Erosion Rates Over Millennial and Decadal Timescales at Caspar Creek and Redwood Creek, Northern California[1]

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Erosion rate measurements are essential for modeling landscape evolution and for understanding how sediment loading affects stream ecosystems. Traditionally, erosion rates have been determined by measuring stream sediment fluxes over timescales of 10 to 100 years. At Caspar Creek and Redwood Creek in northern California, stream sediment fluxes have been measured since 1963 and 1973, respectively (Henry 1998, Nolan and others 1995), and these studies have yielded two of the longest and most detailed records of stream sediment loading in northern California.

We have applied a new technique (Brown and others 1995, Granger and others 1996) at Caspar Creek and Redwood Creek to measure erosion rates averaged over the past several millennia. The concentration of cosmogenic nuclides such as ^{10}Be in stream sediments can be used to estimate whole-catchment erosion rates averaged over thousands of years, a timescale that is unobservable by conventional methods.

Cosmogenic nuclides are isotopes produced through interaction with the cosmic radiation that continually bombards the Earth; ^{10}Be, for example, is an isotope produced in quartz only when quartz is exposed to cosmogenic neutrons and muons (for example, Lal 1991). Since these neutrons and muons only penetrate the upper few meters of soil and bedrock, the concentration of ^{10}Be in quartz reveals how long that quartz was within the penetration depth of cosmic radiation. A high concentration of ^{10}Be in quartz indicates a long exposure time, and hence a slow erosion rate; conversely, a low concentration of ^{10}Be indicates a short exposure time and a fast erosion rate. By measuring the concentration of ^{10}Be in well-mixed stream sediment, we assume that we obtain an erosion rate that is a representative average of the rates of erosional processes upstream of the sample collection site. This method yields an erosion rate that is an average in time (over the past several thousand years) and an average in space (over the drainage basin area).

Comparing long-term (>1000 year) erosion rates from cosmogenic nuclides with short-term (<100 year) sediment yields can shed light on erosional processes and on the effects of land use on sediment delivery to streams. Using cosmogenic ^{10}Be, we measured erosion rates averaged over the past several thousand years at six sites in Caspar Creek and four sites in Redwood Creek, and compared these rates to sediment

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yields measured at Caspar Creek since 1963 and at Redwood Creek since 1974. Millennial-scale erosion rates at Caspar Creek agree with each other within error, and long-term erosion rates at our Redwood Creek field sites vary by about a factor of 3 between basins. Our cosmogenic ^{10}Be measurements at Caspar Creek imply an average erosion rate of 0.09 mm/yr, which agrees with short-term sediment yields (Cafferata and Spittler 1998) within error. Our cosmogenic ^{10}Be measurements at Redwood Creek indicate an average long-term erosion rate of ~0.4 mm/yr, which is in rough agreement with measurements of stream sediment flux over the past several decades. These results imply that sediment yields measured at Caspar Creek and Redwood Creek over the past few decades are broadly consistent with long-term average rates of sediment production by hillslope processes.

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