Diamond crystallisation from methane-rich fluids

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The origin and mechanisms for the diamond formation in the mantle have been intensively discussed in the past few decades on the basis of geochemical analyses of their mineral inclusions or theoretical calculations and high-pressure experiments. Several different mechanisms have been suggested for their formation, including the direct high-pressure transformation from graphite or precipitation from C-bearing fluids and melts introduced to the mantle via subduction. In this study, we demonstrate experimentally, for the first time, how spontaneous crystallisation of diamond can occur from CH_4-bearing fluids at pressure, temperature and redox conditions approaching those of the lithospheric mantle. Different from previous studies, no diamond seeds crystals have been used in experiments and only ~ 4% of a COH-fluid have been introduced to a harzburgitic sample material. Spontaneous diamond precipitation occured in experiments performed at 5-7 GPa and temperature <1300°C using our high-P-double capsule design [1]. Diamond grains exhibit a natural signature characterized by an "ideal" 1332 cm^{-1} Raman peak shift [2].

The process of diamond precipitation occured at fO_2 equilibrium, in the absence of sulfides, metals or carbides, at subsolidus conditions and did not require any shift in pressure or temperature conditions during the run. We further demonstrate that methane must be much more stable at lithospheric mantle conditions than previously thought [3] and is likely to be an important C source for diamonds in the upper mantle environment.

[1] Matjuschkin, Woodland&Yaxley (2019), *Contrib. Mineral. Petrol.,* 174:1

[2] Smith&Godard(2013), *J.Metamorph Geol.*, 31:19-33

[3] Zhan&Duan (2010), *Computers&Geosciences*, 36:569-572