THE PETROLOGY OF KIMBERLITES, RELATED ROCKS AND ASSOCIATED MANTLE XENOLITHS FROM THE KURUMAN PROVINCE, SOUTH AFRICA.

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INTRODUCTION

The Kuruman province comprises some twelve kimberlites and related rock occurrences, emplaced as dykes and pipes in the vicinity of the town of Kuruman in the northern Cape Province, R.S.A. These bodies intrude early Proterozoic Ghaap Plateau dolomites and overlying Asbestos Hills Banded Ironstones of the Griqualand West Sequence, towards the inferred north-western margin of the Kaapvaal craton (∿ 2 500 m.y.). All are apparently barren of diamonds. The four occurrences dated thus far (Elston, Zero, Bathlaros and Riries) have emplacement ages of ∿ 1 600 m.y. (Bristow et al., - this conference) establishing this province as the oldest yet documented. These rocks provide a unique opportunity to study the Kaapvaal upper mantle lithologies, processes and thermal structures of late Proterozoic age.

This paper describes the petrography and matrix mineral chemistry of the four dated intrusives. In addition a suite of mantle-derived peridotites from the Zero kimberlite have been studied with the aim of establishing the pressure - temperature regime under which they last equilibrated. The geochronology, isotopic characteristics and whole-rock geochemistry of these occurrences are described and discussed in a companion paper by Bristow et al. (this conference).

PETROGRAPHY

All four of the above localities are classified as hypabyssal-facies intrusions. Elston and Zero are petrographically similar, being rich in macrocrystic olivines, with a groundmass dominated by carbonate and variable phlogopite together with minor spinel, perovskite, probable monticellite, apatite and ilmenite laths. Heavy mineral concentrates are dominated by chromian spinels and garnet with minor clinopyroxene and rare ilmenite. Subcalcic (G10) garnets (Dawson and Stephens, 1975) with compositions similar to pyropes included in diamonds are abundant.

The Bathlaros kimberlite occurs as macrocrystic and aphanitic varieties with altered olivine macrocrysts and phenocrysts set in a groundmass of phlogopite, calcite, serpentine, apatite, spinel, perovskite, ilmenite laths, minor clinopyroxene and possible amphibole. Matrix mineral chemistry and whole-rock geochemistry indicate that the Bathlaros kimberlite is chemically more evolved than Elston and Zero. Heavy mineral concentrates from Bathlaros consist predominantly of chromian spinel; few other heavy minerals typical of most kimberlites are present.

The Riries dyke consists of altered olivine phenocrysts plus ilmenite and phlogopite macrocrysts set in a groundmass of phlogopite, ilmenite, carbonate, spinel and secondary quartz. Petrography and matrix mineral chemistry suggest that Riries is not a kimberlite but a lamprophyric rock. Heavy mineral concentrates from Riries consist of ilmenite and chromian spinel.

The character of the intrusions changes from east to west in the order Elston and Zero (kimberlite), Bathlaros (evolved or marginal kimberlite) and Riries (lamprophyre).

MATRIX MINERAL CHEMISTRY

Matrix phlogopites and spinels were analysed in the Zero and Bathlaros kimberlites, and Riries parakimberlite.

Phlogopite

Figure 1 is a plot of wt.% TiO_2 versus 100(Mg/Mg+Fe). Shown on the diagram for comparative purposes is the compositional field for matrix phlogopites from the Wesselton kimberlite, Kimberley (Shee, 1986). The micas from the Kuruman occurrences show little compositional overlap with those from Wesselton. The matrix micas show a trend of increasing titanium contents and decreasing 100(Mg/Mg+Fe) ratios in the order Zero, Bathlaros and Riries which confirms the petrographic variations in these intrusions noted above. The Bathlaros micas are mantled by late stage pleochroic colourless - red-brown tetraferriphlogites with low 100(Mg/Mg+Fe) ratios and very low titanium and aluminium contents. These overgrowths probably formed under conditions of higher oxygen fugacity.

Spinel

The spinels in Elston consist of subhedral to euhedral chromites (0.08 mm in size) mantled by thick rims of chromium-poor titanomagnetite. Euhedral titanomagnetite crystals (0.04 mm in size) are also present. The spinels at Bathlaros are relatively large (up to 0.2 mm) euhedral microphenocrysts which occur singly or form aggregates with other spinel or perovskite grains. Some of these spinels have chromium-rich cores mantled by titanium and chromium-poor magnetite mantles. Spinels from Riries are euhedral chromites mantled by titanomagnetite mantles and unzoned titanomagnetites. The compositional variations of the spinels from these localities are shown in Figure 2. Those from Elston are most similar to matrix spinels from Wesselton (Shee, 1984, 1986). Spinels from Bathlaros and Riries have lower chromium and magnesium contents substantiating the more evolved nature of these occurrences.

Ilmenite

Euhedral ilmenite laths (up to 0.1 mm in length) are rare constituents of the Elston and Bathlaros kimberlites but are more abundant in the Riries lamprophyre. The compositions of the laths in Elston are unusual for kimberlitic groundmass ilmenite in being chromium-poor and highly manganoan (0.1 - 0.2 wt.% Cr_2O_3, 13 - 18 wt.% MnO). The magnesium levels are not much lower than normal (12 - 15 wt.% MgO) but iron contents are noticeably low (13 - 16 wt.% FeO). Euhedral ilmenites from Riries are iron-rich (> 46 wt.% FeO) with low magnesium, chromium and manganese contents (all < 0.5 wt.%).

MANTLE XENOLITHS

The Zero kimberlite contains an abundant and lithologically diverse suite of mantle-derived xenoliths. Eclogitic and peridotitic rock types are present in approximately equal proportions. The following peridotite types are present in decreasing order of abundance: chromium spinel harzburgite, garnet harzburgite, garnet lherzolites and aluminium spinel lherzolite. Garnet websterites, orthopyroxenites and phlogopite-clinopyroxenite are also present. The metasomatic assemblages phl + Ti-chromite + cpx and ilm + phl occur as variable equilibrated additions to the above peridotitic hosts confirming the diversity of metasomatic processes in the evolution of subcontinental lithosphere. Other assemblages present are rare large (> 1 cm) ilmenite nodules probably of the Cr-poor megacryst suite and large olivine nodules (1 - 6 cm) sometimes with enstatite, chromite, clinopyroxene and emerald green uvarovite-bearing garnet inclusions.

The garnet peridotites contain a significant proportion (± 50%) of subcalcic garnet-bearing harzburgites some of which have diamond-inclusion type G10 garnets. The orthopyroxenes in these garnet harzburgites have high aluminium contents (> 1 wt.% Al_2O_3) and geobarometric calculations indicate equilibration at relatively shallow pressures (< 40 Kbars at 1050°C) in the graphite stability field. Some garnet harzburgites with no modal clinopyroxene are calcium saturated i.e. > 5 wt.% CaO in the garnet and > 1 wt.% CaO in the orthopyroxenes. These rocks typically yield high calculated temperatures and pressures of equilibration i.e. 1200 - 1360°C at 50 - 55 kbars. Thermobarometric calculations on other garnet peridotites suggest correlation of high temperatures with deformation textures and Ti-enriched mineral compositions. These calculations will allow construction of a thermal profile of the southern African subcratonic mantle at 1600 m.y. for comparison with "geotherms" inferred for 1200 m.y. (Premier) and Jurassic - Cretaceous kimberlites.

CONCLUSIONS

Kimberlites and related rocks near Kuruman have emplacement ages of 1600 m.y. establishing this province as the oldest yet documented. The petrographic character of the intrusions changes from east to west in the order Elston and Zero (kimberlite), Bathlaros (evolved or marginal kimberlite) and Riries (lamprophyre). The compositions of the matrix phlogopites, spinels and ilmenite from these intrusions confirms the petrographic variation.

An extensive suite of mantle-derived xenoliths exists at Zero. Garnet harzburgites with subcalcic G10 garnets yield relatively shallow pressures of equilibration. High temperatures and pressures are recorded in deformed peridotites and in calcium saturated garnet harzburgites.

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Figure 1. MATRIX MICAS ,KURUMAN PROVINCE

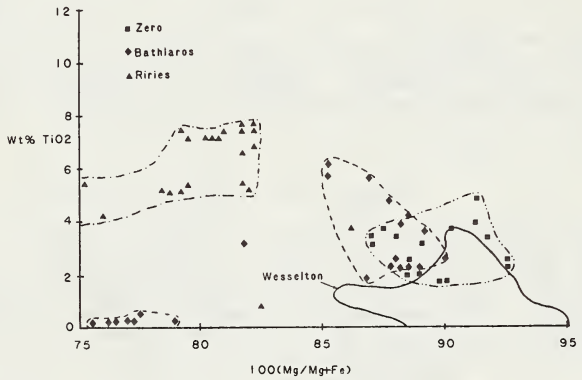

Figure 2. MATRIX SPINELS, KURUMAN PROVINCE