PRECAMBRIAN ULTRAMAFIC DYKES WITH KIMBERLITE AFFINITIES IN THE KIMBERLEY AREA

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INTRODUCTION: A suite of unusual ultramafic dykes has been located in under= ground mine workings near the Wesselton and De Beers kimberlite pipes. Five of these dykes contain abundant diopside and extremely altered olivine and are feldspar-free. Other petrographically similar dykes contain limited amounts of plagioclase (oligoclase to labradorite). The latter occurrences have not been studied in detail and are not discussed further in this paper although they may be genetically associated with the feldspar-free dykes.

FIELD RELATIONS: The dykes cut the granite-gneiss basement rocks and over= lying Ventersdorp System lavas and quartzites. They trend in various directions ranging from northwest to due east. Dips vary between 50^{0} and 80^{0}. Dyke widths vary from a few centimetres to 1.5m. The widest dyke occurs in the wallrocks of Wesselton Mine. The other four occur near the De Beers kimberlite pipe. The Wesselton Mine occurrence was noted by Williams (1932) who classified it as a .... "serpentinized mica augite peridotite or a harde= bank (kimberlite) dyke rock".

PETROGRAPHY: The dykes are tough, moderately hard, dark-grey, generally fine-grained rocks which exhibit varying textures. The wider dykes have prominent chilled margins. The textural variations are particularly well displayed by the Wesselton Mine dyke. Here a thin (1-3mm) vitrophyric selvedge occurs at the contacts. This zone consists of altered olivine phenocrysts (1.0mm or smaller) set in a dark brown glassy base containing very small (< 0.03mm) opaque grains and scattered microlites of diopside. Olivine has been pseudo= morphously replaced by talc together with subordinate serpentine and chlorite. The altered olivine phenocrysts commonly occur as skeletal hopper crystals and complex parallel growth forms.

Inwards from the vitrophyric margin the groundmass consists of very small acicular laths of diopside (up to 0.1 mm long) and similarly fine-grained phlogopite. Both minerals have been partly chloritized. Other minerals present are serpentine, chlorite, opaque oxides, rare calcite and unidentified clay material. Abundant hopper crystals and parallel growth aggregates of altered olivine, commonly measuring between 0.5 and 1.0mm, occur as phenocrysts in the extremely fine-grained groundmass. Talc remains the dominant alteration product of olivine.

The central panidiomorphic-granular parts of the dyke consist mainly of altered olivine and diopside which together make up approximately 60 vol.% of the rock. Diopside is generally slightly more abundant than olivine. Phlogopite, chlorite and serpentinous material are also relatively abundant. Accessory minerals include scattered opaque oxides, apatite, clay (sepiolite or hydromica) and calcite (rare).

As in the marginal areas of the dyke olivine is extensively altered and pseudo= morphous replacement by talc and serpentine is widespread. Skeletal olivine is much less prominent but hopper crystals and parallel growth forms are present.

Most olivine grains are smaller than 1.0mm. Diopside occurs as well formed laths commonly between 0.5 and 1.5mm long. Steatization and chloritization of diopside is extensive.

Phlogopite occurs as laths up to 0.75 mm long and as an anhedral interstitial mineral between altered olivine and diopside crystals. This phlogopite dis= plays prominent pleochroism ($\beta=\gamma$ brown, α pale yellow-brown). Apatite is a prominent accessory mineral. It occurs as highly acicular laths reaching 0.4mm in length. Opaque minerals occur in various forms including equant subhedral and euhedral crystals and acicular laths. Skeletal opaque grains are common.

The De Beers Mine dykes differ from the Wesselton occurrence in that phlogo= pite is rare or absent. In addition sulphides (mainly pyrite) are common accessory minerals and minor quartz is sometimes present within altered olivines.

HEAVY MINERALS: Microprobe analyses of heavy minerals, extracted from four dyke samples, indicate the presence of garnet and opaque oxide suites which fall within the compositional ranges of those commonly found in kimberlites, or within upper mantle peridotites and eclogites which occur as xenoliths in kimberlite. The grains are invariably small (most of those recovered lie between 100 and 28 mesh (Tyler) screen sizes) and are not abundant.

Opaque minerals include picroilmenite, ilmenite, and a variety of spinels ranging from ulvospinels to high-Cr_2O_3 (64 wt.%) chromites. Four grains of an unusual Ti-oxide were found in a sample from one of the De Beers Mine dykes. Although the analyses do not include BaO and V_2O_3 their compositions are in all other respects virtually identical to a new mineral discribed by Haggerty (1975, p.305) from De Beers Mine kimberlite. Six minute fragmental diamonds were recovered from a 22kg. sample of the same dyke. The total weight of these diamonds is 2521 x 10^{-8} carats. Further sampling is being carried out to try and confirm the presence of this mineral in the dyke.

AGE OF THE DYKES: Field relations indicate that these dykes pre-date the Cre= taceous (90m.y.) kimberlite pipes in the Kimberley area. Truncation of the dykes at the contacts of the pipes is evident at both De Beers and Wesselton mines. Furthermore the dykes do not cut Karroo System (Dwyka Series) shales which, together with dolerite sills, form the upper 130m of the geological succession. Field relations therefore indicate a post-Ventersdorp (2300m.y.) pre-Karroo age. In order to fix the age of the dykes more precisely radio= metric dating of the Wesselton Mine dyke was carried out for the authors by Dr. H.L. Allsopp who reports as follows:

"Rb-Sr age determinations were made on one whole rock and four mica concentrates. Data for the E and A standard Sr, analysed by the same method, yielded a $^{87}Sr/^{86}Sr$ ratio of .70795 ± .00002. Measurements on the NBS stan= dard SRM 607 show that the Rb and Sr concentrations are accurate to within 1%. The data obtained are plotted on an isochron diagram (fig. 1) and have been regressed by the method of York (1966). Using a value of 1.42 x $10^{-11}yr^{-1}$ for the decay constant of ^{87}Rb the computed results are:

Age = 1800 ± 40 m.y.
Initial $^{87}Sr/^{86}Sr$ = .7068 ± .0008

where the uncertainties quoted are 1 sigma values. Noting that the Rb/Sr ratios of the four mica concentrates differed by a relatively small amount the data in effect define a whole rock-mineral pair and the result may reflect a minimum age."

RELATIONSHIP OF THE DYKES TO KIMBERLITE: Although these dykes are mineralogically similar to some kimberlites (Skinner and Clement, this volume) they do not conform with current definitions of kimberlite in certain important respects.

There is a complete absence in the dykes of anhedral, commonly rounded, mega=crysts of olivine which, together with smaller euhedral phenocrysts, form the typical olivine assemblage in kimberlite. Similarly the previously described silicate and oxide heavy mineral suites, while clearly akin to those present in kimberlite, are unusual in that again none of the minerals occur as mega=crysts. Furthermore textural features and the morphological characteristics of some minerals differ markedly from those reported from kimberlite. Notable in these respects are the panidiomorphic-granular textures of the major (central) parts of the dykes and the skeletal hopper olivines which have not been found in kimberlite. The abundance of parallel growth forms of olivine is also atypical of kimberlite olivine. An additional mineralogical difference is that diopside is commonly more abundant than olivine. No ultra=mafic nodules of any sort have been found in any of the dykes.

CONCLUSIONS: It is concluded that these ultramafic dykes were emplaced as hot liquids (relative to kimberlite) approximately 1800 m.y. ago. Textural features indicate that most of the minerals crystallized in situ. The abundance of hopper olivine crystals indicates rapid cooling and/or rapid olivine growth (Donaldson, 1976). Extremely rapid cooling at the margins of the dykes is indicated by prominent chill zones.

The garnet and opaque oxide minerals in the dykes indicate affinities with kim=berlite as does the occurrence of the dykes in an area of intensive, albeit much later, kimberlite intrusion. In other respects the dykes differ consi=derably from kimberlites. Although a direct genetic association with the kimberlites cannot on available information be disproved, it seems unlikely in view of the long interval between the two periods of ultrabasic magmatism in the area. On the basis of heavy mineral chemistries it does, however, appear that the magma which gave rise to these dykes originated in the upper mantle within the depth zone postulated for the genesis of kimberlite (140+km.).

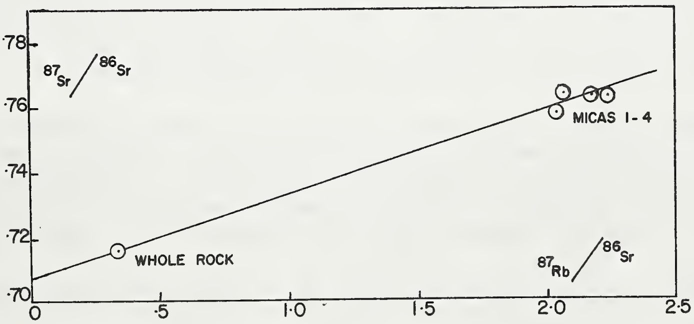

Fig.I: ISOCHRON DIAGRAM - WESSELTON MINE DYKE