Sedimentological evidence of extensive Dinaric glaciation

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Sedimentological study was conducted for more than 20 years in the area of coastal Dinarides. The main goal was to find evidence of a hypothesized extensive glaciation of the Adriatic and the Dinarides. This paper gives a summary of the doctoral thesis (Marjanac 2012) and some new data as part of this ongoing research. Finding true evidence of Dinaric glaciation was crucial to support all pioneer advocates of glaciated Dinarides. For convenience of better understanding the research history is reviewed by Marjanac & Marjanac (this publication).

The sedimentological research concentrated on field study of the Quaternary sediments in the regions of Kvarner (the Krk, Rab and Pag Islands, Senjska Draga and Jablanac), South Velebit (Rujno and Velika Paklenica, Kusača, Seline and the coast of Velebit Channel), and in Northern Dalmatia (south coast of the Velebit Channel, Novigrad Sea, Karin Sea, Obrovac, Paljuv and Smilčić), by methods of detailed logging and outcrop mapping.

The research provided data for glacigenic interpretation of studied sediments, and the following ones were determined:

Glacial sediments are diamicts determined as tills or tillites and interpreted in terms of ground, medial or lateral moraines. The main characteristics of glacial origin are clasts with glacial striae, ice-shaped (faceted, bullet-shape and conical) and ice-shattered clasts.

Glacifluvial sediments comprise both glacial outwash deposits of braided streams and flood plains, and fluvial deposits of meandering rivers, represented with sand and gravel deposits. Their glacigenic origin is based on facies association, meaning that they occur with tills or tillites, and contain glacially-derived boulders and blocks, sometimes also lithologically exotic debris.

Glacilacustrine sediments comprise two types, clay-silt sediments with classic varves, and varve-like calcisiltites, both with drop-stones, which is the main diagnostic criterion for their proglacial character.

Glacideltaic sediments are represented by conglomerate, calcarenite and calcisiltite lithofacies in alternation. Significant characteristics for glacial attribution are ice-striated clasts which were found in conglomerates, and their association with glacilacustrine sediments.

The following depositional palaeoenvironments were reconstructed:

Glacial environment where deposition occurs in contact with ice, regarding terminoglacial environment and ice-contact zones between the ice-margin and valley slopes. Glacial palaeoenvironment is documented by determined ground and lateral moraines. The ground moraines are indentified as Rujno, Paklenica and Novigrad members in terms of lito-, allo- and morphostratigraphy, and two tentative members Sklopine and Raduč. The Paklenica member, found also on Krk and Rab Islands, documents the furthest extent of glaciation. Another characteristic landform of ice-contact zone are kame terraces well preserved on the Krk and Pag islands.

Proglacial environment which is influenced by melting ice and glacial outwash processes is evidenced by glacifluvial sediments widespread in Northern Dalmatia, and proglacial lacustrine sediments of Ždrilo, Seline and Novigrad.

Periglacial palaeoenvironment, less influenced by ice, but dominantly by permafrost, was recognized in sediments of Novigrad section, were many sediment wedges interpreted as ice-wedge casts and kettle-forms occur, which indicate freezing and thawing effects on sediment due to grounded and buried ice-blocks.

The sedimentological research showed that glacigenic sediments are widespread in this north Adriatic region and in Northern Dalmatia, which proves the far seawards extent of the Dinaric glaciation. At the most advanced phase of glaciation the ice covered islands of Krk, Rab and Pag, a large part of Northern Dalmatia, and the whole Velebit Channel as evidenced by distribution of moraines. When the ice retreated, proglacial lakes were formed as evidenced by glaciolacustrine sediments at Ždrilo, Seline and Novigrad. The palaeoenvironment sequences also indicate on ice fluctuation and its at least three advances and retreats.

Tentative chronostratigraphic correlation of sediments was established by combining the litho-, morpho- and allostratigraphy, and the provided ^{14}C and U-series ages of sediments, which allowed attribution of the Middle Pleistocene age to most of the studied sediments. The Paklenica Member, as the most significant, regionally correlates with Ninkovići Member in Montenegro found at altitude of 500 and 800 m, which are attributed to Skamnelian stage MIS 12 (Hughes, 2011). Together with evidence of low-altitude moraines in Boka Kotorska (Stepišnik & Žebre, 2010), the Paklenica Member represents the most westwards or north-westwards reaches of the proposed Dinaric ice-cap (Fig. 1).

The chronostratigraphic interpretation of glacigenic sediments (Marjanac 2012), especially those on Veliko and Malo Rujno, contradicts all previous researchers who attributed glacigenic sediments and geomorphological features of the Velebit Mountain to the Late Pleistocene or LGM. Accordingly, the age of glacigenic sediments in other parts of the NW Dinarides (Risnjak Mt., Northern Velebit Mt., Middle Velebit Mt.) should be revised.

Thereafter, the extensive Dinaric glaciation is apparent, thus new avenues of research are open, regarding its total extent, both inland and seaward, precise timing, and associated glaciotectonic deformations.

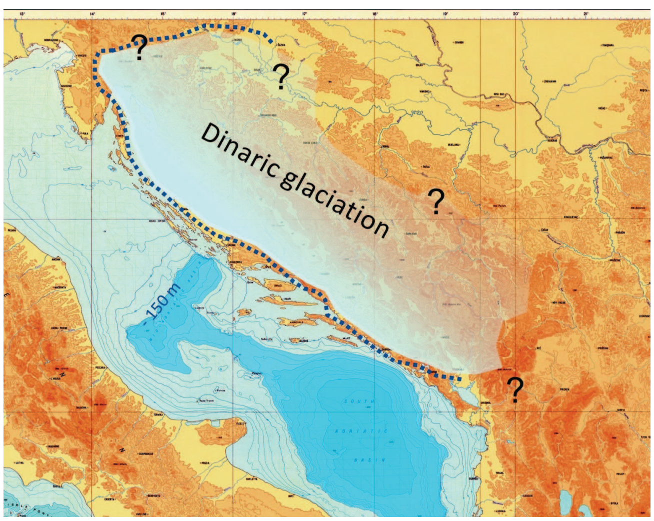

Figure 1. Probable range of Dinaric glaciation. Question-marks indicate unknown relation to Alpine glaciation, NE and SE extent. This proposed Dinaric ice-cap will be hopefully documented by further research.

References

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