THIRD INTERNATIONAL WORKING-MEETING ON SOIL MICROMORPHOLOGY
WROCŁAW, 1969

ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1972 z. 123

Micromorphological characteristics of pseudopodzolic soils in the Transcarpathian region

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Pseudopodzolic soils are those in which the profile is differentiated into a light colour part with lighter granulometric composition and a darker and more clayey one as a result of the combination of such processes as pseudogley and lessive. They are analogous to pseudogley soils and a skin to Fahlerde.

In the Transcarpathian region such soils are found on ancient terraced sites and submountain positions with absolute heights from 150 to 400 m.

The climate here is warm and wet; mean annual temperature is $+8+9°C$ and annual precipitations 800-900 mm with maximum quantity in summer and autumn.

Soils develop from deluvial clay loam deposits; the mineralogical composition of which is the following: hydromica, chlorite, kaolinite, mixed-layered muscovite — montmorillonite and chlorite-montmorillonite.

The profile of pseudopodzolic soils consists of humus horizon (A_1) of light gray colour with a granular structure. Its thickness not more than 8-10 cm. It gradually changes into a subsequent bleached pall horizon (A_21) with weak gley patches, containing a great amount of small iron hydroxide concretions. It is followed by a heterogeneously coloured more compact transitional horizon (A_21B). On ped faces thin grey coatings appear. At a depth of 50-60 cm illuvial marmorized horizon begins. Here it is dense and heterogeneously coloured due to the alternation of yellow-brown patches and bleached tongues. It is characterized by thick coatings on the ped faces and great amount of soft iron hydroxides in the lower part. From the depth of 130-150 cm the indications of a marmorizelike quality gradually disappear, density becomes smaller and at the depth of about 2.0 m the parent rock emerges. Granulometrical data confirm the differentiation of the solum — impoverishment of the upper part of the profile and enrichment of the lower one in clay. Though the bleached part has a rather constant thickness (50-60 cm), mineralogical, micromorphological and granulometrical data show geological homogeneousness of deposits. Thus, the differentiation of soil profile can be explained according to Koppe. We mean his views about "fore soil" leaching of strata or else it may be caused by pedological processes.

We shall discuss this question in detail later on after considering micromorphological structure of these soils. In thin sections humus horizon A_1 has a light gray colour, porous and consists of irregular microaggregates. The skeleton particles are densely distributed. In general the organic matter is well dispersed, but in many voids there are semidecomposed residues of vegetation. Horizon is impoverished in clay substances, it is dispersed and almost isotropic.

Iron neoformations are present in two forms: (a) as a spherical are almost regular dark-brown-reddish concretions (0.8-0.9 mm in diameter) and (b) as iron hydroxide gel, forming cloud-like accumulation which is seen only in reflected light.

The soil fauna activity is quite evident. It can be seen in friability of matrix and accumulation of coprolits. It is possible that most of pores have biogenic origin.

In the foregoing horizon $A_2$1 the colour is lighter due to smaller clay consistency and the skeleton particles are more densely distributed, porosity is the same as in the upper horizon.

In spite of the greater impoverishment in clay substances as compared to horizon A, thin clay cutans appear on the walls of micropores. Besides, in the matrix there are clay micropatches which have reddish colour and high extinction.

Iron hydroxides are present in the same form as in A_1 horizon, but there is much more of gel form. Chemical data confirm this (Fe_2O_3 after Tamm). Thus, two horizons (A_1 and $A_2$1), experiencing a more acute alternation of reduction and oxidation processes, have two extreme states of iron hydroxide neoformation: (1) jellous accumulations, which are probably mobile compounds and which have neither eluted yet from the horizon, nor segregated in concretions; (2) iron concretions — the most stable form of iron neoformations. In the lower part of $A_2$1 complex combinations can be seen. They consist of iron concretions and high anisotrophic clay substance which is coated by a diffusive iron ring. In the transitional horizon $A_2$1B against the background of bleached fabric there appear brown microsections of a more clay-like nature, where grains carry yellowish-brown coatings. The fine clay substance becomes anisotrophic. Optically orientated clays are observed along the pores. Clay substance of cutans differs in iron content: in some places it is red-brown, in others — light-yellow. The iron hydroxides are segregated in concretions and stairs; jellous accumulations are practically absent. The horizon is dense, structureless with rare pores. The following marmorized B_m horizon is non-uniform in fabric and colour. It is very dense, structureless and almost poreless. Some features of bleached horizons are preserved in large tongues and streaks penetrating the whole thick of B_m. They have

Table. Some analitical data of profile No. 28

Depth of sample, cm	0.001 mm	pH water	F_2O_3% after Tamm
3-6	16.9	4.5	0.54
7-15	14.5	4.5	0.67
20-30	14.7	4.7	0.61
60-70	20.7	5.2	0.41
100-110	21.3	5.5	0.36
140-150	21.7	5.9	0.24
190-200	21.8	6.1	0.24

light colour and are generally impoverished in clay. Oriented clay fill pores and cracks. Striated separation of clay plasma is rather well developed. These bleached aggregates are less dense, and more porous than the brown ones.

Brown aggregates are also nonuniform in their fabric because of the variable content of clay substance and iron hydroxides. We can distinguish three types of microsections.

1. One of them is characteristic of the main part of the horizon and is typical generally for illuvial horizons in which all grains of primary minerals have coatings of optically orientated clay. Plasma makes striated separation and possesses high extinction. Walls of voids and cracks are covered with reddish-brown clay cutans of a strongly anisotrophic charac-

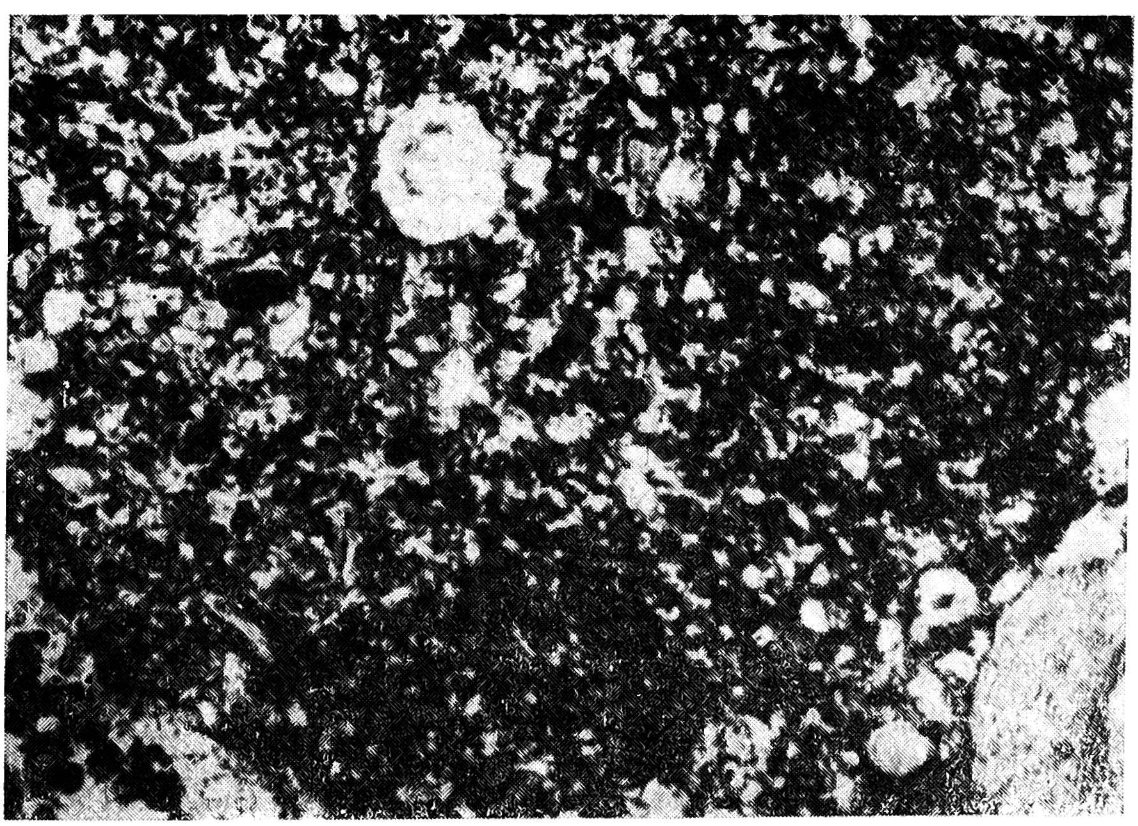

Fig. 1. A_1 horizon there are signs of soil animal activity as caprolits and vegetation remains in voids.

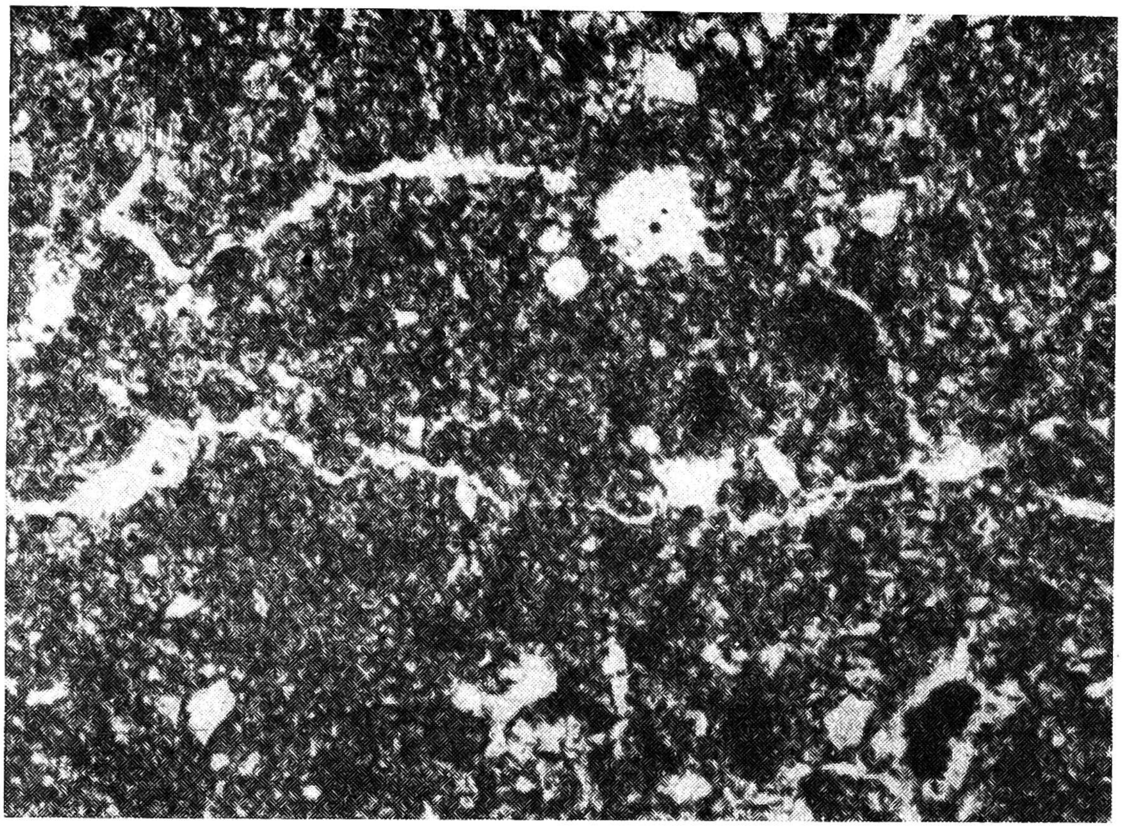

Fig. 2. Common picture of structure A_2I horizon with a lot of iron concretions.

ter. Clay substance in cutans has admixture of silt particles. The reverse character of the iron hydroxide forms testifies to a longer periodic wetting and a lesser contrastic alternation of reduction and oxidation processes. Besides iron concretions, there are soft segregations, diffusion rings (quasicutan) and complex forms.

2. The most dark brown sections are so rich with plasma that grains are hardly seen. Clay plasma is peptized, isotrophic and has a grayish shade. Iron neoformations are absent. Perhaps, these are the most gleyish microsections.

3. It is difficult to decide exactly, what the light-brown microsections are, because there are fewer mineral grains, than in the whole soil mass. Orientated clays possess a high extinction. The loss of colour is conditioned here only by loss of iron. We may suppose that these sections used to be cavities or cracks which later on were filled by fine-dispersed mass. During the wetting and reduction processes the iron became mobile and shifted, forming different kinds of neoformations among dark-coloured spots. Such phenomenon is mentioned by some researchers of pseudogleys [3, 4].

In transitional BC horizon the non-uniformity of the fabric and colour disappear and soil mass obtains a uniform light-brown colour. It becames less dense. Clay substance is optically oriented and has mosepic fabric. Clay cutans become more fine dispersed without admixture of silt particles and occupy wider areas than in the marmorized horizons. The amount of them increases to the bottom.

So the micromorphological studies of pseudopodzolic soil reveal the differences in structure of the upper lessivé-eluvial and lower illuvial parts of the profile. But at the same time they show genetical links between these two zones of the soil profile — penetrating of lessivage (eluvial) process in illuvial horizons and appearing of the accumulation of clay substance already in the most bleached horizon.

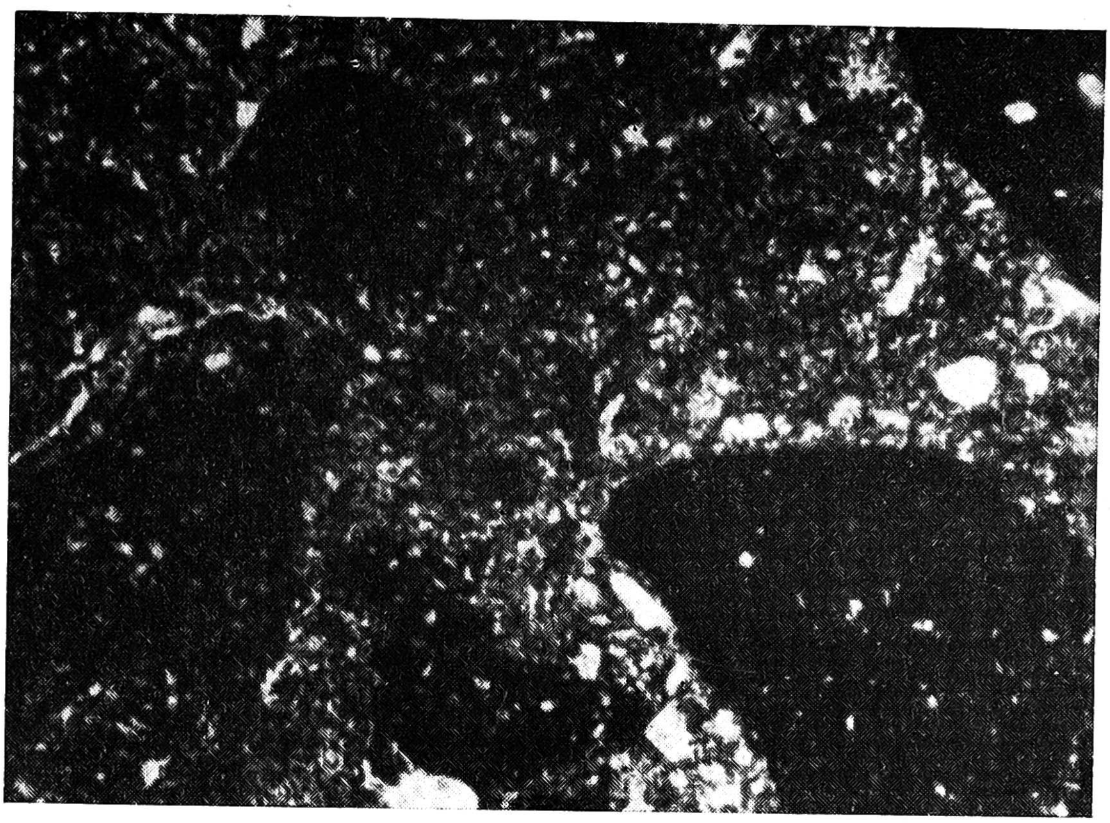

Fig. 3. Iron concretions in matrix. One can see the spherical form and sharp boundaries.

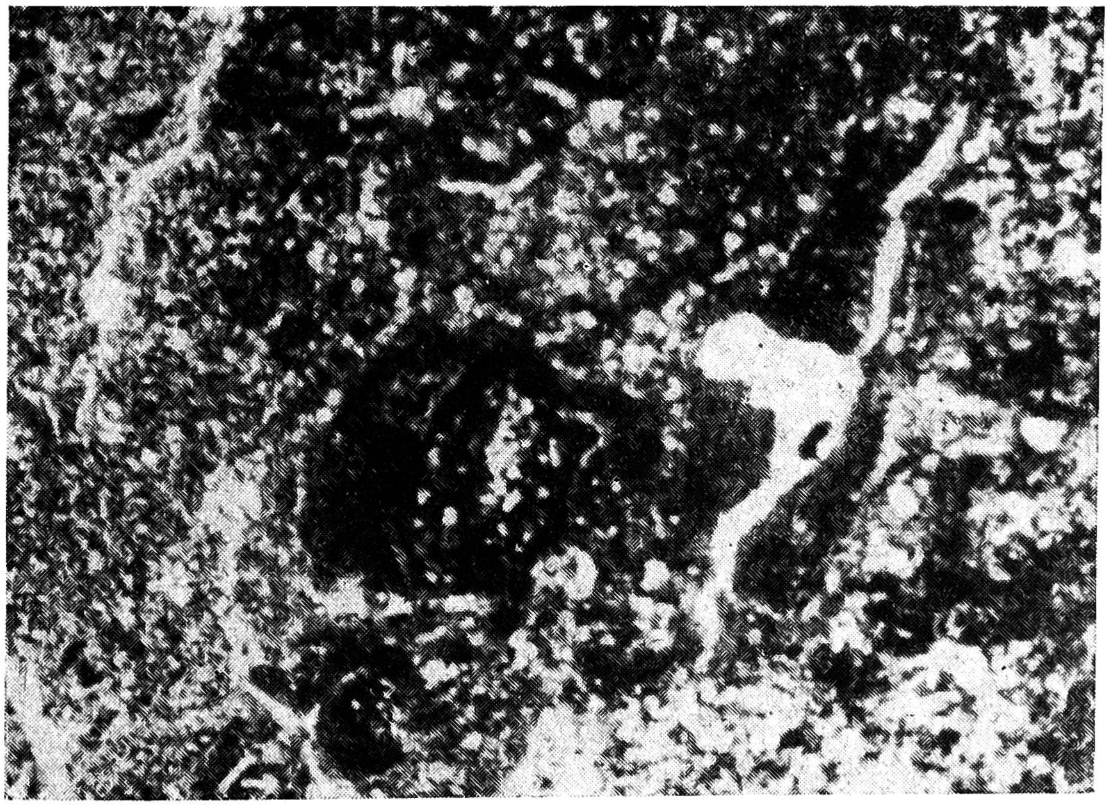

Fig. 4. Non-uniform structure of B_m horizon: alternating dark and light coloured sections.

On the basis of the micromorphological description it is interesting to discuss the question of two ways of the differentiation of such soil profile in Transcarpathian region: "foresoil" differentiation of mononominal strata in periglacial conditions (according to Kopp) and differentiation of mononominal strata by recent pedogenetical processes.

The main difficulty in applying Kopp's view is that in Transcarpathian region there was no glaciation and thus real periglacial conditions in plain region were absent, (this is proved by the fact that during the maximum glaciation this region was a refuge for such warm-loving species as beech).

It seems that profile has subdivided due to pedogenical process, which was going on under bioclimatical conditions similar to those of our time. Lessivage and pseudogleyization were the main processes which were responsible for subdivision of the soil profile. For the pseudogleyization to begin the presence of "foresoil" leaching of parent rock with waterproof horizon is not at all necessary. In wet climate with a distinct summer-autumn period of maximum precipitation surface overmoistening and gleyization of upper part of solum takes place in mononominal, heavy, poorly penetrating loamy deposits.

As it is known, surface gleyization causes peptization of fine particles, which are subtracted from the upper horizons.

According to the micromorphology description clay cutans in illuvial horizons differ in their composition and character of deposition. In the lower part of solum they are finedispersed, homogeneous and form large areas. In upper part of illuvial strata clay substance is more coarse-dispersed with admixture of silt material. There cutans are smaller, but in thin section they can be met more often.

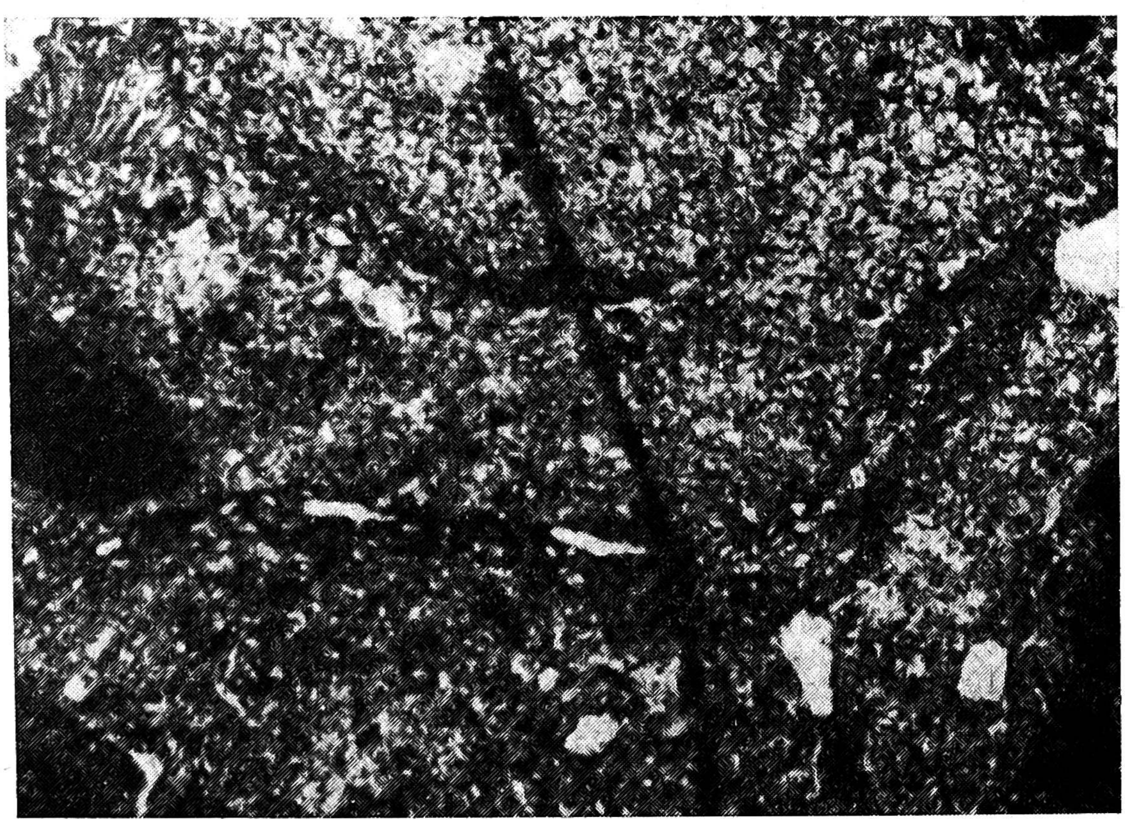

Fig. 5. Along the pores there are clay cutans with high extinction.

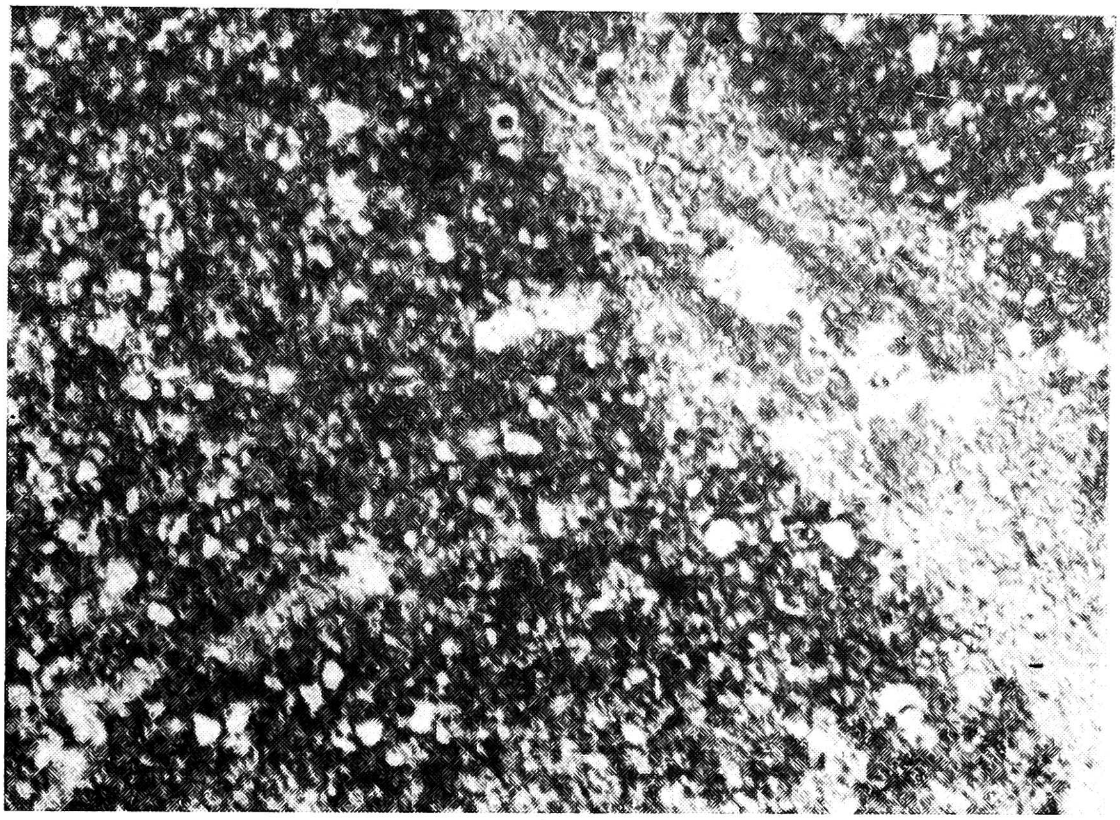

Fig. 6. Also clay cutan impoverished in iron so it has light colour. One can see very dense and compact matrix.

Such distribution of clay cutans allows us to consider possible ways of profile differentiation of the studied soils:

1. Non-simultaneous subtraction of suspensions. On initial stage of solum development the overwetting of the upper part caused peptization of the most fine-dispersed particles (colloidal fraction). It is obvious that such suspensions possessed a maximum mobility due to their high stability of coagulation and precipitation. Thus, they could penetrate through a rather dense loam strata and settle in deep horizon of the profile. As the processes developed, quantity of colloidal fraction diminished and the coarser fractions (clay and silt) began to peptize. Suspensions, containing less dispersed solid phase, were not so stable and mobile, that is why they accumulated in less deep layers. It was also intensified due to the fact that cavities below had been partially filled by coloidal substance.

Thus migration of fine fractions and formation of a differential soil profile took place at different time: first there formed deep layers, and then — upper ones.

2. Quite true is also another explanation — simultaneous peptization and substraction of different coarse suspensions (colloidal, clayey and fine silty). As differently dispersed particles have not the same mobility, so coarser fractions formed upper layers of illuvial strata and more fine washed out into deep ones. This explanation allows for simultaneous and gradually increasing isolation of different parts of illuvial horizon. All this characterizes the distribution of clay fraction and bulk aluminium. It is interesting to examine the distribution of iron in pseudopodzolic profile.

Morphological and micromorphological descriptions show that iron neoformations are present in every horizon, but maximum quantity of them is in the most bleached horizon (A_2l) and in the low parts of marmorized horizons. Mobilization of iron mainly in divalent form takes place in lessivé part of profile. A certain part of them flocculate inside the horizon where it segregates in concretions.

The main cause of flocculation and segregation of hydroxide iron are dry periods. Non-flocculated iron compounds are washed out from this horizon and go through the marmorized horizon as there moisture distributes more equally during a year. Without distinct oxidation conditions they precipitate near the lower boundary of B_m, where the compactness of soil mass decreases and where there is an oxidation zone below the marmorized horizon.

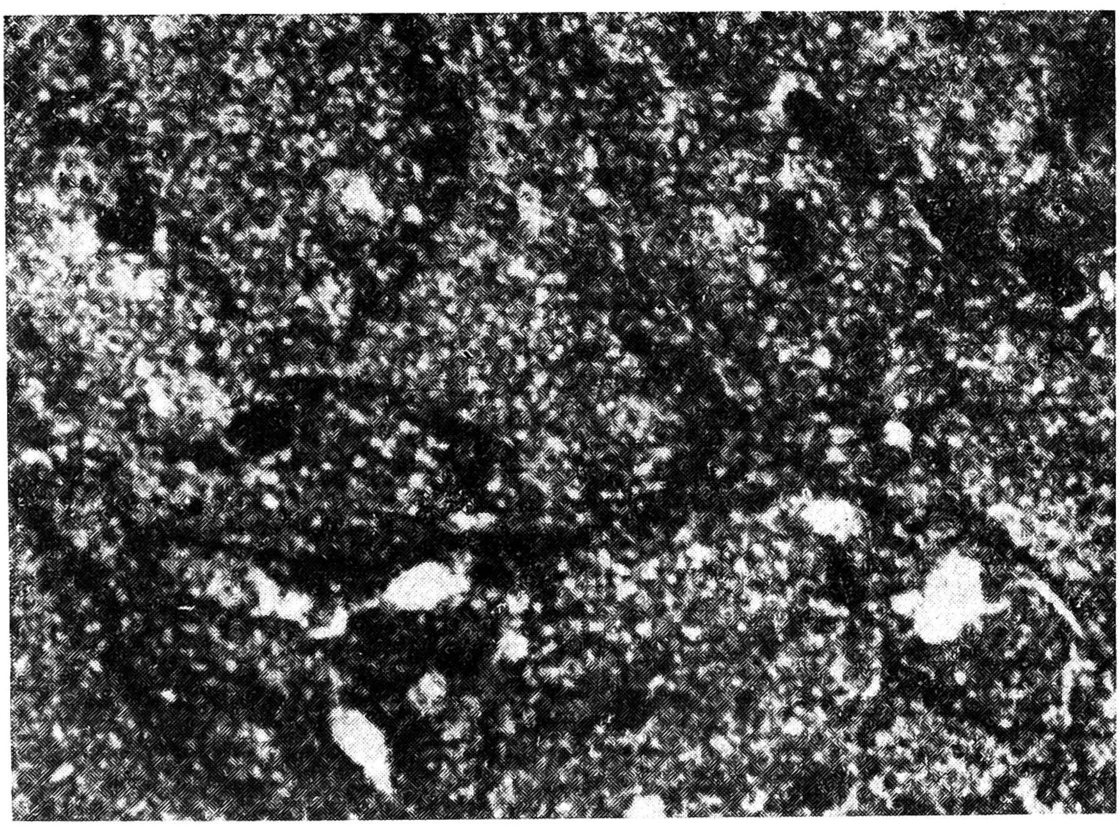

Fig. 7. B_m horizon — the section with iron quasi-cutans.

Some part of the most mobile iron compounds is washed from the profile and gets into ground or river water.

In conclusion we must emphasize that all the considered ways of rearrangement of fine-coarse particles and iron compounds mainly characterize the time of profile formation of a uniform stratum. But it well may be that in the formed profile the processes of distribution of matter are different when there is a water-proof horizon. For instance, suspensions and solutions can be washed out of A_2l both by side run-off along water-proof B_m and in vertical direction through the light-coloured tongues or streaks.

SUMMARY

Pseudopodzolic soils are analogous to pseudogley soils and akin to Fahlerde. In the Transcarpathian region such soils are found on ancient terraced sites and submountain positions. They are developed from deluvial clay loam deposits. The profile of pseudopodzolic soils is differentiated into a light colour part with lighter granulometric composition and darker and more clayey one as a result of the combination of such processes as pseudogley and lessivage.

Micromorphological investigation shows that the eluvial process takes place not only in the upper bleached part of the solum, but it penetrates into illuvial zone where it is in numerous light-coloured tongues and streaks. The processes of clay accumulation we can see in A_2l horizon. In general, for the bleached horizon there is characterized the low content of clay mass and a lot of dark dense iron concretions and gel-form of hydroxide of iron. In illuvial horizon there is redistribution of clay substance and iron hydroxide inside horizon itself, abundant of clay cutan, in upper part being heterogeneous with admixture of silt particles.

Below, the clay substance of cutans becomes more finedispersed and homogeneous. Hydroxide iron neoformation have different forms. On the basis of the distribution of clay cutans the question of two ways of differentiation of the solum is discussed: simultaneous and non-simultaneous subtraction of suspensions. Also, we discuss the moving of iron compounds. Some part of them is segregated into A_2l horizon, other part, more mobile, is washed from bleached horizon and is flocculated in low boundary of B_m horizon as soft concretions.

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