Unravelling the existence of Alpine Nunataks: the hidden paleosols of the Stolenberg Plateau (NW Italy)

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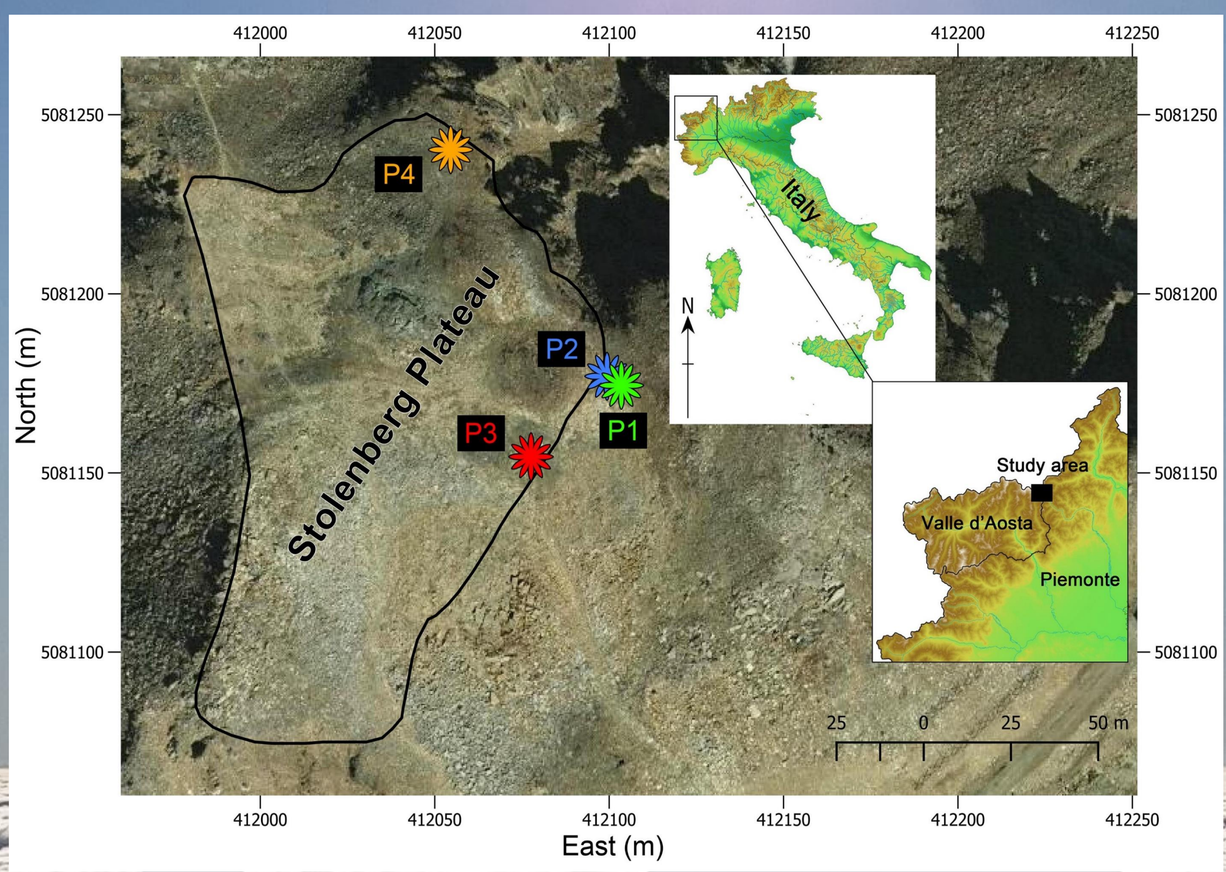
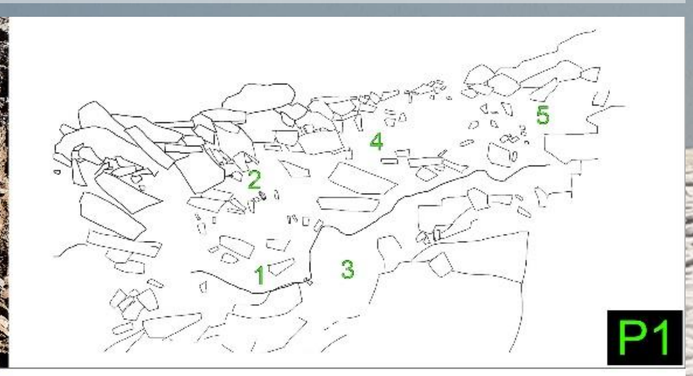
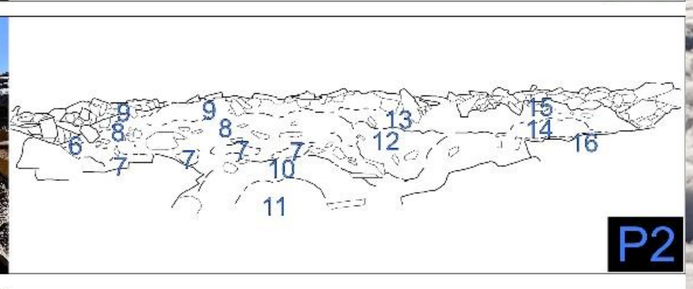
Introduction

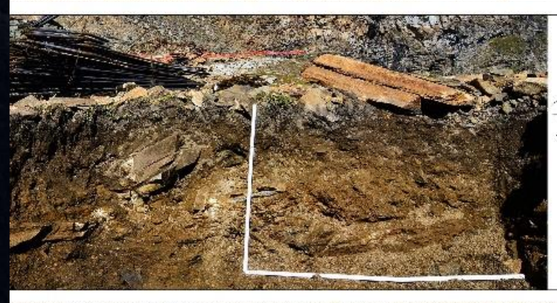
In high-mountain areas, Pleistocene glaciations and erosion-related processes erased most of the pre-existing soils. However, on scattered stable surfaces, ancient soils can be locally preserved for long periods, either through coverage by non-erosive, cold-based, ice or as nunataks.

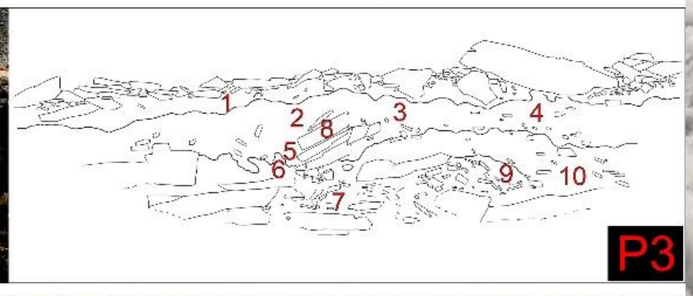
This study was performed in the periglacial environment of the Stolenberg Plateau (LTER site Istituto Mosso) located at ca. 3030 m a.s.l., on the southern slope of the Monte Rosa Massif (Western Italian Alps). The plateau is covered by thick periglacial blockfields and blockstreams, with a scarce plant cover (3-5% of the surface). These periglacial landforms unexpectedly revealed well-developed Umbrisols characterized by thick and dark (between 30 and 65 cm) A horizons. The organic carbon stocks were comparable to forest soils at lower elevation (above 5 kg*m^{-2}). Geophysical investigations showed that these soils were widespread under the stony cover, with a thickness ranging between 20 and 90 cm.

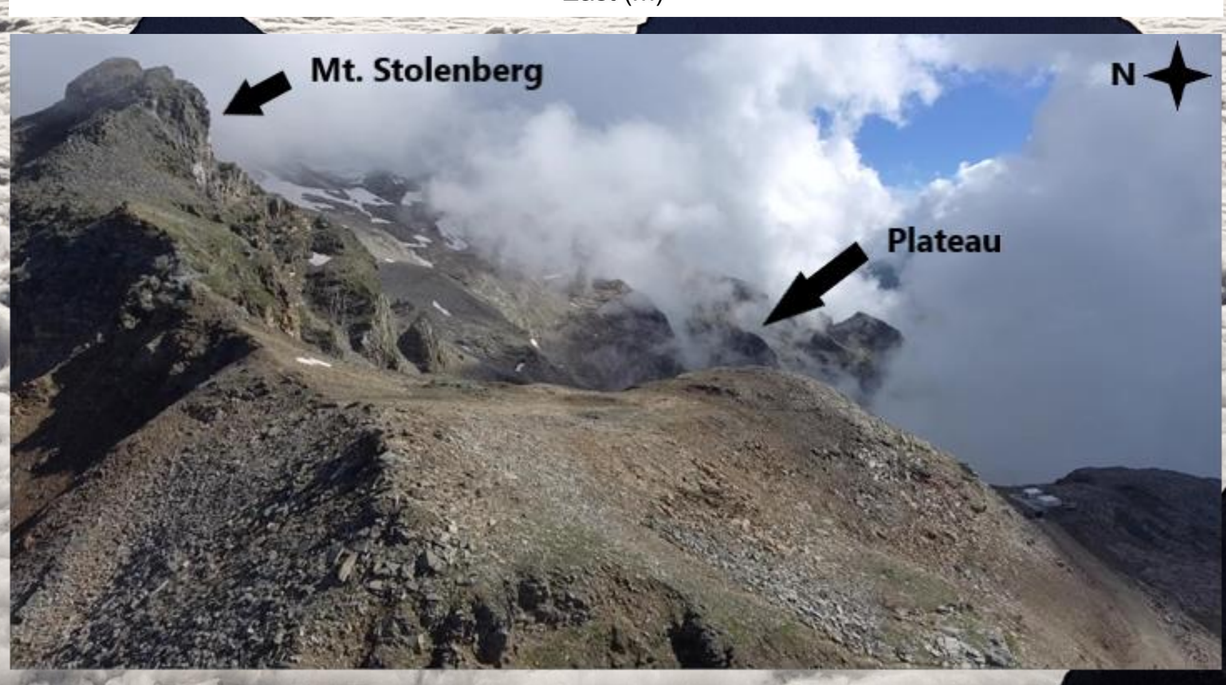












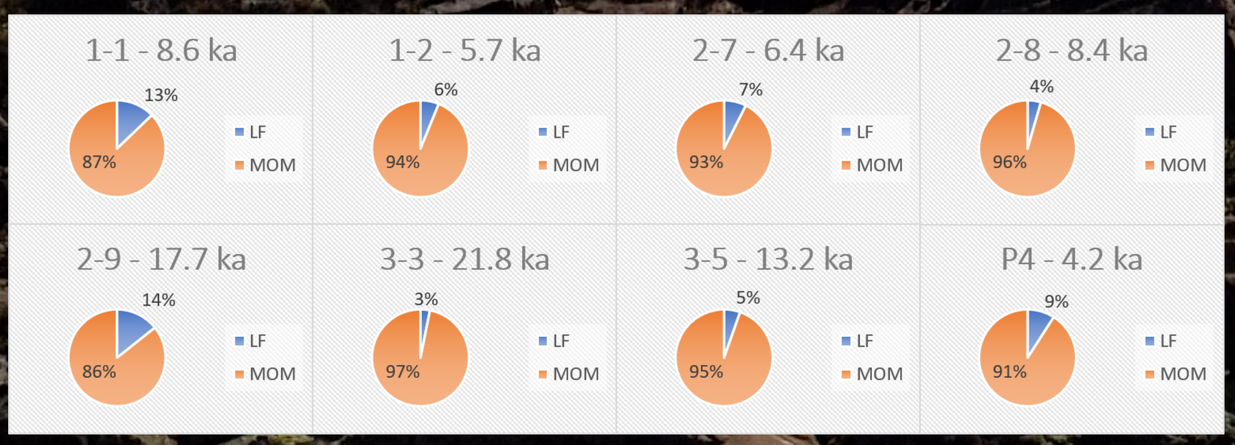
Methods

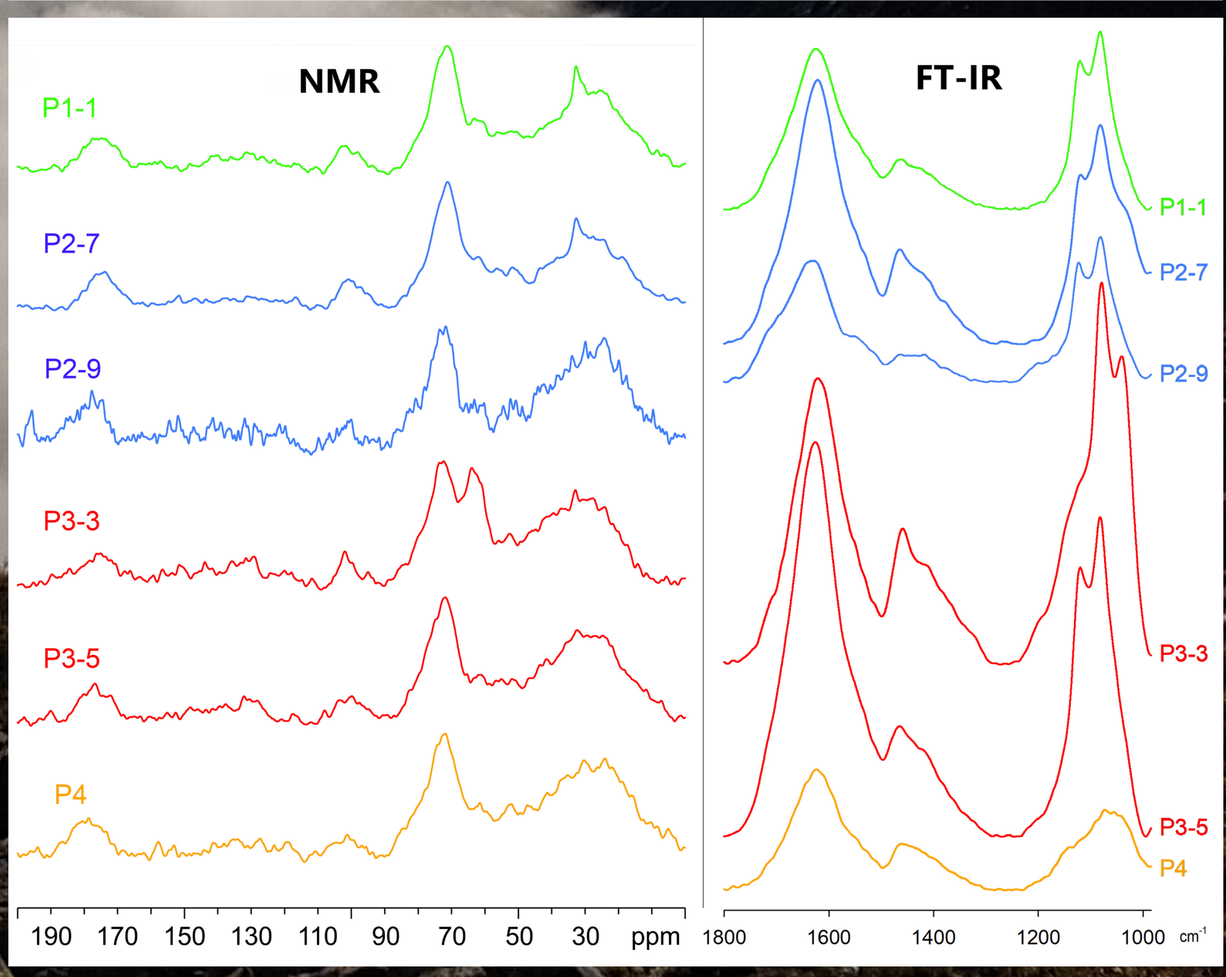
- Soil ^{14}C datings (AMS)
- Soil δ^{13}C (IRMS)
- OM physical and chemical fractionation
- Solid state ^{13}C NMR
- FT-IR spectroscopies

Results

- Radiocarbon dating (^{14}C) spanned from 4.4 to over 22 ka BP
- Soil δ^{13}C correspondence with soils and alpine vegetation in high-elevation ecosystems
- The greatest part of organic carbon was stored in the stable mineral OM pool (MOM)
- The OM consisting mainly of paraffinic substances (lipids and waxes), cellulose and hemicellulose derived from autochthonous, well-adapted, ancient alpine vegetation

Sample ID	Cal. Radiocarbon Age (cal. yr BP) (2s range)	δ^{13}C (‰)	Phase
P1-1	8787-8434	-24.7	Holocene Climatic Optimum
P1-2	5744-5583	-23.9	Holocene Climatic Optimum
P2-7	6500-6306	-24.2	Holocene Climatic Optimum
P2-8	8534-8302	-23.9	Holocene Climatic Optimum
P2-9	17536-17014	-24.5	Early Lateglacial Ice Decay
P2-9bis	18228-17870	-24.5	Early Lateglacial Ice Decay
P3-2	18916-18611	-23.8	Early Lateglacial Ice Decay
P3-3	22168-21431	-23.5	Last Glacial Maximum/ Early Lateglacial Ice Decay
P3-5	13337-13110	-23.6	Bølling-Allerød
P4	4405-4090	-22.7	Late Holocene





Conclusion

Our results indicate that these hidden soils recorded the main warming climatic phases occurred from the end of the Last Glacial Maximum until the Late Holocene ~4,000 yr BP. Thus the environmental conditions on the Plateau were suitable for alpine plant life and pedogenesis, already since 22-21 ka BP. The Plateau represents one of the first documented Alpine Nunataks, which acted as a biological refugia since the end of the LGM, representing therefore, a valuable natural and historical archive for unravelling the post-LGM history of the high-elevation landscape of the European Alps.