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Organic carbon-rich soils in periglacial landforms in a high elevation area, Western Italian Alps

Michele D'Amico (1), Camilla Cappelletti (2), Luigi Perotti (2), Marco Giardino (2,3), Michele Freppaz (1,3)

(1) DISAFA, University of Torino, Grugliasco (To), Italy (ecomike77@gmail.com), (2) DST, University of Torino, Grugliasco (To), Italy, (3) Natirisk, University of Torino, Grugliasco (To), Italy

Reconstructing soil and landscape evolution in high mountain areas can be a difficult task due to the intense geomorphic actions by glacial and periglacial processes, which remove significant parts of the surface geomorphological and soil record.
The object of this study is the periglacial environment of the Stolemberg Plateau and the surrounding area, located along the border between Valsesia and Lys Valley at the foot of the southern slope of Monte Rosa (Western Italian Alps) at an elevation between 2900 and 3100 m a.s.l.. Here we characterized geomorphic features and soils developed within them by means of field surveys, soil trenches description and analysis, mapping and high resolution images interpretation linking GNSS and UAV-based remote sensing.
Spatial distribution and activity of geomorphic processes was represented in a detailed geomorphological map showing intact and remodeled meso- and microforms from different morphogenetic processes: glacial (mainly moraines and roches moutonnées), cryogenic (gelifluction lobes, tilting of stones, blockstreams, sorted patterned ground, wedges) and gravitational (trenches, landslide scarps, and rock block accumulations).
Despite the strong geomorphic activity characterizing this permafrost area (with an active layer thickness of ca. 8m), the observed soils were extremely well developed, particularly inside periglacial landforms such as blockfields and blockstreams, with or without patterned ground reorganization. Below a surface reworked stone layer with a plant cover below 3-5%, thick, dark and organic C-rich horizons were observed. The thickness of these organo-mineral horizons was between 30 and 65 cm. Cryoturbation features, such as inclusions of different materials and convolutions, were often observed. A strong lateral granulometric differentiation or stone tilting caused by periglacial processes was also detected. Below these Umbric horizons, cambic Bw ones were often developed but discontinuous. In contrast, below more stable surfaces covered by alpine grassland (curvuletum), the soils were Cambisols with a thin (10-15 cm depth) A horizon and a moderately developed Bw, showing weak signs of cryoturbation. Below periglacial surface stone layers, carbon stocks were very large, comparable to forest soils (between 2 and 4.5 kg/m2); in comparison, below undisturbed alpine, carbon stocks were below 2 g/m2.
The origin of these extremely high soil organic carbon contents below blockstreams and blockfields is of great relevance for unraveling the history of the high altitude landscape of the Monte Rosa alpine area. It could be related with paleosols buried below moving stone layers or by reduced decomposition associated with the cooling effect caused by the stones.