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Collaborative Research: A 700-Year Tephrochronology of the Law Dome Ice Core, East Antarctica

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Title:
Collaborative Research: A 700-Year Tephrochronology of the Law Dome Ice Core, East Antarctica

Project Participants

Senior Personnel

Name: Zielinski, Gregory
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Name: Kurbatov, Andrei
Worked for more than 160 Hours: Yes
Contribution to Project:
Supervised undergraduate laborator assistants, responsible for finalizing analysis of tephra work and will be responsible for writing of manuscripts to be submitted to professional journals. Salary is monthly salary for 6 mos/year of the study.

Graduate Student

Name: Birkel, Sean
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory Assistant to prepare samples for tephra analysis. Support was hourly wages.

Undergraduate Student

Name: Duan, Hui
Worked for more than 160 Hours: Yes
Contribution to Project:
Laboratory student involved in processing of ice samples and initial scans with petrologic microscope.

Name: Corio, Chris
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory assistant involved in preparation of slides and sample filtering.

Name: Lindsley, Laura
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory assistant involved in preparation of slides and sample filtering.

Name: Otte, Jordan
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory assistant involved in preparation of slides and sample filtering.

Name: Blalock, Brianna
Worked for more than 160 Hours: No
Contribution to Project:

Laboratory Assistant to prepare samples for tephra analysis. Support was hourly wages.

Name: Cavallari, Benjamin
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory Assistant: sample preparation

Name: Koons, Linnea
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory Assistant: sample preparation

Name: Lacey, Jessy
Worked for more than 160 Hours: No
Contribution to Project:
Laboratory Assistant: sample preparation

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

New Mexico Technological Institute

Other Collaborators or Contacts

New Mexico Tech is a collaborating institute in this study, responsible for Scanning Electron Microscope and Electron Microprobe analysis of samples. Dr. Nelia Dunbar is the PI.

Activities and Findings

Research and Education Activities:

The primary goal of this project was to locate and analyze volcanic glass in the Law Dome ice core, East Antarctica, whose record spans the last 700 years. In addition, supplemental funding was granted to evaluate tephra from a core of opportunity recovered from South Pole (Espresso core); however, glaciochemical sampling of that core by others is only now being undertaken. Initial step in the process was melting of samples, filtering and the construction of glass slides for scanning on the petrologic microscope. This work yielded a total of 689 filters and slides for analysis. Although the glaciochemical record of the core was previously developed (Palmer et al., 2001; Journal of Geophysical Research 106, 28089-28095), a revised volcanic-sulfate record was created using statistical techniques more recently developed in the evaluation of other ice cores (e.g., Kurbatov et al., in press, Journal of Geophysical Research). This updated volcanic-sulfate recorded was used for additional guidance in the evaluation of sections of core that may have contained volcanic glass. Samples were then analyzed on the CAMECA SEM/electron microprobe at New Mexico Tech to determine the chemical composition of any glass found in the core. This included samples from layers with large sulfate spikes even if no glass was found in the scan with the petrologic microscope. It is possible that glass shards are small enough that

they are not easily recognized under the petrologic scope. The composition of glass found in the ice core was then matched to glass from volcanic eruptions known to have occurred around the age of the ice layer sampled or to the composition of products from volcanic centers that are likely to contribute material to this part of Antarctica, especially formerly active eruption centers in Antarctica.

Findings:

Volcanic glass was most abundant in sections of core that date to 1641, 1622-1624, 1618, 1600-1601, 1595, 1557, 1552, 1501-1502, 1485-1487, 1470-1471, and 1459-1461. Unfortunately, some key layers from the 1800s, that would have included the Tambora and 1809 layers, were not provided by our colleagues in Tasmania, individuals who drilled and analyzed the ice core used in this study. Nevertheless, the sample that dates to around 1641 is very similar to a sample found in the Siple Dome core that dates to 1641-1642, thus indicating a potential correlative layer (Kurbatov et al., in press, Journal of Geophysical Research). The average composition of the Law Dome tephra is P2O5 0.06, SiO2 78.39, SO2 0.13, TiO2 0.12, Al2Ox 12.66, MgO .03, Ca) 0.81, MnO 0.09, Fe) 0.83, Na2O 2.63, K2O 3.98, F 0.28. Initially it was thought that the composition of this glass was similar to the composition of glass from the Mt. Parker, Philippines, eruption. However, that was found to not be the case suggesting that the source of the glass in the Law Dome core was from another eruption that has not been determined at this time. The eruption that may be recorded by the glass dated at 1600-1601 also is uncertain, as the high silica content (76.36) is slightly suggestive of the very large Huaynaputina, Peru, eruption; however, the tephra population is mixed. Consequently, the most likely source is another eruption. This same scenario could also be applied to the glass found in the layer corresponding to 1595. The most well-known eruption from that time frame is the Columbian Ruiz eruption; however, the glass population in the ice core from the corresponding layer is indicative of a source from a zoned magma chamber. There is no indication that the Ruiz volcanic system is zoned to the best of our knowledge. The glass from the mid-1550s potentially could be related to the Billy Mitchell eruption, although the date of that event has significant error in the calendrical age equivalent. The individual glass shards found are similar in composition, but do not appear to reflect a consistent population. For instance, Si percentages vary from 60-67%. There has not been much petrological work, particularly glass petrology, on the Billy Mitchell eruption. The Law Dome glass that may be related to the Kuwae (possibly 1450s) and El Misti, 1450s eruptions, likewise, are similar in composition but they fail to show the consistency that would suggest a coherent population and definitive source event. The glass found in the section dated at 1552 appears to be similar to Mt. Takahe, Antarctica. Similarly, the sample that dates to about 1623 appears to be much like that from Mt. Takahe. We evaluated other isolated shards, particularly with more recent work others have done on Southern Andes, South American, eruptions, but we have not found likely matches with the Law Dome glass. We also compared their composition to known New Zealand eruptions over the last millennium. It may be possible that the East Antarctica location of Law Dome may be more conducive to deposition from New Zealand eruptions than cores we analyzed from West Antarctica. Unfortunately, we have not been successful in reliably identifying source eruptions for the shards found in the Law Dome ice core, primarily because of the frequency of mixed glass populations. It is very possible that the coreÆs location is not as conducive to shard deposition and preservation as has occurred in other cores. This seems to be especially true for local Antarctica eruptions, that appear to be much better identified in other Antarctica ice cores, such as the Siple Dome core (Kurbatov et al., in press, Journal of Geophysical Research).

Training and Development:

This project provided excellent training for eight undergraduates and one graduate student in the techniques used to evaluate the volcanic record of ice cores. This experience also emphasized the general principles and responsibilities used to guide laboratory research that

may be of great use to these students in their future endeavors. In addition, three high school students, who were part of the Upward Bound program held each summer at UMaine, briefly worked in the laboratory processing samples. Exposing high school students to scientific research in such a program may lead them into a related field during their college studies. This study provided excellent guidance for Andrei Kurbatov, Research Scientist, to further his background in ice core research and particularly in the development of volcanic records from ice cores. He played a major role in directing this study including the presentation of results at an American Geophysical Union meeting (Kurbatov et al., 2003).

Outreach Activities:

The opportunity for public outreach specific to this project has not occurred as of yet. However, lectures to the public and particularly to teachers in educational workshops on the impact of volcanism on climate have benefited from the general findings of this project and other ice core projects dealing with this subject.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):

http://gcmd.nasa.gov/getdif.htm?Law_Dome_Tephra

Description:

GCMD metadata site: A database of chemical composition of particulate material from the Law Dome core has been constructed, and will be expanded as more analyses are made. Backscattered electron images of particulate material has also been collected. Sharing Information:
The data and images will be posted on the AGDC web site. Prior to this happening, data will be shared with other researchers on demand.

Other Specific Products

Contributions

Contributions within Discipline:

The most significant contribution to date is the probable identification of glass from Mt. Takahe dated in the layers that correspond to 1552 CE (Common Era) and 1623 CE. These layers may provide excellent correlative layers for future ice core work in Antarctica such as the proposed deep core in West Antarctica (Inland site). Although the source eruption is not known, this same scenario would apply to the glass found in the 1641 CE layer of the Law Dome core that appears to be very similar to glass found at the corresponding layer in the Siple Dome core. Consequently, several key horizons appear to be identified that could be especially beneficial in future ice-core research for correlating the climatic and environmental records produced from around the continent.
In addition, initial processing of the South Pole Espresso core, as part of the supplemental funding for this project, yielded some interesting results as to future ICP-MS analyses of ice cores. The work done as part of this project was construction of a Class 100 clean room within the freezer that contains a continual melter system. This system is much cleaner than previous laboratory facilities, thereby reducing the potential for sample contamination. Less contamination is especially critical in the evaluation of ice cores from the more pristine environment of Antarctica where glaciochemical levels are lower

compared to Greenland, for example.
Additionally, the revised non-sea salt sulfate record for the Law Dome ice core developed in this study, a record that will better identify the volcanic sulfate time series, was provided to members of the Center for Environmental Prediction at Rutgers University. These data will be used to assist members of that institution in their evaluation of the volcanic component of volcanic forcing of climate.

Contributions to Other Disciplines:

Significant contributions to disciplines other than that to the volcanism-climate system have not been obtained as of yet.

Contributions to Human Resource Development:

This project provided excellent training for eight undergraduates and one graduate student in the techniques used to evaluate the volcanic record of ice cores. This experience also emphasized the general principles and responsibilities used to guide laboratory research that may be of great use to these students in their future endeavors. In addition, three high school students, who were part of the Upward Bound program held each summer at UMaine, briefly worked in the laboratory processing samples. Exposing high school students to scientific research in such a program may lead them into a related field during their college studies. This study provided excellent guidance for Andrei Kurbatov, Research Scientist, to further his background in ice core research and particularly in the development of volcanic records from ice cores. He played a major role in directing this study including the presentation of results at an American Geophysical Union meeting (Kurbatov et al., 2003).

Contributions to Resources for Research and Education:

There are no additional contribution to these fields, at this time, other than those already stated.

Contributions Beyond Science and Engineering:

There are no additional contribution to these fields, at this time, other than those already stated, as of this time.

Categories for which nothing is reported:

Any Journal

Any Book

Any Product