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Synthesis of diamonds from methane-bearing fluids

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The exact mechanism for the formation of mantle-derived diamonds remains a topic of debate, despite progress made in experimental petrology, geochemistry and even in material science and industry producing CVD-diamonds (chemical vapor deposition) at ultra-low pressures of nearly 1-atmosphere. Interestingly, a significant number of high-pressure studies suggest that the diamond formation requires a vast 'overstep' in pressure and temperature conditions (e.g. $>>$12-16 GPa and T$>>$1600˚C) [1], significantly higher than those calculated to be relevant for natural diamonds ($>$4.5 GPa, T$>$1100˚C) extracted from kimberlites [1,2]. Some explain this phenomenon with slow kinetics of natural diamond formation, which is not comparable to the relatively short experimental runtimes. However, the problem is likely to be of a technical character and related to problems with the experimental design. We demonstrate a novel method for the synthesis of diamonds at upper mantle conditions with runs performed at pressures from 5-7 GPa and temperatures $<$ 1300˚C using a belt apparatus and a multi-anvil. Diamonds are produced at equilibrium conditions, in the presence of methane-rich fluid, which does not require any shift in redox conditions, temperature or pressure. No diamond-seed crystals were used in the experiments, but the synthesized diamonds have a natural Raman-signature with a peak at 1332 cm^{-1}. We describe in detail how the choice of experimental materials can contribute to the lack of diamond crystallization in a run and how results obtained in our study can be reproduced using any other high-pressure apparatus. The diamonds are micro-sized crystals occurring as veins and within fluid inclusions. Our diamonds are produced within hours, without employing metal, metal carbide or silicate, or carbonatite melts as catalysts.

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