DR2004130

DATA REPOSITORY: Sample preparation and data analysis

Sample preparation

Samples were prepared by crushing to ~0.5 mm, then purifying quartz through a series of chemical and physical treatments. All samples were first leached in aqua regia. When necessary, mafic minerals were separated magnetically and heavy minerals were separated in lithium metatungstate. All samples were then leached in a series of 1% hydrofluoric/nitric acid baths, agitated first on commercial hot-dog rollers followed by an ultrasonic bath to remove aluminosilicates and meteoric ^{10}Be (Kohl and Nishiizumi, 1991). The purified quartz was then dissolved in 5:1 hydrofluoric/nitric acid, and an aliquot taken for aluminum determination by atomic absorption spectrophotometry. Upon drydown, fluorides were removed by repeated fuming in sulfuric acid. Iron was removed by ion exchange in 10 N HCl. Titanium was removed through ion exchange in sulfuric acid following Child et al. (2000), and aluminum and beryllium were separated on a cation exchange column. Aluminum and beryllium were precipitated as hydroxides and rinsed in water, then oxidized in a furnace at 1100ºC. Aluminum was mixed with silver, and beryllium with niobium for AMS analyses. All measurements were made at Lawrence Livermore National Laboratory

AMS measurements and ^{10}Be half-life

AMS measurements of ^{10}Be/^{9}Be were made at Lawrence Livermore National Laboratory (LLNL) against a standard derived from an ICN solution This standard is calibrated by activity, so its $^{10}Be/^{9}Be$ ratio depends on the half-life of ^{10}Be. There are two conflicting estimates for the ^{10}Be half-life (Middleton et al., 1993): 1.34 m.y. and 1.51 m.y.. The half-life of 1.51 m.y. has been traditionally used at LLNL. Recent evidence suggests that the half-life of 1.34 m.y. is more nearly correct (M. Caffee, personal communication). This half-life is based on activity and Be concentrations measurements made by NIST on the same aliquot. Adjusting the LLNL standard to the NIST half-life requires reducing ^{10}Be concentrations by 14%. Production rates measured against the same standard must also be changed accordingly. These changes do not affect interpretation of surface exposure ages, but are important when accounting for radioactive decay.

Modeling terrace age and erosion rate

Cosmogenic nuclide production and decay was modeled through analytical solution of an approximation made by Granger and Smith (2000), shown as equation (DR1).

$$
\begin{aligned}
N = N_{\mathrm{inh}}e^{-t/\tau} &+ [P_n e^{-\rho z/\Lambda} / (1/\tau + \rho\varepsilon_{\mathrm{terr}}/\Lambda)][1 - e^{-t(1/\tau + \rho\varepsilon_{\mathrm{terr}}/\Lambda)}] \\
&+ [YA_1 e^{-\rho z/L1} / (1/\tau + \rho\varepsilon_{\mathrm{terr}}/L_1)][1 - e^{-t(1/\tau + \rho\varepsilon_{\mathrm{terr}}/L1)}] \\
&+ [YA_2 e^{-\rho z/L2} / (1/\tau + \rho\varepsilon_{\mathrm{terr}}/L_2)][1 - e^{-t(1/\tau + \rho\varepsilon_{\mathrm{terr}}/L2)}] \qquad \text{(DR1)} \\
&+ [Be^{-\rho z/L3} / (1/\tau + \rho\varepsilon_{\mathrm{terr}}/L_3)][1 - e^{-t(1/\tau + \rho\varepsilon_{\mathrm{terr}}/L3)}],
\end{aligned}
$$

where $\varepsilon_{\mathrm{terr}}$ is the terrace erosion rate, $A_1 = 170.6$ and $A_2 = 36.75$ at sea-level and high latitude, $L_1 = 738.6$ g cm^{-2}, $L_2 = 2688$ g cm^{-2} and $L_3 = 4360$ g cm^{-2}, $Y_{Al} = 4.24 \times 10^{-3}$ and

B_{Al} = 0.192 for ^{26}Al and Y_{Be} = 4.91 x 10^{-4} and B_{Be} = 0.023 for ^{10}Be (adjusted for a half-life of 1.34 m.y.). Modeling cosmogenic nuclide concentrations is thus possible through the use of well-constrained production rates and penetration lengths, and the variables t, z, N_{inh} and ε_{terr}.

The last term added in Equation (DR1) addresses cosmogenic nuclide production at depth by fast muons, which remains poorly constrained (e.g., Braucher and others, 2003). The constants B and L_3 in this term are derived from values in Heisinger (1998), which differ from those of Heisinger et al. (2002a; 2002b) due to a different parameterization for muon energy with depth. For our sites, if we use the cross section of Heisinger (2002b) then the terrace age increases by ~0.1 m.y.; ignoring fast muons altogether lowers the apparent age by a similar amount. This additional uncertainty does not affect our conclusions, and is not included in our reported uncertainties.

References:

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