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‰) [1]. 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 $\delta^{13}C$ and $\delta^{18}O$ values of the carbonate in the carbonated eclogites and marbles are -3.5~-7.7‰ (VPDB), 11.3~12.4‰ (V-SMOW) and -0.2~3.6‰ (VPDB), 14~29‰ (V-SMOW) respectively. Alt et al. (1999)[2] suggested that most of carbon in altered ocean crust is taken up as calcium carbonate minerals during aging of crust away from spreading ridge axes. Coggon et al. (2006)[3] indicated that the carbon isotope of the calcium carbonate would decrease with depth along the oceanic crust profile, but the carbon isotope $\delta^{13}C$ > -3‰. Phase equilibria modelling indicates that carbonates in subducted oceanic crust undergo calcite → aragonite → dolomite → dolomite + magnesite transitions during prograde subduction metamorphism. We suggest that the metamorphic reactions during subduction process may cause carbon isotope fractionation between different carbonate minerals and contribute to the carbon isotopic heterogeneities in Earth's mantle.

[1] Cartigny et al. (2014), Annu. Rev. Earth Planet. Sci. 42(1), 699-732. [2] Alt et al. (1999), Geochimica Et Cosmochimica Acta. 63(10), 1527-1535. [3] Coggon et al. (2006), 10. Data Report, ODP Leg 206.