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Geophysical Research Abstracts
Vol. 16, EGU2014-**PREVIEW**, 2014
EGU General Assembly 2014

Contrasting environmental memories by ancient soils on different parent rocks in the South-western Italian Alps

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Ancient soils (pre-Holocenic paleosols and vetusols) are uncommon on the Alps, because of the extensive Pleistocenic glaciations which erased most of the previously existing soils, the slope steepness and climatic conditions favoring soil erosion. However, in few sites, particularly in the outermost sections of the Alpine range, Pleistocene glaciers covered only small and scattered surfaces because of the low altitude reached in the basins, and ancient soils could be preserved for long periods of time on particularly stable surfaces.
We described and sampled soils on 11 stable surfaces in the Upper Tanaro valley, Ligurian Alps (Southwestern Piemonte, Italy). The sampling sites were characterized by low steepness and elevation between 600 to 1600 m, under present day lower montane Castanea sativa/Ostrya carpinifolia forests, montane Fagus sylvatica and Pinus uncinata forests or montane heath/grazed grassland, on different substrata. In particular, we sampled soils developed on dolomite, limestone, quartzite, gneiss and shales.
The soils were always well representative of the pedogenic trends active on the respective parent materials, i.e. the skeletal fraction in each soil was always composed of just one rock type, despite the proximity of lithological boundaries and the small dimensions of the different outcrops, often coexisting on the same stable surface.
All the considered profiles showed signs of extremely long pedogenesis and/or different phases of intense pedogenesis interrupted by the deposition of periglacial cover beds in the steepest sites. Up to four phases of intense pedogenesis were recognized where cover beds were developed, presumably during cold Pleistocene phases, as present-day climate is not cold enough to create such periglacial morphologies. In such cases, each cover bed underwent similar pedogenesis, strongly dependent on the parent material: on quartzite, podzols with thick E horizons and well developed placic ones were formed in all phases except the most superficial one (i.e. Holocene phase), where non cemented spodic horizons or weakly cemented ortstein were formed; placic horizons were never found in Holocene soils. On limestone, each cover bed separated soils with extremely hard petrocalcic horizons overlaid by argillic ones.
Where no cover beds were observed, podzols with extremely thick E horizons (up to more than 2 m thick) and a very hard, very thick ortstein were formed on quartzite. Red Nitisols-like or reddish brown Luvisols were formed on limestone and dolomite, while red, extremely acidic Alisols, with or without fragipan horizons were formed on shales. Very large stone circles and other large patterned ground features, which can be interpreted as evidence of past permafrost conditions, were preserved on coarse quartzitic conglomerate.
These soils represent excellent pedo-signatures of different specific past climatic or environmental conditions, as a response of different lithologies to specific soil-forming environments, which range from warm and humid climates typical of red Luvisols and Nitisols, to cool and wet climates leading to the formation of Podzols with placic or ortstein horizons, to extremely cold and dry ones characterizing permafrost sites and often associated with fragipan formation, to warm and dry leading to the cementation of petrocalcic horizons. The precise dating and interpretation of these soils are intriguing.