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"Lonsdaleite" signatures and shock remnants in mantle diamond?

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The shock deformation of diamond can lead to distinctive crystalline deformation characteristics, identical to those formed in shocked graphite. Using a petrographic microscope these might be recognized as increased birefringence, in Raman spectra by changing or additional peaks, and in X-ray by various features resembling hexagonal symmetry, with random or ordered quantities of both cubic and hexagonal diamond components in the same crystal [1]. The different length scales of observation methods used to characterize different cubic-hexagonal diamond phases, many of which are metastable with respect to ordered end-members, is significant. This has profound implications not only for meteoritic diamond, where “lonsdaleite” was first discovered, but also as a possible record of large impact processes on the Earth. The first textural evidence that “lonsdaleite” in meteorites predates shock metamorphism associated with arrival at Earth was demonstrated in carbonado-type “lonsdaleite”-diamond “nodules” in ALHA77283 [2]. As far as we are aware, the presence of “lonsdaleite” in mantle-derived diamonds has only been recorded at a single locality, Liaoning in China, where cubic and hexagonal forms of diamond are reported as an intimate intergrowth in small (<0.5mm) diamonds [3], which also host various additional mineral inclusions. Large meteorite impacts occurred frequently on the ancient Hadean Earth ($\sim$4.6-4.0 Ga), overlapping times widely attributed to postdate the formation of mantle lithospheric diamond (>3.0 Ga). Taking the normal assumptions for shock attenuation and damage, it seems inescapable that at least some lithospheric mantle diamond would have experienced shock damage, which may or may not have been preserved depending on primarily the time-integrated thermal history and subsequent mantle to surface transit prior to recovery. A model will be discussed to attempt to parameterise the impact conditions required for shock to have induced damage in lithospheric diamond in-situ, including the additional possibility of modifying previously entrained diamond inclusions to high-pressure “eclogitic” forms, as observed in meteorites [4]. Clearly such a disconnection between depth and ambient lithostatic pressure may provide an alternative explanation for diamond inclusions whose calculated pressure stability would otherwise require asthenospheric depths.

References

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