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APPENDIX 1

FIELD AND LABORATORY TECHNIQUES

1) FIELD MAPPING

During field mapping, approximately 700 localities were sampled and 650 thin sections prepared for petrographic study. Technical staff at the University of New England prepared 100 thin sections; the remaining 550 thin sections were prepared by the author. The rocks and thin sections are housed in the Department of Geology, University of New England. Collection numbers are listed in Appendix IV together with rock names and grid references.

Geological formations and boundaries and specimen localities were mapped directly onto New South Wales Department of Lands aerial photographs, namely Nimbin-Byron Bay runs 1-4 inclusive (October, 1958) and Lismore-Ballina runs 1-4 inclusive (October, 1958). The accompanying geological map was prepared using Royal Australian Survey Corps 1 : 50,000 topographic maps as a base. The area mapped included the whole of 5 maps in Zone 8, namely Rosebank 9540-I, Lismore 9540-II, Nimbin 9540-IV, Ballina 9650-III and Byron Bay 9650-IV together with the northern and eastern portions of Casino 9540-III. Geological mapping of the north-western portion of the Nimbin 9540-IV sheet was greatly facilitated by the mapping of Mason (1969). The accompanying map and all text figures were drafted by the author.

2) PETROGRAPHIC TECHNIQUES

In microscopic studies, refractive index measurements were carried out by the oil immersion method in sodium light using an Abbé Refractometer for calibration of oils. Olivine and plagioclase compositions were based on the data of Bowen & Schairer (1935; in Deer *et al.*, 1962) and Chayes (1952; in Deer *et al.*, 1963) respectively.

Modal analyses were performed using a Swift point counter and mechanical stage with a counting interval of 0.3 mm for glassy rocks with large phenocrysts and 0.05 mm for other rocks. At least 1,500 points were counted for each analysis.

Opaque minerals were examined in reflected light in approximately 30 polished sections prepared by technical staff of the Department of Geology, University of New England.

3) CHEMICAL ANALYSES

a) Sample Preparation

Rock specimens selected for chemical analysis were cut into slabs, which were then broken down into small chips (<10 mm) with a small hammer and the chips crushed to -120 mesh in a steel percussion mortar and pestle with a hardened tungsten tip and base. A control sample of pure quartz crushed concurrently indicated negligible contamination by Ni,V and Co. Rock powders were homogenized on a sheet of paper and repeatedly quartered until samples of about 50 g were split off for chemical analysis.

b) Major Element Analyses

With the exception of five whole rock analyses (27290; 28057-60) and two residual glasses; separated from rhyolitic pitchstones (28076, 28078) which were analysed by G.I.Z. Kalocsai, all major element analyses were carried out by the author in the Department of Geology, University of New England. The methods employed are those modified and used by G.I.Z.

Kalocsai and are briefly outlined below. Two U.S.G.S. standard rocks (AGV-1, BCR-1) analysed concurrently as a check of analytical precision (Table I.1) compare favourably with average analyses for these rocks compiled by Flanagan (1969).

$\underline{SiO_2}$: SiO_2 was determined on 1 g samples by the sodium carbonate fusion method (Washington, 1931; Groves, 1951).

$\underline{TiO_2, Al_2O_3}$, total Fe, MnO, MgO, CaO: These were determined by atomic absorption spectroscopy using a Varian Techtron AA5 Atomic Absorption Spectrophotometer. A rock solution was prepared using the method of Shapiro and Brannock (1956) except that perchloric acid was used instead of sulphuric acid (solution B: $HF-HClO_4-HNO_3$). Suitably diluted fractions of solution B, with addition of appropriate additives to supress ionization (Fe,Al) and complex ion formation (Ca,Mg) were then measured on the A.A.S. The operating conditions and additives for individual elements are set down in Table I.2.

$\underline{Na_2O, K_2O}$: Alkalis were determined on suitably diluted portions of solution B using an E.E.L. Flame Photometer with addition of Li^+ to minimize ionization of Na and K.

$\underline{P_2O_5}$: This was determined on an E.E.L. Colorimeter using a solution prepared by addition of a portion of solution B to an ammonium molybdo-vanadate solution using an ammonium phosphate solution as a reference standard.

$\underline{FeO}$: FeO was determined on 0.5 g samples using the method outlined by Groves (1951). The rock sample was dissolved in an $HF-H_2SO_4$ mixture in a Pt crucible with a close fitting lid. When completely dissolved the sample was added to 500 ml of cold boiled H_2O containing 10 ml of 1:1 H_2SO_4 and

TABLE I.1

A.A.S. ANALYSES OF U.S.G.S. STANDARD ROCKS

	BCR-1		AGV-1	
	1	2	3	4
SiO_2	59.00	58.99	54.09	54.48
TiO_2	1.13	1.08	2.05	2.23
Al_2O_3	16.90	17.01	13.61	13.65
Fe_2O_3	4.25	4.51	3.43	3.68
FeO	2.21	2.04	9.01	8.91
MnO	0.09	0.09	0.18	0.17
MgO	1.53	1.49	3.37	3.28
CaO	5.05	4.98	7.00	6.95
Na_2O	4.30	4.33	3.21	3.31
K_2O	2.96	2.89	1.72	1.68
H_2O+	0.99	0.81	1.50	0.77
H_2O-	0.80	1.08		0.82
P_2O_5	0.53	0.48	0.27	0.36
Total	99.74	99.78	99.44	100.29

1,3. Analyses by M.B. Duggan.

2,4. Preferred averages from Flanagan (1969).

TABLE I.2

OPERATING CONDITIONS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRIC ANALYSIS

Element	Working Range (ppm)	Wavelength (nm)	Oxidant-Fuel Mixture	Additive
Ca	10-50	422.7	air-acetylene	La^{3+}
Mg	1-5	285.2	air-acetylene	La^{3+}
Fe	25-100	248.3	air-acetylene	Na^{+}
Al	100-200	309.3	N_2O-acetylene	Na^{+}
Ti	solution B	364.3	N_2O-acetylene	-
Mn	solution B	279.5	air acetylene	-

10 ml of boric acid and then titrated against standard ammonium ceric sulphate solution using n-phenyl anthranilic acid indicator.

$\underline{H_2O}$: Total H_2O was determined using a heater-condenser apparatus devised by G.I.Z. Kalocsai. One gram of sample, weighed in a silica glass tube was connected to a condenser and heated in a Gallenkamp furnace at 1100^oC for one hour. The condenser was then disconnected and the ends plugged. After allowing to cool, the increase in weight was taken as the total water. H_2O- was determined as the weight loss of a 1 g sample when heated at 105^o for one hour.

c) Trace Element Analyses

Trace element analyses (Rb,Sr,Ba,V,Ni,Co) were carried out by the author in the Department of Geology, University of Queensland by X-ray fluorescence spectrographic methods using a Philips PW 1410 X-ray Spectrometer coupled to a 3 kW generator. The techniques and procedures used were those devised by Mr. A.S. Bagley. Analyses were corrected for mass absorption, drift and interference effects. Several U.S.G.S. standards were run concurrently with the analysed rocks to check analytical quality and the results of these analyses are listed in Table I.3. The results indicate a generally high degree of precision and reliability for the analyses.

d) Microprobe Analyses

Microprobe analyses of constituent mineral phases were obtained by the author at the Research School of Earth Sciences, Australian National University using an energy dispersive microprobe system produced by Technisch Physische Dienst, Delft Technical University, Delft, Netherlands. Analytical conditions included an accelerating voltage of 15 kV, a beam diameter of

TABLE I.3

CONTROL TRACE DETERMINATIONS ON U.S.G.S. STANDARD ROCKS

(Preferred Values of M.Kaye, Australian National University, in brackets)

	G2	BCR-1	GSP-1	AGV-1	W1
V		365 (370) 374	40 (52)		250 (245)
Ni	5 (4)	10.5 (11)		17.5 (16)	
Co	4.6 (4.5)	40 (37)	6.6 (7)	17 (15) 15	40 (48)
Ba	1858 (1850)	658 (690)		1192 (1200)	
Rb		48 (47) 47		20.7 (21.5) 21.4 21.6	
Sr		326 (334) 326		186 (187) 188 187	

<1 μm and a specimen current of 3 nA. X-ray spectra were recorded using a Li-drifted Si detector (Ortec type 77016-041655) coupled to a Northern Scientific (NS 710) multichannel pulse height analyser with a 100 second count time. Full details of analytical conditions and correction procedures for quantitative analysis using this instrument are given by Green (1973b) and Reed and Ware (1973).

For calibration standards, $MnSiO_3$ was used for Mn and Si, $CaAl_2O_4$ for Ca and Al, $KAlSi_3O_8$ for K, the respective oxides (MgO, TiO_2, Cr_2O_3) for Mg, Ti and Cr and the pure metal for Fe.

The low accelerating voltage and specimen current and small beam diameter compared with conventional crystal spectrometer microprobes, coupled to a Leitz optical system enabled precise location and analysis of very small groundmass grains (~5 μm) and avoided problems of alkali volatilization from Na and K-bearing minerals. However, it did not prevent some alkali loss from very small areas of hydrous residual glasses as indicated by low Na values for their analyses and decreasing count rates during analysis.

4) MINERAL SEPARATION

Feldspars were separated from their respective host rocks for X-ray diffraction studies by a combination of heavy liquid and electromagnetic techniques. Rock powders (-120 mesh) were prepared dust-free by repeated decantation. After removal of strongly magnetic minerals with a hand magnet the feldspar fractions were concentrated by repeated passage through a Franz Isodynamic Separator-Model L1. Where necessary further purification was obtained by centrifuging in tetrabromoethane-acetone mixtures.

5) X-RAY DIFFRACTION STUDIES

An X-ray diffraction powder photograph of an allanite sample was obtained using a Debye Scherrer powder camera coupled to a Philips PW1010 X-ray diffraction generator.

X-ray diffraction traces (Cu/Ni radiation) were obtained using a Philips X-ray diffractometer comprising a wide range goniometer (PW1050) and proportional counter (PW1965/50). The nature of the $\bar{2}01$ peaks of sanidines from rhyolites were examined to ascertain the degree of unmixing to form cryptoperthites. Values of $\Gamma(2\theta(220) + 2\theta(1\bar{3}1) - 4\theta(131)$; Smith and Gay, 1958) for plagioclases were measured to assess their structural state.

Diffraction traces in the range $2\theta = 20^{\circ}-30^{\circ}$ enabled interpretation of the complex assemblage of silica and feldspar minerals in the microcrystalline groundmass of the rhyolites.

APPENDIX II

MICROPROBE DATA ON OLIVINES, PYROXENES AND FELDSPARS

ABBREVIATIONS IN TABLES II.1 - II.3

MC : Megacryst or inclusion in megacryst

MR : Reaction rim of megacryst

PC : Core of phenocryst

PR : Rim of phenocryst

PM : Microphenocryst

GM : Groundmass grain

MP : Microphenocryst

Analyses along a core-rim traverse indciated by an arrow joining PC and PR.

Table II.1

ANALYSES OF OLIVINES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	PC	PC	PC	PC ———	———→	PR	PR	GM	GM	GM	PC →	PR	GM	GM
SiO_2	39.14	39.19	38.86	38.75	38.46	37.75	37.26	35.51	34.33	34.07	37.37	34.96	35.78	33.31
FeO*	18.27	18.33	18.73	19.50	21.93	25.67	27.87	35.88	41.81	42.42	28.85	39.64	34.25	47.46
MnO	-	0.20	0.23	0.19	0.21	0.29	0.23	0.43	0.70	0.62	0.31	0.49	0.49	0.91
MgO	42.30	42.35	41.98	41.30	39.32	36.70	34.22	27.46	22.25	22.11	33.49	23.95	28.26	16.86
CaO	0.11	0.13	0.22	0.14	0.19	0.19	0.19	0.33	0.27	0.32	0.22	0.36	0.21	0.43
Total	99.82	100.18	100.02	99.88	100.11	100.52	99.77	99.41	99.36	99.54	100.14	99.40	98.99	99.27
					Structural Formula on the Basis of 4 Oxygen Atoms									
Si	0.999	0.998	0.994	0.996	1.004	0.993	0.999	0.996	0.998	0.992	1.000	1.000	1.001	1.002
Fe^{2+}	0.390	0.390	0.401	0.419	0.479	0.565	0.625	0.841	1.016	1.032	0.647	0.950	0.801	1.202
Mn	-	0.004	0.005	0.004	0.005	0.006	0.005	0.010	0.017	0.015	0.007	0.012	0.012	0.023
Mg	1.609	1.607	1.600	1.582	1.530	1.438	1.367	1.147	0.963	0.959	1.339	1.023	1.178	0.756
Ca	0.003	0.004	0.006	0.004	0.005	0.005	0.005	0.010	0.008	0.010	0.006	0.011	0.006	0.014
ΣFe^{2+},Mn,Mg,Ca	2.00	2.01	2.01	2.01	2.02	2.01	2.00	2.01	2.00	2.02	2.00	2.00	2.00	2.00
100 Mg/Mg+Fe	80.5	80.5	80.0	79.1	76.2	71.8	68.6	57.7	49.3	48.2	67.4	51.9	59.5	38.6

	15	16	17	18	19	20	21	22	23	24	25
	GM	GM	GM	GM	GM	GM	PC →	PR	PC	GM	GM
SiO_2	35.45	35.53	35.13	32.58	32.37	32.37	34.72	34.40	34.50	34.85	34.80
FeO*	34.13	34.53	34.98	52.43	52.31	52.86	40.87	41.01	40.61	43.73	39.76
MnO	0.36	0.51	0.56	1.01	1.00	0.70	0.81	0.72	0.83	0.59	0.58
MgO	28.81	28.36	27.39	13.76	13.67	13.34	23.22	22.86	22.77	21.57	24.08
CaO	0.29	0.33	0.41	0.51	0.42	0.38	0.41	0.48	0.45	0.35	0.36
Total	99.29	99.64	98.81	100.62	100.09	99.81	100.03	99.47	99.16	101.09	99.58
					Structural Formula on the Basis of 4 Oxygen Atoms						
Si	0.996	0.989	0.995	0.993	0.993	0.996	0.997	0.994	0.999	0.999	0.995
Fe^{2+}	0.802	0.804	0.829	1.337	1.342	1.360	0.981	0.991	0.984	1.049	0.951
Mn	0.009	0.012	0.013	0.026	0.026	0.018	0.020	0.018	0.020	0.014	0.014
Mg	1.206	1.177	1.156	0.625	0.625	0.612	0.994	0.984	0.983	0.922	1.026
Ca	0.009	0.010	0.012	0.017	0.014	0.013	0.013	0.015	0.014	0.011	0.011
ΣFe^{2+},Mn,Mg,Ca	2.03	2.01	2.01	2.01	2.01	2.01	2.01	2.01	2.00	2.00	2.01
100 Mg/Mg+Fe	60.1	59.4	58.2	31.9	31.8	31.0	50.3	49.8	50.0	46.8	51.9

Table II.1 (continued)

ANALYSES OF OLIVINES

	26	27	28	29	30	31	32	33	34	35	36	37
	MR	GM	PC ⟶	PR	PC	PC	PC	PC	PC	PC ⟶	PR	PC
SiO_2	34.18	32.51	37.76	36.31	35.63	36.14	33.41	39.36	34.59	33.00	32.64	32.72
FeO*	41.90	52.22	24.98	31.72	36.23	33.80	46.14	16.99	42.38	50.62	50.41	50.26
MnO	0.75	0.93	0.30	0.36	0.46	0.52	0.71	0.15	0.54	0.88	0.78	0.95
MgO	22.01	13.14	36.98	31.07	26.92	28.90	18.65	43.42	21.48	14.63	14.59	14.46
CaO	0.28	0.35	0.27	0.25	0.25	0.25	0.48	0.11	0.32	0.37	0.33	0.38
Total	99.07	99.29	100.29	99.71	99.69	99.61	99.39	100.03	99.31	99.50	98.75	98.77
					Structural Formula on the Basis of 4 Oxygen Atoms							
Si	0.997	1.003	0.993	0.995	1.001	1.002	0.995	0.997	1.007	1.006	1.008	1.003
Fe^{2+}	1.023	1.347	0.550	0.727	0.851	0.783	1.149	0.360	1.031	1.290	1.302	1.288
Mn	0.019	0.024	0.007	0.008	0.011	0.012	0.018	0.003	0.013	0.023	0.020	0.025
Mg	0.957	0.604	1.450	1.268	1.127	1.194	0.828	1.639	0.932	0.664	0.671	0.660
Ca	0.007	0.012	0.008	0.007	0.008	0.007	0.015	0.003	0.010	0.012	0.011	0.013
ΣFe^{2+}Mn,Mg,Ca	2.01	1.99	2.02	2.01	2.00	2.00	2.01	2.01	1.99	1.99	2.00	1.99
100 Mg/Mg+Fe	48.8	31.0	72.5	63.6	57.0	60.4	41.9	82.0	47.5	34.0	34.0	33.9

	38	39	40	41	42	43	44	45	46	47	48	49
	PC ⟶	PR	PC ⟶	PR	PC	PC	PC	PC	PC	PC ⟶	PR	GM
SiO_2	39.06	38.30	31.14	31.04	31.04	31.09	31.52	31.51	32.35	37.92	35.09	31.89
FeO*	18.45	22.34	59.79	59.69	59.09	59.26	59.12	59.22	56.14	23.63	38.73	56.27
MnO	-	0.28	1.18	1.07	1.20	0.97	1.08	1.03	0.93	0.23	0.52	1.21
MgO	41.49	38.41	7.26	7.14	7.84	7.94	8.11	8.17	11.66	37.38	24.37	9.29
CaO	0.17	0.23	0.24	0.20	0.27	0.30	0.32	0.29	0.32	0.13	0.16	0.33
Total	99.17	99.56	99.61	99.14	99.44	99.56	100.15	100.22	101.40	99.29	98.87	98.99
						Structural Formula on the Basis of 4 Oxygen Atoms						
Si	1.004	1.001	1.002	1.003	0.997	0.997	1.002	1.001	0.994	1.000	1.006	1.011
Fe^{2+}	0.397	0.488	1.608	1.613	1.588	1.589	1.572	1.573	1.443	0.521	0.929	1.491
Mn	-	0.006	0.032	0.029	0.033	0.026	0.029	0.028	0.024	0.005	0.013	0.033
Mg	1.590	1.496	0.348	0.344	0.375	0.379	0.384	0.387	0.534	1.469	1.041	0.439
Ca	0.005	0.006	0.008	0.007	0.009	0.010	0.011	0.010	0.011	0.004	0.005	0.011
ΣFe^{2+}Mn,Mg,Ca	1.99	2.00	2.00	1.99	2.01	2.00	2.00	2.00	2.01	2.00	1.99	1.98
100 Mg/Mg+Fe	80.4	75.4	17.8	17.6	9.1	19.3	19.6	19.7	27.0	73.8	52.8	22.7

KEY TO ANALYSES IN TABLE I

1-10. Olivines in low-Si ite 28048 (Table 6.1,Anal. 3).

11-14. Olivines in low-Si tholeiitic andesite 28049 (Table 6.1,Anal. 4).

15-17. Olivines in low-Si tholeiitic andesite 28050 (Table 6.1,Anal. 5).

18-20. Olivines in low-Si tholeiitic andesite 28051 (Table 6.1,Anal. 6).

21-23. Olivines in low-Si tholeiitic andesite 28055 (Table 6.1,Anal. 9).

24,25. Olivines in high-Al tholeiitic andesite 27290 (Table 6.1, Anal. 10).

26,27. Olivines in low-Si tholeiitic andesite 27291 (Table 6.1,Anal.15). 26. Olivine in reaction corona to orthopyroxene megacryst (Table II.2a,Anal.20). 27. Groundmass olivine.

28-34. Olivines in high-Si tholeiitic andesite 28061 (Table 6.2, Anal. 1).

35-37. Olivines in icelandite 28067 (Table 6.2, Anal. 7).

38,39. Olivines in icelandite 28071 (Table 6.2, Anal. 11).

40-46. Olivines in icelandite 28072 (Table 6.2, Anal. 12).

47-49. Olivines in rhyodacite 28074 (Table 6.2, Anal. 14).

* All Fe reported as FeO.

Table 11.2a

MICROPROBE ANALYSES OF PYROXENES OF THE LOW-Si SERIES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	GM	GM	GM	GM	GM	GM	GM	GM	GM	GM	GM	GM	GM	GM
SiO_2	51.84	52.37	51.55	51.28	52.70	5[illegible].64	50.23	50.17	50.78	51.12	51.18	50.22	50.02	50.53
TiO_2	1.14	0.85	1.22	1.16	0.71	[illegible].54	1.23	1.37	1.69	1.05	1.10	1.42	1.49	1.30
Al_2O_3	2.15	1.55	2.41	2.20	1.79	[illegible].73	2.55	2.57	2.85	1.66	1.72	2.31	2.59	2.16
FeO^*	11.00	10.61	9.74	11.08	9.62	1[illegible].96	13.80	12.76	11.36	11.98	11.85	12.80	13.04	12.95
MnO	0.32	0.28	0.16	0.21	0.19	[illegible].14	0.26	0.25	0.17	0.24	0.15	0.15	0.28	0.26
MgO	15.68	16.67	15.71	16.09	17.18	1[illegible].49	12.93	13.00	13.94	13.35	13.55	12.05	12.77	12.14
CaO	17.82	17.38	18.62	17.10	17.25	1[illegible].55	18.13	19.01	19.54	19.93	20.00	20.26	19.88	20.25
Na_2O	0.44	0.30	0.40	0.24	0.39	[illegible].29	0.55	0.37	0.54	0.19	0.41	0.42	0.42	0.28
Total	100.42	100.01	99.81	99.36	99.84	9[illegible].34	99.68	99.50	100.87	99.53	100.07	99.63	100.49	99.87
Structural Formulae on the Basis of 6 Oxygen Atoms														
Si	1.925	1.944	1.918	1.921	1.950	[illegible].910	1.910	1.906	1.892	1.936	1.930	1.912	1.891	1.920
Al^{IV}	0.075	0.056	0.082	0.079	0.050	[illegible].090	0.090	0.094	0.108	0.064	0.070	0.088	0.109	0.080
Al^{VI}	0.019	0.012	0.024	0.018	0.025	[illegible].076	0.054	0.021	0.017	0.010	0.006	0.016	0.006	0.017
Ti	0.032	0.024	0.034	0.033	0.025	[illegible].044	0.035	0.039	0.047	0.030	0.031	0.041	0.042	0.037
Fe^{2+}	0.342	0.329	0.303	0.347	0.298	[illegible].377	0.439	0.405	0.354	0.379	0.374	0.408	0.412	0.411
Mn	0.010	0.009	0.005	0.007	0.006	[illegible].005	0.008	0.008	0.005	0.008	0.005	0.005	0.009	0.008
Mg	0.868	0.922	0.871	0.898	0.947	[illegible].702	0.733	0.736	0.774	0.754	0.762	0.684	0.719	0.687
Ca	0.709	0.691	0.742	0.686	0.684	[illegible].750	0.739	0.774	0.780	0.809	0.808	0.827	0.805	0.824
Na	0.031	0.021	0.029	0.018	0.028	[illegible].021	0.041	0.027	0.039	0.014	0.030	0.031	0.031	0.020
Σ xy	2.01	2.01	2.01	2.01	2.01	1.98	2.05	2.01	2.02	2.00	2.00	2.01	2.02	2.00
atom %.														
Ca	37.0	35.5	38.7	35.5	35.5	41.0	38.7	40.4	40.9	41.7	41.5	43.0	41.6	42.9
Mg	45.2	47.5	45.5	46.5	49.1	33.4	38.3	38.4	40.6	38.8	39.2	35.7	35.1	35.7
Fe	17.8	17.0	15.8	18.0	15.4	2[illegible].6	23.0	21.2	18.5	19.5	19.3	21.3	21.3	21.4
100 Fe/Fe+Mg	28.3	26.4	25.8	27.9	23.9	34.9	37.5	35.6	31.3	33.4	33.0	37.4	37.8	37.5

	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	MC ⟶	MR	MC	GM	GM	MC ⟶	MR	GM	GM	PC ⟶		PR	PC ⟶		PR	PC ⟶		PR	PC
SiO_2	49.41	51.14	52.32	50.94	51.61	53.18	50.27	51.08	51.52	51.16	50.76	51.03	49.96	50.49	50.33	50.62	49.13	48.87	50.48
TiO_2	1.24	1.24	0.40	1.32	0.99	0.24	1.06	0.7[illegible]	0.75	0.73	0.66	0.77	1.13	0.99	1.06	0.72	1.63	1.93	1.27
Al_2O_3	5.24	2.14	4.16	2.40	1.81	3.71	2.26	1.8[illegible]	2.74	1.63	1.62	1.91	2.81	2.30	1.89	1.94	3.45	2.68	2.72
FeO^*	11.32	10.32	15.84	10.60	11.80	15.24	14.42	15.0	15.29	14.51	15.07	13.07	13.70	3.13	12.87	12.25	13.11	15.54	12.32
MnO	0.15	0.14	0.24	0.17	0.22	0.16	0.21	0.3	0.33	0.40	0.46	0.27	0.33	0.19	0.29	0.31	0.30	0.39	0.33
MgO	14.38	14.85	25.34	14.57	14.73	25.23	12.03	11.0[illegible]	10.48	13.06	12.43	13.14	12.33	2.38	12.64	13.15	11.76	10.67	12.58
CaO	16.42	19.72	1.96	19.64	18.62	2.05	19.27	19.7	19.05	18.53	18.48	19.41	18.85	19.78	18.99	19.72	19.58	18.88	20.03
Na_2O	0.88	0.32	-	0.23	0.18	-	0.32	0.1[illegible]	0.57	0.21	-	0.52	0.34	0.30	0.30	0.32	0.48	0.56	0.38
Total	99.13[a]	100.09[b]	100.26[c]	99.95	99.96	99.81	99.84	100.0[illegible]	100.73	100.23	99.48	100.12	99.45	99.56	98.37	99.03	99.44	99.52	100.11
Structural Formulae on the Basis of 6 Oxygen Atoms																			
Si	1.858	1.912	1.892	1.908	1.935	1.923	1.918	1.9[illegible]9	1.948	1.939	1.944	1.930	1.907	1.922	1.935	1.931	1.878	1.887	1.907
Al^{IV}	0.142	0.088	0.108	0.092	0.065	0.077	0.082	0.0[illegible]1	0.052	0.061	0.056	0.070	0.093	0.078	0.065	0.069	0.122	0.113	0.093
Al^{VI}	0.090	0.006	0.069	0.014	0.015	0.081	0.020	0.031	0.070	0.012	0.017	0.015	0.033	0.025	0.021	0.018	0.033	0.008	0.028
Ti	0.035	0.035	0.011	0.037	0.028	0.007	0.030	0.0[illegible]3	0.021	0.021	0.019	0.022	0.032	0.028	0.031	0.021	0.047	0.056	0.036
Fe^{2+}	0.356	0.323	0.479	0.332	0.370	0.461	0.460	0.431	0.484	0.460	0.482	0.413	0.437	0.418	0.414	0.391	0.419	0.502	0.389
Mn	0.005	0.004	0.007	0.005	0.007	0.005	0.007	0.010	0.011	0.013	0.015	0.009	0.011	0.006	0.009	0.010	0.010	0.013	0.011
Mg	0.806	0.827	1.366	0.813	0.823	1.359	0.684	0.631	0.591	0.738	0.709	0.741	0.701	0.702	0.724	0.747	0.670	0.614	0.708
Ca	0.662	0.790	0.076	0.788	0.748	0.080	0.788	0.806	0.772	0.752	0.758	0.787	0.771	0.807	0.782	0.806	0.802	0.781	0.811
Na	0.064	0.023	-	0.017	0.013	-	0.024	0.011	0.042	0.015	-	0.038	0.025	0.022	0.022	0.025	0.035	0.042	0.028
Σ xy	2.02	2.01	2.01	2.01	2.00	1.99	2.01	1.99	1.99	2.01	2.00	2.03	2.01	2.01	2.00	2.02	2.02	2.02	2.01
atom %.																			
Ca	36.2	40.6	3.9	40.6	38.5	4.2	40.8	42.0	41.8	38.6	38.9	40.5	40.4	41.9	40.7	41.4	4[illegible].4	41.2	42.5
Mg	44.1	42.6	70.9	42.0	42.4	71.4	35.4	32.9	32.0	37.8	36.4	38.2	36.7	36.4	37.7	38.5	3[illegible].4	32.4	37.1
Fe	19.7	16.8	25.2	17.4	19.1	24.4	23.8	25.1	26.2	2[illegible].6	24.7	21.3	22.9	21.7	21.6	20.1	2[illegible].2	26.4	20.4
100 Fe/Fe+Mg	30.9	28.3	26.2	29.3	31.1	25.5	40.2	43.3	45.0	38.4	40.4	35.8	38.4	37.3	36.4	34.3	38.4	44.9	35.5

KEY TO ANALYSES IN TABLE 11.2a

1-5 Groundmass pyroxenes in low-Si tholeiitic andesite 28048 (Table 6.1, Anal. 3).

6-9 Groundmass pyroxenes in low-Si tholeiitic andesite 28049 (Table 6.1, Anal. 4).

10-14 Groundmass pyroxenes in low-Si tholeiitic andesite 28051 (Table 6.1, Anal. 6).

15-19 Pyroxenes in low-Si tholeiitic andesite 27290 (Table 6.1, Anal. 14): 15. Clinopyroxene megacryst. 16. Reaction rim to pyroxene Anal. 15. 17. Orthopyroxene included in plagioclase megacryst 18,19. Groundmass pyroxenes.

20-23 Pyroxenes in low-Si tholeiitic andesite 27291 (Table 6.1, Anal. 15): 20. Orthopyroxene megacryst. 21. Clinopyroxene in reaction

24-33 Pyroxene phenocrysts in low-Si tholeiitic andesite 28055 (Table 6.1, Anal. 9).

Analyses 15,16,17,18,20 from Duggan and Wilkinson (1973), Table 1.

* All Fe reported as FeO. [a] Includes Cr_2O_3, 0.09%. [b] Includes Cr_2O_3, 0.22%. [c] Includes Cr_2O_3, 0.08%.

Table II.21

MICROPROBE ANALYSIS OF PYROXENES OF THE HIGH-Si SERIES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	PC ⟶	PR	PC	PC	PC	PC ⟶	PR	PC	PC	PC ⟶	PR	PC ⟶	PR	PC	GM	GM
SiO_2	51.74	52.39	54.04	51.49	51.21	51.86	51.54	51.11	52.[illegible]0	49.50	49.62	49.58	49.54	51.97	50.81	49.64
TiO_2	0.45	0.46	0.31	0.38	0.33	0.42	0.34	0.36	0.[illegible]6	0.61	0.64	0.66	0.57	0.93	0.96	0.56
Al_2O_3	1.46	1.13	1.34	0.98	1.01	0.99	0.83	1.16	1.[illegible]8	1.33	1.39	1.34	1.53	2.17	[illegible].70	0.99
FeO*	24.43	23.37	15.74	25.86	25.40	24.64	25.78	25.87	23.[illegible]1	22.18	22.71	22.03	22.85	11.16	16.60	30.03
MnO	0.45	0.43	0.30	0.56	0.52	0.44	0.44	0.59	0.[illegible]1	0.55	0.47	0.48	0.48	0.16	0.28	0.59
MgO	20.50	20.60	25.64	17.61	17.53	17.64	16.71	15.76	19.[illegible]7	7.36	7.62	7.68	7.70	15.42	1[illegible].71	12.47
CaO	0.89	2.17	2.16	2.91	3.37	4.28	4.15	4.02	2.62	18.35	18.08	17.76	17.46	18.00	16.82	4.97
Na_2O	–	–	–	–	–	0.30	0.19	0.23	0.[illegible]8	–	–	–	0.19	0.47	0.23	0.15
Total	99.92	100.55	99.53	99.79	99.37	100.57	100.01	100.11	99.92	99.90	99.53	99.53	100.32	100.27	100.09	99.39
Structural Formula on the Basis of 6 Oxygen Atoms																
Si	1.957	1.960	1.967	1.971	1.968	1.966	1.97[illegible]	1.960	1.967	1.955	1.959	1.959	1.949	1.932	1.937	1.966
Al^{IV}	0.043	0.040	0.037	0.029	0.032	0.034	0.02[illegible]	0.040	0.033	0.045	0.041	0.041	0.051	0.068	0.063	0.034
Al^{VI}	0.022	0.010	0.020	0.015	0.014	0.010	0.01[illegible]	0.012	0.019	0.017	0.024	0.021	0.020	0.027	0.013	0.012
Ti	0.013	0.013	0.009	0.011	0.012	0.010	0.01[illegible]	0.010	0.007	0.018	0.019	0.020	0.017	0.026	0.028	0.017
Fe^{2+}	0.772	0.731	0.479	0.828	0.816	0.781	0.82[illegible]	0.830	0.742	0.733	0.717	0.728	0.752	0.347	0.529	0.994
Mn	0.014	0.014	0.009	0.018	0.017	0.014	0.01[illegible]	0.019	0.016	0.019	0.016	0.016	0.016	0.005	0.009	0.028
Mg	1.155	1.148	1.391	1.005	1.004	0.997	0.95[illegible]	0.958	1.101	0.433	0.448	0.452	0.451	0.854	0.722	0.736
Ca	0.036	0.087	0.084	0.119	0.139	0.174	0.17[illegible]	0.165	0.106	0.776	0.765	0.752	0.736	0.717	0.687	0.211
Na	–	–	–	–	–	0.022	0.01[illegible]	0.017	0.013	–	–	–	0.015	0.034	–	0.011
Σ xy	2.01	2.00	2.00	2.00	2.00	2.01	2.00	2.01	2.00	2.00	1.99	1.99	2.01	2.01	2.01	2.01
atom %.																
Ca	1.8	4.4	4.3	6.1	7.1	8.9	8.7	8.5	5.4	40.0	39.6	38.9	37.9	37.4	35.4	10.9
Mg	58.8	58.4	71.2	51.5	51.2	51.1	48.9	49.0	56.[illegible]	22.3	23.2	23.4	23.3	44.5	37.3	37.9
Fe	39.4	37.2	24.5	42.4	41.7	40.0	42.4	42.5	38.1	37.7	37.2	37.7	38.8	18.1	27.3	51.2
100 Fe/Fe+Mg	40.1	38.9	25.6	45.2	44.9	43.9	46.4	46.4	40.3	62.8	61.6	61.7	62.5	28.9	42.3	57.5

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
	PC ⟶	PR	PC ⟶	PR	PC ⟶	PR	PC – – ⟶	PR	PC ⟶	PR	PC ⟶	PR	PC ⟶	PR	PC ⟶	PR	PC
SiO_2	51.98	51.71	51.89	51.57	52.39	51.72	52.30	51.63	51.41	51.55	52.03	51.91	51.84	51.83	51.93	51.45	52.10
TiO_2	0.45	0.47	0.48	0.52	0.47	0.40	0.51	0.57	0.47	0.53	0.38	0.36	0.41	0.46	0.85	0.85	0.73
Al_2O_3	1.28	1.35	1.24	1.46	1.23	0.90	1.26	0.92	1.31	1.09	1.02	1.01	1.01	1.14	1.85	1.81	1.67
FeO	22.06	21.81	22.19	22.63	21.86	24.06	21.68	23.59	23.75	23.68	23.43	24.20	22.82	22.81	13.56	14.75	14.27
MnO	0.33	0.38	0.36	0.48	0.44	0.48	0.29	0.37	0.37	0.46	0.51	0.59	0.49	0.45	0.22	0.20	0.16
MgO	21.42	20.93	21.07	20.57	21.57	18.00	21.56	18.25	20.19	17.80	18.38	17.72	18.66	18.37	14.28	13.00	13.69
CaO	2.02	2.21	2.03	2.18	2.05	3.93	2.07	4.24	2.10	4.65	4.25	4.20	4.36	4.81	17.80	18.05	17.79
Na_2O	–	–	–	–	–	0.20	–	0.18	–	0.30	0.20	0.26	0.16	0.24	0.25	0.19	0.20
Total	99.54	99.12	99.44	99.81	100.39	99.69	99.93	99.56	100.41	100.06	100.20	100.25	99.68	100.11	100.95	100.56	100.90
Structural Formula on the Basis of 6 Oxygen Atoms																	
Si	1.953	1.956	1.957	1.948	1.957	1.972	1.957	1.968	1.954	1.960	1.968	1.971	1.967	1.961	1.941	1.944	1.954
Al^{IV}	0.047	0.044	0.043	0.052	0.043	0.028	0.043	0.032	0.046	0.040	0.032	0.029	0.033	0.039	0.059	0.056	0.046
Al^{VI}	0.010	0.013	0.012	0.013	0.011	0.012	0.013	0.009	0.012	0.009	0.013	0.016	0.010	0.012	0.022	0.025	0.028
Ti	0.013	0.013	0.014	0.015	0.013	0.011	0.014	0.011	0.013	0.015	0.011	0.010	0.012	0.013	0.024	0.024	0.021
Fe^{2+}	0.693	0.690	0.700	0.715	0.683	0.767	0.673	0.752	0.748	0.753	0.741	0.768	0.724	0.722	0.424	0.466	0.448
Mn	0.011	0.012	0.012	0.015	0.014	0.016	0.009	0.012	0.012	0.015	0.016	0.019	0.016	0.014	0.007	0.006	0.005
Mg	1.199	1.180	1.184	1.158	1.200	1.022	1.202	1.037	1.133	1.009	1.036	1.003	1.055	1.036	0.795	0.732	0.765
Ca	0.081	0.090	0.082	0.088	0.082	0.165	0.083	0.173	0.085	0.189	0.172	0.171	0.177	0.195	0.713	0.751	0.715
Na	–	–	–	–	–	0.015	–	0.013	–	0.022	0.015	0.019	0.012	0.018	0.018	0.014	0.014
Σ xy	2.01	2.00	2.00	2.00	2.00	2.01	2.00	2.01	2.00	2.01	2.00	2.01	2.01	2.01	2.00	2.00	2.00
atom %.																	
Ca	4.1	4.6	4.2	4.5	4.2	[illegible]	4.2	8.8	4.3	9.7	8.8	8.8	9.1	10.0	36.9	37.9	37.1
Mg	60.8	61.2	60.2	59.0	61.1	[illegible]	61.2	[illegible]	57.7	51.7	53.2	51.6	53.9	53.1	41.2	37.9	39.7
Fe	35.1	35.3	35.6	36.5	34.7	39.4	34.6	[illegible]	38.0	38.6	38.0	39.6	37.0	36.9	21.9	24.2	23.2
100 Fe/Fe+Mg	36.6	36.6	[illegible]	[illegible]	36.2	[illegible]	36.1	42.0	39.7	42.7	41.7	43.4	[illegible]	41.0	[illegible]	39.0	36.9

Table II.2b (Continued)

MICROPROBE ANALYSES OF PYROXENES OF THE HIGH-Si SERIES

	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	PC	GM	GM	GM	GM	GM	PC	PC	PC ⟶	PR	PR	PC	PC	PC	PC
SiO_2	52.02	52.09	51.67	51.06	51.16	51.05	53.72	54.10	52.36	51.68	51.20	51.62	50.23	52.75	53.33
TiO_2	0.72	0.60	0.39	1.33	1.00	0.81	0.25	0.28	0.43	0.54	0.89	0.84	1.24	0.48	0.49
Al_2O_3	1.56	1.26	1.09	2.85	2.09	2.08	1.15	1.55	1.26	1.48	2.36	3.31	2.18	1.54	1.63
FeO	14.09	20.84	24.66	12.57	15.23	15.49	16.13	16.13	20.05	19.46	12.96	12.95	13.15	21.77	19.04
MnO	0.28	0.40	0.58	0.22	0.33	0.32	0.29	0.26	0.55	0.51	0.40	-	0.24	0.39	0.23
MgO	14.18	19.64	16.47	15.30	14.70	13.79	25.10	25.26	20.11	19.99	14.57	15.60	13.67	21.11	22.95
CaO	17.17	4.63	4.92	16.57	15.57	15.96	2.18	2.19	4.62	5.10	17.24	19.80	17.83	2.08	2.36
Na_2O	0.27	0.23	0.18	0.39	0.40	0.30	-	-	0.38	0.27	0.35	0.59	0.38	-	-
Total	100.39	99.69	99.96	100.29	100.48	99.80	98.83	99.77	99.76	99.03	99.99	99.71	98.91	100.12	100.03
							Structural Formula on the Basis of 6 Oxygen Atoms								
Si	1.955	1.959	1.975	1.905	1.924	1.937	1.973	1.967	1.962	1.949	1.925	1.912	1.917	1.964	1.962
Al^{IV}	0.045	0.041	0.025	0.095	0.076	0.063	0.027	0.033	0.038	0.051	0.075	0.088	0.083	0.036	0.038
Al^{VI}	0.024	0.015	0.024	0.030	0.017	0.030	0.023	0.033	0.018	0.015	0.030	0.056	0.015	0.032	0.033
Ti	0.020	0.017	0.011	0.037	0.028	0.023	0.007	0.008	0.012	0.015	0.025	0.023	0.036	0.013	0.014
Fe^{2+}	0.443	0.656	0.788	0.392	0.479	0.491	0.495	0.490	0.628	0.614	0.407	0.246	0.420	0.678	0.586
Mn	0.009	0.013	0.019	0.007	0.011	0.010	0.009	0.008	0.018	0.016	0.013	-	0.008	0.012	0.007
Mg	0.794	1.101	0.938	0.851	0.824	0.780	1.374	1.368	1.123	1.123	0.816	0.861	0.777	1.171	1.258
Ca	0.692	0.187	0.201	0.663	0.627	0.649	0.086	0.085	0.186	0.206	0.694	0.786	0.729	0.083	0.093
Na	0.020	0.017	0.013	0.028	0.029	0.022	-	-	0.027	0.028	0.025	0.042	0.028	-	-
Σ xy	2.00	2.01	1.99	2.01	2.02	2.01	1.99	1.99	2.01	2.02	2.01	2.01	2.01	1.99	1.99
atom %															
Ca	35.8	9.6	10.5	34.8	32.5	33.8	4.4	4.4	9.6	10.6	36.2	41.5	37.8	4.3	4.8
Mg	41.2	56.7	48.7	44.6	42.7	40.6	70.3	70.4	58.0	57.8	42.6	45.5	40.4	60.6	65.0
Fe	23.0	33.7	40.9	20.6	24.8	25.6	25.3	25.2	32.4	31.6	21.2	13.0	21.8	35.1	30.2
100 Fe/Fe+Mg	35.8	37.3	45.6	31.6	36.7	38.7	26.5	26.4	35.8	35.3	33.2	22.2	35.0	36.7	37.0

	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
	PC	PC	PC	PC	PC	PC	PC ⟶	PR	PC	PC	PC	PC	PC	PC	PC	GM
SiO_2	53.50	49.40	51.48	51.46	54.12	53.59	54.43	[illegible]	51.12	50.57	50.95	50.16	49.98	[illegible]	50.88	50.69
TiO_2	0.24	1.55	1.24	1.29	0.37	0.41	0.37	[illegible]	0.46	0.55	0.43	0.40	0.70	0.52	0.38	0.41
Al_2O_3	1.04	2.48	2.40	3.80	2.11	1.28	1.90	[illegible]	1.13	1.64	1.07	1.01	1.50	[illegible]	1.51	1.03
FeO	18.35	19.07	13.72	11.02	15.07	20.83	16.70	[illegible]	27.66	23.42	27.41	29.08	25.96	[illegible]	19.24	29.00
MnO	0.39	0.30	0.23	0.20	0.25	0.43	0.26	0.62	0.65	0.51	0.47	0.73	0.52	0.26	0.46	0.64
MgO	22.60	11.27	14.26	15.16	26.40	22.09	24.99	[illegible]	15.14	13.07	14.46	12.90	13.45	13.09	10.58	13.86
CaO	3.52	15.35	16.56	17.81	2.05	2.11	2.53	3.88	4.57	10.32	4.94	5.13	6.89	17.80	16.98	3.89
Na_2O	-	0.38	0.25	0.52	-	-	-	[illegible]	0.17	0.37	-	-	0.15	0.33	0.24	0.15
Total	99.95	99.80	100.14	101.26	100.37	100.94	101.18	100.02	100.90	100.45	99.73	99.41	99.15	99.31	100.27	99.67
						Structural Formula on the Basis of 6 Oxygen Atoms										
Si	1.978	1.911	1.931	1.907	1.946	1.972	1.957	1.990	1.963	1.948	1.977	1.975	1.955	1.953	1.961	1.980
Al^{IV}	0.022	0.089	0.069	0.093	0.054	0.028	0.043	0.010	0.037	0.052	0.023	0.025	0.045	0.047	0.039	0.020
Al^{VI}	0.023	0.024	0.037	0.073	0.035	[illegible]	0.037	0.042	0.014	0.023	0.026	0.022	0.024	0.042	0.030	0.027
Ti	0.007	0.045	0.035	0.036	0.010	[illegible]	0.010	0.011	0.013	0.016	0.013	0.012	0.021	0.015	0.011	0.012
Fe^{2+}	0.567	0.617	0.430	0.341	0.453	[illegible]	0.502	0.934	0.888	0.754	0.890	0.958	0.849	0.444	0.620	0.947
Mn	0.012	0.010	0.007	0.006	0.008	[illegible]	0.008	0.020	0.021	0.017	0.015	0.024	0.017	0.008	0.015	0.021
Mg	1.245	0.649	0.797	0.793	1.415	[illegible]	1.339	[illegible]	0.866	0.750	0.836	0.757	0.784	0.742	0.608	0.807
Ca	0.139	0.636	0.665	0.707	0.079	0.08	0.097	[illegible]	0.188	0.426	0.205	0.217	0.289	0.725	0.701	0.163
Na	-	0.028	0.018	0.037	-	-	-	0.014	0.012	0.028	-	-	0.011	0.024	0.018	0.011
Σ xy	1.99	2.01	1.99	1.99	2.00	1.98	1.99	1.98	2.00	2.01	1.99	1.99	2.00	2.00	2.00	1.99
atom %.																
Ca	7.1	33.4	35.2	37.5	4.0	4.3	5.0	[illegible]	9.7	22.1	10.6	11.2	15.0	33.0	36.4	8.5
Mg	63.8	34.2	42.1	44.4	72.7	62.6	69.1	42.2	44.6	38.9	43.3	39.2	40.8	33.8	31.5	42.1
Fe	29.1	32.4	22.7	18.1	23.3	33.1	25.9	49.3	45.7	39.0	46.1	49.6	44.2	23.2	32.1	49.4
100 Fe/Fe+Mg	31.3	48.6	35.0	29.0	24.3	34.6	27.3	53.9	50.6	50.1	51.6	55.9	52.0	37.4	50.5	54.0

Table II.2b (Continued)

MICROPROBE ANALYSES OF PYROXENES OF THE HIGH-Si SERIES

	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	GM	GM	GM	PC ⟶	PR	GM	GM	GM	GM	GM	GM	GM	GM	PC	PC	PC
SiO_2	51.79	50.19	52.13	50.81	50.24	52.20	51.03	50.26	51.34	49.97	51.10	49.62	51.76	49.08	49.96	49.57
TiO_2	0.40	0.80	0.43	0.35	0.46	0.34	0.34	0.43	0.81	0.86	0.91	0.70	0.52	0.25	0.40	0.14
Al_2O_3	0.94	1.63	1.72	0.94	0.85	1.22	[illegible].32	1.28	1.56	1.49	1.83	1.91	1.05	0.86	1.44	0.84
FeO^*	26.04	26.69	17.86	30.74	31.08	21.03	24.32	28.83	16.54	19.99	17.27	26.89	24.92	37.67	33.71	36.87
MnO	0.56	0.50	0.31	0.97	0.86	0.48	0.53	0.71	0.39	0.40	0.34	0.71	0.62	0.87	0.78	0.80
MgO	16.04	10.36	10.52	13.90	13.12	19.91	16.91	13.10	11.96	10.89	10.94	13.36	16.47	9.80	13.23	10.49
CaO	4.47	9.61	16.51	2.98	3.15	3.65	3.92	5.31	17.56	15.65	17.12	6.58	5.38	1.19	0.96	1.11
Na_2O	0.22	0.16	0.21	0.26	-	0.45	-	0.16	0.25	0.18	0.33	0.26	0.21	-	-	-
Total	100.46	99.94	99.69	100.95	99.76	99.28	98.37	100.08	100.41	99.43	99.84	100.03	100.93	99.72	100.48	99.82
Structural Formula on the Basis of 6 Oxygen Atoms																
Si	1.983	1.967	1.996	1.973	1.979	1.969	1.974	1.964	1.953	1.946	1.959	1.934	1.965	1.987	1.964	1.994
Al^{IV}	0.017	0.033	0.004	0.027	0.021	0.031	0.026	0.036	0.047	0.054	0.041	0.066	0.035	0.013	0.036	0.006
Al^{VI}	0.025	0.042	0.074	0.016	0.018	0.023	0.034	0.02[illegible]	0.023	0.014	0.042	0.022	0.012	0.028	0.031	0.034
Ti	0.011	0.024	0.012	0.010	0.014	0.010	0.010	0.01[illegible]	0.023	0.025	0.026	0.021	0.015	0.008	0.012	0.004
Fe^{2+}	0.829	0.875	0.572	0.998	1.024	0.663	0.787	0.942	0.526	0.651	0.554	0.876	0.791	1.276	1.108	1.240
Mn	0.018	0.016	0.010	0.032	0.029	0.015	0.017	0.02[illegible]	0.013	0.013	0.011	0.023	0.020	0.030	0.026	0.027
Mg	0.910	0.605	0.600	0.804	0.770	1.119	0.975	0.76[illegible]	0.678	0.632	0.625	0.776	0.932	0.591	0.775	0.629
Ca	0.182	0.404	0.677	0.124	0.133	0.148	0.162	0.22[illegible]	0.716	0.653	0.703	0.275	0.219	0.052	0.040	0.048
Na	0.016	0.012	0.016	0.020	-	0.033	-	0.01[illegible]	0.018	0.014	0.024	0.020	0.016	-	-	-
Σ xy	1.99	1.98	1.96	2.00	1.99	2.01	1.99	2.00	2.00	2.00	1.99	2.01	2.01	1.99	1.99	1.98
atom %.																
Ca	9.5	21.4	36.6	6.4	6.9	7.6	8.4	11.5	37.3	33.7	37.4	14.2	11.3	2.7	2.1	2.5
Mg	47.4	32.1	32.5	41.8	40.0	58.0	50.7	39.6	35.3	32.6	33.2	40.3	48.0	30.8	40.3	32.8
Fe	43.1	46.5	30.9	51.8	53.1	34.4	40.9	48.9	27.4	33.7	29.4	45.5	40.7	66.5	57.6	64.7
100 Fe/Fe+Mg	47.6	59.2	48.7	55.3	57.0	37.2	44.7	55.3	43.7	50.8	47.0	53.0	45.9	68.3	58.8	66.4

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
	PC	PC	PC	PC	PC	PC	PC	MP	MP	PC ⟶		PR	MP	PC ⟶	PR	PC
SiO_2	50.89	53.91	50.79	51.24	52.37	52.84	5[illegible].19	54.99	54.26	50.49	50.92	52.13	52.19	49.44	49.67	49.84
TiO_2	0.18	0.35	1.05	1.16	0.61	0.54	[illegible].02	0.19	0.28	0.31	0.41	0.41	0.48	0.37	0.43	0.31
Al_2O_3	0.80	1.48	3.54	3.28	1.93	1.51	3.37	1.90	2.16	1.34	1.10	1.10	1.11	1.25	1.31	1.03
FeO	28.84	17.95	9.56	9.82	8.05	19.55	9.42	12.67	13.81	29.35	29.37	23.81	23.71	23.44	22.55	24.23
MnO	0.51	0.21	0.18	0.26	0.19	0.27	0.15	0.15	-	0.55	0.61	0.55	0.51	0.58	0.48	0.69
MgO	15.97	24.25	15.21	15.94	16.50	22.24	16.46	27.37	26.66	13.33	13.76	17.57	17.61	7.19	8.26	7.39
CaO	1.56	1.82	18.04	17.49	18.25	2.72	17.72	2.22	2.44	4.64	4.83	4.69	5.02	17.26	16 17	16.78
Na_2O	-	-	0.67	0.64	0.47	-	0.49	-	-	-	0.20	0.16	0.22	-	-	0.15
Total	98.75	99.97	99.04	99.83	98.47	99.67	99.81	99.49	99.61	100.01	101.20	100.42	100.85	99.53	98.87	100.42
Structural Formula on the Basis of 6 Oxygen Atoms																
Si	1.989	1.969	1.902	1.903	1.955	1.960	1.89[illegible]	1.970	1.954	1.972	1.967	1.973	1.967	1.965	1.971	1.968
Al^{IV}	0.011	0.031	0.098	0.097	0.045	0.040	0.10	0.030	0.046	0.028	0.033	0.027	0.033	0.035	0.029	0.032
Al^{VI}	0.026	0.033	0.058	0.047	0.040	0.026	0.04[illegible]	0.050	0.046	0.034	0.017	0.022	0.016	0.024	0.032	0.016
Ti	0.005	0.010	0.030	0.032	0.017	0.015	0.02[illegible]	0.005	0.008	0.009	0.012	0.012	0.014	0.011	0.013	0.009
Fe^{2+}	0.943	0.548	0.300	0.305	0.251	0.606	0.29[illegible]	0.379	0.416	0.958	0.949	0.753	0.747	0.779	0.748	0.800
Mn	0.017	0.007	0.006	0.008	0.006	0.008	0.00[illegible]	0.005	-	0.018	0.020	0.018	0.016	0.020	0.016	0.023
Mg	0.930	1.320	0.849	0.882	0.924	1.229	0.90[illegible]	1.461	1.430	0.776	0.792	0.991	0.989	0.426	0.488	0.435
Ca	0.065	0.071	0.724	0.696	0.730	0.108	0.70[illegible]	0.085	0.094	0.194	0.200	0.190	0.203	0.735	0.687	0.710
Na	-	-	0.049	0.046	0.034	-	0.03	-	-	-	0.015	0.012	0.016	-	-	0.011
Σ xy	1.99	1.99	2.02	2.02	2.00	1.99	2.02	1.99	1.99	1.99	2.01	2.00	2.00	2.00	1.98	2.00
atom %.																
Ca	3.4	3.7	38.7	37.0	38.3	5.6	36.9	4.4	4.9	10.1	10.3	9.8	10.5	37.9	35.7	36.5
Mg	48.0	68.1	45.3	46.8	48.5	63.2	47.7	75.9	73.7	40.2	40.8	51.2	51.0	22.0	25.4	22.4
Fe	48.6	28.3	16.0	16.2	13.2	31.2	15.3	19.7	21.4	49.7	48.9	39.0	38.5	40.1	38.9	41.1
100 Fe/Fe+Mg	50.3	29.4	26.1	25.7	21.4	33.1	24.3	20.6	22.5	55.3	54.5	43.2	43.0	64.6	60.5	64.7

Table II.2b (Continued)

MICROPROBE ANALYSES OF PYROXENES OF THE HIGH-Si SERIES

	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
	MP	MP	MP	MP	PC	PC	MP	PC	PC ⟶	PR	PC	GM	GM	GM	GM
SiO_2	52.01	50.13	50.22	50.04	50.77	50.1	49.78	51.51	51.30	51.39	49.58	52.28	52.40	52.05	47.95
TiO_2	0.60	0.45	0.22	0.28	0.17	0.38	0.20	0.29	1.07	1.22	0.48	0.66	0.60	0.69	0.71
Al_2O_3	2.02	1.27	0.96	1.01	1.34	1.5[illegible]	1.51	[illegible].18	2.91	3.06	1.40	2.64	3.08	3.10	1.47
FeO*	12.51	21.96	21.28	21.86	32.45	33.3	34.36	26.89	9.17	9.50	25.25	11.86	11.07	13.38	26.07
MnO	0.26	0.48	0.43	0.57	0.68	0.82	0.75	0.72	0.21	0.27	0.53	0.29	0.16	0.20	0.59
MgO	15.41	7.16	7.48	7.62	15.00	13.79	12.79	17.75	14.38	14.74	6.69	17.84	19.59	16.64	3.68
CaO	16.83	18.72	18.13	18.34	0.45	0.66	0.74	1.13	20.17	19.92	15.45	13.80	12.04	13.64	17.95
Na_2O	-	0.27	-	0.17	-	-	-	-	0.54	0.52	0.23	0.42	0.49	0.48	-
Total	99.64	100.44	98.72	99.89	100.86	100.66	100.13	99.47	99.75	100.62	99.61	99.79	99.43	100.18	98.42
					Structural Formula on the Basis of 6 Oxygen Atoms										
Si	1.948	1.967	1.993	1.973	1.969	1.962	1.968	1.977	1.915	1.903	1.973	1.934	1.928	1.930	1.963
Al^{IV}	0.052	0.033	0.007	0.027	0.031	0.038	0.032	0.023	0.085	0.097	0.027	0.066	0.072	0.070	0.037
Al^{VI}	0.037	0.026	0.038	0.020	0.030	0.032	0.038	0.030	0.043	0.037	0.039	0.049	0.061	0.065	0.034
Ti	0.017	0.013	0.007	0.008	0.005	0.011	0.006	0.008	0.030	0.034	0.014	0.018	0.017	0.019	0.022
Fe^{2+}	0.392	0.720	0.706	0.720	1.052	1.039	1.136	0.863	0.286	0.294	0.840	0.367	0.341	0.415	0.892
Mn	0.008	0.016	0.015	0.019	0.022	0.027	0.025	0.024	0.007	0.008	0.018	0.009	0.005	0.006	0.020
Mg	0.860	0.419	0.442	0.448	0.867	0.804	0.754	1.015	0.800	0.814	0.397	0.984	1.074	0.919	0.225
Ca	0.675	0.787	0.771	0.774	0.019	0.028	0.031	0.047	0.807	0.790	0.663	0.547	0.475	0.542	0.787
Na	-	0.021	-	0.013	-	-	-	-	0.039	0.037	0.018	0.030	0.035	0.034	-
Σ xy	1.99	2.00	1.98	2.00	2.00	1.99	1.99	1.99	2.01	2.01	1.99	2.00	2.01	2.00	1.98
atom %.															
Ca	35.0	40.9	40.2	39.9	1.00	1.4	1.6	2.4	42.6	41.6	34.8	28.8	25.1	28.9	41.3
Mg	44.7	21.7	23.0	23.0	44.7	41.9	39.2	52.8	42.3	42.9	20.9	51.9	56.9	49.0	11.8
Fe	20.3	37.4	36.8	37.1	54.3	56.7	59.2	44.8	15.1	15.5	44.3	19.3	18.0	22.1	46.9
100 Fe/Fe+Mg	31.2	63.3	61.5	61.7	54.8	57.5	60.2	45.9	26.3	26.5	67.9	27.1	24.0	31.1	79.9

KEY TO TABLE II.2b

1-16. Pyroxenes in high-Si tholeiitic andesite 28061 (Table 6.2, Anal. 1).

17-34. Pyroxenes in high-Si tholeiitic andesite 28062 (Table 6.2, Anal. 2).

35-39. Pyroxenes in high-Si tholeiitic andesite 28063 (Table 6.2, Anal. 3).

40-52. Pyroxenes in high-Si tholeiitic andesite 28065 (Table 6.2, Anal. 5).

53-67. Pyroxenes in icelandite 28067 (Table 6.2, Anal. 7).

68-77. Pyroxenes in icelandite 28070 (Table 6.2, Anal. 10).

78-87. Pyroxenes in icelandite 28071 (Table 6.2, Anal. 11).

88-100. Pyroxenes in icelandite 28072 (Table 6.2, Anal. 12).

101-106. Pyroxenes in rhyodacite 28073 (Table 6.2, Anal. 13).

107-111. Pyroxenes in rhyodacite 28074 (Table 6.2, Anal. 14).

* All Fe reported as FeO

Table II.2c

MICROPROBE ANALYSES OF PYROXENES FROM RHYOLITIC PITCHSTONES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	PC → PR		PC	PC → PR		PC	GM	GM	GM	GM	PC → PR		PC → PR	
SiO_2	48.21	48.18	48.65	52.08	50.03	50.48	54.15	54.28	52.35	54.92	48.57	48.75	48.43	48.33
TiO_2	-	0.13	0.13	0.34	0.24	0.39	0.35	0.44	0.76	0.45	0.25	0.15	0.38	0.18
Al_2O_3	0.68	0.74	0.73	0.80	0.97	1.29	3.05	2.35	2.56	1.84	0.78	0.84	1.24	0.81
FeO*	40.54	40.79	40.90	24.25	30.48	21.83	12.15	13.58	9.26	14.16	38.35	37.82	37.86	39.71
MnO	0.84	0.80	0.75	0.44	0.49	0.40	0.18	0.29	0.16	0.26	0.80	0.68	0.79	0.75
MgO	8.33	8.11	8.78	17.95	12.86	9.16	25.78	24.59	16.55	26.78	9.98	10.25	10.04	8.85
CaO	0.92	0.90	0.94	4.07	4.27	16.60	4.19	4.82	18.10	2.68	1.07	1.06	1.20	1.13
Na_2O	-	-	-	0.16	-	0.20	-	-	0.41	-	-	-	-	-
Total	99.51	99.66	100.88	100.08	99.33	100.35	99.85	100.33	100.14	101.09	99.80	99.54	99.93	99.75

Structural Formula on the Basis of 6 Oxygen Atoms

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Si	1.986	1.984	1.976	1.978	1.978	1.966	1.940	1.953	1.931	1.954	1.973	1.979	1.961	1.978
Al^{IV}	0.014	0.016	0.024	0.022	0.022	0.034	0.060	0.047	0.069	0.046	0.027	0.021	0.039	0.022
Al^{VI}	0.019	0.020	0.011	0.014	0.023	0.025	0.069	0.053	0.042	0.031	0.010	0.019	0.020	0.017
Ti	-	0.004	0.004	0.010	0.007	0.011	0.009	0.012	0.021	0.012	0.008	0.005	0.012	0.006
Fe^{2+}	1.397	1.405	1.389	0.770	1.008	0.711	0.364	0.409	0.286	0.421	1.303	1.284	1.282	1.359
Mn	0.029	0.028	0.026	0.014	0.016	0.013	0.005	0.009	0.005	0.008	0.028	0.023	0.027	0.026
Mg	0.511	0.498	0.532	1.016	0.758	0.532	1.377	1.318	0.910	1.420	0.604	0.620	0.606	0.540
Ca	0.041	0.040	0.041	0.166	0.181	0.693	0.161	0.186	0.715	0.102	0.047	0.046	0.052	0.050
Na	-	-	-	0.012	-	0.015	-	-	0.029	-	-	-	-	-
Σ xy	2.00	2.00	2.00	2.00	1.99	2.00	1.99	1.99	2.01	1.99	2.00	2.00	2.00	2.00
atom %.														
Ca	2.1	2.1	2.1	8.5	9.3	35.8	8.5	9.7	37.4	5.3	2.4	2.4	2.7	2.5
Mg	26.2	25.6	27.1	52.0	38.9	27.5	72.4	68.9	47.6	73.0	30.9	31.8	31.2	27.7
Fe	71.7	72.3	70.8	39.5	51.8	36.7	19.1	21.4	15.0	21.7	66.7	65.8	66.1	69.8
100 Fe/Fe+Mg	73.2	73.9	72.3	43.2	57.1	57.2	20.9	23.7	24.0	22.9	68.3	67.4	67.9	71.6

KEY TO TABLE II.2c

1-10 Pyroxenes in rhyolitic pitchstone 28075 (Table 6.3, Anal.1).

11-14 Ferrohypersthenes in rhyolitic pitchstone 28076 (Table 6.3, Anal. 2).

* All Fe reported as FeO.

Table II.3a

MICROPROBE ANALYSES OF FELDSPARS IN MEMBERS OF THE LOW-Si SERIES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	PC →			PR	GM	GM	GM	GM	GM	PC →		PR	GM	GM	GM
SiO_2	51.42	51.23	51.35	51.86	54.60	52.69	52.34	53.99	54.55	54.39	54.12	55.58	55.52	53.10	54.55
Al_2O_3	31.12	30.95	30.53	30.37	28.43	29.50	29.14	28.31	28.04	28.98	28.62	27.24	27.72	28.78	27.22
Fe_2O_3*	0.48	0.44	0.21	0.41	0.67	0.46	0.48	0.79	0.52	0.42	0.51	0.63	0.44	0.59	1.06
CaO	13.51	13.32	13.33	12.69	10.48	11.70	11.74	10.35	9.89	10.63	10.31	8.95	9.43	10.92	9.19
Na_2O	3.80	3.74	3.75	4.16	5.65	4.61	4.60	5.38	5.69	5.27	5.47	6.11	5.84	4.97	5.87
K_2O	0.27	0.24	0.21	0.34	0.48	0.31	0.35	0.57	0.53	0.51	0.60	0.66	0.58	0.52	0.70
Total	100.60	99.92	99.38	99.83	100.31	99.27	98.65	99.39	99.22	100.20	99.63	99.17	99.53	98.88	98.59
Σ (Ab+An+Or)	100.8	99.1	99.0	100.2	102.6	98.8	99.2	100.2	100.3	100.3	100.9	100.0	99.6	99.4	99.4
Ab	31.9	31.9	32.0	35.1	46.6	39.5	39.2	45.4	48.0	44.7	45.9	51.7	49.6	42.4	50.0
An	1.6	1.4	1.2	2.0	2.7	1.8	2.1	3.4	3.0	3.0	3.5	3.9	3.4	3.1	4.1
Or	66.5	66.7	66.8	62.9	50.7	58.7	58.7	51.2	49.0	52.9	50.6	44.4	47.0	54.5	45.9

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	GM	GM	GM	GM	GM	GM	GM	PC →			PR	GM	GM	GM	GM
SiO_2	55.90	55.01	56.44	54.52	55.87	54.5	54.49	53.76	54.00	55.81	55.92	59.03	57.48	55.47	56.72
Al_2O_3	26.42	27.97	26.44	28.17	27.38	27.7	28.42	28.76	28.24	27.37	27.59	25.34	26.45	27.41	26.77
Fe_2O_3*	0.89	0.76	0.86	0.60	0.84	0.9	0.82	0.64	0.68	0.73	0.73	0.56	0.81	0.74	0.84
CaO	8.29	9.87	8.59	10.62	9.42	10.0	10.51	10.80	10.67	9.31	9.52	6.56	8.00	9.32	8.42
Na_2O	6.64	5.70	6.31	5.24	5.91	5.4	5.22	5.21	5.39	6.10	5.92	7.40	6.57	6.06	6.49
K_2O	0.88	0.74	1.02	0.69	0.84	0.7	0.73	0.50	0.45	0.68	0.63	1.08	0.87	0.63	0.78
Total	99.02	100.05	99.66	99.84	100.26	99.5	100.19	99.67	99.43	100.00	100.31	99.97	100.18	99.63	100.02
Σ (Ab+An+Or)	101.6	101.6	102.0	101.1	101.7	100.6	100.6	100.7	101.2	101.8	101.0	101.5	100.4	101.2	101.3
Ab	55.3	47.5	52.4	43.8	49.2	46.2	41.9	43.8	45.0	50.7	49.6	61.7	55.4	50.7	54.2
An	4.2	4.3	5.9	4.1	4.9	4.3	4.3	3.0	2.7	3.9	3.7	6.3	5.1	3.7	4.5
Or	40.5	48.2	41.7	52.1	45.9	49.5	51.8	53.2	52.3	45.4	46.7	32.0	39.5	45.6	41.3

	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
	GM	GM	GM	PC →			PR	GM	GM	GM	GM	PC →		PR	GM
SiO_2	59.10	58.44	64.34	54.25	52.60	52.63	56.79	57.75	57.92	57.54	56.65	56.40	56.46	55.35	56.12
Al_2O_3	24.98	25.89	19.79	28.25	29.51	29.21	26.26	25.65	25.72	25.34	26.59	27.55	27.34	27.81	27.12
Fe_2O_3*	0.58	0.53	0.57	0.34	0.48	0.43	0.68	0.98	0.83	1.18	0.83	0.22	0.22	0.63	0.69
CaO	6.39	6.96	0.78	10.15	11.66	11.61	8.19	7.52	7.69	7.34	8.37	8.78	8.89	9.48	8.48
Na_2O	7.13	7.08	6.86	5.71	4.82	4.7	6.72	6.82	6.96	6.74	6.57	6.19	6.21	5.81	6.44
K_2O	1.58	1.07	6.29	0.43	0.34	0.4	0.83	0.98	0.88	1.11	0.79	0.71	0.68	0.72	0.88
Total	99.76	99.97	99.13	99.13	99.41	99.04	99.47	99.70	100.00	99.25	99.80	99.85	99.80	99.80	100.11
Σ ≠(Ab+An+Or)	101.3	100.7	99.1	101.2	100.6	100.3	102.4	100.8	102.2	100.0	101.8	100.2	100.6	100.5	101.8
Ab	59.5	59.4	58.5	47.7	40.6	40.2	55.6	57.2	57.6	57.0	55.6	52.3	52.2	48.9	53.5
An	9.2	6.3	37.6	2.5	2.0	2.4	4.8	5.8	5.1	6.6	4.7	4.2	4.0	4.3	5.1
Or	31.3	34.3	3.9	49.8	57.4	57.4	39.6	37.0	37.3	36.4	41.5	43.5	43.8	46.8	41.4

KEY TO ANALYSES IN TABLE II.3a

1-9. Feldspars in low-Si tholeiitic andesite 28048 (Table 6.1, Anal. 3).
10-16. Feldspars in low-Si tholeiitic andesite 28049 (Table 6.1, Anal. 4).
17-22. Feldspars in low-Si tholeiitic andesite 28050 (Table 6.1, Anal. 5).
23-33. Feldspars in low-Si tholeiitic andesite 28051 (Table 6.1, Anal. 6).
34-41. Feldspars in low-Si tholeiitic andesite 28055 (Table 6.1, Anal. 9).
42-45. Feldspars in low-Si tholeiitic andesite 27291 (Table 6.1, Anal. 15).
* All Fe reported as Fe_2O_3.
≠ Ab+An+Or:- equivalent total Ab+An+Or (wt %) calculated from CaO, Na_2O and K_2O values.
Ab,An,Or in wt %.

Table II.3b

MICROPROBE ANALYSES OF FELDSPARS IN MEMBERS OF THE HIGH-Si SERIES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	PC →		→ PR	PC →		→ PR	GM	GM	GM	GM	PC →	→ PR	PC	GM	GM	GM
SiO_2	53.60	54.24	55.10	57.56	58.40	54.53	56.8[illegible]	54.81	56.00	58.60	53.77	53.62	54.54	55.47	54.09	53.12
Al_2O_3	28.39	28.60	28.02	26.63	26.13	28.44	26.7[illegible]	28.10	27.33	25.59	29.43	29.28	28.18	27.85	28.99	28.80
Fe_2O_3*	0.48	0.43	0.58	0.47	0.44	0.62	0.4[illegible]	0.62	0.44	0.78	0.40	0.48	0.24	0.54	0.48	1.09
CaO	10.81	10.86	10.07	8.25	7.95	10.58	8.5[illegible]	10.08	9.21	7.04	11.24	11.16	10.34	9.81	11.15	11.41
Na_2O	5.13	5.33	5.60	6.72	6.86	5.23	6.3[illegible]	5.60	6.10	7.04	5.03	4.99	5.51	5.86	5.05	4.56
K_2O	0.34	0.40	0.61	0.61	0.78	0.54	0.73	0.58	0.71	1.10	0.43	0.37	0.53	0.57	0.52	0.55
Total	98.75	99.86	99.98	100.24	100.56	99.94	99.7[illegible]	99.79	99.79	100.15	100.30	99.90	99.34	100.10	100.27	99.53
Σ(Ab+An+Or)	99.0	101.4	101.0	101.4	102.0	100.0	100.7	100.8	101.6	101.0	100.9	99.8	101.0	101.7	101.1	98.5
Ab	43.9	44.5	46.9	56.1	56.9	44.3	53.5	47.0	50.9	59.0	42.2	42.3	46.1	48.8	42.2	39.2
An	2.0	2.4	3.6	3.6	4.5	3.2	4.6	3.4	4.1	6.4	2.5	2.2	3.1	3.3	3.1	3.3
Or	54.1	53.1	49.5	40.3	38.6	52.5	41.9	49.6	45.0	34.6	55.3	55.5	50.8	47.9	54.7	57.5

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	GM	GM	GM	PC →	→ PR	GM	GM	GM	GM	PC →		→ PR	PC →	→ PR	GM
SiO_2	52.99	53.18	54.67	58.17	57.44	56.23	56.49	56.42	57.60	52.11	51.59	53.15	63.39	63.62	53.98
Al_2O_3	29.36	29.02	27.83	27.10	26.37	26.82	29.91	27.20	25.77	30.79	30.80	29.28	22.17	21.95	28.90
Fe_2O_3*	0.57	0.53	0.79	0.44	0.61	0.52	0.56	0.70	0.86	0.28	0.36	0.43	0.44	0.69	0.74
CaO	11.45	11.45	10.01	8.18	7.90	8.63	8.79	8.72	7.61	12.99	13.02	11.69	2.82	3.65	11.05
Na_2O	4.78	4.75	5.57	6.63	6.76	6.41	6.46	6.31	6.87	4.15	3.94	4.64	8.14	8.41	5.18
K_2O	0.50	0.48	0.57	0.62	0.74	0.65	0.63	0.69	0.87	0.28	0.31	0.34	3.17	1.91	0.54
Total	99.65	99.41	99.44	101.14	99.82	99.[illegible]6	99.84	100.04	99.56	100.60	100.02	99.53	100.13	100.23	100.39
Σ(Ab+An+Or)	100.2	99.8	100.2	100.4	100.8	99.6	101.7	100.8	101.0	100.6	99.0	98.7	101.6	100.6	101.2
Ab	40.3	40.3	47.0	55.9	56.7	53.[illegible]	53.6	5[illegible].0	57.5	34.9	33.6	39.8	67.8	70.8	43.3
An	3.0	2.8	3.4	3.7	4.4	3.8	3.6	[illegible].1	5.1	1.7	1.8	2.0	18.4	11.2	3.2
Or	56.7	56.9	49.6	40.4	38.9	42.[illegible]	42.8	4[illegible].9	37.4	63.4	64.6	58.2	13.8	18.0	53.5

	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
	GM	GM	GM	GM	GM	PC →			→ PR	PC →		→ PR	GM	GM	GM
SiO_2	57.67	53.20	55.22	52.84	59.78	59.[illegible]1	59.46	54.78	56.11	57.25	58.37	58.88	56.14	56.58	59.08
Al_2O_3	26.12	29.15	27.51	30.32	24.97	24.[illegible]9	25.04	27.89	26.98	26.27	25.42	25.29	26.72	26.63	24.87
Fe_2O_3*	0.78	0.59	0.77	0.40	0.71	0.[illegible]0	0.23	-	-	0.33	0.44	0.34	0.67	0.53	0.63
CaO	8.11	11.49	9.65	12.25	6.21	5.37	6.10	9.43	8.66	7.83	6.88	6.54	8.50	8.23	6.13
Na_2O	6.71	4.94	5.83	4.41	7.46	7.[illegible]8	7.67	5.00	6.38	6.82	7.34	7.57	6.41	6.77	7.90
K_2O	0.82	0.47	0.66	0.31	1.13	1.[illegible]7	1.18	0.63	0.76	0.72	0.92	1.08	0.76	0.80	1.03
Total	100.21	99.84	99.64	100.53	100.26	99.33	99.67	98.73	98.89	99.23	99.37	99.70	99.20	99.54	99.75
Σ(Ab+An+Or)	101.4	101.4	100.6	99.9	100.6	102.[illegible]	102.2	101.3	101.5	100.3	101.6	102.8	100.9	102.8	103.3
Ab	56.0	41.4	49.0	37.3	62.7	64.3	63.5	50.1	53.2	57.5	61.1	62.3	53.7	55.7	64.7
An	4.7	2.8	3.9	1.8	6.7	7.3	6.8	3.7	4.4	4.3	5.3	6.2	4.5	4.6	5.9
Or	39.3	55.8	47.1	60.9	30.6	28.[illegible]	29.7	46.2	42.4	38.2	33.6	31.5	41.8	39.7	29.4

Table II.3b (Continued)

MICROPROBE ANALYSES OF FELDSPARS IN MEMBERS OF THE HIGH-Si SERIES

	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
	PC ⟶		PR	GM	GM	GM	GM	GM	PC ⟶		PR	PC ⟶		PR	GM	GM
SiO_2	52.57	52.87	57.05	56.02	53.99	53.79	60.64	54.70	60.66	60.90	60.98	65.92	66.48	66.12	55.79	53.42
Al_2O_3	30.04	29.65	26.56	27.40	28.76	29.07	24.49	28.30	24.64	24.37	24.22	19.95	19.97	20.09	27.16	29.08
Fe_2O_3*	0.33	0.30	0.96	0.67	0.86	0.64	0.56	0.91	0.21	-	0.24	0.13	-	-	0.59	0.64
CaO	12.33	11.97	8.56	9.26	11.06	11.30	5.63	10.30	5.63	5.32	5.46	1.02	1.04	0.93	9.19	11.15
Na_2O	4.48	4.50	6.38	6.27	5.14	4.84	7.71	5.59	7.45	7.59	7.46	6.66	7.07	7.09	5.96	4.85
K_2O	0.22	0.29	0.73	0.57	0.50	0.39	1.19	0.53	1.68	1.65	1.70	6.41	5.80	5.86	0.65	0.55
Total	99.97	99.58	100.24	100.19	100.31	100.03	100.22	100.33	100.28	99.84	100.06	100.09	100.35	100.11	99.34	99.69
Σ(≡Ab+An+Or)	100.4	99.2	100.8	102.4	101.4	99.4	100.1	101.5	100.8	100.4	100.2	99.4	99.3	99.2	99.8	99.6
Ab	37.7	38.4	53.6	51.9	42.9	41.3	65.1	46.6	62.5	63.9	63.0	56.7	60.2	60.5	50.5	41.2
An	1.3	1.7	4.3	3.3	3.0	2.3	7.0	3.1	9.8	9.8	10.0	38.2	34.6	34.9	3.8	3.3
Or	61.0	59.9	42.1	44.8	54.1	56.4	27.9	50.3	27.7	26.3	27.0	5.1	5.2	4.6	45.7	55.5

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
	GM	PC ⟶		PR	GM	GM	GM	PC ⟶	PR	PC ⟶		PR	PC ⟶		PR	GM
SiO_2	58.54	52.73	52.80	52.75	53.01	53.69	54.14	60.89	55.69	61.44	61.56	61.32	59.44	59.94	59.21	59.66
Al_2O_3	24.51	29.65	29.73	30.56	29.25	28.99	29.32	23.92	27.79	22.42	22.97	23.38	25.20	24.22	24.74	25.31
Fe_2O_3*	0.73	0.38	0.32	0.46	0.87	0.83	0.72	0.26	0.62	0.79	0.18	-	0.18	0.28	0.31	0.47
CaO	6.66	11.79	11.85	12.40	11.31	11.11	11.03	5.13	9.64	3.76	4.07	4.43	6.43	5.69	6.32	6.53
Na_2O	7.29	4.56	4.77	4.43	4.94	5.07	5.06	7.74	5.78	7.92	7.98	7.88	7.58	7.68	7.39	7.51
K_2O	0.82	0.28	0.40	0.38	0.56	0.51	0.52	1.70	0.73	2.49	2.25	2.14	1.11	1.24	1.22	0.99
Total	98.56	99.39	99.87	100.98	99.94	100.20	100.79	99.64	100.25	98.82	99.01	99.15	99.94	99.05	99.19	100.47
Σ(≡Ab+An+Or)	99.8	98.8	101.6	101.2	101.2	101.0	100.6	100.9	101.0	100.4	101.0	101.3	102.6	100.5	101.1	101.8
Ab	61.8	39.1	39.7	37.0	41.3	42.5	42.5	64.9	48.4	66.8	66.8	65.9	62.5	64.7	61.8	62.4
An	4.8	1.7	2.4	2.2	3.3	3.0	3.1	9.9	4.3	14.6	13.2	12.4	6.4	7.3	7.1	5.8
Or	33.4	59.2	57.9	60.8	55.4	54.5	54.4	25.2	47.3	18.6	20.0	21.7	31.1	28.0	31.1	31.8

	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
	GM	GM	PC ⟶		PR	GM	GM	GM	PC ⟶	PR	PC ⟶	PR	GM	GM	GM
SiO_2	63.76	54.60	58.70	58.65	58.41	63.00	58.36	60.18	58.19	58.50	62.70	63.06	61.41	55.16	63.88
Al_2O_3	21.33	27.99	26.48	26.15	24.97	21.80	25.90	25.03	25.66	25.42	22.50	21.79	23.01	27.54	21.65
Fe_2O_3*	0.21	0.49	0.14	0.24	0.21	0.24	0.18	-	0.20	0.29	-	0.14	0.47	0.38	0.34
CaO	2.57	9.99	7.94	7.62	6.86	2.87	7.41	6.04	7.11	6.92	3.18	2.51	4.19	9.30	2.43
Na_2O	7.62	5.55	6.85	6.85	6.93	7.59	6.64	7.45	7.17	7.33	7.91	8.00	7.99	5.97	8.40
K_2O	3.95	0.52	0.86	0.89	1.04	3.68	1.00	1.46	0.94	0.87	3.07	3.68	2.00	0.54	3.08
Total	99.44	99.14	100.97	100.40	98.42	99.18	99.49	100.16	99.27	99.34	99.34	99.19	99.06	99.91	99.78
Σ(≡Ab+An+Or)	100.5	99.7	102.5	101.1	98.7	100.2	98.9	101.6	101.6	101.4	100.7	101.9	100.2	99.8	101.4
Ab	64.2	47.1	56.6	57.4	59.4	64.2	56.8	62.0	59.7	61.2	66.4	66.4	67.5	50.6	70.1
An	23.2	3.1	5.0	5.2	6.2	21.6	6.0	8.5	5.5	5.0	17.9	21.3	11.8	3.2	18.0
Or	12.6	49.8	38.4	37.4	34.4	14.2	37.2	29.5	34.8	33.8	15.7	12.3	20.7	46.2	11.9

KEY TO TABLE II.3b

1-10. Feldspars in high-Si tholeiitic andesite 28061 (Table 6.2, Anal. 1).

11-19. Feldspars in high-Si tholeiitic andesite 28062 (Table 6.2, Anal. 2).

20-25. Feldspars in high-Si tholeiitic andesite 28063 (Table 6.2, Anal. 3).

26-36. Feldspars in high-Si tholeiitic andesite 28065 (Table 6.2, Anal. 5).

37-46. Feldspars in icelandite 28067 (Table 6.2, Anal. 7).

47-54. Feldspars in icelandite 28070 (Table 6.2, Anal. 11).

55-69. Feldspars in icelandite 28071 (Table 6.2, Anal. 11).

70-80. Feldspars in icelandite 28072 (Table 6.2, Anal. 12).

81-86. Feldspars in rhyodacite 28073 (Table 6.2, Anal. 13).

87-93. Feldspars in rhyodacite 28074 (Table 6.2, Anal. 14).

* All Fe reported as Fe_2O_3

Σ ≡ Ab+An+Or:- equivalent total Ab+An+Or (wt %) calculated from CaO, Na_2O and K_2O values.

Ab,An,Or in wt %.

Table 11.3c

MICROPROBE ANALYSES OF FELDSPARS FROM RHYOLITIC PITCHSTONES AND MICROCRYSTALLINE RHYOLITES

	1	2	3	4	5	6	7	8	9	10	11	12	13
	PC →	→ PR	PC	PC →	→ PR	GM	GM	GM	PC →		→ PR	MP	MP
SiO_2	62.20	62.42	60.64	64.96	64.66	55.34	55.02	56.30	61.55	61.96	61.41	60.89	59.99
TiO_2	24.27	23.72	24.97	19.41	19.54	27.50	28.33	27.60	24.21	23.49	23.68	23.96	24.80
Fe_2O_3*	0.13	-	0.24	-	-	0.48	0.4[illegible]	0.38	-	0.17	-	-	-
CaO	4.95	4.57	6.05	0.31	0.36	9.96	10.3[illegible]	9.36	5.14	4.51	4.63	4.93	5.96
Na_2O	8.06	8.13	7.52	3.60	4.03	5.36	5.37	5.81	7.72	8.05	8.11	7.73	7.58
K_2O	1.53	1.60	1.37	11.29	10.51	0.74	0.54	0.70	1.63	1.77	1.71	1.83	1.32
Total	101.13	100.44	100.77	99.57	99.10	99.33	99.94	100.11	100.25	99.92	99.54	99.34	99.65
Σ (≡ Ab+An+Or)	101.8	101.0	101.7	98.7	98.0	99.2	99.7	99.7	100.8	101.0	101.7	100.7	101.5
Ab	67.0	68.1	62.5	30.9	34.8	45.8	45.5	49.4	64.8	67.4	67.5	65.0	63.1
An	24.2	22.5	29.5	1.5	1.8	49.8	51.3	46.5	25.3	22.2	22.6	24.3	29.2
Or	8.8	9.4	8.0	67.6	63.4	4.4	3.2	4.1	9.9	10.4	9.9	10.7	7.7

	14	15	16	17	18	19	20	21	22	23	24	25	26
	PC →		→ PR	PC →	→ PR	PC →		→ PR	PC	PC →	→ PR	PC →	→
SiO_2	65.21	65.32	65.22	65.44	66.16	61.36	60.05	61.78	61.41	65.19	66.00	65.43	65.63
TiO_2	19.51	19.76	19.83	19.57	20.09	24.13	24.81	23.55	24.17	19.50	19.80	19.69	19.43
Fe_2O_3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CaO	0.38	0.37	0.43	0.43	0.65	5.14	5.78	4.80	4.92	0.34	0.50	0.38	0.30
Na_2O	3.63	3.80	3.77	3.69	5.74	7.81	7.74	8.03	8.04	3.34	5.22	3.56	3.48
K_2O	11.20	10.92	11.06	11.22	8.14	1.72	1.34	1.78	1.61	11.53	9.06	11.29	11.45
Total	99.93	100.17	100.31	100.35	100.78	100.16	99.72	99.94	100.15	99.20	100.58	100.35	100.29
Σ (≡ Ab+An+Or)	98.8	98.5	99.4	99.6	99.9	101.8	102.1	102.2	101.9	98.1	100.2	98.7	98.6
Ab	31.1	32.7	32.1	31.3	48.7	64.9	64.2	66.4	66.7	28.9	44.1	30.5	29.8
An	1.9	1.8	2.1	2.1	3.2	25.1	28.1	23.3	24.0	1.7	2.5	1.9	1.5
Or	67.0	65.8	65.8	56.6	48.1	10.0	7.7	10.3	9.3	69.4	53.4	67.6	68.7

Table II.3c (Continued)

MICROPROBE ANALYSES OF FELDSPARS FROM RHYOLITIC PITCHSTONES AND MICROCRYSTALLINE RHYOLITES

	27	28	29	30	31	32	33	34	35	36	37	38	39
	PR	GM	PC ⟶		PR	PC	PC ⟶	PR	PC	PC ⟶	PR	PC	PC
SiO_2	66.17	62.08	61.40	61.22	61.29	62.01	65.58	65.45	65.53	61.82	61.61	61.32	64.88
TiO_2	19.79	23.75	24.06	23.90	23.83	23.59	19.50	19.55	19.60	24.17	24.01	23.91	19.49
Fe_2O_3*	-	-	0.16	-	-	0.20	-	-	-	-	-	0.14	-
CaO	0.56	4.70	5.08	5.12	4.92	4.62	0.31	0.37	0.38	5.15	5.03	5.19	0.34
Na_2O	5.17	7.93	7.95	7.81	7.95	8.10	3.71	4.09	3.58	7.66	7.16	7.59	3.94
K_2O	9.16	2.00	1.59	1.71	1.67	1.84	11.33	10.64	11.29	1.65	1.71	1.70	10.83
Total	100.85	100.46	100.22	99.76	99.66	100.34	10.43	100.10	100.38	100.45	99.94	99.84	99.48
Σ Ab+Or+An	100.6	102.2	101.9	101.4	101.6	102.3	99.9	99.3	98.9	100.1	99.4	99.9	99.0
Ab	43.4	65.7	66.0	65.1	66.[illegible]	67.0	31.4	34.8	30.6	64.7	64.7	64.3	33.7
An	2.8	22.8	24.8	25.0	24.[illegible]	22.4	1.5	1.9	1.9	25.5	25.1	25.7	1.7
Or	53.8	11.5	9.2	9.9	9.[illegible]	10.6	67.1	63.3	67.5	9.8	10.2	10.0	64.6

	40	41	42	43	44	45	46	47	48	49	50	51
	PR	PC	GM	GM	PC	PC ⟶	PR	PC ⟶		PR	PC	PC
SiO_2	65.22	65.40	60.83	65.43	62.[illegible]7	62.30	62.37	65.38	65.80	66.00	65.72	65.76
TiO_2	19.42	19.59	24.33	19.25	23.60	23.96	23.53	19.60	19.78	19.48	19.82	19.58
Fe_2O_3*	-	-	0.19	0.23	-	-	-	-	-	-	-	-
CaO	0.41	0.28	5.29	0.46	4.40	4.81	4.60	0.26	0.40	0.34	0.33	0.33
Na_2O	3.87	3.86	7.80	5.01	8.10	7.95	8.26	3.98	4.38	4.74	4.16	4.44
K_2O	10.80	11.20	1.42	9.33	1.[illegible]2	1.59	1.74	10.70	10.12	9.51	10.40	10.01
Total	99.72	100.33	99.84	99.69	100.[illegible]9	100.61	100.50	99.92	100.48	100.07	100.33	100.12
Σ Ab+Or+An	98.5	100.3	100.6	99.3	101.4	100.6	103.0	98.2	98.9	98.0	98.3	98.4
Ab	33.2	32.6	65.6	42.5	68.4	66.9	67.9	34.3	37.5	41.0	35.8	38.2
An	2.1	1.4	26.1	2.3	21.5	23.8	22.1	1.3	2.0	1.7	1.6	1.6
Or	64.7	66.0	8.3	55.2	10.[illegible]	9.3	10.0	64.4	60.5	57.3	62.6	60.2

KEY TO ANALYSES IN TABLE II.3c

1-8. Feldspars in rhyolitic pitchstone 28075 (Table 6.3, Anal. 1).

9-18. Feldspars in rhyolitic pitchstone 28076 (Table 6.3, Anal. 2).

19-28. Feldspars in rhyolitic pitchstone 28078 (Table 6.3, Anal. 4).

29-35. Feldspars in rhyolitic pitchstone 28079 (Table 6.3, Anal. 5).

36-43. Feldspars in microcrystalline rhyolite 28084 (Table 6.3, Anal. 10).

44-51. Feldspars in microcrystalline rhyolite 28088 (Table 6.3, Anal. 14).

* All Fe reported as Fe_2O_3.

Σ Ab+An+Or:- equivalent total Ab+An+Or (wt %) calculated from CaO, Na_2O and K_2O values.

Ab,An,Or in wt %.

APPENDIX III

PETROGRAPHIC AND CHEMICAL DATA ON THE ALKALINE ROCKS

Alkaline rocks, predominantly hawaiites with minor alkali olivine basalts and basanites comprise most of the Kyogle Basalt and, in addition, occur sporadically throughout the volcanic pile as occasional flows, dykes and plugs. Rarer alkaline rocks include benmoreites, which are restricted in occurrence to boulders within the Homeleigh Agglomerate, and a plug of alkali rhyolite (comendite). The latter is an elongated body (0.6 km x 0.2 km) dipping steeply to the west which forms Lillian Rock, some 6 km north-north-west of Nimbin (179419).

It is not proposed to discuss these rocks in any detail but instead to give a brief summary of their petrography and list a number of chemical analyses in order to illustrate the essential petrographic and chemical differences between these rocks and the tholeiitic volcanics.

1) PETROGRAPHY

Alkali Olivine Basalts and Basanites: Alkali olivine basalts contain phenocrysts of olivine (~1 mm; Fo_{83}-Fo_{75}) in a groundmass of titanaugite, plagioclase laths (An_{60}-An_{55}) and titanomagnetite with minor alkali feldspar, nepheline, analcime and a pale green mineraloid. Modal analcime is significantly more abundant in the basanites. The texture varies from intergranular (in finer grained variants) to subophitic. Groundmass plagioclase is commonly quite turbid and altered to analcime along fractures in contrast to its fresh glassy appearance in the tholeiitic rocks.

Hawaiites: The hawaiites are petrographically similar to the alkali olivine basalts in most respects although their more evolved nature is reflected in an increase in the modal abundance of plagioclase and titanomagnetite at the expense of olivine and clinopyroxene. Olivine phenocrysts are smaller (up to 0.5 mm) and more Fe-rich (Fo_{70}-Fo_{65}) than in the alkali olivine basalts. Plagioclase (An_{50}-An_{45}) and rarely titan-augite may also occur as phenocrysts in the hawaiites.

Occasional flows of hawaiite contains megacrysts of aluminian augite and less commonly aluminian bronzite (up to 10 mm; rarely larger) indicative of a moderately high pressure origin (e.g. 28093,28094; Table III.1, Analyses 5 and 6; see also Wilkinson and Binns, 1969).

Benmoreites: Benmoreites are composed essentially of laths of sodic plagioclase (An_{30}-An_{25}; up to 0.5 mm) zoned to alkali feldspar, with minor interstitial titanomagnetite and pale grey-green clinopyroxene (? ferrosalite). Small amounts of acmite and interstitial quartz may be present.

Alkali Rhyolite (Comendite): The comendite comprising Lillian Rock contains abundant alkali feldspar and occasional quartz phenocrysts up to 2 mm in diameter in a granular groundmass of quartz, kaolinized alkali feldspar, acmite and arfvedsonite.

2) CHEMICAL ANALYSES

Major and trace element data on the alkaline rocks together with C.I.P.W. norms are listed in Table III.1. Apart from the quartz-bearing benmoreites (Nos. 11 and 12) and comendite (No. 13), the rocks constitute a mildly undersaturated suite; almost all analysed representatives (Nos. 1-8) are ne normative in contradistinction to the predominantly qz normative tholeiitic suite. Minor hy in the norm of the other rocks of the alkaline suite (Nos. 9 and 10) may be attributed to their degree of oxidation (Fe_2O_3 = 5.43 and 7.57% respectively).

Table III.1

ANALYSES OF ALKALINE ROCKS

	1	2	3	4	5	6	7	8	9	10	11	12	13
	28089	28090	28091	28092	28093	28094	28095	28096	28097	28098	28099	28100	28054
SiO_2	45.60	44.52	46.77	46.31	47.51	46.42	47.20	47.50	47.93	48.06	58.35	58.70	nd
TiO_2	2.30	1.95	1.89	2.09	2.38	2.37	3.18	2.31	2.09	2.21	1.42	1.14	0.05
Al_2O_3	14.19	15.09	14.70	13.50	15.79	14.34	15.66	16.34	15.58	16.93	18.19	18.29	12.59
Fe_2O_3	2.64	1.53	1.79	2.72	3.41	4.83	2.78	6.16	5.43	7.57	3.11	3.38	1.70
FeO	9.55	11.04	9.74	8.82	8.04	7.70	10.36	7.78	8.29	5.46	1.31	1.37	0.92
MnO	0.15	0.15	0.14	0.14	0.13	0.15	0.14	0.14	0.14	0.14	0.05	0.10	0.03
MgO	9.27	8.75	9.00	10.19	6.42	9.74	5.30	4.10	4.79	4.83	0.50	0.52	0.01
CaO	9.79	9.23	8.90	9.17	8.09	8.68	7.80	6.87	7.62	7.95	4.02	4.09	0.10
Na_2O	3.03	3.77	3.66	3.07	3.80	3.10	4.10	4.64	3.91	4.06	5.80	5.73	4.26
K_2O	0.99	0.76	1.51	1.23	2.13	1.32	1.50	1.48	1.63	1.49	4.18	4.02	5.00
H_2O^+	1.59	2.34	1.01	1.46	0.80	0.76	1.44	1.08	1.15	0.44	0.72	0.43	0.18
H_2O^-	0.68	0.41	0.23	0.55	0.50	0.26	0.57	0.66	0.78	0.92	0.98	1.24	0.52
P_2O_5	0.57	0.77	0.80	0.37	0.66	0.39	0.64	0.66	0.42	0.35	0.73	0.70	nd
Total	100.35	100.31	100.14	99.62	99.66	100.06	100.67	99.72	99.76	100.41	99.36	99.71	-
C.I.P.W. Norms													
Qz	-	-	-	-	-	-	-	-	-	-	2.17	3.15	-
Or	5.85	4.49	8.92	7.27	12.59	7.80	8.86	8.74	9.63	8.81	24.70	23.76	-
Ab	20.53	18.64	20.55	20.85	25.29	24.42	29.58	36.56	33.08	34.35	49.08	48.48	-
An	22.20	22.01	19.23	19.43	19.75	21.32	19.91	19.40	20.16	23.58	11.26	12.32	-
Ne	2.77	7.18	5.64	2.78	3.72	0.98	2.77	1.46	-	-	-	-	-
Di	18.34	15.35	16.03	19.06	13.02	15.30	12.04	8.42	12.15	10.60	2.69	2.64	-
Hy	-	-	-	-	-	-	-	-	0.47	1.60	-	0.07	-
Ol	18.87	22.17	20.49	19.46	13.01	16.81	13.95	8.54	9.52	4.13	-	-	-
Mt	3.83	2.22	2.60	3.94	4.94	7.00	4.03	8.93	7.87	10.98	0.27	1.44	-
Hm	-	-	-	-	-	-	-	-	-	-	2.92	2.39	-
Il	4.37	3.70	3.59	3.97	4.52	4.50	6.04	4.39	3.97	4.20	2.70	2.17	-
Ap	1.32	1.70	1.85	0.86	1.53	0.90	1.48	1.53	0.97	0.81	1.69	1.62	-
Resc	2.27	2.75	1.24	2.01	1.30	1.02	2.01	1.74	1.93	1.36	1.70	1.67	-
Total	100.35	100.30	100.14	99.63	99.67	100.05	100.67	99.71	99.75	100.42	99.37	99.71	-
100 an / ab+an	52.0	54.1	48.3	48.2	43.9	46.6	40.2	34.7	37.9	40.7	18.7	20.3	
Trace Elements (ppm)													
V	178	169	176	176	146	102	159	140	166	164	nd	8	nd
Ni	187	175	192	171	122	190	56	37	68	49	nd	9	nd
Co	50	50	47	47	40	51	43	66	45	42	nd	8	nd
Rb	12	8	33	26	45	22	28	29	25	26	nd	68	nd
Sr	519	427	607	722	819	561	714	557	563	545	nd	381	nd

APPENDIX IV

SPECIMEN NUMBERS, ROCK TYPES AND GRID REFERENCES

TABLE IV.1

Analysed Specimens

Rock No.	Rock Type	Grid Ref.
27290	High-Al tholeiitic andesite	518397
27291	Low-Si tholeiitic andesite	421033
28046	" " " "	000440
28047	" " " "	970375
28048	" " " "	329133
28049	" " " "	466253
28050	" " " "	478129
28051	" " " "	420033
28052	" " " "	094291
28053	" " " "	001470
28054	Alkali rhyolite	181416
28055	Low-Si tholeiitic andesite	442097
28057	" " " "	326136
28058	" " " "	256042
28059	" " " "	292368
28060	" " " "	058355
28061	High-Si tholeiitic andesite	233291
28062	" " " "	191442
28063	" " " "	464351
28064	" " " "	314279
28065	" " " "	255147
28066	Icelandite	523300
28067	"	147355
28068	"	148358
28069	"	200457
28070	"	319338
28071	"	454370
28072	"	248455
28073	Tholeiitic rhyodacite	242343
28074	" "	291235
28075	Rhyolitic pitchstone	302425
28076	" "	257391
28077	" "	353308
28078	" "	182338
28079	" "	423396

APPENDIX IV (continued)

Analysed Specimens

Rock No.	Rock Type	Grid Ref.
28080	Rhyolitic pitchstone	137332
28081	" "	162339
28082	Rhyolite	296390
28083	"	147349
28084	"	148349
28085	"	355321
28086	"	305392
28087	"	137296
28088	"	313450
28089	Alkali olivine basalt	134389
28090	Analcime basanite	064483
28091	Basanitoid	393440
28092	Alkali dolerite	156450
28093	Hawaiite	559317
28094	"	419275
28095	"	097355
28096	"	990480
28097	"	979371
28098	"	074411
28099	Benmoreite	997436
28100	"	038371

TABLE IV.2

OTHER SPECIMENS

Rock No.	Rock type	Grid Ref.
28101	analcime basanite	139389
28102	alkali olivine basalt	150391
28103	hawaiite	150389
28104	alkali dolerite	154378
28105	" "	163369
28106	alkali olivine basalt	163370
28107	hawaiite	282423
28108	"	282423
28109	low-Si tholeiitic andesite	282423
28110	hawaiite	282422
28111	low-Si tholeiitic andesite	282422
28112	" " "	280423
28113	hawaiite	278421
28114	"	278421
28115	low-Si tholeiitic andesite	274414
28116	rhyodacite	259396
28117	" breccia	259396
28118	low-Si tholeiitic andesite	258393
28119	rhyolite	256390
28120	rhyolitic pitchstone	256390
28121	low-Si tholeiitic andesite	256389
28122	high-Al tholeiitic andesite	256388
28123	" " "	256388
28124	hawaiite	257387
28125	"	254372
28126	rhyolite	209348
28127	welded rhyolitic tuff	232325
28128	hawaiite	231326
28129	welded rhyolitic tuff	231326
28131	high-Al tholeiitic andesite	230328
28132	low-Si tholeiitic andesite	338181
28133	" " "	341782
28134	alkali olivine basalt	373180
28135	low-Si tholeiitic andesite	384196
28136	" " "	401223
28137	high-Si tholeiitic andesite	401223
28138	" " "	409224
28139	low-Si tholeiitic andesite	455231
28140	" " "	517222
28141	" " "	494142
28142	" " "	487138
28143	" " "	242053
28144	" " "	237052
28145	" " "	260353

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28146	high-Al tholeiitic andesite	262348
28147	low-Si tholeiitic andesite	278262
28148	hawaiite	295250
28149	low-Si tholeiitic andesite	324396
28150	rhyolite	364384
28151	rhyolitic pitchstone	363384
28152	" "	363385
28153	" "	362386
28154	" "	362387
28155	" "	364385
28156	" "	369377
28157	" "	371370
28158	rhyolite	375354
28159	"	375353
28160	"	378350
28161	"	380348
28162	"	386345
28163	"	396311
28164	low-Si tholeiitic andesite	379301
28165	" " "	374259
28166	" " "	365251
28167	" " "	352230
28168	rhyolite	194342
28169	"	195343
28170	"	194343
28171	"	194343
28172	rhyolitic pitchstone	194343
28173	rhyolitic tuff	194343
28174	altered basalt from tuff	194343
28175	" " " "	194343
28176	" " " "	194343
28177	" " " "	194343
28178	hawaiite	193344
28179	"	176341
28180	low-Si tholeiitic andesite	173343
28181	rhyolite	216376
28182	"	216376
28183	"	216376
28184	hawaiite	163296
28185	"	157294
28186	"	157294
28187	"	157294
28188	"	157294
28189	"	157294

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28190	rhyolite	148327
28191	"	145329
28192	"	144329
28193	rhyolitic pitchstone	143328
28194	" "	145328
28195	" "	145328
28196	" "	145328
28197	" "	146327
28198	" "	147326
28199	hawaiite	155295
28200	"	153295
28201	"	168316
28202	rhyolitic tuff	163339
28203	hawaiite	194402
28204	"	194402
28205	low-Si tholeiitic andesite	577064
28206	" " "	577064
28207	" " "	577064
28208	" " "	577064
28209	" " "	591105
28210	" " "	591103
28211	" " "	591103
28212	" " "	591103
28213	" " "	591104
28214	hawaiite	559317
28215	"	559317
28216	low-Si tholeiitic andesite	509325
28217	" " "	489325
28218	hawaiite	473331
28219	low-Si tholeiitic andesite	463307
28220	" " "	456304
28221	hawaiite	229263
28222	"	228265
28223	low-Si tholeiitic andesite	228266
28224	" " "	228266
28225	high-Si " "	233291
28226	low-Si " "	245290
28227	rhyolite	229334
28228	rhyolitic pitchstone	229334
28229	hawaiite	230335
28230	"	230337
28231	low-Si tholeiitic andesite	231337
28232	hawaiite	234334
28233	"	241336
28234	"	239336

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28235	hawaiite	238337
28236	"	237335
28237	rhyolitic pitchstone	283399
28238	" "	283399
28239	rhyolite	283399
28240	"	283399
28241	rhyolitic breccia	283399
28242	" "	283399
28243	low-Si tholeiitic andesite	275393
28244	" " "	273386
28245	megacryst-bearing hawaiite	253381
28246	hawaiite	254382
28247	"	255383
28248	"	256383
28249	"	152362
28250	"	152362
28251	low-Si tholeiitic andesite	152364
28252	hawaiite	154368
28253	"	154369
28254	"	155368
28255	"	154367
28256	"	154366
28257	"	214244
28258	low-Si tholeiitic andesite	214244
28259	hawaiite	221172
28260	"	221172
28261	low-Si tholeiitic andesite	221172
28262	" " "	191147
28263	hawaiite	192145
28264	"	319216
28265	low-Si tholeiitic andesite	319215
28266	" " '	319214
28267	hawaiite	319213
28268	low-Si tholeiitic andesite	319212
28269	" " "	319211
28270	" " "	318211
28271	" " "	318209
28272	" " "	312184
28273	hawaiite	372161
28274	high-Si tholeiitic andesite	312279
28275	hawaiite	314277
28276	"	262282
28277	"	262284
28278	"	261285
28279	"	259289

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28280	low-Si tholeiitic andesite	260289
28281	" " "	255189
28282	" " "	280423
28283	" " "	453061
28284	" " "	451061
28285	" " "	418032
28286	" " "	425030
28287	" " "	424026
28288	" " "	424024
28289	high-Si tholeiitic andesite	349037
28290	low-Si " "	316034
28291	" " "	318034
28292	" " "	321034
28293	" " "	321034
28294	" " "	322034
28295	" " "	337044
28296	high-Si tholeiitic andesite	340046
28297	low-Si " "	340047
28298	" " "	478132
28299	hawaiite	483133
28300	low-Si tholeiitic andesite	525153
28301	hawaiite	445118
28302	"	441118
28303	"	441118
28304	"	439118
28305	low-Si tholeiitic andesite	423119
28306	hawaiite	424111
28307	"	429121
28308	low-Si tholeiitic andesite	430120
28309	" " "	324138
28310	" " "	325138
28311	" " "	328135
28312	" " "	351144
28313	" " "	350145
28314	" " "	333155
28315	hawaiite	332157
28316	low-Si tholeiitic andesite	331158
28317	" " "	329160
28318	" " "	328161
28319	" " "	361171
28320	high-Si " "	361171
28321	low-Si " "	365171
28322	" " "	444158
28323	" " "	443159
28324	" " "	442159
28325	" " "	441159
28326	" " "	439159

TABLE IV.2 (continued)

Other Specimen

Rock No.	Rock type	Grid Ref.
28327	low-Si tholeiitic andesite	458206
28328	" " "	457211
28329	hawaiite	457213
28330	low-Si tholeiitic andesite	456216
28331	" " "	446235
28332	" " "	445235
28333	hawaiite	444236
28334	"	443237
28335	low-Si tholeiitic andesite	442239
28336	hawaiite	441239
28337	low-Si tholeiitic andesite	440239
28338	hawaiite	440239
28339	"	439238
28340	low-Si tholeiitic andesite	411207
28341	" " "	411208
28342	" " "	412209
28343	" " "	412209
28344	" " "	413210
28345	" " "	414212
28346	" " "	419228
28347	" " "	419241
28348	" " "	421241
28349	" " "	429255
28350	" " "	429256
28351	" " "	384259
28352	" " "	384262
28353	" " "	379264
28354	" " "	512136
28355	" " "	512136
28356	" " "	511139
28357	" " "	510139
28358	" " "	543239
28359	" " "	544238
28360	" " "	545238
28361	" " "	546238
28362	" " "	547237
28363	" " "	548237
28364	" " "	549237
28365	" " "	550238
28366	" " "	551238
28367	" " "	552237
28368	" " "	580274
28369	" " "	579275
28370	" " "	582275
28371	hawaiite	547296

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type			Grid Ref.
28372	low-Si	tholeiitic	andesite	524301
28373	"	"	"	528302
28374	high-Si	"	"	532303
28375	low-Si	"	"	535310
28376	"	"	"	500220
28377	hawaiite			494226
28378	low-Si	tholeiitic	andesite	489229
28379	"	"	"	488229
28380	"	"	"	487231
28381	"	"	"	487232
28382	"	"	"	487232
28383	"	"	"	468246
28384	"	"	"	465247
28385	"	"	"	464247
28386	"	"	"	463248
28387	"	"	"	463249
28388	"	"	"	464252
28389	"	"	"	453306
28390	high-Si	"	"	454305
28391	"	"	"	456305
28392	low-Si	"	"	457304
28393	"	"	"	431334
28394	high-Si	"	"	429333
28395	low-Si	"	"	424332
28396	"	"	"	423332
28397	"	"	"	422329
28398	"	"	"	420328
28399	rhyolitic	pitchstone		351309
28400	"	"		352308
28401	"	"		354307
28402	"	"		354307
28403	"	"		354307
28404	"	"		354307
28405	"	"		354307
28406	low-Si	tholeiitic	andesite	350268
28407	hawaiite			349266
28408	"			351265
28409	"			352264
28410	low-Si	tholeiitic	andesite	304973
28411	"	"	"	305965
28412	"	"	"	305965
28413	"	"	"	305965
28414	"	"	"	309998
28415	"	"	"	295019
28416	"	"	"	288058
28417	"	"	"	288059

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28418	low-Si tholeiitic andesite	286075
28419	" " "	245098
28420	" " "	235096
28421	" " "	233099
28422	" " "	229102
28423	" " "	229104
28424	" " "	201103
28425	high-Si tholeiitic andesite	201103
28426	" " "	201101
28427	" " "	201100
28428	hawaiite	200095
28429	low-Si tholeiitic andesite	375414
28430	" " "	375414
28431	rhyolitic pitchstone	375414
28432	low-Si tholeiitic andesite	381410
28433	high-Si " "	438389
28434	" " "	439389
28435	low-Si " "	469384
28436	" " "	458379
28437	" " "	454365
28438	" " "	461358
28439	" " "	463354
28440	" " "	464353
28441	hawaiite	464352
28442	low-Si tholeiitic andesite	464350
28443	rhyolitic pitchstone	380376
28444	rhyolitic tuff	375379
28445	" "	375379
28446	rhyolite	375379
28447	altered basalt	375379
28448	rhyolite	359388
28449	rhyolitic pitchstone	353392
28450	rhyolite	354392
28451	rhyolitic pitchstone	316368
28452	" "	319375
28453	" "	324387
28454	rhyolite	333404
28455	high-Si tholeiitic andesite	334382
28456	low-Si tholeiitic andesite	357345
28457	rhyolite	305389
28458	"	304389
28459	low-Si tholeiitic andesite	304392
28460	rhyolitic pitchstone	304398
28461	" "	305425
28462	" "	305425
28463	" "	305424
28464	" "	305422

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28465	rhyolite	298411
28466	rhyolitic pitchstone	297406
28467	" "	297406
28468	" "	297406
28469	" "	297406
28470	" "	297406
28471	" "	341386
28472	rhyolite	376335
28473	rhyolitic pitchstone	374325
28474	rhyolite	375351
28475	crystal tuff	416336
28476	rhyolitic pitchstone	408378
28478	hawaiite	313450
28479	alkali rhyolite	178421
28480	" "	178420
28481	hawaiite	278421
28482	alkaline dyke rock	159447
28483	alkali olivine basalt	156450
28484	alkali dolerite	156450
28485	" "	156450
28486	" "	156450
28487	" "	152448
28488	" "	149440
28489	low-Si tholeiitic andesite	271431
28490	hawaiite	267263
28491	"	267263
28492	"	267261
28493	low-Si tholeiitic andesite	231163
28494	" " "	233159
28495	" " "	235158
28496	" " "	248158
28497	" " "	248158
28498	" " "	203458
28499	alkali dolerite	203463
28500	low-Si tholeiitic andesite	367082
28501	" " "	368082
28502	" " "	370082
28503	" " "	370079
28504	" " "	417033
28505	hawaiite	415032
28506	low-Si tholeiitic andesite	330097
28507	" " "	254075
28508	" " "	224070
28509	" " "	230067
28510	" " "	231065

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28511	rhyolitic pitchstone	302423
28512	" "	288392
28513	rhyolite	295392
28514	"	297392
28515	rhyolitic pitchstone	292368
28516	low-Si tholeiitic andesite	291359
28517	hawaiite	291352
28518	low-Si tholeiitic andesite	291352
28519	rhyolite	232464
28520	hawaiite	232464
28521	megacryst-bearing hawaiite	233465
28522	hawaiite	233466
28523	"	233467
28524	rhyolitic pitchstone	233469
28525	" "	233469
28526	" "	233469
28527	" "	233469
28528	" "	233469
28529	hawaiite (dyke rock)	233475
28530	" " "	233475
28531	rhyodacite	284174
28532	"	284174
28533	"	284174
28534	"	289180
28535	"	210215
28536	"	290217
28537	"	290233
28538	"	291235
28539	"	291235
28540	"	291235
28541	low-Si tholeiitic andesite	391238
28542	" " "	391239
28543	hawaiite	391241
28544	high-Si tholeiitic andesite	388292
28545	hawaiite	310295
28546	"	311294
28547	low-Si tholeiitic andesite	312293
28548	rhyolitic pitchstone	247455
28549	pumice-pitchstone	247455
28550	icelandite	248456
28551	rhyolite	253453
28552	"	253453
28553	high-Si tholeiitic andesite	252454
28554	low-Si " "	251458
28555	hawaiite	253461

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type			Grid Ref.
28556	low-Si	tholeiitic	andesite	211446
28557	"	"	"	210446
28558	"	"	"	209446
28559	"	"	"	208445
28560	"	"	"	207445
28561	"	"	"	206445
28562	high-Si	tholeiitic	andesite	205444
28563	"	"	"	204443
28564	"	"	"	203443
28565	hawaiite			202443
28566	low-Si	tholeiitic	andesite	201443
28567	"	"	"	200442
28568	high-Si	"	"	199441
28569	"	"	"	198441
28570	low-Si	"	"	197441
28571	"	"	"	196441
28572	hawaiite			196441
28573	"			195441
28574	low-Si	tholeiitic	andesite	195441
28575	"	"	"	194441
28576	rhyolite			143345
28577	rhyolitic	pitchstone		147349
28578	"	"		148349
28579	rhyolitic	tuff		148349
28580	"	"		148349
28581	pumice-pitchstone			148349
28582	hawaiite			148349
28583	"			148349
28584	"			148349
28585	"			148349
28586	altered basalt			148349
28587	hawaiite			150349
28588	rhyolitic	pitchstone		279362
28589	low-Si	tholeiitic	andesite	270322
28590	"	"	"	267314
28591	"	"	"	266310
28592	hawaiite			266304
28593	low-Si	tholeiitic	andesite	269299
28594	hawaiite			269291
28596	low-Si	tholeiitic	andesite	309433
28597	"	"	"	310435
28598	rhyolite			309433
28599	"			332435
28600	rhyolitic	pitchstone		332435
28601	hawaiite			332435
28602	low-Si	tholeiitic	andesite	327430
28603	hawaiite			327431

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28604	rhyolitic pitchstone	326428
28605	rhyolite	326428
28606	low-Si tholeiitic andesite	329433
28607	hawaiite	328434
28608	low-Si tholeiitic andesite	329434
28609	" " "	329434
28610	" " "	329435
28611	hawaiite	332437
28612	"	332438
28613	"	332438
28614	rhyolite	319430
28615	hawaiite	315428
28616	"	301495
28617	"	350519
28618	"	350519
28619	" (dyke rock)	350519
28620	rhyolite	418430
28621	"	418430
28622	high-Al tholeiitic andesite	518397
28623	" " "	518397
28624	" " "	518397
28625	icelandite	319338
28626	high-Si tholeiitic andesite	255147
28627	" " "	255147
28628	" " "	255147
28629	" " "	255146
28630	andesitic breccia	255144
28631	palagonite tuff	255144
28632	palagonite sandstone	255144
28633	rhyolite	346353
28634	"	341341
28635	rhyolitic pitchstone	334377
28636	high-Si tholeiitic andesite	333378
28637	rhyolitic pitchstone	332371
28638	" "	335377
28639	" "	331382
28640	high-Si tholeiitic andesite	334383
28641	rhyolitic pitchstone	333387
28642	" "	336393
28643	" "	394389
28644	" "	394389

TABLE IV.2 (continued)

Other Specimens

Rock No.	Rock type	Grid Ref.
28645	rhyolitic pitchstone	397386
28646	" "	404376
28647	" "	396442
28648	" "	397435
28649	" "	404412
28650	rhyodacite	242345
28651	"	243352
28652	low-Si tholeiitic andesite	247356
28653	rhyodacite	242343
28654	low-Si tholeiitic andesite	251356
28655	rhyolite	348399
28656	"	346399
28657	"	344407
28658	rhyolitic pitchstone	344407
28659	rhyolite	349415
28660	rhyolitic pitchstone	370407
28661	rhyolite	369408
28662	hawaiite	379409
28663	low-Si tholeiitic andesite	398447
28664	hawaiite	398447
28665	rhyolitic pitchstone	396426
28666	pumice-pitchstone	400436
28667	rhyolitic pitchstone	402416
28668	pumice-tuff	402413
28669	" "	404413
28670	rhyolitic pitchstone	406410
28671	" "	409407
28672	" "	413406
28673	" "	418403
28674	" "	418403
28675	" "	422401
28676	rhyolite	423398