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Prospect No. 600

DK 59

PACMINEX PTY LIMITED

MICROFILMED

PETROGRAPHIC REPORT

FOR VALLEY EXPL.

SPECIMENS OF DIAMOND DRILL CORES FROM
LIVINGSTONE CREEK, TASMANIA, PART II.

E.L. 53/70

PMR 108/74

OPEN FILE

SYDNEY

August, 1974

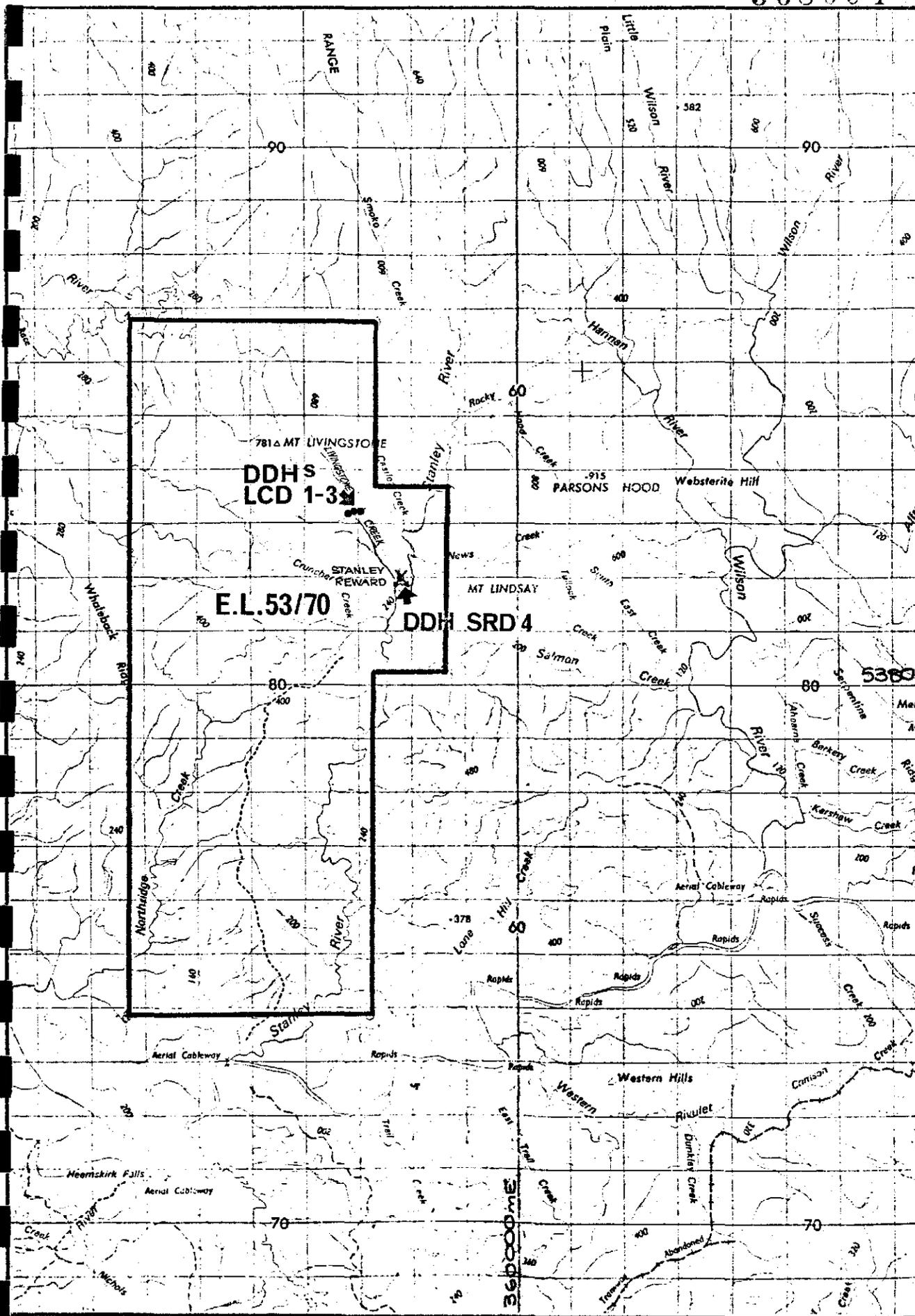
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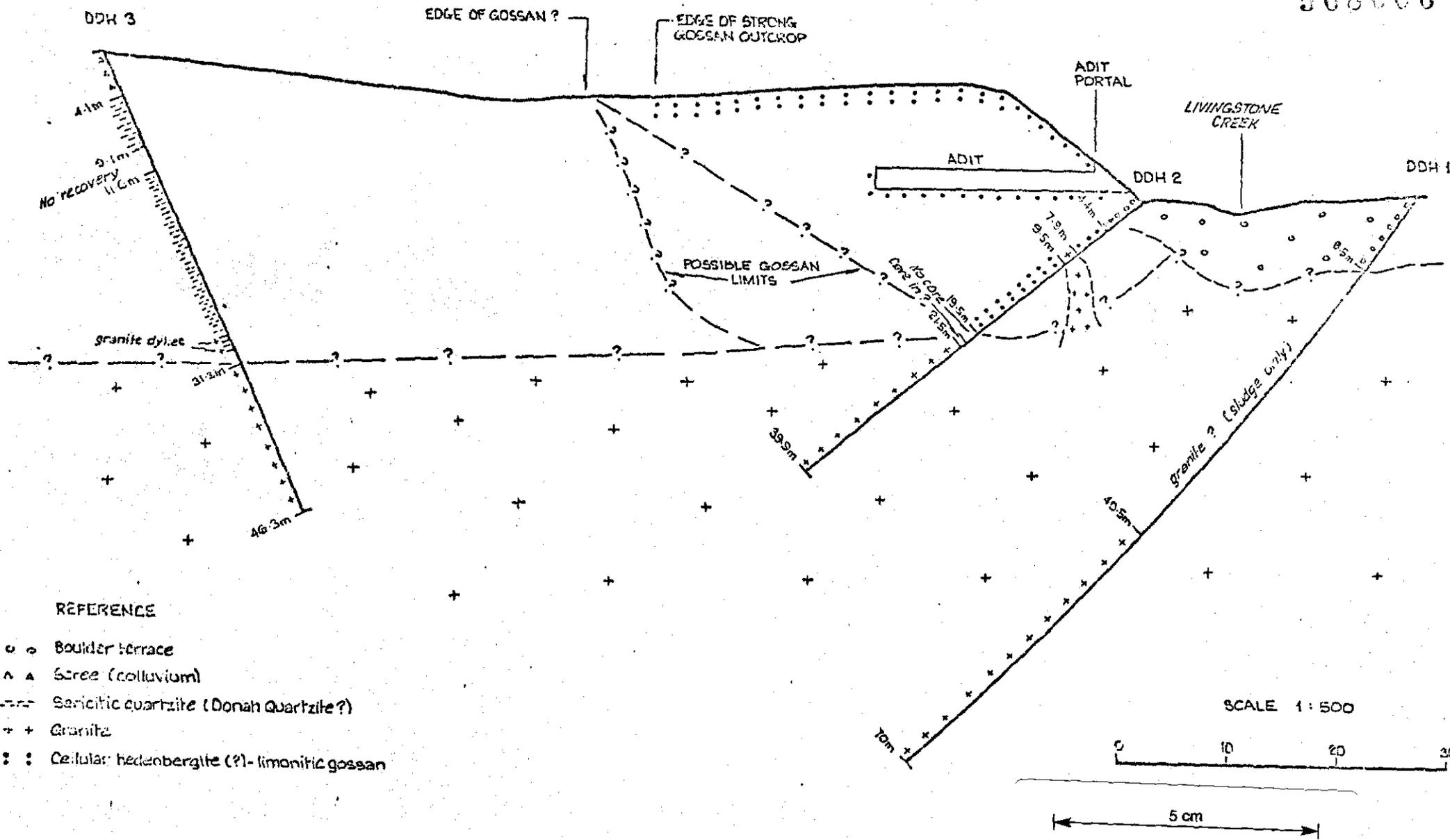
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DRAINAGE MAP OF E.L.53/70 STANLEY RIVER AREA W. TAS.

1. INTRODUCTION

Drill core specimens collected by Mr. Macnamara on a visit to Livingstone Creek, E.L. 53/70, Tasmania, including DDH SRD4 and LCD 3 are discussed. Some specimens of DDH LCD2 discussed in a previous report (Ref. 1) where rocks were thoroughly oxidised and altered are re-described and compared with fresh rock equivalents from DDH SRD4.

568006



REFERENCE

- ○ ○ Boulder terrace
- △ △ △ Scree (colluvium)
- - - Sericitic quartzite (Donah Quartzite?)
- + + + Granite
- · · Cellular heckenbergite (?) - limonitic gossan

PROFILE THROUGH NORTHERN ADIT OF LIVINGSTONE CREEK GOSSAN (Profile direction 064°M)
STANLEY RIVER AREA, WEST COAST TASMANIA

2. SUMMARY

DDH SRD4

A9579 Grey crystalline (0.5 mm) dolomite with black
4.75 m bands (bedding ?).

Check composition of minerals.

Not a carbonatite but a sedimentary carbonate rock with some shaley impurities which have been hornfelsesed and partially altered to form forsterite which was then subsequently hydrothermally altered to form antigorite.

A9580 As for A9584 plus pyrrhotite bands. Crenulated
18.10 m black bands in grey dolomite.

As for A9579 but includes pyrite and magnetite replacing pyrrhotite. Sulphides occur in areas where dolomite is being altered to calcite, forsterite and antigorite.

A9581 Disseminated black material in grey white dolomite.
33.10 m

A contact altered dolomite altered partially to forsterite with calcite then to serpentine (antigorite). A metasediment. The disseminated black mineral is pyrrhotite altering at grain boundaries to magnetite.

A9584 'Typical' white dolomite.
71.0 m

A hornfelsesed nearly pure dolomite with minimal alteration. A little penetration by mineralising fluids is seen to have taken place along dolomite grain boundaries to form pyrite and a little antigorite.

A9583 Black magnetite (?) and sulphides in dolomite.
73.90 m Check non-silicate minerals.

Massive magnetite with small (few microns) pyrite inclusions which is pseudomorphing pyrite (?) euhedra and is veined by goethite. No other sulphides are seen. Antigorite and montmorillonite occur. Suspect the magnetite is altering to maghemite ($\gamma\text{Fe}_2\text{O}_3$).

A9582 Red dolomite with red clay (?) and chlorite (?).
95 m

The rock consists mainly of fine granular calcite with some relict dolomite. Patchy penninite (chlorite), idocrase, periclase and calcite occur. The red blotchiness is due to red hematite, a product which contributed to the composition of primary ankerite (dolomite). A contact metamorphosed (at low pressure) shaley dolomite.

A9585 Disseminated black and sulphide material in a dark
100.3 m fine-grained, grey to black dolomite.

A contact altered impure dolomite to forsterite and calcite. Forsterite granules form a continuous network between large calcite (after dolomite) grains. Opaque minerals present are pyrrhotite being replaced by magnetite.

A9586 Grey dolomite, fairly typical with black and grey
124.7 m bands (bedding ?). Check for skarn minerals.

Contact altered sedimentary dolomite to forsterite and calcite followed by conversion of the forsterite to antigorite and chrysotile by deuteric solutions. No skarn minerals other than forsterite are seen. No bedding characteristics are observed.

A9587 Sulphide and black crystalline mineral (actinolite)
136.85 m in grey dolomite. Bedding (?).

As for A9586 dolomite has altered to forsterite and calcite. The forsterite shows later alteration to serpentine minerals. Bedding is shown by variation in density of fine opaque mineral horizons and concentration differentials of forsterite/serpentine and forsterite/dolomite horizons, reflecting original chemical and physical sedimentary differences before metamorphism and alteration. No actinolite is seen, the coloured mineral is serpentine. Contact altered and metasomatised impure dolomite. Imbricate folding of dolomite before recrystallisation is shown by serpentiferous bands.

A9588
138.70 m

Radiating black mineral (skarn mineral ?) in dolomite.

The black mineral is presently magnetite but it was likely introduced as iron in solution to replace dolomite, i.e. iron metasomatism; later magnetite formed from hematite during contact alteration. Not hedenbergite or tourmaline. A little diopsidic augite as well as the main interstitial mineral, calcite occurs in one corner of the section. Skarn magnetite.

A9589
142 m

Black banded (graphite ? actinolite ?) dolomite in crenulated bedding.

Shows large numbers of (<0.1 mm) of forsterite grains developing along crenulation planes. Minimal dusty magnetite forms here where dolomite (ankerite ?) alters to form forsterite. Bedding is shown by alternating bands (up to 1 mm) of calcite and silicates with carbonate along crenulated planes. The crenulations show best where serpentine minerals are forming from forsterite.

A little diopsidic augite may also have formed from impure dolomite. Contact metamorphosed dolomite.

DDH LCD3

A9591
12.04 m Laminated and banded (0.5 mm) quartz-chlorite-sericite carbonate (?) sediment; brown bands of ? any tuffaceous component ? contact metasomatic minerals.

Hornfelsing of what is essentially a banded micaceous siltstone is shown only by poikiloblastic muscovite and annealed quartzite mosaics.

Chlorite-rich bands occur but no identifiable tuff bands. Pneumatolysis is shown by biotite:chlorite bands containing tourmaline and a little cassiterite. Brown bands contain appreciable biotite.

A9592
14.58 m Similar to A9591, laminated carbonate ? Chloritic sediment, trace chalcopyrite. Check for hornfelsing, sulphides, cassiterite.

A banded micaceous siltstone somewhat hornfelsed. Very similar in mineral composition and textures to A9591; with perhaps slightly coarser bands of quartz and muscovite.

Tourmaline, a little cassiterite and sphalerite occur scattered through the rock but rather less than for A9591.

A9593 Sediment, similar to A9592; quartz-sericite-carbonate trace sulphides. Check for hornfelsing, SnO_2 , etc.

A banded micaceous siltstone similar texturally to A9592. Hornfelsing is indicated only by the annealed quartz mosaics textures and poikiloblastic muscovite present. There is less chlorite than occurs in A9592. Possibly rather more tourmaline, cassiterite and sphalerite than for the previous specimens, (A9591 and A9592).

A9594
20.4 m Sediment as for A9592. Check for progressive increase in hornfel minerals; sulphides, SnO_2 ?

A banded micaceous siltstone similar to A9593 but coarser quartz, chlorite and muscovite grains occur with approach to granite metasomatism) hornfelsing? Traces only of pneumatolytic minerals and sulphides including cassiterite and sphalerite, although tourmaline is still fairly abundant.

A9595
23.6 m Sediment as for A9594. Check for any progressive increase of hornfels minerals, sulphides, SnO_2 .

A banded micaceous siltstone contact altered, pneumatolysed and metasomatised. Clots of coarse muscovite and quartz but background of quartz shows annealed textures. An increase in massive tourmaline in lenticles is seen. Pyrrhotite masses occur.

A9596
26.7 m 3 cm wide granitic veinlet cutting the sediment. Check composition and contact area for hornfelsing etc.

Both granite vein and quartz with mica (mainly muscovite and sericite) are now largely quartz and muscovite, though some potash feldspar occurs in the 'granite' vein. Hornfelsing of banded metasediment is apparent. Tourmalisation occurs less than for A9595 and the mineral is situated mainly near the somewhat gradational 'vein'/metasediment contact. Other pneumatolytic minerals (cassiterite, topaz, etc.) are seen in both phases but mainly in the latter.

A9597
30.3 m Sediment as above, hornfelsed? Check sulphide minerals which have increased compared with samples higher up the drill hole.

A mostly hornfelsed quartz muscovite-chlorite banded metasediment with intermixed granitic material

comprised of coarse quartz mosaics, oligoclase prisms and potash feldspar which occur around 'islands' of the metasediment mosaics. Contacts are gradational. Massive pyrite occurs mainly with granite veins. Pyrrhotite is seen in A9595 (23.6 m), otherwise apart from traces of sphalerite this is the only section which shows appreciable sulphide which occurs as pyrite with a little chalcopyrite.

A9598
36.1 m

Granite with fine biotite and yellow altered (clay?) felspar in contact with a coarser more normal variety. Tourmaline veinlets? Any cassiterite? Any evidence of jarosite in the yellowed feldspars (SO₄ test).

The granite resembles A9536 (Ref. 1) in texture.

Phenocrysts are of mainly quartz and perthite and the groundmass is of euhedral holocrystalline orthoclase, quartz, oligoclase and biotite and accessories.

No cassiterite or jarosite are seen.

A porphyritic alkali microgranite.

A9599
36.9 m

1-3 mm fine-grained, biotite-rich variety of granite. Check for jarosite in yellowed feldspars and cracks, SnO₂ etc. Any evidence of absorption of country rock by the granite to give the fine-grained biotite variety?

A finer-grained groundmass than for A9598 but compositionally similar and porphyritic as is the latter rock, but not so potassic. Plagioclase shows alteration to sericite. No jarosite (SO₄ test) and no cassiterite are seen. No xenoliths of metasediment are obvious so that if some sediment quartz was absorbed then it probably recrystallised. In any case the quartz is a trifle low for a granite as estimated at 20 volume percent; with a very high potash feldspar content at 53 volume percent. A porphyritic biotite alkaline microgranite.

A9600 Coarse grained 'normal' fresh granite. Some feldspars
44.5 m yellowed (jarosite ?). Contrast SnO₂ content with
the biotite-rich varieties (if present). Other
differences?

In grain sizes, very similar to A9598 but with more
perthite phenocrysts which are less altered (to
sericite) than for A9599 and coarser quartz grains
which grade down to matrix quartz and feldspar so
that there are not two distinct granite 'phases'
present. Biotite is ragged, part bleached and contains
abundant radioactive inclusions and possibly some fine
granular cassiterite.

The biotite shows greater alteration than does A9599.

Alkaline biotite granite, showing abundant potassi-
fication of quartz. Probably the only granite in the
series to show cassiterite (in biotite).

DDH LCD2

After comparison with fresh rock equivalents in DDH
SRD4, some weathered rocks of DDH LCD2 have been reinterpreted.

A9530 An iron metasomatised dolomitic rock now containing
5.7 m magnetite/titanohematite and montmorillonite.

A9532 An iron metasomatised dolomite rock.
12.9 m

A9533 Very similar to red chert 'marker' of Renison Mine.
13.6 m

A9535 Resembles A9579 (DDH4, 4.75 m).
18.3 m A contact altered and part metasomatised sedimentary
dolomite.

Renison Bell Mine (specimens for comparison with Livingstone Creek drill core specimens).

A9601 'Red chert'. Deep-red jasper-like rock.

Fine intergrowth of cherty quartz, interstitial finer hematite, cut by veins of carbonate. No firm evidence that this is a silicified volcanic rock although there are resemblances with silicified rhyolite tuffite from Capertee (Ref. 4). Not banded.

A9602 'Red chert'. Dark grey to black chert with reddish tinge and pale bands.

Banded fine cherty quartz containing some angular quartz grains flecked with fine biotite. Banding is mainly due to rhythmic differences in grain size of minerals and the variable abundance and rhythmic graded bedding may be relict. The banding is repeated in places, each depositional sequence varying from quartzite to marly quartzite and marl bands. Some bands contain ungraded scattered quartz which may be present as detrital relicts. This may represent a possible lagoonal deposit with seasonal variations of lithology, indicated by each period.

A9603 Black sediment with sulphide bands.

A banded marly siltstone of biotite and quartz with sulphides (pyrrhotite, sphalerite and specks of bornite) and cassiterite disseminated as clots and in veins cross-cutting the rock.

A9604 Sulphides from Howard's Lode.

Massive pyrrhotite with wedge shaped inclusions of arsenopyrite and euhedral cassiterite.

A9605 Penzance Lode sulphides (1,100 ft. deep).

Massive pyrrhotite with chalcopyrite both of which minerals contain abundant cassiterite euhedra. Quartz and tourmaline occur interstitial to sulphides as well as a little apatite, chlorite and carbonate.

A9606 Sulphide lode material (location unknown).

Coarse pyrrhotite and interlocking smaller grains with less chalcopyrite. Groups of cassiterite crystals are embedded in pyrrhotite. Interstitial mineral, mainly coarse quartz; some biotite and sericite; with tourmaline and cassiterite embedded in quartz grains.

3. DISCUSSION

3.1 Granites

LCD2

A9527 and A9528 are typically acid biotite granites of igneous granite texture containing no xenolithic material.

A9536 is a biotite granite quite different from A9527 and A9528 in being generally finer grained but containing twinned phenocrysts of potash feldspar. The groundmass is of intergrowths of fine anhedral quartz and potash feldspar, also some small plagioclase euhedra and wispy ragged brown biotite. Biotite is intergrown with and is growing along cleavages of potash feldspar and is replacing it. Some plagioclase feldspar and perthites contain scattered sericite as flakes. The biotite is partly chloritised. This granite plainly shows some hydrothermal/metasomatic alteration.

Topaz is seen included in feldspar and zircon and cassiterite inclusions in biotite are observed.

No xenolithic material occurs in any of the granites.

LCD3

A9596. Granite vein contains muscovite plates but is cutting a sericite rich quartz sediment. Feldspar present has been kaolinised by late stage alteration.

A9598 is very close to A9536 (LCD2) in texture and mineralogy but the former rock has not been altered and is quite fresh, and appears to contain no cassiterite.

A9599 resembles A9536 with porphyritic feldspars. The biotite in this (A9599) granite though is red-brown, contains some crystal inclusions but is fresh. It also contains no tin minerals and the section shows no xenoliths or xenocrysts. Alteration of feldspars is seen.

A9600. More normal granite, and does not contain two distinct granitic phases as do A9598 and A9599. Possible cassiterite is seen in altering biotite. Less alteration of plagioclase than for A9599.

Attempts at correlation of LCD2 and LCD3 drill holes.

- (i) Tourmalisation and hornfelsing of sediments of A9529 (LCD2) and A9593 (LCD3) produce rocks of similar texture except for the abundance of poikiloblastic muscovite in A9593.
- (ii) Granites A9598 and A9599 (LCD3), very much resemble A9536 (LCD2).

SRD4 drill core consists largely of contact altered dolomite and is not therefore correlated with LCD2 and LCD3 cores here. See P.8, DDH LCD2 compared with DDH SRD4 and a Renison Mine specimen.

3.2 Checking for Tin Minerals in Gossan of Drill Hole LCD2

Table 3 (Ref. 19)

	<u>m.</u>	<u>% Sn</u>	<u>% Cu</u>	<u>% Zn</u>	<u>% Pb</u>	<u>% Ni</u>
A9529	3.7	0.35	0.01	0.02	< 0.01	< 0.01
A9530	5.7	0.37	0.13	0.03	< 0.01	< 0.01
A9531	10.7	0.45	0.18	0.03	< 0.01	< 0.01
A9532	12.9	0.71	0.08	0.03	0.01	< 0.01
A9533	13.6	0.24	0.18	0.05	< 0.01	< 0.01
A9534	17.1	0.45	0.09	0.02	< 0.01	< 0.01
A9535	18.3	0.34	0.13	0.03	< 0.01	< 0.01

A9529. Specks of cassiterite associated with tourmaline were indicated in the report on LCD2 (Ref. 1).

A9530. No cassiterite is seen but possible that tin is substituting for Ti^{4+} in titanohematite which is present. The small amount of copper present will be adsorbed on the limonite mineral present.

A9531. Careful scanning of the thin-section revealed no cassiterite but possibly tin may be present in the titanohematite lattice if this is present.

A9532. As for A9531, no cassiterite is seen and the Sn^{4+} is either buried in the mass of opaques (only a thin section is available) or it substitutes for Ti^{4+} in titanohematite present, if any.

A9533. Fine aggregates of cassiterite occur with tourmaline. Copper present may be with limonite.

A9534. The section is largely obscured by granular goethite and many voids occur which are presently filled with clay minerals. Any cassiterite present is obscured or has been 'pulled' during section preparation.

A9535. No cassiterite is seen for similar reasons to those given in A9534.

Fragments with sawn edges were tested using the zinc test.

Results

Tin tests (using granulated zinc and 1:1 HCl solution) on gossanous samples from DDH LCD2, show minute specks of cassiterite to less than 1 percent on sawn surfaces of samples A9530 (5.7 m), A9532 (12.9 m) and A9534 (17.1 m). Tin assays on these samples (Ref. 19) indicate values of 0.37, 0.71 and 0.45 percent Sn.

3.3 Petrography and Chemistry

3.3.1 DDH SRD4 - Carbonate rocks

Table 2

Analysis of Carbonate Rocks in DDH SRD4 (by A.C.S. Laboratories Pty. Ltd.)

	<u>Ti</u>	<u>Ba</u>	<u>Sr</u>	<u>La</u>	<u>Nb</u>	<u>Y</u>	<u>P</u>
A9574	<50	<100	100	<20	<10	<10	200
A9584	<50	<100	90	<20	<10	<10	170

Results expressed as parts per million.

These are contact metamorphosed sedimentary carbonate rocks, originally (?) mainly dolomite, (A9584, 71.0 m); although some shaley bands may have been present to give preserved relict bedding (A9587, 136.85 m; A9589, 142 m) towards the bottom of the hole and less definitely (A9579, 4.75 m; A9580, 18.10 m; A9582, 95 m) nearer to the top. The dolomite rocks towards the surface show greater granulation and preservation of dolomite hornfels texture; but greater alteration with abundant calcite with forsterite and serpentine seems to occur towards the bottom (A9585, 9586, 9587; 100.3 m, 124.70 m, 136.85 m respectively) probably because of the presence of the shaley bands and/or other siliceous mineral impurities.

Various iron metasomatised horizons (A9579, 9580, 9583, 9585 and 9588; 4.75 m, 18.1 m, 73.9 m, 100.3 m and 138.70 m respectively) occur and in some cases where iron rich minerals are not so abundant may rather be due to crystallisation of magnetite from the breakdown of ankerite to calcite (?) and iron oxides. The richly iron metasomatised horizons are particularly at 138.70 m and at 73.9 m and 100.3 m.

The only horizon with a miscellany of 'contact' metamorphic minerals is A9582 (95 m) with the occurrence of forsterite, idocrase and penninite and here

the precipitated iron (hematite) appears to come from decomposed ankerite rather than introduced iron which precipitates as magnetite or hematite. This rock was probably a carbonate/shale rock.

The rocks of this drill-core are not part of a carbonatite mass although the alteration textures in some nearly pure carbonate sections show similarity to altered carbonatite (Heinrich, Ref. 16), in containing olivine (forsterite) grains. As mentioned above bedding can be seen, particularly in the altered shaley carbonate mainly towards the bottom of the hole. There is an absence of typical carbonatite minerals such as coarse apatite, zircon, monazite, pyrochlore and except for one iron metasomatised specimen (A9588), there is an absence of pyroxene.

Geochemical evidence of sedimentary carbonate origin of LRD4 specimens analysed is shown in Table 2 where La, Nb and Y (<20 , <10 and <10 ppm respectively) are all very low compared with the average figures given for carbonatites in Table 8-6 (La 516, Nb 1951 and Y 96 ppm) in Heinrich (after Gold - 1963, Ref. 16). SRD4 analyses compare better with those figures for sedimentary limestone (La <1 , Nb 0.3 and Y 30) in Gold's table.

A better trace element comparison is given by Gellatly (Ref. 17) and Crohn & Gellatly (Ref. 18), where in the supposed Strangways Region carbonatites, the following variations were noted (in ppm); Ti 200 to +10,000, Ba 250 to 1,000, Sr 800 to 1,500, La <100 to 700, Nb 20 to 450, Y 80 to 200, P 100 to 10,000, (mainly 1,000 to +10,000). These elements are in greater concentration than is normally found in sedimentary carbonates and in most cases grossly exceed the values quoted in Table 2 of this report. The carbonate rocks intersected by DDH SRD4 from the evidence of petrography and geochemistry are sedimentary carbonates, or shaley carbonate rocks.

3.3.2 DDH LCD3 - Contact altered banded sediments from A9591 (12.04 m) to A9597 (30.3 m)

These rocks show typical granular hornfels texture of quartz mosaics and poikiloblastic micas. Tourmalinisation which results in the alteration of muscovite, chlorite and phlogopite to tourmaline and the introduction of sphalerite, pyrrhotite, magnetite and traces of cassiterite are seen. Tourmaline present (~ 0.10 mm) is chunky, irregular and poikiloblastic with quartz inclusions, mainly red-brown with a tinge of green or as smaller perfect prisms, brown or brown with a tinge of green. Tourmaline abundance increases from A9591 to A9593; occurs less for A9594, but increases in A9595 of a massive lenticular variety associated with micaceous minerals which it is replacing. The tourmaline occurs at granite vein/metasediment 'contact' mainly in A9596 and A9597 but is not so abundant there.

Banding (bedding of original rock) is indicated by alternating variations in quartz, muscovite and chlorite in quantity of grains or median size of grains at horizons a fraction of a millimetre thick. The large muscovite grains occur typically as decussate, poikiloblastic plates with rounded quartz inclusions.

A slight coarsening in grain size of muscovite and quartz is noted in the main matrix from A9591 to A9593 (12.04 to 17.8 m) although there are occasional bands (0.3 to +3 mm) of coarse quartz or coarse quartz with coarse muscovite. Generally the grain size is very fine (~ 0.08 mm for quartz). Towards the aplite vein in A9596 (26.7 m) and from A9595 (23.6 m) there is a gross coarsening of quartz and muscovite grain size adjoining 'vein' but still the main quartz hornfels texture remains intact.

The grade of metamorphism is low (Harker, Ref. 20) and precedes some pneumatolysis and introduction of sulphides. Traces of cassiterite are recorded in

the petrographic descriptions, especially nearer the top of the hole and away (?) from the granite. However, in the assays of the various lengths (Macnamara, Ref. 19) only <0.01 percent was recorded for tin although up to 0.03 percent zinc is recorded.

No variations in kinds of hornfels minerals are seen, only slight differences in coarseness of quartz and muscovite and certainly where the latter is poikiloblastic and decussate this may indicate a slight increase in metamorphic grade, but differences in grade are very slight.

There is no apparent increase in pneumatolysis towards the granite. Sulphides occur only as pyrrhotite in A9595; and pyrite with a little associated chalcopyrite with granite veins in A9597; also as traces of sphalerite which are seen in A9591, A9593, A9594 and A9595.

3.3.3 DDH LCD3 Granite

Table 1

Analysis of Granites in LCD3 (by A.C.S. Laboratories Pty. Ltd.)

	<u>Ti</u>	<u>Sn</u>	<u>Li</u>	<u>F</u>
A9599	2700	< 20	75	350
A9600	540	30	70	150

Results expressed as parts per million.

The granites Groves describes (Ref. 7) from tin bearing areas in N.E. Tasmania are modally and texturally similar to those described from DDH LCD3 (A9598, and A9600). The phenocrysts of perthite, small oligoclase crystals and ragged brown biotite and presence of topaz are characteristically similar. However, the potash feldspar:quartz ratio for the LCD3 granites is remarkably high, these granites being very potassic; the composition falls better into

Hatch and Wells (Ref. 8), potassic granite classification with quartz at ~ 25 percent, subordinate to potash feldspar and with a colour index of 5. The Livingstone Creek granite is a highly differentiated potash granite.

The only chemical analyses performed were on specimens A9599 and A9600 (LCD3, 36.9 and 44.5 m) and then for Ti, Sn, Li and F only, (Table 1).

The Ti is high for the 'biotite granite' (A9599) and low for the 'normal coarse granite' (A9600) when comparing with Groves (Ref. 7) results for porphyritic biotite granites from a tin area. Otherwise the Sn is a little high at <20 and 30 ppm compared with Groves 5 to 16 ppm (av. 8 ppm), Li is about the same and F is decidedly low at 350 and 150 ppm compared with Groves 1,000 to 2,100 (av. 1,400 ppm).

Considering the greater potash feldspar content of specimens A9599 and A9600 compared with Groves samples and assuming the Li to be in the potash feldspar lattice then the enrichment in Li is decidedly low for the Livingstone Creek granites but is still in proportion to potash feldspar present, estimated at 53 and 61 volume percent respectively. The fluorine may be in biotite or topaz present and may reflect a lower topaz content of the Livingstone Creek granites (no fluorite is seen). In Grove's granites the biotite muscovite granites rather than the porphyritic biotite granites appear to represent the end product of a continuous fractionation series which includes the porphyritic biotite granites. The former rocks contain more tin (av. 400 ppm) than the latter granites (av. 8 ppm). The two granites analysed from Livingstone Creek would be classified as 'tin poor' and the small amount of tin present is thought to be present as minimal cassiterite as inclusions in the biotite in the biotite lattice or perhaps in

sphene inclusions in the biotite. However, Rattigan (Ref. 10) has shown that the biotite lattice, though containing more Sn than other granite minerals, still has a low tin-holding capacity and since the sphene has developed during metamorphism from altering biotite, it too would contain minimal tin. Then again a little tin may be accommodated structurally by both potash feldspar and plagioclase in the rock, but the bulk of tin is held by biotite.

A later paper by Groves and Taylor (Ref. 11) is also concerned with tin mineralisation in northeast Tasmania at the Anchor Tin Mine. The zone of mineralisation is in greisen at the upper contact of biotite muscovite granite intruding an adamellite. The greisen is the result of metasomatic alteration of the biotite muscovite granite by hydrothermal fluids in a closed system left over from crystallisation of the highly fractionated melt. The greisenisation and mineralisation are related to processes involving a delicate balance between crystallisation of the melt and the development of an igneous phase (enriched in tin, sulphur and chalcophile, elements) during second boiling relating to crystallisation.

No greisen zone was intercepted at the granite/metasediment contact in LCD3 drill-hole, only tourmalinised and hornfelsed, pelitic and carbonate rocks. Other than tourmaline, a little topaz and cassiterite were the only pneumatolytic minerals found. Otherwise the only changes noted were the introduction of typical contact metamorphic minerals and hornfels textures at and adjoining the granite/sediment contact. Tin bearing and barren granites alike (from north-east Tasmania) show a similar range of Ti; (100, 1,000 ppm respectively); a much greater Sn content (8,000, 500 ppm); much greater Li content (3,000, 1,500 ppm); fluorine figures are not given.

Groves et al then go on to say that the mineralisation is confined to the greisen and greisenised granite formed by metasomatic alteration of the biotite muscovite granite at the Anchor Tin Mine.

Hosking (Ref. 12) states that sphene may contain much tin and rutile more than 2 percent. Also sphalerite, galena and chalcopryrite because of certain structural relationships with stannite may be Sn bearing whereas pyrite and pyrrhotite are free from this element. At Livingstone Creek rutile is reported in most specimens of LCD3, sphalerite at 12.04 m, 17.8 m, 20.4 m and 23.6 m and sphene occurs in biotite of the granites. Sufficient of these minerals are present alone or in combination to contain the traces of Sn reported in the drill-hole assays.

Hosking (Ref. 13) quotes Barsukov (Ref. 14) who observed that tin deposits, (particularly greisen bordered types) owe their development essentially to the release of tin from the biotite in the granite by ascending solutions rich in sodium and fluorine ions, its transportation to major channelways as $\text{Na}_2\text{Sn}(\text{OH},\text{F})_6$ and subsequent deposition as cassiterite with release of $(\text{OH})^{2-}$ as water. However, the absence of fluorine except as traces in topaz and lack of soda metasomatism is characteristic of granites examined so far from Livingstone Creek. So that either Barsukov's theory is inadequate or the Livingstone Creek granite/sediment contact is not a suitable locus for tin mineralisation.

A position below a possible greisen zone at Livingstone Creek is indicated by absence of muscovitisation of granites as is seen to occur in Cornwall (Davison, Ref. 15). Biotite converted to muscovite releases Cu, Zn, As, Li, etc. although Sn and Be are retained by the muscovite. Further conversion to quartz by the greisenisation process released cassiterite which occurs in voids left by feldspar. Hosking also argues that muscovitisation of biotite

releases tin; followed by silicification of muscovite which causes the mobilisation of released tin which migrates into fissures forming the lodes. He states that tin in hydrothermal deposits comes partly from granite mica and partly from the granite metal bearing residuum.

Rattigan (Ref. 10) disagrees with the Barsukov theory for producing tin from granite for the following reasons :-

- (i) the granites most closely associated with tin occurrences are leucocratic, lacking biotite so that this mineral cannot host the abundance of tin in orthomagmatic deposits; and
- (ii) there is no evidence to support the theory of alkaline transport of cassiterite, there is no thorough permeation of the rocks by albite which is seen only at close proximity to perthite grains.

Rattigan postulates that Sn is dispersed through crystallites at levels comparable with or exceeding the magmatic concentration of the element until a critical late stage in serial fractionation of parental granitic melts is reached, and that significant accumulation of the tin is related to the crystallisation of highly felsic parental magmas. Data accumulated from Rattigan's study confirm that Sn is generally dispersed in most igneous rocks and possibly in the earth's crust at a uniformly low level of concentration.

Tin (and base metal sulphides) in the contact zone of granite and country rock (pelite and carbonates) at Livingstone Creek have not so far been intersected except in very minor quantities, and only up to 0.77% Sn in gossanous material in LCD2. Tin has been found

as cassiterite in abundance in neighbouring placer material which could have occupied zones higher in the granite/sediment contact which have since been weathered away.

Probably adopting Rattigan's theory of serial differentiation of huge volumes of magma as the last fractionation products resulting in highly siliceous granites as the residual system of granite genesis rather than employing Barsukov's (Ref. 14) ideas on metasomatic extraction from biotite gives us more hope for finding tin near Livingstone Creek, bearing in mind the present absence of greisen, soda metasomatism, and abundant fluorite veins, etc., i.e. mineralisation targets may be less specific where one looks for a contact of highly siliceous granite with metasediment rather than for greisen effects only?

Petrography shows that the country rocks at Livingstone Creek bear some similarity (chert horizons and dolomitic rocks) with those at Renison Bell, 17 km SE of Livingstone Creek, which are rich with tin and base metal sulphides and which adjoin the same granite mass. Finally, it would seem that in the area of drilling, some zones of tin and base metal sulphides higher in the sequence have been weathered away resulting in the presence of adjoining rich placer deposits which have been mined in the past.

4. PETROGRAPHIC INVESTIGATION

4.1 DDH SRD4

A9579, 4.75 m

Grey crystalline (0.5 mm) dolomite, with black bands (bedding ?). Check composition of minerals.

A coarsely crystalline white rock with carbonate filled vugs lined by black sulphide?

In thin section a finely granular mosaic of carbonate (grains median 0.24 mm, range 0.05 to 0.64 mm). The grains show abundant lamellar twinning and triple junctions between grains which may indicate a hornfels texture. The rock is studded by scattered groups of very pale green forsterite crystals (~0.6 x 0.4 mm), anhedral with irregular veins containing opaques of pseudomorphed by fine fibrous chrysotile. Elsewhere smaller forsterite grains occur in pockets (~0.1 mm) and even smaller grains are seen to be developing from carbonate mineral. Irregular, non-equant plates of calcite* develop around forsterite crystals. This phenomenon is also seen to be taking place along zones of weakness or fracture planes in the rock, the forsterite grains as aggregates being accompanied by fine opaque matter in fractures. Locally, forsterite in these zones is altered to serpentine. Elsewhere the dolomite contains masses of very fine magnetite in exsolution.

The rock is most likely a contact altered impure sedimentary dolomite where forsterite has formed from dolomite and siliceous impurities. Hydrothermal fluids from the neighbouring granite formed serpentine minerals from the existing forsterite.

Rare earth minerals, characteristic apatite, zircon grains or alkaline amphiboles or reverse pleochroic biotites such as commonly occur with carbonatite rocks are not seen. The carbonate is texturally that of a contact recrystallised

* proven by mineral stain

impure carbonate rock.

Major crenulations indicate the positions of original siliceous (shaley ?) matter forming original bedding planes before metamorphism. Magnetite present may be the iron released from decomposing dolomite since it forms islands within the serpentine minerals. Polished section showing traces of pyrite (up to 0.10 mm) occur in the dolomite as mutual intergrowth with the dolomite grains. Possible traces of flakey molybdenite? also occur which are seen intergrown with the dolomite adjoining access fractures. Grains of pyrrhotite (to 0.3 mm) occur intergrown with dolomite. The large pyrrhotite grains show disaggregation lamellae due to deformation (Ramdohr, Ref. 3).

A9580, 18.10 m

As for A9584, plus pyrrhotite bands. Crenulated black bands in grey dolomite.

Carbonate texture is similar to that seen in A9579, grains vary between 0.1 and 0.8 mm, median 0.4 mm; many show lamellar twins and triple junctions are common. Segregations of anhedral serpentine mineral after forsterite and containing residual opaque mineral are common. Fresh forsterite can be seen developing spottily along dolomite grain boundaries and along subparallel fractures in the carbonate mass to the point that parallel lenticles of forsterite occur associated with massive pyrrhotite. A little irregular calcite is seen as growths around forsterite grains, secondary after dolomite and growth of forsterite. Fine subparallel fractures in the olivine aggregate show alteration of forsterite to chrysotile.

Massive pyrrhotite alone is seen to be replacing carbonate grains at the opposite end of the thin-section. Traces of phlogopite also occur intergrown with and replacing carbonate.



Figure 1

Contact metamorphosed and altered dolomite (DDH4, 33.10m/A9581).

Recrystallized dolomite mosaic of roughly equigranular grains (pale yellow, pink and blue etc) surround irregular calcite (buff) speckled with opaques and bright coloured forsterite grains displaying irregular cracking along which serpentine (antigorite) is beginning to form.

Crossed nicols

Magnification X13

A recrystallised impure sedimentary dolomite contact metamorphosed to forsterite. Solutions containing some iron with sulphur have penetrated along sedimentary planes of weakness in the rock and to a lesser extent along grain boundaries forming magnetite and sulphides. This was followed by late stage alteration of much of the forsterite to serpentine.

In polished section are seen irregular intergrowths or fine intergrowths of pyrite and magnetite replacing relatively larger pyrrhotite grains (~ 0.2 mm) around grain edges. Other opaque grains show pyrite to be marginally replacing pyrrhotite direct. Yet other pyrrhotite grains show marginal replacement by magnetite alone.

The crenulated bands were zones of deposition and weakness where hydrothermal solutions have penetrated the dolomite and forsterite, and pyrrhotite (contact altered pyrite?) and serpentinite were formed. It may well be that they represent planes of impure carbonate sedimentation (no organic matter is seen) in an original bedded dolomite. Although it has been postulated elsewhere that iron was formed from decomposition of ankerite to calcite. The crenulation was produced by mobilisation of dolomite before recrystallisation near granite contact. No other bedding characteristics can be seen in the rock.

A9581, 33.10 m (Figure 1)

Disseminated black material in grey-white dolomite.

A sugary granular rock specked with black mineral and pyrrhotite?

A granular carbonate rock, as for A9579 and A9580 and of similar grain size ranges, (0.1 to 1.5 mm, median 0.5 mm). Dolomite grains show recrystallisation and triple junctions and many display lamellar twinning. Irregular calcite with fine opaques is the decomposition product during formation of forsterite. Groups of forsterite

grains have developed at the expense of carbonate and many have been subsequently serpentinised. Scattered forsterite grains have developed along carbonate grain boundaries but there are not the access fractures in this specimen as in A9580 where forsterite and sulphide developed in mass.

No heavy minerals are seen except for flecks of pyrrhotite and magnetite along irregular cracks in forsterite grains or patchily in dolomite. This is the disseminated black material.

As for A9579 and A9580 a contact, recrystallised sedimentary dolomite but no complex fracture patterns through mainly forsterite masses as in the latter specimens and much less forsterite has formed.

Polished section shows mainly pyrrhotite which occurs as polygonal, oblong or rounded grains up to 0.25 mm. The larger grains occur mutually interstitial to carbonate grains and are polygonal; the smaller grains occur within carbonate, are round or oblong and some recrystallisation of the carbonate after introduction of the sulphide is seen to have occurred. A little magnetite of around 0.2 mm also occurs as lone grains in dolomite. Pyrrhotite grains are seen to be altering to magnetite around the grain edges.

A9584, 71.0 m

'Typical' white dolomite.

Fine sugary granular rock containing parallel fractures and specks of pyrrhotite and chalcopyrite (?).

As for A9579 and A9581 specimens, an equigranular carbonate (granules 0.1 to 0.6 mm, median 0.3 mm), the grains showing triple junctions and some lamellar twinning. Recrystallisation under stress occurred. A possible stylolitic boundary traverses the section; this has not been obliterated by recrystallisation. Occasional pockets

of fine rubbly carbonate (calcite) and serpentine fibres show pseudomorphing of former olivine grains. Opaque rubbly matter occurs along narrow fissures accompanied by serpentine, calcite and euhedral pyrite and serpentine pseudomorphs of forsterite are seen. No other heavy minerals or for that matter any other minerals are seen. Dolomite constitutes 99 volume percent of the rock. Almost complete lack of impurities enabled this rock to recrystallise under heat and pressure to almost pure dolomite.

Euhedra of pyrite, 0.02 to 0.5 mm (cube and pyritohedral forms) occur at mainly dolomite grain boundaries; some small primary pyrite grains do occur just within present dolomite grain boundaries and a narrow (<0.02 mm) veinlet of pyrite is crossing the section and moving preferentially, intergranularly in the rock. Minimal metasomatism is seen.

Most carbonate present is hornfelsed dolomite which was confirmed by a staining procedure (Ref. 6).

A9583, 73.9 m

Black magnetite (?) and sulphides in dolomite. Check non-silicate minerals.

A granular white carbonate contains aggregates of black mineral having a yellow grain powder halo. Inside the yellow silicate masses occur segregations of magnetite (altering to maghemite) veined by goethite with a little pyrite occur as inclusions in magnetite in the white dolomite.

A finely fibrous yellow clay of serpentine mineral and minor montmorillonite (confirmed by XRD) surrounds aggregates of opaque octahedra. Relicts of dolomite (?) are situated at the centres of some yellow clay masses where opaques do not occur. The serpentine mineral is rather like clay seen in A9535 of previous report on Livingstone Creek rocks (Ref. 1) which was identified as

montmorillonite only. The carbonate associated with serpentine (antigorite) is rubbly, clear and completely anhedral and may be calcite since it effervesces rapidly with a drop of dilute hydrochloric acid.

At the contact of 'opaques in clay' with dolomite is the fine calcite which is the result of breakdown of the dolomite grains with destruction of the hornfels texture. Beyond this is clear hornfelsed dolomite.

Seen in polished section the opaque mineral has an octahedral or hexagonal form, appears yellow-brown but is strongly attracted to a magnet.

No sulphides except for traces of pyrite are present.

An association of magnetite, dolomite, calcite, serpentine (antigorite) and minor montmorillonite. The calcite is probably the product of contact altered dolomite. Later hydration (hydrothermal activity) resulted in the formation of serpentine and montmorillonite from released magnesium products of dolomite. Abundant magnetite present is due to iron enrichment or metasomatism during contact metamorphism to magnetite skarn.

Serpentine, montmorillonite and magnetite were all confirmed by XRD, (Ref. 21).

Dolomite and calcite present were confirmed by carbonate stain technique, (Ref. 6).

A9582, 95 m

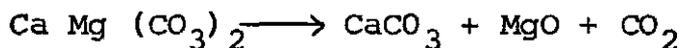
Red dolomite with red clay (?) and chlorite (?).
Check for skarn minerals.

The rock consists mainly of fine granular calcite (proved by staining technique) but patches of relict original (?) dolomite rhombs do occur. Within the calcite are scattered flakes and aggregates of peculiar pale

penninite chlorite (up to 1 x 1 mm) which displays slight oblique extinction, blue grey or anomalous polarisation colours and in places lamellar twinning. Magnetite (euhedral and subhedral, ~ 0.16 mm) and secondary skeletal aggregates (~ 0.7 mm), the latter being now hematite, are probably the decomposition products of a ferruginous skarn mineral. Other shapeless masses in areas several millimetres in extent are probably the result of decomposition of original ankerite before decomposition to calcite.

Crops of idocrase crystals (~ 0.16 x 0.08 mm) occur as length fast prisms having straight extinction, low 1st order grey polarisation colours, are uniaxial negative. Like the chlorite present this mineral occurs sporadically through the section. Idocrase occurs typically in contact metamorphic zones as does penninite and olivine.

The rock, originally impure carbonate (shaley ?) has been subjected to thermal metamorphism under low pressure whereupon the dolomite present dissociates into calcite, periclase and iron oxide.



A scattering of oblong grains (~ 0.03 mm up to 0.08 mm) through the calcite, now containing scaly brucite is likely to be periclase, since altered by hydration.

Penninite, idocrase, periclase and calcite (after ankerite) are all the results of low pressure contact thermal metamorphism of an impure iron-rich dolomite (ankerite). A contact altered shaley (?) dolomite.

The red blotchiness is secondary hematite and is a decomposition product from the original ankerite present.

Chlorite was confirmed by XRD (Ref. 21) because of its peculiar optics.

Calcite was confirmed by a stain procedure.

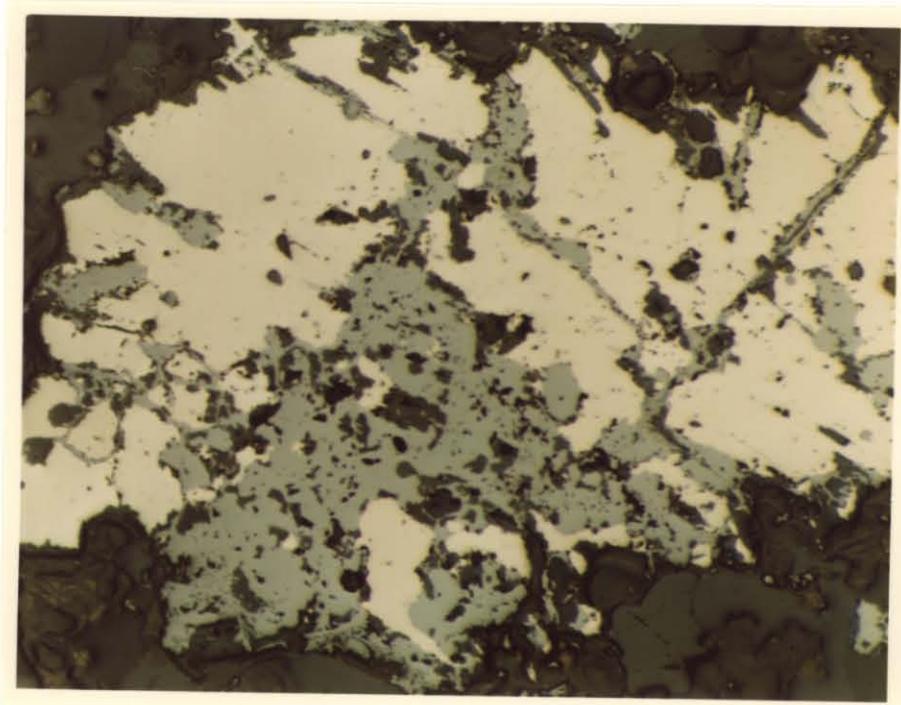


Figure 2

Contact altered dolomite with sulphide and magnetite (DDH4, 100.3m/A9585).

Magnetite (blue-grey) is seen to be replacing pyrrhotite (pink) initially along lattice planes of the sulphide mineral. Dolomite altered to calcite forms the brownish-green background.

Plain light

Magnification X66

A9585, 100.3 m (Figure 2).

Disseminated black and sulphide material in a dark, fine grained grey to black dolomite.

A blotchy black, white and grey rock with abundant sulphide (pyrite ?) associated with the black mineral in channel networks in dolomite.

Mainly, faintly twinned calcite in mosaics with disseminated networks and inclusions of granular forsterite as rounded, rectangular and polygonal granules (0.02 to 0.24 mm, median 0.05 mm). The larger calcite grains show irregular fractures. Granular aggregates of the forsterite are seen to fill calcite grains. Forsterite occurs to about 20 volume percent of the rock. Much of the forsterite fills channels between the calcite grains indicating the rock to be a friable marly carbonate rock, the marl acting as a cement to original dolomite grains. The sulphides occur as small, mainly anhedral granules (0.02 to 0.3 mm) to 5 volume percent of the rock; the sulphides occur intergrown with the forsterite in the channelways.

The rock is a contact-altered impure dolomite to calcite rich hornfels rock. No dolomite showed up in the stain procedure (Ref. 6). The calcite grains do not show the regularity in size and shape of contact-altered recrystallised pure dolomite (A9584).

Single grains of pyrrhotite of anhedral shape (~0.3 mm), veins of magnetite as continuous tiny octahedra (~0.04 mm) and pyrrhotite:magnetite intergrowths (+2 mm) are seen. Magnetite appears to be replacing the pyrrhotite along lattice planes with bulbous extensions into the pyrrhotite groundmass and peripherally around pyrrhotite grains. Much of the pyrrhotite is of similar grain size to the adjoining calcite crystals and obviously was therefore present before contact recrystallisation. Incursion of iron-rich solutions which deposited magnetite has occurred since that time.

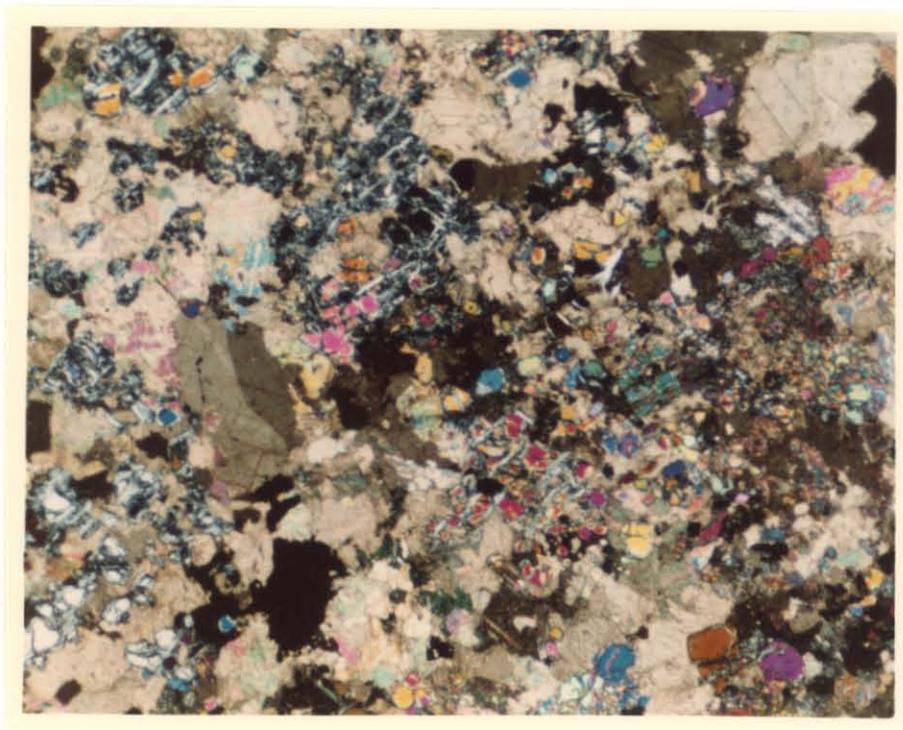


Figure 3

Contact altered dolomite. (DDH4, 124.70m/A9586).

In contact zones such as this, calcite (pale pink and buff) forming from dolomite, forms more irregular crystals with sutured boundaries. Smaller forsterite grains (bright pink, blue, yellow and green) are seen scattered through the rock. Serpentine (grey, white veins) pseudomorphs the forsterite and is seen to be replacing it.

Crossed nicols

Magnification X13

Forsterite is the only calc-silicate mineral present in this section.

A9586, 124.70 m (Figure 3).

Grey dolomite, fairly typical with black and green bands (bedding?). Check for skarn minerals.

Dolomitic, grey rock with green prismatic mineral following 'veins'. A coarser dolomite fabric than that seen for A9585 specimen. Grain size in the dolomite mosaic averages around 0.5 mm. Some grains show incipient alteration to forsterite along cleavages. Limited twinning of dolomite is seen. Large forsterite grains (~1 mm) are seen with irregular cracks filled with chrysotile and with a groundmass containing dolomite relicts. Irregular calcite has formed around groups of forsterite crystals and serpentine after forsterite. Elsewhere, are small (~0.03 mm) scattered forsterite grains, anhedral, of characteristic high relief and high birefringence developing inside large dolomite grains. Again in other parts of the section small and large forsterite grains are riddled with veins of chrysotile or are altered entirely to masses of antigorite veined by chrysotile. The forsterite nature of the olivine is shown by minimal magnetite (~2 volume percent of grains) which has formed after conversion of forsterite to serpentine.

Contact alteration of sedimentary dolomite is followed by hydrothermal alteration of resulting forsterite to serpentine.

No bedding in dolomite is observed but opaque minerals and forsterite grains in marly horizons in the dolomite are, probably also planes of easy access for percolating deuteric solutions.

A9587, 136.85 m

Sulphide and black crystalline mineral (actinolite) in grey dolomite. Bedding?

Grey dolomite with fractures filled with a dark mineral. Pyrite? is seen in one corner of the section.

As for A9586, forsterite with fine calcite, forms as a contact mineral in what appears to be an otherwise pure dolomite. Some forsterite grains are present as euhedral prism phenocrysts (~ 0.3 mm), fine fibrous chrysotile develops first along fractures then whole grains, forms a background of coarse antigorite where entire forsterite grains have been serpentinitised. Several of the 'forsterite' grains are quite yellow and are probably olivine with pleochroism, yellowish green to colourless. Flakey phlogopite develops along cleavages of dolomite, but is scarce. Alteration of dolomite is patchy; generally the formation of forsterite starts in interstices between large dolomite grains (~ 0.5 mm). Irregular calcite forms from altered dolomite. The forsterite grains are small but occasionally whole dolomite grains are replaced by aggregates (~ 0.4 mm) of small forsterite grains and granular calcite leaving some residual dolomite entrapped. More commonly a network of forsterite with optical continuity is established, containing unaltered islands of dolomite. Where masses of colourless forsterite have been serpentinitised the green colour is seen.

As for A9580 the crenulations represent zones of weakness (original impure dolomite sedimentary bands) in an originally bedded dolomite. Some imbricate folding is seen. Mobilisation of dolomite occurs with contact alteration, recrystallisation and penetration by silicate solution adjoining the granite contact.

Dolomite shows granular contact metamorphism but trails of parallel and subparallel fine opaque inclusions and parallelism of dense serpentine and calcite altered horizons of up to 2 mm thick interlaced with alternating layers of more dolomite with some unchanged forsterite bands give the impression of bedding planes.

Contact altered and metasomatised impure sedimentary dolomite.

A9588, 138.70 m

Radiating black mineral (skarn mineral ?) in dolomite.

A black opaque, acicular mineral in stellate groups. Greyish, fine-grain matrix.

An opaque mineral as seen in thin-section which has developed as a contact alteration mineral in coarse dolomite. The opaque mineral is magnetite and the skarn-like texture would suggest the original mineral to be iron metasomatised hedenbergite, a skarn pyroxene (Ref. 5). However, no relict pyroxene cleavage is seen. Montgomery in Waterhouse (Ref. 2) has seen a similar mineral occurrence at neighbouring Mt. Livingstone and he being somewhat puzzled about it thought it was iron metasomatised tourmaline. However, as small granular octahedra of the mineral are seen loosely in places it is suggested that the mineral is probably skarn growths of magnetite.

Metasomatism of the dolomite here preceded contact alteration by the adjoining granite. This resulted in stellate hematite growths replacing dolomite with the presence of abundant iron in metasomatising solutions and at continuing high contact temperature, magnetite replaced the hematite. In places scattered euhedra of magnetite are seen in clusters embedded in dolomite.

At one end of the section diopsidic augite (displaying polysynthetic twinning and with a broad extinction angle $z \wedge c = 30^\circ$) occurs as euhedral and subhedral forms of 0.05 to 1.0 mm, in decussate arrangement embedded in calcite in the interstices. A little forsterite of similar size occurs as well and the two minerals formed at about the same time and are (with calcite) the result of contact alteration of dolomite with a greater abundance of SiO_2 impurity.

An iron rich skarn resulting from metasomatism with contact alteration of an impure dolomite.

A9589, 142 m

Black banded (graphite?, actinolite ?) dolomite-crenulated bedding?

'Dolomite' with laminae of coarse crystallised calcite shows crenulation of black mineral or crumpling flanking both sides of each calcite, lamination. The crenulations are seen only where serpentine is abundant forming a matrix for forsterite grains.

The section shows large numbers of tiny forsterite grains, mainly less than 0.1 mm in size developing along well defined crenulation planes in originally fine dolomite. Coarse calcite laminae, 0.5 to 1.0 mm wide contain little or no forsterite; the calcite grains show lamellar twinning. The calcite and forsterite-rich laminae alternate. A coarse calcite lenticle of several mms. width occurs at the centre of the crenulated mass. The calcite grains (0.1 to 1 mm) of the lenticles are largely clear of forsterite, though there are small pockets of interstitial fine calcite in which small forsterite grains occur.

At the contact of dolomite and forsterite is an orange-brown mineral, pleochroic orange-brown to colourless, traces of phlogopite. Also, nearby is prehnite showing typical bow-tie structure and occurs in the interstices between dolomite grains. A little magnetite occurs in replacement zones between small forsterite grains and dolomite and may be there through the breakdown of ankerite dolomite where forsterite is formed.

It was thought that some dopside also formed in the rock as oblong sections; the mineral appears to have a lower B.R. than forsterite. No cleavage was seen but an apparent wide extinction angle on '100' forms $z^{\wedge}c (>30^{\circ})$. An XRD scan however did not pick up pyroxene and found only forsterite associated with a fine calcite, one of the breakdown products of dolomite during contact alteration.

As for A9587, alternating imbricate bands (0.5 to 2 mm wide) of dolomite and minimal forsterite or none at

all, and fine granular forsterite and calcite; some serpentinitised forsterite laminae with calcite indicate original bedding differences of original dolomite.

4.2 DDH LCD3

A9591, 12.04 m

Laminated and banded, 0.5 mm, quartz-chlorite-sericite-carbonate (?) sediment; brown bands of ? any tuffaceous component?; contact metasomatic minerals.

In thin-section a differentially banded rock of fine grain. Bands contain :-

Poikiloblastic muscovite (~ 0.6 x 0.5 mm) with quartz inclusions, abundant knots of green chlorite blades (interference colours - pale mauve-green); pleochroism, moderate; extinction < 5 degrees; length slow; therefore likely to be penninite. Faintly pleochroic phlogopite, fluffy and prismatic, occurs associated with chlorite. Bands of essentially quartz (~ 0.08 mm), brown biotite and chlorite intergrowth with scattered euhedral and strongly pleochroic brown tourmaline, opaque magnetite, rutile and tiny euhedra of highly birefringent cassiterite (vertically striated prisms, some geniculate twins). The bands are made up of the above minerals in variable and overlapping proportions and with slight differences in median grain size according to each band.

In places, fine intergrowths of brown biotite and chlorite in a background of granular quartz mosaics contain also tiny yellow-brown tourmaline grains, a little cassiterite and apatite.

One other heavy mineral identified is a little sphalerite. The heavy minerals, present to 2 volume percent overall are, tourmaline >> rutile and cassiterite > magnetite, traces of sphalerite.

A hornfelsed, pelitic siltstone that originally contained some carbonate which was subsequently altered to phlogopite. A rock of granular aspect at one end (the biotite end) of section.

Some definite textural and vague mineralogical similarities are seen with A9529 from DDH LCD2 which was however more coarsely crystalline and lacked the micaceous minerals, (muscovite, biotite, chlorite and phlogopite), which were presumably tourmalinised. Tourmalinisation produced a type of fine-grained schorl rock in A9529.

A9592, 14.58 m

Similar to A9591, laminated carbonate? Chloritic sediment, trace of chalcopyrite. Check for hornfelsing, sulphides, cassiterite.

Very similar texturally to A9591 in thin-section. Largely granular quartz; colourless to faintly pleochroic phlogopite; clumps of short chlorite prisms, somewhat bluey-green and moderately pleochroic; a little fine sericite; and some larger poikiloblastic muscovite. Abundant magnetite occurs as anhedral masses (up to 0.5 mm) intergrown with chlorite or as scattered euhedra; all magnetite to 3 volume percent. Short brown tourmaline prisms are less common here to much less than 1 volume percent; and rutile and cassiterite grains to less than 1 volume percent, with geniculate twins of the latter to be seen. Occasional grains of clear brownish sphalerite occur. Pneumatolysed, but not to quite the same extent as A9591. Heavy minerals would not constitute one percent volume of the rock. The occasional equigranular quartz in mosaics with triple junction contacts of grains are the only indications of hornfelsing. Possible later hydrothermal activity has destroyed much of the original hornfels texture as the quartz appears embayed by the mica minerals.

A9593, 17.8 m

Sediment, similar to A9592; quartz, sericite, carbonate, trace of sulphides. Check for hornfelsing, SnO₂, etc.

Texturally similar to A9592, possibly more quartz rich with coarser grain size (maximum 0.6 mm, median 0.15 mm) in bands, which is elsewhere, intimately intergrown with poikiloblastic muscovite. The muscovite occurs abundantly, locally and contains quartz inclusions, with interstitial phlogopite and fine sericite. When not welded into mosaics the quartz is eroded by mainly muscovite. As for A9592 hornfelsing is indicated mainly by textures of quartz mosaics. Blue-green chlorite (green-grey or mauve interference colours) is rather less common than in A9592. Red-brown tourmaline as poikiloblastic grains (~ 0.2 x 0.2 mm) with quartz inclusions and smaller brown pleochroic prisms and brown green lenticular masses are present to about 2 volume percent. Phlogopite is colourless and brown, intergrown with chlorite and some sericite. There is slightly more magnetite here at 2 volume percent than is seen in A9592 and the crystal habit is similar as euhedral and anhedral grains (0.02 to 0.15 mm, median 0.03 mm).

Rutile and cassiterite (including geniculate twin grains) a little schorlite tourmaline (minute stellate groups) and a little sphalerite are seen to less than 1 volume percent of the rock.

The general impression for A9591 to A9593 is that the drill-core shows only slight variations in the hornfels/mineralisation progression.

A pneumatolysed, hornfelsed micaceous siltstone.

A9594, 20.4 m

Sediment as for A9592. Check for progressive increase of hornfels minerals; sulphides, SnO₂.

Similar to A9593 but with more coarse muscovite and some coarse chlorite intergrown with large (~ 0.15 mm) quartz grains in bands. There is segregation into quartzose bands and micaceous bands, (mainly sericite and phlogopite with intermixed much corroded quartz as seen in previous sections of this series). Except in the quartz rich bands, abundant fine sericite and phlogopite intergrowths with appreciable chlorite, occur throughout. Where adjoining quartz grains form triple junction contacts as per hornfels texture; books and sheaves of mica are in decussate arrangement for similar reasons. Quartz and mica in the previous section show more sutured relationships for quartz and less decussate orientation for micas which would suggest a milder hornfelsing influence. No differences in grade of metamorphic minerals are seen. Specimen A9594 is more like A9591 which shows definite hornfels texture since in A9592 the quartz is not equigranular and triple junction textures are not the rule although they do occur in patchy quartz mosaics. Brown tourmaline growths (0.03 to 0.10 mm) occur scattered around the section as irregular knots in lenticles or associated with chlorite to about 1 to 2 volume percent. Magnetite (0.025 mm) as euhedra or anhedral forms, mainly the former occur to less than 1 volume percent. Rutile as minute euhedra and knee-shaped twins (range 0.03 to 0.1 mm) occur scattered through the section to rather more than 1 volume percent. There may be a little cassiterite and sphalerite present and traces of monazite (?) .

A9595, 23.6 m

Sediment as for A9594. Check for any progressive increases of hornfels minerals, sulphides, SnO₂, etc.

Possible lenticles of pyrrhotite are seen on the cut surface of core. Large muscovite flakes are seen on the fractured surface.

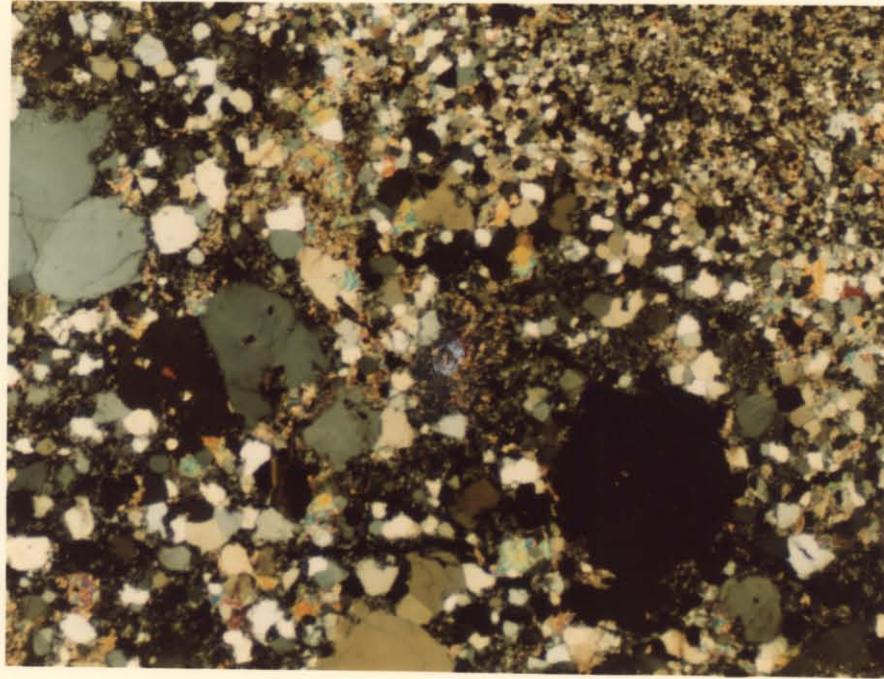


Figure 4

Metasediment/granite contact. (DDH LC3, 26.7m/A9596).

The sediment consists of fine grain granular quartz (white, grey, brown) with interstitial sericite (flakey), upper right.

There is a transition into granite vein of coarse quartz (grey and white) and potash feldspar (grey and white, smaller grains). Muscovite flakes (bright colours) and patchy kaolinite of fine grain flakes (grey and white) also occur in the vein which occupies the left and right bottom part of the photograph.

Crossed nicols

Magnification X14

Very similar to A9594. Scattered quartz grains (0.03 to 0.25 mm, median 0.06 mm) and bands of quartz with triple junction texture and some interstitial sericite. Coarse, (0.3 x 0.15 mm) poikiloblastic muscovite occurs intergrown with some quartz layers and is fairly common.

Shredded, decussate groups of sericite and phlogopite with some pale chlorite clots occur associated with scattered corroded quartz grains and quartz groups occur throughout. Quartz grains in groups are normally joined together by triple junction textures. Brown angular or euhedral, squat grains (0.02 to 0.10 mm) of tourmaline and coarse lenticular brown-green masses of the mineral (several mm's wide) occur along or intergrown with traces of chlorite to about 2 to 3 volume percent. Magnetite (0.01 to 0.05 mm) occurs commonly as euhedra or less so as a secondary segregation with chlorite. Lozenge shaped sphene plus rutile (knee shaped twins 0.003 to 0.10 mm) with minute tourmaline prisms are seen scattered around the section with traces of sphalerite and cassiterite? Massive pyrrhotite is seen associated with quartz and chlorite.

A possible slight increase in metamorphic grade here but pyrrhotite is the only new mineral present. Texturally, little difference from A9594 but hornfelsed quartz mosaics are less continuous with intrusion of coarser muscovite flakes and brown-green tourmaline in lenticles is more common.

A9596, 26.7 m (Figure 4).

3 cm wide granitic veinlet cutting the sediment. Check the composition and contact area for hornfelsing, etc.

Under the low-power stereomicroscope it is seen that the vein which cuts the sediment with a sharp contact is of quartz, kaolinite and tourmaline.

In thin-section the contact between vein and sediment is seen not to be sharp but gradational.

The sediment consists of recrystallised granular quartz (variable to 0.30 mm, median 0.05 mm) with interstitial muscovite, variable in size and unoriented. Abundant sericite occurs, patchy chlorite (penninite), phlogopite and scattered brownish groups of tourmaline needles and larger massive tourmaline sections are seen. Scattered, rutile, small green tourmaline sphene and fine cassiterite and zircon grains are seen to total to 1 volume percent.

The vein has a coarser grain of quartz (up to 0.8 mm) partly in mosaics and somewhat corroded. The interstitial mineral is mainly muscovite, also abundant patchy kaolinite sometimes containing patchy relict potash feldspar. There is an increase in grain size of metasediment minerals adjoining the vein, i.e. a gradational 'contact' occurs. Brown tourmaline as clear prisms and lenticular growths are mainly close to the contact of granite vein and metasediment but occur in both rock types also a little topaz is present. Yellowish brown clay mineral as shreds and fragments are seen altering to chlorite (?) and occurs scattered through the section mainly at interstices of larger minerals. Brownish phlogopite is also seen scattered through the section and is altering to chlorite. Hornfelsing of sediment is showed by fine equigranular quartz in mosaics.

A large grain of topaz and some smaller grains; brown tourmaline near contact and a little sphene is scattered through the granite vein; also some euhedral magnetite (0.02 to 0.08 mm) all total to about 2 volume percent.

Finer cassiterite, sphene, rutile, zircon, topaz, tourmaline and very much finer scattered opaque mineral occurs in the neighbouring metasediment totalling to 2 to 3 volume percent of rock.

A pneumatolysed granite vein is seen to penetrate a micaceous sediment which was being metasomatised by the vein but which also shows evidence of hornfelsing of minerals right up to the vein contact yet no sharp contact is apparent.

A9597, 30.3 m

Sediment as above, hornfelsing? Check sulphide minerals which have increased compared with samples higher up the drill hole. In hand specimen there is an abundance of sulphide (pyrite ?) and of heavy minerals in a fine grained banded sediment.

The thin section shows a rock which is very similar to A9596 with granular hornfelsing quartz of similar size to that seen in A9596 sediment at granite vein/sediment contact with irregular interstitial muscovite including large poikiloblastic plates (0.3 x 0.2 mm) containing quartz inclusions. Patchy chlorite (penninite), the large plates being poikiloblastic with quartz as in muscovite and rare brownish phlogopite.

Locally in intruded granite vein a greater abundance of brown chunky and prismatic tourmaline is seen here (~1 percent) than was seen in A9596 (<1 percent) and a greater abundance of opaque mineral. Coarse clots of tourmaline (each grain, 0.15 mm), coarse penninite, quartz and opaque mineral occur in segregations and associated with a small amount of oligoclase plates and potash feldspar. Elsewhere, the unaltered sediment is very similar to that seen in A9596. No sharp contact between the sediment and vein material is detectable although as for A9596 hornfelsing of sediment is evident. An abundance (~1 volume percent) of fine brown prismatic tourmaline (0.002 to 0.010 mm) is evident. Traces of possible monazite, zircon and rutile are also seen. Larger tourmaline growths around single quartz grains occur, also tourmaline veins to about 2 volume percent. There is no cassiterite present.

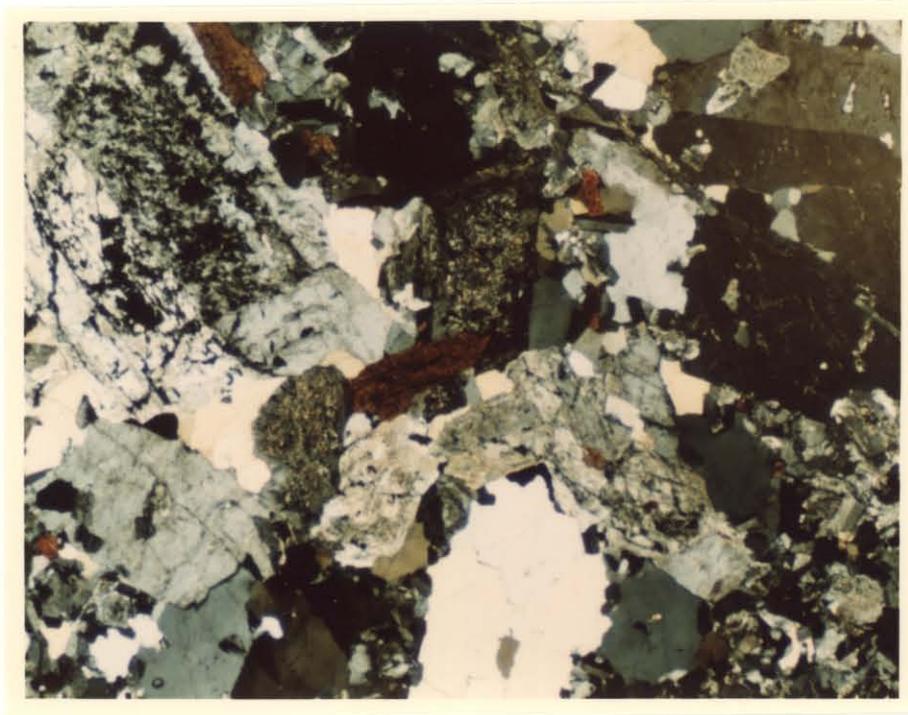


Figure 5

Biotite granite. (DDH LC3, 36.1m/A9598).

Coarse phase of large perthite prisms with part sericitised plagioclase intergrowths (top left corner and centre of photograph); some Carlsbad twins (lower centre). Quartz (irregular, massive; flat grey and white). Biotite (irregular laths; brown specked).

Finer phase of faint twinned plagioclase and Carlsbad twinned orthoclase with some quartz (left and right bottom corners of photograph).

Crossed nicols

Magnification X14

In polished section aggregates of pyrite in masses, several mm's in diameter are seen to occur and small (0.006 to 0.045 mm) rounded or euhedral pyrite grains are scattered through the interstices. Fewer rutile grains are seen of similar size range. The massive pyrite contains scarce inclusions of magnetite (~ 0.030 mm), and is seen to be replacing massive chalcopyrite peripherally. The sulphides appear to be mainly associated with the granite 'veins'.

A9598, 36.1 m (Figure 5).

Granite with fine biotite and yellow altered (clay?) feldspar in contact with a coarser more normal variety. Tourmaline veinlets. Any cassiterite? Any evidence of jarosite in the yellowed feldspar? (SO_4 test ?).

A coarse granite rock of large quartz and perthite prisms. Finer quartz and prismatic feldspar and less plagioclase (0.16 to 0.5 mm) fill spaces between the larger leucocratic minerals. Potash feldspar has Carlsbad twinning and plagioclase has faint albite twinning. Alteration of feldspar is incipient where only plagioclase and perthite grain centres are attacked slightly to form sericite. Rounded quartz grains (0.02 to 0.16 mm) occur as inclusions around margins of perthite grains. Scattered red-brown biotite laths contain radioactive zircon, apatite laths tourmaline and topaz prisms. Bleached biotite which contains sphene is altering to pale green chlorite and sphene along the cleavages.

A green brown massive tourmaline showing no recognisable cleavage is locally evident, intergrown with biotite. Scattered apatite prisms and pyramidal forms are seen enclosed by feldspar. Magnetite is absent.

A potash rich granite with abundant heavy minerals (tourmaline, sphene, topaz, apatite and zircon). The granite shows late stage potash metasomatism of some plagioclase and possible replacement of quartz.

No tin minerals are seen. No evidence of the presence of jarosite. A large (0.8 x 0.3 mm) cross-cutting vein of blue tourmaline is seen intergrown with quartz. The rock resembles granite, A9536 (DDH LCD2, 26.7 m) in its texture.

A calculation of modal composition is difficult because of large differences in mineral grain size but the rock is rather more potassic than the next granite described, A9599.

A9599, 36.9 m

1-3 mm fine-grained biotite-rich variety of granite. Check for jarosite in yellowed feldspar and cracks, SnO₂ etc. Any evidence of absorption of country rock by the granite to give the fine grained biotite variety?

Finer grained groundmass than A9598 but compositionally similar with abundant equigranular potash feldspar, plagioclase and quartz (0.05 to 0.5 mm). Quartz and perthitic potash feldspar occur as large crystals, 2 mm for quartz and up to 10 mm for feldspar. Much of the plagioclase in perthites and elsewhere is showing incipient sericitisation leaving potash feldspar areas clear. Biotite, (iron-rich) is red-brown, altering to chlorite along cleavages and contains radioactive zircon, some topaz, abundant fine lath-like tourmaline, rutile needles and a little apatite. Sphene occurs in bleached biotite present.

Granophyric textures (which are not particularly regular) occur between quartz and potash feldspar and may be evidence of replacement of quartz by late stage orthoclase. As in 9598 this phenomenon is common marginal to large phenocrysts of perthite.

No jarosite and no cassiterite are seen. The rock is finer grained and no so rich in potash feldspar as A9598. No evidence of assimilation of country rock but only of replacement of other minerals by potash feldspar.

The heavy mineral content is high with tourmaline and some topaz, yet fluorite and cassiterite are apparently absent.

Approximate modal mineral composition:-

	<u>Vol %</u>
Potash feldspar	53*
Plagioclase	20
Quartz	20
Biotite	5
Heavy minerals (mainly tourmaline, no magnetite)	2

* Confirmed by stain procedure and includes late stage potash feldspar.

A porphyritic biotite alkaline microgranite.

A9600, 44.5 m

Coarse grained "normal" fresh granite. Some feldspars yellow (jarosite?). Contrast SnO₂ content (if present) with biotite-rich varieties. Other differences.

Rather similar in grain sizes to A9598 but with a greater component of coarser minerals with coarse oblong perthite grains (several mm's) showing sericitisation at centres, or of plagioclase component, and large irregular quartz grains (few mm's). In the groundmass are euhedral plagioclase, An₁₈ (sharp albite twinning and sericitised); euhedral quartz; potash feldspar; and small dark red-brown biotite laths altering to chlorite (1 to 2 volume percent of rock). The biotite is entirely chloritised in places and fresh or chloritised it contains abundant fine prismatic of squat prisms of brownish tourmaline and radioactive zircons. Bleached biotite containing sphene is also seen with prismatic alternating intergrowths of bleached and unaltered biotite. Much tourmaline occurs as veins and intergrowths with feldspar. A little topaz is also seen associated with feldspar. Some very fine granular cassiterite may be present as fine exsolution material along biotite cleavages with the sphene.

Coarse muscovite is seen to be growing and replacing plagioclase. No muscovite was seen in the previous granite specimens, only very fine sericite. Also vermicular quartz occurs in abundance as small rounded grains regularly distributed at margins of perthite adjoining interstitial quartz grains; again there are areas of quartz (a series of rounded inclusions in potash feldspar) of granophyric aspect but probably replacement relicts of quartz left in potash feldspar after replacement. In the stained section, potash feldspar occurs to more than 50 volume percent of the section, probably close to 61 volume percent, with about 20 volume percent quartz; biotite with chlorite 2 volume percent; plagioclase 15 volume percent; and heavy minerals (mainly tourmaline) 2 volume percent.

Greater potash metasomatism and deuteric alteration generally is seen than for other granites in the drill-hole which have been examined so far.

No jarosite is seen.

4.3 Additional notes answering queries with reference to Report PMR 50/74 of heavily weathered altered rocks in DDH LCD2.

A9530, 5.7 m

Radial prisms of opaque minerals of originally hematite reduced by contact metamorphism to mainly magnetite but now mainly reoxidised by weathering to goethite with relict secondary titano-hematite and magnetite. Texturally very similar to DDH SRD4, 138.7 m which is very much fresher. Montmorillonite occurs in the interstices. Probably iron metasomatised dolomite and much of replacement titanohematite was subsequently reduced to titanomagnetite during contact metamorphism since relict patches of grey magnetite are seen at centres of hematite laths. A contact alteration effect of dolomite coupled with iron metasomatism.

A9532, 12.9 m

Skarn or igneous rock?

No further evidence is gathered from textures in this heavily weathered rock but in view of rocks identified in examination of neighbouring fresher core (DDH SRD4, 138.70 m) the rock may be a dolomite which has been subjected to iron metasomatism to form hematite blades replacing dolomite. This is followed by contact alteration to reduce the hematite to magnetite which has since weathered somewhat to limonite. The rock is still however, somewhat magnetic. Serpentine and montmorillonite minerals occur in the matrix presumably contact metamorphic and weathering products after dolomite.

A9533, 13. 6 m

Comparing with A9601, Red Chert (Renison Mine) the two specimens are very similar in having very fine quartz intergrowths, though the weathered specimen A9533, is also somewhat fibrous and chalcedonic in appearance and contact metamorphic triple junctions of fine quartz mosaics are absent. Both specimens contain a high iron content present as hematite granules (Renison), limonite granules and staining (A9533). Quartz veining occurs in both specimens. Differentiated fine and relatively coarse patchiness of quartz grains is characteristic of both specimens.

There are no iron-oxide/carbonate veins in A9533. It may well be that the textures seen in A9533 represent those of the chert marker as would have been seen at Renison before contact alteration. There are marked resemblances in textural forms and mineralogy to A9514 from Capertee (Ref. 4) which was described as an altered rhyolite tuffite. There is however, an apparent absence of mica/clay mineral from A9533.



Figure 6

Red chert (Renison Bell) with cross-cutting vein (A9601).

Black and white, fine cherty rock containing fine scattered hematite is cross-cut by even vein of mainly carbonate but including some quartz segregations (flat grey and white). A carbonate segregation occurs in chert (right, bottom corner).

Crossed nicols

Magnification X90

A9535, 18.3 m

Some resemblance to A9579 in texture. It is possible that brown pseudomorphs showing rhombohedral cleavage are altered pseudomorphed recrystallised dolomite (contact altered) and some of the smaller elong grains are replaced forsterite. The fibrous mineral in the interstices could be serpentine. A possible contact altered then part metasomatised dolomite which contained sulphide originally. Now much altered by weathering. The low nickel content (< 0.01 percent, Ref. 19) would agree with the rock being a metasomatised dolomite, and not an altered ultramafic.

4.4 Specimens from Renison Bell Mine

A9601 - Red chert. Deep red jasper-like rock (Figure 6).

A very fine, (grains range from 0.005 to 0.025 mm, median 0.012 mm) cherty quartzite, the grains being welded into fine mosaics. Very fine hematite flakes ($\sim 1\mu$) occur as clots of grains or lenticles bordering quartz veins or scattered grains; pseudomorphs of sulphide (pyrite euhedra, to 0.16 mm) in carbonate veins; all occur to about 10 volume percent of the rock. Veins of clear secondary quartz are seen (up to 2.0 mm thick but very variable) of equally variable grain size varying (0.015 to 0.10 mm) cut across fine cherty quartz in unoriented fashion. The thicker veins have a coarser quartz core. Fine carbonate veins, fewer than for quartz, with biotite and a little green chlorite cut across the quartz veins.

There is no concrete evidence that this rock is a silicified volcanic rock; though the abundance of iron and presence of some chlorite are very fragile evidence. Some resemblance to silicified rhyolite tuffites from Capertee is noted, (Ref. 4).

A possible silicified acid volcanic rock.

A9602 - 'Red chert'. Renison dark grey to black chert with reddish tinge and pale bands.

An even banded rock of fine cherty quartz ($< 5 \mu$), coarser detrital quartz (~ 0.015 mm), biotite flecks (variable 0.003 to 0.08 mm), detrital muscovite ($\sim 0.05 \times 0.02$ mm) flakes, opaque minerals (0.008 to 0.05 mm), also a little rough looking highly birefringent unidentifiable heavy mineral. Banding is due to very fine biotite with chert and is distinct from coarser biotite with chert and detrital quartz; also a limonite, quartz and biotite association. Rhythmic fine above coarse banding is seen. Not possible to give a modal analysis of the rock because of the variation in mineral content between bands but detrital quartz varies to 30 volume percent, biotite to 15 volume percent. Cassiterite is present to less than 1 volume percent and all heavy mineral (mainly magnetite grains) to about 2 volume percent.

An altered marly shale rock with some rhythmic shale and fine siltstone sequences. Except for fine chert, biotite bands scattered detrital quartz grains occur throughout. A possible contact metamorphosed lagoonal deposit.

A9603 - Black sediment with sulphide bands in core from Renison Bell Mine underground.

A fine grained rock which shows a very rough uneven banding indicated by a variation in density of fine opaque minerals and biotite.

Much of the rock consists of detrital rounded to subangular quartz grains up to 0.6 mm, chlorite (grey-green P.C.'s) probably prochlorite, and brown biotite in that order of abundance. The chlorite and biotite are ragged in appearance and rarely exceed 0.03 mm in size. Masses of opaque minerals (to several millimetres in size) are associated with brown biotite and cross-cut the 'bedding'

as do separately, veins of quartz (grain size to 1 mm). Abundant sphene is associated with opaque minerals and also as anhedral granules throughout. The biotite takes on a pale phlogopitic aspect in bands where chlorite is not so evident.

Polished section shows that aggregates of pyrrhotite grains form veins and segregations in the rock. Islands of pale yellow pyrite (0.04 to 0.20 mm) occur within or form an interrupted periphery to the pyrrhotite vein. The pyrite occurs as mainly euhedral forms. The pyrrhotite contains as inclusions, rare euhedra (prisms, 0.015 x .006 mm) of cassiterite and a little mutually intergrown chalcopyrite. However, more than 99 volume percent of sulphide present is pyrrhotite.

Probable water-clear albite associated with the quartz is indicated by pink staining of granular mineral by Amaranth technique (Ref. 22). Test for potash feldspar (Ref. 22) was negative.

The chloritic, albitic nature of this rock and abundance of opaque minerals suggests the incorporation of some igneous material by banded pelitic or marly siltstone. The pyrrhotite by its irregular form and patchy appearance with other sulphides and cassiterite were introduced later than the sedimentation epoch.

A9604 - Sulphides from Howard's Lode, Renison Bell.

A mass of pyrrhotite grains showing well defined triple junction textures but varying in grain size from 0.008 to 0.5 mm. Wedges of arsenopyrite (to 0.6 mm) are seen and these contain inclusions of gangue and exsolved iron, present as pyrrhotite. Cassiterite euhedra and irregular masses occur which are intergrown with pyrrhotite. Traces of wolframite are seen to be associated with cassiterite.

Supposed paragenesis :-

cassiterite → wolframite → arsenopyrite → pyrrhotite

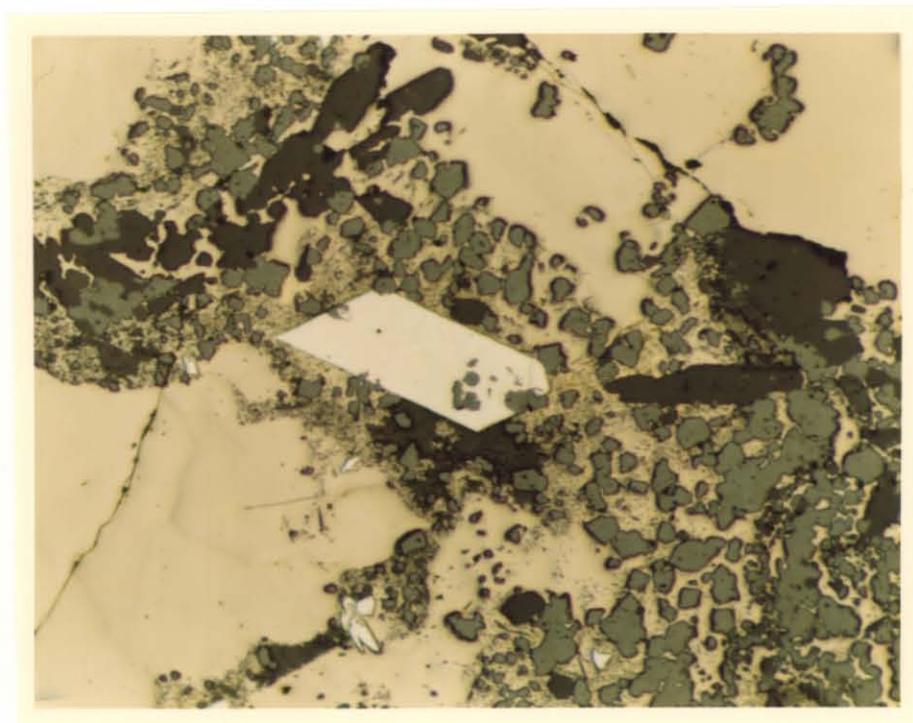


Figure 7

Penzance Lode Sulphides (Renison Bell)

Background of pink-yellow massive pyrrhotite containing inclusions of wedge-shaped arsenopyrite (flat-white) and abundant cassiterite forms (dark grey).

Plain light

Magnification X65

A9605 - Penzance Lode sulphides (1,000 ft. deep).
(Figure 7).

Massive pyrrhotite, large grains (to 1 mm), twinned, contains numerous euhedra of cassiterite grains (0.009 to 0.018 mm), some wedge shaped, white and strongly anisotropic arsenopyrite (~ 0.08 x 0.06 mm) with possible abundant fine prismatic tourmaline in clusters, mainly marginal to sulphide mass (pyrrhotite and chalcopyrite). Chalcopyrite (0.04 x 0.04 to 0.09 x 0.09 mm) occurs as relatively large crystals mutually intergrown with pyrrhotite.

A little stannite as single grains or groups of euhedra occur in pyrrhotite associated with cassiterite.

Abundance

pyrrhotite > chalcopyrite > cassiterite > arsenopyrite

In thin-section, between opaque sulphide minerals is seen euhedral quartz containing fibrous tourmaline and groups of highly birefringent combined prisms and pyramid forms of cassiterite; also present are sections of apatite and a little carbonate and chlorite.

A9606 - Sulphide lode material, (location unknown).

Coarse pyrrhotite with interlocking smaller grains. Quite large (0.05 to 0.30 mm), euhedral groups (pyramids and short prism faces) of cassiterite are embedded in the pyrrhotite; smaller groups of cassiterite crystals also occur in gangue crystals. A little chalcopyrite occurs marginal to the pyrrhotite mass; along fractures in pyrrhotite and along fractures in gangue minerals, in fine fractures in cassiterite; and the chalcopyrite contains minute inclusions of pyrrhotite. Quartz as euhedra (0.60 to 0.80 mm) occur embedded in pyrrhotite, also in pyrrhotite are what appears to be tourmaline.

Abundance

pyrrhotite > cassiterite > chalcopyrite

Possible Paragenesis

Quartz → cassiterite → tourmaline → pyrrhotite → chalcopyrite

Thin-section. Abundant coarse euhedral quartz occurs between the sulphide grains and these contain groups of cassiterite in combined prism and pyramid forms. Smaller lath-like inclusions of sericite and some carbonate also occurs as inclusions in the sulphide, part of the carbonate occurring as a selvage between quartz and sulphide. Inclusions and veins of ragged brown biotite and fine scattered opaque matter occur in the large quartz grains of no crystalline form. Groups of large euhedral cassiterite forms (~ 0.2 mm) occurs in one corner of the massive sulphide and as neighbouring inclusions in massive quartz.

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