by fine grained chlorite (abundant at former ferromagnesian sites), sericite and clay (abundant at feldspar sites and in the groundmass), minor quartz and leucoxene-rutile. A couple of thin quartz veins occur locally.

<u>Handspecimen</u>: The drill core sample is composed of a massive, strongly altered, porphyritic igneous rock, possibly of originally intermediate composition. It contains scattered whitish pseudomorphs after former feldspar phenocrysts, and dark grey-green pseudomorphs after former ferromagnesian phenocrysts, with these occurring in a finer grained, grey-green groundmass (Fig. 149). Pervasive alteration has probably developed significant chlorite (at ferromagnesian sites and in the groundmass) and clay/sericite at feldspar sites. The sample is essentially non-magnetic, with susceptibility of <10 x 10^{-5} SI.

Fig. 149: Drill core sample of strongly altered, porphyritic basalt, with pale, altered feldspar (plagioclase) phenocrysts and dark green-grey pseudomorphs after former ferromagnesian phenocrysts (probably mostly olivine and pyroxene originally). Pervasive alteration has formed chlorite, sericite, clay and minor quartz and leucoxene-rutile.

<u>Petrographic description</u>

a) Primary rock characteristics: In the section, relict porphyritic texture is moderately well preserved, despite the imposed alteration (Fig. 150). There are scattered pseudomorphs after former blocky feldspar phenocrysts up to 4 mm across and also after prismatic to blocky ferromagnesian phenocrysts also up to 4 mm long (Fig. 150). Relict shapes of the latter imply that some were originally olivine and some were pyroxene (Fig. 150), and a smaller possibility that some might have been hornblende. At many interpreted former olivine sites, there are scattered small relict inclusions of FeCr spinel up to 0.1 mm across (Fig. 151). The phenocrystal phases occurred in a holocrystalline groundmass, constituting ~60% of the rock, probably formerly containing abundant ferromagnesian material and feldspar (including small laths, e.g. plagioclase) and minor disseminated FeTi oxide. From the relict characteristics and inferences on primary mineralogy, the original rock is interpreted as a porphyritic olivine basalt.

b) Alteration and structure: The igneous rock underwent strong pervasive alteration, with replacement of all igneous minerals except for the trace small grains of FeCr spinel. Former feldspar phenocrysts were replaced by fine grained aggregates with varying amounts of sericite, a clay phase (maybe illite-smectite), minor chlorite and traces of carbonate. Interpreted olivine phenocrysts were replaced pseudomorphically by chlorite, and pyroxene (± ?hornblende) by chlorite, local quartz and a little leucoxene-rutile (Fig. 150). The altered groundmass is now composed of abundant fine grained chlorite, sericite and clay, with minor quartz and leucoxene-rutile. The alteration assemblage is consistent with transitional propylitic-argillic type. A couple of thin (up to 0.3 mm) sub-planar quartz veins are observed towards one end of the section.

c) Mineralisation: There are trace grains of FeCr spinel up to 0.1 mm across that are preserved at interpreted former olivine phenocryst sites (Fig. 151). No sulphides were observed in the section, although there is a trace in handspecimen.

Mineral Mode (by volume): chlorite 50%, sericite 30%, clay (illite-smectite) 10%, quartz 3%, leucoxene-rutile 2% and traces of FeCr spinel, carbonate and pyrite.

Interpretation and comment: It is interpreted that the sample is a porphyritic olivine basalt overprinted by strong propylitic-argillic alteration, but retaining moderately well preserved relict texture. The rock formerly hosted scattered phenocrysts of blocky feldspar (e.g. plagioclase) and blocky to prismatic ferromagnesian phases, interpreted to have included olivine and pyroxene (and less likely, hornblende). At interpreted olivine sites, there are scattered tiny relict inclusions of FeCr spinel. The phenocryst phases occurred in a fine grained groundmass with abundant ferromagnesian material, feldspar and minor disseminated FeTi oxide. Imposed alteration produced replacement by fine grained chlorite, sericite and clay, minor quartz and leucoxene-rutile. A couple of thin quartz veins occur locally.

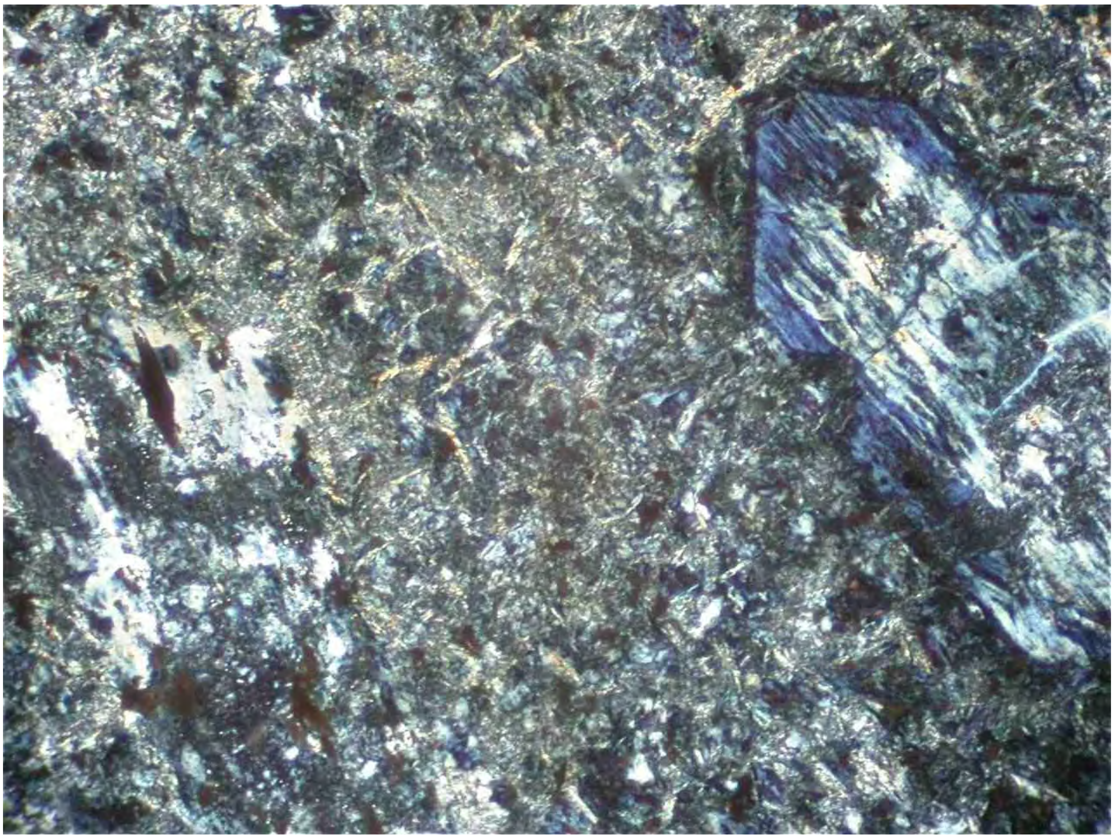

Fig. 150: Pseudomorphic aggregate of chlorite after a former olivine phenocryst at right, and a more diffuse aggregate of chlorite + quartz after a former pyroxene phenocryst at left. The original groundmass was replaced by fine grained sericite, clay, chlorite and a little leucoxene-rutile and quartz. Transmitted light, crossed polarisers, field of view 2 mm across.

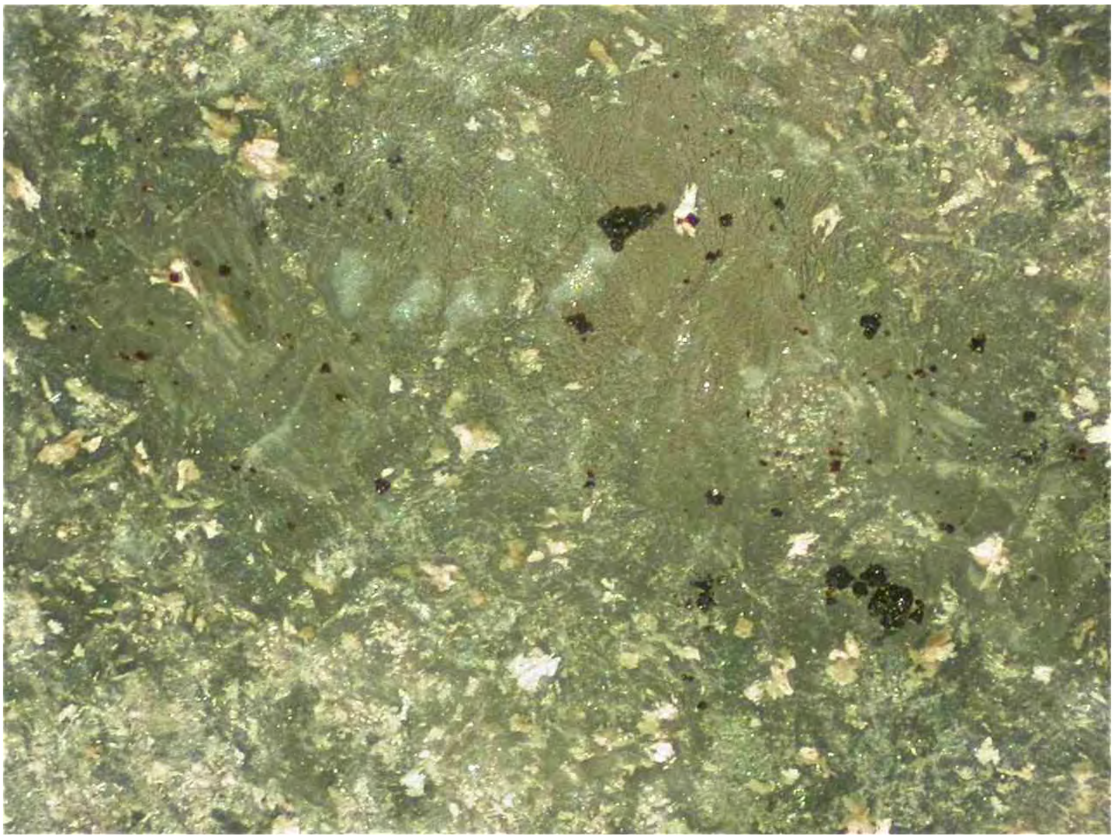

Fig. 151: Small relict grains of dark brown to black FeCr spinel hosted in a chlorite pseudomorph after a former olivine phenocryst. Small whitish aggregates nearby are leucoxene-rutile. Plane polarised oblique reflected light, field of view 2 mm across.