# KIMBERLITE AS A VARIETY OF LAMPROPHYRE

Nicholas M. S. Rock

Dept. Geology, University of Western Australia, Nedlands, Perth 6009, WA.

Kimberlites have often been compared, classified or confused with lamprophyres. The framework in Figure 1 may help to clarify both their respective affinities and differences, by reappraising kimberlite as a 'family' of rock-types within the lamprophyre 'clan'. Kimberlites must be varieties of lamprophyres, not vice-versa, because: (i) micaceous kimberlites are frequently described as 'lamprophyric' (e.g. Skinner & Clement 1979), but relatively few lamprophyres as 'kimberlitic'; (ii) lamprophyre is a less restrictive, purely descriptive term with no type-locality; (iii) lamprophyre has historical precedence (Von Gumbel 1874 versus Lewis 1888).

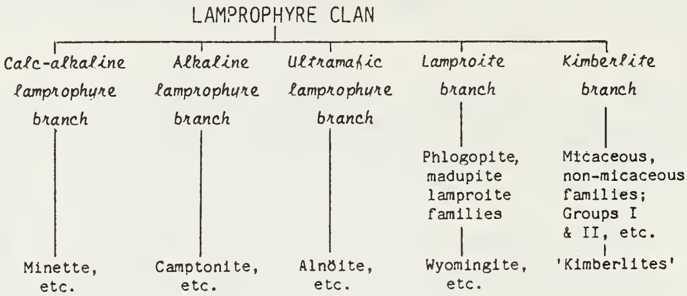


Fig. 1. The lamprophyre 'clan', with kimberlite considered as one of the 'branches'. Definitions of other 'branches' and 'families' after Streckeisen (1979), Mitchell (1986) and Rock (1987).

## JUSTIFICATION FOR GROUPING KIMBERLITES AND OTHER LAMPROPHYRES TOGETHER

Figure 1 unites a coherent grouping of petrologically distinctive rocks, distinguished from other igneous rocks not least by having crystal-laden fluid rather than essentially liquid parent magmas. Contemporaneous kimberlites coexist with other lamprophyres in several areas. All rock-types in Figure 1 also share the following features in common: (1) They occur as minor intrusions, with diatremes and dykes more widespread than sills and lavas very rare. (2) They are emplaced explosively from great depths, commonly yielding fluidised explosion-breccias, intrusion breccias, tuffs or pyroclastics. (3) They have high contents of alkalis (especially K), $H_2O$,$CO_2$,F, Cl,P,Ba,Sr,Rb,Zr,Th,Nb and LREE, typical of highly evolved alkaline rocks, with V, Cr and Ni contents ranging between levels typical of basic and ultrabasic rocks, while Ti, Y and HREE levels lie near or below MORB (Fig. 2). (4) Carbonate minerals are usually abundant, and partly primary. (5) At least one hydrous mafic mineral is present (especially phlogopite, but also serpentine, amphiboles). (6) Typical olivine compositions are $Fo_{80-94}$. (7) Cognate orthopyroxenes are absent. (8) Varied crustal and mantle-derived xenolith and megacryst suites are abundant. (9) The mineralogy is a hybrid, often disequilibrium mixture of macrocryst, phenocryst and groundmass phases, variously formed by magmatic crystallisation, partial or 'arrested' resorption of liquidus phases, autometasomatism, or incorporation of foreign materials. (10) Whole-rock compositions bear little relation to parent magmas.

## COMPARISONS BETWEEN KIMBERLITES AND OTHER LAMPROPHYRE VARIETIES

Kimberlites are most similar to ultramafic lamprophyres and least similar to alkaline lamprophyres. Olivine-lamproites, ultramafic lamprophyres and kimberlites may grade into one another petrologically, being among few igneous rocks to carry rutile, perovskite and Ba±$Fe^{3}$-rich micas. Phlogopite-free kimberlites are the least 'lamprophyric', but they in turn violate the definition of kimberlite itself as a "potassic" rock-type (Clement et al. 1984).

Although calc-alkaline lamprophyre whole-rock compositions and felsic mineralogy differ greatly from kimberlites, many minette phlogopites match secondary phenocryst or macrocryst rims, "Type II" groundmass phlogopites, and unzoned pre-fluidisation phenocrysts in kimberlites (Bachinski & Simpson 1984).

Some lamproites are sufficiently similar to kimberlites to have been confused: e.g. Prairie Creek (USA) and Chelima (India). Lamproites show the following specific links with kimberlites (additional to those of other lamprophyres): (a) They are the only terrestrial igneous rocks carrying armalcolite, diamond or potassium richterite. (b) Lamproite mafic mineralogy mirrors MARID xenoliths in kimberlites.

Figure 2b shows how close ultramafic lamprophyres and kimberlites are in average composition. Many 'kimberlites' and 'mica-peridotites' are really ultramafic lamprophyres. Indeed, ultramafic lamprophyres may be expressions of 'kimberlite magmatism' in tectonic regimes which preclude true kimberlites (e.g. oceanic islands). The two types show the following additional mutual links: (a) Exceptionally low $SiO_2$ and $Al_2O_3$ contents combined with high [MgO+CaO] and $K_2O$. (b) Unusual mineralogy (e.g. picroilmenite, monticellite). (c) Absence of feldspars. (d) Overlapping mafic mineral compositions. (e) Frequent association with carbonatitic rocks. (f) Associated fenite-like metasomatism.

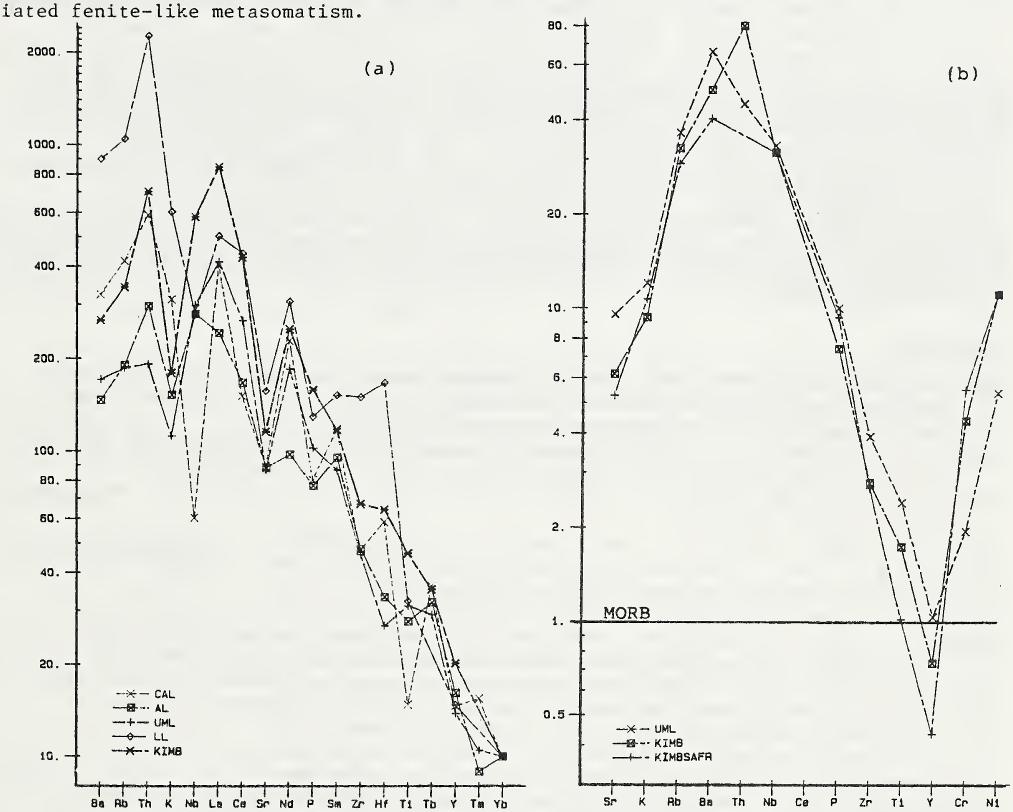


Fig. 2. Comparisons of mean minor and trace element geochemistry for kimberlites and other lamprophyres. Data from Rock (1987), Wedepohl and Muramatsu (1979). CAL = 754 calc-alkaline lamprophyres; AL = 563 alkaline lamprophyres; UML = 245 ultramafic lamprophyres; LL = 293 lamproites; KIMB = 670 kimberlites. KIMBSAFR = 11 South African kimberlites.

Fig. 2a. Chondrite-normalised 'spidergrams'. Element order and normalising values from Thompson et al. (1984).

Fig. 2b. MORB-normalised 'spidergrams'. Element order and normalising values from Pearce (1982).

A NEW DEFINITION OF 'LAMPROPHYRE' (TO INCLUDE KIMBERLITE)

This can be readily adapted from the kimberlite definition of Clement et al. (1984); underlined phrases are quoted verbatim:
"Lamprophyres are volatile-rich, alkalic, ultrabasic to mesotype igneous rocks which occur as small volcanic pipes, dykes, and sills. They are often emplaced explosively, generating associated breccias, tuffs and/or pyroclastics. They have a distinctively inequigranular texture resulting from the presence of phenocrysts and, often, macrocrysts set in a finer-grained matrix. They carry at least one hydrous or carbonate mineral as a prominent primary, phenocrystal and/or groundmass constituent - alkali or calcic amphibole, carbonate (commonly calcite, also ankerite, breunnerite, dolomite), phlogopite-biotite or serpentine. Additionally, phenocrysts and groundmass may include several of the following minerals: apatite, clinopyroxene (commonly diopside, titanaugite), ilmenite (Mg and/or Mn-rich), melanite-andradite garnet (sometimes Zr-rich), melilite, monticellite, olivine ($Fo_{80-95}$), perovskite, spinels (often Mn-rich), and sulphate minerals (baryte etc.) Rare silicates of alkalis or Ba with Fe, Ti and/or Zr (wadeite etc.) or alkali sulphide minerals (e.g. bartonite) may be present. Feldspars (albite, Ba-Fe-K-feldspar, plagioclase), feldspathoids (analcime, nepheline, sodalite group) or minor quartz sometimes occur in the groundmass only. Mafic minerals typical of basic or ultrabasic rocks (e.g. forsteritic olivine, diopside, phlogopite), commonly coexist with minerals typical of highly evolved rocks (quartz, albite, orthoclase, aegirine, alkali amphiboles). Most macrocrysts are anhedral, mantle-derived mafic minerals which include olivine, phlogopite, picroilmenite, chromian spinel, magnesian garnet, clinopyroxene (commonly chromian diopside), orthopyroxene (commonly enstatite) and amphibole (commonly kaersutite). Macrocrysts of mantle-derived anorthoclase, sanidine, apatite and corundum may also occur. The macrocrysts and relatively early-formed matrix minerals are commonly altered by deuteric processes (mainly serpentinization and carbonatization). Phenocrysts and other matrix phases, however, may be strikingly euhedral (panidiomorphic) and fresh. Lamprophyres commonly contain inclusions of upper mantle-derived ultramafic rocks. Variable quantities of crustal xenoliths and xenocrysts may also be present. Some lamprophyres may contain diamond but only as a very rare constituent".

## References


BACHINSKI S.W. and SIMPSON E.L. 1984. Ti-phlogopites of the Shaw's Cove minettes: a comparison with micas of other lamprophyres, potassic rocks, kimberlites and mantle xenoliths. American Mineralogist 69, 41-56.

BOYD F.R. and MEYER H.A.O. 1979. Kimberlites, diatremes and diamonds: their geology, petrology and geochemistry. American Geophysical Union, Washington.

CLEMENT C.R., SKINNER E.M.W. and SCOTT SMITH B.H. 1984. Kimberlite redefined. Journal of Geology 92, 223-228.

LEWIS H.C. 1888. The matrix of the diamond. Geological Magazine 5, 129-131.

MITCHELL R.H. 1986. A review of the mineralogy of lamproites. Transactions of the Geological Society of South Africa (in press).

PEARCE J.A. 1982. Trace element characteristics of lavas from destructive plate boundaries. In Thorpe R.S. ed, Andesites, pp. 525-548. Wiley, New York.

ROCK N.M.S. 1987. The nature and origin of lamprophyres: an overview. In Fitton, J.G. and Upton, B.G.J. eds, The Alkaline Rocks - a review symposium. Special Publication, Geological Society of London (in press).

SKINNER, E.M.W. & CLEMENT C.R. 1979. Mineralogical classification of Southern African kimberlites. In Boyd and Meyer (1979, qv), pp. 129-139.

STRECKEISEN A. 1979. Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites and melilitic rocks. Geology 7, 331-5.

THOMPSON R.N., MORRISON M.A., HENDRY G.L. and PARRY S.J. 1984. An assessment of the relative roles of crust and mantle in magma genesis, an elemental approach. Philosophical Transactions of the Royal Society, London A310, 549-90.

VON GUMBEL C.W. 1874. Die palaeolithischen Eruptivgesteine des Fichtelgebirges. Franz, Munich.

WEDEPOHL K.H. and MURAMATSU K. 1979. The chemical composition of kimberlites compared with the average composition of three basaltic magma types. In Boyd and Meyer (1979, qv), pp. 300-312.