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The reaction between $MgCO_3$ and SiO_2 at high pressure and temperature and genesis of ultra-deep diamonds

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Carbon, one of the important light elements for the Earth science, is reserved in the deep part of the Earth. The evidence of the deep carbon is found in ultra-deep diamonds or estimations of carbon fluxes between the surface and interior of the Earth. Subducting slabs are considered as an important C-source of the Earth. Following reactions of $MgCO_3$ and SiO2 are potentially important in the slabs descending into the deep mantle:

$MgCO_3$ (magnesite) + SiO_2 $\rightarrow$ $MgSiO_3$ (perovskite) + CO_2

CO_2 $\rightarrow$ C (diamond) + O_2

These reactions can play a fundamental role in the deep carbon cycle.

In this work, we investigated the reaction between $MgCO_3$ and SiO_2 up to about 80 GPa and 3000 K using a laser-heated diamond anvil cell combined with in-situ synchrotron X-ray diffraction (XRD) technique and Raman spectroscopy. The starting material is the powered 1:1 (in mole fraction) mixture of natural magnesite (Brazil, Bahia) and reagent α-quartz. 5 wt.% platinum powder was added to the sample mixture in order to absorb laser and estimate the pressure in the sample chamber. NaCl, KCl or SiO_2 glass powder was stuffed into the sample chamber as pressure media. XRD patterns of high P-T samples and recovered samples were acquired at beamline BL10XU of SPring-8. Raman spectroscopy was carried out to high-pressure conditions. Raman spectroscopy was also conducted for the recovered samples.

In the present results made at about 70 GPa, diamond and $MgSiO_3$ perovskite are detected at temperatures greater than 1750 K. The high P-T XRD patterns in the experiments at 50-60 GPa and 2000-3000 K show the appearance of a small amount of $MgSiO_3$ perovskite. Our study demonstrated that formation of diamonds was confirmed in the range of 1300-1500 km depth of the lower mantle in subducting slabs due to the reaction of $MgCO_3$ with SiO_2 and the breakdown of CO_2. This phase relations have a possibility to explain one of the origins of diamonds from the lower mantle.