Altitudinal variation of in situ cosmogenic ^{14}C production rates: Preliminary results from the Southwestern U.S.

NATHANIEL LIFTON[1], JEFF PIGATI[1], A.J. TIMOTHY JULL[1,2], AND JAY QUADE[1]

[1] Geosciences Department, University of Arizona, Tucson, Arizona, 85721 USA
[2] NSF-Arizona AMS Facility, University of Arizona, Tucson, Arizona, 85721 USA

A cornerstone of applications utilizing in situ cosmogenic nuclides is the ability to scale production rates from the few sites where they are well-established to sites under study. Theoretical scaling models currently used for this purpose (e.g., Lal, 1991; Dunai, 2001) are based on modern measurements of cosmic ray variation with latitude and altitude. However, these models have never been thoroughly tested empirically using significant numbers of geologic samples.

The main problem in addressing this issue is the scarcity of samples of well-established age. However, the recent development of a reliable extraction method for in situ cosmogenic ^{14}C (in situ ^{14}C) from quartz (Lifton et al., 2001) provides a unique opportunity to test these theoretical models empirically. Unlike other commonly used in situ cosmogenic nuclides, ^{14}C has a short half-life that allows attainment of secular equilibrium in approximately 15 to 20 ky. In addition, ^{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. These aspects of the in situ ^{14}C system make a wide range of landscape features suitable archives for production rate determinations.

We have sampled along a mid-latitude altitude transect to assess the altitudinal dependence of integrated late Quaternary in situ ^{14}C production rates. Sampling site altitudes range from near sea level in Death Valley, California, to nearly 3.9 km in the Inyo-White Mountains, California. Low-altitude samples were collected from sites on stable alluvial fan surfaces exhibiting well-developed desert pavements, whereas high-altitude samples were collected from stable bedrock sites with low local relief. We plan to present preliminary results from this transect, providing a significant empirical test of the variation of integrated late Quaternary cosmogenic nuclide production rates over a major altitudinal gradient.

References

Dunai T. J. (2001) *Earth and Planetary Science Letters* **193**, 197-212.

Lal D. (1991) *Earth and Planetary Science Letters* **104**, 424-439.

Lifton N. A., Jull A. J. T., and Quade J. (2001) *Geochimica et Cosmochimica Acta* **65**(12), 1953-1969.

Radiolytic H_2 in continental crust: A potential energy source for microbial metabolism in deep biosphere

L.-H. LIN[1], T. C. ONSTOTT[1], J. LIPPMANN[2], J. WARD[3], J. HALL[1] AND B. SHERWOOD LOLLAR[3]

[1]Dept. of Geosciences, Princeton Univ., Princeton, NJ, USA (lhlin@princeton.edu)
[2]Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, USA (Lippmann@ldeo.columbia.edu)
[3]Stable Isotope Lab, Dept. of Geology, Univ. of Toronto, Toronto, Canada (bsl@quartz.geology.utoronto.ca)

Highly diffusive H_2 is essential for life in deep subsurface environments where only trace amounts of organic carbon exist. Lithoautotrophic microbes can acquire energy from the redox reactions involving H_2 with other electron acceptors (NO_3^-, Fe^{3+}, SO_4^{2-} or CO_2), to synthesise organic carbon and can be fully independent of solar-driven photosynthesis. H_2 is also crucial for abiogenic formation of hydrocarbon observed in some of Precambrian crustal gases that exhibit a carbon isotopic signature distinct from that of thermogenic hydrocarbons or biogenic methane.

H_2 concentrations in deep subsurface crustal environments range widely from sub-nM to thousands of μM. This contrasts with shallow sedimentary aquifers where H_2 levels of tens of nM are regulated by the coexistence of autotrophs/lithotrophs and heterotrophs for maximum efficiency of H_2 utilization. The excessive H_2 found in deep crustal environments implies that the microbial ecosystems there are electron-acceptor or substrate limited. The unused H_2 continues to migrate upward to the near subsurface where it is consumed by microbial communities that are electron donor limited.

Our recent analyses of dissolved H_2 and He (1, 2) of groundwater collected from the deep Au mines of the Witswatersrand Basin, South Africa suggest that substantial H_2 is generated by subsurface radiolysis of water on the time scale of millions to tens of millions of years. H_2 and He data for one sample of a saline, isolated water/gas pocket agreed exactly with that predicted by radioactive decays of U, Th, and K in the host rock and indicates a subsurface H_2 production rate of 0.1 to 1 nM/yr. Other samples yielded less H_2 than predicted and require a sink for H_2. Possible sinks include microbial H_2 oxidation and abiotic formation of hydrocarbons at rates slightly less than the H_2 production rate. Microbial H_2 oxidation may dominate over Fischer-Tropsch reactions in crustal environments where formation temperatures are <120°C; and vice versa for deeper crustal environments. This H_2 cycle may be present on extraterrestrial bodies, producing potential chemical energy and crustal scale diffusive fluxes from the interaction subsurface ice/water and radiogenic decay.

References

1. Lippmann J. et al., (2002) unpublished data.
2 .Ward J. et al. (2002) unpublished data.