Petrology of ultramafic lamprophyres from the Beaver Lake area of Eastern Antarctica and their relation to the breakup of Gondwanaland

S. F. Foley¹, A. V. Andronikov², and S. Melzer³

¹Institut für Geologische Wissenschaften, Universität Greifswald, Greifswald, Germany
²Department of Geological Sciences, University of Michigan, Ann Arbor, Mi, U.S.A.
³Projektbereich 4.1, Geoforschungszentrum Potsdam, Potsdam, Germany

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Summary

Mesozoic melilite-bearing ultramafic lamprophyres are developed as sill, dyke and plug-like intrusive bodies in the East Antarctic Beaver Lake area. They consist of varying amounts of olivine, melilite, phlogopite, nepheline, titanomagnetite and perovskite as major phases, accompanied by minor amounts of apatite, carbonate, spinel, glass and, rarely, monticellite. The rocks are mineralogically and geochemically broadly similar to olivine melilitites, differing in higher CO₂ and modal phlogopite and carbonate contents. The ultramafic lamprophyres are MgO-rich (13.4–20.5 wt%) and SiO₂-poor (32.8–37.2 wt%), indicative of a near-primary nature. Major and trace element features are consistent with minor fractionation of olivine and Cr-spinel from melts originating at depths of 130–140 km.

Primary melts originated by melting of upper mantle peridotite which had been veined by phlogopite + carbonate + clinopyroxene-bearing assemblages less than 200 Ma before eruption. The presence of the veins and their time of formation is required to explain high incompatible trace element contents and growth of ⁸⁷Sr/⁸⁶Sr, leaving ¹⁴³Nd/¹⁴⁴Nd unaffected. The major element, compatible trace element, and most radiogenic isotope characteristics are derived from melting of the wall-rock peridotite. The depth of about 130 km is indicated by the presence of phlogopite rather than amphibole in the veins, by control of the REE pattern by residual garnet, by the high MgO content of the rocks, and by the expected intersection of the rift-flank geotherm with the solidus at this depth. The higher CO₂ contents than are characteristic for olivine melilitites favoured the crystallization of melilite at crustal pressures, and suppressed the crystallization of clinopyroxene. The Beaver Lake ultramafic lamprophyres are a distal effect of the
breakup of Gondwanaland, too distal to show a geochemical signature of the Kerguelen plume. Upward and outward movement of the asthenosphere-lithosphere boundary beneath the Lambert-Amery rift led first to the production of phlogopite- and carbonate-rich veins, and later to the generation of the ultramafic lamprophyres themselves.

Introduction

Ultramafic lamprophyres (UML) are rare, but widespread, hypabyssal rocks rich in K, Mg, Cr, Ni, Sr, Ba, REE, and volatiles, containing less Si and more Ca than most other silicate igneous rocks (Rock, 1986). Their mineralogy is characterized by phenocrysts of magnesian olivine, Ti-rich phlogopite, Ti-augite and rarely richteritic amphibole. The groundmass may be made up of feldspathoids, melilitc, Ca–Fe–Mg carbonates (partly primary), Mg–Mn-ilmenite, perovskite, Ti–Cr-spinel, Ti-magnetite, monticellite, and glass. UML can also contain various deep-seated xenoliths.

UML may be subdivided, following Rock (1986, 1991), into two common types defined by the predominance of either melilitc or carbonate in the groundmass as alnoite (v. Eckerman, 1966) and aillikite (Malpas et al., 1986), respectively. Rarer types include polzenite (melilitc and feldspathoids in the groundmass), ouachitite (feldspathoids and carbonates) and damkjerite (feldspathoids, carbonates and rare alkali feldspars).

The intrusive UML bodies of the Beaver Lake area in the northern Prince Charles Mountains (Fig. 1) are one of only three currently known occurrences of the UML in East Antarctica. The other two are Proterozoic damkjerite dykes in the Vestfold Hills area (Delor and Rock, 1991; Mikhalsky et al., 1994), and Paleozoic ouachitite dykes at Schirmacher Oasis (Hoch, 1999).

The Beaver Lake occurrences are related to the Lambert-Amery rift system, the largest continental rift system in Antarctica (Kurin and Grikurov, 1980), and can be divided into two separate spatial groups (Fig. 1). The northern group is represented by a dyke and two-multiphase stocks, known as the Novoe and Konus bodies. In the Konus body a tuffaceous breccia of alkaline nepheline-rich picrite is later intruded by ultramafic lamprophyre. The Novoe body contains three phases of emplacement: autolithic kamafragite breccia, ultramafic lamprophyre, and nepheline-rich alkaline picrite. Following Mitchell (1986), the dyke and the Novoe intrusion may represent different erosion levels of the root zone of a diatreme-like intrusive, whereby the dyke represents a diatreme-related dyke, and the Novoe body can be considered a “blow of a diatreme”. The dyke is 1–2 m thick and is located 500 m west of the Novoe body (Fig. 1; Andronikov and Egorov, 1993). All intrusives of the northern group were emplaced into metamorphic rocks of the Precambrian crystalline basement.

The southern group is represented by two sills ≈ 12 m and 5 m thick which intrude Permian sediments and crop out on the southern shore of Radok Lake (Fig. 1). Only the lower sill Radok-1 is treated here; the other is highly serpentinized and has, therefore, not been investigated in detail. The Radok-1 sill dips between 5 and 10° to the southeast and can be traced for 950 m along outcrop. The timing of the emplacement is constrained by K–Ar determination on bulk rock of 110–117 Ma (Ravich et al., 1978; Laiba et al., 1987) and on mica separates (110 Ma; Walker and Mond, 1971).