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Speciation of various elements and aqueous environment in water in Ryugu related to organic matter synthesis and its location in C-type asteroid parent body

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In this study, we attempted to reconstruct the aqueous environment of Ryugu using a chemical equilibrium calculation method based on the solubility reactions of various minerals formed in Ryugu. For this purpose, speciation of various elements in the Ryugu sample returned from a C-type asteroid was conducted, based on which we could estimate pH and Eh condition of the water. Among them, almost all sodium (Na^+) and potassium (K^+) and a part of calcium (Ca^{2+}) were found to be contained in the interlayer of saponite in the Ryugu sample, while chlorine (Cl) is generally found as Cl adsorbed on lizardite. In addition, Al was shown to be mainly present in the tetrahedral structure of the saponite. On the other hand, the chemical composition of the saponite was analyzed by EPMA using resin-embedded and polished thin section samples. Combining all the results with the partition coefficient of the ion-exchange reaction of the saponite (smectite) and SEM observations and information on coexisting minerals shown in previous studies, the concentration of dissolved ions in the Ryugu water at the time of aqueous alteration could be estimated, which in turn can be used to calculate the precipitation-dissolution equilibrium and the adsorption-distribution equilibrium to estimate the Eh and pH sof the water. The results showed that the water of Ryugu is reductive (Eh: -0.5~-0.8 V) and alkaline (pH: 10.5~11.5), which allows water reduction reactions to occur. Under these conditions, various organic chemical reactions could have taken place, which could be relevant to the origin of life. As aqueous alteration progressed, oxidation reactions of metals such as Fe-Ni alloys are thought to have occurred first, followed by serpentinization of olivine, and finally oxidation of ferrous iron in the octahedral structure of saponite. The high H2 fugacity suggests where the original materials of Ryugu formed in the parent body of C-type asteroid.