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Sub-annual paleoenvironmental information evaluated from intensity variations of fluorescent annual layers in a stalagmite from Ryuo-do Cave, Nagasaki Prefecture, western Japan

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Stalagmites can provide various types of paleoenvironmental information such as information on vegetation and climate changes. Fluorescent annual layers formed by humic substances (mainly fulvic acids: FA) in these stalagmites can also provide a time proxy, and a time series on precipitation. Fluorescence intensity patterns in these annual layers can be classified into symmetric, gradually increasing and gradually decreasing types. Onishi et al. (EGU2016) demonstrated the existence of these fluorescence intensity patterns in the annual layers, and their stratigraphic changes, by numerical simulations, and suggested that the patterns could provide paleoenvironmental information at a sub-annual resolution. In this study, we carried out an analysis of fluorescence intensity patterns in the annual layers of a stalagmite from Ryuo-do Cave, Nagasaki Prefecture, western Japan, and also simulated the patterns in the stalagmite, to obtain paleoenvironmental information.

Fluorescence intensity patterns in the annual layers are strongly affected by annual variations in FA concentration and precipitation rates of calcite. As the result of simulations of fluorescence intensity patterns, cumulative variations and various types of pattern are reproduced. These differences are depending on time lags between the variation of the FA concentration in the drip waters, and that of the growth rate of the stalagmite. Co-precipitation models of FA are divided into the “Hiatus model” in which FA are preferentially preserved in the stalagmite when its growth rate is relatively low, and the ”Partition coefficient (PC) model” in which FA concentrations in the stalagmite increase when the calcite precipitation rate is relatively high. However, various fluorescence intensity patterns in the annual layers could be formed under a combination or either of both of the models.

Fluorescence intensity patterns in an annual layer in the stalagmite from Ryuo-do Cave, Nagasaki Prefecture, western Japan vary stratigraphically, and multiple types of fluorescence intensity pattern are observed in the stalagmite. When the co-precipitation of FA is governed by the hiatus model, it is suggested that a gradual increase in the annual layers will result from a large accumulation of calcite after the annual peak in the FA concentration, whereas there will be a gradual decrease if the main growth occurs before the annual peak in FA concentration. However, in the case of the PC model, a gradually increasing type of pattern is formed if the main growth occurs before the annual peak in FA concentration, and a gradually decreasing type is formed if the main growth occurs afterwards. If the annual peak of FA concentration occurs several months after high summer, it is suggested that intervals showing a gradually increasing type were formed in winter, and intervals showing a gradually decreasing type were formed in the early summer, in the case of the hiatus model. In the case of PC model, the seasons are reversed. In the climatic environment around the Ryuo-do Cave, the growth rates of stalagmites are affected by cave air circulation in winter and by rainfall (rainy season) in early summer.