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AN ATTEMPT AT THE RECONSTRUCTION OF THE PAST AND FUTURE SOIL COVER IN THE LOESS AREA (ON THE BASIS OF THE NAŁĘCZÓW PLATEAU)

Próba przedstawienia dawnej i przyszłej pokrywy glebowej w terenie lessowym (na przykładzie Płaskowyżu Nałęczowskiego)

INTRODUCTION

Literature on the evolution of soils of loess origin and changes that these soils undergo speeded up by human activities is quite substantial (B. D o b r z a ń s k i 1960, Z. K l i m o w i c z 1993, Z. K l i m o w i c z, S. U z i a k 1993, M. L i c z n a r 1985, H. M a r u s z c z a k, S. U z i a k 1978, Z. M a z u r, S. P a ł y s 1985, L. D. N o r t o n 1986, D. S c h r o e d e r 1954, A. N. S h a r p l e y 1985, R. T u r s k i et al. 1987, S. U z i a k, Z. K l i m o w i c z 1984, 1992). However, most of the above mentioned authors concentrate on short 10-20 year long periods or do not give any precise information on the time periods involved. Very few works (D. S c h r o e d e r 1954, L. D. N o r t o n 1986, S. U z i a k, Z. K l i m o w i c z 1992, Z. K l i m o w i c z 1993, Z. K l i m o w i c z, S. U z i a k 1993) deal with the changes in the agriculturally cultivated soils in longer periods of time, i.e. from approximately 50 to 1400 years. Some other works should also be noted here, e.g. a study by H. R. B o r k and W. R i c k e n (1983) that covers the period from pleistocene up to the present.

Basing on our own research work that was carried out for many years as well as on the data by other researchers we reconstructed former soil cover (dating back to 600 years ago) in some chosen areas of the Nałęczów Plateau; we also presented the picture of these soils in the future (in a few hundred years' time).

The areas chosen were used by the present authors to compile a map of the future soil cover in the whole Nałęczów Plateau. The maps of the contemporary soil cover in this region have not been included in the present study as these materials are published elsewhere (agricultural-soil maps of the Lublin district, 1:25,000, 1:100000). Moreover, no

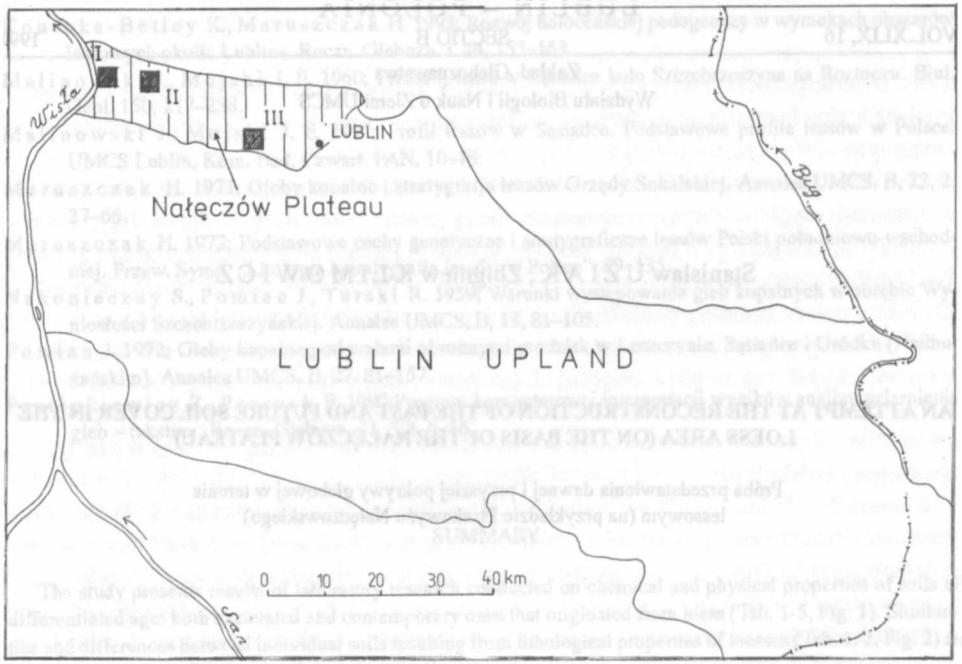

Fig. 1. The location of studied objects
Rozmieszczenie badanych obiektów

major typological changes of the above region are foreseen in the future. The past soil cover is presented only for some chosen areas, as its differentiation before the woods had been stubbed, was only slight.

METHODOLOGY OF RESEARCH

The following basic criteria for the cartographic presentation of the past and the future soil cover have been assumed: a) character of forest soils (never cultivated), b) contemporary soil cover, c) terrain inclination analysis (grades of inclination), d) the influence of other factors modyfyng the amount of rainwash and soil drifting.

The results of research carried out on several areas of forest silty soils representing the upland area in-between the two rivers: Bug and Wisła, lead to the conclusion that the dominat type of soil in the above mentioned region before ploughing started there, used to be grey-brown podzolic soil. It is also true for the terrain with high angle of inclination (Z. Klimowicz 1993, Z. Klimowicz, S. Uziak 1993).

The contemporary soil cover has been present on the basis of agricultural soil maps in the scale of 1:25,000, as well as on the basis of our own research work, i.e. topographic, mainly intercrossing ones, together with soil pits and additional drilling.

An earlier evaluation of the relation between terrain inclination and the degree of soil erosion played an important role in the research. On the basis of the substantial research data collected in the whole area of the Lublin Upland, the value of soil erosion has been established for the following grades of terrain inclination: 0-6, 6-12, 12-18, and above 18% (Z. Klimowicz 1993). The topographic sections carried out in the areas of ploughing have been used.

Tab. 1. Grades on soil erosion intensity in relation to terrain inclination according to Z. Klimowicz*
Intensywność erozji gleby w stosunku do nachylenia terenu

Erosion intensity grades	Terrain inclination %	Soil characteristics
I	0–6	grey-brown podzolic and brown soils with little erosion
II	6–12	mainly brown soils with medium and considerable degree of erosion
III	12–18	weakly developed soils with strong erosion
IV	> 18	initial soils and weakly developed soils, strongly or totally eroded

The magnitude of soil erosion was evaluated according to R. Turski et al. (1987). Moreover, the instruction worked out by C. A. Józefaciukowie (1986) on the detailed evaluation of ground that undergoes erosion, was also used. The indicators taking into account the directions of ploughing proved to be especially important.

On the basis of agricultural and soil maps in the scale 1:25,000**, and topographic maps on the same scale the following three areas, 1,600 ha each, were selected in the Nałęczów Plateau: I. Parchatka – Pożóg Stary. II. Klementowice – Buchałowice. III. Motycz – Uniszowice.

The above areas differed in there relative altitudes, degrees of terrain inclination, characteristics of plant cover and others (Fig. 1).

In the cameral study a detailed analysis of the terrain relief, especially of the degree of inclination, was related to the soil characteristics using the data included in Tab. 1 (taking the direction of ploughing into account). Basing on the above and on the indices describing soil denudation rate typical for the loess areas with a relatively long history of cultivation (Z. Klimowicz 1993, Z. Klimowicz, S. Uziak 1993) a prognostic soil

* For loess and loess-like formations of the Lublin Upland when the direction of ploughing is along or oblique the slope.

** The present authors use the same soil taxonomy as the one used in the map quoted above, i.e. the one that has been obligatory since 1974.

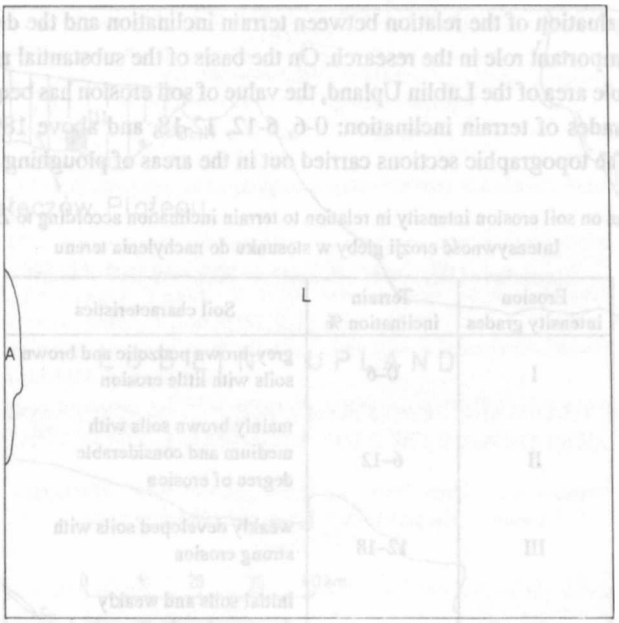

Fig. 2. Soil cover of Parchatka-Pożóg Stary object, 600 yrs ago; A – alluvial soils, L – lessives soils
Pokrywa glebowa obiektu Parchatka-Pożóg Stary, 600 lat temu; A – gleby aluwialne, L – gleby płowe

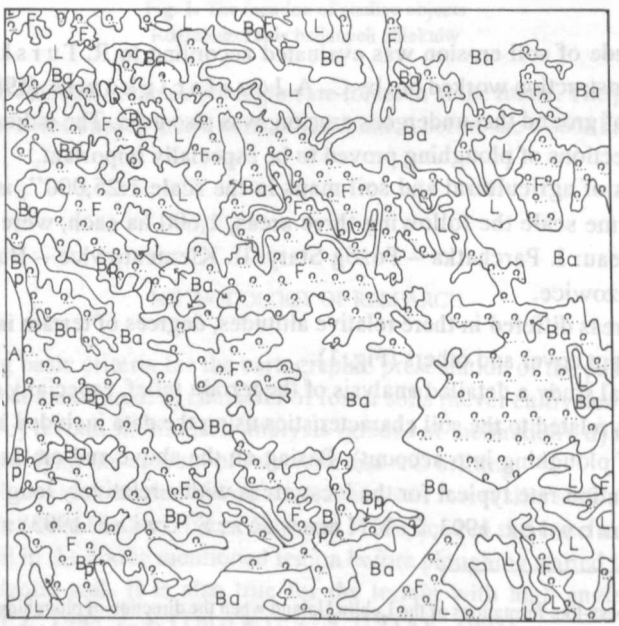

Fig. 3. Soil cover of Parchatka-Pożóg Stary object, at present. A – alluvial soils, Ba – leached and brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest
Współczesna pokrywa glebowa obiektu Parchatka–Pożóg Stary. A – gleby aluwialne, Ba – gleby brunatne wyługowane i kwaśne, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami

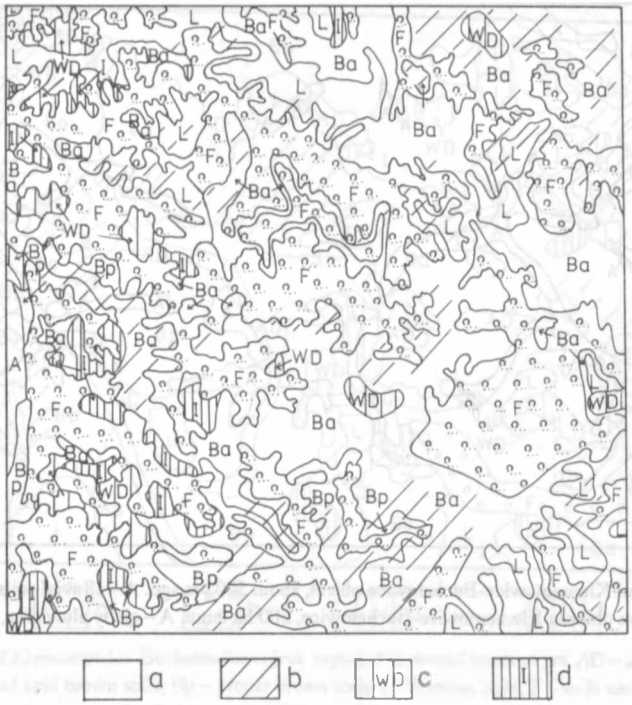

Fig. 4. Soil cover of Parchatka–Pożóg Stary object, expected in several hundred yrs. A – alluvial soils, Ba – leached and acid brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest; a – mainly brown soils, slightly eroded (I), b – mainly brown soils, moderately and severely eroded (II), c – weakly developed soils, severely eroded (III), d – initial soils, severely and completely eroded (IV)

Przewidywana pokrywa glebowa obiektu Parchatka–Pożóg Stary za kilkaset lat. A – gleby aluwialne, Ba – gleby brunatne kwaśne i wyługowane, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami, a – gleby głównie brunatne, słabo erodowane (I), b – gleby głównie brunatne, średnio i silnie erodowane (II), c – gleby słabo wykształcone, silnie erodowane (III), d – gleby inicjalne, silnie i całkowicie zerodowane (IV)

map depicting a fragment of the soil cover a few hundred years has been worked out. In the above study characteristic features of the net of river valleys, potential bog areas, protective plant cover, appearance of back slopes, etc. were also taken into consideration.

CHARACTERISTICS OF THE SOIL COVER: IN THE PAST, AT PRESENT, AND IN THE FUTURE

Soil cover of the past, before forests had been cleared (Figs 2, 5, 8) was rather monotonous. Assuming climatic conditions typical for our region, and the characteristics of the forests (predominance of deciduous and mixed forests in the area of silty soils) one should expect to see the dominat grey-brown podzolic (lessives) soil there. As has been mentioned above the proof of the above assumption are the forests existing now in these areas with predominanting lessive soils. This point of view agrees with the contemporary interpretation of the discussed phenomenon presented by many soil scientists. It is also possib-

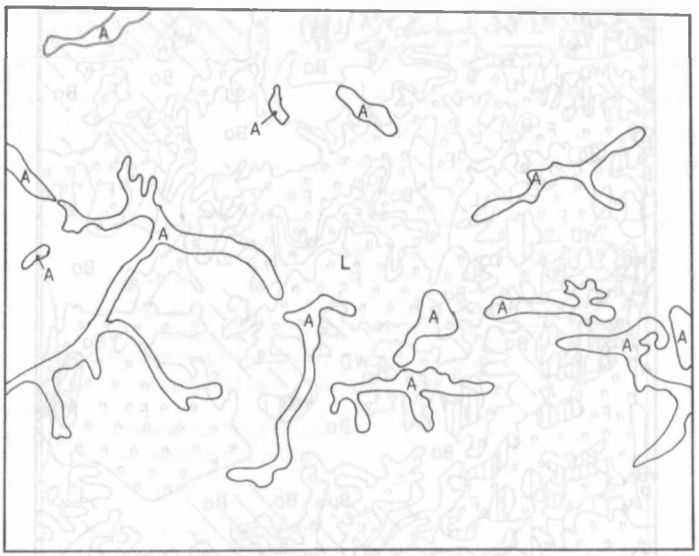

Fig. 5. Soil cover of Klementowice-Buchałowice object, about 500 yrs ago. A – alluvial soils, L – lessives soils
Pokrywa glebowa obiektu Klementowice-Buchałowice, 500 lat temu. A – gleby aluwialne, L – gleby płowe

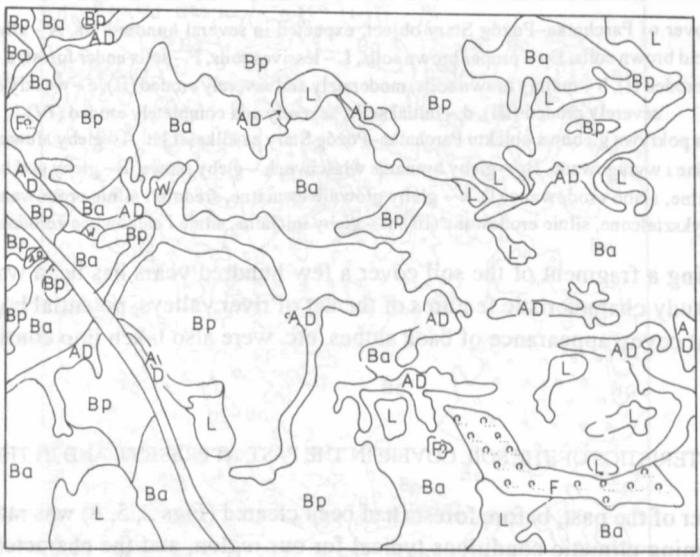

Fig. 6. Soil cover of Klementowice-Buchałowice object, at present. AD – alluvial soils, Ba – leached and acid brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest, W – soils under water
Współczesna pokrywa glebowa obiektu Klementowice-Buchałowice. AD – gleby aluwialno-deluwialne, Ba – gleby brunatne kwaśne i wyługowane, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami, W – gleby pod wodami

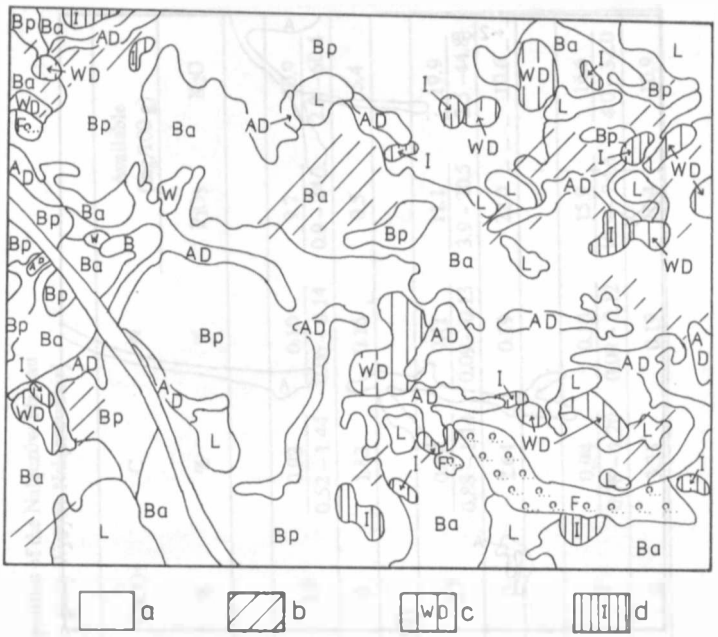

Fig. 7. Soil cover of Klementowice-Buchałowice object, expected in several hundred yrs. AD – alluvial-deluvial soils, Ba – leached and acid brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest, W – soils under water; a – mainly brown soils, slightly eroded (I), b – mainly brown soils, moderately and severely eroded (II), c – weakly developed soils, severely eroded (III), d – initial soils, severely and completely eroded (IV)
Przewidywana pokrywa glebowa obiektu Klementowice-Buchałowice, za kilkaset lat. AD – gleby aluwialno-deluwialne, Ba – gleby brunatne kwaśne i wyługowane, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami, W – gleby pod wodami; a – gleby głównie brunatne, słabo erodowane (I), b – gleby głównie brunatne, średnio i silnie erodowane (II), c – gleby słabo wykształcone, silnie erodowane (III), d – gleby inicjalne, silnie i całkowicie zerodowane (IV)

le that in the western part of the plateau (areas I and II) brown soil could also appear even though only occasionally. It can be gathered from the relatively large areas of brown soils that exist now, as well as from the higher pH values when compared to area III (Motycz-Uniszowice). Places of lower altitude, mainly along water routes, were occupied by alluvial soils in the general sense of the word.

Contemporary soil cover, Figs 3, 6, 9, differs considerably from the soil cover of several hundred years ago. Deforestation activated intense rainwash processes. As has been shown in some earlier studies (Z. Klimowicz 1993, Z. Klimowicz, S. Uziak 1993) these processes were taking places mainly during the few first decades after deforestation and changing forest soils into cultivated land. Common grey-brown podzolic soils got gradually transformed into soils with profiles typical for brown soils. A certain proof of the above is a close resemblance of levels Bt and B. In the western part of the discussed region these changes were most advanced. It is confirmed by the dense net of gullies and characteristic features of the top soils. Even with relatively small inclinations these soils underwent far going transformations. It should be noted, however, that degree of inclinations was higher immediately after deforestation. A topographic section carried out in the

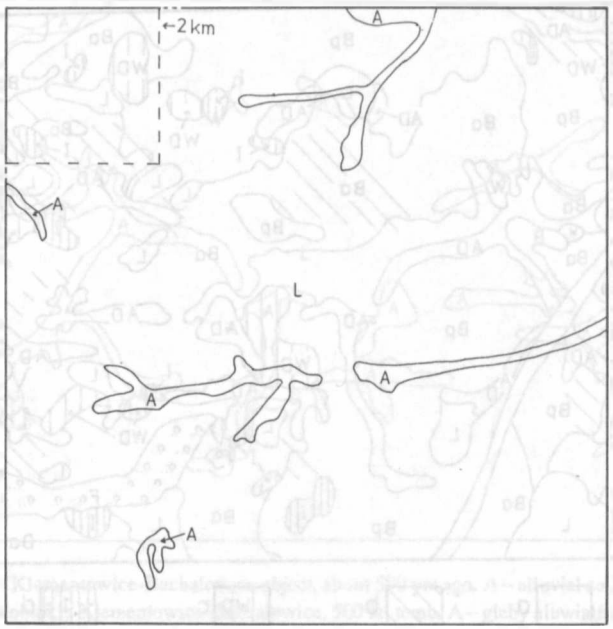

Fig. 8. Soil cover of Motycz-Uniszowice object, 500 yrs ago. A – alluvial soils, L – lessives soils
Pokrywa glebowa obiektu Motycz-Uniszowice, 500 lat temu. A – gleby aluwialne, L – gleby płowe

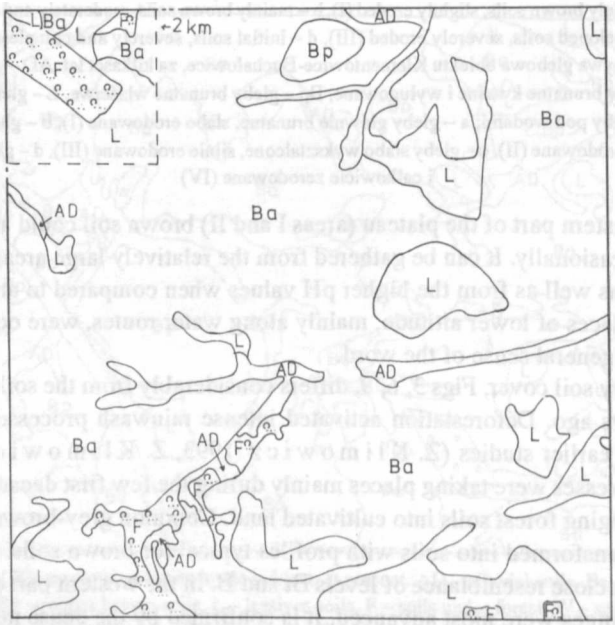

Fig. 9. Soil cover of Motycz-Uniszowice object, at present. AD – alluvial-deluvial soils, Ba – leached and acid brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest
Współczesna pokrywa glebowa obiektu Motycz-Uniszowice. AD – gleby aluwialno-deluwialne, Ba – gleby brunatne kwaśne i wyługowane, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami

Tab. 2. Mean and extreme values of selected soil properities of the Nałęczów Plateau
Średnie i najwyższe wartości wybranych właściwości gleby Wyżyny Nałęczowskiej

Utilization	Grain size content (%)			Ratio "r"	pH	$CaCO_3$	C	N	Available (mg/100 g)	
	0.1–0.02 mm	< 0.02 mm	< 0.002 mm	(0.1 – 0.02) / < 0.002	KCl	%	%	%	P_2O_5	K_2O
				Parchatka–Pożóg Stary (I)						
Arable	73* / 69 – 75**	25 / 25 – 30	7 / 5 – 12	10.4	6.2 / 4.7 – 7.1	3.9	0.93 / 0.52 – 1.44	0.10 / 0.06 – 0.14	9.7 / 0.9 – 24.3	20.9 / 2.9 – 60.4
Forest	67	26	6		5.2	0	1.83	0.15	0.5	5.4
				Klementowice–Buchałowice (II)						
Arable	64 / 61 – 68	36 / 31 – 38	9 / 4 – 15	6.7	5.8 / 4.2 – 2.7	3.7	0.99 / 0.88 – 1.14	0.11 / 0.09 – 0.13	11.1 / 3.9 – 20.5	19.9 / 2.5 –44.8
Forest	63	36	7		3.5	0	2.64	0.19	22.0	10.6
				Motycz–Uniszowice (III)						
Arable	61 / 58 – 66	38 / 33 – 41	10 / 4 – 17	6.1	5.2 / 4.0 – 6.0	0	0.94 / 0.78 – 1.20	0.10 / 0.09 – 0.12	15.9 / 10.3 – 24.6	16.6 / 4.0 – 32.0
Forest	61	38	9		3.3	0	3.35	0.19	16.4	10,9

* mean values, ** extreme values

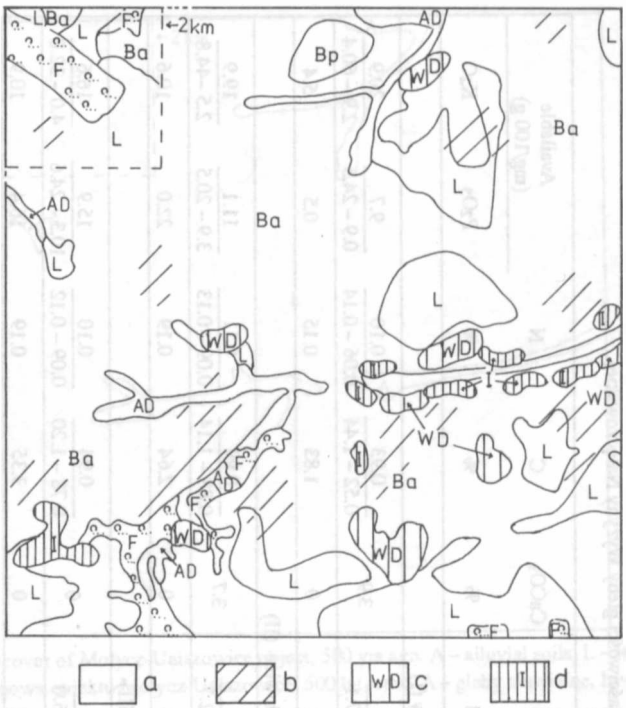

Fig. 10. Soil cover of Motycz-Uniszowice object, expected in several hundred yrs. AD – alluvial-deluvial soils, Ba – leached and acid brown soils, Bp – proper brown soils, L – lessives soils, F – soils under forest; a – mainly brown soils, slightly eroded (I), b – mainly brown soils, moderately and severely eroded (II), c – weakly developed soils, severely eroded (III), d – initial soils, severely and completely eroded (IV)

Przewidywana pokrywa glebowa obiektu Motycz-Uniszowice za kilkaset lat; AD – gleby aluwialno-deluwialne, Ba –gleby brunatne kwaśne i wyługowane, Bp – gleby brunatne właściwe, L – gleby płowe, F – gleby pod lasami; a – gleby głównie brunatne, słabo erodowane (I), b – gleby głównie brunatne, średnio i silnie erodowane (II), c – gleby słabo wykształcone, silnie erodowane (III), d – gleby inicjalne, silnie i całkowicie zerodowane (IV)

discussed area, Fig. 11, points to a high contribution of initial soils, i.e. soil with a very thin humus horizon, that are of a transitional character to the carbonated mother rock (AC). Forest covering large areas of the western part of the plateau is not a typical forest. A predominant part of it is tree-like vegetation and bushes that cover numerous gullies.

The foreseen soil cover in several hundred years, Figs 4, 7, 10, 12, shows further stages of evolution, even though the rate of morphological changes should slow down considerably. As a result of permanent, though less intensive denudation, a contribution of weakly developed and initial soils in relation to strongly eroded brown soils should increase. The above tendency will be favoured by the direction of ploughing (along or oblique to the slope), that is predominant on the fields in this region, and especially in the catchment area of the Bystra river. The soils of alluvial type in the original cover got transformed into alluvial-deluvial soils mainly because of, among others, relatively narrow valleys (except in

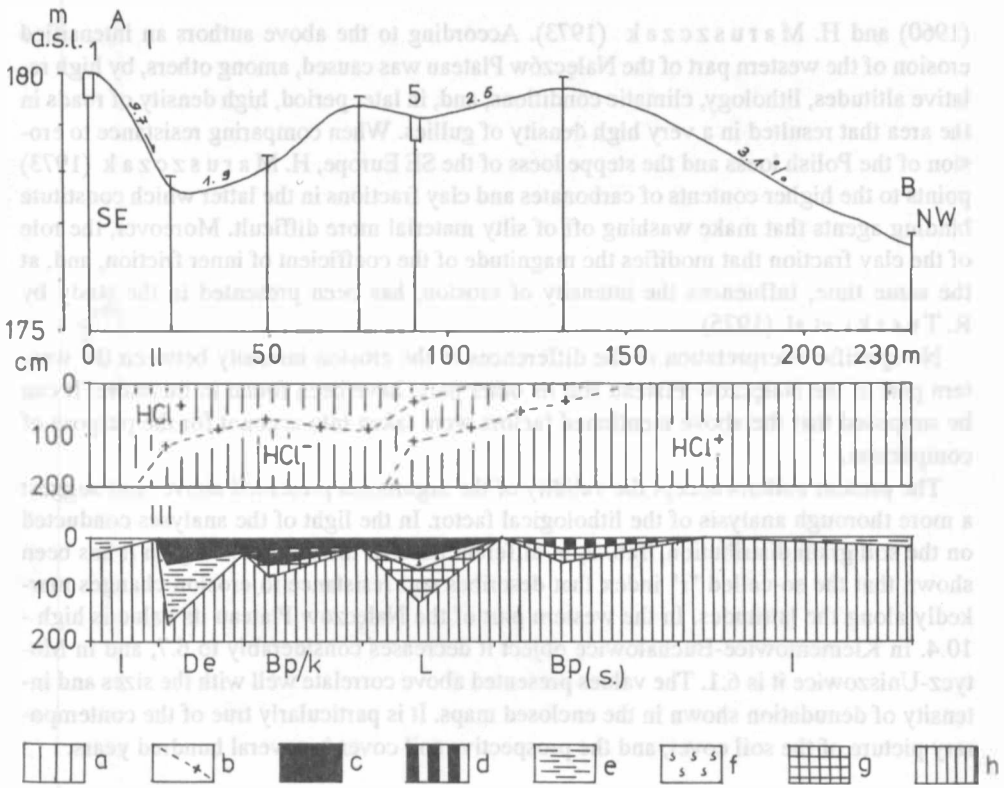

Fig. 11. Puławy–Włostowice section (A-B); I – topographic section, II – geological section, III – pedological section; 1,5 – soil pits, a – silt, b – depth of decalcification, c – humus horizon A, d – transitional horizon AB, e – transitional horizon AC, f – lessivage horizon E, g – illuvial or browned horizon B, h – parent rock C, I – initial soils, De – deluvial humic soil, Bp/k – proper brown soil on buried soil, L – lessives soil, $Bp_{(s.)}$ – proper brown soil, severely eroded

Przekrój Puławy-Włostowice (A-B). I – przekrój niwelacyjny, II – przekrój geologiczny, III – przekrój glebowy; 1,5 – odkrywki glebowe, a – pył, b – głębokość odwapnienia, c – poziom próchniczny A, d – poziom przejściowy AB, e – poziom przejściowy AC, f – poziom przemywania E, g – poziom iluwialny lub brunatnienia B, h – skała macierzysta C, I – gleby inicjalne, De – gleby deluwialne próchniczne, Bp/k – gleby brunatne właściwe na glebie kopalnej, L – gleby płowe, $Bp_{(s.)}$ – gleby brunatne właściwe, silnie erodowane

the neighbourhood of the Vistula. In the forecast soil cover contribution of deluvial soils may increase which will mainly depend on the character of the denudation base.

Comparing the studied areas, contemporary soils included, one is astonished by an unusual contrast between a strongly transformed and degraded western part of the plateau, and significantly less changed centre-western part (Klementowice-Buchałowice) and eastern part (Motycz-Uniszowice).

Studies of some geographers mainly from the Lublin research centre (A. Chałubińska, T. Wilgat 1954, M. Harasimiuk, A. Henkiel 1972, A. Jahn 1956, H. Maruszczak et al. 1984) throws some light that makes the explanation of the above phenomenon easier. A more detailed interpretation has been presented by A. Kęsik

(1960) and H. Maruszczak (1973). According to the above authors an intensified erosion of the western part of the Nałęczów Plateau was caused, among others, by high relative altitudes, lithology, climatic conditions, and, in later period, high density of roads in the area that resulted in a very high density of gullies. When comparing resistance to erosion of the Polish loess and the steppe loess of the SE Europe, H. Maruszczak (1973) points to the higher contents of carbonates and clay fractions in the latter which constitute binding agents that make washing off of silty material more difficult. Moreover, the role of the clay fraction that modifies the magnitude of the coefficient of inner friction, and, at the same time, influences the intensity of erosion, has been presented in the study by R. Turski et al. (1975).

No specific interpretation of the differences in the erosion intensity between the western part of the Nałęczów Plateau and its other parts have been found in literature. It can be supposed that the above mentioned factors were taken into account for the purpose of comparison.

The present authors accept the validity of the arguments presented above, and suggest a more thorough analysis of the lithological factor. In the light of the analyses conducted on the soil grain distribution, Tab. 2, in different parts of the discussed region it has been shown that the so-called "r" index that describes soil resistance to erosion changes markedly along the lattitudes. In the western part of the Nałęczów Plateau its value is high - 10.4. In Klementowice-Buchałowice object it decreases considerably to 6.7, and in Motycz-Uniszowice it is 6.1. The values presented above correlate well with the sizes and intensity of denudation shown in the enclosed maps. It is particularly true of the contemporary picture of the soil cover, and the prospective soil cover in several hundred years.

CONCLUSIONS

1. The soil cover of the past in the region of Nałęczów Plateau was rather monotonous. On the tops and the slopes grey-brown podzolic soils with a low contribution of brown soils were dominant, where as in the valleys alluvial soils dominated.

2. The contemporary soil cover is of a mosaic character. "Artificial" brown leached and acidic soils took place of grey-brown podzolic soils and in the western part of the plateau also proper brown soils. A considerable percentage of the soils constitute brown soils with medium or high degree of erosion, and in the areas of the highest inclinations - weakly developed and initial soils. Alluvial soils got transformed into alluvial-deluvial soils.

3. The forecast soil cover in 500 years' time is the soil with even higher contribution of weakly developed and initial soils that will take place of the strongly eroded brown soils. The changes in the soil cover in the future will be considerably slower than the processes that took place in the first few decades after ploughing had started.

4. Exceptionally intense damage of the soil cover in the western part of the Nałęczów Plateau should be mainly explained by the high de-levelling of the terrain, as well as by the lithological differentiation of the loess formations in this region, which means that the

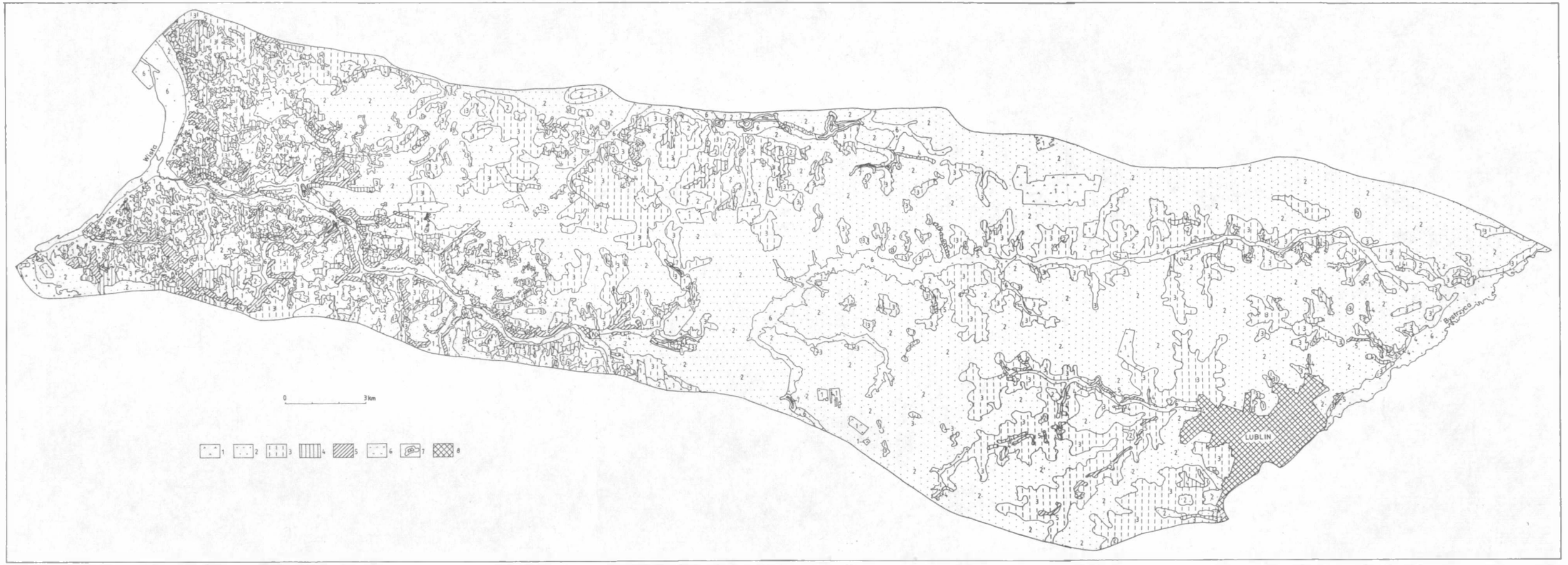

Fig. 12. Soil cover the Nałęczów Plateau expected in about 500 yrs. 1 – mostly lessives soils, under forest, 2 – complex of lessives and brown soils, predominantly slightly eroded, 3 – mainly brown soils, moderately and severely eroded, 4 – predominantly weakly developed soils, severely eroded, 5 – initial and weakly developed soils, severely and completely eroded, 6 – alluvial and alluvial-deluwial soils, 7 – soils under water, 8 – the larger building grounds (towns), K – Kazimierz, N – Nałęczów, W – Wąwolnica

Przewidywana pokrywa glebowa Płaskowyżu Nałęczowskiego za około 500 lat. 1 – gleby najczęściej płowe pod lasami, 2 – kompleks gleb płowych i brunatnych, przeważnie słabo erodowanych, 3 – gleby głównie brunatne, średnio i silnie erodowane, 4 – gleby przeważnie słabo wykształcone, silnie erodowane, 5 – gleby inicjalne i słabo wykształcone, silnie i całkowicie zerodowane, 6 — gleby aluwialne i aluwialno-deluwialne, 7 – gleby pod wodami, 8 – większe (powierzchnie) tereny zabudowane (miasta), K – Kazimierz, N – Nałęczów, W – Wąwolnica

value of the so-called index of soil resistance to erosion, that expresses relation between the silt fraction and the colloidal fraction, is widely spread.

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STRESZCZENIE

Na podstawie wyników wieloletnich badań własnych, a także innych autorów odtworzono dawną (sprzed ok. 600 lat) pokrywę glebową na wybranych obszarach lessowych Płaskowyżu Nałęczowskiego, a także przedstawiono prawdopodobny obraz tych gleb w przyszłości (za kilkaset lat). Autorzy podjęli też, na podstawie wybranych powierzchni (reperowych), próbę odtworzenia pokrywy glebowej dawnej i przyszłej całego Płaskowyżu Nałęczowskiego.

Dawna pokrywa glebowa na obszarze Płaskowyżu Nałęczowskiego przedstawiała obraz dość monotonny. Na wierzchowinach i stokach dominowały gleby płowe lessowe z niewielkim udziałem gleb brunatnych, natomiast w dolinach – aluwialne. Współczesna pokrywa glebowa charakteryzuje się dużą mozaikowatością. W miejsce gleb płowych weszły wtórne gleby brunatne wyługowane i brunatne kwaśne, a w części zachodniej Płaskowyżu – również gleby brunatne właściwe. Znaczny odsetek gleb stanowią ponadto gleby brunatne średnio i silnie erodowane, a w miejscach największych nachyleń – gleby słabo wykształcone i inicjalne. Gleby aluwialne przekształciły się w aluwialno-deluwialne. Przewidywana pokrywa glebowa za 500 lat to jeszcze większy udział gleb słabo wykształconych i inicjalnych, głównie kosztem brunatnych silnie erodowanych. Zmiany pokrywy glebowej w przyszłości będą zdecydowanie powolniejsze od tych, jakie zachodziły w pierwszych dziesiątkach lat po rozpoczęciu uprawy płużnej.

Wyjątkowo silne zniszczenie pokrywy glebowej w zachodniej części Płaskowyżu Nałęczowskiego należy tłumaczyć głównie dużymi deniwelacjami terenu, a także zróżnicowaniem litologicznym utworów lessowych omawianego regionu, a więc szerokim stosunkiem frakcji pyłowej do frakcji koloidalnej wyrażonym w postaci tzw. współczynnika podatności na erozję.