Glacial boulder exposure ages from the Tibetan Plateau – old deposits and post-glacial shielding

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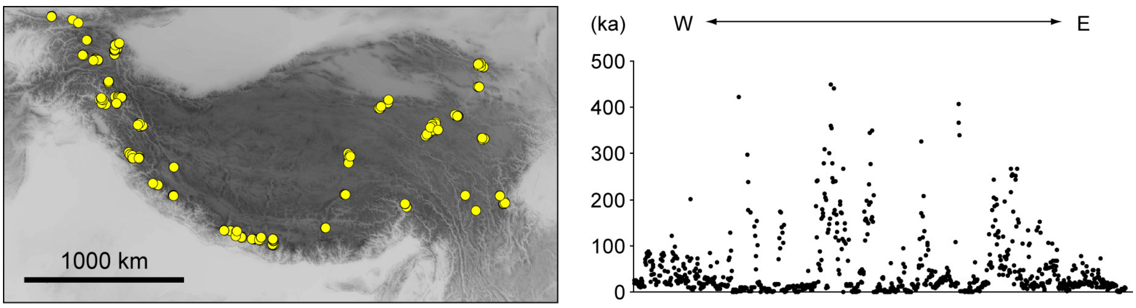
Terrestrial cosmogenic nuclide (TCN) exposure dating is an important chronological tool in Quaternary glacial geology. For the Tibetan Plateau, with its lack of organic material (hindering radiocarbon dating) and high altitude (yielding high cosmogenic isotope production rates), TCN dating has been widely used over the last 10 years to provide evidence for limited glacial expansion during the last glacial cycle. However, for a large number of TCN samples, apparent exposure ages deviate from depositional ages as shown by wide age spreads from multiple samples. There are two principal geological explanations for the presence of incorrect and varying exposure ages; 1) pre-glacial exposure and 2) post-glacial shielding. While pre-glacial exposure results in inherited cosmogenic isotope concentrations (yielding too old exposure ages), post-glacial shielding results in reduced cosmogenic isotope concentrations (yielding too young exposure ages). To evaluate the likelihood of each explanation, and to provide guidance on how to interpret the often complex TCN exposure assemblages, we have compiled a large data set of 945 ^{10}Be TCN ages from glacial boulders on the Tibetan Plateau and 578 ^{10}Be TCN ages from glacial boulders displaced by Laurentide and European ice sheets.

TCN ages from the Tibetan Plateau derive from 237 groups with multiple boulders. The grouping of boulders allows us to evaluate the age spread for locations of the same age. All TCN ages have been recalculated (from original publications) using the CRONUS-Earth online calculator version 2.2 (http://hess.ess.washington.edu/) which standardizes measurements using different ^{10}Be standards (thus allowing comparison of multiple TCN age studies) and applies a new ^{10}Be half-life of 1.36 Ma.

TCN apparent exposure ages range from 0 to 450 ka and reveal a clear trend with wider age spread (higher uncertainty) with increasing age (valid for both minimum and maximum ages). This characteristic may be explained by shielding during post-glacial time, or, alternatively, would require very high and increasing inheritance with age if explained by pre-glacial exposure. To further evaluate these two explanatory models, we have employed two simple numerical models simulating inheritance and post-glacial shielding. We have also compared the Tibetan age spreads with glacial boulder ^{10}Be TCN ages for the Laurentide and European ice sheets, for which we have a relatively good idea of the glacial chronology.

The outcome of our analysis is that, although we can not rule out inheritance for individual boulders, post-glacial shielding is a far more poweful explanatory model to explain the increasingly wide age spreads. By inference, the glacial boulder TCN record of the Tibetan Plateau reveals a paleoglaciological record which is significantly older than normally found in the Northern Hemisphere; with discernable glaciations up to several hundred thousand years old.



Locations of glacial boulder TCN samples on the Tibetan Plateau (left) and apparent exposure ages arranged from west to east (right).