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Soil Stratigraphy from Three Pleistocene Archaeological Sites of the Middle Ter River Valley, Catalonia, Spain

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Abstract

This dissertation summarizes the stratigraphic description of three Pleistocene archaeological sites in the middle Ter river valley. A long history of archaeological research in this region suggests the possibility of developing contextual studies. This work is basically an investigation of two soil formation processes from the deep soil horizons of the Mediterranean region: clay illuviation and carbonatation. This approach has been developed by soil micromorphology, a technique well suited for this type of record, supplemented by fundamental field descriptions and basic cartography of the geomorphological terraces of the middle Ter river valley.
The soil stratigraphy of archaeological sites and Pleistocene landscapes opens the opportunity to investigate a complex subject of study. The soils and paleosols are a source of information for palaeoecology and human occupations. It has been attempted here only to lay the groundwork for the interpretation of genetic factors pointing to the classification of soils.

Keywords: illuviation, carbonatation, soil micromorphology, palaeoecology.

Introduction

In this work I have aimed to investigate the site formation processes of the archaeological sites of Turo de la bacteria, Can Garriga and La Jueria of the Gerona region of Northeastern Spain by means of specific site investigations, soil stratigraphy and micromorphology. The aim has been to present new geoarchaeological data on the environmental and cultural change around the Ter River Valley of Northeastern Spain. Its objective has been to interpret and understand the changing soil stratigraphy and paleoenvironments in the Middle Ter River Valley of Catalonia, Spain.

Regional Setting

The Ter River Valley is situated in the province of Catalonia in the northeast of the Iberian Peninsula, to the south of the Pyrenees, between the parallels of 40º30´ and 42º53´ northern latitudes and meridians 0º2´ and 3º18´ eastern longitudes. Our study area includes the lower middle part of the Ter river basin, from Angles to Sant Julia de Ramis. The River Ter rises in the Pyrenees and runs roughly towards Vich. The valley between Vich and Gerona can be subdivided into three sections—a deep and narrow gorge cut into predominantly acid igneous and metamorphic rock; a wide and deep valley between Angles and Bescano cut into similar rocks; and downstream of Bescano, a wide aggradational alluvial plain. The abstract boundaries between the three sections described correspond with major faults, separating different tectonic block which descend stepwise to the northeast (Mücher *et. al*., 1990).

Different terraces along the middle part of the river Ter and relation with different archaeological sites

In the middle part of the Ter river valley, there exist several river terraces which are prehistorically important because of the fact that these terraces are related with lithic assemblages. The most sublime way to explain this terrace system is with the help of a map that describes the correlation between the terraces and the sites. In context of the terraces, perhaps the pioneering work was done by Lluís Pallí (1976) who found out four terraces, namely I, II, III and IV which signifies numbers and levels. For example, according to him, TI is the lowest terrace and TIV is the highest. We have tried to take a look across these terraces and have tried to draw a synthetic cartographic map to represent these terraces. In the process we came across two more terraces. In this part of the river valley, there are quite a few archaeological sites. La Jueria (1), Can Garriga (3) and Turó de la Bateria (TBEX) (2), are the sites which have been studied for Soil micromorphology (Fig. 1 & Tab.1).

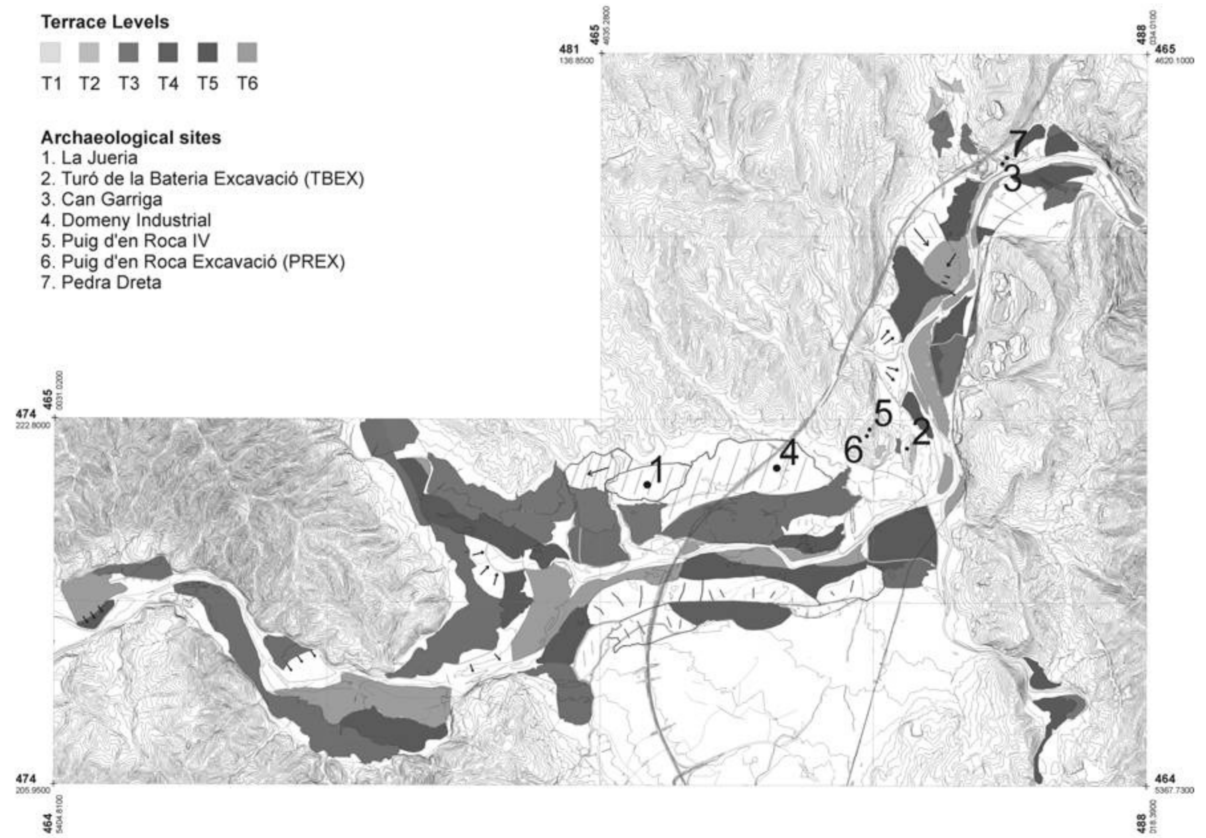

Fig.1. A synthetic map showing the terraces along the river Ter.

Site Presentation

The site of Turo de la Bateria is situated towards the north-east of the city of Gerona in Catalonia (lat 41º59´51´´ N, long 2º49´10´´E). The top of the Turo hill is situated at about 40 mts above the level of the river Ter, the site corresponds to the terrace III of the river. This basin is restricted in the north by the eastern ending of the transversal and Catalan system and in the south in the outcrops of the prelittoral depression, in the gorge of St. Julià de Ramis (Llopis, 1947).

The archaeological site of La Jueria is situated in the town of Sant Gregori in the province of Gerona. This flat plain is located at about 90 metres above sea level and at about 20 metres above the river Ter. The area is represented in the extreme northeast of the sheet no 333-II of the National Topographic map of Spain, Scale-1:25000.The geodesic coordinates are—x: 481993'74 and y: 4649343'45.

The archaeological site of Can Garriga is situated at the north of Gerona, in the town of Sant Julià de Ramis, in the left part of the N-II and the Ter river and in the right part of the Garriga river. The site is about 15mts above the river base level. It is situated on a fluvial terrace, to the left bank of the river, on the way to go to the town of Banyoles.

Materials and Methods

The methodology involved both fieldwork and laboratory work. Two weeks of fieldwork on the site provided us to have a detailed knowledge of landscape. Before leaving for fieldwork, the maps were prepared and general geomorphological features were sketched based on interpretation of aerial photographs, orthographic aerial images, available maps (topographic, bedrock, quaternary deposits), and previously performed surveys in the areas. In the field base maps were used. Useful information was added during the fieldwork based on information provided from people living and working in the mapped areas. Soil samples for micromorphological studies were also collected during fieldwork. Thereafter laboratory work included preparation of thin section slides for microscopic studies and microscopic observations.

Pallí (1976)	This work	Metres above river base level
TIV	T1	+80
TIII	T2	+45
-	T3	+20
TII	T4	+15-20
-	T5	+10-15
TI	T6	+5-10

Tab.1. Correlation between the terraces of Lluis Pallí (1976) and this study.

Results

Analysing different features by means of microscopic observations from soil thin sections of the facies of each site, it has been possible to detect that two main kind of soil forming processes to be active in this region---Clay illuviation and Carbonatation.

Discussion

Clay illuviation in the sites of La Jueria and Can Garriga under present day conditions suggests that it occurs presently only on humid and sub-humid margins of the Mediterranean basin (Federoff, 1997). Mediterranean soils during glacial periods were eroded, colluviated, aggraded with aeolian dust and fragmentation marked by calcitic features and eventually were affected by water logging. Self mixing and faunal churning are undoubtedly active in these soils. Gerona region, where these two sites are located, comes as a boundary between Catalonia Wet and Catalonia Dry, the part above the boundary being Wet. Under this climatic condition, we understand that the water percolation is slow snd the soils have been exposed to various climatic fluctuations. During the Holocene, this red soils characterised by a thick 30-40 cm argillic horizon with some impure clay coatings exist on aeolinates deposited on the shoreline during very late Pleistocene. During the Last Glacial Cycle (isotopic stages 2, 3 and 4), various pedo-sedimentary events did occur. This typical Mediterranean soils as seen in these two sites, were eroded and corresponding red pedo-sediments were deposited on the continental shelf. Then during episodes of low sea stands, the red pedosediments were eroded by wind and redeposited as pseudo-sands on the coastal dune.
During the Last Interglacial (isotopic stage 5) and earlier interglacials, soils are characterised by a deep, karstic, decalcification of aeolinites associated with a penetration in the decalcified zone of illuviated clays in form of dark red, microlaminated clay coatings and infillings. A massive argillic B has progressively developed upon the eolianite. The plasma has dominantly an illuvial origin which signifies that pedoplasmation can be considered as illuvial. Rubification occurred in the upper horizon and then was distributed in lower ones by the process of illuviation. This pedogenesis requires a strong positive drainage which consequently supposes high rain fall well distributed throughout the year and a continuous vegetative cover, climate being wetter during the Interglacial than during the Holocene.

We can relate the dates of the sites of Can Garriga and La Jueria with Isotopic stages by means of this micromorphological studies. La Jueria has a baslatic base which has been dated to about 300,000 BP (sample 1). This basaltic base was formed during the isotopic stage 8 (Glacial). The reworked Bt was horizon was formed during isotopic stage 7 (Interglacial) and eroded at Isotopic stage 6. This is perhaps the fluvial terrace which is about +20 mts (Sample3). In case of Can Garriga, a fluvial terrace evidenced in sample 3, is dated close to isotopic stage 5. Can Garriga sediments were formed and buried in isotopic stage 5 which suggests why we do not find any reworked sediments here.

In case of the site of Turo de la bateria, the pedologic evolution seems to be characteristic of a profound truncated horizon (Bw). Observed pedofeatures suggest clay rich sedimentary material where textural pedofeatures develop. Rare microlaminated clay and fine silt claims to be of illuvial horizon but poorly developed because textural infillings and silt coatings suggest repeated soil surface erosion. Root cast also suggests limited pedological evolution because they are still preserved and indicative of first stage of carbonatation process. This microfacies point out a pedological phase of the decarbonatation and another phase of carbonatation attested by calcitic root pseudomorph and impregnation. Later impregnation is also attested by crystallitic fine fraction B fabric.An important pedological development is suggested by crystalline calcitic pedofeatures. There are many calcite loess as well from local provenance. These loessic materials are composed of calcares dereived from geological substrates where pedological process like carbonatation had been active. Pedological processes and weathering on the Eocene substrate is perhaps the origin of this local loess materials and was perhaps at the end of isotopic stage 3 and 5 because soil forming processes during glacial stage contributed to form carbonated materials very rich in calcite sediments.

This distribution and accumulations in the loess sedimentary complexes are indicative of minor changes in the environment. Bioturbation of calcified root cells leave clusters of few cells or isolated crystals in the groundmass. Temporary absence of loess deposition can be an indication for this. Soil microscopy suggest that in this part of the Ter river loess deposition was far more common than earlier assumed, but probably the loess has often not been recognized as because of the reworked nature of deposits (Mücher *et al.,* 1990).

Loess deposits and $CaCO_3$ accumulation suggests of microecosystem. Exceptional abundance of calcified root cells is an indicator of a long stability of soil surface during favourable climatic conditions. Needle-fibre calcite is related to biomineralization of saprophytes in soils with sufficient moisture and decomposing organic matter. Bioturbation of calcified root cells leave clusters of few cells or isolated crystals in the groundmass. This can be an indication of the temporary absence of loess deposition. We understand that carbonatation is a typical process of aridic soils (ardisols). During the soil forming processes, carbonates precipitate in a dipping horizon by means of a chemical process and is deposited in a calcic horizon in the very first stage. Therefore, sedimenatation and pedogenesis occurs in a rhythmic fashion. Platy microstructure from this site, on the other hand, suggests a cold temperature. Absence of water in the soil indicates two main cycles of humidity---one is when the summer is hot and evapotranspiration occurs and the other is when the winter is cold and the water transforms into ice and is not available for plants. From facies 3 of Turo de la bateria, we can observe this kind of rhythmic loess deposition on which grows grass vegetation. Soil microstructure suggests a very thinner soil with loess deposition and grassland cover. Thin stratified soil suggests minor changes in the environmental condition. Platy microstructure in the upper part of the soil suggests superficial freezing. So, we can determine well that there was grass vegetation with seasonality i.e., freezing and hot summer. Not a lot of water was available for grand vegetation. This facies dates to about 50,000 B.P coinciding with isotopic stage 3.

Conclusion

In this dissertation, it has been attempted to construct a stratigraphic sequence of the sites of Turo de la Bateria, La Jueria and Can Garriga. In doing so, I have come across two main types of soil forming processes evident from the different thin sections. One is illuviation and the other one is carbonatation.

In a nutshell, illuviation is the process of the deposition of colloids, soluble salts, and suspended mineral particles in a lower soil horizon through the process of eluviation (downward movement) from an upper soil horizon. The phase of illuviation is characterised micromorphologically by the existence of reddish or yellowish clay coatings. They show strong orientations and are homogenous, microlaminations only being seen as a result of variations in the iron content which clearly show the successive phases of accumulation. In the sites of Can Garriga and La Jueria this process was very much evident which. This has helped to identify the palaeoenvironment of the area to be humid to sub humid with litter accumulation and little percolation.

The other process that is evident is the process of carbonatation. It identifies calcium carbonate accumulation in loess (a common secondary feature) and involves the accumulation of pedogenic calcium carbonates and an important pedogenic process for arid and semi-arid regions (Sobecki and Wilding, 1983). This process is intrinsically related with the micromorphology of Aridisols where a diagnostic argillic and cambic horizon do develop.

Turo de la Bateria has shown such evidence demonstrating rhythmic loess deposition indicative of microclimatic conditions.

Soil forming process helps us to reconstruct the past by indicating the past bioclimatic environment. According to Jenny (1941), soils and their properties are the product of the different soil-forming factors (climate, organisms, relief, parent material and time) that control the degree of soil development, as indicated by comparisons with the parent material (Harden, 1990). Because the soil-forming factors also govern geomorphic processes, landscape evolution is intimately related to soil development (McFadden and Kneupfer, 1990). Over time, soil-forming factors, especially climate and vegetation, may change in such a way that many old soils, palaeosols, are not related to the present climate and vegetation. Properties of the different soil horizons have also been used to determine the age of soils (Levine and Ciolkosz, 1983; Harrison et al., 1990) and thus the approximate age of the landforms (Semmel, 1989). For this reasoning to be valid, climatic conditions must remain relatively stable over the entire soil-forming period, for only then do the soil properties increase constantly with time (Birkeland, 1990). However, dating becomes complex on surfaces subject to long-term climatic fluctuations. This can be solved if relationships between specific soil properties and climatic fluctuations are known.

This thesis leaves scope for reconstructing palaeoenvironment of the archaeological sites and related geographic domain. In future, a fine knowledge of soil forming processes can led to invoke a more detailed environmental reconstruction.

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