

Greenland NEEM ice core records of As, Cd, Cr and Mo during the period of 1820-1970 AD

Khanghyun Lee, Jangil Moon, Yeongcheol Han, Soon Do Hur, Sungmin Hong

Abstract

Greenland snow and ice core records of various trace elements showed that the large-scale atmospheric cycles of these elements have been strongly modified by human activities. However, such snow and ice core records are only available for the very few elements such as lead (Pb), copper (Cu), zinc (Zn), cadmium (Cd), and thallium (Tl), because concentrations of most of elements in Greenland snow and ice are extremely low at the low and sub-pg/g level. We here present an annual resolution record of changes in the occurrence of arsenic (As), chromium (Cr), molybdenum (Mo) and Cd from Greenland NEEM ice core samples covering the period from 1820 to 1970. To our knowledge, long-term trends of As, Cr, and Mo have never been reconstructed from Greenland ice cores at such a high resolution. Barium (Ba) was also analyzed to calculate the crustal enrichment factors (EF_c), using concentration ratios between the four trace elements and Ba in the samples and in the mean upper continental crust.

Concentrations of As, Cd, Cr and Mo are 1.3~80.4 pg/g, 0.005~21.2 pg/g, 4.3~98.3 pg/g and 0.1~6.4 pg/g, respectively. To help emphasize the main features of anthropogenic inputs, individual data points were averaged for a decadal period, while the whole data before 1850 were averaged as the preindustrial period. All the measured elements show two distinct peaks in concentrations, but contrasting situations are observed for the different elements. As and Cd show a rapid increase in concentrations from 1870 to ~1880s and from 1930 to 1940s, while Cr and Mo show peaks during the 1900s and 1960s. The temporal trends of the EF_cs appear to match with those of concentrations for each element. The different patterns in the periods reaching peaks in concentrations and EF_cs are likely due to the primary anthropogenic sources for the different element. Anthropogenic As and Cd are mainly emitted from non-ferrous metals production, while Cr and Mo are from fossil fuel combustion. Our first comprehensive and reliable time series for As, Cd, Cr and Mo from Greenland NEEM ice core provide valuable insights into significant enrichments of these elements due to human activities from the early-19th to the mid-20th century.