A potassic magma series in the Pilanesberg Alkaline Complex?

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The Pilanesberg Alkaline Complex (South Africa) consists of a partially eroded phonolitic-trachytic package of lavas and tuffs, intruded by consanguinous syenites and nepheline syenites (foyaites). The latter have been divided in several units, based on their colour and mineralogy. Most of the foyaitic units are sodic in composition, but whole rock analyses show that some samples are more potassic, with $Na_2O/K_2O<0.8$. This observation, together with old reports of leucite-bearing lavas [1], could suggest the existence of a second, potassic magmatic lineage. To investigate whether the observed potassium-enrichment is a primary feature, or the result of deuteric alteration, the mineralogical distinction between sodic and potassic samples was investigated.

The mineralogy of the sodic samples is dominated by nepheline, alkali-feldspar and aegirine, ± titanite, amphibole, biotite, and late agpaitic phases [2]. Within the potassic samples, the main primary ferromagnesian mineral is biotite, which shows conspicuous zoning in thin section; nepheline has been extensively replaced by sodalite and cancrinite, but alkali-feldspar appears relatively unaltered. No agpaitic minerals were observed.

U-Pb isotope systematics of titanite are similar for sodic and potassic samples in terms of the age (ca. 1.4 Ga) and composion of common Pb; Ar-Ar dating of biotite also gives ca. 1.4 Ga, showing that biotite is a primary magmatic phase.

Compositions of the biotite in sodic and potassic samples are similar, with the sodic samples having slightly higher Fe# (independent of whole rock Fe#), higher Na, but lower (Na+K) and Ba. Zoning in biotite from potassic samples is related to a decrease in Mg, Ti and F in the rim of the crystals. Despite the primary character of the biotite, the question whether the potassic samples reflect a combination of alteration and perhaps minor crustal contamination, or a separate magma series needs further elucidation with isotopic studies.

[1] Humphrey, W.A., 1912. Annual Reports of the Mines Department of the Union of South Africa, 50: 76-88.

[2] Andersen, T., Elburg, M.A., Erambert, M., 2017. Chemical Geology, in press.