



# Preliminary report on Stonehenge Diamond-Drill Holes 1 and 2, and similar rocks in an Amoco diamond-drill hole near the old Nubeena mine

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## Abstract

Two diamond-drill holes were sited on the northern side of the old Comstock Tramway, near CP583597, in an attempt to obtain the stratigraphic relationship between highly-weathered boninitic lavas and the local Precambrian basement rock succession, the Oonah Formation. Data obtained from the drill holes and chemical analyses of ten lava samples.

## INTRODUCTION

Reconnaissance mapping in the area of the old Stonehenge and T.L.E. mines had outlined a small area of boninitic and low-titanium tholeiitic lavas and breccias to the south of the McIvor Hill gabbro and to the west of the Comstock Tram. The lavas appear to have a faulted contact with the gabbroic rocks of the McIvor Hill area to the north, and be overlain to the south by a sequence of chert and quartzite-derived siltstone, sandstone and conglomerate. The overlying sequence is lithologically similar to the Razorback Conglomerate of the Dundas Group.

In the mapped area small remnant areas of boninitic and low-titanium tholeiitic lavas crop out as hillocks surrounded by swamp, within depressions surrounded by hills consisting of successions belonging to the Precambrian Oonah Formation. Due to the poor outcrop and the swampy nature of the area, no contacts between any of the rock units were observed. Because of the nature of the lavas and the implied tectonic setting given by the Oonah Formation successions, it was attempted to discover the nature of the contact between these two different rock types by means of drill holes.

## STONEHENGE DDH1

The first drill hole was sited at CP583597, on the eastern bank of a cutting on the old Comstock Tram. Although highly weathered, the lavas were recognisable due to a characteristic 'ball structure' weathering pattern, which was observed in the wall of the tramway cutting.

The aim for the hole was not achieved due to the thickness of the volcanic pile. The lavas dipped from 50 to 70° from the horizontal, a fact not obtainable from surface outcrop and not observed in the drill hole until a depth of 30 metres.

## Drill Hole Log

From (m)	To (m)	Log
0.0	2.7	Highly altered fine-grained vesicular lava.
2.7	9.8	Dominantly vesicular lava
9.8	17.5	Dominantly porphyritic lava
17.5	21.5	Tectonically brecciated zone containing hematitic quartz and pyritic mineralisation
21.5	30.0	Vesicular and fine-grained lava
30.0	31.0	Volcaniclastic wacke, dip -70°
31.0	39.5	Fragmental core of fine-grained and vesicular lava with secondary alteration and veining.
39.5	200.34	Throughout the rest of the hole the sequence is partially silicified, and consists of numerous units of highly vesicular, fine-grained porphyritic lava, some with flow banding, with interbedded breccia or agglomerate flows, and minor volcaniclastic wacke units. Throughout the sequence, zones of tectonic shearing and brecciation occur. These zones are up to 2.5 m wide and contain secondary quartz, calcite, hematite and epidote alteration. Secondary alteration and silicification is more evident in the upper 100 m of the hole than in the lower 100 m.

The volcaniclastic rocks and flow banding dip between 50 and 70°. Using an average dip of 60°, a true thickness of approximately 100 m was sampled. Vesicular tops to the lava units varied between one and three metres in thickness, with the rest of the flow being between two and seven metres thick.

## Zones of major alteration

70.0–76.0 m: Zone of epidote, hematite, quartz, calcite and pyrite alteration

120.0–122.5 m: Total replacement of brecciated lava by secondary quartz.

169.0–174.0 m: Secondary mineral replacement of highly vesicular lava flows

195.5–197.5 m: Secondary silicification of brecciated lava

*Samples thin sectioned:*

*Sample C1864, 14.5 m:* Vesicular, very fine-grained lava containing chlorite pseudomorphs after pyroxene crystals (0.7–0.9 mm) and abundant chromite grains (0.15–0.25 mm). Whether the pyroxene crystals were clinoenstatite (CE) or orthoenstatite (OE) could not be ascertained.

*Sample C1885, 38.9 m:* Mineralised Zone 1

*Sample C1906, 51.0 m:* Fine-grained lava, now replaced by chlorite, calcite and quartz.

*Sample C1907, 62.5 m:* Quenched textured lava with 0.2–0.45 mm long acicular crystals and occasional phenocrysts (0.75–1 mm). Contains flow-banding with a dip of 50°.

*Sample C1908, 83.0 m:* Vesicular quenched lava, flow-banded with a dip 52°. Acicular crystals, up to 3.25 mm, now replaced by chlorite, calcite and quartz

*Sample C1886, 86.2 m:* Mineralised Zone 2

*Sample C1909, 106.5 m:* Vesicular quenched lava—similar to 83 metres.

*Sample C1876, 131.5 m:* Vesicular quenched lava—similar to 83 and 106.5 metres

*Sample C1882, 146.0 m:* Hyaloclastite—devitrified and fractured vesicular quenched lava now dominantly calcite and quartz. Euhedral phenocrysts (1.35–1.80 mm), replaced by chlorite, contain chromite grains (0.02–0.04 mm).

*Sample C1883, 151.8 m:* Vesicular crystal mush. Euhedral phenocrysts up to 1.65 mm long, enclosing (0.02–0.04 mm) chromite grains, occur in a quenched groundmass of devitrified and altered glass and acicular crystals between 0.25 and 0.35 mm in length. Most of the euhedral phenocrysts had an outer case of a different composition.

*Sample C1877, 154.5 m:* Vesicular quenched lava, with minor phenocrysts (up to 1.45 mm) of chlorite pseudomorphs, after CE, enclosing chromite grains.

*Sample C1875, 155.2 m:* Crystal mush in quenched groundmass. Pseudomorphed phenocrysts, after CE, are either tabular or form cruciform twins. This sample contains areas of glass and has a high chromite content.

*Sample C1910, 162.0 m:* Vesicular lava with quenched groundmass enclosing crystal mush including pseudomorphed phenocrysts (0.9–1.35 mm) after CE.

*Sample C1878, 166.3 m:* Vesicular lava, quenched groundmass with chlorite pseudomorphs after CE.

*Sample C1911, 171.2 m:* Vesicular lava, quenched groundmass with chlorite pseudomorphs after CE.

*Sample C1884, 198.8 m:* Brecciated, vesicular lava with an occasional rosette of pseudomorphed pyroxene phenocrysts.

*Sample C1912, 200.0 m:* Brecciated, vesicular lava.

*Samples analysed (Analyses listed in Tables 1 and 2)*

<i>Sample No</i>	<i>Depth (m)</i>	<i>Analysis No</i>	<i>Description</i>
C1885	39.0	841442	Mineralised Zone 1 sample
C1886	86.0	841443	Mineralised Zone 2 sample
C1875	155.2	841430	Crystal mush with quenched groundmass
C1877	154.5	841432	Vesicular lava—with pseudomorphed CE
C1878	166.3	841433	Vesicular lava—with pseudomorphed CE
C1911	171.2	850912	Vesicular lava—with pseudomorphed CE

*Summary*

Because of the thickness of the lava pile, and the regional dip, local basement was not reached. Overall the succession consisted of vesicular, fine to coarse-grained pyroxene-phyric lavas with a quenched groundmass. The phenocrysts are now chlorite pseudomorphs after pyroxene. Analyses of the lavas showed them to be highly weathered boninitic lavas. Further details of these rocks, and similar rocks in western Tasmania, can be found in Brown and Jenner (1989).

**STONEHENGE DDH2**

Due to the lack of a basement relationship in Stonehenge DDH1, a second hole was sited 50 m north of the first hole, on the edge of the embankment before a 100 m wide area of swamp separating this outcrop from rock successions belonging to the Oonah Formation. The hole was angled 50° north on a bearing of 040°, in another attempt to intersect the basement successions as well as a quartz-feldspar porphyry dyke which irregularly crops out in the swamp to the north.

The hole was collared at 232 m above mean sea level. At a depth of 219 m the hole had a dip of 47° and a bearing of 037°.

*Drill Hole Log*

<i>From (m)</i>	<i>To (m)</i>	<i>Log</i>
0.0	10.0	No recovery
10.0	23.5	Highly altered quartz-feldspar porphyry with epidote alteration.
23.5	25.2	Brecciated quartz-feldspar porphyry
25.2	31.2	Highly brecciated, veined and mineralised, serpentinised lava
31.2	49.7	Highly altered and mineralised breccia
49.7	50.5	Porphyritic lava with secondary veining and mineralisation
50.5	54.5	Vesicular lava
54.5	61.5	Fine-grained lava
61.5	76.0	Vesicular and fine-grained lava
76.0	77.0	Brecciated lava
77.0	87.0	Mineralised and veined vesicular and fine-grained lava
87.0	91.2	Brecciated lava dominantly replaced by mineralisation
	<i>then</i>	
	95.5	Fine-grained lava
	100.5	Altered and brecciated vesicular lava
	105.0	Alternating beds of very thin vesicular lava
	110.0	Fine-grained lava
115.0	120.0	Deformed zone—lavas
130.0	135.0	Vesicular lava

136.0	137.0	Mineralised zone
143.0	148.0	Mineralised zone
149.0	230.0	Lava flows: vesicular, fine-grained and some with minor phenocrysts. Irregular zones of secondary veining and mineralisation
230.0	232.0	Sheared gabbro
232.0	300.0	Gabbro

*Samples collected for thin sections*

<i>Depth (m)</i>	<i>Sample No</i>	<i>Description of sample</i>
23.0	C1892	Quartz-feldspar porphyry
50.5	C1893	Vesicular lava
57.5	C1894	Fine-grained lava
95.5	C1895	Fine-grained lava
110.0	C1896	Fine-grained lava
129.0	C1897	Fine-grained lava
133.0	C1898	Vesicular lava
149.0	C1899	Vesicular lava with small amount of phenocrysts
172.7	C1900	Vesicular lava
184.7	C1901	Fine-grained lava
185.2	C1902	Fine-grained lava
201.2	C1903	Fine grained lava
207.5	C1904	Silicified fine-grained lava
208.1	C1918	Fine-grained lava
216.0	C1905	Fine-grained lava
234.5	C1919	Two-pyroxene Gabbro
254.0	C1920	Two-pyroxene Gabbro
267.5	C1921	Two-pyroxene Gabbro
284.7	C1922	Two-pyroxene Gabbro
289.7	C1923	Two-pyroxene Gabbro

*Samples analysed (Analyses listed in Table 1)*

<i>Sample No</i>	<i>Depth (m)</i>	<i>Analysis No</i>	<i>Description</i>
C1897	129.0	850909	Vesicular lava
C1901	184.7	850910	Massive, fine-grained lava
C1903	201.2	850911	Massive fine-grained lava
C1921	267.5	850913	Two-pyroxene gabbro
C1922	284.7	850914	Two-pyroxene gabbro
C1923	289.7	850915	Two-pyroxene gabbro

*Summary*

The quartz-feldspar porphyry appears to occupy a steeply-dipping fault between the boninitic lavas to the south and low-titanium tholeiitic lavas to the north. Whether the porphyry was associated with Cambrian acid to intermediate volcanism or to the Devonian granitic rocks was not able to be ascertained.

The lavas and gabbro intersected by this drill hole below the porphyry belong to a faulted block of rocks petrographically and chemically similar to lava and gabbro within the the Serpentine Hill Ultramafic-Mafic Complex (Brown, 1986). The gabbroic samples are also petrographically and chemically similar to gabbroic rocks from the McIvor Hill area, which was considered to be part of the Serpentine Hill Complex (Brown, 1986; Brown *et al.*, 1988).

The contact with the Oonah Formation successions is still not resolved due to lack of contact in either holes. However, the contact must be very steep or dipping to the north, and on evidence from the relationships within the Amoco drill hole near the old Nubeena Mine, the contacts are most probably thrust faults.

**TEXTURALLY SIMILAR ROCKS IN A SIMILAR PHYSICAL SETTING NEAR THE OLD NUBEENA MINE**

Whilst the Stonehenge drilling was underway a request was received from geologists working for the Amoco Exploration Company to inspect the core of one of their drill holes. They had intersected some 'ultramafic/mafic flows' interspersed with tectonised Oonah Formation sequences. Due to the nature of the flows four samples were collected for study.

Diamond-Drill Hole ZT-82N-1 was drilled by Amoco on their Nubeena Grid to the south of Zeehan.

*Location:* Pieman 100 000 Sheet: CP616590, approximately 3 km south of Zeehan and to the east of the old Nubeena mine.

*Bearing:* 255° grid.

*Declination:* -54°.

*Depth:* 229.1 metres.

The hole was collared in highly weathered 'ultramafic/mafic flows' and intersected a number of texturally similar lavas 'intermixed' with a tectonised succession of deformed black and grey mudstone-siltstone units with interbedded siliceous sandstone, which belong to the Precambrian Oonah Formation.

Four samples of chromite-bearing vesicular and brecciated lavas were collected from between 51.5 and 92.5 metres. Three of the four samples contained pseudomorphs after pyroxene phenocrysts. Another zone of the highly weathered lavas, with easily recognisable chromite grains, occurred between 127.3 and 138.6 metres. All contacts between the lavas and Oonah Formation successions are sheared.

*Samples*

*Sample C1754, 51.5 m:* Vesicular, quenched-textured lava. Originally contained sheaths of acicular pyroxene (0.25–0.35 mm long), now replaced by amphibole and chlorite, and chrome spinel grains (0.1–0.15 mm), in a groundmass of devitrified glass. Vesicles are now filled by carbonate and quartz.

*Sample C1755, 80.0 m:* Coarse-grained, porphyritic lava. Phenocrysts of chlorite pseudomorphs (up to 1.55 mm long by 0.65 mm wide) after pyroxene, enclosing chromite grains. The chromite grains have two size ranges, 0.05–0.15 mm and 0.2–0.3 mm. The sample is now replaced by amphibole, chlorite, calcite and quartz.

*Sample C1756, 88.0 m:* Medium-grained porphyritic lava. Contains stubby phenocrysts (0.35–0.55 mm) in a quenched groundmass containing pseudomorphed spear-shaped pyroxene grains between 0.9 and 1.1 mm long.

*Sample C1757, 92.5 m:* Medium-grained lava with phenocrysts either as rosettes (0.9–1.1 mm from the centre) or euhedral grains (up to 1.45×0.25 mm).

*Summary*

All the samples are now replaced by a combination of amphibole-chlorite-carbonate and quartz. The majority of

the flows contain chlorite pseudomorphs after pyroxene, but whether CE or OE could not be ascertained. All samples contained chromite grains.

Because of the nature of the tectonism within the sedimentary rocks and the contacts between these rocks and the volcanic rocks, it is concluded that the two rock successions were juxtaposed by thrust faults, and that the lavas did not intrude the Oonah Formation successions as magma.

### CONCLUSIONS

(1) From the mapping and drill hole data, both from the Stonehenge and Nubeeena areas, it is concluded that the rocks are from two totally different tectonic environments, viz the Oonah Formation, which is a siliceous distal turbidite sequence; and the boninitic and low-titanium tholeiitic lavas/two-pyroxene gabbro, which are related to island-arc volcanism. Although contacts between the different rock types are rare, it is concluded that the present juxtaposition is due to thrusting and intermixing on the collision of two different tectonic terrains prior to the deposition of Late Cambrian fossiliferous sedimentary successions. These fossiliferous successions, which crop out just to the south of the lavas, have an upward gradational contact with rocks belonging to the Mt Zeehan Conglomerate.

(2) The two-pyroxene gabbro at the base of Stonehenge DDH2 is petrographically and chemically similar to samples of gabbro from McIvor Hill and Serpentine Hill (Brown, 1986). The lavas between 50 and 230 m in this drill hole are petrographically and chemically similar to low-titanium tholeiitic lavas in the Black Hill and Cleveland areas (Brown, 1986; Brown and Jenner, 1989).

(3) The boninitic lavas within Stonehenge DDH1 are petrographically and chemically similar to boninitic lavas to the south of the Heazlewood River Ultramafic Complex (Brown and Jenner, 1989)

### REFERENCES

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**Table 1. Chemical analyses of samples from Stonehenge DDH 1 and 2.**

Sample	1	2	3	4	5	6	7	8	9	10
	C1875	C1877	C1878	C1911	C1897	C1901	C1903	C1921	C1922	C1923
SiO <sub>2</sub>	51.85	56.48	55.55	57.33	58.60	49.20	56.63	48.19	47.72	47.19
TiO <sub>2</sub>	0.18	0.20	0.20	0.18	0.49	0.66	0.43	0.14	0.10	0.11
Al <sub>2</sub> O <sub>3</sub>	8.00	8.28	8.46	8.10	13.35	13.25	12.75	12.50	18.00	17.27
Fe <sub>2</sub> O <sub>3</sub>	1.61	1.82	1.64	1.88	0.82	0.87	0.54	0.83	0.83	0.69
FeO	6.88	6.78	6.87	6.58	7.04	11.78	9.33	7.46	3.99	4.48
MnO	0.18	0.15	0.17	0.15	0.18	0.18	0.15	0.19	0.11	0.12
MgO	13.90	14.13	14.82	14.37	4.94	8.30	7.46	8.53	8.57	9.81
CaO	6.76	3.36	3.57	4.00	3.54	4.57	3.14	15.10	13.82	12.48
Na <sub>2</sub> O	0.70	0.49	0.68	0.72	1.79	1.36	1.83	1.74	2.55	2.49
K <sub>2</sub> O	0.04	0.03	0.04	0.04	2.33	0.19	0.15	0.45	0.12	0.23
P <sub>2</sub> O <sub>5</sub>	0.05	0.04	0.04	0.01	0.03	0.05	0.01	0.01	0.03	0.02
H <sub>2</sub> O	6.06	6.27	6.34	5.42	3.99	6.06	5.18	5.09	4.86	5.00
CO <sub>2</sub>	3.09	1.31	0.82	1.55	2.58	3.25	2.27	0.21	0.02	0.60
Cr	1050	1000	1100	1100	145	115	135	730	250	230
Ni	230	210	220	195	48	51	45	185	100	105
Co	46	47	49	47	39	45	36	53	32	35
Sc	nd	nd	nd	32	50	58	47	50	38	35
V	260	250	240	165	270	390	330	165	115	110
Cu	nd	nd	nd	105	8	135	590	28	12	12
Zn	nd	nd	nd	70	75	195	230	110	36	47
Rb	7	8	7	4	92	13	7	39	6	13
Ba	310	550	195	84	2100	150	84	2809	48	64
Sr	94	90	82	81	94	85	67	195	320	330
Nb	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Zr	9	9	9	12	25	29	19	6	8	8
Y	6	6	6	7	13	21	14	7	7	6

Analyses 1-4: Stonehenge DDH 1—Boninitic lavas  
 5-7: Stonehenge DDH 2—Low-titanium tholeiitic lavas  
 8-10: Stonehenge DDH 2—Two-pyroxene gabbro

Trace element values in ppm.

**Table 2. Mineralised samples from Stonehenge DDH 1**

Sample No	Depth (m)	Ag (ppm)	Au (ppm)	As (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)
C1885	39.0	<1	<0.3	<10	40	<4	74
C1886	86.0	10.5	<0.3	23	4400	25	155