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STUDIES ON PALEOGEOGRAPHIC CHANGES IN THE NORTHWESTERN PART OF THE CARPATHIAN BASIN, IN THE VICINITY OF THE SECTION AT DOLNÍ VĚSTONICE

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Abstract:

The *objectives* of our studies were to contribute to a more exact knowledge of the paleogeographic changes along the western margin of the Carpathian Basin, in the Moravian Plateau. The method of granulometric analyses worked out and applied by our team was used in the investigations into Quaternary sediments (mainly loess and loess-like deposits).

The *method* was the joint study of the six parameters as environmental indicators. Quaternary deposits were characterised and conclusions drawn as to the change in the dynamics of rates of sedimentation and correlation between the local layers with similar characteristics. For these analyses the traditional granulometric parameters *(S_o–-sorting, K–kurtosis, S_k–steepness, M_d–median value)*were applied and visualised along with two novel environmental indices (*FG* – fineness grade and K_d – degree of weathering) and with $CaCO_3$ content, percentage of clay, silt, loess and sand fractions.

The *interpretation* of the results provides a more detailed information to be obtained on the geomorphic evolution of the studied areas much more rapidly than previously. This information includes paleogeographic conditions during the deposition of the initial material of loess, changes in the geographical environment such as climatic fluctuations over the past 2 million years, climatic oscillations during the ice age, occurrence of warming and cooling maxima. Using this method a comparative analysis of profiles from different loess regions have become feasible.

Key words:

loess, paleogeographic changes, granulometric analysis, Dolni Vestonice, Carpathian basin.

ISTRAŽIVANJE PALEOGEOGRAFSKIH PROMJENA NA SJEVEROZAPADNOM RUBU KARPATSKOG BAZENA U BLIZINI DOLNÍ VĚSTONICE

Izvadak:

Ciljevi našeg istraživanja su pridonošenje boljim spoznajama o paleogeografskim promjenama duž zapadnog ruba Karpatskog bazena, na području

Moravske zaravni. Za istraživanje kvartarnih sedimenta (uglavnom lesa i lesu sličnih naslaga) primijenjena je metoda granulometrijske analize.

Glavna metoda je bila zajednička studija šest različitih parametara kao indikatora okoliša. Kvartarni sedimenti su istraživani u smislu promjena u dinamici sedimentacije i izvršena je korelacija između lokalnih slojeva sa sličnim značajkama. Za ove analize četiri standardna granulometrijska parametra (S_o – koeficijent sortiranja, K - kurtozis, S_k – koeficijent asimetrije, M_d - medijan) su kombinirana s dva nova parametra (FG – stupanj finoće i Kd – stupanj trošenja) te sa podacima o sadržaju $CaCO_3$ i udjelu frakcija gline, silta, lesa i pijeska.

Interpretacija ovih rezultata daje u odnosu na prethodna istraživanja mnogo detaljnije informacije o geomorfološkoj evoluciji istraživanog područja. Ti podaci obuhvaćaju paleogeografske uvjete tijekom taloženja inicijalnog materijala lesa, promjene u geografskom okolišu poput klimatskih fluktuacija u zadnjih 2 milijuna godina, klimatske oscilacije za vrijeme ledenog doba te pojave toplih i hladnih maksimuma. Upotrebom ove metode komparativna analiza profila iz različitih područja lesa postaje izvediva.

Ključne riječi:

les, prapor, paleogeografske promjene, granulometrijska analiza, Dolní Věstonice, Karpatski bazen

MAIN GEOMORPHIC FEATURES

The section of Dolní Věstonice is located in the Moravian Depression, along the northwestern margin of the Carpathian Basin. The depression can be further subdivided into trenches, hills, plateaus and microregions of mountains.

The section is to be found on the northern foreland of the Pavlov Hills in the Dyje Valley. Here the river is dammed up to form a water reservoir ca 35 km from the city of Brno (*Figs 1, 2, 3, 4*). The lower part of the hills otherwise built of Jurassic limestones is covered by Paleogene marl and sandstone. A considerable amount of Paleogene deposits have been removed from the slopes by mud flows and loess slides. On the foothills marl is directly superimposed by loess of considerable thickness.

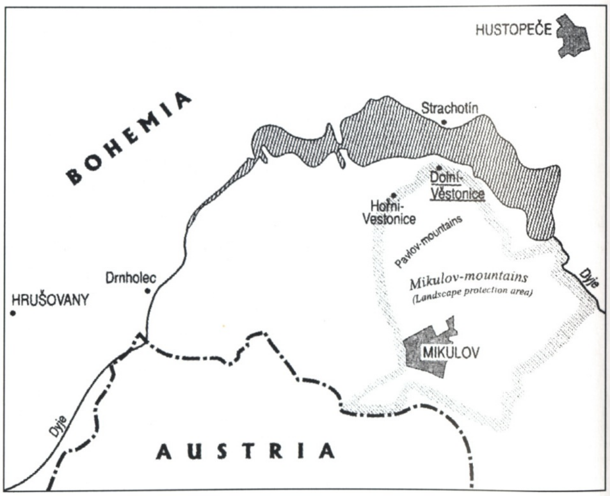

Fig. 1: A sketch of geographical setting of the section at Dolní Věstonice

Sl. 1: Skica geografskog položaja Dolní Věstonice

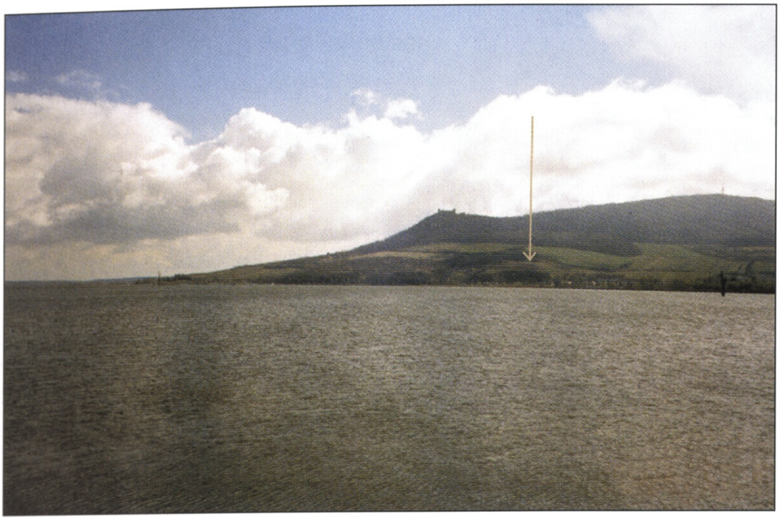

Fig. 2: Cryopediment of the Pavlov Hills (Pollauer Berg), with the section and the loess plateau consisting several Paleolithic sites in the foreground
Sl. 2: Kriopediment Pavlovog pobrđa (Pollauer berg) s profilom i lesnom zaravni s nekoliko paleolitskih lokaliteta u prvom planu

Fig. 3: North-eastern part of the depression along the Dyje River. This water-course was dammed up to form a 16 km long reservoir
Sl. 3: Sjeveroistočni dio bazena duž rijeke Dyje. Ovaj vodeni tok je pregrađen branom i tvori 16 km dugo umjetno jezero

Fig. 4: Panoramic view from the top of the youngest loess pocket. On the opposite side (beyond the river terrace) at Popice ice wedges of various type (ice wedge pseudomorphoses, clay wedges, sand wedges of primary infilling and composite wedges) occur together
Sl. 4: Panoramski pogled s vrha najmlađeg lesnog džepa. Na suprotnoj se strani (iznad riječne terase kod Popica) zajedno pojavljuju različiti tipovi ledenih klinova (pseudomorfi ledenih klinova, glinoviti klinovi, pješčani klinovi s primarnom ispunom, kompozitni klinovi)

Fig. 5: Middle part of the profile
Sl. 5: Središnji dio profila

Fig. 6: Eastern wall of the section with the youngest loess pocket in the upper left corner
Sl. 6: Istočni zid profila s najmlađim lesnim džepom u gornjem lijevom kutu

LOESS AND EOLIAN SAND IN THE VICINITY OF DOLNÍ VĚSTONICE

According to the parameter values used 19 layers could be identified along the profile (*Fig. 7*, *Table 1*, and *Table 2* as for the sedimentological parameter values):

I. *10 soil horizons*

3 soil series (the lower one containing 2 soils; the middle one with 3 soils and the uppermost one with 2 soils)

2 horizons of low humus content

1 recent soil

II. *6 loess horizons*

III. *2 'marker loess' horizons* (of a ca 5 cm thick layer above the lower soil sequence that cannot be depicted on the figure and an another one above the lower chernozem within the middle soil sequence).

A detailed description of the meaning of parameters applied for characterising the profiles and possible interpretations of their values is to be found in the article entitled „The Reconstruction of the Paleoenvironmental History of the Northern Adriatic Region Using of the Granulometric Properties of Loess Deposits on Susak Island, Croatia" of the present volume.

When presenting granulometric parameter values in a table, the newly introduced two parameters, fineness grade (*FG*) and degree of weathering (K_d) are shown side by side. *FG* serves for an exact separation of sediments from each other, reconstruction of paleotopography, and (based on the trend of the percentage value to increase or decrease) for the establishment of wind direction and velocity. K_d index represents extremes of warming and cooling within the sequences. Of the traditional parameters S_o creates opportunity to distinguish between sediments on the basis of their origin, *K* serves for separating loess from soil sediments,

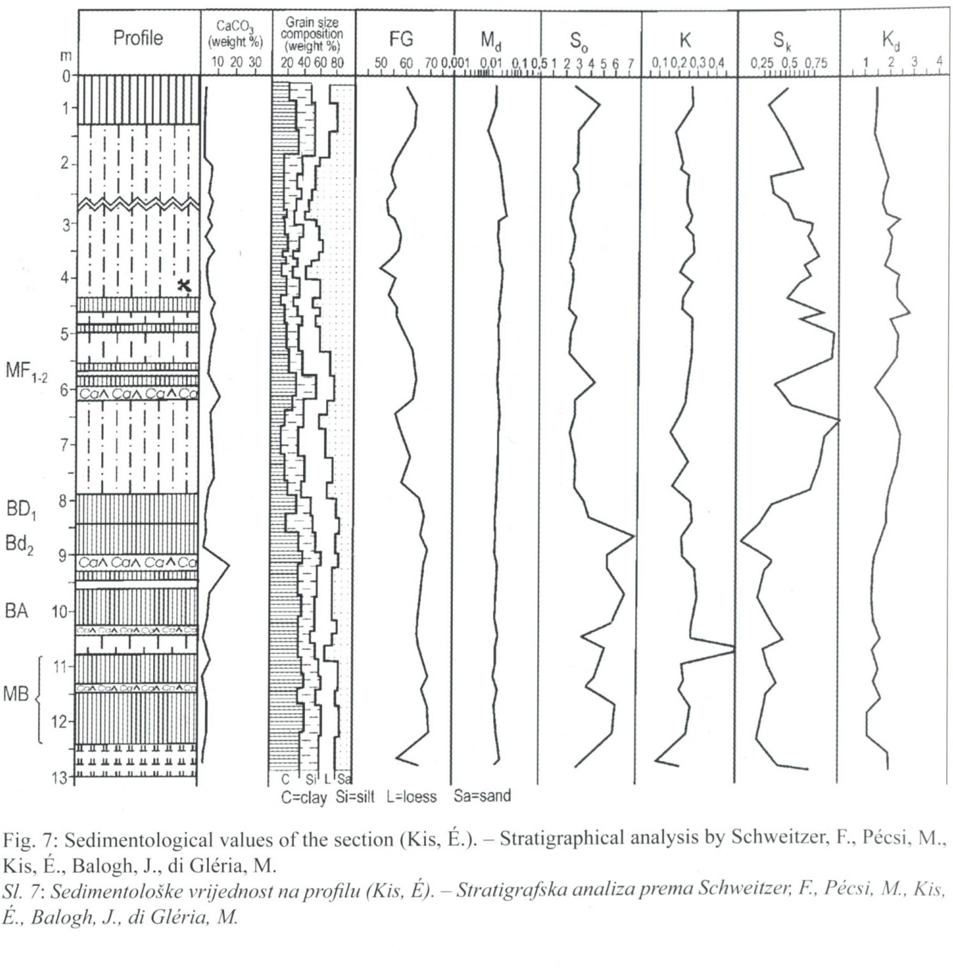

Fig. 7: Sedimentological values of the section (Kis, É.). – Stratigraphical analysis by Schweitzer, F., Pécsi, M., Kis, É., Balogh, J., di Gléria, M.

Sl. 7: Sedimentološke vrijednost na profilu (Kis, É). – Stratigrafska analiza prema Schweitzer, F., Pécsi, M., Kis, É., Balogh, J., di Gléria, M.

Sk divides areas of accumulation from those of denudation. (*Md* parameter values were not shown in the table because *FG* values present much more abundant and reliable information about the changes in grain size.) Possible interpretations are given and specific geographical characteristics of the given sequence are presented.

Boundaries of the layers can be read from *Fig. 7.* and *Table 1.*

On the bottom of the profile old loess is to be found: glacial loess of (*Fig. 8*). It is overlain by two paleosols of the lower interglacial soil sequence (*Fig. 9*): the lower one is a brown forest soil (also called Lessivé base Kukla, J.–Ložek, V. 1961a) and the upper one is a chernozem. On the slope covered by the brown forest soil and from the redeposited layers above this soil interglacial mollusc fauna has been recovered (Prošek–Ložek, V. 1951). Thus the lower soil is an interglacial one. Between the lower and upper soils a loess layer is to be found showing solifluction features. The two soils corresponding to warm spells are separated by a loess horizon indicating cool climate. Within the upper (i.e. younger) brown Lessivé soil two humid and warm climatic maxima can be detected (K_d = 1,3; 1,2).

The lower soil is a brown forest soil (Lessivé base) developed under a mixed deciduous (oak) forest. The lower B horizon of the brown forest soil formed 'in situ' from the 'pure' underlying loess. The upper A horizon

Fig. 8: Old loess in the lower part of the profile
Sl. 8: Stari les u donjem dijelu profila

Fig. 9: Lower soil complex: brown forest soil (above) and chernozem soil (below)
Sl. 9: Donji pedološki kompleks: smeđa šumska tla (iznad) i crnica (ispod)

Tab. 1: Granulometric parameter values of the section at Dolní Věstonice and their interpretation (Kis, É.)
Tab. 1: Vrijednosti granulometrijskih parametara za profil Dolní Věstonice i njihova interpretacija (Kis, É.)

Layer, m	Fineness grade, FG		Degree of weathering, K_d		Sorting trask index, S_o		Kurtosis, K		Steepness, S_k	
	values	sediment	values	sediment	values	sediment	values	Sed.	values	formation
0,00–1,20	61,46–64,26	recent soil	1,29–1,39	recent soil	2,64–4,42	extremely coarse	0,18–0,26	–	0,27–0,49	in situ
1,20–4,30	52,10–57,80	sandy loess	1,60-2,57	sandy loess	2,03–3,28	airborne	0,20–0,27	–	0,33–0,85	in sítu + redeposited
4,30–4,45	58,29	skeletal soil	2,23	skeletal soil	2,16	airborne	0,27	–	0,91	redeposited.
4,45–5,05	61,17	skeletal soil	2,11–2,23	skeletal soil	2,15	airborne	0,27	–	0,87	redeposited
5,05–5,45	64,37	loess	1,30	loess	2,2–2,4	airborne	0,25	–	0,33	in situ
5,55–5,75	61,20	soil	1,80	soil	2,64	airborne	0,23	–	0,55	in situ
5,75–6,20	56,16–57,11	soil	2,07–2,37	soil	2,10–2,46	reworked	0,20	–	0,87–1,00	redeposited.
6,20–7,60	58,33–65,19	sandy loess	1,73–2,10	sandy loess	2,55–3,34	reworked	0,16–0,26	–	0,32–0,87	in situ + redeposited
7,60–8,20	66,56–67,29	soil	1,18–1,59	soil	3,77–7,45	extremely coarse	0,22–0,26	–	0,09–0,22	in situ
8,20–9,40	67,66–68,63	soil	1,06–1,10	soil	5,00–6,28	extremely coarse	0,21–0,30	–	0,16–0,29	in situ
9,40–10,75	65,01–67,97	soil	1,13–1,31	soil	3,07–5,31	extremely coarse	0,22–0,54	–	0,24–0,43	in situ
10,75–10,90	65,83	loess	1,35	loess	3,61	airborne	0,20	–	0,25	in situ
10,90–12,10	68,58–69,11	soil	0,94	soil	3,16–5,55	extremely coarse	0,09–0,26	–	0,17–0,34	in situ
12,10–12,60	64,49	old loess	1,61	old loess	2,81	airborne	0,21	–	0,73	redeposited

Tab. 2: Sedimentological parameter values of samples from the Dolní Věstonice profile (Mária di Gleria, Soil Laboratory, GRI HAS)
Tab. 2: Vrijednosti sedimentoloških parametara uzoraka s profila Dolní Věstonice (Mária di Gleria, Soil Laboratory GRI HAS)

Serial number	Profile. m	$CaCO_3$ weight %	PH distilled water	Clay	Silt	Loess	Sand	Grain size composition. mm weight %								
								<0,002	0,002–0,005	0,005–0,01	0,01–0,02	0,02–0,05	0.05–0.1	0.1–0.2	0.2–0.5	>0,5
1.	0.00–0.20	1.30	8.00	23.00	20.20	19.80	37.00	14.2	8.8	8.6	11.6	19.8	22.1	8.8	5.2	0.9
2.	0.20–0.70	0.40	8.00	26.40	19.40	25.30	28.90	15.9	10.5	7.9	11.5	25.3	18.9	5.5	3.8	0.7
3.	0.70–1.20	0.00	7.90	27.20	16.80	24.40	31.60	19.5	7.7	6.2	10.6	24.4	19.3	6.6	5.1	0.6
4.	1.20–1.40	2.10	8.00	17.80	14.60	19.70	47.90	13.5	4.3	5.8	8.8	19.7	28.7	11.1	6.9	1.2
5.	1.40–1.60	6.40	8.00	16.90	12.60	18.60	51.90	12.8	4.1	3.6	9.0	18.6	31.2	13.3	6.5	0.9
6.	1.60–1.80	5.90	8.10	14.30	11.30	17.70	56.70	10.8	3.5	2.3	9.0	17.7	36.1	13.1	6.1	1.4
7.	1.80–2.00	5.90	8.10	15.30	18.10	11.00	55.60	11.8	3.5	4.5	13.6	11.0	30.9	17.2	6.8	0.7
8.	2.00–2.20	6.30	8.20	14.30	10.90	15.40	59.40	11.2	3.1	3.2	7.7	15.4	30.2	19.7	8.3	1.2
9.	2.20–2.35	3.80	8.20	13.80	8.90	16.40	60.90	9.40	4.4	3.2	5.7	16.4	33.8	22.3	4.4	0.4
10.	2.35–2.40	3.40	8.40	14.40	11.90	24.70	49.00	11.2	3.2	4.1	7.8	27.4	30.9	13.3	4.4	0.4
11.	2.40–2.60	4.20	8.40	17.00	14.60	20.00	48.40	13.4	3.6	4.4	10.2	20.0	27.7	14.4	5.5	0.8
12.	2.60–2.80	0.80	8.30	17.50	16.20	22.60	43.70	13.0	4.5	4.8	11.4	22.6	27.8	10.1	4.9	0.9
13.	2.80–3.10	4.70	8.40	16.00	12.50	22.50	49.00	12.3	3.7	3.6	8.9	22.5	30.8	12.9	4.6	0.7
14.	3.10–3.20	3.80	8.40	14.60	9.30	19.00	57.10	8.10	6.5	3.4	5.9	19.0	33.1	15.7	7.6	0.7
15.	3.20–3.30	3.40	8.30	11.50	9.80	17.90	60.80	8.90	2.6	0.8	9.0	17.9	30.5	17.8	11.1	1.4
16.	3.30–3.60	3.40	8.30	15.70	14.10	24.40	45.80	12.8	2.9	4.7	9.4	24.4	28.8	10.9	5.2	0.9
17.	3.60–3.90	4.20	8.40	13.80	11.00	22.30	52.90	10.9	2.9	2.4	8.6	22.3	33.9	11.1	7.3	0.6
18.	3.90–4.10	4.70	8.60	14.10	13.10	26.70	46.10	10.9	3.2	3.6	9.5	26.7	28.2	11.6	5.7	0.6
19.	4.10–4.25	4.20	8.40	15.90	16.70	17.70	49.70	12.5	3.4	3.6	13.1	17.7	30.0	13.5	5.8	0.4
20.	4.25–4.45	4.70	7.90	16.70	14.00	26.90	42.40	13.2	3.5	3.7	10.3	26.9	31.5	8.0	2.7	0.2
21.	4.45–5.05	4.20	8.50	19.80	16.00	30.60	33.60	14.9	4.9	4.8	11.2	30.6	25.0	5.7	2.7	0.2
22.	5.05–5.45	2.50	8.50	27.70	18.40	24.20	29.70	19.9	7.8	6.6	11.8	24.2	18.2	5.1	5.3	1.1
23.	5.45–5.65	8.00	8.60	21.50	17.50	26.70	34.30	15.4	6.1	5.5	12.0	26.7	22.7	6.3	4.4	0.9
24.	5.65–6.05	4.70	8.60	17.10	13.80	24.50	44.60	12.6	4.5	2.9	10.9	24.5	25.0	9.8	8.6	1.2
25.	6.05–6.40	4.70	8.60	16.30	14.50	29.10	40.10	12.7	3.6	3.5	11.0	29.1	24.4	6.5	8.6	1.6

(continuation of Table 2)

Serial number	Profile. m	$CaCO_3$ weight %	PH distilled water	Clay	Silt	Loess	Sand	Gran size composition. mm weight %								
								<0,002	0,002–0,005	0,005–0,01	0,01–0,02	0,02–0,05	0.05–0.1	0.1–0.2	0.2–0.5	>0,5
26.	6.40–6.90	4.20	8.50	19.80	18.30	28.90	33.00	11.5	8.3	5.6	12.7	28.9	21.2	6.0	4.9	0.9
27.	6.90–7.30	5.10	8.50	19.80	14.30	26.00	39.90	15.3	4.5	3.7	10.6	26.0	23.3	6.6	8.8	1.2
28.	7.30–7.60	3.80	8.50	25.40	18.60	31.70	24.30	19.8	5.6	6.4	12.3	31.6	17.7	3.8	2.1	0.7
29.	7.60–7.90	1.30	8.50	28.30	18.20	32.60	20.90	22.2	6.1	5.7	12.5	32.6	17.7	2.1	0.9	0.2
30.	7.90–8.20	1.30	8.00	31.60	17.00	25.90	25.90	24.8	6.8	5.5	11.5	25.9	14.9	4.6	5.0	1.0
31.	8.20–8.50	0.80	8.00	33.40	23.10	19.30	24.20	27.7	5.7	5.7	17.4	19.3	15.1	4.3	3.9	0.9
32.	8.50–8.75	11.40	7.90	33.00	17.50	23.30	26.20	26.3	6.7	5.8	11.7	23.3	18.7	4.0	2.9	0.6
33.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
34.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35.	9.05–9.40	4.20	8.0	32.20	16.40	22.70	28.70	30.4	1.8	4.7	11.7	22.7	21.7	3.9	2.7	0.4
36.	9.40–9.70	2.10	7.30	31.40	16.20	25.00	27.40	26.3	5.1	5.8	10.4	25.0	19.0	4.5	3.3	0.6
37.	9.70–9.90	0.80	7.50	28.30	14.00	27.80	29.90	23.7	4.6	4.8	9.2	27.8	21.8	4.4	3.1	0.6
38.	9.90–10.20	1.30	7.60	29.80	16.40	23.00	30.80	23.3	6.5	5.5	10.9	23.0	22.1	4.3	3.6	0.8
39.	10.20–10.50	4.20	7.70	31.10	19.50	26.90	22.50	24.4	6.7	5.9	13.6	26.9	14.8	4.1	2.9	0.7
40.	10.50–10.75	0.40	7.40	32.50	20.30	23.20	24.00	21.9	10.6	6.5	13.8	23.2	17.1	3.8	2.6	0.5
41.	10.75–10.90	0.80	7.50	28.50	20.10	23.60	27.80	21.9	6.6	5.1	15.0	23.6	20.0	4.2	2.7	0.9
42.	10.90–11.50	2.50	7.40	34.60	19.10	20.10	26.20	28.6	6.0	6.7	12.4	20.1	19.3	4.2	2.3	0.4
43.	11.50–11.90	2.10	7.50	34.60	17.00	21.80	26.60	28.6	6.0	6.3	10.7	21.8	18.2	5.3	2.7	0.4
44.	11.90–12.10	0.00	7.50	19.10	15.30	20.70	44.90	13.6	5.5	5.3	10.0	20.7	24.3	6.7	5.5	8.4
45.	12.10–12.60	0.00	8.40	24.70	23.30	22.20	29.80	19.8	4.9	5.8	17.5	22.2	21.8	4.2	2.8	1.0

has been eroded and the upper layer of the brown forest soil is enriched with pedified clay. The forest soil is overlain by a chernozem constituted by the material of the former A horizon. This soil has probably formed by mud flow. The chernozem is of dark greyish brown colour. Its humus contains remains of flowers of a continental grass steppe referring to 2°C annual mean temperature indicating long winters and short summers (Kukla, Ložek, 1961a).

On the top of the *lower soil sequence* a ca 5 cm thick *marker loess* lies that has been redeposited from slope sediments. Its relatively abundant sand content is originated from sandstones constituting lower elevations of the Pavlov Hills. This finely porous sediment is of pale greyish colour. Its thickness depends not only on airborne sedimentation but on the position of the slope too.

The *middle soil sequence* (*Fig. 10*) consisting of the lower chernozem soil and of the overlying double soil complex (also chernozem) superimposed by another marker loess. Chernozem was probably redeposited together with this loess. The slope debris with marker loess also contains a sand layer with some pieces of clay.

The *upper soil sequence* is overlain by decalcified loess with a sand strip. A double soil complex of brown colour is superimposed by the youngest loess with sites of early man of the Late Paleolithic („mammoth hunters" of the Gravettian culture). Charcoal remains refer to pine, spruce, in some

Fig. 10: Middle soil complex consisting two chernozem paleosols. Both below and above the lower chernozem there is a marker loess

Sl. 10: Središnji pedološki kompleks s dva horizonta paleotla crnice. Ispod i iznad je marker les places to oak, alder and beech. The upper soil sequence can be correlated with MF paleosol; its ^{14}C age is 28,100 ± 300 yr BP.

Between the upper soil sequence and recent soil a thick loess pocket is found (*Fig. 11.*). This loess layer contains snail fossils suggesting steppe vegetation and climate (Prošek–Ložek, V. 1951). They indicate short vegetation periods and long winters. This corresponds to climatic conditions with –6şC – –8şC annual mean temperatures (similar to present-day Yakutia).

Parameter values can be read from *Fig. 7* and they are interpretable from *Table 1.*

An *exact identification and separation of the layers* is facilitated using *FG* and K_d values.

A joint evaluation of the fineness grade and K_d index values can help clear questions that have not yet been answered exactly. It might be instrumental in separating sediments of various age and origin (e.g. young and old loesses) and in their more precise stratigraphic delimitation and determination, in drawing conclusions concerning environmental conditions during the period of deposition of the initial material, in the identification of sedimentation gaps.

Moreover, using K_d values are informative on the depth and amplitude of warming and cooling within a given layer. *Cooling minima* could be found in $Würm_3$ and $Würm_2$ loess pockets. Cooling minima within $Würm_3$ could be traced at depths 3.15 and 3.9 m (K_d = 2.5–2.5) and between the two skeletal soils at a depth of 4.7 m (K_d = 3.0) whilst those within $Würm_2$ appear between depths 6.7 and 7.3 m. It is conspicuous that a thin

Fig. 11: Würm loess in the north-eastern part of the section
Sl. 11: Würmski les u sjeveroistočnom dijelu profila

loess layer between the two interglacial soils of the lower complex seems to indicate a much lower temperature peak than that of the Würm$_1$ loess pocket upward along the profile. However a substantial hiatus is suggested within this layer by its being very thin. The middle part of the loess contains a layer boundary invisible to the naked eye but detected by an abrupt change of kurtosis value.

Maximum warming can be identified in the 'in situ' formed lower brown forest soil (Lessivé base) within the interglacial soil complex (K_d = 1.1). A similar intense maximum seems to have existed during the formation of BA paleosol (K_d = 1.2). An upper soil of the complex probably redeposited by slope processes comes next (K_d = 1.3) and then the lower member of paleosol MF$_{1-2}$ follows in the rank (K_d = 1.35).

Extreme values of *FG* and K_d values are instrumental in the indication of *erosional hiatuses* (eroded loess or sand layers and soil horizons) when these values change suddenly within a certain sediment, e.g.:

– at a depth of 2.8 m: sand hiatus (*FG* = 51.5)

– at a depth of 3.9 m: another sand hiatus (*FG* = 49.0)

– at a depth of 6.8 m: loess hiatus (K_d = 2.6)

– in the upper part of MF$_1$: soil hiatus; the lower part of the overlying sandy loess have MF$_1$ soil values (*FG* = 65.0)

– between paleosols BD$_1$ and BD$_2$: loess hiatus (K_d = 1.8).

Values of steepness (Sk) refer to in situ or *redeposited character of layers*. The redeposited layers within the profile are (with the depths in brackets): sandy loess (2.35–3.30 m), sandy loess (3.90–4.10 m), upper humus horizon (4.35–4.65 m), lower humus horizon (4.80–5.00 m), loess layer between the lower humus horizon and MF paleosol (5.05–5.55), almost the whole sandy loess between BD$_1$ and MF$_{1-2}$, and the middle part of the loess. Granulometric curves with double or more peaks as e.g. in the loess layer between MF$_{1-2}$ paleosol and two humus horizons (*Fig. 12*, sample 22: granulometric curve with triple maxima) or in the sandy loess pocket below MF$_{1-2}$ (*Fig. 13*, sample 25: curve with double maxima).

Sharp boundaries between layers can be fixed using kurtosis (K) values. They are especially important for drawing exact boundaries between layers that could hardly be separated in the course of a previous sampling.

A specific relevance of this parameter is not only in the specification of boundaries between different types of layers but also in differentiating between layers of a seemingly homogeneous loess pocket (in order to distinguish between redeposited and 'in situ', sand or loess horizons).

A sharp boundary can be drawn in sandy loesses at depths of 2.25, 3.00, 3.20, 4,00, 4.15 m, in sandy loesses underlying and directly superimposing the upper humus horizon at depths of 6.8 and 7.4 m, in loess between BD$_1$ and MF$_{1-2}$, at the boundary of the lower soil sequence (interglacial complex) and the overlying loess, and in the middle part of loess at a depth of ca 13 m.

Values of sorting (S_0) allow to draw conclusions about the *origin of sediments*: S_0 < 2.5 indicate airborne loess, S_0 = 2.5–3.5 refer to water transport of the initial material whilst extremely high values of S_0 suggest soil sediments. S_0 > 3.5 indicate an especially strong mixture of sediments, soils as a rule. Young loess is represented by S_0 = 2.2–2.4 and old loess is ca S_0 = 2.81. Parameter values for sandy loess change between

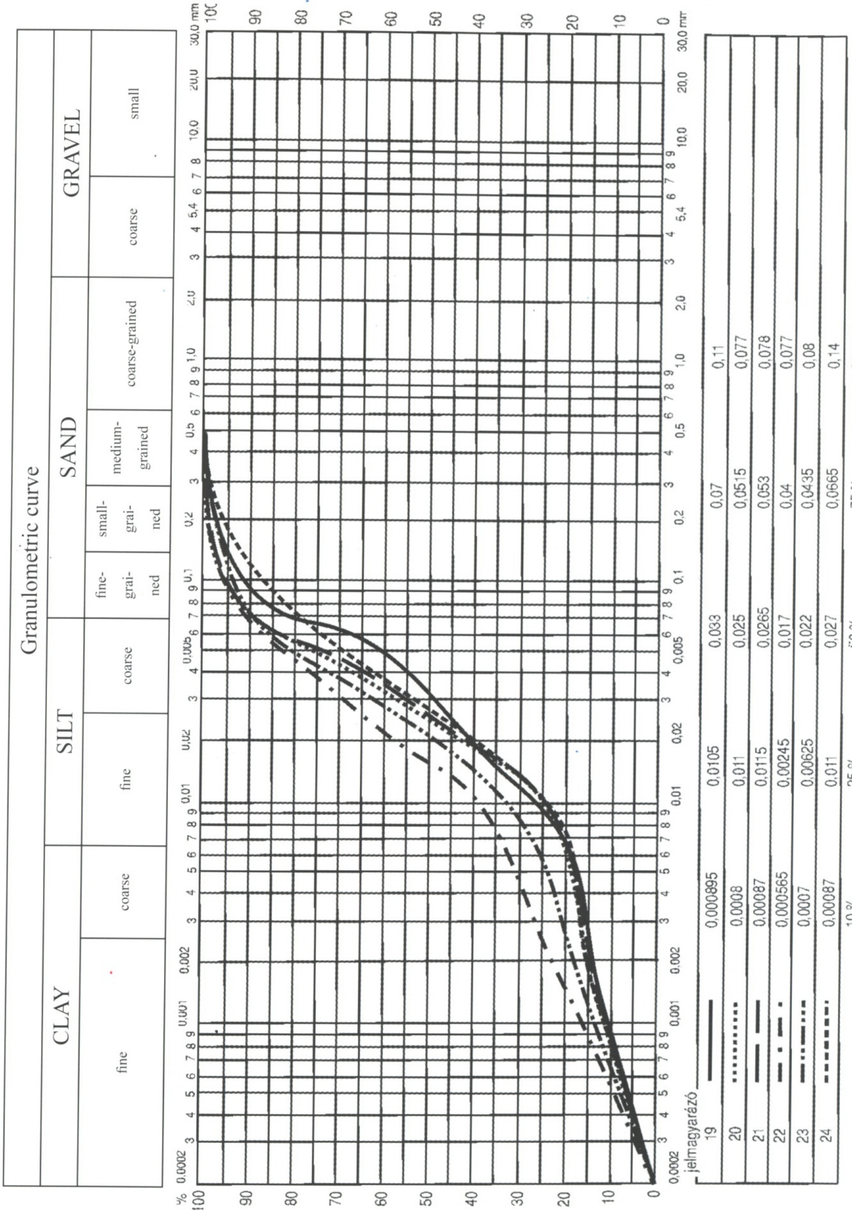

Fig. 12: Redeposited loess with a triple peak between MF paleosol and the two humus horizons (sample 22 at a depth of 5.05–5.45 m)

Sl. 12: Resedimentirani les između MF paleotla i dva horizonta humusa (uzorak 22 na dubini 5,05-5,45 m)

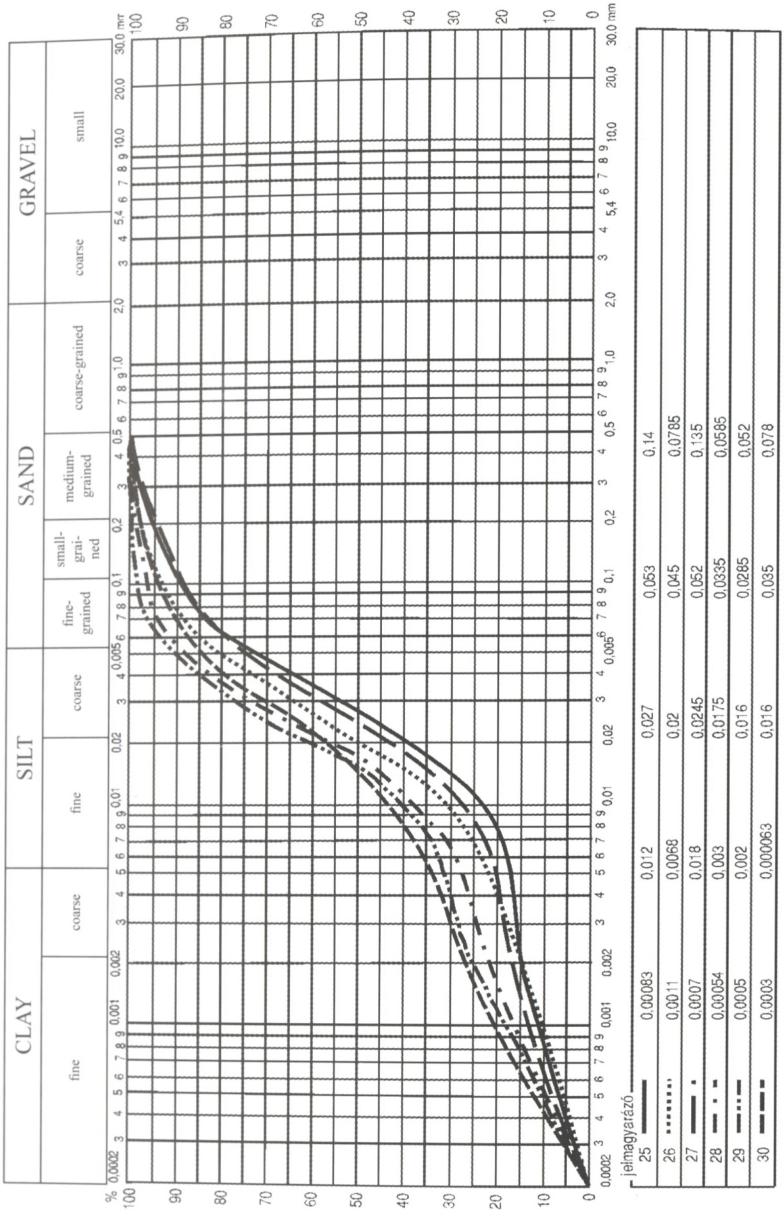

Fig. 13: Granulometric curve with a double peak in the sandy loess pocket below MF_{1-2} (sample 25 at a depth of 6.05–6.40 m)

Sl. 13: Granulometrijska krivulja ispod MF1-2 (uzorak 25 na dubini 6,05-6,40 m)

2.03–3.28 and 2.55–3.34. They are situated between BA and BD_2 (i.e. two paleosols of the middle soil complex) and between BA and MB (upper member of the lower soil complex). A relatively high amount of sand fraction originates from sandstones of the lower lying regions of the Pavlov Hills. These sandy slope sediments were redeposited by solifluction through multiple processes of transport and resulted in values S_0 = 3.2–3.3. This type of loess referred above is called marker loess and it occurs typically in other profiles of the Moravian Plateau as well.

Sorting values are as listed below:

Recent soil:	6.4–4.42
Upper skeletal soil:	2.16
Lower skeletal soil:	2.15
MF_1:	2.64
MF_2:	2.10–2.46
BD_1:	3.77–7.45
BD_2:	5.00–6.28
BA:	3.07–3.51
MB_1:	4.75–5.65
MB_2:	6.00–6.20

A special significance of our studies aimed to obtain a perfect knowledge of the profile at Dolní Věstonice is emphasized by the fact that in the Quaternary deposits of the surroundings there have been archeological sites of utmost stratigraphical importance.

^{14}C datings of Upper Paleolithic sites yielded ages between 30,000–20,000 yr BP (Early Pavlov culture: 30,000–27,000 yr; Middle Pavlov culture: 27,000–25,000 yr and Willendorf–Kostenkian culture: 25,000–20,000 yr (Svoboda, 2001.).

The Upper Paleolithic has three type localities on the territory of Moravia (Gyenis, 2001).

On a cultural level of the *Předmosti* site with an area of 10,000 m², remains of 29 humans were recovered. Most of them were buried in an ellipse-shaped tomb with heads turned northward. The tombs were covered with tablets of chalk and mammoth bones. They were surrounded with bones of ca 500–1000 mammoths. Character of skulls differs from those from Cromagnon in their face being longer and narrower and forehead a bit more bent. On the basis of long bones these people were tall (probably they represented the protonordic race, predecessors of the present day nordic race. The radiocarbon age of the site is 26,000 yr BP.

At *Dolní Věstonice* huts, fire-places, pits for storing, statues and a wealth of bones belonging to at least six Upper Paleolithic settlements have been recovered in the lower part of loess overlying the upper soil complex (Fig. 14). Skeletons of three young humans were found as well. Radiocarbon age of the site level is 29,000–24,000 yr BP (Svoboda 2001).

At the *Pavlov site* located 3 km east of Dolní Věstonice along with the skeleton of an adult male person many stone and bone implements, statues and pieces of burnt clay were found. This is called the Pavlov industry (Gyenis 2001). The site is a type locality of the European Gravettian culture (Klima 1961). Most of the findings are 27,000–25,000 (26,650 ± 230 – 25,020 ± 150) yr BP old (Klima 1959/a, Svoboda 1994).

CONCLUSION

The method of granulometric analyses elaborated for the evaluation of the section of Dolní Věstonice has proven to be wor-

Fig. 14: Human settlements of the Gravettian culture on the north-eastern slopes of the Pavlov Hills in the vicinity of Dolní Věstonice and Pavlov (Svoboda, J. 2001 Praehistoria vol. 2)

Sl. 14: Ljudska naselja Gravettianske kulture na sjeveroistočnim padinama Pavlovog pobrđa u blizini Dolní Věstonice i Pavlova (Svoboda, J. 2001 Praehistoria vol. 2)

kable. Trends of the paleoenvironmental changes (paleogeography, sedimentology, paleoclimates) can be read from the database contained by the tables and diagrams constructed beside the images of the profiles. Using this method a more reliable information can be obtained during the evaluation of the sequences and it can be carried out more rapidly.

The most important loess profiles in the Carpathian Basin and surrounding areas were elaborated with the same method of analyses, and this circumstance has considerably raised the comparability of the sections and reliability of results.

The method is suitable for performing comparative studies of Quaternary sediments formed in different continents but under similar climatic conditions.

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Sažetak

ISTRAŽIVANJE PALEOGEOGRAFSKIH PROMJENA NA SJEVEROZAPADNOM RUBU KARPATSKOG BAZENA U BLIZINI DOLNÍ VĚSTONICE

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Istraživno područje nalazi se u Moravskoj zavali na obroncima Pavlova pobrđa u dolini rijeke Dyje, uz umjetno jezero na toj rijeci. Pobrđe je građeno uglavnom od jurskih vapnenaca, a niži dijelovi pokriveni su paleogenim laporima i pješćenjacima. Znatne količine paleogenih sedimenata snešene su u niža područja blatnim bujicama, klizanjem i drugim padinskim procesima. U podnožju su lapori izravno prekriveni lesnim naslagama razmjerno velike debljine. U podnožju je analiziran profil Dolní Věstonice u kvatarnim naslagama, uglavnom u lesu i lesu sličnim sedimentima. U istražvanju tih sedimenata primjenjena je metoda granulometrijske analize. Izdvojeno je 19 slojeva različitih svojstava, od toga 10 slojava tala, 6 lesnih slojeva i 2 marker lesna sloja. Trendovi paleookolišnih promjena (paleogeografske, sedimentološke i paleoklimatske promjene) mogu se pratiti iz tablica i dijagrama koji prikazuju rezultate analize. Interpretacija rezultata granulometrijske analize daje vrlo detaljne informacije o paleookolišnim promjenama koje su usporedive s rezultatima na drugim lokacijama u Karpatskom bazenu dobivenim istim ili drugim metodama. Primjerice klimatske fluktuacije koje se prate u zadnjih 2 milijuna godina na datom profilu potvrđene su na drugim mjestima u regiji. S obzirom da je ova metoda razmjerno jednostavna, i da je u radu pokazano da se pomoću nje mogu uspješno pratiti promjene koje su dokazane i drugim, složenijim ili skupljim metodama, očita je prednost primjene upravo ove metode analize profila kad je riječ o paleokološnim promjenama. Upotrebom ove metode komparativna analiza profila iz razičitih područja lesa postaje izvediva.

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