Poster

Distribution of Pleistocene glaciolacustrine deposits in southwestern Croatia

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Pleistocene lacustrine fresh-water sediments are found throughout Croatia, although in its northern part they were revealed only by drilling (Šercelj 1969, Sokač 1976, Babić et al. 1978, Sokač et al. 1982). In this short review the emphasis is given to south-western Croatia where many extensive outcrops of typical glaciolacustrine sediments occur (Fig. 1). Recently, studied sites (1 to 6 in Fig. 1) are located along the northeast and southwest coasts of the Velebit Channel and along the southwest coast of the Novigrad Sea and represent remnants of Middle Pleistocene proglacial lacustrine sediments. Other sites (7 to 12 in Fig. 1) are presented upon the data from General Geological Maps of Yugoslavia and respective explanation books (Majcen & Korolija 1973, Ivanović et al. 1976 and 1978, Grimani et al. 1976, Sokač et al. 1976), and upon the data published until the 1990ies. Most of these deposits were recognized as “Neogene Süsswasserbildungen” (Neogene freshwater sediments) and marked on the Austro-Hungarian Geological Maps of Croatia (Schubert 1905, 1907, 1912), and breefly reviewed in Table 1.

Karst poljes Kninsko polje, Mokro polje, Žegarsko polje and Erveničko polje are filled with glaciolacustrine sediments which were successively deposited following the retreat of the Middle Pleistocene glaciers. The age attribution is based on ostracod assemblages studied by Malez & Sokač (1968), Malez et al. (1969) and Sokač (1975), and mammal findings reviewed by Malez (1968). The early Pleistocene (Villafranchian) was also documented in Kninsko polje and Strmica (Fig. 1, localities 11 and 12; Malez et al. 1969, Šimunić 1970). Malez (1968) compared the lacustrine succession of Strmica with the Leffe basin in Italy.

Nevertheless, much greater significance for the reconstruction of Pleistocene environmental and climatic changes as well as for the extent of the Dinaric glaciation (Marjanac et al. 2008), have the glaciolacustrine deposits at Novigrad Sea (Fig. 1, locality 5; Fig. 2C) described by Marjanac et al. (1990) and Marjanac & Marjanac (2004, 2006), varved sediments at Ždrilo (Fig. 1, locality 4; Fig. 2A) that are currently studied (master thesis in preparation by I. Adžić), and glaciolacustrine sediments in alternation with proglacial deltaic conglomerates at Seline (Fig. 1, locality 2; Fig. 2D). Their age is 350 ky at minimum as achieved by Uranium series dating of secondary calcite cement sampled in the overlaying ground moraines at the Ždrilo locality. This leads to the conclusion that the sediments were deposited before or partially during the Mindel/Elster glaciation (MIS 12), which will hopefully be shown by detailed future studies. These glaciolacustrine sediments (Fig. 1, locations 1-6) are found above and below the present sea level (Table 1) and have been greatly destroyed and disturbed by the advancing ice, which is documented by overlaying ground moraines visible at locations Kusača cove, Ždrilo and Novigrad (Fig. 1, locality 1, 4 and 5).

Further detailed studies of varved sediments at Ždrilo and varve-like sediments at Seline and Novigrad will greatly improve our knowledge about glaciations and climate changes in the Mediterranean region. The age of moraines and the assumed age of glaciolacustrine sediments with well preserved fossil leaves of cold climate flora

(Adžić et al., this volume) are new documents of the extensive glaciation of the Dinarides in the Middle Pleistocene, which call for reconsideration of our perception of climatic and paleogeographic conditions in the Mediterranean during the Pleistocene.

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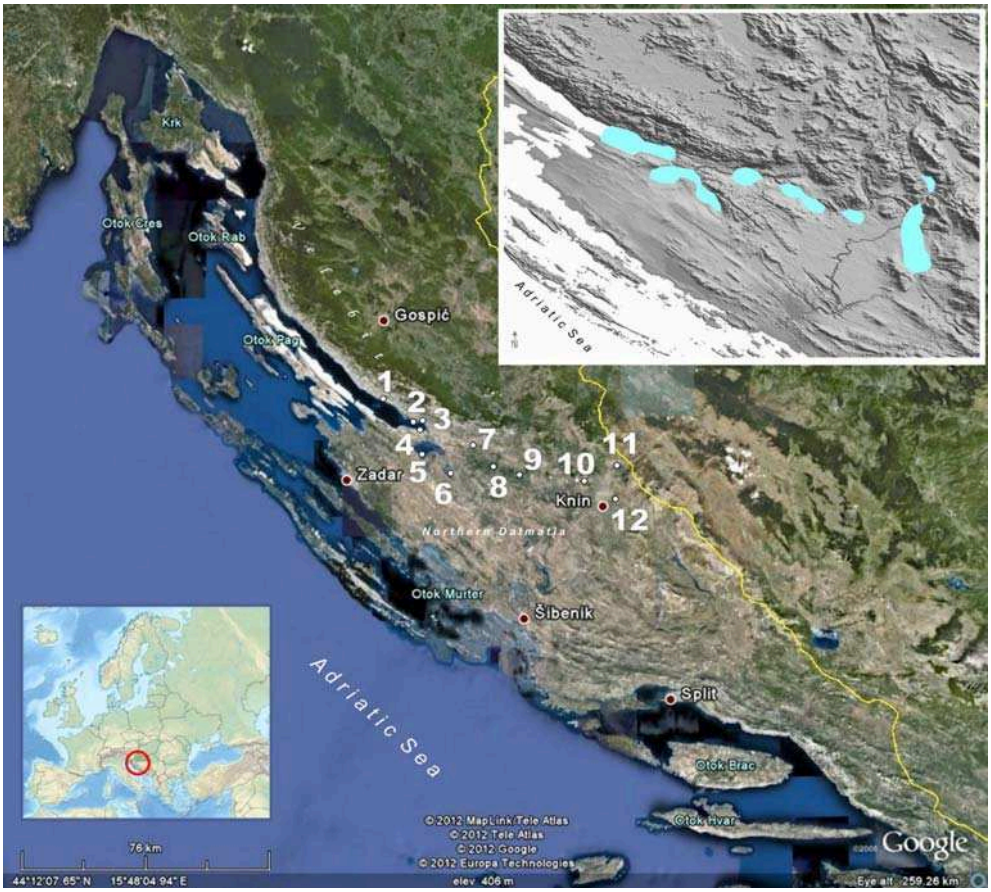

Fig. 1: Location of south-western Croatia where glaciolacustrine sediments are found at 12 locations listed in Table 1. The map at the top right corner shows the possible extent of glacial lakes.

Tab. 1: Review of most important occurrences of Pleistocene lacustrine deposits in south-western Croatia. Most of them were first recognized as Neogene freshwater sediments, and by later studies were interpreted as of Middle Pleistocene age.

	Sediments / paleoenvironment / stratigraphy		
Locations (Fig. 1)	*Registered on Austro-Hungarian geological maps of Croatia in the scale 1:75.000*	*Registered on General geological map of Yugoslavia in scale 1:100.000*	*Recent study, largely unpublished*
1 - Kusaèa Cove 0 - 10 m a.s.l.	Neogene freshwater sediments (Schubert 1907)	not registered	glaciolacustrine sediments, Middle Pleistocene, under study
2 - Seline coastal cliff 0 - 6 m a.s.l.	Neogene freshwater sediments (Schubert 1907)	not registered	proglacial lake sediments (proximal varved-like deposits; proglacial deltaic conglomerates), Middle Pleistocene, under study
3 - Provalija 1 - 2 m a.s.l.	Neogene freshwater sediments (Schubert 1907)	not registered	poorly preserved Seline-type sediments, under study
4 - Ždrilo 0 - 10 m a.s.l.	Neogene freshwater sediments (Schubert 1905)	not registered	varved sediments (clay/silt/sand) of proglacial lake, Middle Pleistocene, under study
5 - Novigrad coastal cliff 0 - 20 m a.s.l.	Old Quaternary sands and marls (Schubert 1905)	not registered	varve-like unit with dropstones (silt and clayey silt) and ripple laminated unit (sands, silt, rarely clay), proglacial lake deposits in association with moraines and glaciofluvial deposits, Middle and Upper Pleistocene; still under study (Marjanac et al. 1990, Marjanac & Marjanac 2004)
6 - Karin 0 - 40 m a.s.l.	not registered	not registered	laminated clayey silt deposits, glacial lake, Middle Pleistocene, under study
7 - Bilišane 20 - 90 m a.s.l.	Neogene freshwater sediments (Schubert 1905)	Middle Pleistocene (Riss glacial) lacustrine marls and clays (Ivanović et al. 1973)	revision in plan
8 - Ervenièko polje	Neogene freshwater sediments (Schubert 1912)	Middle Pleistocene (Riss glacial) lacustrine marls and clays (Ivanović et al. 1973)	revision in plan
9 - Žegarsko polje 50 - 90 m a.s.l.	Neogene freshwater sediments (Schubert 1912)	Middle Pleistocene (Riss glacial) lacustrine marls and clays (Ivanović et al. 1973)	revision in plan
10 - Mokro polje 200 m a.s.l.	Neogene freshwater sediments (Schubert 1912)	Middle Pleistocene (Mindel - Riss) lacustrine marls and clays (Malez & Sokač, 1969)	revision in plan
11 - Strmica	Neogene freshwater sediments (Schubert 1912)	Lacustrine chalk and swamp-lacustrine sediments with mamals and gastro-pods (Villafranchian, Mindel glaciation), clay with gastropods of Mindel-Riss interglacial (Grimani et al. 1972)	revision in plan
12 - Kninsko polje	Neogene freshwater sediments (Schubert 1912)	Lacustrine chalk and swamp, lacustrine sediments with mamals and gastropods (Villafranchian, Mindel glaciation), clay with gastropods of Mindel-Riss interglacial (Grimani et al. 1972)	revision in plan

Fig. 2: Outcrops of Middle Pleistocene glaciolacustrine sediments in southwestern Croatia. A) Varved sediments with fossil flora and fauna (distal facies) at location 4 - Ždrilo; B) Laminated silt/clay sediments disturbed by overlaying ground moraine at location 1 - Kusača cove; C) Varve-like sediments with dropstones at the coastal section of location 5 - Novigrad; D) Varve-like sediments with gastropods and bivalve moulds (proximal facies) at the coastal section of location 2 - Seline; E) Laminated clayey silt sediments disturbed by overlaying ground moraine at location 6 - Karin; F) Clayey silt lacustrine sediment covered with paleosol and younger glacigenic deposits, exposed at location 9 - Žegarsko polje.