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Type IIA diamonds – flamboyant megacrysts?

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Inclusions in diamonds indicate that a majority of stones formed in association with either peridotitic or eclogitic mantle assemblages, probably as a result of metasomatic processes (Gurney et al., 2005). The rare Type IIA diamonds can be distinguished from these dominant diamond populations on the basis of their very low nitrogen contents, the rarity or absence of mineral inclusions, and their large, irregular size and generally superb quality. This suggests that they represent a distinct, but enigmatic paragenesis. In terms of morphology, they show a striking resemblance to the megacryst suite, and would indeed be classified as megacrysts in terms of criteria used to distinguish this suite (eg Harte, 1977). It is therefore proposed here that Type IIA diamonds represent late crystallizing phases of the discrete nodule or megacryst suite. This offers an explanation for many of their unusual characteristics.

Inclusions in megacryst suite phases indicate the parental magma was carbonate-rich, thus providing a source of carbon for diamond crystallization. It is most likely that nitrogen present would be preferentially portioned into the liquid at high pressures. This is analogous to nitrogen being partitioned into a diver's blood at depth, and potentially causing "the bends" if subsequent ascent to the surface is too rapid. Crystallization of Type IIA diamonds from an evolved megacryst (pegmatitic) liquid thus offers an explanation for the characteristic N-poor signature of these diamonds, and their large, irregular size.

Diamond crystallization is only possible at f_{O2} conditions below the CCO buffer. At conditions of megacryst formation (40-50kb), oxygen fugacities buffered by QFM will be below the CCO buffer at temperatures below about 800^{o}C, while the EMOG buffer will be below CCO fugacities at temperatures below around 950^{o}C. These temperatures are at the very low end of the temperature crystallization range reported for silicate megacrysts, although crystallization of non-silicates (eg zircon, ilmenite) may have continued to lower temperatures (Gurney et al., 1979).

The main Cretaceous producers of Type IIA stones in southern Africa are Letseng-la-terai, Jagersgontein, Koffiefontein and some of the Orapa pipes. All of these kimberlites are located near the margins of the Kaapvaal craton, and thus in a tectonic setting where subduction zones, linked to mobile belts surrounding the craton, may be expected. Subducted slabs would be characterized by anomalously low temperatures relative to ambient P-T conditions of typical cratonic mantle at comparable depth (cf Haggerty, 1999). The distribution of the Type IIA-bearing kimberlites may accordingly reflect that it is only in this tectonic environment where megacryst liquids would be in contact with wall rocks that were sufficiently cool to permit oxygen fugacity conditions within the carbon (diamond) stability field. Such low temperatures, below the range of crystallization of silicate megacrysts, would account for the absence of these phases as inclusions in Type IIA diamonds.

Fibrous diamonds formed by rapid crystallization, just prior to, or at the time of kimberlite emplacement (Gurney et al, 2005). It is suggested that these may be diamond analogues of rare mantle inclusions with quench textures that have been linked to the megacryst suite (Boyd et al., 1984; Rawlinson and Dawson, 1979).

On the basis of the model proposed, it would be predicted that inclusions in Type IIA diamonds, if found, will match the exotic late phases characteristic of the megacryst suite.

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