A criterion for recognising rock avalanche sediments in glacial moraines

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Moraines are commonly used as signals of regional climatic change, but there is a long-standing debate on the role of rock avalanches in tectonically active terrains and their contribution to moraine formation. Debris from large mass failures, such as rock avalanches, can be deposited directly onto glaciers, where this supraglacially-emplaced material can alter the glacier mass balance and may consequently be re-deposited as a moraine. These rock-avalanche-induced moraines can be misinterpreted as paleoclimate indicators. To date there has been no reliable technique for the identification of rock-avalanche-derived sediment. In this paper I present a new method for distinguishing rock avalanche deposits from glacial and other sediments, based on the sedimentary characteristics of the clay-sized fraction.

Fines in rock avalanche deposits comprise polymictic agglomerations of clasts that form clay- to sand-size clumps. These clumps are quite resistant to sieving and disaggregation using sodium hexametaphosphate (Calgone) and water. Examination of these clumps under the Scanning Electron Microscope (SEM) demonstrates that they comprise many smaller (down to nanometer-scale) largely sub-angular clasts. They are present in significant quantities in the fine fraction of rock avalanche deposits and are assumed to be produced during the high-stress conditions of emplacement. Similar agglomerations occur in fault gouge which also forms under similar conditions. In contrast, no agglomerations were found in lower-stress process environments (e.g. known non-rock-avalanche-derived glacial sediments from Westland, New Zealand and Jostedalsbreen Glacier, Norway). Therefore, the presence of agglomerates in moraines in tectonically active terrain is evidence that these moraines have incorporated rock avalanche debris. This diagnostic tool has the potential to help resolve long-standing arguments about the role of rock avalanches in moraine formation and the use of moraines in paleoclimatology.