Mass transport during carbonate–silicate rock interaction in a collisional orogen: C-O-Sr isotope study of drill core samples from the Hida Belt, Japan.

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During orogenic process in convergent plate margin, supracrustal carbonate rocks often mingle with silicate-dominant rocks at deep crustal and/or mantle depth, and the process causes a variety of CO_2 -involved reactions. In order to understand the general rule of regional scale carbonate–silicate interaction on large-scale mass-circulation and mass-transports, we conducted an integrated study on impure marble and calcareous gneiss from the Hida Belt, which had formed during a Permo-Triassic suturing between North China and South China Blocks.

The impure marbles of the Hida Belt commonly contain subordinate amount of diopside–hedenbergite series clinopyroxene, grossular-rich garnet, rare wollastonite, vesuvianite, titanite, and quartz; the mineral assemblage suggests a high-temperature metamorphism of upper amphibolite-facies condition. Over 217 C–O stable isotope analyses of calcite from the selected nine drill-core and surface samples of clinopyroxene- and grossular-bearing calculous gneiss and impure marble found a large variation of $\delta^{18}O_{VSMOW}$ values (from +1.6 to +21‰). Overall, marble with less amount of silicate minerals have relatively constant $\delta^{13}C_{VPDB}$ values (from +1.6 to +4.2‰; mostly > +2.5‰) with a wide range of $\delta^{18}O$ (from +8.7 to +21‰). A narrow reaction zone between marble and syenitic intrusion shows a moderate variation of $\delta^{13}C$ (from −0.1 to +4.2‰) with a small variation of $\delta^{18}O$ (from +13 to +19‰). Notably, well-decarbonated samples formed by a carbonate–silicate rock interaction are characterized by a negative $\delta^{13}C$ (from −4.4 to −2.9‰). No correlation among C–O isotope data and $^{87}Sr/^{86}Sr$ ratio (0.707255–0.708220).

Considering applicable isotope fractionation modelling for our data (Hida Belt) and further comparisons with data from LT–HP marble in Syros (own data) and from HT–UHP marble in Kokchetav (literatures), very low $\delta^{13}C$ signature in orogenic impure marble can be formed via significant decarbonation at high-temperature condition during regional metamorphism. In essence, carbon isotope compositions of orogenic marble can be significantly modified by tectonic mingling by high-temperature carbonate–silicate rock interaction at continental collision zone. The high-temperaturecarbonate–silicate rock interaction can form 'hybrid' rock and enhance regional-scale lithological change. Although the process does not affect original $^{87}Sr/^{86}Sr$ ratio, decarbonation can decrease carbon isotope to the value similar to upper mantle value (~−5‰). Throughout the deep continent subduction, high-temperature carbonate–silicate rock interaction in a slab might play an important role to control carbon isotope signature of downgoing calcarious materials into Earth's interior.

Keywords: Hida Belt, marble, stable isotope, strontium isotope ratio

