Annual Report for Period: 08/2008 - 07/2009
Submitted on: 05/14/2009
Principal Investigator: Aizen, Vladimir B.
Award ID: 0754479
Organization: University of Idaho
Submitted By:
Aizen, Vladimir - Principal Investigator
Title:
Collaborative Research: Asian Ice Core Array (AICA)--Reconstruction of Past Physical and Chemical Climate over Asia

Project Participants

Senior Personnel

Name: Aizen, Vladimir
Worked for more than 160 Hours: Yes
Contribution to Project:
Vladimir Aizen has been worked 348 hours total during the year 1 of the project. His duty in the project in year 1 has included but not limited of the research organization and coordination between two teams at the University of Idaho and the University of Maine, work on data analysis and interpretation, preparation of scientific manuscripts and technical reports, presentation results at the national and international meetings, organization and lead complex international expedition to Pamir, Fedchenko Glacier to recover first 200-250 m shallow ice-core.

Name: Aizen, Elena
Worked for more than 160 Hours: Yes
Contribution to Project:
Elena Aizen has been worked 348 hours total during the year 1 of the project. Her duty in the project in year 1 has included but not limited of the meteorological, synoptic, ice-core isotope-chemistry and dust particles data validation, and assessment calibration, preparation of scientific manuscripts and technical reports, presentation results at the national and international meetings, work and assist graduate students involved in the project.

Post-doc

Name: Surazakov, Arzhan
Worked for more than 160 Hours: No
Contribution to Project:
Arzhan Surazakov has worked with Altai (2003)ice-core processing in UofI dedicated ice-core laboratory. He also involved in the Pamir and Altai reconnaissance field trips in summer-autumn 2008.

Graduate Student

Name: Joswiak, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:
Daniel Joswiak, third year PhD student has been involved in the project as assistant researcher during 12 months (whole year). Daniel has processed Siberian Altai and Central Tien Shan ice-cores at the University of Maine and University of Idaho dedicated ice-core laboratories using newly developed ice-core continuous melting system. Together with Vladimir Aizen he run ice-core samples for dust particle and stable isotope analysis producing data for statistical analysis and scientific interpretation. He also worked and completed his PhD thesis related to ice-core research of the current project. He present his preliminary results at the AGU San Francisco Fall Meeting in December 2008 and at a School of young early career development scientists in Helsinki (Finland) in June 2008. Daniel was also involved in preparation of two scientific papers for publication in peer-reviewed scientific journals.

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Climate Change Institute, University of Maine

Prof. Paul Mayewski (paul.mayewski@maine.edu
Dr.Andrei Kurbatov (akurbatov@gmail.com)
Dr.Karl Kreutz (karl.kreutz@maine.edu)
PhD student Bjorn Grigholm (bjorn.grigholm@maine.edu)
PhD student Elena Korotkikh (elena.korotkikh@maine.edu)

are our collaborators in the joint AICA Collaborative Project.

Activities and Findings

Research and Education Activities:

Since July 2008 when UofI and UofM teams received NSF reward, two ice-cores have been processed and melted for further isotope-geochemistry analysis: 165 m depth ice-core from Central Tien Shan, recovered in 2000 and 171 m depth Belukha Plateau ice-core from Siberian Altai, recovered in 2003. The Tien Shan ice-core has been stored at the University of Maine freezer and Altai core was stored at the University of Idaho freezer. PhD students, Daniel Joswiak (UofI) and Bjorn Grigholm (UofM) processed and melted both cores at the UofM Tephra/Particles laboratory in Continuous Melting System (CMS) adjusted with 'Klotz' laser Particle Counter (LPC). The Mill-Q ice-core (pure water) used to test IC line with a particle counter inline before the work has been started with both cores. Test IC line was done to avoid possible contamination by particle counter instrument. The Tien Shan core samples were collected after CMS at resolution of 10 cm depth and Altai core at resolution of 5 cm depth. All core samples were run through LPC.

Oxygen isotope ratios from collected samples were measured in Stable Isotope Laboratory of the University of Idaho using a standard CO2 equilibration technique (Craig, 1957). Hydrogen isotope ratios were measured using Cr reduction in a continuous flow system (Morrison and others, 2001). Data are reported in standard delta (d) notation vs Standard Mean Ocean Water(SMOW). The analytical precision for measurements of oxygen and deuterium isotope ratios was ?0.05% and ?0.5% respectively. Analytic uncertainty in d-excess was 0.52%.

Anion (Cl-, NO3-,SO42- and cation (Na+, Ca2+, K+, Mg2+, NH4+) analyses were performed via suppressed ion chromatography (Dionex 4000). Cations were analyzed with a CS12 column, 125 mL loop, and 20 mM MSA eluent. Anions were analyzed with an AS11 column, 75 mL loop, and 6 mM NaOH. The concentration of chloride, nitrate and sulfate was measured by ion chromatography (Dionex 500 using AS14 separation column and conductivity detection). Calcium, magnesium, sodium and potassium were analyzed with a Varian AA6 atomic absorption spectrophotometer. Acid neutralizing capacity was measured with Grantitration. The remained volume of 3,400 water samples(~100 ml each sample) from the same ice-core slices were frozen and stored in University of Maine freezer for further IC and ICPMS analysis during the second year of the project.

At the end of fall semester 2008, Daniel Joswiak completed and defended his PhD thesis: 'Industrial and Pre-Industrial Climate and Environmental Changes in Siberian Ice-Core Records' where he published some results of isotope-geochemical analyses from Altai ice-core.

Vladimir Aizen and Elena Aizen used results from Tien Shan and Altai stable isotope analyses to add to their course of lectures on Alpine Glaciology and Alpine Environment for the UofI graduate students. During 2008/2009 Vladimir Aizen, Elena Aizen and Daniel Joswiak participated at the National and International Conferences and Seminars presenting the preliminary ice-coring analysis results. V. Aizen had three invited lectures: at the German Geo-Center in Potsdam (GFZ); at a Seminar of the Institute for Computational Earth System Sciences at the University of California, Santa Barbara, and at International Workshop on ice-core research in High Asia at the Institute for Humanity and Nature in Kyoto. The UofI team presented one oral and three poster presentations to San Francisco AGU Fall Meeting 2008 including new results revealed during the current research project.

On December 13, 2008, Vladimir Aizen organized 3rd workshop of the Central Asia Deep Ice-coring Project that has been held in San Francisco to discuss field research in the Pamir in summer 2009 and further ice-core analyses planned in the Project. Fifteen participants from US, Japan, Germany, Switzerland and China came to this meeting and had comprehensive discussions and research result presentations. Finally, joint expedition to the Pamir to drill the first 150-200 m ice-core has been approved for summer 2009.

Findings:

Pamir shallow ice-core 2005, first results.

The location of a prospective site for deep drilling was determined by analyzing two pilot snow/firn cores obtained from Fedchenko glacier. A site on a leeward slope at 5206 m a.s.l. with significantly less accumulation is more appropriate than a site on a windward slope at 5365 m a.s.l. This allows recovery of longer-term paleoclimate records, possibly to 1000m depth. A well-defined, seasonal stratification in isotope and geochemical signals characterized the meteorological and atmospheric-aerosol loading regime of the Pamir and surrounded sub-arid areas. Air temperature and humidity/ precipitation were the primary controls on the stable-isotope records, i.e. precipitation was more depleted during the low temperatures of the winter months and more enriched during the higher temperatures of the summer. Spring?winter maximum and summer?autumn minimum precipitation typical of the central Pamir resulted in the lowest mean isotope ratios among values obtained from other glaciers in central Asia. Low-humidity, intensive re-evaporated/recycled moisture brought from the surrounding low-elevation areas, and prevailing condensation at high elevations of the glacier accumulation zone during the warm season with minimum precipitation, resulted in increasing d-excess values. Pilot snow-/firn-core records for the Pamir are also distinctive in the matched seasonal variation in d-excess and d18O. Values of d-excess as well as d18O were greater in warm seasons. Annual minima in isotope ratios decreased with altitude because of decreasing winter air temperatures and increasing precipitation. The inverse relationship between altitude and maximum air temperature was probably due to the increasing condensation with altitude. The alpine areas of the Pamir have climatic features transitional between marine-originated precipitation and the recycling of atmospheric moisture. The most similar (relative to GMWL) interpretation is the d18O?dD relationship from the most depleted Pamir isotope records, related to greater precipitation during the cold season that originated in the Atlantic without modified recycling. For summer/autumn seasons, increased d-excess reflects complicated sources of precipitation (e.g. South Atlantic and Indian Oceans, warm southern Caspian Sea waters or relatively warm continental waters).

The similarity in REE concentration patterns suggests that loess is the predominant lithogenic material transported to the Pamir from Afghan?Tajik loess deposits. Those deposits are characterized by high concentrations of REE and Al, high or median content of Ca, and a background S concentration.

Samples from the Pamir differed in having low concentrations of Gd. We do not exclude occasional intrusion of Chinese loess into Pamir glaciers.

The REE profiles of Pamir cores documented one of the most extreme droughts of 2001 and 2002 that developed in southwest Asia. Aerosol concentrations in Fedchenko glacier samples are lower than in Tien Shan cores. At the same time, concentrations of REE, major and other elements in snow and firn samples from the Pamir exceeded those from Antarctica, Greenland and even the relatively contaminated Alps and Altai. Heavy-metal concentrations in Fedchenko glacier samples were several times lower than in snow and firn from the Altai glaciers. Concentrations of trace elements (e.g. antimony) were similar to those in the Alps and Arctic Canada. Extensive fertilization in areas close to the Pamir probably explains the significant concentrations of sulfur observed even during background aerosol loading. Heavy-industrial and agricultural development since the mid-20th century have contributed to intensive atmospheric pollution over central Asia.

Siberian Altai surface to bottom ice-core, age dating by isotope-geochemical records.

Aging of the upper 50 m of a 170 m deep ice core was accomplished using the tritium concentration peak widely associated with the 1963 maximum to establish the initial reference horizon, and verified through annual layer counting and multiple peaks in sulfate concentrations coincident with major volcanic eruptions. When compared to the annual layer counting, the depth-age scale was within +/-5 years at 45 m depth, where visual layer differentiation becomes difficult as the ice becomes bubble free. The linear depth-age scale reveals an average annual net accumulation rate of 376 mm. w.e. for the time series preserved since the early 1900's, implying a relatively constant net accumulation balance for the time period represented. Several peaks in sulfate concentrations are coincident with major volcanic eruptions, although caution must be exercised in climatic interpreting due to significantly different mean concentrations associated with industrial and pre-industrial time frames.

A statistically significant increase was reveled for both sulfate and oxygen-18 profiles, (at the =0.001 level) as well as for the 50 yr seasonal temperature data from the Akkem station.

The stratigraphic observation of radiative crusts within the upper 50 m does not significantly alter the geochemical record since they immediately re-freeze within the snowpack of the cold accumulation zone. The increased prevalence of thin radiative crusts within the time period associated with the most recent two decades reinforces previous evidence (Henderson et al., 2006) that the high elevation accumulation plateau is transitioning from a recrystallization to cold infiltration zone.

Ice flow modeling (Nye, 1963) resulted in younger ages compared to stratigraphic/geochemical dating and firn densification modeling (Herron and Langway, 1980), although basal portion ages of 1000 yrs BP are likely, indicating that analysis to the full 170 m depth can provide

important long-term environmental records for a land-based region lacking in paleoclimate/environmental reconstructions.

Siberian Altai surface to bottom ice-core, age dating by plateaumicro-biological analysis

The Belukha Plateaumicro-bilological analysis of microorganisms shows that psychrophilic yeast propagated on the glacier in warm summers. The isolated species belonging to the genus Rhodotorula, which was related to the psychrophilic species Rhodotorula psychrophila. Clonal analysis of the ice core revealed the presence of two types of yeasts in the ice core samples. The ice core was dated on the basis of the seasonal continuity of pollen grains from the 4 taxa. The analysis performed using the known seasonal variations in pollen grains from the 4 taxa revealed that the 48-m ice core upper section contained 90 annual layers that had formed from 1914 to 2003. Annual changes in the δ18O and MFP showed a warming trend over the last 50 years. It has been determined that yeast cell propagation occurred only in warmer summers; therefore, yeast cells have the potential to serve as a new temperature proxy in the analysis of ice cores.

The data received from two ice-core analysis will be downloaded to the Central Asia Data Base that is currently under development at the University of Idaho. This data will be available to ice-core paleoclimatic community after the research results publication.

Training and Development:

V. Aizen and E. Aizen have taught a methodology of alpine ice-core processing, dust particle and isotope chemistry analyses in their Alpine Glaciology and Alpine Environment.

The Tien Shan and Altai ice-cores have been processed and melted at the University of Maine and analyzed in dedicated isotope-geochemical laboratories of both Universities ? UofM and UofI. Daniel Joswiak (UofI PhD student) had intensive training for all steps of ice-core processing and analysis under Vladimir Aizen and Elena Aizen guidance and supervision.

Daniel Joswiak used his results in preparing the PhD thesis on 'Industrial and Pre-Industrial Climate and Environmental Changes in Siberian Ice-Core Records'.

Daniel receive AGU award for the best student presentation on Climate Change in 2008.

After the graduation in December 2008, Daniel Joswiak received two years of fellowship of the Chinese Academy of Sciences to work on ice-core research in Tibetan Plateau Research Institute in Beijing where he is working now.

Outreach Activities:

Vladimir Aizen prepared two seminars at UofI during fall 2008 and spring 2009 semesters and he taught a class of Alpine Glaciology and Alpine Environment in fall semester where he used new results from the Tien Shan, Altai and Pamir ice-core.

V. Aizen elected as a member of CEOP-HE steering committee and he took an active participation in the development of new International High Elevation Program, where his role as ice-core expert was clearly illuminated. During a year 2008/2009, Vladimir Aizen reviewed 16 manuscripts in peer-reviewed journals and 9 proposal submiited to NSF, NASA and DOE.

Daniel Joswiak presented his ice-core results at the Helsinki Conference for Young Scientists in September 2008 and gave a seminar in Tibetan Plateau Research Institute, where he presented his results from Tien Shan and Altai ice-cores as a part of his research on dust particles over the mid-latitude high mountains.

Four papers were published in local media (Northwestern newspapers) and one broadcast presentation about ice-core paleo-climatic activity at the University of Idaho supported by NSF Paleoclimatic Program were done in 2008/2009.

Journal Publications

- Aizen, V., P.Mayewski, E. Aizen, D. Joswiak, A. Surazakov, S. Kaspari, B. Grigholm, M. Krachler, M. Handley, A. Finaev, "Stable-isotope and trace element time series from Fedchenko glacier (Pamirs) snow/firn cores", Journal of Glaciology, p. 275, vol. 55/190, (2009). Published,

Joswiak, D., E. Aizen, V. Aizen, N. Takeuchi, J. Utake, D. Dixon, "A 100 yr ice core record from the Siberian Altai: depth-age and climatic implications", Journal of Geophysical research, p. , vol. , (2009). Submitted,

Utake, J.,S.Kohshima, F. Nakazawa, N. Takeuchi, K. Fujita. T. Miyaki, H. Narita, V. Aizen, M. Nakawo, "Psychrophilic yeast inhabited in ice core from Belukha Glacier, Siberian Altai indicate recent warming in Siberian Altai.", Geophysical Research letters, p. , vol. , (2009). Submitted,

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://www.sci.uidaho.edu/cae/index.html

Description:

This web site create at the University of Idaho, glacio-climatic group to store the project developed data and information about the research activity.

Other Specific Products

Contributions

Contributions within Discipline:

Specific contributions to advancing scientific knowledge that will be derived from this research include:

? extracting and evaluating Altai, Tien Shan and Pamir ice-core dust micro-particle seasonal and annual distribution to understand inter-annual to decadal-scale climate variability in Northern Hemisphere

? evaluating the inter-annual to decadal-scale variability in aridity and atmospheric dust loading over the past 100 to thousand years

? assessing pollutant deposition in the Central Asia and entire Eurasian continent

? provide a record of change for respective sources of moisture flow over time and of air mass transport histories

? time series of isotope, major ion, trace element, isotopes, and particles.

Glaciochemical time series were calibrated to instrumented in-situ data series and NOAA atmospheric pressure distribution data. NOAA Hypslit program modeled the air back-trajectories allowed to found association between the ice core geochemistry records and aerosol sources. To find the circulation patterns, which are closely associated with geochemistry ice core/snow pit records, the correlation coefficients between the Empirical Orthogonal Functions of the atmospheric circulation patterns and geochemistry time coefficients for first two unrotated scores were computed. The loess / dust storm sources with corresponding geo-chemical composition (trace elements, major ions and dust particles) in western, central and northern Asia were identified

Contributions to Other Disciplines:

The spatial paleoclimatic records from Central Asia are relatively rare, but critical for improving our understanding of climate change in Eurasia and particularly in sub arid and arid regions of Central Asia. The research outlined in this proposal largely contribute to the World Climate Research Program (e.g., World Glacier Monitoring Service; WMO), International Climate Cryosphere Program (CliC) and CEOP-HE by developing valuable paleoclimatic records at northern Hemisphere. The results of this research can also be applied in improving our understanding of physical processes associated with the transfer of heat, moisture and momentum across the land/atmosphere interface that is directed by Global Energy and Water Cycle Experiment (GEWEX).

Contributions to Human Resource Development:

Educational material for graduate classes 'Alpine glaciology and Alpine Environment' has been improved and developed using new set of stable isotope-geochemical data retrieved from Tien Shan and Altai ice-cores.

Contributions to Resources for Research and Education:

The results of data analysis from two existing ice-cores recovered in key climatic and environmental areas of central Asia, in Siberian Altai and Pamir, Central Tien Shan, extend our knowledge about dynamics of atmospheric processes and shift in moisture flow over mid- latitudes of Asia hundreds to thousands of years ago. Data of the climate variables: air temperature and precipitation/snow accumulation as well as changes in atmospheric chemistry that reflected intensity of mineral aerosol transport contribute to improvement and development global circulation model and climate prediction sufficiently. The recovered ice-cores are unique and archived incredible information about past climatic and environmental changes that would not be possible to obtain nowhere except from the central Asian high elevation glaciers and ice-caps. This is

the most trustful information we may have to study the Holocene and pre-Holocene history of the Earth Climate. The new expedition to the Pamir, the Fedchenko largest alpine glacier will give us an assurance in a possibility to drill the deepest in the World ice-core ever recovered, 1000 m depth, to obtain 100,000 to 200,000 years climatic and environmental records in mid latitudes of the Northern Hemisphere. This proxy data may help us to understand water resources variability in past and simulate possible water resources in future for the dry arid and semi-arid regions of central Asia, where glacier water was and is the main source of life for many generation of people living in fruitful ancient oasis.

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners

Any Book

Any Product

Contributions: To Any Beyond Science and Engineering

Any Conference