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.