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SOIL OLD AGE

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Abstract

The old and stable landscapes reach a balance with the environmental conditions and have a special beauty, acquired during their long process of formation. Likewise, the very old soils have a special beauty and a unique development of the pedogenetic horizons. This beauty and uniqueness highlighted the paper, by the aim of the researches of an Alosol (SRTS-2012; Alisol - WRB-SR-2014) located on an old and stable terrace relief, researches that starting from the morphological level and reaching the more detailed level of micromorphology. The Alosol had, at least in its upper part, the appearance of a Dystricambosol, due to the high acidity and the destruction processes that penetrated deep into the Bt horizon. The main characteristics that emphasised the oldness of the studied Alosol were the: depleted, textural, and amorphous pedofeatures (whose composition, colour and location reflect their age). The most spectacular was the network (with perfect angles at 90º and greenish-gray reduction colours) expressed more clearly in the Bt_2W horizon. The melioration of such an old soil should be very expensive, the reforestation being the most suitable.

Key words: *soil age, Alisol, Alosol, micromorphology, pedofeatures.*

INTRODUCTION

The soil, as the "epidermis" of our planet, is the major component of the terrestrial biosphere and, in the present age, it is difficult to understand how one could be interested in general ecology without having some knowledge of the soil and further, to study the soil without taking into account its biological components and ecological setting (Lavelle & Spain, 2002).

Soil fauna communities are sensitive to acidity although different groups may react differently, thus, larger invertebrates are more sensitive than smaller ones and, among them, arthropods are more acid tolerant than earthworms (Lavelle et al., 1995).

Such acid environment has Alosols, soils belonging to Luvisol class and defined (according to SRTS-2012) as soils having "eluvial (E) horizon followed by a B argic (Bt) horizon having the cation exchange capacity of clay > 24 me/100 g and base saturation < 53% at least in the upper part of the Bt horizon". While according to WRB-SR-2014, these soils are Alisols and are defined (briefly) as soils having "an argic horizon starting ≤ 100 cm from the soil surface; and a base saturation, calculated on the sum of exchangeable bases plus exchangeable Al of < 50%".

The primary illite is abundant in the Alisol; also the expanding clay minerals have their maximum in this soil (Stahr et al., 2010).

The micromorphological study of a mature profile of Alisol (performed by Krasilnikov et al., 2005), showed few thin clay coatings (occasionally fragmented by biogenic-turbation) in the BW horizon and in the BC and C horizons, the amount of clay coatings and biogenic aggregates decreases.

The acid grassland soils exhibited a faster rate of nutrient turnover than forest climax soils; these differences were emphasised for the N cycle and may be attributable to deposition of dung by grazing cattle, and to the greater rhizospheric activity of the grassland vegetation (Ferreiro et al., 2007).

The old and stable landscapes reach a balance with the environmental conditions and have a special beauty, acquired during their long process of formation. Likewise, the soils, the very old ones have a special beauty and a unique development of the pedogenetic horizons. This beauty and uniqueness wants to highlight the present paper, by the aim of the researches that starting from the morphological level and reaching the more detailed level of micromorphology.

MATERIALS AND METHODS

The researches had been performed on an Alosol Albic Stagnic (according to SRTS-2012; or Albic Stagnic Alisol Hyperdystric, according to WRB-SR-2014) located in Pre-Carpathian Depression of Oltenia, on a terrace, at the absolute altitude of 268 m. The surface is cvasi-horizontal, with < 2% slope (Figure 1).

Figure 1. The landscape of the studied Alosol

The parent material consists of fluvic clayey deposits, while the subjacent rock is represented by the carbonate-free clayey deposits with Holocene substrate of gravels and sands. The groundwater is at 5-10 m depth. The global natural drainage is imperfect. Bioclimatic zone is of oak forest. The vegetation consist of: secondary meadow with *Festuca* sp., *Agrostis stolonifera, Trifolium repens, Trifolium fragiferum, Potentilla recta, Ranunculus cassubicus, Thimus* sp., and *Achillea millefolium*.
The climate is temperate continental, with the average annual temperature of 9.5ºC, and the average annual precipitations of 914.7 mm.
The soil had been sampled in disturbed (for physical and chemical analysis) and undisturbed (for micromorphological study) status, from each pedological horizon. The sample analysis and the data interpretations were performed according to the standard methods of ICPA-Bucharest (ICPA Methodology, 1987).
From the undisturbed soil blocks (air dried and impregnated with epoxy-resins), oriented thin sections (of 25-30 μm) have been made for the micromorphological investigations. The terminology used for micromorphological description was according to Bullock et al. (1985).

RESULTS AND DISCUSSIONS

What does an old soil mean?
Compared to the temporal scale of the human life, all soils can be considered old aged.
In the pedological concept, however, an old soil means an evolved soil, to which the pedogenetic horizons are very well differentiated, and the soil reached a balance with the environment, at a status of „climax“.
Many Luvisols (as Alosols) can be included in the highly evolved soils category.
A representative Stagnic Albic Alosol formed on an old and stable relief of terrace had been studied. The land use was oak forest (the evidence being the fern clumps, reminiscence of the old forest) but in the last 30-40 years the land use has been pasture.
Morphologically (Figure 2) the Alosol had, at least in its upper part, the appearance of a Dystricambisol, being more yellowish (compared to a "classic" Luvisol), and having, in the upper part of the Bt horizon, the specific prismatic structure destroyed.

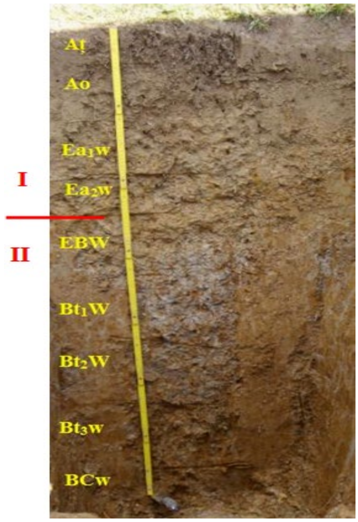

Figure 2. The Alosol profile

This Alosol was formed in stratified parent materials, as a result, the soil is a bisecvum consisting of two sequences of horizons (Figure 2): I) Ao-Eaw and II) EBW-BCw.

The data of the granulometric analysis (Figure 3) also showed this stratification: not only by the clay content differences (which could be mainly pedogenetic) but also by an abrupt decrease of sand (coarse + fine sand) with 10% (from 41.00-43.40% in the upper I sequence to 25.30-34.20% in the second lower one).

As a result, a sharp decreased of the coarse sand appear, from 11.2-13.6% in the upper sequence (corresponding to the depth 0-50 cm) to 5.8-8.1% in the deeper horizons (corresponding to 50-160 cm).

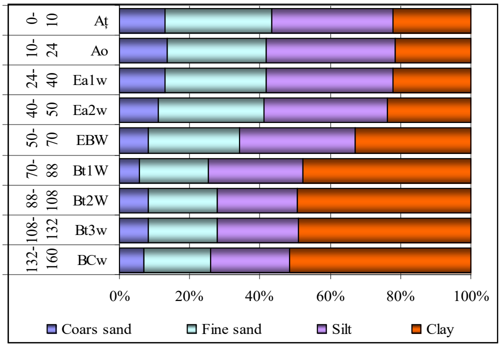

Figure 3. The soil granulometry

The main processes that lead Alosol pedogenesis and further increased, over time, the differences between the two depositional sequences (and which also dominate the pedogenesis nowadays) are: clay illuviation and stagnogleization.

The clay illuviation process was, over time, very intense (both its eluvial and illuvial components) and generated many types of pedofeatures whose composition, colour and location reflected their ages.

The eluviation process was, over time, very hygh, thus, the matrix background of all the pedogenetic horizons became nearly similar to that of the eluvial (Ea) horizon: very poor in plasmic constituents; also emphasised by the pH values and the sum of the exchangeable bases (SB) values (Figure 4).

The destruction processes, lead by the lower values of the soil solution pH, which penetrated deep into the soil profile, throughout the base of the Bt horizon (at 132 cm depth), deeply change the soil physical and chemical characteristics.

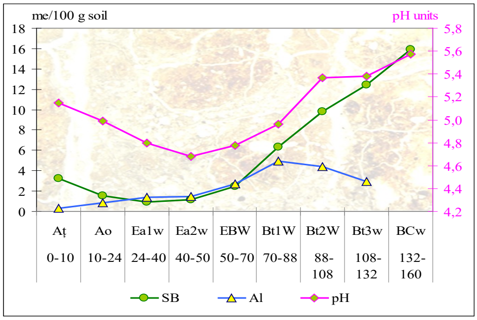

Figure 4. The sum of the exchangeable bases (SB - me/100 g soil), pH and exchangeable Al values

In this respect, only the surface Aţ horizon had a moderate acidity (5.2) as a result of the cation biological accumulation, the SB values reaching 3.23 me/100 g soil (Figure 4). In the major part of the soil profile (10-88 cm) the acidity is strong (pH values ranging from 4.7 to 4.9), while into the BtW horizon, the values increased again to 4.9-5.4, the acidity being moderate.

In this acidic environment, the cation accumulation was hinder, thus the values of the sum of the exchangeable bases (SB) is very low, ranging from 0.94 me/100 g soil (in Eaw horizon) to the higher values of 6.31-15.88 me/100 g soil (into the BtW horizon and BCw respectively).

The soil adsorption complex is dominated by the H^+ cations, followed in the decrease order by Ca^{2+}, Mg^{2+}, Na^+, and K^+. For all these cations, the highest values are reached in the lower horizons (BtW and BCw, respectively).

The exchangeable aluminium content is high, reaching the maximum values (4.91 and 4.39 me/100 g soil) in both Bt_1W and Bt_2W sub-horizons, and decreasing afterwards, in the bottom profile to medium content (2.93 me/ 100 g soil).

Răducu (2019) showed that Al content depends on the amount of colloids (especially clay), thus at very close values of the pH, but different amounts of clay, the content of the (exchangeable) Al is very different (in Alosols).

From the conceptual point of view, Alosol is a Luvisol with high acidity (pH below 5.8) on the

whole profile (holoacid) and, therefore, with very high aluminium content (as its name suggests: "Al-o-sol"). For this reason, to classified this soil, quantitative indices were selected to highlighted the conditions that favour the Al accumulation in soil: the cation exchange capacity of clay (which must be greater than 24 me/100 g clay); and the base saturation (which must be less than 53% - according to SRTS-2012).
Thus the most important chemical parameters used, to separate the Alosols from Luvisols are: base saturation (BS - %) together with the cation exchange capacity of clay (CEC_{clay} - me/100 g clay - Figure 5).

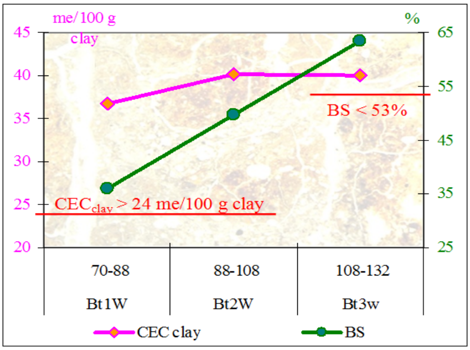

Figure 5. The conditions for the "alic" subtype and "Alosol" type respectively: cation exchange capacity of clay (CEC_{clay}) > 24 me/100 g clay, and the base saturation degree (BS) < 53% (SRTS-2012)

In the studied Alosol, the BS (%) values are low: 34.8% in the surface horizon, decreasing drastically to 15.5-18.4% in Eaw horizon, while in the BtW horizon, the BS values increased again to 63.4-77.5%.
Consequently, the soil is oligomesobazic in both Aț and BtW horizons, and oligobasic in the major part of the soil profile; while in the bottom profile, the soil is mesobasic as a result of the highest BS values.
The Bt horizon of Luvisols is eutric (BS ≥ 53%) by definition, while the Bt of the Alosols is district, at least in its upper part.
In what concerning the eluvial process, it is emphasised, at microscopic level (micro-morphological imagine - Figure 6), by many and relatively extended depleted pedofeatures (depleted in plasmic material) containing greyish clayey-silty matrix and located in the fissure walls (Figure 6a).
The soil matrix appears like scattered islands in the extended depleted pedofeatures.

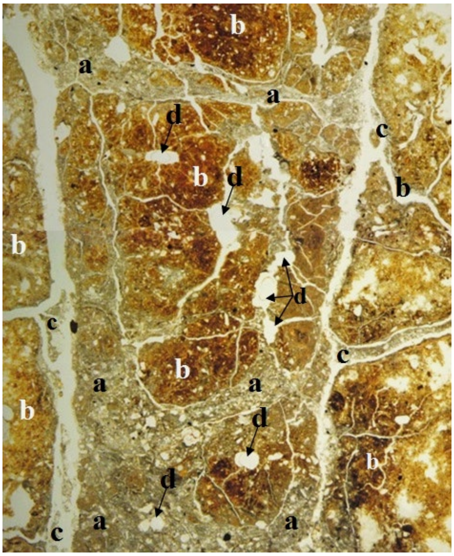

Figure 6. Bt_2W horizon (88-108cm): depleted pedofeatures with grey silty-clayey matrix (a); amorphous pedofeatures inside the structural elements (b); greyish silty-clayey material clogging the (vertical and horizontal) fissures (c); biological porosity (d). PPL

The illuviation process, also very active over time, generated many types of textural pedofeatures in the pedogenetic horizons.
In this general „washed", acid background, the old textural pedofeatures appear inside the structural elements, covered by thin films of Fe oxyhydroxides (Figure 6b).
These Fe films also protect the textural pedofeatures (clay ± Fe coatings) against the aggressive impact of the soil solution.
The intense illuviation process generated coatings and infillings in voids, which had different compositions, colours, and locations, that reveals their ages and depositional conditions (Figure 7).
In the Eaw horizon the sporadic silty coatings had been deposited during the present illuvial process.
In the Bt_2W horizon (88-108 cm), many types of textural pedofeatures deposited during the long period of time and the periodically (annual and/or seasonal) changing climatic conditions.
Clay coatings had been deposited into the intrapedal pores being covered by amorphous

pedofeatures (Figure 7a). Thick micro-laminated infillings of clay ± Fe ± blackish impurities (Figure 7b) were formed at the border between the zones with reductimorphic and oximorphic colours. Old clayey yellowish coatings and infillings with their specific glassy appearance (Figure 7c), cracked and fragmented had been observed. Microlaminated clay ± Fe hypo-coatings (Figure 7 d) had been formed in the walls of the voids, as a result of the soil solution migration from the pores towards inside the aggregates.

Silty-clay coatings (Figure 7e) specific to the depleted pedofeatures matrix, had been deposited in the actual new pores.

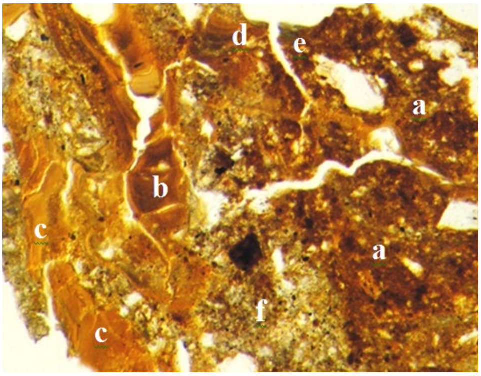

Figure 7. Bt_2W horizon (88-108 cm): clay coatings covered by protected Fe film (a); microlaminated infillings of clay ± Fe ± blackish impurities (b); old glassy-looking infillings (c); microlaminated clay ± Fe hypo-coatings (d); silty-clay coatings (e)

In the bottom horizons (Bt_2W - BCw), the clay±Fe coatings are very old, and had been partially integrated into the soil matrix and had the appearance of mo-unistrial b-fabric.

In the BCw horizon, the presence of the deformed granostriated b-fabric (around some nodules) due to the swelling-shrinking processes had been noticed.

The Alosol being under a permanent seasonal influence of waterlogging, in the soil profile stagnic properties had been developed, under reduction conditions.

The stagnic properties are very old, showed also by the distinct network (Figure 8), with perfect angles at 90^o and greenish-gray (5GY 6/1) reductimorphic colours (when wet) formed into the soil profile. This network (more clearly expressed in the Bt_2W horizon) was generated by the preferential and constant circulation of the soil solution along the same voids over a long period of time.

Figure 8. Bt_2W horizon (88-108 cm): at morphological level (in the soil profile) the greenish-gray network is very well expressed (with clear angles of 90^o)

This grid delimits perfect prismatic structural elements, inside which the oximorphic colours had been concentrated (Figure 8).

The amorphous pedofeatures generated by the water stagnation are: Fe ± Mn nodules, very common in all pedogenetic horizons; blackish Fe ± Mn concentrations (with nodules and concretions inside them) appear in the Ea_2w horizon; many of them seem to have formed on the account of the coprolite channels, the compacted walls of which appear at the border of these mottles, partly covered by the Fe oxyhydroxides; pseudomorphosis on plant debris, had been observed sporadically in the Eaw and EBW horizons.

Biological activity is very high in the surface horizons. The Ea horizon, although having a strong debazification, is burrowed over 50% by the soil mesofauna, which is why the lamellar structural elements (formed both in the lower part of Ao and in the upper part of Ea horizons) had been partially transformed into coprolites, giving them a highly friability. Black sclerotia sporadically appear in the Eaw horizon, reflecting fungal activity.

The presence of soil mezofauna and roots channels in the Bt_2W horizon (88-108 cm) despite of the stagnic properties (waterlogging) showed an active biodiversity (Figure 6d) which improve and renewed seasonally the soil porosity.

A noteworthy aspect is the fact that bioturbation does not appear in this profile (which showed a very low or even a miss of macrofauna activity); a process that would have renewed (rejuvenated) the upper horizons (Ao-ABw) by plasmic material.

The melioration of such an old age soil would impose a drainage system in order to remove the surface water excess, as well as the acidity correction by liming (which would impede the toxic influence of the mobile Al). To increased soil fertility, mainly organic fertilizers (manure) are recommended. The field being pasture, the occasionally fertilization occur, by grazing animals. Also, to improve pasture, overseeding is necessary. However, the most efficient melioration method (which also involves high costs) would be reforestation (taking into account that the land use, 30-40 years ago was forest).

CONCLUSIONS

The studied Alosol (SRTS-2012; Alisol - WRB-SR-2014) is a spectacular, beautiful old aged soil that developed specific characteristics and pedofeatures which emphasised its long pedogenesis (under the main process: illuviation and stagnogleisation). It is a strong acid soil, the aggressive soil solution penetrated deep into the soil profile (until 132 cm depth) and created many depleted pedofeatures, and consequently the matrix background of all the pedogenetic horizons being nearly similar to that of the Ea horizon.

The clay illuviation process was very high, over time, and generated many types of pedofeatures whose composition, colour and location reflect their ages. The stagnic properties are very old, as a result a distinct network formed (with perfect angles at 90^o and greenish-gray reduction colours ascribed to the preferential and constant circulation of the soil solution along the same voids over a long period of time. The most suitable melioration for such an old soil is the reforestation.

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