

THE GEOLOGY OF THE MENGYIN KIMBERLITES, SHANDONG, CHINA.

P.N. Dobbs⁽¹⁾; D.J. Duncan⁽¹⁾; S. HU⁽²⁾; S.R. Shee⁽³⁾; E.A. Colgan⁽⁴⁾; M.A. Brown⁽⁴⁾; C.B. Smith⁽⁵⁾ and H.L. Allsopp⁽⁵⁾ (deceased).

(1)Sino-British Cooperation, Dalian, China; (2)7th Geological Brigade, Linyi, Shandong, China; (3)Stockdale Prospecting, South Yarra, Australia; (4)Chichester Diamond Services, London; (5)Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Johannesburg, RSA.

The Mengyin kimberlite province was discovered in 1965 by geologists of the Shandong Bureau of Geology. Kimberlites Shengli 1 and 2 and Hongqi 1 were subsequently mined for diamonds. Further detailed prospecting between 1986 and 1988, including re-analysis of some of the historical data, shed new light on the mineralogical and petrological nature of the kimberlites, their age and structural setting and also found unusual features in the diamond population.

The kimberlites are located within the He-Huai block of the North China sub-plate, 80 to 100km west of the Tanlu fault, a major NNE-trending fracture that separates Archaean granite-gneiss of the 2 500Ma Taishan Formation in the west of Shandong from the Jiaodong Group, of early Proterozoic age, in the east. Between 520km and 740km of sinistral displacement is indicated for the Tanlu fault, with significant episodes of movement occurring in the Middle Proterozoic and Mesozoic. There are three zones of kimberlites (Changma, Xiyu and Poli) within a NNE-trending belt some 50 km long and 17.5 km wide. Their present structural setting is on the SE flank of a major NE-trending arch, which has been subjected to SSW reverse faulting along listric structures. The tectonic regime that prevailed in the Ordovician is less clear, but the Tanlu fault must by then have formed the eastern margin of the western Shandong terrain.

Each zone consists of many small en echelon dykes, with a dextral orientation. The maximum recorded width for a dyke is 3m at Hongqi 1, while average widths are usually 20 to 40cms. Hongqi 1 is also the longest dyke, at 1.4km. The Poli zone contains only very narrow dykes of limited extent. Clusters of small pipes of irregular shape occur in the central parts of the Changma and Xiyu zones. Drilling to 600m by 7th Brigade showed that the pipes coalesce below the present surface and become more dyke-like, with strong NNE strikes and NW-trending apophyses. Dip angles for pipes and dykes are usually steeper than 70°. An internal dyke is exposed in the open pit at Shengli 1, but the ages of the other dykes, relative to the age of the pipes, are unknown. A kimberlite sill occurs at the southern end of the Xiyu zone, Hongqi 23, and dips approximately 45° to the WNW. Most kimberlites intrude the Archaean gneiss, but the dykes in the Poli zone and those at the southern end of the Xiyu zone have Cambrian to Middle Ordovician limestone wall rock.

Hongqi 1 dyke was mined in an underground operation to a maximum depth of 90m along a strike length of 900m and an average width of 0.7m. Between 20 000 and 30 000 carats were recovered at an approximate mining grade of 80 carats per 100 tons. Shengli 1 has been mined since 1975 in an open-cast operation at a rate of approximately 30 000 tons per year. The grade of this deposit varies between 80 and 120

carats per 100 tons. The largest stone recovered from the Mengyin mine was a yellowish octahedron, weighing 119.01 carats, although three stones of 96.04, 124.27 and 158.97 carats were recovered from alluvial deposits, 130km to the southeast of Mengyin, that may have been derived from the Mengyin kimberlites.

Evaluation sampling of the kimberlites showed that, within each kimberlite zone, the diamond grade varies by between one and two orders of magnitude. There is an overall decline in grade from south to north within both the Changma and Xiyu zones, with a tendency for the central pipe clusters to contain the highest values of 10 carats per cubic metre.

The intrusions are root zone hypabyssal facies Group I kimberlites. Rare examples of tuffisitic kimberlite breccia are found, but these are thought to represent sub-surface fluidisation in the early stages of pipe formation. Kimberlite wall rock breccia, containing Archaean gneiss xenoliths up to 1m across occurs at Shengli 1 and Hongqi 6 and 8. Dykes contain more aphanitic kimberlite than the pipes and show much less mineralogical and textural variation. Present evidence suggests erosion is within the deep root zone.

Hypabyssal kimberlites are predominantly macrocrystic with a fine grained, uniform, granular to felty interlocking groundmass. They consist of abundant altered olivine macrocrysts and phenocrysts set in a groundmass of monticellite, phlogopite, opaque minerals, perovskite, apatite, serpentine and carbonate. Phlogopite and apatite are notably more abundant than in most southern African kimberlites and monticellite in Hongqi 6 reaches 0.1mm in size, while in southern African localities this mineral is typically 0.02mm

Hongqi 6 contains an unusual rock type with a globular texture which may be produced by mechanical rounding during emplacement of a partially consolidated magma. This differs from the globular-segregationary texture that occurs in southern African kimberlites.

Unusual rock types include a clinopyroxene and phlogopite-rich kimberlite breccia and volatile-rich cross-cutting veins. The former variety occurs in Hongqi 6 and Shengli 1 and is thought to be produced by extensive resorption of country rock fragments. Late stage volatile-rich veins of apatite and serpentine occur in Hongqi 6. These infiltrate the kimberlite groundmass and modify the original mineralogy, suggesting volatiles were trapped in deep-seated intrusions.

Systematic heavy mineral sampling of 26 of the kimberlites showed that pyrope and chromite abundances vary substantially over the kimberlite province and also within the Changma and Xiyu zones. The Changma zone contains pyrope and chromite in similar quantities and grain counts decline from south to north. In the Xiyu zone these two minerals are both less abundant than at Changma, but chromite is an order of magnitude more abundant than pyrope. Too few samples were collected from the Poli zone for trends to emerge but chromite is abundant while pyrope is rare.

Clinopyroxene is rare in the +0.5mm concentrates, although smaller grains are commonly seen in thin section. Ilmenite is present in most samples, but is unusually rare for Group I kimberlites. A crichtonite group mineral of the lindsleyite - mathiasite (LIMA) suite occurs in abundance at Hongqi 27, but such grains are not sufficiently widespread for use as prospecting indicators.

The mineral chemistries of the main heavy minerals are consistent with the diamondiferous nature of the province. Pyrope is mainly the low-TiO₂ peridotitic variety, with some discrete and high-TiO₂ types. Subcalcic peridotitic pyrope is common. Both low and high-TiO₂ chromite is present and diamond inclusion compositions are found.

Radiometric dating of macrocrystic mica from the Shengli 1 and Hongqi 1 kimberlites using the Rb-Sr technique gave an age range of 450 to 500 Ma with a current best estimate of 475 Ma. This result is supported by additional age determinations, made by J W Bristow, using the U-Pb ion-probe method on perovskite from the Shengli 1 kimberlite. This gave a mean age of 456 +/- 8 Ma. There appeared to be no detectable difference in the ages of Shengli 1 and Hongqi 1.

A production parcel of diamonds mined from the Shengli 1 open pit were examined by J W Harris in 1986. A total of 1200 diamonds in six sieve classes were classified. A distinctive feature is an increase in the proportion of octahedral shapes in the smaller size ranges, being the reverse of the trend found in other studies. Octahedra, dodecahedra and flattened dodecahedra together form a relatively constant 20% in each sieve class, which may indicate a single diamond population. This implies also that the larger stones have been preferentially released and resorbed by the kimberlite magma. Macles make up 30%, on average, of each sieve class and brown stones constitute 80% of the population; both these features are unique. Syngenetic inclusions in diamonds from Shengli 1 are predominantly peridotitic.

The Mengyin kimberlites are petrographically and mineralogically similar to the kimberlites at Fuxian in Liaoning Province, 550km to the northeast. The latter were dated using the Rb-Sr technique on macrocrystic phlogopites, which produced a reliable isochron age of 461.7 +/- 4.8 Ma. The two kimberlite provinces are therefore coeval.

However, the Fuxian bodies intrude Proterozoic sediments, which are rare at Mengyin, and they occur on the opposite side of the Tanlu fault. It seems that the blocks on either side of the Tanlu fault had substantially different histories from some time during the Proterozoic to at least the early Palaeozoic and may therefore have been widely separated during this period. Similarities in stratigraphy, lithofacies and thickness of the Sinian, Cambrian and Ordovician formations of northern Jiangsu-Anhui provinces and southern Liaoning Province suggest that the Fuxian kimberlites may have been to the south of Mengyin at the time of kimberlite intrusion. The possibility that the scattered alluvial diamonds and associated kimberlitic minerals of northern Jiangsu-Anhui could be derived from the Fuxian kimberlites therefore needs to be considered. Present evidence does not point to the Mengyin and Fuxian kimberlites being contiguous at the time of their emplacement, although it seems that they were closer together than they are today.