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Pliocene to Pleistocene Alluvial Sediments in Drava River Depression, Northern Croatia

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Key words: Sheet flow, Alluvial fan, Braided river system, Drava river depression

Abstract

Facies analysis of the Pliocene to Pleistocene alluvial sediments found out distinct alluvial systems: (1) alluvial fan systems characterized by gravels mostly with discontinuous sheet-like geometry; (2) sandy braided river systems indicated by characteristic sandy facies arrangement. The flora found in flood plain deposits suggest moderately humid climate.

1. INTRODUCTION

This paper deals with the facies, facies associations and sequences of the Pliocene to Pleistocene alluvial sediments in the Virovitica area in northern Croatia (Fig. 1) in relation to provide insight into alluvial evolution and interpretation.

2. GEOLOGICAL SETTING

In the Virovitica area the Pliocene to Pleistocene sediments are up to 50 m thick. They unconformably overlie the Lower Pliocene sands, marls and clays and are overlain by the Pleistocene loess, lacustrine-marsh silts and clays and eolian sands (GALOVIĆ et ah, 1976; MARKOVIĆ, 1984).

The studied quarries are located in hummocky area in the zone of southern marginal fault of Drava river depression - right-hand wrench fault according to DRAGAŠ et al. (1995). The uplift and horizontal movement as well as deformation of Neogene and Quaternary sediments revealed the most intensive tectonic activity in the Virovitica area. Palaeotectonic analysis found out deepening of the studied area until the Upper Pliocene and since that time successive rising (particularly during Quaternary).

3. LITHOFACIES

Sandy facies predominate in the outcrops. Gravelly facies are also common and are mostly present in the lower part of the outcrops. Relativelly thick fine-grained facies are in the outcrop near Cabuna.

Sands are primarily quartz rich but also commonly contain labile components, mostly feldspars and muscovite, carbonate and metamorphic rock fragments.

They vary from fine- to coarse-grained types but medium-grained type is predominant. Grains are subrounded to rounded with generally good sorting.

Gravels are consisting almost completly of quartz clasts (95%) and vary rare clasts of sandstone, metamorphite clasts and dolomite. Clasts are subrounded to rounded. A clast size varies from granule to cobble but prevail finer pebble. Clasts are supported, containing fine-grained to coarse-sand matrix. Some units exhibit open-framework packing. A clast sorting varies from moderate to good.

Fine-grained sediments are silty clays and marls composed of clay minerals and silt-grade quartz. They contain a species rich phytocenozis of *Angiospermae.* Fifteen species have been identified with domination of *Acer* and *Carpinus,* which are indicative of moderate climate and floral colonisation of the young unconsolidated alluvial soils (Table 1).

For the purpose of the facies description and environmental interpretation these layers have been subdivided into 12 lithofacies. The descriptive data of the main lithofacies are presented in Table 2 where have been organized into coded schemes.

4. AN OUTLINE DESCRIPTION AND INTERPRETATION OF LITHOFACIES ASSOCIATIONS

The lower part of outcrops consists of gravels with discontinous sheet-like geometry in vertical view (Figs. 2 and 3). The sheet-like form is expressed by verticaly alternating planar gravel units (facies Gh) with different clast size (granular, pebbly or cobbly units). The units

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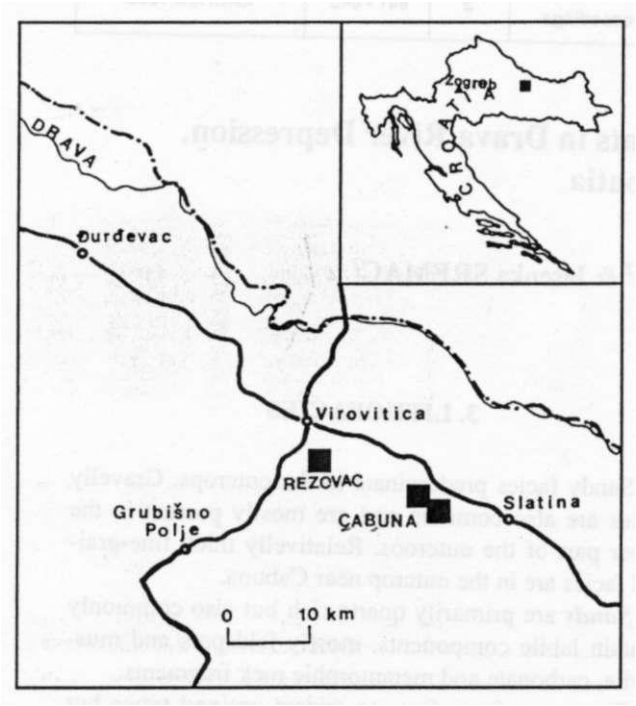


Fig. 1 Situation map.

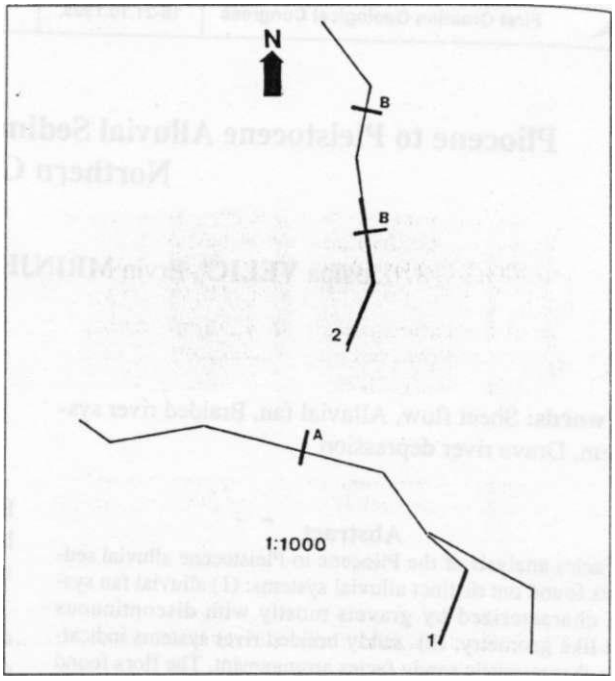


Fig. 2 Position of lateral profiles and logs in Cabuna quarry.

are 5 to 30 cm thick with >10 m lateral extension. The cobble gravel units have a well-developed imbrication indicating palaeocurrents into N and NE directions. The units are regularly interstratified with the laminated pebbly or granular coarse sand (fades Sh and SI).

The low-angle cross stratified pebble to sandy pebble gravel (facies Gp) are found in associations with the sheet-like units. This facies is less common than planar-stratified gravel units. Its sets are 20-80 cm thick and usually dip up fan slope (Fig. 3).

SPECIES	FREQUENCY
I CONIFEROPHYTINA	
GINKGOATAE	
Ginkgo biloba LINNE	S
II MAGNOLIOPHYTINA (=ANGIOSPERMAE)	
A. HAMAMELIDIDAE	
Hamamelidales	
Liquidambar ewopaeum A.BRONGNIART	**S**
Fágales	
Fagus sylvatica LINNE	**S**
Quercus ex.gr. *mediterranea* UNGER	**S**
Q. cf. *loncháis* UNGER	**S**
Q. kamischinensis GOPPERT	**S**
Betida alba LINNE	**S**
Alnus julianaeformis (Steanberg) KVACEK & HOLY	**S**
Carpinus behdus LINNE	L
Urticales	
Ulmus laevis PALLAS	S
Myricales	
Myrica lignitum (UNGER) SAPPORTA	**S**
Myrica sp.	**S**
B. ROSIDAE (=ROSIFLORAE)	
Fabales (=Leguminosae)	
Leguminosae gen. et sp. indet.	M
Sapindales	
Acer platanoides LINNE	L

Table 1 Flora from Cabuna (Virovitica, NE Croatia). Legend: S=small. M=medium, L=Iarge

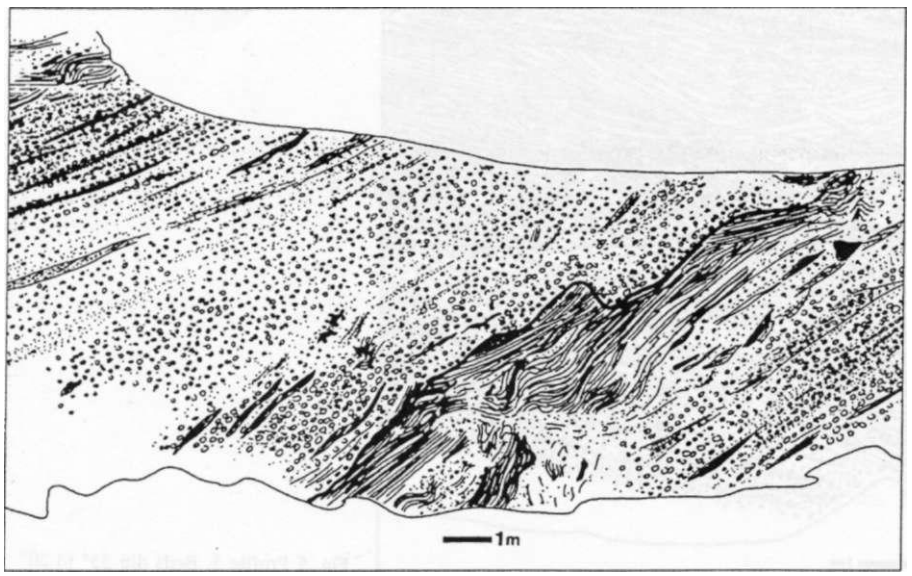
FACIES CODE	LITHOFACIES	SEDIMENTARY STRUCTURES	INTERPRETATION
G m	clast-supported sand, matrix filled, poorly to moderately sorted, granule-cobble gravels	unstratified to crudly stratified rare imbrication	hyperconcentrated flows. unconfined or channelized
Gh	clast-supported, sand matrix filled or sand matrix free framework, moderately to well sorted, granule-cobble gravels	distincly stratified, imbrication	sheet flows, upper flow regime (high Froud number, high capacity, high competency)
G,	clast-supported, well sorted, granule-cobble gravels	planar cross-stratification	low-angle antidune in sheet-flows (upper flow regime)
Ge	clast-supported, poorly to moderately sorted, intraclast rich, pebble-cobble gravels	unstratified, rare imbrication	scour fills
St	wellsorted, medium- to coarse-grained sands, pebbly sands	large-scale trough cross-stratification	three-dimensional mega ripples
Sp	well sorted, fine- to coarse-grained sands, (pebble sands)	large-scale planar cross-stratification	two-dimensional megaripples, linguoid bedforms, sandwaves
Sh	well sorted, medium- to coarse-grained sands, pebbly sands	horizontally stratified	upper and low flow regime, plane beds
SI	well sorted, medium- to coarse-grained sands	low-angle trough cross-stratification	dune complexes, scour fills, crevasse splays
Se	poorly sorted, medium- to coarse-grained sands, pebbly sands with intraclasts	unstratified, rarely crude cross-stratification	scour fills
Sr	well sorted, fine- to medium-grained sands	ripple cross-lamination	two-dimensional small ripples
Fl	matrix-supported silty muds fragments and prints	horizontal lamination, leaf	overbank deposits
Fm	matrix-supported silty muds fragments and prints	massive, common leaf	overbank deposits

Table 2. Lithofacies scheme (after MIALL, 1978; MASSARI, 1983).

The middle portion of the gravel complex in the quarry near Cabuna is characterized by erosional surface (with >3m erosional relief) overlain by massive, pebble to cobble and fine-grained intraclasts (facies Ge and Gm). The surface is incised into disturbed and overturned medium- to coarse-grained up to 4m thick sandy facies (probably facies Sp and Sh) which indistinctly overlie the rest of gravel complex.

The top of gravel part of outcrops is remoulded by erosion of subseqquent overland flows (rills, gullies and shallow channels with a braided distributary pattern).

The vertical and lateral arrangement of facies asso-



LEGEND FOR LOGS AND PROFILES

Granules
Pebbles
Cobbles
Missive clays and marls
Horizontally laminated clays and marls
Planar cross-stratification
Trough cross-stratification
Low angle cross-stratification
Horizontal stratification
Disturbed stratification
Ripple cross-stratification
Erosive surface
Slump surface
Palaeocurrents
t= trough cross-st.
p=pianaf cross-st.
Leaf fragments
•nd prints

Fig. 3 Profile 1. Beds dip 35° to 20° azimuth.

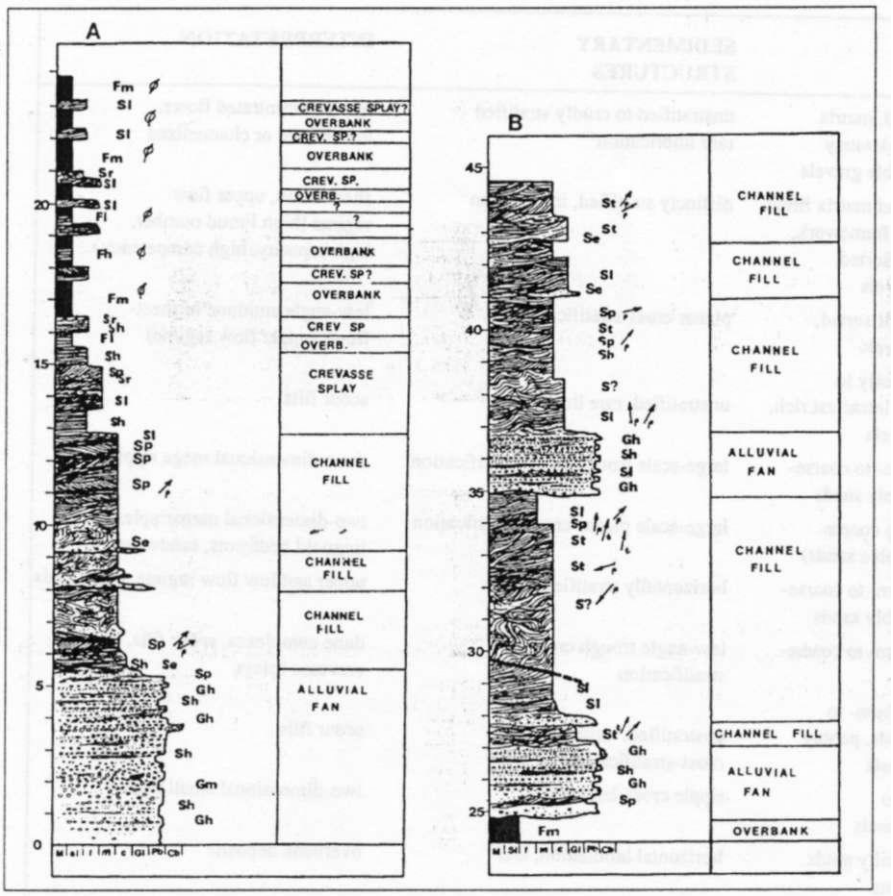


Fig. 4 Description and interpretation of logs A and B.

ciations indicate that gravel units represent catastrophic, unconfined sheet flows that expand as they move down alluvial fan. Flow conditions in major sheet flows are supercritical due to the effect of the relatively high slope **of** the fan surface. The cross-stratified sets (facies Gp) probably represent antidune sets (BLAIR & Mc PHERSON, 1994).

The upper part which entirely consits of sandy facies irregularly (erosively?) overlies the lower part (Fig. 4). Facies arrangement into various sandy bar and chart-

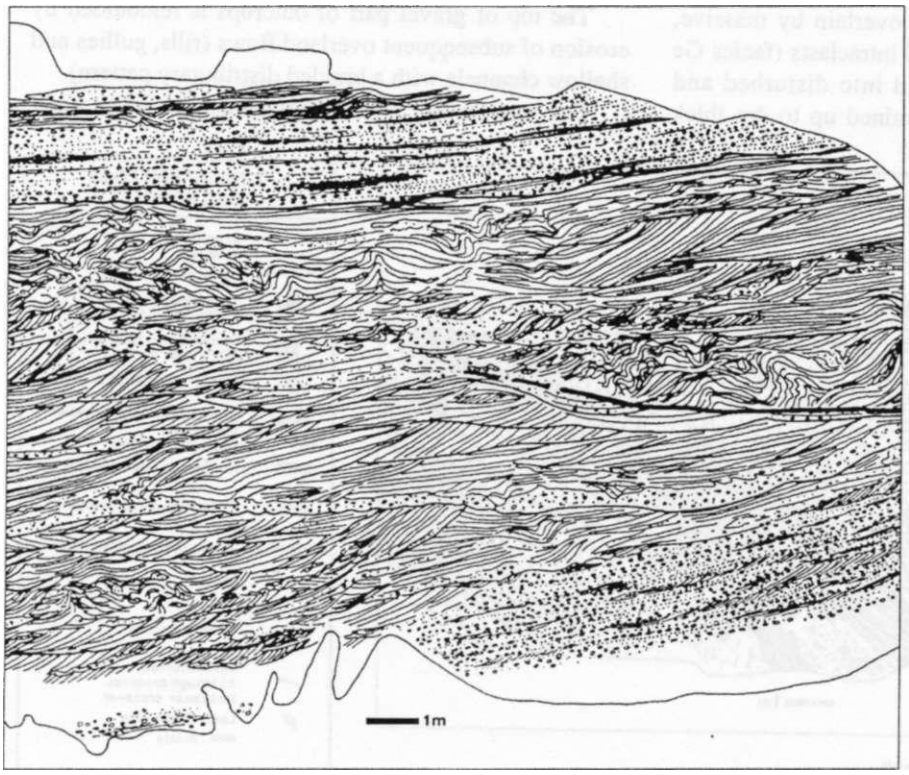


Fig. 5 Profile 2. Beds dip 35° to 20° azimuth.

nel deposits suggest sandy braided river system. The palaeocurrents indicated from trough-axis and planar cross-bed directions were into E direction (Rezovac quarry), and NE direction (Cabuna quarry).

Sandy facies in Rezovac quarry are overlain by 4 m thick flood plain deposits (crevasse splays, leeves and overbank deposits), whereas Cabuna quarry (Fig. 2) the floodplain deposits are 8 m thick and present in the middle portion of the sandy complex (Fig. 4). The significant part of sandy complex in Cabuna quarry is sinsedimentary disturbed or overturned (Fig. 5).

5. SUMMARY

The lower part of the outcrops mostly consits of gravels whose discontinous sheet-like geometry suggest alluvial fan origin. The upper part of the outcrops is dominated by various sandy facies whose characteristics suggest sandy braided river system. The flora found in floodplain deposits indicate moderate climate and the young unconsolidated alluvial soils. The described facies associations are in accordance with the tectonic activity in Virovitica area.

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