V51E-7 1035h

Production Rate and Retention Properties of Cosmogenic ^{3}He and ^{21}Ne in Quartz

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We have measured cosmogenic ^{3}He and ^{21}Ne in a set of 6 samples of quartz from Antarctic mountain rocks. Cosmogenic ^{10}Be and ^{26}Al have previously been measured in these samples[1] so a comparison of ^{3}He and ^{21}Ne production against ^{10}Be and ^{26}Al is possible. An important issue in using cosmogenic noble gases as exposure chronometers is their retention in silicate materials. The ^{3}He and ^{21}Ne from these samples are released at low temperatures. All of the ^{3}He is extracted during a 30 minute heating at 500°C. The same heating releases 50% of the ^{21}Ne from the sample. The remaining ^{21}Ne is released in the 750°C extraction. While ^{21}Ne is better retained than ^{3}He it is nevertheless only loosely bound. In comparison to ^{10}Be and ^{26}Al, ^{21}Ne shows no signs of loss and we calculate a minimum production rate of about 80 atoms per year per gram of quartz (1800 m elevation, 77.6 latitude). In contrast, relative to the Ne, most of the ^{3}He has been lost in these samples. We have also examined ^{3}He and ^{21}Ne release in samples from other locations. In these samples a quartz fraction was prepared by handpicking (as opposed to chemical etching[1]). These more gently prepared samples show similar release properties. We conclude that ^{21}Ne was quantitatively retained in the Antarctic samples, but that for samples with higher peak storage temperatures quantitative retention of ^{21}Ne may be questionable.

[1] K. Nishiizumi *et al.* (1991) *EPSL*, 104, 440-454.
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V51E-8 1050h

Effective Attenuation Lengths of Cosmic Rays Producing Be-10 and Al-26 in Quartz: Implications for Exposure Age Dating

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Determination of exposure ages and erosion rates of surficial rocks using the build up of cosmogenic isotopes (^{10}Be, ^{26}Al, ^{3}He, ^{36}Cl or ^{21}Ne) produced *in situ* within mineral lattices has been the object of several recent studies. The technique has been applied to problems in glaciology and volcanology, and to examination of variability in cosmic ray fluxes. Use of isotope ratios has potential benefits in examining complex exposure histories because it reduces or eliminates uncertainties associated with exposure geometry and absolute production rates. One important parameter in interpretation of cosmogenic isotope data, particularly in regions of high erosion rates or in samples which have been partially shielded, is the mean free path of the cosmic rays producing these isotopes. We have measured ^{10}Be and ^{26}Al as functions of depth in a core of quartz sandstone bedrock collected in East Victoria Land, Antarctica. These data were used to calculate the effective attenuation lengths for cosmic rays producing these isotopes: 152±7 g cm^{-2} and 179±14 g cm^{-2} for ^{10}Be and ^{26}Al, respectively. These results indicate that the mean free paths for nuclear disintegrations producing these isotopes are greater in solids than in air, and suggest that the value for ^{26}Al may be slightly greater than that for ^{10}Be. Although this difference is subtle, it has implications for the interpretation of analytical results from samples with complex exposure histories.

The data were also used to place limits on the exposure age (>1.1 My) and erosion rate (<1.1 x 10^{-4} g cm^{-2} y^{-1}) of the surface. The concentrations of the cosmogenic isotopes are lower than those measured in similar exposures from nearby deposits, suggesting that the present sample has not been exposed long enough to reach steady-state with respect to erosion and radio-decay.

V51E-9 1105h

Depth Dependence of *in situ* Produced Cosmogenic ^{3}He in Antarctic Sandstone Bedrock

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Understanding the systematics of *in situ* cosmogenic nuclides is crucial to their use in Quaternary geochronology. To constrain production and possible loss mechanisms of cosmogenic ^{3}He in quartz, we measured the depth dependence of ^{3}He concentrations in a ~1 m deep core we drilled in sandstone bedrock on a terrace east of Arena Valley, in the Dry Valleys region of Antarctica (1700 m alt.). Preliminary results indicate a surface concentration of 2.64 ± 0.01 x 10^8 at g^{-1} ^{3}He in 0.5-0.7 mm quartz grains, and an exponential decrease with depth with an apparent attenuation length of 244 ± 6 g cm^{-2}. This value is greater than that determined for ^{10}Be and ^{26}Al in this core (see abstract by E.T. Brown - this meeting), and greater than values for cosmogenic ^{3}He in Hawaiian lava flows (164-170 g cm^{-2}). As indicated by the attenuation lengths, ^{3}He/^{10}Be and ^{3}He/^{26}Al ratios increase with depth, from surface values of 13.2 ± 0.8 and 2.7 ± 0.3 to 27.3 ± 5.7 and 4.6 ± 0.6 at 90 cm depth.

We propose that the high apparent attenuation length for ^{3}He is a result of enhanced loss of ^{3}He in the surface samples or enhanced production at depth. Available calculations of production rates of ^{3}He by muons (attenuation length ~ 1000-1500 g cm^2) suggest that this mechanism alone cannot account for the observations. Evidence of ^{3}He loss from other quartz samples in the Dry Valleys region has been observed, however. If the core data are interpreted as evidence of ^{3}He loss they suggest that solar heating of rock surfaces or crystal damage during ^{3}He production contributes to enhanced diffusion of ^{3}He in the surface samples. Analysis of additional core samples, and a number of grain sizes at each depth, should help constrain the relative importance of these processes.

The surface ^{3}He data also indicate a minimum exposure age of ~430 kyr for this bedrock surface, which is a factor of ~ 2 lower than ^{10}Be and ^{26}Al ages for the same sample, consistent with previous results for samples in this age range.

V51E-10 1120h

Lowering Rates of Granitic Landforms Determined by Measurement of *In Situ* Produced Cosmogenic Nuclides

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In order to determine the rate at which granitic landforms erode, we are determining, in >100 samples, the concentration of six isotopes produced in rock by the bombardment of cosmic rays. Comparison of different isotope abundances determined for the same sample may help resolve discrepancies in isotope production rates and pre-exposure inheritance.

In cooperation with Purdue, Livermore, and the University of Arizona, we are measuring the abundance of 14-C, 36-Cl, 26-Al, 10-Be, 21-Ne, and 3-He in aliquots of quartz separated from the granites. In order to constrain better the non-cosmogenic portion of measured isotope abundances we are: 1) measuring the concentration of alpha emitters (U,Th) and various target nuclei and 2) analyzing samples shielded by 5-10 m of overburden.

Preliminary 21-Ne data (B. Hudson, Lawrence Livermore National Lab) indicate that some granitic rock surfaces in semi-arid Owens Valley, CA have effective exposure ages > 0.5 Ma implying erosion rates < 40 cm/Ma.

V52A CA: 306 Fri 1330h
Geology and Geochemistry of Magma Chambers *(joint with T)*

Presiding: **P M Kenyon,** Univ of Alabama; **R T Williams,** Univ of Tennessee

V52A-1 1330h

Thermal Profiling of a Man-Made Magma Chamber: Petrologic Implications

M T Naney, G K Jacobs, N W Dunbar (Environmental Sciences Division, Oak Ridge National Lab, Oak Ridge, TN 37831)

Thermal profiles were obtained during periods of melting, active convection, and crystallization of a man-made basaltic (basanitic) magma body. The lopolith-shaped body (3 m diameter, 2.8 m deep) was formed at Oak Ridge, Tennessee over a 130-h period by joule heating as part of a test of in situ vitrification for treating contaminated soils. Melting progressed downward from the surface at a rate of approximately 2 cm per hour. Type-K, -C, and -S thermocouples (87 total) and six heat flux sensors were used to monitor the growth and thermal history of the body. Hyperliquidus temperatures during active melting ranged from 1200 to 1500 C and were significantly dependent upon power levels supplied by the joule heating. The data from widely-spaced thermocouples located within the melt suggest that no large thermal gradients were present. Chemical compositions of previous melts of this type suggest that the magma bodies are well-mixed with no chemical gradients. Upon termination of power, temperatures decreased at rates of 20 C per hour. After 12 h of cooling, a thermal arrest was observed at 1145 C in the temperature vs time profiles of widely-spaced thermocouples immersed in the melt. This arrest, which lasted for 20 h, indicated extensive crystallization and the concomitant release of latent heat. Approximately 40 h later, thermocouples 1 m from the edge of the melt recorded temperature increases, suggesting the arrival of the latent heat released during the crystallization of the melt. The total latent heat released over this 20-h period is estimated to be 4 gigajoules. This quantity of heat is more than sufficient to account for the temperature rises measured in the volume of soil surrounding the crystallizing melt. Core samples of the body confirmed its crystalline nature. Textures observed in drill core samples include void spaces containing partial fillings of long acicular crystals and holocrystalline masses of coalescing spherulites.

V52A-2 1345h

Seismic Profiling of a Man-Made Magma Chamber

R T Williams and M A Speece (both at Dept of Geological Sciences, University of Tennessee, Knoxville, TN 37996 & Environmental Sciences Division, Oak Ridge National Lab, Oak Ridge, TN 37831)

A lopolith-shaped melt, which was produced during a test of in situ vitrification for treating contaminated soils, was the target for seismic profiling. The primary purpose of this work was to produce a reference seismic data set for a well-known object that is analogous to magmatic structures in the earth, which can be used to test different seismic imaging algorithms. The melt was produced by electrically heating soil and crushed limestone for approximately 130 hours, until a maximum size of 3 m diameter and 2.8 m depth was achieved. The shape, temperature, and chemical composition of the melt were monitored by an array of thermocouples, by sampling gases and particulates, and by core- drilling the cooled, crystalline mass.

Seismic data were recorded before heating, at 3 times during heating, and at 4 times after the electrical current was turned off. Data were obtained along a profile through the center of the melt, using a shotgun source, 3-component 100 Hz geophones on the surface, and 2 vertical arrays of 3-component geophones in boreholes, one on each side of the melt. The shotpoint and geophone spacings were 1 meter. Data were also obtained along a second profile that was offset by 1 meter, approximately through the edge of the melt.

Major differences exist between data recorded at different times during heating and cooling. Changes in the traces on the transmitted or forward-scattered side of the melt are greater than on the reflected or back-scattered side. Also, differences in the travel times for the first arrivals are less obvious than travel time and amplitude changes in the later arrivals.

V52A-3 1400h

Carbon-Controlled Magmatic Oxidation State: Evidence From Reduction of Metal From a Man-Made Andesitic Magma

G K Jacobs, N W Dunbar (Environmental Sciences Division, Oak Ridge National Lab, Oak Ridge, TN, 37831); L A Taylor (Dept. of Geological Sciences, University of Tennessee, Knoxville, TN, 37996)

Metal beads up to 1 cm in diameter were observed suspended in a recently-produced man-made body of andesitic glass. The roughly hemisperical glass block, with a diameter of 6.5 m and depth of 3.6 m, was produced by resistance heating of an andesitic composition sand, as part of an in situ vitrification project at Hanford, Washington aimed at stabilization of some types of chemical waste. A 150-kg slab of metal was also found at the bottom of the melt zone, apparently formed from settled and coalesced beads. The beads are composed dominantly of Fe and P, with subordinant Co and Ni and trace Cr, in the phases schreibersite (Fe-Ni3P) and kamacite (Fe-Ni), minerals usually associated with lunar rocks or meteorites. These two phases are present in all beads, both in bleb- and lath-like forms where the schreibersite has exsolved from the kamacite matrix. Although the beads are widespread in the main glass body, none were observed in the partial melt zone of the glass around the margins of the block. Glass associated with the partial melt zone is enriched in Fe and P with respect to the main body of glass, although the only residual crystalline phase present at the boundary of the fusion zone is minor quartz. The Co/Ni ratio of ~ 1 in the metal beads is similar to that of terrestrial mafic magmas. These observations suggest that the beads were formed by reduction of Fe, P, Ni, Co, and Cr ions from the andesitic melt, and that the melt was strongly reducing, with log fO2 on the order of -12 to -16 at postulated temperatures of 1400-1600 C and P = 1 bar. The reducing conditions were controlled by the presence of abundant carbon in the melt, derived from 4 large (0.3 m diameter) graphite electrodes used to drive the resistance-induced melting. Calculations suggest that CO and CH4 may have been the dominant C-bearing gas species produced in this system.

V52A-4 1415h

Seismic Mapping of a Magma Chamber Beneath the Valu Fa Ridge, Lau Basin

Jenny Collier & Martin Sinha (Dept. of Earth Sciences, Cambridge University, CB3 OEZ, UK)

A dense grid of normal incidence seismic reflection profiles, with 40 kilometre-spaced across-axis lines and 5 ridge-parallel lines, was collected over a 35 km long morphological segment and a small overlapping spreading centre of an active back-arc spreading centre in the Lau Basin (SW Pacific) in 1988 by RRS Charles Darwin. A bright reflector, which is coincident with a velocity inversion at a depth of 3.2 ± 0.2 km below the seafloor, is observed on every across-axis profile. We interpret this reflector as being the roof of a crustal magma chamber. The widest magma chamber reflector occurs beneath the overlapping spreading centre, where it extends up to 4 km, being imaged beneath both ridges and, in places, beneath the overlap basin. Elsewhere the width of the reflector varies between 0.6 and 2.3 ±0.4 km. The narrowest reflectors are observed beneath deviations (devals) of the ridge axis. In addition to being observed on each across-axis profile the reflector is also seen as a continuous event for at least 10 km on the profile along the ridge axis.

V52A-5 1430h

Liquid Immiscibility in the Fuji 1707 Calc-alkaline Magma Chamber, Japan

Tatsuhiko Kawamoto (Dept. of Geology and Mineralogy, Faculty of Science, Kyoto University, Kyoto 606, Japan)