Geographic relevance of Late Pleistocene and Middle Holocene aeolian deposits in Central Tuscany (Italy)

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Abstract

In central Italy, aeolian deposits of different nature are very scarce and often difficult to recognize. This paper reports the results of the work made by our research group during the last twenty years about the polygenetic paleosols with aeolian cover in the Elsa river basin (central Italy). During these studies we analyzed the texture, the chemical-physical parameters, the mineralogy, the micromorphology (soil thin sections and quartz grains exoscopy) and the geochemistry of the paleosols. In addition, we dated some horizons by OSL. The soil profiles with aeolian covers were located in stable landforms as dolines and karstic plateau. Therefore, limestone was the most common bedrock where the aeolian deposits were found, but we also found aeolian material on other lithologies, like Pliocene marine deposits and Pleistocene fluvial sediments. The aeolian covers were characterized by a high content of silt (> 50-60 %), a clear-wavy limit and a lithological discontinuity with the underlying buried paleosol. The research demonstrated that soil wind erosion and deposition of soil materials was accompanied to a large extent by water erosion and colluvial deposition during the Late Pleistocene and the Middle Holocene in the Elsa river basin.

Key Words

Loess, aeolian deposition, paleosols, OSL dating, Mediterranean

Introduction

The occurrence of aeolian deposits can be difficult to recognize when they have been mixed with other sediments and weathered, which is often the case in soils. Aeolian material can derive from either local or short-distance transport, from nearby continental sources, or from longer-distance hemispheric transport, as it is the case for Saharan dust. The difficulties in aeolian material identification result in the underestimation of spatial distribution of loess in soils, especially in Mediterranean Europe, where thick and uniform loess covers are rare, due to the limited extension of the alpine glaciations. In Italy, loess has only been reported for northern Italy and the Adriatic part of central Italy (Cremaschi 1990; Haase *et al.* 2007), with the Tosco-Emilian Apennine chain being regarded as a physiographic boundary of loess sedimentation (Cremaschi 1990). No loess has been described so far in the Tyrrhenian part of central Italy, but Pleistocene aeolian sand dunes have been reported by authors along the Tyrrhenian costs of central Italy (Cremaschi and Trombino 1998). The general aim of the research was to demonstrate the geographic relevance of the loess cover in Central Italy. The paper groups the experiences of twenty years of research work about paleosols of the Elsa river basin (Tyrrhenian side of Central Italy), so to delineate the areas with known aeolian cover.

Methods

The study area is located in central Tuscany (Central Italy) and it is mainly characterized by an eastern ridge (Chianti hills) formed by sedimentary rocks (Figure 1), a western ridge (Middle Tuscany Ridge) formed by metamorphic and sedimentary rocks, and a central ancient marine basin of the Pliocene period (4.8 - 4 My B.P.). The hills of the ridges are usually lower than 600-700 m s.l., whereas the hills formed in the marine deposits of the central basin are lower than 300-400 m s.l.

Previous studies (Mirabella *et al.* 1992; Costantini *et al.* 1996; Napoli *et al.* 2006; Priori *et al.* 2008) suggested the polygenetic nature of most of the soils formed in stable morphologies like dolines, plateau, terraces, and in some cases, lower part of footslopes. The beginning of pedogenesis of the most developed paleosols was estimated from the Early Pleistocene. The soils formed during this period were characterized by thick nitic horizons over the limestone, plinthite or ferrallitic horizons over the other bedrocks. Argic horizons, rubefaction, or ferric properties, were present in paleosols developed from the Middle Pleistocene - beginning of the Late Pleistocene. The soils younger than last interglacial (125 – 85 ky B.P.) usually showed cambic, vertic, calcic, mollic and thin argic horizons with moderate clay illuviation.

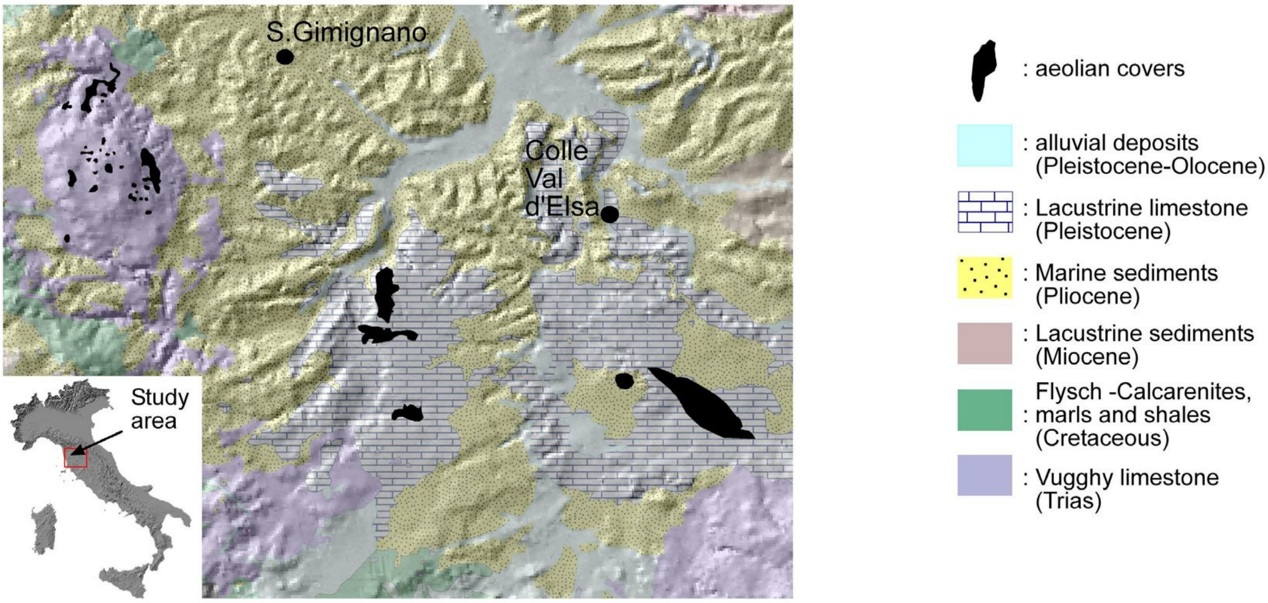

Figure 1. Geological map and aeolian covers of the study area.

Many surficial and sub-surficial horizons of the paleosols in the area had particle size classed in silt, were massive or poorly structured, and showed lithological discontinuities with the underlying argic and other more developed horizons. Priori et al. (2008) and Costantini et al. (2009) demonstrated that some or most part of these horizons formed from aeolian deposits. Some datings by OSL method (Costantini *et al.* 2009) reported an age from Late Pleistocene (about 70-60 ky B.P.) to Middle Holocene (3-5 ky B.P.). The aeolian nature of the parent material was checked by means of texture analysis, geochemistry and micromorhpology, both soil thin section and quartz grains exoscopy (SEM, Figure 4).

Results and discussions

The loess cover was characterized by the high silt content (> 50-60%, Figure 3) and the lithological discontinuity between the buried paleosols and the cover (Figure 2). The aeolian material was only widespread in stable surfaces (plateau, terraces) or natural morphological traps like dolines. The aeolian material was often mixed with colluvial material, gravels and pedorelicts. The texture of the aeolian covers was typically silt loam and silt clay loam, or silty clay. On the contrary, the textures of the buried paleosols varied from clay to clay loam and sandy loam. The thickness of the aeolian covers ranged from 0.20-0.30 to 1-1.5 m. The thickest covers were placed inside the dolines and were often mixed with colluvial material.

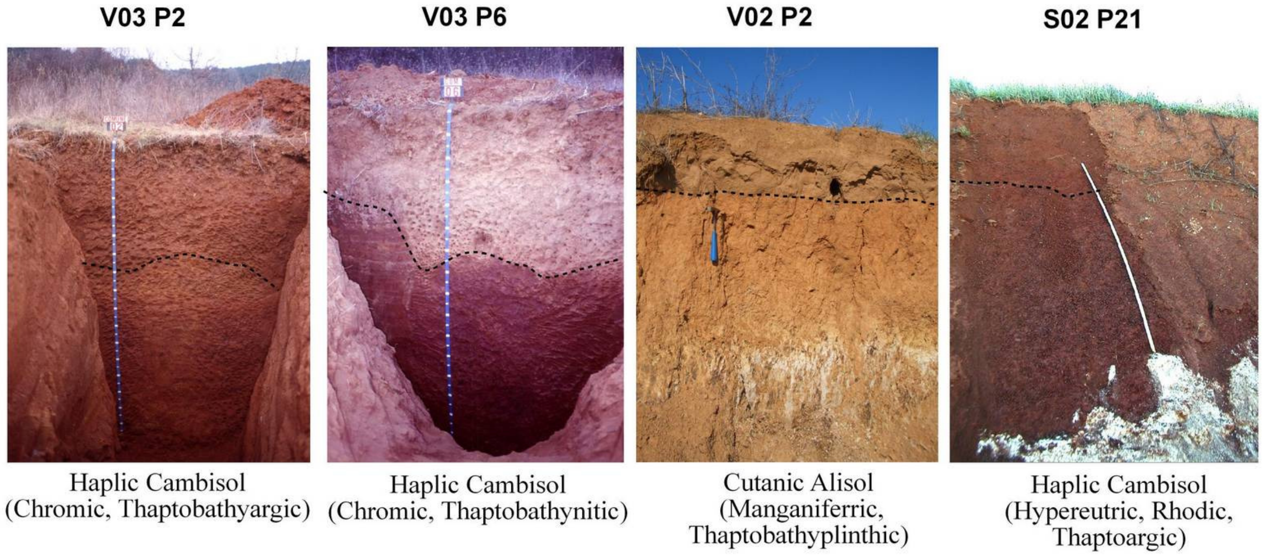

Figure 2. Four profiles with aeolian cover burying more strongly developed soil horizons (dotted line point to the boundary between the aeolian cover and the lower part of the paleosol).

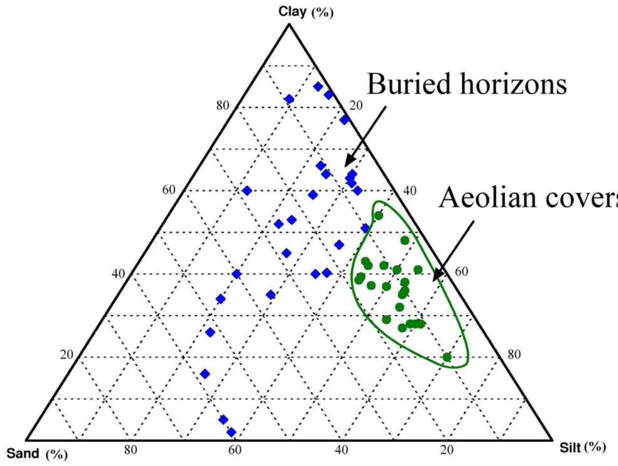

Figure 3. Textural ternary graph of the studied soils. The aeolian covers are grouped between the clay loam and the silt loam classes.

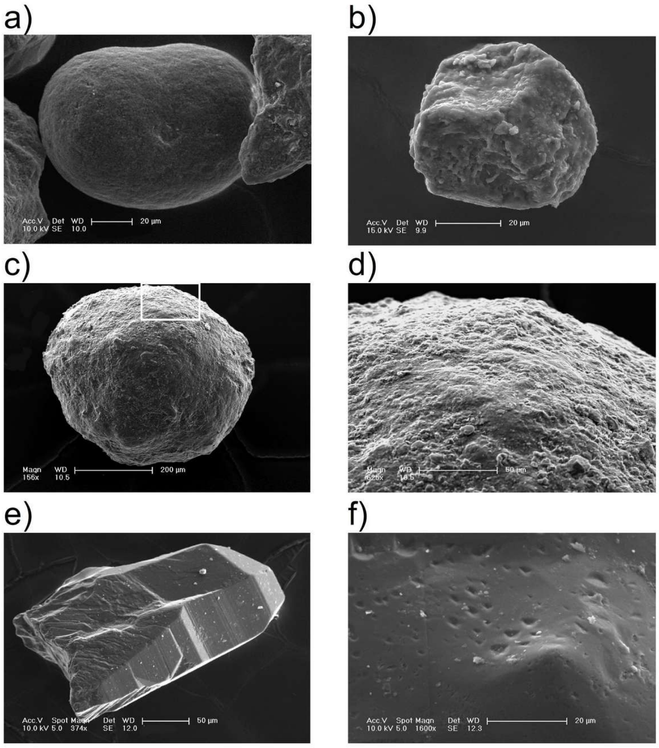

Figure 4. SEM images of quartz grains surfaces of aeolian covers (a,b,c,d) and buried paleosols (e,f). a) rounded coarse silt grain, b) sub-rounded grain with dish shaped concavities, c) rounded fine sand grain with "orange peel" surface, d) close-up of previous picture: upturned plates of silica, e) euhedral quartz grain with poorly smoothened corner, f) V-shaped holes.

The origin of the aeolian cover of the paleosols in the Elsa river basin is not homogeneous. Glacial or periglacial deposits however can be excluded, because there is no evidence of these processes, neither in the landforms, nor in the soils. Moreover volcanic ashes, although sometimes present in some soils, did not affect the bulk composition of the cover. Saharan dust as a major component can also be excluded, because the particle size of the cover is too coarse for an aeolian transport of more than several thousands of kilometres (Pye, 1995). The geochemistry of the covers permitted to attribute the source of the loess material to the alluvial fans and the wide alluvial plains of the rivers that drained the Middle Tuscany ridge and the Chianti hills (Costantini *et al.* 2009). During the driest stages of the Late Pleistocene and Holocene, these environments should have wide, bare and arid surfaces, strongly favourable for the aeolian erosion. The fluvial source of loess is reported in literature by Pye (1995), who called these deposits as "secondary loess", that is, loess redeposited and/or originated by other, non-eolian processes.

Conclusions

This paper demonstrates the presence of a loess cover on some polycyclic paleosols located in the Elsa river basin (Central Italy). The high content of silt of the cover and the clear, wavy limit with the underlying buried horizons, as well as the geomorphological position of the paleosols, helped in the identification of the loess in the field. The thickness of the loess cover, although sometimes affected by colluvial accumulation, was significant, which testifies that the process was not local, but geographically relevant, so to involve all the Elsa river basin, and possibly other areas of Central Italy. In conclusion, the research work demonstrated that soil wind erosion and deposition accompanied to a large extend water erosion and colluvial deposition during Late Pleistocene and Middle Holocene in the Elsa river basin. Although Central Italy is currently considered to be only marginally affected by wind soil erosion, a climatic change which would imply increased arid conditions could trigger a new cycle of slope denudation, wind erosion and loess deposition.

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