Stable Isotopes in Cryosphere and Climate and Environmental Study

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High-resolution isotope records from ice cores that recovered from mid- low-latitude glaciers provide an opportunity to extend climate and environmental changes over the past thousands of years. The $\delta^{18}O$, δD records revealed well-preserved seasonal climatic variability, which is significantly controlled by air temperature, origin of moisture transport, recycling and precipitation amount.

Seasonal variations in isotope composition in the upper part of Siberian Altai, Tien Shan, Pamir and southeastern Tibet ice cores was used as one of the proxy methods for ice core dating, which is crucial for correct interpretation of modern and paleo-climate. Identification of annual accumulation layers in the ice cores was based on the extreme values of $\delta^{18}O$ and δD, as the minimum winter and maximum summer air temperatures. Furthermore, the analysis of stable isotopes in Siberian ice cores has revealed both, moderate and abrupt climatic changes. The enriched isotope transition with thermal maximum of about -7.3‰ let us expect that Siberian glaciers existed throughout the Holocene Climate Optimum when it was a much warmer period than now ($\delta^{18}O$ mean for the last 50 years of -14.25‰). Prior to occurrence of thermal maximum, two periods of abrupt cooling with $\delta^{18}O$ means of -18.49‰ and depleted to -23.7‰ were captured in the ice core records with signs of increased droughts. One of them was most probably the Younger Dryas stadial followed by 8.2 kiloyear event, an abrupt cooling episode.

The variability of the stable isotope records from ice cores are used also to examine isotope/air temperature relationships, which were examined by variability of regression lines. Positive regression line slopes have been observed for the Tien Shan, Pamir and Altai mountains, with minimum $\delta^{18}O$ values associated with minimum winter temperatures. The $\delta^{18}O/\delta D$ relationship in the snow/firn cores from the Fedchenko Glacier (Pamir), Tien Shan and Altai has a similar slope (i.e., 8.5, 8.3) to co-variance of oxygen/hydrogen of the Global Meteoric Water Line (GMWL), i.e., 8. This suggests that the relationship of fractionation factors in the ice cores was the most similar to that in the GMWL, which confirms an absence of strong melt and percolation in ice cores. A negative regression line slope is observed at southeastern Tibet, with minimum $\delta^{18}O$ values associated with heavy amounts of isotopically depleted precipitation occurring during summer months. The developed transfer functions let us reconstruct air temperatures throughout the Holocene over the central Asia.

Understanding the physical processes controlling the $\delta^{18}O$ and δD stable-isotope relationship let us couple these records with large-scale atmospheric dynamics and the precipitation-origin time series. The origins of precipitation nourishing central Asian glaciers wer determined based on clustering analysis of $\delta\ ^{18}O$ and d-excess records. Calibration and validation of the developed clusters occurred at event and monthly time scale using synoptic analysis. It has been discovered, that Tien Shan moisture has prevailing origin from Aral/Caspian closed basin, Eastern Mediterranean and Black seas with high d-ex (23‰) associated with low humidity during evaporation while Altai receives precipitation mainly from Atlantic Ocean (55%), partially from Aral/Caspian closed basin, with intermediate d-excess (10‰) and from Arctic and Pacific oceans (16%, 4.6‰ d-ex). Most precipitation over the Pamir originated in the Atlantic but in summer has occasional monsoon intrusions. All central Asia also receive water vapor re-evaporated from semi-arid regions of central Eurasia.