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Cosmogenic 3He and 21Ne measured in artificial quartz targets after one year of exposure in the Swiss Alps

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All currently used scaling models for Terrestrial Cosmogenic Nuclide (TCN) production rates are based on neutron monitor surveys. Therefore, an assumption underlying all TCN studies is that production rates are directly proportional to secondary cosmic ray intensities for all cosmogenic nuclides. Several efforts are underway to test this crucial assumption in the framework of the CRONUS-EU and CRONUS-Earth initiatives. The bulk of this work is done on lava flows of known age. In a complementary effort, we here present the first results of an alternative approach measuring, for the first time, cosmogenic ^{3}He and ^{21}Ne in artificial quartz targets after one year of exposure at mountain altitudes in the Swiss Alps.

The targets were inconel stainless steel tubes containing one kg of artificial quartz sand (250-500μm), degassed for one week at 700°C in vacuum prior to exposure. Quartz was used as the target material, as it is the most commonly used mineral for exposure dating and both cosmogenic helium and neon are produced and retained in the target container. Pre-exposure blank measurements revealed ^{21}Ne- and ^{3}He-concentrations of about 5×10^{5} and 5×10^{4} atoms per container, respectively. In August of 2006, two targets were exposed at each of five locations in Switzerland: Zürich (556m), Davos (1560m), Säntis (2502m), Jungfraujoch (3571m), and Monte Rosa (4554m). Additionally, a sixth set of two blank targets was stored in the basement of the noble gas laboratory at ETH-Zürich, ~15m below street level, and effectively shielded from all cosmic ray exposure. Exactly one year later, the targets were retrieved and measured in said lab.

Cosmogenic noble gases were measured at room temperature and 700°C. Between 10 and 30% of the cosmogenic ^{3}He was measured in the cold step, confirming earlier experiments indicating that ^{3}He diffuses out of quartz at room temperature. The remaining ^{3}He was released at 700°C. No ^{21}Ne was measured in the cold step, but $>$99% of the cosmogenic ^{21}Ne was released at 700°C, as evinced by a repeat measurement at 800°C for the Monte Rosa target. At the time of writing, significant amounts of cosmogenic ^{3}He was found in four of the five exposed targets, while a blank target showed an almost atmospheric composition. A leak in one of the targets (mount Säntis) precluded its ^{21}Ne measurement, but by April 14, we will measure the duplicate target for this location, as well as the fifth and final target (Zürich), thus further improving the precision of our experiment before the EGU meeting.

As expected, the Monte Rosa target contained the highest cosmogenic nuclide contents, with 1.6×10^6 atoms of excess ^{3}He and 4.3×10^5 atoms of excess ^{21}Ne. After correction for blanks, shielding (roof + container wall), and solar modulation (five solar cycles), this corresponds to weighted mean production rates at sea level and high latitude of 55.2 $\pm$ 2.7 a/g/yr for ^{3}He and 16.9 $\pm$ 1.9 a/g/yr for ^{21}Ne (all errors are 2σ). Assuming a ^{3}H/^{3}He branching ratio of 0.5, the long term ^{3}He production rate would, thus, be $\sim$110 a/g/yr. Given the unusually high solar activity during recent decades compared to the previous 11,000 years which, if corrected for, would slightly increase our production rates, these estimates agree extremely well with production rates derived from long-term exposure experiments at natural calibration sites.

The main goal of the artificial target experiment, however, was not to estimate accurate production rates, but to determine the production rate attenuation length. Because all our targets had an identical design and were exposed at identical conditions, all systematic errors should cancel out in the calculation of an attenuation length. Based on our preliminary results, the best estimates for the ^{3}He and ^{21}Ne attenuation lengths are 132 $\pm$ 22 g/cm^2 and 157 $\pm$ 49 g/cm^2 (2σ), respectively, again agreeing very well with current scaling models. Thus, we see no evidence for an anomalously low attenuation length for the cosmogenic noble gases, as recently suggested by Amidon et al. [EPSL, 2008, vol 265, p. 287-301].