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On New Sections of Loess-like Deposits of the Rożnów Foothills, West Carpathians, Poland

Nowe stanowiska osadów lessopodobnych na Pogórzu Rożnowskim w Karpatach Zachodnich

ABSTRACT

Sedimentological, mineralogical and malacological studies, alongside with thermoluminescent datings of two sections of loess-like deposits of the Rożnów Foothills allow one to infer that deposition of loess covers in that area commenced at the end of the last interpleniglacial and proceeded during the younger pleniglacial times. These deposits represent chiefly deluvial loesses, the granulometric and malacological properties of which do not differ much from those described from other loess-covered areas in Southern Poland.

INTRODUCTION

Loess-like deposits occurring in the Rożnów Foothills mantle talus feet and encroach upon fluvial deposits laid down during the last and penultimate glacial stages. Their thickness ranges from 3 to 10 m. These deposits occur on either side of the Dunajec river valley (Dąbrowa, Rdziostów) and the artificial dammed up lake of Rożnów (Sienna, Tęgoborze, Roztoka, cf. Fig. 1). Loess-like silts and sandy silts occupy more widespread areas in

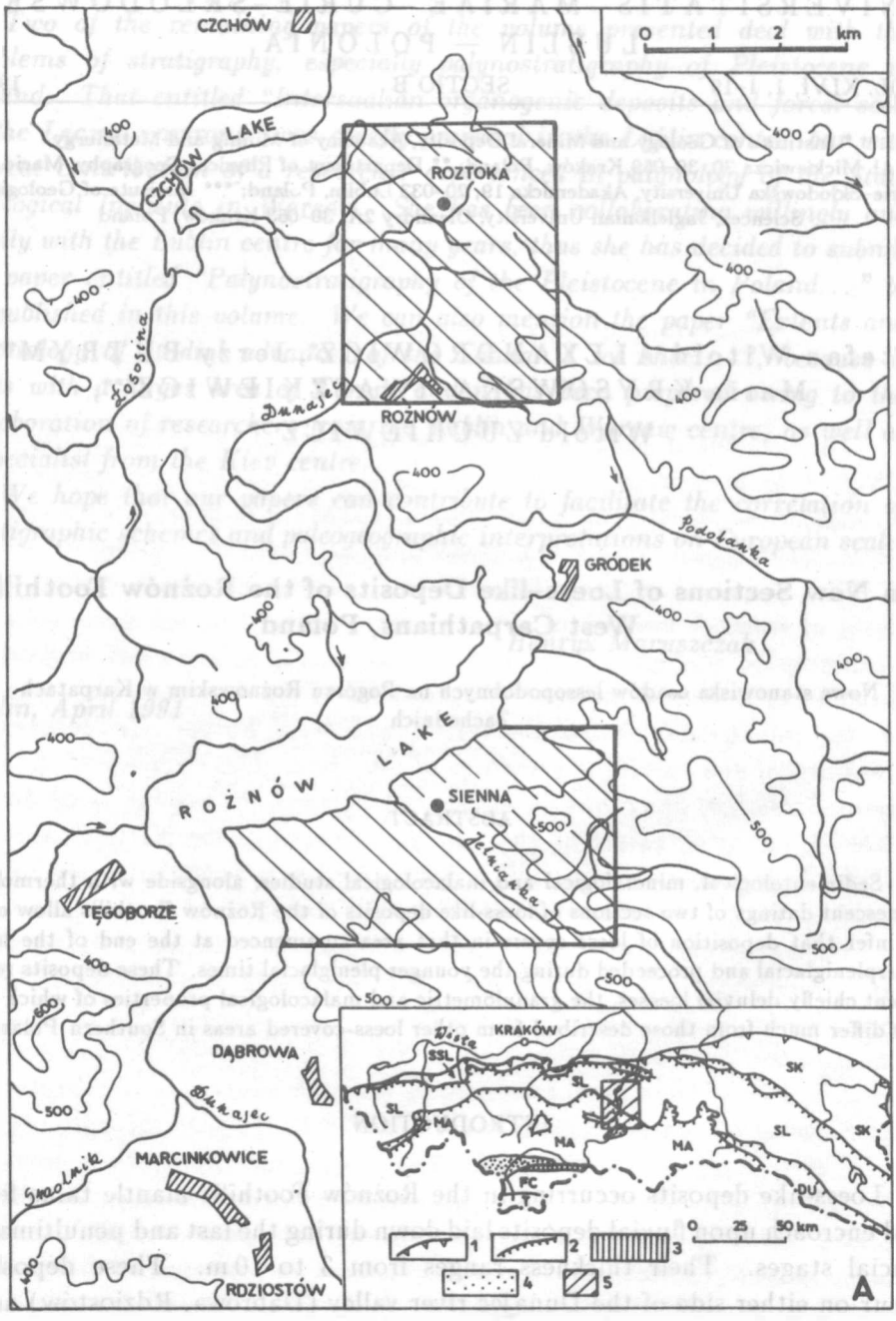


Fig. 1. Localisation sketch of the area studied

A — Geological sketch: 1 — Carpathian frontal thrust; 2 — main nappe thrusts (SK = Skole Nappe, SSL = Sub-Silesian Nappe, SL = Silesian Nappe, DU = Dukla folds, MA = Magura Nappe, FC = Podhale Flysch, T = Tatra unit); 3 — Pieniny clippen belt; 4 — Miocene molasses resting on eroded flysch complexes; 5 — area studied

northern part of the Nowy Sącz Basin, as well as on southern slopes of the Zakliczyn Depression. Both these basins are situated to the south and to the north, respectively, of the Rożnów Foothills.

Loess-like deposits have been mentioned for the first time by W. Szajnocha (1902), S. Sokołowski (1935) and M. Klimaszewski (1937, 1948), and described by J. Cegła (1963), J. Cegła and M. Harasimiuk (1969), W. Zuchiewicz (1984, 1985), S. W. Alexandrowicz and W. Zuchiewicz (1988, 1990), as well as by J. Butrym and W. Zuchiewicz (in print).

The best outcrops of loess-like deposits are situated at Sienna and Roztoka (Fig. 1) on right side of the Dunajec river valley. The section at Sienna, 1 km east of the Rożnów Lake, is located on right side of a small valley of a tributary to the Jelnianka stream, dissecting in its lower reach the medium- to thin-bedded Krosno beds (Oligocene) of the Silesian Nappe. The site at Roztoka, in turn, occupies the Dunajec valley side 2.5 km to the north of Rożnów. The valley bottom consists of a vast, 6.5–7 m high terrace plain dated to the last glacial stage. This terrace is upbuilt close to the Roztoka hamlet (Fig. 1) up to 9–14 m of relative altitude by the alluvial fan of a small tributary stream. Dowstream of the outlet of this stream, a patch of an erosion-accumulational terrace 14–18 m high, resting on a 12 m high rock socles is preserved, being composed of fluvial pebbles intertonguing with solifluction loams. Further upstream, however, a series of 5–10 m thick silt-sandy loams occurs, being composed of silty sands at the bottom and loess deposits at the top. These deposits taper higher upslope to 1.0–2.5 m. The base of this series is formed by the thick-bedded Istebna sandstones (Cretaceous — Paleocene) of the Silesian Nappe.

LITHOLOGY

Loess-like deposits at Sienna are represented by 7–10 m thick (320–330 m a.s.l.) silts and sandy silts, more rarely silty loams, overlying solifluction loams and sand-silty deluvia which intertongue with deposits of an alluvial fan, formed during the Vistulian glacial stage. These deposits mantle the south-exposed talus foot of a hill (401.5 m a.s.l.), forming the interfluve between the right tributary to the Jelnianka stream and the Rożnów Lake (Figs. 1–3). The thickness of silty deposits diminishes upslope.

Site "Sienna S". In southern part of a brickyard at Sienna, the following section (Fig. 4) can be examined, from the top downwards (depth and thickness in metres):

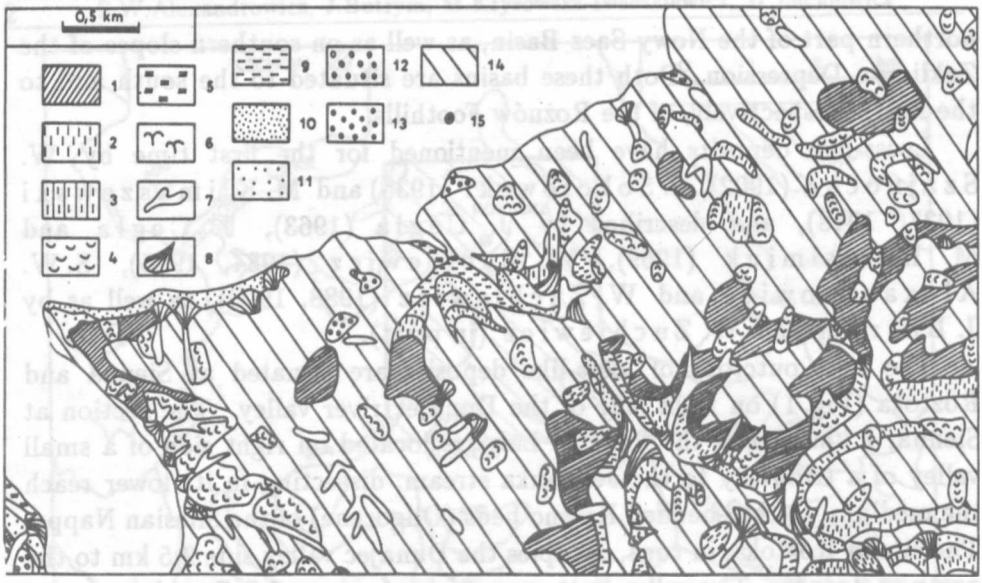


Fig. 2. Map of Quaternary deposits in SE part of the Rożnów Foothills
1 — weathering covers; 2 — solifluction-deluvial deposits; 3 — loess-like deposits; 4 — landslide colluvia; 5 — peat soils; 6 — calcareous tufas; 7 — alluvia infilling small valley bottoms; 8 — alluvial fans; 9 — fluvial deposits of young Holocene floodplains; 10 — fluvial deposits of older Holocene terraces; 11 — fluvial deposits of the Vistulian (Last Glacial) terraces; 12 — fluvial deposits of the Wartanian and Odranian terraces; 13 — fluvial deposits of the Nidanian and Sanian terraces; 14 — solid rocks; 15 — the loess section at Sienna

0.0 — 0.7 Silt-sandy loams and sandy silts, dark-yellow, showing faint lamination parallel to the slope surface. Manifestations of recent pedogenetic processes are visible.

0.7 — 1.0 Silts, pale-yellow, compact and laminated, showing plant intergrowths and bearing a small amount of carbonates. At the base, a 0.5 cm thick limonitic hardpan, rusty and rusty-brownish, has been encountered.

1.0 — 1.5 Silty loams, brown-rusty, laminated, poorly calcareous, bearing malacofauna.

1.5 — 2.0 Sandy silts, light-yellow, laminated, individual laminae attaining 1–3 mm in thickness, interlayered with brown-yellow silts bearing malacofauna, poorly calcareous.

2.0 — 2.5 Compact silts bearing plant remains and infrequent mollusc shells. At the base, singular and angular fragments of the Krosno sandstones, 1–2 cm in diameter, have been encountered.

2.5 — 3.0 Silty loams, yellow, strongly calcareous, bearing small limonitic concretions up to 2 mm in diameter.

3.0 — 4.0 Compact silts, light-yellow, calcareous, bearing infrequent molluscs.

4.0 — 4.5 Silty loams, light-yellow, poorly calcareous, bearing infrequent molluscs.

4.5 — 5.0 Compact silts, light-yellow, structureless, calcareous.

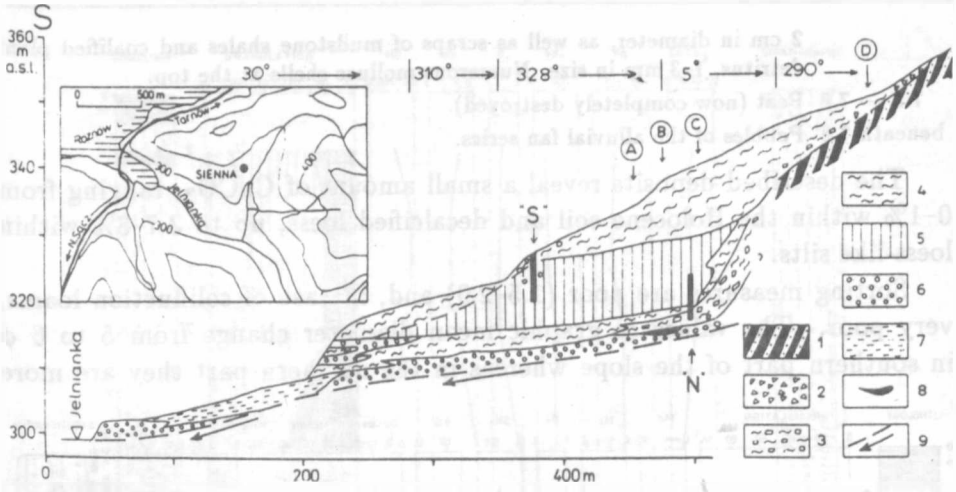


Fig. 3. Stituation of brickyard at Sienna and geological cross-section through the right valley side of the Jelnianka river at Sienna

1 — sandstones and shales of the Krosno beds (Oligocene); 2 — angular weathering debris; 3 — solifluction loams bearing angular debris; 4 — deluvial deposits; 5 — loess-like deposits; 6 — fluvial gravels; 7 — alluvial fan deposits; 8 — peat; 9 — longitudinal profile of the right-hand tributary to the Jelnianka river; A, B, C, D — samples collected from the topmost part of deluvial loesses

5.0 — 5.5 Sandy silts, yellow and rusty, calcareous, bearing plant intergrowths and rich malacofauna. TL date at the base: 25±3 (Lub-1041).

5.5 — 6.0 Silts, light-yellow, structureless, calcareous. TL date at the base: 31±4 (Lub-1040).

6.0 — 7.0 Silts, light-yellow, poorly calcareous.

Site "Sienna N". In northern part of the brickyard, 120 m away from the site "Sienna S", another section (Fig. 5) of loess-like deposits overlying solifluction loams, has been described, from the top downwards;

0.0 — 0.5 Sand-silty loams, brown, bearing infrequent mollusc shells and limonitic rhizoconcretions, 0.5–3 cm in diameter. These deposits pass laterally on the east into loessial muds.

0.5 — 1.0 Silty loams, decalcified, bearing rusty effervescences and containing poor malacofauna.

1.0 — 4.0 Sandy silts and calcareous silts, dark-yellow and brown-rusty at places, heavily jointed.

4.0 — 6.0 Calcareous silts, light-brown, and carbonate-free silty clays, bluish and greenish, forming irregular intergrowths. At the base, isolated angular fragments of the Krosno sandstones, 6–15 cm in diameter, have been encountered. Rich malacofauna.

6.0 — 7.5 Compact silty loams and clays, dark-bluish, greenish when weathered, bearing angular fragments of blue, fine-grained sandstones, 3–6(10) and 0.5–

2 cm in diameter, as well as scraps of mudstone shales and coalified plant detritus, 1–3 mm in size. Numerous mollusc shells at the top.

7.5 — 7.8 Peat (now completely destroyed).

beneath 7.8 Pebbles of the alluvial fan series.

The described deposits reveal a small amount of $CaCO_3$, ranging from 0–1% within the Holocene soil and decalcified loess, up to 3.7–8% within loess-like silts.

Sorting measures are poor (1.5–2.0) and, in case of solifluction loams, very poor. The values of graphic mean diameter change from 5 to 6 ϕ in southern part of the slope whereas in the northern part they are more

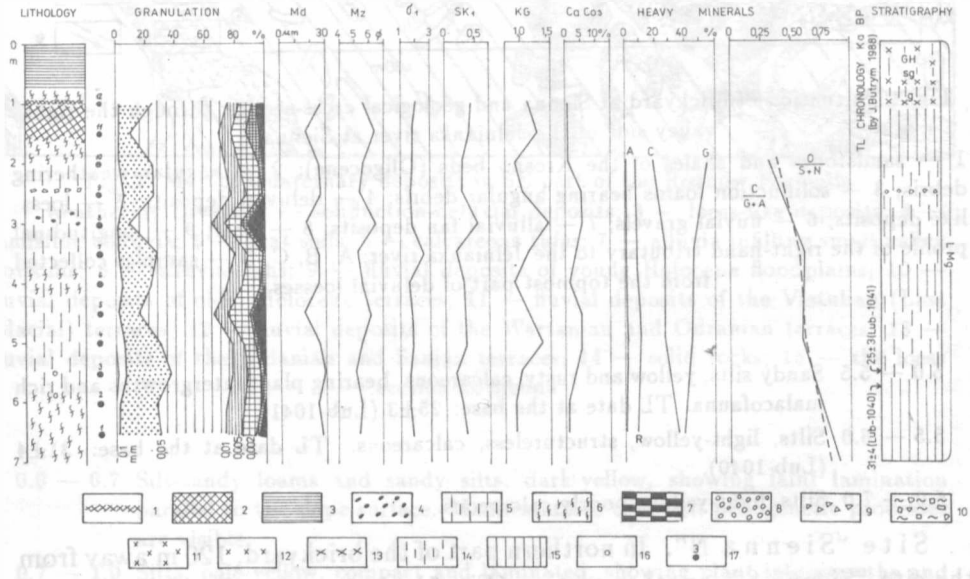


Fig. 4. The loess section S at Sienna

Lithology: 1 — upper, more intensely coloured portion of brownearth and illuvial horizons; 2 — middle, less intensely coloured portion of brownearth and illuvial horizons; 3 — soil sediments showing symptoms of initial humus horizon; 4 — limonitic concretions; 5 — carbonate loess; 6 — decalcified loess; 7 — peat; 8 — fluvial gravels; 9 — angular rock debris; 10 — solifluction loams. Stratigraphy: 11 — soil sediments; 12 — poorly developed soil horizons; 13 — symptoms of the development of pedogenesis; 14 — non-weathered carbonate loess; 15 — weathered carbonate-free loess and deluvia of fossil soils; 16 — TL-dated samples; 17 — sample numbers. Letter symbols for grain-size composition diagrams: M_z — graphic mean diameter; M_d — median grain size; σ_1 — graphic standard deviation; SK_1 — inclusive graphic skewness; K_G —kurtosis. Transparent heavy minerals: A — amphibole; R — rutile; C — zircon; G — garnet; O — most resistant minerals; S — moderately resistant minerals; N — non-resistant minerals. Soil and stratigraphy units: GH — recent (Holocene) soil; sg — soil deposits; (g) — symptoms of the development of pedogenesis; LMg — upper younger loess

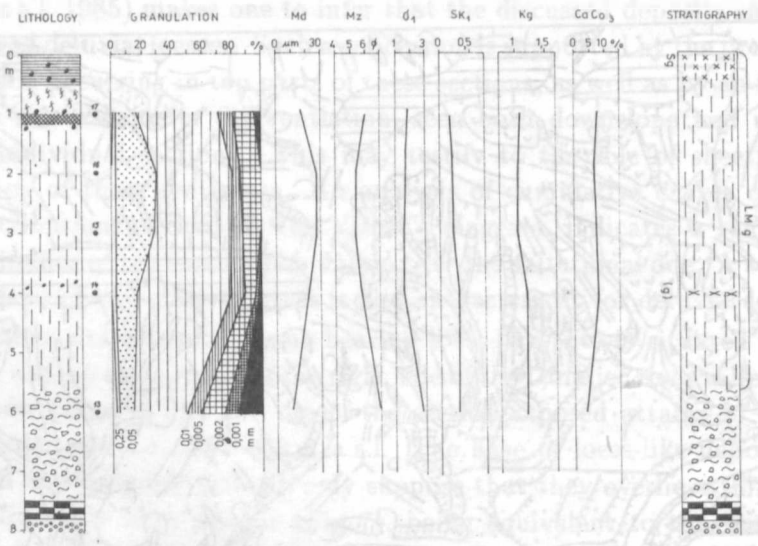
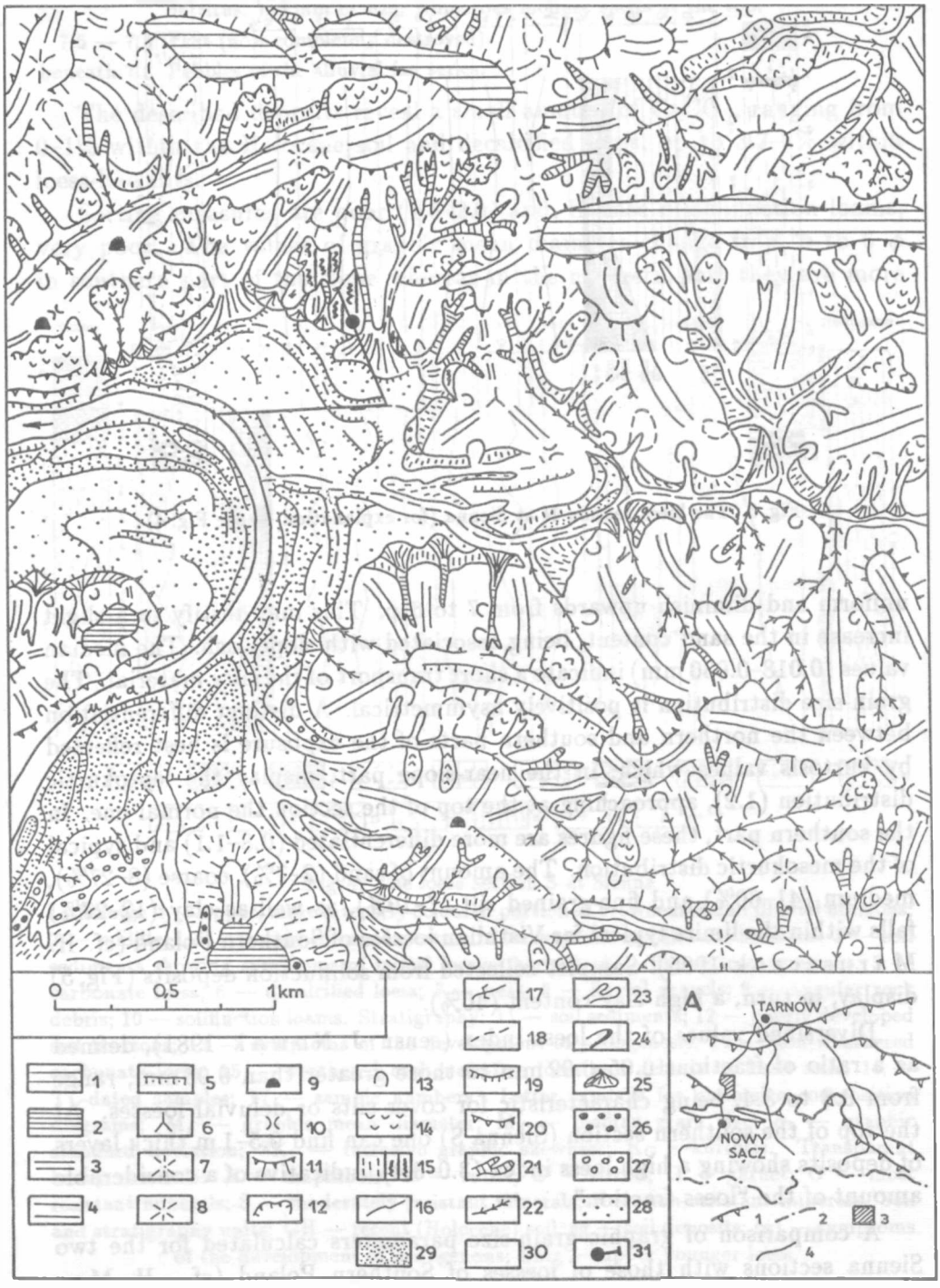


Fig. 5. The loess section N at Sienna (for explanation — see Fig. 4)

uniform and diminish upwards from 7 to 6 ϕ. This may testify to a slight increase in the sand content, being associated with slopewash. The median values (0.018–0.030 mm) indicate a short transport of the silty material. The grain-size distribution is positively asymmetrical. A distinct differentiation between the northern and southern parts of the exposure is best reflected by kurtosis values which, in the near-slope part, display the leptokurtic distribution (1.2), approaching at the top of the section the normal one. In the southern part, these figures are more differentiated (0.8–1.1) and typical of the mesokurtic distribution. The amount of sand (2–7%), coarse (8–27%), medium (41–60%) and fine-grained silt (7–10%), as well as clay (12–27%) falls within the limits typical for Vistulian loesses of Southern Poland (cf. H. Maruszczak 1985). Samples collected from solifluction deposits (Fig. 5) display, in turn, a high clay content (40%).

Diversified values of the loess index (sensu J. Nowak 1981), defined as a ratio of fractions 0.05–0.02 mm to those greater than 0.05 mm, range from 0.8 to 3.4, being characteristic for cover silts or deluvial loesses. At the top of the southern section (Sienna S) one can find 0.5–1 m thick layers of deposits showing a high loess index (3.0–3.4), indicative of a considerable amount of the "loess fraction".

A comparison of graphic grain-size parameters calculated for the two Sienna sections with those of loesses of Southern Poland (cf. H. Ma-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ruszczak 1985) makes one to infer that the discussed deposits should be considered deluvial loesses. Such a conclusion is supported by the presence of lamination occurring in top parts of these sections, as well as by an increase in grain-size parameter differentiation, seen both downslope and upwards within individual sections. This may testify to the role of sheetflood in deposition of these sediments. An analysis of cumulative curves of grain-size distribution, plotted on the Visher's diagram, indicates a remarkable predominance of suspension population over the saltational one. A segment-like pattern of cumulative curves is also characteristic for deluvial loesses.

Another site of malacofauna-bearing loess-like silts is situated at Roztoka, on a steep escarpment of the right side of the Dunajec river valley, north of Rożnów (Figs. 1, 6). The top of the section exposed attains 27–28 m of relative altitude, i.e., 257–258 m a.s.l. The base of loess-like deposits has not been encountered; one can only suppose that they overlie a thin gravel series of the 14–18 m terrace (Fig. 7), being equivalent to the Wartanian terrace plain occurring further south (J. Butrym and W. Zuchiewicz, in print). Loess-like deposits are composed of structureless silts and faintly laminated sandy silts, showing subvertical jointing and bearing rich malacofauna. The section chosen for TL dating and malacological studies reveals the following succession (from the top downwards):

0.0 — 1.0 Silt-sandy loams, yellow, altered by Holocene pedogenetic processes.

1.0 — 3.0 Silty sands, pale-yellow, faintly laminated, bearing frequent platelets of muscovite and scanty malacofauna.

3.0 — 3.5 Silty sands and sandy silts, pale-yellow, laminated, the thickness of laminae being 2–5 mm, bearing poor malacofauna, slightly calcareous.

Fig. 6. Geomorphological map of the Roztoka area

Planation surfaces: 1 — foothills level (Late Pliocene); 2 — river-side level (Early Pleistocene). Ridges formed at intersection of valley-sides: 3 — narrow; 4 — broad and rounded; 5 — isoclinal ridges. Large summits: 6 — cone-like; 7 — rounded; 8 — dome-like. Small summits: 9 — rounded; 10 — passes; 11 — structural escarpments; 12 — scars of landslides; 13 — small landslips and landslumps; 14 — landslide colluvia; 15 — solifluction-deluvial (a) and loess-like (b) deposits; 16 — river beds cut into solid rocks; 17 — hanging valley steps; 18 — river beds cut into alluvia; 19 — terrace risers; 20 — undermined slopes. Small valleys: 21 — gullies; 22 — V-shaped valleys; 23 — dellen; 24 — asymmetrical valleys; 25 — alluvial fans. Terrace plains: 26 — Nidanian and Sanian; 27 — Odranian and Wartanian; 28 — Vistulian; 29 — Holocene (older); 30 — Holocene (younger); 31 — the loess section at Roztoka A — localisation sketch: 1 — main thrusts; 2 — state frontier; 3 — area shown in the geomorphological map; 4 — rivers

3.5 — 4.0 Sandy silts, pale-yellow, indistinctly laminated, bearing infrequent mollusc shells up to 3 mm in diameter, poorly calcareous. TL date at the top: 17 ± 2.5 ka BP (Lub-1172).

4.0 — 4.2 Sandy silts, pale-greyish and light-yellow, structureless, bearing chaotically distributed fine and scanty malacofauna.

4.2 — 4.5 Sandy silts, pale-yellow, faintly laminated, showing rusty spots and bearing poor malacofauna, slightly calcareous.

4.5 — 4.6 Sandy silts, yellow, laminated, bearing redeposited malacofauna, 1–4 mm in diameter.

4.6 — 5.5 Sandy silts, pale-yellow, structureless and compact, bearing poor malacofauna, slightly calcareous.

5.5 — 5.8 Sandy silts, pale-yellow, structureless, bearing plant intergrowths and fine mollusc shells, slightly calcareous.

5.8 — 6.0 Sandy silts, yellow, faintly laminated, lamination underlined by limonitic effervescences, calcareous, bearing malacofauna.

6.0 — 6.4 Sandy silts, pale-yellow, structureless, calcareous, bearing plant intergrowths and malacofauna.

6.4 — 6.5 Sandy silts, pale-yellow, structureless, showing rusty spots.

6.5 — 6.7 Sandy silts, pale-yellow, structureless, calcareous, bearing rare plant intergrowths.

6.7 — 6.8 Sandy silts, yellow, laminated, individual laminae being 4–5 mm thick, underlined by limonitic effervescences, bearing singular mollusc shells.

6.8 — 7.0 Sandy silts, light-greyish, bearing scanty and crushed mollusc shells, slightly calcareous.

7.0 — 7.2 Sandy silts, pale-yellow, faintly laminated, individual laminae 3–5 mm thick, being composed of silt and sandy silts.

7.2 — 7.5 Sandy silts, pale-yellow, structureless, calcareous, bearing chaotically distributed crushed mollusc shells.

7.5 — 7.9 Sandy silts, pale-yellow and light-greyish, structureless and compact, bearing scanty mollusc shells. TL date at the top: 18±2.5 ka BP (Lub-1170).

7.9 — 8.0 Sandy silts, pale-yellow, bearing intercalation of silty sand, yellow, numerous plant intergrowths and limonitic rhizoconcretions.

8.0 — 8.5 Sandy silts, pale-yellow, compact, slightly calcareous, bearing chaotically distributed, undestroyed mollusc shells.

8.5 — 9.0 Sandy silts, pale-yellow, structureless, calcareous, bearing rich, finely crushed malacofauna. TL date at the bottom: 27±4 ka BP (Lub-1171).

This section shows a great resemblance to that exposed in southern part of the Sienna brickyard, being correlated with the upper younger loess (sensu H. Maruszczak 1980, 1985). Thermoluminescent datings suggest a relatively quick deposition during the younger pleniglacial times.

HEAVY MINERAL COMPOSITION

Analyses of heavy mineral composition concerned four samples collected at the Sienna S section, two samples from the Sienna N section, as well as

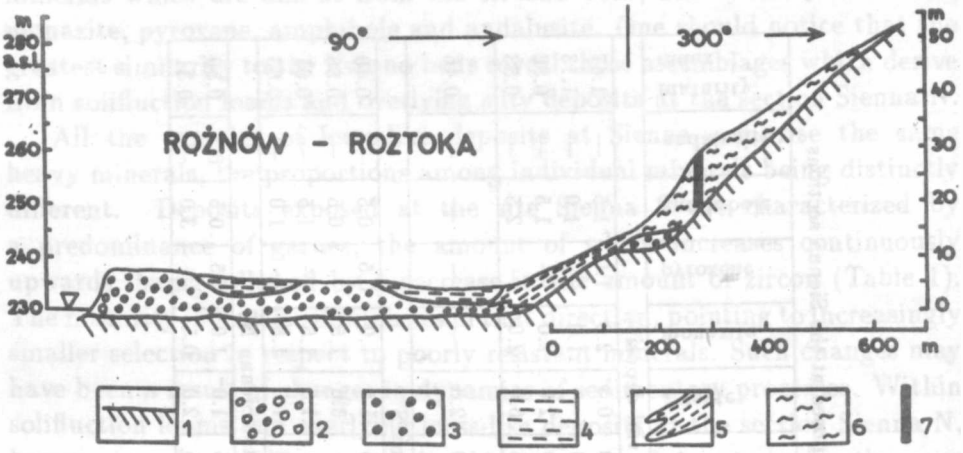

Fig. 7. Cross-section through the right valley side of the Dunajec river at Roztoka
1 — solid rocks (Istebna beds, Upper Cretaceous–Paleocene); 2 — Holocene and Vistulian fluvial deposits; 3 — Wartanian fluvial deposits; 4 — infillings of abandoned channels; 5 — alluvial fan deposits; 6 — loess-like deposits; 7 — localisation of the section studied

four samples taken from the topmost part of the overlying slope cover. For comparative purposes, heavy minerals of the Krosno sandstones have also been analyzed. These analyses consider grains of diameters smaller than 0.5 mm.

Heavy mineral assemblages are composed chiefly of garnet, zircon, rutile and epidote, less frequent are tourmaline, titanite, topase, apatite, monazite and zoisyte, whereas cyanite, staurolith, pyroxene, amphibole and andalusite form subordinate admixtures. Their content is shown in Table 1. These assemblages comprise resistant and very resistant minerals. A ratio of very resistant minerals (zircon, tourmaline, rutile) to the other ones, called the maturity index of terrigenic material, changes from 0.31 to 0.83, testifying to a predominance of resistant minerals. This index attains the highest values for samples C and D (cf. Fig. 3), collected from the upper part of the slope cover and is 1.13 and 1.47, respectively.

Heavy mineral assemblages encountered in loess-like deposits at Sienna show a close resemblance to those in sandstones of the Krosno beds. The former display, however, a lower (Sienna S and Sienna N) and considerably

Table 1. Heavy mineral composition of loess-like deposits exposed at the Sienna sections

Samples	garnet	zircon	tourmaline	staurolith	rutile	cyanite	epidote	titanite	topase	apatite	zoisyte	monazite	pyroxene	amphibole	andalusite	maturity index
The topmost part of section at Sienna — deluvial deposits																
D	26.0	45.0	1.0	0.5	13.5	1.0	6.0	0.5	0.5	1.0	0.5	2.0	1.0	1.5	—	1.47
C	31.0	41.0	1.5	1.0	10.5	—	7.0	3.0	2.0	1.0	—	1.0	—	1.0	—	1.13
B	30.5	32.0	2.0	1.0	10.0	1.0	8.0	4.0	3.5	2.0	2.0	2.0	—	1.5	—	0.80
A	26.0	26.0	2.0	3.0	6.0	1.5	14.0	4.5	3.5	3.5	6.0	2.0	—	2.5	—	0.53
base: Krosno sandst.	57.5	17.0	7.5	—	7.0	—	3.5	1.0	3.5	1.0	2.0	—	—	—	—	0.46
The section of loess-like deposits "Sienna S"																
S–10	55.0	18.5	3.5	1.0	7.0	—	6.5	1.5	2.0	1.5	1.5	1.0	0.5	0.5	—	0.40
S–7	44.5	27.5	2.0	2.5	7.5	0.5	5.0	2.5	3.0	—	3.0	1.5	—	0.5	—	0.58
S–4	44.0	27.0	1.0	2.0	10.0	—	6.0	3.5	2.0	—	1.5	1.5	—	1.5	—	0.61
S–1	39.0	36.0	1.5	1.0	8.0	—	5.5	4.0	1.0	0.5	1.0	1.5	—	1.0	—	0.83
The section of loess-like and solifluction deposits "Sienna N"																
S–16	51.5	21.5	2.5	1.0	9.0	—	7.0	1.5	2.0	0.5	1.0	1.0	0.5	0.5	0.5	0.50
S–13	62.0	19.0	2.0	0.5	3.0	0.5	3.0	2.0	2.0	0.5	2.0	0.5	—	3.0	—	0.31

lower (samples A through D) amount of garnet and tourmaline, that of zircon, epidote and titanite being a little higher. There also occur those minerals which are absent from the Krosno beds, like cyanite, staurolith, monazite, pyroxene, amphibole and andalusite. One should notice that the greatest similarity to the Krosno beds reveal those assemblages which derive from solifluction loams and overlying silty deposits at the section Sienna N.

All the samples of loess-like deposits at Sienna comprise the same heavy minerals, the proportions among individual minerals being distinctly different. Deposits exposed at the site Sienna S are characterized by a predominance of garnet, the amount of which increases continuously upwards, being followed by a decrease in the amount of zircon (Table 1). The maturity index also diminishes in that direction, pointing to increasingly smaller selection in respect to poorly resistant minerals. Such changes may have been a result of changes in dynamics of sedimentary processes. Within solifluction loams and overlying loess-like deposits at the section Sienna N, heavy mineral assemblages contain a high amount of garnet, dominating over that of zircon. These assemblages are fairly similar to those found within sandstones of the Krosno beds; they contain, however, a relatively high admixture of other minerals, like cyanite, staurolith, monazite, pyroxene, amphibole, andalusite and syllimanite. A very low, especially within solifluction loams, maturity index (0.31) points to a poor selection of detrital material.

At the top of overlying silty slope deposits there occur heavy mineral assemblages being considerably different from those of the above described sections Sienna S and Sienna N. These differences consist in a higher amount of zircon and its predominance over garnet (cf. Table 1), except for sample A wherein these two minerals have an equal share. The other minerals occur in quantities comparable with those of the loess-like deposits. The maturity index calculated for deposits of lower part of the slope testifies to a weak selection of poorly resistant minerals, while that determined for the upper part indicates a considerably better selection. Such a differentiation may have resulted either from changes in intensity of depositional processes or from subsequent weathering alterations.

Heavy mineral composition enables us to infer that parent rocks for loess-like deposits at Sienna were sandstones of the underlying Krosno beds. The presence of other minerals, chiefly cyanite, staurolith, monazite, pyroxene, amphibole, and syllimanite, indicates an admixture of the Scandinavian material, derived from glacifluvial deposits associated with the South-Polish inland ice advance and exposed 10–15 km to the north of Sienna. A predominance of resistant and poorly resistant minerals over very resistant

ones testifies to a poor selection of the material, whereas poor rounding of mineral grains implies a short transport route.

Varying proportions among heavy minerals and, especially, the variable amount of garnet indicate that loess-like deposits at Sienna originated due to different depositional processes, including solifluction, aeolian and sheetwash ones. Taking into account that garnet remains unaltered mainly in aquatic environment (M. Turnau-Morawska 1955, B. Kosmowska-Ceranowicz 1966, M. Krysowska-Iwaszkiewicz 1974) one can suppose that garnet-rich deposits of the Sienna sections were being washed out and deposited in a moist environment, unsuitable for garnet weathering. A close proximity to the valley bottom was also important. However, a considerable reduction in garnets in respect to parent rocks, i.e., the Krosno sandstones, observed in overlying silty slope deposits (samples A through D), suggests that the latter may have been deposited under dry conditions. On the other hand, different proportions among garnets recorded in parent rocks and overlying covers may have also result from different size of mineral grains composing the Krosno sandstones and loess-like silts.

MALACOLOGICAL COMPOSITION OF LOESS-LIKE DEPOSITS

Two malacofauna-bearing sites of deluvial loesses have been encountered on the eastern Dunajec valley sides in the Rożnów Foothills. The fauna is relatively rich and distinctly differentiated, showing a great resemblance to that of Vistulian loesses occurring in the Małopolska and Lublin Uplands.

The loess deposits exposed at Sienna bear 9 taxons, namely: *Columella columella* (Martens), *Vertigo parcedentata* (Braun), *Pupilla loessica* Lożek, *P. muscorum densegyrata* Lożek, *Vallonia tenuilabris* (Braun), *Succinea oblonga elongata* Sandberger, *Semilimax kotulai* (Westerlund), *Clausilia dubia* Draparnaud, and *Trichia hispida* (Linnaeus). The dominant components are *Succinea oblonga elongata* and *Pupilla loessica*; from the remaining species only *Columella columella* and *Vallonia tenuilabris* do form more numerous populations, the other ones being accessory components. Malacofaunistic composition and differentiation have been studied at two sections. The southern one (cf. Fig. 8, Sn-S) reveals the presence of 5 snail species. In the lower part of this section, malacological assemblage is composed of a large number of specimens, exceeding 400 shells per sample. The share of two dominant species attains 95%, while the proportion between *Succinea oblonga elongata* and *Pupilla loessica* approaches that of 7:3. *Columella columella* is an accompanying element,

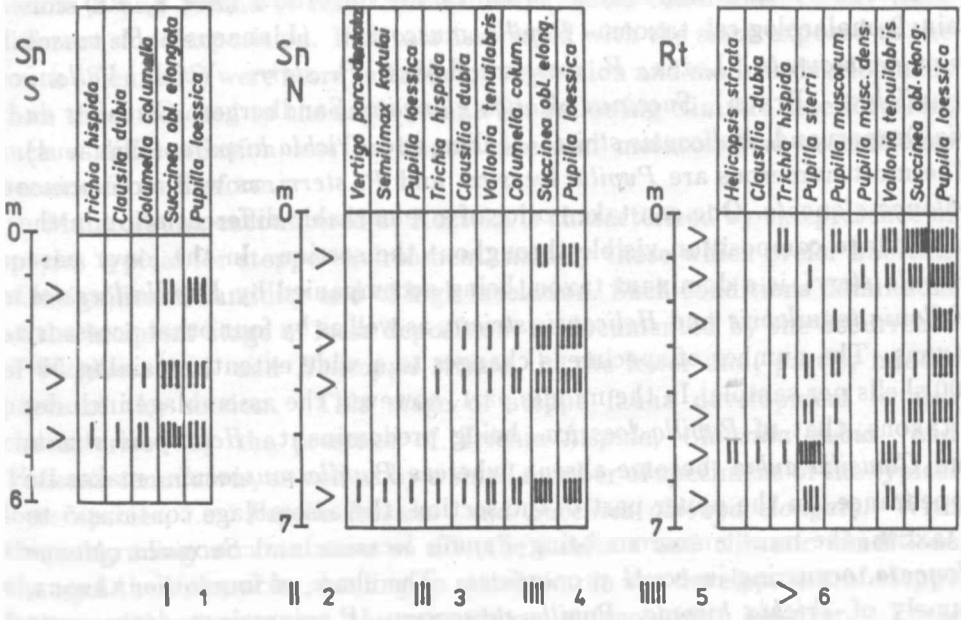

Fig. 8. Malacological sections of loess-like deposits of the Rożnów Foothills: Sn — Sienna (S — southern part, N — northern part), Rt — Roztoka
1–5 frequency of specimens: 1 — singular, 2 — rare, 3 — few, 4 — common, 5 — abundant; 6 — sampling sites

attaining several per cent, whereas *Clausilia dubia* and *Trichia hispida* are represented by isolated specimens. In the middle part of the section, both these accessory components disappear, and the proportion between *Succinea* and *Pupilla* approaches 5:5. In the upper part, however, the assemblage includes only two dominant taxons, that of *Pupilla* being predominant.

In the northern Sienna section (Fig. 9, Sn-N), malacological assemblages are composed of more numerous species. The lower part of this section displays numerous molluscs, up to 350 specimens per sample, the whole of the association being composed of 9 taxons. Dominant components are: *Succinea oblonga elongata* (55%) and *Pupilla loessica* (34%). Two other species, *Columella columella* and *Vallonia tenuilabris* attain up to several per cent each, while the remaining ones constitute only 2%. In the middle part of the section, the assemblage contains 6 species. A slight predominance of *Pupilla loessica* over *Succinea oblonga elongata* is noticeable. From the remaining taxons, only *Columella columella* does attain several per cent of the total number of specimens. In the upper part, the two dominant taxons occur, that of *Pupilla loessica* being predominant.

Deluvial loesses exposed at Roztoka near Rożnów (Fig. 8, Rt) contain 9 malacological taxons: *Pupilla muscorum* (Linnaeus), *P. muscorum densegyrata* Ložek, *P. loessica* Ložek, *P. sterri* Voith, *Vallonia tenuilabris* (Braun), *Succinea oblonga elongata* Sandberger, *Clausilia dubia* Draparnaud, *Helicopsis striata* Müller, and *Trichia hispida* (Linnaeus). The most numerous are *Pupilla loessica* and *P. sterri*, as well as *Succinea oblonga elongata*. One can take notice of a remarkable differentiation in the assemblage composition visible throughout the section. In the lower part, *Pupilla sterri* is a dominant taxon, being accompanied by *Pupilla loessica*, *Vallonia tenuilabris* and *Helicopsis striata*, as well as by four other accessory taxons. The number of specimens changes to a wide extent, attaining 50–300 shells per sample. In the middle part, however, the assemblage includes 7 taxons, that of *Pupilla loessica* being predominant. *Helicopsis striata* and *Clausilia dubia* become absent, whereas *Pupilla muscorum* makes its appearance. In the upper part of the section, the assemblage contains 5 to 6 taxons, the most numerous being *Pupilla loessica* and *Succinea oblonga elongata*, occurring in equal proportions. The share of four other taxons, namely of *Trichia hispida*, *Pupilla muscorum*, *P. muscorum densegyrata* and *Vallonia tenuilabris*, is also significant.

Deluvial loesses exposed at Sienna and Roztoka are, probably, of the same age and refer to the upper younger loess LMg (sensu H. Maruszczak 1980, 1985). The changes observed in malacological composition reflect a prograding evolution of climate while differences among assemblages being characteristic for individual sites seem to portray diversified habitats, which show different humidity, exposition and plant cover.

At Sienna, the most numerous and diversified molluscan assemblages are confined to lower parts of loess sections, becoming distinctly impoverished in their upper parts. The presence of species showing restricted ecological valence indicates that at the beginning of loess deposition, the environment must have been relatively humid and suitable for development of both vegetation and molluscs. Following the prograding silt deposition, a gradual drying up of habitats and the associated climatic cooling resulted in restricted vegetation and elimination of the majority of snails. The upper parts of loess sections display only two species of the widest ecological valence, being typical for different loess facies. A change in proportions between the number of specimens of *Pupilla loessica* and *Succinea oblonga elongata*, visible at Sienna and Roztoka, is also indicative of diminishing humidity.

Differences in malacological composition observed between sections

Sienna S and Sienna N result from different local conditions, chiefly from different slope exposition. Habitats associated with the slope exposed to the south (Sienna N) were more suitable for vegetation and mollusc development than those exposed to the east (Sienna S). Following climatic deterioration, such a differentiation lost its importance and malacological assemblages became more uniform.

Malacofauna encountered at Roztoka is characterized by the presence of species typical for steppe environment, namely those which prefer habitats of insignificant humidity and of high insolation. Such conditions dominated at the incipient stage of loess deposition, as documented by the occurrence of *Pupilla sterri* and *Helicopsis striata* in the lower and, partly, middle parts of the section. This stage of steppe fauna development is also characterized by the presence of *Trichia hispida, Clausilia dubia* and *Vallonia tenuilabris*, as well as by a small number of specimens of the typical loess species, i.e., *Pupilla loessica* and *Succinea oblonga elongata*. With the prograding accumulation of silt, the habitats and climatic conditions changed their character, leading to restriction in the development of steppe fauna, without changing the assemblage composition, however. Local conditions provided possibilities of survival of several species which, at other localities, disappeared earlier. Differences observed between Sienna and Roztoka reflect very well the importance of local habitat differentiation for the character of malacological assemblages.

Malacofauna of deluvial loesses preserved on the Dunajec valley sides shows a great resemblance to assemblages found within different types of the Carpathian loess-like deposits (S. W. Alexandrowicz 1987, 1989), as well as to that occurring in loesses of the Carpathian foreland (S. W. Alexandrowicz 1985). The faunistic composition does not differ much from that described from typical loesses of the Małopolska Upland, the Lublin Upland, and the Sandomierz Basin. The age of this fauna may be associated with the declining phase of the interpleniglacial and the younger pleniglacial times.

FINAL REMARKS

The position of the investigated deposits immediately beneath the poorly developed Holocene soil, alongside with their grain-size parameters and heavy mineral composition, as well as the results of thermoluminescent datings allow us to suppose that deposits at Sienna and Roztoka belong to the upper younger loess (sensu H. Maruszczak 1980). TL age

determinations of samples collected at the base of both these sections indicate that deposition of silts and sandy silts took place at the beginning of younger pleniglacial times of the Vistulian glaciation. Such a conclusion is also supported by malacological analyses. The latter, together with sedimentological obsevations and the results of heavy mineral determinations indicate clearly that deposition of top parts of the loess sections proceeded under increasingly drier climatic conditions, marking the pessimum of the last glacial.

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STRESZCZENIE

Badania sedymentologiczne, malakologiczne oraz składu minerałów ciężkich, jak również datowania metodą TL, wykonane w dwóch profilach utworów lessopodobnych Pogórza Rożnowskiego wykazały, że ich depozycja na osadach rzecznych z przedostatniego (Roztoka) i ostatniego (Sienna) glacjału miała miejsce u schyłku ostatniego interpleniglacjału oraz w młodszym pleniglacjale. Miąższość utworów lessopodobnych wynosi 7–10 m, a ich cechy granulometryczne oraz skład malakofauny nie odbiegają od typowych dla lessów Vistulianu Polski Południowej. W składzie minerałów ciężkich dominują zespoły właściwe skałom bezpośredniego podłoża, wzbogacone w składniki pochodzenia skandynawskiego, dostarczone z osadów glacifluwialnych zlodowacenia Sanu. W profilu pionowym utworów lessopodobnych, w przedziale wiekowym od 31±4 do 17±2.5 ka BP, zaznaczał się stopniowy wzrost suchości klimatu.