8-17-2005

Acquisition of a High Resolution ICP-MS for Environmental Research and Training in Maine

Karl J. Kreutz

Principal Investigator; University of Maine, Orono, karl.kreutz@maine.edu

Final Report for Period: 08/2002 - 07/2005 **Submitted on:** 08/17/2005
Principal Investigator: Kreutz, Karl J. **Award ID:** 0215724
Organization: University of Maine
Title:
Acquisition of a high resolution ICP-MS for environmental research and training in Maine

Project Participants

Senior Personnel

Name: Kreutz, Karl
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Norton, Stephen
Worked for more than 160 Hours: No
Contribution to Project:

Name: Mayewski, Paul
Worked for more than 160 Hours: No
Contribution to Project:

Name: Wells, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer

Name: Handley, Michael
Worked for more than 160 Hours: Yes
Contribution to Project:
Mike Handley serves as the ICPMS Facility Manager, and was responsible for the majority of instrument installation, calibration, and now operation and maintenence.

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

We have run samples for several collaborators and colleagues thus far, both from within the University of Maine, and other organizations and schools throughout

Maine (Bates, Bowdoin, and Colby Colleges; University of Maine-Farmington, and the University of Southern Maine).

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Several UMaine graduate and undergraduate students have been involved in the installation of the ICPMS, and are now running samples associated with their thesis research. Examples include Erich Osterberg, Alan Wanamaker, Susan Kaspari, and Dan Dixon (Earth Science PhD students), Bruce Williamson and Lee Pruett (Earth Science MS students), Zachary Von Hasslen (Earth Science undergraduate), Bjorn Grigholm (Climate Change Institute MS student), Chandra McGee (Plant, Soil, and Environmental Science PhD student), and Erin Owen and Eric Roy (School of Marine Science PhD students). In addition, several students from other institutions have used the facility (e.g., Ty Cook and Kaplan Yalcin, UNH undergraduate and PhD students). We anticipate that several more students will be using the ICP-MS Facility for thesis research over the next several years. The ICP-MS Facility has been used in graduate and undergraduate classes during the spring and fall semesters each of the last three years with great success. Examples include a focused sample collection and analysis exercise in ERS527:Isotope Geology.

Outreach Activities:

The Climate Change Institute maintains a website (http://climatechange.umaine.edu/index.html) for the ICP-MS Facility that serves to alert new and old users to the capabilities of the instrument. We regularly give tours of the ICP-MS Facility to K-12 and other groups, particularly in conjunctions with tours of the UMaine ice core research facilities.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://climatechange.umaine.edu/

Description:

UMaine Climate Change Institute, where the ICP-Ms Facility resides.

Other Specific Products

Contributions

Contributions within Discipline:

Having the ICP-MS Facility at UMaine has allowed each of the PIs (at least) to begin to make significant contributions within their respective disciplines. For example, the UMaine ICP-MS has already analyzed 1000Æs of ice core samples from the St. Elias Range, which provide an

unparalleled look at anthropogenic trace metal impacts on the remote North Pacific mid-troposphere. In chemical oceanography, the ability to measure Fe concentrations at extremely low levels in seawater without pre-concentration has made a direct impact on analytical techniques within the discipline.

Contributions to Other Disciplines:

Our continuing work with analytical method development has yielded important contributions to the broader analytical chemistry discipline. For example, we have spent several months working on a new method for Cd isotope determination, which holds promise for investigating various environmental contaminant processes. Likewise, we continue to work on sulfur isotope measurement in polar and alpine ice cores, a new technique that has already yielded significant information on sulfur cycle dynamics.

Contributions to Human Resource Development:

The ICP-MS FacilityÆs main contribution to human resource development is through the training and education of students using the instrument. However, several UMaine technical staff members (Sharon Sneed, Doug Introne, Andrei Kurbatov) have had the opportunity to train on and run the instrument in addition to Mike Handley.

Contributions to Resources for Research and Education:

The successful installation, and now operation, of the ICPMS represents a significant improvement in the resources for research and education at UMaine and throughout the state. We anticipate that in the years following the grant, the ICPMS will make important contributions in both areas.

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Book

Any Product

Contributions: To Any Beyond Science and Engineering

Major Research and Educational Activities

We proposed to significantly enhance the elemental and isotopic analysis capabilities at the University of Maine through the acquisition of a high resolution inductively coupled plasma mass spectrometer (HR-ICP-MS). No comparable instrumentation existed in Maine prior to this award; UMaine PIs with funded NSF research programs were traveling substantial distances to utilize out-of-state HR-ICP-MS facilities. That situation critically limited the development of new and innovative environmental research programs in the state, and denied hands-on training opportunities for undergraduate and graduate students. A HR-ICP-MS thus is a unique resource at UMaine that enables environmental scientists and students at UMaine, as well as other educational institutions and state agencies, to substantially broaden their interdisciplinary research interests. Specifically, a state-of-the-art HR-ICP-MS enables us to:

- ∞ Dramatically expand our element concentration and element ratio analysis capabilities in aqueous matrices. Existing UMaine research strengths in Quaternary science, environmental geochemistry, and marine biogeochemistry rely upon accurate elemental determinations at part-per-trillion and part-per-quadrillion levels. Each of these programs requires the sensitivity and low detection limits offered by HR-ICP-MS to perform multielemental analyses without pre-concentration protocols;

- ∞ Perform rapid and highly precise elemental isotope ratio determinations, or constrain isotope ratios sufficiently for primary processes to be inferred. Samples are rapidly loaded into the HR-ICP-MS, avoiding time-consuming procedures associated with thermal ionization mass spectrometry. Isotope measurements made with the HR-ICP-MS are being used in several ongoing projects investigating pollutant source and transport, biogeochemical processes, and climate variability.

In addition to its primary research focus, the HR-ICP-MS is used in a range of undergraduate and graduate programs at UMaine including the BS, MS, and PhD programs in Anthropology, Biological Sciences, Civil and Environmental Engineering, Food and Nutrition, Geological Sciences, Marine Sciences, Plant, Soil, and Environmental Sciences; the MS program in the Climate Change Institute; and the MS and PhD programs in Water Resources. Integration of research and education occurs through graduate theses, undergraduate courses such as Analytical Methods (ERS 332) and Principles of Instrumental Analysis (SMS 497), graduate courses such as Isotope Geology (ERS 527) and independent undergraduate research projects under the Honors Program and Capstone Experience, a UMaine graduation requirement. Our ongoing goal is to provide students hands-on expertise with cutting edge instrumentation being used increasingly in academic, industrial, and government laboratories. The HR-ICP-MS Facility will strongly enhance the recruitment of students and faculty to UMaine, particularly for an environmental geochemist faculty position likely to be refilled in the next few years due to retirement.

Major Findings

Creation of UMaine ICP-MS Facility: The UMaine ICP-MS (Inductively Coupled Plasma Mass Spectrometry) Facility was established and began operation during March 2003. The cornerstone of the laboratory is a Finnigan ELEMENT2 magnetic sector high resolution ICP-MS, a state-of-the-art instrument with a range of analytical capabilities. The ICP-MS Facility is managed by Mike Handley, who is responsible for instrument operation, maintenance, and training of users. Financial administration is handled through the Climate Change Institute. The Principal Investigators form the laboratory steering committee (Kreutz, Wells, Norton, Mayewski).

Hardware in use (purchased through project grant):

Finnigan Element2 ICP-MS
CETAC ASX-100 autosampler
Finnigan µ-sampler flow injection system
CETAC Aridus desolvating sample inlet system
ESI Apex high sensitivity sample inlet system

Timeline for installation:

12/02 Instrument arrives
12/022 – 2/03 laboratory renovations
3/10/03 – 4/4/03 Instrument installation and training
4/1/03-4/30/03 Initial method development and testing

Since then we have been running samples for various faculty, student, and collaborator projects.

Examples of research results using ICP-MS analysis:

Method validation for National Ice Core Laboratory
We did a study to test and document our ice core melting and analysis system. This study documented bottle cleaning, ICPMS detection limits, reproducibility, decontamination, and co-registration. To test bottle cleaning and document ICPMS detection limits we processed DI water through the melter system and analyzed it like a sample. To document reproducibility we split a section of ice core into 2 parallel slabs and processed and analyzed them independently. To document decontamination we melted a section of core sideways to show the contamination levels from the outside to the inside of the core. Co-registration of samples is shown by comparing Ca and S values from the IC and ICPMS that are collected on different fraction collectors. These data were compiled and sent to NICL and presented in the poster "A continuous ice core melter system with discrete sampling for major ion, trace element, and stable isotope analysis of the new Mt. Logan summit ice Core" at AGU in San Francisco.

GISP2 Rapid Climate Change Event
7 meters of ice from 2562m to 2572 were melted creating 372 samples; these were run for IC, ICPMS, and isotopes. The IC and ICPMS data compared very well and these data compared well to the original data run at a much coarser resolution.

Carbonate samples
Twenty-four carbonate samples were analyzed for a variety of metals for Brenda Hall (Antarctic paleoclimate research).

Cd isotopes
Lake sediment cores from Side Pistol Pond and Sargent Mountain Pond (Maine) were analyzed for Cd isotope ratios. Cd isotope ratios are difficult to measure due to interferences on the Cd isotopes by Sn and In. The data are preliminary and need to be verified by another method. The data were presented in a talk, "Atmospheric deposition of cadmium in the Northeastern US" at Acid Rain 2005 in Prague.

Cu isotopes
14 phytoplankton culture samples were run for Cu isotopes for Mark Wells. The cultures were grown in a lab and some samples were spiked with ^{65}Cu. These data were presented at the American Society of Limnology and Oceanography (ALSO) summer meeting in Spain.

Al in Atlantic Salmon Gill tissue
About 20 gill tissue samples were analyzed for Al for Terry Haines. Very small samples were taken from live salmon without harming the fish. After digesting the samples, the Al concentrations in the solutions were very low. This was a pilot project to see if HR-ICPMS would be a good technique for determining Al in gill tissue

Maine Geologic Survey (MGS) Annual Groundwater Survey
53 groundwater samples were analyzed for Fe, Mn, Ni, Cd, Sn, As, Sb, Cu, Pb, Au, Ag, Zn, Cr, Al, U, and W. This is an annual ground water survey done by the Maine Geologic Survey. In the past the samples have been analyzed by optical ICP and most elements were below the detection limits. The ICP-MS data had very few non-detects and only Au was below the detection limit for all samples.

Concentrations of Trace Elements in Common Moose Browse
770 plant tissue and soil samples were analyzed for Cd, Pb, Mn, Fe, Zn, P, Ni, Al, Cu. The focus of this project was to look at Cd concentrations in Moose browse and how these trace elements are being cycled/stored in the vegetation and soils. The samples were digested by ECL and then analyzed by ICPMS. A sample was also sent to the Analytical laboratory in Deering for analysis of Ca, Mg, Na, and K. Several elements were analyzed in both labs as a QA check and the data compared very well. I have done ICPMS and IC comparisons for low level samples but this was the first time I could compare results for high level samples done by two different techniques. These data were presented by MS student Chandra McGee in the poster "Concentrations of cadmium in Common Moose Browse in Maine USA" at Acid Rain 2005 in Prague.

International Trans-Antarctic Scientific Expedition Ice Cores
One hundred surface snow samples have been run. These samples have the lowest concentrations we have run so far. The samples showed some contamination so Dan Dixon has re-thought how he sub sampled from the original bulk sample and is going to resample and rerun the samples.

Eclipse Icefield, Canada Ice Cores
The Eclipse snow pit has been competed and the core has been melted and is being analyzed. The core samples will be finished in July.

Dry Valleys, Antarctica Ice Cores
One short core has been melted and those samples will be run this summer. Bruce has processed several snow pits for total and dissolved concentrations. About 100 of these samples have been run.

Mt. Logan, Canada Ice Cores
We continue to run the Mt. Logan core. Erich Osterberg (PhD student in CCI) is trained on the ICP-MS and runs his own samples when he can. We continue to track down occasional contamination problems but for the most part the analysis is going well. We have run about 2000 samples, half have been "test" samples an half have been real samples.

Seawater analysis
We continue to run seawater samples and work on further developing the method. Eric Roy (MS student in oceanography) is trained on the ICP-MS and is doing most of the analysis. The samples from one Ecohab cruise have been run and this summer we will run samples from additional cruises. This summer we will also be modifying this method with a different column to run Ag on samples from lake Bonney. The data from the Ecohab cruise were presented at the annual ECOHAB Pacific Northwest meeting in March.