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Environmental change based on diatom assemblages from Lake Yamanaka at the northern foot of Mt. Fuji, Central Japan

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ABSTRACT: Environmental history in Lake Yamanaka was investigated based on diatom assemblages obtained from the 17.5m length borehole core in the lake center. Lake Yamanaka (surface area 6.89km^2; maximum depth 14.3m; mean depth 9.4m; altitude above sea level 978 m) is one of the Fuji Five Lakes and located at the northern foot of Mt. Fuji. Although this lake had been considered formed by the lava flow from Mt. Fuji about 1850 years ago, results of this research suggested that the formation age more old stage on account of the presence of planktonic diatoms mentioned below.

The borehole core sample has mainly consists of unconsolidated silts and scoria fall deposits associated with sandstone layers. According to the composition of diatoms contained in silts, the geohistory of this lake was divided into 4 periods; i.e.,

1) The 1'st swamp or river period(11.4-9.2m borehole core in depth):Epiphytic or benthic diatoms such as *Flagiralia* spp. or *Epithemia* sp. were dominant in these samples.
2) The 1'st lake period(9.2 - 6.0m borehole core in depth):Planktonic diatoms such as *Aulacoseira* sp. or *Cyclotella* sp. were dominant in these samples.
3) The 2'nd swamp or very shallow lake period (6.0-2.5m borehole core in depth): Epiphytic or benthic diatoms became dominant again.
4) The 2'nd lake period(2.5m - surface borehole core): Planktonic diatoms were dominant again.

Key Words: Lake Yamanaka, diatom assemblage, borehole core, lake history

Introduction

Lake Yamanaka (35° 25'N, 138° 52'E at the center of the lake; surface area 6.5km^2, 982m above sea level) is one of the Fuji Five Lakes located at the northern foot of Mt. Fuji. Lake Yamanaka is largest among these five lakes, also the third highest lake in Japan. These lakes were formed as a result of barrage formation by volcanic debris and solidified magma spewed out of Mt. Fuji. Lake Yamanaka is thought to be formed by dumping up the former river with Takamarubi lava flow (in 864-900 AD). Kosugi et al. (1992) reported that drastic environmental changes around this area happened to form Lake Yamanaka about 1850 years ago depending on the diatom assemblages obtained from lake sediments.

On the other hand, the existence of an earlier and larger lake named Ko- Oshinoko is suggested by the observation of fossil diatom assemblages around Lake Yamanaka[Akutsu, J. and Fujiyama, I. (1982), Fujiyama, I. (1982)]. From this point of view, the environmental changes in Lake Yamanaka are not clarified enough.

The present study intends to clarify the forming histories of Lake Yamanaka depending on the diatom assemblages obtained from the longer borehole core.

Materials and Methods

In 1998, coring was undertaken at the center of Lake Yamanaka (**Fig. 1**). The total penetration was 17.5m long. After slicing the core into 1cm thick sections, samples to observe diatoms were chosen from these sections at 10cm interval principally. Diatom valves were separated from sediment matrix by treating with strong sulfuric acid and potassium dichromate, then slides are prepared using quantitative methods. Diatoms are mounted using a synthetic resin of high refractive index (Mount Media by Wako Pure Chemical Indust.). About 400 diatom frustules (200 diatoms) were identified enumerated from each sample under light microscopy (X 600), however in samples where diatoms were scare or poorly preserved

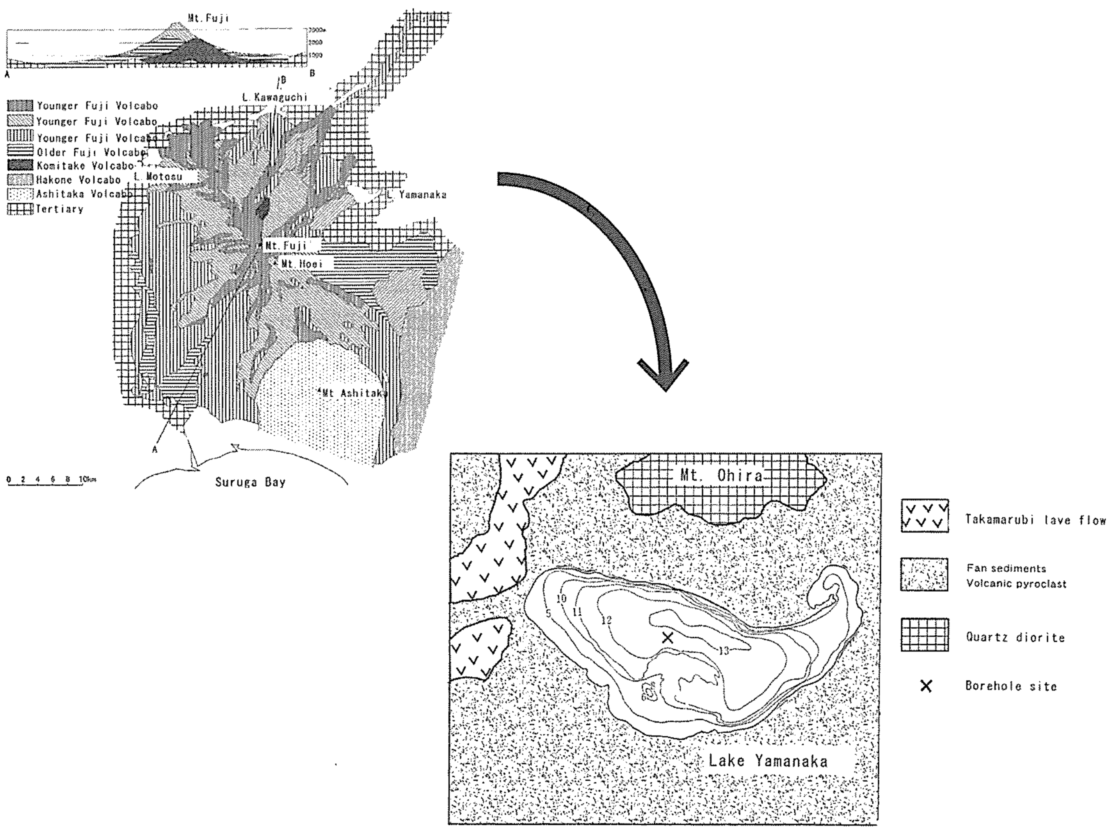

Fig. 1 Map showing the location of borehole core site at the center of Lake Kawaguchi

in sandy sediments, fewer valves were counted. Species identification was based on K.Krammer, H. and Lange-Bertalot (1986) and Haraguchi, K. (1998).

Results

Stratigraphy and lithofacies

The stratigraphy and lithofacies are shown in Fig. 2 (Koshimizu and Uchiyama, 2002). The facies was divided into three parts, lower, middle and upper horizons, at 11.4 m and 13.5 m depth. The horizons upper 11,4 m were composed mainly of silts with large numbers intercalations of scoria fall deposit. The horizons from depth 11.4 m to 13.5 m were mainly of black silt and clay with intercalation of scoriae that may be correlated to so-called Kuroboku soils stage. The horizons lower 13.5 m were consisted of mainly with scoriae and lapilli. The fossil plants at 3.3m depth and 11.4m showed calibrated ^{14}C ages of 1,640±60 yrs BP and 6,160±80 yrs BP, respectively.

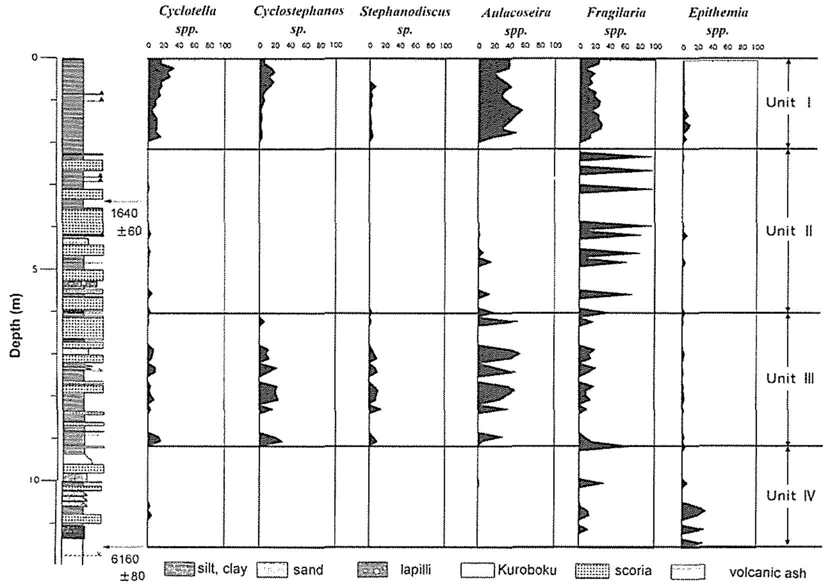

Fig. 2 Diagram of fossil diatom assemblages from the borehole core at the center Lake Yamanaka

Diatom assemblages

Five diatom units (I ~ V) were distinguished at this borehole core (**Fig. 2**). As a result, there were twice remarkable replacements of planktonic diatoms by epiphytic and benthic ones at 2.5 m and 9.2 m depth (**Fig. 3**).

Unit I (lake bottom ~ 2.5 m in depth) is defined by the high percentage of Planktonic diatoms. The majority of the taxa in the assemblages were planktonic forms such as *Aulacoseira granulata*, *Cyclotella radiosa* and

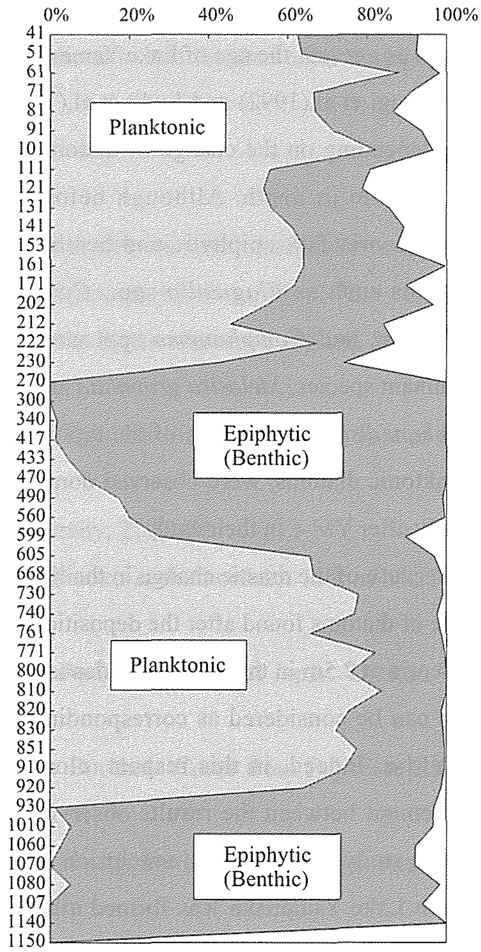

Fig. 3 Changes in the percentage composition of the Planktonic and Epiphytic (Benthic) diatoms from the borehole core

Cyclostephanos dubius.

Unit Ⅱ (2.5m ～ 6.0m in depth) is defined by the high percentage of epiphytic and benthic diatoms, such as *Flagiralia pinnnata*, in contrast to Unit 1.

Unit Ⅲ (6.0 m ～ 9.2 m in depth) is characterized by the presence of planktonic diatoms in high frequency again. *Aulacoseira granulata*, *Aulacoseira subarctica*, *Cyclostephanos dubius* and *Stephanodiscus* sp. are dominant in this unit.

Unit Ⅳ (9.2 m ～ 11.4 m in depth) is defined by the high percentage of periphitic diatoms such as *Epithemia sorex*, *Cocconeis placentura*.

Diatoms are scarcely observed in Unit Ⅴ (lower than 11.4m), corresponding to the drastic change in lithofacies. Only *Hantzschia amphioxys* known as a terrestrial diatom was observed in a few frustules.

As listed in **Table. 1**, 42 taxa among 20 genera diatoms were observed in this borehole core.

Discussion

New findings about environmental history of Lake Yamanaka were obtained comparing the changes of diatom assemblages which is useful method to determine the water level change in freshwater systems. A major change occurred not only once but also twice in sedimentary environmental at 2.5m and 9.2m in depth, as a result, the age of Lake Yamanaka is estimated to be older than it in previous reports.

Kosugi et al.(1992) and Endo et al.(1992) concluded that Lake Yamanaka was formed about 1850 yrs. BP, depending on the change of diatom assemblages just after the deposition of scoria named YM-e at about 1.8m in depth. Although before YM-e scoria fall, epiphytic and benthic diatoms such as *Flagiralia* spp., *Cymbella* spp. and *Gomphonema* spp. were dominant species, *Melosira granulata* and *Stephanodiscus astrea*, one of the typical planktonic diatoms, were observed dominantly after YM-e in their study.

Because of the drastic change in the life style of diatoms found after the deposition of scoria at 2.5m in this study, this deposition can be considered as corresponding to YM-e. Indeed, in this respect, close agreement between the results observed in this study and Kosugi's conclusion in which Lake Yamanaka was formed after this deposition of scoria was obtained, but results of this research suggested that the formation age of Lake Yamanaka became

Table 1 List of diatoms found in the borehole core

Merosila undrata	*Amphora spp.*
Merosila varians	*Cymbella minuta*
Cyclotella radiosa	*Cymbella leptoceros*
Cyclotella sp.	*Cymbella caespitosa*
Stephanodiscus sp.	*Cymbella sinuata*
Cyclostephanos dubius	*Cymbella spp.*
Aulacoseira ambigua	*Gomphonema angustum*
Aulacoseira distans	*Gomphonema spp.*
Aulacoseira granulata	*Epithemia sorex*
Aulacoseira subarctica	*Epithemia trugida v. trugida*
Asterionella formosa	*Epithemia sp.*
Achnanthes lanceolata	*Diploneis elipica*
Achnanthes minuttisima	*Diploneis ovalis*
Achnanthes exigua	*Diploneis spp.*
Achnanthes spp.	*Navicula hasta*
Cocconeis placentura	*Navicula pupula*
Cocconeis placentura v. euglypta	*Navicula pseudosutiformis*
Cocconeis spp.	*Navicula reiharditi*
Fragillaria acus	*Navicula scutelloides*
Fragillaria brevistriata	*Navicula spp.*
Fragillaria capcina	*Nitzschia sinuata*
Fragillaria construens	*Nitzschia sinuata v. tabellari*
Fragillaria crotonensis	*Nitzschia sp.*
Fragillaria pinnata	*Pinnularia gibba*
Fragillaria ulna	*Pinnularia sp.*
Fragillaria spp.	*Rhopalodia gibba*
Rhoicosphenia	*Hantzschia amphioxys*

more old stage on account of the presence of planktonic diatoms in Unit Ⅲ (6.0 m ~ 9.2 m depth). On a assumption that sedimentation rates was constant between the horizons at 3.3m in depth (^{14}C ages of 1,640 ±60 yrs BP) and the horizons at 11.4m in depth (6,160 ± 80 yrs BP) except for intercalations of scoria, the sedimentation period of Unit Ⅲ was estimated from 2700 yrs BP to 4800 yrs BP. Although it must be considered that the diatom assemblages will be influenced not only by the water level but also by other environmental conditions such as water temperature, nutrients and pH [E. F. Stoermer and J. P. Smol (1999), Wetzel, R. G. (1983)], the presence of plnktonic diatoms suggest that the water system has enough depth. Therefor the water level in Lake Yamanaka was suggested to change deep repeatedly (at least twice) as shown in **Table 2**.

Table 2 The units separeted in the core depending on the diatom assemblages

Unit	depth (m)	Age (BP)	Dominant diatoms	Ecology
I	0 - 2.5	0 - 1850?	*Aulacoseira granulata* *Cyclostepahnos dubius*	Lake was formed again
II	2.5 - 6.0	1850? - 2700?	*Fragilaria pinnata* *Fragilaria* spp.	River or Swamp
III	6.0 - 9.2	2700? - 4800?	*Aulacoseira granulata* *Cyclostepahnos dubius*	Lake was formed at first (enougu depth to Planktonic diatoms)
IV	9.2 - 11.4	4800? - 6100	*Fragilaria pinnata* *Epithemia* spp.	River or Swamp
V	11.4 -	6000 -		Land

It is necessary for ensuring the reconstructing lake-level fluctuations to add the data about fine-grained particle analysis, chemical content and pollen.

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