Newsletter

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Table of Contents

Welcome

By Dr. Fred Phillips

The Third Annual CRONUS-Earth Project Meeting was held last fall, in association with the Geological Society of America Meeting in Philadelphia. The meeting was lively and productive. One suggestion was that a newsletter would help to enhance communication and interest in CRONUS events. Since then, Lisa and I have solicited contributions. This has been a somewhat painful process; several of those most vociferous in promoting a newsletter have also been the most difficult ones from whom to extract contributions! The result has been that the newsletter has been quite a bit slower in appearing than we had hoped. Nevertheless, Lisa's persistence has paid off and the result is very informative. Kudos to Lisa for her hard work in making this a reality!

Major upcoming events include a calibration sampling trip to trip to Hawaii, currently being organized by Mark Kurz, one to Maine organized by Greg Balco, preparations to finally distribute standardization materials (to be described in a subsequent newsletter), and the Fourth Annual Meeting, which is scheduled for 8-9 December in Berkeley, right before the AGU

Meeting. Please put this date on your calendars! I will also remind you that CRONUS is sponsoring a Special Session on cosmogenic nuclides at the AGU Meeting, so you will have a double reason to plan your trip to California in December.

Exposure Age Calculators

By Dr. Greg Balco

Genesis of the online exposure-age calculator

The first goal of this part of the project has been to produce an online exposure age and erosion rate calculator which -- while perhaps not at this point delivering the 5% age accuracy which is the eventual project goal -- provides nonspecialist users with an internally consistent calculation scheme that accurately codifies common practice. We assembled the first version in March, 2006, and made it available for testing to folks involved with CRONUS, as well as a few outside geologists and geomorphologists who are major users of cosmogenic-nuclide measurements. Lewis Owen, Dan Farber, Bill Phillips, and Kuni Nishiizumi deserve particular mention for making useful comments on the code and the user interface at this phase. After taking these comments on board and producing a full set of documentation for the user interface and the underlying MATLAB code, we made the first stable version available for public use in May.

Status in 2006:

Between May 20 and the end of 2006, the system handled 9942 total calculation requests, of which 8575 were for exposure-age calculations and 1367 were for erosion-rate calculations, from 201 identifiable IP addresses (not counting ourselves). We have no way of knowing how many of these calculations were or are actually used in published or presented research. However, major usage spikes, up to several hundred requests per day, immediately before the GSA and AGU meetings and their abstract deadlines suggest that calculator results appeared in many meeting presentations (see accompanying figures). We've also been in contact with several college and university faculty who have been using the calculator as a resource for geochronology classes.

User feedback has been generally positive. The majority of comments and requests have fallen into two groups. Cosmogenic-nuclide specialists, including many CRONUS members, would like to see more technical features and more direct access to lower-level results, such as production rate-depth profiles and more finely parsed scaling factors. This will not be a development focus in the near future; however, these capabilities are already available to anyone with access to MATLAB software through downloading and modifying the underlying MATLAB code, which is freely available through the web site.

Citing the online exposure-age calculator

The most common question from nonspecialist users, on the other hand, has been "How should I cite this?" We are hoping to solve this problem by publishing a journal article as documentation for the next version of the calculators, which we hope to release in the next few months. However, the main focus of this second version will be on including the full set of recently published geographic and paleomagnetic scaling schemes. This, of course, will result in a more complicated and potentially more confusing set of information being presented to users -- so the challenge will be to emphasize that the variety of different results is not intended just to confuse people, but to identify situations where calculated exposure ages are sensitive to differences between scaling models, and warn that correlations based on only a single scaling model might not be wise in these cases.

Where to find the calculators

As always, the calculators are available at:

http://hess.ess.washington.edu/math

Comments on the present version of the calculators and suggestions for future versions should be sent to Greg Balco at balcs@u.washington.edu.

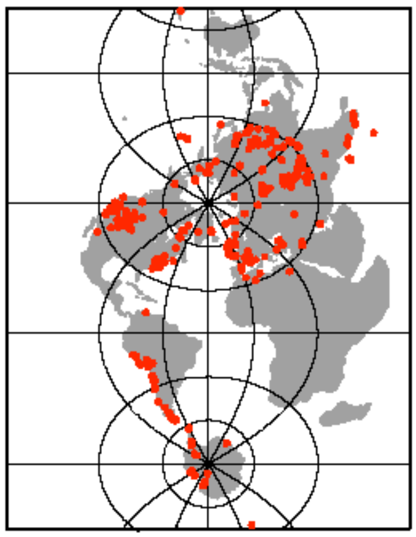
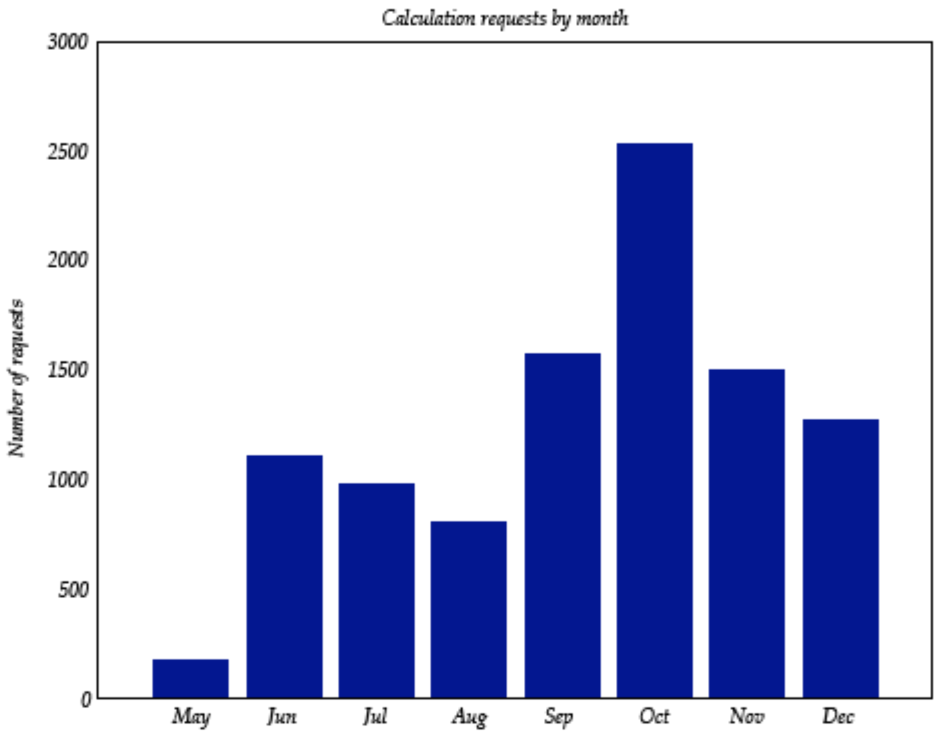
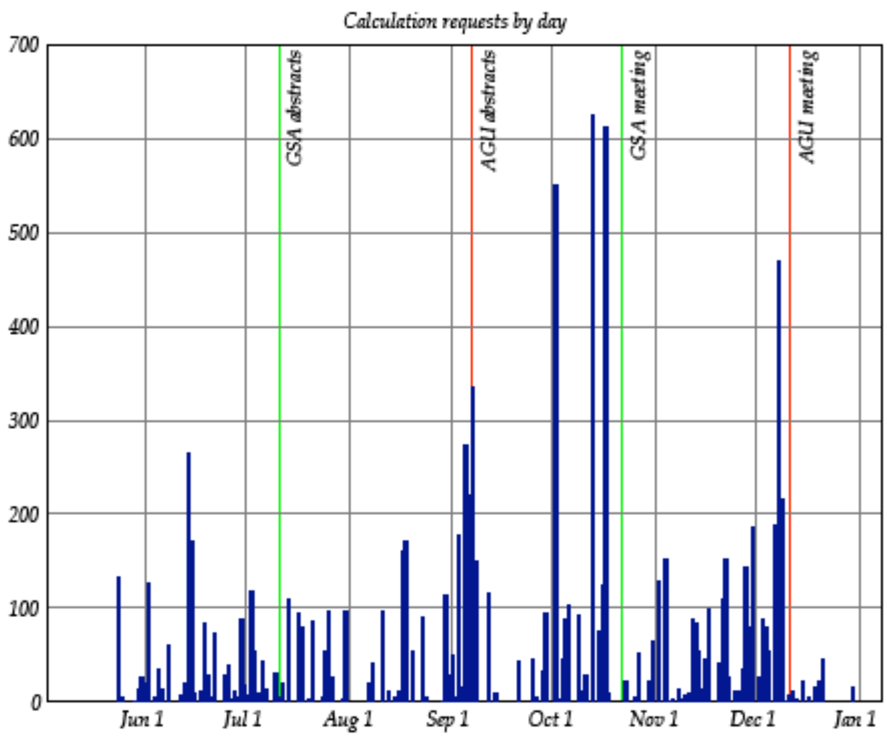


Figure 1. World map showing the geographic distribution of calculator submissions in 2006. We log the latitude and longitude (but no other information) from calculation requests purely as a means of determining how many requests pertain to unique sample sites, and how many are repeated requests for recalculations at a single site. The cluster of points in the north Pacific Ocean near Kamchatka appears to reflect users incorrectly entering positive latitudes for sites in New Zealand.



2. Distribution of 2006 calculation requests by month. (calcs_by_month_2006.pdf)



3. Distribution of 2006 calculation requests by day. Vertical red and green lines show significant meeting deadlines. (calcs_by_day_2006.pdf)

Educational Outreach Report (April 2006-January 2007)

By Dr. Terry Swanson

Overview

The educational outreach program of Cronus Earth commenced in April, 2006 and is funded through April 2009. To date, there have been five undergraduates, who have participated in this program. They include four from the University of Washington (Melissa Fiorintini, Jeff Tracy, Hope Sicily, and Heather Rogers, supervised by Terry Swanson) and one from the University of Cincinnati (Jayme Csonka, supervised by Lewis Owen). All of the participating students have been provided an opportunity to develop their own respective research projects, complete field and/or lab work, data analysis. Several of the students who are further along in their research projects have begun to write up their results or have already presented their papers at research symposia.

Student research projects

Heather Rogers' undergraduate research project utilized a well-constrained outburst flood deposit in the Ohop Valley, WA to help further calibrate the ^{36}Cl production rates within the Puget Lowland. Her calibration sample data was received in August 2006 and she is currently completing the chemical analyses to calculate production rates. Her research will complement the recent calibration sampling (September, 2006) by Cronus-Earth scientists in the northern Puget Lowland. Heather has graduated with her undergraduate degree and has commence graduate work in the University of Washington. Her undergraduate research experience has helped her considerably with the development of her MS research proposal and has prepared her for rigor and dedication required to complete independent research. She has already started her MS thesis research and is presenting a poster at forthcoming AGU meeting in December 2006. The poster is entitled, " Quantitative Analysis of Holocene Shoreline Retreat in Unconsolidated Sediment within the northern Puget Lowland, WA" (Paper Number: H33B-1493) involves research skills that she gained through her undergraduate research experience through Cronus-Earth.

Jeff Tracy was an undergraduate in the Department of Earth and Space Sciences at the University Washington, who recently graduated in June 2006. Jeff reconstructed long profiles of several relict outwash channels that were prograded to the marine high-stand (140 feet above sea level) on Whidbey Island. He used LIDAR imagery to reconstruct channel profiles that were truncated by wave erosion processes as a means to determine the magnitude of shoreline erosion since deglaciation. His research results were presented at the Mary Gates Research Symposium hosted for honors students at the University of Washington. Jeff's research results have provided the foundation for a much larger research project that is attempting to calculate both long- and short- term erosion rate of unconsolidated sediment within the Puget Lowland. Jeff has recently been hired by a major geotechnical consulting firm in Seattle, but he has expressed a desire to return to graduate school to follow-up on the research experience he gained through Cronus-Earth.

Melissa Fiorintini is a recent graduate in the department of Earth and Space Sciences. Melissa completed a detailed paleoecology study of mollusk shells collected from glacial marine drift (GMD) sites on Whidbey Island. She analyzed 20 mollusk shell samples from important GMD type locations where radiocarbon dating has been completed in prior studies. Reported radiocarbon age data have shown that shell ages within a particular stratigraphic unit may vary by as much a 300 to 600 years. One possible hypothesis that may explain this apparent anomaly is that the younger shell ages may represent species that have the capability of burrowing to greater depths within the marine sediment. Melissa's paleoecology study will enable us to determine whether such relationship exists and why such a large ^{14}C age scatter is exists in some sections. Select shells of different species will be sent off for radiocarbon dating to determine whether such a relationship exists. Melissa will be continuing with this research as non-matriculated student in the Winter quarter 2007. Her goal is to publish her results in the spring of 2007 after the radiocarbon results are analyzed.

Hope Sicily has just begun her undergraduate research project within the Cronus-Earth program. She is completing a double major in Mathematics and Earth and Space Sciences at the University of Washington. Hope started working in my lab during the summer of 2006 and spent several weeks in the field assisting me with channel surveys and learning to describe stratigraphic sections on Whidbey Island. Hope's research project will utilize cosmogenic isotope dating to determine the timing of shoreline emergence and isostatic uplift of San Juan Island. The Cattle Point moraine, also located on San Juan Island, represents one of the calibration sites that was sampled in September, 2006 by the Cronus Earth research group.

Jayme Csonka is completing her undergraduate degree at the University of Cincinnati. The Cronus-Earth undergraduate research program funded Jayme to travel to Skye, Scotland to participate in this summer's calibration sampling program. Jayme spent the latter part of the summer working at Purdue University processing samples for future analysis. Jayme will utilize some of the data collected from Skye for her research project. Jayme will also be given the opportunity to travel to Seattle and spend time in the field with the University of Washington undergraduate research group. Jayme will have a formal research proposal submitted to Cronus-Earth outlining her research objectives and design.

Plan for 2007

In closing, the Cronus-Earth undergraduate research program has been very successful in providing undergraduate students with research opportunities. Our plan for 2007 is to provide research training/opportunities for 4 – 5 additional undergraduate students. Several of the senior students within the program will be given the opportunity to present their results at a national professional scientific meeting (i.e., G.S.A. or A.G.U.). The students will also write final report and submit their papers to peer reviewed journals for publication.

3rd Annual Meeting in Philadelphia

By Lisa Majkowski

The 3rd Annual Meeting was held in Philadelphia, PA on October 20-21, 2006. There were a total of twenty-one attendees from 13 institutions, including three students. CRONUS-Earth researchers had the opportunity to meet Dr. Enriqueta Barrera, Geobiology and Low Temp Geochemistry Program Director for the Surface Earth Processes section of the National Science Foundation's Earth Science Division. Each of the project leaders presented the current results of their projects along with short range and long-term future plans.

The CRONUS-Earth 2006 Business Meeting was conducted during the annual meeting. Three positions on the steering committee were up for rotation – Nat Lifton and Tim Jull were re-elected, Brian Borchers will replace Bob Finkel.

CRONUS-Earth Fellowships

by Lisa Majkowski

CRONUS-Earth is sponsoring two fellowships in 2007:

Graduate Fellowship

The Graduate Fellowship is intended to provide three years of support for a Ph.D. student studying at an institution participating in the CRONUS-Earth Project. The proposed research program of the student should contribute to the program and objectives of CRONUS-Earth.

International Fellowship

The International Fellowship is intended to promote student exchange, broaden scientific training, and encourage collaboration with the CRONUS Project counterpart in Europe, CRONUS-EU. The fellowship will support travel costs and subsistence for a semester and/or summer to participate in CRONUS research at an institution in Norway, Sweden, Finland, Denmark, or Iceland. The student must be working on CRONUS-Earth research and can be enrolled in either an M.S. or a Ph.D. program.

Selection

Many thanks are extended to the selection committee, Mark Kurz (Woods Hole Oceanographic Institution), Erik Brown (University of Minnesota), Tim Jull (University of Arizona) and Joe Licciardi (University of New Hampshire). After careful deliberation and consideration of the candidates, the committee decided to split the Graduate Fellowship.

Congratulations to CRONUS-Earth Graduate Fellows David Argento (Earth and Space Sciences, University of Washington) and Brent Goehring (Lamont-Doherty Earth Observation and Department of Earth and Environmental Science, Columbia University). Brent was also awarded the International Fellowship and will conduct research in Norway. Look for articles about their research in the next newsletter.

Neutron Monitor Detector Response

By Dr. John Clem

Our research has demonstrated the neutron-monitor count rates depend on surrounding materials. Recent improvement in the modeling of neutron monitor (NM) latitude survey observations have shown the particle beam used in the simulation may need to be as large as 20 meters in diameter for accuracy of better than 2 percent. Such a large target is sensitive to large cosmic ray air showers and correction timing issues must be considered in the calculation.

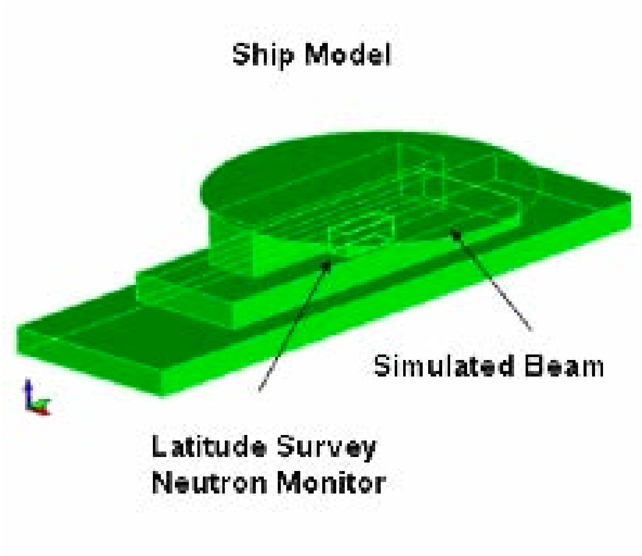


Figure 1) Scaled drawing of the ship model used in the simulation

Figure 1 shows the NM housing (sea- container) on the 2nd level next to the Super-Structure. The circular disk above represents the simulated beam of particles illuminating the ship. Figure 2 shows an image (black dots) of starting points of particle trajectories in the beam that produce at least a single count in the NM64 neutron monitor. The green points represent those counts from a small neutron counter also located in the sea-container. The concentric rings illustrate how the data is binned into the histogram shown in Figure 3 summarizing the results for 3 different incident neutron energies. This plots the integral detection response within a given radius normalized to unity at 15m radius.

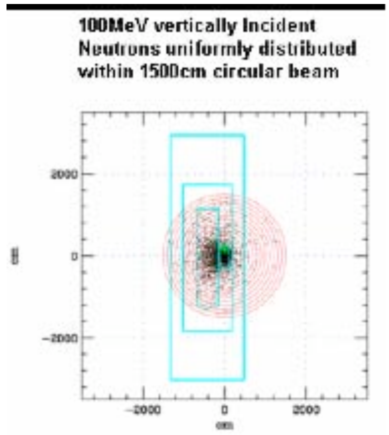


Figure 2) Scatter plot of the starting point values of only those neutron trajectories that produce a count

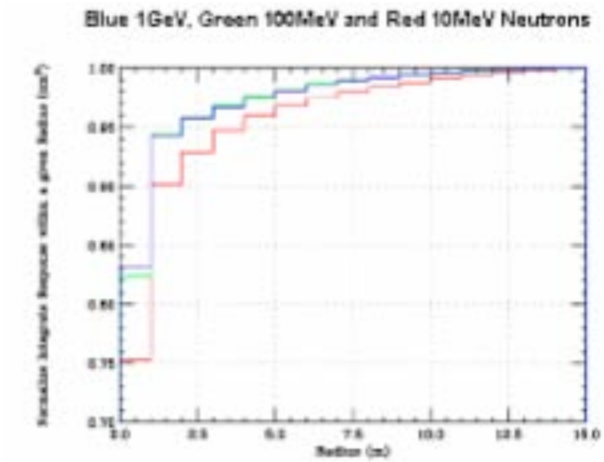


Figure 3) Detection efficiency of neutrons within the full beam cross-sectional area bounded by the given radius on the horizontal axis normalized to detection efficiency of the full 15m radius beam.

Proper photonuclear cross-sections were recently incorporated into the calculation that determines detection efficiency of a neutron monitor (Figure 4). The Giant Dipole Resonance peak as shown above is very important component in the cross-sections. When a gamma ray of the same frequency of the nuclear dipole frequency is absorbed the system becomes excited, and de-excites through the emission of neutrons. Even though this is a narrow peak at relatively low energy, gamma rays or electrons entering the NM with energies above this energy are able to produce neutrons in the lead through this mechanism. The physics of an EM shower is such each generation of photons become progressively lower in energy while number of gammas increase in numbers before possibly overlapping the dipole energy. The photonuclear process plays a significant role in the contribution of counts from gamma rays and e+ and e-, and to a lesser degree muons. In Figure 5 the response to gamma rays and electrons without the Giant Dipole resonance is significantly below the displayed scale. It is therefore very important to account for these cross-sections in a neutron monitor simulation as the propagation of the EM component through the atmosphere is considerably different than that of the nucleonic component. In the context of CRONUS-Earth understanding this additional source of counts in neutron monitors may have significant implications for the altitude dependence in scaling factors.

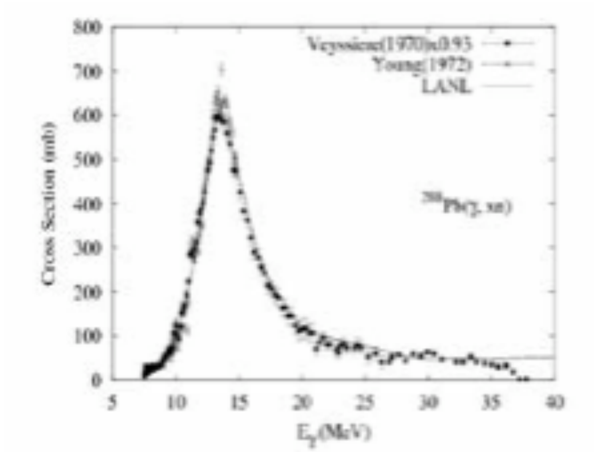


Figure 4) Photonuclear cross-sections for a gamma ray on a Pb target yielding at least a single neutron.

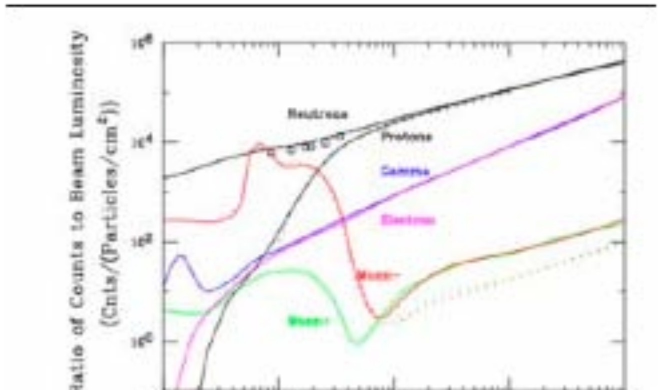


Figure 5) The resulting detection efficiency of a NM-64 for 6 different particle species including neutrons, protons, electrons and gamma rays and muons for vertical incident direction. Dots represent calculation without the Giant Dipole resonance. The response to gammas and electrons without the Giant Dipole resonance is below the shown scale.

Atmospheric Cross-Sections and Interaction Multiplicities

The atmospheric depth dependence of cosmic ray fluxes varies strongly with the interaction path length or cross-sections on nitrogen and oxygen nuclei. Unfortunately, inelastic nuclear cross-sections for Nitrogen targets are not well established to within ~5% accuracy. Due to lack of data, scaling models of Nitrogen and Oxygen are typically used to estimate cross-sections from carbon due to the abundance of carbon measurements. In Figure 6, the curves represent models used in the simulation code while points are measurement results. As demonstrated, the carbon model in the simulation requires some adjustment to better represent the data. This was implemented and corrected in the code. Through a simulation it was demonstrated that a 5% uncertainly can translate to roughly a 50% systematic errors in the calculated sea- level fluxes. The compounding effect with each generation in the cosmic ray shower magnifies small deviation the cross sections.

The effect is clearly demonstrated in Figure 7. The ground-level neutron observations were taken at Hampton, VA by Paul Goldhagen of EML. These were compared to 2 different atmospheric cosmic ray calculations. The only difference is an applied uniform 5% scale factor on the Nitrogen Cross-sections in the atmosphere. The dotted curve represent results determine with cross-sections 5% higher than the results as represented by the solid line. The overall effect is quite dramatic showing the importance of understanding these quantities.

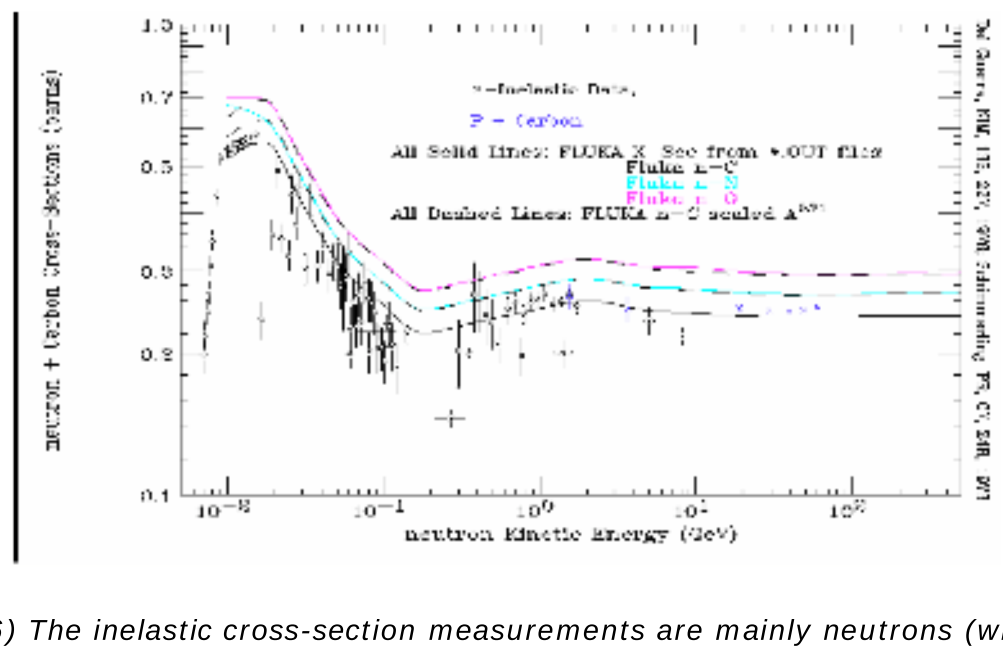


Figure 6) The inelastic cross-section measurements are mainly neutrons (with a few protons as blue symbols) on a carbon target. The solid lines represent FLUKA neutron cross-sections: Black line represents 12C target cross-sections, Cyan line is 14N and Purple line is 16O. The black dashed lines are FLUKA Carbon cross-sections

(solid black line) scaled by A0.71. The simple scaling model seems to reproduce the N and O cross-sections, suggesting this type of scaling is used in FLUKA. This value (A0.71) is the scale factor published in the CERN Particle Physics Handbook.

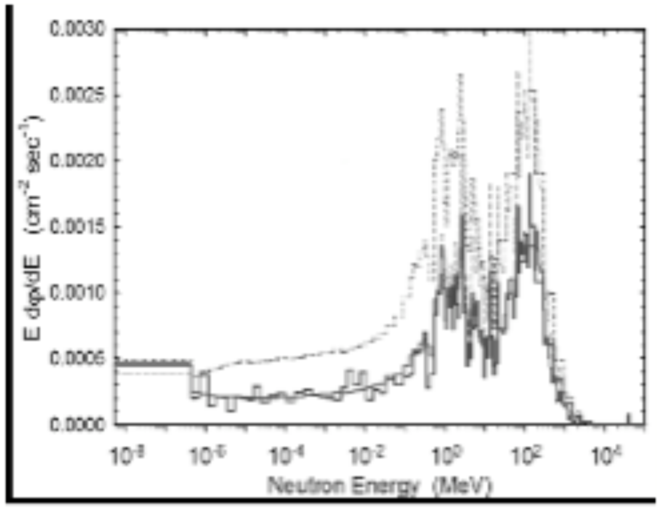


Figure 7) Ground-level observations (solid histogram) of Neutrons at Hampton, VA compared to 2 different atmospheric cosmic ray calculations. The only difference is an applied uniform 5% scale factor on the Nitrogen Cross-sections.

Deviations in the secondary particle multiplicity models can also have a very similar effect on cosmic rays fluxes. On the average it is very difficult to distinguished one effect from the other based solely on changes in the spectral flux of secondaries. Multiplicity and cross-sections are both fundamental characteristics of the interaction governed by nuclear and particle physics. While cross-section defines the probability of an interaction occurring, the multiplicity of the interaction defines the dispersion of kinetic energy from incident particle. In a target where there are many interaction lengths a systematically low average multiplicity could be compensated through artificially increasing the interaction cross-sections.

Figure 8 compares various multiple models of neutron multiplicity for a proton on N14 target. As shown the disagreement is as large as factor of two. However to fully understand the differences a complete analysis of all other particle and nucleon types must be evaluated. As a result it is important to characterize these differences before applying these values to a calculation involving a large number of interaction lengths such as that of Earth's atmosphere.

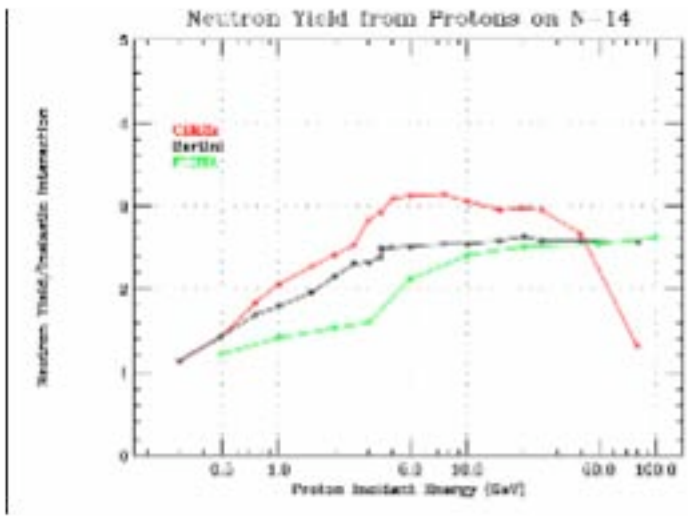


Figure 8) Model Comparison of Neutron Multiplicities from Proton Inelastic Collisions.

Model of Primary Cosmic Rays

To provide a continuous relationship between solar modulation level and the expected spectra shape for both cosmic ray protons and helium, a global fit was performed on this data using the solution to the Fokker-Plank equation assuming the shape of the spectrum of cosmic rays in the local interstellar medium (outside the solar system) is a power law in rigidity multiplied by an ionization energy loss term to account for the effects expected $dF/dR = k1R^{-k2} (1-e^{-k3\beta})$ from galactic propagation. The free parameters (k1, k2, k3) in the fit include the power index and normalization of the local interstellar spectra of protons and alpha particles. Initially, the diffusion coefficient (κ) was modeled in the standard way as $\kappa = \kappa 0\, e^{(r-1)/rd} \beta R$ where R is the rigidity of the particle, β is the speed of the particle normalized to the speed of light, r is the distance from the sun in astronomical units and rd is the diffusion length scale. In this model, the quantities κ and $\kappa 0$ are vectors and each component of $\kappa 0$ is a free parameter, representing the diffusion coefficient value for each data set (same value for both particle species) used in the global fit. Although this unique method provided promising results, the chi square of the fits had a rigidity dependence resulting in systematic errors. As an attempt to reduce the systematic effects, the above diffusion coefficient model is modified to $\kappa = \kappa 0\, e^{(r-1)/rd} \beta\, fn(R)$ where fn(R) is an nth order polynomial in rigidity with the lowest order term forced to zero and the coefficient on the linear term forced to one. Second order results are shown in Figure 9. This technique has decreased the chi square per degree of freedom by ~30%.

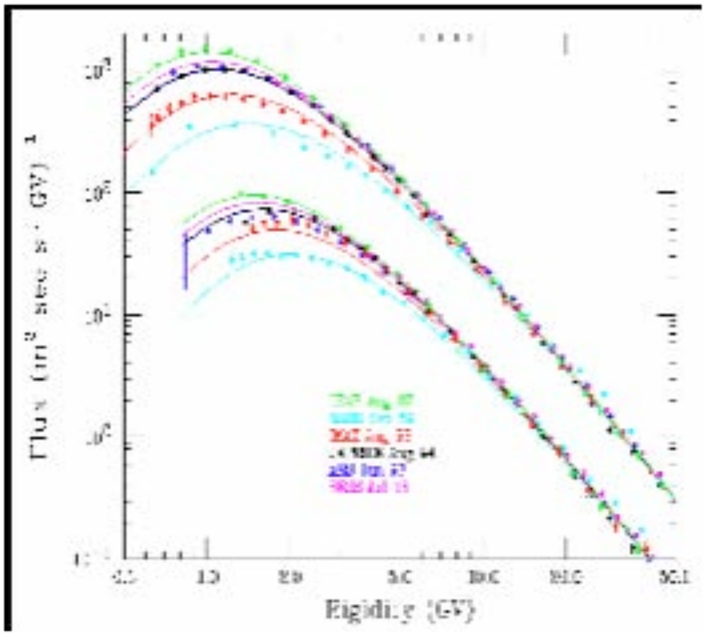


Figure 9) Results of balloon and space-craft measurements of the rigidity spectra of primary cosmic ray protons (upper spectra) and Helium ions (lower spectra) above of the Earth's atmosphere (points) and global fit to all the spectra (curves).

Model of the Geomagnetic Cutoff Rigidity

Upon reaching the inner Heliosphere primary galactic cosmic rays must pass through the Earth's geomagnetic field to enter the atmosphere. The geomagnetic field is more effective at shielding the atmosphere from cosmic rays near the equator than at the poles, producing a latitude effect mainly due to the geometry of the field being horizontal near the equator and vertical at the poles. Shielding effectiveness is quantified by the cutoff rigidity Rc which is the minimum rigidity a particle must have to pass through the magnetosphere and enter the atmosphere. Cutoff rigidities for a particular location above the atmosphere can be calculated by tracing particle trajectories through a model of the magnetosphere. Cutoffs have a strong angular dependence, as shown in Figure 10 in a representation that we refer to as a cutoff skymap. The curved solid lines represent iso- cutoff contours, the radial coordinate represents the zenith angle of incidence, and the angular coordinate represents the azimuthal direction of incidence, with incidence from the north at the top. Note the departure from a simple dipole representation.

For many purposes the effective vertical cutoff (the cutoff for a vertically incident particle) is sufficient, but in reality the effective cutoff rigidity depends on the details of the cosmic ray penumbra in each possible direction of incidence. Since cosmic rays arrive almost isotropically, there are many obliquely incident primaries. Atmospheric absorption increases rapidly with increasing slant- depth, and a good first approximation is to consider only the particles incident vertically. However, scattering from multiple inelastic interactions removes some memory of the primary incidence direction from hadronic daughter particles. This reduces the attenuation of obliquely incident particles, relative to that which would occur if an oblique path were followed all the way to the ground.

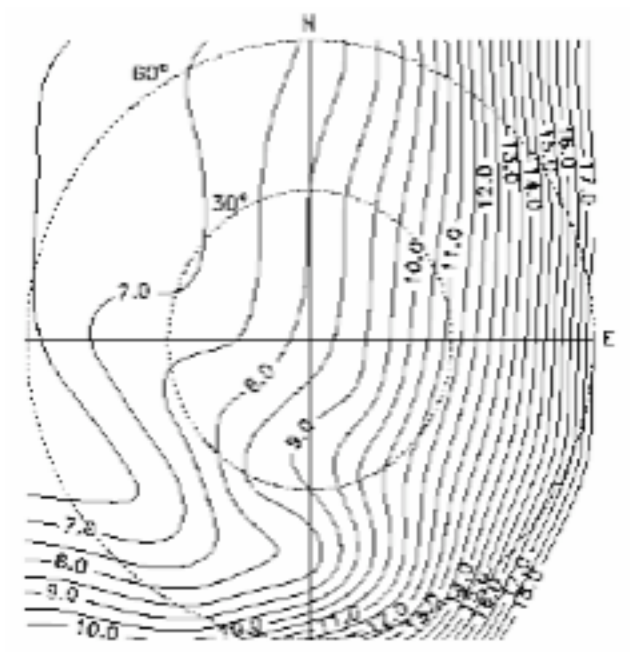


Figure 10) Geomagnetic skymap representing the cutoffs for 43.92 S, 76.64 W at 1995/075 23:30 UT with a vertical cutoff of 8.23 GV.

Skymaps were calculated for two locations shown in Figure 11 where the magnetic inclination is identical. Using these results sea-level neutron fluxes were determine and compared for each location. This analysis illustrates the ability of this approach to quantify the accuracy in neutron fluxes based on various measurable constraints.

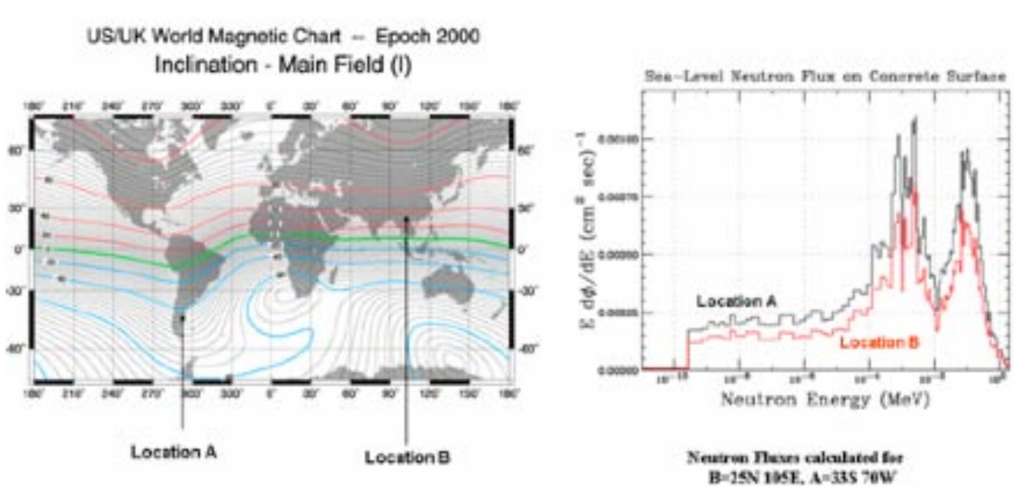


Figure 11a) Magnetic Inclination Chart taken from www.ngdc.noaa.gov. The locations A and B have the same inclination angles. Geomagnetic cutoff rigidity skymap were calculated for these locations. Figure 11b) The skymaps were then used to determine sea- level neutron fluxes assuming a concrete surface and solar minimum epoch.

Sampling on the Isle of Skye

By Dr. Marc Caffee

During the Last Glacial the British Ice Sheet covered much of Scotland, with the exception of a few isolated high peaks such as those on the Isle of Skye. This ice sheet melted away at about 15,000 years before present. During the Younger Dryas Stade (~12.9-11.6 ka) glaciers once more advanced from cirque basins and plateau regions in the Isles of Scotland (e.g. Isle of Skye) and the Highlands. This summer CRONUS participants gathered on the Isle of Skye to collect samples that will allow better calibration of cosmogenic nuclide production rates.

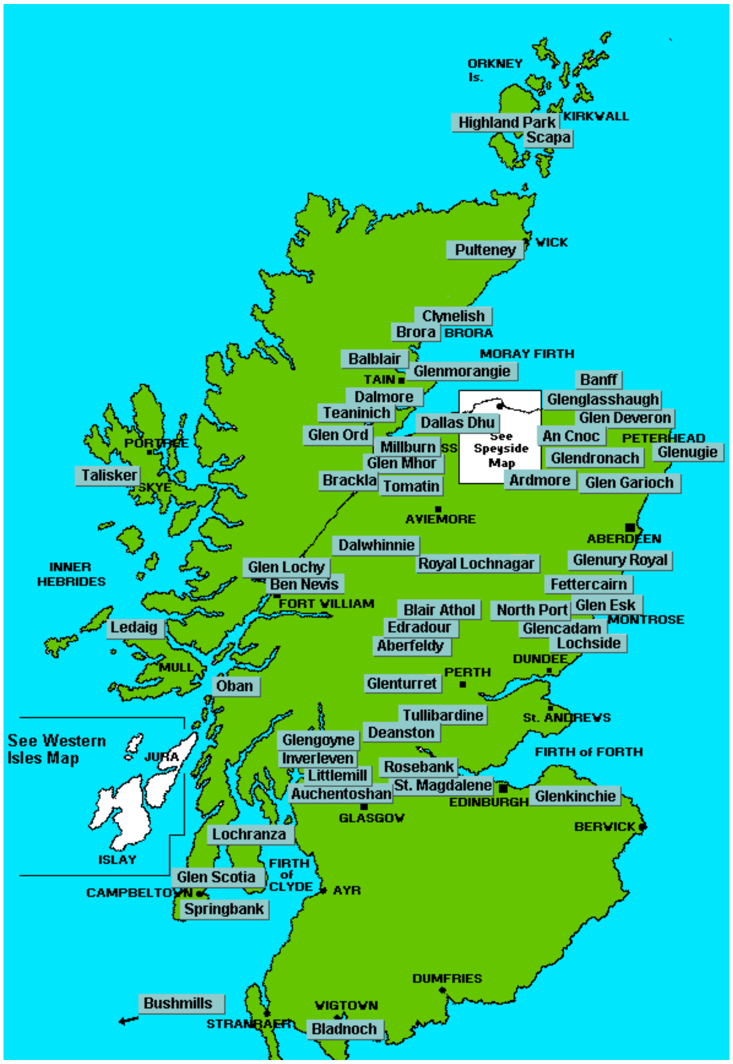
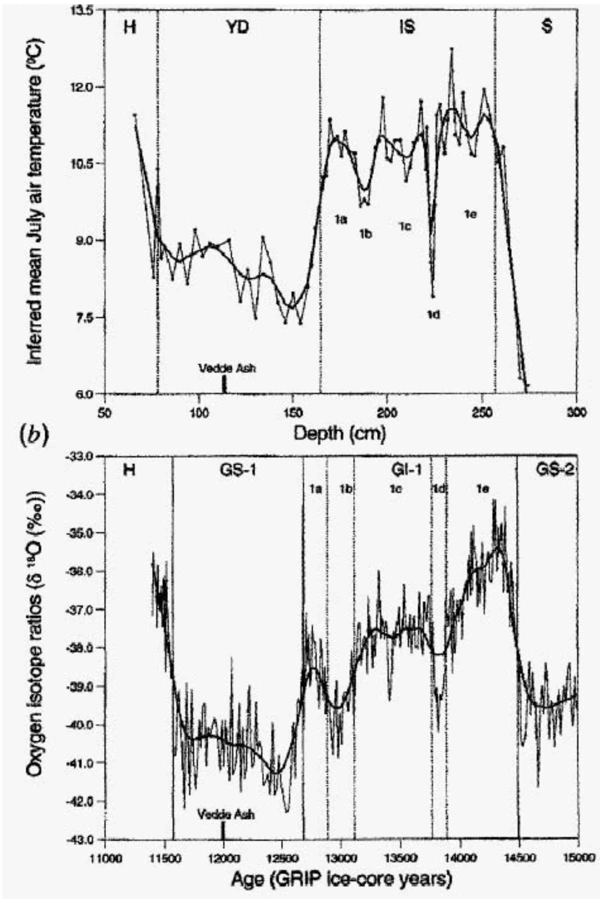


Figure 1. Major distilleries in Scotland. Unfortunately only one of these, the Talisker, was examined while undertaking the field research. However, the scotch produced at this distillery was particularly fine, having a sweet tang, smoky odor, and a translucent deep golden brown color.

The participants in this expedition were Dr. Kuni Nishiizumi (UCB), Dr. Robert Finkel (LLNL), Dr. Nathaniel Lifton (UA), Bailey Dugan (UA), Heather Moor (UA), Dr. Fred Phillips (NMT), Shasta McKee (NMT), Dr. Tim Jull, and Jayme Czonka (Univ. Cincinnati). The leaders of sampling were Dr. Marc Caffee, Dr. Lewis Owen and Dr. John Stone.

The sampling expedition to the Isle of Skye and the Western Highlands is an important element of the geologic calibration of terrestrial *in-situ* cosmogenic nuclides by cosmic rays. Results from this study will help to anchor nuclide production rates at high latitude (57° N) and altitudes from sea level up to 900 meters above sea level. The essential ingredients of geologic calibration are robust independent chronology, simple exposure geometry, and the availability of rocks that have target minerals from which all commonly measured cosmogenic nuclides are produced.

The chronology of the Younger Dryas at these sites is based on a combination of radiocarbon dating and correlations with climatic stages dated by layer-counting in the GRIP core. The radiocarbon chronology was established at several peat bogs throughout the Isle of Skye. Particularly important peat bog chronologies were established at the Whitrig Bog in the Highlands and at Loch Ashik on the Isle of Skye. Additional confirmation of the chronology comes from the well-dated Vedde Ash layer found in both the pollen sequences and the Greenland ice cores. Figure 2 shows the position in time of the Vedde Ash layer in the GRIP cores and those from Skye and



the Highlands. The temperature proxy in the Scottish cores is based on assemblages of *chironomids*, the larvae of midges – tiny biting insects that quicky became familiar to participants on the trip.

A possible complicating issue for these sites is the possibility that the limited size of Younger Dryas glaciers, acting over the brief cold interval of only a few thousand years, would not

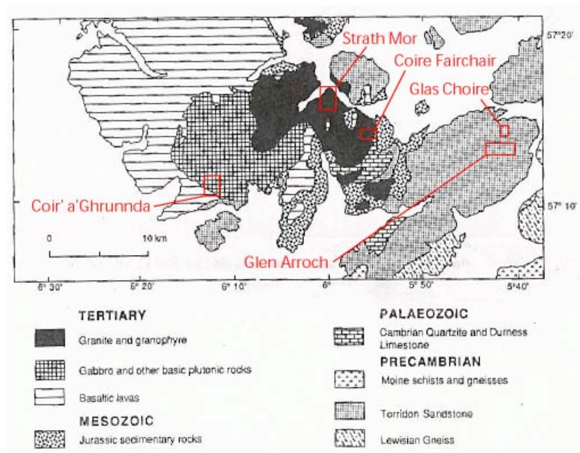


Figure 3. Geologic setting of the sampling sites on the Isle of Skye.

effectively reset the cosmogenic nuclide clock. In other words, the samples might not meet the requirement of a simple single-stage exposure to cosmic rays. Arguing against this possibility is that (e Younger Dryas most of Skye and the Highlands was covered by thicker, more extensive ice during the Last Glacial Maximum to about 15 ka. However, even several thousand years of exposure at depth would negatively impact the value of these sites as calibration sites. This possibility was addressed using samples collected by Caffee and Owen during fieldwork in 2001. Preliminary results from these samples indicate that the concentration of cosmogenic ^{10}Be is consistent with a single-stage exposure to cosmic rays since the retreat of Younger Dryas glaciers. Measurements made by John Stone on samples collected at other sites in the highlands likewise indicate a single-stage exposure.

The CRONUS entourage visited three sites on Skye and two sites in the Highlands. At these sites the group collected samples of granite, gabbro, arkosic sandstone and quartzite. Granite from Coire Fearchair, on Skye, will yield quartz for measurement of ^{10}Be, ^{26}Al, ^{14}C, ^{21}Ne and possibly ^{36}Cl, as well as potassium feldspar for measurement of K-derived ^{36}Cl. Arkosic Torridonian Sandstone from Glen Arroch on Skye and Corrie nan Arr on the mainland will provide the same pair of minerals. Coarse-grained gabbro from Coir' a Ghrunnda will be used for ^{36}Cl measurements, both on whole-rock samples and from Ca-rich plagioclase and pyroxene. Pure Cambrian quartzite samples from Maol Chean-Dearg will be used for ^{10}Be, ^{14}C, ^{21}Ne, ^{26}Al, and possibly ^{36}Cl. Sandstone bedrock outcrops in Glen Arroch were judged by CRONUS participants to be less than ideal, as turf covering the base of the outcrops may have extended higher in the past. Fortunately results from samples collected at this site can be checked for consistency with the large body of data that will be amassed from the other four sites.

Coire Fearchair

Mineral	*Targets*	*Nuclides*
Quartz	Si, O	^{10}Be, ^{21}Ne, ^{26}Al
K-feldspar	K	^{36}Cl

Glen Arroch

Mineral	*Targets*	*Nuclides*
Quartz	Si, O	^{10}Be, ^{21}Ne, ^{26}Al
Ca-plagioclase	Ca	^{36}Cl

Coir' a' Ghrunnda

Mineral	*Targets*	*Nuclides*
Ca-plagioclase	Ca	^{36}Cl
Whole rock		^{36}Cl

Figure 4. Three sampling sites on Skye.

All participants stayed in a bunkhouse at the Sligachan Hotel, Isle of Skye and enjoyed exquisite cuisine both morning and night. Meals were prepared

by meeting participants, under the watchful eye of Chef Owen, known far and wide for spicy mixtures of palette pleasing meats and vegetables. After dinner, the evenings were filled with lively discussions at the local pub or pleasant walks (involving scavenger hunts for US passports).

Photograph collage of Isle of Skye sampling

Upcoming Events

4th Annual Meeting
Preliminary date: December 8-9, 2007

Online Sample Form

By Lisa Majkowski

The online sample submission form is now operational and can be found at: www.ees.nmt.edu/cronus. Here, you will find the sample submission form and a link to check the status of your submission (date approved and date processed). We're still working out some of the bugs. For example, once you enter the date on the form and tab to the next box, the date will revert to 4/30/07. Please ignore this, as the date in the database will be the date that you entered. There will be a feature that will allow you to print out an invoice for the 3He samples. You may then submit this invoice to New Mexico Tech to be reimbursed for processing costs. We hope to have this option working soon.