Table 30. ALKALI FELDSPAR ANALYSES

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
SiO_2	65·76	64·76	64·66	63·66	65·58	64·20	63·68	64·46	67·27	63·62	63·70	66·97	64·28	64·94
TiO_2	0·08	—	—	—	—	—	0·01	—	—	0·08	—	0·04	—	0·00
Al_2O_3	20·23	19·96	19·72	19·54	19·58	19·10	19·57	18·55	18·35	19·12	21·83	18·75	19·19	16·74
Fe_2O_3	0·18	0·08	0·08	0·10	0·21	0·40	0·29	0·14	0·92	0·47	0·18	0·88	0·09	2·56
FeO	—	tr.	—	—	—	—	0·24	—	}	}	—	}	—	0·00
MgO	0·10	tr.	tr.	—	0·12	—	0·05	0·00	0·00	0·05	0·14	0·00	0·10	0·04
BaO	0·63	—	—	—	—	—	0·34	—	—	1·56	—	—	0·11	—
CaO	1·19	0·84	0·34	0·50	0·49	0·34	0·40	0·17	0·15	0·05	2·75	0·36	0·11	0·03
Na_2O	8·44	5·54	3·42	0·80	5·90	2·60	1·56	0·49	6·45	2·66	7·55	7·88	0·92	0·79
K_2O	3·29	8·12	11·72	15·60	7·88	12·76	14·21	16·07	7·05	12·09	3·75	5·39	15·30	15·33
H_2O^+	0·37	0·54	0·18	—	0·23	0·72	0·04	—	0·08	0·11	0·19	0·01	0·36	—
H_2O^-	0·08			—	0·14		0·07	0·06	0·08	0·00		0·03		0·00
Total	100·35	99·84	100·12	100·20	100·13	100·12	100·46	99·94	100·35	99·81	100·09	100·31	100·46	100·43
α	1·528	1·5256	1·5217	1·5188	—	1·5204	—	—	1·5232	—	1·5290	1·5239	1·5192	1·5265
β	1·533	1·5296	1·5259	1·5230	—	1·5240	—	—	1·5289	—	1·5350	1·5299	1·5228	1·531
γ	1·537	1·5326	1·5279	1·5236	—	1·5265	—	—	1·5296	—	1·5365	1·5308	1·5245	1·5315
2V ($2V_\alpha$)	78°	82·8°	69·1°	43·6°	—	79·9°	83°–86°	—	33°	—	51°–52°	46°	68·4°	32°–33½°
Ext. on (010)	14°	11·7°	9·5°	5·3°	—	7·5°	—	—	—	—	6°–8°	—	5·25°	5°
D	—	2·5950	2·5778	2·5632	2·587	2·5771	—	—	—	—	2·589	—	2·5661	—
NUMBERS OF IONS ON THE BASIS OF 32(O)														
Si	11·719	11·750	11·794	11·759	11·825	11·831	11·730	11·938	12·030	11·770	11·383	11·932	11·852	12·011
Al	4·249	4·269	4·240	4·254	4·126	4·148	4·249	4·050	3·868	4·169	4·598	3·938	4·170	3·650
Fe^{+3}	0·024	0·011	0·011	0·014	0·029	0·055	0·040	0·019	0·124	0·096	0·024	0·118	0·012	0·356
Ti	0·011	—	—	—	—	—	0·001	—	—	0·011	—	0·005	—	—
Mg	0·027	—	—	—	0·032	—	0·014	—	—	0·013	0·038	—	0·028	0·011
Na	2·916	1·949	1·209	0·286	2·063	0·929	0·557	0·176	2·236	0·954	2·616	2·722	0·329	0·283
Ca	0·227	0·163	0·006	0·099	0·095	0·067	0·078	0·033	0·029	0·010	0·526	0·069	0·022	0·006
K	0·748	1·880	2·727	3·676	1·813	3·000	3·340	3·797	1·609	2·855	0·855	1·226	3·599	3·618
Ba	0·044	—	—	—	—	—	0·024	—	—	0·113	—	—	0·008	—
Z	16·00	16·03	16·04	16·03	16·02	16·03	16·02	16·01	16·02	16·05	16·00	15·99	16·03	16·02
X	3·96	3·99	4·00	4·06	4·00	4·00	4·05†	4·01	3·87	3·95	4·03	4·02	3·99	3·92
Mol. % Or	20·0	47·1	68·1	90·5	45·3	75·1	83·1	94·8	41·5	75·5	21·2	30·5	90·5	92·4‡
Mol. % Ab	73·6	48·8	30·2	7·1	51·5	23·2	13·7	4·4	57·7	23·9	64·8	67·8	8·3	7·2
Mol. % An	6·4	4·1	1·7	2·4	3·2	1·7	3·2	0·8	0·8	0·6	14·0	1·7	1·2	0·4

1. Sodium-rich orthoclase cryptoperthite, ijolite–nepheline-syenite, Mogok, Burma (Tilley, C. E., 1954, *Amer. Journ. Sci.*, vol. 252, p. 65).
2. Orthoclase microperthite with white schiller, Burma (Spencer, E., 1930, *Min. Mag.*, vol. 22, p. 291).
3. Orthoclase microperthite (moonstone), Ceylon (Spencer, E., 1937, *Min. Mag.*, vol. 24, p. 453).
4. Orthoclase, Mogok, Burma (Spencer, E., 1930, *Min. Mag.*, vol. 22, p. 291).
5. Microcline perthite, nepheline-syenite, Korea (Yoshizawa, H., 1933, *Chikyu*, vol. 19, p. 432).
6. Microcline microperthite, quartz–feldspar–tourmaline pegmatite, Orissa, India (Spencer, E., 1937, *Min. Mag.*, vol. 24, p. 453).
7. Microcline microperthite, charnockite, St. Thomas' Mt., Madras (Howie, R. A., 1955, *Trans. Roy. Soc. Edinburgh*, vol. 62, p. 725).
8. Maximum microcline, pegmatite in grennaite, Norra Kärr, Sweden (MacKenzie, W. S., 1954, *Min. Mag.*, vol. 30, p. 354).
9. Sanidine, rhyolite, Mitchell Mesa, Texas (Tuttle, O. F., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 553).
10. Sanidine, leucite–nepheline dolerite, Vogelsberg, Germany (Tilley, C. E., 1958, *Amer. Min.*, vol. 43, p. 758).
11. Anorthoclase, inclusions in augite, Euganean Hills, Italy (Schiavinato, G., 1951, *Periodico Min. Roma*, vol. 20, p. 193).
12. Anorthoclase, Grande Caldeira, Azores (Tuttle, O. F., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 553).
13. Adularia, St. Gotthard, Switzerland (Spencer, E., 1937, *Min. Mag.*, vol. 24, p. 453).
14. Amber-yellow ferriferous orthoclase, Itrongay, Madagascar (Coombs, D. S., 1954, *Min. Mag.*, vol. 30, p. 409).

† Includes Fe^{+2} 0·037.

‡ Includes 9·0 mol. per cent. Fe-Orthoclase.

Table 31. PLAGIOCLASE FELDSPAR ANALYSES

	1.	2.	3.	4.	5.	6.	7.	8.
SiO_2	67·84	67·41	64·10	58·10	52·96	49·06	44·17	43·88
TiO_2	0·00	—	0·00	tr.	tr.	—	tr.	—
Al_2O_3	19·65	20·50	22·66	26·44	29·72	32·14	34·95	36·18
Fe_2O_3	0·03	0·07	0·14	0·04	0·84	0·27	0·56	0·08
FeO	0·02	—	0·17	0·15	—	—	0·08	0·00
MgO	0·04	0·10	0·25	0·03	—	0·20	0·00	—
CaO	0·00	0·81	3·26	7·84	12·28	15·38	18·63	19·37
Na_2O	11·07	10·97	9·89	6·48	4·21	2·57	0·79	0·22
K_2O	0·29	0·36	0·05	1·10	0·13	0·17	0·05	0·00
H_2O^+	0·56	0·15	0·17	0·03	0·08	0·13	0·84	0·28
H_2O^-	0·30		0·06	0·06		0·03	0·17	0·08
Total	99·80	100·37	100·75	100·27	100·22	99·95	100·24	100·10
α	1·529	1·5283	1·5351	—	1·560	1·5657	1·574	1·5754
β	1·533	1·5327	1·5393	—	1·565	1·5701	1·582	1·5833
γ	1·539	1·5392	1·5437	—	1·570	1·5754	1·586	1·5885
2V	79°(+)	79½°(+)	89°(+)	88°(+)	—	89°(−)	78°(−)	76·8°–77·7°(−)
α':(010)	—	18½°–19°	11½°	—	23½°	—	—	—
D	—	2·619	2·646	—	2·705	—	—	2·749
NUMBERS OF IONS ON THE BASIS OF 32(O)								
Si	11·964	11·785	11·267	10·413	9·589	8·990	8·237	8·126
Al	4·085	4·225	4·695	5·586	6·343	6·942	7·683	7·898
Fe^{+3}	0·004	0·009	0·018	0·005	0·114	0·037	0·078	0·011
Mg	0·011	0·026	0·065	0·008	—	0·055	—	—
Fe^{+2}	0·003	—	0·025	0·023	—	—	0·012	—
Na	3·785	3·718	3·370	2·252	1·477	0·913	0·285	0·079
Ca	—	0·152	0·614	1·505	2·383	3·202	3·723	3·844
K	0·066	0·080	0·011	0·252	0·030	0·040	0·012	—
Z	16·05	16·02	15·98	16·00	16·05	15·97	16·00	16·03
X	3·87	3·98	4·08	4·04	3·89	4·03	4·03	3·92
Mol.% Ab	98·0	93·5	82·5	56·0	38·0	22·7	7·1	2·0
Mol.% An	0·3	4·5	17·2	37·7	61·2	76·3	92 6	98·0
Mol.% Or	1·7	2·0	0·3	6·3	0·8	1·0	0·3	—

1. Albite, pegmatite, near Court House, Amelia Co., Virginia (Kracek, F. C. & Neuvonen, K. J., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 293).
2. Albite, with quartz and sphene in crevice in amphibolite, Val Devero, Italy (Azzini, F., 1933, *Atti Accad. Sci. Veneto-Trentino-Istriana*, vol. 23, p. 45).
3. Glassy oligoclase, pegmatite, Kioo Hill, Kenya (Game, P. M., 1949, *Min. Mag.* vol. 28, p. 682).
4. Andesine antiperthite, two-pyroxene granulite, charnockite series, Madras (Howie, R.A., 1955, *Trans. Roy. Soc. Edinburgh*, vol. 62, p. 725).
5. Labradorite, Millard Co., Utah (Meen, V. B., 1933, *Univ. Toronto Studs., Geol. Ser.*, no. 35, p. 37).
6. Bytownite, norite, Rustenburg platinum mines, Transvaal (Kracek, F. C. & Neuvonen, K. J., 1952, *loc. cit.*).
7. Anorthite, olivine norite, Grass Valley, California (Kracek, F. C. & Neuvonen, K. J., 1952, *loc. cit.*).
8. Anorthite, calc-silicate rock, Sittampundi complex, India (Subramaniam, A. P., 1956, *Bull. Geol. Soc. Amer.*, vol. 67, p. 317; includes SrO 0·01).

Table 35. NEPHELINE AND KALSILITE ANALYSES

	1.	2.	3.	4.	5.
SiO_2	44·65	41·88	40·20	38·47	38·48
TiO_2	0·00	0·03	0·05	0·00	0·05
Al_2O_3	32·03	32·99	32·51	30·81	31·01
Fe_2O_3	0·59	0·74	1·82	1·63	1·12
MgO	0·00	0·00	0·10	0·63	0·00
CaO	0·71	0·78	1·44	0·20	0·03
Na_2O	17·25	16·11	10·86	2·09	0·30
K_2O	3·66	6·82	12·22	25·65	28·33
H_2O^+	0·96	0·71	0·00	0·20	0·67
H_2O^-	0·21	0·03	0·00	0·00	—
Total	100·06	100·16	99·77	99·94	100·00
ϵ	1·531	—	1·539	1·537	1·533
ω	1·535	—	1·543	1·543	1·539
NUMBERS OF IONS ON THE BASIS OF 32 OXYGENS					
Si	8·585	8·179	8·014	8·044	8·125
Al	7·361	7·595	7·641	7·596	7·720
Ti	—	0·005	0·007	—	0·008
Fe^{+3}	0·085	0·109	0·369‡	0·301§	0·180‖
Mg	—	0·102†	0·030	0·196	—
Na	6·428	6·098	4·198	0·847	0·123
Ca	0·147	0·163	0·308	0·045	0·006
K	0·897	1·699	3·018	6·846	7·635
ΣR¶	7·61	8·12	7·92	7·78	7·77
Ne	81·9	76·1	54·7	9·9	96·8
Ks	12·9	23·6	45·3	88·9	1·4
Q	5·2	0·3	—	1·2	1·8

1. Nepheline, phonolite, New Zealand (Tilley, C. E., 1954, *Amer. Journ. Sci.*, vol. 252, p. 65).
2. Nepheline, foyaite, Transvaal (Tilley, C. E., 1956, *Kon. Ned. Geol. Mijnb.*, *Geol. Ser.*, Brouwer vol., p. 403; includes MnO 0·07).
3. Nepheline, potash ankaratrite, Congo (Sahama, Th. G., 1952. *Amer. Journ. Sci.*, Bowen vol., p. 460; includes FeO 0·57).
4. Kalsilite, venanzite, Italy (Bannister, F. A., Sahama, Th. G. & Wiik, H. B., 1952. *Min. Mag.*, vol. 30, p. 46; includes FeO 0·26).
5. Kalsilite, complex phenocryst of kalsilite and nepheline, Congo (Sahama, Th. G., Neuvonen, K. J. & Hytönen, K., 1956, *Min. Mag.*, vol. 31, p. 200. Analysis recalculated after correcting for 10 per cent nepheline, 31·1 atomic per cent K:(K+Na+Ca) in sample; total iron as Fe_2O_3: analysis includes MnO 0·01).

† Includes Mn 0·012.
‡ Includes Fe^{+2} 0·096.
§ Includes Fe^{+2} 0·045.
‖ Includes Mn 0·002.

¶ $\Sigma R = (Na + K + 2Ca)$

Table 36. LEUCITE AND PSEUDOLEUCITE ANALYSES

	1.	2.	3.		Numbers of ions on the basis of 6 oxygens 1.		2.		3.	
SiO_2	54·62	54·66	57·42	Si	1·992		1·992		2·034	
TiO_2	0·00	0·17	0·24	Al	0·986		0·995		0·912	
Al_2O_3	22·93	23·15	21·85	Ti	—		0·005		0·006	
Fe_2O_3	0·26	0·36	1·70	Fe^{+3}	0·007		0·010		0·045	
FeO	0·26	0·11	0·00	Mg	—	1·00	0·002	1·02	0·004	0·98†
MnO	—	0·01	0·03	Fe^{+2}	0·008		0·003		—	
MgO	0·00	0·04	0·07	Ca	0·002		0·004		0·007	
CaO	0·08	0·11	0·19	Na	0·047	1·03	0·045	0·98	0·328	0·93
Na_2O	0·66	0·63	4·78	K	0·978		0·932		0·606	
K_2O	21·02	20·04	13·40							
H_2O^+	0·12	0·36	0·27							
H_2O^-	0·00	0·05	0·03							
Total	99·95	99·77	100·26							
n	1·509	—	—							

1. Leucite, leucitite, Congo (Sahama, Th. G., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 457).
2. Leucite, giant leucite aggregate, Congo (Sahama, Th. G., 1960, *Journ. Petr.*, vol. 1, p. 146; includes P_2O_5 0·08).
3. Pseudoleucite, tinguaite, Montana (Zies, E. G. & Chayes, F., 1960, *Journ. Petr.*, vol. 1, p. 86; includes BaO 0·28).

† Includes Mn 0·001, Ba 0·004.

Table 37. SODALITE, NOSEAN AND HAÜYNE ANALYSES

	1.	2.	3.	4.	5.	6.
SiO_2	36·69	36·70	36·36	36·69	34·04	32·52
Al_2O_3	31·40	32·01	32·09	28·45	28·27	27·61
Fe_2O_3	0·85	0·07	0·07	0·47	—	—
CaO	0·19	—	—	0·63	9·51	6·47
Na_2O	25·96	24·79	24·73	23·90	10·39	19·45
K_2O	0·23	0·17	0·12	—	5·44	0·28
SO_3	—	—	—	7·30	10·02	10·46
S	0·38	tr.	0·00	—	—	2·71
Cl	5·64	7·00	6·79	1·05	0·76	0·47
H_2O^+	0·30	0·36	0·86	}2·15	}0·34	—
H_2O^-	0·04	0·00	0·12			—
	101·71	101·39	101·70	100·64	100·34	99·97
O ≡ Cl, S	1·39	1·58	1·53	0·23	0·17	0·55
Total	100·32	99·81	100·17	100·41	100·17	99·42
n	1·487	1·487	1·483	—	—	—
D	2·285	2·286	2·278	2·299	—	—

NUMBERS OF IONS ON THE BASIS OF THE 21(O) IN THE $3Al_2O_3 \cdot 6SiO_2$ FRAMEWORK

	1.	2.	3.	4.	5.	6.
Si	5·933	5·925	5·894	6·203	6·055	5·998
Al	5·986 } 12·02	6·091 } 12·02	6·132 } 12·03	5·670 } 11·93	5·927 } 11·98	6·000 } 12·00
Fe^{+3}	0·102	0·008	0·008	0·060	—	—
Na	8·138	7·760	7·772	7·834	3·583	6·954
Ca	0·033 } 8·225†	— } 7·80	— } 7·81‡	0·114 } 7·95	1·813 } 6·86§	1·279 } 8·30
K	0·047	0·035	0·025	—	1·233	0·066
Cl	1·546	1·915	1·866	0·301	0·229	0·146
S	0·115	—	—	— } 1·23	— } 1·57	0·936 } 2·53
SO_4	—	—	—	0·926	1·336	1·448
OH	0·324	0·380	0·928	2·415	0·403	

1. Light grey sodalite, pegmatite cutting nepheline-syenite, Kola peninsula (Fersman, A. E. & Bonshtedt, E. M., 1937, *Minerals of the Khibina and Lovozero tundras*; includes MgO 0·03).
2. White or colourless hackmanite, tinguaite, Magnet Cove, Arkansas (Miser, H. D. & Glass, J. J., 1941, *Amer. Min.*, vol. 26, p. 437; includes $CaCO_3$ 0·29).
3. Blue sodalite, associated with colourless hackmanite (anal. 2), Magnet Cove, Arkansas (Miser, H. D. & Glass, J. J., *loc. cit. supra*; includes MnO 0·06, $CaCO_3$ 0·50).
4. Light blue-grey nosean, ejected block, Laacher See, Lower Rhine (Rath, G. vom, 1864, *Zeits. deutsch. geol. Ges.*, vol. 16, p. 82).
5. Haüyne, haüyne riedenite, Monte Vulture, Italy (Rittmann A., 1931, *Schweiz. Min. Petr. Mitt.*, vol. 11, p. 250; includes FeO 0·69, MgO 0·48, CO_2 0·4).
6. 'Lazurite', lapis lazuli, central Asia (Brögger, W. C. & Backström, H., 1891, *Zeit. Kryst.*, vol. 18, p. 209).

† Includes Mg 0·007.
‡ Includes Mn 0·008.
§ Includes Fe^{+2} 0·103 Mg 0·127.

Table 1. OLIVINE ANALYSES

	1.	2.	3.	4.	5.	6.
SiO_2	41·07	39·87	34·04	30·56	30·15	25·59
TiO_2	0·05	0·03	0·43	0·72	0·20	0·61
Al_2O_3	0·56	0·00	0·91	0·09	0·07	6·53
Fe_2O_3	0·65	0·86	1·46	0·10	0·43	31·44
FeO	3·78	13·20	40·37	60·81	65·02	4·64
MnO	0·23	0·22	0·68	3·43	1·01	—
MgO	54·06	45·38	20·32	3·47	1·05	15·83
CaO	0·00	0·25	0·81	1·13	2·18	1·30
Na_2O	—	0·04	—	—	—	0·31
K_2O	—	0·01	—	—	—	0·28
H_2O^+	0·05	0·33	0·09	—	—	9·09
H_2O^-	0·00	0·10	—	—	—	3·74
Total	100·45	100·30	99·11	100·31	100·11	99·36
α	—	1·6626	1·742	1·809	1·827	—
β	—	—	—	1·842	1·869	1·816
γ	—	1·6990	—	1·862	1·879	—
$2V\gamma$	—	90°	103°	128°	132°	—
NUMBERS OF IONS ON THE BASIS OF 4 OXYGENS						
Si	0·979	0·997	0·990	0·996	1·002	—
Al	0·016	—	0·032	0·004	0·003	—
Ti	0·001	0·001	0·009	0·018	0·005	—
Fe^{+3}	0·012	0·016	0·032	0·004	0·011	—
Mg	1·920	1·692	0·881	0·169	0·052	—
Fe^{+2}	0·075	0·276	0·983	1·659	1·808	—
Mn	0·005	0·005	0·017	0·094	0·028	—
Ca	—	0·007	0·025	0·039	0·078	—
$[Y]^6$	2·03	2·00†	1·98	1·99	1·99	—
Atomic ratios						
Mg	96·2	86·0	47·3	8·8	2·8	—
Fe^{+2}	3·8	14·0	52·7	91·2	97·2	—

1. Forsterite, metamorphosed limestone, Finland (Sahama, Th. G., 1953, *Ann. Acad. Sci. Fennicae*, 3. *Geol. Geogr.*, No. 31, p. 1).
2. Chrysolite, allivalite, Rhum (Brown, G. M., 1956, *Phil. Trans. Roy. Soc. London*, Ser. B., vol. 240, p. 1. Includes P_2O_5 0·01, Cr_2O_3 trace).
3. Hortonolite, olivine gabbro, Muck (Tilley, C. E., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 529).
4. Fayalite, porphyritic obsidian, Pantelleria (Carmichael, I. S. E., 1962, *Min. Mag.*, vol. 33, p. 86).
5. Fayalite, fayalite ferrogabbro, East Greenland (Deer, W. A. & Wager, L. R., 1939, *Amer. Min.*, vol. 24, p. 18).
6. Iddingsite, trachybasalt, Gough Island (Gay, P. & Le Maitre, R. W., 1961, *Amer. Min.*, vol. 46, p. 92).

† Includes Na 0·007, K 0·002.

Table 13. PYROXENE ANALYSES

	1.	2.	3.	4.	5.
SiO_2	57·73	50·08	45·95	54·09	48·34
TiO_2	0·04	0·64	0·10	0·28	0·08
Al_2O_3	0·95	1·23	0·90	1·57	0·30
Fe_2O_3	0·42	2·34	0·31	0·74	1·50
Cr_2O_3	0·46	—	—	2·03	—
FeO	3·57	27·85	41·65	1·47	22·94
MnO	0·08	0·85	5·02	0·09	3·70
NiO	0·35	—	—	0·03	—
MgO	36·13	15·78	3·49	16·96	1·06
CaO	0·23	1·44	1·43	21·10	21·30
Na_2O	—	0·05	—	1·37	0·14
K_2O	—	0·02	—	0·15	0·03
H_2O^+	0·52	—	0·65	0·22	0·46
H_2O^-	0·04	0·00	0·09	0·08	—
Total	100·52	100·28	99·59	100·64	99·85
α	—	1·707	1·755	—	1·7225
β	—	—	1·763	> 1·66	1·7300
γ	1·670	1·722	1·773	—	1·7505
$2V_\gamma$	72½°	130°	83°	70°–75°	62½°
D	3·249	—	3·88	—	3·535

NUMBERS OF IONS ON THE BASIS OF 6 OXYGENS

	1.		2.		3.		4.		5.	
Si	1·972	2·00	1·937	2·00	1·972	2·00	1·961	2·00	1·988	2·00
Al	0·028		0·056		0·028		0·039		0·012	
Al	0·010		—		0·018		0·029		0·006	
Ti	0·001		0·019		0·003		0·008		0·002	
Fe^{+3}	0·010		0·068		0·010		0·020		0·046	
Cr	0·012		—		—		0·058		—	
Mg	1·839		0·910		0·223		0·917		0·065	
Ni	0·010	1·99	—	1·98	—	2·00	0·001	2·01†	—	1·99
Fe^{+2}	0·102		0·901		1·495		0·045		0·789	
Mn	0·002		0·028		0·183		0·003		0·129	
Ca	0·008		0·060		0·066		0·820		0·939	
Na	—		0·004		—		0·096		0·011	
K	—		0·001		—		0·007		0·001	
Mg	93·9		46·9		12·4		50·8		3·3	
Fe	5·7		50·0		83·9		3·8		49·0	
Ca	0·4		3·1		3·7		45·4		47·7	

1. Enstatite, pyroxenite, North Carolina (Hess, H. H., 1952, *Amer. Journ. Sci.*, Bowen vol., p. 173).
2. Ferrohypersthene, hypersthene–diopside–plagioclase hornfels, Oslo district, Norway (Muir, I. D. & Tilley, C. E., 1958, *Geol. Mag.*, vol. 95, p. 403).
3. Orthoferrosilite, thermally metamorphosed iron-rich rock, Manchuria (Tsuru, K. & Henry, N. F. M., 1937, *Min. Mag.*, vol. 24, p. 527).
4. Chrome diopside, kimberlite, S. Africa (Holmes, A., 1937, *Trans. Geol. Soc. S. Africa*, vol. 39, p. 379; includes ZrO_2 0·12, V_2O_3 0·07, SrO 0·01, CO_2 0·26, Ca tr., S tr.).
5. Hedenbergite, California (Wyckoff, R. W. G., Merwin, H. E. & Washington, H. S., 1925, *Amer. Journ. Sci.* 4th Ser., vol. 10, p. 389).

† Includes Zr 0·002, V 0·002.

Table 13. PYROXENE ANALYSES—*continued*

	6.	7.	8.	9.	10.
SiO_2	52·92	46·61	49·68	48·90	52·84
TiO_2	0·50	1·18	0·56	0·12	0·22
Al_2O_3	2·80	3·47	0·78	3·86	0·44
Fe_2O_3	0·85	0·90	3·29	4·65	1·06
Cr_2O_3	0·88	—	—	—	—
FeO	5·57	20·18	18·15	25·35	16·89
MnO	0·15	1·11	0·59	0·51	0·56
NiO	0·10	—	—	—	—
MgO	16·40	7·27	16·19	6·87	23·51
CaO	19·97	17·24	9·90	7·96	4·06
Na_2O	0·35	1·04	0·65	0·58	0·19
K_2O	0·01	0·27	0·15	0·20	0·00
H_2O^+	0·10	0·42	0·10	0·57	—
H_2O^-	0·07	0·04	0·00	0·35	0·22
Total	100·67	99·73	100·04	99·92	99·99
α	1·6818	1·710	1·709	—	—
β	1·6865	1·716	—	—	—
γ	1·7085	1·736	1·738	—	—
$2V_\gamma$	49°	52°	28°–30°	—	—
D	—	3·49	—	—	—

NUMBERS OF IONS ON THE BASIS OF 6 OXYGENS

	6.	7.	8.	9.	10.
Si	1·929 } 2·00	1·859 } 2·00	1·905	1·941 } 2·00	1·955
Al	0·071	0·141	0·034 } 2·00	0·059	0·018 } 2·00
Al	0·049	0·021	—	0·121	—
Ti	0·014	0·035	0·016	0·004	0·006
Fe^{+3}	0·024	0·026	0·094	0·139	0·030
Cr	0·026	—	—	—	—
Mg	0·891	0·432	0·925	0·406	1·296
Ni	0·003 } 1·99	— } 2·05	—	— } 1·92	—
Fe^{+2}	0·170	0·673	0·582 } 2·04	0·842	0·523 } 2·02
Mn	0·005	0·037	0·019	0·017	0·017
Ca	0·780	0·737	0·407	0·338	0·161
Na	0·024	0·080	0·048	0·046	0·014
K	0·000	0·014	0·008	0·010	0·000
Mg	47·6	22·8	45·6	23·3	63·9
Fe	10·7	38·6	34·3	57·3	28·1
Ca	41·7	38·6	20·1	19·4	8·0

6. Chromian augite, gabbro, Bushveld Complex (Hess, H. H., 1949, *Amer. Min.*, vol. 34, p. 621).
7. Ferroaugite, syenite, South-West Africa (Simpson, E. S. W., 1954, *Trans. Geol. Soc. S. Africa*, vol. 57, p. 126).
8. Sub-calcic augite, basalt, Japan (Kuno, H., 1955, *Amer. Min.*, vol. 40, p. 70).
9. Sub-calcic ferroaugite, andesite, Japan (Kuno H. & Inoue, T., 1949, *Proc. Japan Acad.*, vol. 25, p. 128).
10. Magnesian pigeonite, andesite, Japan (Kuno, H. & Nagashima, K., 1952, *Amer. Min.*, vol. 37, p. 1000).

Table 13. PYROXENE ANALYSES—*continued*

	11.	12.	13.	14.
SiO_2	49·72	51·92	64·89	59·38
TiO_2	0·85	0·77	—	0·04
Al_2O_3	0·90	1·85	26·74	25·82
Fe_2O_3	1·72	31·44	0·57	0·45
Cr_2O_3	—	—	—	0·01
FeO	27·77	0·75	0·04	tr.
MnO	0·98	—	0·01	0·00
NiO	—	—	—	—
MgO	12·69	—	0·00	0·12
CaO	3·80	—	0·00	0·13
Na_2O	0·23	12·86	0·05	13·40
K_2O	0·12	0·19	0·16	0·02
H_2O^+	1·27	0·17	0·48	0·22
H_2O^-	0·08	—	0·06	0·16
Total	100·13	99·95	100·12	99·75
α	1·7137	1·770	1·661	1·654
β	1·7137	1·812	1·666	1·657
	1·7417	1·830	1·676	1·666
$2V_\gamma$	0°–12°	—	—	70°
D	3·44	—	3·163	3·43

NUMBERS OF IONS ON THE BASIS OF 6 OXYGENS

	11.	12.	13.	14.
Si	1·968 } 2·00	1·986 } 2·00	2·026 } 2·03	1·998 } 2·00
Al	0·032	0·014	—	0·002
Al	0·010	0·069	0·984	1·022
Ti	0·025	0·022	—	0·001
Fe^{+3}	0·051	0·905	0·014	0·012
Cr	—	—	—	0·000
Mg	0·749	—	—	0·006
Ni	— } 1·97	— } 1·98	— } 1·90†	— } 1·92
Fe^{+2}	0·919	0·024	0·001	—
Mn	0·033	—	—	—
Ca	0·161	—	—	0·005
Na	0·018	0·953	0·002	0·874
K	0·006	0·008	0·006	0·001
Mg	39·2	—	—	—
Fe	52·4	—	—	—
Ca	8·4	—	—	—

11. Pigeonite, andesite, Scotland (Hallimond, A. F., 1914, *Min. Mag.*, vol. 17, p. 97).
12. Aegirine, riebeckite–albite granite, Nigeria (Greenwood, R., 1951, *Bull. Geol. Soc. Amer.*, vol. 62, p. 1151).
13. Wine-yellow spodumene, pegmatite, Sweden (Quensel, P., 1938, *Geol. För. Förh. Stockholm*, vol. 60, p. 201; includes Li_2O 7·12).
14. White jadeite, serpentinite, California (Coleman, R. G., 1955, *Amer. Min.*, vol. 40, p. 312).

† Includes Li 0·894.

Table 15. Amphibole analyses

	1.	2.	3.	4.	5.	6.
SiO_2	58·48	44·89	51·53	47·54	51·40	42·05
TiO_2	0·03	0·67	0·31	—	0·74	1·48
Al_2O_3	0·57	17·91	5·02	0·20	3·88	14·69
Fe_2O_3	0·58	0·67	0·82	0·71	3·90	3·21
FeO	7·85	13·31	16·91	47·25	14·91	6·30
MnO	0·27	0·37	0·22	2·14	0·33	0·04
MgO	29·25	18·09	20·84	0·04	11·22	14·91
CaO	0·14	0·40	1·34	0·00	10·17	12·83
Na_2O	0·08	1·45	0·65	0·29	1·67	2·01
K_2O	0·02	0·05	0·00	0·11	0·09	0·65
H_2O^+	2·60	2·02	2·15	1·55	1·90	1·53
H_2O^-	0·20	0·00	0·64	—	0·04	0·09
F	—	—	—	0·01	—	0·5
	100·20	99·87	100·43	99·84	100·25	100·29
O ≡ F,Cl	—	—	—	—	—	0·21
Total	100·20	99·87	100·43	99·84	100·25	100·08
α	—	1·649	1·643	1·686	1·650	1·648
β	—	1·656	1·650	1·709	1·663	1·660
γ	1·632	1·669	1·663	1·729	1·670	1·670
$2V_\alpha$	80°	—	105°	85°	65°	85°
D	3·01	3·15	3·10	3·597	—	3·16

Numbers of ions on the basis of 24 (O,OH,F,Cl)

	1.		2.		3.		4.		5.		6.	
Si	7·885	7·98	6·325	8·00	7·364	8·00	7·968	8·00	7·543	8·00	6·099	8·00
Al	0·090		1·675		0·636		0·032		0·457		1·901	
Al	—		1·301		0·209		0·008		0·215		0·611	
Ti	0·003		0·071		0·033		—		0·082		0·161	
Fe^{+3}	0·058		0·070		0·087		0·088		0·430	5·05	0·350	
Mg	5·876		3·799		4·438		0·010		2·453		3·224	5·12
Fe^{+2}	0·885	6·90†	1·569	7·32	2·022	7·20	6·626	7·15	1·830		0·764	
Mn	0·031		0·044		0·027		0·304		0·040		0·005	
Na	0·020		0·396		0·180		0·093		0·474		0·564	
Ca	0·020		0·060		0·205		—		1·599	2·09	1·994	2·68
K	0·004		0·008		—		0·024		0·018		0·120	
OH	2·338	2·34	1·898	1·90	2·049	2·05	1·732	1·74	1·861	1·86	1·480	1·71
F	—		—		—		0·007		—		0·229	

1. Anthophyllite, serpentinite, outer Hebrides (Guppy, E. M., 1956, *Mem. Geol. Surv. Gt. Britain*; includes Cr_2O_3 0·04, NiO 0·01, CO_2 0·08).
2. Gedrite, kyanite–garnet gedritite, Idaho (Hietanen, A., 1959, *Amer. Min.*, vol. 44, p. 539; includes P_2O_5 0·04).
3. Cummingtonite, oligoclase–biotite schist, Scotland (Collins, R. S., 1942, *Min. Mag.*, vol. 26, p. 254).
4. Grunerite, U.S.A. (Bowen, N. L. & Schairer, J. F., 1935, *Amer. Min.*, vol. 20, p. 543).
5. Actinolite, albite–stilpnomelane–actinolite schist, New Zealand (Hutton, C. O., 1940, *Dept. Sci. and Ind. Res. New Zealand, Geol. Mem.*, No. 5).
6. Hornblende, ultrabasic rock, India (Howie, R. A., 1955, *Trans. Roy. Soc. Edinburgh*, vol. 62, p. 725).

† Includes Cr 0·054, Ni 0·001.

Table 15. AMPHIBOLE ANALYSES—*continued*

	7.	8.	9.	10.	11.	12.
SiO_2	44·99	48·10	37·49	45·17	39·68	40·88
TiO_2	1·46	0·10	0·86	2·11	7·12	0·22
Al_2O_3	11·21	11·05	10·81	7·68	12·81	11·04
Fe_2O_3	3·33	0·67	7·52	14·30	4·04	7·56
FeO	13·17	1·65	25·14	2·81	8·79	17·41
MnO	0·31	—	0·95	0·41	0·16	1·32
MgO	10·41	20·60	1·34	13·44	11·22	5·92
CaO	12·11	12·50	9·77	11·18	11·06	10·46
Na_2O	0·97	2·54	2·06	1·35	3·37	3·75
K_2O	0·76	1·24	1·91	1·09	1·04	0·78
H_2O^+	1·48	0·71	2·01	0·19	0·78	1·16
H_2O^-	0·04	0·11	—	0·06	0·15	—
F	—	1·90	—	0·35	0·33	—
	100·41	101·17	99·86	100·14	100·55	100·50
O ≡ F,Cl	—	0·80	—	0·14	0·14	—
Total	100·41	100·37	99·86	100·00	100·41	100·50
α	1·650	1·613	1·697	1·675	1·685	1·691
β	1·672	1·618	1·713	1·715	—	—
γ	1·681	1·635	1·714	1·735	1·736	1·707
$2V_\alpha$	(+)	119·5°	16°	—	66°–74°	—
D	—	3·069	—	3·246	—	3·418

NUMBERS OF IONS ON THE BASIS OF 24 (O,OH,F,Cl)

	7.	Σ	8.	Σ	9.	Σ	10.	Σ	11.	Σ	12.	Σ
Si	6·669	8·00	6·760	8·00	6·074	8·00	6·728	8· 0	5·937	8·00	0·377	3·00
Al	1·331		1·240		1·926		1·272		2·063		1·623	
Al	0·629	5·13	0·592	5·18	0·138	5·02	0·076	5·30	0·197	5·07	0·407	5·14
Ti	0·163		0·011		0·105		0·236		0·801		0·025	
Fe^{+3}	0·370		0·071		0·917		1·602		0·454		0·886	
Mg	2·300		4·315		0·323		2·984		2·501		1·376	
Fe^{+2}	1·633		0·194		3·408		0·350		1·100		2·271	
Mn	0·039		—		0·131		0·051		0·020		0·174	
Na	0·278	2·35	0·693	2·80	0·648	2·74	0·390	2·38	0·976	2·95	1·134	3·04
Ca	1·923		1·882		1·696		1·784		1·773		1·748	
K	0·144		0·221		0·395		0·208		0·198		0·156	
OH	1·462	1·46	0·667	1·51	2·174	2·17	0·190	0·36	0·778	0·93	1·208	1·21
F	—		0·845		—		0·165		0·156		—	

7. Hornblende, tonalite, Idaho (Larsen, E. S. & Schmidt, R. G., 1958, *U.S. Geol. Surv. Bull.* 1070-A; includes P_2O_5 0·17).
8. Pargasite, metamorphosed limestone, Finland (Laitakari, A., 1921, *Bull. Comm. géol. Finlande*, No. 54).
9. Ferrohastingsite, nepheline-syenite, Sweden (Quensel, P., 1914, *Bull. Geol. Inst. Upsala*, vol. 12, p. 146).
10. Basaltic hornblende, latite, Colorado (Larsen, E. S., Irving, J., Gonyer, F. A. & Larsen, E. S., 3rd., 1937, *Amer. Min.*, vol. 22, p. 889).
11. Kaersutite, cognate xenolith in trachyte (Aoki, K., 1959, *Sci. Rept. Tohoku Univ.*, ser. 3, vol. 6, p. 261).
12. Barkevikite, nepheline-syenite, Norway (Kunitz, W., 1930, *Neues Jahrb. Min.*, Abt. A., vol. 60, p. 171).

Table 15. AMPHIBOLE ANALYSES—*continued*

	13.	14.	15.	16.	17.	18.
SiO_2	57·73	52·41	53·80	48·51	57·10	48·41
TiO_2	—	0·45	0·10	1·32	0·35	1·32
Al_2O_3	12·04	0·61	1·37	6·60	6·19	1·81
Fe_2O_3	1·16	14·37	1·89	4·09	8·01	11·25
FeO	5·41	14·82	0·00	9·48	2·69	23·81
MnO	—	1·46	8·69	0·19	0·34	0·75
MgO	13·02	5·07	18·45	14·79	9·13	0·06
CaO	1·04	1·33	5·43	5·60	0·31	1·18
Na_2O	6·98	4·94	5·63	6·01	9·77	7·37
K_2O	0·68	2·10	1·72	2·20	2·38	1·52
H_2O^+	2·27	2·02	1·91	1·47	0·50	0·94
H_2O^-	—	0·10	—	—	0·08	0·13
F	—	0·30	0·36	—	2·69	2·95
	100·33	99·98	99·88	100·26	101·28	101·50
O ≡ F,Cl	—	0·13	0·16	—	1·13	1·24
Total	100·33	99·85	99·72	100·26	100·15	100·26
α	1·606	1·686	1·622	1·639	1·636	—
β	—	—	1·635	1·658	1·644	—
γ	1·627	—	1·641	1·660	1·649	—
$2V_\alpha$	—	—	66½°	38°	75°	—
D	3·085	—	3·08	—	3·16	—

NUMBERS OF IONS ON THE BASIS OF 24 (O,OH,F,Cl)

	13.	Σ	14.	Σ	15.	Σ	16.	Σ	17.	Σ	18.	Σ
Si	7·789	8·00	7·924	8·00	7·748	7·98	7·119	8·00	8·021	8·02	7·618	7·95
Al	0·211		0·076		0·232		0·881		—		0·334	
Al	1·704	5·05	0·032	4·92	—	5·24	0·259	5·28	1·025	4·89‖	—	4·74
Ti	—		0·051		0·011		0·145		0·037		0·156	
Fe^{+3}	0·118		1·634		0·206		0·452		0·847		1·332	
Mg	2·618		1·142		3·961		3·235		1·911		0·014	
Fe^{+2}	0·611		1·874		—		1·164		0·316		3·134	
Mn	—		0·187		1·061		0·024		0·040		0·100	
Na	1·826	2·09	1·448	2·07	1·572	2·74‡	1·708	3·00	2·660	3·13	2·248	2·75
Ca	0·150		0·215		0·838		0·880		0·046		0·199	
K	0·117		0·406		0·315		0·412		0·425		0·304	
OH	2·043	2·04	2·036	2·18	1·834	2·01§	1·440	1·44	0·469	1·66	0·988	2·46
F	—		0·143		0·163		—		1·193		1·468	

13. Glaucophane, glaucophane schist, Switzerland (Kunitz, W., 1930, *Neues Jahrb. Min.*, Abt. A., vol. 60, p. 171).
14. Riebeckite, aegirine–riebeckite syenite, Korea (Miyashiro, A. & Miyashiro, T., 1956, *Journ. Fac. Sci. Tokyo Univ.*, vol. 10, p. 1).
15. Richterite, metamorphosed limestone, Sweden (Sundius, N., 1945, *Geol. För. Förh. Stockholm*, vol. 67, p. 266; includes BaO 0·30, Cl 0·04, SO_3 0·19).
16. Magnesiokatophorite, theralite, Montana (Wolff, J. E., 1939, *Bull. Geol. Soc. Amer.*, vol. 49, p. 1569).
17. Eckermannite, nepheline-syenite, Sweden (Sundius, N., 1945, *Årsbok, Sveriges Geol. Undersök.*, vol. 39, No. 8; includes Li_2O 1·15, ZnO 0·59).
18. Arfvedsonite, arfvedsonite–aegirine syenite, east Greenland (Deer, W. A., Howie, R. A. & Zussman, J., 1963 *Rock Forming Minerals*, vol. 2, p. 368, Longmans).

‡ Includes Ba 0·017.
§ Includes Cl 0·010.
‖ Includes Li 0·650, Zn 0·061.

Table 18. Mica analyses

Table 18. Mica analyses—*continued*

	1.	2.	3.	4.	5.	6.	7.	8.	9.
SiO_2	45·24	48·42	49·29	40·95	39·14	37·17	35·98	35·03	49·80
TiO_2	0·01	0·87	0·12	0·82	4·27	3·14	2·35	2·56	0·00
Al_2O_3	36·85	27·16	3·17	17·28	13·10	14·60	18·06	20·38	25·56
Fe_2O_3	0·09	6·57	21·72	0·43	12·94	3·75	1·47	1·08	0·08
FeO	0·02	0·81	3·19	2·38	5·05	26·85	21·56	20·41	0·00
MnO	0·12	—	tr.	tr.	0·14	0·06	0·13	0·02	0·38
MgO	0·08	tr.	3·85	22·95	12·75	4·23	7·40	7·11	0·22
CaO	0·00	tr.	0·74	0·00	1·64	0·17	0·15	0·17	0·00
Na_2O	0·64	0·35	0·12	0·16	0·70	0·15	0·42	0·96	0·40
K_2O	10·08	11·23	6·02	9·80	6·55	8·25	9·09	8·62	9·67
F	0·91	tr.	—	0·62	1·11	0·85	0·09	—	6·85
H_2O^+	4·12	4·31	7·21	4·23	2·41	1·35	3·28	3·60	0·38
H_2O^-	0·46	0·19	4·60	0·48	0·58	—	0·23	0·07	0·50
	100·24	99·91	100·35	100·13	100·38	100·57	100·21	100·01	102·96
O≡F	0·38	—	—	0·26	0·46	0·36	—	—	2·89
Total	99·86	99·91	100·35	99·87	99·92	100·21	100·21	100·01	100·07
α	—	—	1·592	1·546	1·594	1·610	—	—	—
β	1·586	—	—	1·588–1·590	1·671	1·676	1·644	1·640	—
γ	1·589	—	1·614	1·590	1·672	1·677	—	1·640	—
$2V_\alpha$	46°	—	10°	0°–13°	10°–25°	5°	—	—	36°
D	—	—	2·580	2·78	2·862	—	—	—	2·898

Numbers of ions on the basis of 24 (O,OH,F)

	1.		2.		3.‡		4.	
Si	6·050	8·00	6·597	8·00	7·634	8·00	5·724	8·00
Al	1·950		1·403		0·366		2·276	
Al	3·860		2·959		0·213		0·562	
Ti	—		0·089		0·014		0·084	
Fe^{+3}	0·093		0·672		2·532		0·340	
Fe^{+2}	0·002	4·26†	0·091	3·81	0·413	4·06	0·276	6·04
Mn	0·014		—		—		—	
Mg	0·022		—		0·889		4·776	
Ca	—		—		0·123		—	
Na	0·166	1·98§	0·092	2·04	0·036	1·35	0·034	1·78
K	1·720		1·952		1·190		1·746	
F	0·385	4·06	—	3·92	—	4·00	0·278	4·22
OH	3·676		3·916		4·00		3·946	

	5.		6.		7.		8.		9.	
Si	5·790	8·00	5·972	8·00	5·545	8·00	5·339	8·00	6·750	8·00
Al	2·210		2·028		2·455		2·661		1·250	
Al	0·074		0·736		0·827		1·001		2·834	
Ti	0·474		0·379		0·272		0·293		—	
Fe^{+3}	1·440		0·454		0·170		0·124		0·008	6·17†
Fe^{+2}	0·625	5·44	3·608	6·20	2·780	5·77	2·602	5·64	—	
Mn	0·017		0·007		0·017		0·003		0·044	
Mg	2·811		1·013		1·700		1·615		0·044	
Ca	0·260		0·029		0·025		0·027		—	
Na	0·199	1·70	0·046	1·77	0·126	1·94	0·282	1·99	0·106	2·02‡
K	1·236		1·691		1·787		1·676		1·674	
F	0·519	2·90	0·431	1·88	0·043	3·42	—	3·66	2·936	3·28
OH	2·378		1·446		3·373		3·660		0·344	

1. Rose-muscovite, pegmatite, New Mexico (Heinrich, E. W. & Levinson, A. A., *Amer. Min.*, 1953, vol. 38, p. 25; includes Rb_2O 0·93, Cs_2O 0·20, Li_2O 0·49).
2. Muscovite, low grade psammitic schist, Inverness-shire (Lambert, R. St J., 1959, *Trans. Roy. Soc. Edinburgh*, vol. 63, p. 553).
3. Glauconite, sandstone, Otago, New Zealand (Hutton, C. O. & Seelye, F. T., 1941, *Amer. Min.*, vol. 26, p. 593; includes P_2O_5 0·32).
4. Phlogopite, marble, New Zealand (Hutton, C. O., 1947, *Trans. Roy. Soc. New Zealand*, vol. 76, p. 481; includes BaO 0·03).

† Includes 0·264 Li.
§ Includes 0·080 Rb, 0·012 Cs.
‡ Nos. of ions calculated on basis of 20 (O) and 4 (OH).

5. Biotite, quartz latite, Colorado (Larsen, E. S., Jr., Gonyer, F. A. & Irving, J., 1937, *Amer. Min.*, vol. 22, p. 898).
6. Biotite, granite, Southern California (Larsen, E. S., Jr. & Draisin, W., 1950, *Int. Geol. Congr. Rep. 18th Session, Gt. Britain*, Pt. 3, p. 66).
7. Biotite, low grade garnet–mica schist, Inverness-shire (Lambert, R. St J., 1959, *Trans. Roy. Soc. Edinburgh*, vol. 63, p. 553).
8. Biotite, garnet–sillimanite–mica schist, Angus, Scotland (Snelling, N. J., 1957, *Geol. Mag.*, vol. 94, p. 297).
9. Lepidolite, Varuträsk pegmatite, Sweden (Berggren, T., 1941, *Geol. För. Förh.*, vol. 68, p. 262; includes Li_2O 5·95, Rb_2O 1·97, Cs_2O 1·20).

† Includes Li 3·244. ‡ Includes Rb 0·172, Cs 0·070.

Table 4. GARNET ANALYSES

	1.	2.	3.	4.	5.	6.	7.
SiO_2	38·03	37·03	38·69	41·52	35·84	35·88	34·48
TiO_2	—	0·04	0·55	tr.	0·03	—	0·03
Al_2O_3	22·05	8·92	18·17	23·01	20·83	1·13	19·87
Cr_2O_3	—	—	—	0·22	—	27·04	—
Fe_2O_3	0·88	18·34	5·70	1·22	0·65	2·46	0·61
FeO	29·17	2·25	3·78	12·86	1·78	—	0·85
MnO	1·57	1·09	0·64	0·33	33·37	0·03	0·02
MgO	6·49	0·83	0·76	16·64	2·48	0·04	2·07
CaO	1·80	30·26	31·76	4·71	5·00	33·31	37·40
H_2O^+	—	0·48	0·13	} 0·16	—	} 0·18	4·65
H_2O^-	—	0·16	0·06		—		0·23
Total	99·99	99·40	100·24	100·67	99·98	100·07	100·24
n	1·793	1·827	1·7692	1·750	1·787	1·85(±)†	1·702
D	4·08	3·77	3·688	3·782	4·12	3·75	3·35
a(Å)	11·529	—	11·844	—	11·653	—	—

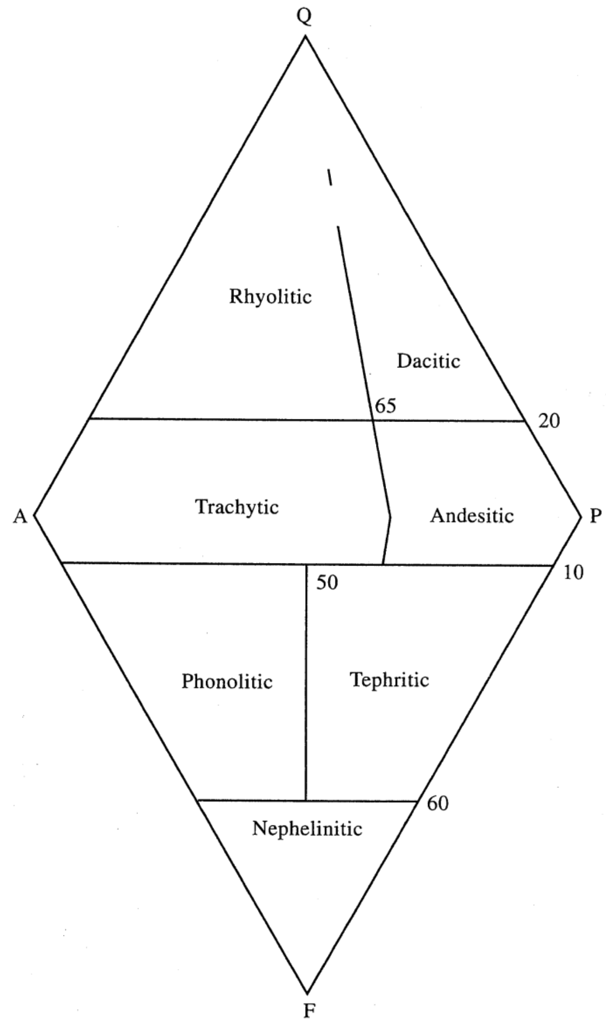
NUMBERS OF IONS ON THE BASIS OF 24 (O)

	1.		2.		3.		4.		5.		6.		7.	
Si	5·951	6·00	6·043		5·966	6·00	5·999	6·00	5·808	6·00	5·964	6·00	5·043	6·18
Al	0·049		—		0·034		0·001		0·192		0·036		1·133†	
Al	4·019	4·12	1·716	3·97	3·268	3·99	3·912	4·07	3·786	3·87	0·186	4·05	3·416	3·49
Cr	0·102		—		—		0·026		—		3·554		—	
Fe^{+3}	—		2·253		0·662		0·132		0·080		0·308		0·070	
Ti	—		0·005		0·064		—		0·004		—		0·003	
Mg	1·513	5·84	0·201	5·95	0·175	5·99	3·580	5·90	0·598	6·29	0·010	5·95	0·452	6·42
Fe^{+2}	3·818		0·307		0·487		1·552		0·241		—		0·104	
Mn	0·203		0·151		0·083		0·040		4·581		0·004		0·002	
Ca	0·302		5·292		5·248		0·730		0·868		5·934		5·858	

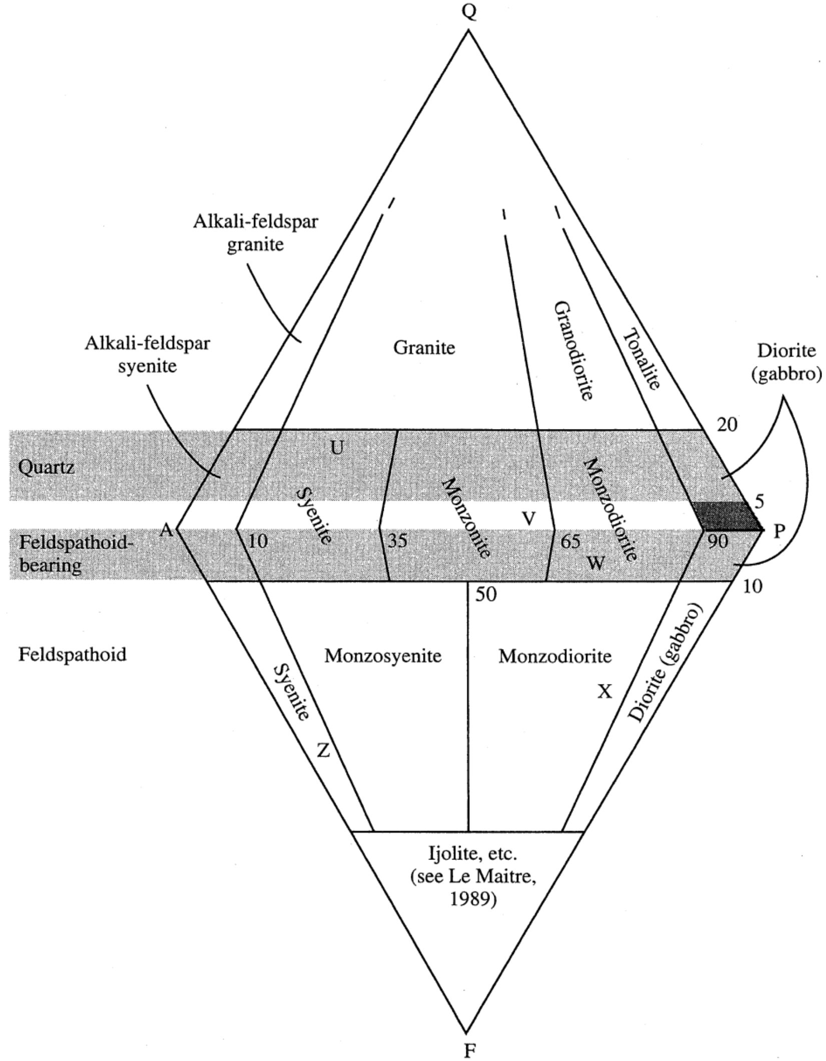
	1.	2.	3.	4.	5.	6.
Almandine	65·4	5·2	8·1	26·1	4·0	—
Andradite	2·7	56·9	18·2	3·3	2·2	7·7
Grossular	2·5	32·0	69·4	8·9	11·2	2·4
Pyrope	25·8	3·4	2·9	60·3	7·9	0·2
Spessartine	3·6	2·5	1·4	0·7	74·7	0·1
Uvarovite	—	—	—	0·7	—	89·6

1. Almandine, quartz–biotite gneiss, Adirondack Mts., New York (Engel, A. E. J. & Engel, C. G., 1960, *Bull. Geol. Soc. Amer.*, vol. 71, p. 1).
2. Reddish brown andradite, metasomatic fissures in thermally metamorphosed andesite, Shap, Westmorland (Firman, R. J., 1957, *Quart. Journ. Geol. Soc.*, vol. 113, p. 205).
3. Brownish red grossular, anorthite–clinozoisite–corundum–garnet gneiss, Sittampundi complex, Madras (Subramaniam, A. P., 1956, *Bull. Geol. Soc. Amer.*, vol. 67, p. 317).
4. Pyrope, eclogite, Rodhaugen, Sandmore, Norway (Eskola, P., 1921, *Vid. Skrift.* I, *Mat.-nat. Kl.*, vol. 1, no. 8).
5. Golden yellow spessartine, rhodonite–spessartine–pyrrhotite rock, calcsilicate hornfels, Meldon, Devonshire (Howie, R. A., 1965, *Min. Mag.* vol. 34 (Tilley vol.), p. 249).
6. Uvarovite, uvarovite–tremolite–tawmawite–pyrrhotite vein, Oütokumpu, Finland (Eskola, P., 1933, *Compt. Rend. Soc. géol. Finlande*, no. 7, p. 26).
7. Hydrogrossular, rodingite, Champion Creek, New Zealand (Hutton, C. O., 1943, *Trans. Roy. Soc. New Zealand*, vol. 73, p. 174; includes Na_2O 0·02, K_2O 0·01).

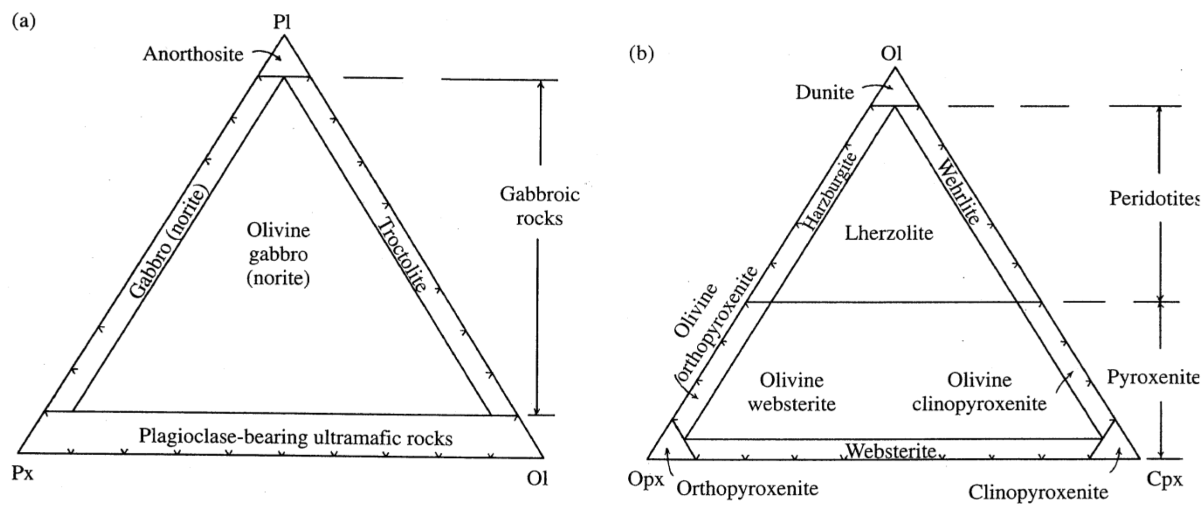
† For green light.
‡ OH/4.



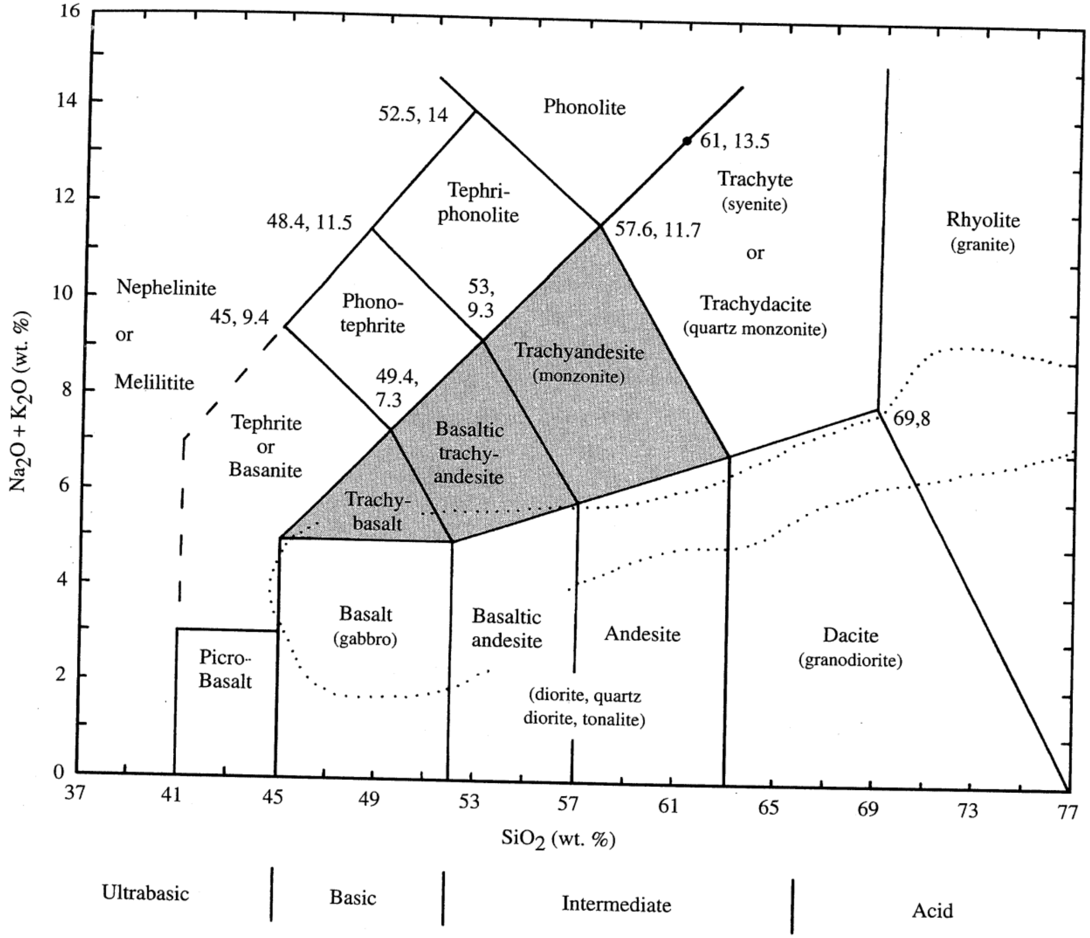
2.13 *Preliminary* classification of aphanitic and glassy rock types for use in cases in which an accurate chemical analysis is not available. This is a useful classification of rocks in the field or in thin section based upon the proportions of phenocrysts. Some rocks that are chemically rhyolite or dacite (Figure 2.12) contain quartz as the only phenocryst. (Redrawn from Le Maitre, 1989.)



2.8 Slightly modified IUGS classification of felsic, phaneritic, magmatic rock types that contain >10 modal % Q (quartz) + A (alkali feldspar) + P (plagioclase) + F (feldspathoids). Coordinates of critical field corners along the A-P join (10, 35, 65, 90) refer to modal percentages of P. Numbers on right side of diagram are modal percentages of Q (5, 20) and of F (10). Mineralogical prefixes on left side of diagram are modifiers to be appended to rock-type names in associated lightly shaded or unshaded fields. For example, a rock whose mode in terms of QAPF plots at U is a quartz syenite, V is a monzonite, W is a feldspathoid-bearing monzodiorite, X is a feldspathoid monzodiorite, and Z is a feldspathoid syenite. Rocks plotting in the small darkly shaded parallelogram near the P apex are **anorthosite** if containing <10% mafic minerals, or, if containing >10% mafic minerals, are gabbro or diorite. **Gabbro** contains plagioclase more calcic than An_{50} and is further classified according to Figure 2.10a. **Diorite** has plagioclase less calcic than An_{50}. The composition of plagioclase can be approximated in a thin section by optical techniques. In the lower part of the diagram, **ijolite** is a rock composed of nepheline and clinopyroxene; it is essentially a phaneritic equivalent of aphanitic to glassy nephelinite (Figure 2.12). For a supplementary classification of phaneritic felsic rocks (granitoids) containing abundant plagioclase and >20% quartz see Figure 2.9. (Redrawn from Le Maitre, 1989, Figure B.4.)



2.10 IUGS classification of phaneritic mafic and ultramafic rock types. (a) Classification of mafic rocks (see gabbro in Figure 2.8 and its tion) based on the proportions of plagioclase, pyroxene, and olivine. **Norite** has more orthopyroxene than clinopyroxene (see Le M: 1989, p. 17, for details). (b) Classification of **ultramafic** rocks that are composed of orthopyroxene, clinopyroxene, and olivine. For h blende-bearing ultramafic rocks see Le Maitre, 1989, Figure B.8. (Redrawn from Le Maitre, 1989.)



Further subdivisions of shaded fields	Trachybasalt	Basaltic trachyandesite	Trachyandesite
$Na_2O - 2.0 \geq K_2O$	Hawaiite	Mugearite	Benmoreite
$Na_2O - 2.0 \leq K_2O$	Potassic trachybasalt	Shoshonite	Latite

2.12 IUGS classification of aphanitic and glassy volcanic rock types. Coordinates of critical points are indicated as, for example, SiO_2 wt.% = 69 and (Na_2O + K_2O) wt.% = 8 at the common corner of the fields of trachyte, rhyolite, and dacite. Rocks plotting in the shaded area may be further subdivided into sodic and potassic rock types as shown in the box below the main part of the diagram. Figure 2.18 shows an alternate classification based on K_2O versus SiO_2. The distinction between trachyte ($Q < 20\%$) and trachydacite ($Q > 20\%$) is based on the amount of normative quartz, Q, from a recalculation in which $Q + An + Ab + Or = 100$. The amount of normative olivine, Ol, in the rock distinguishes tephrite (<10%) from basanite (> 10%). Rock-type names for more or less corresponding common phaneritic rocks are indicated in parentheses. Dotted line encloses 53% of the rocks plotted in Figure 2.4. (Redrawn from Le Maitre, 1989.)

Table 2.1 Whole-Rock Chemical Composition of Basalt from the Columbia River Plateau, Sample BCR-1[a]

SiO_2	54.06	Ag	27*	Er	3.63	Nd	28.8	Tb	1.05
TiO_2	2.24	As	650	Eu	1.95	Ni	(13)	Te	(4.9*)
Al_2O_3	13.64	Au	(0.66*)	F	490	Pb	(13.6)	Th	5.98
Fe_2O_3	3.59	Ba	681	Ga	22	Pr	6.8	Tl	0.3
FeO	8.88	Be	(1.6)	Gd	6.68	Rb	47.2	Tm	0.56
MnO	0.18	Bi	47*	Ge	1.5	Re	0.84	U	1.75
MgO	3.48	Br	(72*)	Hf	4.95	Rh	(0.23*)	V	407
CaO	6.95	Cd	130*	Hg	(7.9*)	S	410	W	(0.44)
Na_2O	3.27	Ce	53.7	Ho	1.26	Sb	0.62	Y	38
K_2O	1.69	Cl	59	In	92*	Sc	32.6	Yb	3.38
P_2O_5	0.36	Co	37	La	24.9	Se	(88*)	Zn	129.5
H_2O^+	0.75	Cr	(16)	Li	12.9	Sm	6.59	Zr	190
H_2O^-	0.81	Cs	0.96	Lu	0.51	Sn	(2.7)		
CO_2	0.03	Cu	(19)	Mo	(1.6)	Sr	330		
LOI	1.67	Dy	6.34	Nb	(14)	Ta	0.81		
Total	99.93								

[a]Major element oxides in wt.%. Less certain values in parentheses. *, Trace element concentration in parts per billion (ppb); all other trace elements in parts per million (ppm).
Data from Govindaraju (1989).

Table 2.2 Average Chemical Compositions of Some Common Rock Types (Recalculated Volatile-Free to Total 100%) and Their Normative Compositions[a]

	PHONOLITE	SYENITE	TRACHYTE	GRANITE	RHYOLITE	GRANODIORITE	DACITE	DIORITE	ANDESITE
n	340	517	534	2485	670	885	651	872	2600
SiO_2	57.43	59.63	62.31	71.84	73.95	66.91	65.98	58.34	58.70
TiO_2	0.63	0.86	0.71	0.31	0.28	0.55	0.59	0.96	0.88
Al_2O_3	19.46	16.94	17.27	14.43	13.48	15.92	16.15	16.92	17.24
Fe_2O_3	2.85	3.09	3.04	1.22	1.50	1.40	2.47	2.54	3.31
FeO	2.07	3.18	2.33	1.65	1.13	2.76	2.33	4.99	4.09
MnO	0.17	0.13	0.15	0.05	0.06	0.08	0.09	0.12	0.14
MgO	1.09	1.90	0.94	0.72	0.40	1.76	1.81	3.77	3.37
CaO	2.78	3.59	2.38	1.85	1.16	3.88	4.38	6.68	6.88
Na_2O	7.96	5.33	5.57	3.71	3.61	3.80	3.85	3.59	3.53
K_2O	5.36	5.04	5.07	4.10	4.37	2.76	2.20	1.79	1.64
P_2O_5	0.18	0.30	0.21	0.12	0.07	0.18	0.15	0.29	0.21
Q		0.83	5.00	29.06	32.87	22.36	22.73	10.28	12.37
C				0.92	1.02	0.26			
Or	30.96	29.29	29.41	24.50	25.44	16.11	12.82	10.42	9.60
Ab	35.48	44.34	46.26	31.13	30.07	31.73	32.07	29.96	29.44
An	1.50	7.24	7.05	8.04	4.76	17.34	20.01	24.40	26.02
Lc									
Ne	16.50								
Di	6.89	5.35	2.14				0.11	4.67	4.84
Wo	0.73								
Hy		4.16	2.06	3.37	1.34	7.40	5.73	12.56	9.49
Ol									
Mt	4.05	4.41	4.33	1.75	2.14	2.00	3.53	3.63	4.74
Il	1.18	1.60	1.34	0.58	0.54	1.03	1.09	1.80	1.65
Ap	0.41	0.70	0.49	0.28	0.17	0.42	0.34	0.68	0.50

PLATE

TOPOGRAPHY OF PLUTONIC ROCKS AND ORTHOGNESSES IN THE BOHEMIAN MASSIF