Advanced micro-XRF method to separate sedimentary rhythms and event layers in Lake Suigetsu sediment

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Event-related sedimentary layers, which are deposited occasionally due to volcanic eruptions, earthquakes or heavy rains, are often contained in the rhythmical sequences of lacustrine and marine sediments. We have developed an analytical method for separating the sedimentary rhythms and the event layers identified using the scanning X-ray analytical microscope (SXAM) and obtained sequential profiles of seven elements Al, Si, K, Ca, Ti, Mn, and Fe in the lacustrine sediment from Lake Suigetsu in Japan which date from 19.0 to 5.7 cal. kyr BP (calibrated thousand years before present).

Two types of event layers could be detected from the elemental composition of 33 layers of sediment: three known volcanic ash layers and 30 clay layers containing 12 turbidites. The recurrence interval of the latter, which may potentially be initiated and archived by locally important earthquakes, is estimated to be an average of 640+-160 years by using Sompi event analysis (SEA) based on an autoregressive (AR) model. After removing those portions that represented event layers from the elemental profiles, we obtained event-removed (ER) temporal profiles based on the tephrochronology of the three volcanic ash layers. The ER temporal profiles of manganese and iron, probably representing the siderite content, showed a periodic variation from the last cold stage to the Holocene.

The increased manganese and iron contents, which mainly indicate the relative abundance of siderite, result from a greater vertical circulation in the lake during a cold period, with a higher mass of manganese and iron oxide being precipitated. The cold periods inferred from the increased manganese and iron contents coincide with the timing of ice-rafting debris (IRD) events in the North Atlantic, which span from the last termination to the Holocene, suggesting that the climate shift was hemispheric or probably global in nature. The manganese variation resembles the residual atmospheric 14C production data of the Holocene that reflect variation in solar activity, and its periodicities correspond with those of solar-related climate changes from paleo-proxy records in the North Atlantic and East Asia from the last cold stage to the Holocene. In particular, the Mn variation was larger in amplitude and shorter in timescale during the last cold stage when compared with those during the last termination and the Holocene, thereby possibly showing a significant difference in climate response to solar irradiance. The transition of the climate system from a glacial to an interglacial state corresponds to the beginning of the last termination.