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Siderite formation rhythm of the lacustrine Takano Formation from MIS 3 to MIS 6, Nagano City, central Japan

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1. Introduction

Climate during the Quaternary has been fluctuated between glacial and interglacial states worldwidely. Abrupt climatic changes on millennial scale have been also detected in ice cores, marine and lacustrine sediments, and stalagmites. Although the air temperature and surface water conditions can be clarified by various proxies such as oxygen isotopes, and pollen and diatom assemblages, the response of lake bottom environments to the climate changes often remains unknown. This point may become serious concerns to reconstruct whole conditions of an ancient lake, and also important to predict the change of lake system in the future.

In this study, we investigated how lake bottom environments were affected by climate change. In order to clarify it, we used a lacustrine sediment, Takano Formation, in southern Nagano City, Japan. Sediment consists of homogenous or laminated clayey silt with many tephra beds, covering from 158 to 30 ka in age. The age estimation is based on the ages and depth of the four marker tephras such as Aso-2, Aso-3, Aso-4 and BW1466. Sedimentation rates are from 34 to 51cm per 1000 years, and are sufficient to resolve millennial-scale variability. We report here depositional process for siderite and its rhythm using major element composition and spectral analysis.

2. Methods

1-cm sliced samples were ground into powder for clay mineralogy and major element analysis by X-ray diffraction and X-ray fluorescence methods. We converted peak area (cps) of siderite to quantitative siderite content (wt.%), using an experimental relationship. There exists a high positive linear correlation (r=0.97) between the peak areas of siderite and the siderite contents. The temporal frequency of siderite contents was detected by a spectral analysis.

X-ray radiographs of slab samples were used for sediment fabric analysis to evaluate oxidation-reduction status in the lake bottom.

3. Results and discussion

TiO_2, Al_2O_3, MgO, CaO and K_2O are major detrital components, judging from the positive correlations amongst these elements, but SiO_2 and Fe_2O_3 indicate negative correlation with Al_2O_3 content. This result implies that SiO_2 and Fe_2O_3 in sediment are of non-detrital origin. With regard to X-ray diffraction profiles, Opal-A and siderite are identified, therefore SiO_2 and Fe_2O_3 might be source of diatom frustules and siderite in sediments. There is a general positive correlation between Fe_2O_3/Al_2O_3 and siderite content (r=0.68). This fact also suggests a major source of Fe_2O_3 to be siderite. Siderite contents oscillate within about 10 wt.% in this sediment. Siderite contents and preservation degree of lamina can be used as a proxy of oxidation-reduction status in the lake bottom. Temporal profile of the siderite amounts is similar to that of preservation degree of lamina.

Wavelet analysis was performed to examine the temporal variations in the spectral power within the siderite profile. Wavelet analysis suggested short and long periodicities, namely, 500-2000 years and 4000-8000 years. With regard to the short periodicity, 500-2000 years, is almost within the range from 970-1970 year cycle of the Dansgaard/Oeshger event in the North Atlantic from the last glacial to the Holocene period. Dansgaard/Oeschger cycles are believed that it were not forced by internal instabilities of ice sheets during glaciations, but instead originated through processes linked to the climate cycle (Bond et al. 1997). Our result suggests that same climate change on Dansgaard/Oeshger cycles during MIS 3-MIS 6 occurred in this region, mid-latitudes of the northern hemisphere, and lake bottom environment oscillated between oxidation and reduction states induced by climate change on millennial scale. On the other hand, long periodicity of 4000-8000 years is difficult to explain. This long periodicity may be generated by the other factors on earth.