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Monitoring cave climate for resolving annual fluorescent layer formation in stalagmites: case study of the Koumori-ana Cave in the Akiyoshi-dai limestone Plateau, SW Japan

Hana Sasaki (1), Yuri Onishi (2), Yoshiro Ishihara (3), Takashi Murakami (4), and Kazuhisa Yoshimura (5)

(1) Graduate School of Fukuoka University, Fukuoka, Japan (sasakihana.study@gmail.com), (2) Oyo Corporation (onishi-yuri@oyonet.oyo.co.jp), (3) Fukuoka University, Department of Earth System Science, Fukuoka, Japan (ishihara@fukuoka-u.ac.jp), (4) Akiyoshi-dai Museum of Natural History (murakamitakashi1020@yahoo.co.jp), (5) Kyushu University (kazz@chem.kyushu-univ.jp)

A 10-100 μm layer accumulates annually in stalagmites; this layer is used as a proxy for time and its thickness is correlated to precipitation. Fluorescent band bounding this annual layer is attributed to a high concentration of fulvic acids from biological activities that attain a maximum in the summer on the surface of the stalagmite via drip waters. Numerical simulation of fluorescent annual layers predicated on the concentration of fulvic acids, rates of dripping of drip waters, the pCO_2, the concentration of Ca2+, and the saturation index of calcite, reproduces various fluorescent patterns observed in annual layers of stalagmite. Monitoring of the annual fluorescent layer formation was conducted to verify a simulation model at the Koumori-ana Cave in the Akiyoshi-dai limestone Plateau in SW Japan. In this study, cave climate data and its effects on the formation of the annual fluorescent layer are presented. The results from monitoring revealed distinctive seasonal variations of the pCO_2 and minor changes in fulvic acid concentrations and drip water rates. Drip rates at two points showed local effects with those located under a thin cave roof showing a correlation to the surface rainfall, while that beneath a thick roof showed no trend. The pCO_2 increased from early to late summer but, rapidly decreased in autumn. Fulvic acid concentrations measured at the points were slightly higher in late summer to autumn. In early summer, the cave temperature ($\sim$15°C) was like the surface temperature while diurnal variation of the pCO_2 ranged from 500 to 2000 ppm. In winter, the pCO_2 in the cave and near-surface remained around 450 ppm. High values of the pCO_2 suggest active degassing of CO_2 from drip waters due to cave ventilation. A high growth rate of stalagmites is therefore expected from early to late summer. When the fluorescence intensity in an annual layer was high during a season with a low calcite precipitation rate (e.g. a hiatus), and the simulation model considered a time gap between the growth rate season and the high fluvic acid concentration, the monitoring result suggests a seasonal pattern of upward decreasing fluorescence intensity in a layer.