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Scaling matters – exposure age uncertainties from a user's point of view with examples from the Central Andes

J. Ilgner, R. Zech, H. Veit

Institute of Geography, University of Bern, Switzerland, (ilgner@giub.unib.ch / Fax: +41 31 631 8511 / Phone: +41 31 631 8019)

Surface Exposure Dating (SED) using terrestrial cosmogenic nuclides, like ^{10}Be, has become an important method to determine the deposition age of moraines and thus to establish glacial chronologies. The potential of this new dating method for the reconstruction of past climate changes is huge. Systematic uncertainties, however, still need to be better constrained. Those are mainly related to the reference production rate and to scaling. Scaling systems are necessary to calculate the altitude- and latitude-dependent production rate for a specific sampling site. Several calculation schemes have been published. They differ, for example, in how they parameterize the cosmic radiation and whether and how they include corrections for the temporal variability of the geomagnetic field.

We compared virtual exposure ages calculated using various scaling systems and illustrate the differences on a world-wide grid for different altitudes and exposure ages. Generally, the more recently developed scaling systems yield similar results, but compared to the still most widely used calculation scheme following Stone (2000: J. Geoph. Res. 105: 23,753-23,759), age offsets at high altitudes (4000 m) can be up to 30%. This constitutes a major problem for paleoclimatic reconstructions based on exposure ages in high mountain areas.

We present a case study from the Central Andes in Bolivia, where calculations according to Stone (2000) would indicate an early local Last Glacial Maximum (LGM) at $\sim$30 ka. Calculations based on the more recent scaling systems, however, yield much

younger exposure ages so that the glacial advances seem to be better in-phase with the temperature minimum during the global LGM and the maximum of the global ice volume. Another example comes from semi-arid NW-Argentina, where exposure ages could either be interpreted to document LGM advances at $\sim$20 ka (Stone, 2000) or as evidence for glacial advances synchronous with the Late Glacial lake transgression phase ("Tauca": $\sim$16 ka) (other scaling systems). Both cases show that the choice of the scaling system can result in totally different paleoclimatic implications and that local calibration studies, particularly at high altitudes, are indispensable to reduce the current systematic uncertainties of SED.