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Pliocene clastic sediments in Western Goričko, Northeastern Slovenia

Pliocenski klastični sedimenti zahodnega dela Goričkega

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Abstract

Upper Pliocene clastic sediments from Goričko have been deposited in fluvial environments. The oldest are alluvial fan and braided river deposits, composed of gravelly sands and sandy gravels. Imbrications indicate the transport directions from northwest to southeast. The following sedimentation was dominated by a meandering river. Sands and flood basin fine-grained sediments infilled the existing paleorelief, produced by alluvial fan, braided river and volcanic deposits.

Kratka vsebina

Zgornjepliocenski klastični sedimenti z Goričkega so bili sedimentirani v rečnih okoljih. Najstarejši so prodnati peski in peščeni prodi, ki so jih nanesli aluvialni vršaji in prepletene reke. Imbrikacije kažejo, da je bila smer transporta od severozahoda proti jugovzhodu. Kasneje so na tem območju odlagale sedimente meandrirajoče reke. Peski in drobnozrnati sedimenti poplavne ravnice so zapolnjevali paleorelief, ki so ga ustvarili nanosi aluvialnih vršajev in prepletenih rek ter vulkansko delovanje.

Introduction

Goričko is a hilly country in Northeastern Slovenia, bordered by Austria and Hungary (Fig. 1). The highest elevation is reached in the North at Sotinski breg (418 m) and Srebrni breg (404 m). Goričko is the southwesternmost part of the Pannonian lowland. The most importan tectonic structure is the Mura basin, which is infilled with clastic sediments, ranging in age from Upper Oligocene (Egerian) to Quarternary. Geological setting of Goričko is closely related to development of the northeast - southwest trending Raba fault and the horst of South Burgenland. The horst of South Burgenland consists of Paleozoic metamorphic and igneous rocks that form pre-Tertiary basement of the Mura basin. In Upper Pliocene, it was also the site of intensive volcanic activity, which produced large alkali basaltic lava flows. The Raba fault developed into the Radgona depression, which underwent the main subsidence in

Upper Pliocene. The rivers, flowing from northwest to southeast, carried huge amounts of coarse-grained clastic material, originating from metamorphic rocks. Along the horst of South Burgenland, a system of alluvial fans and braided rivers developed. They built up a positive relief, which has been susequently infilled by meandering river deposits. In the Upper Pliocene, explosive alkali basaltic volcanism also occurred in the western part of Goričko (Pleničar, 1970; Kralj, 1995). In a dynamic fluvial environment, volcanic deposits were readily eroded and redistributed by fluvial currents.

The present paper deals with lithofacieses recognised in non-volcanic clastic deposits in Western Goričko, their depositional sedimentary environment and mineralogical composition.

Alluvial fan and braided river deposits

Alluvial fan and braided river deposits were settled in the same fluvial system. They are stream sediments, deposited from perrenial water flows in a subenvironment of lower alluvial fan and a proximal braided river of the Scott type (Miall, 1985). Deposits are very similar with respect to the grain-size, composition and sedimentary structures. They have been recognised at Srebrni breg (Martinje), and at the neighboring villages of Boreča, Ženavlje, Šulinci, Kovačevci and Vidonci. According to Winkler (1927), gravelly sediments in this area are referred as the "Silberberg schotter" or the gravels of Srebrni Breg. Their thickness is estimated to about 80 metres (Pleničar, 1970). The following lithofacies have been recognised:

Gp, massive sandy gravel,
Gt^s, through-cross bedded sandy gravel and gravelly sand
$St^{g,f}$, through-cross bedded gravelly-silty sand
St, through-cross bedded sand, which infills small-dimension erosional channels in the sediments of the lithofacies Gt^s, and
Fh, laminated silts and clayey silts, that overlie the sediments of the litofacies Gt^s.

Well exposed outcrops of massive sandy gravel (Gp) occur at the village of Boreča. Imbrication, measured for over 200 pebbles indicates confirmes the transport directions from northwest to southeast, stated by Pleničar (1970). At Srebrni Breg, hematite-cemented conglomerates locally occur.
Sediments of the lithofacies Gt^s and $St^{g,f}$ consist of sandy gravels and gravelly sands, which infill the river channels (Plate 1 - Fig. 1, 2). Grain-size analysis has shown, that they are very poorly sorted, and may contain up to 20 % of silt (Table 1; Fig. 2). Mean-size is 0,4 mm, the sorting S_0 is 6,3 and the coefficient of assimetry S_k is 5,6. Pebble diameter attains up to 20 mm. The pebbles are well rounded; roundness and sphericity amount to Z = 0,7-0,9 and S = 0,5-0,7, respectively

Table 1. Grain-size distribution of a gravelly sand (lithofacies Gt^s, Plate 1 - Fig. 3) from Martinje (Mt). The abundance is in wt. %.

Sample	Gravel >2 mm	Sand 2-0,063 mm	Silt 0,063-0,002 mm	Clay <2 mm
Mt2	39	43	15	3

Lithofacies S^t sands occur within the lithofacies Gts and $St^{g,f}$ gravels, infilling small-dimension erosional channels (Plate 1 - Fig. 2). With respect to the associated gravels and gravelly sands, the St sands are less abundant, and attain up to 10% of the bulk deposit. The channel thickness is less than a metre, and locally they may be several metres wide. The most common internal structure is plannar cross-bedding or through-cross bedding. Individual laminae and thin beds range in thickness from a few mm to 1 cm.

Lithofacies Fh is composed of fine-grained sediments, silty sands, sandy silts or more rare clayey silts. Where developed, they overlie the lithofacies Gt^s and $St^{g,f}$, and attain a thickness of up to 1 metre. Lithofacies Fh is interpreted as a sediment of the flood basin or channel abandoning.

Grain-size distribution of the prevailing lithofacies of gravels and gravelly sands Gt^s and $St^{g,f}$, which infill broad and relatively shallow erosional channels, cross-bedded sands, deposited in broad and shallow erosional channels, and subordinate fine-grained sediments of the lithofacies Fh are

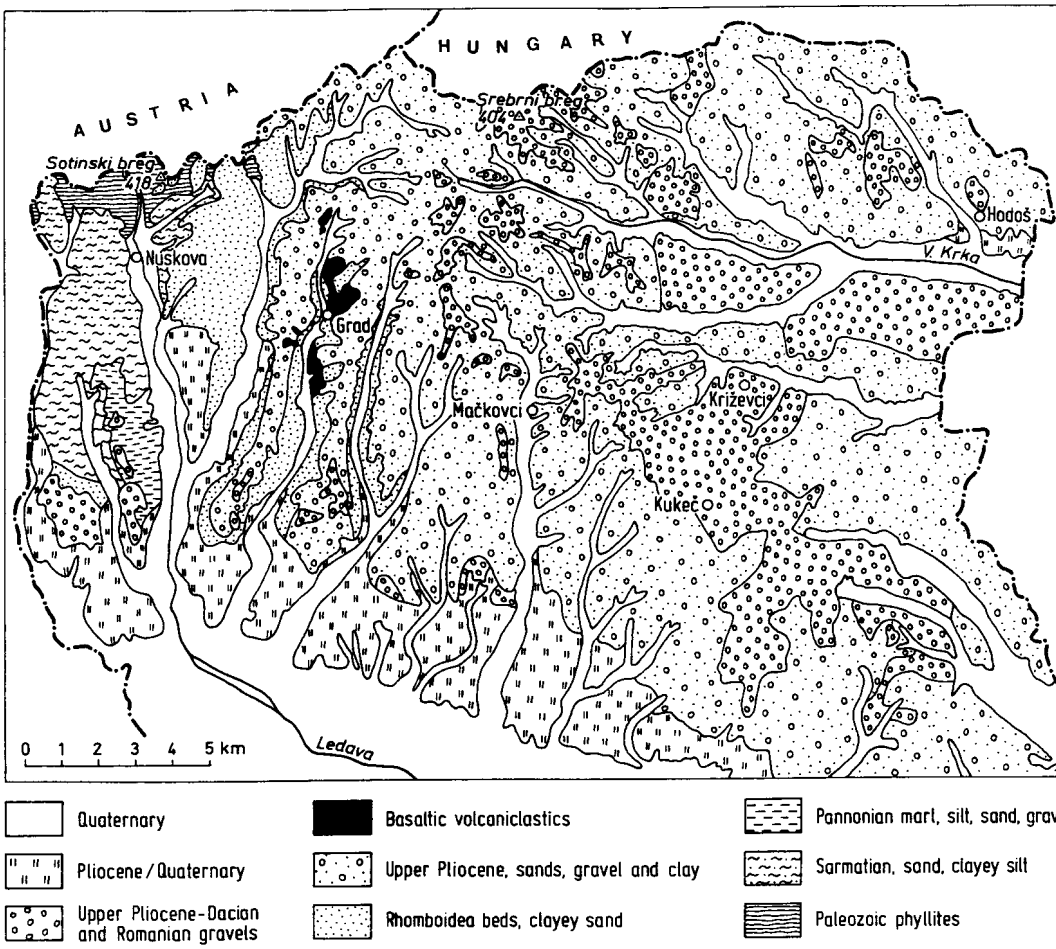

Figure 1. Simplified geological map of Goričko (po Pleničarju, 1970)
Slika 1. Poenostavljena geološka karta Goričkega (after Pleničar, 1970)

characteristic of braided river deposits (Miall, 1978; Galloway and Hobday, 1983; Einsele, 1992; Lewis, 1984).

Meandering river deposits

Meandering river deposits overlie alluvial fan and braided river deposits, but owing to the existing paleorelief, they may be encountered at lower elevations than the al-

Table 2. Grain-size distribution for the St^g lithofacies sands from the V4 drillhole core from Bomčev breg at Grad

Drillhole sample	Gravel >2mm	Sand 2-0,063 mm	Silt 0,063-0,002 mm	Clay <0,002 mm	Md mm	So (after Trask)	Sk (after Trask)
V4/6	12	68	16	4	0,4	2,65	0,44
V4/7	18	52	27	3	0,4	6,05	0,21
V4/9	15	65	17	3	0,3	2,89	1,33
V4/10	12	70	15	3	0,4	2,51	0,77
V4/12	12	58	27	3	0,2	5,6	0,96

V4/6, 4,30 -4,50 m; V4/7, 4,50-4,70 m; V4/9, 7,60-7,80 m; V4/10, 8,80-8,90 m; V4/12, 10,20-10,30 m

luvial fan and braided river deposits. Lithofacies of meandering river deposits were subdivided into:

- St^g, through-cross bedded sands, commonly slightly gravelly
- Sp, sands with planar cross-bedding which may contain some quartzite granules and pebbles
- Sh, horizontally bedded sands, which may contain some quartzite granules and pebbles, and
- Fh, horizontally laminated silts and clayey silts which commonly contain some fine-grained sands.

The sediments form fining-upward sedimentary sequences.

Lithofacies of sands - St^g, Sp and Sh, overlie fine-grained sediments of the lithofacies Fh. The contacts are erosional. They outcrop on many locations, but the most important are core samples from shallow drillholes in Bomčev breg at the village of Grad (Plate 1 - Fig. 4, 5,6).

Lithofacies St^g consists of through-cross bedded sands, which may contain some admixture of granules, pebbles and silt, particularly near the erosional contact with the underlying fine-grained sediments. Upward from the contact, the silt admixture is not present any more, but the gravelly component becomes somewhat finer.

Table 2 comprises grain-size distribution of the St^g lithofacies sands from the V4 drillhole core from Bomčev breg. The maximum grain-diameter is 2 cm. Granules and pebbles are well rounded with high and medium sphericity. Sediments are composed of 12-18 % of gravel, 52-70 % of sand, 15-27 % of silt and 3-4 % of clay. Sorting is very poor and the coefficient of assimetry has shown that the grains, finer than the mean-size predominate.

In the nearby Glažarjev breg, the St lithofacies sands are overlain by the Sp lithofacies sands. They are characterised by planar cross bedding, The bed thickness amounts to some mm to 20 mm, but the

Table 3: X-ray analysis of powdered samples of meandering river sands and silts. Abundance in wt. %.

Sample	Lithofacies	M/I	KL	KL/M	Ca-M	Q	F	Cc	Py	G	S	Mf
DS1	Fh	35	18		10	16	6	6		3	6	
GS1	Fh	47	24	3		26						
GS2	Fh	52	14		9	21				4		
BB1	Fh	32	24		11	17	12			3		
BB2	Fh	40	17		8	21	5			6	5	
MB2a		32	9		7	15	5	28	1			
MB2b		30	13	5	6	14	4	23	1			
MB2c		43			10	23	5					
GB2	St	23	13			34	26			5		8
GB4	Sh	14	8			56	15					
B1	Fh	34	4		31	16	12			2		
B2	Fh	35	5		9	36	14					
B3	Fh	37		12	16	24	10		2			
B4	Fh	36	5			31	12			4	9	
B4a	Fh	35		6	12	25	15		3	2		
B3K	Fh	35		8	19	21	15		2	2		

Localities: DS - Dolnji Slaveči; GS - Gornji Slaveči; BB - Bomčev breg; MB - Majcnov Breg; GB - Glažarjev Breg ; B - Boreča via Sv. Ana

Table 4: X-ray diffraction analysis of braided river sandy and gravelly deposits. Abundance in wt. %.

Sample	Lithofacies	M/I	KL	KL/M	KAO	Ca-M	Q	F	G/H	S	Ch
SB1	St^g	17	19	9	14		39		2		14
SB1a	Gt	10			20		57	8	6		
SB2	St^g	23			16	11	27	18	5		
SB3	Gt	27			25		39	9			
Pi71/2	Gms	42			17		19		7	14	

Localities: SB - Srebrni Breg; Pi - Pirga at Grad

whole unit thickness ranges from 1-3 m. Overlying Sh lithofacies sands are horizontally bedded. The bed thickness ranges from a few mm to 20 mm. The sands are locally cemented with goethite and hematite. The composition is very similar to the St and Sp lithofacies sands. Quartz and quartzite grains predominate, and muscovite is another characteristic mineral, although it occurs in subordinate amounts.

Fine-grained sediments of the Fh lithofacies are the most abundant in meandering river deposits. They were also drilled in Bomčev breg (Plate -1 Fig. 6). The Fh lithofacies sediments consist of horizontally laminated silt. Lamination is reflected in the change of grain-size and sometimes of color. Silts are pale green or blue, and the sands are orange brown and yellowish brown. The majority of 35 studied samples are silts or sandy silts. Except for two samples, they all contain less than 10 % of clay. The sand fraction amounts up to 46 %. In many samples, the amount of silt and fine-grained sand may be very similar, but silt always prevailes.

Lithofacieses St^g, Sp, Sh and Fh are joined into a finig-upward alluvial sequence (Fig. 3). Lithofacies Fh dominates and occurs beneath, above and laterally to the sandy lithofacies which infill the river channel. If the sequence is compared with an idealised sequence of meandering river deposit (Galloway & Hobday, 1983; Lewis, 1984), lithofacies St^g can be interpreted as a channel lag, and lithofacies Fh as a sediment of the flood basin.

Mineral composition of braided river and meandering river deposits

Mineral composition of the river sediments, determined by X-ray diffraction has shown some differences in composition of clay minerals (Table 3, Table 4). Kaolinite occurs in fine-grained sediments of braided river deposits and is absent in meandering river deposits, where illite and calcic montmorillonite occur instead.

According to Winkler (1927) and Pleničar (1970), kaolinite occurs as an alteration product of metamorphic rocks, which outcrop on Sotinski Breg. Transport direction and the sediment provenance seem to be somewhat different for braided and meandering rivers although in general, they both flowed from northwest to southeast.

Conclusions

Pliocene sediments in Goričko were transported and settled by perrenial fluvial current in the environment of lower alluvial fan and proximal braided rivers, and subsequently, by meandering rivers. Tectonic activity, which caused the uplift of the horst of South Burgenland and sinking of the Radgona depression, created favourable conditions for the development of alluvial fans which evolved into a system of braided rivers. Alluvial fan deposits and their continuation to the system of braided rivers created morphologically uplifted bodies, composed mainly of gravels and sands. Younger, meandering river deposits are finer-grained, and dominated by the sediments settled in flood basins. They infill paleorelief, created by older fluvial and volcaniclastic deposits. Clay minerals, recognised in fluvial sediments indicate, that alluvial fan and braided river deposits contain kaolinite, which is absent in meandering river deposits. Kaolinite probably originates from altered metamorphic rocks, exposed in the southernmost part of the horst of South Burgenland.

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Plate 1 - Tabla 1

Fig. 1. Alluvial fan deposits (lithofacies Gt^s) at Ženavlje, South of Srebrni breg
Sl.1. Sediemnti aluvialnega vršaja (litofacies Gt^s) pri Ženavljah, južno od Srebrnega brega

Fig. 2. Alluvial fan deposits (lithofacies $St^{g,f}$ in Gt^s) at Ženavlje , South of Srebrni breg
Sl. 2. Sediemnti aluvialnega vršaja (litofacies $St^{g,f}$ v Gt^s) pri Ženavljah, južno od Srebrnega brega

Fig. 3. Braided river deposits at Martinje - Srebrni breg
Sl. 3. Sedimenti prepletene reke pri Martinju - Srebrni breg

Fig. 4. Cored fine-grained meandering river deposits, Bomčev breg at Grad
Sl. 4. Jedrovani sedimenti meandrirajoče reke na Bomčevem bregu pri Gradu

Fig. 5. Cored fine-grained meandering river deposits, Bomčev breg at Grad
Sl. 5. Jedrovani sedimenti meandrirajoče reke na Bomčevem bregu pri Gradu


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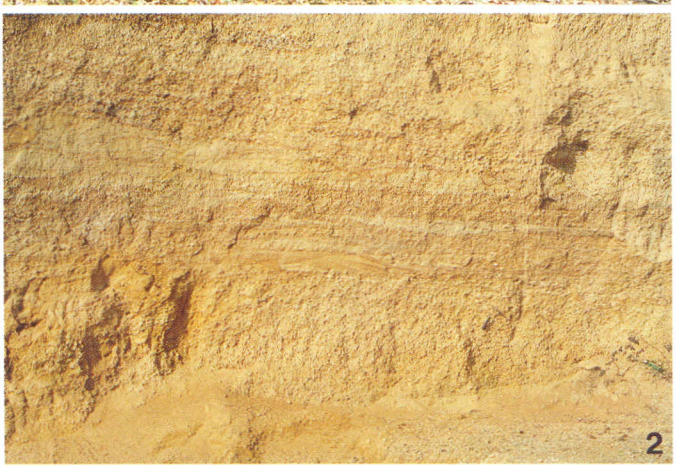
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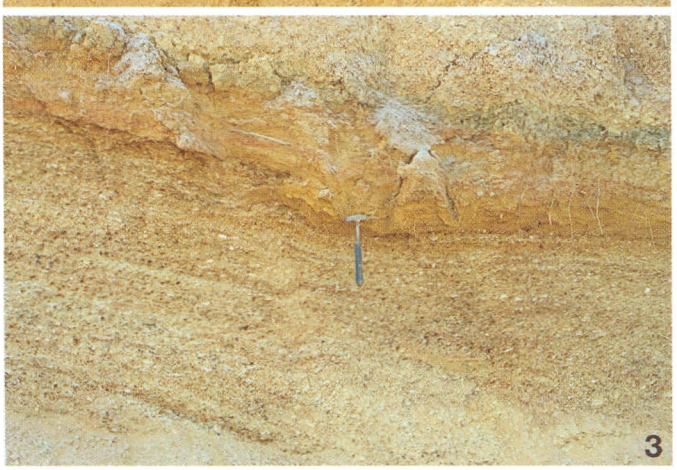
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