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Carbon Isotope Fraction during Subduction Zone Metamorphism

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Carbon isotope derived from mantle rocks and diamonds occurring worldwide show a narrow interval of -8‰ to -2‰, with a very broad distribution to lower values (~-41‰) and higher values (~5‰) (Cartigny et al., 2014). The process that produced the wide $\delta^{13}C$ distributions in Earth's mantle have been extensively debated but very poorly understood. In this study, we use carbonate $\delta^{13}C$ and $\delta^{18}O$ combined with petrology and geochemistry to investigate how the carbonates recycled in the subduction zone would contribute to the C isotopic heterogeneities in Earth's mantle. We studied the carbonated eclogite and marble exhumed in the Southwestern Tianshan UHP metamorphic belt. The marble is mainly composed of calcite (>90% in volume), however, the carbonate minerals in the carbonated eclogite are mainly dolomite. The $^{87}Sr/^{86}Sr$ and ε_{Nd} values of dolomite and calcite indicate that they have the same source of carbon which derived from the ancient sea water. The $\delta^{13}C$(VPDB) and $\delta^{18}O$(V-SMOW) values of the carbonate in the carbonated eclogites and marbles are -3.5‰~-7.7‰ ,11.3‰~12.4‰ and -0.2‰~3.6‰, 14‰~29‰ respectively. The dolomite contains lower $\delta^{13}C$ and $\delta^{18}O$ values. This idicates that the carbon and oxygen isotope of the carbonate in the carbonated eclogites may fractionated during subduction metamorphism. Experiments indicate that dolomite is enriched in ^{13}C and ^{18}O than calcite. And the $\Delta^{13}C_{(CO2\text{-}calcite)}$ is about 4‰ at subduction temperture conditions. So simply carbonate transformation (calcite-dolomite) can not cause the $\delta^{13}C$ and $\delta^{18}O$ values of dolomite decrease. We suggest that CO_2 release triggered by decarbonation or dissolution of carbonate during subduction process may cause carbon isotope fractionation and contribute to the carbon isotopic heterogeneities in Earth's mantle.

Reference

Cartigny et al. (2014), Annu. Rev. Earth Planet. Sci., 42(1), 699-732.

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