

Oxidation of Earth's big mantle wedge by recycled Ca-carbonate

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Recent observations of Fe³⁺-rich majorite inclusions from websterite xenolith and diamond raise a question on the formation mechanism of these Fe³⁺ rich majoritic garnets in deep Earth's mantle. In this study, we experimentally verified a possible redox reaction between carbonate and Fe²⁺-rich mantle mineral at high-pressure and high-temperature condition relevant to subduction zone in deep Earth's mantle. Experimental results show that both Fe²⁺ garnet and Fe²⁺ olivine can be oxidized to (Ca, Fe³⁺) rich garnets with Fe³⁺/ΣFe up to ~1 by Ca-carbonates under deep mantle conditions, whereas carbonate is reduced to graphite/diamond through the redox reaction. Fe³⁺ contents in synthetic majoritic garnets are pressure-dependent. The higher pressure, the more Fe³⁺ contents in the synthetic garnets. This redox mechanism can be used to interpret the relation between Fe³⁺ rich garnet inclusions in diamond from deep Earth' mantle. Our experimental result is a direct link for the formation of diamond and the oxidation of big mantle wedge at high-pressure and high-temperature conditions. Considering the molar ratio of oxidant and reductant in the redox reaction: $C^{4+}_{(Ca-carbonate)} + 4Fe^{2+}_{(mantle\ rock)} = 4Fe^{3+}_{(majoritic\ garnet)} + C_{(graphite/diamond)}$, we propose that recycled Ca-carbonate is the most efficient metasomatic agent of oxidization of Earth's big mantle wedge through geological time.