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The effect of permafrost on soil erosion using meteoric ^{10}Be, ^{137}Cs and $^{239+240}$Pu in the Eastern Swiss Alps

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Permafrost ecosystems are highly sensitive to climate warming. The expected changes in the thermal and hydrological soil regime might have crucial consequences on soil erosion processes. Therefore, the determination of erosional activities on the long- (since the beginning of soil formation) and mid-term (last 50-60 yr) using cosmogenic and anthropogenic radionuclides can provide important information on past and ongoing processes. Permafrost soils in the Alps and their behaviour with climate change are only rarely studied. The expected new insights will lead to a better understanding of the processes of high mountain soils and are a further step towards improving climate-related modelling of fast warming scenarios and increasing system disequilibria.

Our aim is to quantify soil erosion processes in permafrost soils and nearby unfrozen soils in the Alpine (sites at 2700 m asl) and the sub-Alpine (sites 1800 m asl) range of the Swiss Alps (Upper Engadine). We hypothesise that permafrost soils differ distinctly in their long- and mid-term soil erosion rates due to different water retention capacities.

Long-term soil erosion was assessed using meteoric ^{10}Be. Meteoric ^{10}Be in a soil profile was estimated assuming that it is has been deposited as a function of precipitation and adsorbed in the fine earth fraction (<2 mm). Soil erosion can be estimated by comparing the effective abundance of ^{10}Be measured (AMS) in the soil with the theoretically necessary abundance for the expected age. The determination of long-term soil erosion rates using meteoric ^{10}Be together with a non-steady state approach has been, until now, very rarely been done.

Mid-term soil erosion processes were determined using ^{137}Cs, which was for our sites mainly deposited after the Chernobyl accident in 1986 and $^{239+240}$Pu that was released during nuclear weapon testing in the 1950s and 1960s. The measured abundances of ^{137}Cs (GeLi-Detector) and $^{239+240}$Pu (ICP-MS) in the soil profile of interest (fine earth fraction <2 mm) were related to the abundances in undisturbed reference profiles (no erosion). The application and comparison of ^{137}Cs and $^{239+240}$Pu further allows a cross-check on their suitability as mid-term soil erosion tracers.

Our preliminary results clearly show that long-term soil erosion rates (^{10}Be) were higher in permafrost soils at both altitudes (Alpine, permafrost: 35.9 t/km^2/a; sub-Alpine, permafrost: 44.9 t/km^2/a vs alpine (no permafrost): almost 0 t/km^2/a and sub-Alpine (no permafrost): 24.4 t/km^2/a). At the alpine sites the depth distribution of $^{239+240}$Pu and ^{137}Cs within the soil profile was comparable and highlights their potential suitability as soil erosion tracers. ^{137}Cs abundance in permafrost soils shows relatively low soil erosion rates since 1986 (2 t/km^2/a), while non-permafrost soils are indicating soil accumulation (-28 t/ km^2/a; negative value = accumulation). If ^{137}Cs abundance is the result of depositional features or if an inadequate reference site is the potential source of error (e.g. wind erosion) has still to be evaluated. Although Alpine soils have had a complex history and have been subjected to warmer and colder periods, differences in the thermal and hydrological conditions in soils strongly influenced erosional processes.