Stable isotopes of Sr, Nd, and Pb of rock origin in ice-core studies;current status and futurability

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Various geochemical and stable isotope indexes have been developed as a tool to reconstruct the paleoenvironmental change and applied for core sediments in ocean and lake. Sediments are mainly composed of minerals derived from the weathering of rocks. Stable isotopes of Sr, Nd, and Pb are powerful tools for the source identification of sediment materials, because they vary regionally dependent on the diverse petrogenesis of rocks. Despite a few applications, these isotope tools are useful for ice-core studies. For example, Sr and Nd isotopes have suggested the source of aeolian dust on Antarctica to be Patagonian desert and that on Greenland to be Chinese desert. Pb is also a vital environmental tracer, whereas its application is largely on human-impacted environmental studies. This is because most Pb in the atmospheric and ecological system is originated from ore Pb by human activities in addition to its high toxicity. Another unique feature of these isotopes of rock origin is that their ratios are not or less affected by isotope fractionation. Thereby, the stable isotope ratios of Sr, Nd, and Pb can provide constraints not only on the source of aeolian minerals in ice-core but also that of these elements in ice and ice-biota, and further they can serve for the biogeochemical study in glacial environment. By using these isotopes, we have initiated the assessment research of natural and human-activity impact on glaciers in Asia, which is considered to be a hot spot of global environmental problems. We will introduce previous studies and propose an application strategy using these isotopes for ice-core studies.

Recent studies have shown that one remarkable feature in the glacier of Asian mountains is the high activity of ice biota, but the causal relationship remains unsolved. We propose a hypothesis that the atmospheric input on the Asian glacier is enriched in nutrient minerals compared to that on polar and other mountain glaciers. Atmospheric inputs are divided into wet precipitation largely of snow and dry deposition largely of dust minerals. The major emission area of Asian dust is the desert and loess in northern China and southern Mongolia. Soil minerals of desert and loess in arid region is classified into three types, salinization minerals which are soluble into water and weak-acid, phosphate and iron oxides which are soluble in hydrochloric acid, and acid resistant silicates. Previous studies have shown that the three minerals have different Sr isotopic ratios one another, while the Nd isotope ratios are less dependent on the mineral types. Pb isotope ratios are different between wet precipitation and dust silicates. These features suggest the following research possibilities, (1) discrimination of moraine minerals from desert-derived ones and the quantitative evaluation of both minerals on ice-core, (2) source estimation of ice-soluble elements, and (3) source identification of nutrients in ice-biota and human impact on the biogeochemical cycle in the glacier ecosystem. Our hypothesis can be validated by solving these three subjects. Although it is important to compare the multi-isotope and geochemical data on ice-core, moraine, and arid-soils over Asia, preliminary data seem to support this validation.