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Contributions to the Volcanic Succession and Petrology of the Auckland Islands, New Zealand

IV. Chemical Analyses from the Lower Half of the Ross Volcano

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Abstract

THE analysed rocks are from the lower differentiated sequence (olivine basalt–hawaiite–mugearite–trachyte–rhyolite), and from the bottom of the overlying olivine basalt pile. The analyses confirm the mildly alkaline nature of the lava suite, whose only unusual feature is widespread post-magmatic silicification (cristobalite development) of intermediate and salic members.

Obsidians in the differentiated sequence have perhaps suffered hydration and leaching of soda, but they fall close to recently compiled curves relating refractive index and silica content of volcanic glasses.

The intermediate lavas, with compositions in the so-called Daly gap, may be volumetrically the most abundant of those in the differentiated series.

INTRODUCTION

THE physiography, volcanic succession, and petrography of the Ross Volcano having already been described (Speight and Finlayson, 1909; Fleming, 1965; Wright, 1966; 1967; 1968), it will suffice here to recall that a differentiated series ranging from olivine basalt to (locally) alkaline rhyolites, forms the lower part of the pile and is overlain by a much less variable sequence of predominantly olivine-basaltic composition. The analyses and norms in Tables I and II are (respectively) of samples representing the differentiated sequence and lower parts of the overlying olivine basalts, which were collected during the 1962-3 expedition.

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TABLE I.—Chemical analyses and norms (weight percent) for lower differentiated sequence, Groups I to III, Section 1 and Hooker Saddle suite of Wright (1966). Analysed by Chemistry Division, D.S.I.R., Wellington. All samples oven-dried at 110°C before analysis. Norms calculated on Fortran IV programme, prepared by B. G. Cox, Department of Mathematics, Otago University, and J. B. Wright. Details of programme held by Professor D. S. Coombs, Department of Geology, Otago University. All specimens have OU numbers, referring to collection in the Department of Geology, Otago University.

	19533	19530	19529	19526	19538	19536	19545	19539
SiO_2	41.3	55.2	62.6	67.3	71.2	71.5	71.7	73.3
TiO_2	4.6	1.4	0.75	0.38	0.62	0.27	0.13	0.58
Al_2O_3	14.2	16.8	15.2	14.8	13.9	14.3	12.5	14.2
Fe_2O_3	3.3	2.1	2.2	1.3	1.7	1.7	0.95	1.8
FeO	11.5	8.3	5.8	2.3	1.7	1.1	1.5	0.34
MnO	0.16	0.22	0.07	0.11	0.08	0.04	0.05	0.02
MgO	9.2	1.7	0.8	0.59	0.41	0.17	0.15	0.05
CaO	11.0	4.5	3.4	2.1	0.71	0.34	0.42	0.24
Na_2O	2.1	5.0	4.0	3.7	4.9	5.1	3.7	4.4
K_2O	0.75	2.8	3.7	4.7	5.0	5.0	5.5	4.8
P_2O_5	0.34	0.37	0.17	0.08	0.06	0.07	0.05	0.06
H_2O^+	1.4	1.0	0.8	2.5	0.36	0.52	3.2	0.68
	99.85	99.39	99.49	99.86	100.64	100.11	99.85	100.47

Norms

		19533	19530	19529	19526	19538	19536	19545	19539
Q		—	—	14.3	21.4	21.6	21.8	27.4	29.0
C		—	—	—	—	—	—	tr.	1.7
or		4.4	16.5	21.9	27.8	29.6	29.6	32.5	28.4
ab		11.0	42.3	33.9	31.3	41.5	43.2	31.3	37.2
an		27.1	15.1	12.6	9.9	1.2	1.3	1.3	0.2
ne		3.7	—	—	—	—	—	—	—
wo	di	10.6	2.1	1.4	tr.	0.8	—	0.2	—
en		6.7	0.6	0.3	tr.	0.4	—	tr.	—
fs		3.3	1.6	1.2	tr.	0.4	—	0.2	—
en	hy	—	3.6	1.7	1.5	0.6	0.4	0.3	0.1
fs		—	9.9	6.6	2.7	0.5	0.2	1.7	—
fo	ol	11.4	tr.	—	—	—	—	—	—
fa		6.1	0.1	—	—	—	—	—	—
mt		4.8	3.0	3.2	1.9	2.5	2.5	1.4	—
hm		—	—	—	—	—	—	—	1.8
il		8.7	2.7	1.4	0.7	1.2	0.5	0.3	0.8
tn		—	—	—	—	—	—	—	0.4
ap		0.7	0.8	0.4	0.2	0.1	0.2	0.1	0.1

Specimen description and location, after Wright, 1966.

OU19533, Pyroxene- and olivinephyric basalt, sea level, base of Group I.

19530, Sparsely phenocrystic hawaiite/mugearite, *c.* 600ft a.s.l., top of Group II.

19529, Massive mugearite/trachyandesite, *c.* 750ft a.s.l., lowest of the four thick flows of Group III.

19526, Obsidian block, *c.* 900ft a.s.l., in agglomerate layer between second and third thick flows of Group III. R.I. of glass, 1.514.

Remaining samples all from Hooker Saddle suite, *c.* 1,150ft a.s.l.

19538, Flow-banded " cryptocrystalline comendite ".

19536, " Tridymite trachyte " of Hooker Saddle " dyke ".

19545, Obsidian vein in pyroclastics. R.I. of glass, 1.505.

19539, Fissile " comendite ".

TABLE II.—Chemical analyses and norms (weight percent) of lower part of upper olivine basalt suite (Group V of Wright, 1966). Details as Table I.

	19501	19499	19496
SiO_2	44.0	46.9	45.8
TiO_2	2.8	4.1	4.1
Al_2O_3	13.8	16.0	17.3
Fe_2O_3	3.1	3.8	3.8
FeO	9.5	9.1	8.7
MnO	0.38	0.21	0.16
MgO	11.1	4.3	4.8
CaO	11.4	8.7	10.6
Na_2O	2.1	3.9	2.7
K_2O	0.38	1.5	1.1
P_2O_5	0.33	0.67	0.42
H_2O^+	1.1	1.5	0.69
	99.99	100.68	100.17

Norms

		19501	19499	19496
or		2.3	8.9	6.5
ab		15.5	29.9	22.9
an		27.1	21.7	31.8
ne		1.3	1.7	—
wo	di	11.5	7.3	7.6
en		7.6	4.2	4.7
fs		3.0	2.8	2.5
en	hy	—	—	2.8
fs		—	—	1.5
fo	ol	14.0	4.6	3.1
fa		6.1	3.4	1.8
mt		4.5	5.5	5.5
il		5.3	7.8	7.8
ap		0.7	1.5	0.9

Specimen description and location, after Wright, 1966.

OU19501, Pyroxenephyric olivine basalt, *c.* 1,450ft a.s.l., base Group V.

19499, Feldsparphyric olivine basalt, *c.* 1,500ft a.s.l.,

19496, Zeolitic feldsparphyric olivine basalt, *c.* 1,725ft a.s.l.

DISCUSSION

Variation Diagrams and Silicification

Figs. 1 and 2 support earlier conclusions, based on petrography, that this is a mildly alkaline suite (Coombs, 1963) appropriate to salic end-members of trachyte/rhyolite composition. Fig. 2 is in fact an almost perfect replica of a diagram for Scottish Hebridean volcanics, shown by Uchimizu (1966, fig. 24) as one of several comparison diagrams in a study of alkaline volcanics from the Oki Islands, Japan. The Group II and III lavas, with hawaiite/mugearite affinities, show some tendency to iron enrichment (cf. Uchimizu, 1966). Both contain olivine, which in OU19529, of Group III, is an iron-rich variety ($2V\alpha = 61^\circ \pm 3^\circ$, corresponding to Fo_{80-85}; Tröger, 1959: 37; Deer, Howie and Zussman, 1965, vol. 1, fig. 11).

The Groups II and III lavas especially, are, however, chemically much too silicic for their optically determined mineralogy (Table I), and in Fig. 3 the contrast with the Hebridean alkaline rocks—which they resemble on the AFM plot—is well displayed. X-ray diffractograms of the rocks show them to contain cristobalite,

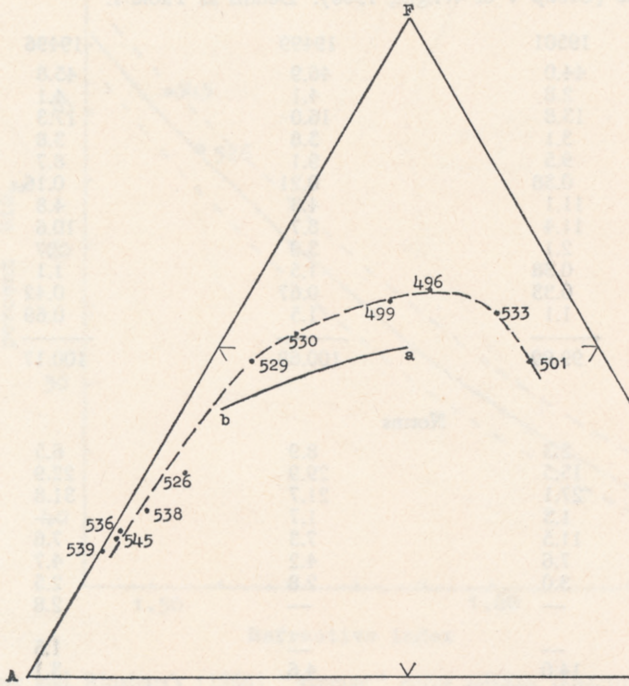

FIG. 1.—AFM (wt. percent) plot for Ross volcano samples. Figures are last three digits of sample numbers from Tables I and II. The line ab, from Uchimizu (1966), separates lavas of mugearite/hawaiite affinity (above) from trachyandesitic varieties (below).

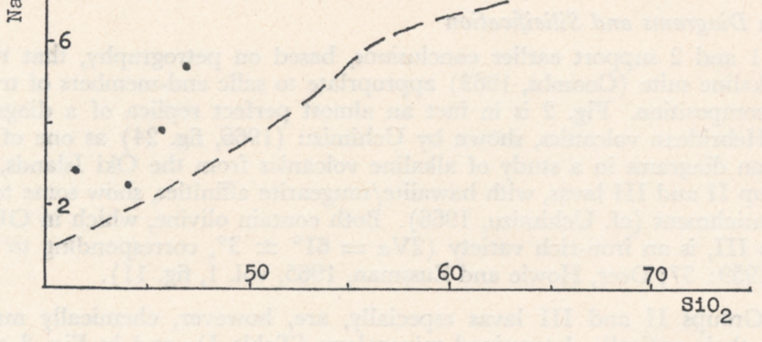

FIG. 2.—Total alkalis *v.* silica plot for Ross volcano samples. Dashed line separating alkaline trends (above) and high alumina/tholeiitic trends (below), from Kuno (1965).

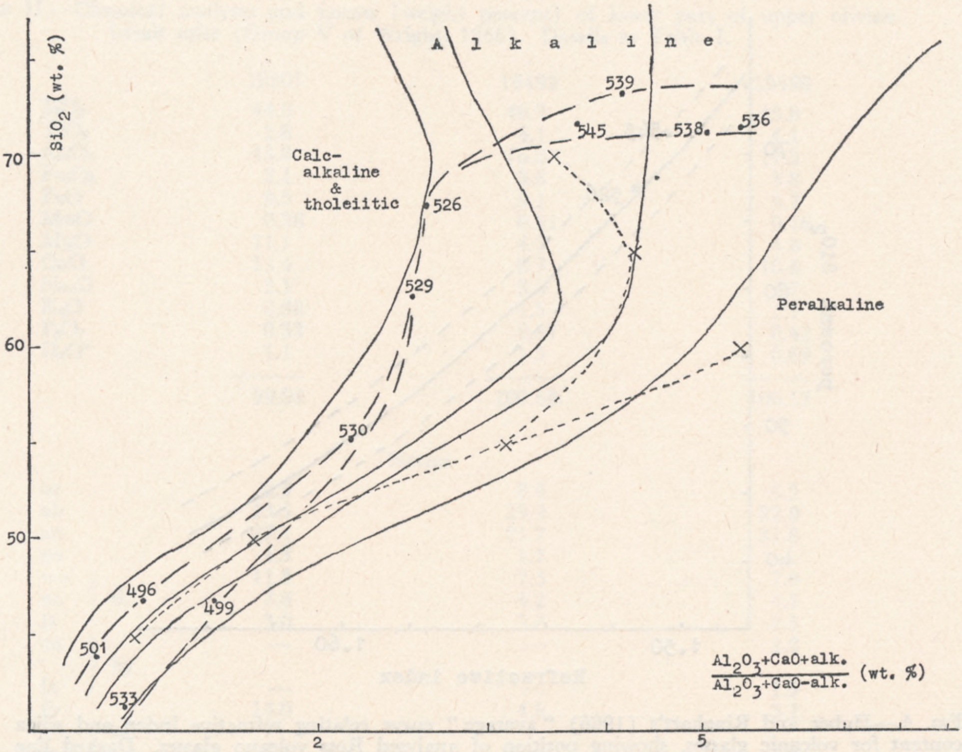

FIG. 3.—Alkalinity ratio plot for Ross Volcano analyses, dots, and Mull alkaline magma series, crosses (from Bailey *et al.*, 1924). The alkalinity ratio has been used (Wright, 1969) to identify mixed petrographic provinces, and shows how silicification of intermediate lavas in the Ross volcano has induced an apparent swing towards calcalkaline affinities compared with the Mull akaline lavas.

so fine-grained as to escape detection under the microscope. Some of the salic Hooker Saddle lavas may also contain occult silica in addition to microscopically recognisable phases (Wright, 1966).

Low-pressure hydrothermal silicification ("opalisation") of lavas is a common enough phenomenon (e.g., Höller, 1968; Thompson, 1967), but it is not clear here whether the silica was introduced from outside or released by partial alteration of silicates (especially feldspars) under the influence of dilute alkaline aqueous solutions (Höller, 1968).

Obsidians

As in other volcanic associations, the glassy rocks are appreciably more hydrous and potassic than their crystalline equivalents (Table I), probably as a result of postmagmatic processes (e.g., Ewart, 1964; Aramaki and Lipman, 1965; Walker, 1969). In view of possible compositional changes induced by hydration, leaching, and perhaps silicification, it may well be fortuitous that the two analysed obsidians from Group III and the Hooker Saddle suite fall so close to Huber and Rinehart's (1966) "average" silica *v.* refractive index curve (Fig. 4).

The "Daly Gap"

The proportion of salic rocks (Hooker Saddle suite) and of the basal (Group I) basalt, in the lower differentiated series of the Ross volcano, is very much less than

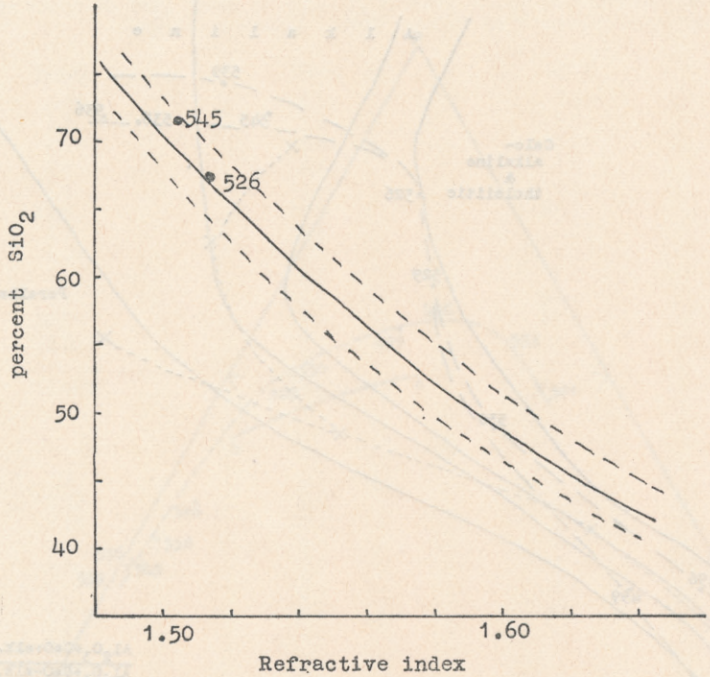

FIG. 4.—Huber and Rinehart's (1966) "average" curve relating refractive index and silica content for volcanic glasses, showing position of analysed Ross volcano glasses. Dashed line on either side of curve indicates approximate spread of values for the majority of Huber and Rinehart's data.

that of the intermediate lavas of Groups II and III. However, it is not known how far the volcanic sequence extends below sea level, nor of what it consists there. The exposed succession may thus either represent a progressive diminution in the volume proportion of intermediate and salic rocks, as on St Helena (Baker, 1968), or a predominance of intermediate lavas over both basic and salic members of the sequence, as on the exposed parts of Tristan da Cunha (Harris, 1963) and at the Nandewar volcano, New South Wales (Abbott, 1969).

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