Fluctuation of marine osmium isotope ratio during the Quaternary climate cycles

YUSUKE KUWAHARA1, KAZUTAKA YASUKAWA1,2,3, KOICHIRO FUJINAGA2,3, TATSUO NOZAKI2,3,4,5, JUNICHIRO OHTA2,3,6, JUN-ICHI KIMURA8, KENTARO NAKAMURA1, YUSUKE YOKOYAMA8,9,10,11 AND YASUHIRO KATO1,2,3,4

1Department of Systems Innovation, School of Engineering, The University of Tokyo
2Ocean Resources Research Center for Next Generation, Chiba Institute of Technology
3Frontier Research Center for Energy and Resources, School of Engineering, The University of Tokyo
4Submarine Resources Research Center, Research Institute for Marine Resources Utilization, Japan Agency for Marine-Earth Science and Technology
5Department of Planetology, Graduate School of Science, Kobe University
6Volcanos and Earth’s Interior Research Center, Research Institute for Marine Geodynamics, Japan Agency for Marine-Earth Science and Technology
7Department of Geosciences, University of Padova
8JAMSTEC
9Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo
10Graduate Program on Environmental Sciences, Graduate School of Arts and Sciences, The University of Tokyo
11The University of Tokyo

Presenting Author: yusuke-kuwahara326@g.ecc.u-tokyo.ac.jp

The solid earth plays a major role in controlling Earth’s surface climate. Volcanic degassing of carbon dioxide (CO₂) and silicate chemical weathering are known to regulate the evolution of climate on a geologic timescale (>10⁶ yr) [1], but the relationship between the solid earth and the shorter (<10⁵ yr) fluctuations of the Quaternary glacial−interglacial cycles is still under debate. We employed the paleo-seawater osmium isotope composition (187Os/188Os), as a proxy for the solid earth’s response to the Quaternary climate change. The marine 187Os/188Os reflects the relative intensity of two dominant influxes to the ocean: radiogenic continental-derived materials (187Os/188Os = ~1.4) and unradiogenic mantle-like materials (187Os/188Os = ~0.126) such as hydrothermal fluids and cosmic dust [2].

Our analytical results of deep-sea sediments at ODP Site 834 in the South Pacific Ocean showed that the seawater 187Os/188Os has varied during the past 300,000 years in association with glacial−interglacial cycles [3]. We implemented marine Os isotope mass-balance simulations and revealed that the observed 187Os/188Os fluctuation cannot be explained solely by changes in global chemical weathering rate corresponding to the Quaternary glacial−interglacial climate cycles [3]. Instead, the fluctuation can be reproduced by taking account of short-term inputs of (i) radiogenic Os derived from intense weathering of glacial till during deglacial periods [4] and (ii) unradiogenic Os derived from enhanced seafloor hydrothermalism triggered by sea-level falls associated with increases of ice sheet volume [5]. Our results constitute the first evidence that ice sheet recession and expansion during the Quaternary systematically and repetitively caused short-term (<10⁵ yr) solid earth responses via chemical weathering of glacial till and seafloor magmatism. This finding implies that climatic changes on <10⁵ yr timescales can provoke rapid feedbacks from the solid earth, a causal relationship that is the reverse of the longer-term (>10⁶ yr) causality that has been conventionally considered.