An in situ ^{14}C erosion rate method to improve the accuracy of exposure dating

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Abstract

My PhD research regards the development of a new vacuum system to extract in-situ produced cosmogenic ^{14}C from quartz and to develop new geological applications for in-situ ^{14}C. This talk will focus on a new strategy to improve the accuracy of exposure dating used to establish slip rates of active faults in Panamint Valley, Eastern California Shear Zone, USA.

The concentration of terrestrial cosmogenic nuclides (TCN) such as ^{10}Be or ^{36}Cl is dependent not only upon the duration of exposure to cosmic radiation at a given site, but also on surface erosion history, because concentration diminishes exponentially with mass depth. Establishing erosion rates of sedimentary landforms is essential for TCN dating because an imprecise estimate of erosion rate will result in an erroneous age. The process of erosion is complex and cannot be expected to be uniform either spatially or temporally. There has been no reliable and universally applicable method to determine the erosion history of a surface. Here, we demonstrate a method which takes advantage of the saturation concentration reached by in-situ ^{14}C after 35 ka. Using a measured ^{14}C concentration of a subsurface sample and its decay constant and production rate at the site, we can calculate the unique erosion rate of the surface over the past 35 ka. To test the approach, we revisited four sites in Panamint Valley where ^{10}Be depth profile exposure ages had been measured. Subsurface (35-65 cm below the surface) samples were taken in each pit in 3-5 cm thick layers avoiding soil mixing zones. The samples were purified to quartz sand and the Dalhousie carbon-14 extraction line laboratory was used to extract the ^{14}C as CO_2 from 5-g aliquots of each purified sample. The gas was analyzed for ^{14}C at the ETH Zurich AMS laboratory. Using the ^{14}C concentrations, the erosion rates for each site were calculated using a depth-dependent erosion rate calculator. The field-estimated erosion rates (negative rates indicate aggradation) and the calculated erosion rates at each site were: PAN-01: -1.5±4.5 mm/ka and -6.3±2.6 mm/ka, for PAN-27: 0±4 mm/ka and 0.9±0.8 mm/ka, for PAN-28-02: 0±4 mm/ka and -5.4±3.2 mm/ka and for PAN-28-03: 0±4 mm/ka and 2.1±1.2 mm/ka. The last site, PAN-10, was deemed unusable due to complications in the extraction resulting in lower than expected ^{14}C concentrations and unreasonably high erosion rates. The resulting ages calculated using the ^{14}C-calculated erosion rates and the Hidy et al. (2013) depth profile calculator were within error of those calculated using the field-estimated erosion rates, however, for PAN-01 the uncertainty was reduced (PAN-01 was $79^{+24.5}/_{-18.2}$ ka and is now $61.5\ ^{+13.5}/_{-17.7}$ ka), and for PAN-27 and both of the PAN-28 samples the ages are now slightly older. The results provide a more robust chronology for slip rates on strike-slip and normal faults in Panamint Valley.

By reducing the process blank (the ^{14}C extracted under normal conditions but without a ^{14}C-bearing sample), the measurement of the ca. 10^5 atoms of in-situ ^{14}C is achieved more precisely. In order to improve the process blank, a new extraction line was designed over the past two years and is currently being built. The current status of this new line will also be presented.
