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Diamond formation at mantle-friendly temperature condition

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Diamond synthesis was once Holy Grail of high pressure research, and numerous attempts have been reported. Now diamond can be synthesized with ease, however, it is still not clear whether we can experimentally synthesize diamond at mantle-friendly condition; i.e., at the temperatures near geotherms, and with solvent which does exist in the mantle. Here I report syntesis of diamond at modest temperature (1350C or above) with assistance of hydrous alumino-silicate fluid/melt.

Original purpose of present experiment was to study high pressure and temperature phase relation of topaz-OH($Al_2SiO_4(OH)_2$) using in-situ X-ray diffraction technique. I reported experimental detail two years ago. In some runs, I used graphite capsule in order to get better diffraction pattern. At these experimental conditions. topaz-OH or high-PT form of topaz-OH (topaz II) is stable, but we observed some fluid. Recovered sample from certain PT conditions show a white layer between sample and graphite capsule. The layer was analysed by micro-Raman spectrometer, and we find typical diamond peak (with fluorescence). The fluorescence is characteristic to quenched fluid, and it suggests that the diamond is formed with assistance of the fluid (fluid acts as solvent). Grain size was about few micron. As a pressure marker, gold particles are present in the samples. However, gold is not know to be solvent of diamond synthesis to date, and gold was not molten during our experimental conditions as revealed by in-situ X-ray diffraction, and still finely dispersed in the sample after quenching. So we think gold had no effect on diamond synthesis. We noted that diamond formed only at interface of sample and graphite capsule. Also we do not observe any graphite or hexagonal diamond by Raman in the white layer. Therefore, possibility of direct conversion from graphite to diamond can be rejected. This diamond is likely formed with assistance of fluid formed from the sample. Diamond was observed in the runs above 1350C at 13-14GPa. There is a trend that with increasing pressure, formation temperature decreases. This roughly coincides with topaz I/II boundary, however, this transition will not produce fluid.

One of important findings of present study is quite modest synthesis temperature, and no exotic solvent was used. Recently phase egg ($AlSi0_3(OH)$) was found as diamond inclusions (Wirth et al., EPSL,259,p384,2007). The phase egg is stable phase at the conditions of our present experiment, and actually topaz-OH decomposes to phase egg-containing assemblage at a bit higher pressure. Considering this natural observation and present study, I present a following model for this natural diamond formation. Sedimentary material brought by subducting slabs into near top of mantle transition zone dehydrates and melts, and produces aluminum-silica-rich fluid/melt. This fluid acts as solvent for diamond formation. From a trapped fluid/melt in the diamond, phase egg crystallized.