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Quantifying site-specific Holocene soil erosion using depth-profiles of cosmogenic in-situ ^{14}C and ^{10}Be

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The sustainable use of soils represents one of the key challenges that society faces. Glacial sediments (tills and moraines) form the parent material of soils in many parts of the northern hemisphere but little is known about the histories of these soils. Several methods of estimating soil erosion exist but these have limitations, mainly in that they are unable to quantify at-a-site soil erosion rates over Holocene timescales.

The cosmogenic exposure age of an erratic on a moraine is an estimate of the moraine's age and an uneroded soil/till on the moraine must have the same total cosmogenic nuclide inventory as the erratic given that they have been exposed to cosmic radiation for the same lenght of time. Any cosmogenic nuclide inventory shortfall in the soil/till is therefore a measure of loss, most likely by erosion but also potentially by other mechanisms. Depth-profiles of two cosmogenic nuclides of substantially different half-lives and production rates, such as ^{10}Be and ^{14}C, should indicate the timing of any erosion that is identified, with a broad resolution to, for example, Middle or Late Holocene. If the technique proves successful, it will provide for the first time a means of measuring and broadly dating Holocene at-a-site soil erosion, complementing techniques that rely on basin sedimentation to assess catchment-wide average soil erosion based on sediment flux to receiving basins.

We are assessing these principles using the soil formed on the Younger Dryas Loch Lomond Readvance moraine near Glasgow. ^{10}Be determinations on vein quartz in erratics on the moraine surface yield a mean exposure age of 10,500 $\pm$ 900 years confirming the Younger Dryas age of the moraine. Eighteen ^{10}Be determinations in till material of varying size fractions collected from a depth-profile in a 240 cm pit from the moraine crest confirm that the cosmogenic nuclide depth-profile to be expected from a sediment body of Holocene age can be reconstructed and, thus, the technique can be applied for estimating amounts and timing of at-a-site Holocene soil erosion. Moreover, the agreement between the cosmogenic ^{10}Be results in the erratics and till samples indicate that there has been no soil erosion at the sample site since the deposition of the till/moraine.

This interpretation is now being tested more rigorously using in-situ ^{14}C data from erratics and clasts in the depth-profile in the till/moraine.