Newsletter

Volume 2
August 2008

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REMINDER – The CRONUS-Earth 5th Annual Meeting will be held on December 13-14, 2008 in Berkeley, CA (9:00 am to 6:00 pm each day). Please plan to arrive on Friday night, December 12. Details will be sent out next month

Littleton Moraine Geological Calibration Site

By Dr. Greg Balco

Background and literature

The Littleton Moraine is a prominent bouldery moraine in northern New Hampshire. The moraine is correlated with a till sheet. The till sheet is stratigraphically bracketed by varved lake sediments. The varved sediments are matched to the NE varve chronology, which is linked to the calendar year time scale by radiocarbon dates on individual varves. Thus, we know that the moraine was deposited 13600 +/- about 300 yr ago.

Woody Thompson has written a number of excellent descriptions of the history of work on the Littleton Moraine complex, as well as the results of his more recent mapping in the area. This work is summarized in the following papers:

Historical summary: Thompson, W. B., 1999. History of Research on Glaciation in the White Mountains, New Hampshire (U.S.A.) Geographie physique et Quaternaire, 1999, vol. 53, no. 1, p. 7-24.
Full description of the Littleton moraine complex: Woodrow B. Thompson, Brian K. Fowler, Christopher C. Dorion, 1999. Deglaciation of the Northwestern White Mountains, New Hampshire. Geographie physique et Quaternaire, 1999, vol. 53, no. 1, p. 59-77

2002 NEFOP Field Guide: Woodrow B. Thompson, Carol T. Hildreth, Richard A. Boisvert, Christopher C. Dorion, Brian K. Fowler, 2002. Glacial geology and archaeology of the norther White Mountains, New Hampshire. Guidebook for the 65th annual reunion of the Northeastern Friends of the Pleistocene. Littleton, NH, May 17-19, 2002.
Link to the NE varve chronology: John C. Ridge, Mark R. Bensonen, Marc Brochu, Sarah L. Brown, Jamie W. Callahan, Glenn J. Cook, Robert S. Nicholson et Nathaniel J. Toll, 1999. Varve, Paleomagnetic, and 14C Chronologies for Late Pleistocene Events in New Hampshire and Vermont (U.S.A.) Geographie physique et Quaternaire, 1999, vol. 53, no. 1, p. 79-106.

Existing calibration measurements:

There have been a few calibration measurements already made from this and related sites. The results, as well as a lot of information about the age control on the moraine complex, are summarized here:

http://depts.washington.edu/cosmolab/littleton/NE_us_calibration.html

Site and sample information:

Location: We visited the Beech Hill moraine field and collected 7 samples (see the above papers for the overall context of this site). The site is located at http://maps.google.com/maps?ie=UTF8&t=h&om=1&ll=44.3114,-71.575&spn=0.010932,0.016866&z=16. It consists of a series of ENE-WSW-trending bouldery moraine ridges and intervening marshy swales. This is sort of visible on the overhead air photo. Yes, all those white spots visible on zooming in are large granite boulders.

Field party: Folks present at the site on Nov. 17-18 included:

- CRONUS senior personnel: Greg Balco (Berkeley Geochronology Center). Not much of a showing in this category.
- CRONUS cooperating investigators: John Gosse (Dalhousie).
- Recognized local expert: Woody Thompson (Maine Geological Survey).
- Graduate students: Brent Goehring (LDEO), Amanda Henck (UW)
- Other interested parties: Joe Licciardi (UNH), Sara Mitchell (Holy Cross), Thom Davis (Bentley College), Roger Hooke (UMaine), Amy Gaffney (LLNL).

Overall geomorphic context of the boulders: Everyone present at the site generally agreed that the boulders were in stable landscape positions. We were easily able to find boulders that lay on flat ground and were interlocked with other boulders in large groups, suggesting that they could not have moved since deposition. Steep slopes were present on the flanks of some of the moraine ridges, suggesting the possibility of postdepositional uncovering of boulders lying on these slopes, but we were easily able to avoid boulders in this position. All, however, were more concerned about the possibility of boulder surface shielding by vegetation or snow. The natural vegetation at the site is a dense spruce-fir forest, and we observed boulders of all sizes with 2-6 cm moss and litter accumulations on their surfaces. In several cases this litter accumulation rose to the level of 'soil' and small trees were rooted in it. It appeared that boulders with flat upper surfaces were more likely to have thick moss cover, but we did observe moss and saplings attached to a few boulder surfaces dipping at 30 degrees or more. In addition, the site experiences seasonal snow cover -- typical winter snow depths are somewhere in the area of 0.5 m [GB will obtain snow cover statistics]. Taking all this into account, we agreed that we ought to be sampling relatively tall boulders (> 1.5 m), and we ought to try to avoid boulders with large, perfectly flat surfaces that might be the most efficient moss accumulators.

Boulder surface erosion: Nearly all of the boulders had rough surfaces with 0.5-1 cm of small-scale (1-cm-scale) relief. We observed a few upstanding quartz veins on boulder surfaces. Heights of these veins above the surfaces were generally near 0.7 cm. The highest relief quartz vein we observed was 1.5 cm in relief. This suggests that boulder surface erosion has been restricted to 0.5-1.5 cm since emplacement. On a few boulders, we observed etching along joints up to 2-3 cm deep. We avoided these areas and sampled boulder surfaces that were generally flat and subject only to grain-scale roughness.

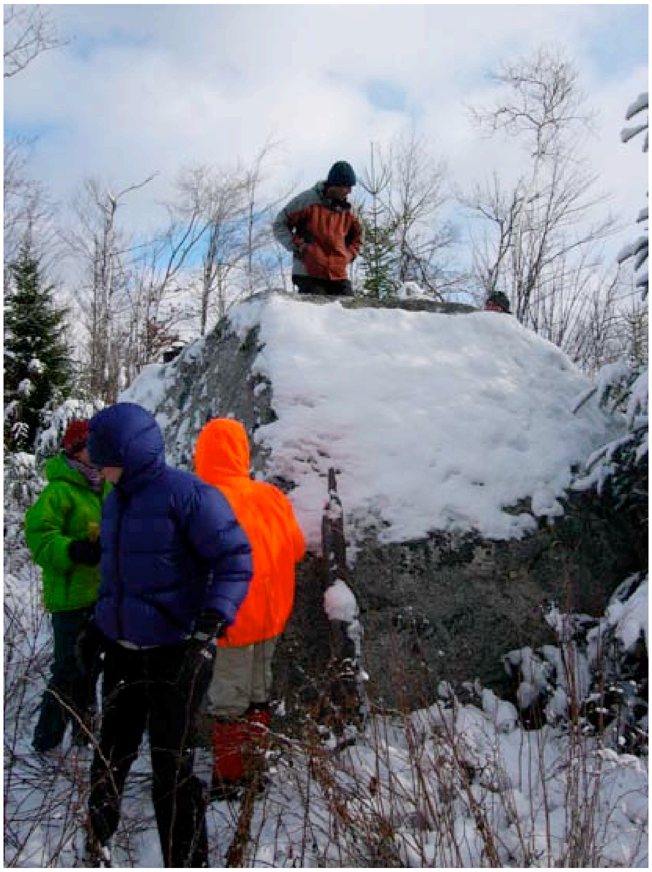
Topographic shielding: All the samples are located in the same broad lowland, and are all subject to the same topographic shielding from distant hills. The horizon description is:

Azimuth (degrees)	50	80	90	115	145	170	210	260	320
Horizon angle (degrees)	0	0	5	5	3	4	6	0	2

Following the usual procedure, this yields a shielding factor of 0.9999.

Site and sample data: I measured sample locations by handheld GPS, and elevations by barometric leveling from a nearby USGS benchmark using a SUUNTO Escape handheld altimeter. Unfortunately, barometric pressure changes were large both days, resulting in a large drift correction. The altimeter is temperature-compensated. A spreadsheet detailing the altimeter correction is available online. I estimate 2-3 meter uncertainties on the elevation measurements. Locations, elevations, and links to sketches of the boulder and sample geometry appear in the following table.

Sample name	Latitude	Longitude	Elevation (m)
07-NE-001-BH	44.3143	-71.5740	417
07-NE-002-BH	44.3139	-71.5750	412
07-NE-003-BH	44.3110	-71.5766	411
07-NE-004-BH	44.3114	-71.5750	412
07-NE-005-BH	44.3108	-71.5761	409
07-NE-006-BH	44.3083	-71.5765	413
07-NE-007-BH	44.3082	-71.5770	412



Overview from 07-NE-002-BH

Before sampling

After sampling

Notes on individual samples: Notes on individual samples reproduced from GB's field book. Please send your own notes for inclusion here. Thanks.

Sample Name	Who?	Notes
07-NE-001-BH	Balco	Boulder on top of moraine crest -- several meters from edge of ridgetop. Sitting directly on other boulders. Lichen common on top surface, little moss present. Surface is rough at 0.5-cm scale. Some linear etching features, several cm wide, ca. 1 cm deep. Estimated sample thickness 3 cm.
07-NE-002-BH	Balco	Top of moraine crest, well away from any break in slope. 2-4 cm moss covers most of boulder surface. Small-scale surface roughness has 0.5-cm relief. Gentle 20-30-cm-wide swales in surface have 1-2 cm relief.
07-NE-003-BH	Balco	Quartz vein exposed on top and side of boulder. Max relief of quartz vein is 1.5 cm by calipers. Most of vein has 0.7 cm relief. Moraine crest well away from breaks in slope.
07-NE-004-BH	Balco	Small-scale surface roughness has ca. 0.5-cm relief. Sample collected from area of 3-5 cm positive relief, ca. 50 cm wide. Estimated sample thickness is 5 cm. In flat terrain on gently (few degrees) sloping moraine crest. At least 10-15 m from nearest break in slope.
07-NE-005-BH	Balco	On moraine crest sitting in nest of other large boulders. Resting on other boulders. Flat area. At least 3 m from break in slope. Surface is rough at 1-cm horizontal scale with ca. 0.5-cm relief. No apparent difference in roughness between top and sides of boulder. Some moss on surface but few lichens.
07-NE-006-BH	Balco	Balco Large boulder embedded in soil. Surrounded by pile of interlocking lesser boulders. In inter-moraine-ridge swale, surface is gently sloping (a few degrees). 15 m to S, ground rises toward a moraine crest. Adjacent to skid road, but road curves to go around boulder. 2-4 cm moss on some areas of surface, area sampled has little moss but is pretty well lichen-covered.
07-NE-007-BH	Balco	Large boulder, on end, leaning on pile of interlocking lesser boulders. The whole package forms an interlocking clast-supported boulder pile. In swale between ridges, adjacent to swampy area. Light lichen and moss cover. Boulder top is well above forest floor. Top is gently rounded...approximated by 5-m spherical surface? Sample thickness estimated 3 cm.

Lab description

Sample photos, measured sample thicknesses, and rock densities will be posted when they exist:
http://depts.washington.edu/cosmolab/littleton/Littleton_report.html

Baboon Lakes Sampling Trip

By Dr. Fred M. Phillips

Although CRONUS-Earth has collected samples from a number of sites at mid-latitude, they are all at low-to-moderate elevation (i.e., <1600 m). Additional sites to test altitude scaling at mid-latitude would be very desirable. One potential category of such sites is the deposits left by the Recess Peak glacial advance in the Sierra Nevada of California. This was the last advance of the range's glaciers, beyond Little Ice Age limits, during the latest Pleistocene deglacial period. Chronological constraints on the advance are good. Radiocarbon dating of macrofossils immediately above Recess Peak outwash at several locations by Douglas Clark at Western Washington University has yielded ages of ~13,100 cal years B.P. The very small volume of the moraines indicates that the advance was brief. My own previous ^{36}Cl dating of boulders from Recess Peak moraines gave results consistent with an age in this range. Samples from these moraines would appear to be suitable for comparison with ^{10}Be and ^{36}Cl results from other CRONUS sites to test altitude-scaling models.

I visited the Recess Peak moraine at Baboon Lakes in the Bishop Creek drainage, eastern Sierra Nevada, on June 30, 2007. This site was selected because one of the cores drilled by Doug Clark that yielded a 13,100 cal years B.P. age was from the lower Baboon Lake. The locality is at ~3400 m elevation. The route is about a 10-mile roundtrip hike and walking plus sampling took me from early morning until very nearly complete dark.

I collected large (3-4 kg) samples from the tops of three boulders on the ridge on the left of the photograph. This locality was sampled because snow depths are considerable in the Bishop Creek drainage and the top of the ridge is very exposed to the prevalent west winds. I did not collect additional samples because I didn't care to lug out any on my back. The boulders were granodiorite and contain quartz, potassium feldspar, and hornblende. Please contact me (Phillips@nmt.edu) or Shasta Marrero (Shasta@nmt.edu) if you would like splits of these samples.

The first (lowest) Baboon Lake is on the right, with the second lake peeking out in the center of the photo. The Recess Creek moraine crest is indicated by the pink line; the sample locality is the grey area below the left end of the line.

The Great Peru Expedition of 2008

By Dr. Fred M. Phillips

One of the most significant goals of the CRONUS-Earth Project has been to obtain geological calibration samples from a low-latitude, high-altitude site. These are critical to the Project because this is the area of greatest uncertainty in the global scaling models. In order to accomplish this goal CRONUS-Earth funded an expedition to the vicinity of the Quelccaya ice cap in Peru during June and July 2008.

The expedition was led by Meredith Kelly of Lamont-Doherty Earth Observatory (now at Dartmouth College). Other participants included Tom Lowell from the University of Cincinnati, yours truly from New Mexico Tech, Colby Smith who just completed a Ph.D. at Cincinnati, Adam Hudson who is starting the M.S. program at the University of Arizona with Nat Lifton, Roseanne Schwarz from LDEO, and Patrick Applegate who is a Ph.D. student with Richard Alley at Penn State. This mötley crüe was supposed to meet up at JFK Airport in New York the evening of June 10, but düe to uncooperative weather ended up strung out all the way from Lima to Fort Worth. All suffered to some extent, but the longest-suffering was Adam, who spent the night on the floor at JFK. After numerous rebookings, everybody assembled in Cusco on the 13th.

The primary objective of the expedition was two-fold: (1) to obtain radiocarbon samples from on top of the Huancáne II moraines at Quelccaya in order to complement previously collected radiocarbon samples from below the till, and thus completely constrain the age of the advance, and (2) to collect a sufficient number of large-mass rock samples from boulders on the moraine to enable cosmogenic nuclide inventories to be measured. A secondary objective was to collect radiocarbon and TCN samples from other features that could potentially be used for production-rate calibration.

Bright and early on the morning of June 14 two trucks were heavily loaded with equipment, supplies, and scientists and started the 6-hour drive southward to the Cordillera de Vilcanota, of which the Quelccaya ice cap constitutes the southern end. The party arrived at the road end, at an elevation of approximately 16,000 feet, in the late afternoon. Camp was set up and one day and two nights spent there to begin to acclimate to the altitude. We were to start for the Huancáne Valley on the 16th, but woke up to find everything under 10 cm of heavy snow and more pouring out the clouds. After a brief war council we decided not to delay the departure and set out on foot through the snowstorm. Meanwhile, the local Quechua Indians who were contracted to provide logistical support loaded the supplies and gear onto ~20 horses and followed. We reached the site of our base camp in the afternoon. Most members of the party suffered from altitude sickness to one degree or another, but none severely. Your writer is very pleased to report that in spite of being older than any two of the three youngest members of the party, combined, altitude sickness was not a problem (although he is forced to admit that he was a lot *slower* than those whippersnappers).

The next day was spent in a reconnaissance of the area, in the course of which I noticed that streamcuts through moraines in an adjoining valley exposed small beds of peat. We returned the next day with picks and shovels and dug three deep pits into these sections. The two lower ones proved to contain peat that had been overridden by the first advance responsible for this set of moraines and had been glaciotectonically thrust upward beneath the till. The upper section was a thin peat bed interlayered between this front moraine and the following one. Samples of peat were collected for radiocarbon analysis. We have high hopes that these samples will provide tight chronological constraints on this episode of moraine construction. Seven boulder-surface samples were later collected from the moraine for TCN analysis.

On the following days the party split up, with several members (including Adam and myself) collecting boulder samples from the "original" moraine (the one radiocarbon dated by Mercer back in the 1970's and later sampled by Meredith and Tom for ^{10}Be) and the rest assisting Tom in attempting to core lakes and bogs dammed by the moraine. After numerous attempts, he felt that he obtained several good basal organic sections from these cores, thus we should soon have a minimum as well as maximum age constraint on the type Huancáne II advance.

The head of the Huancáne Valley is covered by Little Ice Age (LIA) moraines from ice advances that spilled over the cliffs that now lie between the valley and the edge of the ice cap. While climbing to the ice margin we noticed that an outburst flood from a proglacial lake on top of the cliff had eroded a canyon about 20 m deep through the moraines. This canyon was not present when Meredith last visited Huancáne in 2006. On a subsequent day we climbed to the LIA moraines and inspected the cut. We found that depressions in the lee of the moraine crests contained buried paleosols with well-preserved grass roots. One moraine proved to be superposed on a paleosol behind the next moraine down valley, and also to have a paleosol behind and on top of it. We collected samples of the grass roots for dating and 5 TCN samples from boulders on the moraine.

Four of the party left the Cordillera de Vilcanota on June 29, but Meredith, Tom, and Patrick stayed on for another two days of fieldwork. All of the goals of the expedition were accomplished, provided that the samples return the expected results. In addition to obtaining radiocarbon samples to provide independent age control on the type Huancáne II moraines (~12 ka), radiocarbon samples were obtained to provide upper and lower chronological constraints for two other moraines, one thought to be ~750 years old and the other unknown but much older age. The TCN samples from these moraines were of good quality and contain abundant coarse-grained quartz and sanidine. The largest problem with the samples was loss of material from the boulder surfaces by granular disintegration. Remnants of glacial polish on a bedrock surface below the Huancáne II moraine (older than it) stood 6 to 8 cm above adjoining eroded surfaces. We collected samples from this site in order to test and calibrate a method of estimating erosion on our samples using multiple nuclides. The samples from the LIA moraine showed little erosion. I anticipate that the data from the samples collected on this expedition will meet CRONUS-Earth's need for a low-latitude, high-altitude calibration site. Thanks to all the participants for their efforts in making this trip a success. Please contact me (Phillips@nmt.edu) or Shasta Marrero (Shasta@nmt.edu) if you would like splits of these samples.

Photo 1: Expedition members set off on the first day, ignoring the lessons of the Scott Expedition to the South Pole.

Photo 2: Newly discovered section of glaciotectonically deformed peat in “South Huancáne Valley”.

Photo 3: Overview of Huancáne Valley.

Photo 4: Adam sampling typical moraine boulder using .27 cal power tool cartridges.

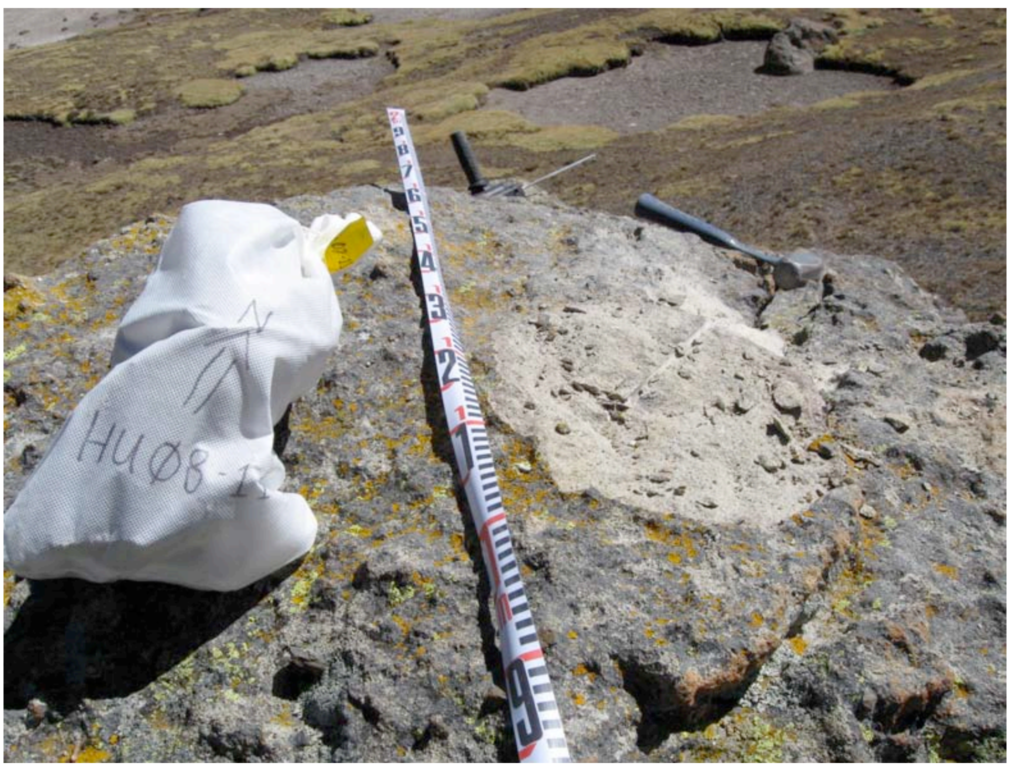


Photo 5: Typical boulder surface showing pit blasted by .27 cal charge.


Photo 6: Meredith and Colby sampling a boulder exposed by retreat of the ice cap since the 1960's.

CRONUS Workshop at Goldschmidt

By Dr. Fred M. Phillips

A workshop on cosmogenic nuclide calibration issues was held in conjunction with the V.M. Goldschmidt Geochemistry Conference in Vancouver on July 12-13. This was a joint CRONUS-Earth/CRONUS-EU workshop and the main purpose was to share information on the status of geological calibration results between the two projects. The CRONUS-Earth participants were Fred Phillips, Tim Jull, Devendra Lal, Jozef Masarik, Kuni Nishiizumi, Greg Balco, Nat Lifton, , Shasta Marrero, John Stone, and Jörg Schäfer. Participants from CRONUS-EU were Tibor Dunai, Irene Schimmelpfennig, and Kristina Hippe. Enriqueta Barrera and Stephen Macko from the NSF also participated.

On July 12 the main topics for discussion were the laboratory intercomparison results, fallout from the revision of the ^{10}Be half life, and progress on environmental production targets. Tim Jull reported that the ^{10}Be intercomparison materials (quartz from Antarctica and Namibia) had been sent to 23 laboratories around the world. To date, results have been returned by 7 of these. Results will not be released until the exercise is deemed to have been finished, but the preliminary summary is that for ^{10}Be in the high-level quartz the standard deviation of the ratios reported for the 7 samples was 4.9% and for ^{26}Al it was 7%. For the low-level quartz the ^{10}Be figure was 9.3% and that for ^{26}Al was 9%. A limestone intercomparison material for ^{36}Cl has been ground and homogenized by Shasta Marrero. The material is available from Tim Jull. It has been distributed to several labs but no results are available to date. A pyroxene intercomparison material has been prepared by Jörg Schäfer and distributed to 7 laboratories, no results reported yet. The most pressing need is for additional ^{36}Cl intercomparison materials, specifically ones composed of potassium feldspar (most easily available from a pegmatite), pure low-chlorine marble, and whole-rock basalt. Phillips, Marrero, and Stone will work on identifying and processing these. All investigators are requested to give priority to analyzing and returning data on their intercomparison materials, if they have not already done so.

I reported on the recent expedition to the Quelccaya ice cap in Peru. It was very successful and a summary report is included in this newsletter.

Kuni Nishiizumi led a discussion of the implications of the revision of the ^{10}Be half life. The picture is very complicated because numerous AMS standards have been used by different laboratories. Depending on the type of standard, previous analytical results may or may not need to be recalculated. He also pointed out that some standard dilutions used at LLNL were inaccurate and may affect data differently in some concentration ranges than in others. He is in the late stages of writing a paper that will review all of these issues. Jörg Schäfer concurred that results from European investigators substantiated the revised half life. Efforts to publish these new finding are underway.

Devendra Lal reported on the deployment of sulfur targets to quantify the scaling of low-energy neutron reactions using the production of ^{32}S. Early efforts to test a methodology using CS_2 targets were successful, but placement of the targets proved impossible due to the hazardous chemical classification of CS_2. This resulted in a one-year delay while an alternative sulfate target methodology was developed and tested. These have now been deployed in the White Mountains of California and Mauna Loa in Hawaii. Jörg Schäfer reported on the status of water targets for the production of ^{3}He. These have been produced by Mark Kurz and a set has been deployed in Hawaii. As the workshop was in progress, Mark was deploying targets in the White Mountains. Nat Lifton reported for Marek Zreda regarding the water-target experiment in Hawaii for the production of ^{10}Be. These targets were difficult to produce and deploy due to the large volumes of water required. They have been exposed in Hawaii for over a year and will have to be left out for an additional 1.5 years.

Kuni gave a brief summary of the progress in the beam-line target experiments. The irradiations scheduled for the LANSCE facility at Los Alamos have been completed. One set of irradiations at the monoenergetic neutron-beam facility in Japan has been performed and a second one is scheduled for the weeks after the workshop. Kuni was flying directly from the meeting to the accelerator facility in Japan. Preparation and analysis of the targets already irradiated is underway.

The second day of the workshop focused on the geological calibration work. Tibor Dunai presented a summary of work performed by CRONUS-EU investigators at a range of sites. These were nearly all lava flows, including ones in Argentina, the Cape Verde Islands, and Mount Etna. ^{3}He and ^{36}Cl yielded variably reproducible results. In several cases ^{40}Ar/^{39}Ar dating for independent chronology did not provide the degree of precision that was expected. Additional dating is underway. Irene Schimmelpfennig reported on ^{36}Cl calibration work at Mount Etna. The analytical results for Ca-feldspars were generally good. The main uncertainty at this site is from the radiocarbon age control. Her results on ^{36}Cl production from calcium were within the range reported by previous investigators and will provide a basis for comparison with CRONUS-Earth data.

John Stone gave a summary of CRONUS-Earth geological calibration work. Samples have been collected from Tabernacle Hill and Promontory Point along the ancient shoreline of Lake Bonneville in Utah, Skye and the western Highlands of Scotland, islands in Puget Sound, the Littleton moraine in New Hampshire, from the margin of the Quelccaya ice cap in Peru, from the Breque site in Peru (by Dan Farber), from Mauna Loa in Hawaii, from long-exposed bedrock in Antarctica, and from a deep core at Yucca Mountain, Nevada. In addition, secondary sites sampled include boulders on the Recess Peak moraines in the Sierra Nevada, landslides in New Zealand (by Jörg Schäfer and not funded by CRONUS), historical lava flows on the Canary Islands and Mauna Loa, and deep roadcuts in Australia. Results (not necessarily complete) are available from Tabernacle Hill, Promontory Point, Scotland, Breque, the New Zealand landslides, and Antarctica. The only principal site that remains to be sampled is the drilling of several deep cores in Antarctica for the quantification of muon production. Calibration site sampling is generally on schedule; the only site that is lagging is a more comprehensive sampling in Hawaii. Results are too preliminary to draw any conclusions, but the comparison of the “heritage” calibration data set for ^{10}Be with that from CRONUS-Earth sites to date demonstrates that the new CRONUS-Earth results are much more consistent than the old data.

Shasta Marrero presented preliminary ^{36}Cl calibration results from the Lake Bonneville sites. She noted that the degree of convergence in the inferred ^{36}Cl production rate from potassium spallation between Bonneville and John Stone’s results from Antarctica and Scotland was encouraging. Shasta and Fred also briefly reviewed progress in programming a ^{36}Cl web calculator similar to Balco’s ^{10}Be/^{26}Al one. This project is moving ahead nicely.

An evaluation of the status of the geological calibration showed a lack of results for ^{21}Ne and ^{26}Al. That for ^{21}Ne is apparently due to lack of suitable materials; this should be further evaluated and additional sites sampled, if necessary. That for ^{26}Al is mainly due to the infrequency of aluminum runs at LLNL; there are numerous processed calibration samples in the queue. Some investigators have not returned data from sample materials they received long ago. These need to be encouraged to produce results. Finally, the status of radiocarbon dating of flows on Mauna Loa needs to be reevaluated and additional materials sent in for analysis, if necessary, so that additional sampling at that site (important for noble gas calibration) can go forward.

John Stone and Jörg Schäfer presented a short summary of activities by CRONUS-funded students and on the educational outreach activities by Terry Swanson.

The workshop concluded with a general discussion and evaluation of priorities. These included the following:

(1) The $^{10}Be/^{26}Al$ calculator needs to be updated to employ the revised ^{10}Be half life.

(2) More noble gas data are needed. Samples from the Cuillan Hills in Scotland and from Hawaii should help address this.

(3) Encourage LLNL folks to do a ^{26}Al run.

(4) Produce additional ^{36}Cl intercomparison materials.

(5) Encourage slow laboratories to return intercomparison and calibration-site data.

(6) Need to evaluate how to “wrap up” calibration sites. How do we decide when sufficient results have been obtained? How will data be published? Will all data be in one big paper or will different nuclides be handled separately? Those responsible for organizing the sampling expeditions to each site should be responsible for overseeing the evaluation and publication of the results (and be first author on the publication(s)).

(7) Results from the environmental-target experiments will probably be slower coming in than originally scheduled. We need to evaluate when these will be available and how it might affect the interpretation and publication of the calibration site results.

Upcoming Events

GSA 2008 Joint Annual Meeting
October 5-9, 2008 (Houston, TX)

CRONUS-Earth 5th Annual Meeting
December 13-14, 2008 (Berkeley, CA)

AGU 2008 Fall Meeting
December 15-19, 2008 (San Francisco, CA)