LITHOSTRATIGRAPHIC AND POLLEN ANALYSIS OF QUATERNARY DEPOSITS IN THE GROSUPLJE POLJE AREA

Stevo DOZET* and Metka CULIBERG**

Abstract
In the Grosuplje polje area in the central part of Slovenia detailed geological mapping and palynological research studies were performed in the last two years. Our research has revealed, that the deposits of the Grosuplje polje consist regularly of six lithological units (from bottom to top): 1 – dark grey greasy clay, 2 – grey and medium grey silty clay, 3 – orange-yellow sandy loam, 4 – light grey marly clay, 5 – dark brown marly clayey organic layer. At the top of the described succession there is a relatively thin layer of dark alluvial marshy soil (6). Pollen analysis showed that these deposits are all of Quaternary age.

Izvleček
Na območju Grosupeljskega polja v osrednjem delu Slovenije so bili v zadnjih dveh letih opravljeni detajlno geološko kartiranje in palinološke raziskave. Ugotovljeno je bilo, da usedline Grosupeljskega polja praviloma sestavlja šest litoloških enot (od spodaj navzgor): 1 – temnosiva mastna glina, 2 – siva in srednje siva meljasta glina 3 – oranžnorumena peščena ilovica, 4 – svetlosiva laporna glina, 5 – temnorjava laporno glinena organska plast. Prav na vrhu opisanega sedimentnega zaporedja so temna aluvialna barjanska tla (6). Pelodna analiza je pokazala, da so vse zgoraj naštete usedline kvartarne starosti.

Key words: central Slovenia, Quaternary deposits, Grosuplje polje, lithostratigraphy, palynology
Ključne besede: osrednja Slovenija, kvartarne usedline, Grosupeljsko polje, litostratigrafija, palinologija

1. INTRODUCTION

During the systematic regional geological mapping for the Geological map of Slovenia 1:50 000 on the Map Sheet Grosuplje, carried out by the Geological Survey of Slovenia, we devote every attention to detailed geological mapping of the Pliocene and Quaternary formations. They are above all red and brownish red Dolenjsko loams, as well as limnic and marshy deposits. The open question was first of all that of their superposition and age. Previous researchers supposed that these formations originated in the Upper Pliocene and Quaternary. The geological investigations in the study area solved superpositional and stratigraphic relations. Due to the scarce fossil contents, paleontological methods could not be taken into consideration. Strictly speaking, useful results were obtained up to present only by pollen analysis, performed in the Institute of Biology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts in Ljubljana. The samples for pollen analysis have been taken from limnic and marshy clays and soils in the Grosuplje surroundings.

Geographical setting. The area in question comprises the Grosuplje polje lying about 30 kilometres to the southeast of Ljubljana. The Grosupolje polje is actually a composed border plain, with a flat gently undulating area, having few irregularities (hills, valleys) and a more or less ex-

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pressive margin. It has been developed to the south of the contact of water-tight and karstic rocks.

The Grosuplje polje comprises about 14 square kilometers of the surface, lying between the hills Molnik (582 m) and Kucelj (748 m) in the north, and the Turjak area in the south. Towards the west it borders on Ljubljana Marsh, while its continuation towards the southeast is named Radensko polje.

Geological setting. The study area lies to the south of the contact between two large geotectonical units, the Sava Folds and the Dolenjsko-Notranjsko Mesozoic Blocks (Dolenjsko Karst). Kossmat (1905, 1906) believed that the Sava Folds are partly in a normal contact and in part overthrusted upon the Karst of Dolenjska. Rakovec (1955) considered, that the southern part of Litija anticlinal passes gradually into the Karst of Dolenjska. Germovšek didn't conceive the Alpine-Dinaric boundary line – in the sense of a boundary line between the Sava Folds and the karstic Dinarides – as a tectonic line but rather as a transition belt of less tectonic importance. Sedlar et al. (1948), Buser (1974) and Dozet (1985) found out that at Pleše near Ljubljana the Sava Folds are thrusted over the Karst of Dolenjska under an angle of 15° to 20°. However, non-thoroughly developed and non-wholly modelled, the Grosuplje polje is a karstic plain which originated on the Upper Triassic dolomite. Melik (1955) supposed that this plain originated in Diluvial or Pliocene. In our opinion, the Grosuplje polje is not a typical tectonical depression like many other large Slovenian karstic plains. Actually, this plain originated in the combined activity of selective erosion and tectonics.

Previous investigations. The considered part of Dolenjska was first mapped by Lipold (1858). The result of the mapping was the manuscript geological map Višnja gora – Cerknica 1:75 000 (Lipold & Stache 1959). Kerčmar (1961) mapped out the surroundings of Taborska jama at Grosuplje. The Quaternary vegetation of Slovenia was described by Šercelj (1962, 1963). In the frame of the systematic regional geological mapping for the Basic Geological Map of Slovenia 1:100 000, the geological map of the map sheet Ribnica with an explanation text has been printed (Buser 1969, 1974). Gregorič (1969) investigated the connection between carbonate rocks and red soils. The minerals determined in the carbonate rocks and soils proved a direct connection. In her opinion, the red brown soil has developed from the insoluble rest of the carbonate rocks. She has also proved that the red brown loam between Škofljica and Šmarje was autochthonous fossil soil. She believed, that the loam in Dolenjska and Bela Krajina is partly alluvial. Hrovat (1953) considered that the brown and red loams in Dolenjska are a product of weathering of limestone and dolomite.

2. METHODS

The data and results presented in the paper are obtained in the frame of the systematic regional geological investigations for the Geological map of Slovenia 1:50 000, and research – scientific co-operation between the Geological Survey of Slovenia and the Institute of Biology, Scientific Research Centre of the Slovenian Academy of Sciences and Arts Ljubljana. The geological mapping is carried out on topographic maps 1:10 000. The principal mapping methods are the method of all outcrops and stratimetric profiling. Besides, in the Grosuplje polje area the method of mapping of water trenches and construction pits is also applied. The clastic rocks are classified according to Folk's (1959) and Pettijohn's (1975) classification. The color of the rocks is defined according to the Rock-Color Chart prepared by Rock-Color Chart Committee and distributed by the Geological Society of America, Boulder, Colorado (1970).

Ten sediment samples for pollen analysis were collected from open profiles at two localities near Grosuplje (Fig. 1). They were prepared using stan-

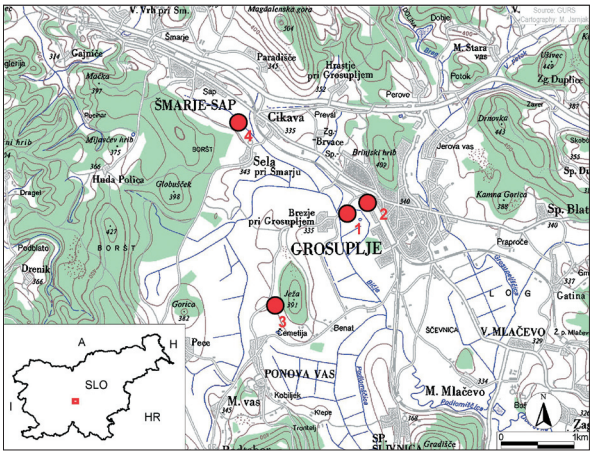

Figure 1: Grosuplje polje area. The localities of palynological and sedimentological investigated sediments. 1. Brezje near Grosuplje, 2. Grosuplje, 3. Ponova vas and 4. Cikava.
Slika 1: Grosupeljsko polje. Na označenih lokalitetah so bili palinološko in sedimentološko raziskani sedimenti. 1. Brezje pri Grosupljem, 2. Grosuplje, 3. Ponova vas in 4. Cikava.

dard laboratory procedures (Faegri & Iversen 1992). The pollen key of Reille (1992) was used for the identification of pollen types.

Six samples were collected from an almost 7 m deep profile of a construction pit near the settlement of Brezje. Because of the scarce pollen content we examined four microscopic slides from each sample. The results are shown in Table 1 in absolute numbers of pollen grains.

Included are also four samples of grey clay from a depth of 120 to 140 cm which were collected from the profile of an archaeological test trench near the village of Ponova vas. Percentage values of individual taxa are given in Table 2. The quantity of pollen of tree and herb vegetation (AP + NAP) was taken for calculating the percentage values, and spores of ferns were taken separately. For the herb vegetation (NAP) we state only the percentage value of the amount of all taxa found.

The data and results of the detailed geological mapping and sedimentologic researches are a basis for lithological subdivision and explanation of sedimentary superpositional relations. The pollen analysis enabled both the biostratigraphic classification of the considered sedimentary succession, and also its chronological situation.

3. RESULTS

3.1 Results of stratigraphical researches

During the detailed geological mapping of the Plio-Quaternary deposits of the Grosuplje polje, we have not yet succeeded in separating and proving the Pliocene formations anywhere on the surface. Nevertheless, we suppose that the dark red and brick-red bauxitic loams in the Zagradec at Grosuplje, Spodnje Blato, Duplica, Brinjski hrib (409 m), Perovo, Hrastje at Grosuplje, Cikava, Sela at Grosuplje and Šmarje are chiefly of the Upper Pliocene age. It is also quite possible that the Pliocene sediments were deposited in some places on the bottom of the Grosuplje polje, but they are at present covered with younger deposits. In this case, they belong to the Upper Pliocene or the Pleistocene epoch. With regard to lithologic characteristics the Quaternary sedimentary succession could be subdivided into six lithostratigraphic units, namely (from bottom to top): 1 – dark grey greasy clay, 2 – grey and medium grey silty to sandy clay, 3 – orange yellow more or less sandy loam, 4 – light grey marly clay with numerous plant remains, 5 – dark marly clayey peaty horizon, 6 – alluvial-marshy soils.

The above-described succession of soils, peat, clays and loams lies discordantly upon the Upper Triassic hauptdolomit, on the surface of which a rather expressive and various palaeorelief had been developed even before the deposition of the above-enumerated deposits. Pollen analysis showed that the described lithostratigraphical units (except for the sixth) at Grosuplje are of the Pleistocene and at Ponova vas of the Holocene age.

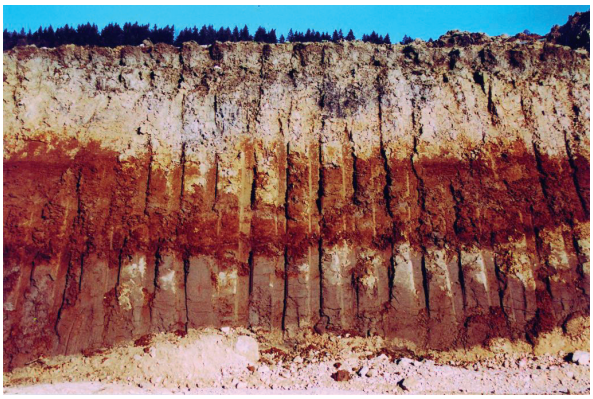

Figure 2: 7-metres-deep profile in the Grosuplje area. The bedrock is built by the Upper Triassic hauptdolomit.
Slika 2: 7 metrov globok profil na območju Grosuplja. Trdna podlaga je zgrajena iz zgornjetriasnega glavnega dolomita.

As eaerlier mentioned, the Grosuplje polje was developed completely on the Upper Triassic hauptdolomit. In the Grosuplje polje area, the bed rock crops out on the bottom of construction pits. The hauptdolomit is grey, dark grey and greyish black, appearing in 20 cm to 60 cm thick beds. It is characterized by an expressive fine lamination and fine stromatolitic structure. Apart from indeterminable gastropod remains, the rock does not contain any other fossil remains. Nevertheless, it is easily recognizable according to the typical Lofer texture and structure.

- The hauptdolomit is discordantly overlain by the dark grey, bluish grey and greenish grey greasy clay (1). The thickness of the considered clay varied from 2 to 2.5 metres. The dark greasy clay is relatively pure without any gravel or rock fragments having a rather high plasticity. In the study area, the dark clay layer properly shows a fairly equable thickness.
- Upon the dark grey greasy clay lies a layer- about 1.5 to 2.5 metres thick- of grey silty clay (2) passing at some places laterally into the dark grey

laminated, banded and thin bedded micaceous silt or fine sand.

- Upwards follows the lithostratigraphic unit of orange and orange yellow, more or less sandy loam, with irregular lenses and spots of greyish clay (3) The thickness of this unit is not constant, changing laterally from 1 to 2.5 metres. Likewise, its mineral composition varies, both laterally and vertically.
- The orange yellow loam is overlain by a 0.35 to 0.75 –metre- thick layer of light grey marly clay with charred plant remains (4). In spots, it is poorly slaty.
- It follows upwards up to 0.25 –metre- thick layer of very dark to black marly clay (5). This layer is at some places more or less peaty.
- The hanging wall of the described succession of the Quaternary deposits is represented by dark alluvial marshy soil (6), about 0.5 metres thick. Its upper part is saturated with water and in the lower part there is a clayey soil with fragments of carbonate rarely clastic rocks of different age. The surface is overgrown with sedges (*Magnocaricion)* and reeds *(Phragmition).*

Figure 3: The surface of the Grosuplje Quaternary sediments is overgrown with sedges (*Magnocaricion)* and reeds (*Phragmition).*
Slika 3: Površje Grosupeljskega kvartarnega sedimenta poraščajo šaši (*Magnocaricion*) in trstje (*Phragmition*).

3.2. Results of pollen analysis

There was very little pollen in all the samples of sediment from the Brezje profile, and the lower sample from a depth of 6.5 m was completely free from pollen. Pollen of herb species predominated. Only in grey sandy clay from a depth of 5.75 m was there also pollen of tree species, of which there was most pine pollen (*Pinus*) and only a few pollen grains of spruce (*Picea*) and birch (*Betula*). There were also some spores of lesser clubmoss (*Selaginella selaginoides*). In a sample from a depth of 3.5 m we found some tiny fragments of charcoal for which we could establish only that they belonged to coniferous wood. However there was no pollen of any tree species in this sample, like in others above, in which beside some herb pollen there were numerous monolete spores of ferns (Tab. 1).

We also found a similar pollen content as that from a depth of 5.75 m at the Brezje profile, in sediment from a depth of 7.5 m at an excavation by Grosuplje railway station: *Pinus* 36, *Picea* 2, *Betula* 1, *Artemisia* 5, *Helianthemum* 4, Chenopodiaceae 4, Gramineae 20, Caryophyllaceae 5, Compositae 1, Cyperaceae 3, *Selaginella selaginoides* 137, but here *Selaginella* is most characteristic.

The prevailing herb vegetation and trees of eurothermic taxa of pine, birch and spruce, and especially *Selaginella* reliably indicate a Pleistocene age of all these sediments. Šercelj found similar vegetation in sediment from the course of a brook by the settlement of Cikava and placed this sediment in the Pleistocene, probably at the time of the Würmian glaciation, but also he did not exclude its being older (1963: 392).

Table 1: Pollen in sediment from the profile at Brezje near Grosuplje (absolute pollen values).
Tabela 1: Pelod v sedimentu iz profila Brezje pri Grosupljem (absolutne vrednosti peloda).

Depth	1 m	2 m	3.5 m	4.5 m	5.75 m	6.5 m
Pinus	–	2	–	2	24	–
Picea	–	–	–	–	4	–
Betula	–	–	–	–	2	–
Artemisia	1	8	2	–	6	–
Helianthemum	–	–	–	–	4	–
Chenopodiaceae	–	–	1	–	6	–
Graminenae	1	1	–	–	–	–
Caryophyllaceae	–	–	–	1	–	–
Compositae-tub.	–	–	2	–	–	–
Ericaceae	–	–	1	–	–	–
Plantago	–	1	–	–	–	–
Polygonum	–	2	–	–	1	–
Selaginella sel.	–	–	–	–	3	–
tril. spores	2	3	6	–	8	–
monol. spores	399	153	69	–	–	–

Pollen content from the profile beside the hill Ježa near the village of Ponova vas, only about 2 km south of Brezje, showed completely different, Holocene like vegetation (Šercelj & Culiberg, un-

published), in which hazel (*Corylus*) dominated with a share of around 60 percent (Tab. 2). Other tree species are represented much less. The only exception is alder (*Alnus*), which was a local particularity on damp ground. The sediment was not radiocarbon dated, and in view of the vegetation found and the relatively short segment of profile, it is difficult to classify with certainty the period when this sediment was deposited in the Holocene. The hazel phase was certainly one of the succession stages in the primary development of forests in the early Holocene. However, in view of the fact that the hazel phase in the majority of pollen diagrams from Slovenian territory was relatively short and never such a pronounced phase as in this case, there is a greater probability of a younger anthropozoogenic impact, and the sediment could thus also be of Middle or even Late Holocene age.

Table 2: Pollen in sediment from the profile at Ponova vas (percentage pollen values).
Tabela 2: Pelod v sedimentu iz profila pri Ponovi vasi (odstotne vrednosti peloda).

Depth (cm)	120–123	123–126	126–130	137–139
Pinus	0.8	0.9	1.8	–
Picea	–	–	0.6	–
Abies	–	–	0.6	–
Juniperus	–	–	0.6	–
Betula	6.2	5.6	1.8	5.4
Alnus	19.8	21.5	22.2	15.0
Corylus	58.5	64.5	52.2	64.5
Carpinus	–	1.3	2.4	0.3
Quercus	0.8	5.2	3.6	2.4
Tilia	–	0.9	–	–
Ulmus	0.3	0.4	–	–
Fagus	6.8	6.9	3.6	1.5
Salix	–	–	–	0.3
Rhamnus	–	–	0.6	–
NAP	6.0	7.7	6.0	4.5
Sporae monol.	0.7	–	6.6	1.2
Sporae tril.	5.5	0.9	1.2	0.3

4. CONCLUSIONS

On the basis of field investigations, pollen analysis, correlation and results of previous researchers we arrived at the following conclusions:

- The Grosuplje polje is a composed border plain, a flat gently undulating area respectively, having few irregularities and a more or less expressive margin. It lies to the south of the contact between two large geotectonical units, the Sava Folds and the Dolenjsko-Notranjsko Mesozoic Blocks, Karst of Dolenjska respectively. Non-completely developed and non-wholly modelled, the Grosuplje polje is a typical karstic plain which originated on the Upper Triassic dolomite. In our opinion, this plain is not a typical tectonical depression like many other Slovenian larger karstic plains originating with selective erosion and by tectonics.
- The bed rock of the Quaternary deposits in the whole Grosuplje polje is fine-laminated and fine-stromatolihtic hauptdolomit.
- With regard to lithological composition and superposition, the Quaternary sedimentary succession is separated into six lithostratigraphic units (from bottom to top): 1 – dark grey greasy clay, 2 – grey and medium grey silty clay, 3 – orange yellow more or less sandy loam, 4 – light grey marly clay with numerous plant remains, 5 – dark brown marly clayey organic layer and 6 – alluvial marshy soils.
- On the basis of the stratigraphic position and composition we suppose that the dark red and brick-red bauxitic loams in the Zagradec at Grosuplje, Spodnje Blato, Duplica, Brinjski hrib (409 m), Perovo, Hrastje at Grosuplje, Cikava, Sela at Grosuplje and Šmarje Sap are chiefly of the Upper Pliocene age. The red loams were probably deposited in some places on the bottom of the Grosuplje polje as well, but they are at present covered with Quaternary deposits.

5. POVZETEK

Litostratigrafske in pelodne analize kvartarnih usedlin na Grosupeljskem polju

V članku so podani rezultati geoloških in palinoloških raziskav pliocenskih in kvartarnih sedimentov Grosupeljskega polja. Teren, ki ga obravnavamo, leži južno od stika dveh velikih geotektonskih enot: posavskih gub in dolenjsko – notranjskih mezozojskih grud (Dolenjski kras). Grosupeljsko polje je v bistvu sestavljeno robno polje, ki je nastalo južno od stika vododržnih in kraških kamnin. Obsega okoli 15 km^2 površine. Leži 30 km od Ljubljane med Molnikom (582 m) in Kucljem (748 m) na severu in Turjaškim ozemljem na jugu. Na zahod se odpira v Ljubljansko barje, njegovo nadaljevanje v jugovzhodni smeri pa je Radensko polje. Grosupeljsko polje je dokaj tipično kraško polje, ki

se je v celoti izoblikovalo na zgornjetriasnem dolomitu. To polje ni tipična udorina kot večina naših večjih kraških polj. Nastalo je s selektivno erozijo dolomita z drobno krojitvijo ob pomoči tektonskih sil. Po mnenju Melika (1955) je nastalo v diluviju ali pliocenu. Dvignjene predele na obrobju polja gradi dolomit, na samem polju pa se dolomit izdanja le v redkih izkopih za gradbene objekte. Je siv, svetlosiv, temnosiv in sivkastočrn. Pojavlja se v obliki 20 do 60 cm debelih plasti. Je značilno drobno laminiran in drobno stromatoliten. Razen nedoločljivih ostankov hišic drobnih polžev ne vsebuje drugih fosilov, vendar ga po tipičnih loferskih teksturah in strukturi zlahka prepoznamo.

Pri detajlnem geološkem kartiranju Grosupeljskega polja in bližnje okolice doslej nismo nikjer uspeli izdvojiti in dokazati pliocenskih formacij. Predpostavljamo, da so zgornjepliocenske starosti temnordeče in opekastordeče boksitne ilovice na območju Zagradca pri Grosupljem, Spodnjega Blata, Duplice, Brinjskega hriba (409 m), Perova, Hrastja pri Grosupljem, Cikave in Sel pri Šmarju Sap. Možno je tudi, da so pliocenski sedimenti bili odloženi na dnu Grosupeljskega polja, kjer pa so jih prekrile mlajše usedline. V slednjem primeru starostno pripadajo zgornjemu ali vrhnjemu delu pliocenske dobe. Lipold (1858) je menil, da je rdeča ilovica diluvijalni sediment in da jo je naplavila voda. To je dokumentiral z najdbo molarja vrste *Equus fossilis* Linné v okolici Trebnjega. Buser (1974) je dal palinološko preiskati sivo glino, ki jo je našel nad rdečo ilovico severozahodno od Spodnje Slivnice. Šercelj (1962) je ugotovil, da je ta glina würmske starosti. S tem je dokazano, da je rdeča ilovica še starejša. Šercelj in Dozet (1982) sta s pelodnimi raziskavami ter po stratigrafski legi in sestavi (Dozet 1982, 1983) dokazala, da je boksitna ilovica oziroma terra rossa na Kočevskem pliokvartarna, ilovica s prodniki kremena in železnatega boksita na Kočevskem in Ribniškem polju pa kvartarna.

Med kvartarnimi usedlinami so na raziskanem ozemlju najbolj razširjene pleistocenske tvorbe. Pri litoloških značilnostih in legi je kvartarno sedimentno zaporedje razčlenjeno v šest litostratigrafskih enot, in sicer (od spodaj navgor): 1 – temnosiva mastna glina, 2 – siva in srednjesiva meljasta glina, 3 – oranžnorumena bolj ali manj peščena ilovica, 4 – svetlosiva laporna glina z drobci lesnega oglja, 5 – temnorjava laporno-glineno-šotasta plast in 6 – aluvijalna barjanska tla. Našteto zaporedje sedimentov: šota, glina in ilovica leži diskordantno na glavnem dolomitu, na katerem se je še pred odložitvijo teh usedlin razvil dokaj izrazit in razgiban paleorelief.

Palinološka analiza je pokazala, da so opisane litostratigrafske enote (razen šeste) pri Grosuplju pleistocenske, pri Ponovi vasi pa holocenske starosti.

- Diskordantno na glavnem dolomitu leži temnosiva, modrikastosiva ali zelenkasto siva mastna glina (1). Debelina opisane gline je 2 do 2,5 metra. Glina je sorazmerno čista. V njej ni prodnikov ali drobcev drugih kamnin. Temnosiva glina je relativno visoko plastična. Plast gline kaže v opazovanih točkah dokaj enakomerno debelino.
- Na temnosivi mastni glini leži 1,5 do 2,5 metra debela plast sive drobnomeljaste gline (2). Ta ponekod bočno prehaja v temneje siv laminiran, pasnat in zelo drobnoplastnat sljudnat melj oziroma zelo drobnozrnat sljudnat pesek.
- Naslednja litostratigrafska enota je oranžno in oranžnorumena bolj ali manj peščena ilovica (3) z nepravilnimi lečami sivkaste gline. Debelina te enote ni enakomerna, saj se bočno spreminja od 1 do 2,5 in več metrov. Tudi njena sestava precej variira tako bočno kot v navpični smeri.
- Na oranžno rumeni ilovici leži 0,35 do 0,75 metra debela plast svetlo sive laporne gline z drobci lesnega oglja (4). Ponekod je rahlo skrilava.
- Sledi do 25 cm debela plast zelo temne do črne laporne gline (5). Ta plast je ponekod močno pošotenela.
- Krovnino opisanega zaporedja kvartarnih usedlin predstavljajo okoli 0,5 metra debela temna aluvijalna barjanska tla (6). Zgoraj so nasičena z vodo, globlje pa je bolj ali manj temna precej zaglinjena prst. V vrhnjem delu so v prsti drobci karbonatnih in redkeje klastičnih kamnin različne starosti. Površje preraščata visoko šašje (*Phragmition*) in trstičje (*Magnocaricion*).

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