In situ cosmogenic ^{14}C from surfaces at secular equilibrium

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Theoretical models currently used for scaling *in situ* cosmogenic nuclide (CN) production rates ([1], reparameterized by [2-5]) are based on modern measurements of cosmic ray variation with latitude and altitude. *In situ* cosmogenic ^{14}C (*in situ* ^{14}C) in quartz provides a unique opportunity to test these theoretical models empirically 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.

Under the CRONUS-Earth project, we are analyzing samples from saturated surfaces along altitude transects in Antarctica, Mid-Latitudes (western North America, 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. The transects extend from near sea level to as much as 5 km altitude. Surfaces for which *in situ* ^{14}C should be at secular equilibrium are being identified by prior measurements of long-lived or stable CNs, as well as geomorphic and geologic indicators of antiquity.

Results from these transects to date yield coherent trends that suggest deficiencies in each scaling model as currently implemented, despite uncertainties due to scatter potentially arising from environmental or other inter-sample variability. Initial data from both the Antarctic and Low Latitude transects agree best with predictions of the Lal/Stone model [1, 2], which neglects geomagnetic variations. Predictions of the neutron monitor-based models [3-5] for these transects agree well with the data at low altitudes, but overpredict high altitude production rates. In contrast, the western North America data agree best with the neutron monitor-based models. Interestingly, none of the models agrees with initial results from Tibet, yet each offers similar predictions. Additional analyses in progress should help further elucidate these scaling relationships.

[1] Lal (1991) *EPSL* **104,** 424. [2] Stone (2000) *JGR* **105,** 23, 753. [3] Dunai (2001) *EPSL* **193,** 197. [4] Lifton *et al.* (2005) *EPSL* **239,** 140. [5] Desilets & Zreda (2006) *EPSL* **206,** 21.

Hydropedologic investigations in the Shale Hills catchment

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Understanding complex subsurface heterogeneity and their relations to soil moisture spatial-temporal patterns and preferential flow dynamics is fundamental to watershed hydrology and biogeochemical reaction pathways. Despite significant progress made in the past decades, our ability to predict preferential flow patterns, thresholds, and pathways in the subsurface across space and time remains limited.

We hypothesize that an internal network structure exists in the subsurface of many hillslopes, which governs vertical and lateral preferential flow dynamics and a threshold-like hydrologic response under different precipitation inputs, soil types, and antecedent wetness conditions. We investigated soil moisture spatial-temporal patterns, heterogeneity of soil moisture response to varying rainfalls, triggering of sharp increase in soil moisture content, and subsurface network-like flow behaviors under varying conditions of precipitation, soil, landform, and bedrock in the Shale Hills Catchment, a Critical Zone Observatory recently established in USA. Based on our extensive soil hydrologic monitoring, we proposed different hydropedologic functional units in the catchment that show contrasting wetting-drying patterns and different first-order controls of subsurface preferential flow. By integrating soil-landscape mapping, geophysical imaging, tracer studies, and real-time monitoring, we are constructing a subsurface flow network that captures critical nodes (i.e. important junctions of flow networks that control the threshold behavior of subsurface stormflow) and the first controls of soil hydrology in the catchment.

Our study demonstrates the benefits of integrating pedological and hydrological expertise within the framework of hydropedology to enhance the monitoring and modeling of subsurface preferential flow patterns and its connection to soil and landscape features. This has important implications for better understanding of weathering processes and biogeochemical reaction pathways at different scales.