KIMBERLITES AND RELATED ROCKS FROM THE NAMA PLATEAU OF SOUTH WEST AFRICA

by A.J.A. JANSE formerly Research Institute for African Geology
The University of Leeds, England

presently Australian Selection Pty. Ltd.
Box R.1274, G.P.O. PERTH, W.A. 6001

The Gibeon kimberlite province contains at least 46 pipes and 16 dykes which show a variety of rock types transitional from basaltic massive kimberlites and kimberlitic breccias to carbonatitic dykes. It is located between 25° and 26° S.Lat. and 17°30' and 18°30' E. Long. Besides kimberlites, it also comprises the Gross Brukkaros carbonatite complex (Janse 1969), the Blue hills monticellite-bearing porphyritic peridotite (Janse 1971), the Hatzium dome (Heath & Toerien 1965) and several carbonatitic dykes. The writer believes that all these rocks are related and form part of the Gibeon kimberlite province.

Rocks of the Nama System (Precambrian to Lower Paleozoic) cover most of the country side. They are unconformably overlain to the east by the Dwyka Series (Carboniferous). The upper part of the Fish River Series (upper Nama), represented by maroon shales, and the lower part of the Dwyka - tillites and mudstones - underlie the Great Namal and Plain, which has an average altitude of 1000 metres. West of the plain lies the higher Schwarzrand Plateau (1500 to 1800 metres a.s.l.) formed by sandstones of the Fish River Series. The eastern border of the plain is outlined by the Urinanib escarpment (45 metres in height) where the Dwyka rocks disappear beneath the Kalahari Beds (middle Tertiary?)

Outcrops of fine-grained bluish-black amygdaloidal basalt and coarser ophitic dolerite which can be correlated with the Stormberg lavas in Lesotho (DuToit 1954) occur between the Dwyka rocks and the Kalahari Beds in areas north and east of Mariental, i.e. north of the Gibeon kimberlite province. Accidental inclusions of similar amygdaloidal basalt in the Gibeon kimberlites suggest the existence of a far more extensive basalt cover at the time of intrusion of the kimberlites.

The kimberlites are intruded into the Nama and Dwyka rocks, but are overlain by the Kalahari Beds. Eleven of the pipes are located in the Schwarzrand Plateau in Nama sandstones, one pipe outcrops from underneath the Kalahari Beds on the slopes of a small hill outlier in front of the Urinanib escarpment, while the rest of the pipes lie in the Great Namaland Plain in Nama shales and Dwyka tillites. It is probable that more kimberlites are hidden under the Kalahari Beds.

The kimberlites were found by aerial photo interpretation and stream sediment panning for the typical kimberlitic heavy minerals. The streams are dry for most of the year and the lack of soil formation and strong deflation in the prevailing hot dry climate favours the formation of eluvial heavy mineral concentrates on the kimberlite outcrops which consist generally of hardebank and less often of softer blue ground. Yellow ground is absent in this climate.

The typical outcrop in this area is flush with the surrounding surface or forms slight depressions bordered by steeply upturned host rocks which flatten out in a distance of less than 15 metres. Contact metamorphism is very slight. In some places the red colour of the Nama rocks has been changed into green for less than 10 metres, while angular fragments of country rock included in the kimberlite are bleached and bordered by baked edges which indicates a slight thermal reaction. The basalt inclusions in some kimberlites possess angular cavities filled with dark green earthy chlorite, translucent calcite and much fibrous, nodular or massive matrolite, unlike the basalt at Mariental which contains only chlorite. This change in mineralogy suggests also a slight metasomatic reaction.

In some occurrences most of the outcrop is covered by a continuous mass of dolerite which suggest that these vents represent the feeding ducts to lavas of the Mariental type which have been eroded from this area. Blue ground or hardebank forms only a minor part of the outcrop at the side of the vent or occurs only in fractures in the dolerite. It appears that the kimberlite used the older feeding ducts as intrusion channels.

The size of the Gibeon kimberlites is rather small compared to kimberlites from other areas; it varies from a mere 10 metres to 900 metres for the HanausNo. 1 pipe which is formed by the coalescence of two intrusion chimneys. Many of the occurrences are distinct fissure-pipes; i.e. 2 or 3 pipes elongated in outcrop on the same fissure or in a straight line not visibly connected on the surface. The strike of the fissures and the elongation of the pipes follows the directions of the fracture pattern in the Nama sandstones (N 55^{O}E and N 125^{O}E) or in the Nama shales (N 65^{O}E to N 75^{O}E and N 145^{O}E to N 160^{O}E.)

Most of the vents and fissures (dykes) contain basaltic hardebank; only 8 out of the 46 pipes show much phlogopite on the surface and these outcrops are mainly composed of blue ground. In hand specimen the basaltic hardebank consist mainly of numerous macroscopic crystals of forsterite, more or less replaced by serpentine, few crystals of phlogopite and occasional crystals of pyrope, ilmenite and chrome-diopside set in a fine-grained dark grey matrix. Aggregate crystals of pyrope, chrome-diopside, forsterite and ilmenite and intergrowths of pyrope/chrome-diopside and forsterite/ilmenite also occur. Diamonds have not been found. The replacement of forsterite by serpentine occurs in every stage of transition but appears to have progressed least in basaltic fissure hardebank. The forsterite of the more micaeous blue ground is completely replaced. Thin sections show the usual mineral assemblage, i.e. olivine, phlogopite, serpentine, calcite, ilmenite, perovskite, apatite and magnetite.

The Gibeon kimberlites contain numerous angular and rounded inclusions. The angular inclusions consist mainly of sedimentary country rock or basalt - dolerite fragments, while the rounded ones are derived from rocks from a deep seated origin as indicated by their mineralogy which comprises variable proportions of olivine, pyroxene, garnet, plagioclase and amphibole. Included amongst the various modular rock fragments are: garnet peridotite, garnet pyroxenite, hyperstene or pyroxene granulite, anorthosite and nodules containing garnet (almandine-pyrope), pyroxene. plagioclase, amphibole, quartz and kyanite which are believed to represent retrograde eclogites.

Several kinds of rocks with more carbonatitic affinities are found in the periphery of the Gibeon province. The Gross Brukkaros carbonatite complex with its central explosion vent filled with fine-grained, layered, comminuted country rocks, its satellite vents with coarse breccias set in a carbonate matrix and its radial beforsite dykes (Janse 1969) is located at the southern end. At the northern end, 110 km north of Brukkaros, lies the Hatzium dome, which is a Brukkaros type complex in an incipient stage (Janse 1969) while at the eastern side occurs an olivine melilitite (Mukorob dyke, Frankel 1956) and the carbonatitic Amalia dyke; similar dykes occur at the western side in the Ovas area, The Mukorob dyke contains peculiar black shiny ellipsoidal inclusions of olivine with concentric shells of ilmenite forming the outside of the inclusions which have also been found in the carbonate-rich Hatzium pipe. This pipe (at the northern end of the province) contains also an apatite-rich rock in its centre.

The major element analysis (see table) show the usual kimberlitic characteristics i.e. low SiO_2 and Al_2O_3, high TiO_2, Fe_2O_3 and MgO, but CaO is higher than the usual Nockold's average and corresponds better to Lebedev's average. The left hand side of the table presents the more "normal" kimberlite with K_2O NaO, while towards the right hand side increasingly carbonatitic rocks are shown with Na_2O K_2O and high CO_2 and H_2O.

Trace element analyses show a pronounced decrease in heavy metals (Co, Cr, Ni, Ti and V) and a less distinct increase in light elements (La, Y and Zr) moving from the kimberlites to the carbonatitic rocks.

Garson (1962) and Dawson (1966) plotted rocks from different world-wide localities in a variation diagram to show the chemical gradation between kimberlites and carbonatites. Mitchell (1970) remarked that the deduced trends are artificial because the plotted rocks were not likely to be related in time and space. When the consaguineous rocks of the Gibeon province are plotted in such a diagram, there is a better suggestion of such a trend.

Milashev and Tabunov (1973) presented evidence from world-wide distribution patterns of kimberlites that the ideal kimberlite province is formed by concentric zones of a) most ultrabasic diamond-bearing kimberlites in the centre, b) pyrope-bearing ones next and c) increasingly alkaline rocks towards the periphery where pyrope disappears. The Gibeon kimberlite province corresponds to the pyrope zone of Milashev while the central diamond zone is lacking. It further corresponds to the non diamondiferous zone pattern in that the individual bodies are rather small while the largest one (Hanaus) is located in the centre.

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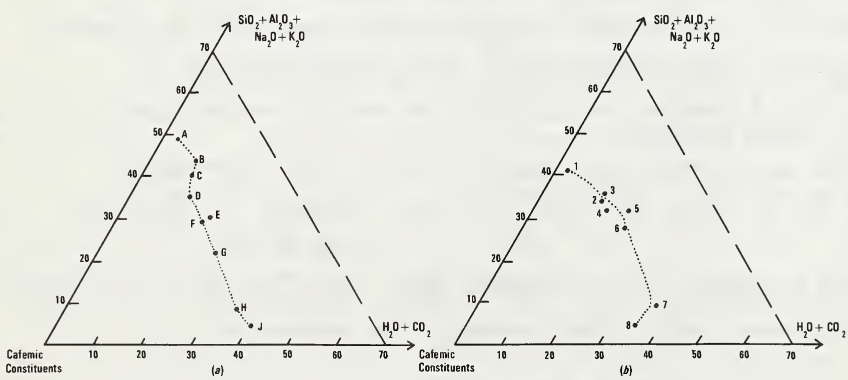
TABLE 1. Major element analyses of Gibeon kimberlites and related rocks

	1	2	3	4	5	6	7	8	9	10
SiO_2	31.16	28.0	33.0	30.0	30.67	25.0	4.6	2.93	35.62	29.57
TiO_2	3.44	2.28	1.15	1.77	0.82	1.17	0.49	0.69	1.22	1.31
Al_2O_3	5.63	3.8	2.2	2.7	2.34	2.4	3.5	0.68	3.90	3.48
Fe_2O_3	7.32	8.18	6.27	9.69	6.28	7.69	1.08	9.69	5.15	5.04
FeO	9.04	2.37	4.19	1.89	2.47	0.99	2.41	0.00	4.14	2.63
MnO	0.27	0.22	0.19	0.19	0.15	0.15	0.25	0.33	0.06	0.11
MgO	20.18	19.0	27.0	27.0	20.4	26.0	9.4	0.79	31.29	26.26
CaO	17.09	20.3	12.49	11.1	16.94	15.9	39.35	45.63	6.80	11.92
Na_2O	2.12	0.44	0.30	0.33	0.21	0.20	0.23	0.22	0.34	0.25
K_2O	1.52	2.71	0.70	0.30	0.18	0.41	0.07	0.03	1.05	0.54
H_2O+	1.45	5.53	7.61	13.79	9.51	9.60	1.57	1.49	7.43	- -
P_2O_5	0.28	n.d.	0.90	0.40	1.10	1.40	1.0	2.53	0.87	0.45
CO_2	0.62	8.12	5.52	1.17	10.76	11.63	36.87	34.29	2.73	18.06*
Total	100.65	100.95	101.52	100.30	101.83	102.54	100.82	99.30	100.00	100.30

18.06* = total loss on ignition

Specimen references for table 1 and the diagrams below:

1- Monticellite peridotite, Brukkaros complex
2- Calcite-phlogopite rock, Brukkaros complex
3- Surface hardebank, Gibeon Reserve no 2 pipe
4- Surface blueground, Hanaus no 1 pipe
5- Surface hardebank, Amalia no 1 pipe
6- Surface hardebank, Hatzium pipe
7- Carbonatitic dyke, Amalia
8- Beforsite dyke, Brukkaros complex
9- Average composition of basaltic kimberlite, 10 analyses Nockolds
10- Average vein kimberlite, 210 analyses- Lebedev 1964.



Diagrams illustrating the petrogenetic relationship of kimberlitic and carbonatitic rocks. (*a*) After Garson; (*b*) This Paper.