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Micromorphology and micromorphometry of chernozem

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INTRODUCTION

Since the time when V. V. Dokuchayev created in the past century the basis for genetic pedology, the study of individual horizons of soil types has made considerable advance. This classical soil typology has further been elaborated by eminent scientists (Gedroyts, Vilyams, Pallmann, Kubiëna, etc.). It was in particular Kubiëna [9-11] who introduced new methods of micromorphological soil investigation. The new scientific field elaborated by Kubiëna and his students [1-4, 7, 8] permitted an essential advance in our knowledge of the soil not only in its relation to genetics but also to the factors of soil fertility.

METHOD

In this part of our work we were concerned with the study of the width of pore cross-sections of degraded Chernozem from the surroundings of Líbeznice near Mělník. The characteristic of the investigated soil profile has been described in a paper by Palán [15]. The micromorphological investigation of the aggregates was carried out according to the methods published by Beckmann [5], Geyger [6], Kubiëna [10] and in cooperation with these authors in the Pedological Institute in Reinbek. The soil samples in grown state were taken from the following horizons:

Denomination according to A. N. Sokolovski	V. Kosil	Depth in cm	Sample No.
H	A	5-10	1
H′	A′	35-40	2
h/p(Ca)	A/C	65-70	3
PCa	C	120-130	4

The preparation of the samples, their hardening and the preparation of sections were carried out according to the method of Altemüller [2]. For a quantitative investigation of large sections we made a larger number of structural photograms by means of a Leitz table projector, equipped for this purpose with a holder for inserting the photographic paper. This paper retained chemically the structural image projected from the section on to the ground-glass screen of the table projector so as to show the width of the pore cross-sections in grey colour, transparent minerals black and other soil substances white. The evaluation of the structural photograms was performed by means of a particle-size analyser, which classifies the different cross-section widths into 48 groups. The measured values are entered into a table where the pore diameter widths are divided into groups according to Odén [14]:

2,000-1,000 μm	Non-capillary pores
1,000- 500 μm	(Grobporen)
500- 200 μm	
200- 100 μm	Semi-capillary pores
100- 50 μm	(Mittelporen)
50- 20 μm	
20- 10 μm	Capillary pores
10- 5 μm	(Feinporen)
5- 2 μm	

EVALUATION OF THE RESULTS OF THE ANALYSES OF THE STRUCTURAL PHOTOGRAMS

The measured values exhibit a so-called frequency of the occurrence of the cross-section widths of visible pores, i.e. the amount of the most frequently occurring cross-sections of visible pores. We ascertained the following quantities:

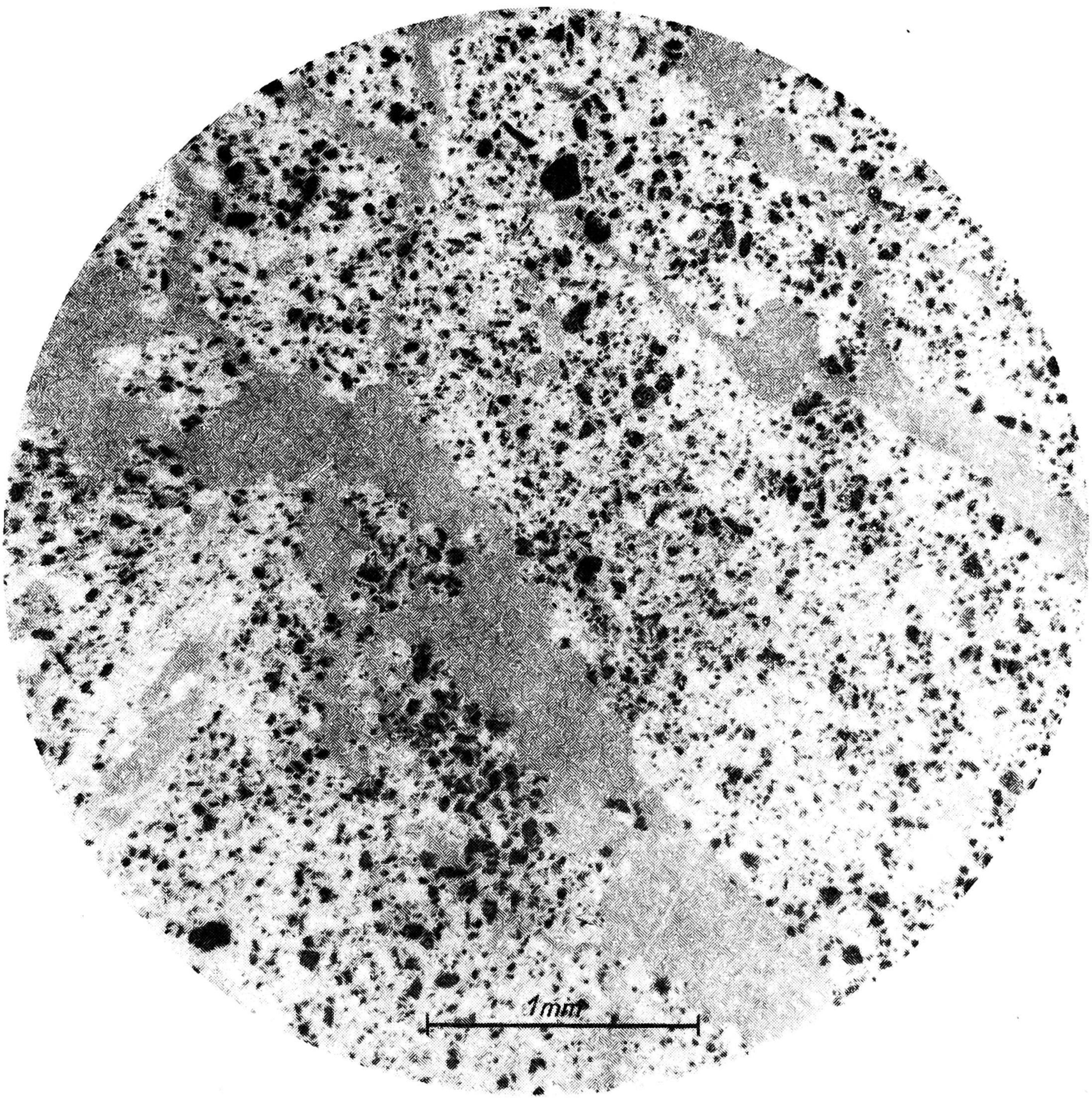
(1) Percentage of the frequency of occurrence of a certain cross-section width of visible pores.

(2) Percentage of the area of the cross-sections of visible pores.

Table. (a) Frequency of occurrence of cross-section width of visible pores in %; (b) Width of cross-sections of visible pores in %

Sample No.	Type of measure-ment	Width of pore cross-sections					
		1,000-500 μ	500-200 μm	200-100 μm	100-50μm	50-20 μ	total
1	(a)	6.12	43.53	33.24	16.32	0.79	100
	(b)	0.47	6.31	9.62	11.02	1.08	28.50
2	(a)	8.37	48.41	25.43	15.79	2.00	100
	(b)	0.53	5.71	6.03	8.73	2.25	23.25
3	(a)	4.50	52.47	20.65	16.00	6.38	100
	(b)	0.28	6.25	4.92	9.05	7.20	22.70
4	(a)	2.66	50.38	27.11	13.30	6.55	100
	(b)	0.19	6.85	7.45	14.69	8.39	37.57

These values are listed in Table. We found that the sample No. 1 (earth sample from the H horizon, depth 5-10 cm) contained in 0.79% of all measurable values cross-section widths of visible pores of 20-50 μm, in 6.32% such of 50-100 μm, in 33.24% widths of 100-200 μm, in 43.53% widths of 200-500 μm, and in 6.12% such of 500-1000 μm. The frequency of the occurrence of the cross-section widths of visible semi-capillary pores predominated slightly over the frequency of occurrence of the cross-section widths of non-capillary visible pores. Moreover, the area of the cross-section of semi-capillary visible pores amounts to 21.72%, while the area of the cross-section of non-capillary visible pores equals 6.78%. A comparison of the frequency of the occurrence of the cross-section



Figs. 1 and 2. Structural photograms from sample No. 1, from the H horizon (grey area: pore cross-sections; black area: microskeleton; white area: other soil constituents. The aggregates exhibit a spongy structure).

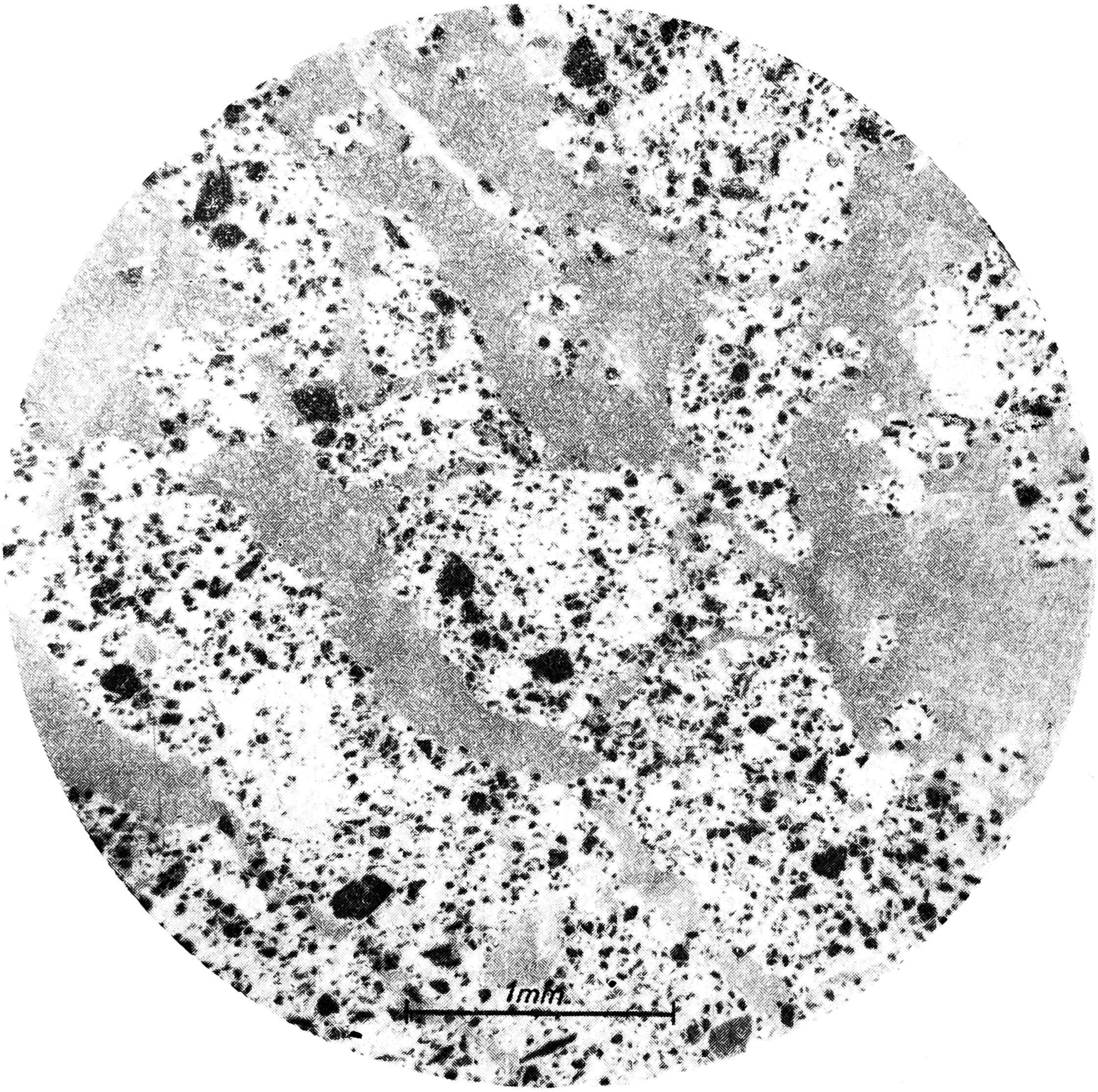


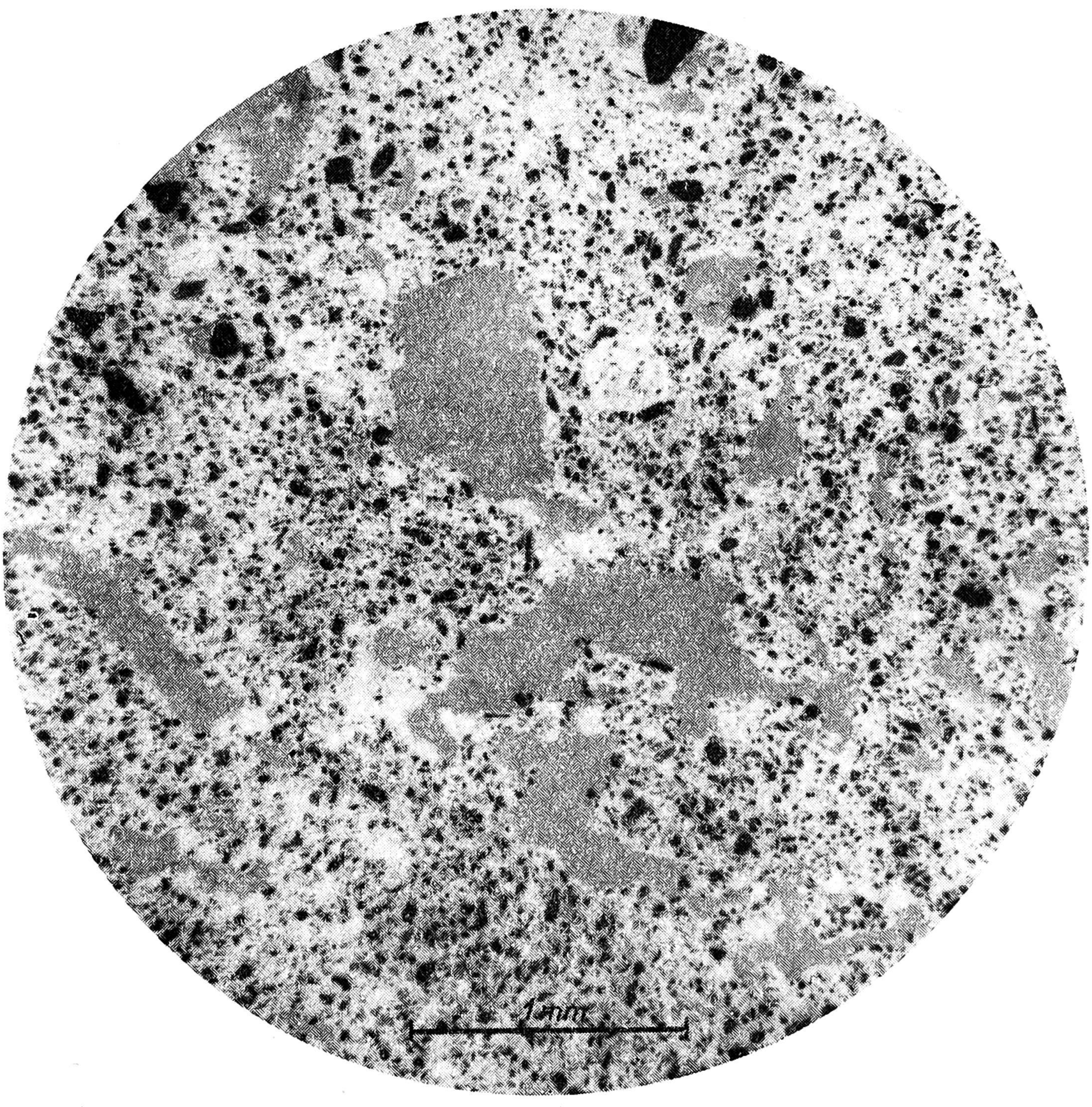
Fig. 2.

widths of the pores shows that the percentage of the frequency of occurrence of the cross-section widths of visible pores of the category of 200-500 μm amounts to 43.53%, while the frequency of the occurrence of the cross-section widths of visible pores of the category of 20-50 μm is lowest in this horizon (0.79%).

Sample No. 2 (H′ horizon, depth 35-40 cm). In this horizon, the frequency of the occurrence of the cross-section widths of visible non-capillary pores (56.78%) predominates over the frequency of the occurrence of cross-section widths of semi-capillary visible pores (43.22%). The area of the cross-section of visible pores of the category of 50-100 μm predominates and amounts to 9.05%.

Sample No. 3 (h/p(Ca) horizon, depth 65-70 cm). Here predominates the frequency of the occurrence of cross-section widths of visible pores of the category of 200-500 μm. The lowest frequency of this occurrence is encountered in the category of 500-1000 μm. The area of the cross-sections of visible pores of the category of 50-100 μm likewise predominates and amounts to 9.05%.

Sample No. 4 (PCa horizon, depth 120-130 cm). In this horizon, too, the frequency of the occurrence of cross-section widths of non-capillary visible pores prevails over that of semi-capillary pores. The area of the cross-sections of the visible pores of the category of 50-100 μm predominates and amounts to 14.69%.



Figs. 3 and 4. Structural photograms from sample No. 2, H′ horizon (grey area: pore cross-sections; black area: microskeleton; white area: other soil constituents). Here appear concretions of ferric hydroxide.

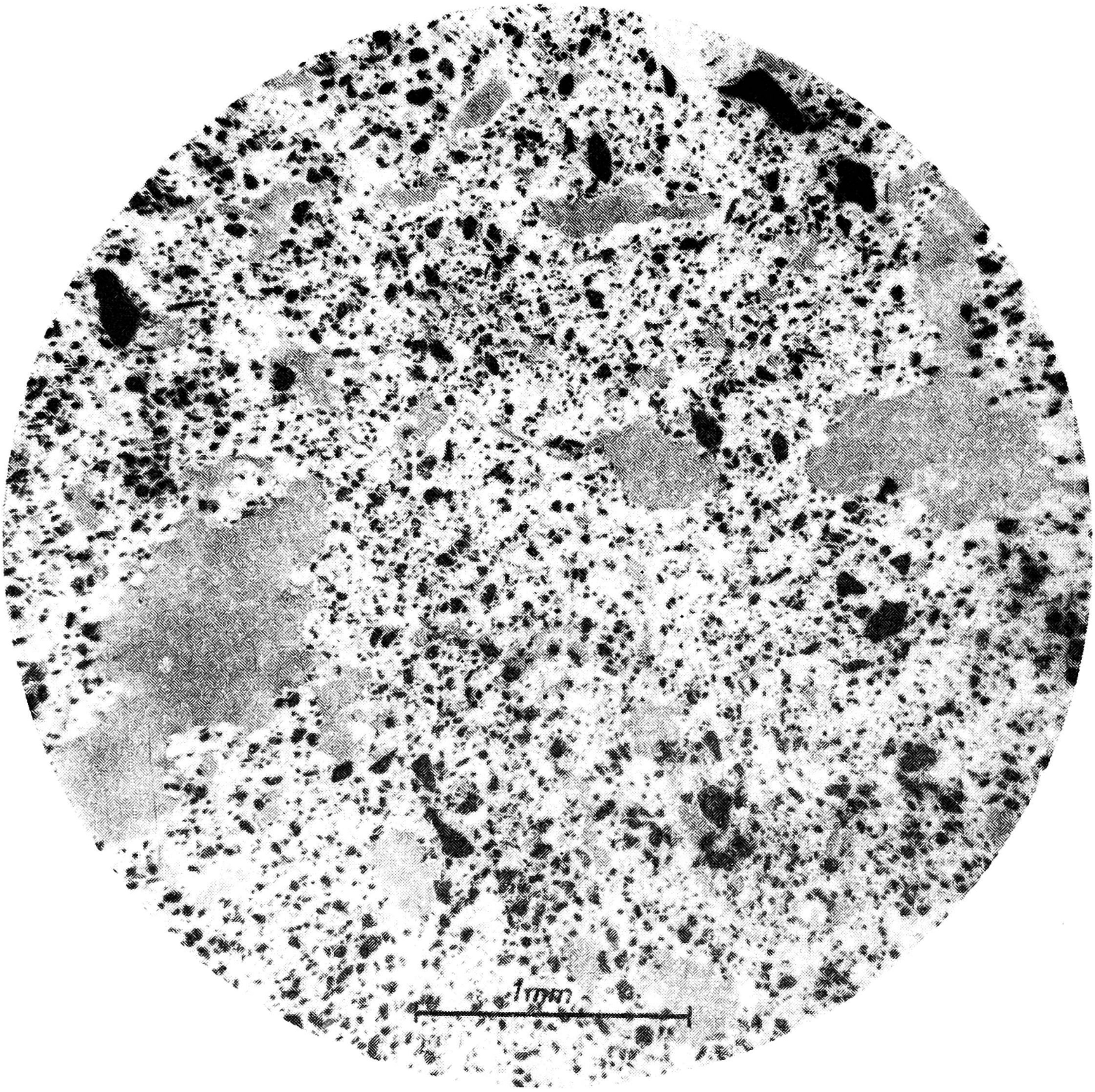
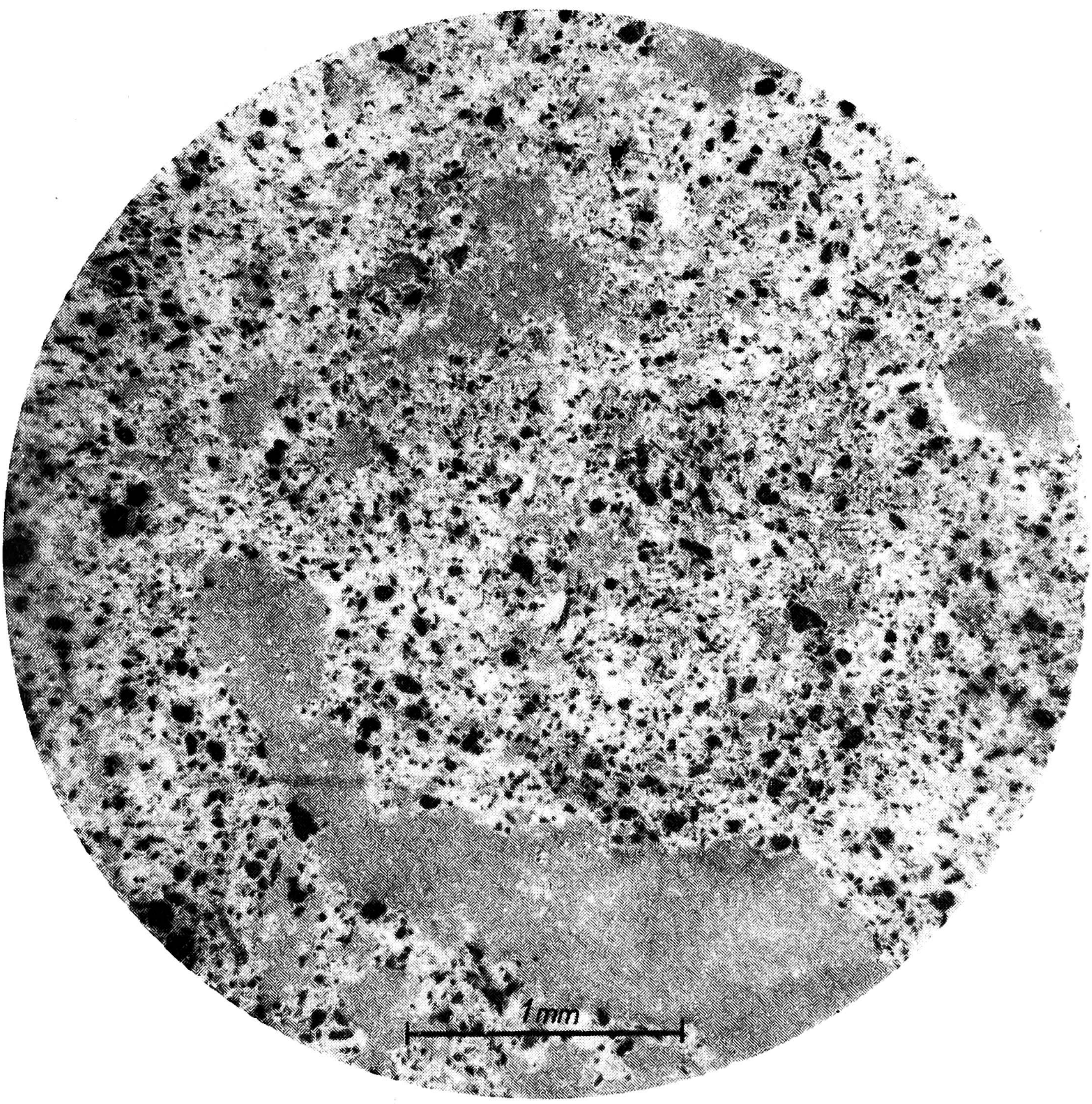


Fig. 4.

The structural Figs. 1-8 illustrate the micromorphological aggregates from the horizons described above. The structural Figs. 1 and 2 were made from samples of earth in a depth of 5-10 cm, of the H horizon. The cultivation of the soil results in considerable changes of the morphology of the aggregates. A larger number of non-capillary pores produced from decayed roots or by the activity of the zoo-edaphon are partly filled up with coprogenic aggregates (Fig. 2, upper part). The microaggregates in which pores are formed mostly by cracks are rather compact. They contain a large quantity of the microskeleton which is mutually grouped with the other fine soil substance. The formed slits are filled up with plasma which consists of loam fractions as well as of very fine colloidal fractions of organic substances. The aggregates exhibit spongy structure.

The structural Figs. 3 and 4 from a depth of 35-40 cm, of the H′ horizon, differ from the preceding ones by the shape of the cross-section width of the pores and by the over-all arrangement of the internal structure of the cross-sections of the aggregates. The cross-sections of the pores are not so elongated, but wider and shorter, of various shapes. The walls of the pore cross-sections are filled up with colloidal coatings (observed under the microscope with crossed Nicol prisms). The compact soil substance contains dark brown concretions of ferric hydroxide and plasma, which connects the microskeleton. In particular on the surface of the aggregates, the plasma is agglomerated to the highest degree and forms a protective coating of the spongy aggregates.



Figs. 5 and 6. Structural photograms from sample No. 3, h/p/(Ca) horizon (grey area: pore cross-sections; black area: microskeleton; white area: other soil constituents). The microaggregates are rich in $CaCO_3$.

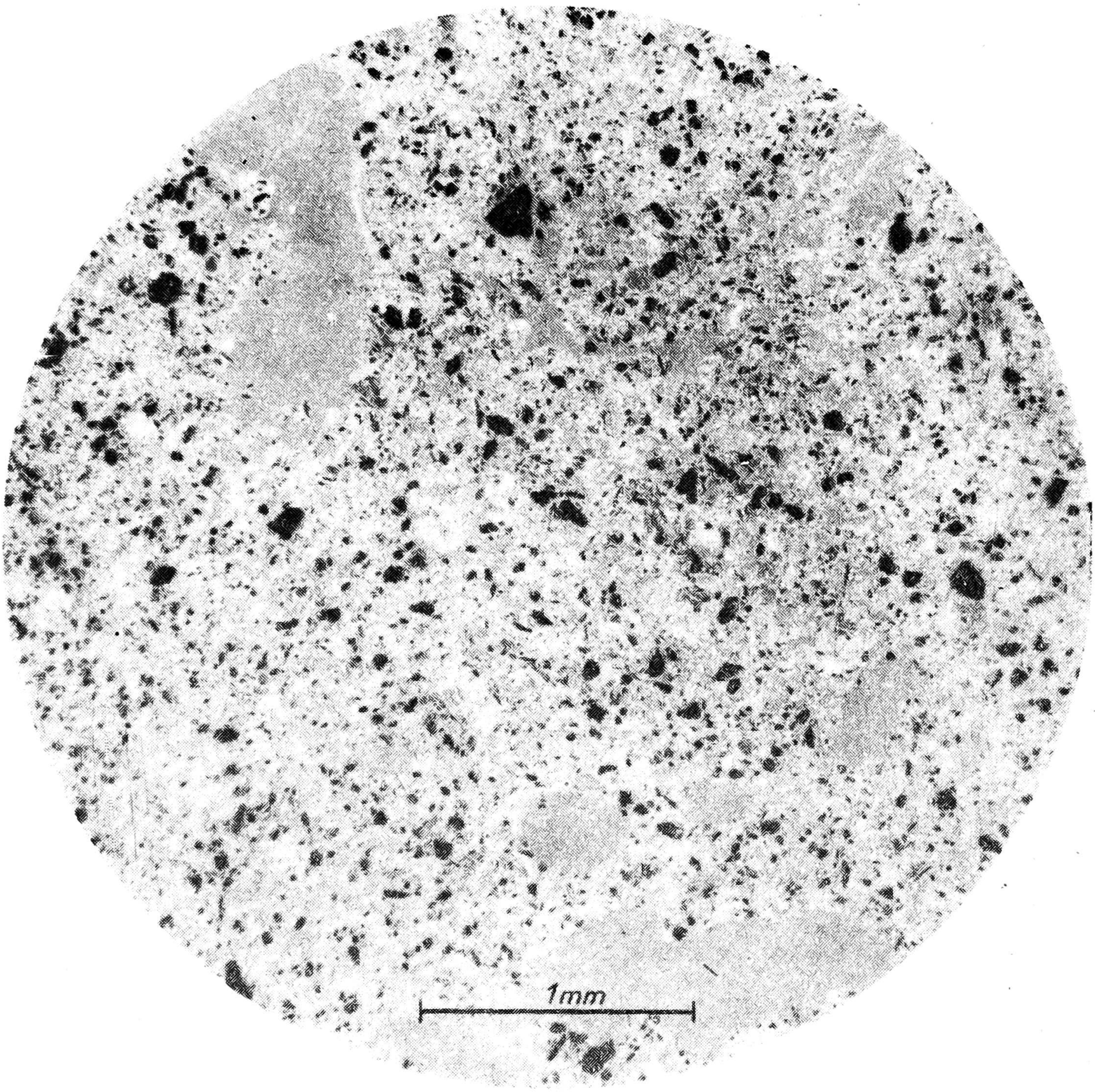
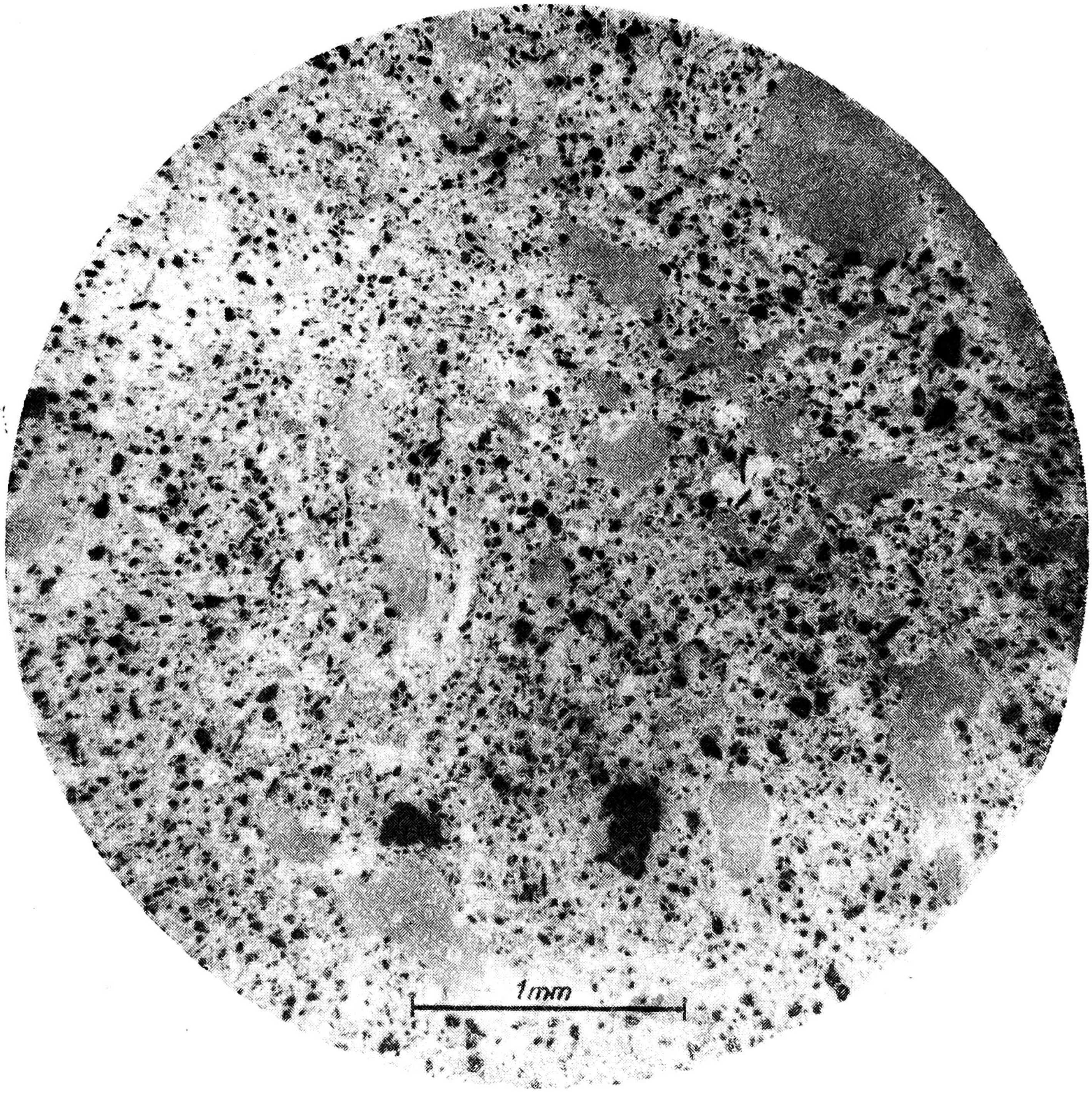


Fig. 6.

Structural Figs. 5 and 6 from a depth of 65-70 cm, from the h/p(Ca) horizon. The microaggregates are compact, rich in $CaCO_3$, which accumulates in wider pore cross-sections, which develop by the action of microorganisms. The aggregates consist of the fine substance of the coatings of agglomerates of greyish brown colour as well as of coarser granular agglomerates of dark brown colour.

Structural Figs. 7 and 8 from a depth of 120-130 cm, from the PCa horizon, represent the cross-section of part of a compact aggregate considerably interspersed with cross-sections of visible pores, 200-500 μm and 100-200 μm in width. The cross-sections of the visible pores are of oval shape with various bends. The aggregate consists of light brown colloids and contains larger amounts of $CaCO_3$. Its structure is spongy.



Figs. 7 and 8. Structural photograms from sample No. 4, PCa horizon (grey area: pore cross-sections; black area: microskeleton; white area: other soil constituents). The cross-sections of visible pores are of oval shape with bends.

CONCLUSIONS

The evaluation of the cross-section widths of visible pores of degraded chernozem was carried out by means of micromorphological methods on the basis of structural photograms and with the use of a grain-size analyser. We found that:

1. In the H horizon, in a depth of 5-10 cm, the frequency of occurrence of cross-section width of visible semicapillary pores predominates slightly (by 0.7%) over the occurrence of the cross-section width of non-capillary visible pores.

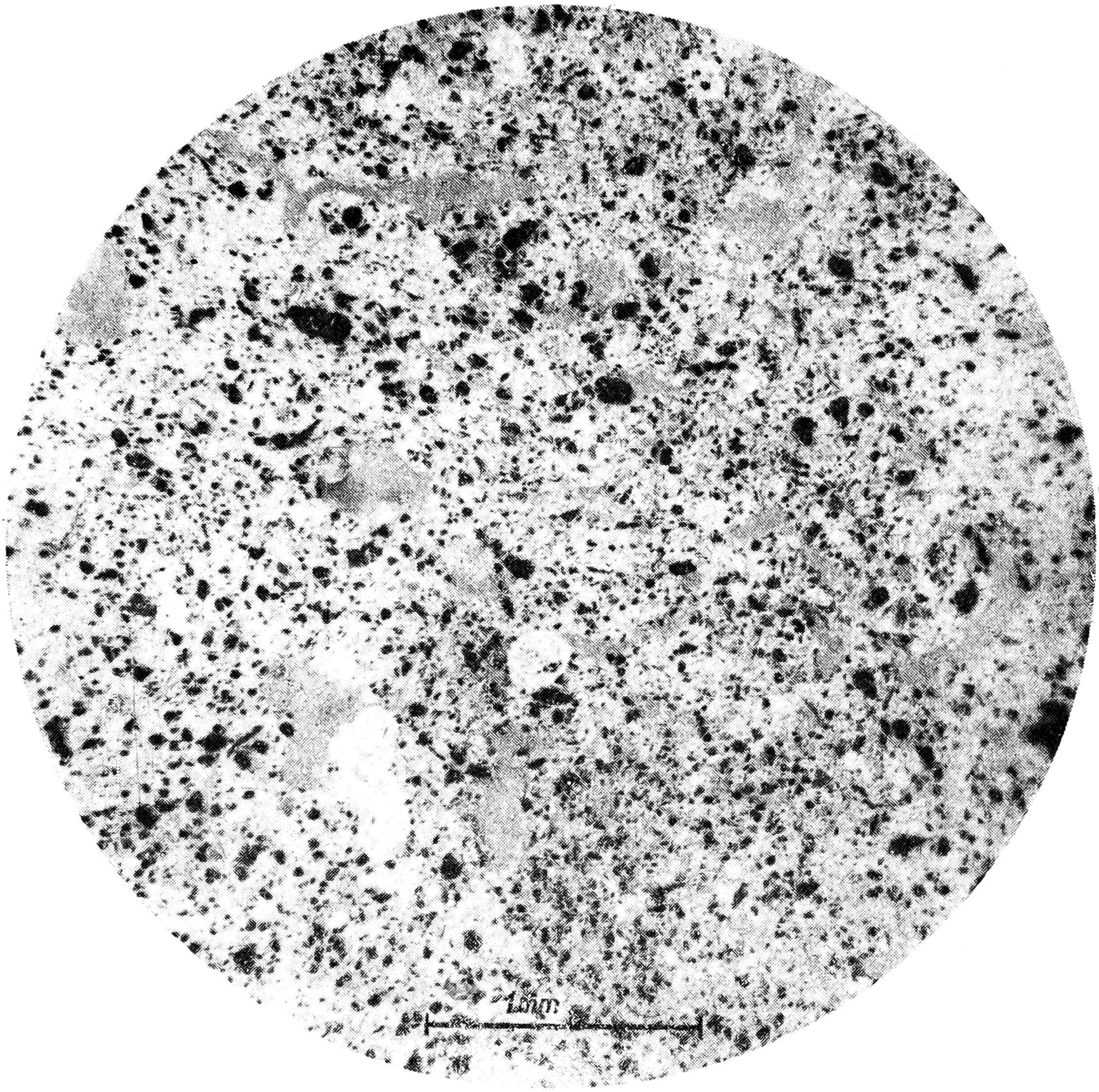


Fig. 8.

2. In the H′ horizon, in a depth of 35-40 cm, the frequency of occurrence of cross-section width of non-capillary pores predominates (in a value of 56.78%) over the frequency of the occurrence of the cross-sections of semicapillary visible pores (53.22%).

3. In the h/p(Ca) horizon, in a depth of 65-70 cm, the frequency of occurrence of cross-section width of visible pores of 200-500 μm predominates. The total area of the cross-section of visible pores is here the lowest (23.25%).

4. In the PCa horizon, in a depth of 120-130 cm, the frequency of occurrence of cross-section width of non-capillary pores predominates over that of semi-capillary pores. The total area of the pore cross-sections is here the highest (37.57%).

SUMMARY

The most widely extended taxonomic unit of chernozem on the territory of the Czechoslovak Republic is presented by degraded chernozems. They develop in the milieu of forest-steppes, or they may be the result of unsuitable agrotechnical measures. They are characterized by a second humus horizon with a somewhat higher content of organic substances and finely dispersed colloids. By means of micromorphometrical methods we succeeded in evaluating the differences in the occurrence of the cross-section widths of the pores as well as the differences of the areas of certain pore cross-sections in the individual horizons.

REFERENCES

1. Altemüller H.-J., 1956. Neue Möglichkeiten zur Herstellung von Bodendünnschliffen. Z. F. Pfl., Dung., Bodenk. 72, 117.
2. Altemüller H. J., 1962. Verbesserung der Einbettungs- und Schleiftechnik bei der Herstellung von Bodendünnschliffen mit Vestopal. Z. f. Pfl., Düng., Bodenk. 99, 144.
3. Altemüller H.-J., 1962. Arbeiten aus dem Gebiet der Mikromorphologie des Bodens. Verlag Chemie Weinheim.
4. Beckmann W., 1958. Zur Mikromorphologie von Hohlräumen und Aggregaten. Vortrag im Rahmen der Arbeitstagung für Mikromorphologie des Bodens, Völkenrode.
5. Beckmann W., 1962. Zur Mikromorphometrie von Hohlräumen und Aggregaten im Boden. Z. f. Pfl., Düng., Bodenk. 99, 2/3.
6. Geyger E., 1962. Zur Methodik der mikromorphometrischen Bodenuntersuchungen. Zeitsch. f. Pfl., Düng., Bodenk. 99, 2/3.
7. Jabłoński B., 1963. Zastosowanie mikroskopowych szlifów glebowych w badaniach nad rozkładem resztek roślinnych w glebie. Rocz. gleb. XIII, 1. Warszawa.
8. Kowaliński S., 1960. Zróżnicowanie właściwości morfologicznych, fizycznych i chemicznych czarnych ziem pod wpływem zmiany ich użytkowania. Zeszyty Naukowe, WSR Wrocław, 29.
9. Kubiëna W. L., 1938. Micropedology. Ames, Iowa.
10. Kubiëna W. L., 1948. Entwicklungslehre des Bodens. Verlag Springer, Wien.
11. Kubiëna W. L., Beckmann W., Geyger E., 1961. Die Verwendung des Tischprojektors TP 200 in der Strukturanalyse des Bodens. Leitz-Mitteilungen, 3.
12. Kubiëna W. L. *et al.*, 1967. Die mikromorphometrische Bodenanalyse. Stuttgart.
13. Mückenhausen E., 1962. Entstehung, Eigenschaften und Systematik der Böden der Bundesrepublik Deutschland. DLG-Verlags-GMBH-Frankfurt am Main.
14. Odén S., 1957. Förslag till klassifikation av markporer. Kungl. Skogs Landbr. Acad. Tidskr. 96.
15. Palán J., 1965. Příspěvek k mikromorfologii agregátů černozemě. Rostlinná výroba 6.
16. Parfenova J., Yarilova J., 1960. K voprosu o lessivaže i opodzolovanii. Počvovedenie 9, 1-15.
17. Smolíková L., (v tisku). Mikromorphologie und Mikromorphometrie der fossilen Bodenkomplexe. Rozpravy ČSAV.