New Method to Produce Nanodiamonds from Research Into the Younger Dryas Impact Event

Conference Paper · August 2010

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New Method to Produce Nanodiamonds from Research Into the Younger Dryas Impact Event

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INTRODUCTION: Research into the proposed Younger Dryas impact event *(1)* revealed that across North America and NW Europe, 12,900-year-old sediments contain nanodiamonds at >1 billion cm^{-1} and ranging in size from 1 to 1700 nm *(2)*. They appear in bulk sediment but mostly occur inside carbon spherules and glass-like carbon, which appear to be the charred, amorphous-carbon byproducts of intense, impact-related wildfires and which are derived mostly from flammable plant resins (e.g., spruce and pine sap). No diamonds have been observed above or below the impact layers for the YD event.

Analysis by selected area electron diffraction (SAED) using transmission electron microscopy (TEM) produced reflections of 2.06, 1.26, 1.07, and 0.89 Å, which correspond to the lattice planar d-spacings of cubic diamonds. SAEDs also revealed lonsdaleite, or hexagonal diamond, found in meteorites and impact craters, but never found associated with mantle-derived diamonds *(3)*. In other cases, "forbidden" reflections were apparent at 1.78, 1.04, and 0.796 Å, which are characteristic of a metastable cubic diamond polymorph called "n-diamond" *(4)*, the most abundant type found in the YDB and which have been identified in the K/T boundary and meteorites *(4)*. By reverse-engineering cosmic impact conditions, we were able to synthesize n-diamonds inside carbon "char," a product similar to charred material from impact-generated fires.

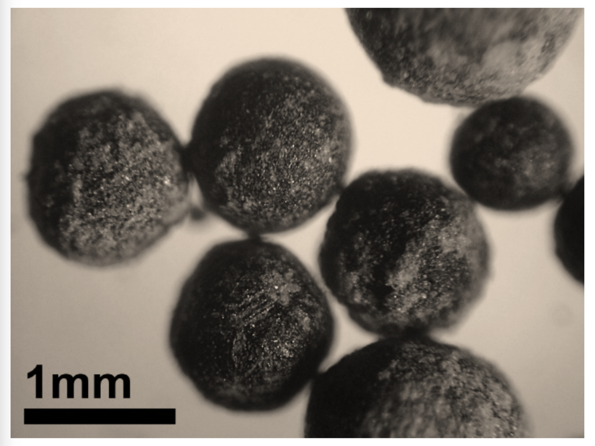
A) IMPACT DIAMONDS

A1: Cosmic impacts, such as the YD event at 12.9 ka and Tunguska in 1908, create extremely high temperatures and pressures. Those conditions are capable of incinerating carbon-rich vegetation.

THERMAL OXIDATION

A2: Both impacts and airbursts produce thermal pulses of energy that ignite ground fires, which burn from about 500°C to 900°C. That rapid and severe oxidation affects both plants and animals.

CARBONIZED SPHERULES



A3: Ash, soot, and charred carbon are produced in the fire. However, temperatures and pressures are too low to form diamonds.

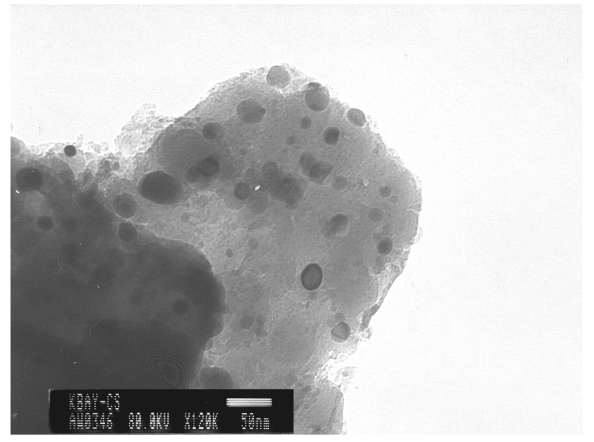
HYPOXIC HEATING

A4: When the shock wave arrives, (1) air temperatures may rise to above 1000°C; (2) air pressure rises, then falls; and (3) oxygen levels decrease and/or steam content rises. All these create diamonds.

HYPOXIC QUENCHING

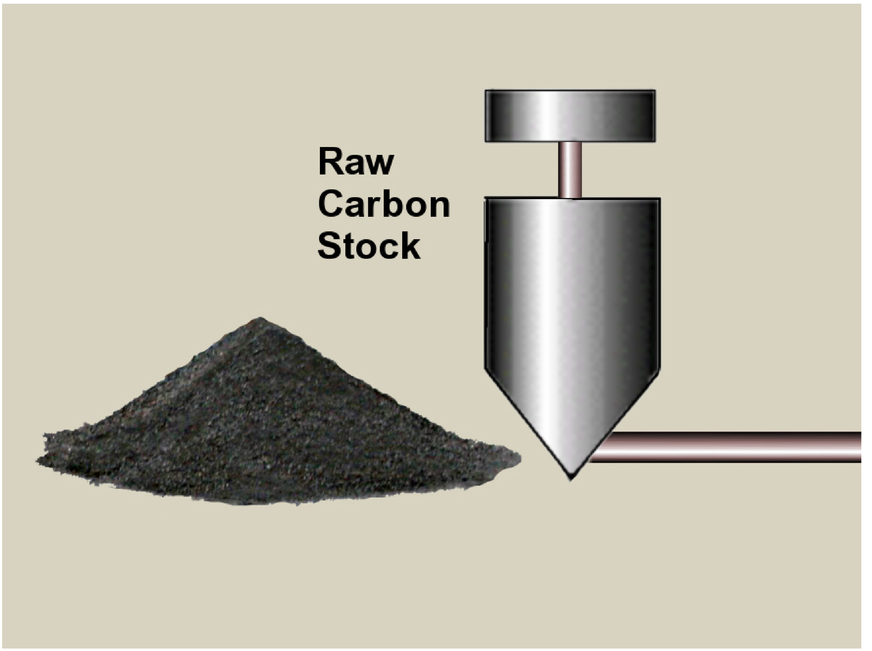
A5: As Tunguska demonstrated, the fires can be extinguished by the shock wave. Behind the shock front, oxygen deficiency and declining temperatures keep diamonds from converting to CO^2 or graphite.

DIAMONDS IN MATRIX



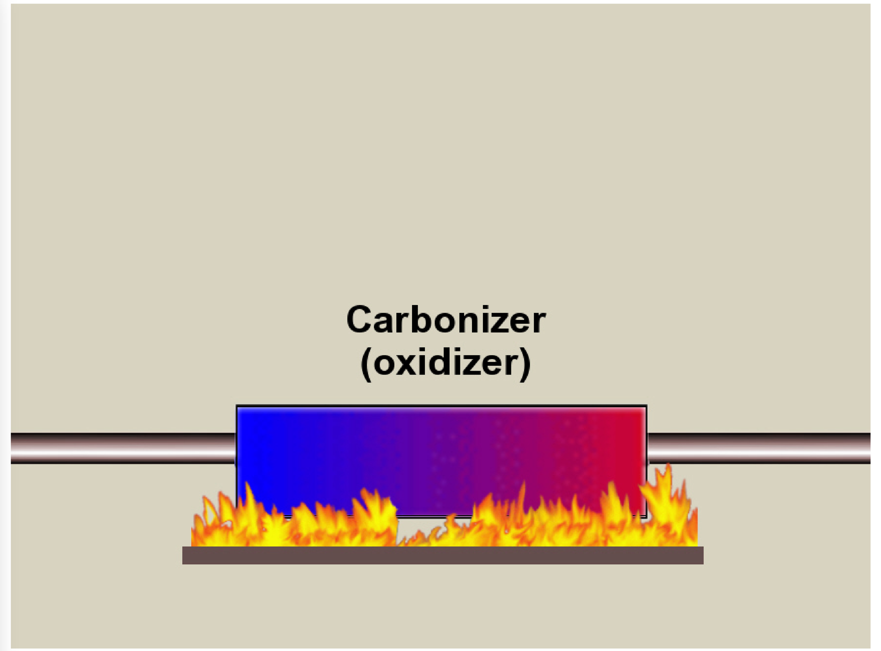
A6: Rounded diamonds created by the YD impact event are shown inside the amorphous carbon of a spherule from Germany.

B) LAB DIAMONDS



B1: Various carbon-rich materials, such as coal, coconut shells, and resinous wood from conifers, were tested as feedstock for producing diamonds.

THERMAL OXIDATION

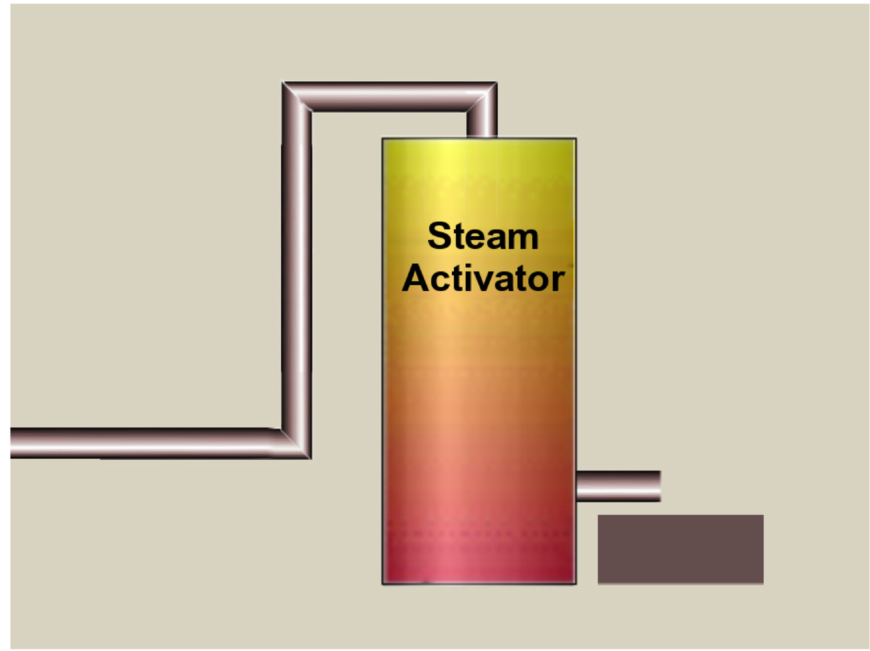


B2: The carbonaceous feedstock was oxidized at from 500°C to 800°C under atmospheric pressure. The material was charred but not converted to ash.

CARBONIZED GRANULES

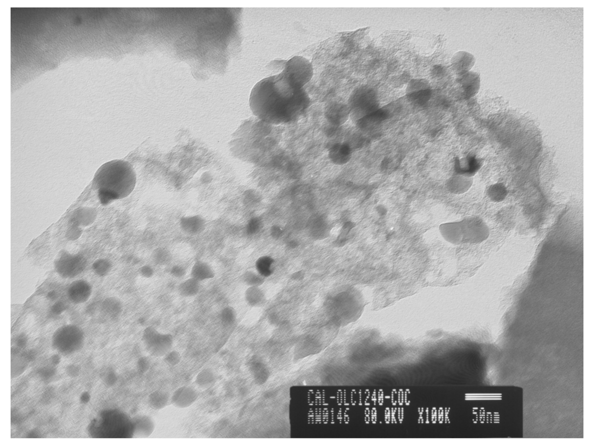
B3: The carbon char that was produced at this stage did not contain detectable nanodiamonds.

HYPOXIC HEAT+QUENCH



B4+5: The char was heated to >900°C while limiting oxygen and/or introducing steam at near-atmospheric pressure. After cooling, diamonds were found in the char.

DIAMONDS IN MATRIX



B6: Rounded diamonds created in the charred carbon are identical to those created by impacts.

References:

1. **Firestone**, R.B., *et al., Proc. Natl. Acad. Sci.* 104,16016 (2007).
2. **Kennett**, D.K., *et al., Science,* in press (2009).
3. **DeCarli**, P. S., Bowden, E., Jones, A. P., Price, G. D., In C. Koeberl, K. MacLeod, Eds., *Catastrophic Events and Mass Extinctions: Impacts and Beyond* (GSA Special Paper 356, Boulder, CO, 2002), p. 595-605.
4. **Wen**, B., Zhao, J. J., Li, T.J., *Inter. Mat. Rev.* 52, 131 (2007).
5. **Grady**, M.M., Lee, M.R., Arden, J.W., Pillinger, C.T., *Earth Planet. Sci. Lett.* 136, 677 (1995).

CONCLUSION: This process of creating diamonds requires conditions unlike those normal to the surface of the Earth. Instead, requirements match the extreme conditions that exist during an ET impact or airburst: (1) transient high temperatures and high pressures; (2) an oxygen-poor or steam-rich atmosphere within the fireball and behind the shock front; and (3) quenching of the diamonds in a low-oxygen environment.

PATENT: Our research group has a pending-patent for this previously unknown, impact-inspired method for producing diamonds.