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Sedimentology and petrography of Lukáčovce Mb. in the Nitrianska pahorkatina Upland

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Abstract: Lukáčovce Mb. is comprised by coarse-grained and very coarse-grained sandy fluvial-limnic sediments having admixture of gravels with grain-size up to 30 mm. The sediments are characterized by conspicous rusty, dark red and brownish red colour. They subhorizontally and horizontally overlie Neogene deposits of Volkovce Formation. Their contact is erosive. The gravel is mostly composed of sandstone, quartz, chert and limonite concretions. It often contains coatings of limonite and Mn. Sublithic and lithic sands are poorly sorted. Except clastic quartz and feldspar the clay fraction contains smectite (montmorillonite), illite, kaolinite and goethite. Based on preliminary results, the sediments of Lukáčovce Mb. are assigned to the Early Pleistocene (Biber).

Key words: Nitrianska pahorkatina upland, Lukáčovce Mb., Early Pleistocene, fluvial-limnic sediments

Introduction

Nitrianska pahorkatina upland and Nitra flood plain comprise areally the most widespread and the northernmost intermountain promotory of the Danube lowland. The promotory tapers into the Považský Inovec, Tríbeč and Strážovské vrchy Mts. According to Mazúr and Lukniš (1978) from north toward south the area can be divided into Nitra table, Záluzie, Bojňany and Bánovce uplands (Fig. 1) respectivelly. The geographic division is geologically and tectonically identical with the northern promotory of the Danube basin consisting of Rišnovce and Bánovce depressions separated by Závada-Bielice ridge (Vass et al., 1988). The main part of the basin fills is comprised by Tertiary deposits capped by the youngest Pliocene Volkovce Formation (Elečko and Fordinál in Pristaš et al. 2000) and Quaternary cover mainly represented by eolic, fluvial nad deluvial deposits ranging from the Early to Late Pleistocene and Holocene.

In order to elucidate geological structure and evolution of the area a detail regional geologic research and mapping was done in period from 1994 to 2000. The results are published in the latest works of Pristaš and coworkers (2000a, 2000b) where also a detail list of previous works is given. Based on the mentioned research Maglay (Maglay et al., 1997, 1998) drew attention to the repeating horizon of conspicous redish-brown sandy-loamy gravel prevailingly occurring in summit parts of interdepressional ridges of the upland. The occurrence was mainly recorded from the middle part of the Nitrianska pahorkatina upland which is marked as Blatňany upland. The northern part of the upland trends to the neotectonically active Ripňany depression (Fig. 2). Sedimentary-petrographic analysis of Quaternary deposits including gravels of the Lukáčovce Mb. was given in the framework of a wider draft work by Šarinová (2000). The limonitized sandy-loamy gravels were later described and based on the Lukáčovce locality defined as Lukačovce Mb. (Maglay in Pristaš et al., 2000).

Brief characteristics of Lukáčovce Mb.

Lukáčovce Mb. forms specific, irregularly preserved phenomenon of the oldest Quaternary acummulation not only in the Nitra upland region but also, according to the latest knowledge, in the other uplands of the Danube lowland. According to the genesis, habitus, location, deposition, lithologic and sedimentary-petrographic characteristics the gravels are preliminary suggested to be an equivalent of Strekov Mb. (Biber) described by Harčár and Schmidt (1965) and Schmidt and Halouzka (1970) from the Hronská pahorkatina upland. In the Nitrianska pahorkatina upland they mainly occur in the area of the young Ripňany depression intervening into the Bojňany upland.

At localities without loess cover the occurrence of the Lukáčovce Mb. sediments is indicated by a striking change in colour and lithology of overlying slope deposits and exposures of colouring very conspicous rusty, dark red, redish-brown and maroon sandy loams and fine-grained, limonitized gravels lithified by the loams. The gravels are either regularly scattered in the whole profile or they are concentrated at the base or eventually they form multiple repeating layers. In the basal parts of layers sporadically thin layers of coarser gravel with scattered boulders occur. At individual localities slight differences

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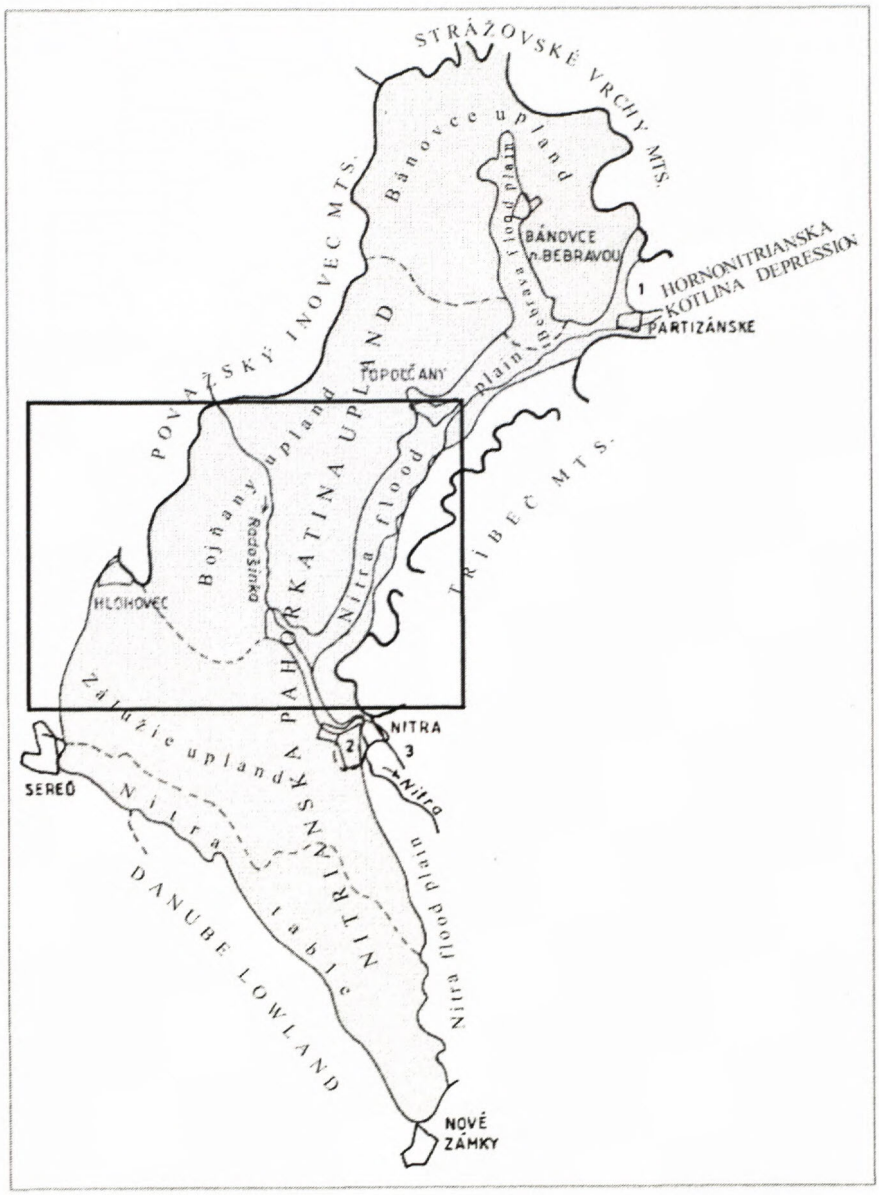

Fig. 1. Geomorphological units of the Nitrianska pahorkatina upland (according to Mazúr & Lukniš, 1978), adopted and partly modified from the work by Pristaš et al. (2000b). The thick – framed part designate the area of interest.

in lithology, sedimentology, sedimentary petrographic and other analysed parameters were recorded. The common and characteristic sign of the sediments is their subhorizontal and horizontal position and exclusively erosive contact with sediments of the Volkovce Formation having a gravely-sandy lothology with clay intercalations (Locality Lukáčovce – point 1).

The most of recorded outcrops (Fig. 2) is located in the upper parts of small depression slopes at sites where the slopes pass into plain interdepression ridges covered by loess. This suggests their location immediately beneath or on the level of the older Late Pliocene river level (SSE of Tekoľďany in the Rybníky part – point 7, in the village Merašice near cemetery - point 4, in the Veľké Ripňany - Piesočnica - point 3, in the Cerový creek valley near the water dam SW of Veľké Ripňany – point 8, W of Biskupová, in the part Surdok - point 6 and others). The originally unified base level of the Lukáčovce Mb. was during the Pleistocene tectonically vertically differentiated into more altitude levels having max. difference about 50 m today. Other occurrences probably form remnants of littoral sections of an open lake or remnants of input of distributary channels with features of abrasive activity in the underlying deposits of the Volkovce Formation (Dolné Otrokovce - part Bučovské – point 9, sand pit between Horné and Dolné Otrokovce – point 2, Horné Trhovište - Farské – point 10 and others). Depositional characteristics suggest postgenetic redeposition into lower morphologic position at some localities during the Quaternary.

Vague, however, the most frequent outcrops are comprised by directly exposed coarse-grained and very coarse-grained loamy-sandy gravels having redish brown and maroon colour. In deluvium they typically are developed as rusty and redish-brown sandy gravels (W of Biskupová – point 6 and others). At base of field roads (SSE of Tekoľďany – point 7 and near Merašice - point 4 and others) they only form 2 – 3 cm thick beds. The gravel and sand with Mn–Fe oxides coatings is almost exclusively composed of quartz and quartzose arenites (87,5%). Feldspar, mica and carbonate contents vary from 4 to 9%. In light fraction of minerals high amount of limonitized quartz and limonite grains occur.

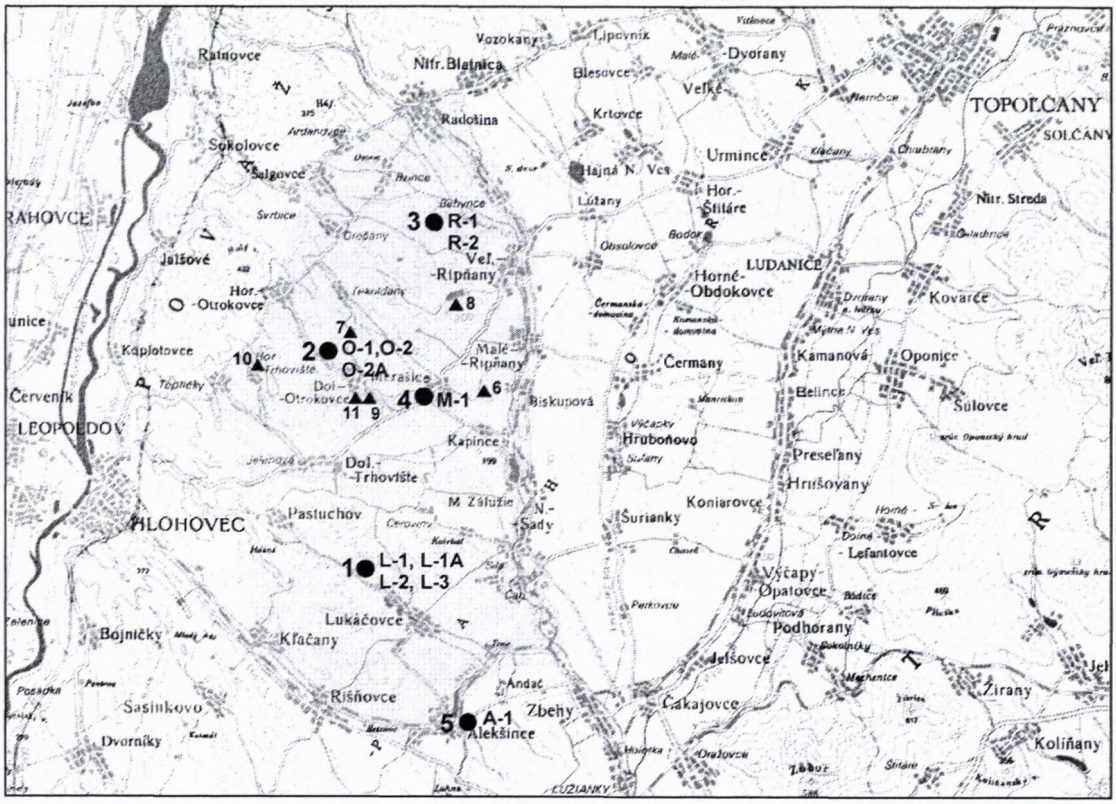

Fig. 2. Wider part of young neotectonic structures of the Ripňany depression (darker area) with designation of localities of the occurrence of the Lukáčovce Mb. (▲) and sampling sites (●).

In the sand pit NW of Lukáčovce (point 1) the deposits form very conspicous, up to 80 cm thick layer of red and rusty-red loamy, slightly lithified coarse-grained sands and fine-grained gravels with angular clasts. The sediments are horizontally layered and discordantly overlie older deposits. The bed thickness is strikingly reduced and irregular due to postsedimentary erosive processes.

In sediments of the Lukáčovce Mb. coarse-grained sand (55 - 97%), fine-grained gravel up to the clast diameter 30 mm (2 - 36%) and silt and clay (0 - 27%) prevail according to Šarinova (2000). In mineral composition of the fraction from 0.25 - 0.10 limonitized quartz prevails (63 %) having coating of dendritic manganese. The rest of mineral composition consists of feldspar (15 - 21%), phantomic carbonate grains (11 - 18%), muscovite, which prevails from micaceous minerals (6.47%) and other grains, mainly black manganese oxide and limonite (6.45%) which aggregates form individual crusts resistent against weathering. In the upper part of the Lukáčovce Mb. illite and montmorillonite together with clastic quartz, albite and orthoclase occur in the clay fraction. In small amount occasionally also kaolinite and probably mix-layered illite-smectite occur.

The above mentioned sediments occur in the sand pit near the road between Horné and Dolné Otrokovce villages at altitude 203 m a.s.l. In this case there is only 50 cm thick layer of partly lithified rusty-red and dark red sandy gravels which are stronly loamed in their upper part. The gravel clasts are in this part up to 15 cm in diameter and the size decreases upward to some 2 cm. The matrix is composed of lithified limonitized, dark red and rusty sand containing several layers of sandy loams upward gradually passing into fine-grained sandy wash outs derived from loess and finally changing into calcareous loess. The gravels are almost exclusively composed of quartz and quartzose arenietes (82%) which are coloured by Fe and Mn oxides on surface. Concretions lithified by limonite and manganese grains and their aggregates comprise also here in sandy layers individual dark, more resistant crusts. The feldspar, mica and carbonate contents vary from 1.5 to 8%.

Similar occurrence may be also recorded in the eastern part of Tepličká village in a small abandoned sand pit.

In a ditch of gas pipe line south of Dolné Otrokovce village (point 11) at altitude 205 m a.s.l. mostly sandy, dark red, clayey loams having 5 m thickness occur. The gravel clasts are very rare here, however, the loams are more lithified comparing to the underlying sands.

An extensive and continual occurrence of the sediments may be found in an old sand pit SW of Veľké Ripňany village (point 8) and in an exploatated sand pit in the surroundings of Veľké Ripňany – "Piesočnica" (point 3). On the left (eastern) side of the sand pit it is possible to observe pale ochre and white fine-grained sands and gray Neogene clay gradually passing into Early Pleistocene redish-brown and maroon laomy gravels. The gravels, thick about 5 m, predominate in the upper part of the outcrop. The entire succession including underlying

sands, is deformed by microtectonics of NW-SE and W-E direction. The deformations dissect the sediment into a system of small, intermutally shifted blocks.

Based on the field data and new knowledge from other parts of marginal uplands of the Danube lowland we can state that the sediment extension has a global character and is depended on specific climatic conditions governing type of weathering. This also suggests sediment occurrence on higher blocks of marginal parts of the Ripňany depression beneath the loess cover at altitudes corresponding to the level or closely below the level of the Late Pliocene river plain. The individual deviation corresponds to the deposition mode in local open lakes. Stratigraphically we can assign them into the oldest part of the Early Pleistocene (Biber). From the lithological viewpoint they are identical to the Strekov Mb. which stratigraphy was proved by fauna of vertebrate (Harčár and Schmidt, 1965; Schmidt and Halouzka, 1970) in the Hronská pahorkatina upland.

The paper brings several new sedimentary-petrographic knowledge and opinions on environment and characteristics of sedimentation of the Lukáčovce Mb. Laboratory analyses were performed on larger amount of samples taken from selected localities by using newer methods.

For laboratory evalutions samples from following localities were used (Fig. 2):

- Lukáčovce sand pit, samples 1= L+, L+A, L2, L3
- Dolné Otrokovce sand pit, samples 2 = O1, O2, O2A
- Veľké Ripnany sand pit Piesočnica, samples 3 = R1, R2
- Merašice road cut, 4 = sample M1
- Alekšince road cut 5 = sample A1

Petrography of Lukáčovce Mb.

Granulometry and petrography of gravel fraction

The most frequently occurred fraction of 7 – 15 mm was used for granulometric analysis. The fraction is sufficiently represented in all samples except the sample L2 from the locality Lukáčovce.

In the lithologic composition (Tab. 1) sandstone clasts predominate. In average they comprise 43% of the volume amount. They are represented by lithified sandstones having high degree of sphericity (0.8), marly sandstones and other sandstones without macroscopically conspicuous features. The coarse grained sandstones comprise about 1vol.% of the whole amount of sandstones at every locality. The marly sandstones take about 2 vol.% and they are strikingly oblate. Cherts are represented by some 18 vol.% and their shape and sphericity vary depending on locality. A part of cherts has singns of eolic abrasion. Quartz is represented by some 26 volume percents and it prevailingly has disc-like shape with shape factor Fr (Sneed and Folk, 1958) close to 0. Limonite concretions are represented by some 9.5 % of the volume amount which is several times exceeded at locality Alekšince where concretions form about 42% of the volume amount. Granitoid rocks, glassy pyroclasts and calcareous concretions occur in small amount (0 – 3 vol.%). The mean clast composition is shown in the Fig. 3.

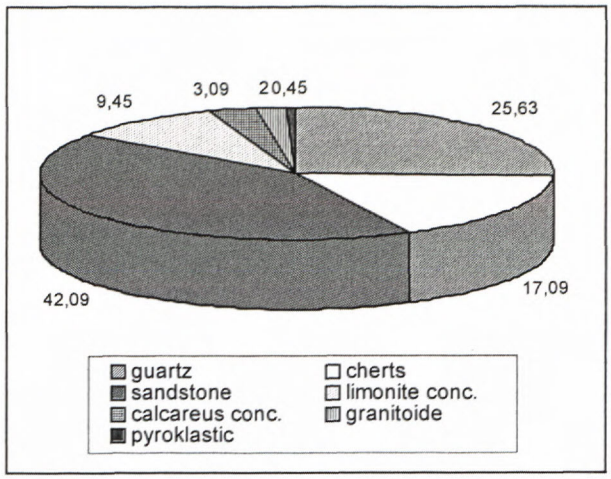

Fig. 3. Average composition gravels of the Lukáčovce Mb.

The values of maximum projection sphericity and shape factor (Fr) calculated for cherts and quartz pebbles and their comparison to values given by Sneed and Folk (1958) suggest a medium long transport of deposits. The only exception is made by sediments from the locality Otrokovce where sediments underwent a short and medium long transport. The relationsship between the Fr and maximum projection sphericity is shown in the Fig. 4.

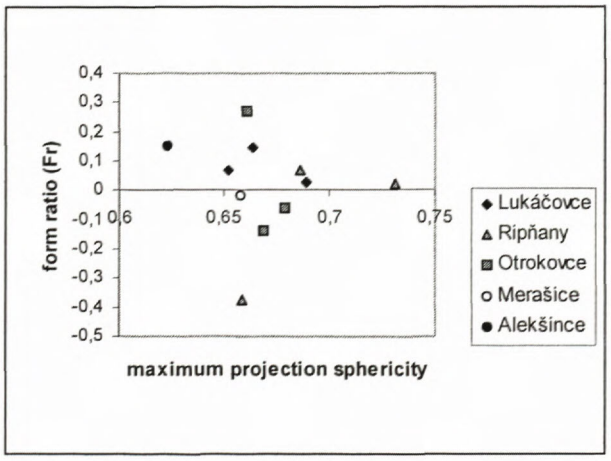

Fig. 4. Plot of form ratio and maximum projection sphericity gravels of the Lukáčovce Mb.

The sandstone clast occurrence decreases with the decreasing size of the gravel clasts. The granulometric analysis of the larger grain size fractions is not reliable due to small amount of clasts available. The gravels of larger clast size were used for analysis of litholigic composition.

Lithology of gravel fraction

Based on petrographic analysis we can divide several type of sandstones:

- Arcose metawackes of Permian age with recrystalized sericitic pseudomatrix and grains of undulatory quartz, twinned crystal of plagioclasses, K-feldspars and in smaller amount also heavy minerals (zircon, rutile).

Tab. 1. Results granulometry and litological analyse gravels of the Lukáčovce Mb.

Locality	Quartz				Cherts				sandstone	limonite con.	calcareous con.	granitoides	pyro-klastics	together		
15-7 mm	content %	Fr	sphericity	form	content %	Fr	sphericity	form	content %	content %	content %	content %	content %	form ratio	sphericity	form
L-1	26	0,25	0,724	platy	22	0,1	0,634	platy	46	2	2	0	0	0,07	0,652	platy
L-1A	31	0,142	0,685	platy	11	0,4	0,652	platy	48	2	0	6	2	0,144	0,664	platy
L-3	35	0,125	0,641	platy	13	0,08	0,705	platy	40	8	4	0	0	0,03	0,689	platy-elong.
R-1	29	0,076	0,69	platy	11	0	0,698	blade	53	2	0	4	1	0,02	0,731	platy-elong.
R-1A	14	0,07	0,692	platy	24	-0,3	0,642	elongated	61	1	0	0	0	-0,375	0,659	elongated
R-2	22	0	0,715	blade	26	0,08	0,672	platy	40	2	8	2	0	0,07	0,686	platy
O-1	20	0,111	0,652	platy	8	0,125	0,612	platy	42	20	4	6	0	0,27	0,661	platy
O-2	20	0,05	0,643	compakt	17	-0,875	0,681	elongated	48	15	0	0	0	-0,14	0,669	elongated
O-2A	44	-0,07	0,72	blade-elong.	15	0,142	0,648	platy	30	6	1	3	1	-0,06	0,679	blade-elong.
M-1	26	0,08	0,676	platy-blade	33	-0,2	0,626	elongated	35	4	0	1	1	-0,02	0,658	blade
A-1	15	0,42	0,71	platy	8	0,25	0,602	platy	20	42	15	0	0	0,15	0,623	platy
average	25,63				17,09				42,09	9,45	3,09	2	0,45			

- Early Triassic subarcoses composed of quartz, less orthoclase, plagioclase, microcline, in smaller amount mica, heavy minerals and felsitic volcanic glass. The matrix is composed of sericite.
- Early Triassic quartzose arenites composed of quartz, orthoclase and microcline. Plagioclase is less common. Felzites and heavy minerals are rare. The matrix is mostly composed of recrystalized quartz which is locally of syntaxial character.
- Non-metamorphosed fine-grained sandstones having clayey matrix and composed of weakly rounded quartz and feldspar clasts. Less common are mica, felsites and heavy minerals.
- Marly lithic sandstones have clayey carbonate matrix containing quartz, feldspar and other rocks clasts. The rock clasts are represented by fine-grained sandstones, micritic limestones and radiolarites. They also contain organic remnants, probably bottom of algae.

After then silicites in a form of cryptocrystallized cherts with organogenic structure follow. Brown silicites predominate. They contain silicified radiolarites of Spumelaria type and spicule of sponge. Sometimes cherts only contain filaments. They have various colours ranging from brownish-red to green. The brown colours prevail. The only exceptions are black cherts which only occur in fraction below 15 mm. They have organogenic structure and cryptocrystalic matrix. They also contain silicified radiolarites of Spumelaria type with preferred orientation. The silicites are probably of Jurrasic age and originate from the Tatric envelope unit or/and Krížna Nappe.

The limonites consist of pure limonite concretions or they form matrix among grains of sand size. The composition of sandy grains corresponds to the neighbouring rocks. These type of concretions predominate and the amount of sandy grains in individual concretions varies.

Pyroclastics are represented by pumice and volcanic glass which contain nucleus of mafic minerals and plagioclasses. Occasionally they contain magmatic corroded grains of monocrystalline quartz.

Sands of Lukáčovce Mb.

Lukáčovce Mb. mainly consist of sandy sediment. Prevailingly coarse-grained sands (Tab. 2) are poorly sorted (So from 0.87 fi to 3.77 fi) and contain admixture of gravel having maximum grain size rarely exceeding 30 mm. The exception is only made by channel fills at the Otrokovce locality where the gravel is medium to coarse-grained. Sk values varys from -0.43 fi to 0.78 fi and Kg values vary from 0.69 to 4.31 (the calculation was made by arithmetic method by the programm KORN).

According to the mineral composition of the light fraction the sands comprise boundary between subarcoses and sublithic arenites and they fall into field of lithic arenites (Fig. 5). The light fraction is composed of quartz (37 – 82%), feldspar (6 – 20%), mica and lithic clasts where carbonate grains and grains of dark colour were assigned. These grains are probably composed of silicites, limonite and grains coated by Fe and Mn oxides (together 6.3 – 44%). The precise content is given in Tab. 3.

Heavy minerals

Composition of heavy minerals is given in Tab. 4. The content of magnetic fraction is relatively small and only in few samples it exceeds 1 vol.%. In parafraction limonite (5-41 vol.%) and ilmenite (6-35 vol.%) predominates. Minor occurrence has garnet (1-8 vol.%), epidote (1-7 vol.%) and turmaline (0-2 vol.%). In diafraction zircone occurs in larger amount (3-11 vol.%), rutile (5-11 vol.%) and milky grains. Sillimanite, kyanite, apatite, staurolite, monazite (ceric) and gold only occurs as scattered grains with contents rarely higher than 0.1 vol.% (staurolite, monazite).

Rutils indicating two different sources of heavy minerals are interesting. Rutiles with quartz inclusions indicate more acid source, rutiles with inclusions melting of basanite and foid composition indicate source formed by alcaline basalts. A part of rutiles contains niob.

The calculated ZTR and GAS indices suggest medium mature and mature degree of Lukáčovce Mb. sands. The weathering coeficients (K3 = 0.01-0.2, F = 0, KV = 8-56.7) (Tab. 5) were compared to values calculated for limnofluvial sediments by Vaškovská (1992). They indicate Early Pleistocene age. The mean occurrence of heavy minerals is given in Fig. 6.

Composition of clay minerals in matrix

Clay minerals at locality Lukáčovce are represented by smectite, illite and minerals from the kaolinite group, most probably by halloyzite.

At locality Ripňany the clay contains illite, kaolinite and smectite. On X-ray graph specialized for Fe hydroxide low content of weakly crystalline goethite was found. The shape and thickness of the kaolinite peak (Ripňany) suggest non-structuralized, possibly redeposited kaolinite.

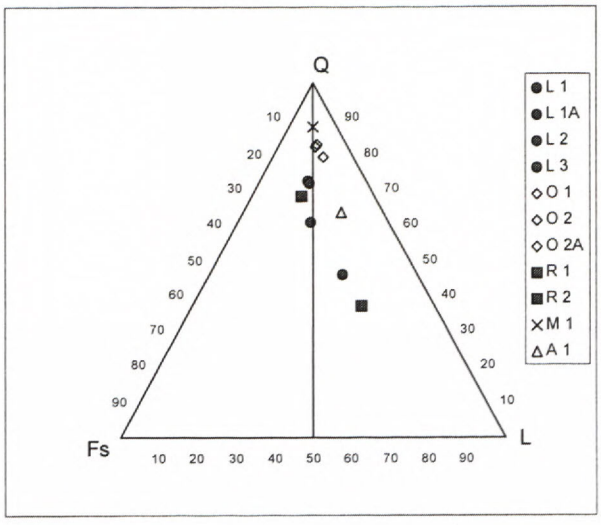

Fig. 5 Classification diagram for sands, Petijohn, Poter and Siever (1972)

In sample from locality Merašice smectite, kaolinite and illite are present. All these minerals are typical by low crystallinity. Hydroxide is represented by goethit.

Sedimeny source

The gravel lithology and composition of clay and heavy minerals suggest several sedimentary sources during deposition of Lukáčovce Mb.

Early Triassic sandstones and silicites as well as rare granitoid clasts suggest source area consisting of acid magmatic and crystalline rocks with their Mesozoic envelope of the Tatric Unit and Mesozoic rocks of higher nappes (mainly Fatric Nappe). Based on the absence of

Tab. 2. Grain-size analyse of the Lukačovce Mb. Results was obtained mathematical calculation. T = Trask (1930), I = Inman (1952), F/W = Folk and Ward (1957).

sample	L-1	L-1A	L-2	L-3	O-1	O-2	O-2A	R-1	R-2	M-1	A-1
Md (mm)	0,685	0,923	0,571	0,49	0,691	35,565	42,660	0,900	0,652	0,960	0,58
Md	0,544	0,114	0,807		0,531	-5,152	-5,414	0,150	0,616	0,058	
Mz (T)	1,005	1,866	0,578	0,908	0,593	27,571	43,541	2,505	0,665	1,639	2,669
Mz (I)	1,514	1,160	0,965	1,481	0,241	-3,086	-5,415	-0,834	1,627	-0,730	0,252
Mz (F/W)	1,191	0,812	0,912	1,252	0,338	-3,775	-5,415	-0,506	1,290	-0,467	0,190
So (F/W)	3,774	3,461	0,878	3,023	1,726	2,454	1,132	2,274	2,754	1,724	3,426
Sk (F/W)	0,421	0,262	0,167	0,232	-0,214	0,789	0,414	-0,365	0,362	-0,437	0,030
Kg (F/W)	1,896	0,695	1,094	1,486	1,144	1,142	4,312	0,825	2,208	1,144	0,940
Typ of sediments	mediumsand	coarse sand	coarse sand	medium sand	coarse sand	pebble	cobble	very coarse sand	medium sand	very coarse sand	coarse sand

Tab. 3. Association light minerals of the Lukáčovce Mb., fraction 0,25–0,10 mm.

sample	L-1	L-1A	L-2	L-3	O-1	O-2	0-2A	R-1	R-2	M-1	A-1
quartz %	60,80	45,84	72,40	71,50	82,09	82,73	79,06	68,08	37,08	87,50	63,49
feld spar %	20,16	19,50	15,06	15,27	8,20	7,77	7,98	19,04	18,82	6,16	11,11
mica %	6,47	8,25	5,26	4,77	5,24	2,88	5,39	9,85	23,52	2,51	3,10
other %	12,57	26,43	7,28	8,24	4,47	6,62	7,57	3,03	20,58	3,83	22,22

Tab. 4. Association heavy minerals of the Lukáčovce Mb., fraction 0,25 – 0,10 mm.

Sample	HM %	magnetite	limonite	ilmenite	garnet	epidote	turmaline	staurolite	monazite	zircone	rutile	sill.	kyanite	apatite	amfib.	gold	milky grain	together %	ZTR	GAS
L-1	1,75	0,15	10,1	35,92	3,11	0,77	0	0	0	4,18	6,15	0		0			38,99	100	72,69	21,88
L-1A	1,59	0,16	5,67	34,03	7,69	2,49	0	0	0,17	2,08	3,56	0	0	0			43,3	100	35,27	48,09
L-2	0,5	0,36	7,89	28,93	8,23	3,68	1,06	0	0	4,26	8,29	0		0			36,68	100	52,1	33,8
L-3	0,85	0,15	7,13	27,48	8,21	5,69	0,53	0,17	0,7	2,81	4,92	0	0				42,21	100	35,85	36,37
O-1	0,94	0,47	9,61	31,36	5,85	0,84	2,09	0,17	0	6,59	10,65		0	0		0	32,02	100	73,8	22,98
O-2	1,68	1,69	20,64	23,97	3,59	0,26	0,67	0,16	0,16	11,89	8,97	0		0			27,77	100	83,77	14,59
O-2A	2,07	2	15,06	28,14	3,8	0,61	1,36	0,17	0	11,52	10,7	0	0	0		0	26,01	100	83,73	14,09
R-1	0,8	0,44	23,6	19,68	0,58	1,37	1,57	0,29	0,14	2,9	11,04		0	0			38,39	100	86,69	4,86
R-2	0,73	0,16	20,35	12,71	5,08	7,16	0,69	0,45	2,77	6,84	11,04	0		0	0		32,34	100	54,56	16,25
M-1	1,53	0,27	41,02	5,99	1,41	1,1	0,32	0,3	0	5,19	8,3		0				36,12	100	83,09	10,28
A-1	2,26	0,14	12,52	34,27	2,23	0,52	0,13	0,25		2,96	5,5			0			41,47	100	74,11	21,39

Tab. 5. Weathering coeficients of the Lukáčovce Mb. (calculation by Vaškovská (1992).

sample	K1	K2	K3	F	K-A	K-B	K-V
L-1	0	0	0,01	0	0	0	
L-1A	0	0	0,06	0	0	0	21,36
L-2	0	0	0,09	0	0	0	29,86
L-3	0	0	0,16	0	0	0	9,01
0-1	0	0	0,02	0	0	0	
0-2	0	0	0,005	0	0	0	
0-2A	0	0	0,01	0	0	0	
R-1	0	0	0,03	0	0	0	43,65
R-2	0	0	0,21	0	0	0	7,94
M-1	0	0	0,02	0	0	0	56,81
A-1	0	0	0,01	0	0	0	

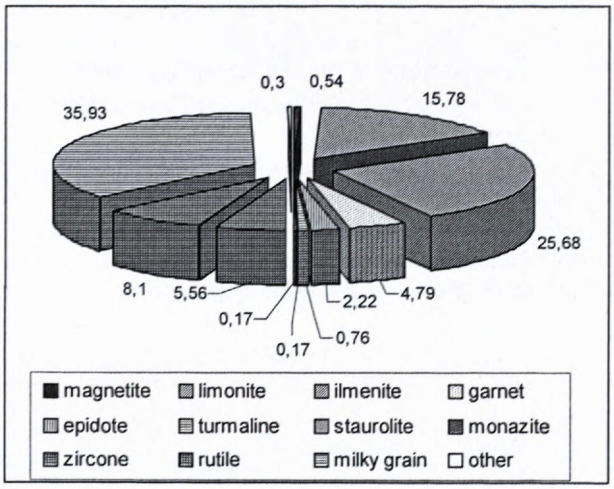

Fig.6. Average composition heavy minerals.

Cretaceous fossils (Boorová, pers. communication) it is possible to assume Jurassic silicites (partly structured black silicites) of Mesozoic envelope unit and Fatric Nappe as main source area of the sediments. The composition of source area is also confirmed by the composition of heavy minerals (turmaline, staurolite, sillimanite).

Pumice, volcanic glass having corroded quartz and glasses with plagioclasses and nucleus of mafic minerals indicate volcanic source area. The source is confirmed by heavy minerals. Together they suggest neotectonic character of the source probably represented by the Vtáčnik Mts. Taking into account their small amount and flow direction, we assume that the volcanoclastics could be redeposited from the underlying Neogene sediments.

Clay minerals, Fe hydroxides and red colour of fine-grained fraction of Lukáčovce Mb. sediments has a character of redeposited subaerial weathering crusts and red paleosoils. There are indications that the red paleosoils are still preserved on the top of the Neogene sediments in the Nitrianska pahorkatina upland.

The genesis and source of limonite concressions is not clear. Theoretically, the source area could be represented by:

- ore deposits which, however, were not found in the area
- by limonite concretions originated in pedogenic process and after then rounded during a transport
- syngenetic lake environment

According a detail study and analysis of more data the most probable source area of limonite concretions seems to be lake environment (Kukal, 1964). The origin of limonite concretions in so called iron-ore lakes is supported by fact, that concretions lithified by limonite contain sand grains of identical composition as sediments of the Lukáčovce Mb. including lithic clasts of silicites having psamitic grain-size. From literature it is generally known that lacustrine limonite concretions originate in near-shore shallow waters and near tributaries. Maximum occurrence of limonite concretions in coarse-grained sediments corresponds to this knowledge. The medium-grained sands of the Lukáčovce locality were probably deposited in deeper part of lake. The theory is also confirmed by high content of limonite grains in heavy fraction and by absence of fossils suggesting lake rich in organic matter (acids) and barren of living organisms.

The idea that the source area is represented by humificate lakes without great organic production, located in the northern part of the temperate zone, is questioned by results of sediment pH analyses. According Kukal (1964) the recent sediments of the same type have pH 5.5 - 6.5. The samples of Lukáčovce Mb. have pH higher. At the locality Lukáčovce the value of pH was 7.29, in Merašice 7.92 and in Ripnany 8.25. This increasing may be a result of diagenetic change as well as postgenetic infiltration of carbonates from overlying loesses.

Alcalic pH (7.2 and 8.2) is typical for arid climate and acid pH connected with formation of limonite concretions is typical for humid climate. As far as the pH of Lukáčovce Mb. was not postsedimentary changed, the increased value confirms formation of limonite concretions (orzstein) in pedogenic process during existence of red paleosoils in humid climate and their redeposition after change of climatic conditions.

Climate

Because the redish-brown sediments can not originate subaquaeosly, it is possible to state that fine-grained material of the Lukáčovce Mb. was at some places postgeneticaly redeposited in a form of red paleosoils and weathering crusts into smaller local lakes from the neighbouring area of higher relief. The redeposition is evidenced by a thick peak of kaolinite.

The soils of such colour and mineral composition originate in subtropic and tropic conditions. Such conditions prevailed in our region until the Cromerian which corresponds in the Alpine paleoclimatic scale to interglacial G/M. After this stage, such paleosoils have not originated (cooler climate).

However, in the Lukáčovce Mb. also eolic material in smaller amount occurs. It is mainly represented by eolic abraded cherts. Such type of material is also suggested by results of grain size analysis applied to a Fig. 7 after Friedman (1961). Alcaline pH also indicates arid climate. It suggests that during the formation of red soils, which characterize Lukáčovce Mb., tropic climate prevailed and redeposition process started after the transition of climate from tropic to arid.

Sedimentary environment

The grain-size analyses (Fig. 7 and 8) imply prevailing formation of the Lukáčovce Mb. sediments in fluvial-limnic environment with admixture of eolic material during the sedimentation. As long as we consider all red horizons as Lukáčovce Mb. we have to assign all primary occurrences of red soils into residual sediments - weathering crust.

If we apply this model, all analysed samples are entirely and partly redeposited into fluvial - limnic environment. The redeposition occurred after the change of climate from tropic to arid mode when also more intensive eolic activity existed.

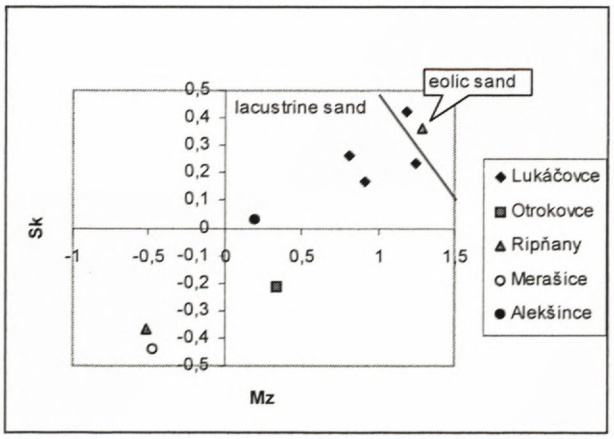

Fig.7. Plot of first moment (Mz) and third moment (Sk-skewnees) using phi scale, Friedman (1961).

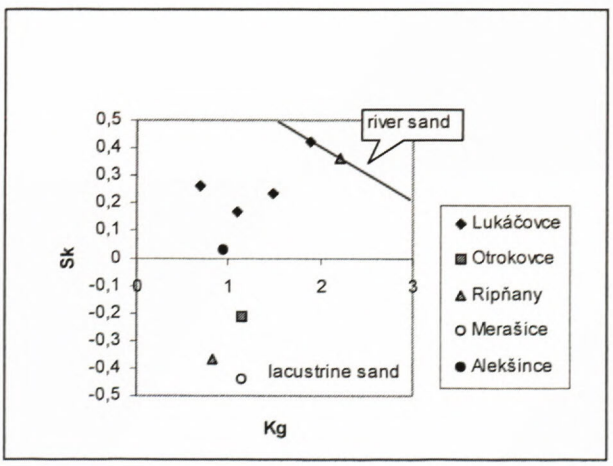

Fig.8. Plot of third moment (Sk-skewnees) and fourth moment (Kg-kurtosis) using phi scale, Friedman (1961).

Based on results of grain size analysis we may assume transport of the sediment in fluvial environment while a part of the material was before or during the transport and sedimentation redeposited by eolic processes. Gravel clasts floated in sandy matrix without preferred orientation suggests redeposition by torrential floods when mixing of paleosoils and coarser clasts from the Považský Inovec Mts. occurred.

Conclusion

The results of complex sedimentary-petrographic analysis of sediments comprising the Lukáčovce Mb., which were analysed at several localities, suggest their depositional environment. They originated in a sporadically closed and open shallow lake and fluvial-lacustrine environments occurring in neotectonically young Ripňany depression. Characteristic feature of sediments is a striking input of alluvial fan sediments transported for a short distance from the Považský Inovec Mts. Occurrence of redeposited sands and gravels from the underlying Volkovce Formation (Dacian) is important.

The sediments comprising Lukáčovce Mb. originated in several sources, however, dominant direction is from the Považský Inovec Mts. The fine-grained part was formed by red paleosoils. Change of climatic conditions probably resulted in loss of vegetation and eolic sedimentation. Probably in this period local heavy rainfalls occurred driving redeposition of sediments and soils by floods on the level of the Late Pliocene river plain. From this level the sediments were redeposited into lower levels into a fluvial - lacustrine system.

The results of the sample analyses show Early Pleistocene age (Biber?, Günz) of primary sediments and Cromerian age of redeposited sediments. This corresponds to the age of similar deposits in the area of Starý Grunt yielded by paleomagnetism (Vaškovská and Vaškovský, 1989).

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