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MICA LAMPROPHYRE (ALNÖITE) FROM RADOK LAKE, PRINCE CHARLES MOUNTAINS, ANTARCTICA

by

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Early in 1969, geologists of the Bureau of Mineral Resources working with the Australian National Antarctic Research Expedition noted basic sills in the Permian sediments at the southwest corner of Radok Lake (latitude 70°54'S, longitude 67°56'E). Laboratory work showed that the sills are examples of the fairly rare mica lamprophyre alnöite, and are of Cretaceous age.

Two sills occur in conglomerate near the base of the sedimentary sequence, the Amery Group (Mond, in press), which is of Upper Permian age (Kemp, 1969). They are exposed in vertical cliffs, and can be traced horizontally over a distance of 1000 metres. The lower sill is about 4 metres thick at its western exposed extremity, its thickness increasing eastwards to 20 metres. The upper sill, which is stratigraphically about 300 metres above the lower, is about 5 metres thick. The sills were sampled at different times by A. Mond and J.H. Bain. Four specimens were selected for detailed study.

Thin dykes were found in the sediments 6½, 7, and 11 km northeast of the sills. The outcrops of all three are too weathered to enable their compositions to be determined with any confidence.

Basic dykes occur in the metamorphic rocks of the region. Most have been metamorphosed to various extents, and are probably unrelated to the sills described here.

The rocks of the sills are massive and dark grey, and they glisten with small dark mica flakes. In some of the most altered varieties, however, only olivine facets are seen. Thin section examination reveals distinct mineralogical variations amongst the rocks. These variations are in the proportion of primary minerals present as well as in the extent of secondary mineral development. All of the rocks are deuterically altered to various degrees, and modal estimations of primary phases necessarily include some of the associated alteration products of each phase.

The porphyritic and panidiomorphic textures, together with the mineral compositions, are characteristically those of lamprophyres. The least altered rocks consist mostly of phlogopite, melilite, olivine, and nepheline, and minor amounts of opaque iron mineral, perovskite, and apatite. Crystals, except those of nepheline, are euhedral or subhedral, though some of the phlogopite flakes have battlemented ends. Grainsize is variable for each phase, and ranges from about 0.1 to 3 mm for phlogopite, olivine, and nepheline, whereas melilite formed narrow laths from 0.5 to 1 mm in length.

Olivine appears to occur in two size ranges, as phenocrysts, some of which are corroded, and as a groundmass phase. Melilite laths may be roughly parallel, or in a sheaf-like arrangement, or grouped around the olivine phenocrysts. Some of these laths pierce large phlogopite flakes and anhedral nepheline grains in a subophitic fashion. These relationships suggest that the mineral paragenesis was olivine, melilite, phlogopite, and nepheline.

Because of extensive deuteric alteration secondary minerals make up from 30 to 70 percent of the rocks. There are various sheet-structure minerals pseudomorphing olivine, such as greenish serpentine, talc, and probably some antigorite. Prehnite, with typical spherulitic and bow-tie structures, replaces melilite in part. Carbonates, probably mainly dolomite, fill interstitial patches, and with them are apatite needles and small phlogopite and talc flakes.

Rock 69280071 is the most altered; only the numerous olivine phenocrysts, together with some phlogopite flakes and small perovskite grains, escaped alteration. However, in general, olivine nearly always shows some alteration along grain cracks and margins; the serpentine-like mineral formed is commonly dusted with opaque iron mineral inclusions, and as a consequence has a blue-grey streaky appearance, and grain margins may be nearly opaque. In one specimen (69280153) it is completely altered.

Olivine makes up from 10 to 25 percent of the rocks. Most grains are in the range Fo_{82} to Fo_{89} (microprobe determinations) and are fairly homogeneous. Some may show normal and reverse zoning in this range, and one large embayed crystal in 69280071 has a Fo_{72-75} core and Fo_{84-87} rim.

However, variations are usually much less than this, and groundmass and phenocrystic olivine in all three rocks is predominantly about Fo_{88}.

The mica content is also very variable and in the analysed rocks ranges from 35 to 55 percent, but is less than 10 percent in 69280071. It is the mineral least affected by deuteric alteration, and is found amongst prehnite and carbonates. Its Fe content ranges from 5.5 to 6.6, 7.0 to 8.1, and 8.9 to 9.6 percent (microprobe determinations) in 69280152, 69280334, and 69280071 respectively. The K content ranges from 7.5 to 7.9 percent in the rocks used for age determination. These values indicate that the mica is phlogopite.

Melilite forms from 15 to 40 percent of the rocks, but is prone to alteration, and consequently is entirely replaced by secondary minerals in, for example, 69280071. Where laths remain they have parallel extinction and typical bluish first order interference colours. The identification of this mineral was confirmed by microprobe. A similar check confirmed the presence of nepheline. This makes up 5 to 10 percent of the rocks, but it also is commonly altered. Grains are uniaxial negative, and have refractive indices $\varepsilon = 1.543$ and $\omega = 1.547$.

Opaque iron mineral grains are scattered throughout, and the abundant small ones, including cubes, range from 0.025 to 0.1 mm. They make up 3 to 5 percent of the rocks, and most are ilmenite embayed and fringed with magnetite. Commonly associated with them, particularly in the carbonate-rich patches, are similar-sized octahedra and grains of greenish brown perovskite. These are nearly isotropic between crossed nicols and make up about 2 percent of the rock. Rare pyrite is associated with them in places but may be secondary. The other conspicuous minor phase is apatite, needles of which are up to 2 mm in length; it forms up to 1 percent of the rocks and, apart from being in the carbonate-rich patches, is mainly seen between phlogopite cleavages.

Mica concentrates were separated from three rocks for K/Ar age determination. There is good agreement, within experimental error, in the ages obtained (Table 1), and the minimum age is $110 \pm 3 \times 10^6$ m.y.

TABLE 1 : AGE OF MICA LAMPROPHYRE

		K content (%)	K/Ar age*(m.y.)
69280152[+]	Mica concentrate	7.878	110 ± 3
69280153[+]	Mica concentrate		110 ± 3
69280334[+]	Mica concentrate	7.544	108 ± 3

Geochronologist: A.W. Webb, Amdel, Adelaide, South Australia

* Constants used: $K^{40} = 0.0119$ atom %, $\lambda_\beta = 4.72 \times 10^{-10}$/yr., $\lambda_e = 0.584 \times 10^{-10}$/yr.

\+ Bureau of Mineral Resources Registered Specimen Number

The two freshest dated rocks were chemically analysed, and were found to have very similar compositions (Table 2). The compositional variations between them do not reflect secondary mineralogical variations, indicating that these are mainly the result of deuteric alteration. Both the petrographic and chemical features of these rocks are consistent with their being alnöite.

TABLE 2 : ANALYSES OF MICA LAMPROPHYRES

	69280152[1]	69280334[2]	Orkneys[3] Alnöite	Average[4] Alnöite
SiO_2	36.0	36.2	35.54	32.31
TiO_2	2.20	2.20	2.03	1.41
Al_2O_3	9.45	9.50	11.72	9.50
Fe_2O_3	2.95	2.20	5.86	5.42
FeO	7.65	8.35	5.99	6.34
MnO	0.18	0.20	-	-
MgO	14.5	14.7	13.56	17.43
CaO	16.1	15.6	15.83	13.58
Na_2O	1.95	1.78	1.91	1.42
K_2O	2.85	2.75	2.24	2.70
P_2O_5	0.84	0.69	0.32	2.39
H_2O^+	3.55	4.10	1.67	3.15
H_2O^-	0.32	0.51		
CO_2	1.40	1.20	4.30	4.35
	99.94	99.98	100.97	100.00

Analysts: 1 & 2 A.H. Jorgenson, Amdel, Adelaide; 3 Sir J.S. Flett, 4 Average of 6 alnöite analyses, quoted from Hatch and Wells (1937, p.248).

The uniform age and/chemical composition of the rocks suggest that the sills were emplaced rapidly in a single magmatic event, and that they crystallized without significant differentiation having taken place in them.

Their petrogenesis is unclear, but possibly they derive from an ultrabasic magma-type, as they are extremely low in silica and very basic. Moreover, they are lower in total alkalis (particularly in Na_2O) and much more basic than the abundant types of lamprophyre (the camptonites and monchiquites on the one hand, and the minettes, vogesites, kersantites, and spessartites on the other). Metáis and Chayes (1963) have established fairly reliable average compositions for the members of these two groups, and Joplin (1966) has discussed their petrogenesis. She considers that the first group largely originates from normal alkali basalt, and the second from a very potash-rich basaltic magma, shoshonite. However, the alnöite now described from Antarctica, like that from the type area at Alnö in Sweden, and that from other well-known occurrences such as the Orkney Islands (Table 2), is more basic than the lamprophyres in either of these two groups. The Na_2O content of alnöites is not inconsistent with that in many ultrabasic rocks, but K_2O content is generally much higher. Indeed, in this regard the alnöites are more comparable with average monchiquite, and Joplin (1966) has suggested already that the monchiquites themselves may be divisible into two groups of which the main one probably derives from alkali basalt magma.

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