Two olivines from South African melilite-basalts.

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Introduction.—The separation and analysis of the olivine phenocrysts from the Spiegel river and Klaasvoogds melilite-basalts was undertaken in order to ascertain whether the olivines contain significant amounts of Ca_2SiO_4 in their constitution in view of the fact that the closely allied rock-types, alnöite (Bowen, 1922) and the basalt from Shannon Tier, Tasmania (Tilley, 1928), are known to contain monticellite, and that Taljaard (1936) has tentatively identified monticellite in one of the melilite-basalts from the Sutherland district, Cape Province.

The Spiegel river melilite-basalt from the Riversdale district of the Cape Province was first described by Corstorphine (1898). Petrographic descriptions of the rock have been given by Rogers and Schwarz (1898), Rogers and du Toit (1903), Rogers (1905), Wagner (1914), du Toit (1926), Taljaard (1936), and Holmes (1936). Partridge (1934) examined some of the minerals spectroscopically and recorded the presence of two grains of anatase in the heavy residue. The latest petrographic description, that by Holmes (1936), has been supplemented only in respect of the optical, chemical, and physical properties of the olivines. The author agrees with Taljaard (1936) in recording a complete absence of peg-structure in the melilites examined, but finds that the optical properties of the olivines differ somewhat from those he gives. It should be pointed out, however, in this connexion, that melilite-basalts are notoriously variable in their composition and that it is therefore quite possible that samples taken from different parts of the outcrop should show different concentrations and optical properties of their constituents.

The Klaasvoogds melilite-basalt from the farm Goedemoed Annexe in the Robertson district of the Cape Province was first discovered by M. S. Taljaard (1936), and his description of the rock is the only one as yet published. The writer has found some interesting variations in the optical properties of the olivines, and records for the first time the presence of nepheline, leucite, analcime, apatite, and zircon.

The present research includes a more detailed description of the

Klaasvoogds rock as well as chemical and optical data on the olivines from Spiegel river and Klaasvoogds.

Methods.—The olivines were separated for analysis by heavy liquid and magnetic methods, followed by hand-picking. 2V determinations were carried out on a four-circle universal stage and the refractive indices were measured by the immersion method using a Tully refractometer and sodium-light. Specific gravity was measured in alcohol by the pyknometer method.
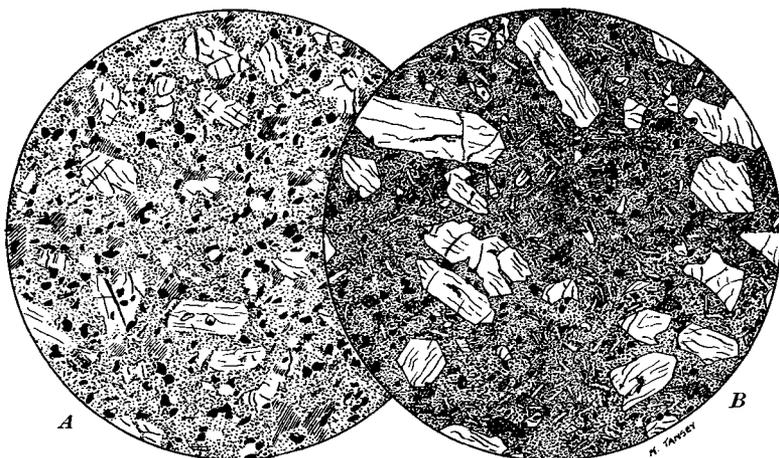

FIG. 1. *A*. Klaasvoogds melilite-basalt (×22 diam.). *B*. Spiegel river melilite-basalt (×22 diam.).

General petrography of the Klaasvoogds melilite-basalt.—In hand-specimen the melilite-basalt from Klaasvoogds can be distinguished readily from that of Spiegel river by the less compact nature of the groundmass. It is a porphyritic greenish-black rock containing phenocrysts of olivine measuring up to 10×6 mm. in size. The olivine is usually very fresh, but the larger crystals occasionally show complete serpentinization. In thin section (fig. 1) the olivine is colourless, rarely shows alteration, and has an average grain-size of 0·4×0·2 mm. Brachy-pinacoidal cleavage is frequently seen. The olivine may enclose magnetite; while biotite, clinopyroxene, and perovskite have occasionally formed along cracks within the crystals. The groundmass is composed of microporphyritic crystals of magnetite, melilite, perovskite, ±nepheline, set in a matrix composed of predominantly lath-like clinopyroxene,

magnetite, perovskite, melilite, interstitial biotite, nepheline, and colour-less isotropic material which it was not possible to identify in section. The proportion of nepheline and biotite present in the rock is variable. Melilite is optically negative and generally builds rectangular or hour-glass-shaped crystals elongated parallel to the base. It sometimes shows mechanical zoning of inclusions. The basal parting is rarely observable though prismatic cleavage is occasionally seen. Clinopyroxene is pale brown in colour, and has a maximum extinction angle of 44° and γ 1·724.

After separation in bromoform the light crop yielded nepheline (α 1·532, γ 1·536); leucite (n 1·508); analcime (n 1·486), and apatite (α 1·633). Analcime was identified by its refractive index and the nega-tive results to microchemical tests for sodalite, nosean, and haüyne.

Optical and chemical data for the olivines.—Two distinct sets of optical properties were found for the olivines in the Klaasvoogds melilite-basalt. The first, (A) values, were yielded by the samples collected for separation and analysis of the olivines. Later, samples were kindly collected by a student, Mr. E. S. W. Simpson, and these yielded similar values in some specimens and dissimilar values in others. The latter are indicated (B). It is, unfortunately, impossible to state with accuracy from which parts of the outcrop the two collections were made. All that can be said with certainty is that the basalt is variable in character. This is borne out not only by the difference in properties of the olivines, but by the con-siderable variation in the proportions of biotite, melilite, and nepheline.

TABLE 1. Chemical and optical data.

Olivine from the Spiegel river melilite-basalt. (Analyst, Geochemical Laboratories.)

Analysis.			100 %.	Atomic ratios.			Atomic ratio to 4O.	
SiO_2	...	... 39·12	39·24	Si⋯⋯	...	... 0·654	0·947	0·95
TiO_2	...	... 0·09	0·09	Ti⋯⋯	...	... 0·001	0·001	
Al_2O_3	...	... 0·58	0·58	Al⋯	...	... 0·011	0·016	
Fe_2O_3	...	... 1·69	1·70	Fe⋯	...	... 0·021	0·031	
FeO	...	... 10·76	10·80	Fe⋯	...	... 0·150	0·224	2·03
MnO	...	... 0·16	0·16	Mn⋯	...	... 0·002	0·003	
MgO	...	... 46·51	46·67	Mg⋯	...	... 1·167	1·739	
CaO	...	... 0·48	0·48	Ca⋯	...	... 0·009	0·013	
Na_2O	...	... 0·15	0·15	O⋯	...	... 2·685	4·000	4·00
K_2O	...	... 0·06	0·06	Formula:	$(Mg,Fe'',Ca,Mn)_2[SiO_4]$			
P_2O_5	...	... 0·07	0·07		$Fo_{89}Fa_{11}$			
H_2O+	...	... 0·21	100·00					
H_2O-	...	... 0·07		α 1·656, β 1·674, γ 1·695, 2Vγ 89°.				
			99·95					
Sp. gr.	...	... 3·33						

TABLE I (cont.).

Olivine from Klaasvoogds. (Analyst, Geochemical Laboratories.)

Analysis.			100 %.	Atomic ratios.			Atomic ratio to 4O·
SiO$_2$	...	37·33	37·43				
TiO$_2$	...	0·09	0·09	Si····	... ...	0·624	0·979	0·98
Al$_2$O$_3$	...	0·18	0·18	Al···	... ...	0·003	0·005
Fe$_2$O$_3$	...	1·60	1·61	Fe···	... ...	0·020	0·031
FeO	...	21·58	21·64	Fe··	... ...	0·300	0·471
MnO	...	0·27	0·27	Mn··	... ...	0·004	0·006	2·02
MgO	...	38·13	38·23	Mg··	... ...	0·956	1·500
CaO	...	0·38	0·38	Ca··	... ...	0·007	0·011
Na$_2$O	...	0·03	0·03	O··	... ...	2·550	4·000	4·00
K$_2$O	...	0·05	0·05				

Formula: $(Mg,Fe'',Ca,Mn)_2[SiO_4]$

P$_2$O$_5$ ... ... 0·09 0·09   Fo$_{76}$Fa$_{24}$

H$_2$O+... ... 0·17 100·00   (A): α 1·683, β 1·704, γ 1·722, 2Vα 85°.

H$_2$O−... ... 0·04   (B): α 1·657, β 1·672, γ 1·692, 2Vγ 89°.

99·94

Sp. gr. ... 3·53

TABLE II. Comparative chemical analyses.

		1.	2.	3.	4.	5.	6.	7.	A.	B.	C.
SiO$_2$	...	39·12	37·33	40·33	40·27	40·87	38·11	40·84	36·15	36·95	37·13
TiO$_2$	...	0·09	0·09	0·08	—	nil	trace	0·04	2·30	4·59	3·61
Al$_2$O$_3$	...	0·58	0·18	0·42	2·21	0·57	nil	0·19	15·18	7·85	10·58
Fe$_2$O$_3$	...	1·69	1·60	1·13	—	trace	0·15	0·13	4·87	4·78	2·00
FeO	...	10·76	21·58	10·39	7·14	6·77	31·48	8·18	9·11	8·70	10·43
MnO	...	0·16	0·27	0·11	—	trace	0·22	0·17	0·33	0·20	0·26
MgO	...	46·51	38·13	47·20	48·61	50·84	30·50	50·27	13·63	15·87	19·12
CaO	...	0·48	0·38	0·16	—	nil	0·02	—	11·40	13·60	13·02
Na$_2$O	...	0·15	0·03	0·12	—	—	—	—	2·42	2·32	1·32
K$_2$O	...	0·06	0·05	0·06	—	—	—	—	1·81	2·04	0·51
P$_2$O$_5$	...	0·07	0·09	—	—	—	—	—	0·26	0·83	nil
H$_2$O+	...	0·21	0·17	—	1·10	0·81	—	<0·37	1·95	1·64	0·83
H$_2$O−	...	0·07	0·04	—			—		0·37	0·49	0·37
&c.*	...	—	—	—	—	—	—	0·19	0·65	0·39	0·47
		99·95	99·94	100·00	99·33	99·86	100·48	100·38	100·43	100·25	99·65
2V	...	89°(+)	85°(−)	—	—	—	79°(−)	90° ca.	—	—	—
α	...	1·656	1·683	—	—	—	1·710	1·649	—	—	—
β	...	1·674	1·704	—	—	—	1·733	1·666	—	—	—
γ	...	1·695	1·722	—	—	—	1·748	1·684	—	—	—
Sp. gr.	...	3·33	3·53	—	—	—	—	3·3	—	—	—

1, Olivine, Spiegel river. 2, Olivine, Klaasvoogds. 3, Olivine (average), Hawaii (Daly, 1944). 4, Olivine, kimberlite, de Beers mine, South Africa (Wagner, 1914). 5, Olivine, kimberlite, Klipfontein mine (Wagner, 1914). 6, Olivine, Skaergaard, Greenland (Deer and Wager, 1939). 7, Olivine, California (Hawkes, 1946). A, Melilite-basalt, Spiegel river (Rogers and du Toit, 1903). * Cr$_2$O$_3$ 0·10, BaO 0·06, SO$_3$ 0·49. B, Melilite-basalt, Spiegel river (Holmes, 1936) *Cr$_2$O$_3$ 0·03, NiO 0·04, ZrO$_2$ 0·04, F 0·05, V$_2$O$_3$ 0·04, SrO 0·04, BaO 0·09, CO$_2$ 0·06. C. Melilite-basalt, Klaasvoogds (Taljaard, 1936) * CO$_2$ 0·47.

The analyses show excellent agreement with the compositions deduced from the optical properties in the forsterite–fayalite solid solution series. The presence of ferric iron is undoubtedly due to a small admixture of magnetite as impurity in the samples. The low percentages of CaO are

noteworthy. This shows that the olivines belong to the forsterite–fayalite series, and that monticellite is absent. Fayalitic olivines from Skaergaard in Greenland show the same low values for CaO, and Deer and Wager (1939) note a discrepancy between the actual weight percentage CaO in the analysed olivines and the theoretical values deduced from the system CaO–FeO–SiO_2. In one, a rock containing 9·05 % CaO, the lime content of the fayalite was 2·18 % instead of a theoretical value of 6–7 %.

It is known from the work of Bowen, Schairer, and Posnjak (1933) that the lime-iron-olivine ($CaFeSiO_4$) and fayalite (Fe_2SiO_4) form a series of solid solutions with a minimum. The relationship between monticellite ($CaMgSiO_4$) and forsterite (Mg_2SiO_4) is not fully known. In their investigation of the system CaO–MgO–SiO_2, Ferguson and Merwin (1919) state that monticellite takes up forsterite in solid solution to the extent of about 10 %. Bowen, Schairer, and Posnjak (1933) refer to the identical crystal structures of monticellite and forsterite as determined by Bragg and Brown (1926), and Brown and West (1927), but doubt whether complete solid solution exists between them. The evidence from rocks appears to favour the view that, under igneous conditions, there is little lime present in either the forsteritic or the fayalitic olivines, and that, where present, monticellite is of replacement origin.

Abstract.—Two olivines from the Spiegel river and Klaasvoogds melilite-basalts of the Cape Province are analysed. Optical properties for the olivines are given. These show excellent agreement with the chemical results. The olivines belong to the forsterite–fayalite series and do not contain significant amounts of Ca_2SiO_4. The presence of nepheline, leucite, analcime, apatite, and zircon in the Klaasvoogds melilite-basalt is described for the first time.

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