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Micromorphological properties of rendzinas and soils on limestone developed out of Triassic carbonate-calcareous formations

S. KOWALIŃSKI, S. LICZNAR, and M. LICZNAR

Department of Soil Science, University of Agriculture, Wrocław, Poland

INTRODUCTION

In the soil science literature one finds many reports on the subject of the formation and transformation of various soil types developed out of noncarbonate parent materials. Among these studies, one ought to mention the investigations of the following authors: Kubiëna [10], Altemüller [2], Fedoroff [6], Kowaliński [8], Albareda Herrera [1], and Reuter [13], who to a large extent used micromorphological methods in their investigations, beside other methods. However, there are few studies concerning the evolution of soils developed out of carbonate-calcareous rocks [5, 9, 11, 12, 14]. Among these studies particular attention is merited by the work W. L. Kubiëna, who — on the basis of micromorphological studies — discusses rendzinas and rendzina-like soils developed out of rocks containing calcium carbonate.

In Polish soil science literature, though one finds many works concerning soils developed out of limestone formations, their micromorphological structure is not discussed. The basic purpose of our study was to investigate the micromorphological properties of rendzinas developed out of Triassic limestone and other types of soils lying thereon.

Our starting point was the assumption that in rendzinas, para-rendzinas and other soils on limestone the influence of the parent material and bedrock occupies the foremost place in the group of soil-forming factors and determines the properties of the soil profile.

MATERIAL AND METHODS

The investigations were carried out on five soil profiles taken in the vicinity of Strzelce Opolskie, which were developed or lying on carbonate-calcareous rock of the lower shelly limestone of the Triassic formation.

The profiles of these soils were located rather close to each other, so they were developed in very similar climatic and topographic conditions. They were characterized by a genetic bond in their developmental cycle comprised of the following systematic units:

profile 1 — shallow mixed brown rendzina;
profile 2 — medium-deep mixed brown rendzina;
profile 3 — brown soil on limestone;
profile 4 — lessive soil (leached soil) lying on limestone;
profile 5 — weakly podzolized soil lying on limestone.

These soil profiles showed an admixture of material of glacial origin. The parent material or bedrock of these soils is limestone rock which was found at a depth of 40-60 cm in the profiles under discussion. This rock is characterized by a high content of calcium carbonate, ranging from 83-96%.

MACROMORPHOLOGICAL CHARACTERISTICS OF THE INVESTIGATED SOILS

Profile 1 — shallow mixed brown rendzina. Utility category: turf soil.

A_{1d}	0-6 cm	gray-brown (10 YR 5/2), medium silty loam, crumb structure, numerous plant roots, distinct transition;
(B)/C	6-15 cm	yellow-brown (10 YR 5/4), heavy loam, prismatic crumb structure, numerous limestone fragments.
C	〉15 cm	gray (10 YR 7/2), debris of Triassic limestone.

Profile 2 — medium-deep mixed brown rendzina. Utility category: arable soil.

A_1	0-19 cm	gray (10 YR 5/1), strongly loamy sand, crumb structure, sharp transition;
(B)	19-42 cm	yellow-brown (10 YR 5/6), heavy loam, prismatic structure, few limestone fragments, sharp transition;
C	〉42 cm	gray (10 YR 7/2), debris of Triassic limestone.

Profile 3 — brown soil on limestone. Utility category: arable soil.

A_1	0-25 cm	light brown-gray (10 YR 6/2), medium silty loam, crumb structure, single roots of cultivated plants, gradual transition;
A_1(B)	25-35 cm	yellow-brown (10 YR 5/4), with humus tongues (10 YR 6/2), heavy loam, crumb-prismatic structure;
(B)	35-65 cm	yellow-brown (10 YR 5/4), heavy loam, highly compacted, prismatic structure, gradual transition;
D	〉65 cm	white (10 YR 8/1), and yellow (10 YR 7/6) debris of Triassic limestone, heavy loam accumulated in cracks.

Profile 4 — lessive soil (leached soil) lying on limestone. Utility category: arable soil.

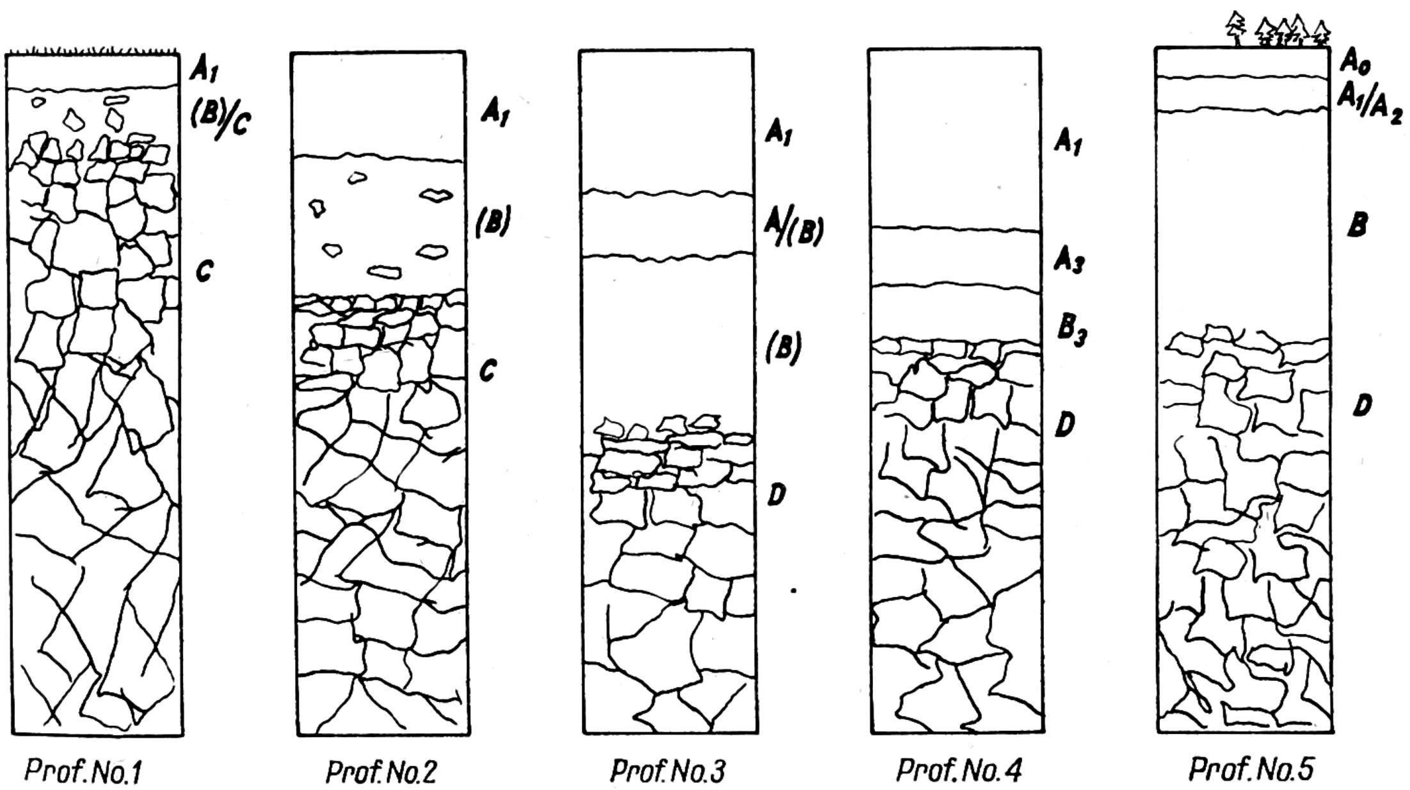
A_1	0-31 cm	gray-brown (10 YR 5/2), medium loam, crumb structure, sharp transition;
A_3	31-41 cm	light yellow-brown (10 YR 6/4), medium loam, nut structure, distinct transition;

B_3	41-52 cm	yellow-brown (10 YR 5/6), heavy loam, prismatic structure, distinct transition;
D	〉52 cm	gray (10 YR 7/2), debris of Triassic limestone.

Profile 5 — weakly podzolized soil lying on limestone. Utility category: forest soil.

A_0	0-5 cm	forest litter in varying degrees of decay, decomposed organic matter with easily visible layers of fermentation and humification;
A_1/A_2	5-11 cm	gray (10 YR 5/1), coarse sandy soil, without structure, sharp transition.
B	11-53 cm	yellow-brown (10 YR 5/4), coarse sandy soil, smooth transition.
D	〉53 cm	gray (10 YR 7/2), debris of weathered Triassic limestone, loamy weathered material in cracks.

Mechanical composition and some chemical and sorption properties of these soils are presented in Table 1. The schematic structure of the profiles described above is presented below.



Macromorphological structure of mixed brown rendzinas and soils on limestone.

MICROMORPHOLOGICAL CHARACTERISTICS OF THE INVESTIGATED SOILS

The micromorphological properties of the investigated soils are presented in Tables 2-6. The above descriptions indicate that the investigated soils are differentiated regarding their micromorphology, their genetic horizons, and likewise within each particular profile.

Least differentiated are the accumulation horizons with agglomerated structure, in which there is much organic matter in various degrees of decomposition and argillasepic type plasma.

This plasma is composed of clay and an admixture of organic sub-

Table 2. Profile No. 1, micromorphological properties

Description unit	Horizon A₁	(B)/C	C
Soil groundmass:			
Skeleton	quartz grains Ø 325-400 μ shaped rounded up and numerous smaller grains Ø 20 μ, calcium carbonate splinter fragments	calcium carbonate splinters, strongly rounded up quartz grains Ø 520 μ and smaller ones, sharply shaped, non numerous microclines	calcium carbonate rock, calcite mixed with weakly rounded up quartz grains, gray-brown of colour with high range interference colours
Plasma composition	clay mixed with ferric compositions and calcium carbonate, brown-gold coloured	as on the left, but darker coloured	
Plasma structure	argillasepic, locally masepic and skelsepic	omnisepic, lattisepic, masepic	
Free spaces	recesses and voids Ø 300 μ, with coarse and curved walled shapes	voids and recesses as on the left, besides, aggregate-inside fissure	
Organic substance	cell-structured plant tissue fragments and dark dots of strongly humified organic substance	small dark dots of strongly humified organic substance	
Proportions	pl>V>sk	pl>V>sk	
Soil features:			
Plasma separation	small dots on the whole background	proportionately on the whole background	
Plasma concentration	not regular agglomerations on the grains	not proportionate concentration on skeleton grains, and very numerous stripes	
Bioformations	plant originated voids, coprogenic elements	—	
Concretions	—	—	
Elementary structure:	agglomerated, spongy; closed clots smooth-walled	agglomerated, fragmental, closed smooth-walled splinters	

stance. It forms small glittering points on the background of the remaining soil substances (Figs. 1-4).

In the shallow brown rendzina, beside the argillasepic type of plasma, fragments of masepic and skelsepic type are found, as well as in the A_1/(B) horizon of brown soil on limestone and the A_3 horizon of lessive soil lying on limestone. The plasma structures appearing here additionally are undoubtedly brought about by the course of soil processes.

Table 1. Some mechanical and physico-chemical soil properties

Profile No.	Soil type	Horizon	Sampling depth	Particle contents in %: skeletal >1.0 mm	Particle contents in %: earthy <1.0 mm	Particle size distribution in % (mm): 1.0-0.1	0.1-0.02	0.02-0.006	0.006-0.002	<0.002	<0.02	pH: H_2O	pH: KCl	$CaCO_3$ %	Fe_2O_3 in 20% HCl %	H_h (meq/100 g soil)	S (meq/100 g soil)	$S+H_h$ (meq/100 g soil)	V %	C total %	N total %	C/N
1	Shallow mixed brown rendzina	A_1d	0-6	3.1	96.9	28.0	31.0	17	9	15	41	7.5	7.1	1.96	1.7	0.57	28.30	28.87	98.0	2.20	0.17	12.9
		(B)/C	6-10	32.6	67.4	20.0	11.0	13	14	49	76	7.7	7.0	5.55	7.7	0.39	51.85	52.24	99.3	0.66	0.11	6.0
		C	>15	—	—	—	—	—	—	—	—	—	—	96.51	—	—	—	—	—	—	—	—
2	Medium-deep mixed brown rendzina	A_1	11-18	4.9	95.1	72.0	9.0	7	9	3	19	7.7	7.1	0.00	1.35	0.32	11.67	11.99	97.3	0.79	0.08	9.9
		(B)	26-33	5.9	94.1	33.0	6.0	9	10	42	61	7.9	7.1	0.34	7.7	0.18	37.78	37.96	99.5	0.51	0.04	12.6
		C	>42	—	—	—	—	—	—	—	—	—	—	85.52	—	—	—	—	—	—	—	—
3	Brown soil on limestone	A_1	10-20	1.2	98.8	32.0	26.0	16	9	17	42	6.7	6.1	0.00	2.2	1.19	11.32	12.51	90.5	1.20	0.11	10.9
		A_1/(B)	25-35	0.5	99.5	29.0	20.0	14	9	28	51	6.5	5.8	0.00	3.8	1.19	13.20	14.39	91.7	0.61	0.06	10.2
		(B)	40-50	0.0	100.0	10.0	11.0	7	21	51	79	7.5	6.8	1.16	5.6	0.59	30.14	30.73	98.1	0.37	0.04	9.3
		C	>65	—	—	—	—	—	—	—	—	—	—	83.10	—	—	—	—	—	—	—	—
4	Lessive soil (leached soil) lying on limestone	A_1	7-15	1.1	98.9	44.0	20.0	17	7	12	36	6.3	5.3	0.00	2.6	1.69	8.58	10.27	83.5	1.18	0.13	9.1
		A_3	32-40	2.1	97.9	35.0	22.0	15	11	17	43	6.4	4.9	0.00	1.9	1.97	12.25	14.22	86.1	0.58	0.04	14.5
		B_3	45-52	31.0	69.0	13.0	10.0	11	14	52	77	7.4	6.3	0.13	6.0	0.70	40.49	41.19	98.3	0.68	0.08	8.5
		D	>52	—	—	—	—	—	—	—	—	—	—	83.73	—	—	—	—	—	—	—	—
5	Weakly podzolized soil lying on limestone	A_0	0-5	—	—	—	—	—	—	—	—	4.7	4.0	0.00	0.9	14.80	15.53	30.33	51.2	8.23	0.64	12.9
		A_1/A_2	6-10	5.4	94.6	86.0	6.0	3	4	1	8	4.6	4.0	0.00	0.6	3.58	2.65	6.23	42.5	0.52	0.04	13.0
		B	35-47	10.1	89.9	87.0	4.0	4	3	2	9	5.0	4.4	0.00	1.0	1.61	2.81	4.42	63.6	0.20	0.04	5.0
		D	>53	—	—	—	—	—	—	—	—	—	—	90.56	—	—	—	—	—	—	—	—

The browning horizons of rendzinas, illuvial and elluvial horizons of soils on limestone are particularly differentiated concerning the type of plasma structures (Figs. 5-8). The above changes are presented in Table 7.

In accordance with the soil processes occurring, the elemental structure also changes from agglomerated to porphyroskelic, followed by impoverishment of the types of plasma structures. The type of lattiseptic plasma, characteristic for brown rendzinas changes toward the vosepic and skelsepic type. Lattisepic is completely lacking in weakly podzolized soil; the dominating plasma is argillasepic and weakly discernable skelsepic (Fig. 9).

The presence of lattisepic type plasma is caused by the influence of

Table 3. Profile No. 2, micromorphological properties

Description unit	Horizon A_1	Horizon (B)	Horizon C
Soil groundmass:			
Skeleton	very numerous quartz grains Ø about 700 μ with very well rounded up shapes and somewhere less rounded up grains, non numerous microcline grains	quartz grains not so numerous as on the left is said	calcium carbonaceous rock mixed with quartz grains, gray-brown colour with high range interference colours
Plasma composition	clay mixed with dark brown organic substance	clay mixed with calcium carbonate and gold-brown ferric compositions	
Plasma structure	argillasepic	lattisepic, omnisepic and masepic	
Free spaces	not regular	aggregate-inside fissures, recesses, and voids smooth-walled and often straight	
Organic substance	dark dots of strongly humified organic substance	as on the left	
Proportions	sk>pl>V	sk>pl>V	
Soil features:			
Plasma separation	small lighting dots	mixed with skeleton, small agglomerations	
Plasma concentration	—	directed stripes, and on the whole background	
Bioformations	not numerous organic carbon agglomerations	—	
Concretions	—	small, not proportionate ferric composition agglomerations	
Elementary structure:			
	granular	agglomerated, fragmentary; fragments open-surfaced	

Table 4. Profile No. 3, micromorphological properties

Description unit	Horizon			
	A_1	A_1 (B)	(B)	D
Soil groundmass:				
Skeleton	quartz grains strongly rounded up Ø 490 μ, non numerous microcline grains	quartz grains Ø 400 μ, beside them calcium-carbonate splinters	quartz grains Ø 50 μ middly rounded up	calcium carbonate rock fragments brown-gold of colour, calcite with interference high range colours
Plasma composition	clay mixed with ferric compositions brown-yellow coloured	as on the left	as on the left	
Plasma structure	argillasepic	argillasepic, rests skel-lattisepic	skel-lattisepic, sporadically omnisepic	
Free spaces	coarse walled voids and recesses	voids curved and coarse-walled	voids and fissures smoothwalled	
Organic substance	plant tissues rests and dark dots of much humified organic substance	dark dots of much humified organic substance	as on the left	
Proportions	pl > sk > V	pl > sk > V	pl > V > sk	
Soil features:				
Plasma separation	small lighting spots	not proportionate spots on the whole background	as on the left	
Plasma concentration	—	local agglomerations of various measures	elongatedly striped agglomerations	
Bioformations	ferric compositions saturated plant tissues	organic carbonate	—	
Concretions	not numerous ferric composition concretions	ferric composition and mineral-organic concretions	ferric compositions	
Elementary structure:				
	agglomerated, porous; closed, coarse-surfaced fragments	agglomerated, clotty; open, smooth-walled clots	porphyroskelic, not regularly coherent; open, smooth-walled fragments	

Table 5. Profile No. 4, micromorphological properties

Description unit	Horizon			
	A_1	A_3	B_3	D
Soil groundmass:				
Skeleton	numerous quartz grains Ø 20-400 μ weakly rounded up shapes	quartz grains Ø 325 μ, much smaller Ø 20 μ, weakly rounded up, not numerous biotits	not numerous quartz grains Ø 700 μ, weakly rounded up	calcium-carbonate rock fragments, brown-yellow of colour
Plasma composition	clay with organic substance admixture dark-brown coloured	clay mixed with organic substance and ferric compositions dark brown coloured	clay mixed with ferric compositions and calcium-carbonate, brown-yellow coloured	
Plasma structure	argillasepic	argillasepic, somewhere lattisepic	lattisepic, omnisepic, somewhere vosepic	
Free spaces	not regular	coarse-walled pores and recesses Ø 400 μ	Ø 300 μ pores and Ø 20 μ fissures smooth-walled	
Organic substances	small dark dots of strongly humified organic substance	as on the left	as on the left	
Proportions	pl > sk > V	pl > sk > V	pl > sk > V	
Soil features:				
Plasma separation	small lighting dots	as on the left	—	
Plasma concentration	—	—	striped agglomerations, more or less equably directed	
Bioformations	pores originated after plant tissues decomposition	organic carbon		
Concretions	agglomerations of ferric compositions	as on the left	as on the left, but greater in number	
Elementary structure:				
	agglomerated, porous; big coarse-surfaced clots	agglomerated, not regularly coherent, closed, smooth-walled aggregates	porphyroscelic, not regularly coherent, big closed smooth-walled aggregates	

Table 6. Profile No. 5, micromorphological properties

Description unit	Horizon			
	A_0	A_1/A_2	B	D
Soil groundmass:				
Skeleton	non-numerous well quartz grains with 300 μ Ø	many quartz grains with 300-800 μ Ø with well rounded up forms	rounded up quartz grains and non-numerous calcium-carbonate splinters	calcium-carbonate rock of brown colour, with high range interference colours and visible ooliths
Plasma composition	—	—	clay mixed with organic substance of dark brown colour	
Plasma structure	—	—	argillasepic, skelsepic	
Free spaces	—	—	—	
Organic substance	plant tissue fragments with preserved cell structure and dark agglomerations strongly humified organic substance	dark dots strongly humified organic substance	as on the left, but fewer dots	
Proportions	sk	sk>V>pl	sk>V>pl	
Soil features:				
Plasma separation	—	—	not regular small agglomerations	
Plasma concentration	—	—	dark surroundings on the quartz grains	
Bioformation	resting plant tissues and coprogenic elements	resting plant tissues	—	
Concretions	—	—	organo-ferrous concretions	
Elementary structure:	granulated	as on the left	as on the left	

the parent material or bedrock, which is Triassic limestone characterized by the presence of calcite (crystalline) (Fig. 9), a small amount of quartz and remains of ooliths (Figs. 11, 12).

MICROMORPHOMETRIC STUDIES

The micromorphometric measurements were done according to the methods worked out previously [3, 7], which allowed to count the per-

Table 7. Structure changes of plasma in mixed rendzinas and soils lying on limestone

Soil type		Shallow brown rendzina	Medium deep brown rendzina	Brown soil lying on limestone	Lessive soil lying on limestone	Weakly podzolized soil lying on limestone
Horizon symbol		A_1,(B)/ C, C	A_1, (B), C	A_1,A_1/(B), (B), D	A_1,A_3, B_3, D	A_0,A_1/A_2, B, D
Predominating processes		weathering and stabilization of weathered products		(weathering) medium decalcification	strong decalcification, degradation and leaching	strong decalcification, weak podzolization
Process dynamics		relative stabil		pseudostabil	dynamic	
Characteristic of the:	horizons	(B)/C	(B)	(B)	B_3	B
	plasma structure	omnisepic lattisepic masepic	lattisepic omnisepic masepic	skel-lattisepic omnisepic	lattisepic omnisepic vosepic	argillasepic skelsepic

Decrease of the $CaCO_3$ content.
Increase of the content of foreign material not bounded with the initial carbonate-calcareous rock.
Increase of soil acidity.
Decrease of the degree of saturation of the soil sorption complex by bases.

centage of voids, skeletal grains, and the remaining soil substance in the differentiated horizons of the investigated soils. The above measurements were done on microscope pictures of the soil thin sections (in transparent light and with crossed nicols). The percentage of the different soil components in the soil profile are graphically shown in Fig. 13.

The profile percentage order of the different soil elements depends on the mechanical composition, genetic horizons, organic substance content, and the depth of sampling. The most important of all the above mentioned factors is the mechanical composition, which, in the case of soil with a larger content of material of glacial origin, decides of the order of the soil elements discussed.

RESULTS AND DISCUSSION

The soils characterized, which form a developmental cycle, came into being under the influence of carbonate-calcareous rock. The kind of this rock, its physical structure and chemical composition, amount and activity of $CaCO_3$ contained in it, and the content of noncarbonate admixture can

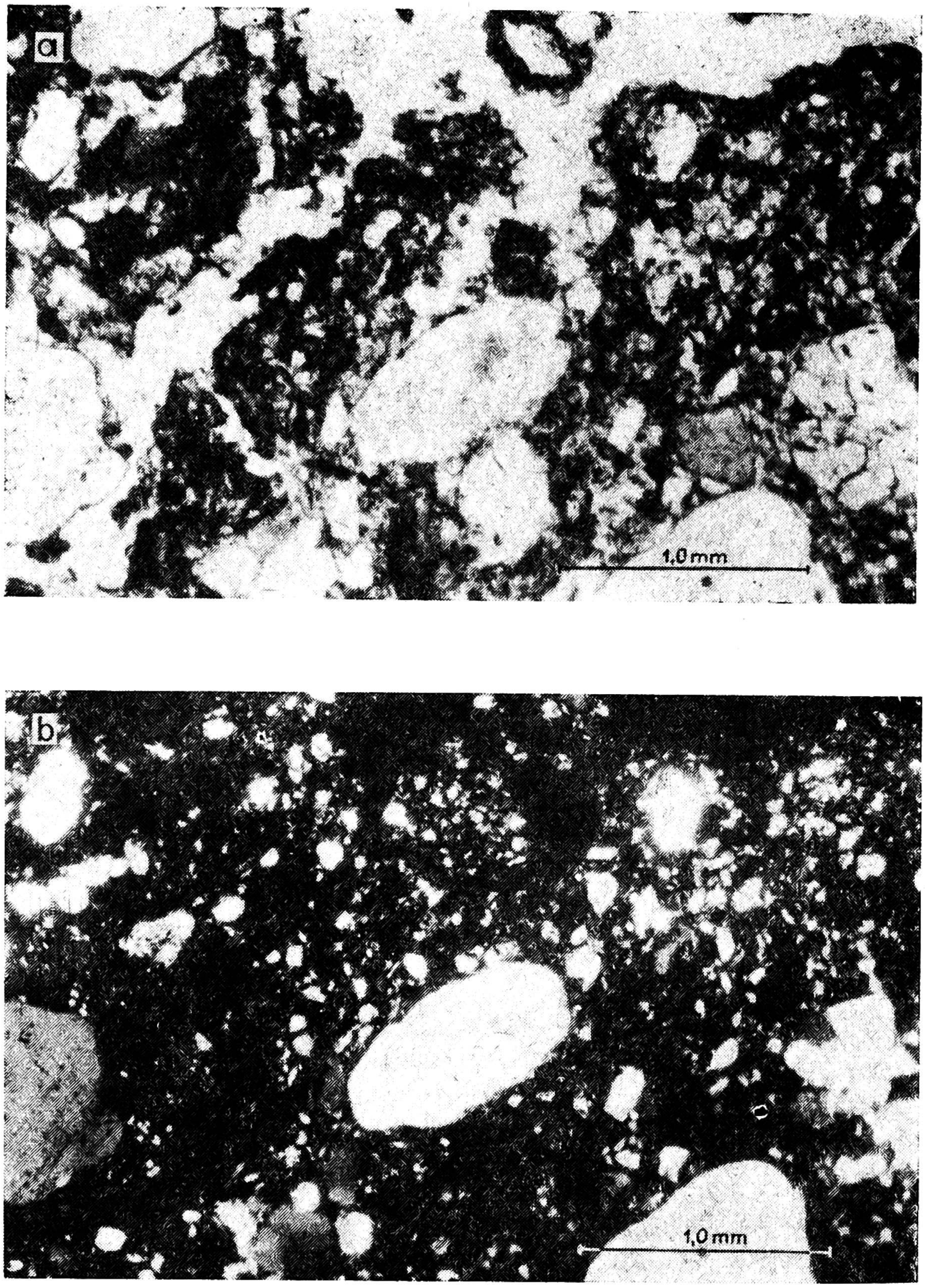


Fig. 1. Argillasepic, loose quartz grains with well rounded shapes. *a* — parallel nicols, *b* — crossed nicols. Profile No. 1, horizon A_1d, depth 0-6 cm.

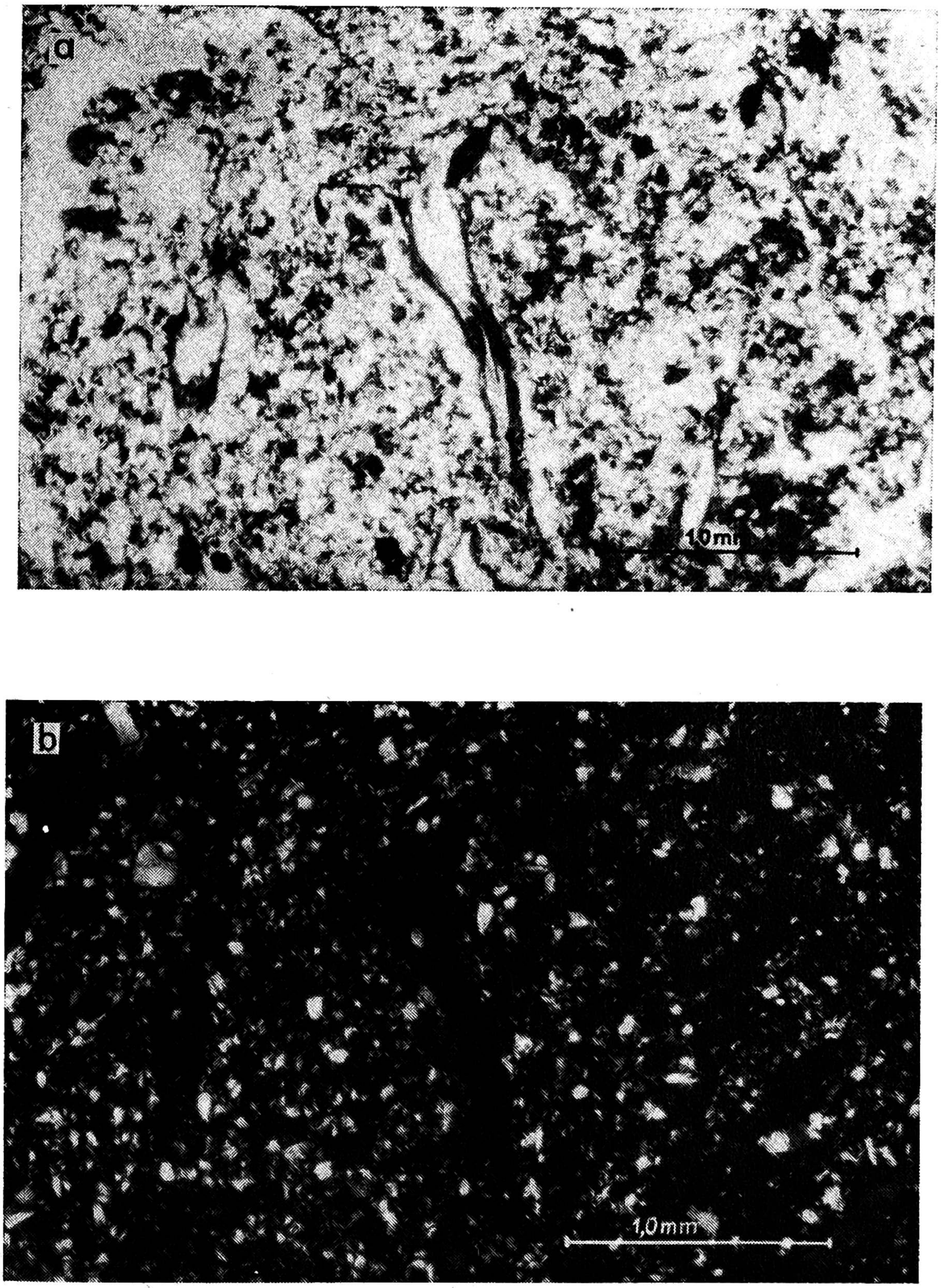


Fig. 2. Argillasepic, fragments of plant tissues in pores of biogenic origin. *a* — parallel nicols, *b* — crossed nicols. Profile No. 1, horizon A_1d, depth 0-6 cm.

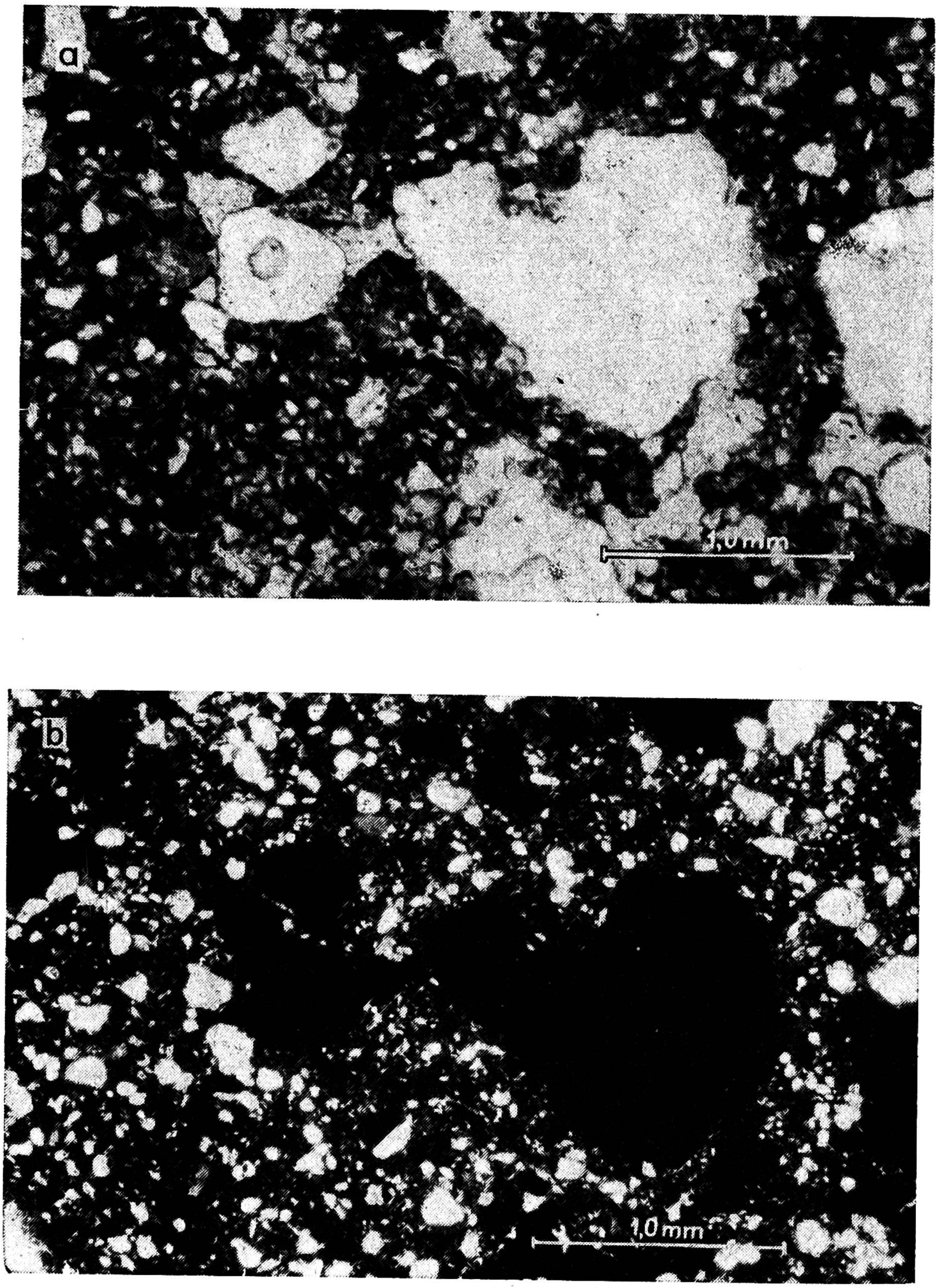


Fig. 3. Argillasepic, large admixture of mineral detritus. *a* — parallel nicols, *b* — crossed nicols. Profile No. 3, horizon A_1, depth 10-20 cm.

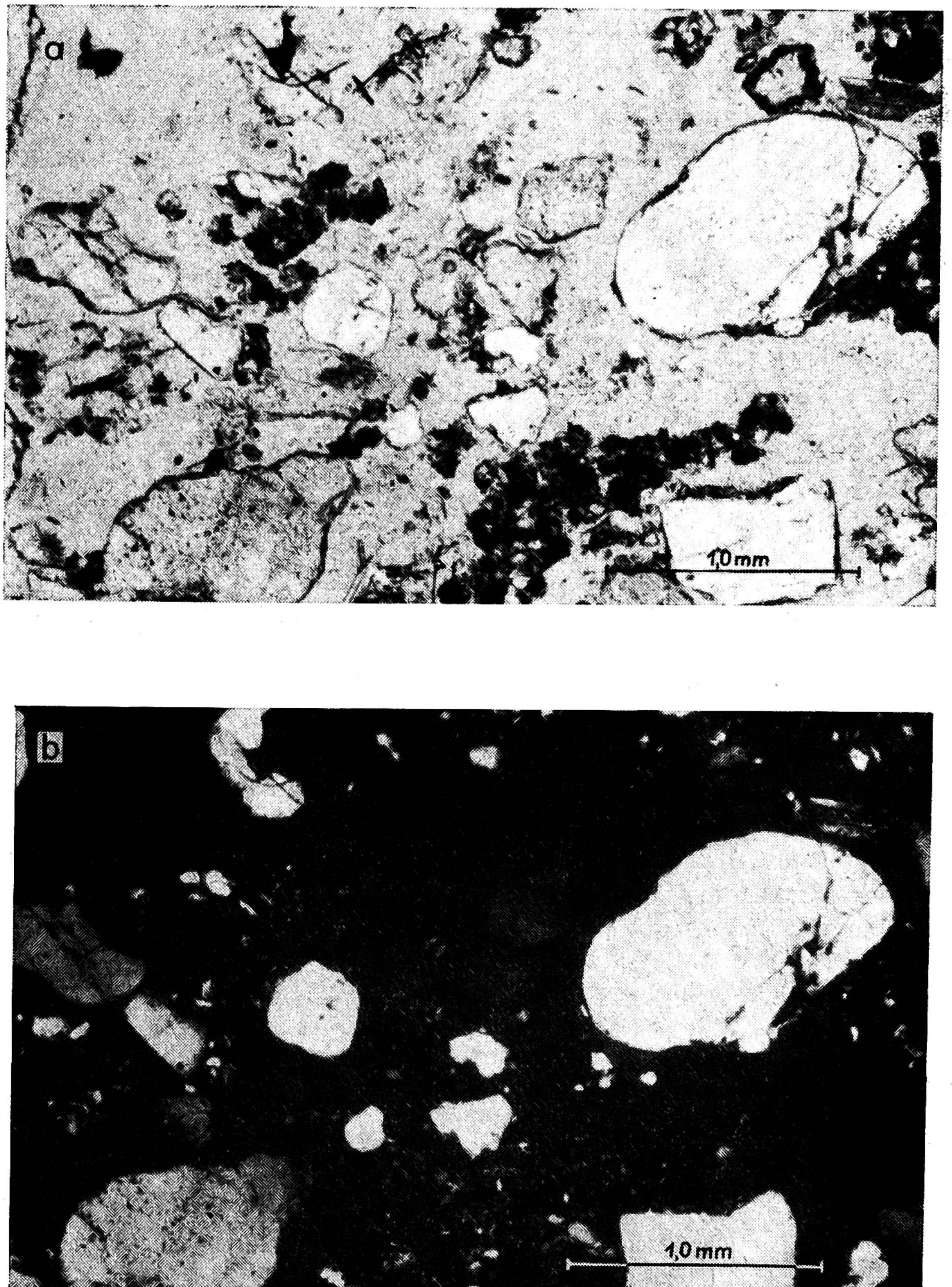


Fig. 4. Very well rounded quartz grains and concentrations of markedly humified organic substance. *a* — parallel nicols, *b* — crossed nicols. Profile No. 5, horizon A_1/A_2, depth 6-10 cm.

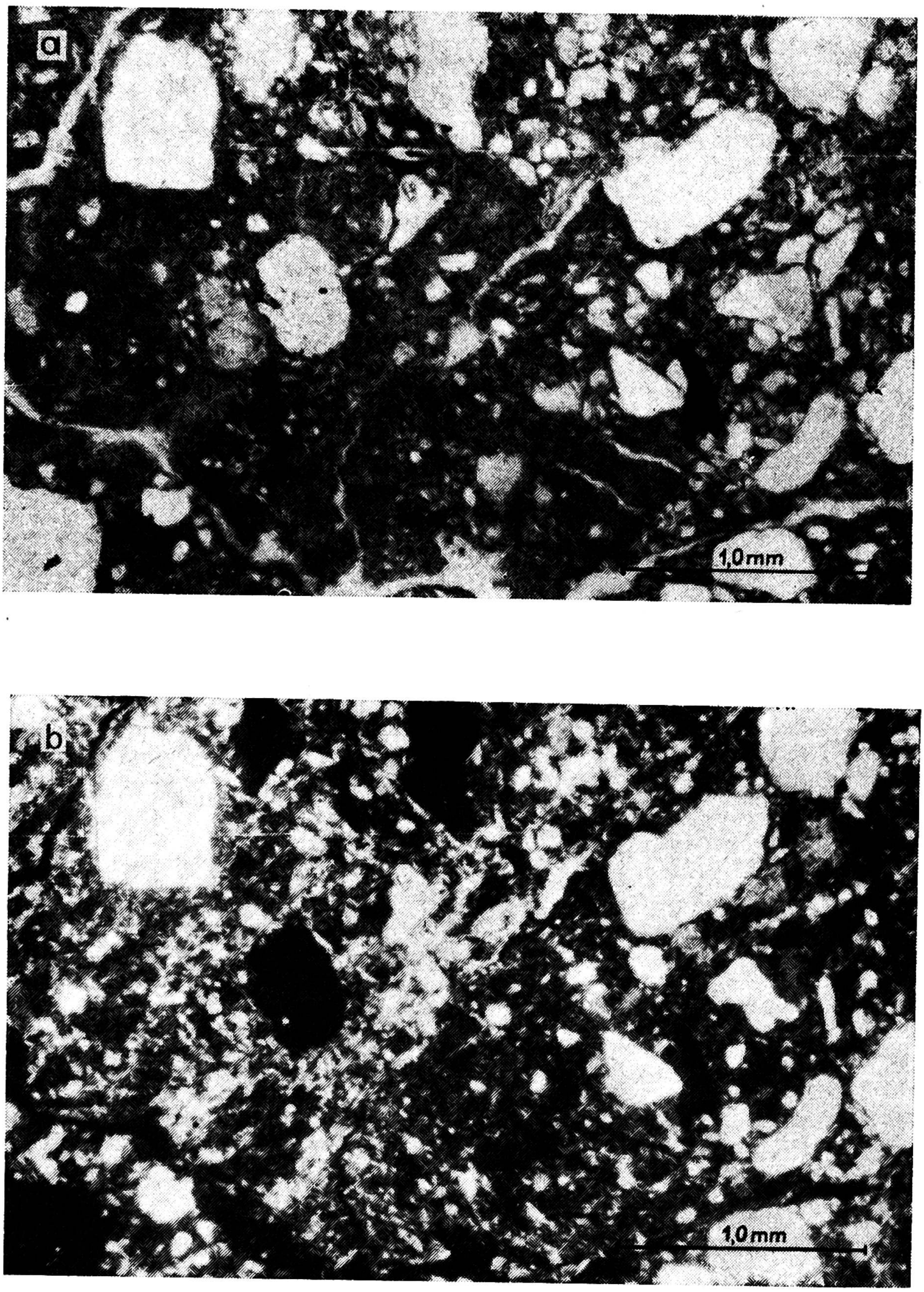


Fig. 5. Lattisepic and omnisepic, irregular joint structure. *a* — parallel nicols, *b* — crossed nicols. Profile No. 4, horizon B_3, depth 45-52 cm.

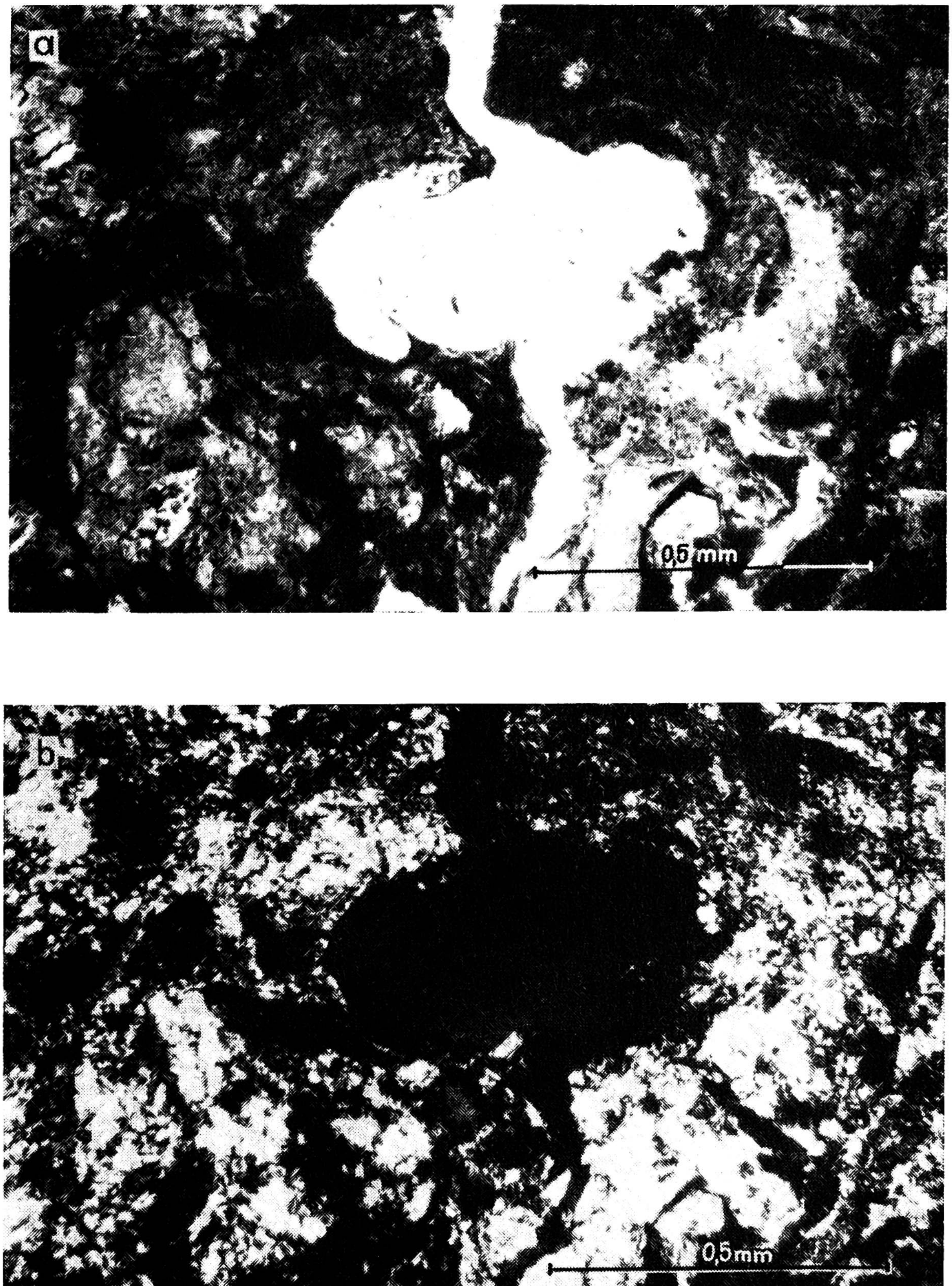


Fig. 6. Unevenly spread concentrations of omnisepic and lattisepic type plasma. *a* — parallel nicols, *b* — crossed nicols. Profile No. 1, horizon (B)/C, depth 6-10 cm.

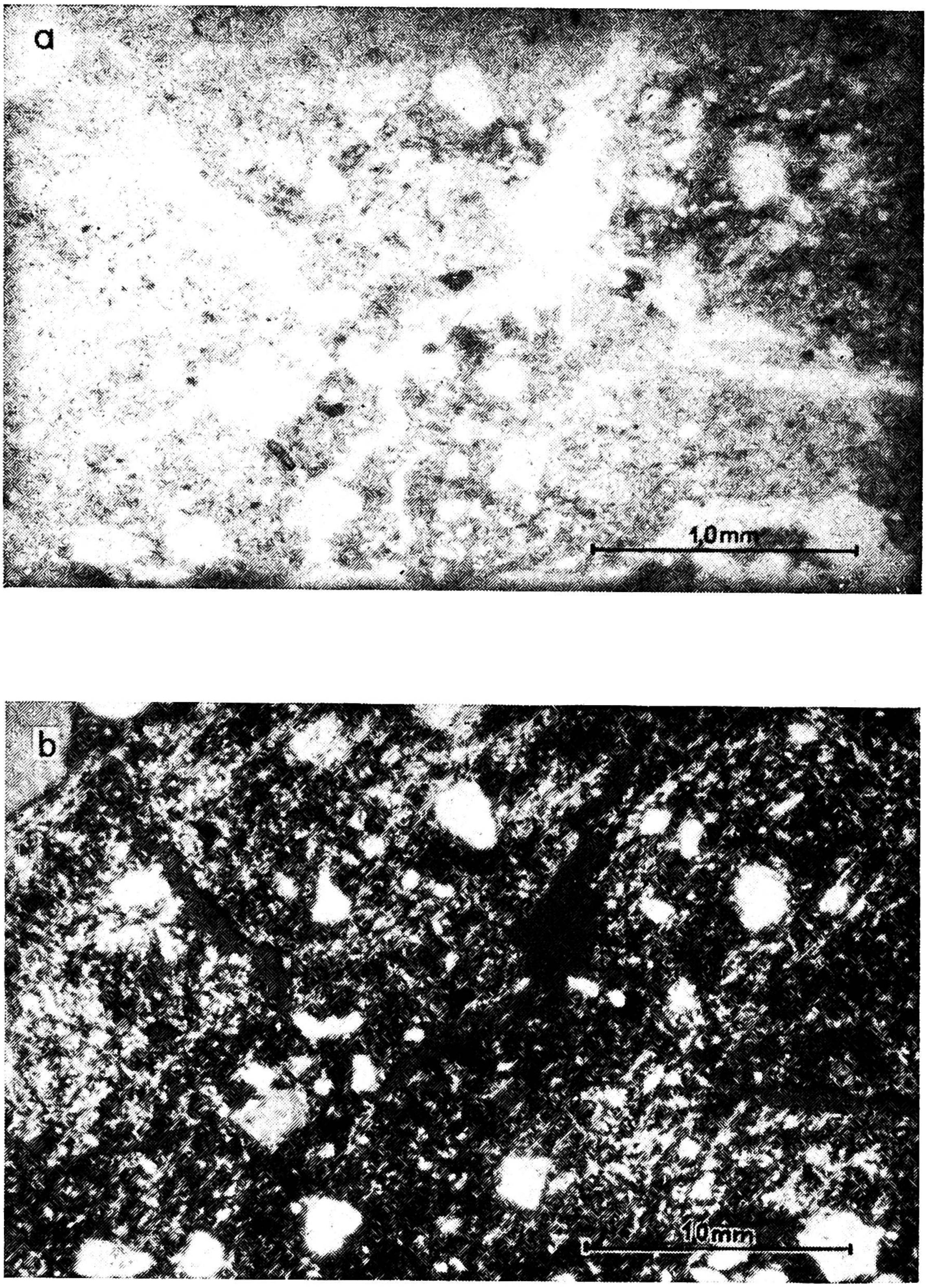


Fig. 7. Lattisepic, masepic, pores and intraaggregate cracks. *a* — parallel nicols, *b* — crossed nicols. Profile No. 2, horizon (B), depth 26-33 cm.

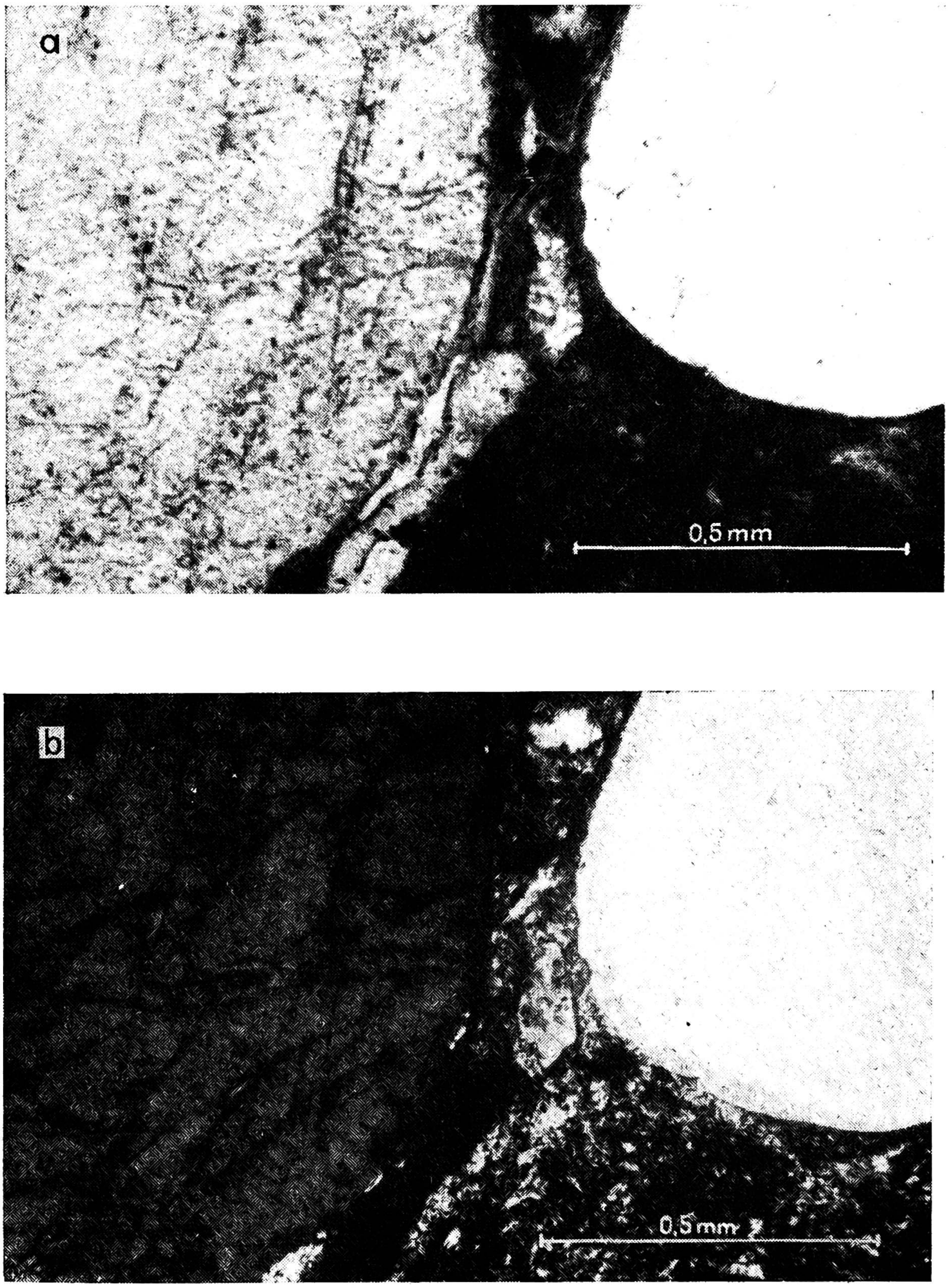


Fig. 8. A fragment of skel-lattisepic plasma beside quartz grains. *a* — parallel nicols, *b* — crossed nicols. Profile No. 3, Horizon (B), depth 40-50 cm.

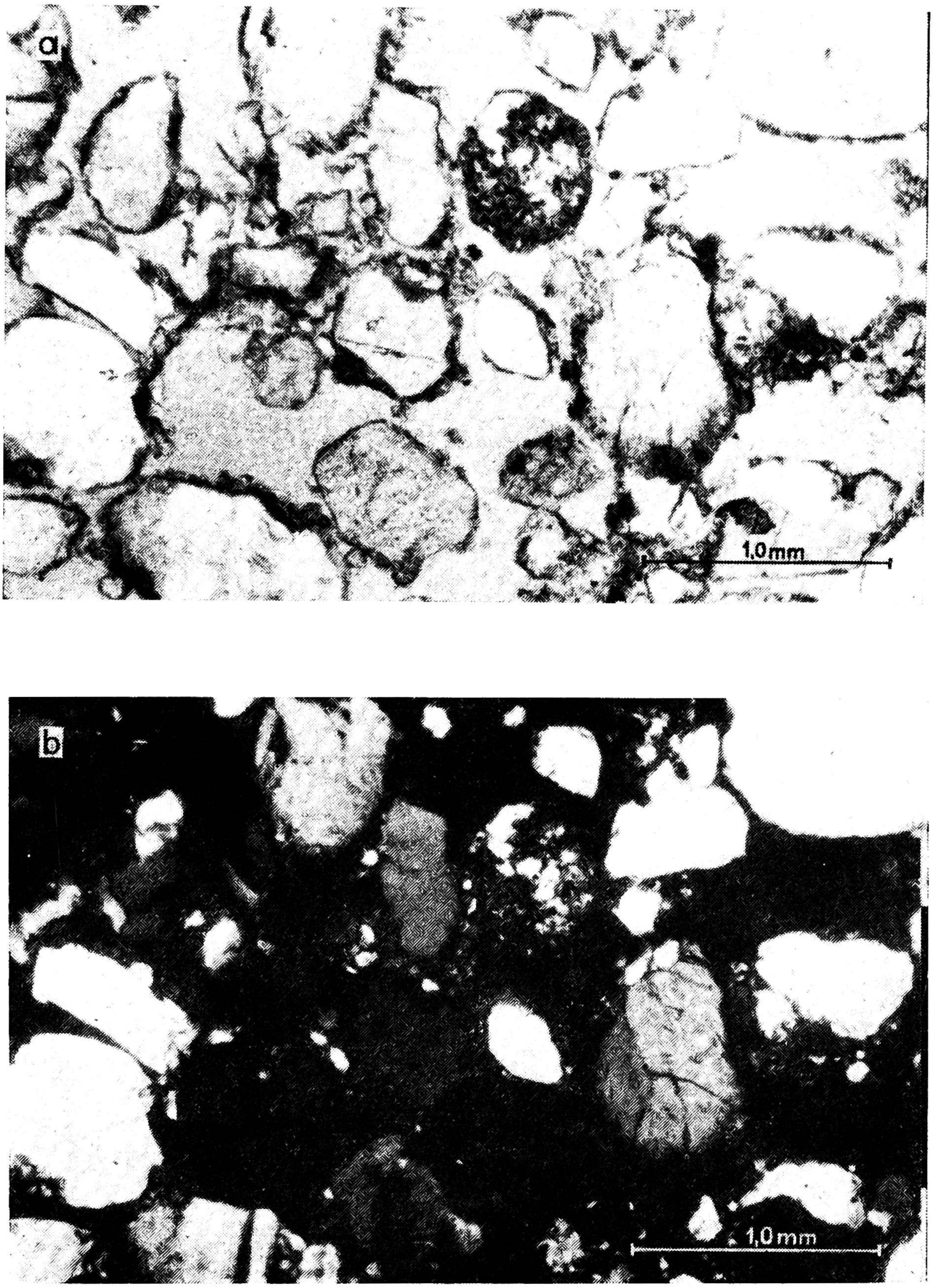


Fig. 9. Concentrations of argillasepic beside well rounded quartz grains. *a* — parallel nicols, *b* — crossed nicols. Profile No. 5, horizon B, depth 35-47.

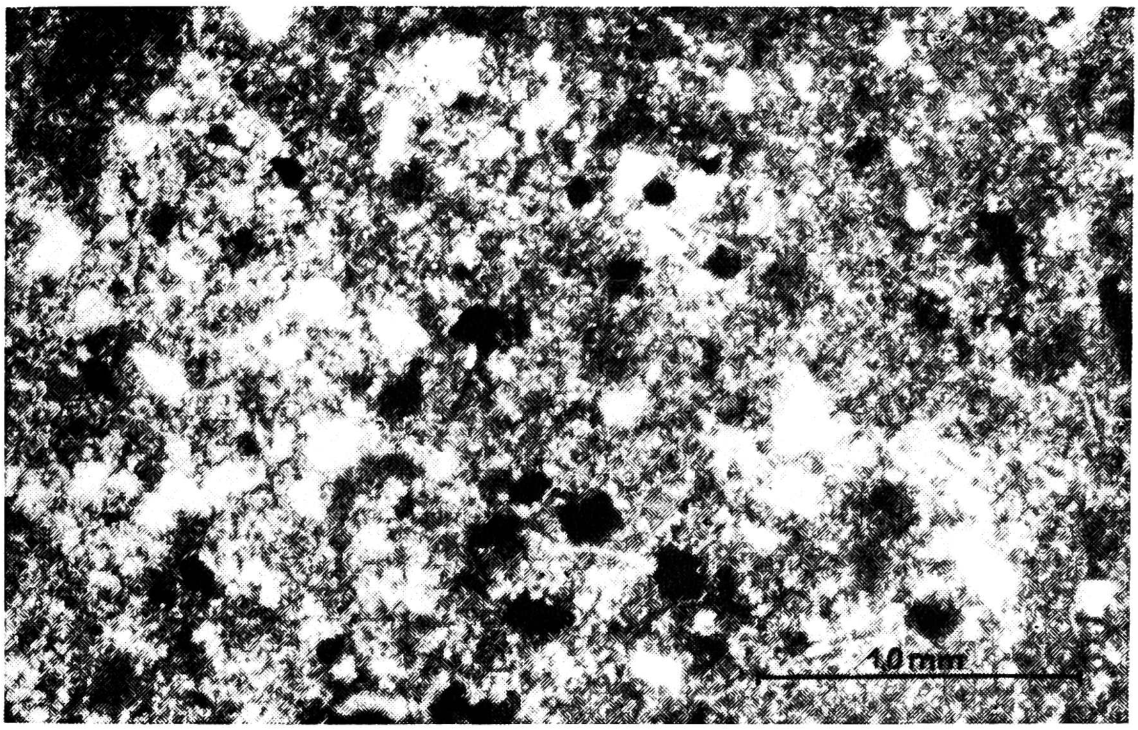


Fig. 10. A fragment of carbonate-limestone rock with fine quartz grains, crossed nicols. Profile No. 1, horizon C, depth below 15 cm.

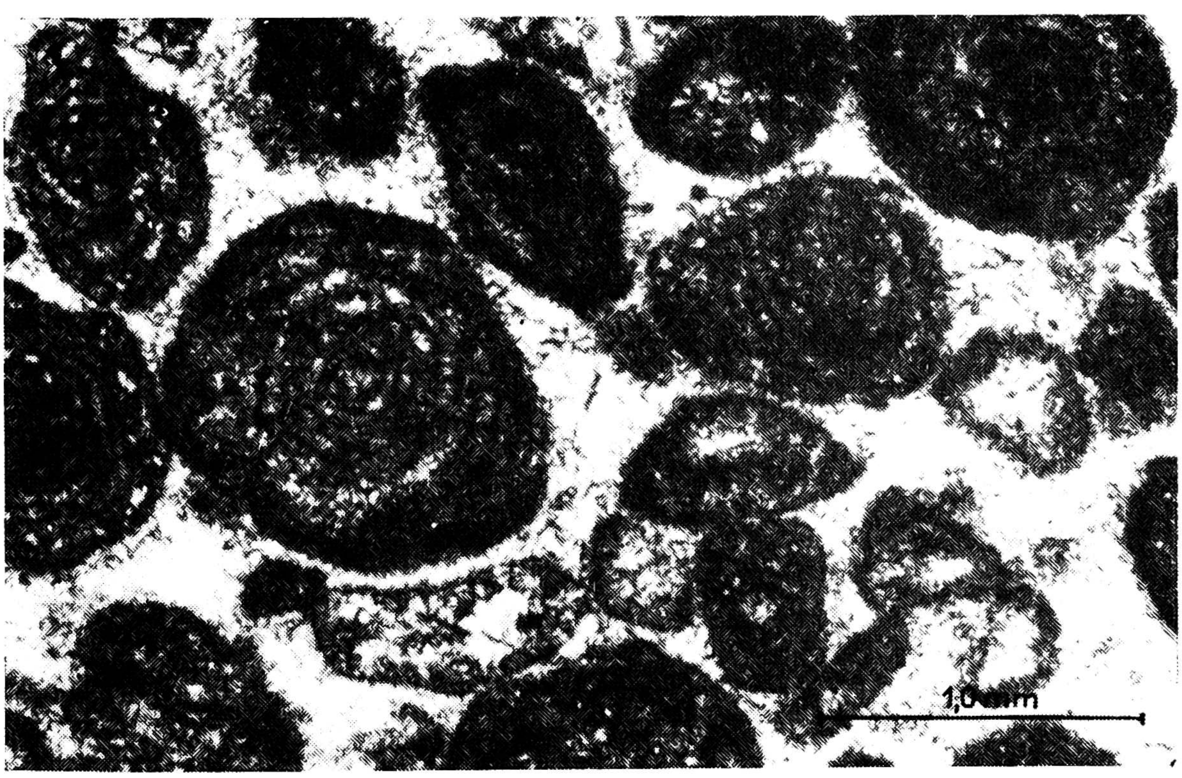


Fig. 11. A fragment of carbonate-limestone rock with visible oolites, crossed nicols. Profile No. 5, horizon C, depth below 53 cm.

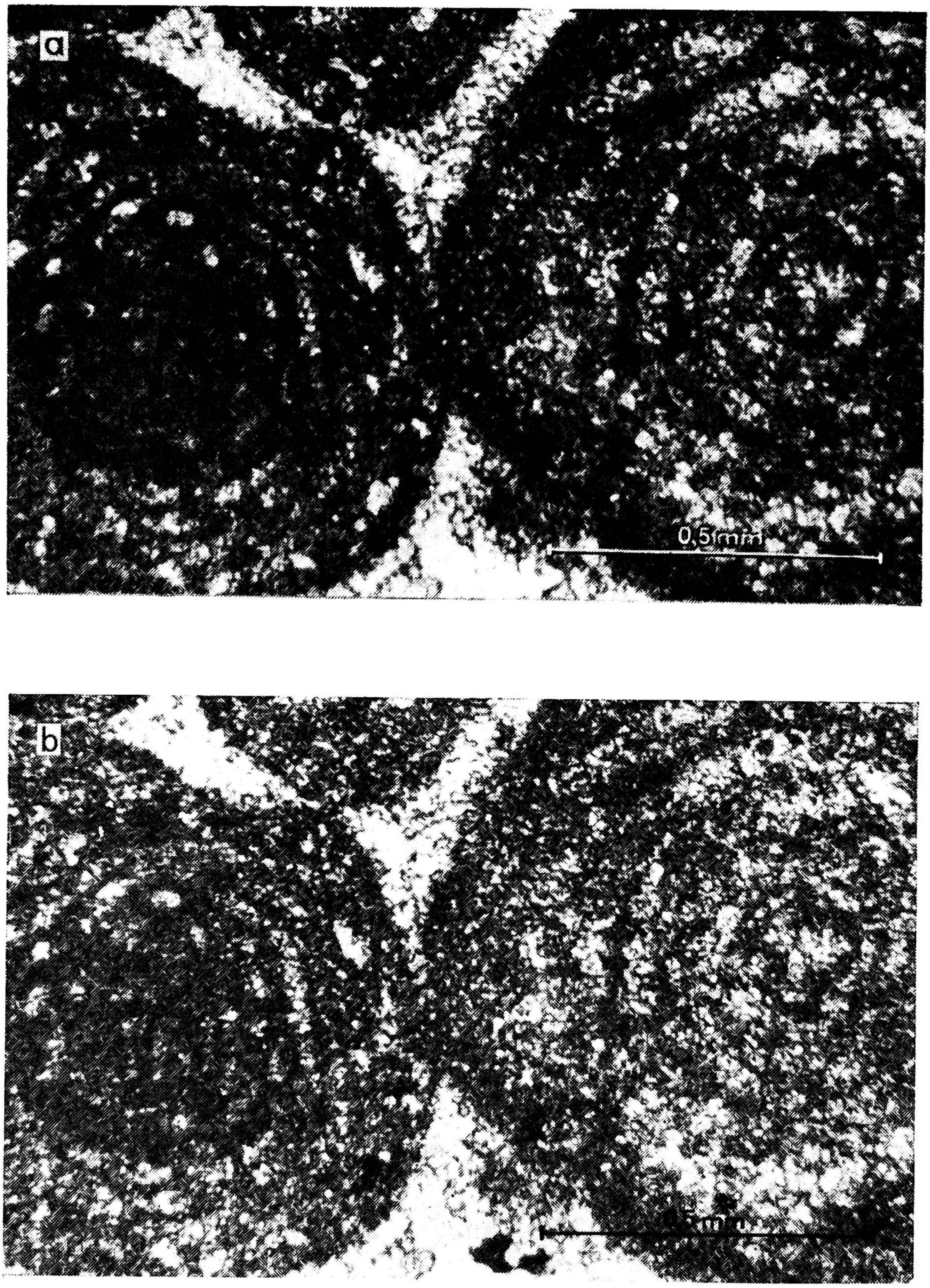


Fig. 12. A fragment of carbonate-limestone rock with visible oolites. *a* — parallel nicols, *b* — crossed nicols. Profile No. 5, horizon C, depth below 53 cm.

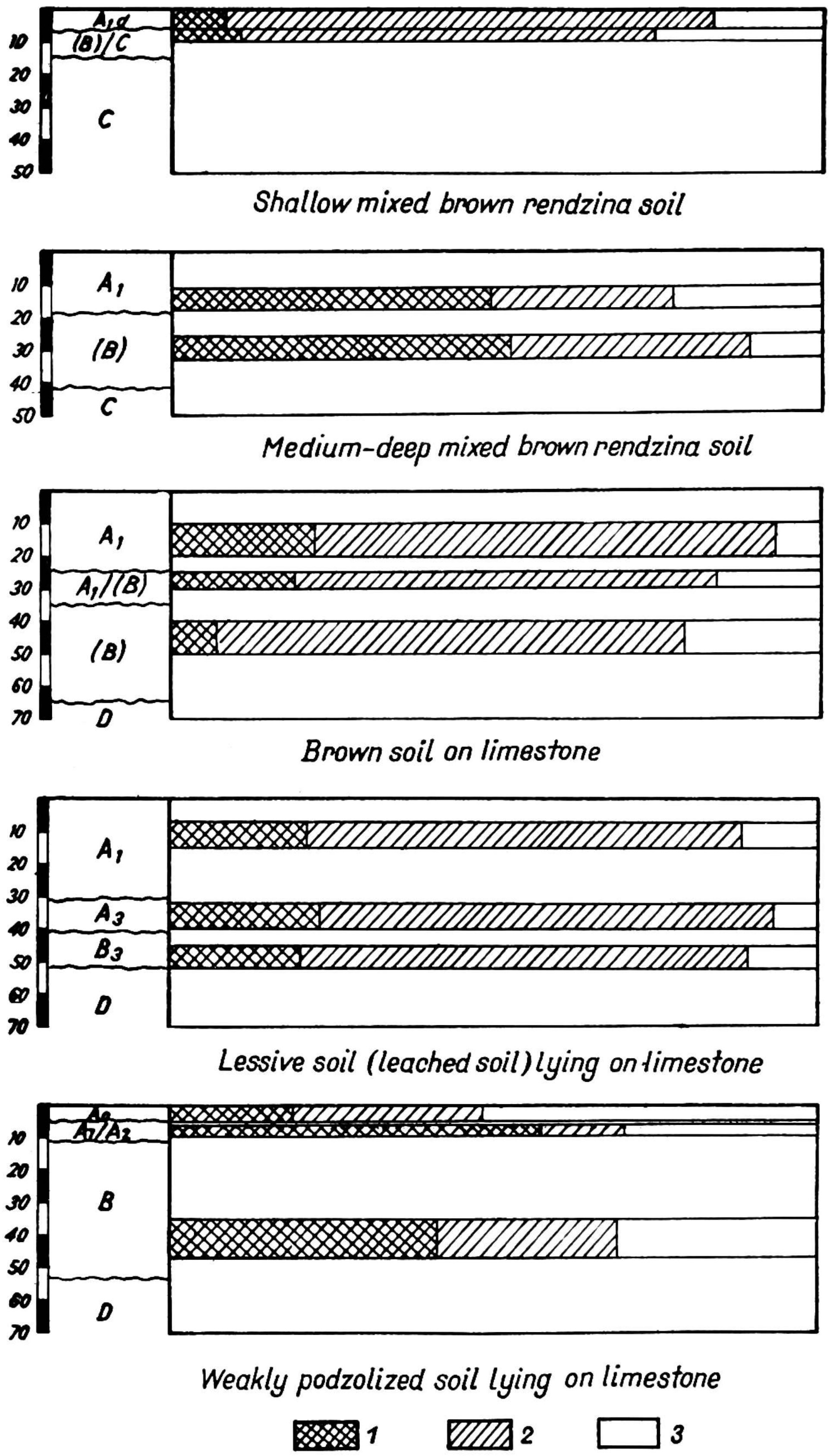


Fig. 13. Micromorphometric properties of mixed brown rendzina soils and soils on limestone. *1* — skeleton, *2* — remaining soil substance, *3* — visible voids.

either accelerate or retard the course of the soil and soil-forming processes.

Leaching of the $CaCO_3$, or its occurrence deeper in the soil, cause an increase of degradation processes, which indirectly effect a change of the soil types. It is easy to grasp the course of these processes using micromorphologic investigations.

Fedoroff [6], describing the developmental cycles of soils (using loess as an example), discusses succession in time and space of the following stages: deliming, leaching, decalcification and podzolization. These stages cause the formation of brown soils and their transformation into lessive soils and later on into podzols. The soils investigated undergo similar transformation. However, the initial stage was the weathering of the limestone rock in the presence of noncalcareous admixture.

The weathering of the carbonate-calcareous rock leads to the development of brown rendzinas. Calcium carbonate occurring in the soil profile influences the accumulation of a large amount of plasma. This plasma is mainly accumulated in the browning horizon, being of lattisepic and omnisepic type, characteristic for brown rendzinas.

The removal of $CaCO_3$ from the upper horizons of soils causes the development of soils on limestone. Initially, brown soils on limestone are formed which, as a result of further degradation, become lessive soils lying on limestone. The lack of $CaCO_3$ in the upper horizons intensifies the changes of the plasma structure. In brown soil on limestone plasma of the lattisepic type declines, and plasma of skelsepic type begins to appear. On the other hand, in the B_3 horizon of lessive soil, the vosepic type plasma also appears in small quantities, beside lattisepic and omnisepic plasma. This horizon is characterized by a relatively high content of plasma in relation to the genetic horizons of other soil types.

Reuter [10] investigating the coefficient determining the percentage content of plasma in relation to the soil mass, obtained maximal values of this coefficient in the B_3 horizons of lessive soils. However, strikingly low coefficients were found in the case of the A_2 horizon of podzol soils. This fact is connected with the translocation of plasma in the soil profile. In the investigated soils on limestone this translocation is very small, due to the effect of the carbonate-calcareous rock [12].

Iron compounds and organic substances, as well as other soil contents, are also translocated to the B_3 horizon; these are visible in the form of concretions both of iron and organic-mineral compounds. Further degradation of lessive soil or a higher admixture of material of glacial origin enabling the leaching of $CaCO_3$ from the soil profile leads to the development of podzolic soils in conditions of forest environment. However in case of a stronger effect from the limestone rock occurring in the bedrock, in spite of favorable podzolization conditions such as suitable climate, plants and mechanical composition, this process occurs very slowly, as is evidenced by the formation of weakly podzolized soil lying on limestone. This soil is very poor in plasma in the upper horizons. Only in the illuvial horizon does plasma of an argillasepic type occur and weakly noticeable skelsepic on quartz grains. The course of the above developmental cycle of the investigated soils has been confirmed by additional physico-chemical analyses, which are presented in Table 1.

CONCLUSIONS

On the basis of the micromorphological studies carried out and the complemented with physico-chemical analyses, it was found that:

1. The development of the investigated soils was determined not only by the $CaCO_3$ content in the parent rock, but also by the participation of some other noncarbonate admixture of glacial material of various thickness deposited on the older limestone formations.

2. The formation of the soil forming processes and the typological soil processes is dependent on the thickness of foreign material covering the Triassic limestone formations. Therefore mixed rendzinas of brown type and soils lying on limestone of other genetic types also occur in the investigated evolutional cycle.

3. Soils in which the carbonate-calcareous rock appeared nearer the surface, had the character of mixed brown rendzinas or brown soils on limestone and containing lattisepic and omnimasepic type plasma. On the other hand, soils developed out of weathered limestone covered by a thicker layer of material of glacial origin had lost the character of rendzinas and pararendzinas, and constitute a further evolutionary stage of soils on limestone. They exhibit more distinct features of a profile translocation of clay, which indicates their lessivage or weak podzolization.

4. Mixed brown rendzinas can undergo degradation and transformation toward the development of various types of soils lying on limestone depending on the bio-ecological conditions. The direct cause of this is the dicalcification of the upper horizons of the investigated soils. The course of this decalcification is facilitated by the presence of an admixture of foreign noncarbonate material.

5. In the decalcified soil mass there occurs a weak translocation of soil plasma and iron compounds, which are accumulated in the illuvial horizons of soils lying on limestone and form there following plasma structures: (1) vosepic in lessive soils; (2) skelsepic in podzolic soils.

6. In weakly podzolized soils on limestone, plasma is not visible in the humus and elluvial horizons, but only in the illuvial horizon the quartz grains have distinct coverings of organic-mineral substance with a small admixture of iron compounds. These iron compounds are also visible in the form of ortstein concretions.

7. The appearance of carbonate-calcareous bedrock in soils lying on limestone, which are in further developmental states of mixed rendzinas, limits the rate of the podzolization process. This leads to the formation of more differentiated genetic horizons, which expresses itself in the micromorphological properties of the investigated soils.

SUMMARY

This work aimed at examining the micromorphological properties of rendzina soils formed out of Triassic limestones and soils deposited on them. These soils appeared in similar climatic and topographic conditions and were genetically bound in their evolution cycle comprising such soils like (1) shallow mixed brown rendzina soil, (2) medium deep mixed brown rendzina soil, (3) brown soil on limestones, (4) lessive (leached) soil lying on limestone, and (5) weakly podzolized soil lying on limestone. The soils contained an admixture of material of glacial origin, and debris of carbonate-calcareous rock appearing at 40-50 cm depth. Micromorphological examinations of thin soil sections revealed some alterations of the properties and especially of the composition and the structure of plasma in several genetic horizons of the soil types under discussion. These micromorphological alterations have been certified by physico-chemical analyses as well.

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