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Understand seasonal variation of the stalagmite growth rate with the hydrochemical parameters of dripwater

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Carbon dioxide (CO_2) degassing is given for a main factor to control the stalagmite growth recently. The seasonal variation (high pCO_2 in summer and low pCO_2 in winter) of the CO_2 partial pressure (pCO_2) of the cave air by ventilation of the cave air which occurred with a temperature difference between the cave outside and the cave air was observed. Because a change of this pCO2 changes easiness (difference ($dpCO_2$) cave air pCO_2 and dripwater equilibrium pCO_2) of the CO_2 degassing, the seasonal variation of the stalagmite growth rate is supposed (Spotl et al., 2005; Baldini et al., 2008). In addition, there is the study (Genty et al., 2001) that was going to see the cyclic variation of the stalagmite growth rate by the theory equation found from an annual growth thickness and chemical kinetics of the dripwater, and stalagmite growth rate increase is supposed regardless of a season when the Ca^{2+} concentration of dripwater is high in this study. The common understanding of the mechanism of the short-term variation of the stalagmite growth rate is not provided in this way. Therefore we built technique to estimate the stalagmite growth rate from the hydrochemical parameter of the dripwater and observed a stalagmite growth rate (Calcite deposition rate) monthly in Inazumi limestone cave in mie-machi, bungo-ono-shi, Oita-ken, Japan. As a result, we report that we got the seasonal variation and the control factor of the growth rate.

As Spotl et al. (2005) and Baldini et al. (2008) guessed, the stalagmite growth rate of the Inazumi limestone cave showed a slow tendency in the summertime and fast tendency in the wintertime, but we got that growth became slow in winter by taking it finely. Genty et al. (2001) insisted that the Ca^{2+} concentration of dripwater controlled stalagmite growth, but there was not the correlation between Ca^{2+} concentration and the stalagmite growth rate, and this observation result did not support the claim. Many researchers believe (e.g. Spotl et al. (2005) and Baldini et al. (2008)) that a difference between cave air pCO_2 and dripwater equilibrium pCO_2 controls stalagmite growth but the variation is not seasonal variation. Furthermore, dripwater dissolves a stalagmite at the time of plus pCO_2 value if equilibrium is concluded in a chemical reaction of the stalagmite growth but a stalagmite grows up even at the time of plus pCO_2 value of the summertime. The observation result of the Inazumi limestone cave does not support the claim of Spotl et al. (2005) and Baldini et al. (2008).The control factor of the stalagmite growth has calcite saturation index (CSI) and dripwater quantity besides $dpCO_2$. Because CSI value of the dripwater always shows pluses (supersaturation for calcite), stalagmite is going to always grow up. Furthermore, the variation of CSI resembles the variation pattern of the stalagmite growth rate closely. However, the variation of the stalagmite growth rate in the Inazumi limestone cave cannot explain a variation of the winter only by CSI. The fall of this growth rate is caused by the decrease of the dripwater quantity, and this observation result support a claim of Genty et al. (2001) that the dripwater quantity controls the stalagmite growth most when the dripwater quantity is very few.

A key result is that a stalagmite grew up because dripwater is always a supersaturation condition, and the seasonal variation of the stalagmite growth rate is controlled by the seasonal variation of CSI. In the Inazumi limestone cave, there is the peculiarity that quantity of the dripping water decreases in winter and tends to depend on dripping quantity of water than CSI in the time. We are conscious of contribution to the study of the paleoclimate reconstruction that used the striped pattern to appear in the growth direction of the stalagmite and want to clarify the reason of seasonal variation of CSI of the dripwater and the variation of the drip rate of the dripwater in future.

Keywords: Stalagmite growth rate, Hydrochemical parameters of dripwater, Seasonal variation of growth rate