

Neogene exhumation and denudation of the Central Western Carpathian nappe units in the Danube Basin

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Abstract: The Blatné Depression located in the NW part of the Danube Basin represents the northernmost sub-basins of the Pannonian Basin System. Its subsidence is associated with oblique collision of the Central Western Carpathians with the European platform, followed by the back-arc basin rifting stage in the Pannonian domain. The Cífer conglomerate Fm. documents the latest Burdigalian–early Langhian deposition in fan delta lobes situated above the footwall and hanging wall of a WSW–ENE trending fault system. The activity of this fault preceded the opening of the late Langhian–Serravallian accommodation space with a NE–SW direction. During the thermal subsidence of the synrift stadium, the main direction of the extension was NW–SE. The imbrication of the Doľany conglomerates is oriented in the SE direction, towards the basin depocenter. The provenance of conglomerates points to the Central Western Carpathian source, especially when similar rocks occurs today in the Malé Karpaty Mts.

Introduction

The Danube Basin, located at the junction of the Eastern Alps, Western Carpathians and Transdanubian Range represents the NW part of the Pannonian Basin System. It is bordered by the Malé Karpaty Mts. in NW and by the Považský Inovec Mts. in the NE and passes into the Gabčíkovo–Győr Depression in the south (Fig. 1).

The basin fill consists of marine to freshwater deposits reaching up to 3 000 m (Adam & Dłabač 1969). The main part of the basin fill is represented by the middle Miocene marine deposits of the Central Paratethys Sea, which are overlain by sequences of the late Miocene Lake Pannon, and by the late Miocene to Pliocene alluvial to fluvial sediments (e.g., Kováč et al. 2011). The primarily fine-grained sedimentary fill is intercalated with sandy to gravely facies, often at the base of Transgression–Regression (T–R) cycles (e.g., Kováč 2000).

The aim of this work is to revise the conglomerates from the Blatné depression (Danube Basin) in respect to their age, petrography and provenance. The definition of transport mechanisms and the character of depositional paleoenvironment will be derived from facies analysis, well-logs study, and seismic facies interpretation. The acquired knowledge should contribute to confirmations of the geodynamic development model of the area at the Eastern Alpine–Western Carpathian junction during the rifting phase of the Danube Basin (Kováč et

al. 2018). It should also contribute to paleogeographic models before and during the maximal flooding of the Central Paratethys Sea in the back-arc basin system (e.g. Kováč et al. 2017a).

Material and methods

During the research, well cores (Cífer-2, Vištuk-1, Suchá nad Parnou-3, Trakovice-1, Ratkovce-1 and Bučany-2) and also outcrops were studied (Fig. 1). The well core samples were obtained from the repository of Nafta a.s. — Oil and Gas Company (Gbely town). The clast composition was confirmed by thin sections studied under a polarizing microscope. Abbreviations of minerals follow Whitney and Evans (2010). Grain size classification of clast follows Wentworth (1922) and the shape classification of clast follows Powers (1953). The sedimentary structures of the individual well cores and outcrops were evaluated in sense of Boggs (2006) and Nichols (2009). The conglomerates classification follows the work of Pettijohn (1975). Carbonate classification follows the work of Flügel (2010).

One reflection seismic line (554/77) was used for the purposes of seismic facies analysis. Interpretation was made in the Schlumberger Petrel software using the standard methods described by Mitchum & Vail (1977). The well logs data were evaluated based on Rider & Kennedy (2011).

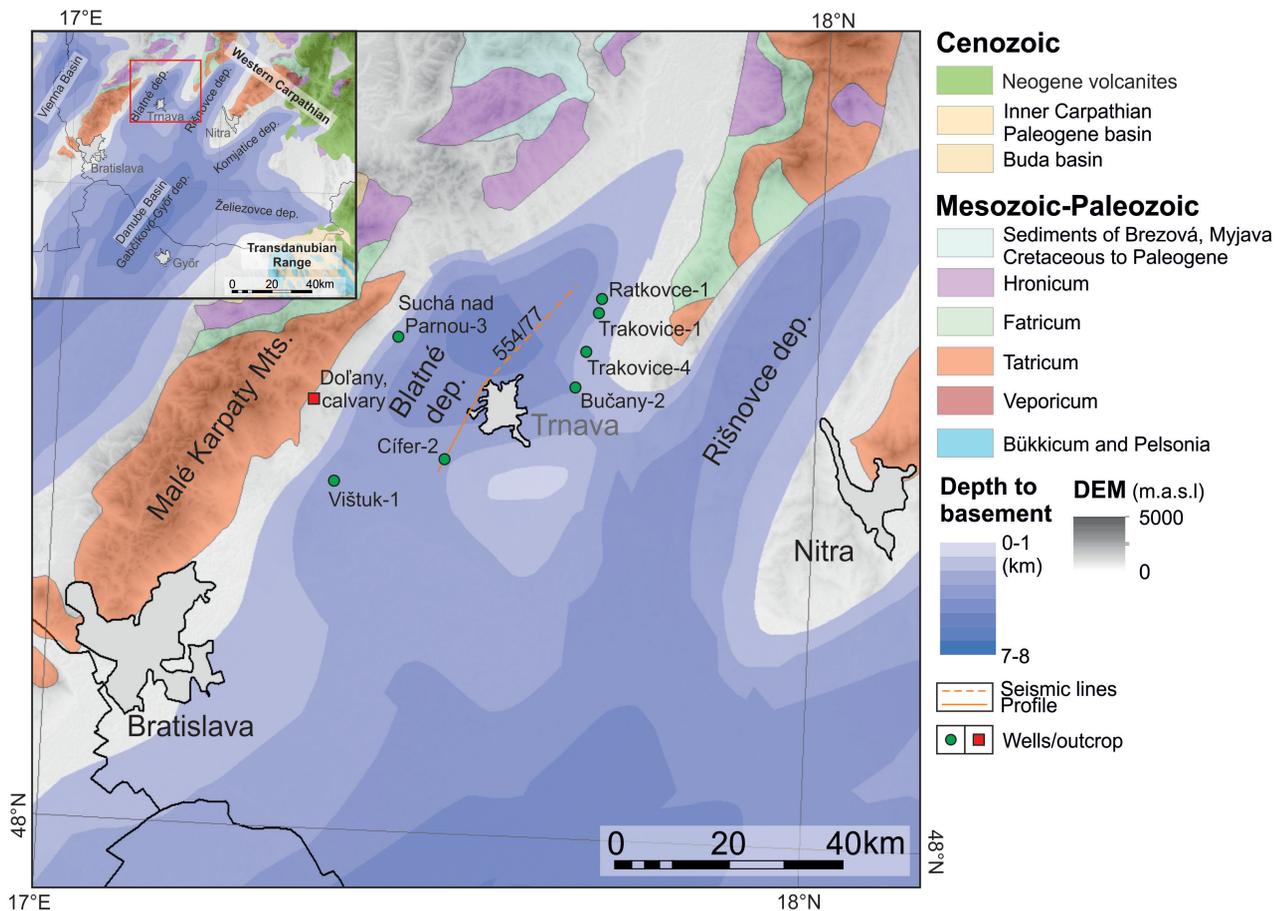


Fig. 1. Localization of the studied wells and outcrop in the Danube Basin.

Coarse-grained sediments of the Blatné depression

In the Blatné depression are two types of conglomerates, different in age and petrographical composition.

The Cifer conglomerate Formation (Karpatian/Lower Badenian)

The Cifer conglomerate Formation is named after the well Cifer-2, where the stratotype section was described by Csibri et al. (2018). The base of the formation is created by older, resedimented blocks of monomict conglomerates and breccias (Paleogene?). These coarse-grained sediments consists clasts only from the Pre-Cenozoic crystalline basement of the Danube Basin. The monomict blocks are overlapped by clast supported polymict orthoconglomerates with sparitic matrix. In the clast composition, the carbonate rocks dominates. The deposition area was linked in to the proximal part of the fan delta. The overlying

conglomerate strata is separated by 40 meter thick siltstone layer. These conglomerates have higher portion of the granitoid clasts. They have higher proportions of matrix, even they are matrix supported. Therefore, the depositional environment is linked in to the distal part of fan delta. The fan delta character of both aforementioned conglomerate layer can be backed up by the sigmoid clinofom visible on the seismic line 554/77 (Csibri et al. 2018).

As a part of the Cifer conglomerate Formation are interpreted the conglomerates from the wells Suchá nad Parnou-3, Trakovice-1, Ratkovce-1 and Bučany-2.

Provenance of the “Cifer conglomerates”

The provenance of all processed conglomerates points to the Central Western Carpathian source. The source of granitoids can be associated with biotitic granodiorites exposed in the Modra Massif of the Malé Karpaty Mts. The metamorphic rocks (chloritic–sericitic schists, graphitic schists and biotitic paragneisses) are exposed in

the upper part of the crystalline complexes of the Pezinok Group in the Malé Karpaty Mts. The Lower Triassic is represented by quartz arenites, which source may be in the Lúžna Fm. which represents the sedimentary cover of the Tatric Unit. Similarly, the dark carbonates may belong to the Gutenstein Fm. (Middle Triassic). The wells, oriented in the northern part of the Blatné depression consist also sericitic fylites and chloritic schists derived from the Infratatric Orešany Unit. The source of the crinoidal limestone (Middle Jurassic) may be in the Vilská Fm. of the Vysoká nappe (Fatric Unit). From the Hronic Unit were derived the paleo-basalt of Malužiná Fm. (Permian) and oolitic limestones of Dachstein Fm. (Upper Triassic).

The Dol'any conglomerates (Špačince Fm., Lower Badenian)

The Dol'any conglomerates are named after the village Dol'any, which is situated nearby the Malé Karpaty Mts. The type section is situated in the calvary of Saint Lenhard. It overlies the pre-Neogene basement discordantly and transgressively. The thickness of these conglomerates reached several tens meters and is spread only in the eastern margin of the Malé Karpaty Mts. The outcrop conditions of the Dol'any conglomerate are poor. During the field research, only fragments of clasts from the conglomerates was found. The only one outcrop is situated on the type locality.

The Dol'any conglomerates consists from two part. The lower part is represented by fine to medium-grained breccias with calcareous–sandy matrix. The composition of the clast is nearly monomict. The carbonate rocks (crinoidal limestones and grey, spotted limestones) represents the 94 % of the composition, the rest is created by metamorphic rocks (fylites and chloritic schists) and quartz arenites. The upper part continuous by coarse-grained polymict conglomerates. The clasts are well rounded and moderately sorted. The gradation is inverted and the conglomerates are imbricated (35° to the SE). The matrix is calcareous sand. The composition is still similar, but the portion of carbonates are lower.

Similar conglomerates according to the position were found in the well Vištuk-1. The base of the well is created by well sorted polymict medium-grained conglomerates with calcareous matrix. The composition in this case is different. The main lithological elements are the metamorphic rocks (chloritic schists, fylites and biotitic paragneisses). Minor clasts of granitoids and carbonates were observed.

Provenance of the Dol'any conglomerates

The source of the individual clasts is explicitly local — from eastern part of the Malé Karpaty Mts. The source of the metamorphic rocks (chloritic schists and fylites) is in the Orešany Unit, with the exception of the biotitic paragneisse. The Biotitic paragneisses were derived from the crystalline complexes of the Pezinok Group. The quartz arenites may belong to the Lúžna Fm. The source of the carbonatic rocks may be in the Fatric Unit — the Lower Jurassic grey, spotted limestones (“fleckenmergel” Allgäu Fm.) and the Middle Jurassic crinoidic limestones (Vilské Fm.).

Tectonic context

The sedimentation of the coarse clastic facies is generally influenced by tectonic activity (Vail et al. 1977). From the paleogeographical point of view, the accommodation space of the “Cífer conglomerate” was connected with the early Miocene WSW–ENE oriented fault system, active until the earliest-middle Miocene (Marko et al. 1991; Marko & Kováč 1996; Hók et al. 2016;). This process in a transtensional/extensional tectonic regime, associated with the lateral extrusion of the ALCAPA lithosphere eastward (Ratschbacher et al. 1991), which led to the opening of new depocenters situated between the Eastern Alps and Western Carpathians (e.g., lower Miocene terrestrial to marine deposits of the Styrian, Eisenstadt and Danube basins; Kováč et al. 2003). The Danube Basin pre-Cenozoic basement is built up in its central part by crystalline complexes of the Tatric Super-unit (Fusán et al. 1987). Gradual Oligocene–early Miocene uplift of these complexes is documented in the Malé Karpaty Mts. by AFT (Apatite Fission Track) cooling ages ~52 to 20 Ma (Králiková et al. 2016). The initial rifting at the western border of the Pannonian domain led to development of horsts and grabens within the pre-Cenozoic basement (Hók et al. 2016). This may have led to erosion and deposition of coarse clastics on the southern margin of the Middle Miocene Blatné depression in the form of the “Cífer conglomerate” during the synrift phase of the Danube Basin (Kováč et al. 2011; Rybár et al. 2016). The transport direction can be deduced from dip of the clinofolds, which seems to be prograding from S-SW to N-NE. This is in accordance with the above presented results of the provenance analyses. Later, in the middle–late Langhian, the accommodation space was enlarged (Kováč et al. 1999). The opening of

the Blatné Depression in its present form was a result of the oblique collision of the Central Western Carpathians, with a spur of the Bohemian Massif, representing the margin of the European platform (e.g., Hók et al. 2016; Kováč et al. 2017b). During the thermal subsidence of the synrift stadium, the main direction of the extension was NW–SE. The imbrication of the Doľany conglomerates are bending to the SE direction, towards to the basin depocenter.

Acknowledgements: Our appreciation goes to Nafta a.s. — Oil and Gas Company management for allowing access to their well core repositories. This work was supported by APVV agency under the contract No. APVV-16-0121, APVV-15-0575, APVV-14-0118 and by UK Grant 9/2018.

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