REFINING ESTIMATES OF ^{10}BE AND ^{26}AL PRODUCTION RATES

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We have taken a variety of approaches to refine the existing ^{10}Be and ^{26}Al production rate estimates of Nishiizumi et al. (1989) including measuring nuclide abundances on boulders and bedrock surfaces exposed on the relatively well-dated Laurentide moraine, making altitude and latitude corrections using different, now currently-accepted protocols, and modeling the effect of changing geomagnetic field strength on production rates over time.

In north-central New Jersey, we collected 16 samples of quartzite and gneiss from striated and/or glacially molded outcrops and large glacial erratics on or just behind the terminal moraine of the Laurentide ice sheet (Larsen, 1995). The exposure age of the moraine is estimated to be ~21.5 ky sidereal years on the basis of several limiting ^{14}C ages. The calibration of these radiocarbon ages is based on the recommendations of Stuiver et al. (1991). Average concentrations and standard errors of the mean of $1.37 \pm 0.04 \times 10^5$ (n=12) atoms g^{-1} SiO_2 for ^{10}Be and $8.03 \pm 0.29 \times 10^5$ (n=14) atoms g^{-1} SiO_2 for ^{26}Al can be used to calculate integrated sea-level, high-latitude production rates and associated standard errors of the mean of 5.17 ± 0.15 and 30.40 ± 1.01 atoms g^{-1} $year^{-1}$ for ^{10}Be and ^{26}Al, respectively. The isotope abundances show no significant variation between boulder and outcrop sample locations and quartzite and gneiss sample lithologies implying that the effects of erosion and till cover are negligible. We have scaled these abundance data to sea level and high latitude using the neutron data of Lal (1991) following the finding by Brown et al. (1995) that muon production is insignificant; however, because our samples were collected at relatively high latitude (41°) and low altitude (300 m), the choice of scaling protocol is unimportant. The integrated production rates calculated over the past 21.5 ky period are about 18% lower than previously determined integrated production rates over the 11 ky (Nishiizumi et al., 1989) and 50 ky (Nishiizumi et al., 1991b) time frames.

Comparing these three different production rate estimates is not straightforward. Each was calculated from samples exposed for varying lengths of time at different altitudes and latitudes. Scaling the lower-latitude, higher-altitude measurements from the Sierra Nevada and Meteor Crater to sea level and high latitude involves choosing an effective geomagnetic latitude for the duration of exposure, determining the contribution of muons to ^{10}Be and ^{26}Al production as a function of altitude and latitude, and determining how instantaneous production rates have changed over the duration of exposure at each site.

We find that by assuming muon production is inconsequential at sea level (Brown et al., 1995), scaling the three data sets for spallation only, and incorporating a geomagnetically-driven production rate forcing model (Clark et al., 1995; Clapp and Bierman, in review), the three different production rate estimates can be reconciled to within several percent if the exposure age of the Sierra Nevada calibration sites is taken to be 13.5 ky as suggested by Clark et al. (1995). Although such agreement is promising, additional data must be gathered to test these findings. Until those data have been gathered, nuclide production rates as a function of altitude, latitude and exposure duration will remain a significant uncertainty in the interpretation of nuclide abundance data.