THIRD INTERNATIONAL WORKING-MEETING ON SOIL MICROMORPHOLOGY
WROCŁAW, 1969

ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1972 z. 123

Application of micromorphology to water erosion studies

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INTRODUCTION

On May 23th and 24th, 1967 due to heavy rains arable soils were damaged in some parts of the Olsztyn province. Most effected were the non-uniform sandy soils formed on very fine sand. The objective of this paper was to discuss the application of morphological studies as they pertain to water erosion.

SITE AND METHODS

Studies on water erosion were conducted at Stary Dwór situated 2 km south of Olsztyn. The area damaged by erosion was 0.94 ha (Fig. 1); it is characterized by a slope of about 20%.

Soil samples were taken from particular horizons of soil profiles for mechanical analysis by the method of Casagrande in modification of Prószyński [3]. The oriented soil samples of undisturbed structure were also taken into Kubiëna containers [1]. Soil thin sections were prepared by the method of Altemüller-Kubiëna in modification of Kowaliński and Bogda [2]. Water sorption was determined by the method of Richards [3].

Based on soil thin sections the grain-size curves and grain orientation to the surface were determined. Grain-size curves were prepared by measuring the diameter of 500 grains using a microscope. Depending on soil kind different magnifications were applied (18 to 100×). With strata consisting mainly of large grains low magnifications were used and *vice versa*. When the peeling was omitted in grain measurements it was difficult to discern boundaries of the grain outlines. Using thin sections it was easy to obtain sharp boundaries of the grain outlines and determine grain diameters. Grain orientation to the surface was determined in the same thin sections. After orienting these sections to the terrain surface the angles of 500 grains were set at 0°, 45° and 90°.

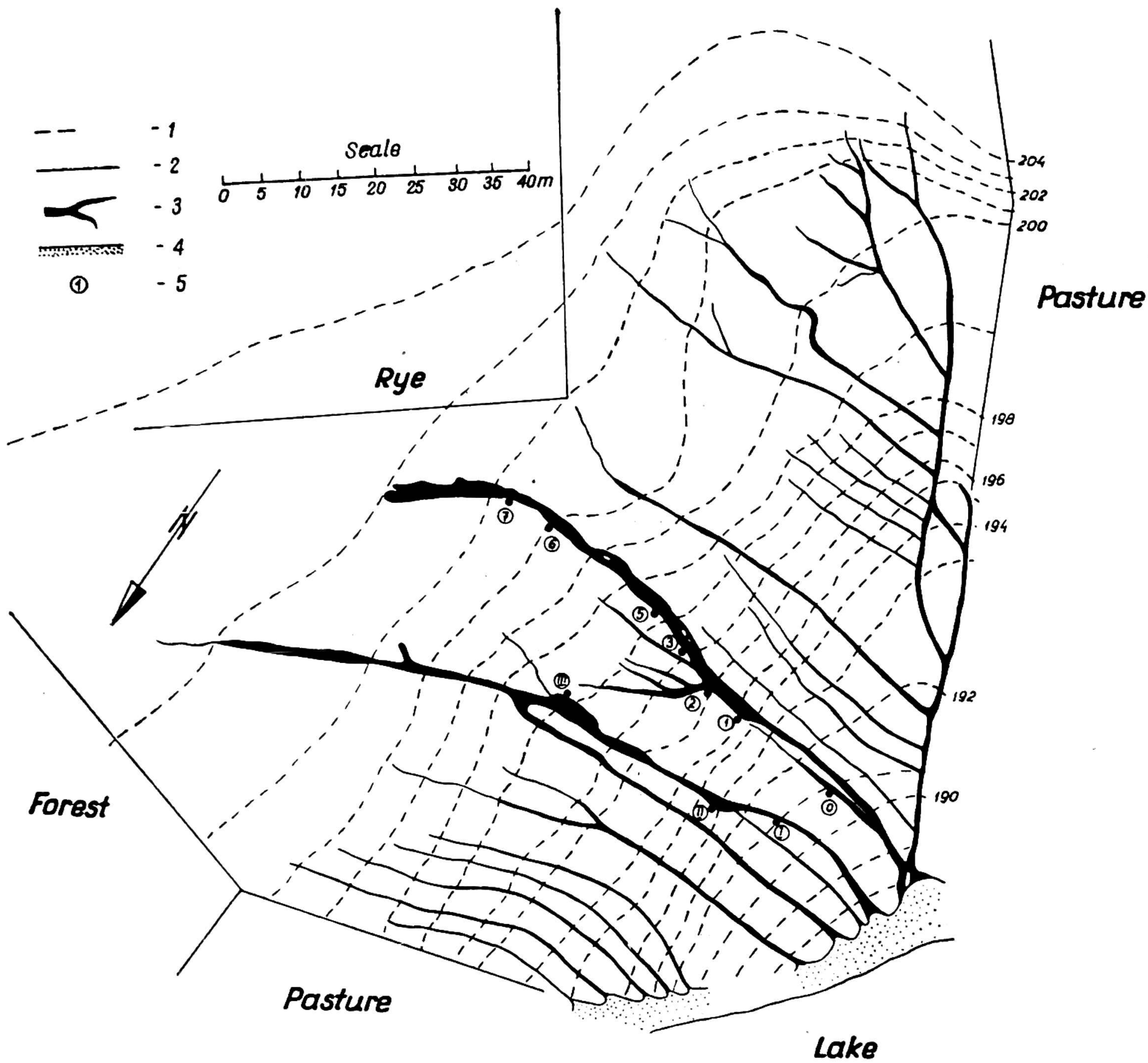

Fig. 1. Map of washouts. *1* — relative heights, *2* — line of uses, *3* — washouts, *4* — deluvial deposits, *5* — No. of profile.

RESULTS AND DISCUSSION

The soil was a pseudopodzolic one formed on silty materials. In the middle part of the slope silt loams reach the very surface (Fig. 2). In the upper part of the slope there occur deep non-uniform soils and at the foot deep deluvial soils formed of coarse sands (Table 1). Silt loam (of low permeability) that occur in subsoil creates good conditions for above-laying sands to hold water, which makes this material subject to erosion.

GRAIN-SIZE CURVES

The grain-size curves are representation of the contents of medium sand fraction, very fine sand fraction, and coarser silt fraction. The diameter of particular grains was measured with the exactness to 0.015 mm. Distribution of particular grains according to size in arbitrary divisions allowed to detect differences even within the same fractions (Fig. 3). The smallest differences in grain content in the particular divisions were found with medium sand fraction. In case of very fine sand fractions and (profile 3/I) the grain curves approximate the straight line. With the coarse sandy soil (profile 6/I and 0/I) the grain curve shows some inclination solely in divisions with smaller diameters of medium sand fractions. In case of fine sand fraction occur considerably greater fluctuations between particular divisions with the general tendency towards curve rising. Only in case of silt clay (profile 3/I, depth 38-50 cm) the grain curve of that fraction approximates straight line. With coarse sandy soil there is noticeable difference between deluvial soil (profile 0/I) and soil from uppermost part of the slope. In the deluvial soil fluctuations between particular divisions of fine sand fraction are apparently smaller than in the soil from the uppermost part of the slope. In the latter (profile 6/I) there are also greater fluctuations between particular divisions of very fine sand fraction. In coarser silt fraction there predominate grains 0.03 mm in diameter.

The smooth shape of the grain-size curve for the soil from the slope (profile 3/I, depth 38-50 cm) indicates that this material is also hydro-

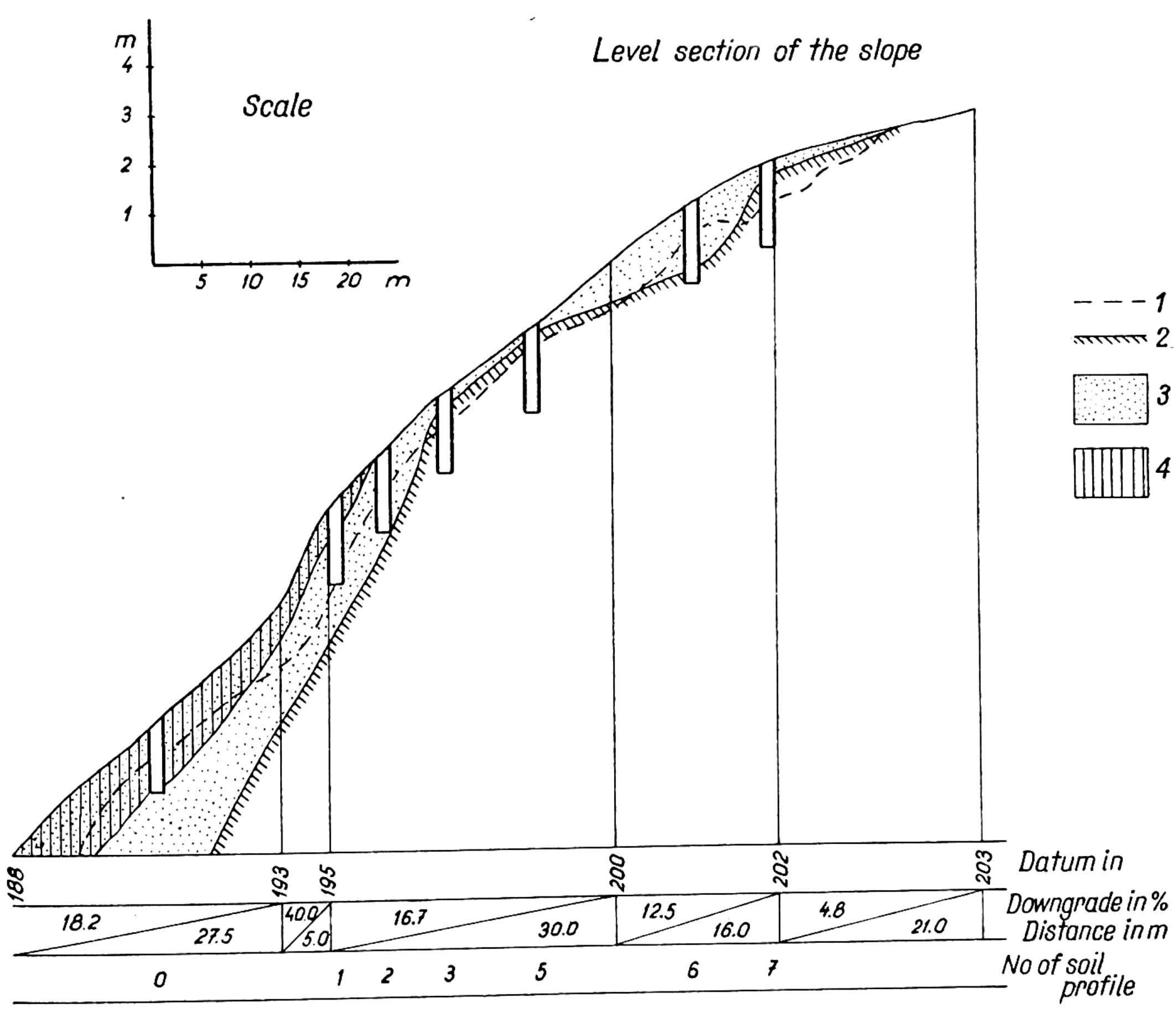

Fig. 2. Legend: *1* — bottom of washout, *2* — silt, *3* — sand, *4* — deluvial deposits.

Table 1. Mechanical soil composition

No.	Relief element	Profile No.	Depth, cm	Skeletal, %	Sand, %			Fine sand, %		Silt and clay, %				0.25-0.1	0.1-0.02
				>1	1-0.5	0.5-0.25	0.25-0.1	0.1-0.05	0.05-0.02	0.02-0.006	0.006-0.002	<0.002	< 0.02 total	0.1-0.02	<0.02
				part. diameter, mm											
1	base	0/1	5-20	1.00	2.53	13.43	56.04	18	5	0	3	2	5	2.4	4.6
2			62-70	0.70	2.53	12.22	56.25	20	1	2	1	5	8	2.7	2.6
3			116-130	0.75	2.53	10.89	54.58	19	7	0	2	4	6	2.1	4.3
4	slope	1/I	5-20	0.70	3.93	14.37	48.70	19	6	2	3	3	8	1.9	3.1
5			55-65	0.63	2.03	9.38	55.59	20	2	5	2	4	11	2.8	2.0
6			80	0.75	2.53	9.96	55.51	20	3	5	2	3	10	2.4	2.3
7	slope	2/I	2-10	0.60	3.80	12.43	50.77	15	7	3	4	4	10	2.3	2.0
8			70-80	0.75	4.94	17.49	51.57	17	1	1	3	4	8	2.8	2.2
9			120-130	0.15	2.53	9.50	52.97	22	6	2	0	5	7	1.9	4.0
10	slope	3/I	5-20	—	2.66	10.09	39.25	18	15	5	3	7	15	1.2	2.2
11			38-50	—	—	0.51	7.49	15	33	24	5	15	44	0.16	1.1
12	slope	5/I	2-51	0.20	1.77	8.49	54.74	21	8	0	2	4	6	1.9	4.8
13			25-35	—	1.70	4.18	62.12	32	12	0	0	4	4	1.4	11.0
14			35-40	—	1.93	7.10	35.97	21	13	6	4	11	21	1.1	1.6
15	slope	6/I	3-20	0.50	2.53	11.66	50.81	22	6	2	2	3	7	1.8	4.0
16			22-35	—	1.27	8.41	51.32	26	8	0	1	4	5	1.6	6.8
17			48-58	—	0.73	7.55	66.72	14	4	2	1	4	7	3.7	2.6
18			77-90	—	3.34	14.12	55.54	16	7	0	1	3	4	2.4	5.8
19	summit	7/I	2-10	—	2.74	13.74	55.52	16	6	1	2	3	6	2.5	3.7
20			13-25	1.50	3.55	9.76	56.69	20	6	0	1	3	4	2.2	6.5
21			56-70	—	0.25	0.38	16.37	29	38	9	2	5	16	0.24	4.2

genic in origin. In this case it is difficult to ascertain the dependence between the depth of the breach and the grain curve character. It results from the fact that sandy soil in this field is only slightly differentiated. On the other hand, silt loam which underlies the soil was not equally damaged by erosion. In profile 7/I one can see a breach, but in profile 3/I silt loam was not damaged by erosion (Fig. 2). Grain in the profile 7/I (Fig. 3) indicates that the said silt loam consists mainly of coarser silt

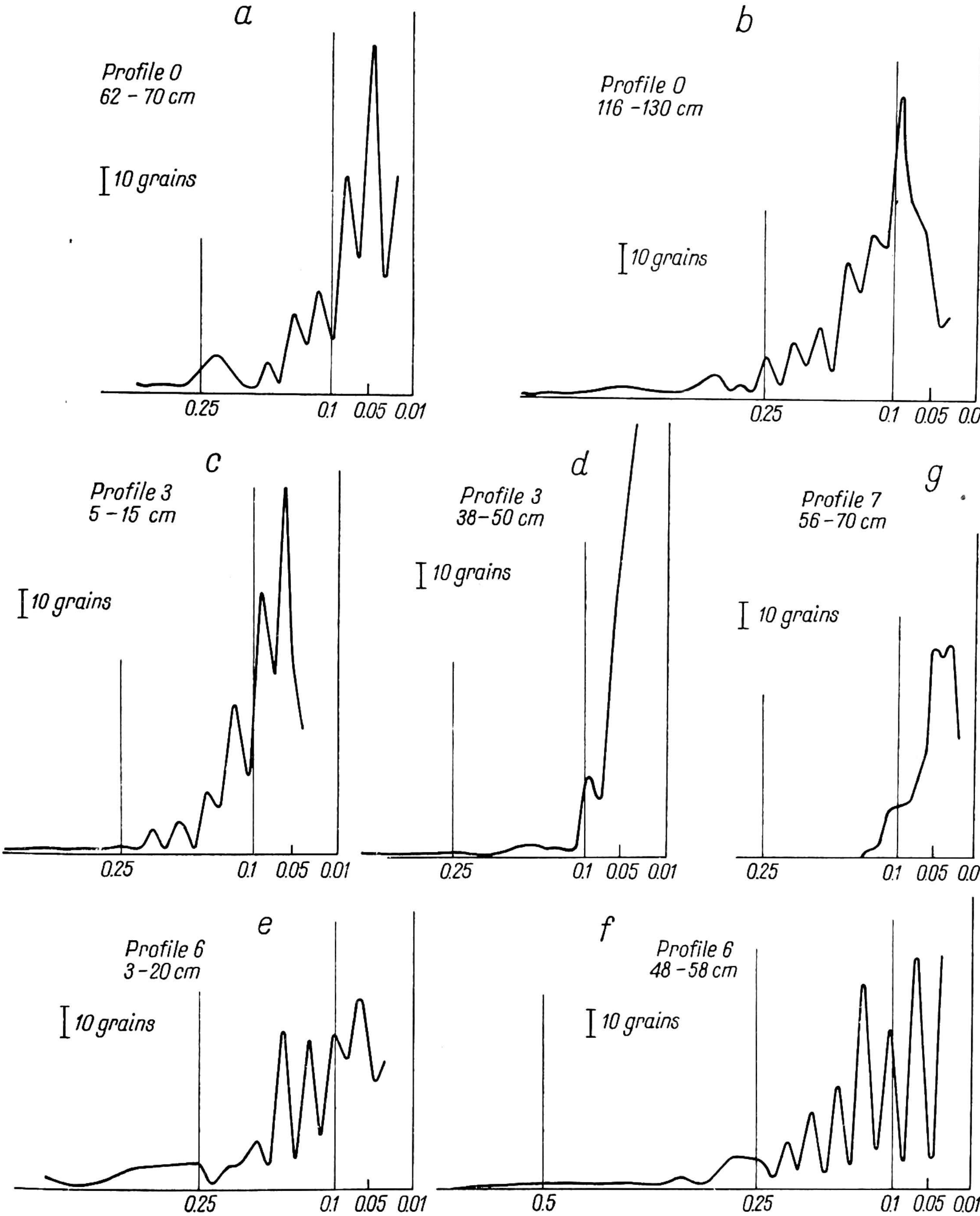

Fig. 3.

fraction sized 0.05-0.03 mm. The soil from the profile 3/I contains most coarser silt fractions of 0.045 mm in diameter. It follows that finer particles of silt fraction make the soil more subject to erosion.

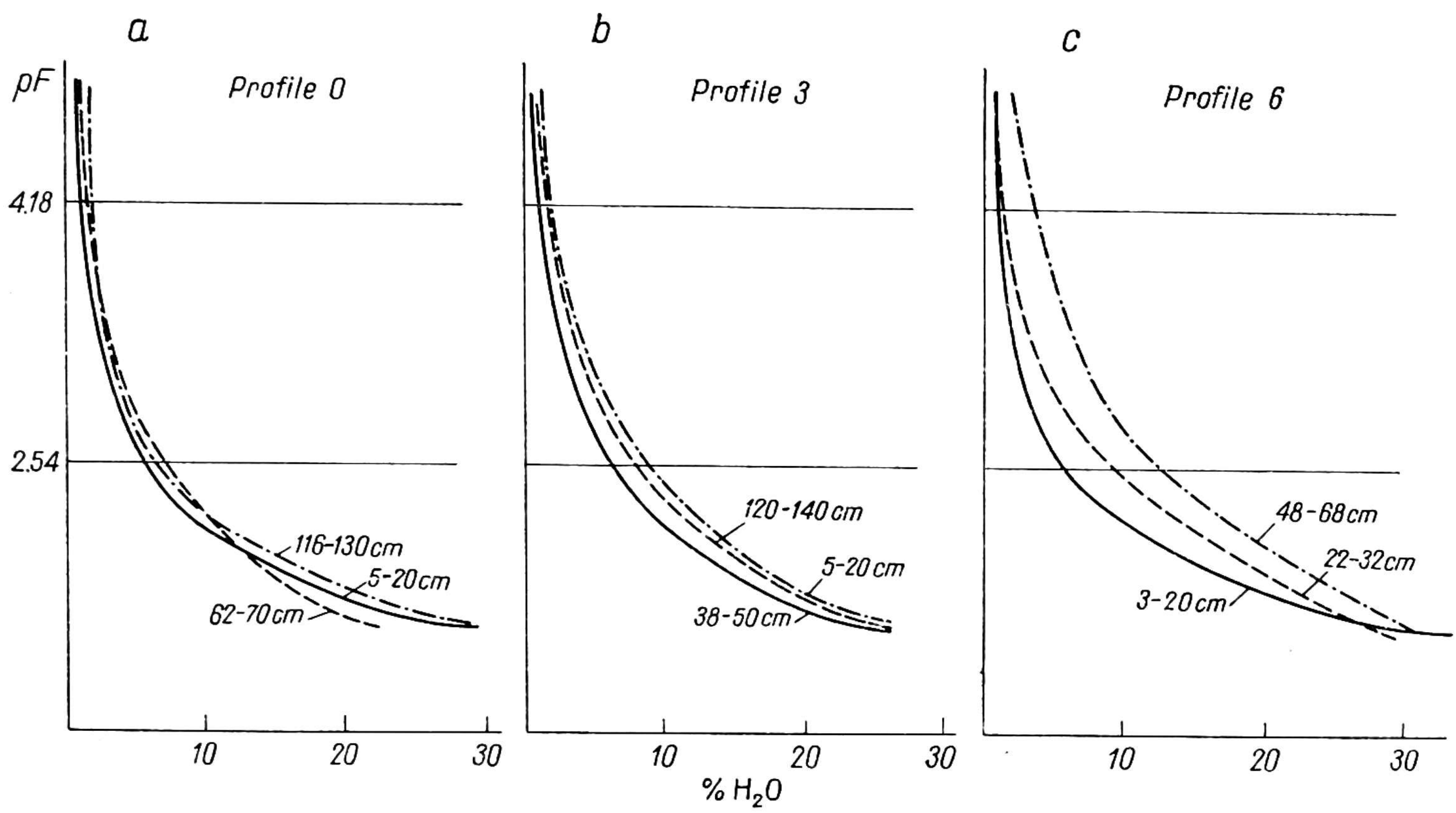

Fig. 4.

WATER SORPTION CURVES

In general, water sorption curves are associated with the grain curves. An increase in fine grains even within the same textural group in reflected in increased water sorption by the soil (Table 1, Fig, 4a, b, c). An exception is the profile 3 where the soil layer 5-20 cm shows a greater water sorption than that of 38-50 cm although the latter contains more fine fractions. However, at the depth of 5-20 cm is a large content of very fine sand fraction and a higher content of dry matter (horizon A_p).

Table 2. Percentage of grains to surface level at angles of 0°, 45°, 90°

Profile	Depth of sampling	Angle of grain orientation		
		0°	45°	90°
0	62-10	34.38	55.39	13.21
Foot	116-130	34.29	51.42	17.85
3	5-15	18.35	64.06	17.57
Slope	38-58	27.84	49.87	22.79
6	3-20	25.71	59.59	14.69
Top	22-32	21.42	66.07	12.49
	48-58	15.04	62.83	22.12

GRAIN ORIENTATION TO THE SURFACE OF TERRAIN

It was found that in all the examined thin soil sections most grains were set at an angle of 45°. Least grains were found to be at an angle of 90° (Table 2).

Taking into account particular parts of the slope it was found that the largest amounts of grains parallel oriented to the terrain surface (sorting over) were present in deluvial soils. Parallel grain orientation in deluvial soils results from the particle setting by down flowing waters. Having reference to each other, the grain orientation in the middle part of the slope and at its top shows hydroglacial origin.

CONCLUSIONS

1. Based on micromorphological studies it was possible to distinguish deluvial and non-deluvial soils. The material from deluvial soils shows more uniform grain curves than that from the middle and uppermost parts of the slope. Deluvial soils are characterized by the greatest number of grains oriented parallel to the surface.

2. Grain-size curves allow to ascertain which material is potentially more subject to erosion. Sandy material was equally subject to water erosion. Silt loam was not equally damaged by water erosion. Grain curves show that coarser silt fraction makes the soil more subject to water erosion.

3. There is rather close correlation between the character of the grains and pF curves. Fine grain material absorbs more water than the coarse grain one within the same textural group and within the same division of a given fraction.

4. Based on the grain orientation it is to conclude that the studied silt is of hydro-glacial origin.

SUMMARY

The samples of the soils which had been eroded by a violent storm in May 1967 were examined. The samples taken from the eroded soils (formed from slightly loamy sand underlayed by silt) of different parts of the slope, uppermost, middle and from the deposited soil (colluvial soil) at the foot, as well as from the deeper strata of the underlaying rocks. Conclusions: (1) On the basis of the thin sections of the investigated soils there may be distinguished eroded soils and deposited soils. (2) The character of the granulation of the soil allows, to some degree, to estimate the susceptibility of the soil to erosion. (3) There has been found a correlation between the granulometric composition of the soil (within the same textural range of soil determined by the mechanical analysis according to Cassagrande and Prószyński methods) and the course of pF curves.

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