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# Significance of biogenic silica on paleoenvironmental studies in South Korea

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## Abstract

Paleoenvironmental evolution in South Korea is investigated on the basis of fluctuations in biogenic silica content in sediments from Cheollipo coast on western shore. The biogenic silica measurement was done by alkaline extraction technique. The concentration of the biogenic silica in the Cheollipo coastal sediments is generally low, with an average of 1.2 %. The proxy of biogenic silica records in Cheollipo sediments implies the significant difference of bio-productivity on Korean Peninsula in comparison with those in lacustrine sediments in interior terrestrial continent of the Eurasia.

**Keywords**: Biogenic silica, Paleoenvironment, Cheollipo coast, Korea

## 1. Introduction

For reconstruction of the fluctuation in sea level and environmental changes, coastal area is one of the important study backgrounds, along with lakes and ice sheets. Along with pollen records, diatom assemblages and other geochemical indicators, biogenic silica ($SiO_2$) is one of important methods in reviewing global climatic changes, regional paleoenvironmental changes and local geomorphological evolution. The biogenic silica is known to one of main indicators for bio-productivity abundance in lakes, reservoirs and coasts, and sediment discharges in these catchments (Liu et al, 2002; Matsuda et al, 2002; Lyle et al, 2002). Therefore, the most crucial issue for paleoenvironmental proxy is to determine the biogenic silica records reflecting environmental changes where bio-productivity is abundant.

Silica is a component of the diatom cell wall. The cell walls of some diatom species become very thin, because the cells still divide after the cessation of silica uptake below the silicon limitation (Werner, 1977). The silica content of diatom may not be constant, as indicated by changes in ratio of the particulate silica to total diatom volume, i.e., the low particulate silica accompanying the decrease in total diatom volume suggests the possibility of a disturbance in silicification (Takano et al, 2004). The silica content of diatoms fluctuates depending on other factors such as insolation, temperature and pH. The proliferation of bioproductivity

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materials contributes to the decrease in HCl soluble material and mineral fractions.

The main purpose of the present study is to reconstruct the paleoenvironmental changes around the Cheollipo coast in Western Korea, based on the biogenic silica fluctuations in the sediments, providing a record for the occurrence of bio-productivity in paleoenvironments.

## 2. Materials and Method

Cheollipo coastal area (N 36° 47′ 57″, E 126° 09′ 04″) is located on the coastline in Euhang-ri, Sowon-Myun, Taean-Gun, Chung cheongnam-Do in western Korea (Fig 1).

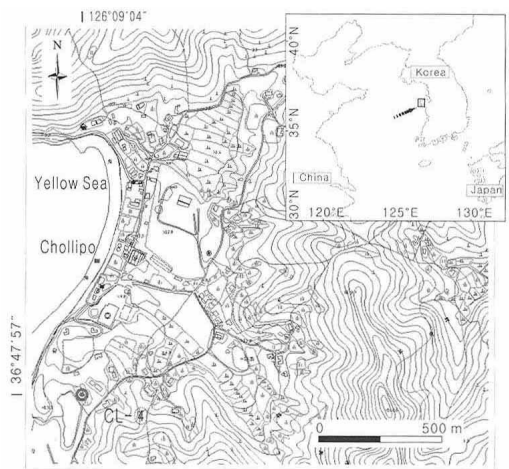


Fig 1. Topography of the Cheollipo area

A coastal area of Western Korea is a submerged epicontinental sea typified by bays, islands, beaches, tidal flats and estuarine subenvironment, which are characteristic of a ria-type coastline (Park et al, 2001). The coast is surrounded on the eastern side by sand dunes and lowland and by the Yellow Sea on the western side. The sand dunes were formed during the marine transgression of the early Holocene, migrating landward with the rising sea level (Ryu et al, 2005). The surrounding area of the coast lands are widely used as paddy fields.

The sediment samples were obtained along the coastline. In order to collect undisturbed bulk sediments, frames consisting of subsections from CH-1 to CH-10 were used. Sediment samples were collected from the 275 cm thick layer in February, 2007 using 30 cm length core tube sampler with 5 cm diameter. The geology of the coastal area is dominated by a Granite-Gneiss complex of Precambrian age. The upper and lower parts of the total profile are composed of yellow sands, whereas middle part is composed of deep black silty muds with interbedded peat layers (Fig. 2).

An analysis of biogenic silica was done

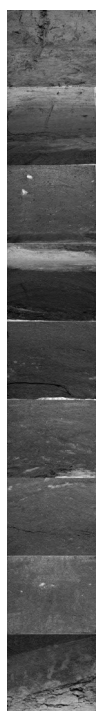

Fig 2. Sediment in Cheollipo coastal area

according to the method of Prof. Kashiwaya at hydro-geomorphologic laboratory, Institute of Nature and Environmental Technology, Kanazawa University, Japan (Matsuda et al, 2002). In order to measure the fluctuations of biogenic silica productivity within the samples, total mineral material, organic matter and HCl-soluble material have been also determined by above-mentioned method. Total samples were subdivided at 0.5 cm interval, and in total 550 subsamples were analyzed using chemical solutions such as 30% $H_2O_2$, 1N and 4N HCl, 2M $Na_2CO_3$, 6N $H_2SO_4$, and hexaammonium heptamolybdate tetrahydrate. The method of biogenic silica analysis involved in brief of a preparation of spitz-tubes and dry samples at 770℃; an elimination of organic matter by $H_2O_2$ in a water bath preheated to 600C; the elimination of $CaCO_3$ by HCl with centrifugation supernatant; a solution of biogenic silica (biogenic opal) measurement of light-absorption. Finally, dissolved silica in the extractions was measured by the molybdate blue spectrophotometric method (Mortlock and Froelich, 1989). Other parameters including organic matter, HCl-soluble material and mineral fractions can be analyzed during the course of biogenic silica measurement.

## 3. Results and Discussion

The measurement of biogenic silica in the Cheollipo coast sediments indicate that the content of biogenic silica is not uniform vertically (Fig. 3), indicating that the abrupt variations in the biogenic silica records in the coastal sediments. Such abrupt variations may represent several environmental events around the Cheollipo coast in Western Korea.

The biogenic silica content in the Cheollipo coastal sediments is generally less

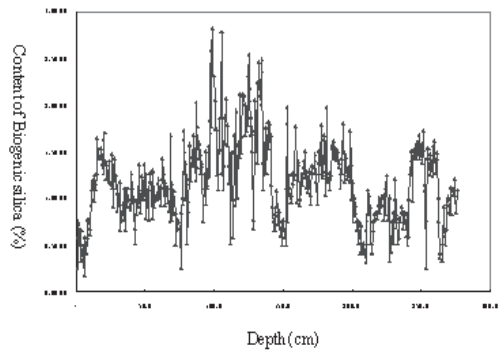


Fig 3. Fluctuation of biogenic silica of the bulk sediments on Cheollipo coast

than 3% with an average of 1.2%. This suggests that the bio-productivity in Korean Peninsula was very low, in comparison with biogenic silica records in lacustrine and marine sediments from Eurasia and North-East Asia during the last interglacial period (Kashiwaya et al, 2004). One interesting fact is that low concentration (generally less that 10 %) of biogenic silica is also observed in other Korean ponds. The average content of the biogenic silica in the short core sediments is 3.65% in the Yeongcheon pond, and 6.95% in the Seondong pond, respectively (Orkhonselenge et al, 2006). In contrast to Korean examples, the content of the biogenic silica in some lacustrine sediments often make up a great part of sediments about 50% in Lake Baikal and 20-30% in Lake Khuvsgul in interglacial time (Kashiwaya et al, 2004). Biogenic silica proxies or diatom productivity in Lake Khuvsgul are likely to reflect higher precipitation, runoff and the associated nutrient supply to the lake, whereas in Lake Baikal these proxies are likely to reflect thermal stratification and heat balance of the lake (Prokopenko et al, 2005). Consequently, a comparatively low content of the biogenic silica in Cheollipo coast sediments suggests the different environmental con-

ditions and evolution, between continental interior and coast sediments during the interglacial periods.

On the basis of OSL dating, the timing of peak content of biogenic silica was determined at 54±3 Ka BP, when the warmer and wetter environmental conditions might contribute to increase of bio-productivity. As for environmental evolution due to climatic changes occurred in Cheollipo coastal area, some important points have been indicated by previous results from studies related to mineralogy (Yang et al, 2005) and diatom assemblages (Ryu et al, 2005) in core sediments in Cheollipo wetland located at 200 m east of the coastline. Results from geochemical proxies and mineralogy in the CL4 core sediments in Cheollipo wetland during the Holocene show some environmental events, including generation of enrich gypsum during the late Holocene, and chemical weathering at 2.5-2.0 Kyr BP, eolian activity at 2.1 Kyr BP and evaporation at 4.5-4.3 Kyr BP and 2.4-1.7 Kyr BP. The surrounding area of the Cheollipo wetland changed from a deep freshwater-limnic environment into a shallow freshwater wetland environment during 6.0 to 2.5 Kyr BP, which resulted from changes in sea level and geomorphic development of the coast.

In the present study, besides measurement for the biogenic silica, other physical parameters including mineral fraction, organic matter and HCl-soluble material were also measured and their vertical distribution is shown in Fig. 4. The change of physical parameters in the coastal sediments reflects not only climate change-driven environmental events, but also the features of runoff generation, in particular, the activity of much powerful outflow from melting water of glacier and its associated sedimentation. The vertical fluctuation

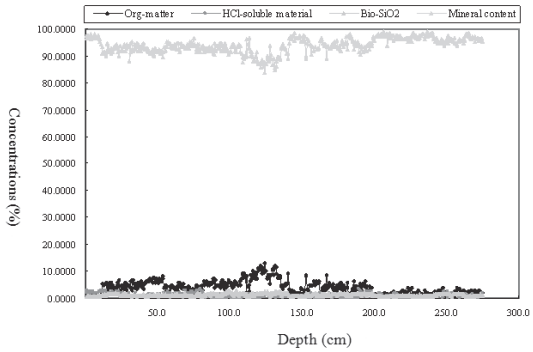


Fig 4. Sediment composition on Cheollipo coast

of organic matter contents is generally consistent with that of biogenic silica content, but is not with that of HCl-soluble materials which generally reflects lowering of sea level in arid environments. The analytical method of Kashiwaya used in this study has advantage of determining sediment composition qualitatively, that is relative proportion of four components (biogenic silica, HCl-soluble material, organic matter and mineral). The average proportions of each component in total sediments are 1.18 % of biogenic silica, 93.97 % of mineral, 3.89 % of organic matter of 3.89% and 0.96 % of HCl soluble material). In addition, vertical distribution patterns of these components (i.e. qualitative composition) show that there are three stages of environmental evolution around the Cheollipo coast area: Stage I (arid, 19±3 Ka BP to 47±3 Ka BP), Stage II (wet, 47±3 Ka BP to 55±3 Ka BP) and Stage III (arid, 55±3 Ka BP to 60±3 Ka BP).

## 4. Conclusion

Based on the vertical distribution of the biogenic silica content and other physical parameters of sediments from the Cheollipo coast along the western shore of Korea, local environmental changes and sedimentation have

been discussed. The biogenic silica content in the Cheollipo sediments indicates the distinctive difference in bio-productivity on the Korean Peninsula in comparison with those in lacustrine sediments in interior terrestrial continents of Eurasia. In the future, in order to reconstruct the environmental changes on regional and local scales in the Western Korea, further studies including diatom analysis and accurate age dating shall be continued.

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