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Microstructural study of synthetic sintered diamond and comparison with carbonado, a natural polycrystalline diamond

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ABSTRACT

Efforts to simulate the extreme toughness of the polycrystalline diamond variety known as carbonado typically entail the sintering of diamond powders in the presence of metal solvent-catalysts. In this study, we have attempted to duplicate the carbonado microstructure by sintering diamond powders without catalysts in a multi-anvil press at pressures of 6 to 9 GPa, temperatures of 1200 to 1800 °C, and times up to 6 h. The resultant microstructural defect assemblages for each experimental condition were characterized by transmission electron microscopy (TEM). Despite the absence of catalysts, sintered compacts were successfully produced for all runs, though intergranular porosity was significantly higher than that observed in natural carbonado. Primary grain sizes were reduced by more than 50% from their original dimensions in some experiments due to surface fracturing and abrasion, and aperiodic slip planes rigorously parallel to {111} consistently emerged in high densities, with lamellar spacings of 3 to 30 nm. In addition, sintering over all conditions produced polysynthetic spinel twinning in close association with the partial slip defects.

Compacts compressed at 8 GPa produced some euhedral crystals with very low dislocation densities surrounded by grains in which dislocation densities were quite high. In addition, curviplanar defects loosely constrained to {111} were visible within some specimens sintered at the highest pressures. These textures resembled the polygonalization fabrics and defect microstructures observed in natural carbonado (De et al. 1998), and the appearance of these features suggests that our experiments at their most extreme pressure and temperature parameters reproduced carbonado-like defect assemblages. The formation of such textures in quasi-hydrostatic experiments suggests that shock metamorphism is not required to produce the periodic defect lamellae observed in carbonado.