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Mineralogy and petrography of some rocks from the Glovers Bluff/Weld River area

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Abstract

A large number of rocks from the Glovers Bluff/Weld River area were examined petrographically and mineralogically. The major rock groupings identified in this study are Precambrian dolomite, Cambrian ultrabasic-derived sedimentary rocks, lamprophyres (Devonian or Cretaceous?), Jurassic dolerite, a range of marbles, calc-silicate hornfels and skarns (including ophicalcites: calcite-serpentine rocks), various cherts and siliceous breccias. Some miscellaneous rock types include opal, gossans, a feldspathic phyllite and a Permian hornfelsed fossiliferous mudstone. The calcareous rocks appear to be derived mostly by the metamorphism, intensive brecciation and metasomatism of Precambrian dolomite, perhaps related to the intrusion of Jurassic dolerite or an unexposed intrusive body. The siliceous skarns appear to have been derived from Ca-metasomatism of siliceous breccias which form in the dolomite, and contain several rare minerals, e.g. xonotlite and scawtite. Over fifty different mineral species have been recorded from the site, some rather rare, making it one of the most mineralogically complex deposits in Tasmania.

There is some minor Zn-Pb-Ni-Cu-Fe sulphide and arsenide mineralisation in the xonotlite and serpentine-rich rocks, which again may be related to the intrusion of the dolerite or a hidden intrusive body. Gold has been observed as one grain (<2 m), with magnetite, protographite, andradite, sphalerite and other sulphides in a serpentinised brucite marble.

INTRODUCTION

Present work

This report is an interim assessment of the nature of some rocks collected in the Glovers Bluff/Weld River area of southwest Tasmania, with a brief assessment of their likely origin and the nature of their mineralisation. Future work will concentrate on integrating this work with ongoing mapping and geochemistry, to resolve many outstanding questions.

A total of 132 rock samples collected by R. Bottrill, the late Mr Mac Forster, and others working in the Glovers Bluff/Weld River area, were submitted for petrographic description and interpretation. Many samples were from two diamond-drill holes located in the area. The samples were variously examined by thin and polished section microscopy, x-ray diffraction (XRD), and electron microprobe analysis. The samples are described in their major groupings, and their origins are briefly described in the final section of this report.

The sample details are provided in Appendix 1. Some of the samples were taken from diamond-drill holes South Weld DDH 1 and 2. Logs of these holes are provided in Appendices 2 and 3.

Previous work

The early exploration of the area is described by Summons (1985) and is summarised below.

The earliest known prospecting in the area was in 1890, when a Gold Reward Claim was granted in the Mt Weld area (perhaps at Reward Claim Creek, north of Mt Weld), and gold was reported in the bed of the river itself (*Cyclopaedia of Tasmania*, 1900). In 1917 a reward lease for nickel and cobalt was granted as ML7275M, north of the Weld River and immediately east of Hogsback Hill. Two small shafts were sunk. An article in the *Huon Times* (4 November 1921) considered this prospect would be payable with facilities, and also referred to the presence of "big" deposits of iron and "proven" scheelite in the area. No production was recorded and the lease expired in 1928.

A reward lease was granted in 1926 for osmiridium, during the osmiridium boom, on the south bank of the Weld River. Workings in the area, presumably resulting from the above activities, consist of several shallow shafts and pits. An adit was also driven in the south end of Hogsback Hill (on the north bank), and Summons (1985) considered this to be for gold. A sluiced creek just east of the adit may also have been worked at this time.

Mac Forster, a part-time prospector, applied for two Special Prospecting Licences in the area in 1968, during the 'nickel boom'. A road was constructed into the then relatively inaccessible area, but little other work was done. Due to inactivity the Special Prospecting Licence lapsed.

Inland Exploration NL took out an exploration licence covering the area in 1970 and F.K.H. Scheppein took out two mining leases in the area in 1970 and 1971 to explore for marble, but apparently little work was done and no success was reported for any of these exploration programmes.

Mac Forster applied for a new SPL and four mining leases in the area in the 1970s, to explore the silica prospects on the lease. The leases were joint ventured with Consolidated Goldfields of Australia (later Kemmerton Pty Ltd, who ran the Electrona Carbide Works). A moderate amount of exploration and drilling was conducted, but none of the silica resources identified proved suitable for exploitation.

The Broken Hill Proprietary Company , through its subsidiary Tasmanian Electro Metallurgical

Company (TEMCO), entered an option agreement in 1980 and drilled six cored holes in the Glovers Bluff silica deposit. The agreement was terminated in 1982.

The Kaiser Chemical Corporation of Australia and Pioneer Concrete Services Ltd joint ventured the Glovers Bluff mining lease, plus the Bernard Spur and Camels Back mining leases north of the Weld River, in 1982. Kaiser's options were taken over by Pechiney Australia Ltd in 1985. Pioneer and Pechiney conducted considerable drilling, analyses, and detailed feasibility studies for silicon production.

The area is presently covered by EL11/84, originally held by Mac Forster's North West Bay Company, but joint ventured with various other companies, including Pioneer, Pechiney, Pegasus Gold Australia Ltd, Metals Exploration Pty Ltd, and Sedimentary Holdings NL. The EL has been explored for various commodities, including silica, talc, platinoids, chromite, nickel, gold, jade and marble (Summons, 1985; Carthew *et al.*, 1988). Work conducted to date has included numerous reverse-circulation drill holes and two diamond-drill holes. Some significant gold intersections (including 11 m @ 3 g/t Au) have recently been reported during a current phase of exploration by Sedimentary Holdings NL, which has termed the area the Forster Prospect in memory of Mac Forster. A low-grade resource of 1.14 million tonnes @ 0.45 g/t Au was recently delineated from twenty drill holes (Sedimentary Holdings, 1996).

The only mineral production recorded from the vicinity was a small amount of silica from Glovers Bluff, which was used for trials in the now defunct Electrona silicon works.

GENERAL GEOLOGY

The geology of the area is complex and poorly known, but is currently being mapped by the Geological Survey of Tasmania. Some detailed local mapping has been conducted by Summons (1985) and Metals Exploration Pty Ltd (Carthew *et al.*, 1988).

The oldest units are Precambrian quartzite and dolomite of the Jubilee block. Some mudstone, greywacke and conglomerate units have been considered to be Cambrian in age and part of the Adamsfield Trough (Carthew *et al.*, 1988; C. Calver, pers. comm.). Some of the dolerite is of Jurassic age, but the age of the other igneous rocks is uncertain.

Little scientific work has been conducted on the ore geology, although Taheri (1990) conducted some petrographic, oxygen isotope, clay mineralogy and fluid inclusion studies on some samples from the area.

DESCRIPTIONS

The major rock groupings identified in this study are, from oldest to youngest:

1. Precambrian dolomite;
2. Cambrian? talc amphibole-rich clastic rocks, ranging from amphibolitic greywacke and conglomerate to talc-rich mylonite and breccia;
3. Devonian or Cretaceous? hornblende-rich lamprophyre;
4. Chert and siliceous breccia, derived variously from dolomite, ultrabasic rocks and siliciclastic mudstone;
5. Jurassic dolerite, some metasomatically highly altered;
6. A range of calc-silicate hornfels and skarns (including brucite marble, diopside hornfels, ophicalcite, calcite-serpentine rocks, and quartz-xonotlite ($Ca_6Si_6O_{17}(OH)_2$)-bearing rocks), probably derived from the dolomite;
7. Opal; and
8. Some miscellaneous rock types.

Dolomite

Six samples of dolomite have been described. One (G400240) was analysed for major elements (Table 1) and four were examined in thin section and by x-ray diffraction (XRD). The samples were all white, massive and fine to medium grained, and all were composed of almost pure dolomite, of sedimentary origin, with very minor metasomatic alteration and rare quartz grains, serpentine and brucite.

Sample G400238 consists of very fine mesocrystalline (~0.05–0.1 mm) massive, sparry carbonate, with some rare carbonate veinlets but no evidence for layering or other inhomogeneities. XRD indicates only dolomite.

Sample G400240 exhibits a very fine mesocrystalline grain size (~0.05–0.1 mm) with little evidence for layering or other inhomogeneities, except for some small augen structures (<2 mm diameter, ~0.2 mm grain size). There are some small rare blebs and contorted streaks (up to 0.5 mm thick) of serpentine, indicating some silica metasomatism. XRD indicates only dolomite.

Sample C107644 (fine-grained white dolomite) exhibits abundant angular to rounded clasts, some resembling oolites, of micritic dolomite (<1 mm diameter, <10 m grain size), in a fine to medium-grained matrix (<0.1 mm grain size). In some rare clasts there are small granular blebs and patches (<1 mm across) of serpentine containing minor brucite (pseudomorphs after forsterite?, see discussion), indicating that some silica was present

and that the rock has undergone metamorphism and metasomatism. XRD indicates dolomite with traces (<1%) of clays (smectite and illite) and (?)talc. The rock is a dolomite breccia.

Sample S371 (fine-grained white dolomite) exhibits abundant angular to rounded clasts, some probably oolites, of micritic dolomite (<1 mm diameter, <10 m grain size), in a fine mesocrystalline sparry matrix (<0.1 mm grain size). In some rare clasts there are small granular blebs and patches (<0.4 mm across) of serpentine (pseudomorphs after forsterite?), indicating that some silica was present, and that the rock has undergone metamorphism and metasomatism. There are also rare quartz grains (<0.3 mm) and minor dolomite veining, which may be related to the serpentine in origin.

Table 1

XRF major and trace element analyses, Weld River

Anal. No.	861804	861805	861806	861807	861808
Description	chert	skarn	ophicalcite	dolomite	chert
Reg. No.	G400235	G400238	G400239	G400240	G400243
SiO_2	99.51	53.52	30.71	3.19	98.31
TiO_2	<0.01	<0.01	<0.01	<0.01	<0.01
Al_2O_3	0.18	0.07	0.03	0.25	0.07
Fe_2O_3	0.19	0.08	1.24	0.07	0.28
FeO	<0.05	<0.05	<0.05	<0.05	0.23
MgO	<0.02	15.73	26.65	20.45	0.21
MnO	<0.01	<0.01	0.02	<0.01	<0.01
CaO	0.04	27.96	18.59	31.23	0.61
Na_2O	0.03	<0.01	<0.01	<0.01	<0.01
K_2O	<0.01	<0.01	<0.01	<0.01	<0.01
P_2O_5	<0.01	0.14	0.11	0.22	<0.01
H_2O^+	0.05	0.52	8.94	1.00	0.30
CO_2	0.14	1.12	14.00	42.70	0.78
S	<0.05	<0.05	<0.05	<0.05	<0.05
Total	100.14	99.14	100.29	99.11	100.79
Trace elements					
Ag	<5	<5	<5	5	<5
As	<10	<10	<10	<10	<10
Bi	9	<5	7	6	9
Cd	4	<4	<4	<4	<4
Ce	15	14	<6	<6	30
Co	5	<4	<4	<4	<4
Cr	86	29	15	17	220
In	<3	<3	3	<3	<3
La	<6	<6	<6	<6	<6
Mo	7	6	6	6	9
Nb	<3	<3	<3	<3	<3
Nd	16	16	<9	11	20
Ni	7	<3	<3	<3	8
Pb	38	23	12	13	40
Rb	10	21	15	19	9
Sb	10	<4	<4	<4	<18
Sc	<10	<10	<10	<10	<10
Sn	<4	<4	5	<4	<4
Sr	4	35	62	64	4
Th	<4	<4	<4	<4	<4
U	<5	<5	<5	<5	<5
V	<3	<3	3	<3	5
W	<9	<9	<9	<9	<9
Y	<2	<2	<2	<2	<2
Zn	69	28	17	25	58
Zr	<2	<2	2	2	<2

Talc-amphibole rocks

Fourteen of these rocks were collected; seven were studied in thin section and ten by XRD. They are a variable group of ultramafic-derived rocks, varying from amphibolitic greywacke to talc-amphibole conglomerate and breccia, to talc mylonite. Most contain chromite and magnetite, some in heavy-mineral layers. Lamination, where present, is disrupted and irregular, and the rocks mostly appear poorly sorted (e.g. pebbles in the greywacke and matrix-supported rudites). They are probably derived from Cambrian intrusive rocks, but are highly tectonised and metasomatised.

Sample C102098 is a fine-grained, grey, talcose, phyllitic rock with a moderate cleavage. In thin section it is dominantly fine-grained talc (~95%, <0.2 mm), with ~2% irregular, angular spots of (?)serpentine (<0.5 mm), ~2% disseminated and vein (?)kaolinite (<0.1 mm), traces of fine-grained, disseminated magnetite and hematite (<20 m), and traces of coarser-grained, brecciated chromite (<1 mm). The texture is mylonitic, with lenticular/lamellar texture. Pressure shadows about chromite contain some green chlorite and smectite(?). There are some fine siderite talc veinlets. The rock is a mylonite of ultramafic origin, but its precise precursor is unknown.

Sample G402038 is a mottled red-black, matrix-supported breccia or conglomerate with angular and rounded clasts <40 mm in size and a weak cleavage. XRD indicates that the rock is composed principally of talc, with hematite, chlorite and calcite. In thin section it is composed of angular to rounded clasts in a talc-calcite-chlorite matrix. The clasts are composed of talc, chlorite and hematite, of uncertain origin, and are slightly heterogeneous in texture (i.e. clasts have undergone some transport and mixing). There are minor veinlets of talc and calcite. The rock is a talc-hematite-chlorite altered ultramafic conglomerate, but its precise origin is unknown.

Sample G402137 is a mottled red-black massive phyllitic rock with a moderate cleavage. In thin section it is dominantly fine-grained talc (~95%), with regular hematite-rich lamellae or veinlets and spots (<0.5 mm) and traces of fine-grained, disseminated magnetite (<0.5 mm). The talc is fine to coarse grained and crenulated; the texture is more schistose than mylonitic. XRD indicates talc, hematite and kaolinite. The rock is a talc phyllite of ultramafic origin, but its precise precursor is unknown.

Sample G402138 is a pale grey, finely arenaceous, phyllitic rock in hand specimen, with irregular, disrupted heavy mineral-rich laminae. In thin section it contains amphibole porphyroblasts or crystal fragments (~20%), amphibole talc magnetite clasts (~20%), serpentine clots (~5%), and crystals and shards of magnetite (~10%) and chromite (~5%) in a fine-grained talc-amphibole-

clay matrix. Magnetite and chromite are largely concentrated in layers, but these are disrupted by talc-tremolite veining. There are rounded structures <10 mm, with the same mineralogy as the matrix, which could be pebbles. There is minor hematitic alteration of the oxides. XRD indicates amphibole, talc, smectite and kaolinite. The rock is of ultramafic-derived greywacke.

Sample G402139 is a pale grey, finely arenaceous rock with some rare rounded pebbles <30 mm (i.e. a diamictite). There are some disrupted heavy mineral-rich laminae. In thin section the rock contains amphibole porphyroblasts or crystal fragments (~10%), amphibole talc magnetite clasts (~20%), and crystals and shards of magnetite (~5%) and chromite (~5%) in a fine-grained talc-amphibole matrix. One large altered, rounded clast (~20 mm) resembles a dolerite in texture. Magnetite and chromite are mainly concentrated in layers. There is minor hematitic alteration of the oxides, and some talc-amphibole-serpentine veins disrupt the layering. Microprobe analysis indicates that the amphiboles vary from magnesio-hornblende to tremolite in composition, and the chromite includes magnesiochromite (Table 2). XRD confirms amphibole, talc and spinels. The rock is an ultramafic-derived greywacke.

Sample G402140 is a mid-grey, coarse-grained mafic igneous rock, with a grain size of about 15 mm. It contains tremolite (~55%, 0.01–10 mm), talc (~40%, 0.01–10 mm, partly replacing tremolite?), smectite (~5%, patches and veins), hematite (trace, fine grained, disseminated), magnetite (trace, <0.4 mm), and trace patches of serpentine and kaolinite. XRD confirms amphibole, talc, smectite and kaolinite. The rock is probably an altered Cambrian pyroxenite, probably originally containing orthopyroxene, clinopyroxene and minor feldspar.

Sample G402148 is a black to pale green phyllitic rock with buff coloured veins. XRD indicates talc, magnetite and calcite. The rock is a talc phyllite of ultramafic origin.

Sample G402214 is a waterworn rock, consisting of pale grey to buff coloured phyllitic, matrix-supported conglomerate or breccia, with rounded and angular clasts to ~10 mm and white veins. In thin section it contains amphibole porphyroblasts or crystal fragments (~50%), talc clasts (~10%), and crystals and shards of magnetite and chromite (~5%) in a fine-grained talc-rich matrix. Abundant serpentine veins (~25%) anastomose and replace clasts. The rock is an ultramafic-derived conglomerate.

Sample G402437 is a mottled red and dark grey, massive phyllitic rock with white coloured veins. XRD indicated talc and hematite. The rock is a talc phyllite of ultramafic origin.

Sample G402438 is a dark grey, massive phyllitic rock with brown clasts (<15 mm) and buff coloured veins. XRD indicated talc, chlorite and hematite. The rock is a talc phyllite of ultramafic origin.

Sample G402439 is a mottled red and white phyllitic conglomerate or breccia with angular and rounded clasts to ~40 mm. XRD indicated talc, kaolinite and hematite. The rock is a conglomerate of ultramafic origin.

Sample G402441 is a pale khaki colour, with a matrix-supported conglomerate/breccia texture and a moderate cleavage. XRD indicates smectite, amphibole, plagioclase and talc. The rock is probably an altered conglomerate derived from basic and ultrabasic rocks.

Sample G402448 is identical to the above sample.

Sample WR67 is a matrix-supported conglomerate or breccia, with very fine-grained, massive, dark grey, rounded and angular clasts (<1–30 mm) in a white fine-grained matrix. There are clasts of talc serpentine (~0.1–20 mm) in a matrix of fine-grained calcite (~25%). The larger clasts are predominantly talc (~55% overall) with serpentine rims, but the smaller clasts are wholly serpentinised (~20% overall). The clasts are mesh-textured, sheared, and carbonate veined. They also contain coarse chromite (<0.5 mm) and fine-grained magnetite (<0.1 mm, particularly in rims). Some give evidence of relatively coarse olivine(?) (<5 mm) replaced by talc. XRD indicates talc, serpentine, and minor chlorite, clinopyroxene, calcite, amphibole and smectite(?). The rock is a highly sheared and metasomatised ultrabasic conglomerate, and the high carbonate content may reflect proximity to altered dolomite.

Hornblende-rich igneous rocks

Six of these rocks were collected; five were studied by thin section and four by XRD. These samples are moderately altered, fine to coarse-grained basic igneous rocks which range from basalt to dolerite and gabbro. They originally contained variable amounts of plagioclase, hornblende, clinopyroxene, olivine(?), biotite and iron-titanium oxides. They have been variably to highly metasomatised to assemblages including tremolite-actinolite, chlorite, epidote-clinozoisite, sericite and serpentine. These rocks could be described as lamprophyres (spessartites). The results of some whole-rock analyses are awaited to fully describe these rocks.

Sample C107639 is an altered mafic igneous rock which is dark grey in hand specimen. It originally contained plagioclase (~40%), hornblende (~40%), clinopyroxene (~10%) and olivine(?) (~5%), with minor Fe-Ti oxides. The original texture was doleritic, with a medium grain size (~1–2 mm) and there is a suggestion of crystal-settling layering. Olivine and clinopyroxene are slightly coarser than other constituents. Some of the minerals and groundmass have been hydrothermally altered, probably pneumatolytically rather than by

metamorphism, as the rock lacks any grain orientation fabric. The plagioclase has been altered to albite, sericite and possibly kaolinite. The hornblende is brown, euhedral, with pale green tremolite-actinolite overgrowths. Olivine(?) is almost totally altered to mixtures of chlorite and smectite(?). Fine-grained chlorite (amphibole(?) leucoxene) patches are probably pseudomorphs after clinopyroxene. There is also some interstitial chlorite, serpentine and actinolite. The rock is an altered doleritic lamprophyre (spessartite).

Sample G400337 is an altered mafic igneous rock, dark grey in hand specimen. The original texture was doleritic, with a fine to medium grain size from ~0.5 to 4 mm. Some of the minerals and groundmass have been hydrothermally altered, probably pneumatolytically rather than by metamorphism, as the rock lacks any grain orientation fabric. It originally contained plagioclase (~25%), hornblende (~25%), clinopyroxene (~20%) and olivine(?) (~15%), biotite (~10%), unidentified groundmass (~10%) with minor Fe-Ti oxides, apatite and sphene. The plagioclase has been altered to albite, sericite, clinozoisite, chlorite and possibly kaolinite. The hornblende is brown and euhedral, with pale green tremolite-actinolite overgrowths. Clinopyroxene is totally altered to mixtures of chlorite, leucoxene and actinolite. Fine grained chlorite smectite patches are probably pseudomorphs after olivine. There is also some interstitial chlorite and actinolite. The rock is an altered doleritic lamprophyre (spessartite).

Sample G402039 is an altered mafic igneous rock, dark grey in hand specimen. The original texture was doleritic, slightly porphyritic, with a fine to medium groundmass, ~0.3–0.8 mm and phenocrysts <2 mm. Some of the minerals and groundmass have been hydrothermally altered, probably pneumatolytically rather than by metamorphism, as the rock lacks any grain orientation fabric. It originally contained plagioclase (~35%), hornblende (~40%), clinopyroxene (~10%), olivine (~10%) and <5% pyrite, apatite, magnetite, rutile and chalcopyrite. The plagioclase has been altered to albite and sericite. The hornblende is red-brown (titaniferous), euhedral, with pale green tremolite-actinolite overgrowths. Fine-grained chlorite-serpentine-leucoxene patches are probably pseudomorphs after clinopyroxenes (with rare relicts) and olivine. XRD confirms amphibole, chlorite, plagioclase and minor mica. The rock is an altered doleritic lamprophyre (spessartite).

Sample G402040 is an altered mafic igneous rock, dark grey in hand specimen. The original texture was doleritic, with a grain size ~0.5–4 mm. There is some lamination (mafic-rich layers) and spherical structures (?amygdules, <2 mm, with zeolites, carbonate and pumpellyite?). Some of the minerals and groundmass have been hydrothermally altered, probably pneumatolytically rather than by metamorphism, as the rock lacks any grain orientation fabric. It originally contained plagioclase (~30%), hornblende (~25%), clinopyroxene (~30%), olivine(?) (~10%) and <5% pyrite, apatite, rutile, sphene, epidote, carbonate and magnetite. The plagioclase has been altered to albite, clinozoisite and sericite. The hornblende is red-brown (titaniferous), euhedral, with pale green tremolite-actinolite overgrowths. Fine-grained chlorite-serpentine-leucoxene patches are probably pseudomorphs after olivine and clinopyroxene. XRD confirms amphibole, chlorite, plagioclase and mica. The rock is an altered doleritic lamprophyre (spessartite).

Sample W112 is a medium-grained, aphyric, dark grey rock with fine white spotting. It is composed of ~50% brown hornblende, 30% plagioclase (altered, lamellar), 10% colourless clinopyroxene, 10% (?)altered olivine and trace quartz. The rock is relatively equigranular, with a fine grain size, ~0.1–1 mm, but some of the pyroxene is phenocrystic, up to ~2 mm. The (?)olivine was euhedral but is now highly altered to clays. XRD indicates amphibole, plagioclase, K-feldspar and chlorite-vermiculite. The rock is a fine-grained calc-alkali lamprophyre (a spessartite).

Jurassic dolerite

Twelve samples of this rock were collected; eleven thin sections were prepared, and three samples were analysed by XRD. The rocks are mostly dark grey where unaltered and vary from khaki green to almost white where altered. They are medium to very fine grained, mostly hard and dense (except when altered), with no obvious inhomogeneity or foliation. Most are petrologically relatively undifferentiated and quenched, and contain orthopyroxene microphenocrysts. Some were formed as chilled margins, and some of these are variably to completely altered to prehnite, serpentine, amphiboles and smectites. There are some laumontite, calcite, quartz and prehnite veins, and rare chert and ophicalcite wallrock clasts.

Sample G400237 is a medium grey, medium-grained rock, composed mostly of plagioclase (~35%, 0.2–1 mm, An_{50-70}), clinopyroxenes (~35%, 0.5–1.5 mm, pigeonite and augite), granophyric mesostasis (~20%) and orthopyroxene (5%, 1–3 mm). There are traces of green-brown hornblende (partly replacing pyroxenes), green-brown biotite, chlorite, pyrite and ilmenite-magnetite-chalcopyrite intergrowths. The orthopyroxene phenocrysts are partly to completely altered to chlorite and serpentine. There is pervasive but minor alteration of plagioclase to sericite and pyroxene to chlorite. The rock is a slightly metasomatised Jurassic dolerite.

Sample G400242 is a medium grey, fine-grained rock, composed mostly of plagioclase (~50%, 0.1–0.5 mm), clinopyroxenes (~30%, 0.5–1.5 mm, pigeonite and augite), devitrified glass/mesostasis (~20%) and

orthopyroxene (5%, 1–2 mm). There is about 5% chlorite as small clots, and traces of pale green actinolite, biotite and possibly pumpellyite. The rock is a relatively fresh, chilled Jurassic dolerite.

Sample G400338 is a medium grey, medium-grained rock, composed mostly of plagioclase (~40%, 0.2–1 mm), clinopyroxenes (~40%, 0.5–1.5 mm, pigeonite and augite), granophyric mesostasis (~15%) and orthopyroxene (~2%, 1–2 mm). There are traces (~6% total) of green-brown hornblende (partly replacing pyroxenes), green-red-brown biotite, clays and carbonate. The orthopyroxene phenocrysts are partly to completely altered to smectite and serpentine. There is pervasive but minor alteration of plagioclase to sericite and pyroxene to chlorite. The rock is a slightly altered Jurassic dolerite.

Sample G401280 is a contact between a fine-grained Jurassic dolerite and an ophicalcite. The dolerite is serpentinised and porphyritic (with serpentinised orthopyroxene?, <1 mm), and is veined and brecciated. The ophicalcite is about 40% serpentine and 60% calcite, both minerals showing abundant vein textures.

Sample G402154 is a brecciated, pale green to yellow brown fine-grained rock with white veining. The rock represents a contact between Jurassic dolerite and a chert/quartz zone, and was analysed by XRD and studied in thin section. The dolerite is highly altered but was apparently a very fine-grained, porphyritic dolerite typical of those in chilled margins. Phenocrysts comprise clinopyroxene and prehnite (pseudomorphic after plagioclase?) and the matrix is composed mostly of prehnite, smectite, amphiboles and quartz (XRD). Xenoliths of chert are partly recrystallised at their borders, and are faulted and cut by prehnite veinlets. The dolerite near the contact is laminated, flow banded and brecciated.

Sample G402155 is fine grained and green-grey with black spotting. It is composed mostly of clinopyroxenes (~25%, prismatic crystals ~0.1 1.5 mm), plagioclase (~25%, laths and rare phenocrysts ~0.1 0.7 mm), devitrified glass/ mesostasis (~40%, dark green-brown) and orthopyroxene (5%, 1–2 mm, partly altered). There is about 5% of small clots (~1 mm diameter), containing smectite, quartz, prehnite, and pumpellyite(?). There are veins of laumontite and small tension gashes with quartz, prehnite and albite. The rock is a brecciated, chilled Jurassic dolerite.

Sample G402161 represents a contact between Jurassic dolerite and an ophicalcite wallrock, and was analysed by XRD, polished thin section and electron microprobe. The dolerite is pale pink to pale green and buff coloured, brecciated and very fine grained. It is highly altered but was apparently a laminated, glassy, porphyritic dolerite typical of those in chilled margins. Phenocrysts comprise orthopyroxene (~5% of the rock, ~0.5 mm, altered to chlorite-serpentine-carbonate aggregates) and clinopyroxenes, while the matrix is composed mostly of XRD-amorphous Ca-Al-Fe-Mg silicate (altered, hydrated palagonite/volcanic glass?). The rock is cut by veins of calcite and serpentine. Xenoliths of various rock types occur, variably rich in diopside, serpentine and calcite. The wallrock is a brecciated, veined, inhomogeneous calcite-serpentine-diopside rock, with minor, fine-grained, disseminated patches of andradite, sphalerite and galena (<0.1 mm) in serpentine veins. The rock is a highly altered dolerite in contact with an altered calc-silicate hornfels.

Sample G402180 represents an altered contact between Jurassic dolerite and an ophicalcite wallrock, and was analysed by XRD, polished thin section and electron microprobe analysis. The dolerite grades from a fine-grained, pale green phase to greenish black serpentine at the contact, and it is cut by numerous thin white veins. It is highly altered but was apparently a very fine-grained, porphyritic dolerite typical of those in chilled margins. Phenocrysts comprise clinopyroxene (augite), serpentine (after orthopyroxene) and smectite prehnite pseudomorphs after plagioclase. The matrix is composed mostly of smectite, serpentine and calcite (XRD), and is cut by veins of calcite, prehnite, serpentine and chlorite. The wallrock is a calcite-serpentine-brucite rock, mostly serpentine at the contact, with minor fine-grained, disseminated andradite, sphalerite and chalcopyrite.

Sample G402181 is medium grained, dark grey-green and cut by numerous white veins. It is composed mostly of plagioclase (~45%, 0.2–1 mm), clinopyroxenes (~35%, 0.5–1 mm, pigeonite and augite), granophyric mesostasis (~15%) and orthopyroxene (~5%, 1–2 mm). There are traces of green-brown hornblende (partly replacing pyroxenes), chlorite, clays and carbonate. The orthopyroxene phenocrysts are partly to completely altered to smectite, calcite and serpentine. There is pervasive but minor alteration of plagioclase to sericite and pyroxene to chlorite. There are laumontite-calcite-smectite veins and micro-veinlets of quartz. The rock is a brecciated and altered Jurassic dolerite.

Sample G402184 is composed mostly of medium to fine-grained, dark green-grey Jurassic dolerite (as above). It has been highly brecciated and altered, resulting in a rock with about 30% laumontite, as irregular, cross-cutting veins and clots.

Sample G402185 is medium grained, medium to dark grey-green, with fine mottling and rare white veinlets. It is composed mostly of plagioclase (~45%, 0.2–1 mm), clinopyroxenes (~45%, 0.5–1.5 mm, pigeonite and augite), granophyric mesostasis (~10%) and traces of orthopyroxene (~1%, 1–3 mm). There are traces (<1% total) of green-brown hornblende (partly replacing pyroxenes),

green-red-brown biotite, clays and carbonate. The orthopyroxene phenocrysts are partly to completely altered to chlorite and serpentine. There is pervasive but minor alteration of plagioclase to sericite and pyroxene to chlorite. The rock is a slightly metasomatised Jurassic dolerite.

Sample G402211 is dark brownish grey, very fine grained with black spotting and rare white veinlets. It is composed mostly of plagioclase (~40%, ~0.1 mm, rarely microphenocrysts to 1 mm), clinopyroxenes (~40%, ~0.1 mm, pigeonite and augite), devitrified glass/mesostasis (~15%) and orthopyroxene (~5%, 1–3 mm, partly altered to serpentine and smectite). There are some medium-grained plagioclase-clinopyroxene glomerocrysts. The rock is a relatively fresh, chilled Jurassic dolerite.

Sample G402447 is coarse grained and grey, with slight weathering. It was not prepared as a thin section, but XRD indicates clinopyroxene, plagioclase, quartz, kaolinite, amphibole and smectite. The rock is a weathered, coarse-grained Jurassic dolerite.

Sample G402479 is medium grained and dark grey. It is composed mostly of fine-grained plagioclase (~35%, 0.1–0.5 mm), pyroxenes (~45%, 0.5–1 mm), oxide-rich mesostasis (~15%) and orthopyroxene (5%, 1–3 mm). The orthopyroxene phenocrysts are partly to completely altered to chlorite and serpentine. There are a number of small quartzo-feldspathic, amygdular clots, containing alkali feldspar or zeolites(?), quartz, hornblende, pumpellyite, calcite and clays. There is pervasive but minor alteration of plagioclase to sericite and pyroxene to chlorite. The rock is a medium-grained Jurassic dolerite.

Skarns and calc-silicate hornfels: altered carbonates

This is a diverse group of rocks, which range from ophicalcites (calcite-serpentine rocks, e.g. G402149 and G402170) to calcite-brucite rocks (e.g. G402162, WR113), diopside rocks (e.g. G402037 and G400263), quartz-wollastonite-xonotlite ($Ca_6Si_6O_{17}(OH)_2$) rocks (e.g. G402141 and G402166), opalised ophicalcites (e.g. WR51), and intermediates between all of these. These rocks were probably derived predominantly from the dolomite and some intercalated dolerite and siliceous units, but now contain little or no dolomite. The dolomite has been thermally metamorphosed, probably originally forming forsterite, periclase, calcite and diopside hornfels and marbles, but has been largely retrogressed to hydrous assemblages. Retrograde assemblages include serpentine, brucite, talc, andradite, siderite, sjogrenite (a hydrated Mg-Fe carbonate), magnetite and sulphides.

The quartz rich rocks are complex, containing xonotlite and various calcium silicates, plus calcite, diopside and minor sphalerite. These rocks are probably skarns formed by Ca-metasomatism of quartz breccias derived by silicification of dolomites.

Veining is common, and includes quartz, calcite, aragonite, xonotlite, wollastonite and other minerals.

Sample G400239 is a mottled brown-green and white rock with veining and breccia textures. In thin section it varies over three thin sections from ~20–95% calcite, 5–75% serpentine, <10% brucite and <5% diopside. The calcite is mostly fine grained, in patches and veins, but there appears to be a late stage coarser phase. Serpentine occurs as poorly crystalline veins intergrown with brucite (<0.4 mm), and as pseudomorphs after forsterite(?) (equant grains ~0.1–0.4 mm). Diopside occurs as massive, fine-grained aggregates and rare crystals ~0.1–0.4 mm in calcite, and is apparently mainly altered to calcite. There is possibly a trace of talc and (?)andradite (very fine grained, pale brown) in the serpentine veins. Small vugh-like lenses (<1 mm) in the serpentine veins contain some euhedral to subhedral calcite and diopside, growing into coarse-grained radial-fibrous serpentine. XRD confirmed only calcite and serpentine (lizardite?). The rock is an ophicalcite.

Sample G400241 is a white, fine-grained diopside-rich rock.

Sample G400263 is a white, fine-grained diopside-rich rock. Diopside (~75%) is massive and very fine grained (~1–30 m). Quartz (~20%, ~10–80 m) occurs in cherty veinlets and disseminated cherty aggregates (chert interstitial to pre-alteration dolomite grains?). Xonotlite (~5%, ~20 200 m) occurs in thin, fibrous veins and disseminated bands. XRD confirmed only diopside and quartz. The rock is a diopside-quartz hornfels.

Sample G400904 is a mottled brown and white carbonate rock with granular serpentine veining and breccia textures, very similar to G400239. It contains some small bluish opal veins, which give a tridymite-like pattern under XRD. The rock is an opalised ophicalcite.

Sample G402037 is a very fine-grained, pale brown massive rock, with white calcite blebs and zones with veins and disseminated dark brown material. It contains ~60% diopside (1–30 m), 25% serpentine, 10% brucite and 5% calcite. The diopside grains are enclosed by a serpentine matrix, containing ragged patches of poikiloblastic calcite (<1 mm) and blebs of brucite (<0.5 mm, very irregular, pre-dating diopside). There are veins and brecciated zones with serpentine, calcite, brucite and some secondary, coarser diopside (<0.1 mm). These contain some serpentine-brucite aggregates with an olivine-like morphology. The rock is cut by later calcite veinlets. XRD confirmed diopside, serpentine and calcite. The rock is a brecciated, serpentinised, diopside hornfels.

Sample G402141 is a white to pale grey cherty rock. In thin section it is quite unusual and variable in texture and mineralogy, containing ~65% quartz, 20% xonotlite and wollastonite, 10% diopside and 5% scawtite ($Ca_7(Si_3O_9)_2(CO_3).2H_2O$), and trace pectolite ($NaCa_2Si_3O_8OH$). The quartz textures are very similar to some of the siliceous breccias (e.g. G402194), with a network of very fine-grained cherty quartz enclosing vughs (<5 mm) lined by quartz (<1 mm, subhedral to euhedral). The chert grades into the coarser quartz. The vughs are filled with fibrous aggregates of xonotlite, wollastonite and scawtite. The scawtite occurs as fine-grained, micaceous patches. The xonotlite occurs as fine veinlets; these and the coarse aggregates partly replace quartz. Diopside occurs as very fine-grained (<0.05 mm) murky brown aggregates in the chert bands. XRD indicated quartz, xonotlite, clinopyroxene, scawtite, pectolite and wollastonite. The rock is a quartz-xonotlite skarn.

Sample G402142 is a mostly white rock with abundant brown veinlets and stockworking, plus blue opaline veins. The rock contains ~40% cloudy, fine-grained calcite, ~40% coarser vein calcite, 5% opal veins (including some chalcedony and fine-grained pyrite?), and 15% serpentine (brown veins and granular aggregates <0.2 mm). There are at least four stages of veining; calcite veins are cut by brucite veins, these are both cut by serpentine veins, and all are cut by opal veins. XRD confirmed serpentine, opal and calcite. The rock is a brecciated ophicalcite.

Sample G402149 is fine grained and variegated, mostly yellow serpentine, but with white and pale green areas. The rock contains about 40% calcite (mostly fine grained; some as late-stage veinlets) and 60% serpentine (veins and aggregates <0.5 mm). There are patches of very fine-grained, leucoxene-like material in the serpentine veins (andradite or sphalerite?). XRD confirmed serpentine and calcite. The rock is a brecciated ophicalcite.

Sample G402150 is a breccia, with pale grey to white clasts in an apple green serpentine matrix, with some fine black spotting. The rock contains ~85% calcite (fine grained and coarser veins) and 15% serpentine (veins), with trace andradite (very fine grained aggregates, <0.1 mm, in serpentine veins). XRD confirmed serpentine, brucite and calcite. The rock is a brecciated ophicalcite.

Sample G402157 is fine grained and variegated, mostly white to cream, with pale green, pale grey and white veins. It contains ~80% calcite (fine to coarse grained, some in late veinlets), 10% serpentine (veins and patches), 5% diopside and 5% clays(?). There are ~10% angular clasts of a crystalline rock, replaced by serpentine siderite(?). Diopside occurs in calcite, is relatively coarse grained (<0.5 mm), subhedral to euhedral and poikiloblastic, and is partly altered to calcite. Andradite may be present as brown equant (cubic?) crystals and aggregates <0.01 mm in diameter in the serpentine veins. XRD indicated calcite, serpentine, clinopyroxene, mica, quartz and smectites. The rock is a diopside hornfels/ophicalcite breccia.

Sample G402158 has pale green, yellow, grey and white mottled zones. It contains ~50% calcite and 50% serpentine, with a trace of brucite and diopside(?). Calcite is mostly very fine (<0.05 mm), with some coarser patches and veins. Serpentine occurs as fibrous veins and granular aggregates (<0.1 mm). Brucite occurs as micaceous aggregates in serpentine veins. Diopside may be present as brown equant rounded aggregates <0.02 mm in diameter in serpentine veins. There are some late calcite aragonite veins cutting serpentine. XRD confirmed serpentine, calcite and brucite The rock is a brecciated ophicalcite.

Sample G402159 is similar in appearance to G402158. It contains ~80% calcite and 20% serpentine, with a trace of brucite. Andradite may be present as brown equant (cubic?) aggregates <0.01 mm in diameter in serpentine veins. There are some late calcite veins cutting serpentine. XRD confirmed serpentine and calcite, and possible trace quartz? The rock is a brecciated ophicalcite.

Sample G402160 exhibits networks of pale grey veins in a white rock. It contains ~90% calcite (fine grained) and 10% serpentine (as veins). There are some late calcite veins cutting serpentine. The rock is a brecciated ophicalcite.

Sample G402162 has networks of yellow veins in a pale grey to white rock. It contains ~85% calcite (fine grained), 10% brucite (in veins and distinct crystals), and ~5% serpentine (veins and aggregates <0.2 mm). Brucite occurs as bladed crystals <0.1 mm, disseminated in calcite, and is probably primary. The rock is a brecciated ophicalcite.

Sample G402163 is a mottled pale grey, green and white rock. In thin section it is quite unusual and highly variable in texture and mineralogy, containing ~25% quartz, 60% xonotlite, 10% diopside, ~5% of an unidentified, green Ca-Fe silicate (referred to in this report as UNK1), and traces of calcite, magnetite and sulphides. Quartz occurs as massive, anhedral medium-grained chert zones, and euhedral (vugh-filling) grains (<1 mm). This quartz is largely replaced by xonotlite (mostly radial-fibrous but retaining quartz textures). Diopside occurs as very fine-grained (<0.01 mm), massive, brown patches and rounded, vuggy structures (originally ooids?, <2 mm) with coarser crystals (<0.1 mm) growing into the xonotlite and UNK1-filled cores. It also occurs as some very fine-grained diopside-quartz veinlets in the chert and xonotlite zones. The UNK1 silicate occurs mostly at the contact of the xonotlite and diopside-rich zones. Fine-grained magnetite is intergrown with Ca-Fe silicates, pseudomorphic after an unidentified mineral (aggregates <2 mm).

Late xonotlite veinlets cut the diopside. There are traces of sulphides (checked qualitatively by electron microprobe): sphalerite (<0.2 mm) and millerite (<0.05 mm) in the xonotlite. XRD confirmed quartz, xonotlite, UNK1, sphalerite and clinopyroxene, with possible magnetite, tobermorite and rosenhahnite. The rock is a quartz-xonotlite-diopside skarn, a metasomatised siliceous dolomite-replacement breccia.

Sample G402164 is a cherty white rock with a breccia zone containing white wallrock clasts in a black matrix. It contains ~15% calcite and 85% diopside, with a trace of arsenides. The rock contains medium-grained diopside and calcite in clasts in a very fine-grained (<5 m) brownish diopside matrix. The clasts contain diopside <0.25 mm and calcite patches <0.2 mm (interstitial to earlier diopside clasts?). The black breccia matrix contains rounded aggregates of niccolite ($NiAs_2$), partly replaced by an Fe-Ni-As mineral (nickeloan loellingite?, $(Ni,As)As_2$), <30 m diameter. XRD confirmed calcite and clinopyroxene. The rock is a brecciated diopside skarn.

Sample G402165 is a breccia with pale grey cherty clasts in a white matrix. It contains ~20% calcite and 75% diopside, ~5% apophyllite (?, <2 mm) and a trace of tobermorite (fine grained). It is similar to G402164, but apophyllite and tobermorite form crystals and zones surrounding calcite (patches <10 m in vughs in diopside <0.5 mm). There are minor, late stage calcite aragonite veins. XRD confirmed calcite, tobermorite, quartz, apophyllite and clinopyroxene. The rock is a diopside skarn, probably a metamorphosed siliceous dolomite breccia.

Sample G402166 is a medium grey, massive, cherty rock with white spotting and diffuse pale grey bands. It contains ~90% quartz, 5% diopside and 5% xonotlite and a trace of calcite, sulphides and other phases. It is similar to G402141, with a fine-grained network of chert and very fine-grained diopside (<5 m), surrounding coarser quartz and quartz-crystal lined vughs (<5 mm). The vughs are filled with xonotlite (fibres <2.5 mm) and minor diopside (<0.1 mm), minor tobermorite(?), and rare sphalerite (aggregates <1 mm). There are late stage veins with calcite/aragonite(?) xonotlite sphalerite (<0.2 mm) and millerite (<0.05 mm). There is also minor sphalerite and millerite disseminated in the chert, but this may also be vein-related. XRD confirmed major quartz and xonotlite with trace calcite and clinopyroxene. The rock is a quartz-xonotlite skarn, a metasomatised siliceous dolomite-replacement breccia.

Sample G402167 is a crumbly, white, fine-grained diopside-rich rock. XRD indicated only diopside. It is probably a leached skarn.

Sample G402169 is a breccia with pale greenish grey clasts (<20 mm) in a pale grey to green and black matrix, the dark green material being micaceous. It contains ~70% quartz, 5% diopside, 10% xonotlite, 5% carbonates, 5% of an unidentified, green Ca-Fe silicate (UNK1), 2% prehnite, ~1% sphalerite, and <5% of other minerals. It is similar to G402163, with a network of chert (20–100 m) containing diffuse network veinlets of very fine-grained diopside (<5 m). The chert is more massive and even-textured than in G402163, and encloses patches of coarser quartz (<1 mm) and lensoid, quartz-crystal lined vughs (<6 mm). The vughs are filled with prehnite (<1 mm, radiating crystals), diopside? (<0.5 m, fine-grained replacement of xonotlite), UNK1 (<1 mm, micaceous), laumontite (blocky crystals <1 mm), and rare sphalerite (<0.1 mm). The mineralogy of the vughs may suggest Ca-metasomatism of Mg-Fe-Al clays (smectites?) in vuggy siliceous breccias. The vughs are linked with a network of veins containing the hydrous Ca silicates and carbonates. The xonotlite forms a fine network throughout the chert, with fibrous crystals to 0.3 mm. Small grains of quartz and a dark green mineral are also disseminated in the chert. There are late-stage veins with calcite/aragonite(?) xonotlite sphalerite (<0.1 mm). There is also minor sphalerite and millerite disseminated in chert, but this also appears vein-related. XRD confirmed major quartz, xonotlite, UNK1, with minor laumontite, talc, prehnite, calcite, sphalerite, mica(?) and aragonite. The rock is a quartz-rich skarn, probably formed by Ca-metasomatism of a clay-filled siliceous dolomite-replacement breccia.

Sample G402170 has green and white carbonate clasts in a pale brown serpentine matrix, with calcite serpentine veins <10 mm wide. It contains ~30% calcite and 70% serpentine, with ~5% brucite (coarse-grained aggregates in serpentine). Serpentine occurs as a pervasive, replacement network and as discrete veins. There is ~1% of brown to black (organic?), very fine-grained, isotropic, angular to rounded and flaky spots <20 m in the serpentine veins. Calcite occurs as medium-grained aggregates in a serpentine network, and contains sparse, ragged diopside relicts (<0.2 mm). It also occurs as late-stage veinlets (maybe aragonite?). XRD indicated serpentine and calcite, with trace quartz(?). The rock is a brecciated, calcite-serpentine altered diopside skarn or ophicalcite.

Sample G402171 is a pale grey to white, fine-grained rock with green serpentine veins and white calcite veins. It contains ~95% calcite (fine grained with some later veinlets), 2% serpentine (veins) and 2% brucite (mostly in the cores of serpentine veins). Traces of diopside(?) occur as brown irregular aggregates <2 m, mostly in serpentine veins. There is a late stage (?)xonotlite/wollastonite vein. XRD confirmed serpentine, brucite and calcite. The rock is a brecciated ophicalcite.

Sample G402172 is a pale grey, fine-grained rock with white to yellow and green veins of coarse-grained calcite and serpentine clasts. It contains ~70% calcite (fine grained with some later veinlets) and 30% serpentine (veins), with a trace of brucite. The rock is a brecciated ophicalcite.

Sample G402173 is cherty and white to pale pink and cream, with lenses and irregular patches of serpentine (dark green with pale green cores and yellow-green rims and white and green veinlets). It contains ~25% calcite, 30% serpentine, 45% diopside, <2% garnet and trace sulphides. Diopside-rich clasts, <10 mm across and with a grain size of ~5 m to 1 mm, occur. The diopside is dispersed in poikiloblastic coarse-grained calcite, with diopside-free calcite and serpentine interstitial to this. Some diopside also occurs as partly serpentinised grains in serpentine veins. Serpentine veins are platy to granular (~50–200 m) in texture. Andradite(?) occurs as brown, rounded, equant, zoned crystals <0.1 mm, mostly in serpentine veins. Calcite occurs in granular ophicalcite clasts (~50–200 m), and as coarse-grained rims to clasts and as veins. The rock is cut by later veinlets containing calcite, aragonite and siderite. Late-stage fractures are coated with coarsely crystalline aragonite and calcite. Sulphides occur as disseminated grains and aggregates <150 m, and include sphalerite (<100 m), galena (<20 m), loellingite (<10 m, euhedral) and chalcopyrite (<5 m). XRD indicated serpentine, garnet, diopside, aragonite and calcite. The rock is a brecciated ophicalcite with serpentinised diopside hornfels clasts.

Sample G402174 is a fine-grained speckled rock, and varies in colour from white to medium and dark grey to brown-grey. It is cut by veins of yellow-green serpentine and white calcite. It contains ~75% calcite, 15% serpentine, 5% brucite and 5% clay-like minerals, with traces of diopside(?), sulphides, magnetite and protographite(?). Brucite occurs as primary flakes <0.1 mm, in calcite. Clays (or hydromagnesite and sjogrenite?) occur as very fine-grained yellow-green and colourless spots and patches <0.1 mm in serpentine and calcite; some are equant, cubic aggregates <0.1 mm, possibly pseudomorphing periclase. Magnetite occurs as poikilitic, anhedral grains <0.2 mm and very fine networks. Sulphides include sphalerite (<30 m), galena (<30 m), loellingite (<20 m), pyrrhotite (?, <30 m) and ruby silver minerals (??, <30 m). The sulphides are associated with magnetite, protographite (<0.1 mm) and prehnite (?, <0.1 mm) in serpentine-brucite veins. The rock is cut by late carbonate (aragonite/calcite?) veinlets. XRD confirmed serpentine, brucite, calcite, hydromagnesite and a sjogrenite-type mineral (a hydrated Mg-Fe carbonate). The rock is a brecciated ophicalcite.

Sample G402175 is a pale grey to white rock cut by a fine network of pale green, yellow and white serpentine veins, with some red-brown spotting. It contains ~70% calcite and 25% serpentine, with <5% brucite, <5% clay-like minerals (as above) and trace diopside, magnetite(?) and limonite(?). The rock is texturally and mineralogically very similar to G402174. Magnetite occurs as anhedral to euhedral grains <30 m in serpentine. XRD confirmed serpentine, brucite, diopside, garnet and calcite, and also indicated a sjogrenite-type mineral. The rock is a brecciated ophicalcite.

Sample G402177 is a medium to dark grey, cherty rock, brecciated and veined by white to pale green serpentine. It contains ~85% calcite, 10% brucite and 5% serpentine, with traces of garnet, clays, diopside(?), magnetite, protographite, sulphides and gold. Calcite occurs as fine-grained brown patches (<20 m), overgrown by coarser carbonate (~0.1–0.5 mm). Serpentine occurs as narrow veins with garnet, brucite and diopside on the selvages. Brucite occurs as primary flakes (<0.2 mm) in serpentine and calcite, and brown equant (cubic?) aggregates <0.1 mm in calcite and serpentine; these are probably an alteration product of periclase. Garnet occurs as colourless to brown rounded crystals <0.1 mm, mostly in the serpentine veins. Diopside occurs as very fine-grained aggregates in serpentine. Protographite, magnetite, gold and sulphides all occur in thin carbonaceous zones in serpentine. Protographite occurs as aggregates and patches up to 50 m in size. Magnetite occurs as anhedral grains <60 m. Sulphides include sphalerite (<150 m), galena (<100 m), loellingite (? <6 m), and chalcopyrite (<10 m). Gold was seen as one 1 2 m grain in serpentine. The sulphides are associated with magnetite, protographite (<0.1 mm) and prehnite (?, <0.1 mm) in serpentine- brucite veins. The rock is cut by later aragonite calcite veinlets. XRD confirmed serpentine, garnet, pyrite and calcite, and also indicated vesuvianite and aragonite. The rock is a brecciated ophicalcite.

Sample G402178 is a pale grey to dark brown rock with white vein networks of serpentine, plus olive green, ragged patches of serpentine <50 mm. These zones represent:

(a) a granular calcite-serpentine rock;

(b) a diopside-rich rock; and

(c) serpentine garnet veins.

Overall the rock contains ~75% diopside, ~15% calcite and 10% serpentine, with traces of garnet, vesuvianite(?) and sphalerite. Diopside occurs as coarse-grained clasts (<1 mm, with interstitial serpentine and calcite) in a fine-grained, brecciated (mylonitic?) matrix of very fine-grained diopside, serpentine and calcite. Calcite occurs in ophicalcite clasts, in the matrix of diopside aggregates, and in late-stage veins with serpentine. Garnet and vesuvianite occur as colourless to yellow equant irregular grains <0.5 mm, but mostly <0.05 mm, in serpentine veins. Serpentine veins, carbonate and garnet grains, cut the diopside-rich clasts.

Sphalerite occurs as fine-grained, pale yellow grains <0.1 mm in serpentine. XRD confirmed serpentine, garnet, sphalerite, diopside and calcite. The rock is a brecciated mixture of diopside hornfels and ophicalcite.

Sample G402179 is a white to medium grey rock with white, yellow-green, and medium grey veining, plus small patches and veins of pale green serpentine black cores. It contains ~65% calcite, 35% brucite and 5% serpentine, with traces of diopside. Calcite occurs as fine to medium-grained sparry carbonate, poikiloblastic with brucite and veined with serpentine. Brucite occurs as equant (cubic?) aggregates ~0.01–0.1 mm in calcite, probably an alteration product of periclase. It also occurs as small intergranular patches in serpentine. Serpentine occurs with brucite as granular aggregates <0.1 mm, and in lenses ~1 mm wide, possibly derived by hydration of brucite. It also occurs as fibrous veinlets. Diopside(?) occurs as colourless to brown very fine-grained aggregates in serpentine clots in calcite. The rock is cut by later carbonate veinlets. XRD confirmed serpentine, brucite, diopside, garnet and calcite, and also indicated a sjogrenite-type mineral. The rock is a brecciated and serpentinised brucite marble, derived by retrograde metamorphism of a periclase-forsterite marble.

Sample G402183 is a relatively soft, greenish white rock with dark green mottled patches and pale grey veining. There are minor late-stage fibrous white veins. XRD indicates serpentine, smectite and diopside. The rock is a weathered serpentinised diopside hornfels.

Sample G402206 is a pale brown rock with white spotting, and veins of brown and blue opal. It contains ~45% calcite, 40% opal, 5% siderite and 10% serpentine, with traces of dolomite and a micaceous mineral. Calcite occurs as fine-grained patches, poikiloblastic with serpentine grains (<0.3 mm), and overgrown by medium to coarse-grained sparry calcite (<1 mm and partly euhedral). Serpentine occurs as angular clots and small rounded grains (pseudomorphs after forsterite and/or periclase?), and is largely opalised. The opal and chalcedony occur as late-stage, colourless to brown colloform veins with calcite and siderite, and as brown material replacing serpentine veins and aggregates. Siderite occurs as medium- grained (<0.5 mm), poikiloblastic yellow material with opal veins. Zones with calcite and micaceous brucite (<0.5 mm) occur. The rock is cut by later carbonate veinlets. XRD indicated opal, serpentine, dolomite, siderite, quartz, chlorite(?) and calcite. The rock is an opalised, brecciated ophicalcite.

Sample G402208 is a weathered, limonitic breccia with yellow-brown clasts <20 mm. The clasts are mostly fine-grained yellow siderite, some containing fine-grained massive clinopyroxenes(?), and are cemented by siderite. The rock is partly oxidised and leached to irregular boxwork-like structures. XRD indicates an impure siderite, plus goethite and quartz. The rock is apparently a siderite-altered skarn breccia.

Sample G402335 is a pale brown, fine-grained rock, similar to G402037, with dark brown spots and veins. XRD indicated predominant diopside, with minor serpentine and calcite. The rock is a diopside hornfels.

Sample G402336 is a breccia with pale brown, pale grey and some medium brown carbonate clasts and veins of medium to dark brown, granular serpentine. XRD indicated serpentine and calcite. The rock is an ophicalcite.

Sample G402440 is a pale brown, fine-grained rock, similar to G402335. XRD indicated diopside, serpentine and calcite, with trace quartz(?). There are some coarse-grained serpentine-calcite clots. The rock is a diopside hornfels.

Sample G402442 is very similar in appearance to G402336, but contains coarse-grained calcite-serpentine clots <20 mm. It contains ~40% calcite, 20% diopside and 40% serpentine. The rock is mostly a nodular diopside-rich rock, with very fine-grained diopside (<20 m) dispersed in a calcite matrix, with interstitial calcite and serpentine. The nodules are angular to rounded and some have diopside-free calcite cores (replaced ooids?). Diopside is rarely <0.1 mm in a serpentine matrix or network. Coarse-grained calcite and cryptocrystalline serpentine also occur in the irregular patches. XRD confirmed serpentine, diopside and calcite. The rock is a diopside-serpentine-calcite hornfels.

Sample G402443 contains clasts and lenses of buff, brown-flecked rock, veined and enclosed in medium brown serpentine. It contains ~20% calcite, 5% siderite and 75% serpentine. Calcite occurs as fine to medium-grained (0.02–0.2 mm) patches, and some is poikiloblastic with serpentine grains. The rock is cut by later carbonate (siderite?) veinlets. Serpentine occurs as granular veins, and small angular to rounded grains in calcite (pseudomorphous after forsterite and/or periclase?). The rock is a brecciated ophicalcite.

Sample G402480 is pure white on fresh surfaces, but is generally slightly weathered to chalky material. It is fine grained, massive, hard and cherty. The bulk of the rock is composed of very fine-grained diopside (~70%, ~0.02–0.2 mm), with areas of disseminated quartz (~20%, 0.02–0.01 mm), veins of calcium silicates (wollastonite and xonotlite) (~10%, 0.02–0.2 mm), and traces of calcite. The mineralogy was confirmed by x-ray diffraction. The rock is inhomogeneous; some parts are almost pure diopside, but others are rich in disseminated fine, anhedral quartz grains. Xonotlite and wollastonite occur mostly as diffuse veins, containing more pure micro-veinlets and clots which cut and replace bands (sedimentary?) of variable quartz content. On a finer

scale, however, the diopside replaces the xonotlite, indicating some re-equilibration. The rock is a diopside-quartz-xonotlite hornfels, derived from a siliceous dolomite.

Sample WR47 is a pure white, fine-grained, massive, hard and cherty rock, with pale grey veins. It is composed mostly of diopside (~80%) and quartz (~15%), with ~5% of an unidentified pale brown fibrous mineral (veins and disseminated patches, <0.2 mm). Quartz is disseminated, in stringers, veins and lobate, amoeboid cherty patches <0.5 mm. Diopside is very fine to medium grained, <0.05 mm, the finer zones being patchy. There is a quartz vein with the brown fibrous mineral, partly altered to opal. XRD confirmed quartz, opal and diopside. The rock is a quartz-diopside hornfels.

Sample WR51 is a breccia, with white clasts in a pale brown matrix. It contains ~65% opal, 30% calcite and 5% serpentine. The calcite is ~0.1–0.5 mm, some in micritic patches, and is partly replaced by coarser secondary calcite. There is a trace of chalcedony (in opal veins). Serpentine is largely opalised. There is a granular, veined network texture in the opal, inherited from the serpentine (inherited in turn from forsterite, brucite or other minerals). XRD confirms calcite, opal and serpentine, and indicates traces of dolomite, (Mg-?) siderite and quartz. The rock is an opalised ophicalcite.

Sample WR64 is coarse grained and white, with irregular patches of fine-grained, pale grey material. It contains ~75% carbonate, 20% talc, and 5% tremolite(?). There are clasts of primary, micritic carbonate (dolomite?, nodular, granular and oolitic), with rims of secondary, coarser calcite (<4 mm), with talc and tremolite(?) as a selvage between the two carbonates. XRD confirms talc, calcite and serpentine, and suggests traces of amphibole, quartz(?) and smectite(?). The rock is a talc-carbonate skarn.

Sample WR65 is fine grained and banded white and pale grey. It contains ~90% carbonate (calcite and dolomite), 10% serpentine, and traces of brucite, siderite(?) and talc. The carbonate occurs as primary oolitic patches, and secondary veins and patches <1 mm, with traces of serpentine and brucite. Serpentine also occurs as late veinlets. Dolomite/ankerite(?) is coarse grained, brown and appears to be partly replaced by calcite. Talc is coarse grained, and occurs as patches and veins. XRD indicates calcite, talc, serpentine, dolomite and clinopyroxene. The rock is an ophicalcite/hornfels breccia.

Sample W113 is white, fine grained, massive, hard and cherty. This rock contains ~90% calcite and 10% brucite (as aggregates <2 mm). The brucite appears to replace periclase porphyroblasts. There are trace serpentine veinlets. The rock is a brucite marble.

Sample S365 is white, fine grained, massive, hard and cherty. It is composed of nodular and oolitic carbonate (~50%, 0.1–1 mm), with ~10% interstitial granular quartz. Fine-grained diopside (~40%) occurs as reaction rims between the carbonate and quartz. The rock is a quartz-diopside-carbonate hornfels.

Chert and siliceous breccia

Twenty-three samples of chert and related quartz-rich rocks were collected. Fifteen were examined in thin section and five were analysed by XRD.

These breccias are remarkably variable, and range in colour from white to pink, green, brown and black. They are usually completely disaggregated and many appear polymict, with a large range of clast types in some samples. Remnant textures indicate various origins, including silicified Permian (and/or Precambrian) mudstone, dolomite, ultrabasic rocks and skarns. Clasts of these different groups are not usually intermixed, although some may possibly be (e.g. G402190, G402207?).

Sample G400235A is a mottled, pale grey to pink and white chert breccia, with a grain size ~50–100 m. The chert is brecciated by numerous irregular veins of fine to medium-grained quartz and there are some small limonitic patches. *G400235B* is similar but coarser grained, and contains ubiquitous very fine-grained carbonate inclusions (<10 m). *G400235C* is similar but contains traces of chromite (~1%, euhedral and shards, <~1 mm, including magnesiochromite: Table 2) and very fine-grained pyrite. The subsamples appear to indicate different origins, probably including dolomite and an ultrabasic rock.

Sample G402036 is a silicified cherty mudstone. The rock is finely micaceous and silty, and is cut by a zone of cherty to vein-style quartz, suggestive of multiple stages of brecciation and silicification. The vein quartz occurs as small lenses and discontinuous veinlets. This zone is cut by late-stage quartz-sericite veinlets. The rock resembles some Permian mudstones, but it may be Precambrian.

Sample G402136 is a chert breccia, with buff to off-white clasts in a matrix of pale grey quartz, opal and chert, with some limonite veinlets. The grain size is about 10–100 m. The chert is brecciated by numerous irregular veins of fine to medium-grained quartz. There are traces of very fine-grained calcite, limonite, organic material and clays, plus minor opal veins. XRD confirmed the quartz and calcite. The rock may be a silicified dolomite.

Sample G402151 is a mottled pale grey-white chert breccia with pale grey clasts in a matrix of white quartz and chert. The grain size of clasts is about 10–100 m. The chert is brecciated by numerous irregular veins of fine to medium-grained quartz, in part vuggy. The rock may be a silicified dolomite.

Sample G402152 is a mottled chert breccia, with pale grey, pink, medium brown and dark green clasts in a matrix of white, vuggy quartz, opal and chert. The chert is brecciated by numerous irregular veins of opal and very fine to medium-grained quartz. The grain size of clasts is about 10–100 m. There are traces of very fine-grained calcite, limonite, organic material and clays, plus minor opal veins. XRD confirmed the quartz and calcite. The rock may be a silicified dolomite.

Sample G402153 is a pale, mottled chert breccia, with pale grey, dark grey, yellow, orange (opaline) and pale brown angular clasts cut and surrounded by white to pale brown quartz and chert, plus orange-brown opal. The rock is ~90% quartz and 10% opal, with a few trace constituents. The chert is brecciated by a network of cherty quartz veins (~10–50 m), with fine clays (?altered diopside). These are overgrown by increasingly coarser quartz, terminating in vughs with euhedral quartz crystals <1.5 mm. The vughs are filled with colourless to brown opal and chalcedony, and have a fibrous-radiating structure inherited from the precursor xonotlite (compare with quartz-xonotlite skarn G402166). Some small patches of siderite and clays may pseudomorph diopside. There are minor veinlets of opal. XRD confirmed the quartz and opal. The rock may be a silicified dolomite, subsequently Ca-metasomatised and later leached and re-silicified.

Sample G402156 is a weathered, clayey, porous, pale brown-yellow to white chert. XRD indicated quartz, smectite, mica, opal and dolomite(?). The rock may be a silicified dolomite.

Sample G402182 is a chert breccia, with pink clasts <15 mm, in a green-grey cherty matrix. The rock is cut by limonite veinlets and contains some open fractures. The grain size is about 10–100 m. The chert is brecciated by numerous irregular veins of fine to medium-grained quartz. It contains traces of chromite (~1%, euhedral and shards, <1 mm), very fine-grained talc and very fine-grained hematite. There are talc-quartz pseudomorphs (~0.2–0.5 mm) after a rhombohedral mineral, probably a carbonate. XRD confirms quartz, hematite and talc. The rock was probably derived from the talc-amphibole rocks.

Sample G402186 is a chert breccia, mottled off-white with dark grey laminated patches, pale grey quartz veins and limonitic zones. The grain size is variable, about 20–100 m, and there is a trace of very fine dusty carbonate grains. The chert is brecciated by numerous irregular, discontinuous veins of very fine to medium-grained quartz. The rock is probably a silicified dolomite.

Sample G402187 is a chert breccia, a porous, leached red jasper with white quartz veinlets. The grain size ranges from about 20–100 m. The chert is brecciated by some irregular veins of very fine to medium-grained quartz. The rock contains abundant very fine-grained hematite, showing remnant textures similar to mesh textures in serpentine. Texturally, it resembles the talc amphibole-rich rocks, and may be a silicified equivalent.

Sample G402189 is a weathered, laminated, mylonitic, cherty breccia, with pink, grey and white clasts (<20 mm). The grain size is variable, about 10– 100 m. Clasts include chert, sandy mudstone, sandstone, and phyllite. The chert is brecciated by numerous irregular to laminated veins of fine to medium-grained quartz (<200 m) containing minor sericite. There are traces of limonite pseudomorphs after pyrite (~1%, euhedral and brecciated, <1 mm), chromite?, and abundant very fine-grained hematite in some clasts. XRD indicated dominant quartz with traces of kaolinite, mica and rutile. Most of the clasts are probably of Permian derivation, but the chromite, if confirmed, suggests a mixed origin.

Sample G402190 is a mottled pale green and pale brown chert breccia, with fine hematite veining. The chert is sericitic, with a grain size ~10–100 m, is weakly layered and foliated, and contains minor silt and fine, rounded quartz sand (detrital?). It is brecciated by numerous irregular, anastomosing veinlets of very fine to medium-grained quartz, and contains abundant, very fine-grained hematite in clasts, disseminated patches and veins. There may be traces of chromite (angular grains, <~0.5 mm). XRD indicated dominant quartz with traces of hematite, mica and rutile. The rock may be of Permian derivation, but the chromite, if confirmed, suggests a mixed origin.

Sample G402194 is a siliceous breccia, with black cherty clasts <20 mm in a white quartz matrix, and drusy white to pale pink quartz-lined vughs, <20 mm. The drusy quartz crystals are <2 mm in size. The black chert mostly has a grain size ~20 m but up to ~200 m, and contains disseminated, microscopic dark-brown to black organic material. The chert is brecciated by numerous irregular veins of fine to medium-grained quartz, in part vuggy. By comparison with similar rocks at Mt Weld, the rock appears to be a silicified dolomite.

Sample G402196 is a mottled brown, dark grey and white chert breccia, with clasts <10 mm and quartz and limonitic veinlets. The grain size is mostly <20 m. The chert is variably pyritic and is brecciated by numerous irregular veins of fine to medium-grained quartz. There are clasts of quartzite, cherty mudstone and phyllite. The rock may be derived from silicified, brecciated Permian sediments.

Sample G402207 is a chert breccia, but comprises two sub-types:

(a) white chert breccia, with some brown clasts, cut by vuggy, black chert veins; and

(b) mottled pale to dark brown cherty clasts, cut by bluish opal veins.

The grain size of the chert is ~10–100 m. The chert is brecciated by numerous irregular, disrupted and brecciated veins of very fine to medium-grained quartz. The brown clasts contain radial-fibrous aggregates of a brown clinopyroxene, variably altered to opal, carbonates (siderite and calcite?), limonite and clays(?). These aggregates appear to pseudomorph a rhombohedral mineral (a carbonate?, ~0.1–0.2 mm), and are intergrown with blocky white chert pseudomorphs, in a matrix of chert and fibrous clinopyroxene. The rock contains quartz, calcite, clinopyroxene, mica and prehnite (XRD) and appears to be a silicified skarn, with silica crystallinity intermediate between opal and chert.

Sample G402209 is a mid-grey chert with some limonitic weathering and possible sedimentary laminations and cross-bedding. The grain size is ~10–100 m, with abundant intergranular limonite, hematite and opal(?). There are abundant discontinuous, thin lamellar hematitic and pyritic(?) streaks and patches (disrupted veinlets?). The chert is brecciated by some discontinuous, irregular veinlets of very fine to coarse-grained quartz, some vuggy. The rock may be a silicified sediment.

Sample G402481 is slightly weathered and rounded (float?), is mottled in white, grey and pink tones, with an irregular breccia texture and some colloform banding. There are dismembered white to dark grey cherty veins with numerous vughs, to ~4 mm, lined with drusy quartz. The pink and grey zones appear red-brown when sawn. There are red, yellow and white irregular to lamellar clasts <15 mm. The thin section indicates that the rock is composed almost entirely of very fine to medium-grained quartz (confirmed by XRD). The finer-grained patches (20–100 m) are very irregular in shape and impure, with abundant fine-grained to dusty limonite. Some of the limonite is cubic in form, suggesting the original presence of pyrite (<50 m). The coarser quartz shows comb and geode textures, with subhedral, mostly strained, crystals from 0.5–2 mm in size. This coarser quartz shows fluid inclusion-defined growth zoning in places. The textures may indicate a breccia-style carbonate-replacement origin (of dolomite?).

Sample C107642 is a silicified matrix-supported conglomerate. The rock contains rounded pebbles and granules of stressed Precambrian quartz and smaller, angular, unstressed vein quartz patches (vugh-filling?) in a cherty quartz matrix. Chert veins cut the pebbles. The matrix contains very fine patchy dustings of carbonate (<5 m), and the resemblance of these textures to those in the silicified dolomites (cherts, e.g. G402186 and G400235B) indicates that this may have originally had a dolomitic or calcareous matrix. The rock may thus have been a dolomitic quartz conglomerate of Precambrian age.

Opal

Eight samples of opal were collected. One (G402168) was analysed by XRD and one (G402205) was prepared as a thin section. The rocks range from translucent, pale grey-blue and white to opaque, brown and black. They are usually glassy with a conchoidal fracture. XRD on many samples indicates a tridymite-like pattern, suggesting it is opal-CT, a weakly crystalline variety. The opal represents rapid deposition of silica from solution, and may reflect epithermal fluids, perhaps reacting with the carbonate and/or ultrabasic wallrocks. The fresh nature of the opal suggests that the hydrothermal activity is relatively young (Mesozoic or younger). It is probably related to the chert breccias in origin, but indicates more rapid precipitation of silica. Some opal veins are found in the cherts, ophicalcites and skarns.

Sample G402168 exhibits pale brown to red-brown opaline clasts (<15 mm) and brown-yellow clayey clasts, in a variably opaline and clayey matrix. It was analysed by XRD and found to contain opal, smectite and minor quartz.

Sample G402205 exhibits irregular patches (<5 mm) of yellow to brown, weakly birefringent opal, cut and partly replaced by chert and quartz veinlets. There are a few small limonitic clasts. The rock may be a completely silicified and brecciated dolomite, by comparison with the opalised ophicalcites.

Miscellaneous

Samples C107643 & G402198: These gossans were not tested by XRD or thin sectioning. Geochemical analyses are in progress.

Sample G402210 is a chloritic, feldspathic phyllite. There are numerous small (<0.1 mm) quartz grains in a micaceous, cherty matrix, with a strong metamorphic foliation. XRD indicates quartz, chlorite, plagioclase, K-feldspar, mica and smectite. The sample may be an altered Cambrian volcaniclastic or epiclastic rock.

Sample G402444 is a hornfelsed, silicified mudstone. Prehnite veinlets or laminae occur, and may in part represent calcareous, fossiliferous horizons. XRD indicates quartz, prehnite, diopside, amphiboles and chlorite. The diopside is disseminated to massive, patchy and brownish, with a grain size ~10–100 m. The rock is probably a hornfelsed, silicified, calcareous mudstone of Permian age.

Sample WR83 is a brecciated, dark green mafic rock. It contains lensoid clasts (<10 mm) of basalt and augite-plagioclase xenoliths (<2 mm) in a matrix largely replaced by chlorite and prehnite. Quartz occurs in small cherty patches (vesicles?). The rock is sheared, and the foliation is cut by prehnite-calcite-chlorite veins. It is a basaltic agglomerate, possibly Cambrian in age.

Sample WR106 appears to be a flow-banded, autobrecciated, porphyritic glassy volcanic rock, perhaps related to WR83. The matrix, phenocrysts and some amygdules have been almost completely replaced by prehnite (~75%), with patches of yellow-green smectite and chlorite, and disseminated patches and lamellae of very fine-grained carbonate and epidote(?). There is about 5% disseminated euhedral pyrite, <0.5 mm, largely altered to limonite. Lenticular patches of coarse- grained prehnite quartz yellow (?andradite) garnet vesuvianite(?) probably represent altered amygdules. The rock is an autobrecciated, vesicular, porphyritic, intermediate to basic volcanic, probably related to WR83 and possibly Cambrian in age.

DISCUSSION & CONCLUSIONS

Dolomites

The dolomites studied are fine grained, vary from textureless to oolitic, and include a breccia. They are relatively pure but may contain minor quartz, serpentine, brucite and clays. The quartz grains indicate that some silica was originally present, although more silica may have been introduced during a brecciation event. Subsequent metamorphism, probably from Jurassic dolerite or a Cretaceous intrusion at low pressure (<1 kb?), high temperatures (>500°C) and high f_{CO2}, formed forsterite. This was hydrated to serpentine and brucite during retrograde, low temperature hydrothermal alteration. The probable reactions (from Winkler, 1976) are shown below:

Talc amphibole rocks

This is a variable group of ultramafic-derived rocks, varying from amphibolitic greywacke to talcose, phyllitic talc-amphibole rudite and talc mylonite. The talc probably replaces mafic minerals such as orthopyroxene and olivine, and tremolite may replace clinopyroxene. Most of these rocks contain chromite and magnetite. One sample is a carbonate-hosted breccia, with the talc clasts altering to serpentine. The rocks appear to be poorly sorted arenite and rudite rather than purely tectonic breccias. They may have been ultrabasic-derived sediments, related to the Cambrian intrusive rocks, but were highly tectonised and metasomatised.

Hornblende-rich igneous rocks

These rocks are variably altered, medium to fine-grained, slightly porphyritic, amphibole-rich igneous rocks, which originally contained moderate amounts of plagioclase, clinopyroxene, olivine(?) and biotite. The rocks have been variably to moderately altered to assemblages including tremolite- actinolite, chlorite, carbonates, sericite, epidote-clinozoisite and serpentine. They require geochemistry (in progress) and probe analysis for classification, but appear to be a calc-alkaline lamprophyre in texture and composition, probably spessartite (Rock, 1991). The coarser grained rocks may be classified as appinite. They may be either Devonian or Cretaceous in age, and comparable with suites in western and northeastern Tasmania (Sutherland and Corbett, 1974; McClenaghan *et al.*, 1994). Cretaceous lamprophyres occurring in the Cygnet area are mineralogically different but may be temporally related (Ford, 1989; Bottrill, unpub. data).

Jurassic dolerite

These rocks are medium to very fine grained, mostly hard and dense (except when altered), with no obvious inhomogeneity or foliation. Most contain orthopyroxene microphenocrysts, indicating that they are relatively undifferentiated and crystallised rapidly. Some were formed as chilled margins, and some of these are bleached and variably to completely altered to prehnite, serpentine, amphiboles and smectites. There are sporadically common laumontite, calcite, quartz and prehnite veins, and rare wallrock clasts (ophicalcite and chert). It is noteworthy that siliceous alteration both predates and postdates the dolerite.

Skarns and calc-silicate hornfels: altered carbonates

The **diopside-rich hornfels** are mineralogically variable and contain mostly diopside, usually with major amounts of quartz, calcite, serpentine and xonotlite; some contain minor wollastonite, brucite, talc, apophyllite and tobermorite. They are mostly very fine grained, with some coarser patches, breccias and veins. Some textures closely resemble

$$2CaMg(CO_3)_2 + SiO_2 \rightarrow 2CaCO_3 + Mg_2SiO_4 + 2CO_2 \quad (1)$$
Dolomite + Quartz → Calcite + Forsterite

$$2Mg_2SiO_4 + 3H_2O \rightarrow Mg_3Si_2O_5(OH)_4 + Mg(OH)_2 \quad (2)$$
Forsterite → Serpentine + Brucite

$$2Mg_2SiO_4 + 2H_2O + CaCO_3 + CO_2 \rightarrow Mg_3Si_2O_5(OH)_4 + 2CaMg(CO_3)_2 \quad (3)$$
Forsterite + Calcite → Serpentine + Dolomite

ooids and other sedimentary carbonate textures (as in the dolomites). Sample S365 exhibits diopside reaction rims between carbonate grains and disseminated chert patches. Fine-grained diopside veins and zones grade into coarser patches (cement fill texture), suggesting that replacement of carbonates was initiated from early net-fracturing.

The textures suggest mostly rapid crystallisation at low fluid pressure. The rocks were probably derived from the metamorphism of siliceous dolomite, the silica perhaps being metasomatic in part. The prograde reaction (Winkler, 1976) is:

$$2CaMg(CO_3)_2 + 2SiO_2 \rightarrow 2CaMgSi_2O_6 + 2CO_2 \quad (4)$$
Dolomite + Quartz → Diopside

The direct reaction of dolomite and quartz to diopside (there is only rare talc and only rare evidence for any tremolite) indicates very high CO_2 fugacity and temperatures of ~495–545°C, at ~1 kb pressure (Winkler, 1976). The Ca-silicates are uncommon and occur mostly in veins and vughs, suggesting late stage Ca-metasomatism at temperatures from >400°C to less than ~100°C. Wollastonite is stable above ~400°C, xonotlite ~140–400°C, tobermorite ~85–140°C and apophyllite <100°C (Speakman, 1968; Gustafson, 1974; Winkler, 1976; Jakobsson and Moore, 1986). There is some serpentine- carbonate alteration of diopside, but this appears mostly minor.

The brucite marbles contain mostly calcite, with up to 35% brucite and 10% serpentine, plus minor diopside, garnet and other minerals. The brucite occurs mostly as small equant grains (<0.5 mm but usually <0.1 mm), some probably pseudomorphing periclase (MgO). Brucite appears to be partly to completely replaced by serpentine in some rocks. These rocks probably derive from the thermal decarbonation of dolomite and their subsequent hydration during retrograde metamorphism. The reactions (Winkler, 1976) are:

$$CaMg(CO_3)_2 \rightarrow MgO + CaCO_3 + CO_2 \quad (5)$$
Dolomite → Periclase + Calcite

$$MgO + H_2O \rightarrow Mg(OH)_2 \quad (6)$$
Periclase → Brucite

$$3Mg(OH)_2 + 2SiO_2 \rightarrow Mg_3Si_2O_5(OH)_4 + H_2O \quad (7)$$
Dolomite + Quartz → Serpentine

This indicates peak temperatures >600°C, at low CO_2 fugacity and ~1 kb pressure (Winkler, 1976). In some cases, however, brucite occurs as well crystallised flakes in calcite, suggesting direct crystallisation of brucite at temperatures ~550–600°C, also at low CO_2 fugacity and ~1 kb pressure (Winkler, 1976). The reaction is:

$$CaMg(CO_3)_2 + H_2O \rightarrow Mg(OH)_2 + CaCO_3 + CO_2 \quad (8)$$
Dolomite → Brucite + Calcite

The ophicalcites contain widely varying proportions of calcite, serpentine and diopside, with minor amounts of other phases including brucite, andradite, talc, tremolite, magnetite, protographite, sphalerite and galena. The ophicalcites appear to be derived, in part, from the silicification of the brucite-bearing rocks, but probably also in large part by retrograde or hydrothermal alteration of forsterite marbles (from relict textures). The probable reactions are given above (1–8). Forsterite is stable above 545°C, at very high CO_2 fugacity and ~1 kb pressure (Winkler, 1976). Talc (in samples WR64 and WR65) indicates intermediate values of f_{CO_2} at T ~350–550°C, and is probably formed by the reaction:

$$3CaMg(CO_3)_2 + SiO_2 + H_2O \rightarrow 3CaCO_3 + Mg_3Si_4O_{10}(OH)_2 + 3CO_2 \quad (9)$$
Dolomite + Quartz → Calcite + Talc

Andradite occurs mostly in the serpentine, and may derive its iron content from the hydrothermal fluids, rather than the Fe component of dolomite. The sulphides are also restricted to serpentine, and are probably also introduced with the serpentine-forming fluids. Ophicalcites are commonly considered to be altered ultramafic rocks (Lavoie and Cousineau , 1995), but there is little evidence for this with these rocks (e.g. no chromite, and the presence of sedimentary carbonate textures).

The opalised ophicalcites contain calcite and opal, with rare chalcedony and minor serpentine (altering to opal). They may represent groundwater-related silicification of serpentine and other minerals.

The quartz-xonotlite skarns are complex, variable and unusual rocks. They contain major quartz and xonotlite, with small and variable amounts of wollastonite, diopside, scawtite, talc, prehnite, laumontite and several unknown Ca-Fe, Ca-Mg and Ca silicates. Xonotlite is a hydrous calcium silicate of the pyroxenoid group, similar to wollastonite, but forming at lower temperatures (~140–400°C: Speakman, 1968; Harker, 1964). Scawtite (sample G402161) is another hydrous calcium silicate, which usually forms in low temperature assemblages (?<100°C). With the exception of wollastonite, these Ca silicate minerals do not appear to form directly from metamorphism of carbonates. They probably formed from the reaction of Ca-rich hydrothermal fluids (derived from the retrograde metamorphism of the calc-silicate hornfels?) with silicified, cavernous (?clay filled), dolomite-derived breccias (see under cherts) under relatively low pressure and fluid-poor conditions, perhaps due to intrusion of dolerite. Some rocks contain sphalerite and minor millerite, in xonotlite clots and veins.

Summary of metamorphism and alteration of carbonates

Overall, the skarns and calc-silicate hornfels indicate a range of metamorphic conditions, probably initiated at very high CO_2 fugacity and high temperature (>600°C) by the intrusion of dolerite. The thermal decarbonation probably resulted in crackle brecciation due to fluid

overpressure. This brecciation and pressure drop may have resulted in an influx of CO_2-poor groundwater and/or metamorphic water, forming periclase, brucite and serpentine in turn, at varying times with waning temperatures. There is some serpentine-carbonate alteration of carbonate-hosted dolerite veins (some may be clasts in tectonic breccias?) but they do not appear to be altered ultramafic rocks.

Pre-existing silicified zones in the dolomite were attacked by calcium-rich hydrothermal fluids, forming xonotlite, wollastonite, sulphides and other minerals. Some peculiar Ca-Fe-Mg-Al assemblages are probably derived from metasomatism of clays filling these breccias.

The traces of base metals in these altered siliceous and carbonate rocks (as pyrite, millerite, loellingite, niccolite, sphalerite, chalcopyrite and galena) were probably introduced with late-stage metamorphic fluids, although some (e.g. nickel) may have been sourced locally (in the ultrabasic rocks or dolerite).

Gold may have been introduced at the same time as the sulphides, and the one grain seen is associated with sulphides, protographite and magnetite, in carbonaceous zones or veins in ophicalcite. This suggests that the gold may have precipitated by reduction of a relatively oxidised gold-transporting fluid with organic material. The association of gold with magnetite and sulphides in carbonaceous zones in carbonate rocks may be somewhat analogous with the Carlin style of mineralisation (Radtke *et al.*, 1980; Kuehn and Rose, 1995), but this requires more study. There are also similarities with auriferous skarns (Boyle, 1979), but geochemistry is required to confirm this.

Chert and siliceous breccia

These breccias are remarkably variable in origin. Remnant textures indicate various origins, including silicified Permian (and/or Precambrian) mudstone, dolomite, ultrabasic rocks and skarns. Clasts of these different groups are not usually intermixed, although some may possibly be (e.g. G402190, G402207?). They are probably, in part, silicified collapse breccias formed in the dolomite and overlying Permian rocks, as at Mt Weld. Some contain pyrite, hematite, magnetite and organic material, and this mineralogy indicates that there is some potential for Carlin-style gold mineralisation (Kuehn and Rose, 1995), although no visible gold was observed in this rock type. The chert textures resemble those in the Relief Canyon gold deposit of Nevada (Wallace, 1989).

The coarser-grained quartz breccias (e.g. G402153) are probably straightforward dolomite-replacement breccias (as form the caves at Mt Weld), although some have been Ca-metasomatised and resilicified (compare with the quartz-xonotlite skarns).

Clasts of chert in dolerite indicate that some of the chert is pre-Jurassic in age, but chert has probably formed at various stages, some possibly quite recently. Some cherts with diopside veinlets appear to have been overgrown by quartz, indicating that the devolatisation and brecciation forming the diopside predated some silicification (e.g. G402153, G402141 and G402166). Minor quartz veins in dolerite also indicate some late silicification.

Opal

The opal represents rapid deposition of silica from solution, and may reflect epithermal fluids, perhaps reacting with the carbonate wallrocks. Some opal-veined limestones are probable intermediate rocks (e.g. WR51). The fresh nature of the opal suggests that at least some of the hydrothermal activity is relatively young (late Mesozoic or younger).

Miscellaneous

G402210: This quartz-bearing, chloritic, feldspathic phyllite may be an altered Cambrian volcanic or volcaniclastic rock.

G402444: This rock is probably a hornfelsed, silicified, calcareous mudstone of Permian age.

W106 and WR83 were probably volcanic or sub-volcanic rocks: autobrecciated, flow banded, porphyritic basaltic or andesitic(?) igneous rocks. They are variably to almost completely replaced by prehnite, plus chlorite and smectite. They are possibly of Cambrian age(?).

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[19 June 1997]

Table 2

Electron microprobe analyses

Analysis No.	402169-12	402169-13	402169-14	402169-15	402169-16	402169-17	402169-18	402169-19	402169-20	402169-21	402169-22	402169-23
Description	CaFeSi	CaFeSi	Prehnite	Prehnite	CaFeSi	CaMgSi	CaMgSi	talc	CaFeSi	calcite	CaFeSi	Prehnite
SiO_2	51.30	48.78	42.38	42.93	48.94	53.53	54.13	60.32	49.02	0.08	50.30	42.49
TiO_2	0.02	0.02	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00
Al_2O_3	2.13	2.07	19.05	20.85	2.01	1.27	1.37	0.60	1.90	0.00	2.52	19.51
Cr_2O_3	0.01	0.00	0.03	0.06	0.04	0.00	0.00	0.03	0.00	0.00	0.00	0.00
MgO	8.35	4.89	0.00	0.00	4.28	14.46	13.97	25.54	5.55	0.00	4.68	0.07
CaO	14.42	18.03	26.61	27.01	18.90	10.45	12.00	2.55	17.06	61.81	15.89	26.54
MnO	0.13	0.02	0.00	0.03	0.00	0.07	0.06	0.04	0.12	0.02	0.17	0.00
FeO	14.01	15.86	6.01	3.29	15.47	10.37	11.45	4.63	15.73	0.06	15.38	5.26
NiO	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Na_2O	0.36	0.41	0.04	0.05	0.35	0.28	0.32	0.12	0.43	0.00	0.34	0.04
K_2O	0.02	0.00	0.00	0.00	0.00	0.05	0.04	0.07	0.02	0.01	0.01	0.00
F							0.00				0.00	
Total	90.75	90.10	94.14	94.22	90.00	90.46	93.35	93.92	89.83	62.01	89.29	93.91
Atomic ratios												
No. oxygens	20	20	11	11	20	20	20	11	20	1	20	11
Si	7.003	6.893	3.066	3.056	6.923	7.087	7.015	3.982	6.922	0.001	7.065	3.066
Ti	0.002	0.002	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Al	0.343	0.345	1.623	1.748	0.335	0.198	0.209	0.047	0.316	0.000	0.417	1.659
Cr	0.001	0.000	0.002	0.003	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Mg	1.699	1.029	0.000	0.000	0.903	2.852	2.699	2.513	1.169	0.000	0.981	0.008
Ca	2.110	2.729	2.062	2.060	2.865	1.482	1.666	0.180	2.581	0.996	2.390	2.052
Mn	0.015	0.002	0.000	0.002	0.000	0.008	0.007	0.002	0.015	0.000	0.021	0.000
Fe	1.599	1.874	0.364	0.196	1.830	1.148	1.241	0.256	1.857	0.001	1.806	0.317
Ni	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Na	0.095	0.113	0.006	0.008	0.095	0.072	0.081	0.015	0.118	0.000	0.093	0.006
K	0.003	0.000	0.000	0.000	0.000	0.008	0.007	0.006	0.003	0.000	0.001	0.000
Total cations	12.872	12.990	7.124	7.073	12.955	12.854	12.924	7.004	12.981	0.999	12.774	7.108

Analysis No.	402163/1	402163/2	402163/4	402163/7	402163/8	402163/9	402163/10	402163/12	402163/13	402163/3/1	402163/3/2
Description	CaFeSi	xon	CaFeSi	cpx	cpx	cpx	CaFeSi	cpx	xon	CaFeSi	cpx
SiO_2	45.90	49.70	48.51	50.75	51.95	51.61	47.16	54.80	49.58	42.95	52.00
TiO_2	0.01	0.02	0.00	0.01	0.03	0.00	0.00	0.01	0.00	0.00	0.00
Al_2O_3	2.22	0.10	1.03	0.46	0.28	0.36	1.60	0.05	0.05	2.02	0.19
Cr_2O_3	0.00	0.03	0.01	0.00	0.02	0.04	0.00	0.01	0.00	0.02	0.00
MgO	0.18	0.00	0.21	9.48	12.49	10.40	0.36	18.01	0.00	0.61	11.03
CaO	26.29	46.89	28.73	23.57	24.39	24.18	30.77	25.62	46.56	19.98	23.68
MnO	0.00	0.00	0.05	0.03	0.09	0.04	0.02	0.01	0.04	0.00	0.01
FeO	16.68	0.30	11.98	15.06	10.02	13.02	12.90	1.68	0.31	24.54	12.37
NiO	0.01	0.00	0.00	0.08	0.07	0.09	0.09	0.00	0.03	0.07	0.38
Na_2O	0.25	0.01	0.40	0.09	0.08	0.06	0.21	0.00	0.00	0.40	0.12
K_2O	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00
Cl	0.02	0.01	0.02	0.01	0.02	0.03			0.01	0.02	
Total	91.56	97.07	90.94	99.55	99.44	99.84	93.12	100.20	96.59	90.61	99.77
Atomic ratios											
No. oxygens	12	18	12	6	6	6	12	6	18	12	12
Si	3.980	5.958	4.146	1.971	1.975	1.980	3.993	1.987	5.971	3.882	3.977
Ti	0.001	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Al	0.226	0.014	0.103	0.021	0.013	0.016	0.160	0.002	0.008	0.215	0.017
Cr	0.000	0.003	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.002	0.000
Mg	0.024	0.000	0.027	0.549	0.708	0.595	0.045	0.974	0.000	0.082	1.257
Ca	2.443	6.024	2.631	0.981	0.994	0.994	2.791	0.996	6.009	1.935	1.940
Mn	0.000	0.000	0.003	0.001	0.003	0.001	0.002	0.000	0.004	0.000	0.001
Fe	1.210	0.030	0.856	0.489	0.319	0.418	0.914	0.051	0.031	1.854	0.791
Ni	0.000	0.000	0.000	0.003	0.002	0.003	0.006	0.000	0.003	0.005	0.023
Na	0.042	0.003	0.066	0.007	0.006	0.005	0.034	0.000	0.000	0.070	0.017
K	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.000
Cl	0.004	0.004	0.005	0.005	0.001	0.003	0.004	0.000	0.006	0.006	0.000
Total cations	7.926	12.034	7.835	4.021	4.020	4.014	7.945	4.011	12.026	8.045	8.024

Table 2

Electron microprobe analyses (continued)

Analysis No.	402180A/1	402180A/2	402180A/3	402166	402166	402166	107640	107640	107640	403139/13	403139/14	403139/15
Description	cpx	cpx	cpx	xonotlite	xonotlite	xonotlite	cpx	cpx	amph	amph	amph	amph
SiO_2	49.29	53.52	49.25	53.35	51.07	51.45	51.80	49.96	45.24	56.86	53.89	57.32
TiO_2	0.40	0.20	0.38	0.02	0.03	0.00	0.35	0.90	1.69	0.20	0.11	0.05
Al_2O_3	4.51	1.45	3.87	2.34	0.51	1.03	2.95	4.72	10.65	3.18	6.49	2.77
Cr_2O_3	0.17	0.25	0.13	0.00	0.02	0.00	0.61	0.55	0.01	0.11	1.60	0.10
MgO	19.50	19.36	17.98	0.00	0.01	0.00	16.83	14.93	12.55	18.82	20.70	21.74
CaO	11.37	17.91	16.63	35.31	43.00	40.81	22.31	22.82	10.74	11.24	12.69	12.17
MnO	0.40	0.32	0.23	0.00	0.02	0.02	0.12	0.11	0.46	0.17	0.04	0.00
FeO	11.52	6.84	8.85	0.09	0.10	0.10	4.06	5.66	15.75	8.87	3.31	3.94
NiO	0.02	0.00	0.03	0.00	0.04	0.00	0.02	0.09				
Na_2O	0.09	0.10	0.09	0.25	0.08	0.13	0.27	0.30	2.05	0.40	0.91	0.41
K_2O	0.02	0.00	0.02	1.77	0.10	0.70	0.01	0.03	0.82	0.03	0.09	0.08
Cl	0.01		0.01							0.12	0.15	0.09
Total	97.31	99.96	97.49	93.13	94.97	94.24	99.33	100.07	99.95	100.04	100.06	98.65
-O=F,Cl				0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.03	0.00
Total				93.13	94.97	94.24	99.33	100.07	99.95	100.03	100.03	98.65
Atomic ratios												
No. oxygens	6	6	6	18	18	18	6	6	23	23	23	23
Si	1.864	1.954	1.865	6.395	6.150	6.210	1.909	1.848	6.580	7.792	7.312	7.806
Ti	0.011	0.005	0.011	0.002	0.003	0.000	0.010	0.025	0.184	0.021	0.011	0.005
Al	0.201	0.063	0.173	0.331	0.073	0.147	0.128	0.206	1.826	0.513	1.038	0.444
Cr	0.005	0.007	0.004	0.000	0.002	0.000	0.018	0.016	0.001	0.012	0.172	0.011
Mg	1.099	1.054	1.015	0.000	0.001	0.001	0.924	0.823	2.719	3.844	4.186	4.412
Ca	0.461	0.700	0.675	4.535	5.549	5.279	0.881	0.904	1.675	1.650	1.845	1.775
Mn	0.013	0.010	0.008	0.000	0.002	0.002	0.004	0.004	0.056	0.020	0.005	0.000
Fe	0.364	0.209	0.280	0.009	0.010	0.010	0.125	0.175	1.916	1.017	0.376	0.449
Ni	0.001	0.000	0.001	0.000	0.003	0.000	0.001	0.003	0.000	0.000	0.000	0.000
Na	0.007	0.007	0.007	0.058	0.019	0.031	0.019	0.022	0.580	0.107	0.239	0.108
K	0.001	0.000	0.001	0.270	0.015	0.107	0.001	0.001	0.152	0.005	0.016	0.013
Cl	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.030	0.000
Total cations	4.026	4.009	4.039	11.602	11.827	11.786	4.019	4.027	15.688	14.995	15.229	15.023

Analysis No.	402164/34	402164/35	402161/25	402161/26	402161/27	402161/28	402161/32	402161/33	402177	402161/29	402161/30
Description	cpx	sap	chl	cpx	?	?	chl	cpx	brucite	garnet	garnet
SiO_2	54.51	49.45	36.52	52.44	28.27	29.51	36.00	54.49	1.16	34.97	35.89
TiO_2	0.00	0.00	0.00	0.14	0.96	0.32	0.00	0.03	0.03	0.00	0.00
Al_2O_3	0.12	0.00	10.38	1.12	15.73	18.12	11.86	0.09	0.71	2.38	5.07
Cr_2O_3	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03
MgO	17.08	22.59	37.67	17.10	1.77	1.78	36.66	17.41	72.88	0.56	0.36
CaO	26.26	0.35	0.27	23.07	36.16	35.60	0.15	26.17	0.36	34.38	35.02
MnO	0.03	0.00	0.06	0.22	0.12	0.06	0.16	0.17	0.11	0.05	0.00
FeO	1.79	0.48	0.76	5.11	6.19	4.56	1.11	2.07	2.96	24.35	20.92
NiO	0.38	0.81	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Na_2O	0.03	0.07	0.02	0.10	0.00	0.00	0.01	0.03	0.01	0.02	0.02
K_2O	0.00	0.09	0.00	0.00		0.02	0.00	0.01	0.00	0.00	0.00
Cl		0.04									
Total	100.23	73.89	85.71	99.30	89.21	89.97	85.95	100.47	78.25	96.70	97.30
-O=F,Cl	0.00	-0.01									
Total	100.23	73.88									
Atomic ratios											
No. oxygens	6	11	28	6	9	9	28	6	1	8	8
Si	1.986	4.055	6.883	1.944	1.921	1.950	6.772	1.980	0.010	3.148	3.125
Ti	0.000	0.000	0.000	0.004	0.049	0.016	0.000	0.001	0.000	2.782	2.829
Al	0.005	0.000	2.306	0.049	1.259	1.411	2.630	0.004	0.007	0.000	0.000
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.223	0.470
Mg	0.927	2.761	10.581	0.945	0.180	0.175	10.279	0.943	0.943	0.000	0.002
Ca	1.025	0.031	0.055	0.916	2.632	2.521	0.029	1.019	0.003	0.066	0.043
Mn	0.001	0.000	0.009	0.007	0.007	0.003	0.026	0.005	0.001	2.931	2.957
Fe	0.055	0.033	0.120	0.159	0.352	0.252	0.174	0.063	0.021	0.003	0.000
Ni	0.011	0.053	0.006	0.000	0.000	0.000	0.000	0.000	0.000	1.620	1.379
Na	0.002	0.011	0.009	0.007	0.000	0.000	0.004	0.002	0.000	0.000	0.000
K	0.000	0.009	0.000	0.000	0.000	0.001	0.000	0.000	0.000	7.625	7.679
Cl	0.000										
Total cations	4.013	6.955	19.968	4.031	6.400	6.329	19.915	4.018	0.986		

Table 2

Electron microprobe analyses (continued)

Analysis No.	400235/11	400235/12	400235/13	400235/14	403139/16	403139/17	403139/18
Description	Chromite	Chromite	Chromite	Chromite	Chromite	Chromite	Chromite
SiO_2		0.28			0.09	0.00	0.00
TiO_2					0.03	0.02	0.01
Al_2O_3	5.23	5.95	4.82	4.72	3.14	10.01	19.44
Cr_2O_3	70.47	66.88	72.27	70.60	61.51	57.98	46.32
MgO	8.84	10.53	9.69	10.15	4.18	9.72	11.17
CaO							
MnO					0.74	0.30	0.35
FeO	15.72	13.42	15.17	16.93	28.38	19.68	21.52
NiO					0.00	0.03	0.04
Na_2O		0.90					
K_2O							
Total	100.26	97.96	101.95	102.40	98.06	97.73	98.85
Atomic ratios							
Cations	3	3	3	3	3	3	3
Si	0.000	0.010	0.000	0.000	0.003	0.000	0.000
Ti	0.000	0.000	0.000	0.000	0.001	0.001	0.000
Al	0.210	0.242	0.189	0.184	0.134	0.398	0.727
Cr	1.895	1.822	1.906	1.847	1.757	1.547	1.163
Fe	0.000	0.000	0.000	0.000	0.105	0.054	0.110
tot tet	2.105	2.073	2.095	2.031	2.000	2.000	2.000
Mg	0.448	0.541	0.482	0.501	0.225	0.489	0.528
Fe	0.447	0.387	0.423	0.468	0.752	0.502	0.461
Ni	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Mn	0.000	0.000	0.000	0.000	0.023	0.009	0.009
tot oct	0.895	0.927	0.905	0.969	1.000	1.000	1.000

Abbreviations: amph: amphibole
cpx: clinopyroxene
xon: xonotlite (or other Ca silicate)
CaMgSi: unidentified Ca-Mg-silicate
chl: chlorite
grt: garnet (hydroandradite)
CaFeSi: unidentified Ca-Fe-silicate

APPENDIX 1
Summary of samples, Weld River

Reg. No.	Name	Minerals	Modifiers	Age	Unit code	Location (mE)	Location (mN)	Accuracy (m)	Locality	Coll.	Year	Treatment	Keywords	Comments
C102098	mylonite	tlc		Pzc	Cal	478050	5233600	500	Forsters Pr	P.Ruzica	1985	PTS		
G400234	opal	brow	vugg			478400	5234800	100	Forsters Pr	RSB	8.86			
G400235	chert	chr, dol				478200	5235100	100	Forsters Pr	RSB	8.86	TS, WR		
G400236	silica flour					478300	5234800	100	Forsters Pr	RSB	8.86			pit
G400237	dolerite	py, hbd, opx	mgd	Mj	Jdl	478150	5234450	50	Forsters Pr	RSB	8.86	TS, PTS		
G400238	dolomite		whit	PR	Pw	477750	5235500	50	Forsters Pr	RSB	8.86	XRD, WR, PTS		river bed
G400239	ophicalcite	di				477800	5235550	50	Forsters Pr	RSB	8.86	XRD, WR, TS		pit
G400240	dolomite	srp		PR	Pw	477750	5235500	50	Forsters Pr	RSB	8.86	XRD, WR, TS		pit
G400241	hornfels	di	whit			477750	5235500	50	Forsters Pr	RSB	8.86			
G400242	dolerite	opx	fgd	Mj	Jdl	477750	5235700	50	Forsters Pr	RSB	8.86	TS		big eddy
G400243	chert					478400	5234800	100	Forsters Pr	RSB	8.86			
G400263	hornfels	qtz, di, xon				477750	5235500	50	Forsters Pr	McF	1985	TS		
G400279	chalcedony					478000	5234100	200	Forsters Pr	McF	1985			
G400299	dolomite			PR	Pw	477750	5235500	50	Forsters Pr	McF	1985			
G400336	schist	tlc, mag, chr	CO_3	Pzc	Cal	477600	5234800	200	Forsters Pr	DJ	5.88	TS		
G400337	lamprophyre	chl, hbd				477600	5234800	200	Forsters Pr	DJ	5.88	TS		
G400338	dolerite	opx	mgd	Mj	Jdl	477600	5234800	200	Forsters Pr	DJ	5.88	TS		
G400904	Ophicalcite	opa, srp				478200	5234400	200	Forsters Pr	DJ	5.88	TS, XRD		
G402036	mudstone/chert	mica	chert			477600	5234800	500	Forsters Pr	McF	4.94	XRD, TS		
G402037	hornfels	di, srp, cal				477600	5234800	500	Forsters Pr	McF	4.94	XRD, TS		'jade'
G402038	conglomerate	tlc, hem, chl	red, blak	Pzc	Cal	477600	5234800	500	Forsters Pr	McF	4.94	XRD, TS		
G402039	lamprophyre	chl, mica, hbd	fgnd			477600	5234800	500	Forsters Pr	McF	4.94	XRD, TS		
G402040	lamprophyre	chl, px, hbd	fgnd, cgnd			477600	5234800	500	Forsters Pr	McF	4.94	XRD, TS		
G402136	chert	cal	lim, clay			477600	5234800	500	Forsters Pr	McF	3.92	XRD, TS		
G402137	phyllite	tlc, hem, kao		Pzc	Cal	478050	5233700	200	Forsters Pr	McF	3.92	XRD, PTS		Ni adit
G402138	greywacke	am, tlc, sme	wthd	Pzc	Cal	478050	5233700	200	Forsters Pr	McF	3.92	XRD, TS	mt, chr	Ni adit
G402139	greywacke	am, chr, tlc		Pzc	Cal	478050	5233700	200	Forsters Pr	McF	3.92	XRD, PTS, EMP		Ni adit
G402140	pyroxenite	tlc, mem, mt	wthd	Pzc	Cal	478050	5233700	200	Forsters Pr	McF	3.92	XRD, TS		Ni adit

Reg. No.	Name	Minerals	Modifiers	Age	Unit code	Location (mE)	Location (mN)	Accuracy (m)	Locality	Coll.	Year	Treatment	Keywords	Comments
G402141	skarn	qtz, wo, gro				478050	5233700	500	Forsters Pr	McF	3.92	XRD, PTS	xonotlite	DDH
G402142	ophicalcite	brc, opl				478050	5233700	200	Forsters Pr	McF	3.92	XRD, TS		Ni adit
G402148	phyllite	mag, tlc	blac			478050	5233700	500	Forsters Pr	McF	5.92	XRD, TS		
G402149	ophicalcite					478050	5233700	500	Forsters Pr	McF	5.92	XRD, TS		DDH
G402150	ophicalcite	brc				478050	5233700	500	Forsters Pr	McF	5.92	XRD, TS		DDH
G402151	chert					478214	5233560	5	Forsters Pr	RSB	7.92	TS		Weld DDH1, 49.2
G402152	chert	opl, cal	clay, pink			478214	5233560	5	Forsters Pr	RSB	7.92	TS		Weld DDH1, 54.8
G402153	skarn	qtz, opl				478214	5233560	5	Forsters Pr	RSB	7.92	TS, XRD		Weld DDH1, 55.7
G402154	dolerite	prh, qtz, px	wthd, amph, brx	Mj	Jdl	478214	5233560	5	Forsters Pr	RSB	7.92	TS, XRD	dolerite?	Weld DDH1, 59.1
G402155	dolerite	opx	amyg	Mj	Jdl	478214	5233560	5	Forsters Pr	RSB	7.92	TS, XRD	laumontite	Weld DDH1, 62.8
G402156	chert	opa, sme	clay			478214	5233560	5	Forsters Pr	RSB	7.92	XRD		Weld DDH1, 63.7
G402157	ophicalcite	brc				478214	5233560	5	Forsters Pr	RSB	7.92	XRD, TS		Weld DDH1, 66.9
G402158	ophicalcite	brc, sl				478214	5233560	5	Forsters Pr	RSB	7.92	XRD, TS		Weld DDH1, 67.6
G402159	ophicalcite	brc, and				478214	5233560	5	Forsters Pr	RSB	7.92	XRD, TS		Weld DDH1, 68
G402160	ophicalcite		brx			478214	5233560	5	Forsters Pr	RSB	7.92	TS		Weld DDH1, 68.3
G402161	Jdl contact	srp, qtz, and	Pb, CO3, Cu			478214	5233560	5	Forsters Pr	RSB	7.92	XRD, PT, EMP	sphalerite,galena, dolerite, ophicalcite	Weld DDH1, 69.2, contact
G402162	ophicalcite	brc	brx			478214	5233560	5	Forsters Pr	RSB	7.92	TS, XRD		Weld DDH1, 73.3
G402163	skarn	qtz, xon, di	Cu, Ni, Zn			478214	5233560	5	Forsters Pr	RSB	7.92	XRD, PTS, EMP	green?, white?, millerite, mt	Weld DDH1, 76.1
G402164	hornfels	cal, di, tlc	Ni, Zn			478214	5233560	5	Forsters Pr	RSB	7.92	PTS, EMP	nicc, ramm, loll	Weld DDH1, 78.7
G402165	skarn	cal, di	Zn			478214	5233560	5	Forsters Pr	RSB	7.92	XRD, TS	apophyllite, tobermorite	Weld DDH1, 79.7
G402166	skarn	qtz, xon, di	Zn, Ni			478214	5233560	5	Forsters Pr	RSB	7.92	XRD, TS, EMP	cal, sl, mill	Weld DDH1, 81.9
G402167	hornfels	di				478133	5233563	5	Forsters Pr	RSB	7.92	XRD		South Weld DDH 2, 34.0
G402168	opal/chalc	sme, srp	brow, clay			478133	5233563	5	Forsters Pr	RSB	7.92	XRD	smectite, tridymite	South Weld DDH 2, 41.0
G402169	skarn	qtz, xon, prn	Zn			478133	5233563	5	Forsters Pr	RSB	7.92	TS, XRD, EMP	green??, tlc, laum, sl, mill, arag.	South Weld DDH 2, 46.6
G402170	ophicalcite	brc, di				478133	5233563	5	Forsters Pr	RSB	7.92	TS, XRD		South Weld DDH 2, 50.2
G402171	ophicalcite	brc				478133	5233563	5	Forsters Pr	RSB	7.92	TS, XRD		South Weld DDH 2, 52.5
G402172	ophicalcite	brc	vein			478133	5233563	5	Forsters Pr	RSB	7.92	TS		South Weld DDH 2, 53.2
G402173	ophicalcite	di, grt	brx			478133	5233563	5	Forsters Pr	RSB	7.92	TS, XRD	gn, loll, cpy, sl	South Weld DDH 2, 56.1

Reg. No.	Name	Minerals	Modifiers	Age	Unit code	Location (mE)	Location (mN)	Accuracy (m)	Locality	Coll.	Year	Treatment	Keywords	Comments
G402174	ophicalcite	brc, mt	vein			478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD	sjog, hydromag	South Weld DDH 2, 58.2
G402175	ophicalcite	brc, di	grey green			478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD	garnet	South Weld DDH 2, 67.0
G402176	calcite					478133	5233563	5	Forsters Pr	RSB	2.92			South Weld DDH 2, 69.9
G402177	ophicalcite	brc, grt, sl				478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD, EMP	gn, loll, cpy, gold	South Weld DDH 2, 72.0
G402178	ophicalcite	di, and				478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD	sl	South Weld DDH 2, 74.7
G402179	ophicalcite	brc, mt, mica				478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD	sjogrenite	South Weld DDH 2, 89.9
G402180	dolerite contact	srp, prn, di	fgd	Mj	Jdl	478133	5233563	5	Forsters Pr	RSB	2.92	TS, XRD, EMP	ophicalcite	South Weld DDH 2, 103.8
G402181	dolerite	opx	mgd	Mj	Jdl	478133	5233563	5	Forsters Pr	RSB	2.92	TS	laumontite	South Weld DDH 2, 107.5
G402182	chert	qtz, tlc, hem				478133	5233563	500	Forsters Pr	RSB	2.92	XRD, TS	chr	
G402183	skarn	sme, di, srp				478133	5233563	5	Forsters Pr	RSB	2.92	XRD		South Weld DDH 2, 48.0
G402184	dolerite		brx, vein, mgd	Mj	Jdl	478133	5233563	5	Forsters Pr	RSB	2.92	TS	laumontite	South Weld DDH 2, 109.1
G402185	dolerite			Mj	Jdl	478133	5233563	5	Forsters Pr	RSB	2.92	TS		South Weld DDH 2, 110.4
G402186	chert					477950	5233550	50	Forsters Pr	RSB	7.92	TS		
G402187	Chert	hem	red clay			477950	5233550	50	Forsters Pr	RSB	7.92	TS		
G402188	breccia	hem, qtz	red			477950	5233550	50	Forsters Pr	RSB	7.92			
G402189	Chert	hem	pink white clay			477950	5233550	50	Forsters Pr	RSB	7.92	TS	chr	
G402190	Chert	hem	pink green			477950	5233550	50	Forsters Pr	RSB	7.92	TS		
G402191	Chert					477950	5233550	50	Forsters Pr	RSB	7.92			
G402192	Talc			Pzc	Cal	478050	5233650	50	Forsters Pr	RSB	7.92			
G402194	breccia	qtz	black white carb			478200	5233750	50	Forsters Pr	RSB	7.92	TS		
G402196	chert	hem, py	brown brx			478100	5233870	50	Forsters Pr	RSB	7.92	TS		
G402197	breccia	qtz	green			478100	5233870	50	Forsters Pr	RSB	7.92			
G402198	Gossan		sifd			478100	5233870	50	Forsters Pr	RSB	7.92			
G402199	Opal					478100	5233870	50	Forsters Pr	RSB	7.92			
G402200	Opal		brown			478100	5233870	50	Forsters Pr	RSB	7.92			
G402205	opal/chalc	lim	brown, brx, chert			478100	5233870	50	Forsters Pr	RSB	7.92	TS		
G402206	ophicalcite	opl, sid, qtz	wthd, brx			478200	5234320	50	Forsters Pr	RSB	7.92	PT, EMP, XRD	dol	
G402207	chert	opl, di, cal	brown white			478140	5234370	50	Forsters Pr	RSB	7.92	TS, XRD		
G402208	breccia	di, sid				478000	5234450	50	Forsters Pr	RSB	7.92	TS		
G402209	chert	hem	grey			478000	5234450	50	Forsters Pr	RSB	7.92	TS		
G402210	schist	chl, qtz, fsp	cherty, mic	Pzc	Cal	478000	5234450	50	Forsters Pr	RSB	7.92	TS		tuff?

Reg. No.	Name	Minerals	Modifiers	Age	Unit code	Location (mE)	Location (mN)	Accuracy (m)	Locality	Coll.	Year	Treatment	Keywords	Comments
G402211	dolerite	opx	fgd, glass	Mj	Jdl	478070	5234465	50	Forsters Pr	RSB	7.92	TS		
G402214	conglomerate	tlc, trm, chr		Pzc	Cal	478000	5234100	200	Forsters Pr	McF	7.92	TS	mt	
G402335	hornfels	di, srp, ca				478000	5234100	200	Forsters Pr	McF		XRD		
G402336	ophicalcite					478000	5234100	200	Forsters Pr	McF		XRD		
G402437	phyllite	hem, tlc		Pzc	Cal	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402438	phyllite	chl, tlc		Pzc	Cal	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402439	conglomerate	kln, hem, tlc		Pzc	Cal	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402440	hornfels	cal, di, qtz	green			478000	5234100	200	Forsters Pr	McF	6.93	XRD	srp	
G402441	conglomerate	tlc, am, pl	wthd	Pzc	Cal	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402442	hornfels	di, srp, cal		PzP		478000	5234100	200	Forsters Pr	McF	6.93	TS, XRD		
G402443	ophicalcite	spl				478000	5234100	200	Forsters Pr	McF	6.93	TS		
G402444	hornfels	di, qtz, prn				478000	5234100	200	Forsters Pr	McF	6.93	TS, XRD	am, chl	
G402445	opal					478000	5234100	200	Forsters Pr	McF	6.93			
G402446	mudstone		chert breccia	PzP		478000	5234100	200	Forsters Pr	McF	6.93	TS		
G402447	dolerite			Mj	Jdl	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402448	pyroxenite	tlc, sme, kln		Pzc	Cal	478000	5234100	200	Forsters Pr	McF	6.93	XRD		
G402449	dolerite?			Mj	Jdl	478000	5234100	200	Forsters Pr	McF	6.93			
G402450	opal					478000	5234000	500	Forsters Pr	RSB	2.93			
G402479	dolerite	opx	mgd	Mj	Jdl	477200	5235450	50	Forsters Pr	KCM	10.95	TS		
G402480	hornfels	di, qtz, wol				477750	5235550	50	Forsters Pr	KCM	10.95	TS, XRD	Xon, calcite	
G402481	breccia	qtz, lim	vug, pink, white			478150	5233800	50	Forsters Pr	KCM	10.95	TS, XRD		
C107635	quartz		white, vug			478200	5233750	50	Forsters Pr	RSB	11.94			
C107636	quartz		white, vug, black			478200	5233750	50	Forsters Pr	RSB	11.94			
C107637	quartz		white, vug, grey			478200	5233750	50	Forsters Pr	RSB	11.94			
C107638	opal		black			478150	5234100	50	Forsters Pr	RSB	11.94			
C107639	lamprophyre	hbd				478200	5234100	50	Forsters Pr	RSB	11.94	PTS		
C107640	appinite	hbd				478100	5234100	50	Forsters Pr	RSB	11.94			
C107641	breccia	tlc	red	Pzc	Cal	478000	5234100	50	Forsters Pr	RSB	11.94			
C107642	conglomerate	qtz	chert			478150	5234350	50	Forsters Pr	RSB	11.94	PTS		
C107643	gossan					478100	5234400	50	Forsters Pr	RSB	11.94			
C107644	dolomite	tlc	brx, clay	PR	Pw	478100	5234450	50	Forsters Pr	RSB	11.94	PTS, XRD		

Reg. No.	Name	Minerals	Modifiers	Age	Unit code	Location (mE)	Location (mN)	Accuracy (m)	Locality	Coll.	Year	Treatment	Keywords	Comments
C107693	mudstone	brx							Mt Weld	RSB	1.96	PTS, XRD		
WR47	hornfels	di, qtz, tlc				477550	5237950	50	Forsters Pr	CRC	1.96	TS		
WR51	ophicalcite	opl				478200	5234350	50	Forsters Pr	CRC	1.96	TS		
WR64	marble	tlc				477530	5235065	50	Forsters Pr	CRC	1.96	TS		
WR65	ophicalcite	tlc, sid	brx			477550	5235190	50	Forsters Pr	CRC	1.96	TS		
WR67	conglomerate	tlc, cal, srp		Pzc	Cal	478020	5234475	50	Forsters Pr	CRC	1.96	TS		
WR83	basalt	prh, chl	brx, xen	Pzc		480450	5232780		Huon River	CRC	1.96			
W106	basalt?	prn	altd, abrc	Pzc		477850	5237500	50	Forsters Pr	CRC	1.96	TS		
W112	lamprophyre	hbd	fgd			477800	5237500	50	Forsters Pr	CRC	1.96	TS		
W113	marble	brc				477720	5237470	50	Forsters Pr	CRC	1.96	TS		
S365	hornfels	qtz, di, cal				477750	5235600	50	Forsters Pr	CRC	1.96	TS		
S371	dolomite			PR	Pw	477650	5234650	50	Forsters Pr	CRC	1.96	TS		

For explanations and list of abbreviations, see Unpublished Report 1988/13 or the TASROCK database.

APPENDIX 2
Drill Log: Diamond Drill Hole South Weld DDH1

Drilled for:	Northwest Bay Co. Ltd	***Drilled by:***	Department of Mines
Logged by:	R. S. Bottrill, 1992	***Project:***	Southgold
For:	Tasmanian Geological Survey	***Date:***	16 July 1992
Bearing:	090° Mag	***Dip:***	-50°
Total Length:	82 m	***Core Size:***	NQ: 34.2–54.6 m, BQ: 54.6–82.0 m
Location (AMG):	478 214 mE, 5 233 560 mN		

Depth (metres)	Description	Samples
0–34	No core (percussion)	
34–58.8	Vuggy, medium to fine-grained quartz and chert. Pink and grey zones. Minor skarn and opal near base.	49.2 m: G402151 (grey chert) 54.8 m: G402152 (pink chert) 55.7 m: G402153 (skarn/chert)
58.8–59.1	Jurassic dolerite, fine grained.	59.1 m: G402154 (dolerite)
59.1–62.0	Vuggy quartz and chert, as above.	
62.0–63.0	Jurassic dolerite, fine grained.	62.8 m: G402155 (dolerite)
63.0–66.5	Vuggy quartz and chert, finer and more massive between 63.7–64.7.	63.7 m: G402156 (chert)
66.5–79.8	"Dolomite marble": fine-grained dolomite, largely replaced by "ophicalcite" (calcite-serpentine rock). Some opal veining. Towards the base it is increasingly brecciated and grades into a diopside hornfels. Some small, altered, dolerite dykes occur.	66.9 m: G402157 (ophicalcite) 67.6 m: G402158 (ophicalcite) 68.0 m: G402159 (ophicalcite) 68.3 m: G402160 (ophicalcite) 69.2 m: G402161 (dolerite/ophicalcite) 73.3 m: G402162 (brucite marble) 76.1 m: G402163 (quartz-xonotlite skarn) 78.7 m: G402164 (diopside hornfels) 79.7 m: G402165 (diopside hornfels)
79.8–82.0	Skarn (quartz-diopside-xonotlite).	81.9 m: G402166 (quartz-xonotlite skarn)
82.0	EOH	

APPENDIX 3
Drill Log: Diamond Drill Hole South Weld DDH2

Drilled for:	Northwest Bay Co. Ltd	***Drilled by:***	Department of Mines
Logged by:	R. S. Bottrill, 1992	***Project:***	Southgold
For:	Tasmanian Geological Survey	***Date:***	23 July 1992
Bearing:	270° Mag	***Dip:***	-50°
Total Length:	113 m	***Core Size:***	HQ: 0–113.0 m
Location (AMG):	478 133 mE, 5 233 563 mN		

Depth (metres)	Description	Samples
0–21	Pink and yellow clays, with weathered siliceous pebbles.	
21–24	White clay.	
24–27	Red clay with manganese oxides (?).	
27–41	White clay, with some relict diopside skarn.	34 m: G402167 (diopside skarn)
41–42	Opal-montmorillonite zone.	41 m: G402168 (opal & clay)
42–45	Vuggy quartz and chert.	
45–48.4	"Dolomite marble": fine-grained, largely replaced by "ophicalcite" (calcite-serpentine rock). Variably weathered.	46.6 m: G402169 (quartz skarn) 48.0 m: G402183 (diopside skarn)
48.4–69.0	"Dolomite marble": fine grained, partly replaced by "ophicalcite" (calcite-serpentine rock).	50.2 m: G402170 (ophicalcite) 52.5 m: G402171 (ophicalcite, blue and white zones) 53.2 m: G402172 (ophicalcite, veined) 56.1 m: G402173 (ophicalcite/ diopside hornfels, with clots) 58.2 m: G402174 (ophicalcite, with veins) 67.0 m: G402175 (ophicalcite/skarn, green & grey)
69.0–69.9	Brecciated zone in "dolomite marble", with large calcite crystals.	69.9 m: G402176 (calcite)
69.9–73.5	Grey "dolomite marble": fine grained, partly replaced by skarn and "ophicalcite" (calcite-serpentine rock).	72.0 m: G402177 (ophicalcite/skarn)
73.5–103.7	White "dolomite marble"/ ophicalcite/skarn.	74.7 m: G402178 (ophicalcite/skarn) 89.9 m: G402179 (ophicalcite)
103.7–110.0	Jurassic dolerite. Fine grained, serpentinised top contact. Calcite-zeolite veining.	103.7m: G402180 (contact) 107.5 m: G402181 (dolerite) 109.1 m: G402184 (dolerite) 110.4 m: G402185 (dolerite)
110.0	EOH	