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Petrographic examination of rocks from DDH Shittim 1, Variety Bay, Bruny Island

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INTRODUCTION

The Shittim 1 diamond drillhole at Variety Bay, Bruny Island, was drilled as part of an exploration program to assist in determining the petroleum potential of the licence area. It has also been suggested that metallic minerals are present in the core (M. R. Bendall, pers. comm.). Forty samples of drill core, and rocks from nearby outcrops, were collected by Malcolm Bendall, Ralph Bottrill and Steve Forsyth, and submitted to the Mineral Resources Branch of Industry Safety and Mines for mineralogical and petrographic description.

The samples were examined by polarised light microscopy, X-ray diffraction and Electron Microprobe Analysis (Central Science Laboratory, University of Tasmania) for economic minerals and petroleum indicators. The results are summarised below. Sample depths and brief descriptions are listed in Appendix 1. Selected microprobe analyses are listed in Table 1.

ROCK TYPES

Two major lithologies were encountered in the drillhole; dolerite and variably hornfelsed limey mudstone of the Parmeener Supergroup.

Dolerite

Two dolerite bodies were encountered, the upper intersection (103.7–105.9 m) possibly representing a thin dyke, and the lower body a thick sill (154.9–729.9 m; 575 m thick). The dolerite is fairly typical of other Jurassic dolerites, varying from very fine to relatively coarse grained (<5 mm), with granophyre, mesostasis, incipient alteration and veining all widespread. Coarse-grained red-brown biotite is locally abundant (<2%), associated with clayey alteration (e.g. G402091, 670 m). Sulphide minerals are mostly fine grained and minor (except in the upper contact of the sill; G402083, ~156 m). Fractures and cavities, partly to completely filled with zeolites (stilbite, stellerite, heulandite and laumontite), montmorillonite and calcite, are locally abundant.

Parmeener Sequences

These rock types are dominated by poorly sorted and variably fossiliferous sandy mudstone, and probably represent the Permian Lower Parmeener Supergroup sequences. Forsyth (1995) considered that the interval from 20 to 116.5 m was Deep Bay Formation; 756–847 m Bundella Formation; and 847–876.4 m Woody Island Siltstone. The intervening units are presently unassigned.

The dolerite has contact metamorphosed much of the sequence to a hornfels. Fossiliferous marl and limestone are present in some horizons, particularly above 150 m, and these are mostly metamorphosed to skarns. Below the dolerite sill the mudstone is variably to highly brecciated, and generally becomes less limey or fossiliferous with depth. Some bladed calcite and/or prehnite aggregates may represent 'glendonites' (pseudomorphs after ikaite).

The skarns are very variable in texture, grainsize and mineralogy, but are dominated by wollastonite, garnet (grossular and andradite), vesuvianite, feldspars (plagioclase and orthoclase), prehnite and clinopyroxenes (diopside, hedenbergite and acmite). They vary from very fine grained (<0.01 mm) to coarse grained (<5 mm) in grainsize. The skarns grade into hornfels, which are distinguished by subordinate calcic minerals and more quartz and feldspar. Biotite and 'blastic sericite' (after andalusite?) are sporadically present, as are most of the skarn minerals mentioned above, plus epidote. The mineralogy indicates that the skarns and hornfels probably reached temperatures of 550–650 C, at 1–2 kb and low CO_2 fugacity (<0.2), i.e. the pyroxene hornfels metamorphic grade, but was locally overprinted by late stage, lower grade, hydrous and CO_2-bearing assemblages.

Minor veining is widespread. This is very variable in mineralogy, and includes zeolites, calcite, prehnite, epidote, acmite and pyrite. Apophyllite occurs with laumontite-calcite veins in quartz-diopside hornfels at 94.5 m (Trent Woods, pers. comm.)

In some samples from mudstone outcrop in the area (G402053, G402054) there is a bright bluish green coating. This is common in many parts of southern Tasmania, particularly on coastal outcrops. Thin section studies indicate that this is a thin (<2 mm) coating on weathered, weakly limonitic mudstone, and appears to be clayey groundmass material intermixed with quartz. X-ray diffraction and electron microprobe analysis indicate that the clay mineral is variable in composition but of the illite-glauconite series (Table 1). It appears to indicate bleaching and reduction of the iron oxides by humic acid or other organic materials in groundwater, and perhaps partial incorporation of the iron into fine-grained micas.

ECONOMIC GEOLOGY

Petroleum

No definitive indicators of petroleum or other carbonaceous material were observed in the core samples, with the exception of kerogen or protographite in two samples (G402621; 745.2 m and G402081; ~150 m). In these samples the carbonaceous material occurs as small blebs and patches, which are black and dendritic in hand specimen. In polished thin section the carbonaceous aggregates are irregular, and up to about 0.1 mm in size. Some are moderately anisotropic but very fine grained (coal?) and some are very soft and interstitial, non-polishable(?) bituminous material. The lower sample is a hornfelsed mudstone from just below the base of the dolerite sill, while the upper sample is a hornfelsed mudstone from just above the upper dolerite contact.

Table 1

Selected mineral analyses, by electron microprobe (wt.%)

	402054 mica 1	402054 mica 2	402054 mica 3	402054 mica 4	402091 montmorillonite	402091 heulandite	402607 vesuvianite	402607 grossular
SiO_2	40.72	39.85	41.53	61.64	56.65	56.70	36.40	39.47
TiO_2	5.46	0.10	0.14	0.25	0.00	0.02	0.06	0.09
Al_2O_3	19.57	26.03	27.71	24.28	24.56	18.47	16.06	20.79
Cr_2O_3	0.00	0.06	0.00	0.00	0.02	0.03	0.03	0.05
MgO	0.68	1.00	1.12	1.67	3.79	0.00	3.84	0.24
CaO	0.15	0.20	0.23	0.08	0.50	8.14	36.70	37.47
MnO	0.00	0.00	0.00	0.00	0.02	0.00	0.47	0.20
FeO	13.12	9.08	8.15	2.00	1.26	0.02	1.68	1.99
NiO	0.09	0.11	0.14	0.25	0.35	0.38	0.01	0.00
Na_2O	2.64	4.18	5.10	6.06	4.63	3.45	0.00	0.01
K_2O	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	82.54	80.60	84.11	96.23	91.79	87.20	95.24	100.30
Atomic ratios								
No. oxygens	22	22	22	22	22	72	73	12
Si	6.12	5.998	6.021	7.819	7.359	25.937	17.935	2.994
Ti	0.62	0.011	0.015	0.023	0.000	0.006	0.022	0.005
Al(4)	1.88	2.002	1.979	0.181	0.641	(9.954	9.321	1.858
Al(6)	1.58	2.614	2.755	3.449	3.118	(		
Cr	0.00	0.008	0.000	0.000	0.002	0.010	0.011	0.003
Fe	1.65	1.143	0.989	0.212	0.137	0.008	0.692	0.126
Mg	0.15	0.224	0.241	0.316	0.733	0.000	2.821	0.027
Ca	0.02	0.032	0.042	0.061	0.089	3.987	19.374	3.045
Mn	0.00	0.000	0.000	0.000	0.003	0.000	0.195	0.013
Ni	0.00	0.000	0.000	0.000	0.007			
Na	0.03	0.031	0.040	0.061	0.088	0.334	0.009	0.000
K	0.51	0.802	0.943	0.981	0.767	2.011	0.002	0.001
Total cations	12.556	12.865	13.024	13.103	12.945	42.248	50.381	8.071

All Fe expressed as FeO

A soft black mineral, relatively common in joints and fractures through the dolerite, was analysed by X-ray diffraction and a gave a smectite clay pattern. This, and the colour, suggest nontronite, an iron-rich smectite. One analysis of a typical dark brown clay replacing dolerite (in G402091, 670 m), however, gave a montmorillonite composition on the electron microprobe analyser (Table 1). Some similar material occurs in small amounts in the hornfels.

Gold

The reported 'gold' in the core (M. Bendall, pers. comm.) appears to represent both bronze-coloured biotite flakes, which are relatively common in parts of this dolerite, and minor pyrite (see below).

Metallic Minerals

Sulphide minerals are widespread but are mostly very fine grained and are rarely abundant.

Pyrite is present in the hornfels and skarns as rare microveinlets and as disseminated, sparse, fine grains, some intergrown with marcasite. Coarse-grained bladed pyrite in one skarn (G402626, 828 m) may be a late-stage mineral, replacing pyrrhotite. It also occurs as fine grains in many samples of the dolerite, and is relatively abundant in the upper dyke, associated with pyrrhotite (G402083, ~156 m), and in the lower contact of the sill, replacing mafic minerals and associated with quartz veinlets (G402620, 723 m). Pyrrhotite was only noted in one sample (G402083, 156 m), where it occurs as disseminated tabular grains to about 0.1 mm.

Chalcopyrite is sparsely distributed as very small disseminated grains in the dolerite, and is particularly abundant in sample G402091 (670 m). A few grains were also noted in one skarn (G402604, 100 m).

There are some small native copper specks, locally abundant and visible to the naked eye, in thin zeolite (heulandite)-montmorillonite veins in the dolerite (e.g. G402091, 670 m). This indicates some remobilisation of copper from the chalcopyrite in the dolerite, presumably by oxidation of the iron by oxygenated groundwaters. The alkalinity of zeolite-precipitating fluids would enhance the stability field of native copper (Garrels and Christ, 1965).

Industrial Minerals

Wollastonite is locally abundant in some of the skarns (up to 70%). It is up to 2 mm in size, and is commonly intergrown with calcite, garnets, vesuvianite, clinopyroxenes and other skarn minerals. The occurrence is very similar to that described from the Proctors Road quarry, Hobart (Hughes, 1957).

Zeolites are locally abundant in both the dolerite and hornfels, associated with veins and breccias, but are not rich enough to be of any commercial interest. Species identified include stilbite (and/or stellerite), laumontite, chabazite and heulandite (Table 1).

CONCLUSIONS

The dolerite contains only traces of metallic mineralisation; pyrite, pyrrhotite, chalcopyrite and native copper. Industrial minerals include minor zeolites.

The hornfelsed Parmeener sequences contain only traces of sulphide minerals (pyrite, chalcopyrite and marcasite) and sporadic zeolite veins. The wollastonite occurrences are notable, and some samples are of good grade, grainsize and concentration. Further work would be required to assess this possible resource, but present indications suggest that it may be rather variable in concentration, grainsize and quality.

REFERENCES

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APPENDIX 1

Summary of Shittim 1 drillhole sampling mineralogy and petrography

Depth (m)	*Reg. No.*	*Rock type*	*Description, minerals*	*Treatment*
100.0	G402604	Skarn	Wollastonite-prehnite-grossular-orthoclase-clinopyroxene	XRD, PT
101.0	G402605	Skarn	Wollastonite-vesuvianite-grossular-calcite-clinopyroxene-orthoclase	XRD, PT
102.0	G402606	Skarn and limestone	Wollastonite-vesuvianite-grossular-calcite	PT
~150	G402081	Hornfels	Sandy mudstone, carbonaceous, cherty, pyritic, with biotite, chlorite	PT
~150	G402082	Hornfels		
154.0	G402607	Skarn	Wollastonite-grossular-vesuvianite-hedenbergite-calcite-plagioclase-laumontite	XRD, PT
155.0	G402608	Hornfels/skarn	Quartz-plagioclase-calcite-clinopyroxene-orthoclase-laumontite-stilbite/stellerite	XRD, PT
~156	G402083	Dolerite	Fine grained, sulphidic, porphyritic	PT
166.0	G402084	Dolerite	Medium to coarse grained, granophyric, quartz rich, altered	PT
167.0	G402085	Dolerite	Fine to medium grained, biotite rich	PT
388.5	G402609	Dolerite	Stellerite veins	
510.5	G402610	Dolerite	Medium to coarse grained, trace biotite. Stilbite-montmorillonite veins with copper	XRD, PT, EMPA
518.5	G402611	Dolerite	Medium to coarse grained, trace biotite. Stellerite-calcite-montmorillonite veins with native copper	XRD, PT
528.0	G402612	Dolerite	Medium to coarse grained, with fayalite. Stilbite-calcite-montmorillonite veins	XRD, PT
534.3	G402613	Dolerite	Calcite-stilbite veins	
543.2	G402614	Dolerite	Calcite-stilbite veins	
554.8	G402615	Dolerite	Calcite-stilbite veins	
557.6	G402616	Dolerite	Calcite-stilbite veins	
665.5	G402617	Dolerite	Calcite-stilbite veins	
667.0	G402090	Dolerite	Medium to coarse grained, trace biotite. Stilbite-montmorillonite veins with copper	PT
670.0	G402091	Dolerite	Medium to coarse grained, trace biotite. Stilbite-montmorillonite veins with copper	PT
673.5	G402618	Dolerite	Serpentine-montmorillonite-stilbite-heulandite veins	XRD
698.5	G402619	Dolerite	Chabazite-stilbite veins	XRD
700.0	G402092	Dolerite	Medium-coarse grained, trace biotite. Stilbite-montmorillonite veins with copper	PT
729.8	G402620	Dolerite	Basal contact, glassy, porphyritic, altered, pyritic, quartz veined	PT

Depth (m)	*Reg. No.*	*Rock type*	*Description, minerals*	*Treatment*
745.2	G402621	Hornfels	Sandy mudstone, cherty, pyritic, carbonaceous, with pyrite-zeolite veins	PT
747.5	G402622	Breccia	Sandy mudstone/spotted hornfels clasts cemented with stilbite/stellerite	PT, XRD
759.0	G402623	Skarn	Plagioclase-andradite-aegirine-grossular-prehnite-wollastonite-vesuvianite-calcite. Carbonaceous	PT, XRD
774.4	G402624	Hornfels	Sandy mudstone, fossiliferous, cherty, with plagioclase-epidote-prehnite-smectite-calcite	PT, XRD
783.0	G402093	Hornfels	Sandy mudstone with granules (quartz, chert, slate, quartzite), fossiliferous, cherty, with plagioclase-clinopyroxene and wollastonite? (in fossils). Veins of calcite	PT
793.5	G402625	Hornfels	Sandy mudstone, fossiliferous, cherty, with plagioclase-epidote-clinopyroxene-wollastonite? (in fossils). Veins of epidote-prehnite and zeolite-calcite	PT
~804	G402094	Skarn	Sandy mudstone, altered to prehnite-quartz-clinopyroxene. Veins of calcite-prehnite	PT, XRD
~804	G402097	Hornfels	Sandy mudstone, cherty, with clay spots replacing porphyroblasts?	PT
810.4	G402098	Breccia	Sandy mudstone, cherty, with plagioclase-clinopyroxene. Veins of calcite.-prehnite?	XRD
828.0	G402626	Hornfels/skarn	Sandy mudstone: cherty, with plagioclase-smectite-clinopyroxene-wollastonite? Skarn: Prehnite-calcite-wollastonite?-smectite-pyrite	PT, XRD
837.0	G402627	Hornfels	Sandy mudstone, spotted, with sericitised porphyroblasts (after andalusite?)	PT
860.9	G402628	Breccia	Sandy mudstone, quartzo-feldspathic groundmass. Trace pyrite	PT
Outcrop	G402052	Hornfels	Siltstone, with feldspars, biotite, chlorite, clinopyroxene, amphiboles	XRD, TS
Outcrop	G402053	Mudstone	Sandy, fossiliferous, weathered, with green coating of glauconitic mica	XRD, PT
Outcrop	G402054	Mudstone	Sandy, fossiliferous, weathered, with green coating of glauconitic mica	XRD, PT, EMPA

Abbreviations:
XRD: X-ray diffraction
EMPA: Electron microprobe analysis
PT: Polished thin section
TS: Thin section