Geophysical Research Abstracts
Vol. 21, EGU2019-3043, 2019
EGU General Assembly 2019
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Interaction of carbonates with the reduced Fe–containing peridotite and its role in the deep carbon cycle

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The oxygen fugacity of the mantle peridotites decreases with the depth to the iron-wustite buffer (IW) [1]. Below ∼250 km detectable amounts of Fe or Fe-Ni alloy are likely presented in the mantle [1]. Under IW buffer conditions, diamond or carbide are stable phases, while carbonates delivered to the deep mantle by the subduction of the oceanic slabs will interact with the Fe-containing peridotites [2].
In the present study, we investigated the interaction of Fe with $MgCO_3$ and $CaCO_3$ in the complex natural systems with peridotite composition at 6-8 GPa and 900-1400° using multi-anvil apparatus. We used sandwiched loading, where Fe and carbonates were separated by the layer of natural garnet lherzolite. After experiments, samples were analyzed by EDS and Raman-spectroscopy.
In the $MgCO_3$ – peridotite – Fe system only small amounts of graphite (Gr) and magnesiowustite (Mws) were detected near the carbonate/silicate boundary after annealing during 26h at 1100ºC. The reaction is in good agreement with the previous investigations in $MgCO_3$ –Fe system [3], and can be written as follows:
$MgCO_3$ + Fe= [MgO+2FeO] (Mws)+C (Gr) (1)
In the $CaCO_3$–peridotite–Fe system we observed total consumption of Ca-carbonate in less than 26h. Formation of Mws, Gr, carbonatite melt, and merwinite (Mw), monticellite (Mtc) was observed. The interactions in the systems can be described by the following reactions:
Mg2SiO4 (Ol)+$CaCO_3$+Fe→CaMgSiO4 (Mtc)+[2MgO+FeO] (Mws)+C (Gr) (2)
2 CaMgSiO4 (Mtc) + $CaCO_3$+2 Fe→Ca3MgSi2O8 (Mw)+[MgO+2 FeO] (Fp)+C (Gr) (3)
Based on the obtained data it can be concluded that the reactions in the $MgCO_3$ – peridotite – Fe0 system due to the sluggish kinetics will not affect the preservation of $MgCO_3$ in the reduced mantle below 250 km. In the same time, in the $CaCO_3$ – peridotite – Fe system Ca-carbonate will be significantly consumed with the formation of diamond in the upper mantle.

This work was supported by the Russian Foundation of Basic Research projects no 18-35-00104 and no 18-35-20047

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