COMPOSITIONAL VARIATION OF MICAS IN KIMBERLITES, ORANGEITES, LAMPROITES AND LAMPROPHYRES

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The compositions of micas in alkaline rocks are sensitive indicators of parental magma type. Micas in diverse diamond-bearing and diamond-free alkaline rocks follow distinct evolutionary trends of composition that may be of use in distinguishing between these rock types. Compositional trends are best determined from groundmass micas as early-forming macrocrysts or phenocrysts in most of these rock types do not differ significantly in their major element compositions.

KIMBERLITES

Kimberlites show two mica evolutionary trends. The dominant and characteristic one being of Al and Ba enrichment. Micas belonging to this trend evolve from phlogopite towards aluminous phlogopites which are commonly enriched in Ba. Late stage poikilitic micas are colorless, complexly zoned members of the phogopite - kinoshitalite [$BaMg_3Al_2Si_2O_{10}(OH)_2$] series. Late stage Ba-rich micas are commonly depleted in FeO_T relative to unevolved micas. TiO_2 contents are low (<4 wt.%) and do not show any systematic trends. The high TiO_2 (>5 wt.%), Ba-rich pink-colored micas characteristic of leucitites and melilitoids are absent.

A second less common, evolutionary trend is towards TiO_2-poor tetraferriphlogopite. This forms as thin mantles upon pre-existing Al-rich phlogopites. Tetraferriphlogopite formation is related to late stage groundwater influx and/or degassing processes; it does not occur in all facies of a given kimberlite and has not occurred in most archetypal kimberlites. Examples are known from Antochka (Guinea), Orroroo (Australia) and Koidu (Sierre Leone).

ORANGEITES

Micas in orangeites (a.k.a. group II kimberlites) form a complex hybrid transported assemblage. Complex mantling and zoning demonstrate that the microphenocrystal/macrocrystal assemblage has been derived by the mixing of micas derived from many batches of compositionally similar magmas. Subsequent to mixing and emplacement, each batch of crystal-laden magma underwent crystallization in a particular P-T-oxygen fuagacity regime. Differences in these intensive parameters result in different compositional trends developing in the groundmass micas. Two principal trends are evident: (1) a tetraferriphlogopite trend, characterized by extreme Al-depletion coupled with Fe enrichment at relatively constant Mg contents. Ti may decrease slightly or remain constant but is always low; (2) a biotite trend, characterized by Fe-enrichment and Mg-depletion accompanied by moderate Al depletion. Ti may increase or decrease slightly. Groundmass micas following the biotite trend may be more common in occurrences which differentiate to felsic residua, i.e. Postmasburg, Voorspoed.

Ti-rich and Ba-rich micas are not present. Mica solid solutions are primarily between phlogopite, annite and tetraferriphlogopite. Only micas from Sover North and Besterskraal exhibit solid solution towards Ti-octahedral site deficient phlogopite.

LAMPROITES

Groundmass mica compositions fall between two extreme evolutionary trends. One is a slight-to-moderate Al-depletion coupled with increasing Ti and Fe and decreasing Mg, i.e. a trend reflecting Fe^{2+} increase and representing evolution from titanian phlogopite towards titanian biotite. The other is a trend of strong Al-depletion associated with increasing Ti and Fe at essentially constant Mg, i.e. a trend reflecting increasing Fe^{3+} and representing evolution from titanian phlogopite towards titanian tetraferriphlogopite. The compositional trend exhibited by mica in any given lamproite may lie anywhere between these two extremes and reflect the local post-emplacement crystallization environment with respect to redox conditions, water content and cooling conditions. Other characteristic features include high F (1-7 wt.%) and Na_2O (0.5 - 1.8 wt.%) contents. Lamproite micas are typically enriched in TiO_2 (1-12 wt.%) relative to orangeite micas and compositions evolve towards increasing Ti contents. However, some sanidine and richterite-bearing orangeites contain micas which have similar compositions and evolutionary trends to lamproite micas.

MINETTES AND ULTRAMAFIC LAMPROPHYRES

Micas in minettes form a complex, mantled continuously or reversly-zoned assemblage of phenocrysts which may be mantled by micas identical in composition to those occurring in the groundmass. The characteristic evolutionary trend is one of increasing Fe with slightly increasing or constant Al. Ti contents may increase or decrease slightly with respect to Al. Many minette micas are aluminous and do not exhibit any tetrahedral site deficiency. The presense of Al^{vi} indicates solid solutions from Al phlogopite towards the "eastonite"-siderophyllite series. Minette micas are always Al-rich relative to orangeite and lamproite micas of equivalent Fe-content.

Micas in ultramafic lamprophyres show an extremely wide range in composition as a consequence of their derivation from a number of distinct magma types. Micas in ultramafic lamprophyres belonging to the alnoite-polzenite suite are typically-rich in Al and evolve fom phlogopite towards the "eastonite"-siderophyllite series, a trend identical with that found in minettes. Some occurrences contain Ba rich mica, i.e Polzen, Haystack Butte. These micas may be distinguished from Ba-rich micas in kimberlites on the basis of their evolutionary trends towards increasing Ti and Fe.

Figures 1 - 2 illustrate some typical examples of the trends of compositional variation exhibited by micas from diverse rock types. Figures 1 - 2 may be used as an aid to the identification of the parent magma of mica in a particular rock sample, although final classsification should not be based on these data alone.

Fig. 1

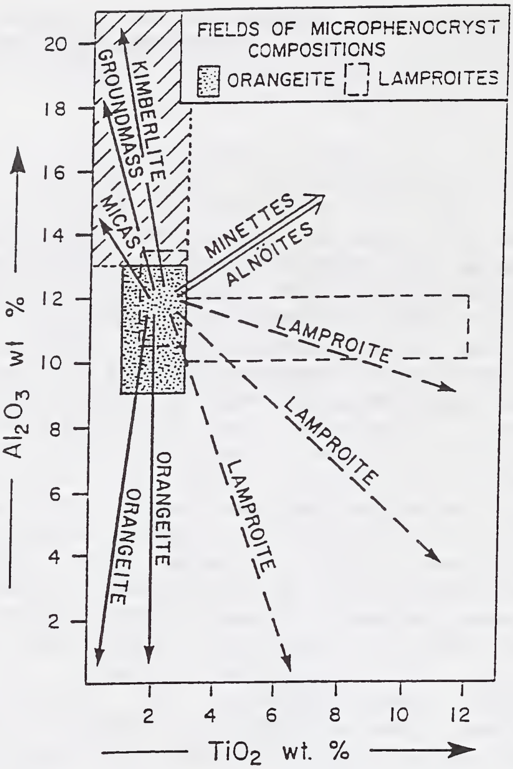
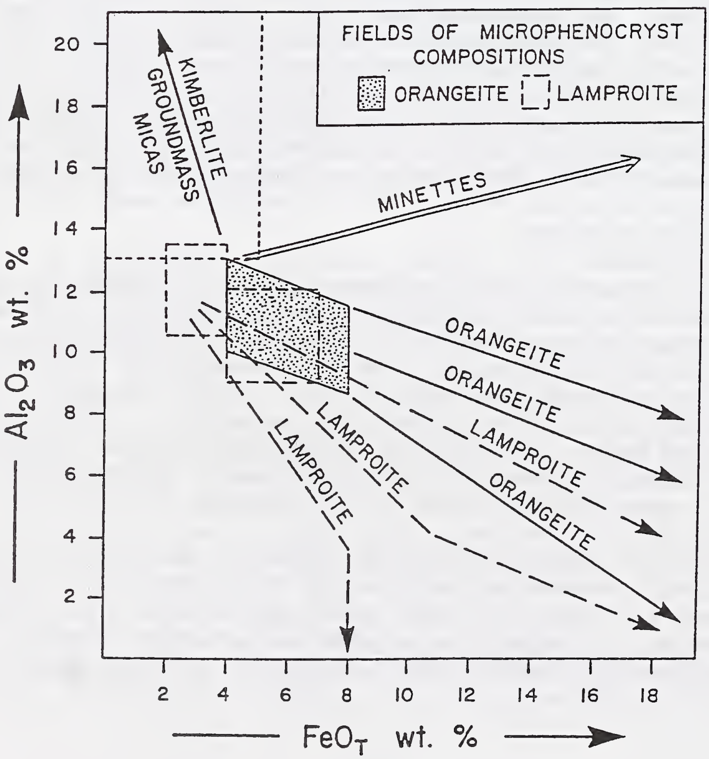

FIELDS OF MICROPHENOCRYST COMPOSITIONS
ORANGEITE
LAMPROITES
KIMBERLITE GROUNDMASS MICAS
MINETTES
ALNÖITES
LAMPROITE
LAMPROITE
LAMPROITE
ORANGEITE
ORANGEITE
Al_2O_3 wt %
TiO_2 wt. %

Fig. 2.


FIELDS OF MICROPHENOCRYST COMPOSITIONS
ORANGEITE
LAMPROITE
KIMBERLITE GROUNDMASS MICAS
MINETTES
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LAMPROITE
Al_2O_3 wt. %
FeO_T wt. %