THIRD INTERNATIONAL WORKING-MEETING ON SOIL MICROMORPHOLOGY
WROCŁAW, 1969

ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1972 z. 123

Comparative micromorphological characteristics of some rendzina and derno-podzolic soils

T. C. ZVEREVA

Agrophysical Research Institute, Leningrad, U.S.S.R.

The aim of the present investigation is to study the changes of soil microstructure, the soils formed in the southern taiga on parent materials with different base content. A number of soils has been chosen on the territory of the Estonian Soviet Republic: humus carbonate soils on limestone eluvium, the typical rendzina soil on a local calcareous moraine, rendzina podzol on a calcareous moraine, derno-podzolic soils with various degree of podzolization on red-brown calcareous and noncalcareous moraines.

Flat-parallel thin sections, 0.03-0.05 mm thick [4] have been prepared of specimens. The technique of taking the specimen was as follows: a metal sharp edged box was introduced into the wall of soil cut. The microscope observations of thin sections showed the following peculiarities in micromorphology of humus carbonate soils.

A_1 — brown or dark brown with a reddish shade in the reflected light. The colour is non-uniform due to the different degree of vegetable remains decomposition. The organic matter forms a significant part of the thin section area. It consists of live roots and non-decomposed as yet vegetable remains, vegetable remains well decomposed but retaining their original form and well aggregated brown-yellowish humus. The two last forms prevail. The aggregation is excellent. The mineral mass is poorly sorted. The edges of mineral grains are corroded. No formations with orientated clay have been observed. Ferrugious concretions in the form of grains and dots are typical.

AC — brown-yellowish; the colour is more uniform than in the horizon A_1, though organic matter inclusions produce a kind of mottling. The organic matter is again in a great number, but here it is mainly yellowish humus consisting of the smallest aggregates or it may be well decomposed vegetable remains retaining their shape. No formation of orientated clay. Ferruginous concretions in form of grains and dots are numerous.

C (Limestone) — dense fine-crystallic limestone of yellowish-grey colour; the yellowish shade is stronger along the cracks; the edges are corroded. The ferruginous concretions in the form of grains and dots are rare.

The micromorphology of a typical rendzina on a local calcareous moraine with limestone basement is as follows:

A_1 — grey-brown. The organic matter is presented by vegetable remains retaining their shape and lattice structure (sometimes they are ferruginized), by vegetable remains well decomposed and retaining their original shape, by aggregated yellow humus. The aggregation of soil mass is good. No formations of oriented clay. The mineral mass is badly sorted. Fine ferruginous concretions (frequently with not clear edges) are obseved. There are intimate ferruginous compounds.

B (C) — grey yellow. Little organic matter, i.e. yellowish humus. There appear fragments of limestone in the mineral mass. Accumulation of silty and clay particles have been observed in cracks and pores. No orientated clay formations. Ferric hydrooxides are in form of flakes in the pores, cracks and mineral mass.

C — grey, composed of lime stone fragments. The microscope observations of the type and colours of the calcareous rubbish from the horizon A_1 and B (C) showed that in the upper horizon the rubbish is white with washed out surface whereas in the lower one it has some brown ferruginous film.

The rendzina podzol on yellow-grey calcareous moraine.

A_1 — yellow-grey; the colour is comparatively uniform. The organic part is presented by slightly decomposed vegetable remains (frequently ferruginized), carbonized organic matter, and slightly aggregated humus of gold-yellow colour. Aggregation is good. Mineral part is badly sorted. The mineral grains are highly corroded. Sometimes there a weak orientation of clay could be noticed in the aggregates of fine disperse mass. Organic ferruginous and ferruginous formations are observed in form of grains, dots and compact concretions with clear or not-clear edges.

A_1A_2 — yellowish-grey. Organic part is presented by yellowish-grey humus and some carbonized vegetable remains. Clay mass is non-uniformly distributed along the thin section area. Clay with mixed-fibre and parallel fibre structures is observed in central parts of microstructural separates. Scales of orientated clay were seen between the mineral grains. But in general the soil mass is clearly washed from clay. The number of compact ferruginous and humus ferruginous concretions is greater in this horizon than in the previous one.

A_2B — grey with yellow and reddish-brown spots of clayey and ferruginous accumulations. The organic matter is in form of carbonized vegetable remains and of yellow non-aggregated humus. The accumulations of thin disperse mass are various. Sections with mixed-fibre and parallel-fibre structures in the middle of aggregates are typical of the upper part of the horizon. Thin disperse mass along the pores and cracks

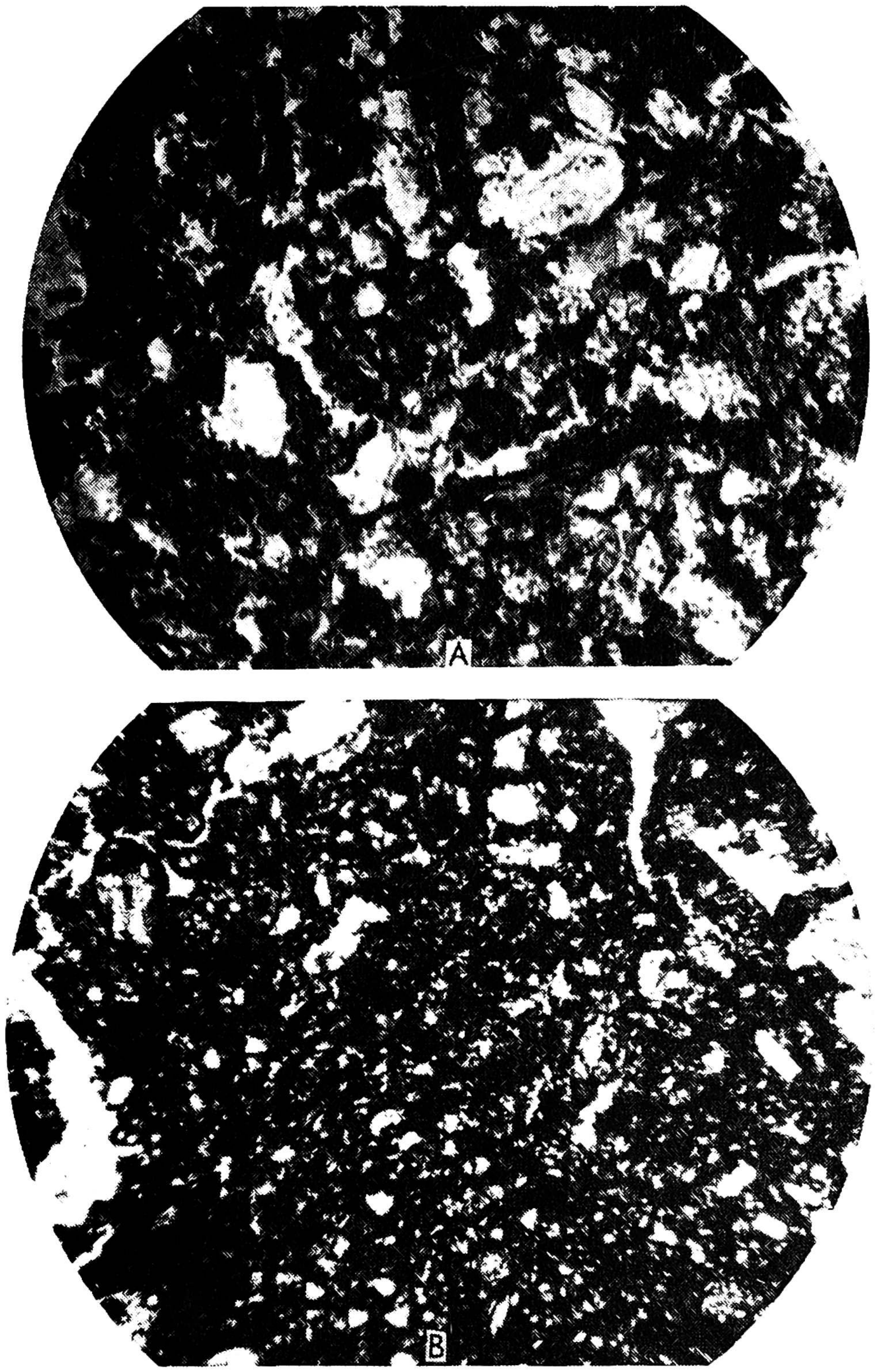

Fig. 1. *A* — humus carbonate soil, horizon A_1. The different forms of organic matter: non-decomposed vegetable remains—"a", vegetable remains well decomposed but retaining their original form—"b", aggregated humus—"c". Magnif. 9.0×5, Nicols II. *B* — derno-strong-podzolic soil, horizon A_1. Magnif. 9.0×5, Nicols II.

often has a parallel-fibre structure. Scale structure and fine incrustations have been observed. However, similar to the hor. A_1A_2, the clay washing off is observed here, particularly in sections along pores and cracks and at the edges of aggregates. Besides the above mentioned, a lattice structure could be observed. Of all ferruginous new formations compact concretions, numerous and various in shape and size, could be observed in this horizon.

B — grey with yellow and ochrous spots of clayey accumulations. The horizon is rich in clay. In pores and cracks the clay has the form of incrustations, uniform or in layers; in total it has mixed-fibre structure and near the pores the structure is parallel fibre. Accumulations of well-oriented clay are observed here. They may be not associated with pores and cracks and do not form any incrustations. The number and area of clayey incrustations are greatest in the upper part of the horizon. The escapes of ferric hydroxides of worm-like or round shape were isolated in clayey accumulations. Compact ferruginous accumulations are rare.

BC — greyish-yellow. The primary minerals are less corroded compared to the horizon A_1. Carbonates were observed in great number. The

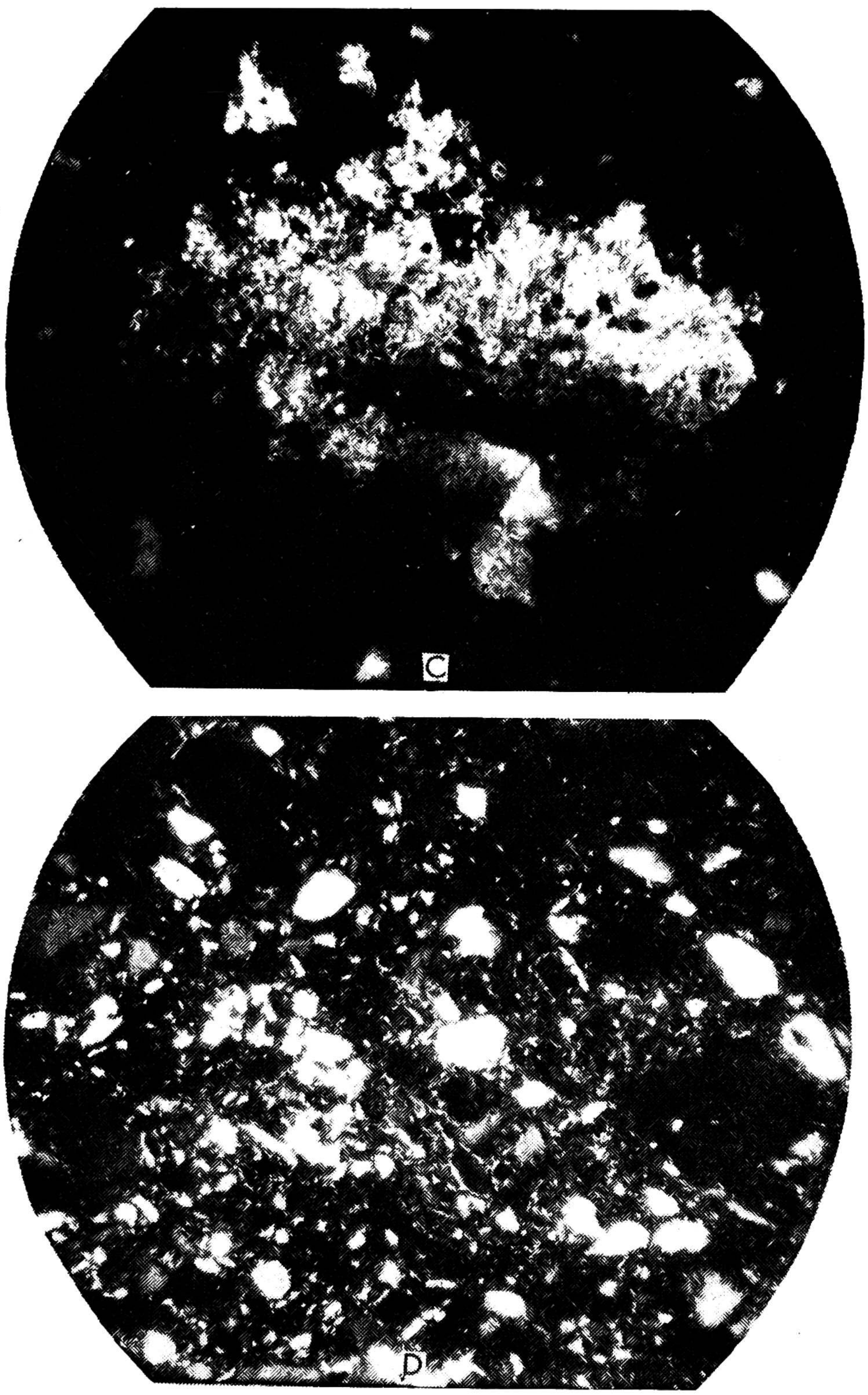

Fig. 2. *C* — rendzina typical, horizon B(C). The calcareous rubbish. The ferruginous flakes on a rubbish. Magnif. 3.7×5, Nicols II. *D* — rendzina podzolic, horizon A_2B. The lattice structure of clay. Magnif. 9.0×5, Nicols X.

clay is of mixed-fibre or parallel-fibre structure. Occasionally thin incrustations could be seen along the pores. Flakes of ferric hydroxide have been noticed.

The derno-middle-podzolic soil on red-brown calcareous moraine.

A_1 — yellowish-brown. The colour is non-uniform because of organic matter inclusions. The aggregation is not strong. The organic matter is presented by slightly decomposed vegetable remains, carbonized organic matter and by yellow-brown humus aggregated to a small degree. Organic remains are ferruginized. The mineral mass is sorted poor enough. Mineral grains are greatly corroded. No orientated clay. Ferruginous new-formations are observed in form of grains and flakes. Compact humus ferruginous concretions are singular. Grains of primary minerals (biothite, feldspars) are often ferruginized. The content of ferruginous formations is much greater than in the similar horizon of rendzina-podzolic soils.

A_p* — yellowish grey (rosy in the reflected light). Little organic matter presented by carbonized vegetable remains and humus. Some parts of thin sections consist of clay of mixed-fibre structure, the removal of clay is noticed, but is not so great as in the previous case. Ferruginous new-formations are similar to the horizon A_1.

A_2B — yellowish-grey with brown spots of clay accumulations. Organic matter is almost absent. Orientated clay is in the form of incrustations and constricted. Clay incrustations are poor enough sorted. Sometimes lattice structure was observed. The clayey mass and primary minerals are ferruginized. Compact ferruginous concretions are not in a great number.

B — greyish-yellow with reddish-brown spots of clay. Strong clay accumulations occur. The structures of clay formations are as follows: incrustated, mixed-fibred, and parallel-fibred. Some parts of clayey accumulations are highly ferruginized. Isolàtions of ferric hydroxides of worm-like or round shape predominate; they may occur in form of dots or efflorescences.

BC — reddish-grey. Carbonates and fragments of limestone appear in great number. No accumulation of oriented clay. Thin disperse ferric oxides are present in great quantity, so that in reflected light all thin sections of this horizon are of uniform rosy colour with bright inclusions of ferruginized primary minerals.

The derno-middle podzolic soil on non-calcareous red-brown moraine is similar in its micromorphology to the soil on a calcareous red-brown morain. Its microcomposition is characterized by the following features:

A_1 — contains ferruginized organic matter. Vegetable remains are decomposed to a smaller degree than in the previous section. No formation

* A_p — a pale yellowish-rosy horizon.

of orientated clay. Ferruginous new formations look like grains and dots.

A_p — ferruginization of thin disperse mass is not so strong as in the soil on a calcareous red-brown moraine. Small incrustations and spots with mixed-fibre structure of clay; they are associated with middle parts of microstructure separates. Compact ferruginous concretions are widely spread.

A_2B — clay of mixed-fibre and parallel-fibre structure. Compact ferruginous concretions and isolation of ferric hydroxides are more frequent

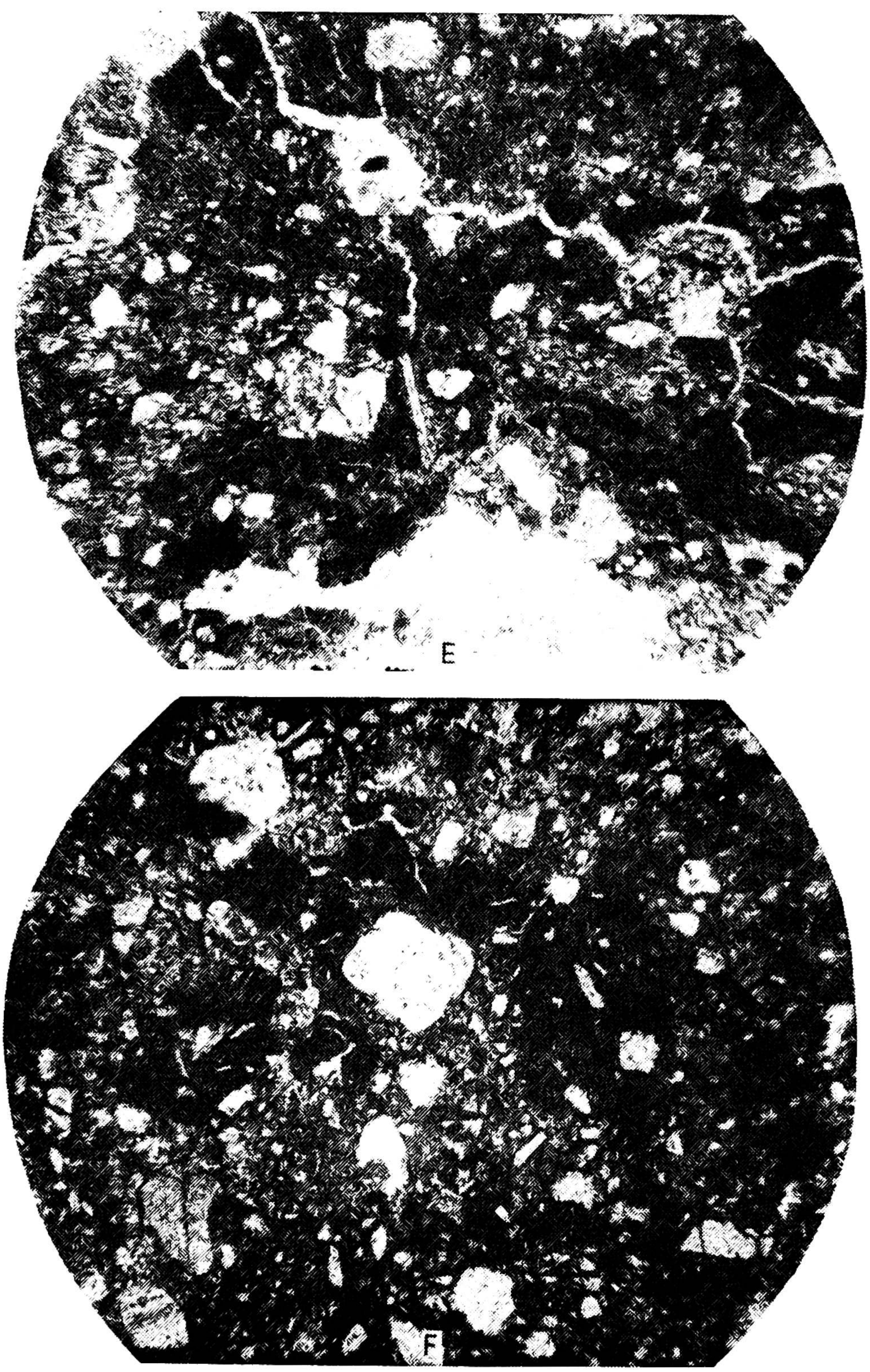

Fig. 3. *E* — derno-middle-podzolic soil, horizon B. Isolations of iron in clay accumulation—"a". Magnif. 9.0×5, Nicols II. *F* — derno-strong-podzolic soil, horizon A_2B. The compact ferruginous concretions—"a". Magnif. 9.0×5, Nicols II.

than in the horizons mentioned above. Parts with removed clay alternate with clayey accumulations of incrustated structure.

B — rich in clay. The structures of clay formations are incrustated (mainly in the upper part of the horizon), mixed-fibred and parallel-fibred. Isolations of ferric hydroxide are observed in clay accumulations. The thin disperse mass is greatly ferruginized.

BC — is characterized by the most marked ferruginization of the thin-disperse mass (silty ferric oxides). The clay is slightly orientated.

The derno-strong-podzolic soil on the red-brown non-calcareous moraine.

A_1 — gold-yellow of non-uniform colour due to the organic matter inclusions. The organic matter is presented by poorly decomposed vegetable remains, carbonized vegetable remains and humus forming intimates and coagula between the grains of primary minerals. The typical forms of ferruginous isolations are dots, grains and small coagula of ferric hydroxides or ferric humus compounds, individual compact concretions with not clear edges.

A_p — brownish-yellow. Humus is uniformly distributed; it is lighter and its aggregation not so strong as in horizon A_1. Some parts of thin sections contain clay with mixed-fibre, parallel-fibre or occasionally lattice structures. An intensive washing off of fine particles is observed. Compact ferric humus and ferruginous concretions are in a great number; they are of different size and colour intensity; the edges are either clear or not; sometimes they are rimmed with orientated clay.

A_2B — greyish-yellow. Organic matter is only in the upper part of the horizon; it is presented in form of carbonized clots or non-aggregated humus. This part of the horizon is very poor in clay. Small clay incrustations are singular; their quantity increases with depth and reaches its maximum in the lower part of the horizon where there are ferruginous clayey and clayeysilty incrustations. Ferruginous new-formations occur most frequently in this horizon. They are compact ferruginous concretions, dense, dark-brown of clear shape, reddish-brown with not clear edges and light yellow-brown, the latter being dimly seen on the total background. Ferruginous clayey concretions and hydroxide isolations on the clayey accumulations have in this horizon also been observed.

B — non-uniformly grey with ochric and yellow-red spots of clayey formations. The horizon is rich in thin disperse mass. Most clay accumulations do not possess good orientation due to the poor sorting. Coagulum, scale structure of clay formations is typical of this horizon. There occurs mixed-fibre and parallel-fibre structure of clay. Parts impregnated with clay are often greatly ferruginized.

BC — red-brown. Large mineral grains are included into a highly ferruginized thin disperse mass.

The above micromorphologic descriptions show considerable difference in the nature of decomposition and accumulation of organic matter, in the behaviour of thin disperse mass and ferruginous compounds depending on the degree to which a soil profile is poor in bases.

Shallow soils of a slightly differentiated profile develop on the limestone eluvium. They are characterized by great accumulation of vegetable remains well decomposed but retaining their original form, and that of not highly mobile aggregated humus. The thin disperse mass in coagulated state. Ferruginous concretions are inherited from a soil-

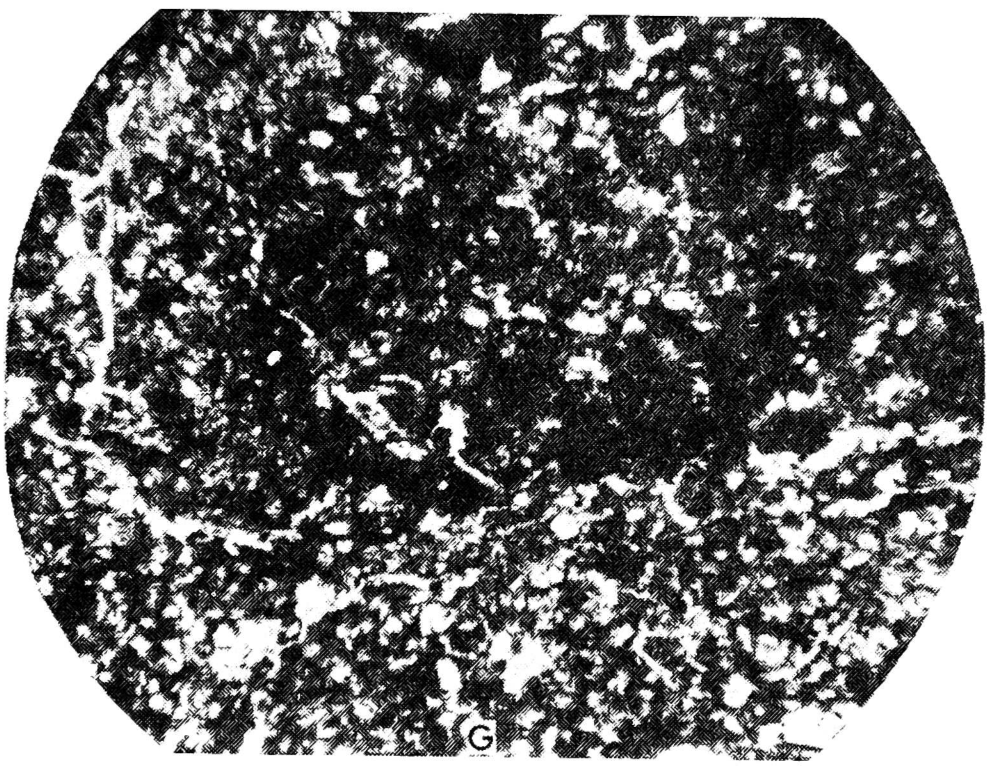

Fig. 4. *G* — derno-strong-podzolic soil, horizon B. Isolation of iron in soil mass. Magnif. 9.0×5, Nicols II.

forming parent material. The main effect of soil acids (humic acids including) is limestone decomposition.

In the rendzina typical, the soil forming processes occur under greater leaching of the bases than in humus carbonate soils. The profile of the considered soil is differentiated to a greater extent. The horizon A_1 is characterized by lower accumulation of organic matter, but the forms of the latter are similar to humus carbonate soils. The clay particles saturated with Ca'' and Mg'' are in coagulated state along all the profile. Ferric oxides and hydrated oxides inherited from the parent material acquire some mobility under the medium acid reaction of the horizon A_1 and are transferred into the horizon B (C), where they precipitate. The above statement is justified by observation of the colour of the carbonate rubbish surface in the horizon A_1 and B (C), as well as by accumulation of hydrated ferric oxides in pores and cracks of the horizon B (C) and by coagulated flakes of ferruginous compounds in the mass of that horizon.

Microconfiguration of the rendzina podzol and derno-podzolic soils has similar character. The difference in their micromorphology is due to the intensity of podzolization. These soils may be arranged into the following row depending on the degree of intensifying the soil podzolic process (according to the data obtained in field and as a result of chemical and mineralogical analyses): the derno-middle-podzolic on calcareous moraine, the rendzina podzol, the derno-middle-podzolic on non-calcareous moraine, the derno-strong-podzolic on non-calcareous moraine.

The humus content in all the podzolized soils decreases sharply as compared to the rendzina non-podzolized ones. The way of organic matter decomposition changes too: there appear carbonized vegetable remains whose content increases with the degree of podzolization; the humus becomes less aggregated and more mobile.

Clay particles in the acid upper horizons of the soils under consideration are saturated with H to a considerable extent, and are dispersed. As a result, they become mobile and are rapidly being washed off. That is proved by the fact that the upper horizons are poor in clayey mass, especially the parts adjoining the pores and cracks, and that the mixed-fibre clay structure inherited from the parent material remains in the middle of microstructural separates. Clay of lattice structure is observed only in the horizon A_2B; according to a number of authors [2, 3], this is explained by the periodic excessive wetting followed by drying in that horizon. In the horizon B there occurs coagulation of clay transferred from the upper horizons and its accumulation in pores and cracks in the form of incrustations.

Isolation of iron in clay accumulations shows that ferruginous compounds are transferred together with clay particles (probably, these compounds are organic). The nature of all ferruginous new formations is similar in all the podzolized soils. In the horizon A_1 and A_1A_2 (or A_p) they are presented by fine ferruginous and ferruginous organic concretions in form of grains and dots. Compact concretions are here singular, they occur mainly in the horizon A_1A_2 (A_p). Their occurrence is maximum in the horizon A_2B. Ferruginous isolations, wormlike or round, on clay accumulations are peculiar to the horizon B. In the soils considered, the horizon BC has no ferruginous new formations, but in the derno-podzolic soil this horizon is characterized by a considerable content of thin disperse ferric oxides inherited from the parent material due to which the soil acquires the red-brown colour and the thin section becomes rosy in reflected light.

Ferruginous new formations in the podzolized soil profile are probably of microbiological origin. According to Aristovskaya [1], some soil microorganisms because of their life activity can destroy humus ferruginous complexes, which results in accumulation of ferric (and aluminium) hydrated oxides. This accumulation may be either low or very high, the latter taking place if decomposition of the complexes is accompanied by oxidation of ferrous oxides into ferric ones.

Probably in the horizon A_1 and A_1A_2 (A_p) of the considered soils the activity of the microorganisms of the first group prevails, for decomposition of organic matter is not accompanied by any considerable iron accumulation in form of compact concretions. The activity of the second group of microorganisms is associated with the presence of ferrous oxides. i.e. with the conditions of periodic dead water and is shown by the formation of compact concretions or even orthosand bands or horizons. In the soils considered the maximum accumulation of compact ferruginous concretions is in the horizon A_2B. Besides, worm-like and round isolations on clay accumulations in the hor. B are obviously associated with the decomposition by microorganisms of humus-ferruginous complexes from the upper horizons.

A peculiar structure of the derno-podzolic profile is obviously associated with properties of the soil forming material. In the process of soil formation the thin disperse ferric oxides inherited from the parent material can easily be washed out, which should be accompanied by clarification of red-brown colour of the parent material. In addition, the colour of this material in the horizon A_1 is shaded by a darker tone of humus and in the hor. B the accumulation of sesquioxides, ferric including. As to the horizon A_2B, there abviously occurs the strongest transfer of iron, and a periodic gleization (dead water is possible on the boundary with the heavier horizon B) favours the transition of ferric oxides into ferrous ones, which intensifies the whitish shade of the material. This explains, why the horizon A_p, being poorer in iron than the B and BC, but possibly containing it in greater quantities than the horizon A_2B, still retains the rosy shade of the parent material.

The stated supposition is proved by the fact that soils with the hor. A_p are timed to the red-brown parent material or to the two layer deposits with the bottom of red-brown moraine [5, 6], the intensity of the A_p colour decreases with greater podzolization. The nature of configuration of podzolized soils formed on calcareous red-brown and yellow-grey moraines is similar, the difference being only a quantitative one, which is due to different degree of podzolization and to the initial content of ferric oxides in the parent material.

CONCLUSIONS

1. The humus carbonate and rendzina typical soils are characterized by the intensive accumulation of humus and poor decomposition of vegetable remains. The thin disperse mass is in coagulated state. No clay migration into the profile of such soils. However, in the typical rendzina soil some mobility of ferruginous compounds may be observed.

2. The rendzina podzol and derno-podzolic soils have much in common in respect of their microcomposition. The difference is either due to

different intensity of podzol-forming process or to the peculiar soil forming material.

3. The humus of the podzolized soils is more mobile and rawer than that of the humus carbonate ones. The degree of humification of vegetable remains decreases from the derno-middle-podzolic soil on the calcareous moraine to the derno-strong-podzolic one.

4. The profile of all the podzolized soils shows mobility of humus, clay and ferruginous compounds (inherited from the parent material or "liberated" in the process of mineral weathering). The upper part of the profile is poor in clay. Accumulation of the thin disperse material transferred from the upper horizon is observed in the B.

5. Ferruginous new formations are probably associated with the activity of microorganisms.

6. Seasonal gleization is possible in the horizon A_2B.

7. The presence of the horizon A_p in the derno-podzolic soils on the red-brown moraine is probably associated with the presence of thin disperse ferric oxides in the soil forming parent material.

SUMMARY

The present investigation is to study the changes of micromorphological nature in some soils formed in the Southern taiga on parent materials with different base content. The following soil profiles were examined: humus carbonate soils on limestone eluvium, typical rendzina and rendzina podzols on a calcareous moraine, and derno-podzolic soils with various degrees of podzolization on red-brown calcareous and non-calcareous moraines.

The micromorphological investigation of these soils has shown some peculiarities in such features as the content and decomposition of the organic matter forms, the differentiation of the mineral mass, voids, ferruginous concretions, plasma separations, and concentrations. The micromorphological features showed considerable differences in the nature of accumulation and decomposition of organic matter, in the behaviour of thin dispersed mass and ferruginous compounds depending on the degree to which a soil profile is poor in bases. Therefore the microconfiguration of the rendzina podzol and derno-podzolic soils is of similar character. The difference in their micromorphology is due to the intensity of the podzolization processes.

REFERENCES

1. Aristovskaya T. V., 1965. Microbiologija podsolistich potchv. Nauka, M.
2. Brewer R., 1956. Optical oriented clay in thin section of soils. VI Congs. Intern. Sci. Soil, Com. I-II.

3. Brewer R., Sleeman J. R., 1960. Soil structure and fabric, their definition and description. J. Soil Sci. II, NI.
4. Mochalova E. F., 1956. Isgotovlenie schlifov s nenaruschenoji structuroji. Potschvovedenie NIO.
5. Nogina N. A., 1952. O palevo-podsolistuch potschvach Belorussii. Potchvovedenie N2.
6. Reintam L. J., 1956. Kagu-Eesti Kamar-leetmuldade puhverdusamadustest Eesti Ppollumajanduse. Acadeemia Teadustike Tööde. Kogumik 2.