Speeds of climatic and sea-level flucturations from Late Glacial to Holocene estimated by using varves

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Varved lacustrine sediments provide a potentially continuous, high-resolution records of the Last Glacial and Holocene paleoenvironments. During the last few years, the many efforts to reconstruct high-resolution changes in climate and environment have been carried out to Japanese varved lacustrine sediments. In1991-1993, long sequences of varved lacustrine sediments were successfully taken from two lakes in the southwestern Japan; Lake Suigetsu and LakeTougouike. The detailed sedimentological analysis of these sediments revealed varve chronology, process of varve formation and annual to decadal climatic and sea-level changes of Japan suggesting close correlation to the abrupt changes (Younger Dryas and Heinrich Events) observed in Greenland ice cores and marine sediments.

During the Late Glacial period, we identified four types of lamina in the varved lacustrine sediments from Lake Suigetsu and Lake Tougouike; (1) clastic varve, (2) clastic varve including resting spores, (3) bio-clastic varve including resting spores, (4) biogenic varve (Fukusawa, 1999). The formation of four types of lamina can be relevant to the change in environment and climate in this regions.

Type (1) shows clastic lamination consisting of alternations between light grey coarser terrigenous lamina intercalating siderite ($FeCO_3$) crystals and fine terrigenous lamina. The lamination formed mainly from allochthonous matter often arose in oligotrophic lakes where other sources of suspended matter were minute (Boygle, 1993). This formation mechanism is similar to that of classical varves (de Geer, 1912). Type (2) is clastic laminations with siderite intercalations including resting spores. Type (3) is characterized in alternations between diatomaceous lamina including siderite crystals and terrigenous lamina. It is formed by weak blooming of diatom prior to siderite precipitation in summer. Existence of diatom-poor lamina in type (3) suggests that absence of diatom blooming occurs in three seasons except summer due to the colder climate than the Holocene climates. Type (4) is biogenic lamination observed in Holocene varves. It is formed by seasonal changes in diatom productivity and/or seasonal breakdown of the stratified water column.

Supply of nutrients such as NO_3^- and PO_4^{2-} caused blooming of diatom continuously occurs in Lake Suigetsu, because many organic materials originating from forest vegetations and soils are decomposed and then flow into lake water. In supply of oversaturated nutrients, the appearance of biogenic varves suggests that the climate was relatively warm because diatom production inferred from the concentration of diatom frustules is controlled by the surface water temperature.

An example of the sequential changes of varved sediment from Lake Suigetsu (Fukusawa, 1999) shows 8 cm long section from 13.96 m in depth of SGP3 piston cores of Lake Suigetsu. The section yields 85 years varves of about 11,320 yr BP (Kitagawa and van der Plicht, 1998). The sequential change of this section can be interpreted climatologically as follows: 1) abrupt cooling term of 9 years suggested by the disappearance of biogenic varves, 2) extremely cold term of 23 years suggested by appearance of clastic varves and 3) abrupt warming term of 19 years suggested by the shift from clastic varves to biogenic varves. The frequency of terrestrial-origin organic remains increases in cooling periods and turbiditic muddy layers in warming periods. Such similar sequential changes are also seen in the other sediment section. The increase of terrestrial-origin organic remains in sediments seems to correspond to the reduction of forest by the climatic cooling. The turbidites may be episodically occurred by the strong precipitation, related to intensive Asian summer monsoon.

The abrupt cooling event at about 11,320 years BP by AMS 14C dating (Kitagawa and van der Plicht, 1998) may correspond to about 100 year long cooling event from 11,300 to 11,400 years ago recorded in the Greenland ice core (GISP2) (Stuiver et al., 1995). The possible teleconnection of the abrupt cooling events in the East Asia and the Greenland is recognized and suggests that abrupt climatic changes did not only occur at high latitudes such as North Atlantic around the Greenland, but also at low latitudes.