MICRODIAMONDS FROM KIMBERLITES AND LAMPROITES: OBSERVATIONS AND IDEAS CONCERNING THEIR ORIGIN

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For macrodiamonds (>1 mm diameter), the question of whether most are phenocrysts in their igneous host, or are xenocrysts plucked from deep in the mantle during ascent of these magmas has been resolved in favour of the latter. Morphological and geochemical studies of macrodiamonds show that they are generally older than their igneous host, and have been partially resorbed by hostile reaction with magmatic volatiles (Robinson, 1979; Orlov; 1971; Richardson et al., 1990,1993; Smith et al., 1989; Kramers, 1979). The process of resorption changes the macrodiamond crystal from a primary octahedron or cube to a tetrahexahedral shape with curved crystal faces, a tetrahexahedroid (Robinson, 1979; Robinson et al., 1989). Diamonds in various stages of resorption are found in kimberlites and lamproites and indicate that not all diamonds are liberated from their xenolith hosts at the same time. One trend that holds generally is that smaller diamonds, with higher surface area to mass ratios, are more resorbed than larger diamonds. Given the trend toward more resorption with smaller stone size, one would anticipate that microdiamonds (<1 mm) would be almost exclusively tetrahexahedroida.

Microdiamonds are instead an enigma with respect to resorption, because, when whole crystals are considered, they are commonly unresorbed octahedra. This has led to speculation that some microdiamonds have a genesis separate and distinct from macrodiamond xenocrysts, possibly as phenocrysts in the kimberlite or lamproite (Haggerty, 1986; Levinson and Pattison, 1995). Much this speculation is based on the early studies of Tolansky and co-workers (Tolansky, 1973; Tolansky and Rawle-Cope, 1968) in which *unbroken* microdiamonds from Premier and Finsch were obtained for determining nitrogen aggregation states. They reported that over 96% of their crystals were octahedra at Premier, 53% were octahedra at Finsch, and the remainder were referred to as dodecahedra (Tolansky, 1973), possibly a form equivalent to cubo-octahedra that are reported in Russian kimberlites (Varshavskii and Bulanova, 1975). In contrast, recent studies suggest that, although octahedra are the most common unbroken crystal form, fragments dominate the microdiamond population (McCandless, 1989). Furthermore, microdiamonds from kimberlites and lamproites have surface textures identical to microdiamonds from diamondiferous xenoliths, which suggests a xenocryst relationship to the igneous host (McCandless et al., 1994).

In this study we examine microdiamonds from U.S., South African and Australian kimberlites and lamproites, and confirm that microdiamonds from lamproites and kimberlites worldwide have morphologies that contrast with those for macrodiamonds. The most noticeable difference is that the tetrahexahedroid, which is so common amongst macrodiamonds is rare or absent as a microdiamond, and that octahedra microdiamonds are the dominant crystal shape (Table 1). Although octahedra are the most common whole crystal, broken crystals far outnumber whole crystals. This misconception can have serious consequences when the macrodiamond potential of a kimberlite or lamproite is projected solely on the numbers of microdiamonds recovered in small test samples (Jennings, 1993).

Microdiamonds are believed to be xenocrysts, based on the overwhelming dominance of surface features that are similar to those observed on microdiamonds from xenoliths. Resorption of microdiamonds is non-systematic and can result in wholesale destruction of the microdiamond rather than conversion to a tetrahexahedroid. Microdiamonds therefore are not a product of, nor in equilibrium with, the transporting magma. The observed morphology is product of shielding the microdiamonds from the resorption process in small xenolith fragments and does not require a phenocryst origin to explain unresorbed octahedral shapes. The use of microdiamond surface textures as a means of evaluating macrodiamond grades of kimberlite or lamproite is presently under investigation.

TABLE 1. Relative percentages of octahedra, tetrahexahedroida, and dodecahedra, and the percentage of twin and aggregate crystals in macrodiamond and microdiamond populations from kimberlites and lamproites. For microdiamonds, the total percentage of the population consisting of fragments is also given.

Location	octahedra	tetrahexahedroida	dodecahedra	twins and aggregates	% of fragments
Macrodiamonds					
Sloan[1]	59%	41%	0%	15%	
Koffiefontein[2]	33%	67%	0%	41%	
Prairie Creek[3]	0%	100%	0%	9%	
Ellendale 4[4]	2%	98%	0%	52%	
Microdiamonds					
Sloan[5]	92%	6%	2%	53%	83%
Koffiefontein[5]	100%	0%	0%	0%	58%
Prairie Creek[3]	100%	0%	0%	33%	62%
Ellendale 4[5]	100%	0%	0%	50%	57%

Sources: (1) McCandless, 1990; (2) Harris et al., 1975; (3) McCandless et al., 1994; (4) Hall and Smith, 1984; (5) this study.

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