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The Mesoproterozoic Pilanesberg Complex – Whole Rock Geochemistry

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The Pilanesberg Complex (PC) is a prominent feature of South Africa's geology, and the second -largest alkaline complex in the world [1]. Its age, geology and geochemistry are, however, quite poorly known.

New whole rock major and trace element data have been combined with published analyses and thin section observations to characterise the extrusive (trachytic-phonolitic lavas and tuffs) and intrusive (Red Syenite, Red Foyaite, White Foyaite, Green Foyaite Suite and Tinguaita) units within the complex. Most samples are dominated by perthitic alkali feldspar, with variable amounts of aegirine and/or nepheline. Many samples have undergone extensive deuteric alteration, most notably the lavas and tuffs, Red Syenite and Red Foyaite. Alteration may be the cause for some of the samples' having $\text{Na}_2\text{O}/\text{K}_2\text{O}$ ratios < 1 , but reports of leucite-bearing volcanic samples [2], and the presence of apparently primary biotite within some of the Red Foyaite samples suggest the presence of a sodic and a potassic lineage within the complex. The presence of unaltered potassium-rich phases also permits Ar-Ar age dating of some of the samples, while titanite can be used for U-Pb dating.

All units, apart from the Red Foyaite, contain a number of peralkaline (molar $\text{Na}+\text{K} > \text{Al}$) samples, but no unit is exclusively peralkaline. The few samples that are peraluminous (molar $\text{Al} > \text{Na}+\text{K}+\text{Ca}$) are likely influenced by alteration. Agpaitic samples (peralkaline samples with unusual HFSE-bearing silicates such as aenigmatite, astrophyllite and eudialyte) occur among the White Foyaite, Green Foyaite Suite and Tinguaita. All rock types are evolved ($\text{MgO} \leq 2$ wt.%), but no clear differentiation trends can be established from the whole rock data, neither within or between the different units.

High Sr contents of the Foyaites and Tinguaita indicate that plagioclase cannot have been a major phase within the crystallising or residual mineral assemblage during magma genesis. Moderate contents of Y and M-HREE suggest that this role could have been taken by clinopyroxene or amphibole. The latter mineral is, however, an uncommon phase that does not appear to be particularly early within the fractionating assemblage.

Although primitive mantle-normalised trace element patterns are somewhat variable between units, they invariably show positive Nb anomalies, in line with the inferred intraplate occurrence of magmatism. Levels of trace element enrichment are significantly greater than for the silicate rocks associated with the Spitskop complex of similar age [3]. Published data from other alkaline complexes show a greater resemblance of the PC with the Devonian Kola peninsula occurrences than with the Mesoproterozoic Ilimaussaq Complex of Greenland. However, the PC is unique in its elevated Mn/Fe ratios, which could reflect either source feature or a higher oxygen fugacity during differentiation than typical for alkaline complexes.

Preliminary LA-MC-ICPMS Sr isotope data on high Sr/Rb mineral phases show that the magma was derived from a moderately depleted mantle source, not dissimilar to that of the slightly younger Premier kimberlite [4].

References:

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- [2] Humphrey WA (1912) Ann Rep Mines Dept S Afr 50: 76-88
- [3] Harmer (1999) J Petrol 40: 525-548
- [4] Wu et al. (2013) Chem Geol 353:83-95

