Constraints on the history and origin of carbonado from luminescence studies

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In order to examine the internal structure of carbonado diamond, a number of carbonado samples from alluvial sources in Brazil and the Central African Republic (CAR) were laser-sectioned and polished. A combination of optical and cathodoluminescence (CL) work has shown that carbonados do not all have the same microstructure. Two textures are observed. The first is an essentially equigranular aggregate composed of 10-20 micron diameter anhedral diamond grains often with intricately sutured margins and regions showing possible preferred orientation of grains. The second 'microporphyritic' texture comprises 25-100 μm diameter zoned, cubic microdiamonds set in a fine-grained diamond matrix (Figure 1). Some of these microdiamonds are broken. Development of such a texture requires a two-stage process indicating that these carbonados cannot have formed by short time scale processes such as meteorite impact. It is not yet known if the first textural type is simply a strongly deformed sample of the second, or if there is a genetic relationship between the two types of carbonado. One recently polished sample from the CAR appears to exhibit both textures.

A cathodoluminescence and photoluminescence (PL) study of five carbonados from the CAR and Brazil has revealed several illuminating features. CL shows that the pores in carbonado are surrounded by non-luminescent haloes, which contrast sharply with the other brightly luminescent areas of the stones. Raman spectroscopy and PL data indicate that in the areas surrounding the pores, the diamond lattice has been intensely damaged by radiation. Radioactive decay products have been reported in bulk carbonado (Ozima et. al. 1991), but the internal spatial distribution of the damage has not previously been described. Other types of radiation damage include the presence of dark concentric rings caused by point radiation sources, and linear zones of radiation damage localized on fractures along which radioactive fluids probably flowed. There is also evidence of intra-stone heterogeneities in the extent to which radiation damage has been annealed. Such features suggest that the diamond was formed prior to irradiation, which makes radiation induced synthesis unlikely. Nevertheless, the presence of similar radiation damage features in both textural types of carbonado strongly suggests that they have been subjected to similar geological processes since the carbonados came into contact with radioactive materials. This event has been estimated by previously published Pb isotope work to date from 2.8-3.6 Ga (Ozima and Tatsumoto 1997). Surprisingly, the minerals currently found in the pores of carbonado, which include a number of rare earth phosphates, are not U or Th rich. SHRIMP measurements on the phosphate inclusions show that they have recent, common Pb isotopic signatures which suggests that the previous radioactive pore minerals have been replaced during the weathering process. U or Th bearing minerals may have been the original pore minerals, but it is likely that reduced phases such as the metals and carbide observed by De and Heaney (1996) were present, and that those were replaced by redox reactions with U bearing surficial waters.

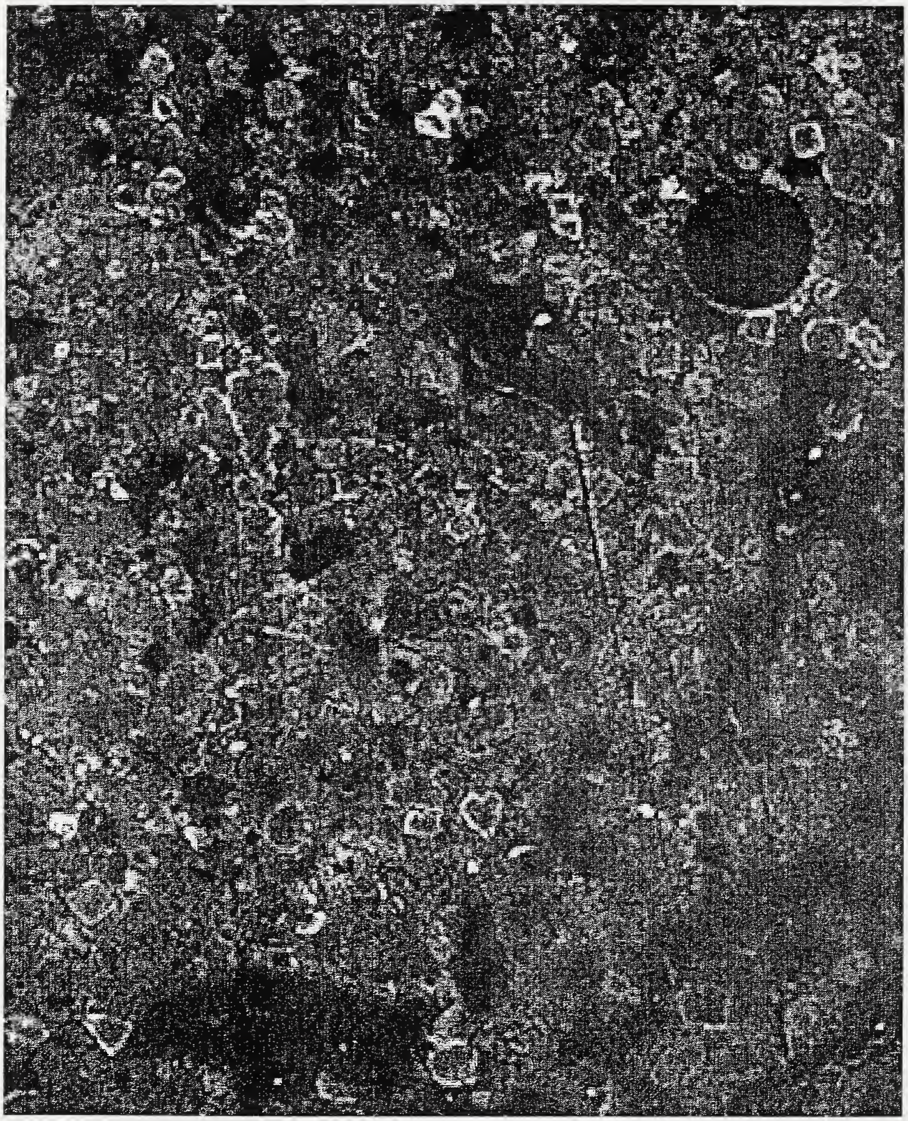

Figure 1. Microporphyritic textured carbonado. The dark circle is a ~180 um diameter laser ablation hole. The irregular dark shapes on the left-hand side are radiation haloes surrounding pores.

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Ozima, M., and Tatsumoto, M., 1997, Radiation induced diamond crystalization: Origin of Carbonados and its implications on meteorite nano-diamonds: Geochimica et Cosmochimica Acta Vol. 61, No. 2, p 369-376.

Ozima, M., Zashu, S., Tomura, K., Matsuhisa, Y., 1991. Constraints from noble gas contents on the origin of carbonado diamonds: Nature vol. 351, p. 472-474.