REGIONAL AND LOCAL VARIATIONS IN THE CHARACTERISTICS OF DIAMONDS FROM SOME SOUTHERN AFRICAN KIMBERLITES

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The diamond classification scheme (Harris et al 1975) has been used to obtain new data about diamond characteristics from several major kimberlite sources in southern Africa. Of the numerous relationships determined only the variation in crystal form and colour as a function of diamond size are considered in the following results because these relationships not only enable distinction to be made between the diamond sources studied, both on a local and regional basis, but also provide information about the environment of the diamond during and subsequent to its growth. The results are conveniently divided into four sections.

(1) Studies on diamonds from single kimberlite diatremes

a. Koffiefontein: The completion of the development levels at 244 m and 488 m at this mine has enabled crystal form and colour of diamond to be examined as a function of depth within the mine. The comparisons with surface productions indicate that crystal habit versus diamond size varies only slightly with depth. There is a steady increase in the proportion of octahedra from 5-20% with increasing diamond size, and this variation is not at the expense of the dodecahedra which contribute a fairly steady 20-25% to the diamond population. Macles and polycrystalline aggregates are also essentially constant through the size ranges at about 12% and 3% respectively. Broken and irregular diamonds constitute the remaining shape.

Colour variations are pronounced. With increasing depth over the common diamond size range, colourless diamonds decrease in proportion from about 60% to 40% and yellow and brown stones increase from 30% to 50%. A similarity of colour variation in each of the levels however is that yellow diamonds increase in proportion at the expense of browns as diamond size increases.

b. Finsch: At this mine, diamonds from the current production are compared with those from the new 348 level. Only minor variations of crystal habit with size are noted for both levels. Again there are very constant proportions of flattened dodecahedra (3%), macles (20%), irregulars (35%), and polycrystalline aggregates (2%) over the size ranges. Octahedra and dodecahedra account for the remaining 40% of the diamond population and with increasing size the octahedra steadily increase in proportion from 15-20%.

Colour variation between levels is dominated by the virtual disappearance of the transparent green-coated diamond on the 348 m level and this is accompanied by a complementary increase in the brown and colourless stones by some 10% and 5% respectively. At both levels yellow diamonds increase against brown with increasing diamond size.

c. Premier: From this mine diamond samples from two specific kimberlites on the 520 m level are characterised and compared with diamonds from the general production. At the 520 m level the brown and grey kimberlites respectively occupy one-fifth and four-fifths of the pipe area. Only very slight differences in morphology are observed from diamonds in the two specific kimberlites and the general production. With increasing diamond size octahedra and polycrystalline aggregates remain constantly low ($<5\%$), the dodecahedra constitute about 15%, but macles steadily increase from 15-25%. The proportion of irregular diamonds is high, varying between 50-60%.

Differences of diamond colour between the two specific kimberlites are again marked. Relative to the brown kimberlite there is a 10% decrease in colourless diamonds, a 20-25% increase in yellows, an 8-10% increase in transparent green-coated diamonds, and a 30% increase in brown diamonds. Yellows also increase against browns as diamond size increase. Relative to diamond colour in the general production diamonds from the specific kimberlites show a 10% decrease in colourless stones.

(2) Studies on diamonds from a kimberlite dyke swarm at Zwartruggens

Classification of these diamonds showed them to be morphologically unique in comparison with other southern African sources in that the diamond population contained less than 2% macles; other sources have a macle content of at least 10%. Another prominent feature is the presence of between 5-10% of cubes; other sources so far studied have only 1%. Predominant amongst the several colours are between 2-5% of orange and amber stones compared to $<$ 1% elsewhere. Multiply coloured diamonds (amber/colourless) are also a feature of this diamond source.

(3) Studies of diamonds from adjacent kimberlite diatremes

a. The Main and Satellite Pipe at Letsing-le-terai: A characteristic of the morphology of the diamonds from these diatremes is the very low octahedron content ($<2\%$) coupled with a low macle content at about 10%. Differences in morphology between diamonds from the two mines appear slight, but there are colour differences, particularly in the proportion of brown and grey stones. An unusual colour feature for both mines is the absence of transparent green-coated diamonds.

b. Koffiefontein and Ebenhaezer diatremes: The only difference between the diamond morphology of these diatremes is that over the common size ranges there is a slightly higher proportion (3%) of flattened dodecahedra at Ebenhaezer. A diamond colour comparison shows that the proportion of specific colours varies, the diamond colours at Ebenhaezer being more similar to those of the 244 m or 488 m levels at Koffiefontein than with the surface production, (see before).

c. The Kimberley Group of Mines: Only preliminary data are available. The results show that the morphologies of the diamonds from Bultfontein, De Beers, Dutoitspan, and Wesselton are similar whilst colour differences are evident.

(4) Regional Variations of Diamond Morphology

On the basis of morphology the diamonds from the various sources can be broadly divided into two groups which appear independent of kimberlite emplacement age. The first group comprises the Kimberley mines, Koffiefontein and Finsch and are characterised by the steady increase in the proportion of octahedra with increasing diamond size. There are also similar proportions of flattened dodecahedra, macles, and polycrystalline aggregates, although the proportion of irregular diamonds varies considerably between sources. Premier, Zwartruggens, and Letsing-le-terai form the other group which has a much lower proportion of octahedra remaining essentially constant throughout the diamond size range studied. The diamonds from each of these mines however varies in proportion of dodecahedra, macles, cubes and irregulars. The particularly distinctive diamond characteristics from the kimberlite dykes at Zwartruggens are not a function of the mode of kimberlite intrusion, as such characteristics are absent from other fissure mines such as those at Bellsbank.

Variation of Morphology and Colour

The principal primary morphologies of diamonds beneath southern Africa are the octahedron, macle, and their aggregates. Subsequent to their formation the diamond population from each of the kimberlites underwent modification. Resorption processes, possibly caused by the volatiles during kimberlite ascent, resulted in the formation of the dodecahedra and flattened dodecahedra. Most of the irregular or broken diamonds post-date the resorption event and fracturing probably occurred during kimberlite emplacement. The slight differences between the morphologies of the diamonds from the grey and brown kimberlites at Premier, or between diamonds from adjacent kimberlite diatremes can also be related to those late-stage processes.

The colourless, yellow, amber and brown colours noted in these studies are explained either by the way in which the impurity nitrogen became aggregated in, or combined with, carbon in the initial diamond growth environment, or by the extent to which the various established diamond populations subsequently underwent plastic deformation. The variations in the proportions of diamond colour with depth are not due to post-emplacement effects but are considered to be a consequence of the variation of the size distribution of diamonds within the kimberlite. Transparent green-coated diamonds result from α-particle irradiation by uranium or thorium atoms after kimberlite emplacement. The diamonds in unweathered kimberlite, as at Premier and Koffiefontein, are damaged according to the original distribution of radioactive elements in the kimberlite, but in weathered kimberlite, as until recently at Finsch, these elements have probably been mobilised in the groundwater and consequently a much higher proportion of the diamond population is affected.

References

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