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Limitations and prospects for surface exposure dating precision

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The timing and rate of Younger Dryas (YD) ice cap deglaciation in Scotland is contested. Contradictory empirical studies have inferred that the Younger Dryas (YD) ice cap in Scotland was at its maximum extent late in the YD and conversely that Scotland was entirely deglaciated. Understanding how the abrupt YD temperature change influenced ice retreat rates relies on precise constraints on deglaciation rates. Currently the only technique for determining deglaciation ages directly from landforms left behind by retreating ice is surface exposure dating using accelerator mass spectrometry (AMS), but AMS suffers from metrological limitations. For 10Be, the most commonly used cosmogenic nuclide, precision of 1% has been claimed in some publications but this is usually based on individual sample measurement statistics rather than the repeatability of YD equivalent 'age' standards, which usually perform at 2-3% during AMS experiments. This introduces relative uncertainties of 200-300 years which prevents resolution of chronological inconsistencies.

AMS measurement precision can be improved with operational changes but there will always be limitations associated with sputter ion sources. Here we present a state-of-the-art new technology, invented at SUERC, which has been demonstrated to be able to measure the rare radionuclides 14C and 26Al using positive ion mass spectrometry (PIMS). PIMS represents a step change in rare isotope metrology equivalent to the change from 14C decay counting to 14C-AMS. PIMS addresses current limitations of sputter ion sources in sample to sample scatter and counting statistics by using a plasma ion source to extract a large, stable positive ion beam from the sample. A patent pending process removes interferences to the measurement from the beam by simultaneously destroying molecules and converting the beam from positive to negative charge. The treated beam is free from any interferences because the isobaric interference to both 14C and 26Al (which are 14N and 26Mg) do not form negative ions. Other advantages to using Al-PIMS over Be-AMS include lower backgrounds (there is no meteoric contamination for 26Al) and aluminium samples usually do not need to have carrier added, plus simpler and safer (no toxic BeO) sample preparation chemistry. A customised system has been built and used to demonstrate that the technique can surpass conventional AMS for 14C measurements. This process is now being extended to 26Al.