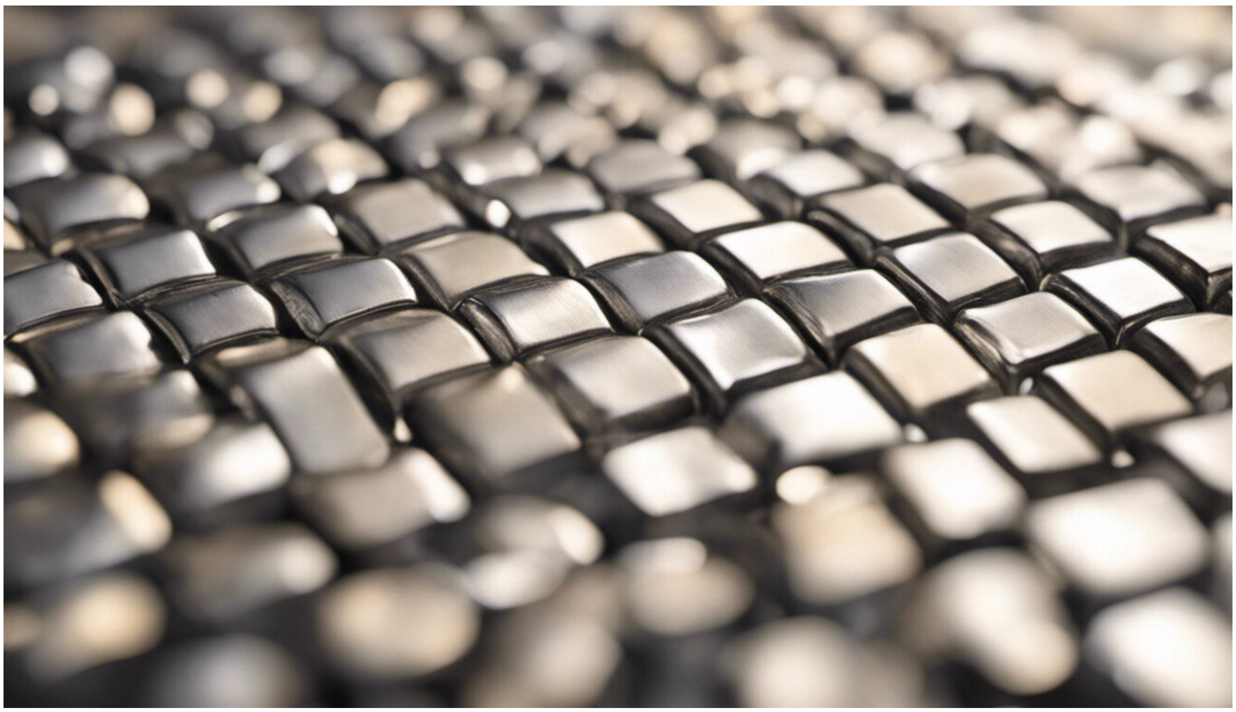
The case of the missing diamonds

December 19 2016, by Diana Lutz



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It all began innocently enough. Tyrone Daulton, a physicist with the Institute for Materials Science and Engineering at Washington University in St. Louis, was studying stardust, tiny specks of heat-resistant minerals thought to have condensed from the gases exhaled by dying stars. Among the minerals that make up stardust are tiny diamonds.

In 2007, Richard Kerr, a writer for the journal *Science*, knowing Daulton's expertise, called to ask whether nanodiamonds found in sediments could be evidence of an ancient impact.

Daulton said it was possible the heat and pressure of such a cataclysm could convert carbon in Earth's crust to diamond, but asked to see the paper, which had been published in *Science*.

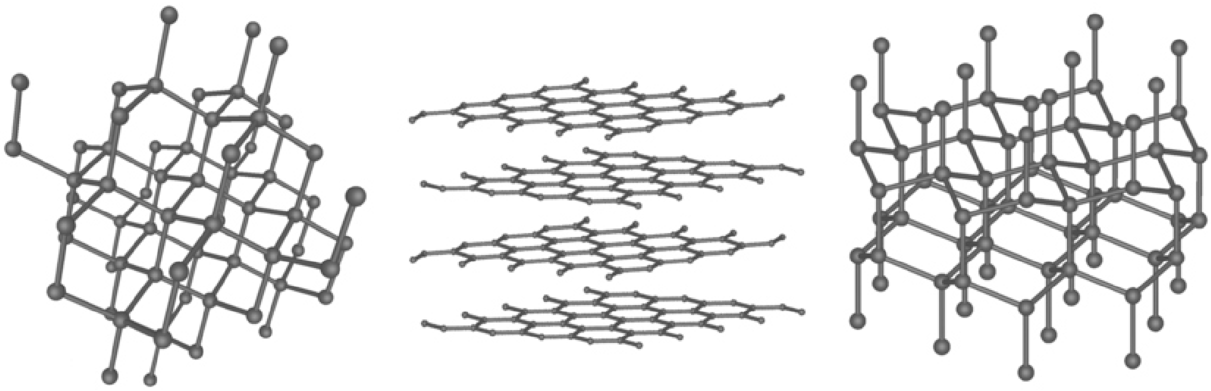
The *Science* paper argued that a shower of exploding comet fragments over the North American ice sheet had triggered a sudden climate reversal called the Younger Dryas. Having read the paper, Daulton told the reporter, "It looks interesting, [but] there's not enough information in this paper to say whether they found diamonds."

Since then, Daulton has periodically been asked to evaluate Younger Dryas sediments for nanodiamonds. In the issue of the *Journal of Quaternary Science* released online Dec.19, he reviews the accumulated evidence and reports on his own analysis of new samples from California and Belgium.

For the second time in 10 years, Daulton has carefully reviewed the evidence, and found no evidence for a spike in nanodiamond concentration in Younger Dryas sediments. Since nanodiamonds are the strongest piece of evidence for the impact hypothesis, their absence effectively discredits it.

And so a great idea apparently has been brought low by the humblest of evidence.

What went wrong?



Three arrangements of carbon atoms: diamond (left), graphite (middle), and lonsdaleite (right). Credit: Michael Ströck

Nanodiamonds, it bears emphasizing, are tiny—smaller than bacteria. Impact supporters often claim to find them inside small spheres of carbon, and those spheres are about the size of the period at the end of this sentence.

Even so, how is it possible for some scientists to find diamonds in samples and others to find none? One answer is that carbon atoms can arrange themselves in many different configurations. These arrangements, which make the difference between pencil lead and diamond, can be confused with one another.

Impact supporters often claim to have found lonsdaleite, a rare form of diamond that has a hexagonal rather than the common, cubic atomic structure. "Lonsdaleite is usually reported in the literature associated with impact sites or in meteorites that were shock processed," Daulton said. "It can also be formed by detonation in the laboratory, so the presence of lonsdaleite to me would be a strong suggestion of an impact."

But when he examined Younger Dryas samples reported to contain lonsdaleite, Daulton couldn't find it. Instead, he found aggregates of single-atom-thick sheets of carbon atoms (graphene) and sheets of carbon atoms with attached hydrogen atoms (graphane) that looked "very, very similar to lonsdaleite." So the claim of lonsdaleite was based on a misidentification: Daulton published this result in 2010.

End of story? Not so fast.

In 2014, a group of researchers reported that they had found a nanodiamond-rich sediment layer that spanned three continents. While claiming to find cubic and hexagonal diamond, they also claimed to find much more abundant n-diamond, a controversial form of diamond characterized by electron diffraction patterns similar to diamond, but with extra "forbidden" reflections that diamond does not exhibit.

Pulled back into the controversy, Daulton again found no diamond or n-diamond in the samples from the Younger Dryas horizon. What he found instead was nanocrystalline copper, which produces diffraction patterns just like the controversial n-diamond.

Daulton also attempted to reproduce the analyses that found a spike in the concentration of nanodiamonds at the Younger Dryas but found flaws in the methodology that invalidated the result.

Paradoxically it was Daulton's experience finding nanodiamonds in stardust that prepared him not to find them in sediments.

Provided by Washington University in St. Louis