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Effects of inheritance and erosion on cosmogenic ages of glacial landforms: too young, too old or just right

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Interpretation of cosmogenic surface exposure data is complicated by possible effects of inheritance and erosion. In the case of inheritance, the material consists of clasts with different histories of exposure to cosmic radiation. Their apparent ages will range from the youngest (containing the smallest amount of inherited isotope) to the oldest (containing the largest amount), and the youngest of the obtained ages will be closest to the true age of the landform. In the case of erosion, each of the boulders at the surface today originated at a different depth and, consequently, each has had a different history of exposure to cosmic radiation. Apparent ages of these boulders will range from the youngest (boulder that spent longest time below the surface, shielded from cosmic radiation) to the oldest (clast that spent shortest time below the surface), and the oldest apparent age will be usually closest to the true age of the landform. Essentially the same distribution of apparent boulder ages can be caused by inheritance and by erosion. Without knowing which one is responsible, it is impossible to calculate the correct age of the landform because the calculated apparent ages of the boulders will be somewhere between too young and too old, depending on the relative importance of inheritance and erosion. The effects of inheritance and erosion can be quantified by comparing cosmogenic isotope inventories in boulders with the inventory of the same isotope in the matrix from the same surface. Only two assumptions are necessary for the analysis: (1) that boulders and matrix have the same geological exposure history (or, that, on average, the cosmogenic inventory in boulders is the same as that in the matrix); and (2) that erosion gradually exposes boulders that were initially at different depths, and after exposure these boulders remain at the surface. Under these assumptions, if the apparent age of the matrix is similar to the age of the youngest boulders, we have the case of erosion. In contrast, if the apparent age of the matrix is much older than the age of the youngest boulder, we have the case of inheritance. In

surfaces where both inheritance and erosion play a role, the difference between the apparent age of the youngest boulder and of the matrix provides additional information necessary to analyze the joint effect of these two factors. The boulder-matrix approach allows for a more reliable, less arbitrary determination of the age of glacial landforms in the presence of inheritance and erosion.