

## High Resolution X-ray Microtomography of Polycrystalline Diamond

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Several varieties of polycrystalline diamond have been described from ultramafic xenolith-bearing kimberlite localities, including framesite and ballas. Given the lithologic association and  $\delta^{13}\text{C}$  values, these microdiamonds appear to be derived from the same mantle source as their larger single-crystal cousins. Conversely, carbonado is a polycrystalline variety of diamond found exclusively in placer deposits in Central Africa and South America and lacks an accepted protolith. All three forms of polycrystalline diamond have been examined by high resolution X-ray microtomography in an effort to evaluate whether carbonado nodules share microstructural characteristics with microdiamonds of known origin. Three dimensional X-ray imaging has been conducted using both synchrotron and laboratory X-ray sources, yielding voxel edge lengths of 6 and 7-16  $\mu\text{m}$  respectively. Because synchrotron data are not currently available for all diamond varieties, only the laboratory system results are presented here.

Differences among the microstructures of nodules of the three types of polycrystalline diamond were noted in the volume fraction occupied by pores and mineral inclusions. Ballas and framesite were found to contain only 1-2 vol % mineral inclusions, whereas carbonados from the Central African Republic contain 6-40 vol % inclusions. Even more striking is the degree of porosity of carbonado (up to ~30 % in a single X-ray slice) whereas the pore volume of ballas is near zero.

The abundant voids and mineral inclusions of the carbonado nodules were also analyzed for their principal direction and shape anisotropy. Volume- and length-based measurements were performed and yield a degree of anisotropy for both pores and inclusions equivalent to a mineral component of a rock containing a well-developed mylonitic fabric (Ketcham, J. of Structural Geology, in review).

The results from 3D X-ray imaging suggest that carbonado are microstructurally distinct from kimberlitic polycrystalline diamond and that carbonados have been subjected to some degree of deviatoric stress.

## The lanthanide tetrad effect: computation and interpretation

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Rare earth elements (REE) are commonly associated to accessory minerals presenting structures large enough. They present high ionic charge and associated large ionic radius. They correspond to transition metals ranging from  $4f^0$  to  $4f^{14}$ , since they progressively fill the  $4f$  electronic shell. Chemical properties slowly vary from La to Lu, according to their decreasing ionic radius. The trend usually decreases from LREE to HREE. However, within the 15 elements of the group, the respective ionisation potentials present large variations. Values increase first, correlating with the increase in nuclear charge, that in turns increases the repulsion between electrons. However a break is observed between  $f^6$  and  $f^7$ , i.e. Eu and Gd, caused by the exchange energy resulting from coupling between paired electrons. It represents the half shell effect. Similar effects, but with reduced amplitude, occur at quarter and three-quarter filling of the electronic shell. REE vary by group of four elements, or tetrads. The four groups include La to Nd, Pm to Gd, Gd to Ho and Er to Lu. The four tetrads,  $t_1$  to  $t_4$ , present specific variations superimposed to the linear trend from LREE to HREE. In each group, the tetrad effect is superimposed on the linear trend, and manifests by a curved shape that develops on the four elements. But, depending of the chemical reactions that involve REE elements, those can be more favourably incorporated or not to the mineral assemblage. Two mutually opposite effects are observed, noted W and M types. We propose to characterise first the linear trend, and after removal to determine the curved effect through approximation by a quadratic form. Examples of tetrad effects are documented in hydrothermally affected granitic magmas, but also in the residual products of mafic melting experiments.