PETROGRAPHIC REPORT ON TWENTY DRILL CORE SAMPLES FROM THE CLONCURRY AREA, NORTHWEST QUEENSLAND

For

CuDeco Limited

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SUMMARY

Twenty small samples of drill core from the Cloncurry region of northwest Queensland were submitted for petrographic preparation, description and interpretation. The samples constituted short intervals (2-3 cm) of core offcuts and were from five different drill holes (DODH240, 247, 248, 250, 251). Five samples each were from DODH240 (A-E), DODH247 (A-E) and DODH251 (A-E), with four from DODH248 (A-D) and one from DODH250 (A). Downhole depths in the drill holes from where the samples were derived were all rather shallow, ranging from ~3.7 m depth to ~19.6 m depth. Consequently, many samples display effects of supergene alteration. Polished thin sections (PTS) were prepared from each sample at Petrographic International Pty Ltd in Brisbane. The PTS were subsequently examined microscopically in transmitted and reflected light. Photomicrographs were taken of some of the more prominently minerals samples. Drill core offcuts were measured for magnetic susceptibility and all were found to have very low susceptibility. They were also measured for radioactivity using a BGS-1SL scintillometer.

Summary descriptions of each sample are listed following:

DODH240A 8.40-8.42 m PTS

Summary: Carbonate-biotite-albite-quartz rock, with scattered finer grained domains that have been invaded and probably replaced by medium to coarse grained textural domains. The finer grained domains have vague preservation of relict fine to medium grained relict igneous texture and it is speculated on this basis that the protolith could have been of andesite or microdiorite character. It was replaced by abundant albite, with a little irregularly distributed carbonate, biotite, quartz and rutile. The invasive masses have the same mineral assemblage, differing proportions, with larger masses rich in quartz, or biotite, or carbonate, and associated locally with minor albite and rutile. Assuming that the protolith could have been of intermediate igneous type, then it was subjected to considerable metasomatic introduction of alkalies, SiO_2 and CO_2.

DODH240B 8.68-8.70 m PTS

Summary: Albite-carbonate-quartz (-biotite-rutile) rock, with scattered irregular domains retaining moderate preservation of relict porphyritic igneous texture. The remainder of the rock was totally reconstituted by occurrence of veinlike to irregular metasasomatic aggregates. The original rock probably had scattered small plagioclase phenocrysts in a plagioclase-rich groundmass, with minor ferromagnesian material and FeTi oxide. It is speculated to have been of intermediate (-mafic) composition. The rock was replaced mostly by albite, but with minor carbonate and a little rutile, quartz, biotite, muscovite and chlorite. The invading metasomatic masses contain abundant medium to coarse grained carbonate, with subordinate quartz, patchy biotite and minor albite and rutile. It is likely that the metasomatic alteration process added alkalies (especially Na) and CO_2 and occurred under possible medium grade metamorphic conditions.

DODH240C 10.10-10.12 m PTS

Summary: Medium to coarse grained heterogeneous metamorphic/metasomatic rock containing abundant carbonate, altered amphibole and subordinate albite. There are also a few isolated rather coarse grains of brannerite. Retrograde alteration was imposed, leading to replacement of all amphibole by pseudomorphs of sericite/muscovite and carbonate, and

albite is slightly altered to carbonate. Sparse grains of gold (up to 120 μm across), a galena-like phase (maybe clausthalite), tiny grains of an unidentified ?sulphide mineral and native copper are scattered, mostly in association with brannerite and albite. It is speculated that these phases relate to the retrograde alteration phase. Subsequently, the rock was affected by supergene oxidation, causing development of a little impregnation and veining by a green secondary U phase (e.g. torbernite), a trace of a jarosite-type phase, and local impregnation by goethite.

DODH240D 10.45-10.48 m PTS

Summary: Coarse grained, inequigranular albite-amphibole-carbonate rock, with imposed retrogression effects, Cu-Au mineralisation and subsequent supergene oxidation. The rock originally contained abundant intergrown blocky to prismatic amphibole and albite, with minor interstitial coarse carbonate, a little finer grained interstitial K-feldspar and muscovite, and a few small grains of rutile. The rock is likely to be the product of metasomatic replacement under metamorphic conditions, with nature of the protolith being obscure, but speculated to have been ultimately of mafic igneous type. All amphibole was retrogressively replaced by fine grained sericite and carbonate. Mineralisation in the sample appears to be related to retrogression and is manifest by sparsely distributed grains of copper, grading into, or rimmed by gold, uncommon small grains of a galena-like phase and rare grains of a possible telluride phase (e.g. calaverite). There has been variable replacement of the galena-like phase by a jarosite-like phase and goethite, with these oxidation products also occurring as thin veins. In places, it appears as though a Cu-Au alloy phase was rimmed by spongy "mustard gold".

DODH240E 15.12-15.15 m PTS

Summary: Fine to medium grained, inequigranular albite-rich rock, with minor intergrown carbonate, muscovite and a little rutile, and showing possible metasomatic patches of coarser grained carbonate and minor albite, microcline, rutile, brannerite and muscovite. In places, there are pseudomorphs after possible former amphibole/pyroxene grains. The nature of the protolith of the sample is obscure due to recrystallisation and probable replacement. Retrograde alteration occurred with replacement of all former ?amphibole/pyroxene by carbonate, sericite, chlorite and hematite, and some albite was also altered to chlorite, carbonate and hematite. It is possible that brannerite masses have replaced rutile. Associated with retrograde products are traces of electrum, a galena-like phase, and a possible telluride phase. Slight supergene oxidation effects were imposed, leading to local impregnation by hematite/goethite and local replacement of ?sulphides/tellurides by goethite and a jarosite-like phase.

DODH247A 6.68-6.71 m PTS

Summary: The sample represents a type of hydrothermal breccia, displaying a generally clast-supported texture. Lithic clasts are sub-rounded to angular and are mostly fine grained and recrystallised, but with local gradations to medium grained. Generally, due to recrystallisation of clasts, relict texture is not preserved, but rarely, there are relict fine sedimentary bedding laminations. This fact, together with the observation that the majority of clasts are albite rich, locally with abundant quartz, carbonate and biotite, is interpreted to indicate that the majority of clasts could represent a former feldspathic siltstone. The original sedimentary protolith material was recrystallised under metamorphic and/or metasomatic conditions and was hydrothermally brecciated, with development of a medium grained matrix component that is commonly biotite-rich, but with locally abundant carbonate and quartz. Minor disseminated hematite is disseminated throughout. The rock was subject to slight supergene alteration, with partial replacement of biotite by nontronitic clay.

DODH247B 7.74-7.82 m PTS

Summary: Carbonate-albite rock, with irregular and veinlike masses of fine grained turbid carbonate, plus associated impregnations and scattered aggregates of supergene goethite (± hematite). No recognised relict texture occurs and much of the rock is characterised by fine to

medium grained, blocky albite, enclosed in medium grained (locally coarser) carbonate (calcite), with a little associated rutile. The fine grained carbonate masses and Fe oxide aggregates and impregnations are interpreted to be of supergene derivation (e.g. the carbonate could be pedogenic). In albite and medium grained carbonate, there are rare tiny grains of a galena-like phase as well as copper. The latter could also have a supergene origin.

DODH247C 12.51-12.54 m PTS

Summary: Retrogressed and partly weathered medium to coarse grained amphibole-albite carbonate rock, containing a few grains of altered brannerite. Original coarse amphibole (now replaced by illite-sericite and carbonate) was intergrown with albite, carbonate, minor K-feldspar, quartz, a few grains of muscovite and rutile. Minor retrogression has also affected feldspars. Interpreted brannerite has been replaced by possible low-U metamict products. Minor sulphides could have originally occurred, but were affected by supergene oxidation and replaced by goethite aggregates. Patchy supergene goethite/hematite also occurs elsewhere, e.g. at altered amphibole sites.

DODH247D 13.72-13.76 m PTS

Summary: Retrogressed and partly weathered medium to coarse grained amphibole-albite rock, with minor interstitial quartz, carbonate and K-feldspar and containing traces of fine grained rutile, biotite and muscovite, and a single grain of degraded (metamict) brannerite. The nature of the protolith is obscure and the rock is regarded as the product of metamorphism and/or metasomatic replacement under metamorphic conditions. Original amphibole was completely retrogressed and replaced by illite-sericite, carbonate and K-feldspar, with a little hematite. Weathering effects have led to formation of goethite-impregnated fine grained clay, mostly interstitial to original amphibole and albite, and possibly largely forming from originally more abundant biotite. In one part of the section, retrogressed amphibole hosts at least 10 small metallic grains up to 40 μm across that include copper and gold.

DODH247E 14.68-14.72 m PTS

Summary: Medium to coarse grained carbonate (calcite)-albite-quartz rock with scattered aggregates and individual grains of brannerite, along with minor rutile. The nature of the protolith is obscure and the rock is considered to be the product of metasomatic replacement and complete recrystallisation. Inequigranular masses and individual grains of albite and quartz (the latter commonly strained) are variably enclosed and locally replaced by medium grained carbonate. Retrograde alteration was imposed leading to local replacement of the silicates by carbonate, albite by chlorite (mostly in the vicinity of brannerite) masses and emplacement of a few carbonate veins (with a little chlorite and hematite). Brannerite is probably metamict and locally enclosed by thin rims of fine grained acicular hematite. Tiny traces of pyrite and galena tend to be associated with brannerite.

DODH248A 3.93-3.95 m PTS

Summary: Texturally heterogeneous albite-carbonate-quartz rock that originally contained patches with a ferromagnesian mineral, e.g. amphibole. The sample contains abundant domains of fine to medium grained, inequigranular albite, with subordinate quartz and carbonate, interspersed with coarser grained carbonate that locally contains pseudomorphs after locally abundant amphibole, along with minor albite and K-feldspar. A little rutile is scattered throughout the rock, for which no definite protolith characteristics are recognised. The rock is interpreted to represent the product of complete recrystallisation and replacement. Retrograde alteration was imposed, causing all amphibole to be replaced, mostly by chlorite. Subsequently imposed supergene alteration caused some degradation of chlorite to nontronite and goethite.

DODH248B 9.22-9.25 m PTS

Summary: Originally a medium to coarse grained rock containing an abundant blocky to prismatic ferromagnesian phase (e.g. amphibole), intergrown with subordinate carbonate and

albite. This rock preserves no recognisable relict characteristics from a protolith and is probably the product of metamorphism and/or metasomatic replacement, resulting into complete recrystallisation of protolith material. The original mineral assemblage also contained a little muscovite, fine grained rutile and a couple of grains of brannerite. Strong retrogression occurred, with complete replacement of amphibole by illite-sericite, carbonate, chlorite and a little hematite. Alteration-derived carbonate is also dusted by hematite. Brannerite was metamictised and replaced by fine grained leucoxene.

DODH248C 10.93-10.96 m PTS

Summary: The sample was originally a medium to coarse grained aggregate of blocky to prismatic ferromagnesian mineral (e.g. amphibole) that was intergrown with interstitial K-feldspar and carbonate, plus minor albite. A few grains of brannerite, muscovite, fine grained rutile and biotite also formed part of the assemblage that is considered to have formed by complete replacement of undefined protolith material due to metamorphism and/or metasomatic replacement. Strong retrograde alteration ensued, causing complete replacement of amphibole, initially by considerable K-feldspar, but subsequently by carbonate and sericite, with a little chlorite. K-feldspar was also partly retrogressed to sericite and carbonate. Brannerite was degraded to fine grained metamict products. At least 30 grains of metallic phases up to 120 μm across, and ranging from copper to gold are observed, mainly associated with retrograde products and with supergene clay and goethite.

DODH248D 18.90-18.92 m PTS

Summary: The sample is mostly composed of a medium to coarse grained albite-carbonate rock, with blocky albite grains generally enclosed in a medium to coarse grained carbonate matrix. In places, albite forms larger semi-massive aggregates, including occurring as fine grained recrystallised masses that are speculated to represent former protolith material (e.g. possibly albitic metasiltstone). Within the albite-carbonate assemblage, there are a few individual grains and aggregates of rutile. In places, there is minor fine grained chlorite interstitial to albite and enclosed in carbonate. This is probably a retrograde phase and it is locally associated with dark brown to opaque impregnation by a coffinite-like phase. Within one of the coffinite masses is a single grain of brannerite.

DODH250A 19.60-19.63 m PTS

Summary: Fine grained recrystallised inequigranular albite-carbonate rock, with minor quartz and hematite, and trace rutile and tourmaline. Although there are no preserved relict textures, it is speculated from bulk compositional constraints that the rock could have been of fine grained feldspathic sedimentary type (e.g. siltstone), perhaps with an evaporitic (carbonate) component. The recrystallised rock was cut by a few initial veins that are irregular to anastomosing and contain medium grained quartz and carbonate. There was a later set of prominent veins emplaced that contain medium to coarse grained carbonate and fluorite, with a little quartz and trace hematite.

DODH251A 3.73-3.75 m PTS

Summary: Medium to coarse grained albite-biotite-carbonate (-quartz) rock, with a little disseminated rutile and hematite. This represents a recrystallised metamorphic and/or metasomatic replacement assemblage and the nature of the protolith remains obscure. In places, carbonate occurs in rather coarse veinlike aggregates, with local quartz associated. Rutile and/or hematite occur as fine discrete grains and as small aggregates, mostly hosted in quartz and albite. The rock shows imposition of supergene effects, with slight degradation of biotite to goethite-stained nontronite.

DODH251B 9.41-9.44 m PTS

Summary: Recrystallised rock with two major compositional domains. One is weakly foliated and generally medium grained containing somewhat banded aggregates rich in one or more of biotite, carbonate, quartz and albite, and containing scattered small masses of finely recrystallised albite-K-feldspar-biotite-carbonate-quartz rock that is interpreted to represent

the possible protolith (e.g. former feldspathic to psammopelitic metasedimentary rock). The other compositional domain originally contained abundant medium to coarse grained amphibole, carbonate and K-feldspar, with a little biotite. Minor disseminated rutile occurs throughout the rock as part of the recrystallised assemblage. The sample is probably the product of strong reconstitution involving metamorphism and metasomatic replacement. Later, there was retrograde alteration of all amphibole by K-feldspar, chlorite and sericite, and the rock was subsequently slightly affected by supergene alteration, leading to local degradation of chlorite and biotite by nontronite.

DODH251C 13.49-13.51 m PTS

Summary: Strongly retrogressed and supergene altered rock that originally contained abundant medium to coarse grained amphibole and interstitial carbonate. It also hosted a little feldspar, a couple of aggregates of coarse brannerite and trace biotite and rutile. The nature of the protolith for this assemblage remains obscure and the rock was probably the product of metamorphism and metasomatic replacement. Retrograde alteration led to all amphibole and some feldspar being replaced. The dominant alteration assemblage was initially composed of sericite, chlorite and carbonate. Subsequently, weathering effects caused considerable degradation of the rock to nontronitic clay and minor supergene Fe oxides (goethite and hematite). Locally, boxwork structures developed due to leaching (e.g. of carbonate). Brannerite was metamictised and replaced by a fine grained, low-U aggregate that probably includes leucoxene.

DODH251D 14.29-14.32 m PTS

Summary: Medium to coarse grained carbonate-amphibole (-quartz-albite) rock, with a little rutile, biotite and brannerite in the original assemblage. The rock has no relict textures and is considered to be the product of complete replacement/recrystallisation of protolith material. Subsequently, there was strong retrogression, with replacement of all amphibole by sericite, chlorite and carbonate, plus local replacement of albite by carbonate, and metamictisation of brannerite. Supergene alteration was also imposed, leading to development of nontronite, goethite and hematite.

DODH251E 18.25-18.28 m PTS

Summary: Medium to coarse grained carbonate-rich rock, with patchy pseudomorphs after a former ferromagnesian phase (e.g. amphibole) and containing medium to coarse scattered grains of brannerite and traces of disseminated rutile. Retrogression of the rock led to replacement of amphibole by K-feldspar, chlorite, carbonate and a little hematite, development of irregular masses and veins of chlorite, and formation of fine dusty hematite pigmentation of carbonate. Brannerite is metamict and is associated with traces of radiogenic galena, along with a little fine grained hematite and pyrite. Elsewhere in the rock, there are traces of disseminated galena and Ag-rich electrum interstitial to carbonate and associated with chlorite.

Interpretation and comment

The rocks in the suite are strongly reconstituted and in most samples, the nature of protolith material is speculative or completely obscure. This is due to total recrystallisation, retrogression and in many samples, the imposition of supergene alteration. Samples 240A and 240B have some preservation of relict igneous texture (e.g. porphyritic) and can be inferred to have had protoliths of possible intermediate to mafic igneous composition. Samples 247A, 247E, 248D, 250A and 251B could be implied to represent former fine grained feldspathic (and carbonate-bearing) fine grained sedimentary protoliths (maybe evaporitic), in part based on vestiges of preserved material, but also

on bulk composition. Similarly, it could be inferred that sample 251E could have been developed from a carbonate-rich sedimentary precursor based on bulk composition. Other samples do not have any recognised relict textures and their reconstituted mineral assemblages are not definitive as to protolith type. It could be speculated, however, that at least some of the samples with an original recrystallised assemblage containing amphibole, albite and carbonate (and with accessory rutile) could represent former mafic to intermediate igneous protoliths.

All protolith materials were totally recrystallised to form reconstituted rocks that are mostly medium to coarse grained (but locally grade to finer grained) and granular to inequigranular. It is interpreted that in many samples, there was an initial mineral assemblage developed which was later overprinted by retrograde and/or supergene alteration effects. The initial mineral assemblages are similar throughout the suite and typically contained significant amounts (not necessarily present in all samples) of carbonate (calcite as indicated by testing with dilute HCl), albite, biotite, a blocky to prismatic ferromagnesian phase (considered most likely to have been amphibole prior to retrogression) and accessory (to trace) rutile. Several samples also have quartz as a significant component, and there are small to trace amounts of muscovite, K-feldspar, hematite and tourmaline in some. Several samples also have a few grains or aggregates of rather coarse grained brannerite (or its degradation products) that is also interpreted to be part of the initial mineral assemblage.

The texture and mineralogy of the initial mineral assemblage infer that crystallisation occurred under metamorphic conditions, possibly amphibolite facies, but bulk compositions are unusual to be derived solely from the isochemical recrystallisation of protolith materials. Alternatively, it appears likely that there was a significant metasomatic component occurring during recrystallisation, with introduction and mobility of several constitutents, e.g. CO_2, Na, K, U, Au (see later).

Retrograde alteration is manifest in many samples and is most obvious in those that initially contained the ferromagnesian (e.g. amphibole) phase. None of the primary ferromagnesian phase is preserved and it was pseudomorphed by alteration minerals that include sericite (or illite-sericite), chlorite, carbonate, K-feldspar and a little hematite. Alteration is commonly of either sericite and/or chlorite, or of K-feldspar and/or carbonate types, although there are intergradations. Other retrograde alterations tend to be minor, but include local replacement of albite and K-feldspar by carbonate, sericite and chlorite, biotite by chlorite, and dusting of albite and carbonate by very fine hematite. In a couple of samples (248D, 251E), chlorite is locally more abundant as a retrograde alteration product, occurring in patches and veinlets, in places with U minerals and trace hematite. Tiny amounts of sulphide minerals and other metallic phases could have also been formed

during retrogression. Retrograde alteration evidently occurred under low grade conditions (e.g. lower greenschist facies or below) that were oxidising (e.g. hematite stability).

Many samples show effects of supergene alteration. These include the impregnation of initial and retrograde mineral assemblages by nontronitic clay and goethite and/or hematite (especially layer silicate phases), the local leaching of carbonate to form boxwork textures (e.g. in 251C), alteration/destruction of former sulphides, degradation of brannerite to low-U products that probably include leucoxene, and formation of a possible secondary U phase (e.g. torbernite in 240C). The occurrence of scattered tiny grains of a metallic phase that appears to range between gold and copper in several samples (e.g. 240C, 240D, 247D, 248C) could also be attributed to supergene oxidation.

Several samples (e.g. 240C, 240E, 247C, 247D, 247E, 248B, 248C, 248D251C, 251D, 251E) contain a radioactive phase that it identified as brannerite. Commonly this is medium to coarse grained, occurring as isolated single grains, and in aggregates, and intergrown with minerals forming the initial assemblage (see above). In three samples that show little or no supergene alteration (247E, 248D, 251E), brannerite is considered to be little-degraded and is a dark brown colour and slightly translucent in transmitted light. Locally, this type of brannerite is accompanied by traces of fine grained galena, interpreted as a radiogenic breakdown product. In other brannerite-bearing samples that have been affected by supergene oxidation, it is interpreted that there has been variable degradation of the mineral to a very fine grained leucoxene-like phase, in places accompanied by goethite, with the aggregates being translucent turbid yellowish (-green-brown) in transmitted light. This type of brannerite could have lost considerable U due to supergene leaching. In the samples with fresher brannerite, the mineral tens to be accompanied by chlorite and trace fine grained hematite. In 248D, trace brannerite is accompanied by chlorite hosting a considerable amount of an impregnating very dark brown translucent phase interpreted to be a coffinite-type mineral. Sample 240C shows likely supergene oxidation effects that have caused formation of a little fine grained green secondary U phase, e.g. torbernite, e.g. from the breakdown of brannerite. All brannerite observed is of metamict type, with fresher examples of the mineral (e.g. in 247E, 248D, 251E) being isotropic under crossed polars. This is probably due to radiation damage.

Sulphide minerals are mostly absent from the sample suite, although as mentioned, traces of galena occur locally associated with brannerite as a possible radiogenic breakdown product. A possible galena-like phase (e.g. galena, clausthalite) occurs in tiny grains in 240C, 240D and 247B, and there is a trace of a possible telluride phase associated with ?galena and with possible Ag-rich electrum in 240D and 240E. Tiny traces of fine grained pyrite (of

likely retrograde origin) are observed in 247E and 251E, in places in association with brannerite, and in 247C, there are a few pseudomorphs composed of supergene goethite after possible earlier pyrite. Two samples (240E and 251E) contain traces of possible Ag-rich electrum, in places in composites with galena and a metallic phase with optical properties that suggest a range from gold to copper occur in several samples (e.g. 240C, 240D, 247D, 248C), with individual grains up to 120 μm across and up to 30^{+} grains per section. The latter occurrence appear to occur in samples with at least some supergene alteration effects, implying that there is a possibility that the metallic phases could be of supergene derivation. Some of the metallic grains could be a Au-Cu alloy (auricupride) and there are local occurrences of alteration to/replacement by a fine grained, pitted gold phase ("mustard gold", e.g. in 240C, 240D).

The origin, source and mineral deposit style of the observed mineralisation remains speculative. It could be surmised that there was some type of metasomatic replacement of varied host rock compositions under medium grained metamorphic conditions to form locally sparse, but coarse grained brannerite. Subsequently, during retrogression, some U could have been mobilised (e.g. leaching from brannerite) and locally formed coffinite (in 248D). Traces of metals (Ag, Au, Cu) and possible S, Se, Te could have been introduced, e.g. during retrogression, but sulphides were largely destroyed by supergene oxidation. The latter process could have been important in leaching U out of brannerite, formation of trace secondary U minerals (e.g. torbernite in 240C) and maybe the precipitation of the metallic phases ranging from gold to copper in several samples.

It is recommended that a better assessment of the mineralogy and mineral chemistry would be derived from application of electron microprobe work on selected samples. This would assist confirmation of the identity of the U minerals, the galena-like phase, possible telluride phase and the metal/metal alloy phases (electrum, gold-copper). This information could be essential in devising metallurgical recovery strategies in the event that the deposit has potential economic viability.

Individual sample descriptions

DODH240A 8.40-8.42 m PTS

Summary: Carbonate-biotite-albite-quartz rock, with scattered finer grained domains that have been invaded and probably replaced by medium to coarse grained textural domains. The finer grained domains have vague preservation of relict fine to medium grained relict igneous texture and it is speculated on this basis that the protolith could have been of andesite or microdiorite character. It was replaced by abundant albite, with a little irregularly distributed carbonate, biotite, quartz and rutile. The invasive masses have the same mineral assemblage, differing proportions, with larger masses rich in quartz, or biotite, or carbonate, and associated locally with minor albite and rutile. Assuming that the protolith could have been of intermediate igneous type, then it was subjected to considerable metasomatic introduction of alkalies, SiO_2 and CO_2.

Handspecimen: The drill core sample displays heterogeneity, with interspersed domains rich in medium to coarse grained, pale orange-pink feldspar and pale grey quartz, white carbonate and dark brown-black biotite. Testing of the section offcut with dilute HCl only produced local reaction, implying that there is minor calcite, but that the majority of the carbonate could be dolomitic. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. The sample has a background radiometric measurement of 80 cps.

Petrographic description

a) Primary rock characteristics: In the section, about 20 % of the sample exhibits scattered domains up to several millimetres across that might represent breccia-type fragments. These are albite-rich and have likely relict igneous texture, albeit not well preserved. The original rock appears to have been fine to medium grained, probably rather feldspathic and with abundant small stubby feldspars. It is speculated that it was originally of intermediate composition, perhaps andesite or microdiorite. The dominant alteration assemblage of albite, with smaller amounts of biotite, carbonate, quartz and rutile, also implies a relatively feldspathic igneous composition.

b) Alteration and structure: It is interpreted that protolith igneous rock was strongly hydrothermally altered and invaded by abundant veinlike and irregular metasomatic replacement and infill masses. The original rock was replaced by dominant fine to medium grained albite, with minor patchy biotite, carbonate, quartz and a little finely disseminated rutile. The invading masses have generally medium to coarse grainsize (up to several millimetres) and have monomineralic patches rich in quartz, or in carbonate, or in biotite. Commonly, these minerals are intergrown and can also be associated with minor albite are sparsely scattered anhedra of rutile. It is notable that the invading, hydrothermal textured patches have the same overall mineralogy as the altered host rock (but in differing proportions). It is implied that the hydrothermal fluid that pervaded the rock introduced significant alkalies, SiO_2 and CO_2 and that the protolith recrystallised under syn-tectonic, probably medium grade, metamorphic conditions.

c) Mineralisation: No sulphide minerals are observed in the sample. There are irregularly scattered grains of rutile up to 0.8 mm across.

Mineral Mode (by volume): quartz 30%, carbonate 25%, biotite 24%, albite 20% and rutile 1%.

Interpretation and comment: It is interpreted that the sample is a carbonate-biotite-albite-quartz rock, with scattered finer grained domains that were invaded and probably replaced by medium to coarse grained textural domains. The finer grained domains have some preservation of relict fine to medium grained relict igneous texture and could represent a protolith of andesite or microdiorite character. It was replaced by abundant albite, with a little irregularly distributed carbonate, biotite, quartz and rutile. The invasive masses have the same mineral assemblage, differing proportions, with larger masses rich in quartz, or biotite, or carbonate, and associated locally with minor albite and rutile. Assuming that the protolith was of intermediate igneous type, then it was subjected to considerable metasomatic

introduction of alkalies, SiO_2 and CO_2 and recrystallised under syn-tectonic, medium grade, metamorphic conditions.

DODH240B 8.68-8.70 m PTS

Summary: Albite-carbonate-quartz (-biotite-rutile) rock, with scattered irregular domains retaining moderate preservation of relict porphyritic igneous texture. The remainder of the rock was totally reconstituted by occurrence of veinlike to irregular metasasomatic aggregates. The original rock probably had scattered small plagioclase phenocrysts in a plagioclase-rich groundmass, with minor ferromagnesian material and FeTi oxide. It is speculated to have been of intermediate (-mafic) composition. The rock was replaced mostly by albite, but with minor carbonate and a little rutile, quartz, biotite, muscovite and chlorite. The invading metasomatic masses contain abundant medium to coarse grained carbonate, with subordinate quartz, patchy biotite and minor albite and rutile. It is likely that the metasomatic alteration process added alkalies (especially Na) and CO_2 and occurred under possible medium grade metamorphic conditions.

Handspecimen: The drill core sample is composed mostly of an assemblage of medium to coarse grained white-creamy carbonate and quartz, with reddish-brown feldspar, and with subordinate patchy black biotite. A few sub-metallic, dark brown aggregates of rutile up to 2 mm across are sparsely scattered. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. The sample has a background radiometric measurement of 80 cps.

Petrographic description

a) Primary rock characteristics: In the section, approximately half of the sample comprises irregular shaped domains up to 1.5 cm across that have moderate preservation of relict igneous texture, with the remainder representing coarser grained irregular to veinlike hydrothermal masses. Relict texture indicates that the original rock was fine to medium grained and porphyritic, with scattered plagioclase phenocrysts up to 1 mm across, in a plagioclase-rich groundmass that probably included minor ferromagnesian material and FeTi oxide. From the relict characteristics, it is speculated that the protolith was of intermediate (-mafic) type.

b) Alteration and structure: There was strong hydrothermal replacement of remnant host rock and it was invaded by irregular to veinlike metasomatic masses up to 1.5 cm across of generally coarser grainsize. The host rock was pseudomorphically replaced by albite, accompanied by minor fine to medium grained carbonate and a little disseminated rutile, quartz, muscovite and in places, rare biotite and chlorite. The invading masses are composed of dominant medium to coarse grained inequigranular carbonate, commonly intergrown with subordinate quartz (grainsize up to 5 mm across), with patchy medium grained biotite in one part of the section, plus minor albite, scattered poikiloblastic aggregates of rutile up to 2 mm across and a trace of muscovite. The metasomatic masses are similar mineralogically to the host rock, but the proportions are widely different, with carbonate predominating. The replacement of the host rock and metasomatic masses imply significant addition of alkalies (especially Na) and CO_2, probably under medium grade metamorphic conditions.

c) Mineralisation: No sulphide minerals are observed in the sample. There are irregularly scattered grains of rutile up to 0.6 mm across and poikiloblastic aggregates up to 2 mm across.

Mineral Mode (by volume): albite 45%, carbonate 35%, quartz 13%, biotite 5%, rutile 2% and traces of muscovite and chlorite.

Interpretation and comment: It is interpreted that the sample represents a former porphyritic intermediate (-mafic) igneous rock that has experienced strong hydrothermal alteration and invasion by metasomatic masses. The original rock displays moderate preservation of primary texture (scattered small plagioclase phenocrysts) and was replaced by dominant albite, with minor carbonate and a little rutile, quartz, biotite, muscovite and chlorite. The remainder of the rock was totally reconstituted by occurrence of veinlike to irregular metasasomatic aggregates composed of abundant medium to coarse grained carbonate, with

subordinate quartz, patchy biotite and minor albite and rutile. It is likely that the metasomatic alteration process added alkalies (especially Na) and CO_2 and occurred under possible medium grade metamorphic conditions.

DODH240C 10.10-10.12 m PTS

Summary: Medium to coarse grained heterogeneous metamorphic/metasomatic rock containing abundant carbonate, altered amphibole and subordinate albite. There are also a few isolated rather coarse grains of brannerite. Retrograde alteration was imposed, leading to replacement of all amphibole by pseudomorphs of sericite/muscovite and carbonate, and albite is slightly altered to carbonate. Sparse grains of gold (up to 120 μm across), a galena-like phase (maybe clausthalite), tiny grains of an unidentified ?sulphide mineral and native copper are scattered, mostly in association with brannerite and albite. It is speculated that these phases relate to the retrograde alteration phase. Subsequently, the rock was affected by supergene oxidation, causing development of a little impregnation and veining by a green secondary U phase (e.g. torbernite), a trace of a jarosite-type phase, and local impregnation by goethite.

Handspecimen: The drill core sample is composed of pale brown domains rich in medium to coarse grained carbonate, interspersed with patchy pale to darker grey feldspar-rich material. In the pale brown domains, there are a few brown prismatic grains (?altered amphibole) up to several millimetres long. The sample contains a few green-yellow resinous grains up to 4 mm across of a radioactive mineral (e.g. brannerite) and this is locally associated with a few grains of visible gold up to 2 mm across. Also in this mineralised zone, there is patchy green staining by a possible secondary U phase, e.g. torbernite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units and is significantly radioactive with a radiometric measurement of 300 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the sample is heterogeneous mineralogically and texturally. It is dominated by compositional domains rich in carbonate, and in altered amphibole, with significant albite scattered irregularly in both domains. Each of these phases is typically medium to coarse grained and have an inequigranular texture, in which there is no recognisable relict texture from a protolith. The presence of minor rutile in the assemblage implies that the protolith contained significant Ti and thus could have been of ultimately mafic igneous type.

b) Alteration and structure: It is interpreted that protolith material was completely recrystallised, most likely by processes of hydrothermal metasomatism under metamorphic conditions (e.g. at amphibolite facies). It was recrystallised to a medium to coarse grained assemblage that ranges from being dominated by inequigranular carbonate (individual grains up to 5 mm across) to one that was originally rich in stubby to elongate prisms of amphibole (up to 5 mm long). There is a gradation between the two compositional domains, and in places there is significant albite (grains up to 2 mm) intergrown. Minor, fine grained rutile in grains up to 0.2 mm across, is irregularly distributed. There is also a trace of fine to medium grained muscovite and microcline. Several anhedral grains of brannerite up to 3.5 mm across are sparsely scattered, hosted in carbonate and also in proximity to albite. This interpreted primary mineral assemblage shows effects of retrograde alteration, with all amphibole being pseudomorphically replaced by fine grained carbonate and sericite/muscovite, and albite is locally replaced by carbonate. Throughout the sample, but mostly in proximity to brannerite and albite, are sparse grains of gold up to 120 μm across (Figs 1, 2), along with tiny (<80 μm) grains of a galena-like mineral (maybe clausthalite), a tiny trace of an unidentified ?sulphide (high reflectivity, silvery, anisotropic) and a tiny trace of native copper (in places associated with the galena-like phase and rarely enclosed in gold. The rock has experienced slight supergene oxidation, manifest in local goethite pigmentation (mainly at altered amphibole sites) and development of a little fine grained interstitial and veinlike masses of a green, turbid ?secondary U phase (e.g. torbernite) (Fig. 2) and a khaki-yellow ?jarosite-type phase.

c) Mineralisation: The sample contains a few medium to coarse grained anhedral of brannerite up to 3.5 mm across (Fig. 1). At least 25 grains of gold have been observed in the

sample, mainly in proximity to brannerite and albite. Gold forms grains up to 120 µm across and commonly displays development of pitted "mustard gold: on rims (Fig. 2), as well as rarely containing inclusions of copper. The samples contains rare grains of a galena-like phase (maybe claustahlite) up to 80 µm across, attached to rare copper and to an anisotropic, silvery, high reflectivity ?sulphide phase. Supergene oxidation is interpreted to be responsible for the formation of a little fine grained interstitial and veinlet green ?secondary U mineral (e.g. torbernite) (Fig. 2) and a khaki-yellow ?jarosite-like phase.

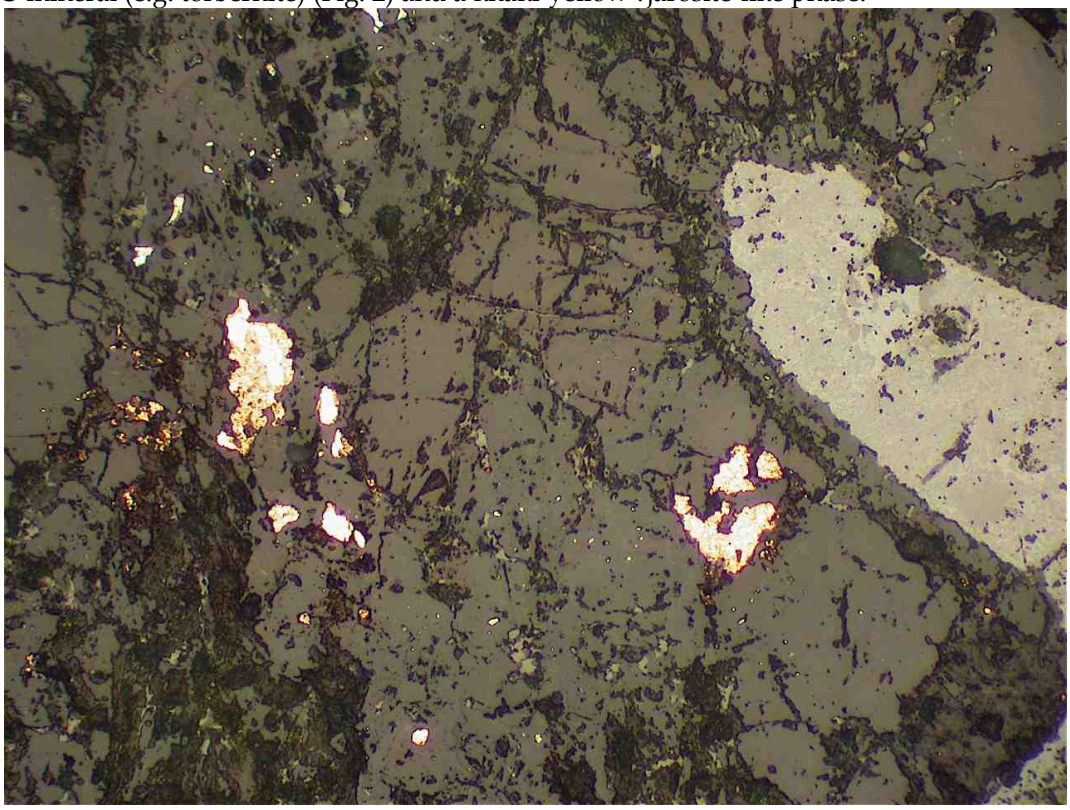

Fig. 1: Grains of gold (bright) adjacent to portion of a large grain of brannerite (pale grey, right), hosted mostly in albite (darker grey). Plane polarised reflected light, field of view 1 mm across.

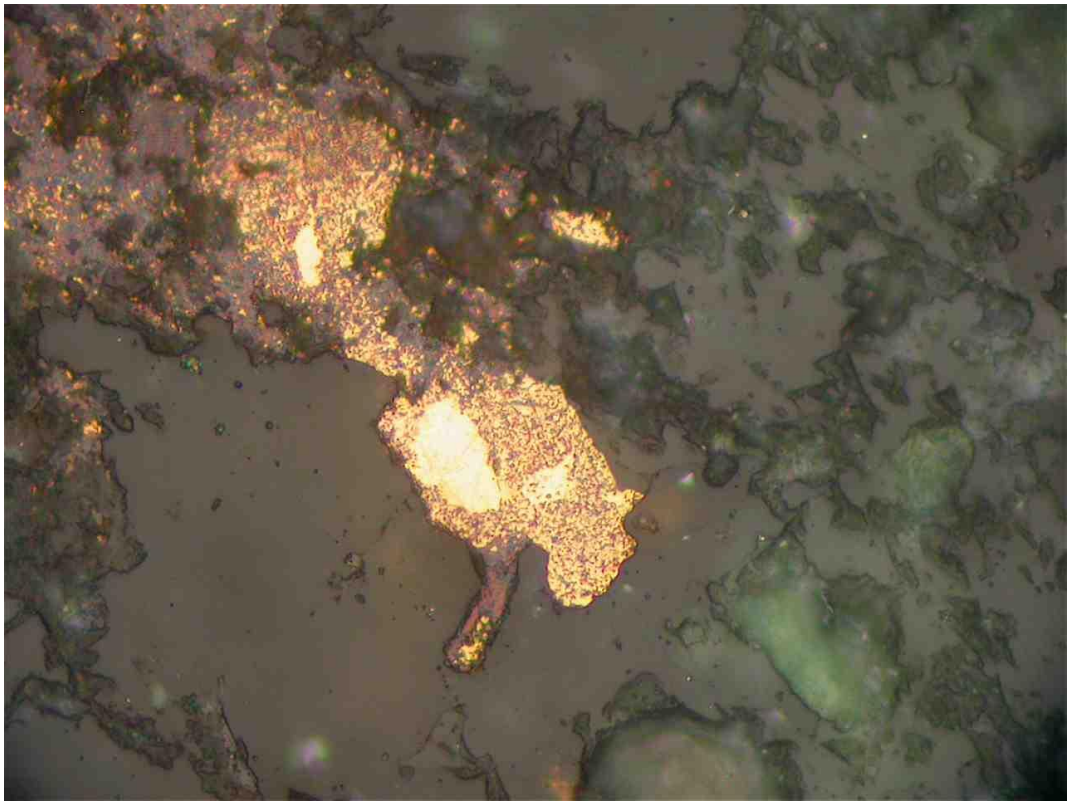

Fig. 2: Grains of gold showing rims of "mustard gold" (orange to mauve-brown), hosted in albite and adjacent to greenish patches of secondary ?U phase (e.g. torbernite). Plane polarised reflected light, field of view 0.25 mm across.

Mineral Mode (by volume): carbonate 70%, albite 15%, sericite/muscovite 12%, rutile and brannerite each 1% and traces of microcline, ?galena-like phase, gold, copper, ?torbernite, ?jarosite-type phase and unidentified ?sulphide phase.

Interpretation and comment: It is interpreted that the sample is a heterogeneous metamorphic/metasomatic rock containing abundant medium to coarse grained carbonate, altered amphibole and subordinate albite. There are also a few isolated grains of brannerite and fine grained rutile. Retrograde alteration was imposed, leading to replacement of all amphibole by pseudomorphs of sericite/muscovite and carbonate, and albite is slightly altered to carbonate. Sparse grains of gold (up to 120 µm across), a galena-like phase (maybe clausthalite), tiny grains of an unidentified ?sulphide mineral and native copper are scattered, mostly in association with brannerite and albite. These phases were possibly deposited during the retrograde alteration phase. The rock was later affected by supergene oxidation, producing a little impregnation and veining by a green secondary U phase (e.g. torbernite), a trace of a jarosite-type phase, and local impregnation by goethite.

DODH240D 10.45-10.48 m PTS

Summary: Coarse grained, inequigranular albite-amphibole-carbonate rock, with imposed retrogression effects, Cu-Au mineralisation and subsequent supergene oxidation. The rock originally contained abundant intergrown blocky to prismatic amphibole and albite, with minor interstitial coarse carbonate, a little finer grained interstitial K-feldspar and muscovite, and a few small grains of rutile. The rock is likely to be the product of metasomatic replacement under metamorphic conditions, with nature of the protolith being obscure, but speculated to have been ultimately of mafic igneous type. All amphibole was retrogressively replaced by fine grained sericite and carbonate. Mineralisation in the sample appears to be related to retrogression and is manifest by sparsely distributed grains of copper, grading into, or rimmed by gold, uncommon small grains of a galena-like phase and rare grains of a possible telluride phase (e.g. calaverite). There has been variable replacement of the galena-like phase by a jarosite-like phase and goethite, with these oxidation products also occurring as thin veins. In places, it appears as though a Cu-Au alloy phase was rimmed by spongy "mustard gold".

Handspecimen: The drill core sample is composed of pale khaki-grey to pale grey compositional domains on the millimetric scale, with the former containing significant fine grained sericite and the latter abundant carbonate and feldspar. A couple of carbonate veins up to 1.5 mm wide cut the rock. Sparsely scattered throughout are pink to gold metallic grains up to 1 mm across that appear to range from copper to gold. There are also a couple of silvery ?sulphide grains up to 1 mm across. In places, the rock shows slight effects of supergene oxidation, with orange-brown goethite staining. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units and is weakly radioactive with a radiometric measurement of 170 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the sample is dominated by rather coarse grained albite and altered amphibole, with minor interstitial carbonate. Each of these phases is typically medium to coarse grained and have an inequigranular texture, in which there is no recognisable relict texture from a protolith. However, the presence of a little rutile in the assemblage implies that the protolith contained significant Ti and thus could have ultimately been of mafic igneous type.

b) Alteration and structure: It is interpreted that protolith material was completely recrystallised, by hydrothermal metasomatism under metamorphic conditions (e.g. at amphibolite facies). It was recrystallised to a medium to coarse grained assemblage of blocky to bladed amphibole and albite (grainsize of each up to several millimetres), with minor interstitial coarse carbonate, a little interstitial finer grained K-feldspar, a few aggregates up to 1 mm across and individual flakes up to 0.6 mm across of muscovite, and sparsely scattered grains and aggregates of rutile up to 0.3 mm across. Subsequently, retrograde alteration was imposed, causing replacement of all amphibole by fine grained sericite + carbonate aggregates. There is a small amount of replacement of albite by the same phases. Sparsely dispersed throughout the retrograde products are irregular grains up to 0.4 mm across of phases that range from copper to gold, an uncommon galena-like phase up to 0.2 mm across, and a couple of grains up to 1 mm across of a possible telluride mineral, e.g. calaverite. The galena-like phase is commonly partly to completely replaced by a very fine grained jarosite-like phase and goethite, with the latter material also occurring in a few thin later veins. It is interpreted that the jarosite-like phase and goethite are supergene oxidation products. Similarly, at least some of the copper-gold phase could be of supergene derivation.

c) Mineralisation: The sample contains at least 30 grains of a phase that ranges between metallic pink and gold, and is interpreted to represent a range of composition from copper to gold (e.g. copper-gold alloy – "auricupride") (Figs 3, 4). These irregular grains are up to 0.4 mm across (and range down to <10 μm) and are associated with retrogression products.

Commonly, more copper-rich cores are rimmed by spongy gold (Fig. 3) and both gold and copper are locally rimmed by dark red-brown, ultrafine spongy ?copper and local ?jarosite-type phase ± goethite. One copper grain hosts a few tiny inclusions of a chalcocite-like phase. The rock contains a few grains of a galena-like phase (possibly clausthalite, as in sample 240C) up to 0.2 mm across (Fig. 4), with this phase being variably replaced by goethite. There are also a couple of grains of a possible telluride phase (high reflectivity, silvery-cream, weakly anisotropic – maybe calvaerite) up to 1 mm across. The rock has been affected by supergene oxidation with the formation of thin veins and interstitial masses of very fine grained yellow to brown jarosite-like phase and goethite. It is possible that the grains ranging from gold to copper in composition could also be at least partly of supergene derivation.

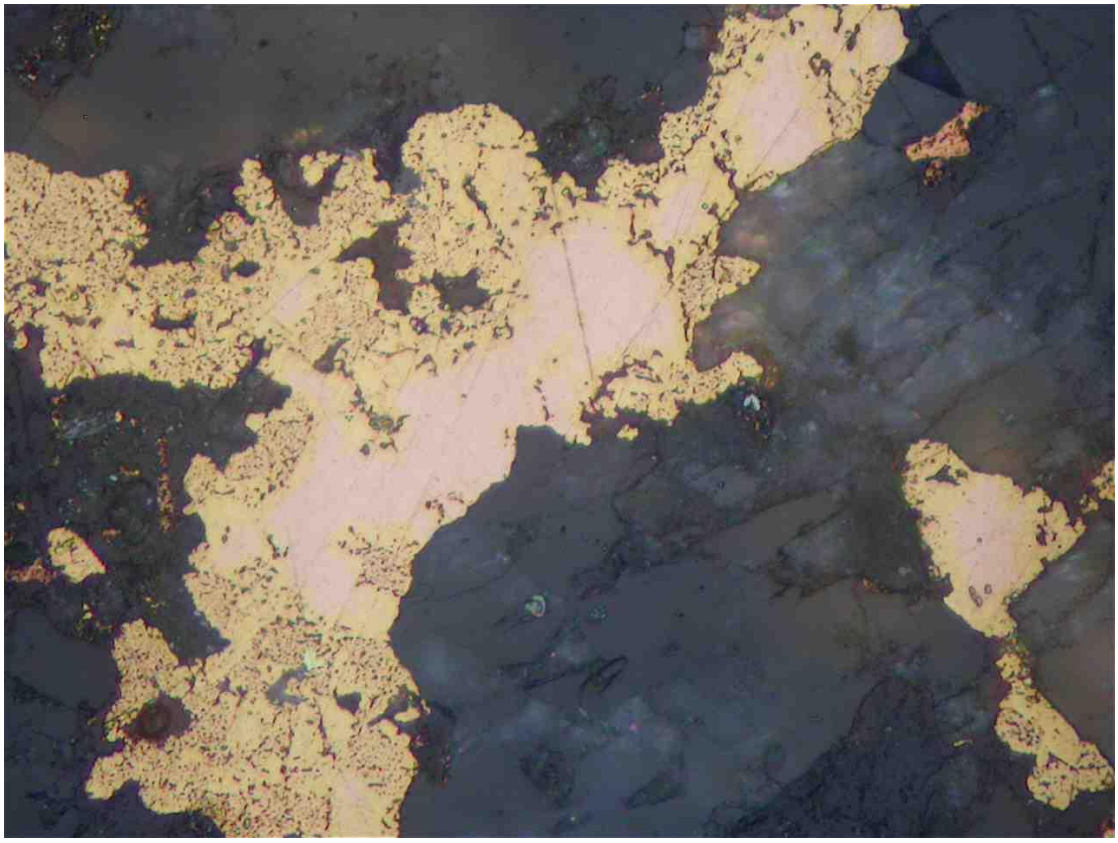

Fig. 3: Pale pink metallic phase, interpreted to be a Cu-Au alloy, with a possible reaction rime of yellower, spongy gold. Plane polarised reflected light, field of view 0.25 mm across.

Mineral Mode (by volume): carbonate 40%, sericite/muscovite 35%, albite 15%, jarosite-type phase + goethite and K-feldspar each 2% and traces of rutile, gold-copper phases, ?galena-like phase, ?telluride phase and ?chalcocite.

Interpretation and comment: It is interpreted that the sample represents an albite-amphibole-carbonate rock, with imposed retrogression effects, Cu-Au mineralisation and subsequent supergene oxidation. The rock originally contained abundant intergrown blocky to prismatic amphibole and albite, with minor interstitial coarse carbonate, a little finer grained interstitial K-feldspar and muscovite, and a few small grains of rutile. It could have been derived ultimately from a mafic igneous protolith with metasomatic replacement occurring under medium grade metamorphic conditions. All amphibole was later retrogressively replaced by fine grained sericite and carbonate. Mineralisation in the sample is related to retrogression and includes sparsely distributed grains of copper, grading into, or rimmed by gold, uncommon small grains of a galena-like phase and rare grains of a possible telluride phase (e.g. calaverite). There has been variable replacement of the galena-like phase by a jarosite-

like phase and goethite, with these supergene oxidation products also occurring as thin veins. In places, it appears as though a Cu-Au alloy phase was rimmed by spongy "mustard gold".

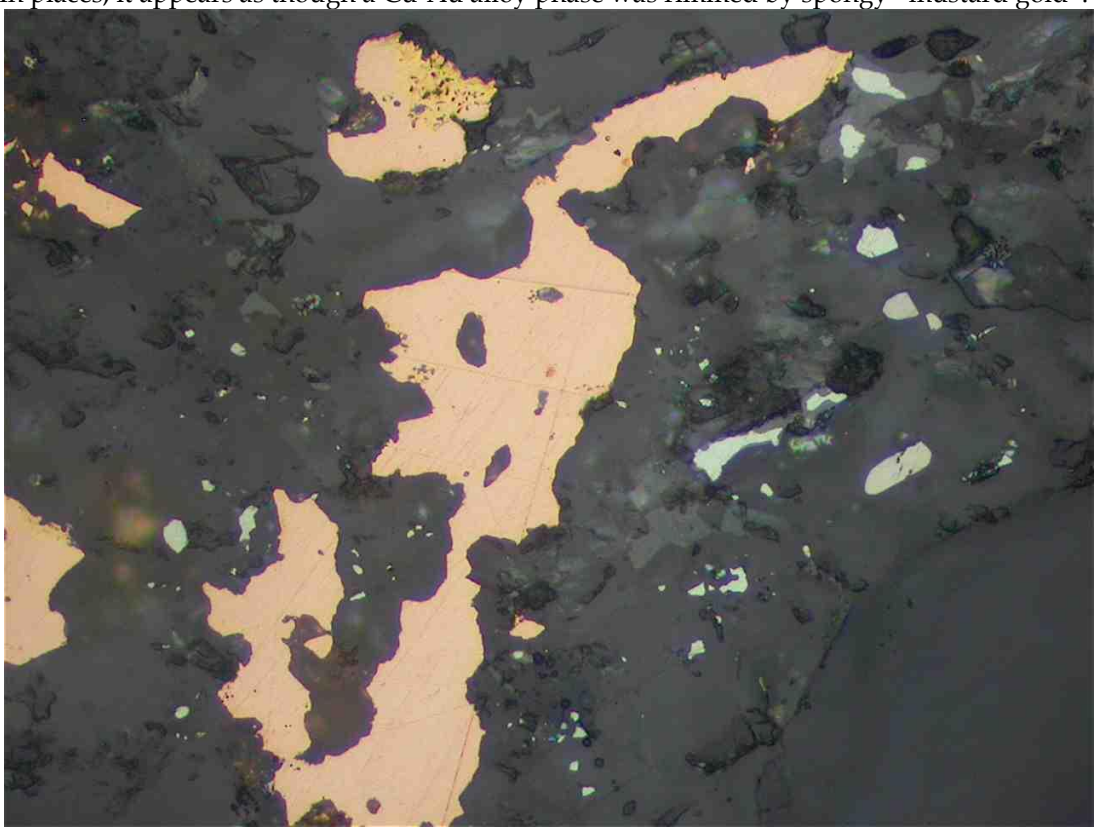

Fig. 4: Irregular grains of copper, with one at top containing a small mass of "spongy" gold, and associated with a few small grains of a galena-like phase (pale grey, right). Plane polarised reflected light, field of view 0.5 mm across.

DODH240E 15.12-15.15 m PTS

Summary: Fine to medium grained, inequigranular albite-rich rock, with minor intergrown carbonate, muscovite and a little rutile, and showing possible metasomatic patches of coarser grained carbonate and minor albite, microcline, rutile, brannerite and muscovite. In places, there are pseudomorphs after possible former amphibole/pyroxene grains. The nature of the protolith of the sample is obscure due to recrystallisation and probable replacement. Retrograde alteration occurred with replacement of all former ?amphibole/pyroxene by carbonate, sericite, chlorite and hematite, and some albite was also altered to chlorite, carbonate and hematite. It is possible that brannerite masses have replaced rutile. Associated with retrograde products are traces of electrum, a galena-like phase, and a possible telluride phase. Slight supergene oxidation effects were imposed, leading to local impregnation by hematite/goethite and local replacement of ?sulphides/tellurides by goethite and a jarosite-like phase.

Handspecimen: The drill core sample is composed mostly of a brick red, hematite-pigmented, fine to medium grained feldspar-carbonate rock, with a few pale pink to white carbonate patches up to 1.5 cm across, and sparse yellow-brown, semi-translucent radioactive grains up to 3 mm across (e.g. brannerite). The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units and is moderately radioactive with a radiometric measurement of 270 cps.

Petrographic description

a) Primary rock characteristics: In the section, the rock is texturally heterogeneous, with a considerable amount of fine to medium grained, inequigranular material, and irregular patches of significantly coarser material. The former is dominated by albite, whereas the latter has abundant carbonate and lesser albite. In a few places, there are individual and patches of pseudomorphs up to several millimetres across that are interpreted to be after a former amphibole or pyroxene phase. The dominant mineral assemblage of the rock is composed of albite and carbonate, with minor muscovite, a little microcline and a few grains of rutile. This assemblage is non-diagnostic with respect to protolith type and the rock is considered to be the product of metasomatic alteration under metamorphic conditions.

b) Alteration and structure: It is interpreted that protolith material was completely replaced by/recrystallised to a generally fine to medium grained albite-rich assemblage, with minor intergrown carbonate (locally hematite-pigmented), muscovite, an original porphyroblastic ?amphibole/pyroxene phase (restricted occurrence) and a little rutile. In places, significantly coarsermetasomatic growth occurred with formation of coarse grained aggregates of carbonate (individual grains up to 5 mm) and subordinate albite (up to 2 mm), with local patchy microcline (grains to 3 mm), irregularly disseminated rutile (up to 2 mm), muscovite and a few grains of brannerite up to 3.5 mm long. The rock was subject to retrograde alteration that caused replacement of the possible amphibole/pyroxene phase by fine grained carbonate, sericite, chlorite and local hematite. Albite is also locally replaced by chlorite, carbonate and hematite. Large rutile masses associated with brannerite show possible replacement by brannerite (Fig. 5), implying that at least some brannerite was a retrograde phase. Retrograde alteration sites also contain traces of electrum (Fig. 6), a galena-like phase and a possible telluride phase. There was also slight supergene oxidation imposed on the sample, leading to local impregnation of some of the retrogressed parts of the rock by hematite and goethite, and replacement of ?sulphide/telluride phases by goethite and a possible jarosite-like phase.

c) Mineralisation: Sparse medium to coarse grained of brannerite up to 3.5 mm long occur in the sample, in places associated with rutile masses, with which there is a possible replacive relationship (Fig. 5). The sample contains rare irregular grains of an electrum-like phase up to 70 μm across (possibly rather silver-rich, judging by tarnishing) (Fig. 6), and rare grains of a galena-like phase and a possible telluride phase. Grains of the latter are up to 0.4 mm across

and enclose the galena-like phase. Slight supergene oxidation effects have led to local replacement (or encrustation) by phases that include goethite and a jarosite-like mineral.

Mineral Mode (by volume): albite 65%, carbonate 23%, sericite+ muscovite 5%, microcline 2%, chlorite, rutile, brannerite and hematite each 1% and traces of a galena-like phase, a possible telluride phase, electrum and goethite + jarosite-like phase.

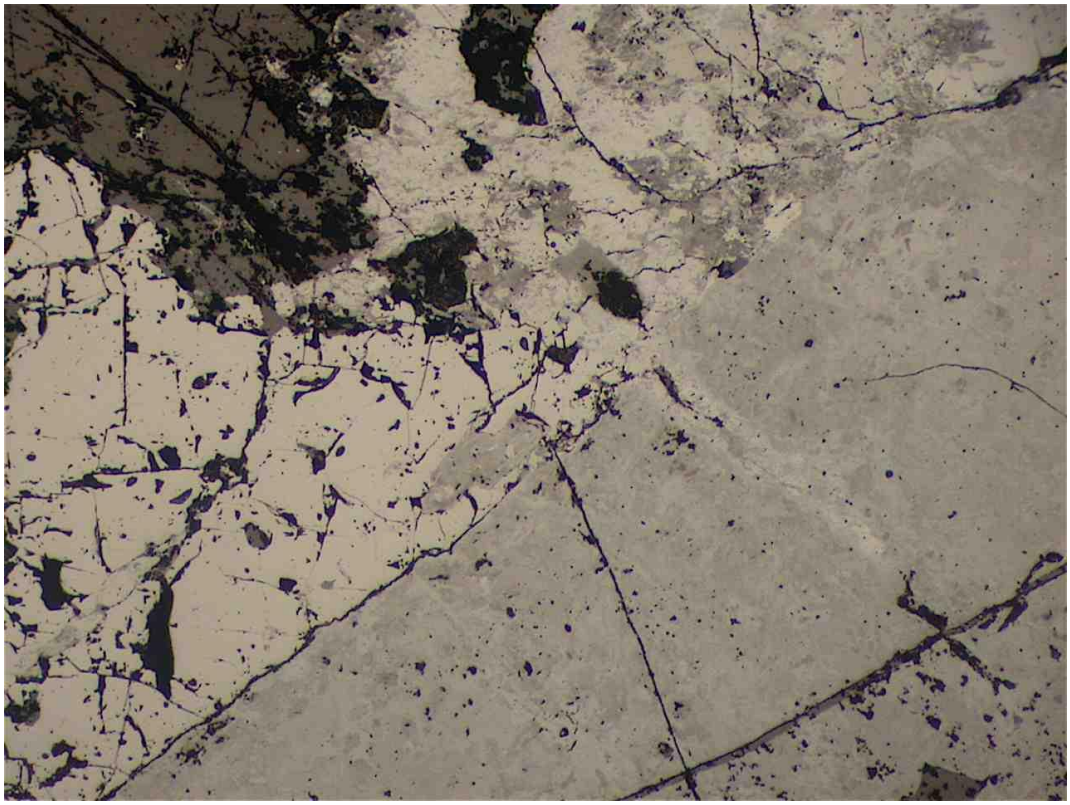

Fig. 5: Aggregate of rutile (pale grey) abutting brannerite (slightly darker grey), with possible local replacement of the former by the latter. Plane polarised reflected light, field of view 2 mm across.

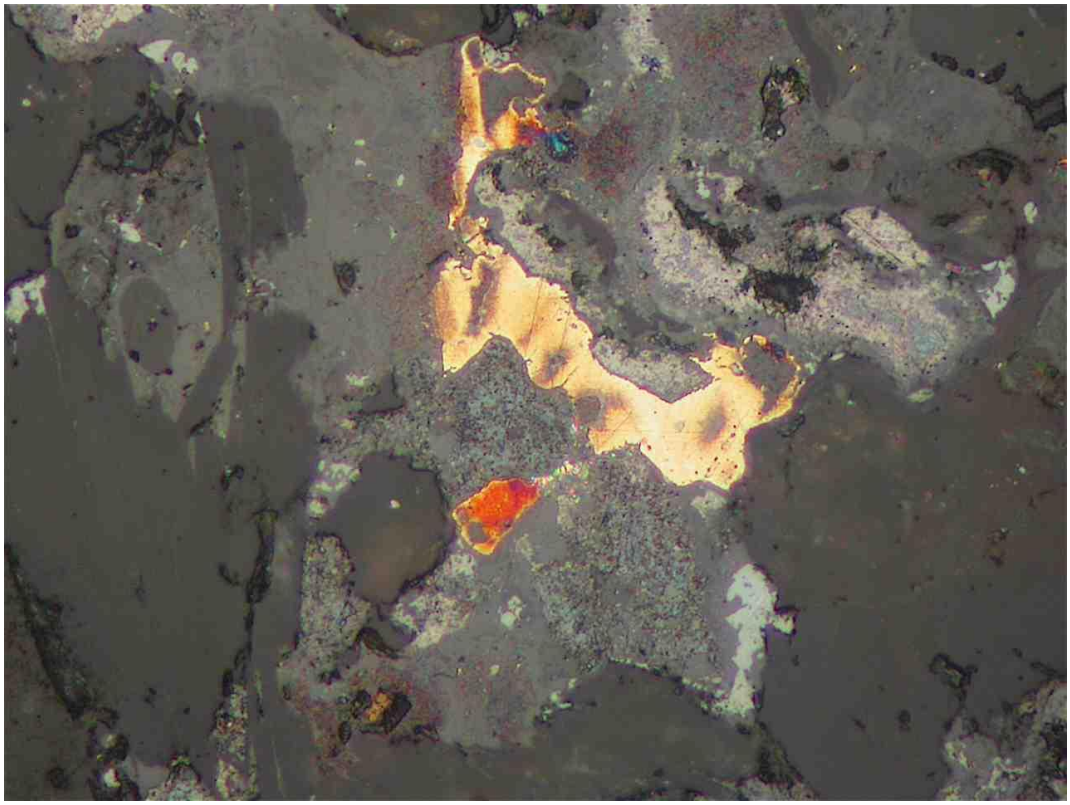

Fig. 6: Grains of slightly tarnished electrum (creamy to orange) associated with supergene oxidation products (mid grey to pale grey) after former sulphides. Plane polarised reflected light, field of view 0.25 mm across.

Interpretation and comment: It is interpreted that the sample is a Au- and U-mineralised albite-carbonate rock. The nature of the protolith of the sample is obscure due to recrystallisation and probable replacement. The interpreted metasomatic assemblage is commonly albite-rich, with minor intergrown carbonate, muscovite and a little rutile, and showing coarser patches of carbonate and minor albite, microcline, rutile, brannerite and muscovite. In places, there are pseudomorphs after possible former amphibole/pyroxene grains. Retrograde alteration occurred with replacement of all former ?amphibole/pyroxene by carbonate, sericite, chlorite and hematite, and some albite was also altered to chlorite, carbonate and hematite. It is possible that brannerite masses locally replaced rutile. Associated with retrograde products are traces of electrum, a galena-like phase, and a possible telluride phase. Slight supergene oxidation effects were imposed, leading to local impregnation by hematite/goethite and local replacement of ?sulphides/tellurides by goethite and a jarosite-like phase.

DODH247A 6.68-6.71 m PTS

Summary: The sample represents a type of hydrothermal breccia, displaying a generally clast-supported texture. Lithic clasts are sub-rounded to angular and are mostly fine grained and recrystallised, but with local gradations to medium grained. Generally, due to recrystallisation of clasts, relict texture is not preserved, but rarely, there are relict fine sedimentary bedding laminations. This fact, together with the observation that the majority of clasts are albite rich, locally with abundant quartz, carbonate and biotite, is interpreted to indicate that the majority of clasts could represent a former feldspathic siltstone. The original sedimentary protolith material was recrystallised under metamorphic and/or metasomatic conditions and was hydrothermally brecciated, with development of a medium grained matrix component that is commonly biotite-rich, but with locally abundant carbonate and quartz. Minor disseminated hematite is disseminated throughout. The rock was subject to slight supergene alteration, with partial replacement of biotite by nontronitic clay.

Handspecimen: The drill core sample is composed of a coarse grained clastic rock, maybe representing a type of breccia, and containing abundant angular to sub-rounded, commonly fine grained clasts up to 1.5 cm across. The clasts range from pink to mauve-brown to brown and grey, and occur in a brown-khaki matrix. The latter appears to contain carbonate and a mica/clay (e.g. nontronite) phase. Clasts commonly have a granular texture and their mineralogy might include carbonate, feldspar and quartz, with minor hematite pigmentation. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, and it has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the sample is a type of breccia, with a generally clast-supported texture. There are abundant angular to sub-rounded recrystallised lithic clasts up to 7 mm across and isolated individual mineral grains (carbonate, quartz, albite), enclosed in an interpreted hydrothermal matrix. Lithic clasts are dominantly fine grained, with a granular recrystallised texture, but there is a gradation into slightly coarser grained types, e.g. recrystallised grainsize ranges from <0.05 mm to 0.5-1 mm. Compositions of clasts varies, but they are dominated by albite, with minor to abundant amounts of quartz, carbonate and biotite, plus a little hematite. Mostly, there are no recognisable relict textures in the clasts, but rare thin compositional laminations that are interpreted to reflect bedding, have been observed. The recrystallised texture and bulk compositions of the clasts are suggested to indicate that much of the clast population was composed originally of a fine grained feldspathic psammopelite (siltstone), but with gradations to more carbonate-, quartz- and pelitic compositions.

b) Alteration and structure: It is speculated that an original sedimentary dominated sequence underwent hydrothermal brecciation, with development of a generally clast-supported texture and with angular to sub-rounded clasts up to 7 mm across. The breccia texture is not definitive as to whether recrystallisation of clasts occurred before, during or after breccia development. Clasts have fine grained to locally medium grained recrystallised assemblages that are commonly albite-rich, but also include locally abundant quartz, carbonate and biotite, plus a little hematite. Enclosing the breccia clasts is a matrix that is common dominated by fine to medium grained biotite, but with locally abundant medium grained carbonate, minor quartz and a little hematite. A single extensional texture carbonate vein up to 0.3 mm wide cuts the breccia. Supergene oxidation effects were imposed on the sample, with variable degradation of biotite to orange-brown nontronitic clay.

c) Mineralisation: No sulphides or U minerals were observed. The rock contains minor disseminated grains of fine to medium grained (specular) hematite up to 0.7 mm across. Most hematite occur in the breccia matrix, but a minor amount occurs in the clasts.

Mineral Mode (by volume): carbonate (calcite) 40%, biotite/nontronite 23%, albite 20%, quartz 15% and hematite 2%.

Interpretation and comment: It is interpreted that the sample represents a hydrothermal breccia, with a generally clast-supported texture. Lithic clasts are sub-rounded to angular and are fine to medium grained and recrystallised. Generally, relict texture is not preserved, but rarely, there are relict fine sedimentary bedding laminations. This fact, together with the observation that the majority of clasts are albite rich, locally with abundant quartz, carbonate and biotite, is interpreted to indicate that the majority of clasts could represent a former feldspathic siltstone. It is interpreted that the sedimentary protolith was recrystallised under metamorphic and/or metasomatic conditions and was hydrothermally brecciated, with development of a medium grained matrix component that is commonly biotite-rich, but with locally abundant carbonate and quartz. Minor disseminated hematite is disseminated throughout. The rock was subject to slight supergene alteration, with partial replacement of biotite by nontronitic clay.

DODH247B 7.74-7.82 m PTS

Summary: Carbonate-albite rock, with irregular and veinlike masses of fine grained turbid carbonate, plus associated impregnations and scattered aggregates of supergene goethite (± hematite). No recognised relict texture occurs and much of the rock is characterised by fine to medium grained, blocky albite, enclosed in medium grained (locally coarser) carbonate (calcite), with a little associated rutile. The fine grained carbonate masses and Fe oxide aggregates and impregnations are interpreted to be of supergene derivation (e.g. the carbonate could be pedogenic). In albite and medium grained carbonate, there are rare tiny grains of a galena-like phase as well as copper. The latter could also have a supergene origin.

Handspecimen: The drill core sample is composed of a pink to pink-brown, fine to medium grained, granular feldspar-carbonate-rich, containing a pale creamy to pale grey veinlike fine grained carbonate mass up to 2 cm wide, locally incorporating fragments of the host rock. In places, the veinlike mass and its margins are impregnated by orange-brown supergene goethite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, and it has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction on the host rock and veinlike masses, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, most of the sample is composed of a fine to medium grained (to locally coarser grained) rock dominated by carbonate and albite. Texturally, it is interpreted that this represents a totally recrystallised assemblage and there is no recognised relict texture from a protolith. The bulk mineralogical constitution of the rock could suggest a prior sedimentary protolith, e.g. feldspathic marl or evaporite.

b) Alteration and structure: The nature of the protolith remains obscure, but it is speculated that it was recrystallised by metamorphism and/or metasomatic processes to form abundant to scattered, fine to medium grained blocky albite grains (up to 2 mm across), locally tending to semi-massive aggregates, and enclosed in generally medium grained carbonate (locally this is coarser and up to 3 mm grainsize). The rock also displays sparse, irregularly distributed grains of rutile up to 0.3 mm across. Subsequently, it appears as though the rock was pervaded by sub-planar to irregular veinlike masses up to several millimetres wide of fine grained, turbid carbonate that also ramify into the adjacent host. In places, these fine grained carbonate masses and the adjacent host rock were variably impregnated by significant goethite staining and by development of a few fine grained goethite ± hematite aggregates up to a few millimetres across. The Fe oxide phases are considered to represent a supergene oxidation product and it is speculated that the fine grained turbid carbonate masses could also be the result of supergene, pedogenic carbonate deposition.

c) Mineralisation: Two tiny silvery grains of a galena-like phase up to 20 µm across are observed in albite and carbonate. Two grains of copper (20 and 40 µm) are also observed, one in coarser grained carbonate interstitial to albite, and the other in fine grained carbonate. It is speculated that copper could be a supergene product. Minor fine grained goethite (± hematite) is interpreted to be a supergene product.

Mineral Mode (by volume): carbonate (calcite) 65%, albite 32%, goethite (± hematite) 3% and traces of rutile, copper and a galena-like phase.

Interpretation and comment: It is interpreted that the sample is a generally medium grained carbonate-albite rock, with irregular and veinlike masses of fine grained turbid carbonate, plus associated impregnations and scattered aggregates of supergene goethite (± hematite). No recognised relict texture occurs and it is interpreted that much of the sample represents a totally recrystallised assemblage of blocky albite, enclosed in medium grained (locally coarser) carbonate (calcite), with a little associated rutile. The fine grained carbonate masses and Fe oxide aggregates and impregnations are interpreted to be of supergene derivation

(e.g. the carbonate could be pedogenic). In albite and medium grained carbonate, there are rare tiny grains of a galena-like phase as well as copper. The latter could also have a supergene origin.

DODH247C 12.51-12.54 m PTS

Summary: Retrogressed and partly weathered medium to coarse grained amphibole-albite carbonate rock, containing a few grains of altered brannerite. Original coarse amphibole (now replaced by illite-sericite and carbonate) was intergrown with albite, carbonate, minor K-feldspar, quartz, a few grains of muscovite and rutile. Minor retrogression has also affected feldspars. Interpreted brannerite has been replaced by possible low-U metamict products. Minor sulphides could have originally occurred, but were affected by supergene oxidation and replaced by goethite aggregates. Patchy supergene goethite/hematite also occurs elsewhere, e.g. at altered amphibole sites.

Handspecimen: The drill core sample is composed of a speckled pale brown-pink, dark red-brown and grey coloured, medium to coarse grained rock containing abundant feldspar, carbonate, altered ferromagnesian material (e.g. former blocky to prismatic amphibole). There are a few resinous, yellowish grains of possible altered brannerite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, and it has a background radiometric measurement of 70 cps.

Petrographic description

a) Primary rock characteristics: In the section, the rock shows imprints of retrograde alteration and weathering superimposed on an original medium to coarse grained, thoroughly recrystallised aggregates that texturally appears to be the product of metamorphism and/or metasomatic replacement. No definite protolith characteristics are recognised.

b) Alteration and structure: Prior to retrograde alteration, the rock had a dominant mineral assemblage of medium to coarse grained blocky to elongate prismatic amphibole (individual grains up to 5 mm long), blocky albite (up to 2 mm across), subordinate interstitial medium grained carbonate (up to 2.5 mm across), with local K-feldspar, minor quartz, plus a few grains of muscovite up to 0.6 mm across and uncommon rutile grains up to 0.1 mm across. Sparsely distributed are equant to elongate pseudomorphs up to 3 mm across that are interpreted to represent altered brannerite (Fig. 7). There are also a few pseudomorphs after former possible sulphide grains and aggregates. Retrograde alteration is manifest in the total replacement of all former amphibole by fine grained illite-sericite, patchy carbonate and local fine dusty hematite. Feldspar are locally replaced by carbonate and a little illite-sericite. It is interpreted that original brannerite was replaced by isotropic, metamict, low-U material that could include leucoxene and is stained by supergene goethite (Fig. 7). Interpreted former sulphides formed sparse medium grained aggregates up to a few millimetres across and were later replaced by supergene goethite pseudomorphs. Relict shapes of these suggest that pyrite was probably present. Supergene effects are also indicated throughout by goethite impregnations, especially at altered amphibole sites.

c) Mineralisation: There are sparsely scattered grains of interpreted altered brannerite up to 3 mm across. The original mineral appears to have been replaced by near-isotropic metamict products that could include leucoxene. Many of the pseudomorphs are also impregnated by goethite (Fig. 7). The rock also has a few goethite pseudomorphic aggregates up to several millimetres across that are considered to have replaced former medium grained sulphides (e.g. pyrite).

Mineral Mode (by volume): albite 40%, carbonate 25%, illite-sericite + muscovite 23%, K-feldspar 7%, quartz 3%, altered brannerite and goethite/hematite each 1% and traces of rutile/leucoxene.

Interpretation and comment: It is interpreted that the sample represents a retrogressed and partly weathered amphibole-albite carbonate rock, containing a few grains of altered brannerite. Original coarse amphibole (now replaced by illite-sericite and carbonate) was intergrown with medium grained albite, carbonate, minor K-feldspar, quartz, a few grains of

muscovite and rutile. Minor retrogression has also affected feldspars. Interpreted brannerite has been replaced by possible low-U metamict products. Minor sulphides could have originally occurred, but were affected by supergene oxidation and replaced by goethite aggregates. Patchy supergene goethite/hematite also occurs elsewhere, e.g. at altered amphibole sites.

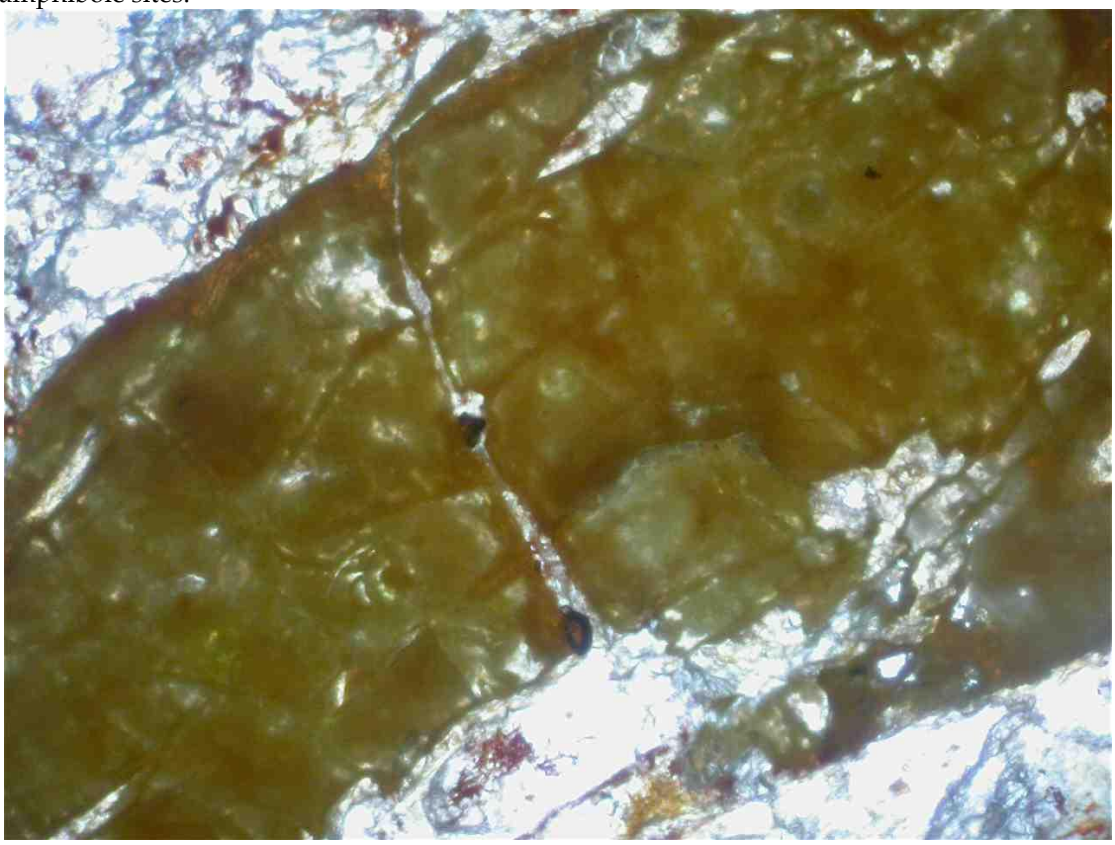

Fig. 7: Large pseudomorph after interpreted former brannerite grain, hosted in fractured albite, altered amphibole and carbonate (all whitish). It is interpreted that brannerite was replaced by metamict material, perhaps also including leucoxene and minor orange-brown goethite impregnation. Plane polarised transmitted light, field of view 2 mm across.

DODH247D 13.72-13.76 m PTS

Summary: Retrogressed and partly weathered medium to coarse grained amphibole-albite rock, with minor interstitial quartz, carbonate and K-feldspar and containing traces of fine grained rutile, biotite and muscovite, and a single grain of degraded (metamict) brannerite. The nature of the protolith is obscure and the rock is regarded as the product of metamorphism and/or metasomatic replacement under metamorphic conditions. Original amphibole was completely retrogressed and replaced by illite-sericite, carbonate and K-feldspar, with a little hematite. Weathering effects have led to formation of goethite-impregnated fine grained clay, mostly interstitial to original amphibole and albite, and possibly largely forming from originally more abundant biotite. In one part of the section, retrogressed amphibole hosts at least 10 small metallic grains up to 40 μm across that include copper and gold.

Handspecimen: The drill core sample is composed of a pale pink to pink-brown and dark grey-brown mottled rock, evidently with imposition of supergene effects. It contains abundant medium grained feldspar, fine grained sericitic alteration products and minor hematite pigmentation. There may have been a considerable amount of a prismatic ferromagnesian phase up to several millimetres long, but this material was altered to sericite, carbonate and hematite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, and it has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the original rock was medium to coarse grained and rich in a blocky to prismatic ferromagnesian phase (e.g. amphibole), along with albite and minor interstitial quartz and carbonate. This is interpreted as the product of metamorphism and/or metasomatic replacement, and no relict textural characteristics from a protolith are recognised. Subsequently, there were considerable retrogression and supergene alteration effects imposed.

b) Alteration and structure: It is interpreted that protolith material (whose nature is obscure) was metamorphosed and/or metasomatically replaced under metamorphic conditions by abundant blocky to prismatic amphibole (individual grains up to several millimetres across), along with considerable albite (grains up to 3 mm across) and minor interstitial quartz (up to 1.5 mm), K-feldspar, carbonate and traces of disseminated rutile (grains up to 0.2 mm), biotite and muscovite. Subsequently, all amphibole was retrogressively replaced by varying amounts of fine grained illite-sericite, fine to medium grained K-feldspar and carbonate, and a little fine grained hematite. A single grain of degraded brannerite about 3 mm across occurs, with replacement by near-isotropic material that could include leucoxene. Supergene effects are manifest by development of anastomosing masses of fine grained pale brown clay (maybe kaolinite, nontronite), weakly impregnated by goethite and associated with fine grained turbid carbonate. This association could have replaced formerly more abundant interstitial biotite as well as larger grains of amphibole and albite. Within one part of the section, altered amphibole sites host several tiny metallic grains that include gold and copper (Fig. 8). They are interpreted to most likely be of supergene origin.

c) Mineralisation: A single grain of brannerite about 3 mm across is observed, but it has been degraded to a very fine grained, near-isotropic mass that could include leucoxene. In one part of the section, altered amphibole sites host at least 10 metallic grains up to 40 μm across that include gold and copper, with one grain showing copper encrusted by gold (Fig. 8).

Mineral Mode (by volume): illite-sericite + muscovite 35%, albite 30%, carbonate, K-feldspar and clay phases each 10%, quartz and goethite + hematite each 2% and traces of biotite, altered brannerite, rutile/leucoxene and gold + copper.

Interpretation and comment: It is interpreted that the sample is a retrogressed and partly weathered medium to coarse grained amphibole-albite rock, also containing minor interstitial quartz, carbonate and K-feldspar, along with traces of fine grained rutile, biotite and muscovite, and a single grain of degraded (metamict) brannerite. The nature of the protolith is obscure and the rock is the product of metamorphism and/or metasomatic replacement under metamorphic conditions. Original amphibole was completely retrogressed and replaced by illite-sericite, carbonate and K-feldspar, with a little hematite. Weathering effects have led to formation of goethite-impregnated fine grained clay, mostly interstitial to original amphibole and albite, and possibly largely forming from originally more abundant biotite. In one part of the section, retrogressed amphibole hosts at least 10 small metallic grains up to 40 μm across that include copper and gold.

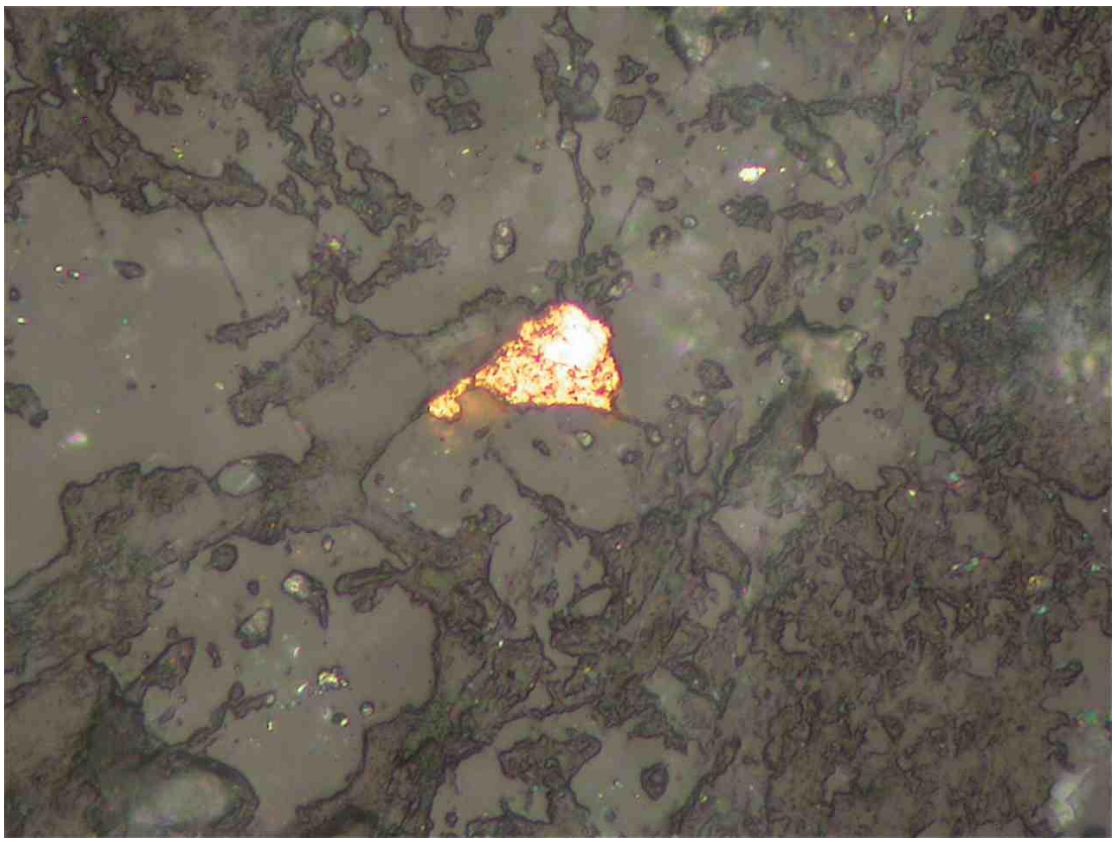

Fig. 8: Single composite grain of copper, enclosed in gold, and hosted in a site representing altered amphibole. Plane polarised reflected light, field of view 0.25 mm across.

DODH247E 14.68-14.72 m PTS

Summary: Medium to coarse grained carbonate (calcite)-albite-quartz rock with scattered aggregates and individual grains of brannerite, along with minor rutile. The nature of the protolith is obscure and the rock is considered to be the product of metasomatic replacement and complete recrystallisation. Inequigranular masses and individual grains of albite and quartz (the latter commonly strained) are variably enclosed and locally replaced by medium grained carbonate. Retrograde alteration was imposed leading to local replacement of the silicates by carbonate, albite by chlorite (mostly in the vicinity of brannerite) masses and emplacement of a few carbonate veins (with a little chlorite and hematite). Brannerite is probably metamict and locally enclosed by thin rims of fine grained acicular hematite. Tiny traces of pyrite and galena tend to be associated with brannerite.

Handspecimen: The drill core sample is composed of a pink-brown, medium to coarse grained carbonate-feldspar-quartz rock containing scattered dark brown aggregates up to several millimetres across of a radioactive mineral (e.g. brannerite). The rock is probably pigmented by fine dusty hematite and is cut by a couple of sub-planar whitish carbonate veins up to 1.5 mm wide at a high angle to the core axis. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units, and it is strongly radioactive, with a radiometric measurement of 1100 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, no relict texture or minerals from a protolith are recognised and the sample is regarded as the product of metasomatic replacement and recrystalliation of protolith material. It is dominated by medium to coarse grained albite and quartz, with varying amounts of interstitial carbonate and scattered aggregates and individual grains of brannerite. The nature of the protolith remains obscure, but it could be speculated to have been of quartzofeldspathic-carbonate sedimentary type, possibly evaporitic in character.

b) Alteration and structure: It is interpreted that protolith material was totally recrystallised, probably under metamorphic conditions, and replaced by irregularly distributed medium to coarse grained masses of albite and quartz, commonly intergrown with minor to abundant interstitial carbonate. Individual quartz grains are up to 5 mm across and are commonly strained, and blocky albite is up to 2 mm across. In carbonate, there is a trace of muscovite. The rock contains scattered grains of dark brown brannerite up to 3 mm across, in places coalesced into aggregates up to 5 mm across. Retrograde alteration is interpreted to have been imposed, leading to local replacement of albite and quartz by carbonate, local veining up to 1 mm wide by carbonate (with a little chlorite, hematite), minor replacement of albite by chlorite (mostly adjacent to brannerite aggregates), metamictisation of brannerite and its rather common rimming by fine grained acicular hematite (Fig. 9). Adjacent to brannerite, it is common to observed radiation damage cracking, and there are traces of fine grained galena in brannerite (radiogenic product) and rare small aggregates of fine grained pyrite adjacent. The rock is also cut by a couple of interpreted thin late veins, one with carbonate and chlorite, and another with fine grained pyrite. The rock has also been subject to slight supergene oxidation, leading to goethite impregnation in places, mainly around brannerite and adjacent chlorite.

c) Mineralisation: The sample contains scattered grains and aggregates of brannerite, with individual grains up to 3 mm across and commonly fringed by fine grained acicular hematite (Fig. 9). Rare tiny grains of galena in brannerite would be a radiogenic breakdown product. There is a trace of fine grained pyrite adjacent to brannerite and this type of pyrite also forms a thin vein.

Mineral Mode (by volume): carbonate (calcite) 50%, albite 22%, quartz 20%, brannerite 5%, rutile, chlorite and hematite + goethite each 1% and traces of muscovite, pyrite and galena.

Interpretation and comment: It is interpreted that the sample represents a carbonate (calcite)-albite-quartz rock with scattered aggregates and individual grains of brannerite, along with minor rutile. The nature of the protolith is obscure and the rock is considered to be the product of metasomatic replacement and complete recrystallisation. Inequigranular, medium to coarse grained masses and individual grains of albite and quartz (the latter commonly strained) are variably enclosed and locally replaced by medium grained carbonate. Retrograde alteration caused local replacement of the silicates by carbonate, albite by chlorite (mostly in the vicinity of brannerite) masses and emplacement of a few carbonate veins (with a little chlorite and hematite). Brannerite is probably metamict and locally enclosed by thin rims of fine grained acicular hematite. Tiny traces of pyrite and galena tend to be associated with brannerite.

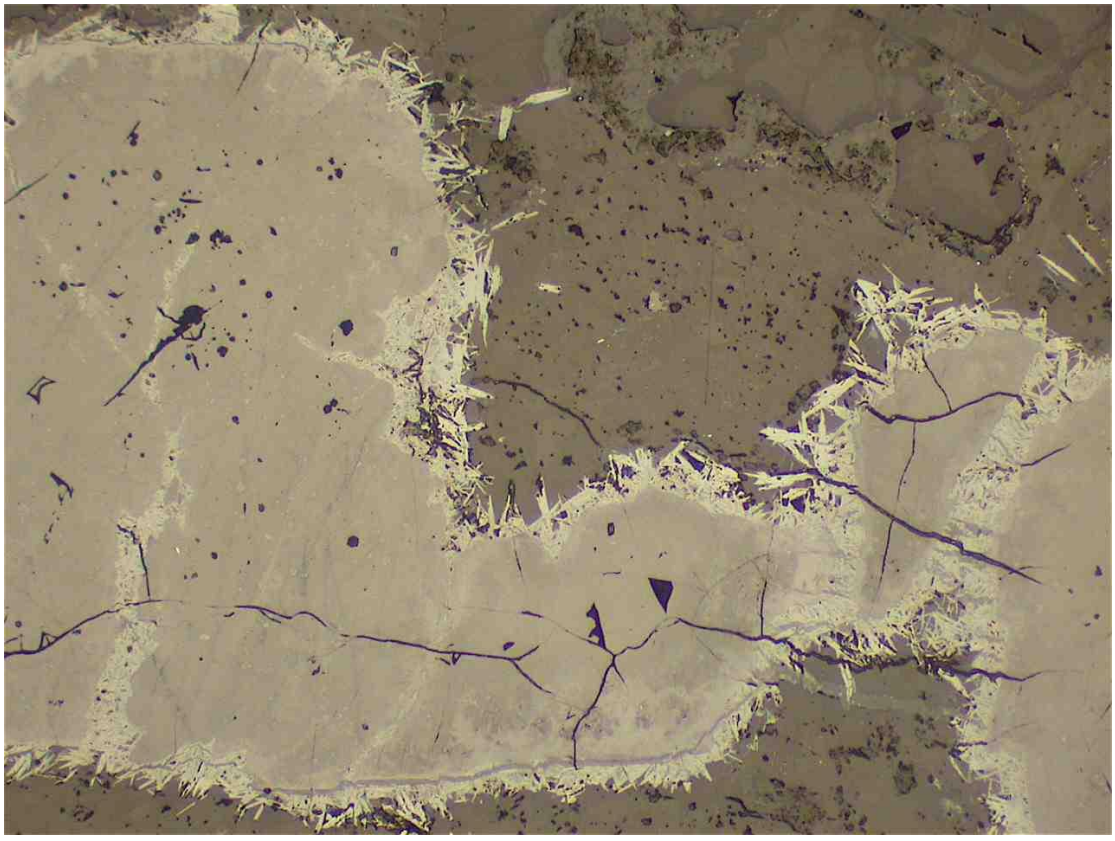

Fig. 9: Aggregate of brannerite grains, rimmed by fine grained acicular hematite (paler grey needles) and hosted within albite + carbonate (darker grey). Plane polarised reflected light, field of view 1 mm across.

DODH248A 3.93-3.95 m PTS

Summary: Texturally heterogeneous albite-carbonate-quartz rock that originally contained patches with a ferromagnesian mineral, e.g. amphibole. The sample contains abundant domains of fine to medium grained, inequigranular albite, with subordinate quartz and carbonate, interspersed with coarser grained carbonate that locally contains pseudomorphs after locally abundant amphibole, along with minor albite and K-feldspar. A little rutile is scattered throughout the rock, for which no definite protolith characteristics are recognised. The rock is interpreted to represent the product of complete recrystallisation and replacement. Retrograde alteration was imposed, causing all amphibole to be replaced, mostly by chlorite. Subsequently imposed supergene alteration caused some degradation of chlorite to nontronite and goethite.

Handspecimen: The drill core sample is composed mostly of a pale pink to pale brown, medium grained feldspar-carbonate rock, containing a few irregular dark grey aggregates that appear to represent an altered ferromagnesian phase (blocky grains up to a few millimetres across and possibly originally an amphibole). These aggregates are now composed of dark chlorite. It is likely that the rock is lightly pigmented by dusty hematite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the rock is considerably heterogeneous with respect to texture and it exhibits differences in mineralogical/compositional domains. However, no definite relict texture or mineralogy from a protolith is recognised and the rock is interpreted as the product of complete recrystallisation and replacement of protolith material to form an assemblage dominated by albite, carbonate and quartz, and with patchy ferromagnesian material originally (probably amphibole, but now totally retrogressed).

b) Alteration and structure: Protolith material was replaced and recrystallised, probably under metamorphic conditions, and formed a texturally heterogeneous rock. There are scattered domains up to 1-2 cm across of fine to medium grained, inequigranular albite + quartz + carbonate, with a little rutile, and these are interspersed with patches (locally veinlike) that are richer in carbonate (locally up to 3 mm grainsize) that contains scattered coarser albite (up to 2 mm), and in places, abundant pseudomorphs after a former blocky to prismatic ferromagnesian phase (e.g. amphibole) up to 4 mm long, plus minor patchy K-feldspar and a little rutile. Retrograde alteration was imposed, causing complete replacement of interpreted amphibole by chlorite and a little K-feldspar and trace muscovite/sericite. Traces of ultrafine hematite commonly dust carbonate and feldspars and could also represent a retrograde phase. Slight supergene alteration effects were later imposed, leading to variable degradation of chlorite to khaki-coloured nontronite, with local orange-brown goethite staining.

c) Mineralisation: No discrete U mineral and sulphide mineral has been observed. Sparse rutile occurs throughout in the more albitic domains, mostly as grains <0.1 mm across, but there is a single aggregate about 1.5 mm across.

Mineral Mode (by volume): albite 40%, carbonate (calcite) 30%, quartz 15%, chlorite + nontronite 8%, K-feldspar 6%, rutile 1% and traces of muscovite/sericite and hematite + goethite.

Interpretation and comment: It is interpreted that the sample is an albite-carbonate-quartz rock that originally contained patches with a ferromagnesian mineral, e.g. amphibole. No definite protolith characteristics are recognised and the rock is viewed as representing the product of complete recrystallisation and replacement. It is texturally heterogeneous, displaying domains of fine to medium grained, inequigranular albite, with subordinate

quartz and carbonate, interspersed with coarser grained carbonate that locally contains pseudomorphs after locally abundant amphibole, together with minor albite and K-feldspar. A little rutile is scattered throughout. Retrograde alteration was imposed, causing all amphibole to be replaced, mostly by chlorite. Subsequently imposed supergene alteration caused some degradation of chlorite to nontronite and goethite.

DODH248B 9.22-9.25 m PTS

Summary: Originally a medium to coarse grained rock containing an abundant blocky to prismatic ferromagnesian phase (e.g. amphibole), intergrown with subordinate carbonate and albite. This rock preserves no recognisable relict characteristics from a protolith and is probably the product of metamorphism and/or metasomatic replacement, resulting into complete recrystallisation of protolith material. The original mineral assemblage also contained a little muscovite, fine grained rutile and a couple of grains of brannerite. Strong retrogression occurred, with complete replacement of amphibole by illite-sericite, carbonate, chlorite and a little hematite. Alteration-derived carbonate is also dusted by hematite. Brannerite was metamictised and replaced by fine grained leucoxene.

Handspecimen: The drill core sample is composed of a mottled dark red-brown to pinkish and khaki coloured, altered, carbonate-feldspar rock with alteration patches after a former coarse grained, blocky ferromagnesian phase. The latter are now composed of sericite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a near-background radiometric measurement of 75 cps.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that an original medium to coarse grained assemblage was strong retrogressed. There are abundant pseudomorphs after a former blocky to prismatic ferromagnesian phase (interpreted to have been amphibole) up to several millimetres long, which were intergrown with subordinate medium grained carbonate and albite. This mineral assemblage is interpreted as being the product of metamorphism and/or metasomatic replacement and no relict characteristics from a protolith are recognised.

b) Alteration and structure: It is interpreted that protolith material whose original nature is obscure, was metamorphosed and/or metasomatically replaced to form a medium to coarse grained assemblage of dominant blocky to prismatic amphibole (up to several millimetres) with subordinate interstitial carbonate (grains up to 3 mm), blocky albite (grains up to 2 mm), a few grains and aggregates of muscovite up to 1 mm across, and sparse grains of rutile up to 0.1 mm across and a trace of biotite. A few aggregates of brannerite, up to 1 mm across, also formed part of this assemblage. The rock was subject to strong retrograde alteration, leading to replacement of all amphibole by fine grained aggregates of illite-sericite, carbonate and subordinate chlorite, with trace hematite. There is a fine dusting of hematite within alteration-derived carbonate. Brannerite was altered to a low-U, metamict product that probably includes leucoxene and traces of fringing hematite.

c) Mineralisation: The rock originally contained a few aggregates of brannerite up to 1 mm across, with individual grains up to 0.7 mm across. The mineral was metamictised and replaced by very fine grained leucoxene and fringed by trace hematite.

Mineral Mode (by volume): illite-sericite + muscovite 50%, carbonate 40%, albite 7%, chlorite 3% and traces of rutile + leucoxene, hematite and biotite.

Interpretation and comment: It is interpreted that the sample represents a former medium to coarse grained amphibole-carbonate-albite rock that has no preservation of relict characteristics from a protolith. It is interpreted as the product of metamorphism and/or metasomatic replacement, resulting into complete recrystallisation of protolith material. The original mineral assemblage also contained a little muscovite, fine grained rutile and a few grains of brannerite. Strong retrogression occurred, with complete replacement of amphibole by illite-sericite, carbonate, chlorite and a little hematite. Alteration-derived carbonate is also dusted by hematite. Brannerite was metamictised and replaced by fine grained leucoxene.

DODH248C 10.93-10.96 m PTS

Summary: The sample was originally a medium to coarse grained aggregate of blocky to prismatic ferromagnesian mineral (e.g. amphibole) that was intergrown with interstitial K-feldspar and carbonate, plus minor albite. A few grains of brannerite, muscovite, fine grained rutile and biotite also formed part of the assemblage that is considered to have formed by complete replacement of undefined protolith material due to metamorphism and/or metasomatic replacement. Strong retrograde alteration ensued, causing complete replacement of amphibole, initially by considerable K-feldspar, but subsequently by carbonate and sericite, with a little chlorite. K-feldspar was also partly retrogressed to sericite and carbonate. Brannerite was degraded to fine grained metamict products. At least 30 grains of metallic phases up to 120 μm across, and ranging from copper to gold are observed, mainly associated with retrograde products and with supergene clay and goethite.

Handspecimen: The drill core sample is composed of a mottled khaki to pale pinkish and locally red-brown altered rock containing considerable sericite and carbonate, but with the pinkish zones containing feldspar. Sparse translucent olive grains of a radioactive mineral (e.g. brannerite) up to 3 mm across are observed, and there are several grains of metallic gold and/or copper up to 0.2 mm across, dispersed in fractures containing possible supergene clay. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It is moderately radioactive, with a radiometric measurement of 200 cps.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that an original medium to coarse grained rock has been strongly retrogressed. There are abundant pseudomorphs after an original abundant blocky to prismatic ferromagnesian phase (e.g. amphibole) that was intergrown with interstitial K-feldspar, subordinate carbonate and minor albite. This assemblage does not possess any relict characteristics from a protolith and is considered to be the product of metamorphism and/or metasomatic replacement, resulting in a completely recrystallised assemblage.

b) Alteration and structure: Protolith material, the nature of which remains obscure, was totally recrystallised to a medium to coarse grained assemblage that included abundant amphibole (up to 4 mm), interstitial K-feldspar, subordinate carbonate (individual grains up to 3 mm across) and minor blocky albite (up to 2 mm). Several grains of brannerite (now altered) up to 2 mm across occur (Fig. 10), along with a few aggregates of muscovite up to 1 mm across, sparse grained of rutile up to 0.1 mm across and a trace of biotite, all forming part of the recrystallised assemblage. Subsequently, the rock was strongly retrogressed and all amphibole was replaced, initially by K-feldspar, and later by carbonate, sericite and a little chlorite. K-feldspar is also partly altered to sericite and carbonate. Brannerite has been rendered metamict and alteration products could include leucoxene. There are at least 30 grains up to 120 μm across of metallic phases ranging from gold to copper (Fig. 11), found in retrograde products and in association with thin anastomosing veins that might have originally been composed of chlorite, but which were replaced by nontronitic clay and goethite. These materials and the metallic phases could be of supergene derivation, as are a couple of thin goethite veins.

c) Mineralisation: The sample contains sparsely distributed grains of metamict brannerite up to 2 mm across (Fig. 11). There are at least 30 metallic grains up to 120 μm across that range from copper (pink) to gold (Fig. 11) that may include intermetallic phases, e.g. auricupride.

Mineral Mode (by volume): K-feldspar 45%, carbonate 25%, sericite + muscovite 22%, albite and chlorite/nontronite each 3%, degraded brannerite 1% and traces of rutile/leucoxene, gold-copper, goethite and biotite.

Interpretation and comment: It is interpreted that the sample is a retrogressed and supergene altered assemblage that originally contained medium to coarse grained amphibole,

intergrown with interstitial K-feldspar and carbonate, plus minor albite. A few grains of brannerite, muscovite, fine grained rutile and biotite also formed part of the assemblage that is considered to have formed by complete replacement of undefined protolith material due to metamorphism and/or metasomatic replacement. Strong retrograde alteration ensued, causing complete replacement of amphibole, initially by considerable K-feldspar, but subsequently by carbonate and sericite, with a little chlorite. K-feldspar was also partly retrogressed to sericite and carbonate. Brannerite was degraded to fine grained metamict products. At least 30 grains of metallic phases up to 120 μm across, and ranging from copper to gold are observed, mainly associated with retrograde products and with supergene clay and goethite.

Fig. 10: Large brannerite grain, showing internal heterogeneity due to metamictisation. Plane polarised reflected light, field of view 1 mm across.

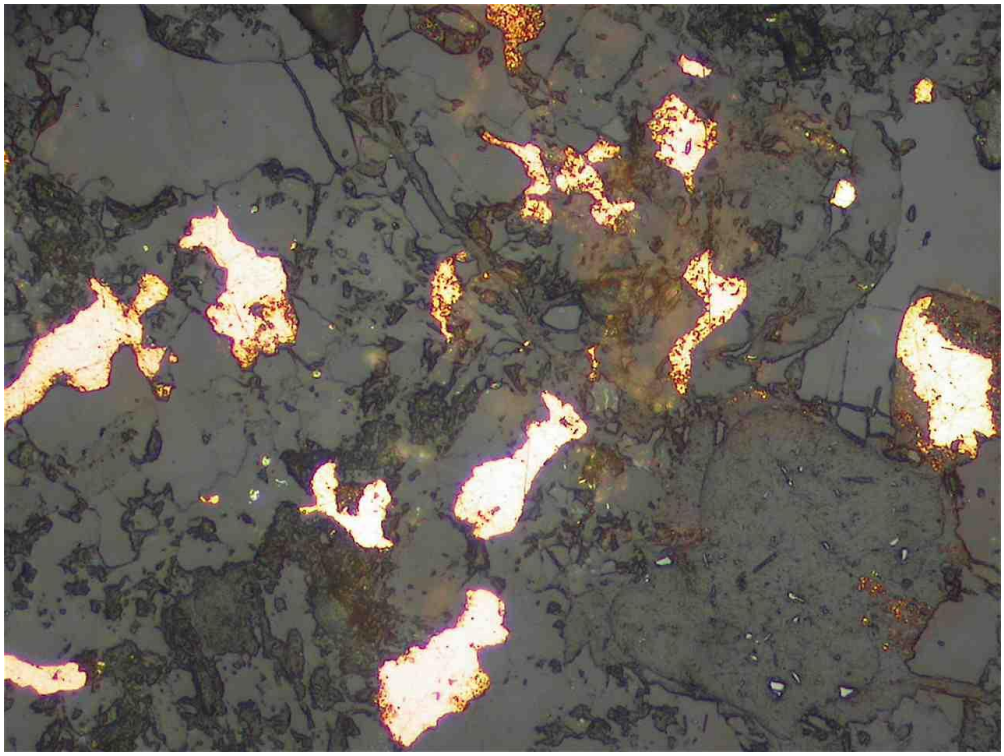

Fig. 11: Cluster of metallic grains that range from copper to gold, associated with retrograde products (breakdown of amphibole, K-feldspar) and supergene clay in fractures. Plane polarised reflected light, field of view 0.5 mm across.

DODH248D 18.90-18.92 m PTS

Summary: The sample is mostly composed of a medium to coarse grained albite-carbonate rock, with blocky albite grains generally enclosed in a medium to coarse grained carbonate matrix. In places, albite forms larger semi-massive aggregates, including occurring as fine grained recrystallised masses that are speculated to represent former protolith material (e.g. possibly albitic metasiltstone). Within the albite-carbonate assemblage, there are a few individual grains and aggregates of rutile. In places, there is minor fine grained chlorite interstitial to albite and enclosed in carbonate. This is probably a retrograde phase and it is locally associated with dark brown to opaque impregnation by a coffinite-like phase. Within one of the coffinite masses is a single grain of brannerite.

Handspecimen: The drill core sample is composed of a medium to coarse grained brick red to black, carbonate-feldspar rock that also contains a few dark brown rutile grains up to 2 mm across. The black zones are radioactive and probably represent dispersed U minerals. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It is strongly radioactive, with a radiometric measurement of 1200 cps.

Petrographic description

a) Primary rock characteristics: In the section, much of the sample is a medium to coarse grained albite-carbonate rock, with blocky albite grains enclosed in carbonate, although in places, albite forms semi-massive aggregates up to 8 mm across. Mostly, there is no relict texture and the sample is regarded as the product of substantial recrystallisation. However, there scattered irregular to ovoid domains up to 4 mm across composed largely of finely granular albite (possibly being replaced by coarser albite) and these are speculated to represent fragments of finely recrystallised protolith, e.g. albitic metasiltstone.

b) Alteration and structure: It is interpreted that possible fine grained recrystallised albitic metasiltstone was brecciated and fragments engulfed in a medium to coarse grained recrystallised matrix of probable metasomatic (hydrothermal) derivation, composed dominantly of blocky albite (individual grains up to 4 mm across) enclosed in carbonate (the latter with individual grains up to 3 mm across), with a few grains of rutile up to 1 mm across (aggregates up to 2 mm across). Rare small grains of biotite are locally enclosed in albite. In places, there is considerable retrograde fine grained chlorite developed interstitial to albite and hosted in carbonate. Chlorite masses are up to 1 mm across and locally they are associated with strong dark brown to black impregnations, interpreted to be a fine grained coffinite-like phase. In one part of the section, where coffinite is common, there is a single grain of brannerite about 0.6 mm across, and surrounded by a trace of fine grained acicular hematite (Fig. 12).

c) Mineralisation: The sample contains a single grain of brannerite about 0.6 mm across, with a little fine grained acicular hematite immediately surrounding, and hosted in one of the more extensive masses of chlorite that has been impregnated by a fine grained, near-opaque coffinite-like phase (Fig. 12).

Mineral Mode (by volume): albite 50%, carbonate 44%, chlorite 4%, coffinite-like phase and rutile each 1% and traces of biotite, hematite and brannerite.

Interpretation and comment: It is interpreted that the sample represents an albite-carbonate rock, with blocky albite grains generally enclosed in a medium to coarse grained carbonate matrix. In places, albite forms larger semi-massive aggregates, including occurring as fine grained recrystallised masses that are speculated to represent former protolith material (e.g. possibly albitic metasiltstone). There are a few rutile grains in the albite-carbonate assemblage. In places, there is minor fine grained chlorite interstitial to albite and enclosed in carbonate. This is probably a retrograde phase and it is locally associated with dark brown to opaque impregnation by a coffinite-like phase. Within one of the coffinite masses is a single grain of brannerite.

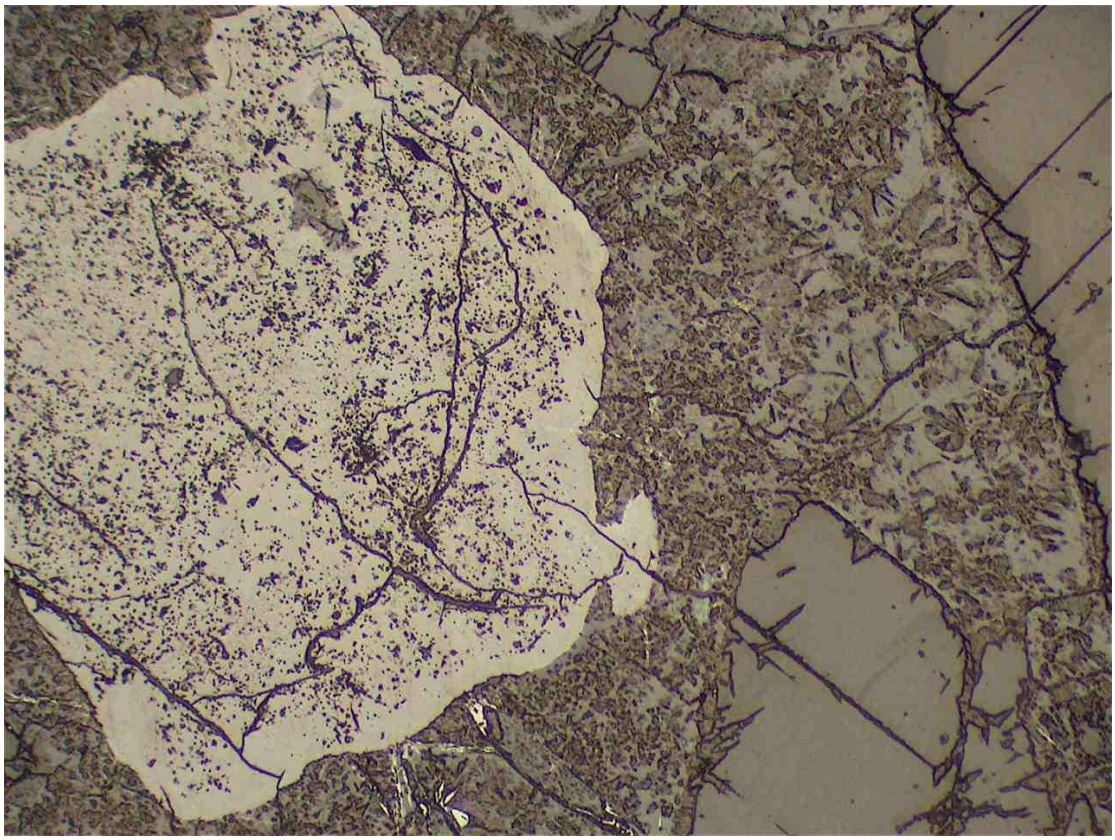

Fig. 12: Brannerite grain (pale grey, pitted), hosted in fine grained chlorite that is impregnated by mid-grey coffinite-like phase. The blocky grains to right are albite. Plane polarised reflected light, field of view 1 mm across.

DODH250A 19.60-19.63 m PTS

Summary: Fine grained recrystallised inequigranular albite-carbonate rock, with minor quartz and hematite, and trace rutile and tourmaline. Although there are no preserved relict textures, it is speculated from bulk compositional constraints that the rock could have been of fine grained feldspathic sedimentary type (e.g. siltstone), perhaps with an evaporitic (carbonate) component. The recrystallised rock was cut by a few initial veins that are irregular to anastomosing and contain medium grained quartz and carbonate. There was a later set of prominent veins emplaced that contain medium to coarse grained carbonate and fluorite, with a little quartz and trace hematite.

Handspecimen: The drill core sample is composed of a dark pinkish-brown, fine grained feldspathic rock, probably lightly pigmented by dispersed hematite and containing minor carbonate. It is cut by a few thin (<1 mm) dark grey quartz veins, and subsequently by prominent (up to 6 mm) sub-planar veins of white carbonate and subordinate dark purple fluorite. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the majority of the sample is composed of a finely granular, recrystallised texture, albite-rich rock, with subordinate carbonate and a little quartz and hematite. Where unveined, it is massive and there is no recognised relict texture. The bulk mineralogical composition suggests that the protolith could have been a fine grained feldspathic and carbonate-bearing clastic/chemical sedimentary rock, e.g. siltstone with an evaporitic component.

b) Alteration and structure: It is interpreted that protolith material was recrystallised to a fine grained (generally <0.1 mm) inequigranular aggregate rich in albite, with subordinate intergrown carbonate and a little quartz and disseminated hematite, plus trace tourmaline and rutile. The recrystallised assemblage could be due to metamorphism, but it is also possible that some components of the rock were introduced metasomatically, e.g. some Na and CO_2. The rock has been cut by several veins and it is apparent that two generations exist. The first veining was by irregular masses of medium grained quartz and carbonate up to 1 mm wide. This type is cut by a later, generally sub-planar vein set up to 5 mm wide containing medium to coarse grained carbonate and fluorite, with local quartz and a trace of fine grained hematite (mainly at vein margins).

c) Mineralisation: No discrete U mineral has been observed. The rock contains minor disseminated hematite (grains up to 0.2 mm) as part of the metamorphic/metasomatic mineral assemblage, and there is also a trace of hematite in the later veins.

Mineral Mode (by volume): albite 50%, carbonate 28%, quartz and fluorite each 10%, hematite 2% and traces of tourmaline and rutile.

Interpretation and comment: It is interpreted that the sample is an inequigranular, fine grained albite-carbonate rock, with minor quartz and hematite, and trace rutile and tourmaline. Although there are no preserved relict textures due to recrystallisation, it is speculated from the bulk composition that the rock could have been a feldspathic and carbonate-bearing clastic/chemical sedimentary type, e.g. siltstone with an evaporitic component. The recrystallised rock was cut by a few early veins that are irregular to anastomosing and contain medium grained quartz and carbonate. There was a later set of prominent veins emplaced that contain medium to coarse grained carbonate and fluorite, with a little quartz and trace hematite.

DODH251A 3.73-3.75 m PTS

Summary: Medium to coarse grained albite-biotite-carbonate (-quartz) rock, with a little disseminated rutile and hematite. This represents a recrystallised metamorphic and/or metasomatic replacement assemblage and the nature of the protolith remains obscure. In places, carbonate occurs in rather coarse veinlike aggregates, with local quartz associated. Rutile and/or hematite occur as fine discrete grains and as small aggregates, mostly hosted in quartz and albite. The rock shows imposition of supergene effects, with slight degradation of biotite to goethite-stained nontronite.

Handspecimen: The drill core sample is composed of a mottled brown-khaki, pink-brown and white, slightly weathered feldspar-biotite-carbonate rock. It is commonly medium grained, with biotite occurring as khaki-brown aggregates showing some supergene degradation (e.g. to clay, goethite). Carbonate forms a few white aggregates up to 5 mm across. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a background radiometric measurement of 70 cps.

Petrographic description

a) Primary rock characteristics: In the section, much of the sample has an inequigranular, interlocking, medium to coarse grained texture, interpreted to be due to complete recrystallisation and/or replacement of protolith material. The rock contains abundant albite, with subordinate biotite and carbonate, minor quartz and a little hematite and rutile. This assemblage is not considered to be diagnostic as to protolith type, and no relict textures from a protolith are recognised.

b) Alteration and structure: It is interpreted that protolith material, whose original nature is obscure, was recrystallised probably by metamorphism and accompanying metasomatic processes, to form an inequigranular, interlocking mass of elongate to blocky albite (largest grains up to 3 mm long), intergrown with subordinate biotite (individual grains up to 1.5 mm across and aggregates up to 4 mm), patchily distributed carbonate (some as veinlike masses, with individual grains up to 3 mm across), minor quartz, and a little disseminated hematite and rutile. Quartz locally occurs in the carbonate-rich masses and also, along with albite, hosts scattered fine grained aggregates of rutile and/or hematite. The recrystallised assemblage contains a trace of green tourmaline and fine dusty hematite occurs as a slight pigmentation of albite and carbonate. Mild supergene alteration effects were superimposed on the rock, with local degradation of biotite to nontronite and goethite impregnation.

c) Mineralisation: No discrete U mineral has been observed. The rock contains minor disseminated hematite and rutile, in places as composite aggregates up to 0.6 mm across, as part of the recrystallised assemblage.

Mineral Mode (by volume): albite 50%, biotite (+ nontronite and goethite) 25%, carbonate 15%, quartz 8%, rutile and hematite each 1% and a trace of tourmaline.

Interpretation and comment: It is interpreted that the sample represents an albite-biotite-carbonate (-quartz) rock, with a little disseminated rutile and hematite. This represents a generally medium to coarse grained recrystallised metamorphic and/or metasomatic replacement assemblage from a protolith whose type remains obscure. In places, carbonate occurs in rather coarse veinlike aggregates, with local quartz associated. Rutile and/or hematite occur as fine discrete grains and as small aggregates, mostly hosted in quartz and albite. The rock shows slight imposition of supergene alteration, with local degradation of biotite to goethite-stained nontronite.

DODH251B 9.41-9.44 m PTS

Summary: Recrystallised rock with two major compositional domains. One is weakly foliated and generally medium grained containing somewhat banded aggregates rich in one or more of biotite, carbonate, quartz and albite, and containing scattered small masses of finely recrystallised albite-K-feldspar-biotite-carbonate-quartz rock that is interpreted to represent the possible protolith (e.g. former feldspathic to psammopelitic metasedimentary rock). The other compositional domain originally contained abundant medium to coarse grained amphibole, carbonate and K-feldspar, with a little biotite. Minor disseminated rutile occurs throughout the rock as part of the recrystallised assemblage. The sample is probably the product of strong reconstitution involving metamorphism and metasomatic replacement. Later, there was retrograde alteration of all amphibole by K-feldspar, chlorite and sericite, and the rock was subsequently slightly affected by supergene alteration, leading to local degradation of chlorite and biotite by nontronite.

Handspecimen: The drill core sample is composed of a partly foliated, partly massive, medium to coarse grained feldspar-biotite-carbonate-quartz assemblage. Parts are pink, due to abundance of feldspar, whereas other parts are dark brown-black and grey, due to abundance of biotite, quartz, feldspar and carbonate. The latter domain type is foliated, with foliation defined by preferred orientation of biotite aggregates. Foliation is at a low angle to the core axis. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a background radiometric measurement of 60 cps.

Petrographic description

a) Primary rock characteristics: In the section, the rock contains a substantially heterogeneous recrystallised assembage, showing considerable compositional variation. Although mostly reconstituted texturally, there are rather sparsely scattered domains up to a few millimetres across that are fine grained and have an inequigranular recrystallised texture, composed of albite, K-feldspar, biotite, minor quartz, carbonate and trace rutile. These are speculated to represent former host rock, perhaps originally composed of fine grained feldspathic to psammopelitic sedimentary material.

b) Alteration and structure: The interpreted protolith material has been largely reconstituted, as well as being deformed. This has led to recrystallisation, most likely due to metamorphism and associated metasomatic replacement. Two mineralogical/textural domains are apparent. One contains scattered relicts of the interpreted protolith that have been variably replaced and engulfed in a weakly foliated and crudely compositionally banded assemblage of medium grained biotite, quartz, albite, carbonate and a little rutile. Banding is defined by biotite-rich foliae versus those containing a higher proportion of quartz, albite and carbonate, and is on a scale of a few millimetres. The other domain originally contained scattered medium to coarse grained amphibole (now completely altered), K-feldspar, carbonate, with a little biotite, albite and trace rutile. In this, carbonate patches are locally up to several millimetres across. All amphibole was subsequently retrogressively replaced by K-feldspar, chlorite and sericite. The rock was then weakly affected by supergene alteration, with variable degradation of chlorite and biotite to khaki-coloured nontronite.

c) Mineralisation: No discrete U mineral has been observed. The rock contains minor disseminated rutile, forming grains up to 0.4 mm across, as part of the recrystallised assemblage.

Mineral Mode (by volume): K-feldspar 25%, carbonate, quartz and biotite each 20%, albite 10%, chlorite (and nontronite) 3% and 1% each of sericite and rutile.

Interpretation and comment: It is interpreted that the sample is a thoroughly reconstituted rock with two major compositional domains. One is weakly foliated, medium grained and contains banded aggregates rich in one or more of biotite, carbonate, quartz and albite. It also hosts small masses of finely recrystallised albite-K-feldspar-biotite-carbonate-quartz rock that

is interpreted to represent possible protolith feldspathic to psammopelitic metasedimentary rock. The other compositional domain originally contained medium to coarse grained amphibole, carbonate and K-feldspar, with a little biotite. Minor disseminated rutile occurs throughout. The sample is interpreted to be the product of strong reconstitution due to metamorphism and metasomatic replacement. Later, there was retrograde alteration of all amphibole by K-feldspar, chlorite and sericite, and the rock was slightly affected by supergene alteration, leading to local degradation of chlorite and biotite by nontronite.

DODH251C 13.49-13.51 m PTS

Summary: Strongly retrogressed and supergene altered rock that originally contained abundant medium to coarse grained amphibole and interstitial carbonate. It also hosted a little feldspar, a couple of aggregates of coarse brannerite and trace biotite and rutile. The nature of the protolith for this assemblage remains obscure and the rock was probably the product of metamorphism and metasomatic replacement. Retrograde alteration led to all amphibole and some feldspar being replaced. The dominant alteration assemblage was initially composed of sericite, chlorite and carbonate. Subsequently, weathering effects caused considerable degradation of the rock to nontronitic clay and minor supergene Fe oxides (goethite and hematite). Locally, boxwork structures developed due to leaching (e.g. of carbonate). Brannerite was metamictised and replaced by a fine grained, low-U aggregate that probably includes leucoxene.

Handspecimen: The drill core sample is composed of a weathered, goethite-impregnated rock containing pseudomorphs up to a few millimetres across after an initially abundant coarse grained mineral phase (e.g. ferromagnesian material), with subordinate interstitial pink to brown, goethite-impregnated carbonate and feldspar. There are a couple of pale yellow fine grained aggregates representing sites of degraded (metamict) brannerite up to a few millimetres across. These are probably now composed of leucoxene. The pseudomorphs after former ferromagnesian material are impregnated by orange-brown to red-brown supergene Fe oxides (goethite, hematite). The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It is slightly radioactive, with a radiometric measurement of 100 cps.

Petrographic description

a) Primary rock characteristics: In the section, it is evident that the rock is strongly retrogressed and weathered. There are pseudomorphs after an original medium to coarse grained ferromagnesian phase (e.g. amphibole) forming blocky to elongate prismatic grains up to 4 mm long, enclosed by fine to medium grained carbonate. This assemblage is non-diagnostic as to protolith type and no relict textures are recognised.

b) Alteration and structure: It is interpreted that protolith material, whose type is obscure, was recrystallised to/replaced by, an assemblage with abundant medium to coarse grained amphibole, enclosed by fine to medium grained carbonate, and containing a little feldspar (K-feldspar and albite), biotite and a trace of rutile. A few prominent grains and aggregates up to 4 mm across of brannerite are also considered to be part of the primary mineral assemblage. Subsequently, the rock was strongly retrogressed. All amphibole was replaced, mostly by fine grained sericite, chlorite and minor K-feldspar, and locally by abundant fine grained carbonate. Feldspars were also partly replaced by carbonate, and brannerite was metamictised and replaced by very fine grained material that probably includes leucoxene. Later supergene alteration was imposed, causing further breakdown of retrograde products (and biotite) to nontronite, with development of goethite and hematite impregnation, especially at former amphibole sites. In places, considerable carbonate was leached out, forming boxwork voids.

c) Mineralisation: A few coarse grains and aggregates of brannerite up to 4 mm across formed as part of the primary mineral assemblage. It was later metamictised and replaced by a low-U, very fine grained aggregate that probably includes leucoxene.

Mineral Mode (by volume): sericite + nontronite 50%, carbonate 45%, goethite + hematite and rutile + leucoxene (degraded brannerite) each 2% and feldspars 1%.

Interpretation and comment: It is interpreted that the sample represents a strongly retrogressed and supergene altered amphibole-carbonate rock, which also hosted a little feldspar, a couple of aggregates of coarse brannerite and trace biotite and rutile. The nature of the protolith for this assemblage remains obscure and the rock was probably the product of metamorphism and metasomatic replacement. Retrograde alteration caused replacement of

all amphibole and some feldspar by sericite, chlorite and carbonate. Subsequently, supergene alteration caused further degradation of the rock to nontronitic clay and minor supergene Fe oxides (goethite and hematite). Locally, boxwork structures developed due to leaching (e.g. of carbonate). Brannerite was metamictised and replaced by a fine grained, low-U aggregate that probably includes leucoxene.

DODH251D 14.29-14.32 m PTS

Summary: Medium to coarse grained carbonate-amphibole (-quartz-albite) rock, with a little rutile, biotite and brannerite in the original assemblage. The rock has no relict textures and is considered to be the product of complete replacement/recrystallisation of protolith material. Subsequently, there was strong retrogression, with replacement of all amphibole by sericite, chlorite and carbonate, plus local replacement of albite by carbonate, and metamictisation of brannerite. Supergene alteration was also imposed, leading to development of nontronite, goethite and hematite.

Handspecimen: The drill core sample is composed of a mottled pink-brown, dark brown and pale grey rock, containing a medium to coarse grained assemblage of carbonate, feldspar, quartz and an altered blocky to prismatic ferromagnesian phase. A couple of grains of pale yellow, degraded brannerite up to 2 mm across are observed. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It has a background radiometric measurement of 70 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the sample is composed of abundant medium to coarse grained carbonate, intergrown with pseudomorphs after a former blocky to prismatic phase (e.g. amphibole) and with subordinate quartz and albite, and a little biotite and rutile. This assemblage is considered to be the product of metamorphism and probable metasomatic replacement, and no relict texture is recognised. Consequently, the nature of the protolith is not defined.

b) Alteration and structure: It is interpreted that protolith material was totally recrystallised and replaced by an assemblage of medium to coarse grained carbonate (individual grains up to 3 mm), locally abundant amphibole (grains up to 4 mm long), subordinate quartz (up to 2 mm) and albite (up to 1.5 mm), and a little biotite and rutile. A couple of grains of brannerite up to 2.5 mm across were also part of the recrystallised assemblage. Quartz and albite tend to be more common in the carbonate-rich zones. The rock was subject to retrogression, with all former amphibole being replaced by fine grained sericite, chlorite and carbonate. Albite is also locally replaced by carbonate, and original grains of brannerite were metamictised and replaced by fine grained aggregates that include leucoxene. The rock was also affected by supergene alteration, resulting in further degradation of retrograde products and formation of nontronite, goethite and/or hematite, including from carbonate, and in associated with degraded brannerite.

c) Mineralisation: A couple of grains of brannerite up to 2.5 mm across formed as part of the primary mineral assemblage. These were later metamictised and replaced by a low-U, very fine grained aggregate that includes leucoxene and goethite.

Mineral Mode (by volume): carbonate 60%, sericite 15%, chlorite/nontronite 10%, quartz 7%, albite 6%, goethite + hematite and rutile + leucoxene (degraded brannerite) each 1% and a trace of biotite.

Interpretation and comment: It is interpreted that the sample is a carbonate-amphibole (-quartz-albite) rock, with a little rutile, biotite and brannerite in the original assemblage. The rock has no relict textures and is considered to be the product of complete replacement/recrystallisation of protolith material to a medium to coarse grained aggregate. There was strong retrogression imposed, with replacement of all amphibole by sericite, chlorite and carbonate, plus local replacement of albite by carbonate, and metamictisation of brannerite. Supergene alteration was also imposed, leading to development of nontronite, goethite and hematite.

DODH251E 18.25-18.28 m PTS

Summary: Medium to coarse grained carbonate-rich rock, with patchy pseudomorphs after a former ferromagnesian phase (e.g. amphibole) and containing medium to coarse scattered grains of brannerite and traces of disseminated rutile. Retrogression of the rock led to replacement of amphibole by K-feldspar, chlorite, carbonate and a little hematite, development of irregular masses and veins of chlorite, and formation of fine dusty hematite pigmentation of carbonate. Brannerite is metamict and is associated with traces of radiogenic galena, along with a little fine grained hematite and pyrite. Elsewhere in the rock, there are traces of disseminated galena and Ag-rich electrum interstitial to carbonate and associated with chlorite.

Handspecimen: The drill core sample is composed of a pink to brick red, hematite-pigmented, medium to coarse grained carbonate-rich rock, cut by a network of thin black veinlets and containing a few coarse grained dark brown-black, sub-metallic lustre grains of a strongly radioactive mineral up to 1.5 cm across (e.g. brannerite). Associated with the black veinlets and the margins of brannerite grains are rare silvery metallic lustre grains up to 1 mm across. The sample is essentially non-magnetic, with susceptibility of $<10 \times 10^{-5}$ SI units. It is strongly radioactive, with a radiometric measurement of 1800 cps. Testing of the section offcut with dilute HCl gave a strong reaction, indicating that the carbonate is calcite.

Petrographic description

a) Primary rock characteristics: In the section, the sample is dominated by medium to coarse grained, inequigranular carbonate. There are a few blocky grains of brannerite up to 8 mm across, irregularly distributed pseudmorphs after a former medium grained ferromagnesian phase (e.g. amphibole) and locally significant chlorite and K-feldspar, plus a trace of rutile. This assemblage is not diagnostic as to protolith type, as it is probably totally recrystallised and has no relict texture. However, it could be speculated that since the rock is carbonate-rich, the protolith could have ultimately been of sedimentary carbonate type.

b) Alteration and structure: It is interpreted that the protolith was totally recrystallised/replaced by medium to coarse grained inequigranular carbonate, with maximum grainsize up to 4 mm. Within carbonate were sparsely scattered to locally abundant grains of a possible amphibole up to 1.5 mm long, together with a few large grains of brannerite up to 8 mm across and traces of rutile (grains up to 0.2 mm) and rare tourmaline. Pervasive retrograde alteration was imposed, causing replacement of all former amphibole by one or more of K-feldspar, chlorite and carbonate, plus a little hematite pigmentation. There was also development of dusty hematite pigmentation in carbonate, and formation of irregular to veinlike anastoming aggregates of chlorite (largest masses up to 3 mm across). Brannerite is now metamict and locally contains inclusions of radiogenic galena up to 0.2 mm across and apparent alteration rims of chlorite, with traces of fine grained hematite and pyrite (Fig. 13). Interstitial to carbonate and locally associated with chlorite aggregates are scattered irregular individual grains and composites up to 0.4 mm across of Ag-rich electrum (locally tarnished) and galena (Fig. 14), along with uncommon fine grained pyrite, and fine grained hematite aggregates.

c) Mineralisation: The sample contains a few prominent grains of brannerite up to 8 mm across. These are metamict and have a few small associated grains of radiogenic galena up to 0.2 mm across and apparent alteration rims of chlorite, fine grained hematite and rare pyrite (Fig. 13). Elsewhere in the rock, there are sparsely scattered small grains and composite aggregates up to 0.4 mm across of galena and Ag-rich electrum (Fig. 14).

Mineral Mode (by volume): carbonate 75%, chlorite 10%, brannerite 8%, K-feldspar 5%, hematite 1% and traces of rutile, galena, Ag-rich electrum, tourmaline and pyrite.

Interpretation and comment: It is interpreted that the sample represents a carbonate-rich rock, with patchy pseudomorphs after a former ferromagnesian phase (e.g. amphibole) and

containing medium to coarse scattered grains of brannerite and traces of disseminated rutile. Retrogression caused replacement of amphibole by K-feldspar, chlorite, carbonate and a little hematite, development of irregular masses and veins of chlorite, and formation of fine dusty hematite pigmentation of carbonate. Brannerite is metamict and is associated with traces of radiogenic galena, along with a little fine grained hematite and pyrite. Elsewhere, there are traces of disseminated galena and Ag-rich electrum interstitial to carbonate and associated with chlorite.

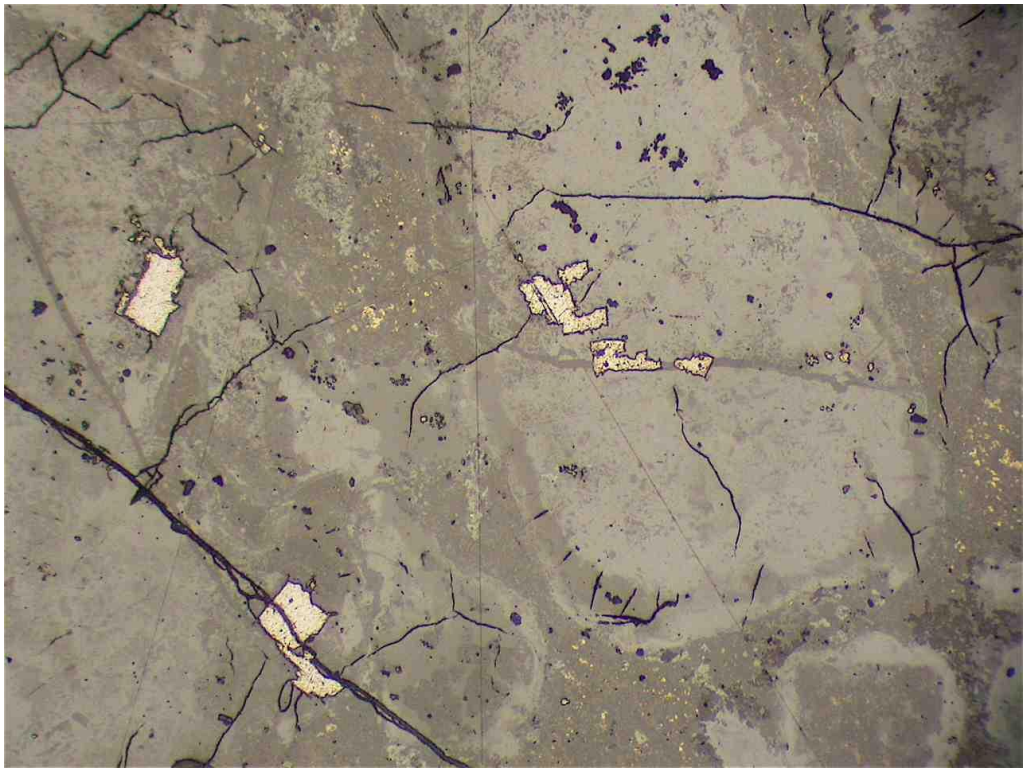

Fig. 13: Portion of large brannerite grain, (pale grey) showing fracture controlled replacement by darker aggregates of chlorite containing very fine grained hematite (pale bluish grey) and pyrite (pale creamy). The bright silvery grey grains are galena, interpreted to be a radiogenic breakdown product. Plane polarised reflected light, field of view 1 mm across.

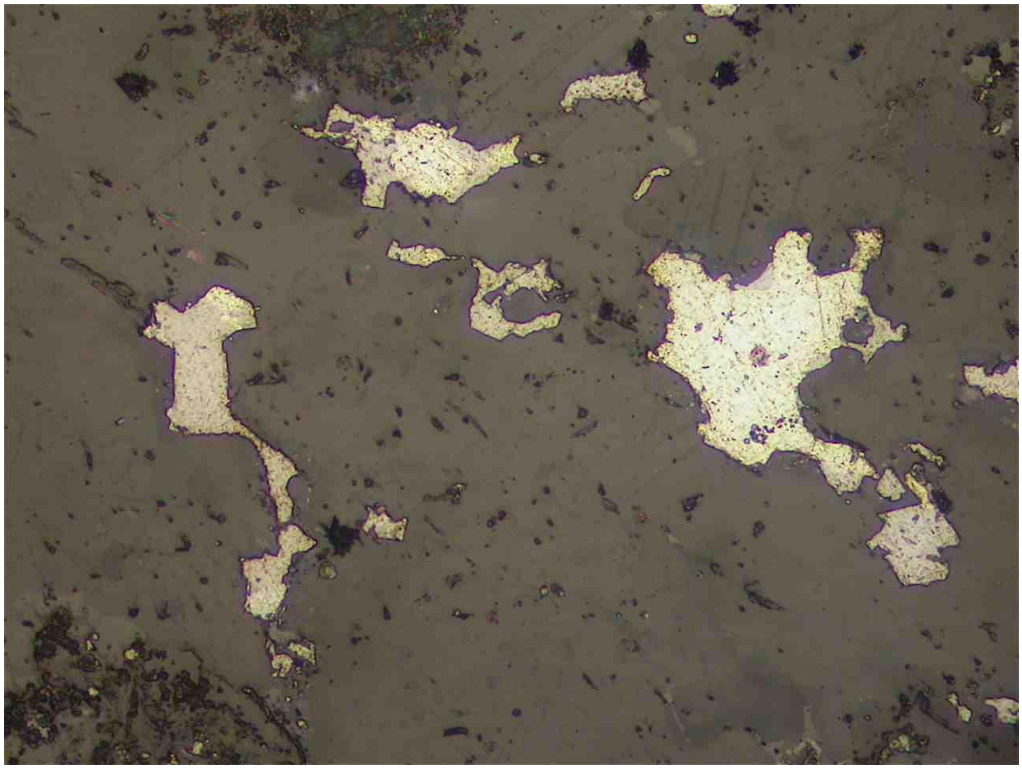

Fig. 14: Isolated grains and composites of Ag-rich electrum (silver-white) and galena (pale grey) hosted interstitially to carbonate (darker grey). Plane polarised reflected light, field of view 0.5 mm across.