Rapid climate change during the deglaciation of Lake Hovsgol, Mongolia

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ABSTRACT

A 120-cm core recovered from Lake Hovsgol, the northern Mongolia provides evidence for climate variability since the Marine Isotope Stage 3, representing a sharp lithological change. The lowermost part of the core consists of diatom-barren calcareous silty clay without coarse sands, framboidal pyrite, and biogenic components deposited during the MIS 3. Following the last glacial maximum, in-situ moss is included in the sediments, as lake-level was retreated by cold and dry environment with low precipitation. The AMS radiocarbon ages of the plant fragments match a marked lithologic boundary between 14,060 and 14,325 ^{14}C yr BP. The contents of coarse sands abruptly increase, indicating probably wind-derived sandy dust or coarse grains contributed from floating icebergs. And abundant framboidal pyrite grains were deposited in an anoxic environment, as reflected by high accumulation of organic matters at a low lake stand. During the deglaciation, quantities of coarse sands, ostracod, shell fragments, framboidal pyrite, and diatom markedly varies by regional and global scale climate regimes. Some allochthonous coarse sands were probably ice-rafted debris derived from floating icebergs. A rapid increase in diatom productivity probably marked the onset of Bolling-Allerodwarming. Subsequent high concentration of framboidal pyrite probably represents a dry and cold condition, such as Younger Drays events. Consistent warm period with high precipitation at Holocene is documented by diatomaceous clayey ooze without framboidal pyrite, coarse sands, and ostracod.

Keyword: Hovsgol lake, deglaciation sediment, framboidal pyrite, allochthonous coarse sands

Introduction

Paleoclimate reconstructions from the bottom sediments of Lake Hovsgol in northern Mongolia have been carried out by diatom, biogenic silica, photosynthetic pigments, total organic carbon, lithology, and rare earth elements analyses (Fedotov *et al*., 2004 Karabanov *et al*., 2004 Chun and Cheong, 2005; Nara *et al*., 2005 Prokopenko *et al*., 2005). Sediments at deglaciation time plentifully accumulated at the southern part of Lake Hovsgol, allowing interpretation of high-resolution climatic change. These sediments contain authochthonous and allochthonous constituent materials, indicating a detailed record of bottom water condition and climate variability.
This study focuses on a rapid climatic variation during the deglaciationtime from a gravitysediment core obtained at the southern part of Lake Hovsgol (Fig. 1). Constituent materials (framboidal pyrite, coarse sands, and biogenic components) can provide abrupt climatic variations through the last glacial maximum to the following deglaciation periods. Variations in constituent materials would be forced by fluctuations of precipitation, meltwater input, and wind-driven sediments.

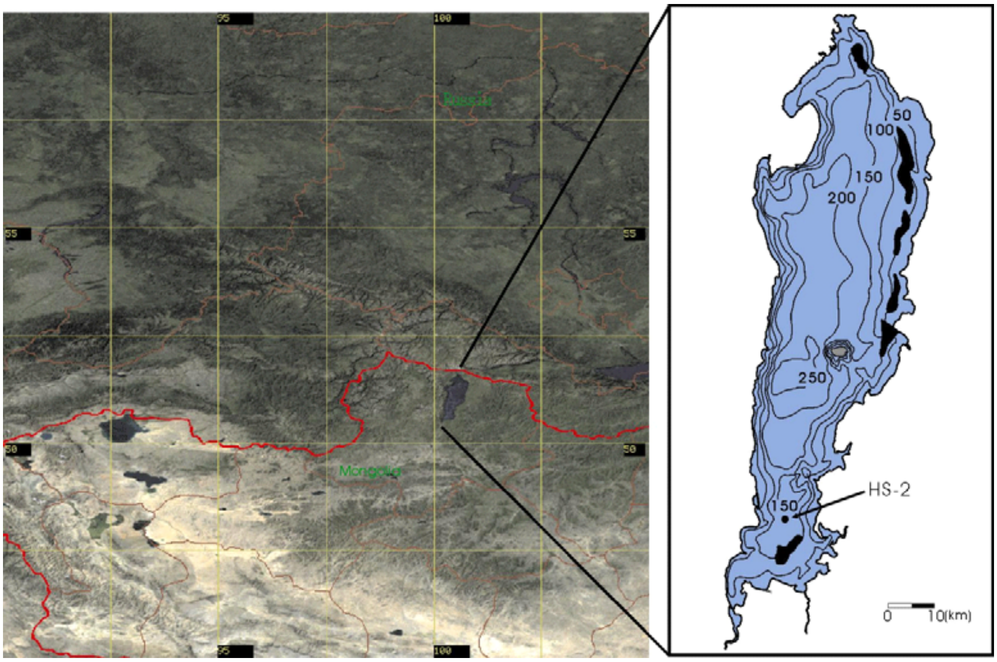

Figure 1. Location map of Lake Hovsgol in northern Mongolia (from Image

Science and Analysis Laboratory, NASA-Johnson Space Center).

Results and discussion

The sediment core consists of distinct four lithologies: diatomaceous clayey ooze (0-16 cm), finely laminated carbonate mud (16-64 cm),diatom-barren calcareous clayey silt with in-situ moss (64-100 cm), and diatom-barren calcareous silty clay (100-120 cm) (Fig. 2). Coarse sands concentration is high at an interval between 64 and 100 cm throughout the sediment core. The origin of coarse sands is probably wind-derived sandy dust or ice-rafted debris because of enhanced winter monsoon or partial melting of continent glaciers at the time of deposition, respectively. Detailed observation of surface textures was carried out with a scanning electron microscopy-energy dispersive X-ray microanalysis. This interval includes in-situ moss and ostracod, representing a retreated lake-level. There are three AMS radiocarbon dates of plant fragments for core HS-2; 14,060±40 (78-80 cm), 14,210±40 (88-90 cm), and 14,325±40 (94-96 cm) ^{14}C yr BP, respectively (Fig. 2). These AMS radiocarbon ages nearly agree with those from other cores at the same interval such as 12,950±70 and 13,100±140 ^{14}C yr BP (Prokopenko *et al*., 2005). Diatom-barren calcareous clayey silt with in-situ moss was deposited during the last glacial maximum at a low lake stand under a cold and dry environment. Figure 2 depicting content of shell fragments reveal minor peaks at the uppermost and lowermost parts of last glacial maximum sediments (Fig. 2).

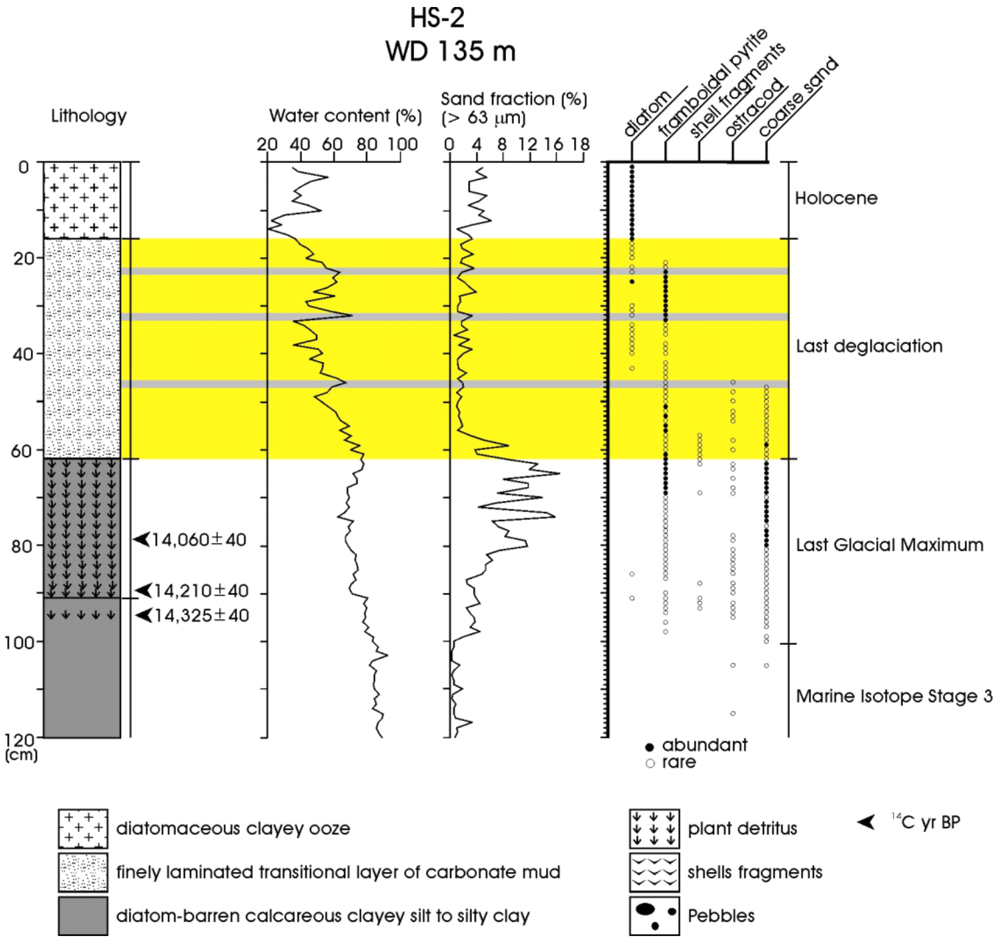

Figure 2. Lithology, water content, sand fractions, and constituent compositions in core HS-2 from Lake Hovsgol.

Finely laminated carbonate mud is subdivided into four stages based on dramatic variations in constituent materials such as coarse sands, ostracod, framboidal pyrite, and diatom. Such dramatic variations may be related to short-term climatic changeswith Bolling-Allerod and Younger Dryas events during the deglaciation. Appearance of coarse sands and ostracod at the lower part of finely laminated carbonate mud suggests that icebergs were calvedinto marginal lake at the end of the glacial period (Fig. 2). First occurrence of diatom after the last glacial period indicates that the water chemistry of lake changed to an onset level of initiation for primary production (Fig. 2). The brief increase in precipitation during the Bolling-Allerod warm event probably induced the change in water chemistry. The following dry and cold environment is represented by rapid concentration of fraomboidal pyrite (Fig.

2). The water chemistry temporally changed to an anoxic condition due to low precipitation and evaporation at Lake Hovsgol. The upper part of core sediments deposited at the deglaciation period only consists of diatom due to enhanced precipitation. Consistent warm climate with high precipitation is documented by diatomaceous clayey ooze during the Holocene.

Conclusions

The paper briefly presents reconstruction of a rapid climatic change during the deglaciation time of Lake Hovsgol based on abrupt variations in constituent materials, such as framboidal pyrite, ostracod, diatom, and coarse sands. The study suggests sequential changes of water chemistry due to precipitation variability and release of meltwater from the glacier. The rapid climatic changes during the deglaciation period may have coincided with occurrence of coarse sands, diatom, and framboidal pyrite, respectively.

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