High-resolutional stable isotopic records in Tufa at Ogadai, Okayama Prefecture

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Tufas are freshwater carbonates developed in limestone areas, and have been recognized as potential paleoclimate media. One of the largest tufas in Japan was found in a stream at Nagaya in the northern Oga limestone Plateau (Takahashi City, Okayama Prefecture). The stream is originated from a spring located at the thrust boundary between the limestone and the lower-lying mudstone, and flows along a long water passage. These conditions allow the water in the stream to contain high Ca2+ (more than 60mg/L) and degass CO2 (PCO2 more than 2.0matm). Some of the tufa specimens display very regular annual laminations, which consist of thick (3~5mm) summer dense laminae and thin (0.5~2mm) winter porous laminae. This annual lamination pattern is associated with precipitation rate of calcite, which mainly results from regular seasonal change of flow rate. In the period of summer-autumn, which includes rainy season and typhoons, large amount of rainfall, together with inflow of cultivation water from rice field, make the flow rate rising.

In this study, we analyzed oxygen and carbon isotopes of a tufa sample of 73mm thickness. The sample was divided parallel to the laminae at 0.2mm intervals. We also analyzed the water stable isotopes of the stream water.

This sample consists of 12 repetitions of dense and porous laminae, and therefore, it has been deposited in 12 years from 1992 to spring 2004. Isotopic ratios of carbon and oxygen show cyclic change corresponding to the annual lamination structure, and the two values show strong positive correlation. Sign curve of carbon isotope is regular, whereas, there are small fluctuations in the oxygen curve. The carbon isotope tends to decreases from 1995. For the stream water, oxygen isotope is stable through a year and has little variation in the spring. In contrast, carbon isotope shows some seasonal variation, low in summer and high in winter. Furthermore, it increases to down current.

The results of isotopic analysis show that isotopic equilibrium was confirmed in the tufa deposition. The very regular sign curve of carbon isotope suggests that the value changes under the control of a temperature-depending process. The most appropriate process is natural ventilation owing to the difference in air density between underground and atmosphere. In winter, relatively light underground air effectively diffuses and exchanges with the atmosphere, and then, underground PCO2 decreases. The following degassing releases lighter CO2 from the water. Finally, the increased carbon value of DIC is recorded in tufa. General decreasing trend of carbon isotopic values in the last decade may be associated with weaken CO2 degassing in underground by tufa deposition decreasing permeability of limestone aquifer. Some correlation was also found between depositional rate and amount of rainfall, as well between perturbation in oxygen isotope curve and dry periods.