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Heavy minerals in the key Late Pleistocene loess-palaeosol section at Kolodiiv (East Carpathian Foreland, Ukraine)

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Successions of loess and other deposits in the Kolodiiv profile, formed during the Eemian Interglacial and Vistulian Glacial (OIS 5–2), are characterized using the results of heavy mineral analysis. Weathered local carbonate rocks and fluvial deposits (Wartanian Glacial, OIS 6) are used for comparison. It was found that the content of minerals derived from weathered and redeposited Carpathian Flysch increases from bottom to top of the profile. The entire loess succession accumulated under similar lithodynamic conditions and the palaeosols are of similar character.

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INTRODUCTION

Studies of heavy minerals in the loess deposits of the Halyč Prydnistrov'ja region were initiated in 1999 by Racinowski (Racinowski *et al*., 1999, 2004*a*, *b*; Boguckyj *et al*., 2000). The Kolodiiv section, situated in the Sivka River valley (tributary of the Dniester River) is one of the most important Late Pleistocene profiles in this region. The heavy mineral spectrum of deposits from the Kolodiiv 2A profile (Fig. 1) has already been described in outline in an earlier paper (Łanczont and Boguckyj, 2002; Racinowski, 2002; Łanczont and Boguckyj, 2007). These studies showed that the entire profile contains a number of mineral classes, though the range of extreme values is large. Larger differences in the contents of transparent minerals can indicate significant changes in source. Detailed analysis of the heavy mineral spectrum in the Kolodiiv profile is particularly interesting because these deposits accumulated in a relatively narrow stratigraphical interval. This includes the interval of the Eemian Interglacial and the Vistulian Glacial (OIS 5–2). Local Upper Cretaceous calcareous sandstones and fluvial deposits from the Wartanian Glacial (OIS 6), which occur in the profile beneath the loess deposits, were also examined for comparison.

This paper gives the results of heavy mineral analysis. Heavy minerals were separated in bromoform from the 0.1–0.05 mm fraction. The components of the entire mineral spectrum were ranked into four main classes (Table 1): opaque minerals, concretions (ferruginous and sporadically carbonate), micas (muscovite together with chlorite), and transparent minerals (excluding biotite). Transparent minerals were classified into the main mineral groups (Table 2). All amphiboles were put in one group, and other groups garnets, comprised pyroxenes and tourmalines. Epidotes were classified with zoisites, and rutile with other titanium minerals.

Using Kikukazu-Doi's method (Racinowski and Coufal, 1991; Racinowski *et al*., 2000; Racinowski, 2002) three subsets were distinguished in the transparent minerals set: dominant minerals, accessory minerals and subordinate minerals. Dominant minerals comprised more than 20% of the mineral spectrum; they are denoted with capital letters. Accessory minerals are expressed in capital letters in parentheses; their content is usually 5–20%. The content of these minerals is close to the lower boundary of the dominant minerals content. The presence of some subordinate minerals was additionally indicated. Their content is usually lower than 5%, but due to their specific character they may be of considerable importance in palaeogeographical studies. They are written in small letters in parentheses. The following symbols are used for the dominant minerals: C — zircon, G — garnets, R — rutile (Fig. 2).

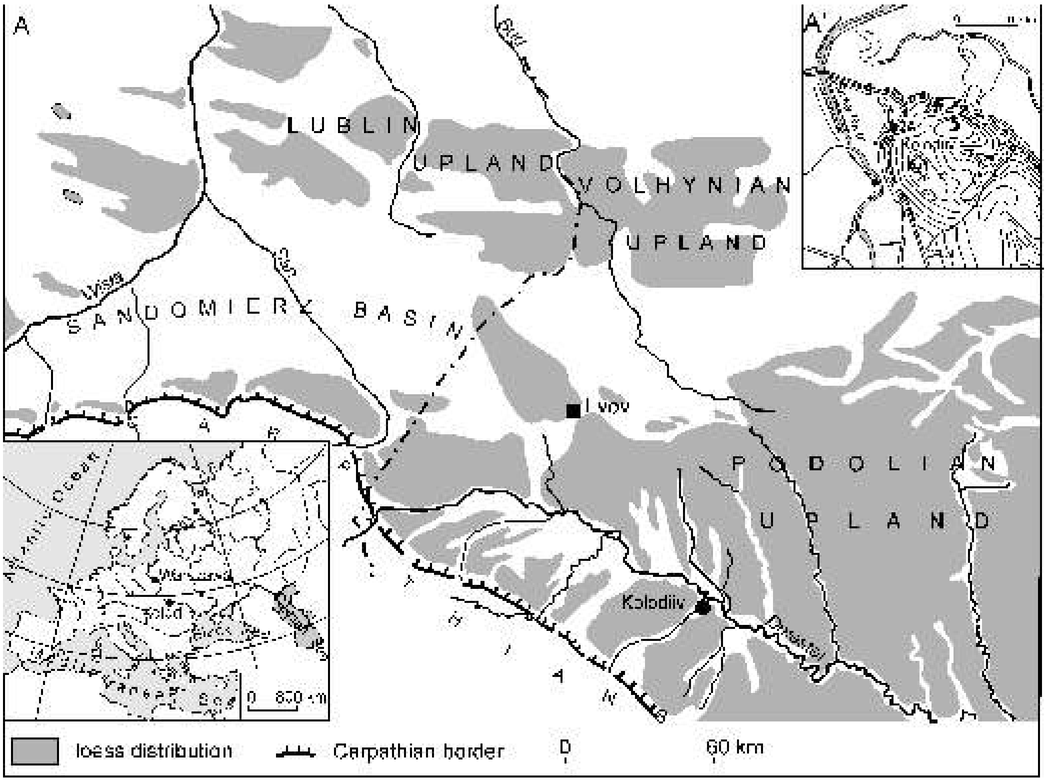

Fig. 1. A — sketch map of loess regional distribution; A' — location of profiles investigated at Kolodiiv (after Łanczont and Boguckyj, 2007)

Table 1

Heavy minerals compositions in the Kolodiiv profile deposits

Symbol	Lithogenesis	Age	Depth [m]	No. of samples	Heavy minerals in [%] weight	Heavy minerals (quantity in %)			
						Opaque	Concretions (Fe,Ca)	Micas	Transparent
1	loess	Upper Plenivistulian (Rivne)	2.0–5.2	4	0.43	12.6	31.2	26.4	29.8
2	mineral soil (horizon Ag)	Interplenivistulian (Dubno 1)	6.0	1	0.32	6.4	29.6	32.2	31.8
3	mineral soil (horizon B)	as above	6.8–8.7	3	0.29	11.1	24.9	40.1	23.9
4	mineral soil (horizon Ag)	as above	9.7	1	0.23	12.4	22.2	34.6	30.8
5	mineral soil	as above	10.8–11.6	2	0.28	12.4	25.6	31.6	30.4
6	sandy loess	as above	12.2	1	0.19	12.1	31.1	25.5	31.3
7	dusty sand	as above	13.6–14.1	2	0.25	16.1	29.9	25.5	28.5
8	mineral soil (horizon B)	Interplenivistulian (Dubno 2)	15.6	1	0.28	13.9	32	21.3	32.8
9	stratified sands	Lower Plenivistulian	16.5	1	0.29	5.5	35.2	26.4	32.9
10	mineral soil (horizon B)	Early Vistulian	17.8	1	0.29	12.0	28.7	23.9	35.4
11	mineral soil (horizon A)	as above	18.6	1	0.23	7.3	24.4	48.9	19.4
12	mineral soil (horizon E)	Eemian	19.2	1	0.15	14.9	34.7	31.0	19.4
13	mineral soil (horizon B)	as above	19.4–19.9	2	0.23	17.8	35.5	29.7	17.0
14	mineral soil (horizon A)	as above	20.1	1	0.27	16.4	27.9	30.4	25.3
15	mineral soil (horizon B)	as above	21.0–21.8	2	0.32	14.9	31.5	31.5	22.1
16	river sand	Wartanian	–	1	0.45	5.3	44.8	17.4	32.5
17	calcareous sandstone	Upper Cretaceous	–	1	0.33	45.4	11.3	25.8	17.5

Table 2

Transparent heavy mineral compositions in the Kolodiiv profile deposits

Symbol	Transparent heavy minerals (quantity in percentage: sum = 100%)													
	Amphiboles	Biotite	Zircon	Disthene	Epidotes	Glauconite	Garnet	Monacite	Pyroxenes	Rutile	Staurolite	Sillimanite	Tourmalines	Others
1	2.2	1.7	25.6	0.2	1.3	0.5	49.6	0.4	2.5	12.1	1.3	0.2	2.4	0.0
2	1.0	0.6	23.7	0.2	0.4	1.0	41.5	0.4	1.0	27.0	2.2	0.0	1.0	0.0
3	0.6	0.6	28.7	0.0	1.0	0.2	46.0	0.3	0.7	18.1	2.3	0.1	1.3	0.1
4	1.7	0.9	21.9	0.2	0.8	0.0	46.0	0.0	0.9	20.8	4.7	0.2	1.9	0.0
5	0.7	0.7	18.5	0.2	0.4	0.7	59.1	0.3	1.2	14.4	2.3	0.1	1.3	0.1
6	1.3	0.2	25.6	0.2	0.7	0.0	45.2	0.0	3.3	18.7	2.0	0.2	2.6	0.0
7	0.9	0.8	25.5	0.0	0.8	0.0	47.6	0.0	1.4	18.0	2.4	0.2	2.4	0.0
8	0.3	0.7	25.1	0.3	1.3	0.0	44.3	0.0	1.6	22.1	2.3	0.0	2.0	0.0
9	3.6	1.5	28.5	0.4	1.1	0.0	49.6	0.0	1.1	10.2	2.5	0.0	1.5	0.0
10	0.7	0.0	37.9	0.0	1.0	0.3	27.9	0.5	0.8	27.0	1.5	0.5	1.7	0.2
11	0.9	0.4	29.6	0.4	1.7	0.0	40.4	1.3	2.6	14.4	3.0	0.0	5.2	0.1
12	1.7	0.4	45.8	0.0	1.3	0.0	11.4	0.4	1.7	30.5	1.7	0.0	5.1	0.0
13	1.6	0.7	44.3	0.6	1.5	0.5	9.9	1.0	3.1	32.8	1.0	0.0	3.0	0.0
14	1.3	0.0	39.9	0.0	1.0	0.0	17.0	0.0	1.3	36.4	0.6	0.6	1.9	0.0
15	1.5	0.4	53.1	0.5	1.1	0.7	6.8	0.6	2.2	24.9	2.0	0.5	5.6	0.1
16	1.3	0.6	61.7	0.0	0.0	0.6	9.8	0.8	0.5	19.9	1.3	0.3	3.2	0.0
17	0.0	0.0	61.8	2.2	4.4	1.5	1.5	0.7	2.2	20.5	3.7	0.0	1.5	0.0

VARIABILITY OF HEAVY MINERALS IN SUCCESSIONS OF DIFFERENT AGES

The stratigraphy of the deposits examined has been published by Boguckyj and Łanczont (2007).

In the heavy mineral assemblages of the Cretaceous rocks, opaque minerals and concretions play the main role. There is also a moderately high mica content. Zircon predominates among the transparent minerals, while rutile is an accessory component. Garnets appear in very small amounts.

Fluvial sandy deposits from the Wartanian Glacial (OIS 6) are characterized by similar contents of transparent minerals as in the Cretaceous deposits. The significant amount of micas (for fluvial deposits) is notable and suggests sedimentation from low-energy currents. Zircon is the dominant mineral among transparent minerals, and rutile is an accessory. There is more garnet in these deposits than in the Cretaceous rocks.

In the lower part of the silt deposits of the Eemian Interglacial and the Early Vistulian (OIS 5) there are generally similar contents of minerals in the individual heavy mineral classes as in the older deposits. However, micas are found in smaller amounts. Zircon is a dominant mineral among the transparent heavy minerals; rutile is an accessory, and garnet a subordinate mineral. Such a mineral spectrum likely indicates that silt was blown mainly from eroded local Cretaceous rocks, which had been redeposited in water. The heavy minerals analysed comprise an assemblage of components that are resistant or medium-resistant to destruction, which does not allow distinction of variable weathering effects between individual palaeosols. At the same time, the mineral spectrum contains components of more or less constant aerodynamic equivalence, suggesting that similar wind conditions prevailed during the deposition of this succession.

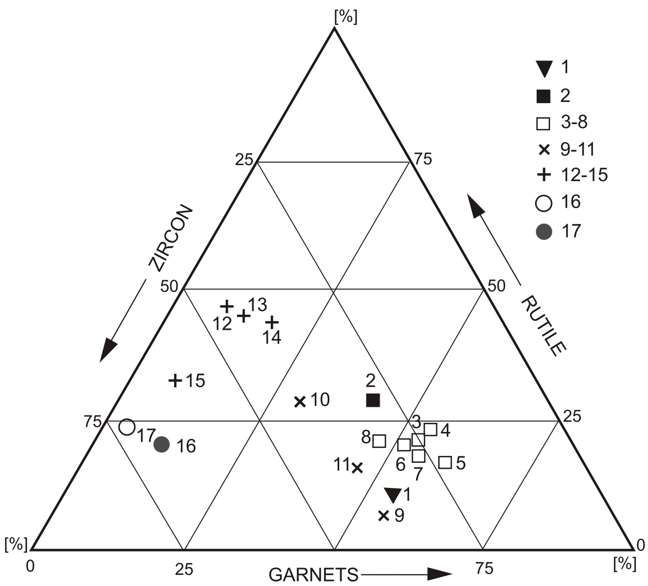

Fig 2. Distribution of loess sample points at the Kolodiiv 2 profile showing the varying contents of the main transparent heavy minerals

Symbols according to description given in Tables 1and 2

Deposits from the Lower Plenivistulian (OIS 4) are represented by soliflucted silts and sands, which are characterized by compositions within individual classes similar to those found in the underlying units. However, among the transparent minerals some considerable changes appear. Garnet and zircon become dominant, and rutile is accessory. The increase in the garnet content indicates a change in source area. Ultimate derivation from Carpathian Flysch rocks is likely, via transport by flowing water or in local ephemeral lakes. Information about the mineralogical characteristics of the Carpathian rocks was mostly taken from Lazarenko *et al*. (1962).

The Interplenivistulian (OIS 3) sediments, represented by the Dubno (1+2) set of palaeosols and the loess between them, are characterized by the similar contents of minerals in the main classes as occur in the older deposits. However, among the transparent minerals, the garnet content strongly increases. It can be supposed that detritus from the Carpathian Flysch rocks provided the main source of blown-in silt material. The loess-forming process likely occurred in a more or less constant and calm environment. This is suggested by the significant content of micas. Also in this succession one cannot observe a relationship between the heavy mineral spectra and different degrees of weathering of the accomponging palaeosols.

The upper part of the Kolodiiv profile is composed of Upper Plenivistulian (OIS 2) loess with the Rivne palaeosols. The heavy mineral composition is similar to that of the underlying loess-palaeosol sequence (Dubno 1+2).

CONCLUSIONS

In the entire Kolodiiv profile, variations in the mineral contents in the individual classes does not show patterns that would allow unequivocal conclusions to be drown concerning lithogenesis and lithostratigraphy. However, analysis of the transparent mineral spectra allows a number of different lithostratigraphical units to be distinguished (Table 2 and Fig. 2).

The local basement beneath the Late Pleistocene deposits, is composed of Upper Cretaceous calcareous sandstones. Detritus from these is characterized by transparent minerals in the order C>(R)>(G). In the lower part of the Kolodiiv profile these are overlain by Wartanian fluvial deposits C>(R)>(G), also characterized by as are the succeeding Eemian Interglacial deposits. Above these are Lower Plenivistulian slope silts and sands, in which the order is G, C>(R). The succeeding Interplenivistulian and Upper Plenivistulian deposits, along with the Dubno (1+2) and Rivne palaeosols, include transparent minerals that may show either G>C>(R) or G>(C>R).

The diversity of the dominant transparent minerals likely reflects the composition of the source materials. Originally this was locally redeposited detritus from Cretaceous rocks. Components derived from redeposited Carpathian sediments increases from bottom to top of the profile.

As the original material is composed of minerals that are resistant or moderately resistant to weathering, differences in weathering effects between individual palaeosols are not easily distinguished.

The low variability of the contents of opaque minerals and concretions in the mineral spectra suggests that the intensity of pedogenesis was similar in all warm phases. The similar mica contents throughout the entire Kolodiiv profile indicate that the dynamics of aeolian accumulation were generally similar throughout the sedimentation cycle.

REFERENCES

BOGUCKYJ A., ŁANCZONT M. and RACINOWSKI R. (2000) — Conditions and course of sedimentation of the Middle and Upper Pleistocene loesses in the Halič profile (NW Ukraine). Stud. Quater., **17**: 3–17.

LAZARENKO E. K., GABINET M. P. and SLYVKO E. P. (1962) — Mineralogia osadočnych utvorieni Prikarpatia. Vid. Lvivskogo Universitieta. L'viv.

ŁANCZONT M. and BOGUCKYJ A. (2002) — The examined loess sites in the Halyč Prydnistrov'ja region (in Polish with English summary). Stud. Geol. Pol., **119**: 33–181.

ŁANCZONT M. and BOGUCKYJ A. (2007) — High-resolution terrestrial archive of the climatic oscillation during Oxygen Isotope Stages 5–2 into loess-palaeosol sequence at Kolodiiv (East Carpathian Foreland, Ukraine). Geol. Quart., **51** (2): 105–126.

RACINOWSKI R. (2002) — Heavy minerals of loess deposits in the Halyč Prydnistrov'ja region (in Polish with English summary). Stud. Geol. Pol., **119**: 219–236.

RACINOWSKI R. and COUFAL R. (1991) — The determination importance of principal elements in sets of some lithological features of seashore sediment (in Polish with English summary). Pr. Nauk. Pol. Szczec., **451** (1): 5–20.

RACINOWSKI R., ŁANCZONT M. and BOGUCKI A. (1999) — Interpretacja wyników badań minerałów ciężkich lessu z profilu Halicz koło Iwano-Frankowska (zachodnia Ukraina). VI Konf. Stratygrafia plejstocenu Polski. "Czwartorzęd wschodniej części Kotliny Sandomierskiej", Kraków-Czudec: 59–60.

RACINOWSKI R., ŁANCZONT M. and BOGUCKI A. (2000) — Próba określenia tendencji zmian składu minerałów ciężkich w lessach okolic Iwano-Frankowska (na podstawie profili Halicz i Zagwizdje). Seminarium terenowe II "Glacjał i preglacjał na międzyrzeczu Sanu i Dniestru". Univ. M. Curie-Skłodowskiej. Lublin: 77–85.

RACINOWSKI R., ŁANCZONT M. and BOGUCKYJ A. (2004*a*) — Sediments from the Halyč Prydnistrov'ja Region and San-Dniester interfluve in the light of lithostatistic analysis of heavy minerals (in Polish with English summary). In: Geneza, litologia, stratygrafia utworów czwartorzędowych (ed. A. Kostrzewski). IV Ser. Geogr., **68**: 373–396. Wyd. Nauk. Univ. A. Mickiewicza, Poznań..

RACINOWSKI R., ŁANCZONT M. and BOGUCKYJ A. (2004*b*) — Comparison of heavy minerals composition in loess in eastern Poland and western Ukraine (in Polish with English summary) In: Geneza, litologia, stratygrafia utworów czwartorzędowych (ed. A. Kostrzewski). IV Ser. Geogr., **68**: 397–412, Wyd. Nauk. Univ. A. Mickiewicza, Poznań.