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Soil evolution and related erosion rates derived from a carbonate moraine chronosequence of the Swiss Alps

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Young soils are typical in high-alpine regions as more and more new terrain is exposed to the atmosphere by the retreat of glaciers. Physical and chemical weathering alters the young soils' physical and chemical properties and deepens the soil profile with time. The trend of this development can be traced by using chronosequences. The high Alps are especially suitable to investigate early soil development, due to the relatively high proportion of young surface. Chemical weathering proceeds faster or slower depending on whether the parent material is siliceous or calcareous.

Soil redistribution processes reshape the landscape by eroding the loose glacial sediments and by redepositing them downslope. Fallout Radionuclides (FRN) are often used to quantify such soil distribution processes. Using FRN, average erosion/accumulation rates for last few decades can be estimated. The FRNs have been deposited in soils worldwide following the numerous nuclear weapons tests which peaked in the 1960s. Plutonium (239+240Pu) is currently the most suitable element for this purpose. In contrast to 137Cs, its isotopes have a long half-life and will therefore be still available decades from now.

This study pursued two goals: 1) gain data on calcareous soil evolution and 2) quantify how soil erosion differs with soil age. We investigated a soil chronosequence with moraines of different ages in the calcareous proglacial area of Griessgletscher, close to the Klausenpass in the Swiss Alps. Soil ages span from a century to about 13'000 years. We measured a variety of parameters in order to cover the most important physical and chemical processes soil development. We also measured the 239+240Pu inventories and the short-term erosion rates for each soil age. The top soil showed a strong decrease in the sand fraction from ca. 65% to 15% while clay-sized particles increased by the same factor after several millennia of soil development. Both the decarbonatization and the accumulation of organic matter may have caused this step-wise development. The isotopic composition of the Plutonium inventories showed that the input was almost exclusively from global fallout. The comparison of the short-term soil erosion rates with the soil ages showed lower erosion rates with increasing soil age. It suggests that the youngest soils are more prone to soil erosion than the older. This behavior was expected, as the more mature soils are also more vegetated soils and therefore more protected.