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Numerical simulation of fluorescent annual layer in stalagmites: implication for extracting sub-annual information

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Fluorescent annual layers are frequently reported from stalagmites in various caves of the world. In recent years, fluorescent asymmetrical patterns in annual layers, such as fluorescent intensity growing upward and interrupting at uppermost part in a layer, have also been reported. Since the formation of annual layers in stalagmites is probably influenced by the accumulation rates of calcite and fulvic acids in dripwaters, the parameters controlling the fluorescent asymmetrical patterns of annual layers are not clarified.
In this study, we reviewed various types of fluorescence patterns in annual layers reported from Japan, and simulated them considering the accumulation conditions of stalagmite and the amount of fulvic acids in dripwaters. Hence, it is suggested that formation of various types of fluorescent annual layer is influenced by (1) seasonal fluctuations in the accumulation rate of stalagmites and the amounts of fulvic acids in dripwaters, (2) seasonal time lags between favorable conditions for stalagmite accumulation and the predominant season for accumulation of fulvic acids in dripwaters, and (3) durations of the lags. The time lags are caused by seasonal gaps between variations in the amounts of fulvic acids in dripwaters and the accumulation rates of stalagmite influenced by dripwater intervals and cave air conditions. The results of this study will provide new insight into the seasonal signature in annual layers and suggest that the geochemical information bias from stalagmites can be evaluated from analyses of the annual layer patterns.