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# MICROBIOTA FUNCTIONALITY AS THE MAIN SOIL ECOSYSTEM SERVICES IN EUTRICAMBOSOLS

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**Abstract**

The Eutricambosol are young soils with a simple morphological profile (A-Bv-C/R). Taking into account their genesis and location, there are two main problems concerning the „Eutricambosol classification“: they were classified, by mistake as Luvosols (due to the presence of an „alteration bed“); they were restricted to the zones with > 600mm precipitations.

The researches focused on these two problems, detailing the characteristics of the „alteration bed“ on two profiles of Eutricambosols located in the Oriental Carpathian Mountains.

The micromorphological investigation of the „alteration bed“ (which appears at the bottom of the two studied profiles) showed clay coatings, generated mainly by the skeleton grains weathering. The weathered products (clay+Fe+etc.) leached and reorganised on short distances, mobilized mainly by the laminar circulation of the soil solution.

In what concerning the second mistake, the precipitations > 600mm is not a condition in the soil classification/taxonomy, it was inherited from the old ('60-s –'70-s) „Pedology manuals", when both Cambisols (Eutricambosols and Districambosols) were included into the 〞Forest Brown Soils〞, developing in the deciduous forests zone, with 632–1035mm precipitations.

In reality, Eutricambosols are ubiquitous, being formed in a wide variety of landscapes: from tabular plain, to hilly and low mountains regions.

In this respect, it would be desirable to know the concept and the correct classification of each soil, which leads to a correct management and further to the adequate conservation technologies, in order to preserved and/or improve the biota habitat for a better delivery of the soil ecosystem services.

***Key words: Eutricambosols, micromorphology, alteration bed, soil microbiota, ecosystem services***

## INTRODUCTION

Cambisols are soils with a broad range of properties and occurring in diverse environments, but lacking conspicuous features (Gherasimova et al., 2021)

Cambisol as a term and a concept was first introduced in the world of soils by Dudal (as a compromise among terms of national schools), as a legend unit for the FAO-UNESCO Soil map of the world (FAO-UNESCO, 1971–1981; Driessen and Dudal, 1989; Gherasimova et al., 2021).

The soil properties are strongly influenced by the parent material (Marques et. al., 2007).

Neto et al. (2019), studying the micromorphology and genesis of seven profiles from three topolitosequences, showed that in the studied Cambisols with a lower degree of weathering, the cambic horizons are typically shallow, with preserved grains of primary minerals, while the microgranular structure indicates intense pedobiological activity at present times, superimposed on pre-weathered materials.

Romero et al. (1992) distinguished two mineralogical microsystems that emphasised different weathering stages, as following: (i) for the feldspars, exsolution and mass transformation lead to the delineation of parallel domains, and to formation of gel or paracrystalline minerals; while for the micas, alteration starts with a physical breakdown (exfoliation and crystal microdivision) and further the individualization of monolayers is followed by gel formation.

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

Cambisols contain clays with great activity, rich in $Ca^{++}$ and carbonates, having well-developed structures (Gava et al., 2022).

Torres-Sallan et al., (2018) stated that the dynamics of soil organic carbon in subsoil horizons is soil-type dependant, i.e. in Cambisol group (Haplic and Stagnic Cambisols) and also, under the similar management conditions with similar amounts of soil organic carbon inputs, both pH and CEC have a strong role to play in aggregation process (the formation of microaggregates within macroaggregates).

In what concerning the location of the Cambisols (Haplic Cambisols) there are among the soils found on the erosional slopes, and colluvial erosional slopes, while in the alluvial colluvial valley bottom, the Fluvic Cambisols were formed (Machado et al., 2018).

The present paper evaluated in detail the problems concerning the „Eutricambosol classification“, which implied two main mistakes: their naming as Luvosols (due to the presence of an „alteration bed“ at bottom profiles); and the restrictive condition concerning their location in the areas with > 600 mm precipitations. The researches focused on these two problems, detailing the characteristics of the „alteration bed“ on two soil profiles of Eutricambosols.

## MATERIALS AND METHODS

Two Eutricambosols (Haplic Cambisols according to WRB-SR–2014) located in the Oriental Carpathiens (in Obcina Mare) had been studied. The climatic data are represented by an average annual temperature of 3–4$^{o}$C and the average annual rainfall of 800mm. Both soils had a humid humidity regime, while the temperature regime was criic.

The soil profile P1 is Typic Eutricambosol (according to SRTS–2012), formed in the parent materials originate in from silt-clay deposits (solifluxion?) alternating with sandstones and argillaceous shale. The profile was located at 750 absolute altitude, on a slope of 30–35% south-facing. The bioclimatic zone is of the beech forests. The land use is (secundary) pasture with *Agrosticetum–Festicetum: Agrostis tenuis, Festuca rubra, Briza media, Anthoxanthum odoratum, Trifolium pratense, Potentilla argentea, Potentilla erecta, Agropyron cristatum.*

The soil profile P2 is Pelic Eutricambosol (according to SRTS-2012), formed in the same parent materials (as P1), at 1050 m absolute altitude, on a slope of 20–25% facing south–west. The bioclimatic zone is of the coniferous forests (mixed forests:

beech, fir, and spruce). The land use is (secondary) pasture with *Nardet: Nardus stricta, Festuca rubra, Arrhenatherum elatius, Briza media, Anthoxanthum odoratum, Trifolium medium, T. repens, Potentilla erecta, Potentilla ternata*.

Soil samples, both disturbed (for physical and chemical analysis) and undisturbed (for micromorphological investigation), were analyzed according to the standard methods of ICPA-Bucharest (ICPA Methodology–1987).

The micromorphological undisturbed samples were air drayed and impregnated with epoxidic resins. After hardening, large (6x9 cm) oriented thin sections were prepared and studied at micromorphological level (with microfilms reader Carl Zeiss Jena DL 5–20 X; and petrographic microscope Amplival at 50–100 X; and Stereomicroscope 1–6X; 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

### 1. Micromorphological characteristics of the Eutricambosol

The results of the micromorphological investigation emphasize that Typic Eutricambosol (P1) has been formed in a stratified parent material: the upper part (0-60cm) was deposited as a result, probably, of the massive solifluctions) over an old soil (corresponding to the lower part of the soil profile 60–110cm - the current horizons sequence II BC(w)–Cn(w)), which evolved under favourable conditions for both *in situ* clay formation and clay illuviation. This stratification resulted in the formation of a bisecvuum that later evolved as a unitary profile of Eutricambosol, under the influence of the most active pedogenetic process, the argillization *in situ*, resulting the current soil with the cambic horizon (Bv – 30–60cm).

In the $Bv_1$ sub-horizon (30–42cm), frequent fragments of aleuritic sandstone appear (with fine sand sizes minerals of feldspars, galuconite, quartz) in different degrees of alteration. Some of these have many cracks coated with light brown clay coatings (with good optical orientation and sharp extinction). In the case of the smaller strongly altered sandstone grains, the clay resulting from the alteration, more or less pigmented with Fe, preserves the spatial arrangement of the rock and integrates into the soil matrix as sepic plasmic fabric (insepic, omnisepic, massepic). These fabrics are relatively stable and resisted long time to the repeated wetting-drying cycles. The sandstone grains with ferruginous cement, are important sources of supplying the horizon with clay and Fe, and through fragmentation, they generated „ferric nodules“.

Fragments of fungal mycelia were observed in the cracks of the sandstones, their installation in these places accelerates the weathering.

The $Bv_2$ sub-horizon (42-60cm) initially constituted the parent material for the upper part of the bisecvuum, while the Cn(w) horizon (80-110cm) represented the parent material for the old soil. The two horizons have, in general terms, similar characteristics, being made up of deluvium rich in sandstone fragments (arcosian, abundant in feldspars, many with ferruginous cement). The deeper horizon have specific characteristics of an „alteration bed‟ dominated by the presence of the sandstone fragments highly altered (or in different stage of alteration) and containing a significant amount of clay either on cracks or on the edges. Part of the clay resulting from the alteration is optically oriented and organized in in-massepic plasmic fabrics inherited from the rocks; while the clay deposited in the planar voids (delineating the rock fragments from the soil matrix) or filling the circular pores is strongly-moderately optically oriented and with sharp extinction. They are the result of the local mobilization, and/or the lateral migration. In the cracks and cavities of many sandstone fragments (with mineral grains of the fine sand sizes) light yellowish-brown clay coatings appear, optically oriented.

The essential difference between the two previously described horizons is that (Cn(w) - 80-110 cm) is older (with the clay from the coatings having the polarization colours close to those of the second-order degree and being under the destruction process), while $Bv_2$ (42 - 60 cm) is a younger horizon.

The soil fauna activity is intense in P1 and has a positive influence on the porosity by creating channels that appear frequently in the profile.

The activity of fungi is also important, showed by the presence (throughout the profile) of the black opaque sclerotium. Also, in the cavities of highly altered sandstone grains (from the $Bv_1$ horizon), fungal spores (blackish brown, strongly ornamented) and ferobacteria were observed.

The organic matter appears in the profile both as vegetal remains (in various degrees of fragmentation and shredding), and as humified organic matter (the humus being calcic mull).

In the deeper horizons, melanized fragments of woody roots appear, being a clear testimony of the fact that this profile previously developed under the forest.

In this respect, the soil profile evolved as Eutricambosol, the current pedogenetic process being the argilization *in situ*.

In what concerns the Pelic Eutricambosol (P2), the soil profile developed in a relatively uniform parent material consisting of alluvium and alteration products resulting from the weathering of predominantly arcosian sandstones (of Fusaru-Tarcău).

*In situ* clay formation is the major pedogenetic process in this soil and resulted in the genesis of the cambic horizon. Aspect highlighted by the presence of the altered mineral grains (feldspars totally or partially weathered to clay) and small fragments of strongly weathered sandstones, part of them in the process of integration into the soil matrix as clay±Fe with weakly developed in-masepic plasmic fabrics.

Within the profile, greyish (greyish-blue) spots also appear, more evident in the lower horizons. These are either inherited from the rock fragments, or the result of the preferential circulation of the soil solution, especially on the cracks around the rock fragments. This circulation also influenced the mobilization of clay which, over time, partially filled these cracks (more obvious in the bottom horizon). The soil solution flow both gravitational and laterally (throughout the soil profile, parallel to the slope direction/surface). The plasma in the AB horizon is very stable.

In what concerning the plasma mobilization, it could be noticed that in the Bv horizon (28–47cm) the plasmic material was locally mobilized into the matrix with the formation of impure clay coatings (with the same composition as the matrix plasma). Older yellowish-brown clay coatings were also observed, in the process of cracking. Rarely quasi–coatings also appear, in the cambic horizon, as a result of plasma migration from the matrix to the voids.

The organic matter in the profile is dominated quantitatively by the vegetal remains (in various degrees of fragmentation and decomposition) and less humified (the humus being also calcic mull as in P1).

The presence of woody root fragments in the profile suggests that the profile initially evolved under the forest.

The activity of the soil fauna is relatively intense, having an important role in mixing and homogenizing the mineral and organic material as well as in creating good porosity and viable structure.

Also, the activity of fungi is important, highlighted by the presence of the black resistance and fruiting bodies and spores.

Concluding, this soil (P2) is a relatively young Eutricambosol, which has developed under the influence of the „cambization" / argillization process (*in situ* clay formation).

Although the recent impure clay coatings, as well as older clay coatings, were observed in the Bv horizon, it could be underlined that the clay illuviation process is relatively recent.

Lateral migration/ illuviation (parallel to the slope direction/surface) of the clayey±Fe plasma should not be neglected either.

The alteration bed of P2 was less developed and younger (comparing to P1), having less clay mobilization.

In what concerning the mineralogical composition of both soil profiles (fig. 1 and 2), the clay is dominated by the smectite (which showed double values comparing to the illite).

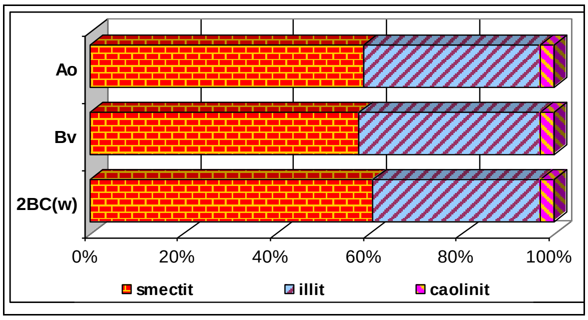


**Figure 1. The mineralogic composition of the clay (%) from P1.**

In both soil profiles, the smectite is almost identical quantitatively, while the illite is slowly increased in P1 (comparing to P2) as a result of many weathered mica flecks and others rock fragments that liberated by alteration this type of clay.

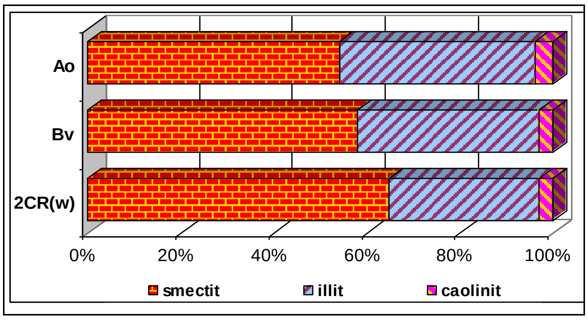


**Figure 2. The mineralogical composition of the clay (%) from P2.**

## 2. *The Eutricambosol classification problems*

During the time, even if the Eutricambosols have a simple, differentiated profile, frequent mistakes had been done considering their naming into classification systems/taxonomy.

The Eutricambosols are young soils with a simple morphological profile (A-Bv-C/R). Taking into account their genesis and location, there are two main problems concerning the „naming of Eutricambosol":

1) In many cases, the Eutricambosols had been classified, by mistake, as Luvosols, due mainly to the presence of their „alteration bed" (at the bottom of the soil profiles);

2) Their distribution area is restricted (by some soil scientists) to the zones with > 600 mm precipitations.

### *2.1. The alteration beds of the studied Eutricambosols*

The micromorphological investigation of the „alteration bed" (which appears at the bottom of the two studied profiles, as well as in the majority of the Eutricambosols) as the clayey layers, with many clay coatings, generated mainly by the skeleton grains weathering.

The alteration bed is defined as: „a non-pedogenetic underlying mineral layer, representing a young deposit with a fine texture (usually clayey), located at the base of the soil, resulting from the rocks alteration, in which both the initial organization of the rock is locally preserved, as well as strongly altered rock fragments, very friable, containing oxidation-reduction spots; it can be confused with B (Bv or Bt) horizon" (Conea et al., 1977).

The micromorphological investigation showed that in these alteration beds, clay coatings appear sporadically, being generated mainly by the skeleton grains weathering (fig. 3 and 4).

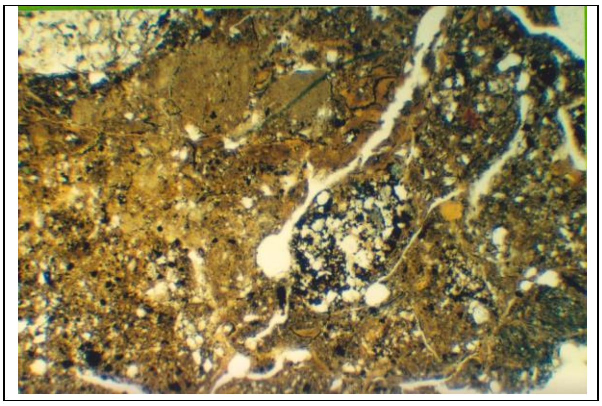

**Figure 3. P1 – Cn+R horizon: strongly weathered rock fragments embedded in the clayey alteration bed. PPL.**

The weathered products (clay+Fe+etc.) leached and reorganised on short distances, near the formation places (vicinity of the weathered skeleton grains) mobilized mainly by the laminar circulation of the soil solution (parallel to the direction of the slope, respectively).

Several generations of clay coatings were deposited in the cracks and delineated the strongly altered sandstone fragments from the surrounding matrix, and partially filled them (fig. 4). They are the result of the local mobilization of clay resulted from the weathered rock fragments, under the influence of the soil solution flow (gravitationally or laterally through the soil horizons).

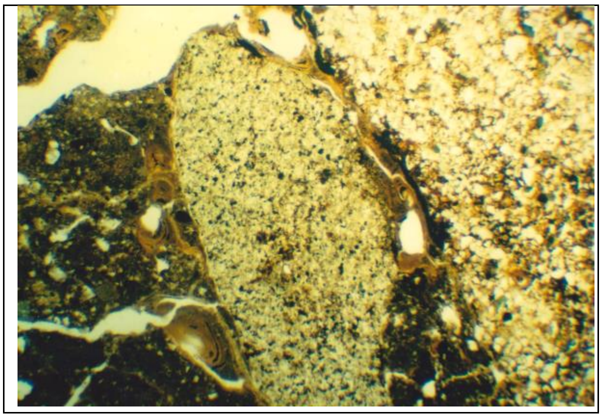

**Figure 4. P1 – Cn+R horizon: the weathered rock fragments surrounding by the weathered products locally reorganized. PPL.**

The amount of iron is also very high (due to the presence of many sandstone grains with ferruginous cement).

In these horizons, light-yellowish brown or dark-yellowish brown clay coatings (rich in ferric gels) filled the cracks around the altered fragments; as well as older coatings (with polarization colours close to those of the second-order degree).

The alteration bed (from P1) is younger than in P2, less evolved, with less mobilized clay. In P2, the strong alteration of the sandstones (Fusaru-Tarcău) resulted in the genesis of a clayey horizon (fig. 5).

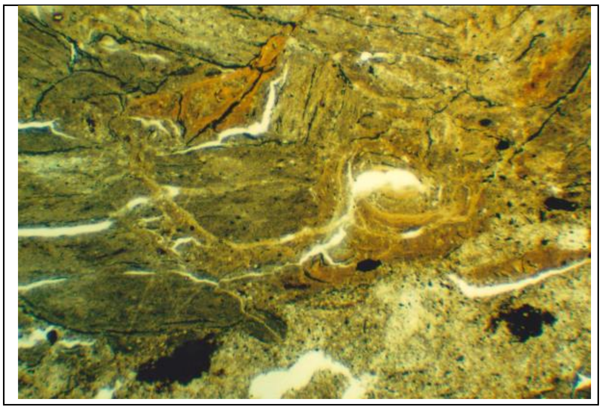

**Figure 5. P2 – Cn+R horizon: clayey alteration bed. PPL.**

These horizons have clear characteristics specific to the „alteration beds", where the friable material consist of clay with plasmic fabrics inherited from the rock texture. This aspect highlights the fact that the deeper layers (from the bottom profiles) are little pedogenetically transformed, which allowed the preservation of the rock texture.

### *2.2. The restriction of Eutricambosol distribution area to the zone with more than 600 mm precipitations*

Many Romanian soil scientists reduce the area of Eutricambosols occurrence, of the zones with precipitation > 600 mm.

This condition does not appear in SRTS-2012 or in another soil classification however, they are still used in the soil mapping of some areas.

This condition was inherited from the old ('60-s – '70-s) „Pedology textbooks" (as Paunescu, 1963), when both genetically type of soils of the Cambisol class (Eutricambosols and Districambosols respectively) were not separated, being included to the „Forest Brown Soils" developing into the area of deciduous forests, with precipitation between 632–1035 mm.

In reality, Eutricambosols are ubiquitous soils that appear in different climates and landforms: from tabular plains, to hills and low mountain regions.

The „*in situ* argilization" process is present even in the Chernozem zones, where the precipitation rarely exceed 500mm.

In general, precipitation between 600-1000 mm ensures a transpercolative soil regime (with mobilization and leaching of plasma).

Eutricambosols are young soils, in which the constituents only migrate locally or over short distances within the horizons. In most cases, the alteration products remain at the place of formation, undergoing only local reorganizations (due to the cations presence as the weathering products).

In conclusion, we consider that the amount of precipitation is a wrong restrictive condition for Eutricambosols, especially since this criterion does not represent a condition for naming Eutricambosols in SRTS-2012 (or in another soil classification/taxonomy system).

According to the paper results, the microbiota is the main supplier of the ecosystem services in Eutricambosols, in which the main process is that of microbial alteration.

## CONCLUSIONS

The „alteration beds", consist mainly of clay with plasmic fabrics (inherited from the rock) and strongly weathered rock fragments, while the mineralogical composition of the clay is dominated by the smectite.

The amount of precipitation could not be a restrictive condition for naming the Eutricambosols, since such a criterion does not represent a condition in SRTS-

2012 (or in another soil classification/ taxonomy).

There is not a specific area for Eutricambosols (as for the Districambosols or Podzols), these soils being ubiquitous and formed in different climates and landforms: from tabular plains, to hills and low mountain regions.

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