

Applications of mass spectrometry on polar snow and ice core samples

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Snow and ice core samples recovered from polar region have provided valuable information on past climate and environmental changes. That information has been mainly come from various proxy records measured by mass spectrometries.

Primarily, past changes in atmospheric temperature are reconstructed from hydrogen and oxygen isotope ratios in polar snow and ice core samples analyzed by isotope ratio mass spectrometry (IR-MS). When water evaporates, light isotopes of oxygen and hydrogen are enriched in water vapor, while heavy isotopes preferentially fall during precipitation. For the glacial period, low air temperature caused large precipitation before it reached a polar region, and thus water stable isotopes of polar snow became light. On the other hand, during the interglacial period, more water vapor can reach a polar region with heavier water stable isotopes. Using this, in the late 1960s, the first record of glacial-interglacial changes were reconstructed from Greenland deep ice core. Since then, a number of ice core records have been reported in both polar regions and they have revealed the global climate changes for the past 800,000 years.

Secondly, trace metals records of ice cores determined by inductively coupled plasma mass spectrometry (ICP-MS) have shown changes in atmospheric input of those elements corresponding to various environmental changes. The ice core records of representative crustal elements such as aluminum (Al), barium (Ba), iron (Fe) and scandium (Sc) have represented the changes in natural dust input depending on climate change. Bismuth (Bi) peaks are strong evidence for large volcanic eruptions. Heavy metals such as cadmium (Cd), copper (Cu), lead (Pb) and zinc (Zn) have shown that the anthropogenic air pollution occurred in hemispheric scale even during ancient Greek and Roman period. However, most of those elements exist in extremely low concentrations of pg g^{-1} level. Therefore measurements of trace metals in polar

snow and ice are still hard challenges. In order to avoid contamination of samples, ice cores are carefully decontaminated by mechanical chiseling, all sample vessels are cleansed with nitric acid for more than several months before using them and whole analytical processes are performed in a clean laboratory by trained researchers wearing clean garment.

Pb and strontium (Sr) isotope ratios have been analyzed from ice cores using thermal ionization mass spectrometry (TIMS). Those non-traditional isotopic data, together with rare earth elements, are very useful tools for source identification of air mass. Recently, it is known that climate changes are closely related to changes in air circulation, but detailed mechanisms are not fully understood. In this regard, ice cores can provide records of past climate changes and source region transitions simultaneously. Unfortunately, trace metals isotope ratios in ice core samples have not been widely reported because very few laboratories can properly treat analytical samples. In addition, TIMS measurement is time consuming. Therefore, at present, new analytical method for isotopic ice core data using multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS) is being developed. MC-ICP-MS can be applied for more various elements which are known to be fractionated by various natural and anthropogenic processes. Therefore, if MC-ICP-MS is successfully applied to ice core measurement, it is expected to reconstruct not only sources transitions but also changes in other geochemical processes corresponding to climate changes.