LAMPROITES FROM THE LUANGWA VALLEY, EASTERN ZAMBIA

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INTRODUCTION

Kimberlite-like intrusions were found in the Luangwa Valley of Eastern Zambia during the early 1960's. They are located along the Kapamba River, a tributary of the Luangwa River, approximately 150km west-north-west of Chipata. The occurrences (some of which yielded rare diamonds) were initially referred to as kimberlites, although differences from kimberlites elswhere were noted. Subsequently, however, one of the authors (EMWS) recognised their lamproitic character.

GEOLOGY

The Kapamba bodies lie within a downfaulted, north-east trending graben which is contained within the Irumide tectonic belt (1355 my). The Luangwa graben is considered to be a south-westward extension of the East African Rift system. The Kapamba intrusions cut through upper Karoo sediments and are thus younger than 250 my in age.

The Kapamba occurrences comprise fourteen single, or groups of small, pipe-like bodies and an associated suite of dykes. Together they form a north-west to south-east trending province approximately 25km long. Many of the pipes form distinct topographic features and exposure is fairly good. Most of the pipes are approximately circular in shape and range in size up to 45 hectares.

The geology of the pipes is variable, and often complex, and numerous rock types are present. They include magmatic rocks (with some autolithic breccias) and crater-facies rocks which vary from massive to well bedded (including some cross- and graded-bedding). In some pipes only crater-facies material is found, while in others significant (up to 200m) outcrops of magmatic material occur.

PETROGRAPHY

Crater-facies rocks

These rocks are mostly fragmental composed of juvenile lapilli, single grains of quartz and feldspar and a few xenoliths. The juvenile lapilli have a porphyritic texture, with olivines set in fine-grained or glassy groundmass. The olivines comprise abundant phenocrysts which occur as multiple-growth aggregates and anhedral, rounded or subhedral macrocrysts. The nature of the matrix of the lapilli varies between pipes and even within a single thin section. The matrix includes microphenocrysts of phlogopite, or clinopyroxene and leucite, set in a glassy base. Vesicles may be present. The other main constituents are individual, angular grains of quartz and lesser amounts of feldspar. Where these xenocrysts are abundant, the rocks resemble sandstones. Most of the xenolithic material is derived from the country rock sediments. The fine matrix of the crater-facies rocks is composed of brown indiscernible clayey material. The crater-facies rocks are broadly similar, but differ with respect to: (1) fragment or grain size, (2) variation in proportion of dark juvenile and leucocratic xenolithic material, (3) absence or nature of bedding, (4) variation in olivine content, (5) degree of alteration, (6) megascopic and macroscopic colour.

Magmatic Rocks

The magmatic rocks, which occur within the pipe-like intrusions, are often fairly fresh and have porphyritic textures. The olivines are fresher, but otherwise similar to those described from the juvenile lapilli. The macrocrysts may show some detailed euhedralism resulting in serrate margins. The abundance of macrocrysts varies. Two main varieties of groundmass occur. The first type is very fine-grained and displays a distinct segregationary texture with orange-brown, phlogopite-rich and grey, clinopyroxene-rich areas. This groundmass type usually also contains leucite, amphibole, oxide minerals and apatite. These minerals are set in a glassy base. The second type of groundmass has uniform textures, is medium-grained and is composed of leucite, clinopyroxene, phlogopite, amphibole, sanidine, opaque minerals, apatite and glass. The leucite may be either isotropic or replaced by a mosaic of low birefringent mineral(s) and sometimes may also be brown and somewhat turbid indicating some alteration. The phlogopite has a distinctive orange-brown colour and occurs only as late-stage, interstitial, poikilitic grains. The amphibole displays yellow to pink pleochroism.

Dyke Rocks

The dyke rocks are coarser grained and have a non-porphyritic texture. They are altered but primary constituents include olivine phenocrysts, clinopyroxene, leucite and sanidine.

Discussion

The magmatic rocks at Kapamba are classified as lamproites based on their mineralogy, textures, the colour and pleochroism of the phlogopite and amphibole (after Scott Smith and Skinner 1984 or Mitchell in press). A variety of mineralogical types are present which include clinopyroxene-olivine-phlogopite, clinopyroxene-leucite, clinopyroxene, and phlogopite-leucite lamproites. It is important to note that the phlogopite occurs only as a groundmass mineral and no phenocrysts are present. Such lamproites would be termed madupitic by Mitchell (in press). An overview of the mineralogy of the Kapamba province suggests that generally the rocks become more evolved to the south-east, with decreasing amounts of olivine and the increasing abundance of leucite. The juvenile lapilli are best termed glassy-olivine lamproite. The crater-facies rocks include both pyroclastic and epiclastic varieties. The former are interpreted as comprising mostly lapilli tuffs but ash deposits and slightly welded, juvenile lapilli-rich tuffs are also present.

MINERAL CHEMISTRY

Phlogopites are similar in composition to groundmass or madupitic micas in other lamproites being titaniferous (5 - 9.5 wt.% TiO_2) and poor in alumina (4 - 11.5 wt.% Al_2O_3). Some of the phlogopites, however, do have higher Mg/(Mg+Fe) atomic ratios (0.83 - 0.65), FeO (7 - 14 wt.%) and BaO (0.9 - 4.1 wt.%) contents than is typical of other lamproites. Olivines range in composition with Mg/(Mg+Fe) ratios of 0.820 to 0.935. The cores of the most of the xenocrysts fall in the range 0.905 to 0.925. The compositions of the cores of the phenocrysts differ from each of the intrusions analysed, but together fall in the range 0.880 to 0.915 and are less magnesian than most of the xenocrysts. The rims of all the olivines show very restricted compositions suggestive of late-stage overgrowths or equilibration. The clinopyroxenes are diopsides which are zoned. The zoning, higher FeO and, more significantly, higher Al_2O_3 contents distinguish them from most other lamproitic clinopyroxenes, but their compositions do not extend into the fields of clinopyroxenes from other potassic rocks. Amphiboles are titanian potassic richterite which have higher Na_2O and Al_2O_3 contents than typical of most lamproites. Spinels are mostly titanomagnetites with some cores of titaniferous, magnesian-chromite. They are similar to those in other lamproites. Leucite appears to have been replaced by a mixture of sanidine and sodium aluminosilicates, mostly with compositons closely resembling analcite. The replacement by analcite has been noted in other lamproites and is considered to be a secondary process. Groundmass feldspar is Fe-bearing sanidine as found in other lamproites. Perovskites have high Na_2O and SrO, features typical of lamproitic perovskites.

Discussion

Some of the mineral compositions are very similar to those found in lamproites elsewhere, but there are some significant differences which, in many cases, are evident in the more evolved varieties. These differences may reflect the Kapamba 'signature', because each lamproite province is characterised by certain minerals having different compositions. Minerals from Kapamba which have compositions that can be distinguished from other lamproites, however, also begin to approach those found in other potassic rocks (South-west Uganda and the leucitites of New South Wales and Western Italy). Although not documented here, the mineral compositions vary between each of the Kapamba intrusions examined. Using mineral chemistry to assess their relative degree of evolution suggests that the intrusions become more evolved from north-west to the south-east of the province.

WHOLE-ROCK GEOCHEMISTRY

The whole-rock compositions of some of the Kapamba rocks support the classification of these rocks as lamproites. The most notable feature of these data is the variable alkali content. Some samples have high K_2O contents (+/- 5wt.%) and high K_2O/Na_2O ratios (3 to 5), as is the case in other lamproites. Other samples, however, have high Na_2O contents (+/- 4 wt.%) and low K_2O/Na_2O ratios (0.3 to 0.4) which are very different from lamproites. Primary mineral compositions cannot account for this variation. The only feature which might explain this variation is the secondary replacement of leucite by analcite. It does not appear to be related to late-stage enrichment of the magmas represented by the rocks examined. It seems more likely that the high Na_2O values have resulted from some other process, such as the interaction with groundwater (Gupta and Fyfe 1975).

HEAVY MINERAL CONCENTRATES

The nature of the heavy mineral concentrates from the different intrusions is extremely variable. Some pipes yield abundant garnets which have peridotitic compositions with the majority being chrome pyropes. Spinels may also occur in some pipes and are magnesian chromites. Rare chrome diopside also occurs. Some of the pipes are diamondiferous but none are economic.

CONCLUSIONS

The Kapamba intrusions are classified as lamproites according to their petrography, mineral chemistry and whole-rock geochemistry. They therefore represent another province of diamond-bearing lamproite.

The geology and petrography of the Kapamba pipes suggest that they comprise craters predominantly infilled with pyroclastic, lapilli tuffs and intruded by younger, magmatic lamproite which appear to have formed an extrusive, ponded lava lake-type body. This model is similar to those of other lamproites. Mineral and whole-rock geochemistry suggests that the intrusions generally become relatively more evolved from the north-west to the south-east of the province.

The compositions of some of the minerals, usually those from the more evolved varieties, display distinct differences from data for lamproites elswhere. These features, however, are not extreme enough to preclude their classification as lamproites. They may rather reflect the 'signature' of the Kapamba lamproite province. These variations, however, indicate a similarity with other potassic rocks including South-west Uganda, which is is notable because the Kapamba province occurs within, what is considered to be, a south-westerly extension of the East African Rift.

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