Fast primary succession and pedogenesis on proglacial areas: examples from Valle d'Aosta Region (north-western Italian Alps)

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Abstract Climate changes have huge impacts on alpine ecosystems. One of the most visible effects is glacial retreat since the end of the Little Ice Age (190-190 years ago), which caused the exposure of previously glaciated surfaces. These surfaces are open-air laboratories, verifying theories regarding ecosystem and soil development. In order to increase our knowledge on the effect of time and substrate on vegetation primary succession and soil development in proglacial areas, we sampled soils and surveyed plant communities on stable points in the proglacial areas of the Lys and Verra Grande glaciers, in the Italian north-western Alps (Valle d'Aosta). Sampling sites were located on dated sites (based on literature or historical photographs). Glacial till is attacked by weathering processes immediately after deposition and stabilization, such as loss of soluble compounds, acidification, primary mineral weathering. The speed of these processes are largely increased after the establishment of a continuous vegetation cover, thanks to organic matter accumulation caused by litter input and root decomposition below the surface. On sialic glacial tills, below timberline, patches of larch-Rhododendron forest were formed in less than 90 years, and a quasi-climax subalpine forest was formed on surfaces deposited before 1921. Under a larch - Rhododendron forest, a fast and steady decrease in pH values, increase in organic matter content and horizon differentiation is observed. In particular, genetic eluvial horizons form in just 60 years, while diagnostic albic horizons are developed after ca. 90 years, evidencing an early start of the podzolization processes. Cheluviation of Fe and, secondarily, Al are analytically verified. However, illuviation of Fe, Al and organic matter in incipient B horizons was not sufficient to obtain diagnostic spodic horizons on LIA materials. Under grazed grassland below timberline and alpine prairie above timberline, acidification and weathering were slightly slower, and no redistribution with depth of Fe and Al oxi-hydroxides was observed. The slower rate of soil development was related with the slower vegetation succession from pioneer communities to more evolved, quasi-climax ones. On ultramafic materials, vegetation succession was inhibited by toxic concentration of available Ni and Mg and scarcity of nutrients, which inhibited the organic matter input on the soil surface, slowing down acidification, base leaching and mineral weathering. In fact, plant cover remains scattered and dominated by heavy metal-adapted species for more than 150 years. However, soon after the establishment of the typical subalpine larch-Rhododendron forest on 190-260 years old moraines, acidification and weathering became extremely fast, and a visible E horizon could form, overlying an organic matter and metal-enriched incipient Bs.

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