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THE WEATHERING PRODUCTS CREATING GOOD VITAL ENVIRONMENT TO BIOTA FOR BETTER DELIVERY SOIL ECOSYSTEM SERVICES

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Abstract

There is little information about the plasmic constituent intimate arrangement of the Phaeozem groundmass. In this respect, a micromorphological investigation of a Vertic Phaeozem (located in Perchiu Hill) was performed.

The research results emphasise the presence of many types of striated birefringent fabric (b-fabric) in the groundmass of the pedogenetic horizons, induced by the swell-shrink processes (and representing criteria for the quantification of stress processes in Vertisols and vertic subgroups) as: porostriated and granostriated b-fabric, are rarely and weak developed; and both reticulate and parallel striated b-fabric developed on short distances. Into the pedogenetic horizons, rock fragments also appear in different degrees of weathering and integration into the groundmass, emphasising different evolution steps in the solification process. The linear and cross-linear alteration types of the rock fragments induced optical orientation of the clay domains similar to the different types of the striated b-fabric.

It could be concluded, that the b-fabrics, which are generally used as criteria for the quantification of the swell-shrinking processes stress (that disturbed the plant roots development and the soil life environment) also formed *in situ* from the strong weathered rock fragments. Consequently, the striated b-fabric generated by the weathering process created a friendly environment in soil and underlined a less stress forces (during the swell-shrink processes) in the studied soil.

The weathering products enriched the soils in the most precious constituents (the clay and nutrients) responsible for soil fertility, and further creating a good vital environment for biota to better delivery the soil ecosystem services.

***Key words: ecosystem services, biota,* micromorphology, Vertic Phaeozem, striated b-fabric.**

INTRODUCTION

The arrangement of the mineral constituents and their relationships in the soils are probably more complex than those found in most rocks since many types of minerals and their weathering products can occur in juxtaposition (Fitz Patrick, 1993).

Parent material is a pedogenetic factor which plays an essential role in the formation of soil stationary equilibrium; thus it could produces either weak "modulations", or true "renversements" to the climatic evolutive tendency of a soil pedogenesis (Duchaufour, 1977).

Meunier (1983) underlined that plasma is compose of primary minerals debris surrounded by secondary minerals and is characterise by a high porosity.

In the case of stratified parent material, its influence on soil pedogenesis depends on depth, thickness, degree of alteration, etc. of each layer type.

As showed Blokhuis et al. (1990), the mechanical soil movement is the most characteristic process in Vertisols, but also in some related clayey soils.

Burnham (1970) showed that, when soils are formed on weakly consolidated sediments, the fabric of subsoil horizons is much influenced by the fabric of parent material.

Thus, the microfabrics of argillaceous sediments differ from those of soil profiles, and often showing a distinct alignment of the domains parallel to the bedding (strial fabric).

Burnham (1970) pointed out that parallel striated b-fabric, together with porostriated and granostriated b-fabric are important fabric parameters of Vertisols. The width of the porostriated (planar vosepic) fabric and the percentage of parallel striated (masepic) fabric can be used as parameters to determine the stress process in Vertisols.

Mc Cormack and Wilding (1974) suggested that lattisepic plasmic fabric (reticulate striated b-fabric) also formed by swelling and shrinking, in soils that have high swelling pressure and relatively low shear strength.

The striated b-fabrics (skel-vo-ma-insepic) reflect a differential movement within the groundmass due to swelling and contraction.

There is strong evidence for attributing the striated orientation patterns of some of the plasma separations in sepic (birefringent) fabric to the effects of pressures and tensions produced by wetting and drying, as vosepic, masepic, skelsepic fabric; while a more readily acceptable origin for mosepic and insepic fabric is by inheritance, due to many sedimentary rocks sepic fabrics (Brewer, 1964).

Mermut et al. (1988) suggests that the presence of omnisepic (speckled b-fabric) shows some evidence of strain in the soil.

Mineral evolutions are influenced by good drainage conditions, which allow rapid leaching of elements, and by the abundance of organic matter.

Gilkes (1998), discussing the weathering behaviour of some common rock forming minerals, showed that initial stage of weathering of micas often consists of exchange of interlayer K to form vermiculite. This reaction is accelerated by the capacity of plants to reduce the K concentration of soil solution to extremely low values that represent the external K requirements of plants. In contrast the release of K from K feldspars requires that the framework aluminous-silicate structure be destroyed which is accelerated by the generation of low pH in rhizosphere.

Some studies showed that halloysite was the dominant clay minerals in the granite gnaiss saprolite (pH 4.18) and transformed to kaolinite clay in the overlying soil, while kaolinite was dominant clay in the saprolite developed from mica (pH 4.19). This suggest that the particular chemical microenvironment rather that the primary mineral structure controls the formation of secondary mineral structure controls the formation of secondary minerals during saprolite weathering (Harris et al., 1985; Kretzschmar et al., 1997).

Many authors underlined that the rate of weathering as well as weathering pathways may also be influenced (together with the microenvironment) by the chemical structure and grain size

(Gilkes, 1973; Kretzschmar et al., 1997) of the minerals.

Present study emphasised, at the micromorphological level, the intimate spatial arrangement of the plasmic constituents from a Vertic Phaeozem groundmass, in order to better understand the genesis of the striated b-fabric (which showed the stress forces intensity during the swell-shrink processes) that could affect the biota vital environment and consequently the soil ecosystem services.

MATERIALS AND METHODS

The studied area is located on Perchiu Hill, in the pedoclimatic microzone of Luvisols and Euthric Cambisols, with a hot semi-humid climate and non-uniform topography (ICPA Methodology–1987). The mean annual temperature is 9.3^{o}C and the mean annual precipitation is 580 mm.

The soil profile is located on a slope (15%) facing east of Perchiu Hill (fig. 1), at an absolute altitude of 320 m.

Figure 1. Perchiu Hill.

The soil is Vertic Phaeozem (according to WRB-SR–2014; and Vertic Pseudo-rendzina according to SRCS–1980) formed in a stratified parent material compose of marls, sandstones and gypsum and their colluvium.

The natural vegetation is pasture with Festucetum (*Festuca valesiaca* and *Medicago sativa*).

Large thin sections (6 x 9 cm), were prepared from undisturbed soil sampled from each pedogenetic horizon, after air drayed and hardened (afterwards impregnation with epoxidic resins). Soil thin sections had been studied at micromorphological level with: microfilms reader Carl Zeiss Jena DL at 5–20 X; petrographic microscope Amplival at 50–100 X; and Stereomicroscope Nikon SM2800 at 1-6 X; in plain (PPL), polarized (XPL) and oblique light, to described and interpret the soil constituents, their features and fabrics, according to Bullock et al. (1985) terminology.

RESULTS AND DISCUSSIONS

The results of the micromorphological investigation pointed out, in the top A mollic (Am – 0–16 cm) horizon the presence of a single to double-spaced porphyric coarse/fine (c/f$_{20\mu m}$) related distribution patterns and isotic birefringent fabric, due to the lower content of the organic matter.

Mineral components are represented by the quartz, feldspars, biotite, glauconite (almost colourless), calcite fragments, and opaque minerals.

The feldspars are in different degrees of alteration: from weak (with very small sericite flakes) to strong weathered (covered by clay).

Some feldspar fissures were partially clogged with blackish (more or less decomposed) fungi mycelium.

Biogenic mineral components, as diatoms and phytoliths (opal bodies formed in vegetal cells), were also observed.

The transition horizon (A/B – 30–37 cm) had open porphyric coarse/fine ($c/f_{20\mu m}$) related distribution patterns due to the relatively high clay content (36.6% - fig. 2).

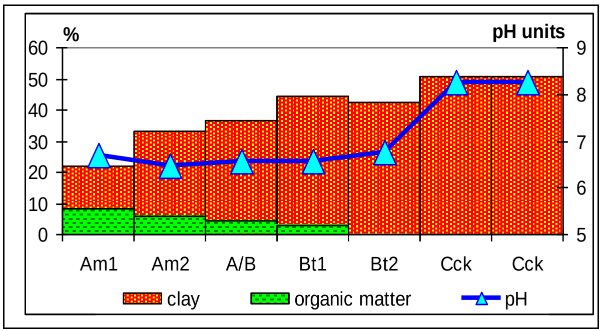

Figure 2. The main plasmic constituents (clay and organic matter) related to the pH values.

The groundmass showed a mosaic-speckled b-fabric, with short patches of oriented clay distributed throughout the horizon matrix. In some areas, parallel and reticulate striated b-fabric occurred on very short (200 – 1 000 µm) distances.
The shape of these area and the b-fabric patterns pointed out their origin in old weathered rock fragments and less into the shrink-swell processes. Rounded spots of Fe oxy-hydroxides (gels) were also present in these areas, as well as in the highly weathered fragments.
Coprolites with more birefringent clayey material (brought by the fauna from deeper horizons) were embedded into the groundmass.
Feldspars with masses of secondary clay (yellowish black in PPL and greyish in oblique light) were frequent. Highly altered feldspars fragments also appeared. They preserved initial shape, while the internal altered structure showed oriented clay domains distributed mainly parallel to the cleavages and intimately mixed with Fe oxy-hydroxides. Rounded (or spherical) spots (10 – 30 µm ∅) of reddish-brown Fe gel concentrations are randomly distributed.
Marl fragments (≥ 1 mm) subangular and ellipsoidal, highly altered, with Fe gel spots, were present. Inside the marl fragments, the parallel orientation of the clay domains was preserved, which will further generate parallel striated b-fabric during their embedding into the groundmass.
All these details emphasised that many striated b-fabric had been inherited from the weathered rock structures and not generated only by the swell-shrink processes.
In the upper part of the Bt horizon (Bt_1 – 37–50 cm), the coarse/fine ($c/f_{20\mu m}$) related distribution patterns were open porphyric, due to the high clay content (44.4% - fig. 2).
The speckled b-fabric was mosaic (with short patches of oriented clay distributed throughout the groundmass), as well as parallel and reticulate striated b-fabric (developed on short distances (as in the upper horizon).
The skeleton had almost the same composition as the previous horizon, but the rock fragments are highly weathered.
The primary texture of the very many rock fragments had been modified during the weathering process, and replaced by the optically oriented clay plasma (secondary clay minerals). Biotite is also weak altered (with the interference colours of the I order). Many yellowish brittle subangular fragments of completely clayey (kaolinized) pseudomorphs of biotite were observed.
Gilkes (1998) discussing the weathering behaviour of some common rock forming minerals, showed that initial stage of weathering of micas often consists of exchange of interlayer K to form vermiculite. This reaction is accelerated by

the capacity of plants to reduce the K concentration of soil solution to extremely low values that represent the external K requirements of plants. In contrast the release of K from K feldspars requires that the framework aluminous-silicate structure be destroyed which is accelerated by the generation of low pH in rhizosphere.

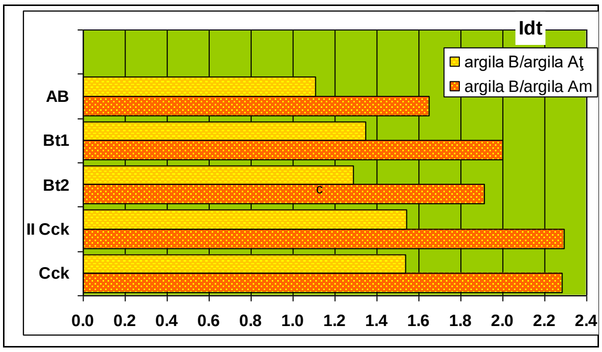

Figure 3. The index of the textural differentiation (as ratio between the clay content of either At or Am horizon ant the clay content from the Bt horizon).

The result of the granulometry pointed out two maximum values of the clay content: in Bt horizon (44.4%) and in the bottom Cck horizon (50.9%) respectively.

Consequently, the index of the textural differentiation (the ratio between the clay content of either At or Am horizon ant the clay content from the Bt horizon - fig. 3) is very high: 2 in Bt (comparing to 1.2 representing the condition for the Bt horizon – according to SRTS–2012) and 2.29 in Cck horizon (fig. 3).

Highly altered feldspars fragments also appeared (coated with secondary clay).

In temperate regions, feldspars (especially K-feldspars) are often considerate as relatively stable, and phyllosilicates (mica or chlorite) are the main source of clay minerals, such as vermiculite or smectite (Romero et al., 1992).

Fitz Patrick (1993) suggested that orthoclase, in cool moist conditions is altered to allophane or hydrous mica, and contrary, in highly temperature and humidity, kaolinite and gibbsite formed, as partial or complete pseudomorphoses.

Marl fragments (≥ 1 mm) subangular and ellipsoidal are highly altered, and the parallel orientations of clay domains were preserved, which will generate parallel striated b-fabric during their embedded into the groundmass.

Thus, emphasised that even in this horizon many striated b-fabric are inherited from the weathered rock structures.

Many sedimentary rocks have sepic fabrics. If such rocks weathered physically without drastic disturbances, many types of b-fabric may result, depending on the original patterns of the minerals in the rock fragments.

The next step in their evolution (after weathering), is their embedded into the groundmass as striated b-fabric.

In what concerning the gypsum, although it is easily removed from the soil, due to its solubility, silt-size gypsum grains were also observed in the soil matrix. Their presence at this depth could be the consequences either of fauna pedoturbation (transported from the top layer), or inherited from the parent material.

Some fragments with onmisepic fabric were entirely covered by thick Fe oxy-hydroxides films. In other fragments, the secondary weathered products had clay coatings morphology (moderate birefringence and diffuse extinction).

In the lower part of the Bt horizon (Bt_2 – 50–67 cm), according to the weathering structures in the case of sand and silt-size sandstone, marls and biotite flaks, the degree of preservation of the original shapes and volume is very high.

Some feldspars fragments shown an intense microfracturing associated with the formation of the secondary crystals (clay neoformation). Marl microfacturing is rather absent, that is why the secondary weathering structures appears as a striated b-fabric. Only after their complete integration into the groundmass there were crossed by the planar voids (during horizon desiccation).

Into the bottom horizon (Cc – 67–82 cm) the weathered fragments appeared also in lumbric coprolites. At low magnification seems to be yellowish-brown clay coatings, with moderate optical orientation and diffuse extinction, while to the higher magnification it showed weak optical orientation and absent extinction due to the local reorganization of secondary clay domains under the influence of the soil solution flow.

Summarising the studied soil characteristics, it must be underlined few important threats.

Although the studied Vertic Phaeozem was formed in the Luvisols microzone, and the index of the textural differentiation is very high (2.00 – 2.29), the plasma mobilisation or leaching were not observed. Also the soil pH (6.55 – 6.75 in AB and Bt_1 horizons respectively) would favour leaching.

Thus suggests that soil is young, being kept in a youth state by the cations released by weathering, cation that impede the leaching of the clay (and other weathered products).

Bt_1 horizon is not a argiloilluvial horizon. Its morphology suggests rather a B cambic (Bv) horizon with clay formation *in situ* (*argilization/ cambization*).

More than 50% of the Bt horizon groundmass represented weathered rock fragments.

If such rocks weathered physically without drastic disturbance, many b-fabrics may result depending on the original orientation pattern of the mineral constituents in the rocks. The degrees of both disturbance and alteration of the orientation pattern had been strongly influenced by the pressures formed in the groundmass movement during the wetting and drying periods. Less pressure developed in the soil matrix, less deformations of the pattern orientation result, and consequently more evident b-fabric types formed.

The groundmass of the Bt horizons had a specific vertic micromorphology, due to the fabric of the fine material.

The multitude of the weathered rock fragments could permit a reconstitution of the temporal sequences of the different rock weathering types. Such sequences were very useful to understand the b-fabric genesis.

Thus, the altered fragments preserved their shape and texture (according to geological concepts), while weathering product do not leached. Moreover, between the weathering products there are also strong connections.

It could be concluded, that the b-fabrics which had been used as criteria for the quantification of the stress pressure generated by the swell-shrink processes, that stressed the plant roots development and the soil life environment, had also formed *in situ* from the strong weathered rock fragments.

Consequently, the striated b-fabric generated by the weathering process created a friendly environment in soil and underlined a less stress forces during swell-shrink processes.

In this respect, the analysed soil striated b-fabrics are not the exclusive result of the swell-shrink processes; they originated also in the strongly weathered fragment rocks with preserved orientation of the alteration products (clayey±Fe, etc.), orientation similar to the different types of b-fabric.

The weathering products enriched the soils in the most precious constituent (as clay) responsible for soil fertility, and further creating a good vital environment for biota to better delivery the soil ecosystem services.

CONCLUSIONS

In the pedogenetic horizons of the studied soil, rock fragments in different degrees of weathering and integration into the groundmass were observed, emphasising different evolution steps in the solification process of the parent material.

The primary texture of these rock fragments is partially to totally modify (under weathering) and appears as a mass of microcrystalline plasma of secondary clay particles strongly optical oriented: consequently, the linear and cross-linear alteration types of the rock fragments induced optical orientation of the clay domains similar to the parallel and reticulate striated b-fabric and further, in time, they are embedded into the soil groundmass, preserving their orientation.

This study underlined, as a general conclusion, that in the analysed soil, striated b-fabrics are not the exclusive result of the swell-shrink processes, being also generated by the weathering of the rock fragments inherited from the parent material.

This emphasises the important role of the rock fragments weathering to create a friendly environment and rich in nutrients, in soil and underlined a less stress forces during swell-shrink processes.

The weathering products enriched the soils in the constituent responsible for the soil fertility, which generated a friendly environment for soil biota to better provided soil ecosystem services.

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