

湖底堆積物中の Rb/Sr 比は気候変動の指標となるか
The Rb/Sr ratio in Lake Baikal sediment for the last 33 kyr

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Abstract

The long-term and high time resolution analysis of inorganic elements from Lake Baikal sediment revealed that source provenance of Rb has been changed during last glacial and post glacial period. Simultaneous fluctuations between the Rb/Sr ratio and the mean grain size indicate that the Rb/Sr ratio was influenced from the precipitation change (humidity) during the post glacial period. On the other hand, it can be supposed that the influence of loess sediment on the Rb/Sr ratio was found during the last glacial period. The 200-yr period variation of the Rb/Sr ratio was found during the post glacial period. This 200-yr period is very close to those of TSI variation. This result indicates the strong influence of solar irradiance on the precipitation change in Lake Baikal region.

Keywords, the Rb/Sr ratio, new geochemical proxy, East Asian winter monsoon

Introduction

In this study, to establish the climate proxy of humidity using the Rb/Sr ratio, we analyze major elements, Rb and Sr in Lake Baikal sediment core by ED-XRF as well as the mean grain size (MGS). Since, MGS variation in Lake Baikal sediment indicate the precipitation variability(Kashiwaya et al., 2001), we can investigate the possibility of the Rb/Sr ratio for the weathering proxy comparing with MGS.

Materials and methods

VER99G12 sediment core

Lake sediment core sample (VER99G12, 466cm core length) was taken from the Bulgdeika saddle in Lake Baikal (52°31'36"N, 106°9'08"E; 365 m water depth). The core VER99G12 is strongly

influenced from the deposition materials from the Selenga River and its watershed (Kuzmin et al., 2000), because the sampling point of the core is located on the opposite side from Selenga River which is the largest inflow into Lake Baikal (ca. 50% of total river input (Osipov and Khlystov, 2010)). Therefore, the core VER99G12 can record the environment change not only Lake Baikal water column but also in its watershed including in Mongolia (Fig. 1).

¹⁴C age model

The radiocarbon (¹⁴C) age for the core VER99G12 were measured on carbonate-free materials using a Tandemron accelerator mass spectrometry system (High Voltage Engineering Europe, Model-4130 AMS, The Netherlands), at the Center for Chronological Research, Nagoya University, Japan. The ¹⁴C age model for the core VER99G12 was established by Nara et al., (submitted). The core VER99G12 covered for 33 kyr (Nara et al., 2010), so this core experienced the rapid climate change from cool and dry climate to wet and warm climate at around 11.7 kyr (Wang et al., 2001). The core was sliced into subsamples with a thickness of 1 cm, and the time-resolution of each sample is estimated in 70 year.

ED-XRF measurement

Energy dispersive X-ray fluorescence (ED-XRF, Epsilon 5, PANalytical) measurement was used to determine the quantity of inorganic elements (K₂O, CaO, Rb and Sr). Pressed powder pellets were prepared for ED-XRF measurements using hydraulic press operated at 200kN (Specac Ltd., UK). The instrument has user-selectable secondary target and a germanium (Ge) solid-state high-resolution detector. A 3-dimensional design was also used to eliminate the X-ray tube spectrum by polarization. Detection limits were reduced by at least one order of magnitude with this technique. K₂O and CaO were measured using Calcium fluoride (CaF₂) and Fe as the secondary target, respectively.

Results and Discussion

High correlations between CaO and Sr were observed through the core. This result show that the behavior of Ca and Sr are very similar, and the provenance of these elements could be same in Lake Baikal watershed during 33 kyr. On the other hand, the correlation between K₂O and Rb showed different profiles between pre LGM and post LGM. Although high correlation between these elements was observed during post LGM, there is no correlation between K₂O and Rb during pre LGM. During pre LGM, K₂O concentration showed constant value at around 3 wt. %, but Rb concentration varied from ca. 110 to 160 ppm. This result suggests that Rb could be concentrated in the lake sediment relative to K₂O during pre LGM. The variation of the Rb/Sr ratio during the late Pleistocene is associated with the variation of MGS from loess sediment in China(Sun et al., 2011).

Summary

The long-term and high time resolution analysis of inorganic elements from Lake Baikal sediment revealed that source provenance of Rb has been changed during last glacial and post glacial period. Simultaneous fluctuations between the Rb/Sr ratio and the mean grain size indicate that the Rb/Sr ratio was influenced from the precipitation change (humidity) during the post glacial period. On the other hand, it can be supposed that the influence of loess sediment on the Rb/Sr ratio was found during the last glacial period.

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日本語要旨

南シベリア南東部に位置するバイカル湖より長さ 436cm の堆積物試料を採取し、堆積物中の無機金属元素測定を行った。試料は 1cm 間隔で切り分けられ、試料間隔ごとの時間解像度は約 70 年と見積もられる。堆積物中の Rb 及び Sr は、完新世（約 11,700 年前から現在）にかけて、それぞれ K と Ca に対して高い相関を示した。一方、後期更新世（約 33,000 年前から 11,700 年まで）においては、Sr と Ca は高い相関を示すが、Rb と K に相関は見られなかった。乾燥化した時代において、Rb の濃集が起きていたと考えられる。Rb/Sr 比の分布は、後期更新世において冬季モンスーン(East Asian winter monsoon)の指標である中国レス堆積物の粒度分布(Sun et al., 2011)とよく対応を示した。寒冷、乾燥期においてバイカル湖堆積物中の Rb/Sr 比が冬季モンスーンの指標となりうる可能性を示唆している。