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CHEMICAL ANALYSES OF SUBMARINE BASALTS

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ABSTRACT

Five new chemical analyses of four submarine basalts are presented. The two rocks from the Pacific are hypersthene-normative alkali basalts, whereas the two from the Atlantic are olivine-normative tholeiites.

LOCATION AND DESCRIPTION

Sample 1. Basalt, Henderson Seamount, 25° 34.3′ N., 119° 33.3′ W., Scripps Dredge Haul no. 2. Depth 220 fathoms (402 m). Fine-grained, highly vesicular rock. Small vesicles filled with olive serpentine. Sparse microphenocrysts of augite and serpentinized olivine. Ground-mass with numerous andesine microlites, augite granules, small rods of black ore, and interstitial dark glass or olive serpentine. Hematite as irregular masses, in narrow veinlets, and in vesicles.

Sample 2. Basalt (MP-25 F), Mid-Pacific Mountains, 19° 07′ N., 169° 44′ W., Scripps. Depth 935–960 fathoms (1710–1755 m). Fine-grained, porphyritic, slightly vesicular rock. Sparse vesicles filled with clay minerals, chlorite, and serpentine. Abundant labradorite microphenocrysts with crudely parallel arrangement and fewer olivine microphenocrysts altered to pale green serpentine-talc aggregates, locally stained brown by hydrated iron oxides. Ground-mass mainly labradorite microlites and granular opaque ore, with occasional augite granules, in a dark mesostasis.

Sample 3. Basalt, Station 20, Mid-Atlantic Ridge, 34° 04′ N., 42° 16′ W., Lamont. Depth 2250 fathoms (4115 m). Slightly vesicular rock. Sparse, small vesicles partly or wholly filled with olive chlorite or yellow-brown chlorophaeite. Occasional microphenocrysts of labradorite, olivine, and rare augite. Groundmass of labradorite microlites, augite granules, occasional olivine, and dark mesostasis with skeletal ilmenomagnetite.

Sample 4. Basalt, Station 7, Mid-Atlantic Ridge, 30° 01′ N., 45° 01′ W., Lamont. Depth 2340 fathoms (4280 m). Fine-grained, massive rock. Sparse labradorite and olivine microphenocrysts. Groundmass with

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microlites of the same minerals with augite and skeletal ilmenomagnetite in a dark mesostasis.

Sample 5. Same rock as sample 4, glass selvage. Labradorite and skeletal olivine microphenocrysts in a clear yellow-brown glass with crystallites and scattered plagioclase microlites. The glass has dark borders around plagioclase insets and locally light borders around olivine insets. There are a few spherical vesicles.

Samples 3–5 were described by Shand (1949), whereas sample 4 was also described by Carr and Kulp (1953), who determined a K/Ar age of 30±15 m.y. for this rock.

Chemical Compositions

Table 1 lists the five analyses and their norms. Samples 1 and 2 are highly oxidized. The norm of analysis 1 is just saturated (q=0, ol=0)

Table 1. Chemistry of Submarine Basalts

Chemical Analyses

Index	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	S	H_2O^+
1	47.62	3.21	14.74	0.30	7.92	2.88	0.14	5.16	7.61	3.41	1.69	0.91	0.07	1.81
2	43.33	3.10	16.51	0.28	12.98	1.08	0.20	4.00	7.31	2.89	1.15	0.72	0.08	3.52
3	48.48	1.54	14.08	0.38	3.55	7.34	0.24	9.07	10.67	2.48	0.20	0.12	0.18	1.49
4	48.81	1.66	12.77	0.38	3.74	9.07	0.22	9.01	9.91	2.54	0.25	0.16	0.09	0.83
5	48.41	1.87	12.58	0.34	2.89	10.00	0.21	9.23	9.86	2.49	0.05	0.15	0.15	0.20

Index	H_2O^-	CO_2	Total	O for S	Total
1	1.58	nil	99.04	0.02	99.02
2	2.24	nil	99.39	0.02	99.37
3	0.50	nil	100.32	0.04	100.28
4	0.13	nil	99.57	0.02	99.55
5	0.02	nil	98.45	0.04	98.41

Analyst Dr. H. B. Wiik

Norms

Index	q	or	ab	an	c	di			hy		ol		mt	hm
						wo	en	fs	en	of	fo	fa		
1	2.32	9.99	28.85	19.92	—	5.07	4.38	—	8.47	—	—	—	—	7.92
2	3.77	6.80	24.45	25.35	1.22	—	—	—	9.96	—	—	—	—	12.98
3	—	1.18	20.98	26.70	—	10.66	7.37	2.42	13.29	4.38	1.35	0.74	5.15	—
4	—	1.48	21.49	22.71	—	10.65	6.72	3.27	14.29	6.94	1.00	0.39	5.42	—
5	—	0.30	21.07	23.01	—	10.45	6.32	3.56	13.88	7.82	1.95	1.00	4.19	—

Index	il	tn	ap	pr	cm	H_2O	Total
1	5.92	0.23	1.99	0.13	0.44	3.39	99.02
2	2.24	4.71	1.57	0.15	0.41	5.76	99.37
3	2.92	—	0.26	0.34	0.56	1.99	100.28
4	3.15	—	0.35	0.17	0.56	0.96	99.55
5	3.55	—	0.33	0.28	0.50	0.22	98.41

when 4.76 per cent Fe_2O_3 is reduced to FeO (Fe_2O_3 3.16, FeO 7.16 per cent). That of analysis 2 is just saturated when 8.31 per cent Fe_2O_3 is reduced to FeO (Fe_2O_3 4.67, FeO 8.56 per cent). Even when Fe_2O_3 is completely reduced to FeO, neither of the two analyses becomes nepheline-normative. The total of analysis 5 is low, probably because of an error in the K_2O determination.

Kuno *et al.* (1956, p. 128) give analyses of rocks dredged near Jimmu Seamount, regarded by them as probably dropped by Pleistocene icebergs and derived from Kamchatka or the Kuril Islands. Yagi (1960, p. 215) gives an analysis of a dolerite block dredged from the Mariana trench. Six other analyses of basalts dredged from the northeastern Pacific Ocean are given by Engel and Engel (1963, p. 1322). They also include the basalt cored in the experimental Mohole at the Guadalupe site (Engel and Engel, 1961). Two of the Engels' Pacific analyses are of special interest because they are high-alumina basalts (Kuno, 1960) found beyond the continental slope. Finally, Richards (in press) gives two analyses of the interior and oxidized crust of a nepheline-normative basalt dredged near San Benedicto Island. This is also a high-alumina basalt.

Analyses of rocks dredged from the Atlantic Ocean include three older analyses of basalts obtained by the Challenger expedition (Murray and Renard, 1891, p. 307), three basalts and two andesites dredged between the Faroes and Iceland (Noe-Nygaard, 1949, p. 354), one basalt reported by Correns (1930, p. 80), two basaltic glasses described by Nicholls (1963, p. 19), five dredged basalts given by Engel and Engel (1964, p. 1332), and four basalts reported by Nicholls and others (in press). All these samples are from the Mid-Atlantic Ridge.

Macdonald and Katsura (1964, p. 87) used Tilley's method (1950, p. 42) of plotting total alkalies against silica, to distinguish Hawaiian alkali basalts from tholeiites. Figure 1 shows this diagram with the five analyses of Table 1, the nine Pacific analyses, and the eighteen Atlantic analyses. The division line of Figure 1 is empirical and apparently applies to Hawaiian basalts, but it does not seem to hold for submarine basalts located near the line. This may well be due to alteration, or it may be inherent in this oversimplified type of representation of the differences between tholeiites and alkali basalts. Noteworthy is: (1) All definitely alkali-basaltic rocks are from the Pacific. (2) Nearly all the samples from the Mid-Atlantic Ridge are tholeiites. (3) The wide spread of definitely alkali-basaltic rocks, compared with tholeiitic rocks. (4) The three Challenger rocks are lower in alkalies than all other samples.

Engel and Engel (1963; 1964) contrast the tholeiitic basalts obtained from oceanic plateaux, ridges, swells, and scarps with the alkali basalts that appear to predominate on seamounts and oceanic islands. They note

(1964, p. 1333), "the height, shape, and origin of the conduit appear to be major factors in the diversification of basalts." The writers agree that the results obtained so far, though admittedly scanty, indicate that central volcanoes of islands and seamounts in the oceans tend to be associated with alkali basalts, whereas oceanic basalts that probably formed by fissure eruptions are tholeiites. This suggests a "chimney effect" that tends to produce alkali-basaltic magmas from parent olivine-tholeiitic magma within the conduit by gravitation and/or diffusion, rather than by partial melting of the upper mantle at high pressures.

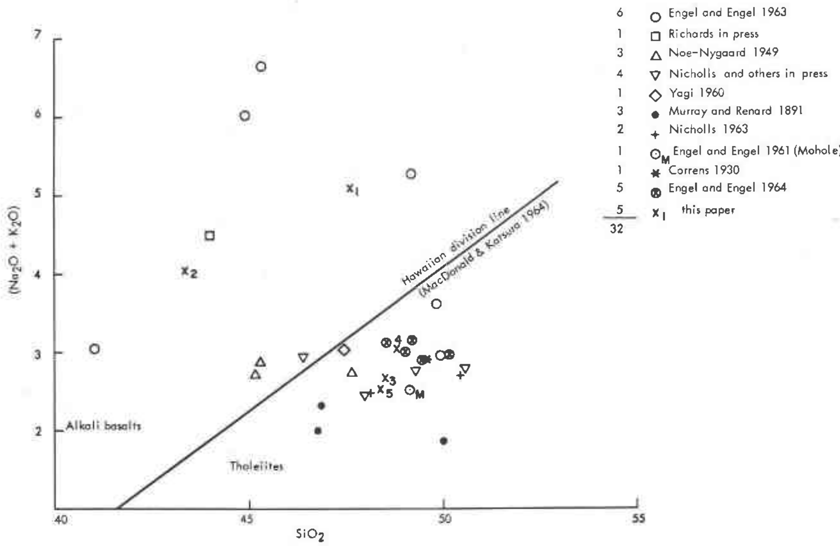

FIG. 1. Alkali-silica diagram of submarine basalts.

Analyses 4 and 5 (Table 1) represent the lithic interior and glass selvage of a dredged block that resembles a basalt pillow (Shand, 1949, p. 90). The close correspondence of the two analyses is noteworthy, especially if it be remembered that hot basaltic glass readily absorbs water and alters to palagonite (Peacock and Fuller, 1928, p. 375). Pairs of analyses of lithic interior and glass selvage of two basalts described by Nicholls and others (in press) show a similar close correspondence. Fresh sideromelane is rather common among oceanic dredge or core samples, and contrasts with highly oxidized basalts and with samples of palagonite (Nicholls and Bowen, 1961). More mineralogical and chemical data are needed on the submarine alteration of basaltic glasses (Matthews, 1962).

Like Korzhinsky (1962) and the Engels (1963), we failed to find any spilitic basalts among submarine samples. There is also no obvious correlation of vesicle size with depth of the samples. Poldervaart (1957) suggested that the low magnetic intensity of the oceanic crust may be due to basaltic magmas crystallizing to plagioclase-hornblende at the high water pressures of the deep oceans, instead of forming the usual plagioclase-olivine-pyroxene-ilmenomagnetite assemblage of basalts. Yoder and Tilley (1962) showed experimentally that melts of basaltic composition crystallize to plagioclase-hornblende or hornblende only at high water pressures. However, so far we have found no evidence in support of this suggestion among samples of submarine basalts, but no basalt samples have yet been obtained from the abyssal plains. Many samples show a high degree of oxidation and partial conversion to reddish brown serpentine-chlorite aggregates with or without hydrated iron oxides. This type of alteration requires further study.

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