THE GROUP–2–KIMBERLITE – LAMPROITE CONNECTION: SOME CONSTRAINTS FROM THE BARKLY-WEST DISTRICT, NORTHERN CAPE PROVINCE, SOUTH AFRICA.

Kenneth M. Tainton and Paul Browning.

Dept. of Earth Sciences, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, UK.

Group-2 (micaceous) kimberlites and lamproites are derived from enriched source regions within the sub-continental lithosphere. Comparison of the petrogenesis of these rock types has, however, been complicated by the fact that they have not previously been described from the same cratonic block. The Sover-Doornkloof and Sover-North intrusions lie within the Barkly-West Group-2 kimberlite cluster in the northern Cape Province, South Africa. The bodies intrude andesites of the Ventersdorp Supergroup. Sover-Doornkloof and Sover-North would be described on petrographic grounds as having kimberlitic and lamproitic affinities respectively. These bodies therefore allow comparison of the petrogenesis of kimberlite and lamproitic intrusions from a common cratonic setting.

Sover-Doornkloof is a 6.5km long bifurcating, en echelon dyke set striking NNE-SSW. The dyke consists of diamondiferous, macrocrystic phlogopite kimberlite (Group-2), and shows evidence for multiple intrusion. The individual magma pulses are indistinguishable in terms of mineral chemistry and whole-rock geochemistry. Flow differentiation has resulted in an inhomogeneous distribution of olivine macrocrysts through the kimberlite. The whole-rock composition of the kimberlite is correlated with the modal proportion of olivine macrocrysts. Mixing between entrained mantle peridotite and the host kimberlite magma is the primary cause of whole-rock geochemical variation within the intrusion.

The Sover-North intrusion, lying 1.5 km W of Sover-Doornkloof, is an elliptical plug having a surface area of approximately $600m^2$. Sover-North is a composite intrusion, consisting of an early, xenolith-rich phase (SN1), and a later, auto-intrusive plug (SN2). The SN1 intrusion contains rare macrocrysts and abundant phenocrysts of olivine, poikilitic phlogopite, diopside microlites and pseudomorphs after leucite set in a base of altered sanidine and glass. Potassic-richterite is also present in the groundmass of the SN2 intrusion. Both the poikilitic (madupitic) phlogopite of SN1 and the euhedral groundmass plates in SN2 are strongly zoned to Al_2O_3-poor, TiO_2-rich rims. This zoning scheme has been described by Mitchell (1985) from numerous lamproite occurrences and is regarded as atypical of kimberlite micas. In addition, the groundmass of the SN1 intrusion contains an accessory hollandite mineral compositionally similar to priderite. On the basis of the classification schemes of Scott-Smith and Skinner (1984) and Mitchell (1985), SN1 is described as an olivine-leucite-phlogopite lamproite, and SN2 as an olivine-potassic richterite-phlogopite lamproite. Despite marked differences in the petrography and groundmass mineral chemistry of the SN1 and SN2 intrusions, they are geochemically identical.

In terms of major and compatible trace element compositions, the Sover-North intrusions are intermediate between those of the Kaapvaal Craton Group-2 kimberlites and olivine lamproites from Western Australia and North America. However, mixing with entrained mantle peridotite and surface alteration processes have disturbed these geochemical systems, obscuring the major element compositions of the initial magmas.

Both the Sover-North lamproites and the Sover-Doornkloof kimberlite show extreme enrichment in the incompatible trace elements. However, the kimberlite shows a greater degree of enrichment in the highly incompatible elements (Th, Ta, Nb) than the lamproite, allowing discrimination between the respective intrusions (Fig. 1). This relationship is also demonstrated by the rare-earth elements (Fig. 2). Although chondrite normalised rare-earth element profiles of Sover-North lamproite samples show complete overlap with the compositional range of Sover-Doornkloof kimberlite samples, the fractionation of LREE relative to HREE is greater for the kimberlite (mean La/Yb = 179) than for the lamproite (mean La/Yb = 129). This relationship would argue against generation of the lamproites by fractional crystallisation from the (more primitive) kimberlite magma.

The intrusions have radiogenic strontium ($^{87}Sr/^{86}Sr$ = 0.7071-0.7076) and unradiogenic lead ($^{206}Pb/^{204}Pb$ = 17.062-17.428, $^{207}Pb/^{204}Pb$ = 15.441-15.529, and $^{208}Pb/^{204}Pb$ = 37.440-37.716) isotopic compositions. The Sover-North lamproite has, on average, slightly less radiogenic Sr and Pb than the Sover-Doornkloof kimberlite. This would not be consistent with generation of the compositional differences between these bodies by crustal contamination, as the observed contaminants of the Sover-North lamproitic magma have higher $^{87}Sr/^{86}Sr$ than the kimberlite.

The isotopic compositions of the intrusions indicates that the magmas were derived from source reservoirs that had been isolated from the convecting mantle for at least 1Ga. The similarity in isotopic ratios indicate that the enrichment histories and incompatible trace element compositions of the respective source regions were similar. The observed geochemical differences between the intrusions suggest that, for the Kaapvaal Craton at least, Group-2 kimberlite and lamproite magmas may be derived by variable degrees of partial melting of similar, enriched source reservoirs.

References:

Jaques, A.L., Sun, S.-S., and Chappell, B.W. (1989) Geochemistry of the Argyle (AK1) lamproite pipe, Western Australia. In Kimberlites and related rocks, Vol. 1, p. 170-188. Blackwell, Victoria.

Mitchell, R.H. (1985) A review of the mineralogy of lamproites. Trans. geol. Soc. S. Afr., 88, 411-437.

Scott-Smith, B.H., and Skinner, E.M.W. (1984) A new look at Prairie Creek, Arkansas. In Kornprobst, J., Ed., Kimberlites 1: Kimberlites and related rocks, p. 255-283. Elsevier, Amsterdam.

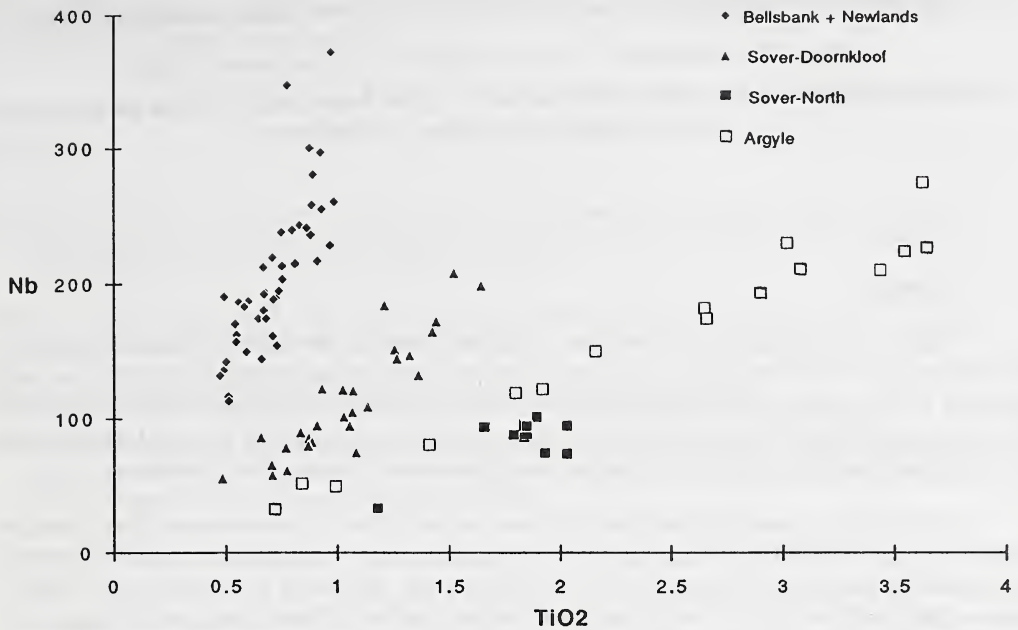

Fig.1: Plot of Nb (ppm) versus TiO2 (wt. % oxide) for samples of the Bellsbank, Newlands and Sover-Doornkloof kimberlites, Sover-North and other lamproitic intrusions from South Africa, and the Argyle lamproite (Jaques et al, 1989).

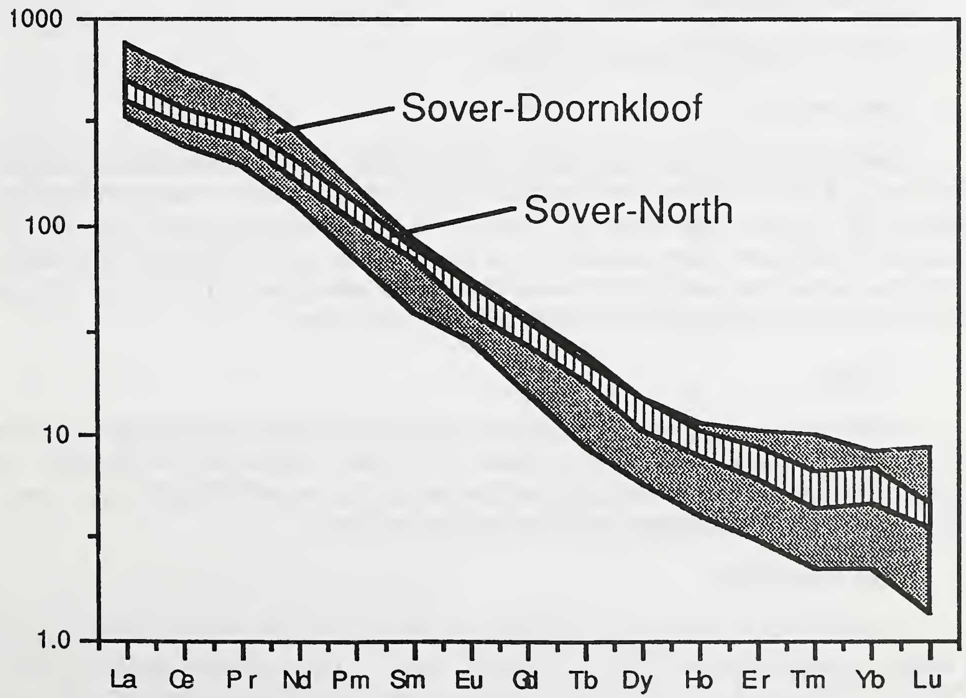

Fig. 2: Chondrite normalised rare-earth element spidergram for samples from the Sover-Doornkloof kimberlite and Sover-North lamproite.