Quaternary evolution of the Danube along Iron Gates and Oltenia Plain (Romania, SE Europe)

- a literature review -

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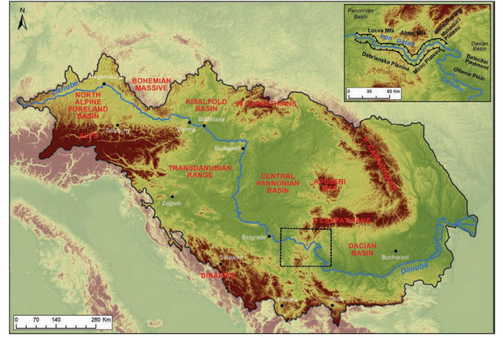


Fig 1. Study area: Iron Gates & Western Dacian Basin

INTRODUCTION

This study presents a review of the scientific works covering the last 100 years of research on the area of the Lower Danube at the boundary of Romania and Serbia (Fig. 1). Our study focused on identifying and coupling the relevant morphological, sedimentological, and tectonic information regarding the history of the Danube along the Iron Gates (Lower Danube Gorge) and Western Oltenia Plain (Western Dacian Basin) (Fig. 2). Besides reviewing literature data, morphometric investigations has been started to reveal the presence and position of all geomorphological levels that document different stages of landscape evolution.

Key Questions:

Q1: How many geomorphic levels exist along the Iron Gates? Which level is the first one belonging to the appearance of the Danube at ~4 Ma (Olariu et al, 2017)?

Q2: What are the relict relief forms and sedimentary units (if they are conserved) associated with the history of about 4 Ma years of the Danube along the Iron Gates?

Q2a: What is the altitudinal range in which these fluvial relics are distributed along the valley?

Q2b: Are there differences between distinct mountain units along the Iron Gates in their elevational distribution?

Q3: What is the estimated uplift rate or the area? Is it variable along the valley as it crosses the junction of the Carpathian and Balkan orogens?

LANDSCAPE EVOLUTION

Late Cretaceous - Miocene

- The CBBZ was put in place and exhumed during Late Cretaceous - Paleogene), its high peaks are relief relicts perfected over time until the Early Miocene.
- Early-Mid Miocene back-arc extension phase of the Pannonian Basin lead to the appearance of small tectonic basins and the delimitation of the present orogenic blocks.

Miocene-Early Pliocene:

-Western extremity of the Central Parathetys during Miocene, first connected, then disconnected from the Pannonian Basin to the east, along a marine corridor along the Miocene small tectonic basins and crossing than the few hundread meters high hilly area of the Carpathian Balkan Bend Zone (CBBZ) (Krézsek, Olariu, 2021).

Mid-Late Pliocene:

-Appearance of the large river form the west (Danube) ~4.2 Ma, and the connection to the Black sea was established after ~3.7 Ma (Jipa et al., 2007; Leever et al., 2010; Olariu et al., 2017).
- Deltaic than alluvial sedimentation (sandy and clayey sediments & lignite, followed by 5-15 m thick sands and pebbles of an alluvial fan at the Pliocene - Pleistocene boundary, at the exit from the Iron Gates (Jipa et al., 2007; Enciu, 2009)-
- This fluvial aggradational phase has the remains located at over 180 - 200 m arl, in the Bălăciței Piedmont (Coteț, 1957)

Pleistocene:

- The Danube incised to its former alluvial fan, constant southward migration to its current position, fomation of 7 terraces (gravels, sands) between ca. 140 - 170 m arl to 4-7 m arl, in the Western Oltenia Plain (Cotet, 1957, Enciu, 2009).
- loess deposition during the last ca 850 ka on top of the aluvial fan sediments and the upper - mid fluvial terraces of the W Oltenia Plain, thiner loess sequences and aeolian dunes on top of the lower fluvial terraces. (Badea, 1969; Enciu, 2009).

AGE OF THE DANUBE TERRACES

Sip area - Kljuc Meander (paleontological dating, Rakić 1977, 1997, Tanasković et al., 2017, Nenadić et al., 2015) (Fig. 5)
T8: in this study level "c", the former Pontian valley bottom described first by Cvijic (1908) (260-320 m arl) early Romanian (age of terrace abandonment: ~3.6 Ma)
T7: first 'classical' terrace of the Danube (200-210 m arl) - mid Romanian (End Pliocene) (2.6 Ma)
T6: (150-160 m arl) Late Romanian - Early Pleistocene (~1.8 Ma)
T5: (90-115 m arl) Early Pleistocene - Günz (~0.8 Ma)
T4: (55-65 m arl) Mid Pleistocene – Mindel (~0.37 Ma)
T3: (27-35 m arl) Mid Pleistocene – Riss (~0.13 Ma)
T2: (10-15 m arl) Late Pleistocene – Würm (~0.012 Ma)
T1: (3-5 m arl) Late Holocene

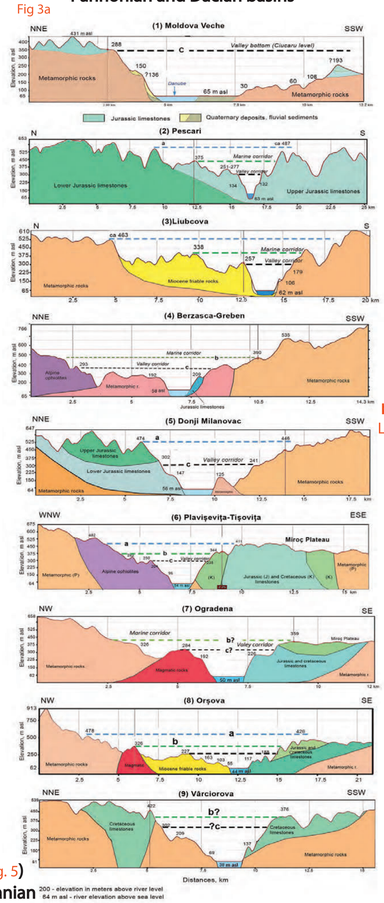
Western Oltenia Plain (paleontological dating, Cotet, 1957, Badea, 1969; Enciu, 2009, 2014) (Fig. 6)
T8: (140-170 m arl) Late Romanian - Early Pleistocene, equivalent of level "c", or T8 in Sip area (~1.8 Ma)
T7: (110-115 m arl) Early Pleistocene - Günz, equivalent of T5 in Sip area (~0.8 Ma)
T6: (90 m arl) Mid Pleistocene
T5: (70-75 m arl) Mid Pleistocene - Mindel (~0.37 Ma)
T3: (27-35 m arl) Mid Pleistocene - Riss (~0.13 Ma)
T2: (13-27 m arl) Late Pleistocene - Würm 1 (~0.012 Ma)
T1: (5-6...12-13 m arl) Late Pleistocene - Würm 2
floodplain Holocen

Iron Gates (U-Th ages in Ponicova cave , Constantin et al., 2001) (Fig. 4)
T4: (60-80 m arl): min 277 ka; T2: (10-20 m arl) ca. 30 ka

IRON GATES (LOWER DANUBE GORGE)

It is the narrow, 134 km long valley of the Danube, cut into the SW part of the Southern Carpathians and NE part of the Balkans (here named Carpathian - Balkan Bend Zone, CBBZ).
- This transverse valley connects the Pannonian and the Dacian Basins.
- Alternating narrow gorges e with high relief energy (over 500 m) and widerbasins controlled by lithological differences (narrowings on hard, Mesozoic and older rocks, widenings in Miocene tectonic depressions)
- frequent orientation changes (iin 90 angles)
- flat hilltops representing remnants of Miocene and Pliocene marine corridors connecting the Pannonian and Dacian basins

Fig 3a



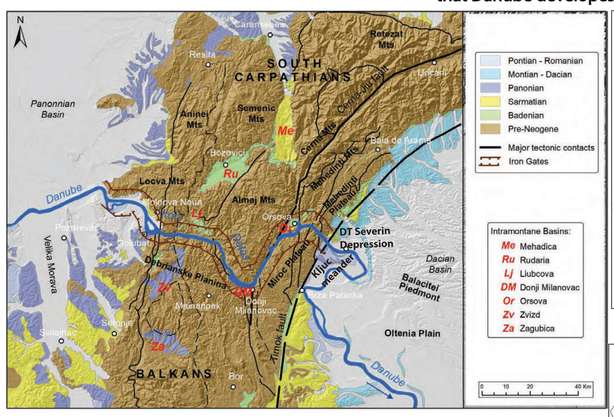


Fig 2. Geology of the Iron Gates and Western Dacian Basin, 5elief units (adapt. after Leever, 2007, Posea, 2002)

Fig 3b

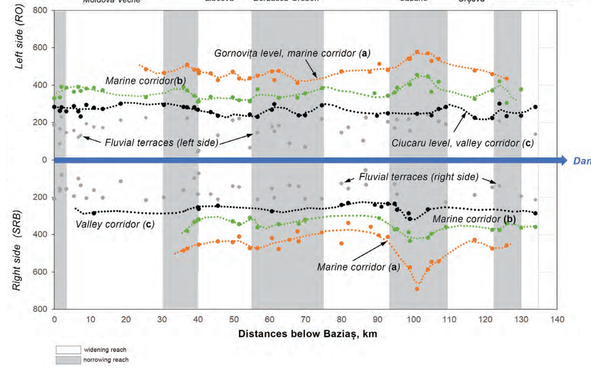


Fig 3a,b. Consecutive cross sections along Iron Gates, atesting high litological diversity along the gorge and the long profile distribution of three distinct morphological levels: (levels "a"& "b", - marine corridors, level"c" (T8)- Danube valley floor

WESTERN DACIAN BASIN

- **Kljuc meader - Turnu Severin Depression** complex is the exit area from the Iron Gates, with well developed fluvial terraces mainly on the serbian side of the river
- **Bălăciței Piedmont** (the higher alluvial plain), is the morphological expresion of the alluvial fan developed by Danube during Late Romanian - Early Quaternary (T8), abandoned trough incision min. 0.9 Ma ago.
- **W Oltenia Plain** in the large alluvial plain located S of Bălăciței Piedmont, with 7 alluvial terraces & floodplain that Danube developes in Western Dacian Basin during Mid - Late Quaternary.

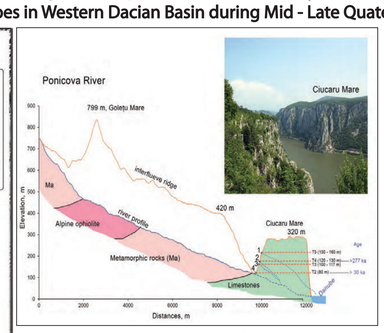
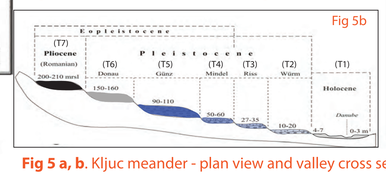


Fig 4. Ponicova cave system (U-Th ages), Iron Gates

Fig 5b



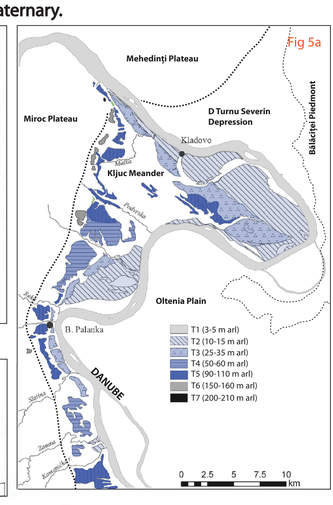


Fig 5 a, b. Kljuc meander - plan view and valley cross section (Tanasković et al., 2017, Nenadić, 2015

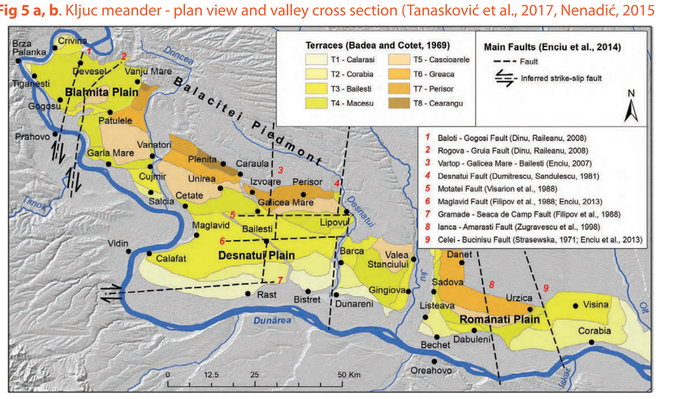


Fig 6. Map of the Danube terrace system in Western Oltenia Plain

INCISION/UPLIFT RATE ALONG IRON GATES

The incision rate of the Danube (Fig 7) is supposed to keep pace with the uplift of the CBBZ, therefore the relative elevation of the geomorphic levels (river terraces and higher marine levels) and their estimated age enables us to calculate the uplift/incision rate of the area.
After the quantification of the age of the terraces based on the reviewed literature data and their elevations using also the published data combined with DEM-based GIS methods, the calculation of the uplift rates was possible.
The first results for the Iron Gates area are as follows:
The incision/uplift history of the area was divided in two phases. The 1st phase is the period before the appearance of the Danube River in the area, and the 2nd phase is when it appeared and started to incise into the orogen dividing the Pannonian and Dacian Basins.
1) For the period between the end of Sarmatian (11.7 Ma) and the onset of incision of the Danube in the Iron Gates (at ~3.6 Ma) an uplift rate of ~15 ± 7 m/Ma was calculated.
2) After the onset of the incision of the Danube (starting with the abandonment of the first Danubian level (T8) at ~3.6 Ma) until present a mean uplift rate of 76 ± 9 m/Ma was estimated, which is five times larger than it was during the previous period.

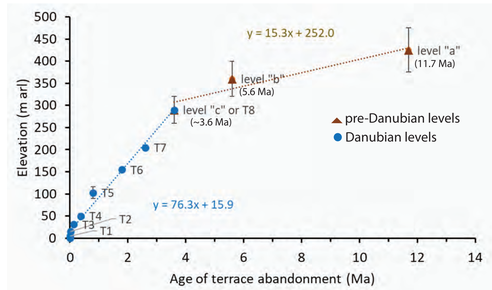


Fig 7. Estimates on incision/uplift rate along Iron Gates

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