Raman micro-spectroscopic study of carbonates on the surafce of Y-980115

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Carbonaceous chondrites are among the most pristine extraterrestrial materials available for the study of the chemical evolution occurred at the early stage of solar system. They are classified into at least eight groups based on their mineralogical, bulk-chemical, isotopic properties. However, there are several carbonaceous chondrites recovered from Yamato in Antarctica that does not fit into the traditional eight groups. They are proposed to be categorized as CYs [1] and have been revisited from the viewpoint of the analogues for the rubble-pile asteroid Ryugu [2]. They are extensively aqueously altered, and thermally metamorphosed, but the exact mechanism, timing, and duration of post-hydration heating of them remain poorly constrained. For example, among CY meteorites, Y-980115 has been tentatively categorized into CI1 meteorites, but has several characteristic features not seen in CI1s. Here we studied the micro-crystals of carbonates on the surface of Y-980115 particles by Raman micro-spectroscopy. This is because Raman frequency of ν_1 band and those of lattice modes of the carbonate crystals (T band at ～175 cm^{-1} and L one at ～300 cm^{-1}) sensitively reflect the kind of carbonates [3] and their physical/chemical states. Thus, those Raman spectroscopic features would provide further information on the changes in (and the history of) aqueous environments on the corresponding parent body(ies). Figure 1 compares ν_1 Raman bands of carbonates found on Y-980115 and those on Orgueil (CI1) and Y-791198 (CM2.4, unheated) as references. Among 59 carbonates measured on Y-980115, 46 were assigned to dolomites, showing the excellent agreement with the features observed in CI1 meteorites. However, interestingly, most of them showed the remarkable broadening and the increase in slightly higher component of ν_1 peak (～1100 cm^{-1}). In addition, the disappearance of the T and L lattice modes were observed. Calcite, which is relatively minor carbonate on CIs, also showed the similar features for that on Y-980115. These spectroscopic features indicate that the crystal structures of both dolomite and calcite were extensively decomposed on Y-980115. Interestingly, we also found several aragonite crystals on Y-980115, which is usually found on the CM type meteorites. But in contrast to dolomite, their Raman spectrum had a sharp ν_1 peak and clear T and L bands. Based on the survival of fragmented dolomites and on the coexistence with less-damaged aragonites, we infer that the parent body of Y-980115 experienced extensive aqueous alteration similar to other CIs' at first. Then, its remarkable part was thermally metamorphosed by the collision of other comparable sizes of planetesimal having similar features of CM type meteorites, resulted in the decompositon of the initially formed dolomite. Finally, no further significant hydration ocurred after the collision event. The results observed in carbonates on Y-980115 are in good accordance with the previous studies [1,2], where CY meteorites have mineralogy, textures and elemental compositions often intermediate between the CI and CM chondrites that experienced aqueous alteration and also record a late stage thermal metamorphic event at peak temperatures > 500 °C [1].

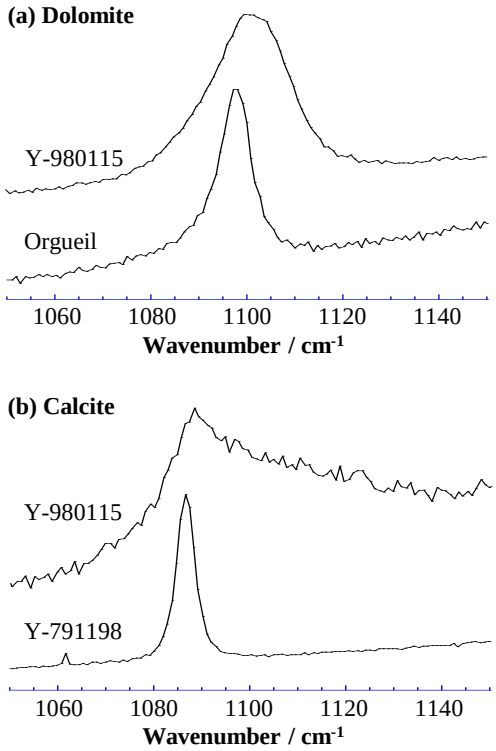

Figure 1 Comparison of the Raman shift and band shape of ν_1 modes of (a) dolomite on Y-980115 (Ref. on Orgueil CI1) and (b) calcite on Y-980115 (Ref. on Y-791198 CM2.4 unheated).

References

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