GEOLOGY OF THE DOKOLWAYO KIMBERLITE AND ASSOCIATED PALAEO-ALLUVIAL DIAMOND DEPOSITS

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During 1973 exploration in northeastern Swaziland resulted in the discovery of diamond bearing grits and conglomerates of Red Beds (upper Triassic) age in the Karroo System sedimentary rocks of the Lebombo monocline. The richest and most extensive deposits occur in the Hlane Game Sanctuary. Palaeocurrent analysis of the diamond bearing beds indicate that they were deposited by an ancient river system flowing in a south-easterly direction. Further exploration carried out during 1975 in an upstream direction relative to the paleoslope resulted in the discovery of the Dokolwayo kimberlite diatreme some 30km. W.N.W. of the Hlane deposit. Despite intensive exploration no other diamondiferous kimberlites have been found in the area between Dokolwayo and the Hlane deposits.

In this paper the geology of the Hlane deposit is described and its possible relationship to the Dokolwayo diatreme is discussed. Results of the studies of the structure, petrography, xenoliths and mineral chemistry of the Dokolwayo kimberlite are presented; these studies are directed towards the elucidation of the age of formation of the diatreme, its mechanism of emplacement and the origin of the Hlane diamonds. So far no mica or zircon suitable for radiometric age determination of the kimberlite has been found.

THE HLANE DIAMOND DEPOSIT occurs near the top of the Karroo sedimentary sequence (Table I). These sediments dip at 10^{o} -12^{o} E., are intruded by a swarm of dolerite dykes and are dislocated by numerous N. -S. trending faults downthrowing to the west. High diamond concentrations are found in two similar sedimentary units at the base of the Red Beds. The lower unit (0,5-2m.) occupies a system of broad irregular channels shallowly incised into underlying siltstones; the overlying unit (0,5-0,8m.) extends beyond the channel confines and laps onto the channel interfluves. Both units consist of cyclic deposits of carbonate cemented sediments fining upwards from carbonate and siltstone clast conglomerates set in a grit matrix, to muddy cross-bedded grits and ripple marked sandstones. Both units contain abundant kimberlitic garnet and less frequent Cr. spinel, Cr. diopside and diamond. The vectoral mean of 25 measurements of channel orientation and foreset azimuths of crossbeds was 106^{o} from T.N. The high incidence of kimberlitic garnet relative to non kimberlitic garnet and the lack of Archaean clasts suggests that the source of the diamonds and kimberlite derived minerals lay within the Karroo basin at the time of deposition of the Red Beds.

THE DOKOLWAYO KIMBERLITE DIATREME is located on the Kaapvaal craton near its eastern margin and intrudes late Archaean granite gneisses. Drilling and pitting have shown that it is irregularly elongate in outline with steeply dipping walls. The surface area is 2,8 ha. increasing to 3,4 ha. at a depth of 50 m.

The central part of the diatreme is occupied by kimberlite characterised by a clastic texture and abundant xenogenic material. The xenogenic components range from

large (>1m.) blocks of country rock to microscopic xenocrysts. The most prominent feature in thin section is the abundance of quartz and felspar xenocrysts, the majority of which are < 0,5mm. Also prominent are numerous altered olivine grains 2-3 mm. in diameter. The most common alteration products are a micaceous clay mineral, serpentine and calcite. Other microxenoliths consist of coal fragments, fine grained clastic kimberlite and porphyritic kimberlite. These mineral and rocks fragments are set in a mixture of finely comminuted quartz and felspar fragments, minute laths of mica, iron oxide, calcite and yellow clayey material. The larger wallrock blocks consist of granite gneiss and medium grained sandstones and grits, commonly associated with coals. The coals and sandstones are similar to those of the middle Ecca found elsewhere in Swaziland and it is concluded that they were incorporated in the kimberlite by downward slumping during emplacement of the diatreme from overlying Karroo horizons subsequently removed by erosion. Tuffisite veins containing up to 80% of quartz grains cut the central kimberlite and included xenoliths, disrupting and brecciating the latter.

The diatreme margins are occupied by a narrow zone of porphyritic kimberlite which contains numerous altered olivine insets and small wallrock xenoliths set in a grey-green aphanitic matrix. Phlogopite and serpentine are the most abundant groundmass minerals.

The clastic texture of the central kimberlite and the high proportion of xenogenic material are but two of the many features which suggest that the diatreme formed as a result of at least one major phase of gas-solid fluidized intrusion, probably preceded by an explosive breakthrough to a higher (now eroded)level. The abundance of tuffisite breccia suggests that this type of intrusive activity played a major role in filling and shaping the diatreme at higher (eroded) levels. The previously described irregularities in outline and the presence of marginally disposed porphyritic kimberlite suggest that processes such as magmatic stoping and inward spalling of country rock were responsible for shaping the diatreme walls at the present near surface levels.

Sedimentological studies indicate that the Hlane diamonds are possibly derived from the Dokolwayo diatreme but insufficient numbers of diamonds of comparable size are available for meaningful comparisons to be made. To test this hypothesis of origin comparison of the mineral chemistry of garnets and spinel from both sources was undertaken; virtually no ilmenite is found in either source. Roughly 1000 garnet grains in the 16-28 mesh (Tyler) range were selected from representative samples from each source and grouped into 7 colour categories. 22-52 Garnet grains selected at random from each colour category and 20-48 spinel grains in the same size range were analysed using an A.R.L. SEMQ automated electron microprobe. The mean chemical composition of grains analysed is shown in Table II. Comparison of the results strongly suggests that the grains analysed are from a common source.

If it is accepted that the Hlane diamonds are derived from the Dokolwayo diatreme it follows that the diatreme was emplaced in pre-upper to mid-Triassic times. Similarly if the coals found in the kimberlite are accepted as being derived from middle Ecca coal measures the diatreme must have been intruded during or after Permian times.

It is concluded that the Dokolwayo diatreme was intruded prior to the Stormberg volcanic event in Permo Triassic times; this represents a unique age of kimberlite emplacement in southern Africa.

TABLE I

STAGE/SERIES		LITHOLOGY	THICKNESS	AGE
Drakensberg Stage	Stormberg Series	Basalts, rhyolites agglomerates and stratified tuffs	>3000m	Triassic-Jurassic
Cave Sandstone Stage		Massive aeolianite	±70m	Upper-Mid Triassic
Red Beds Stage		Siltstones	±50m	Upper-Mid Triassic
HLANE DIAMOND DEPOSIT	EMPLACEMENT OF DOKOLWAYO KIMBERLITE DIATREME			
Molteno Stage		Fluvial sandstones and siltstones	±40m	Upper-Mid Triassic
Beaufort and Ecca Series		Sandstones, grits, shales and coals*	±800m	Permian
Dwyka Series		Tillite	±5m	Upper Carboniferous
		Granite gneiss		Late Archaean

*The lowest coals are found in the Middle Ecca approximately 250m above the base of the Karroo succession.

TABLE II

ANALYSES OF GARNETS AND SPINEL FROM DOKOLWAYO(D) AND HLANE(H)

Mean Chemical Compositions

GARNET Colour Group		Al_2O_3	FeO	TiO_2	CaO	Cr_2O_3	MgO	No. of Grains Analysed
Mauve	D	17,6	6,4	0,1	6,2	7,3	19,4	49
	H	20,5	7,3	0,4	4,7	3,2	20,5	50
Cerise	D	20,5	7,3	0,4	4,7	3,2	20,5	48
	H	20,7	7,2	0,3	4,9	4,0	20,4	51
Pink	D	21,0	7,1	0,3	4,6	2,4	21,2	50
	H	21,1	7,1	0,3	4,6	3,1	21,1	28
Red	D	20,9	8,3	0,7	4,5	2,1	20,4	50
	H	21,1	8,2	0,7	4,6	2,4	20,8	50
Dark Orange	D	21,7	9,8	0,9	4,0	0,4	20,0	50
	H	22,1	10,0	0,9	4,2	0,5	19,7	51
Pale Orange	D	22,0	10,5	0,8	3,8	0,2	19,5	52
	H	22,9	11,4	0,3	4,5	0,1	18,2	50
Straw	D	22,9	11,5	0,3	4,5	0,3	18,5	22
	H	23,2	10,1	0,1	4,6	0,2	19,4	38
SPINEL	D	5,8	16,7	1,4	0	59,9	13,5	48
	H	5,3	17,5	1,3	0	59,8	12,8	20

Analyst: G. Hutchinson