112. Elemental Distributions and Geochemical Features of the 1,000 and 1,400-Meter Sediment Core Samples in Lake Biwa

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(Communicated by Kenjiro Kimura, M. J. A., Nov. 12, 1985)

Introduction. Since elements in the atmosphere, lithosphere, and hydrosphere are deposited on and cooperated with primary minerals to form sediments in the lake, it is reasonably assumed that paleoenvironments have been recorded in sediments. Such processes called the scavenging action were suggested by Goldberg (1954). Some of the materials have probably changed their original forms, but the elements in the changed or unchanged minerals may remain in sediments preserving their geochemical features such as sedimentation ages and paleoenvironments around the lake areas. For example, Goldberg et al. (1976) reported that the pollution with metallic elements in the modern period of Tokyo was recorded in the Palace Moat sediments. The present author investigated the vertical distributions of mercury (Takahashi et al., 1979) and simultaneous multielement determination of the 1,000-meter sediment core samples from Lake Biwa (Iwata et al., 1980; Iwata et al., 1982). As our continued work, we have joined the working group of the 1,400-meter sediment core samples, which have been conducted by Prof. S. Horie of Kyoto University since 1982.

Analytical methods and procedures. Major, minor, and trace elements in sediments have been determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) (Tao et al., 1983). The sediment samples were digested with \( \text{HNO}_3-\text{HF-\text{HClO}_4} \), after drying at 110°C for 4 hr, and finally dissolved in HCl. The digested solutions were applied to simultaneous determination of 25 elements by ICP-AES. Consequently the vertical distributions of 19 elements (Al, Fe, K, Mg, Na, Ca, Ti, Mn, P, Ba, Sr, V, Cr, La, Cu, Ni, Y, Sc, and S) for about 150 sediment samples (each about 5 m from the bottom surface down to 800 m) have been measured.

Geochemical characteristics of the 1,000-meter sediment core samples. According to the analysis of the 1,000-meter sediment core samples by the sequential extraction method (Iwata et al., 1980), Al, Ti, Na, and K were contained as residual minerals more than 95%, which means that these elements were originated mainly from clay minerals. On the other hand, Fe and Mn often increased in the free oxides fraction (10–20%) as well as exchangeable, carbonates, and organic matter fractions. These facts suggest that Al, Ti, Na, and K reflect the vertical distributions of rock-forming and residual minerals produced as the result of the weathering of the primary minerals, while Fe and Mn show representatively the aquatic sedimentation induced by biological and chemical processes. Some of other elements such as Co, Cu, La, Pb, Sc, V, Y, and Zn showed relatively high percentages (20–75%) in free oxides and organic matter fractions. This may be attributed to the scavenging action of such elements in
sedimentation processes, as suggested by Goldberg (1954).

As for the 1,000-meter core samples obtained in the delta deposits of River Yasu (Yokoyama et al., 1976), fluctuations of the Fe and Mn concentrations in the fractions of free oxides are larger than those in other fractions. Four consistent peaks were found in the free oxides fractions of Fe and Mn at 364 m, 753 m, 805 m, and 833 m. This result suggests the occurrences of crustal movements or climatic variations at such periods. In the case of Al, Ti, Na, and K, fluctuations of the vertical distributions of Na and K are to some extent larger than those of Al and Ti. These facts may be understood as the unchanged properties of parent materials (mainly clay minerals) in Lake Biwa sediments. The behaviors of Na and K reflect differences in the abundances of silicate rocks and their weathering processes through the sediment cores of Lake Biwa.

Geochemical features of paleoenvironments around Lake Biwa. Total elemental compositions have been analysed in terms of the 1,400-meter sediment core samples, which are divided into 4 Beds; T: 0–250 m, S: 250–582 m, R: 582–732 m, and Q: 732–804 m, as reported by Yokoyama and Takemura (1983) and Horie (1984). As some examples, the vertical distributions of Al, Fe, Mn, and P are shown in Figs. 1 and 2. As described earlier, Al is a good index for learning the behaviors of parent materials, and Fe and Mn may record the biological and chemical processes in the aquatic environments. It is noted that the following significant behaviors of the elemental distributions characterize the sediment cores from Lake Biwa. (1) Remarkable variations of the vertical distributions for all the elements are seen near 260 m and 580 m. These points correspond to the boundaries of the different sediment beds, i.e., between T and
S Beds, and between S and R Beds, respectively. (2) Aluminum and Fe behave in opposite ways in the distributions of T Bed, while those of Fe and Mn do in similar manners. (3) The concentrations of Fe and Mn are higher in the T and R Beds. These facts suggest that the aquatic environments were predominant in the T and, may be R Beds ages, where biological and chemical processes were quite active. The large concentration of P in the T and R Beds also support biological activities. Furthermore, trace elements such as S, Cr, Cu, Ni, Sc, and V which were deposited in sediments as a result of the scavenging action showed similarity to Fe, Mn, and P. From these experimental results, it may be concluded that, at the location where the 1,400-meter core samples were collected, Lake Biwa was a quite deep (probably 40–100 m) and large lake since 600,000 years ago, but it was a shallow one or on the land surface with or without water sometime before 600,000 years. The water depth of the Lake Biwa was also large during the age of the R Bed. In other words, some significant geological variations took place between the later age of the R Bed and the early age of the T Bed. In addition, the contents of S in sediments were no more than 600 μg/g. This may indicate that Lake Biwa has not been in marine environment since the time of the formation of Q Bed.

**Acknowledgements.** The author thanks Prof. K. Fuwa of the University of Tokyo for his kind and valuable discussion. He also thanks Prof. S. Horie of Kyoto University for his encouragement through the present work. The author
is also indebted to Dr. Y. Iwata, Ms. N. Ukita, and Mr. K. Toyoda in keeping the author in the experimental work.

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