

Preliminary petrographic examination of rock samples from Minna Bluff suggests bimodal basanite to phonolite compositions, similar to volcanic rocks found elsewhere in the Erebus volcanic province (Kyle 1976).

It is probable that the lava flows at Minna Bluff were extruded subaerially and that hyaloclastites were erupted in subglacial environments produced by thickening of the Ross Ice Shelf.

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Geochemistry of some rocks from Dry Valley Drilling Project borehole 1, Hut Point Peninsula, Ross Island

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Dry Valley Drilling Project borehole 1 was drilled to the northeast of McMurdo Station at the foot of Twin Craters (70°50'45"S 166°40'11"E), an extinct volcano on Hut Point Peninsula. Drilling began 21 January 1973 and was terminated 29 January 1973. During that time, 196.54 meters of core were recovered.

Detailed relogging of the core is now in progress. Data in hand indicate that the core consists of 31 or 32 flow units, a paleosol, 7 or 8 pyroclastic units, and 2 dikes. The flows are generally thin (table 1) and slightly oxidized. Pyroclastic units are slightly thicker than the flows and consist of tuff, lapilli tuff, and breccia. The basal pyroclastic unit is probably a hyaloclastite. Drilling was terminated in the hyaloclastite after penetrating 52.52 meters; hence, its true thickness is not known. The paleosol is less than 1 meter thick and consists primarily of rounded fragments of basalts. The dikes are grey and, hence, distinctive. Contacts with flow units are sharp and inclined. Streaky-flow banding is common.

Mineralogy. The flow units consist primarily of plagioclase, clinopyroxene, amphibole, olivine, and glass. Plagioclase occurs as microphenocrysts and microlites and ranges in composition from bytownite to oligoclase (table 1). The clinopyroxene occurs as microphenocrysts in the groundmass, and as xenocrysts. Brown to pink titan-augite is most common; aegirine-augite occurs in the more sodic units. Xenocrysts consist of diopsidic-augite and are commonly rimmed with titan-augite.

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The amphibole of these rocks is kaersutite, which occurs as phenocrysts, microphenocrysts, and as reaction rims on olivine. Locally, it is replaced, partially or completely, by opaque minerals.

Olivine occurs as microphenocrysts and phenocrysts and is magnesium-rich. Glass is present in almost every unit. It is commonly charged with opaque minerals and ranges from brown to tan to clear.

Opaque minerals and apatite occur in all units. Rhönite (Kyle and Price 1975) occurs in unit 33 and perhaps in some of the older units.

Petrography. Mineralogy and texture, the parameters ordinarily used to define rock types and to assign rock names, cannot be used exclusively to name these rocks because most units contain a great deal of glass. The nomenclature must, therefore, be based, at least in part, on chemical analyses of the rocks.

Geochemistry. Forty chemical analyses were made of these rocks in the laboratories of the Japanese Geological Survey under the direction of Dr. Kurasawa (table 2). These analyses show clearly that the rocks are alkaline. If the nomenclature used by Goldich and others (1975) is used to name these rocks, most are trachybasalts, four are basanitoids, and one is a phonolite. Trachybasalts of Goldich and others are resolved into nepheline hawaiites, mugearites, and nepheline benmoreites if Coombs and Wilkinson's (1969) nomenclature is adopted.

The flows do not occur in any well-defined differentiation series, except that the basanites occur near the bottom of the pile and the intermediate rocks near the top.

In conclusion, the rocks of this hole resemble the surface flows of the Ross Island province described by Goldich and others (1975). The AFM (A = alkalis; F = iron oxide; M = magnesium oxide) plots (figure) show the similarity clearly. Hence, these rocks are also differentiations of a basanitoid magma that probably was generated initially by partial melting of the mantle.

The most striking feature of the flows of this hole is the abundance of intermediate rock types represented. In contrast, the surface flows of this province are primarily basanites and phonolites.

Table 1. Modal analyses of flow units of DVDP 1, Hut Point Peninsula, Ross Island

Flow unit	Thickness (meters)	Location of thin section (meters)	Mode (percentage)				
			Plagioclase	Pyroxene	Amphibole	Olivine	Glass
1	2.02	1.00	28	22	Trace	0	40
2	3.93	4.82	30	25	2	0	28
2	3.93	5.58	30	22	8	0	24
2	3.93	6.78	24	26	9	0	29
3	1.98	7.67	26	21	4	0	15
3	1.98	8.17	40	25	2	0	6
4	4.58	12.21	37	24	2	0	11
4	4.58	13.18	38	24	2	0	11
6	2.31	15.08	38	25	2	0	12
7	1.75	17.10	37	17	5	0	15
8	1.77	18.43	35	17	5	0	17
9	1.41	20.04	35	18	5	0	18
10	2.36	22.09	30	18	1	0	22
11	6.08	23.91	32	17	1	0	22
11	6.08	27.26	30	20	6	0	20
12	2.97	32.33	38	19	1	0	17
13	3.83	32.95	58	24	2	0	0
14	7.24	39.04	50	26	2	0	0
14	7.24	41.01	47	26	3	0	0
15	6.15	44.14	42	11	4	0	21
15	6.15	48.14	42	20	3	0	11
16	1.91	50.95	43	19	3	0	10
17	4.54	54.51	33	19	4	0	19
18	2.52	57.94	35	18	3	0	25
19	3.78	59.03	36	26	3	0	6
19	3.78	62.00	56	12	5	0	11
20	0.88	63.00	34	13	8	0	37
23	6.61	81.53	43	20	10	0	0
23	6.61	81.62	66	16	2	0	0
23	6.61	85.35	60	16	6	0	0
23	6.61	87.18	64	15	4	0	0
24	4.56	88.55	60	18	0	0	0
24	4.56	91.43	53	19	2	0	0
24	4.56	91.45	53	25	2	0	0
25	0.85	93.93	25	29	0	18	18
26	2.29	94.51	25	30	0	17	18
30	0.99	104.80	24	33	0	16	7
31	6.87	111.37	22	29	0	23	6
32	0.70	112.27	21	34	0	20	5
33	7.05	121.88	22	30	0	17	13
36	2.52	131.36	61	18	1	0	0
37	0.50	131.84	53	10	8	0	20
38	0.36	133.76	60	19	1	0	0
38	0.55	134.41	56	22	1	0	0
38	3.22	137.11	52	19	2	0	0
38	3.81	138.12	50	22	0	0	0
39	2.31	142.51	57	18	1	0	0
40	0.70	146.68	23	30	0	18	17

(Text continues on page 31.)

Table 2. Chemical analyses of flow units of DVDP 1

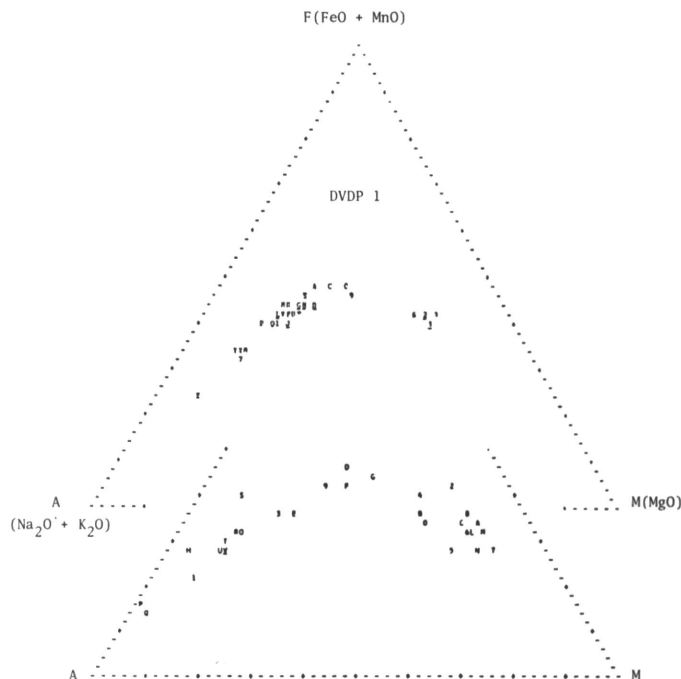
	1	2	3	4	5	6	7	8	9	10
SiO ₂	42.12	45.71	46.55	45.08	46.14	48.60	46.89	46.08	49.11	49.32
TiO ₂	2.85	3.00	2.70	3.44	2.65	2.19	2.64	2.83	2.66	2.70
Al ₂ O ₃	17.33	16.98	16.23	16.34	17.41	18.04	17.55	17.90	18.24	17.96
Fe ₂ O ₃	3.62	3.83	3.99	4.01	5.23	3.30	4.24	3.82	3.80	3.49
FeO	8.02	7.26	8.10	7.53	6.24	6.44	6.37	6.78	5.08	5.02
MnO	0.20	0.23	0.22	0.21	0.21	0.19	0.17	0.20	0.21	0.22
MgO	4.26	4.70	5.40	4.97	4.32	3.43	4.03	4.44	3.08	3.40
CaO	7.93	9.06	7.52	8.56	7.71	7.66	8.00	8.31	7.69	8.21
Na ₂ O	5.11	6.03	5.34	6.33	6.04	6.11	6.03	6.28	6.31	5.76
K ₂ O	3.02	2.68	2.61	2.77	3.27	3.20	3.40	2.81	3.40	3.11
P ₂ O ₃	0.73	0.59	0.66	0.54	0.61	0.51	0.56	0.49	0.44	0.52
H ₂ O ⁺	0.26	0.36	0.36	0.18	0.26	0.22	0.40	0.22	0.26	0.31
H ₂ O ⁻	0.21	0.11	0.14	0.20	0.08	0.09	0.13	0.07	0.13	0.08
Total	99.66	100.55	99.82	100.16	100.17	99.98	100.41	100.23	100.41	100.10
	11	12	13	14	15	16	17	18	19	20
SiO ₂	48.96	50.20	47.56	47.49	50.24	50.44	50.86	47.26	46.84	48.00
TiO ₂	2.60	2.65	2.55	2.71	2.08	2.66	2.50	2.88	2.48	2.40
Al ₂ O ₃	17.71	18.08	18.41	18.80	18.41	18.74	18.92	18.10	17.95	18.10
Fe ₂ O ₃	3.06	3.60	3.48	4.22	3.27	2.40	3.16	2.77	2.46	4.02
FeO	5.96	5.19	6.35	5.20	5.42	5.62	4.78	7.56	7.74	5.92
MnO	0.21	0.20	0.21	0.23	0.21	0.19	0.20	0.21	0.22	0.20
MgO	3.61	2.89	3.07	3.33	2.86	2.55	2.74	3.98	4.31	3.94
CaO	8.05	7.59	8.80	8.32	7.56	7.22	6.88	7.77	8.02	7.88
Na ₂ O	6.22	5.88	6.40	6.00	5.97	6.37	5.89	5.79	5.88	6.22
K ₂ O	3.08	3.12	2.54	2.83	2.97	3.35	3.10	3.08	3.26	2.91
P ₂ O ₃	0.49	0.48	0.51	0.55	0.49	0.44	0.48	0.51	0.54	0.46
H ₂ O ⁺	0.34	0.27	0.33	0.21	0.16	0.23	0.22	0.34	0.21	0.18
H ₂ O ⁻	0.11	0.08	0.15	0.26	0.08	0.18	0.14	0.15	0.10	0.08
Total	100.40	100.23	100.36	100.15	99.72	100.39	99.87	100.40	100.01	100.31
	21	22	23	24	25	26	27	28	29	30
SiO ₂	46.70	48.41	49.12	54.02	55.34	55.71	43.37	41.85	42.48	41.64
TiO ₂	2.66	2.46	3.02	1.85	1.21	0.98	3.84	3.74	3.84	3.94
Al ₂ O ₃	18.75	19.08	19.02	19.12	19.07	20.46	16.68	13.57	13.24	13.66
Fe ₂ O ₃	3.38	2.80	2.66	2.85	2.88	1.74	6.93	4.01	3.25	4.55
FeO	6.44	6.40	6.21	3.66	3.41	2.68	5.61	8.02	8.88	7.66
MnO	0.21	0.19	0.21	0.17	0.18	0.18	0.20	0.18	0.20	0.18
MgO	4.06	3.21	3.00	2.14	1.98	1.40	6.21	12.51	11.84	12.26
CaO	7.69	6.66	6.21	5.07	4.48	3.54	9.65	11.00	11.20	10.96
Na ₂ O	6.52	6.24	5.97	7.41	7.21	8.08	4.77	3.22	3.33	3.04
K ₂ O	3.00	3.23	3.47	3.40	3.19	4.16	2.26	1.46	1.24	0.91
P ₂ O ₃	0.48	0.34	0.46	0.31	0.33	0.21	0.55	0.46	0.44	0.56
H ₂ O ⁺	0.36	0.94	0.81	0.43	0.45	0.22	0.27	0.25	0.10	0.33
H ₂ O ⁻	0.20	0.20	0.12	0.04	0.08	0.02	0.10	0.06	0.02	0.12
Total	100.45	100.16	100.28	100.47	99.84	99.38	100.44	100.33	100.06	99.84
	31	32	33	34	35	36	37	38	39	40
SiO ₂	41.44	41.79	42.28	53.56	54.23	44.15	43.82	54.32	43.33	54.36
TiO ₂	3.84	4.11	3.86	2.60	1.90	3.48	3.64	1.20	3.80	1.49
Al ₂ O ₃	13.47	13.11	14.04	19.62	19.01	16.52	16.77	19.43	16.09	18.97
Fe ₂ O ₃	3.74	3.84	3.48	2.36	2.23	4.22	3.69	2.08	4.37	2.22
FeO	7.77	7.82	8.20	4.20	4.43	7.85	8.87	4.52	8.47	4.30
MnO	0.21	0.18	0.20	0.18	0.18	0.20	0.18	0.18	0.20	0.18
MgO	12.41	11.80	11.11	2.60	2.44	6.64	6.40	2.32	6.60	2.04
CaO	11.02	12.04	10.98	3.10	4.71	9.06	9.02	4.20	8.98	4.43
Na ₂ O	2.89	3.13	3.22	7.55	6.89	5.00	5.12	6.98	5.22	7.06
K ₂ O	1.70	1.51	1.66	4.00	3.62	2.34	2.09	3.51	2.38	3.76
P ₂ O ₃	0.57	0.62	0.55	0.32	0.40	0.42	0.45	0.24	0.46	0.25
H ₂ O ⁺	0.32	0.23	0.12	0.26	0.22	0.12	0.24	0.20	0.22	0.31
H ₂ O ⁻	0.14	0.12	0.04	0.08	0.10	0.14	0.08	0.14	0.08	0.12
Total	99.52	100.30	99.73	100.43	100.36	100.14	100.37	99.32	100.20	99.49

Two conventional potassium-argon (K-Ar) ages were determined on samples from 25.52 meters (a nepheline hawaiite) and from 148.81 meters (a basanite). The ages are 1.21 ± 0.11 million years for the shallow sample and 1.32 ± 0.16 million years for the deeper sample (Kyle, Sutter, and Treves 1979). The ages are not statistically different from each other, indicating that the flows were erupted relatively rapidly slightly more than 1 million years ago.

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AFM (alkalies, iron oxide, and magnesium oxide) plots of chemical analyses of rocks from DVDP 1 (this report) surface rocks from Ross Island and vicinity (Goldich et al. 1975) showing general similarity of the suites.

McMurdo Sound upper crustal geophysics

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Gravity and seismic measurements were made from sea ice 2.8 meters thick during November and December of 1980 along an east-west profile crossing McMurdo Sound. The profile is in line with Cone Hill on Hut Point Peninsula on the east and the Strand Moraine on the west along latitude $75^{\circ}46.3'S$ (figure 1). Additional data were collected across the mouth of the Ferrar Valley, north of the Strand Moraine. Instruments were contained in a geophysics van mounted on skids and pulled by a Spryte tracked vehicle. This article describes field operations and preliminary interpretations of collected data.

A damped LaCoste-Romberg gravity meter (model G) permitted gravity observations from sea ice with an accuracy of ± 2 milligals. Sea-floor bathymetry was obtained using a Geometrics/Nimbus 1210F signal enhancement seismograph and three to five sledgehammer blows struck on the sea ice for the reflected energy source. Water velocity is 1.44 kilometers per second as determined from the direct wave arriving from long refraction shots. The higher velocity wave propagating

through the sea ice quickly attenuates so that at shot-detector distances of 2–3 kilometers it is no longer discernible. Depths to the ocean floor were measured from seafloor reflections at each gravity station; this permits construction of a Bouguer gravity map with errors resulting primarily from sea-ice movement. Reflection and refraction depths to the seafloor agreed to within 5 meters.

Depths to acoustic layers below the seafloor were derived from reversed refraction shooting at nine stations located at 5-kilometer intervals across the Sound. An SIE-RS 4, 12-channel refraction seismograph was used with 8.25- and 4-hertz geophones connected to a 650-meter cable, with 50-meter separations between geophones. In preceding years a standard black cable with 30.49-meter geophone separations was used; on warm, sunny days the cable melted its way into the sea ice, refroze, and then had to be chopped out with an ice axe—a situation not particularly conducive to long cable life. The 650-meter cable has a white jacket and could be laid out on the ice for many hours without freezing, saving much time and cable-repair cost.

The procedure used in refraction shooting was such that the recording system and cable were held stationary while the shot point was moved out away from the spread at 1-kilometer intervals. The maximum shot-detector distance was 42 kilometers and the deepest refractor was found to lie at a depth of 7 kilometers. Charge size ranged from 1 kilogram for close-in shots to 454 kilograms for those at greatest distance (see figure 2).

Excellent reflections from sledgehammer blows were obtained from the seafloor, due to the high velocities and