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SOIL MICRO-MORPHOLOGY: A BASIC AND APPLIED SCIENCE

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INJECTION FEATURES IN MID-ALTITUDE MEDITERRANEAN SOILS.

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ABSTRACT

During the 1986/87 winter in a Mediterranean area at 625 m altitude (in the Montserrat Mountains, Catalunya, Spain), injection features have been recorded on Cambisols . Soil freezing occurred in areas burned down by a 1986 summer fire but did not affect vegetated areas. Injected material from the subsurface horizon, yellow-red in colour, became apparent in contrast to the black, burnt organic matter of the soil surface. Besides injections, other frost action features were observed: pipkrakes, frost heaving and gaps around stones.

Field work and macromorphological analysis of polished blocks enabled the understanding of extrusions as being due to freeze-thawing cycles. Micromorphological analysis contributes new data and confirms this interpretation.

Micromorphological features related to the injection phenomena include: a) parallel-striated b-fabric in protruding B-horizon material, not related to faunal passages, b) high porosity in soil masses lying adjacent to injected material and c) sand grain alignment. Other micromorphological features related to the freeze-thaw process are horizontal planar pores.

Injections as frost features are consequently not exclusive to Alpine or Arctic soils, but in this case, they are associated to a local microclimate change due to fire devegetation.

1. INTRODUCTION

Periglacial processes are usually found in high latitude or high altitude areas. In Catalonia, NE Spain, such processes have only been described in the Pyrenees Range and in the Montseny, always at high altitudes. Even though in lower areas winter frosts are commun, and some authors write about its possible effect in soils (Porta et al., 1985), there are no references about freeze related processes in such areas.

A geomorphological study carried out by two of us in the Prelittoral Range to observe the effects of summer forest fires on soil erosion, enabled cryoturbation processes to be detected during the 1986/87 winter survey. The features related to the frost action were observed in intensively burned areas and in other devegetated zones (pathways, tilled land, etc). Such features were absent in neighboring vegetated areas. Devegetation induced more severe soil temperature conditions as is discussed in Marques et al.(in press).

The frost and frost-thawing processes have given rise to pipkrakes, frost heaving, gaps around stones , sponginess of soil surface and extrusions of subsurface material towards the soil surface, apparently not related to biological activity. The observation of this last feature was possible because of the colour contrast between the black, burnt organic matter of the soil surface and the yellow-red clay loam-extruded material.

A detailed macromorphological survey and interpretation about some of these frost-induced features have been reported elsewhere (Marques et al., in press).

In this paper we deal with the micromorphological characterization of the extrusions (or injections) in order to deduce their origin.

2. MATERIALS AND METHODS

The surveyed area is located in St. Pau de la Guardia, at 625m a.s.l., in the Montserrat Mountains, in the Catalan Prelittoral Range. Annual rainfall, 675 mm, attains two marked maxima in May and September (85 and 75 mm respectively), and an absolute minima in July (30 mm). Mean annual temperature is 13°C. Absolute minima is -6°C. According to the Papadakis classification, the thermal regime is warm-temperate and the humidity regime is wet-Mediterranean (Elias and Ruiz, 1973).

The soils of the area are mainly Lithosols, Rendzinas and Cambisols (FAO-UNESCO classification) depending on the soil thickness, physiography and exposure. The Eutric Cambisols, typical from the forested areas, are quite shallow and their horizons from the surface down are:

O (0 - 0.5 cm): black, 5YR2.5/1, organic, loamy-sand;

A (0.5 - 15 cm): reddish brown, 5YR4/4, loamy;

Bw (15 - 30 cm): yellowish red, 5YR5/6, sandy-clay-loam;

C (from 30 cm): gravelly horizon derived from the conglomeratic parent material.

A complete macromorphological description is given in Marques et al. (in press).

In an area showing abundant extruded material, samples were taken in kubiena boxes (10x8x5cm) and after impregnation and consolidation, seven slices were made from each block from most of which were prepared thin sections (Murphy, 1986). Descriptions were done following Bullock et al. (1985).

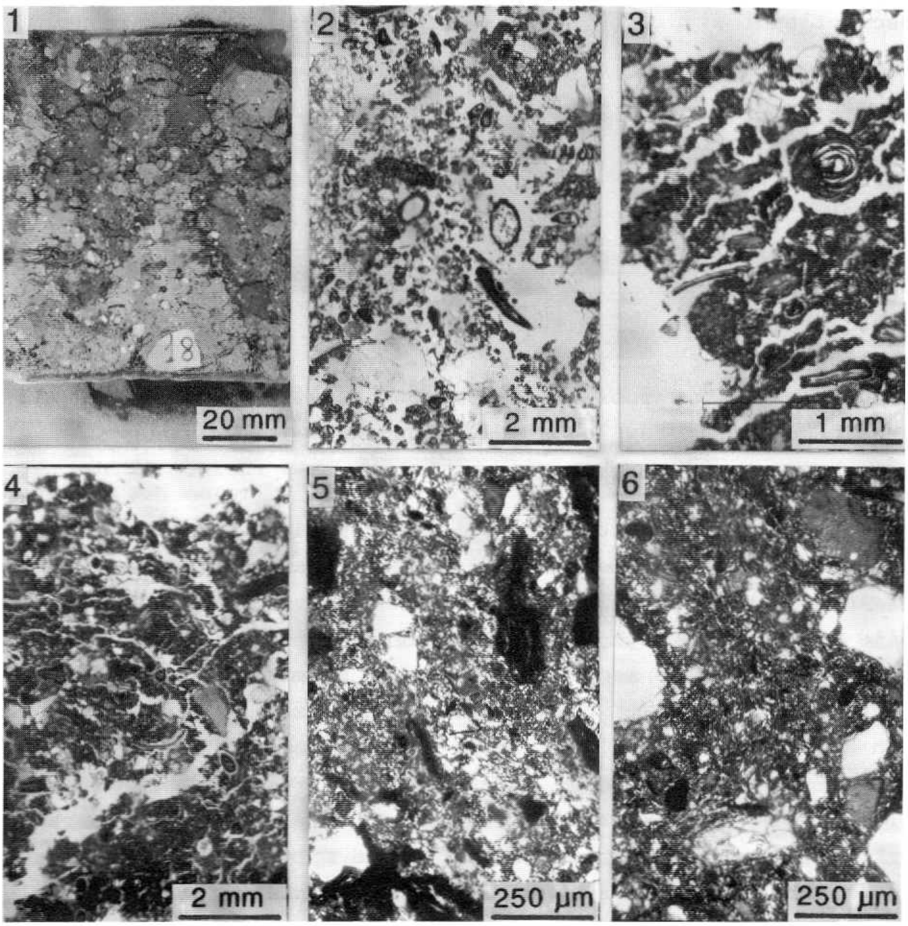

Fig. 1: *Bw horizon mass protruding through A- and O-horizons. Polished block.*
Fig. 2: *Comminuted plant remains and small aggregates giving a very loose structure. Horizon O. PPL.*
Fig. 3: *Horizontal planar pores in O-horizon. PPL.*
Fig. 4: *Horizontal planar pores in the A-horizon. PPL.*
Fig. 5: *Sand grain alignement in B-horizon material surrounded by A-horizon material. XPL.*
Fig. 6: *Speckled b-fabric in "P" material from the B-horizon. XPL.*

3. MICROMORPHOLOGY

Thin sections from the central part of the blocks show a quite different pattern to that of the outer sections: in the former, horizons O and A appear in a quite regular position; in the latter, on the contrary, materials from horizons O, A and B appear either heterogeneously mixed or showing a cone-like feature from the B horizon material protruding through A and O horizons (Fig. 1). The description follows the sequence of the three upper horizons.

1) The black surface O horizon is formed by rounded aggregates and partly decomposed plant remains, giving a very loose structure, with a very high porosity (>50%) made up of packing voids (Fig. 2). Aggregates have also a high internal porosity, made up of packing voids and horizontal planar pores (Fig. 3). Their mass is made up of minute plant residues (>60%). The mineral particles (<10%) are essentially quartz sand grains. The groundmass is yellow-brown, formed by amorphous material and speckled clay, showing a low anisotropy, with undifferentiated b-fabric to poorly developed stipple-speckled b-fabric. Aggregates of this type, which will be named "L", are in few occasions found as pedotubules in other horizons.

2) The reddish-brown A horizon comprises masses of welded aggregates and individual rounded aggregates of likely faunal origin with packing voids and some fine megachannels. The porosity, while still high, is lower than in aggregates of "L" type. Some aggregates are also separated by planar pores (Fig. 4). 40% or less of the mass is made up of organic particles, red-brown coloured, with a low anisotropy. The coarse mineral components include sand grains of quartz (90%), micas (10%), rare highly seritized feldspars and some limestone fragments. Mineral grains are randomly distributed. Groundmass is brown, formed by impure clay and organic fine material, with a low anisotropy and a poorly developed stipple-speckled b-fabric. Aggregates from this horizon will be named the "M" type.

3) The yellowish-red Bw horizon usually shows a sub-angular blocky microstructure with peds, which will be named the "P" type, with a very low internal porosity. The coarse mineral components are essentially the same as in the former horizon. Mineral grains are randomly distributed except when they show some alignments related either to natural surfaces (voids, ped borders) or to boundaries with "L" or "M" aggregates (Fig. 5). The grain alignment only appears in the thin sections from the central part of the sliced blocks. The groundmass, much more abundant than in both previous horizons, appears reddish-yellow and is made up of impure clay; it is quite anisotropic and shows a quite developed

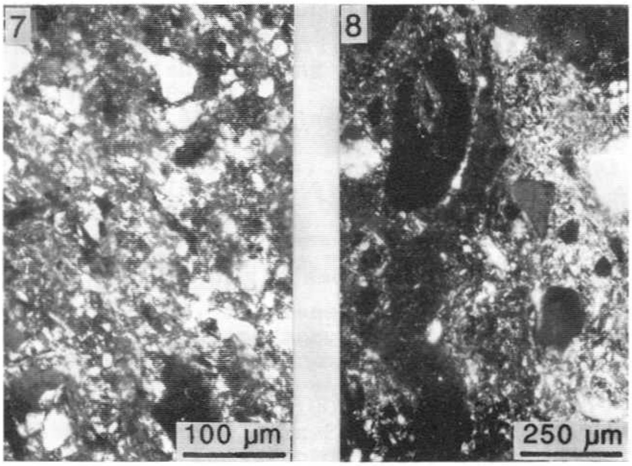

Fig. 7: *Parallel-striated b-fabric in a protruding "P" mass.*
Fig. 8: *Shear contact between B-horizon material (to the right) and A-horizon material (to the left).*

mosaic-speckeled b-fabric (Fig. 6); locally and only in the central thin sections it shows a moderately developped parallel-striated b-fabric (Fig. 7). Oriented domains are always parallel to shear contacts between "P" and "L" or "M" aggregates (Fig. 8).

4. DISCUSSION AND CONCLUSIONS

The pedological features, which are related to the freeze-thaw cycles occurred in the burnt areas and which support field surveys and macromorphology (Marques et al, in press), have been as follow:

- A. Horizontal planar pores affecting "L" and "M" masses (Figs. 3, 4): they are interpreted as the result of freeze-tawing cycles. According to Van Vliet-Lanoe (1987), similar structures may be recorded during a single freeze-taw cycle.

- B. oriented domains or striate b-fabric in soil masses which are always between very porous highly organic masses are attributed to any compressional stress affecting the soil mass (Brewer, 1964). Clay is oriented by shearing due to the movement of adjoining peds relative to one another after swelling has closed the planar voids (McCormack and Wilding, 1974). The compaction produced when invertebrates burrow through the soil mass can also create some fabric orientation. In the studied case, this possibility does not seem to be likely since the adjacent material is highly porous, so adequate conditions for the shearing to appear did not exist. Neither do we consider effective the swelling-shrinking mechanism since oriented domains are laterally surrounded by higly porous masses.

It is suggested that these adjacent highly porous masses, upon freezing and ice-lense formation (which is responsible for the lamellar porosity) became hard and expanded. This frost process exerted a considerable pressure and played a role of swelling against the softer "P" masses (possibly not frozen) giving rise to extrusions and oriented domains.

- C. Sand grain alignements parallel to oriented domains in striated b-fabric (Fig. 5): they suggest a soil-mass injection beetween harder (frozen) masses.

From the experimental data presented by Coutard and Mücher (1985) and Van Vliet-Lanöe et al. (1984) from 15 to 23 cycles are needed for the injections to appear. Normally freeze-thaw experiments are carried out using well layered standard materials. However in the studied soil, bioturbation by promoting mixing may have enhanced injection formation and decreased the number of required cycles.

It is not known whether conditions of quick slope evolution like those in the Mediterranean regions could preserve such features upon soil burial. Nevertheless, in most cases, these cryoturbation features will probably be destroyed by faunal activity as it has been recorded in Tierra del Fuego, Argentina (Solé-Benet et al., in press). Sampling for soil micromorphological studies has to take such seasonal phenomena into account.

Injections as frost features are not exclusive to high latitude or high altitude soils, but in these Catalan soils, they are associated to a local microclimate change due to fire devegetation.

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