Our program calculates instantaneous ^{10}Be and ^{26}Al production rates at any given sample site (altitude and latitude) and outputs both geomagnetically calibrated and uncalibrated exposure ages from sample isotopic abundance data. Calibration, such as we propose, will likely increase the accuracy of exposure ages and once verified by additional data, may allow for more robust cosmogenic dating and correlation of relatively brief geomorphic and climatic events. Our program is available as user-friendly, compiled Macintosh code by anonymous ftp from `beluga.uvm.edu`.

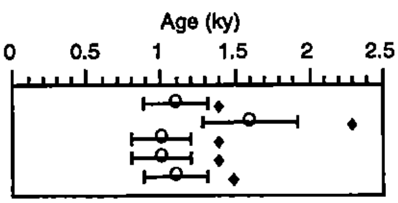

Fig. 1. Calibrated ^{10}Be exposure ages from COSMO-CALIBRATE 1.7 (diamonds) and uncalibrated ^{10}Be exposure ages (Bierman *et al.*) calculated using production rates of Nishiizumi *et al.* (1989), for 11,000 cal yr BP (open circles).

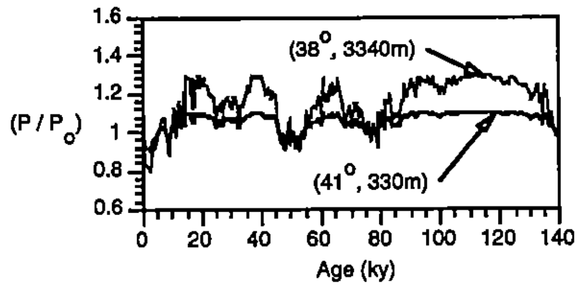

Fig. 2. Relative instantaneous production rates calculated by COSMO-CALIBRATE for two study sites: Sierra Nevada (38°, 3340 M) and the Laurentide Terminal Moraine (41°, 330 m)

^{10}Be AND ^{26}Al PRODUCTION RATES AND A REVISED GLACIAL CHRONOLOGY FOR THE SIERRA NEVADA

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New ^{14}C ages for Sierra Nevada deglaciation suggest that currently accepted late-Pleistocene production rates of *in-situ* cosmogenic ^{10}Be and ^{26}Al are ~20% too high because the assumed age of exposure is too young. The original production rates for the isotopes were calibrated based on measurements of glacially polished granite from the Sierra Nevada, assumed to have been deglaciated ~11,000 calibrated (or sidereal) years ago (11,000 cal yr BP) (Nishiizumi *et al.* 1989). This exposure age was estimated from minimum-limiting conventional radiocarbon ages of ~10,000 ^{14}C yr BP for basal bulk sediments from two sites, a lake and a meadow, dammed behind Tioga (last late-Wisconsin maximum) recessional moraines (Adam 1967; Mezger and Burbank 1986).

Calibrated ages (Bard *et al.* 1990; Stuiver and Reimer 1993) of 12 new ^{14}C dates, of basal or near-basal lake sediments from cores of ten postglacial lakes, show instead that Sierra Nevada deglaciation was underway by 16,000–19,000 cal yr BP (~13,500–16,000 ^{14}C yr BP) and that the range was effectively deglaciated before ~13,100 cal yr BP (11,190 ^{14}C yr BP) (Clark *et al.* 1995; Clark and Gillespie, in press). The coring sites all lie inside the maximum Tioga ice limits, as do the two cited by Nishiizumi *et al.* (1989), and thus provide minimum ages for onset of deglaciation. The highest sites near the crest of the range, however, provide minimum ages for complete retreat of Tioga glaciers and thus minima for the exposure age of sites sampled by Nishiizumi *et al.* for calibration. The highest lakes we cored, in the headwaters of Bishop Creek, are formed behind moraines of the Recess Peak advance, which ended before 13,100 cal yr BP (Clark and Gillespie, in press). We have mapped and correlated Recess Peak moraines along the crest of the Sierra from southern to northern limits of the advance, and find that all calibration sites of Nishiizumi *et al.* lie downstream from Recess Peak moraines in those drainages. Thus, our minimum age control for the Recess Peak advance in Bishop Creek also provides a firm minimum age for exposure of the calibration sites. The accuracy of the AMS ^{14}C dates from the Bishop Creek cores is supported by: 1) other dates from higher in the same cores that are internally consistent; 2) parallel dates between adjacent gyttja and macrofossils in the cores that are indistinguishable within 1-sigma analytic error (typically <1%); 3) similar findings in dates of cores from other areas that also are internally consistent; and 4) absence of sources of contamination, especially "old" carbon, in the drainage basins upstream from the lakes. These observations substantiate the stability of carbon in high Sierran lake basins. Together, the new limiting ^{14}C dates indicate that Tioga deglaciation occurred at least 2000 cal yr before 11,000 cal yr BP.

Recalculating the production rates using the formulation and measured abundances of Nishiizumi *et al.* (1989) but assuming the sites were deglaciated 13,500 cal yr BP yields sea-level, high-latitude production rates that are ~20% lower than in the original calibration for both isotopes. This difference agrees within several percent of an independent late-Pleistocene calibration from the Laurentide terminal moraine in New Jersey (Larsen 1995), if appropriate latitudinal scaling and the affects of geomagnetic field-strength fluctuations on production rates are considered (Clark *et al.* 1995; Clapp and Bierman 1995). Our results emphasize the need for accurate, independent age control and geologic context as primary foundations for production-rate calibrations of cosmogenic nuclides.

Additional references

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PLANS FOR CALIBRATION OF THE COSMIC RAY FLUX OVER THE PAST 500,000 YEARS USING VOLCANIC ROCK

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While recent measurements of neutron fluxes can be combined with nuclear reaction data using Monte Carlo simulation techniques to predict the current production rates of cosmogenic nuclides, such techniques cannot be used to explore the past history of the cosmic ray flux (CRF). Although certain effects are fairly well understood or modeled, such as short-term cycling of the CRF at the surface of the Earth in response to variations in the Earth's magnetic field, other variations are not as well categorized. While some ice cores and similar historical record-keepers provide some insight into the past, it is the intent of this project to calibrate the method of ^{36}Cl rock exposure dating, and hence the cosmogenic production rates, back through 500 ka by comparing the ^{36}Cl concentrations with $^{40}Ar/^{39}Ar$ data in collected samples from the central Andes.