Calculating and presenting cosmogenic nuclide ages

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Cosmogenic Nuclide Calculators

A number of calculators are available for the calculation of cosmogenic nuclide ages. These presently include IceTEA (Jones et al., 2019), CREp (Martin et al., 2017) and the online calculators formerly known as the CRONUS-Earth online calculators (Balco et al., 2008; Marrero et al., 2016a; Phillips et al., 2016).

These calculators allow for the selection of various scaling schemes and production rates and allow cosmogenic nuclide ages to be easily recalculated. These calculators require that data is formatted in a particular way.

Essential required data to include in publications

Essential required data include when presenting cosmogenic nuclide exposure-ages:

- sample ID
- AMS standard
- $^{10}Be/^{9}Be$ ratio
- latitude
- longitude
- altitude
- AMS measurement of nuclide concentration and measurement uncertainty,
- Sample thickness,
- Sample shielding,
- sample density,
- Erosion rate,
- Date of sample collection

(Balco, 2011; Balco et al., 2008; Dunai and Stuart, 2009; Gosse and Phillips, 2001).

Specify scaling scheme and production rate

The practitioner should present and justify their chosen production rate and scaling scheme. These data will allow readers to recalibrate ages with different production rates or scaling schemes.

Specify corrections applied

The practitioner should explain their chosen erosion rate, and ideally present results with a zero erosion rate as well as any other erosion rate used. Any other corrections used (e.g. snow cover) should also be explained and evaluated.

Elevation change due to isostatic uplift may be a significant cause of age variation, and can be taken into account by some calculators (such as IceTEA, Jones et al., 2019).

Internal and external uncertainties

Exposure-age calculators will produce *internal* and *external* uncertainties. Both should be presented.

Internal uncertainties are those only associated with the measurement error in the nuclide concentration. They are the same for all scaling schemes (Balco, 2011; Balco et al., 2008).

External uncertainties include those corresponding to the production rate and scaling scheme, with production rate sites that may be hundreds to thousands of kilometres apart and elevational scaling over thousands of metres. External uncertainties are systematic when all cosmogenic nuclide data is processed in the same way, and so exposure ages can be compared within a given area using internal uncertainties.

However, when comparing exposure age data to other independent dating methods (such as radiocarbon dating), external uncertainties should be used