AN ANTARCTIC PERSPECTIVE ON IN-SITU COSMOGENIC NUCLIDE PRODUCTION

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Long-term average production rates of some nuclides can be constrained by examining slowly eroding, old rock surfaces. At steady state with respect to production and radioactive decay, production rates are simply calculated from concentration data (e.g., P=Nλ), as long as erosion is negligible (Brook et al. 1995). The possibility that erosion is non-negligible makes these production rates minimum values. Examination of our and other published 26Al data (half-life 7.2 × 10^5 yr) from a total of 15 Antarctic rock surfaces with 10Be exposure ages older than 2 Ma (and therefore model erosion rates <7 cm/Ma) yields 26Al production rates that agree well with the published Sierra Nevada rates (Nishiizumi et al. 1989), assuming the altitude/latitude scaling of Lal (1991). The samples span an altitude range of 1380 to 2650 m and at each sample altitude the calculated production rates agree with the scaled Sierra Nevada rates within ~10%. The sea level production rate derived from the data (Lal 1991) is 35 ± 2 at/g/yr, close to the predicted value (Lal 1991) of 37 at/g/yr. These observations suggest that the long-term average 26Al production rate is not higher than, and is probably close to, the value determined for glaciated bedrock in the Sierra Nevada exposed over the last ~11 ka. The results also imply that the scaling factors (Lal 1991) are accurate within the latitude and altitude range considered here (excepting the possibility of compensating errors). As there is no reason to expect temporal variations in the 26Al/10Be production ratio, the long-term 10Be production rate is also probably close to the Sierra Nevada rate (Nishiizumi et al. 1989). These conclusions are similar to those of Nishiizumi (this issue).

We have also collected two 1–1.5 m drill cores in Antarctic sandstone bedrock to examine the depth dependence of 10Be, 26Al, and 3He production. 10Be and 26Al profiles from one core were reported previously (Brown et al. 1992). Both cores have exponential profiles; scale lengths are close to expected values and are 152 ± 5 and 145 ± 5 g/cm² for 10Be and 153 ± 13 and 152 ± 5 g/cm² for 26Al. Contrary to the calculations of Nishiizumi et al. (1989), these data indicate that muons produce <1–3% of total 10Be and 26Al at the altitudes and latitude of these cores, consistent with previous conclusions (Brown et al. 1995) based on a depth profile of 10Be at low altitude near the equator.

The situation for 3He is more complicated. One of the two cores exhibits an exponential decrease in cosmogenic 3He with a scale length of ~150 g/cm². The second has a distinctly higher scale length, 227 ± 14 g/cm², over a similar depth interval. Studies of different size quartz grains in each core show that the discrepancy, which can be thought of as "extra 3He" at depth, or loss of 3He at the surface, is not an artifact of diffusion. It also does not appear to be caused by the presence of a non-cosmogenic 3He component. Production of 3He by muons is a remaining possibility. A model that includes the processes of erosion, diffusion, and 3He production by neutrons and muons can approximately reproduce the observed profile with reasonable parameters, if exposure times are very long (e.g., of order 20 Ma or greater), and if production of muons is ~10% of total production at 1700 m. While we are uncertain if this explanation of our data is correct, our observations suggest that further investigation of production rates of 3He due to muon interactions is warranted.

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