Newsletter

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GOLDSCHMIDT 2009
ABSTRACT DEADLINE – FEBRUARY 21

CRONUS-EU/CRONUS-Earth Science Workshop
at GOLDSCHMIDT 2009
June 24, 2009

Recap of the 2008 Annual Meeting

By Fred Phillips

The 2008 Annual Meeting was held at the Spaces Sciences Lab in Berkeley on 13-14 December. Thanks to Kuni Nishiizumi for providing the meeting space. Twenty Cronusites attended the meeting. The main focus of the meeting was scheduling and planning the completion of our individual products so as to smoothly accomplish the grand synthesis that is CRONUS' raison d'être. The meeting ended with agreement on a timetable of deliverables and a synthesis plan. It is clear that we will have to request no-cost extensions for an additional year of work, but the good news is that we seem to have on hand funds adequate to complete the work. One aspect that is lagging is the reporting of analyses on the geological calibration and laboratory intercomparison samples – please push these through as soon as possible!

Other highlights included Lisa presenting the web interface for the billing of sample preparation and analysis costs (a highlight because you get money for using it!), reports from our two CRONUS Student Fellows on their research, a demonstration of a beta version of the new ^{36}Cl calculator, and a presentation on the Quelccaya ice cap expedition last summer. Detailed notes from the annual meeting can be found on the CRONUS website. Thanks to everyone for good results and enthusiastic participation. See you next year in Oregon!

CRONUS-EU/CRONUS-Earth Science Workshop

By Tibor Dunai and Fred Phillips

With the maturation/conclusion of data collection by the international CRONUS initiatives, this workshop aims at providing a forum to exchange data and ideas on cosmogenic nuclide calibration. The presentations are intended to provide a basis for continuing scientific discussion on the goals of the CRONUS initiatives. Naturally, one important topic of this workshop will be the improvement of the accuracy of in-situ cosmogenic nuclide methodology. However, there will also be opportunity to present and discuss novel applications/ approaches that were developed in the context of CRONUS.

The workshop will be held during the Goldschmidt Conference, probably in the afternoon of Wednesday 24th June; in anticipation of the usual mid-week conference break at Goldschmidt Conferences. The venue will be at a convenient location within Davos (location to be confirmed at a later stage). The workshop will be open to all interested investigators, but for logistic reasons (unpredictability of numbers), will not be actively advertised to CRONUS-external researchers.

We see this workshop as an unique opportunity to meet the near-complete set of our mutual trans-Atlantic colleagues, and we hope for a good turn-out and a lively discussion.

CRONUS-Earth Mailing List

By Lisa Majkowski

As requested at the annual meeting, we have set up an email mailing list for the CRONUS-Earth Project on the New Mexico Tech Lyris ListManager. You will receive an email asking to confirm your participation or you can go to http://lyris.nmt.edu/read/all_forums/, scroll down to **cronus-earth** and hit the “subscribe” tab. All members can post messages.

In Situ Cosmogenic ^{14}C from Surfaces at Secular Equilibrium

By Nathaniel Lifton

Theoretical models currently used for scaling in situ cosmogenic nuclide (CN) production rates are based on modern measurements of cosmic ray variation with latitude and altitude (Nuclear Disintegrations and Neutron Detectors: Lal (1991), reparameterized by Stone (2000); Neutron Monitors: Dunai (2001), Desilets et al. (2006), and Lifton (2005)). In situ cosmogenic ^{14}C (in situ ^{14}C) in quartz provides a unique opportunity to test these theoretical models empirically over millennial time scales using significant numbers of geologic samples. Unlike other commonly used in situ CNs, ^{14}C has a short half-life that allows attainment of secular equilibrium, or "saturation," in approximately 25-30 ky. Also, ^{14}C loss from decay far outstrips loss from erosion in many geomorphic settings. Under such conditions, the measured concentration of in situ ^{14}C is only a function of its integrated average production rate.

As part of the CRONUS-Earth project, we are analyzing samples from ^{14}C-saturated surfaces along altitude transects (near sea level to as much as 5 km altitude) in Antarctica, Mid-Latitudes (western U.S., Tibet) and Low Latitudes (Chile, Namibia, Australia) to assess the altitudinal, latitudinal, and longitudinal dependence of integrated late Quaternary in situ ^{14}C production rates (Figure 1). Surfaces for which in situ ^{14}C should be at secular equilibrium have been identified by prior measurements of long-lived or stable CNs, as well as by geomorphic and geologic indicators of antiquity. Our approach with these transects is to compare our measurements along each transect to predictions made using each of the published scaling models, using a common geomagnetic and atmospheric framework (Balco et al., 2008; Lifton et al., 2008) and calibrated sea level, high latitude (SLHL) production rates for in situ ^{14}C appropriate for each scaling model.

These SLHL production rates were derived under CRONUS-Earth using calibration samples from Promontory Point, Utah (41.26°N, 112.48°W, 1600 m), and from two sites in northwestern Scotland (Corrie Nan Arr: 57.42°N, 5.65°W, 135 m; and Maol Chean Dearg: 57.49°N, 5.45°W, 520 m). Weighted mean results from 6 Promontory Point samples yield a mean site production rate of 52.0 +/- 0.7 ^{14}C atoms/g/yr, indistinguishable from the value of 52.9 ± 1.7 ^{14}C atoms/g/yr measured by Lifton et al. (2001), and slightly higher than that measured by Miller et al. (2006) (49.2 ± 0.7 ^{14}C atoms/g/yr). We are more confident in the new value since it reflects both inter- and intra-sample variability, whereas the earlier estimates were based only on multiple analyses of a single sample. 3 samples from Corrie Nan Arr and 7 samples from Maol Chean Dearg yielded weighted mean site production rates of 19.0 ± 0.6 and 24.5 ± 0.5 ^{14}C atoms/g/yr, respectively. Analysis of samples from additional calibration sites is pending.

To compare results between the three sites, we scaled the time-integrated site production rates to SLHL using each of the published scaling models, again driven by the common atmospheric and geomagnetic framework. Weighted means of the resulting SLHL production rates range from 15.8 ± 0.5 ^{14}C atoms/g/yr using the Lal (1991)/Stone (2000) model (assuming a geocentric axial dipole, without any geomagnetic variation), to 17.8 ± 0.6 ^{14}C atoms/g/yr using the Lifton et al. (2005) model with geomagnetic variations described by Lifton et al. (2008). Predicted SLHL production rates for the Dunai (2001) and Desilets et al. (2006) models were intermediate between those two.

With those production rates in hand, we can now compare scaling model predictions with in situ ^{14}C measurements along each transect. Here we present our current results for the Antarctic, Mid-Latitude Western U.S., and Low-Latitude transects (Figure 1). An important characteristic common to all three transects is that, using our new calibration measurements as input to the scaling models, each model agrees with the data at altitudes less than 1 km. The western U.S. transect exhibits minimal scatter about the best-fit exponential line, which agrees best with predictions of the neutron monitor-based models that include geomagnetic variations (Desilets et al., 2006; Desilets and Zreda, 2003; Dunai, 2001; Lifton et al., 2008; Lifton et al., 2005) (Figure 2). Data from the Low-Latitude (~20° S) transect also agrees best with the neutron monitor-based models, albeit with a bit more scatter (Figure 3).

In contrast, the Antarctic transect data seem to agree best with the Lal (1991)/Stone (2000) model, but significant scatter remains in that dataset (Figure 4). If we take the upper envelope of the transect data as the best approximation of the time-integrated scaling function (since burial or erosion would tend to reduce in situ ^{14}C concentrations), then that envelope agrees best with the neutron monitor models, although they still under-predict the measurements (Figure 5). This may in fact reflect strengthened Antarctic low-pressure systems during the Last Glacial Maximum in the latest Pleistocene (thus yielding higher Antarctic cosmogenic nuclide production rates) (Stone, 2000; Toggweiler and Russell, 2008). We have recently obtained several more Antarctic samples from Greg Balco, in the 1-2 km altitude range lacking from our current dataset. These samples may help clarify time-integrated scaling in the Antarctic – analyses are planned for 2009.

In summary, our current measurements of in situ ^{14}C from saturated surfaces tend to support the use of neutron monitor-based scaling models, along with the Lifton et al. (2008) geomagnetic framework, over that of Lal (1991) (as modified by Stone (2000)), as driven by the assumption of a geocentric axial dipole. However, potential complex exposure histories not apparent from long-lived CN data alone can complicate these interpretations, as can changes in the atmospheric pressure regime. With new SLHL production rate estimates derived from CRONUS-Earth research, we have shown that measurements of in situ ^{14}C in saturated surfaces can provide valuable empirical tests of scaling models integrated over millennial time scales.

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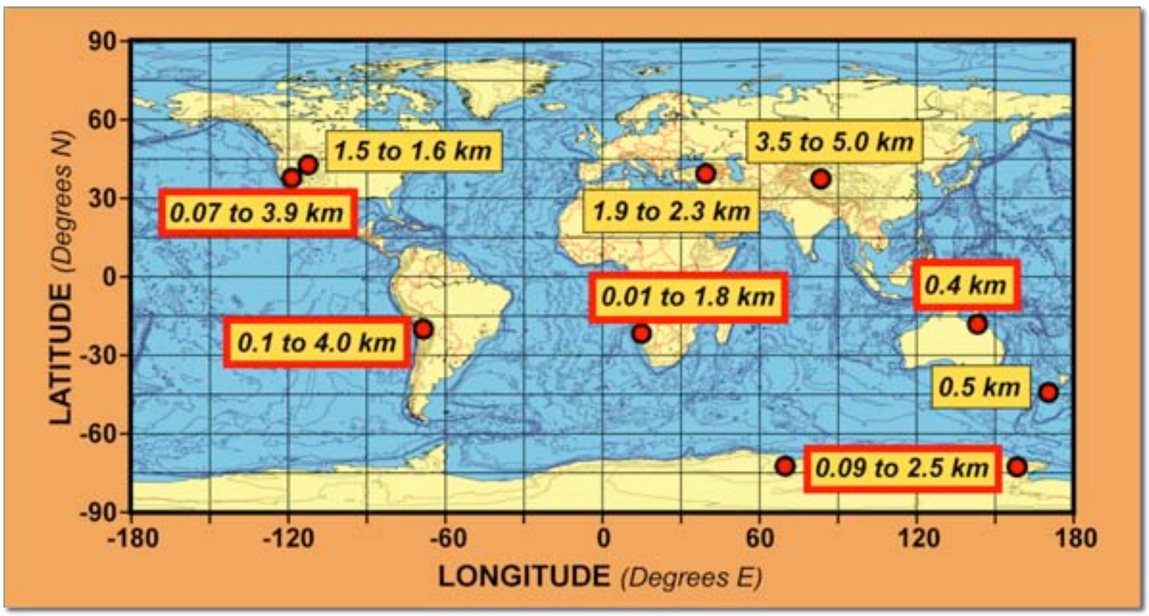


Figure 1 – Map showing locations of CRONUS-Earth altitude transect samples. Sample results from locations with red boxes are presented here.

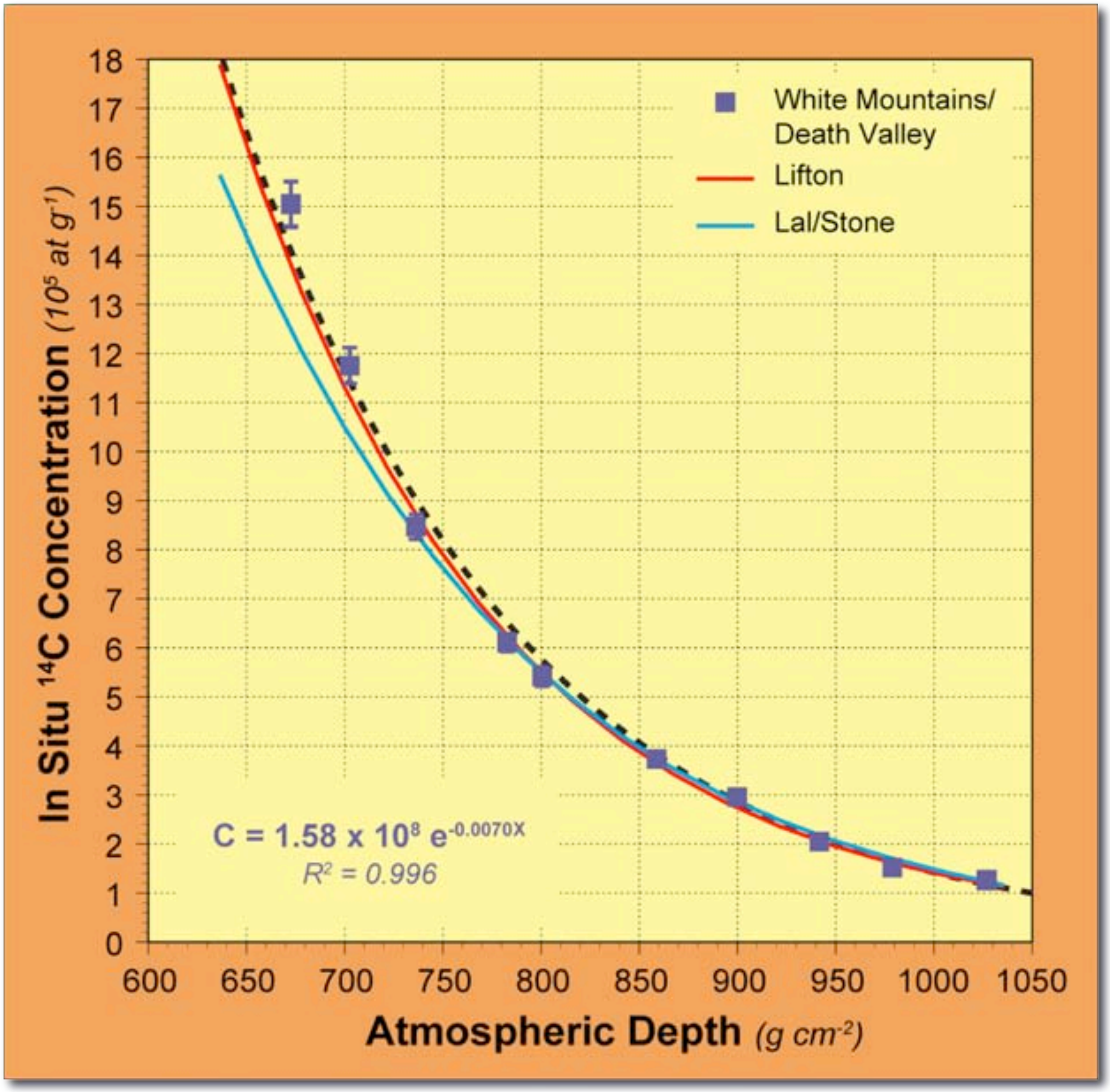


Figure 2 – Plot showing measured in situ ^{14}C concentrations vs. atmospheric depth of each sample for the western U.S. altitude transect. The Lifton et al. (2005) model essentially coincides with the best-fit exponential line (black dashed line), while the Lal (1991)/Stone (2000) model underestimates the high altitude concentrations.

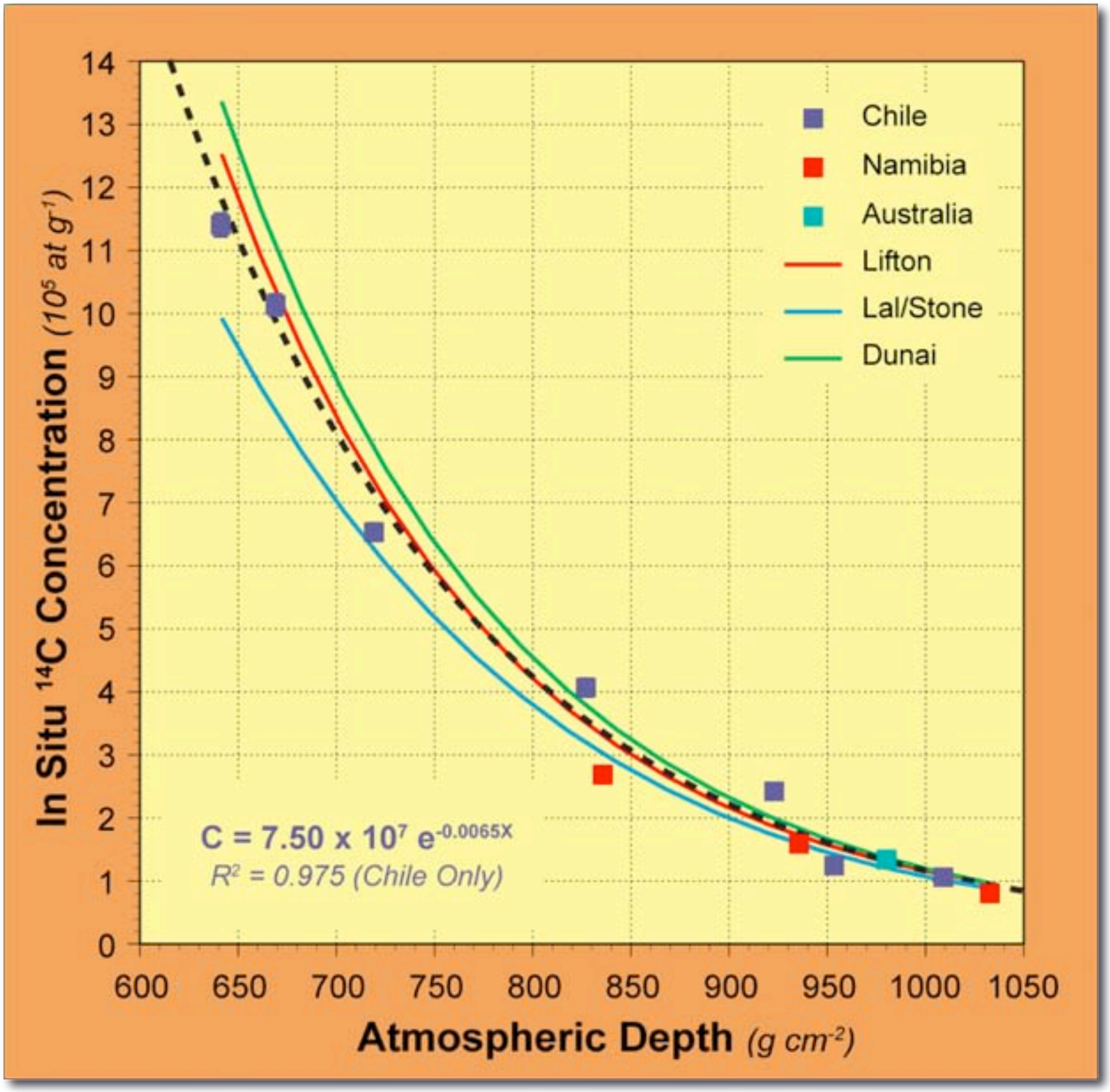


Figure 3 – Plot showing measured in situ ^{14}C concentrations vs. atmospheric depth of each sample for the low latitude (ca. 20° S) altitude transect. The Lifton et al. (2005) model agrees somewhat better with the data in this case than that of Dunai (2001), but once again both are an improvement over the Lal (1991)/Stone (2000) model.

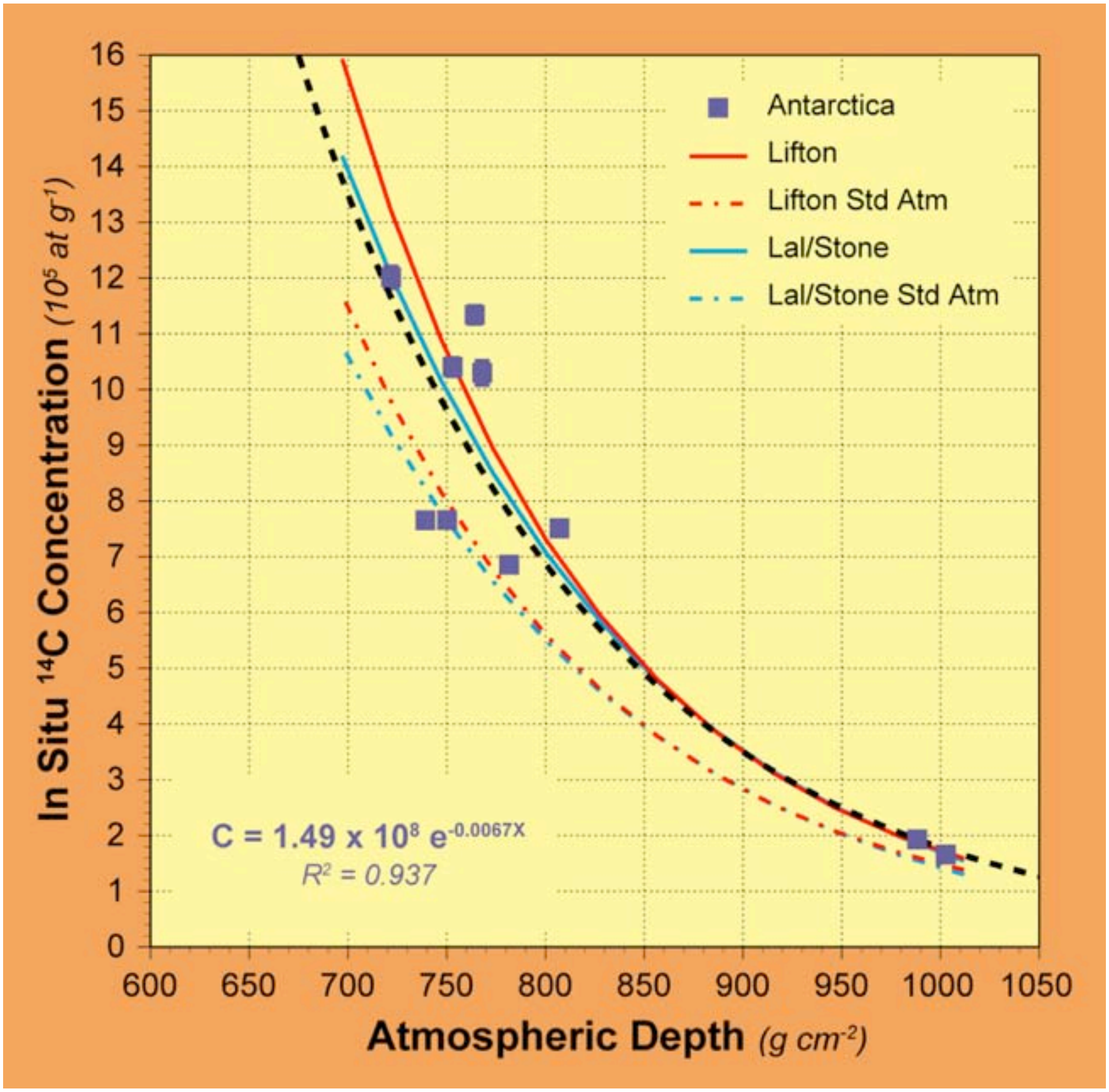


Figure 4 – Plot showing measured in situ ^{14}C concentrations vs. atmospheric depth of each sample for the Antarctic altitude transect. At first glance, the Lal (1991)/Stone (2000) model provides the best overall fit to the dataset, which exhibits significant scatter at higher altitudes. The predicted curves that assume a Standard Atmosphere (dash-dot pattern) are shown only to illustrate the potential magnitude of atmospheric effects – not to suggest that Standard Atmospheric conditions should apply to Antarctica.

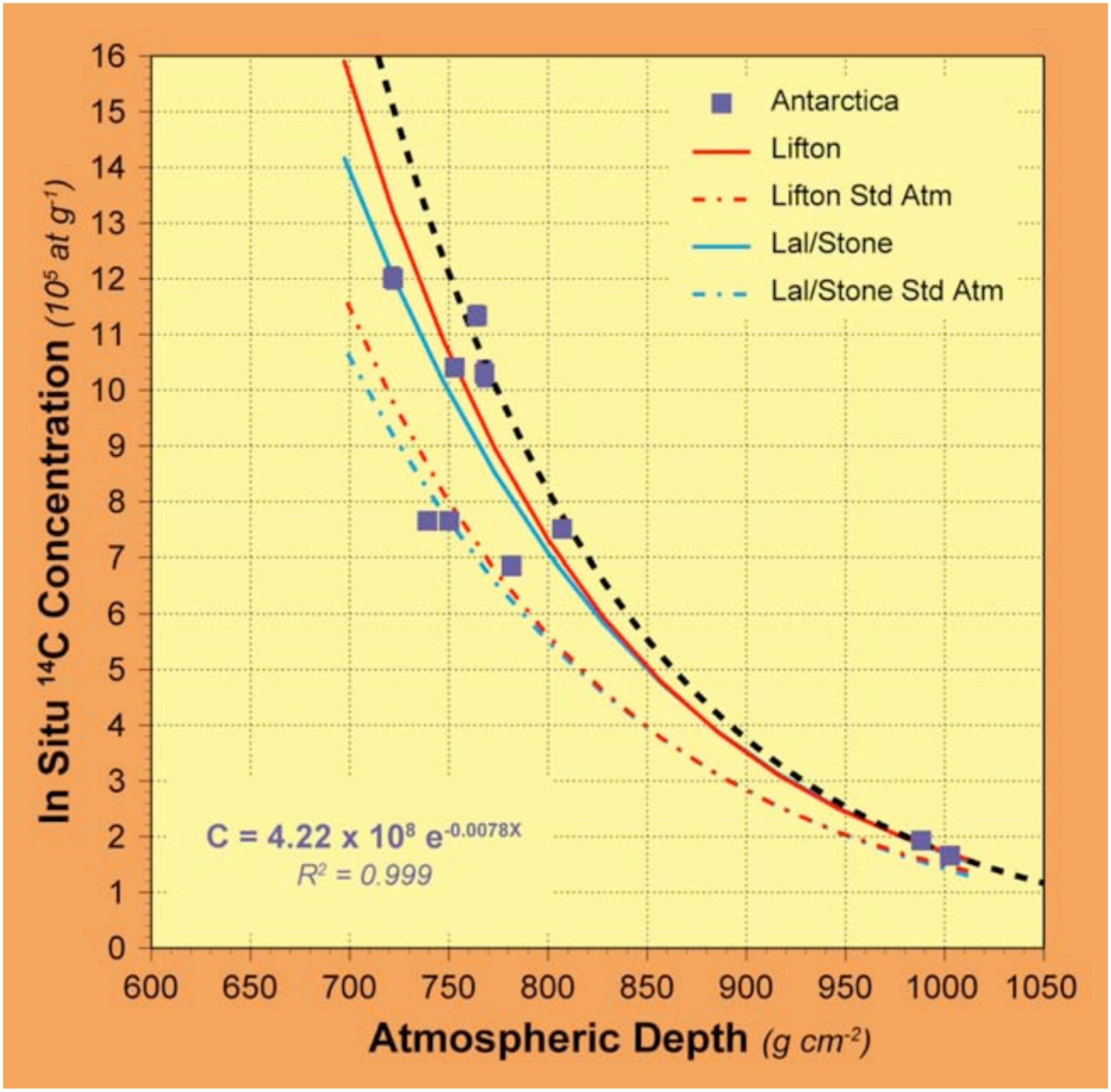


Figure 5 – Same plot as in Figure 4, but with a best-fit line only for the upper envelope of the dataset, since complex exposure histories would tend to decrease measured in situ ^{14}C concentrations. In this scenario, the Lifton et al. (2005) model agrees best with the best-fit curve, although it still underestimates those data. This is consistent with suggestions that the low-pressure system over Antarctica today may in fact have been stronger in the late Pleistocene (see text).

Update on Geological Calibration

By Brian Borchers and Shasta Marrero

An updated geological calibration of production rates is an important goal of the CRONUS project. In order to perform the geological calibration, we need to bring together scaling and production models and data from the geological calibration sites. Our goal is to have all of the pieces in place so that we can begin to perform geological calibration of production rates by the end of the summer of 2009. Here's an update on progress in this area, an outline of ongoing work, and a plea for your help.

Greg Balco has made a major contribution to the project by implementing a MATLAB code for $^{10}Al/^{26}Be$ production. Greg has also implemented the five models for elevation and latitude scaling of neutron production rates. The group at New Mexico Tech has implemented a model for ^{36}Cl production based on the old CHLOE code. Improvements in the new version include incorporation of ^{36}Cl production by spallation of Fe and Ti and allowing for time-dependent elevation/latitude scaling factors. Greg Balco's implementations of the muon depth-scaling models are currently being integrated into the code.

The web-based calculator that Greg Balco developed for Al/Be dating was based on a web interface to MATLAB that is no longer supported by the vendor. The group at NMT has developed a new web-based calculator written in JAVA that interfaces directly with the $^{10}Al/^{26}Be$ and ^{36}Cl MATLAB codes. The new web calculators are available for your testing at:

http://www.cronuscalculators.nmt.edu/al-be/al_be_age.html
http://www.cronuscalculators.nmt.edu/cl-36/

Of course the calculator uses previously published production rates that were calibrated using older production and scaling models. These production rates need to be recalibrated in light of the newer models and newer data. Thus results from this prototype web calculator should not be published.

The group at New Mexico Tech has been working on calibration of production rates using existing data sets from previous research and the MATLAB codes described above. A technique called orthogonal distance regression (ODR) is used to simultaneously account for uncertainties in independently measured ages and uncertainties in the cosmogenic nuclide concentrations. Brian Borchers gave a presentation on calibration of Cl-36 production rates using this technique at the meeting in Berkeley. The same approach will be used to perform the geological calibration of production rates for all of the cosmogenic nuclides.

This brings us to our plea for help. In order to perform the geological calibration of production rates, we need your data. Furthermore, the CRONUS project is also obliged to document and share all of the sample data collected during the project. Eventually, this information will be entered into the EarthChem database. However, the development of the database has not progressed to the point that it will be ready before we need the data for geological calibration. In order to bridge the gap between the need for data now and the start of the EarthChem cosmogenic database, we are assembling all the available data at New Mexico Tech.

Data templates for the submission of your sample data via email are available at the bottom of the online calculator pages (listed above) as well as included with the newsletter email. Please note that these data templates are NOT the same templates used to format data for the calculators themselves.

Please enter as much information about each sample you have processed into the appropriate template and email if back to Shasta@nmt.edu. We realize that the form includes many inputs, but please fill out the information for each sample as completely as possible. We are trying to collect sample data instead of sample results. Please return the form even if there are a few inputs missing. As you complete more samples, please continue to update the sample spreadsheet and send us updated copies. Another important aspect of each site is the independent-age constraint. The details of each site, including ages, references, and other site information, should also be easily accessible to all CRONUS-Earth participants. For geological calibration, the independent ages need to be available. These will need to be discussed on a case-by-case basis. We will be contacting the site organizers for this information and arranging conference calls to discuss the sites when necessary. Please contact the individual site organizers if you would like to be involved in this process.

Peru Sample Characterization

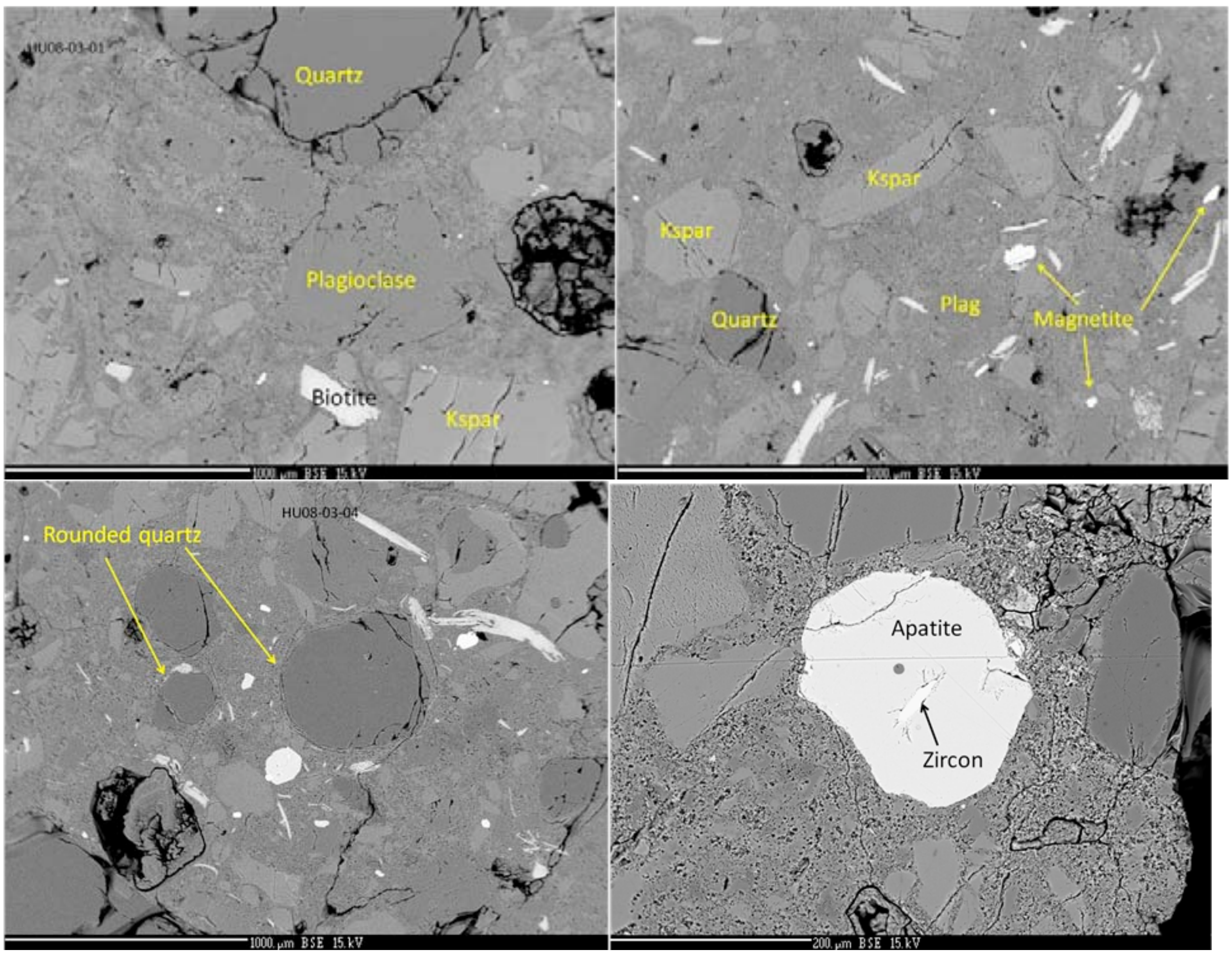
By Shasta Marrero

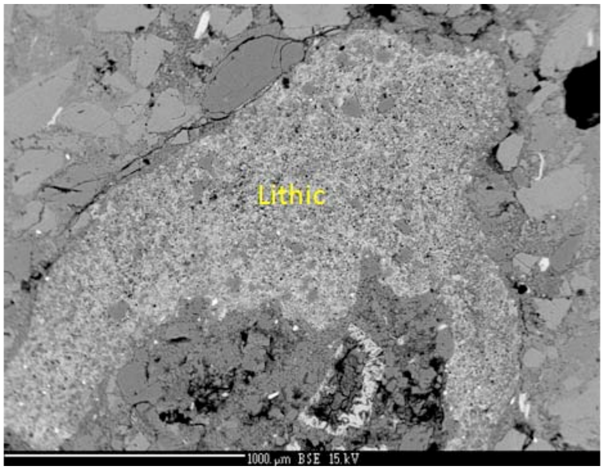
In the previous newsletter, Fred wrote a great article about the collection trip in Peru. In the lab, I have started characterization and sample crushing. At this point, the samples are crushed and split and ready for distribution. If you are interested in receiving some of the sample, please contact me (Shasta@nmt.edu) and provide your mailing address and some estimate of the quantity of material you need.

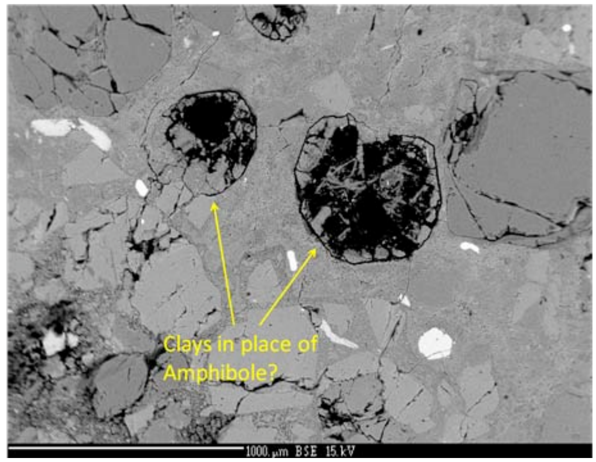
The samples from Peru (CRONUS sample names HU08-XX) are crystalline-rich samples. Several sets of analyses have been performed including electron microprobe analysis and thin sections. Based on these analyses, the samples have a significant amount of quartz, ca-rich feldspar, K-spar, and biotite in a clay-rich groundmass. There are also trace amounts of monazite, apatite, magnetite, and zircon. Overall, the samples are very consistent from sample to sample, both in hand sample and in microprobe analysis. Density measurements, XRF, and Cl determinations are scheduled for the near future.

The compositional details for some of mineral phases were determined using the microprobe. The biotite is relatively high in iron, with some potassium and no detectable Ca. The Cl in the sample is most likely in the biotite and apatite phases.

The Ca-rich phase, plagioclase, is approximately midway between the Na and Ca endmembers. When I performed a mineral separation, the usable fraction by mass were ~5-10% Ca-rich plagioclase, ~7-12% quartz, and ~5-10% K-rich plagioclase. There are also significant amounts of lithic fragments present in the samples (some up to 10 cm long). These lithics proved to be compositionally similar to Fe-rich illite. In thin section and electron microprobe the quartz grains are clearly rounded. In general, the biotite in the sample looks very intact. Finally, there are some holes in places and it appears that something like amphibole has been weathering to clay. These areas look red in hand sample. I have included some of the labeled microprobe images below. Please feel free to email me (Shasta@nmt.edu) if you would like these or any other images.







Upcoming Conference and Meetings

AGU Chapman Conference on Abrupt Climate Change
June 15-19, 2009 (Columbus, Ohio)
http://www.agu.org/meetings/chapman/2009/ccall/

Goldschmidt 2009
June 21-26, 2009 (Davos, Switzerland)
http://www.goldschmidt2009.org/
Abstract Deadline: February 21, 2009

CRONUS-EU/CRONUS-Earth Science Workshop
During Goldschmidt 2009
June 24, 2009 (Davos, Switzerland)

GSA 2009 Annual Meeting
October 18-21, 2009 (Portland, Oregon)
http://www.geosociety.org/meetings/2009/

AGU 2009 Fall Meeting
December 14-18, 2008 (San Francisco, California)
http://www.agu.org/meetings/

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