What are the major drawbacks or limitations of cosmogenic nuclide dating of glacially transported boulders or glacially eroded bedrock in Antarctica?

Asked by Subrat

Hi Subrat,

This is a great question. Cosmogenic nuclide dating works really well in Antarctica because the lack of organic material often precludes radiocarbon dating (although advances have been made, for example, by dating bird vomit!). Cosmogenic nuclide dating can be applied to glacially transported boulders or glacially eroded bedrock, and gives an indication of when an area became ice-free. The key limitations are:

1. Insufficient erosion. Cold-based glaciers in Antarctica may transport erratic boulders slowly but may apply minimal erosion. This means that boulders or bedrock may have an 'inheritance', where they contain cosmogenic isotopes inherited from a previous exposure. This is particularly possible in bedrock. You can screen for this using a two isotopes with different isotopes (typically aluminium-26 and beryillium-10) but this will only pick up large-scale inheritance.
2. Exhumation and burial. Periglacial environments are subject to strong rock cycling within the active layer, which can bury or exhume boulders, leading to inaccuracies in their estimated exposure age.
3. Rolling and rotation. Landforms such as moraines are subject to degradation and anything on a slope moves downslope under solifluction. This can lead to previously hidden faces of the boulder being exposed, and again can lead to errors in age estimation.
4. Burial by snow. This can be a problem in Antarctica, but it is windy, so if your boulder is in an exposed location and raised above the local land surface, it should not be a problem.

If the above criteria have not been satisfied, the boulder has had a *complex exposure history* and the results will typically show *geological scatter*, with a wide range of ages. To avoid these errors, it is vital to have a good sampling strategy. The ideal boulder should have:

1. Signs of glacial transport (rounded edges, faceting, striations), which suggest that sufficient erosion has occurred;
2. Be on a stable platform that has not moved, rotated or rolled;
3. Little evidence of rotting and disintegration through *in situ* rock weathering, through wind erosion or otherwise;
4. Be located on a stable platform ideally raised about 1 m above the local land surface to reduce the likelihood of burial by snow, vegetation (less likely in Antarctica) or superficial sediments;
5. Be large (about 1 m b-axis), meaning that you can sample in the centre, away from any cracks and joints, thus avoiding edge-effects (some people argue that you can sample smaller cobbles,

as long as the above criteria are satisfied);

6. Ideally the boulder should relate to a datable landform such as a moraine; the context that the boulder relates to is key.

Further reading:

- Cosmogenic nuclide dating (this site)
- Cosmic rays (this site)
- Quantifying ice-sheet thinning using cosmogenic nuclides (this site)
- Cosmogenic nuclide analysis (Darvill, 2013)