210-lead dating of lacustrine sediment: Tsagaan Lake in Valley of the Gobi Lakes in Mongolia

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Introduction

Mongolia is a landlocked country in North-Central Asia in transition zone between Siberian taiga and arid region of Central Asia through dry steppes. Climate is extremely variable relative to same latitude's countries, as it is controlled by the Westerlies, East Asian Summer Monsoon (EASM), and Siberian anticyclone. The climate change intensively impacts its environment and life of local people (IPCC, 2014). Paleoenvironment study is important to understand the intensity of climate fluctuation and related environmental issues, and to implement the environmental management. Past environmental information is often reconstructed by analyses of sedimentary archives. A reliable age dating method is a crucial to explain the climate oscillation in the past. Thus, we aim to conduct the ^{210}Pb dating method for the recent sediment collected from Tsagaan lake in Mongolia.

A total ^{210}Pb activity in the sediment is comprised of the unsupported ($^{210}Pb_{xs}$) and supported ^{210}Pb. A fraction of the ^{222}Rn atoms produced by the decay of ^{226}Ra in soils escape into the atmosphere where they decay through a series of short-lived radionuclides to ^{210}Pb. Whereas, supported ^{210}Pb radionuclide is continuously produced by the in-situ decay of ^{226}Ra in bottom sediments. $^{210}Pb_{xs}$ is expressed as subtracting the supported ^{210}Pb from total ^{210}Pb. According to the radio decay law, the $^{210}Pb_{xs}$ concentration is exponentially decreased along the sediment profile when sediment input and $^{210}Pb_{x}$ input is constant through the time. Based on the exponentially decreasing pattern of $^{210}Pb_{xs}$ profile, it is possible to establish the last ~150 years of sediment chronology. We retrieved a short core sample (~130 cm depth, CoreID - 18TS1) from the Tsagaan lake in 2018. Total 26 samples were prepared by 1 cm and 2 cm intervals for radioisotope measurement. The activity concentration of each prepared sample was measured by a high purity Ge-detector in the RI laboratory, Kanazawa University. To interpret the $^{210}Pb_{xs}$ profile, we used the Constant Rate of Supply (CRS), Constant Initial Concentration (CIC), and Constant Flux and Constant Supply (CFCS) models (Appleby and Oldfield, 1978; Krishnaswamy et al., 1971; Robbins and Edgington, 1975) to establish the relative age of the lacustrine sequences.

Results and Discussions

A concentration of $^{210}Pb_{xs}$ was 132 Bq/kg on SWI (Sediment Water Interface), then decreased between 0 and 26 cm depth (Figure 1-A). However, the profile does not show monotonic decreasing trend, showing that the assumption of constant sediment and $^{210}Pb_{xs}$ supply is not realistic in this lake. Based on the concentration of $^{210}Pb_{xs}$, CRS, CIC, and CFCS models were applied (Figure 1-B). According to the comparative estimation of different models, the CRS model can reveal the reliable age estimation for the down core profile relative to other models, and this model estimated 24 cm sediment deposited during 87 years. Mass accumulation rate is calculated based on the CRS age and mass depth profile, and it varies through time (Figure 1-C) . The average is approximately 1.001 g/ cm^2 year. The low accumulation rate is associated with the increasing concentration of $210Pb_{xs}$ obtained at 15 cm depth and 20 cm depth (Figure 1-A, C). Whereas the CIC model results are not sequenced with depth profile. Because this model assumes the constant rate of sedimentation, the increasing concentration of $^{210}Pb_{xs}$ in 10-14 cm and 18-20 cm depths is impossible to explain. The CFCS model ages, based on both the sedimentation rate and atmospheric flux of ^{210}Pb are constant, were relatively older than the CIC and CRS age model. This model calculated 139 years at 28 cm depth. The age estimation range of the CFCS model is wider than the CRS and CIC models. But the uncertainty of age estimation was higher than in the CRS and CIC models.

Summary

The concentration of $^{210}Pb_{xs}$ is measured from the top sediment until 26 cm depth. The ^{210}Pb age dating results reveal relatively different sedimentation rate for the 18TS1 core based on distinct assumptions in age estimate. Age estimation by the CIC model reports shorter sedimentation time, whereas the CFCS model reveals a longer age estimation, the uncertainty was wider than the CIC and CRS models' age uncertainty. The CRS model can prove a reliable age with less uncertainty and indicates the variable sediment input rate..

References

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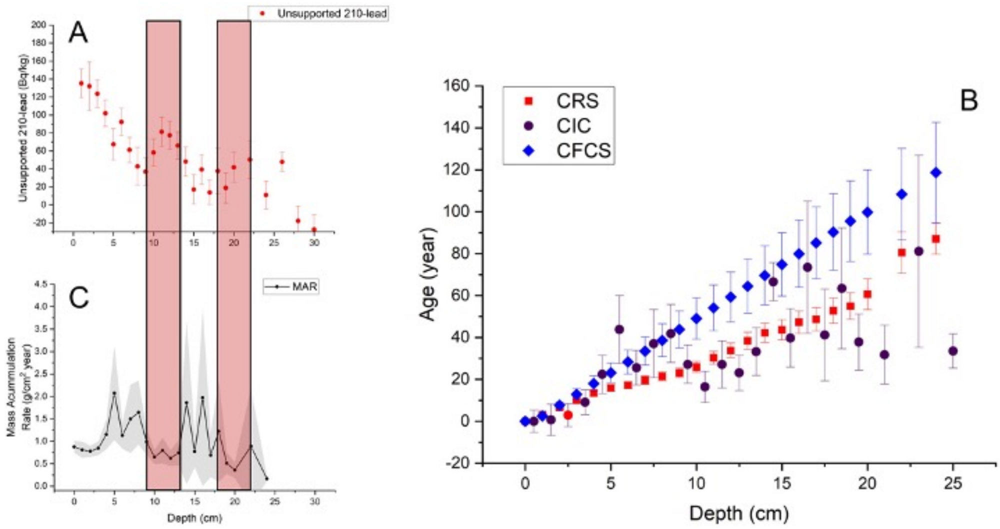

Figure 1. (A) Down core profile of $^{210}Pb_{xs}$ (Unsupported ^{210}Pb). (B) Chronology Results obtained by 3 different models, Constant Rate of Supply (CRS), Constant Initial Concentration (CIC), and Constant Flux and Constant Supply (CFCS) models. (C) Mass Accumulation Rate based on CRS model result, red bars indicate that the mass accumulation rate associates to the increasing pattern of $^{210}Pb_{xs}$ concentration.