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Stratigraphic variations of lacustrine sediment gravity flow deposits and their recurrence intervals in the Middle Pleistocene Miyajima Formation, northeastern Japan: an implication for paleoenvironmental analysis

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Lacustrine sediment gravity flow deposits have been proposed as archives for flood and earthquake events. Holocene lacustrine deposits are especially valuable because they can be correlated with historical records and other detailed paleoenvironmental indices. When sediment gravity flow deposits are intercalated in varved deposits, they can potentially be used for high resolution reconstruction of recurrence intervals of events in addition to environmental changes. The Shiobara Group in the Shiobara Basin, Tochigi Prefecture, northeastern Japan, consists of the upper Miyajima Formation and the lower Kamishiobara Formation. The Miyajima Formation includes varved deposits distributed at the center of the basin. These units are interpreted as lake floor deposits of the Paleo-Shiobara Caldera Lake. The varved deposits of the Miyajima Formation consist of cyclic repetitions of light-colored seasonal sub-layers mainly composed of diatoms (Stephanodiscus niagarae) and dark-colored seasonal sub-layers mainly composed of river inflow deposits. For this study, we measured lacustrine deposits of the Miyajima Formation and analyzed stratigraphic variation of varved deposits. Stratigraphic units of approximately 4 m in total thickness were studied, which included 416 events of sediment -gravity flow deposition over ca. 700 years.

Sedimentary facies of the lacustrine sediment gravity flow deposits: The sediment gravity flow deposits can be classified by their erosional and internal features: whether they have an erosional base, whether they are graded, and whether they have rip-up clasts. Because high density currents were suggested from above features, most of the deposits are interpreted as the result of hyperpycnal flow. Also, the features suggest that the sediment gravity flow deposits originated from rivers around the lake.
Stratigraphic variation of varved deposits: Average thicknesses of varves decrease from the lower and middle portions of the section to the upper part. Overall thinning of the varves is due to upward thinning of the light-colored seasonal sub-layer deposited during winter. This upward thinning suggests a warming trend.
Stratigraphic variation of lacustrine sediment gravity flow deposits: Depositional frequency of sediment gravity flow deposits increases upward in the lower part of the section, remains consistent in the middle part, and increases upward again in the upper part. The upward increase in depositional frequency of these deposits is concordant with the upward thinning of winter sub-layers. The frequency of erosional sediment gravity flow deposits further increases in the upper segment. However, the thickness of sediment gravity flow deposits does not show any clear trend.
These results suggest that frequency of hyperpycnal flow occurrences correlates with the decrease of diatom production in the winter season, i.e. that floods affecting the lake were more frequent when the climate was warm.