

# Oxygen isotopic composition of dolomite in Ryugu: New insights into the thermal history of the Ryugu parent body.

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**Introduction:** Ryugu samples underwent extensive aqueous alteration, and a variety of secondary minerals such as phyllosilicate, oxide, sulfide, and carbonate formed during water-rock interaction [1-5]. Among the secondary minerals, carbonates are of particular interest because their O and C isotopic compositions reflect the conditions of aqueous alteration, and because they can be dated using the <sup>53</sup>Mn-<sup>53</sup>Cr systematics. Previous studies of the O and C isotopic compositions of dolomite (CaMg(CO<sub>3</sub>)<sub>2</sub>) in Ryugu have suggested that it formed at temperatures lower than 80 °C [1,2,6,8] when the system was approaching equilibrium [7,8]. The <sup>53</sup>Mn-<sup>53</sup>Cr dating of Ryugu carbonate suggests that their formation may have spanned as much as 5 Myr [1,6]. Therefore, Ryugu carbonate potentially helps us decipher the thermal history of the Ryugu parent body. However, it is unclear whether Ryugu carbonate formed during prograde alteration when temperature was increasing or during retrograde cooling, which makes it difficult to establish a realistic thermal history model. In this work, we investigated the O isotopic compositions of dolomite in Ryugu samples A0203 and C0192 to further constrain its formation conditions. Also, we will measure the O isotopic compositions of magnetite in these samples to estimate the O isotopic equilibrium temperatures between dolomite and magnetite.

**Experimental:** Prior to isotope work, the microstructures of dolomite grains in samples A0203 and C0192 were characterized by Transmission Electron Microscopy (TEM) using a FEI T20 operated at 200 kV. The *in-situ* O-isotope analyses on two and six dolomite grains from A0203 and C0192, respectively, were performed using CAMECA IMS 1280-HR [9]. Negative ions of <sup>16</sup>O<sup>-</sup>, <sup>17</sup>O<sup>-</sup>, and <sup>18</sup>O<sup>-</sup>, produced by a focused Cs<sup>+</sup> primary ion beam (~30 pA, 3-4 μm in diameter), were simultaneously detected with a Faraday cup (FC) for <sup>16</sup>O<sup>-</sup> signals and two electron multipliers (EMs) for <sup>17</sup>O<sup>-</sup> and <sup>18</sup>O<sup>-</sup>. Instrumental mass fractionation was corrected using a series of dolomite-ankerite standards [10]. The uncertainties on δ<sup>17</sup>O, δ<sup>18</sup>O, and Δ<sup>17</sup>O values were typically ±1.12, ±0.86, and ±1.35‰ (2σ), respectively.

**Results and discussion:** TEM showed that dolomite grains in A0203 and C0192 differ in their crystal size and habit, with those in A0203 typically being 1-2 μm size euhedral crystals whereas C0192 dolomite is coarser and anhedral. The analyzed dolomite grains have only a small variation in δ<sup>18</sup>O values as observed by previous studies [1,6-8]. The δ<sup>18</sup>O values of A0203 and C0192 dolomite are at the higher and lower end of those reported previously and clustered at 32.91 ± 0.47‰ (N = 6; 2SE) and 26.54 ± 0.58‰ (N = 2; 2SE), respectively. Notably, the Δ<sup>17</sup>O values of A0203 and C0192 dolomite are also systematically different (-1.13 ± 0.82‰ and 0.46 ± 0.36; 2SE). A similar anti-correlation between δ<sup>18</sup>O and Δ<sup>17</sup>O values can also be recognized for the previous data, implying that Ryugu dolomite with higher δ<sup>18</sup>O values tends to have lower Δ<sup>17</sup>O values [6-8]. The Δ<sup>17</sup>O, and possibly, δ<sup>18</sup>O values of aqueous fluids are expected to have decreased during progressive aqueous alteration because of the O-isotope exchange between water and anhydrous rock which initially had higher and lower Δ<sup>17</sup>O (and δ<sup>18</sup>O) values [11,12]. Thus, the A0203 dolomite with lower Δ<sup>17</sup>O values likely precipitated from more evolved fluids that underwent O-isotope exchange to a greater extent than the C0192 dolomite. On the other hand, the equilibrium O isotopic fractionation between water and dolomite is larger at lower temperatures with the δ<sup>18</sup>O values of dolomite being higher than those of water [13]. Therefore, the A0203 dolomite with higher δ<sup>18</sup>O values likely precipitated at lower temperatures than the C0192 dolomite. These observations may suggest that Ryugu dolomite formed during retrograde cooling. This argument is in line with the small variation in δ<sup>13</sup>C values observed for Ryugu dolomite, which suggests its formation in higher O fugacity at the later stage of aqueous alteration [7]. For further information regarding the formation conditions of dolomite, we plan to measure the <sup>53</sup>Mn-<sup>53</sup>Cr ages of dolomite in A0203 and C0192.

## References:

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