MICROMORPHOLOGY OF SOME RENDZINAS DERIVED FROM TRAVERTINES

by

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I. INTRODUCTION

In the soil science literature we can find many papers concerning the genesis and properties of rendzinas formed out of hard limestones of older geological formations /Dobrzanski, Turski, 1.972; Kowalinski, 1.974; Licznar, 1.976; and others/. However, there are only few works dealing with rendzinas formed out of soft carbonate-calcareous rocks, young or contemporary, which are travertines; these deal, first of all, with the genesis of the latter and the conditions of their formation, as well as related geological and paleogeographical aspects Bech, 1.969/.

From the pedological point of view travertines are a good parent material for soils. The profiles formed out of them have the morphology of rendzina soils. Therefore the aim of this research has been:

/1/ to learn the micromorphological differentiation of travertine rendzinas subject to the formation degree of the soil profile;

/2/ to show the variability of some morphological, physicochemical and chemical properties of typical travertine rendzinas subject to the course of more important soil-forming processes.

II. MATERIAL AND METHODS

The object of a field study were the profiles of tra

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vertine rendzinas sporadically met in lower, moist sites of the area with loess and boulder loam formations occuring within the Strzelinskie Hills /geographical unit 332. 14/. For the purpose of detail laboratory examinations, two profiles were chosen, representing shallow rendzina and medium-deep rendzina on subfossil chernozemic, soil occuring in strict forest reservation in the region of Muszkowice near Henrykow /Kowalinski et al,. 1.971; Wiktor, 1.975/. The conditions of their occurence are following : altitude above sea level- 250 m; relief-medium inclined north slope; plant association - complex Mercuriali Fagetum/Cel. 1.962/; annual precipitation 622 mm; average annual temperature - + 7.7ºC; Lang's coefficient 80.8.

The macromorphology of the soil profiles has been described according to the standard ways. Thin sections were prepared by use Polish polyester resins. The micromorphology was described according to Brewer's /1.964/ and Barratt's /1.969 terminology. The rest of the determinations have been done by the usual methods /Kowalinski, 1.974/.

The results of the analyses are shown in Tables 1-2. and the characteristic fragments of micromorphology in Figures 1-6.

III. RESULTS

1.- Macro and micromorphological properties of the soils.

Profile 1. - Shallow rendzina.

Horizon A_1, 0-10 cm :

Gray (10 YR 5/1) humus - rich very fine sandy loam with fragments of travertine, high content of $CaCO_3$, crumbly structure, many roots porous, smooth boundary.

The groundmass consists of skeleton grains and plasma. The skeleton is composed, first of all, of travertine chips, detritus or malacofauna shells, carbonate-calcareous concretions, quartz grains, more rarely feldspars. There appear pieces of charcoal and small quantities of humiskel.

The plasma consists of a mixture of clay, clayey minerals, organic matter in form of humicol and argilla humicol/mullicol/, as well as large amount of calcium carbonate. The plasma with crystalline structure is not homogenous in its mass: in more compact places it consists mainly of fine-crystalline calcite with little admixture of clayey minerals, while in more porous places there are amorphous humus compunds (Fig. 1).

The voids are mostly biogenic of the type mammillated vughs or, in more porous places, mammillated interconnected vughs of metavoid character; now, in compact places there are voids of the type of channels or planes of metavoid character. In larger voids there occur coprogenic structural microaggregates.

In some voids there are found fine-crystalline neocalcitans and lublinite. In some parts of the soil mass there appear concretions of iron oxides or hydroxides in form of brown or dark brown points or patches with irregular diffusive shapes.

Horizon A_1/C, 10-22 cm:

Light gray (10YR 7/1) fragments of weathered travertine, high content of $CaCO_3$, crumble blocky structure, in cracks some earthy material rich in humus.

The skeleton is composed, first of all of weathered travertine chips, partly crumbs of malacofauna shells and small quantity of quartz. Poorly decomposed plant roots appear in form of humiskel. The plasma consists of fine crystalline calcite and clayey minerals. The plasmic fabric is mainly crystic. In some places the composition of plasma is entered b y few fragments of humicol as well as some iron compounds (Fig. 2).

The voids have usually the character of planes or vughs, the latter occuring in case of slight welding of the granular peds. Some of them have a random or clustered distribution pattern. On the walls of the voids, corresponding first of all to ortho-meta- and meta-voids, there are secondarily crystallized calcitans. In some voids there are met bridges of lublinite connectiong the structural aggregates into systems of higher organization degree. Sometimes the fecal pellets occuring in the voids are impregnated with neocalcitans and lublinite.

The ferric concretions have various forms: the regular ones are of more or less clustered distribution pattern, the irregular ones - of diffusely shaped ferric nodules. In some places manganese-ferric concretions can be found as brown or dark brown spots.

Horizon C. 22-120 cm :

White (10 YR 8/1) weathered travertine rich in $CaCO_3$, patches of ferruginous precipitations, gray earthy material in cracks of the upper part of the horizon.

The travertine is very porous. Fragments of malacofauna shells are less abundant. The voids are mainly compound packing ones and channels. In some voids there occur secondary micropeds of crystic plasma fabric. The pores have a form of metavoids, or a transtition form between ortho-and metavoids. The number of geogenic voids has considerably increased. On the walls of the pores a lot of neocalcitans occur, but there are no formations of lublinite. In some places concentric recrystallization of calcium carbonate can be seen. Special features include several neocalcitans and diffusely calcitic nodules as well as some irregular diffusely bounded fe - rric nodules.

Profile 2 - Medium-deep rendzina on subfossil cherno - zemic soil.

Horizon A_1, 0-20 cm :

Dark grayish brown (10 YR 4/2) medium heavy very fine sandy loam with numerous fragments of travertine, high content of $CaCO_3$, some roots, porous, crumbly structure, smooth boundary.

The groundmass consists of a mixture of skeleton grains and plasma. The skeleton grains consist of sub - rounded and rounded fragments of weathered travertine and malacofauna shells, quartz grains and partly felds - pars. The plasma consists of clay minerals, calcium carbonates, iron compounds and some humicol and argilla - humicol/mullicol/. Some humiskel from leaves and roots occur. Regularly observed are charcoal particles.

The plasmic fabric is mainly crystic, and partly masepic. Some grains with crystic plasma fabric are surrounded by iron oxides/hydroxides/. Moreover, a lot of neoferrans and quasiferriargillans are found in the groundmass. Besides, smaller and bigger diffusely bounded ferric nodules and spots occur (Fig. 3)

The pores are mainly of biogenic character and they are metavoids in form of channels, vughs and intercon. - nected bughs. On the walls of the voids lublinite occurs very rarely.

Special features include several neocalcitans, calcitic nodules and some random and clustered fecal pel - lets of different ageing, which occur in the larger pores.

Horizon A_1/C, 20-30 cm :

Light brownish gray (10 YR 6/2), medium heavy very fine sandy loam with high content of $CaCO_3$, numerous fragments of weathered travertine, ferriginous concretions in form of patches.

The groundmass consists of strongly weathered travertine chips, detritus of malacofauna shells, few quartz grains and plasma. The plasma is composed of calcium carbonate, iron compounds, clayey minerals and in places argillahumicol. Humiskel appears here and there as organic remains of roots, Crystic predominates in the plasma fabric. There are numerous pores of mammillated interconnected vughs with predominance of orthovoids. In some pores lublinite and discrete carbonate crystal tubes can be seen. Special features include diffusely bounded calcitic nodules, channels with neocalcitans of brushlike forms, neoferrans of concentric and diffusely bounded forms, some abraded sesquioxidic iron nodules and some clusters of matric fecal pellets (Fig. 4).

Horizon C_{Ca} 30-60 cm:

White (10 YR 8/2) weathered porous travertin with scarce ferruginous precipitations in some brownish stains (10 YR 4/3) and(7.5 YR 4/4) smooth boundary.

Strongly wethered travertine with a lot of malacofauna shells fragments. The most skeleton grains are subrounded. The domain of plasma fabric is crystic. The pores are orthovoids and belong to irregular interconnected vughs and channels. Some of them are filled up with clustered irregular clacitic and ferric microaggregates. In some places the peds are surrounded with lublinite and neoferrans of concentric and diffuse forms. Recrystallized calcium carbonate on the walls of the voids are sometimes covered with iron sesquioxides. Special features include calcitic nodules with diffuse boundaries, concentric neocalcitans, concentric calcitic neocutans and some regular neoferrous and manganiferrous globules.

Horizon C_{Ca+Fe}, 60 - 100 cm :

Light yellowish brown (10 YR 6/4) and white (10YR 8/2) porous travertine with high content of ferruginous precipitations in form of patches, streaks and spots, clear boundary.

The groundmass is identical to that of the overla - ying horizon, but it contains more iron compounds in form of iron oxides bearing the skeleton grains, ferric nodu- les with diffuse boundaries and ferrans occuring in irre gular forms in the planes, channels and mammillated vughs. The pores are orthovoids in the places with less amount of iron oxide precipitations, and metavoids in those with a lot of iron compounds. Some discontinuous ferriargi - llans and iron oxides can be seen along the pores (Fig. 5)

Horizon A_f, 100-140 cm :

Very dark-gray (2.5Y 3/0) heavy loam with small fragments of travertine, weakly structural.

The groundmass, consisting of a mixture of skele- ton grains and plasma, has rather low homogeneity. The skeleton grains include fragments of weathered traverti ne, detritus of malacofauna shells and a lot of quartz in the fraction above 20 µm. The plasma consists of clay minerals, calcium carbonate, iron compounds and some humicol and argillahumicol/mullicol/. The plasma fabric is argilla-masepic and partly crystic. The skeleton grains are porphyroskelically embedded in the soil mass. In some places the plasma and skeleton grains are inten- sively mixed up, while in others they occur in more or less separated fields. The places with crystic plasma fa bric are more dense than those with other fabrics (Fig. 6).

The voids, mainly of biogenic origin, are in form of planes, channels and mammillated interconnected vughs metavoids predominationg over orthovoids. Almost all of them have calcium carbonite and/or iron oxide coatings on their walls.

The primary and secondary peds are connected into higher level of organization by neocalcitans, iron oxides and ferriargillans. Some quartz grains are coated with microcrystalline calcite. A weak tendency of lublinite formation can be observed on the walls of the voids.

Special features include several calcitic and ferric nodules with sharp boundaries, some diffusely bounded ferric concretions, and matric fecal pellets occuring in a random and clustered distribution pattern.

Horizon C_f, 140 cm :

Pale yellow (2.5 Y 8/4) medium heavy loam with some fragments of weathered travertine.

The skeleton grains consist of quartz incorporating feldspars, fragments of travertine and residual malacofauna shells mainly in the silt fraction. Plasma is composed of clay minerals, iron oxides and calcium carbonate. In some places humiskel and humicol occur. Some skeleton grains are surrounded with microcrystalline calcite. The plasma fabrics are crystic and argillaskelsepic, partly masepic. More or less irregular spots of iron hydroxides, small iron nodules with diffuse boundaries and quasicutans occur in some fields. In less porous places diffusely bounded calcitic nodules can be seen. Geogenic voids of simple forms are more abundant, being mostly metavoids and partly orthometavoids. Some of them are surrounded with calcitic cutans

2.- Physical and chemical properties of the soils.

In the mechanical composition of the rendzina soils there appear some differences depending on the formation degree of the profiles. There is more skeleton and sand, and less colloidal clay in the A_1 horizon of the shallow than in the medium-deep rendzina. Besides, the shallow rendzina distinguishes itself by lower porosity and it contains less pores larger than 300 μm. The A_f horizon of subfossil soil underlaying the medium-deep rendzina contains most clay, its mechanical composition is heaviest and its total porosity simewhat lower /Table1/.

The reaction of all the rendzinas examined approaches neutral tending to slightly alkaline. In all the horizons $CaCO_3$ appears in rather large quantities, least of it having been observed in horizon C_f of subfossil soil. Some decrease of $CaCO_3$ content, due to partial decalcification, takes place in horizon A1 of medium-deep rendzina. The sorption complex of both the profiles are highly saturated with basic cations /up to about 99 % /.

The content of organic matter is highest in medium deep rendzina. The A_1 horizon of this soil contains about 5 % organic carbon, including relatively much non-hydrolyzing carbon. A lot of organic matter is found also in horizon A_f of subfossil soil, containing most hydrolyzing carbon and the carbon of humic acids bounded with calcium cations /Table 2/.

IV. DISCUSSION

The morphological, and particularly micromorphological properties of rendzinas derived from travertines clearly show that in the soil profiles under investigation there are met, first of all, the products of travertine weathering as well as fragments of malacofauna shell detritus. Small content of some allogenic skeletal fractions, composed of mainly quartz and feldspars, has no essential effect on the course of soilforming processes or the typology of soils. Therefore, these profiles can be reckoned among pure rendzinas of more or less lithogenic character.

Travertines are generally good parent material to soils. Beside large $CaCO_3$ content, reaching up to 80% they contain certain amount of organic matter as well as admixture of clayey, silty and sandy fractions. In respect of their mechanical and physicochemical properties, travertines are carbonate-calcareous formations of high porosity and ready susceptibility to weathering processes. Percolating water carries ready-soluble $Ca/HCO_3/2$ which then precipitates in the soil mass in form of secondarily crystallized calcium carbonate, being the essential part of plasma. Therefore, the predominating type of the plasma fabric is crystic, being the essential part of the soil groundmass in the profile of shallow travertine rendzina. In medium-deep rendzina crystic is accompanied with masepic. In both the profiles crystic domains increase in the transition horizons A_1/C. In subfossil the number of crystic domains is smaller in the C_f horizon compared with the A_f one.

The examined rendzinas are characterized by a considerable biological activeness. This is proved by a lot of biogenic pores and structural microaggregates of irregular shapes, being the fecal fragments of soil mesofauna. The result of this high biological activeness is the humus type mull found in the surface horizon, as well as amorphous forms of humus compounds being the component of the soil plasma. The analysis of the fractional composition of humus compounds showed that the soils contained little ready-hydrolyzing carbon and much that of humic acids bounded with Ca cations. These properties are undoubtedly related with the influence of active $CaCO_3$ contained in weathered travertines on preservation of the products of organic matter humification. This phenomenon is rather characteristic of the chernozemic process occuring in conditions of humid and semihumid climate. It was also confirmed by the results of analyses of some physical and physicochemical properties of the soils, chiefly the levelled mechanical composition of earthy particles, neutral or weakly alkaline reaction and high degree of saturation with bases.

The presence of numerous chips of ready-weathering matrix abundant in $CaCO_3$ controls the course of the accumulation processes and leaching of some components of the soil mass, and in higher or lesser degree stabilizes the balance between the soils and the bioecological habitat. In given conditions of forest soil habitat the predominating soil-forming process is the peculiar variant of the humus matter accumulation process approximating the chernozemic one. Along with its development the soil profiles change in the system: travertine → protorendzina → shallow rendzina → medium-deep rendzina. On the way from shallow to medium-deep rendzina there occurs gradual decalcification of the soil mass, the thickness of the accumulation horizons A_1 increases, and in the structure of plasma the amount of crystic decreases for the better of masepic. In all the profiles crystic predominates in the transsition horizons to parent rock.

Concretionary and non-concretionary forms of iron compounds appearing in the point to variable redox systems, resulting from periodical changes of humidification degree. Rain water is retained in the surface layer of soils for a rather long time, then to percolate down changing the oxygenic conditions. Some iron compounds, being the products of organic and mineral matter decomposition, get precipitated, what is particularly clearly seen in horizon $C_{Ca + Fe}$ of medium-deep rendzina.

In the profile of subfossil soil underlying the medium-deep rendzina some micromorphological and physicochemical properties are not only relict, but also contemporary character, conditioned by the influence of rain water percolating through the surface soil. The migration of waters, carrying some substances of the soil mass, changes the primary properties of subfossil soil, particularly so in its humus horizon. The A_f horizon is characteristic by higher amount of ready-hydrolyzing carbon of humic acids bounded with calcium, iron compounds, and the presence of crystic plasma. The C_f horizon contains much less $CaCO_3$ and is characteristic by crystic→masepic domains of plasma. Generally, the subfossil soil underlying medium-deep rendzina bears the micromorphological and physicochemical characters of chernozemic rendzinas, in which the content of $CaCO_3$, has had a significant effect on the structure, composition and properties of the soil mass.

V. CONCLUSIONS

The research results have helped to draw following conclusions :

/1/ The soils derived from travertines have all the characters of chernozemic rendzinas in as well micromorphological as physicochemical respect.

/2/ The characteristic domain of plasma of travertine rendzinas is crystic with variable content of masepic. In the A_1 horizon of shallow rendzina predominates crystic, while in the medium deep one it is accompanied with masepic. In horizon A_1/C the amount of crystic considerably increases.

/3/ The travertine rendzinas distinghish themselves by high biological activeness, neutral weakly alkaline reaction, high degree of the saturation with bases and high content of non-hydroly zing carbon.

/4/ In the micromorphological composition of humus predominating are humicol and argillahumicol /mullicol/ with a slight admixture of humiskel. The content of carbon of humic acids bounded with calcium is pretty considerable.

/5/ The subfossil soil bears the characters of secondary chernozemic rendzina, in which crystic plasma prevails over masepic and the A_f horizon contains most of carbon of humic acids bounded with calcium as well as of ready-hydrolyzing one.

/6/ Further evolution of chernozemic rendzinas derived from travertines in a given bioecological conditions will gradually lead to formation of chernozem-like soils with the profiles of different formation degree.

Table 1. - Some physical properties of travertine rendzinas.

Profile number and horizon	Depth of sampling /cm/	Particlas 2 mm %	Particle size distribution in % um					Total porosity %	Pore size distribution in % um				
			Clay	Sitt		Sand							
			0-2	2-20	20-50	50-200	200-2000		< 3	3-6,5	8,5-60	60-300	>300
1. A_1	4-9	16,2	9,0	22,0	23,0	25,0	22,0	65,3	39,9	5,1	4,7	8,1	7,5
A_1/C	15-20	n.o	n.o	n.o	n.o	n.o	n.o	62,9	38,7	5,1	7,4	6,2	5,5
C	80-95	n.o	n.o	n.o	n.o	n.o	n.o	58,3	34,4	4,3	5,9	4,7	9,0
2. A_1	3-10	6,0	10,0	31,0	28,0	20,2	10,8	68,4	40,1	6,3	5,7	6,2	10,1
A_1/C	22-28	7,6	n.o	n.o	n.o	n.o	n.o	68,2	34,4	6,6	8,0	7,0	12,2
C_{ca}	40-46	n.o	n.o	n.o	n.o	n.o	n.o	61,2	33,9	4,3	5,6	4,6	12.8
C_{ca+Fe}	62-68	10,0	n.o	n.o	n.o	n.o	n.o	67,5	38,1	8,5	5,7	5,3	9,9
A_f	110-116	8,3	25,0	33,0	8,0	18,0	16,0	60,6	36,3	9,4	2,3	3,7	8,9

Table 2. - Some chemical properties of travertine rendzinas.

Profile number and horizon	Depth of sampling /cm/	pH KCl	$CaCO_3$ %	Sorption complex S	T	V	O.M. %	C/N	C hydrolizing	C nonhydrolizing	C bounded with Ca
				meq/100g		%			in % of C-total		
1. A_1	4-9	7,2	48,2	40,73	41,16	99,0	4,15	9,9	35,6	64,4	10,3
A_1/C	15-20	7,4	74,7	34,41	34,64	99,3	1,86	13,3	31,4	68,6	8,4
C	80-95	7,7	83,7	n.o	n.o	n.o	0,87	14,5	n.o	n.o	n.o
2. A_1	3-10	7,2	36,1	48,22	48,68	99,1	4,93	9,5	33,2	66,8	9,8
A_1/C	22-28	7,3	50,3	41,49	41,86	99,1	2,85	16,8	30,6	69,4	8,3
C_{Ca}	40-46	7,4	72,8	n.o	n.o	n.o	0,70	6,4	n.o	n.o	n.o
C_{Ca+Fe}	62-68	7,8	80,7	n.o	n.o	n.o	0.50	12.5	n.o	n.o	n.o
A_f	110-116	7,4	47,7	46,68	47,14	99,0	3,29	14,9	47,9	52,1	36,8
C_f	150-160	7,5	25,5	34,24	34,61	98,9	0,28	14,0	n.o	n.o	n.o

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Fig. 1.- Crystic and masepic fabric with fragments of mullicol, biogenic ortho-metavoids; a- plain light, b- crossed polarized light. Profile 1 : horizon A_1, depth 4 - 9 cm.

Fig. 2.- Crystic fabric; clay-calcium carbonate coprogenic elements; biogenic ortho-metavoids. a- plain light, b- crossed polarized light. Profile 1: horizon A_1/C, depth 15- 20 cm.

Fig. 3.- Crystic and partly masepic fabric with mullicol biogenic microaggregates of irregular shapes ; some neoferrans. a- plain light, b- crossed polarized light. Profile 2: horizon A_1 depth 3-10 cm.

Fig. 4.- Crystic and masepic fabric, calcitic nodules and clustered fecal pellets of different ageing. a- plain light, b- crossed polarized light. Profile 2 : horizon C_{Ca}, depth 40 - 46 cm.

Fig. 5.- Crystic fabric; scarce irregular pores; concentrinc neocalcitans; iron oxide precipitations. a- plain light, b-crossed polarized light. Profile 2: horizon $C_{Ca + Fe}$ depth 62-68 cm.

Fig. 6.- Argilla-masepic and partly crystic fabric; fragment of malacofauna shell. a-plain light. b- crossed polarized light. Profile 2: horizon A_f , depth 110-116 cm.

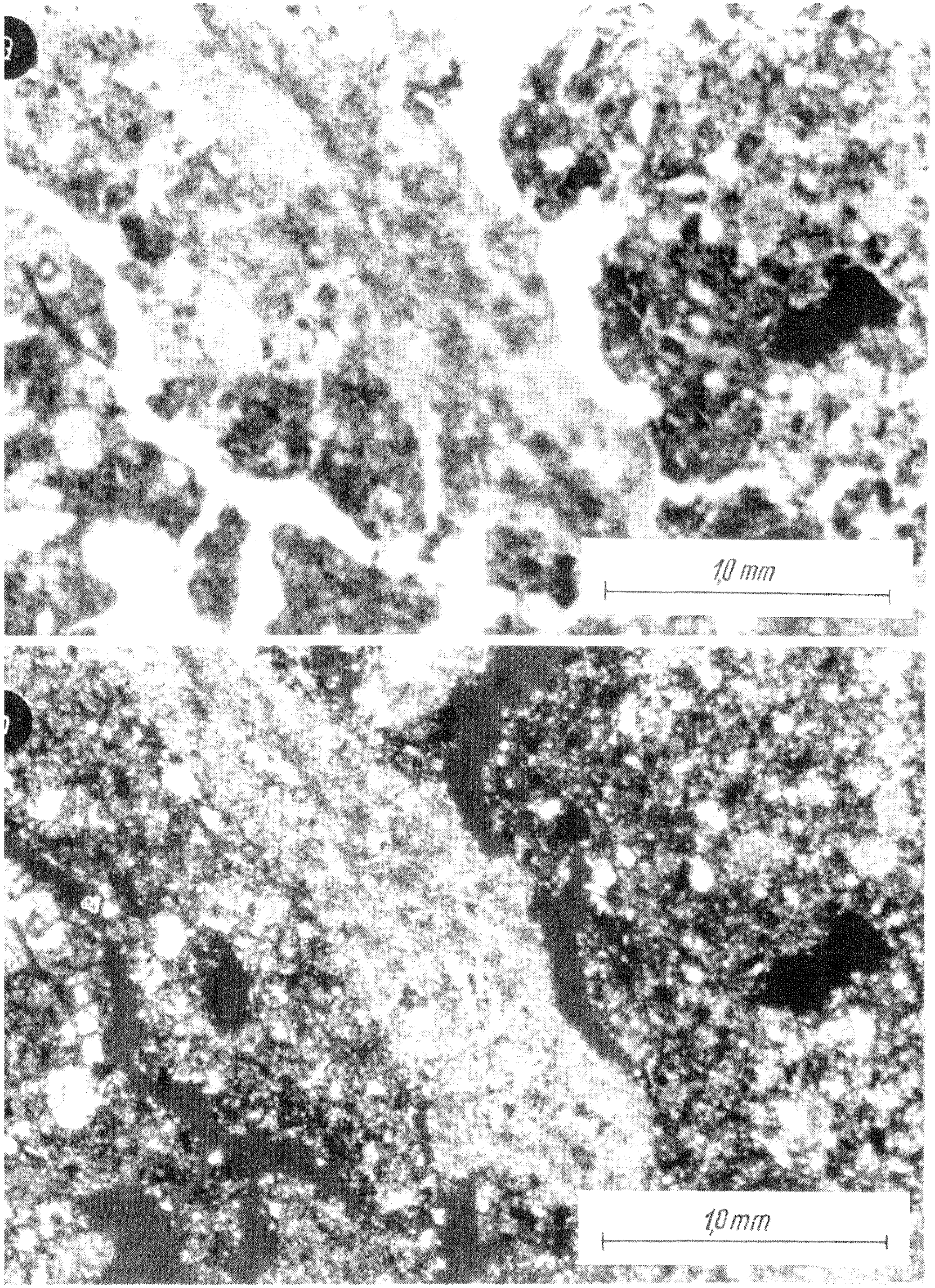
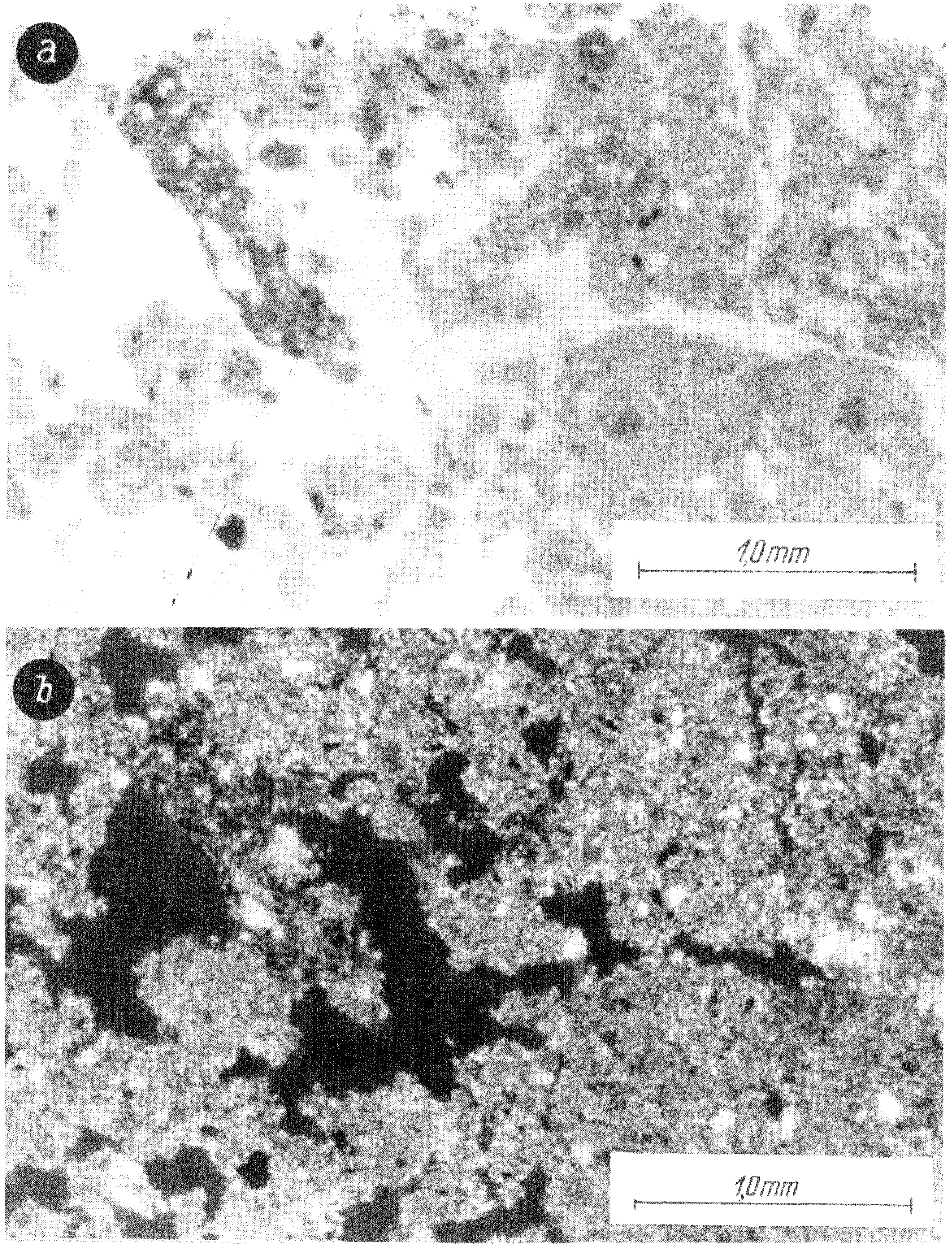


Figure 1



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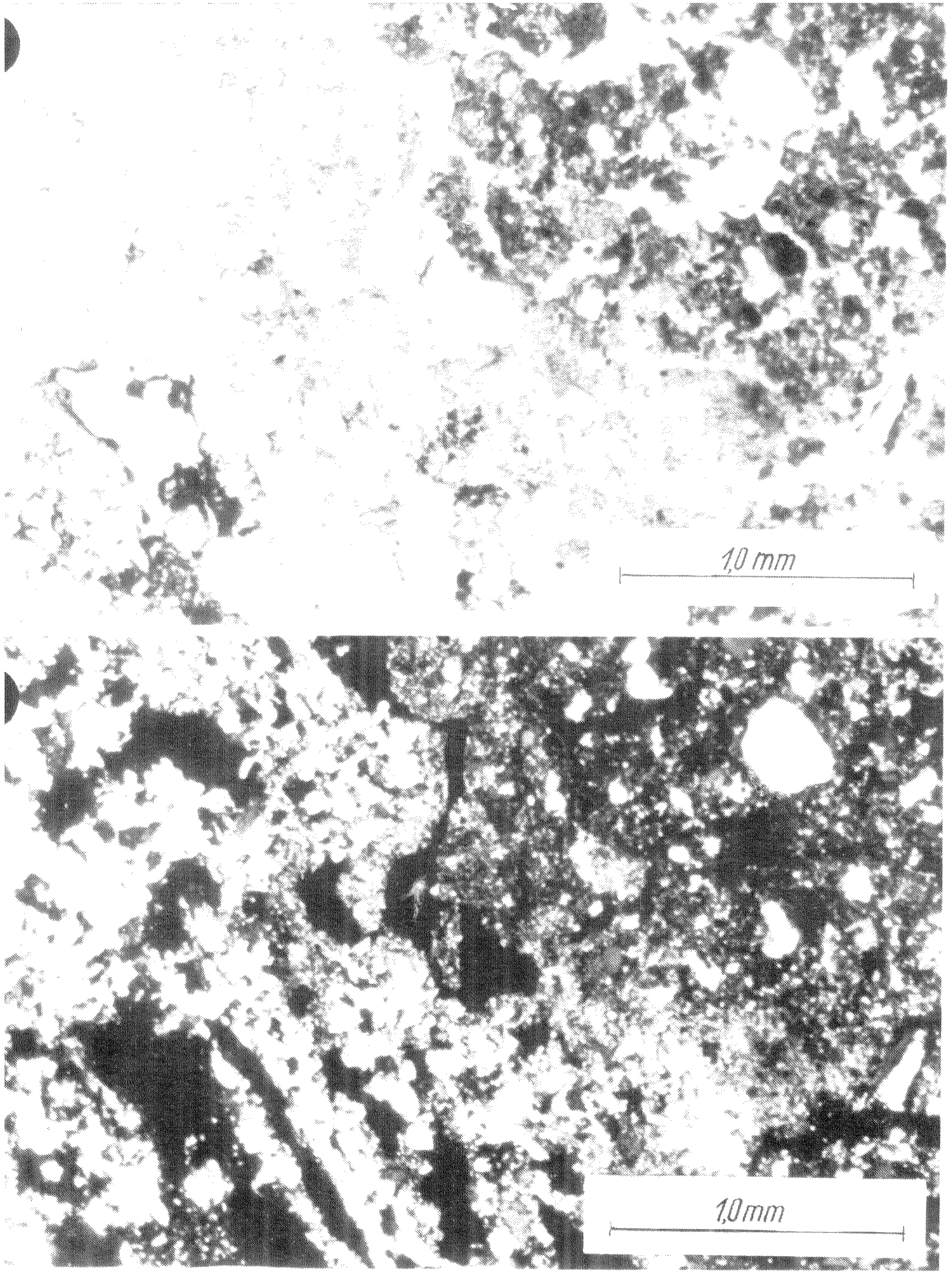

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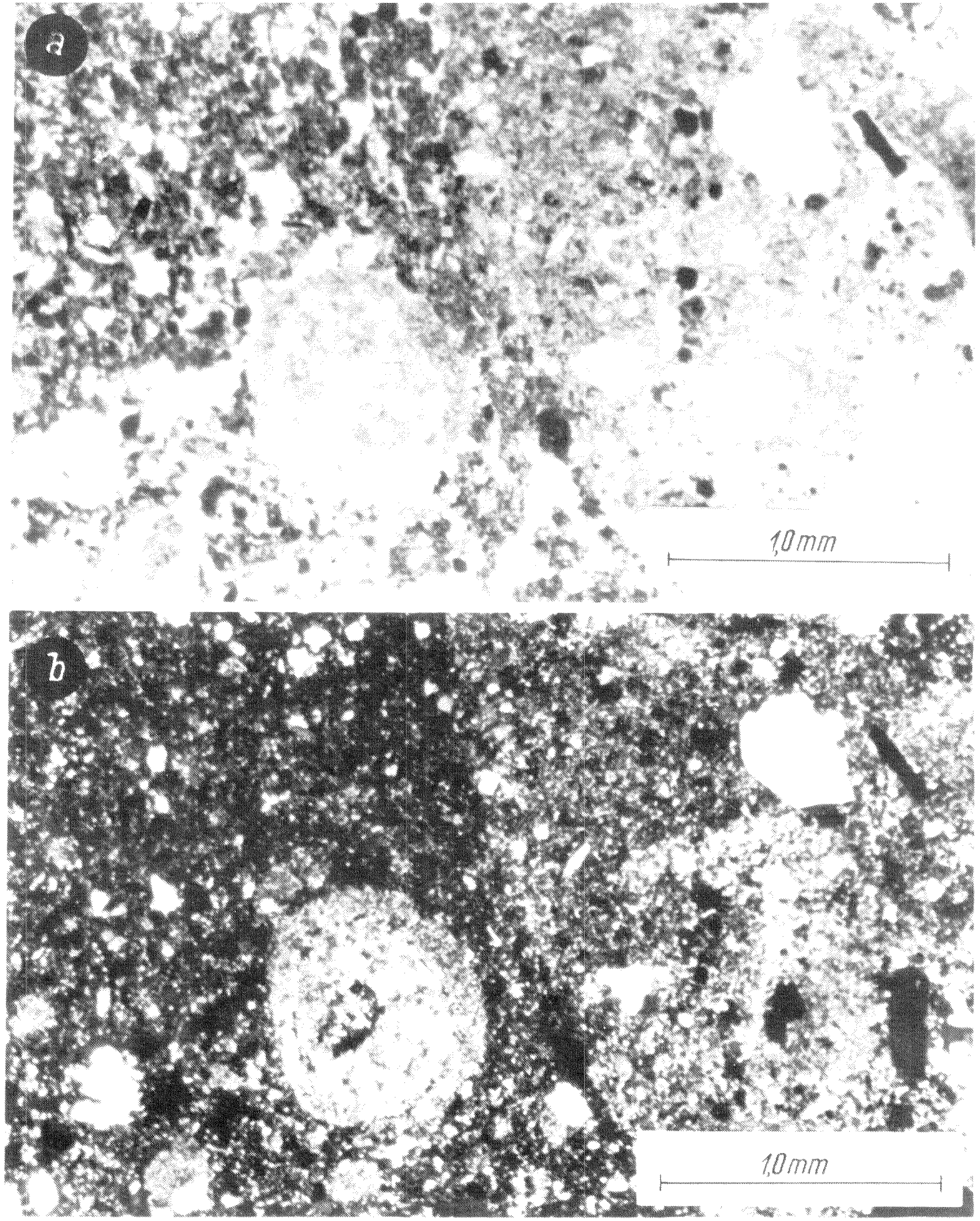

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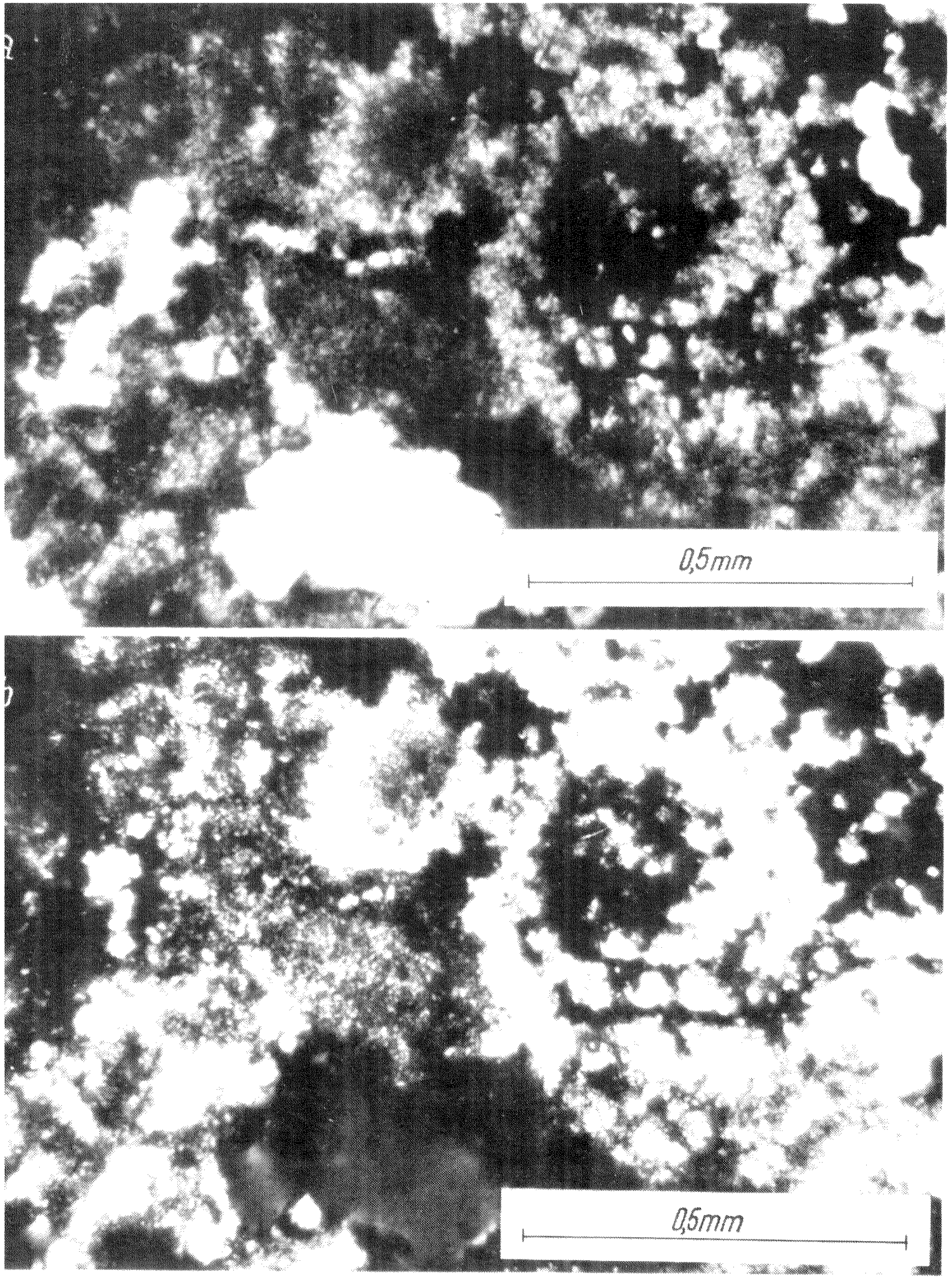

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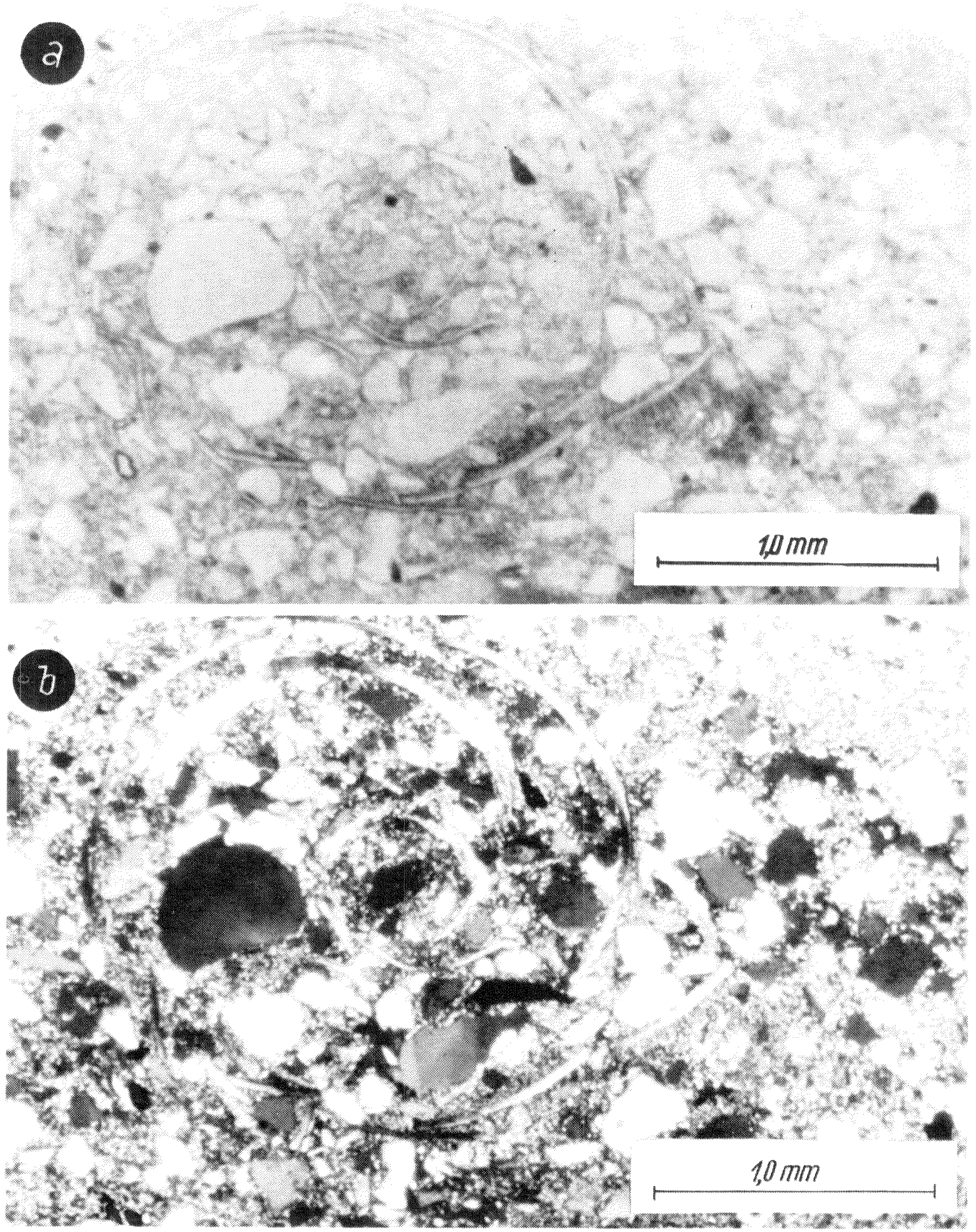

Figure 6

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SUMMARY

Travertines are generally a good parent material for soils formations. Beside large $CaCO_3$ content rea - ching up to 80 %, they contain certain amount of organic matter as well as admixture of clayey, silty and sandy fractions. In respect of their mechanical and physicoche mical properties, travertines are carbonate calcareous rocks of high porosity and ready susceptibility to weathe ring processes. The most soil profiles formed out of them have the morphology of rendzinas.

In pedological literature there are only a few stu - dies dealing with travertine rendzinas, because of their local occurring and importance. Therefore, the main task of the present study was:

- to examine the micromorphological properties of some travertine rendzinas;
- to demonstrate the relation between morphology and physicochemical features of these soils.

The object of detail examinations were travertine rendzinas sporadically met in lower, moist sites of the area with loess and boulder loam formations occurring in the forest region of Henryków within the Strzelinskie Hill /geographical unit 332/. The profiles have represen ted shallow rendzina, and medium-deep rendzina on sub-fossil chernozemic soil. The examination results validate the following conclusions:

/1/ The soils derived from travertines possess all the features of chernozemic rendzinas in as physicochemical respects. They distinguish themselves by special domain of plasmic fabric high biological activeness, neutral or alkaline reaction, high saturation with bases and high content of non-hydrolizing carbon.

/2/ The characteristic domain of plasmic fabric in travertine rendzinas is crystic with variable content of masepic. In the A_1 horizon of shallow rendzina predominates crystic, while in the medium-deep one it is accompanied with masepic fabric. In the A_1/C horizon the amount of crystic fabric considerably increases.

/3/ In the micromorphological composition of humus predominating are humicol and argillahumicol - /mullicol/with a slight admixture of humiskel. The content of humic acids bounded with calcium is considerable in the investigated soils.

/4/ The subfossil soil underlying the medium-deep travertine rendzina shows the micromorphology of secondary chernozemic rendzina. In this soil crystic fabric prevails over masepic. The A_f-horizon containts most of carbon of humic acids bounded with calcium as well as of ready-hydrolyzing one.

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