Identification of origins and biogeochemical process of cryoconite on glaciers using Sr and Nd stable isotope ratios

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Recent shrinkages of glacial mass are not only due to global warming, but also possibly to accumulation of cryoconite on glaciers. Cryoconite is a biogenic surface dust consisting of organic matter mainly derived from glacial microbes, and mineral dusts originated from basal till and/or wind-blown dust. Since cryoconite is dark color, it can reduce surface albedo of glaciers and accelerate their melting. Thus, it is important to understand their origins and formation process.

Stable isotopic ratios of strontium (Sr) and neodymium (Nd) provide a means of identifying sources of substances and have been commonly used in loess or sediment studies (e.g. Nakano et al., 2004). Furthermore, Sr isotope can be used as a tracer of Ca ion in studies of geochemical process. Thus, Sr in organic matter including such organisms on the glacier may reveal their nutrient sources and ecology of them (Nagatsuka et al*.,* 2010). In this study, we analyzed Sr and Nd isotopic ratios of mineral and organic fractions in cryoconite on Asian and Polar glaciers. Based on the isotopic ratios, we identified origins of minerals in cryoconite and mineral sources used as nutrients by microbes on the glaciers.

Sr and Nd isotopic ratios of mineral fractions in cryoconites showed geographical variations, indicating that the origins of minerals differ among the glaciers. Compared with the isotopic ratios of minerals in sediments such as moraine, desert, and loess, the isotopic values in cryoconites were close to those in respective regions, which revealed that the minerals were derived from surrounding the glaciers. Furthermore, the Sr and Nd ratios showed altitudinal variations within a glacier. For example, the isotopic ratios in cryoconite on a Chinese glacier showed no significant variation between the sites. This result suggests that the mineral dust was derived from a single source and deposited uniformly across the ice surface. On the other hand, those on Alaskan glacier and Greenlandic glaciers showed altitudinal variations, indicating that the minerals were derived not from a single source but from multiple sources. Thus, the Sr and Nd isotopic ratios of cryoconite can be used to identify the regional variations in sources and transportation process of mineral dust on glaciers.

Sr isotopic ratios of organic fraction also showed geographical variation among the glaciers. The isotope ratios in organic matters were close to those of saline and carbonate minerals in Central Asia, but were intermediate between those of the saline and carbonate minerals on the one hand, and phosphate mineral on the other hand in the other Asian regions and Polar region. These values may be controlled by the mixing ratio of the minerals that are the sources of the Ca incorporated into the microbes on the glaciers. The isotopic results also suggested that nutrient cycles in the glacier ecosystems differ between the glaciers. Nutrient conditions on glaciers are thought to be one of important for cryoconite formation. Thus, the Sr isotopic ratio in the organic matter could provide a means of revealing the biogeochemical process in cryoconite.

References

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