

**PS A Key Section for the Early Pannonian (Late Miocene) of the Transylvanian Basin (Romania):  
Integrated Stratigraphic Results from the Gușterița Clay Pit\***

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## **Abstract**

The Transylvanian Basin (TB), enclosed between the Eastern and Southern Carpathians and the Apuseni Mts. in Romania, accommodates a several-hundred-meter thick Upper Miocene (Pannonian) sedimentary sequence. Data on its fossils are few and scattered in the literature, consequently its biostratigraphic assessment implies much uncertainty. The magnetostratigraphic correlation of some recent polarity measurements partly remained disputable. Radiometric age measurements have never been published from these formations. To improve the stratigraphic resolution and the reliability of correlations in the Pannonian of the TB, we investigated 17 outcrops of deep-water formations across the TB. The largest and one of the most fossiliferous outcrops is Gușterița (today part of Sibiu), therefore we regard it a reference section for the entire TB. The deep-water Pannonian marl, outcropping in ~55 m thickness in the clay pit of Gușterița, has been mined there for more than hundred years, and consists of grey, laminated and massive silty marl layers and thin, very fine, cross-laminated sand intercalations. We studied four sections within the clay pit. In October 2015, macrofossils and marl samples for authigenic <sup>10</sup>Be/<sup>9</sup>Be isotopic measurements were collected from the lower, middle, and upper parts of the mine (Gușterița 1, 2, and 3). Later, in June 2017, the uppermost 25 metres of the quarry (Gușterița 4) was sampled for macro- and microfossils, and a detailed magnetostratigraphic investigation was carried out as well. All the four studied sections can be assigned into the *Undulotheca rotundata mollusc* lineage

subzone of the *C. banatica mollusc* assemblage zone (~11–10.2 Ma) and into the *Hemicytheria tenuistriata?* and *Propontoniella candeo* ostracod biozones. According to the palynological and calcareous nannoplankton studies, the Gușterița 4 section belongs to the *Spiniferites bentorii* oblongus (~11.3–10.8 Ma) and the *Pontiadinium pecsvaradense* (~10.8–10.6 Ma) organic-walled microplankton biozones. All samples from the Gușterița 3 and 4 profiles contain endemic Pannonian calcareous nannofossils represented by the species *Isolithus semenenko*, *I. pavelici*, *Noelaerhabdus jerkovici*, and *Praenoelaerhabdus banatensis*. Blooms of ascidian spicules (*Perforocalcinella fusiformis*) in some of the samples were observed. Samples also contain calcareous nannofossils redeposited mostly from the Middle Miocene. Nine samples were analyzed for authigenic  $^{10}\text{Be}/^9\text{Be}$  isotopic measurements. The calculated age data suggest an interval of ~11–10.6 Ma. Magnetostratigraphic samples showed normal polarity for the entire Gușterița 4 section, therefore, taking into consideration the biostratigraphic data, we correlate it with the C5n.2n magnetic chron (11.056–9.984 Ma, ATNTS2012).

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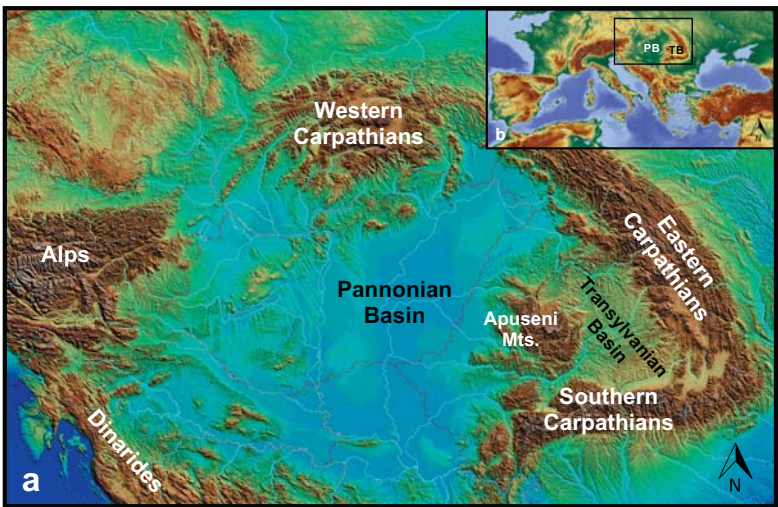
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# A key section for the Early Pannonian (Late Miocene) of the Transylvanian Basin (Romania): integrated stratigraphic results from the Gușterița clay pit

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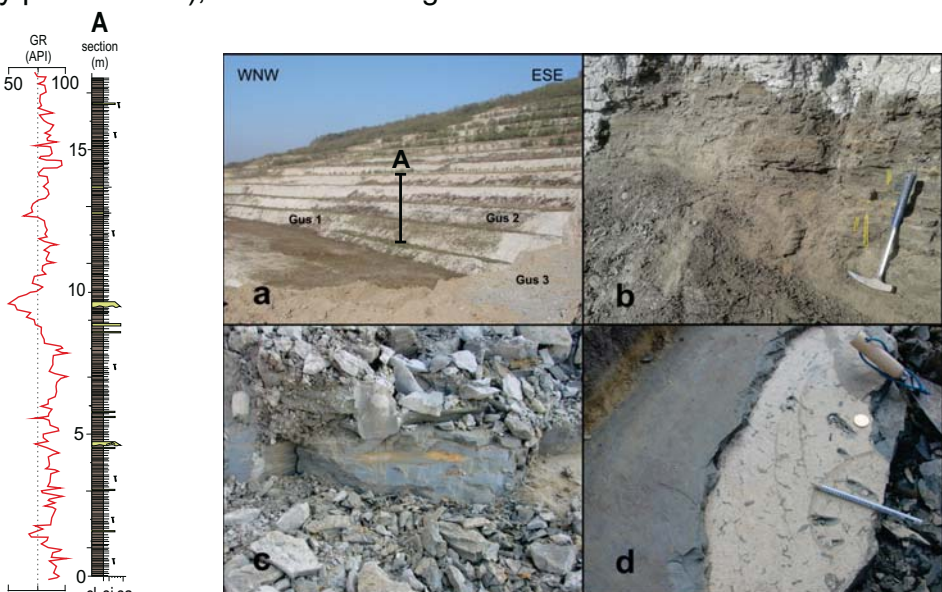
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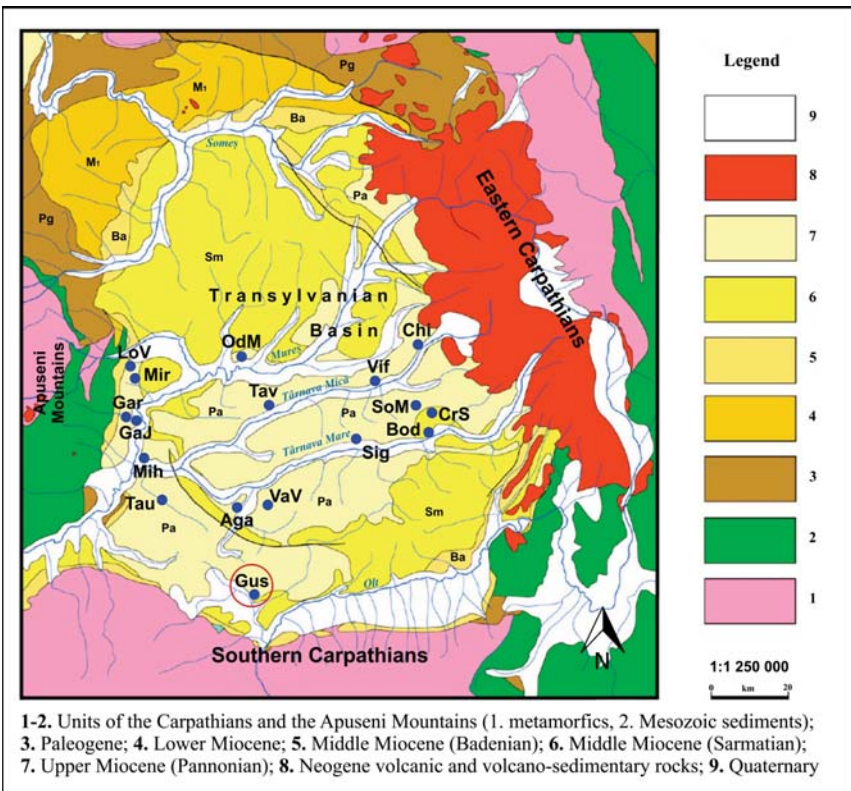
Why to study the Pannonian (Late Miocene) of the Transylvanian Basin (TB)?

1. The TB accommodates a several-hundred-meter thick Early Pannonian sedimentary sequence. Sediments of similar facies and age are mostly deeply buried in the Pannonian Basin (PB) proper.
2. Data on the Pannonian fossils of the TB are few and scattered in the literature, consequently its biostratigraphic assessment implies much uncertainty.
3. The magnetostratigraphic correlation of some recent polarity measurements partly remained disputable (VASILIEV et al. 2010 & DE LEEUW et al. 2013).
4. Radiometric age measurements have never been published from these formations.

**Objective:** To improve the stratigraphic resolution and the reliability of correlations in the Pannonian of the TB. We investigated 17 outcrops of deep-water formations across the basin. The largest and one of the most fossiliferous outcrops is Gușterița (today part of Sibiu), therefore we regard it as a reference section for the entire TB.



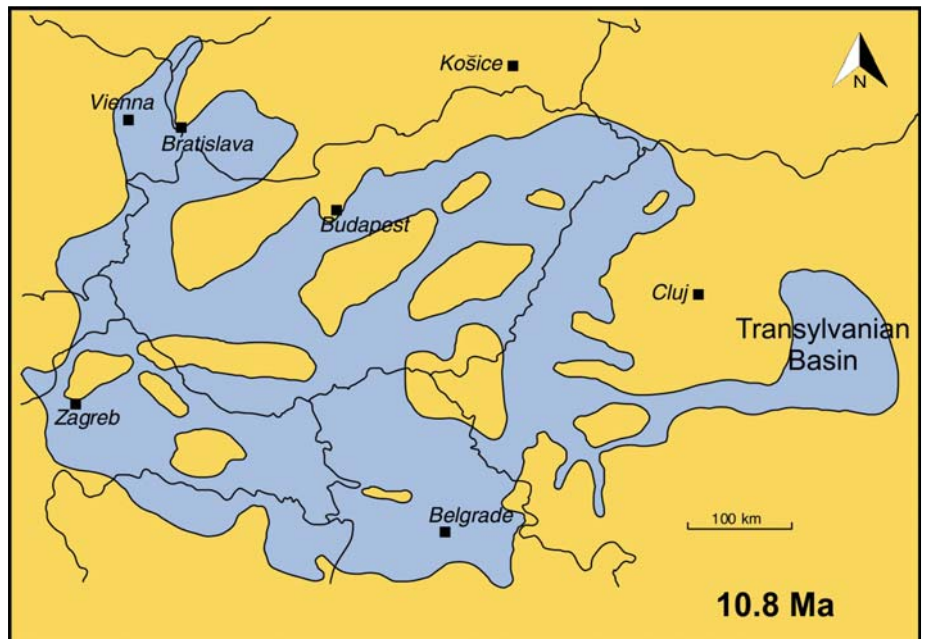
Clay pit of Gușterița and sedimentary log of the lower part of the mine. a: The mining site, with view from the upper part (Gus 3). The three sampled levels are indicated by the captions; b: Cleared surface in the lower section (Gus 1). Yellow outlines mark vertical burrows; c: Very fine cross-laminated sand lenses in the upper part (Gus 3); d: Light grey laminated calcareous marl with *Diplocraterion* isp. traces on the bedding plane in the upper part of the quarry (Gus 3)



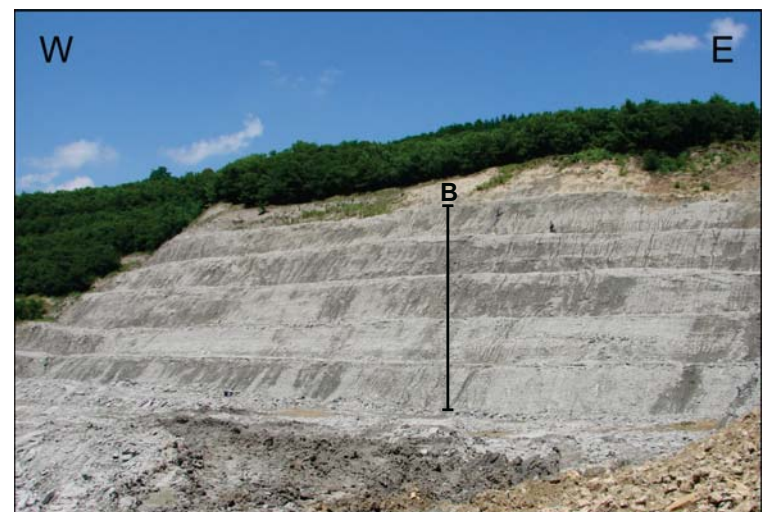
Geological map of the TB showing the 17 studied deep-water outcrops (after SÂNDULESCU et al. 1978)

## Abbreviations of the localities:

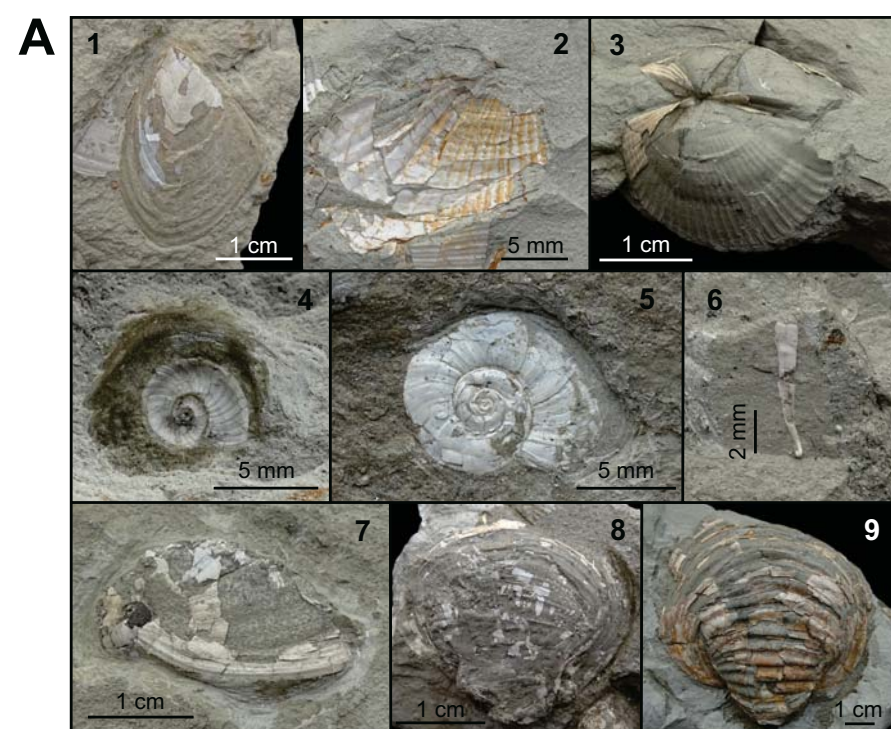
Agârbiciu (Aga), Bodoagaia (Bod), Chibed (Chi), Cristuru Secuiesc (CrS), Gârbova de Jos (GaJ), Gârbovița (Gar), **Gușterița (Gus)**, Lopadea Veche (LoV), Mihalț (Mih), Mirăslău (Mir), Oarba de Mureș (OdM), Sighișoara (Sig), Șoimușu Mic (SoM), Târnăveni (Tav), Tău (Tau), Valea Viilor (VaV), & Viforoasa (Vif)



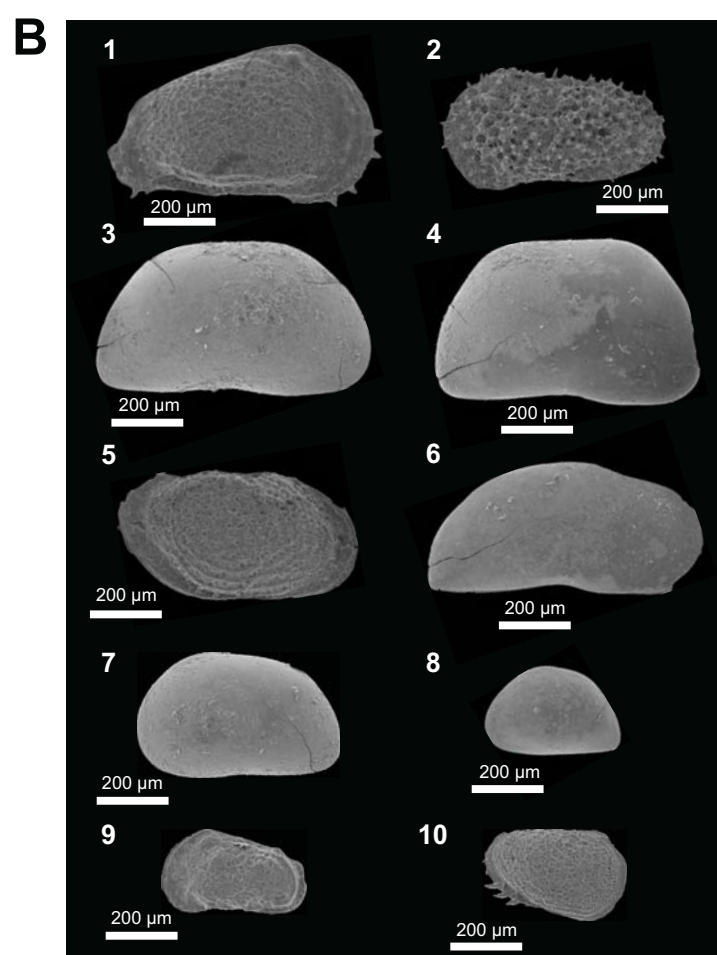
Extent of Lake Pannon 10.8 million years ago (MAGYAR 2010)



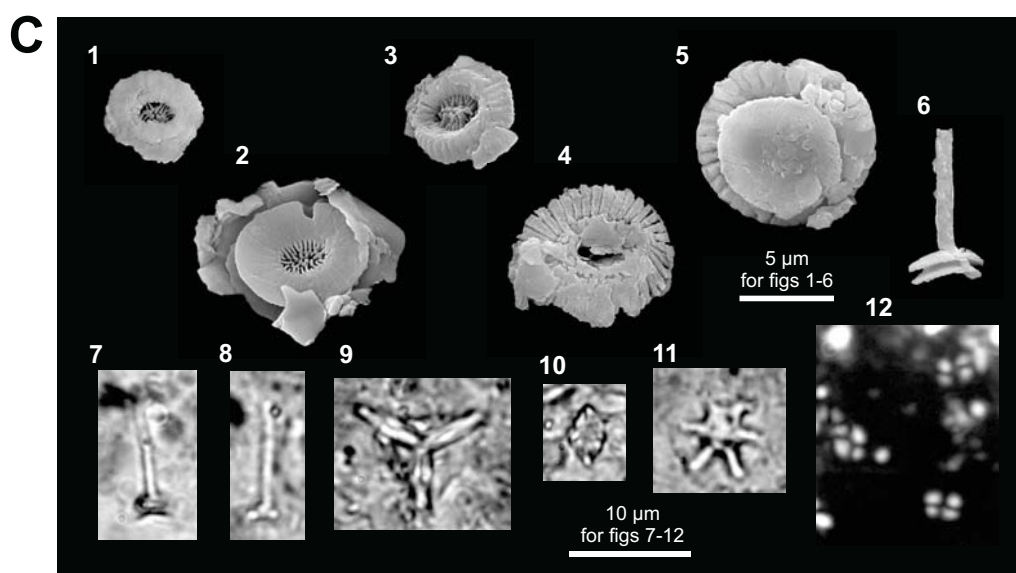
The 25 m high Gușterița 4 section (uppermost part of the mine), from where magnetotatigraphic and detailed micropalaeontological analyses were carried out



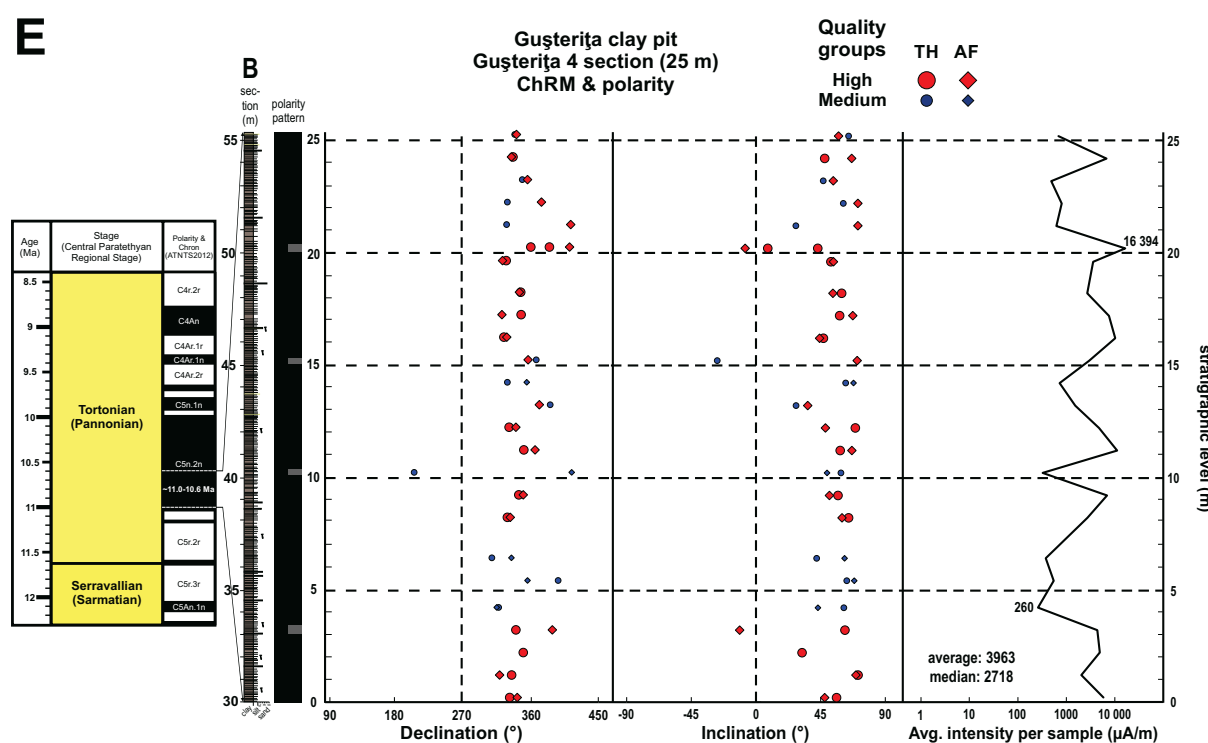
**Plate A: Deep-water molluscs of the *Congeria banatica* biozone**  
1: *Congeria banatica*  
2: *Lymnocardium undatum*  
3: *Paradaena symiense*  
4: *Gyraulus ponticus*  
5: *Gyraulus tenuistriatus*  
6: *Orygoceras levis*  
7: *Velutinopsis cf. velutina*  
8: *Undulotheca cf. nobilis*  
9: *Undulotheca rotundata*



**Plate B: Ostracods of the *Hemicytheria tenuistriata?* and *Propontoniella candeo* ostracod biozones**  
1: *Hemicytheria croatica*  
2: *Amnicythere naca*  
3: *Candona (Thaminocypris) aspera*  
4: *Candona (Thaminocypris) transilvanica*  
5: *Loxoconcha rhombovalis*  
6: *Candona (Propontoniella) sp.*  
7: *Candona (Sinegubiella) illyrica*  
8: *Candona (Thyphlocypris) sp. juv.*  
9: *Leptocythere (Amnicythere) stanchevae*  
10: *Loxoconcha granifera juv.*



**Plate D: Dinoflagellates of the *Spiniferites bentorii oblongus* and *Pontiadinium pecsivadense* organic-walled microplankton biozones**  
1: *Spiniferites bentorii oblongus*  
2: *Virgodinium asymmetricum*  
3: *Spiniferites bentorii ssp.* (with pyrite inclusions)  
4: *Spiniferites sp.* (membranous form)  
5: *Nematosphaeropsis bicorporis*  
6: *Pontiadinium pecsivadense*  
7: *Spiniferites bentorii granulatus*  
8: *Chytroisphaeridia cariacensis*  
9: *Spiniferites thianensis*  
10: *Virgodinium transformis*  
**Plate C: Endemic (1-3, 6-10, 12) and re-worked (4-5, 11) calcareous nannoplankton**  
1-3, 12: *Praenoelaerhabdus banatensis*  
4: *Coccolithus pelagicus*  
5: *Calcidiscus leptoporus*  
6-8: *Noelaerhabdus jerkovici*  
9: *Isolithus semenko*  
10: *Isolithus pavelici*  
11: *Discoaster sp.*



Magnetostratigraphic summary chart of the Gușterița 4 section (uppermost 25 m of the quarry). Declination, inclination, and average intensity per sample values, with polarity pattern, sedimentary log, and Central Paratethyan stratigraphic chart. All the relevant samples showed normal polarity, i.e. positive inclination values and declination values above 270°. (ChRM: Characteristic remanent magnetization, TH: Thermal demagnetization results, & AF: Alternating field demagnetization results)

Age (Ma)	Stage	Magnetic polarity	Magnetic chron	Mammal biozones	Biozones of Lake Pannon deposits		
					Organic-walled microplankton	Molluscs	
6	Messinian	C3r	MN13		Galeacysta etrusca	Congeria (Candona) murensis	Prosodanomya vutskitsi
							Prosodanomya dainelli
							Prosodanomya carbonifera
							Lymnocardium decuratum
7	Messinian	C3Ar	MN12		Dreissenomya digitifera	Congeria praehomoboides	Lymnocardium porticum
							Lymnocardium conjugens
							Lymnocardium conjugens
							Congeria foersteri
8	Messinian	C4r	MN11		Spiniferites validus	Congeria praehomoboides	Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
9	Tortonian	C4An	MN10		Spiniferites paradoxus	Congeria praehomoboides	Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
10	Tortonian	C4Ar	MN9		Spiniferites paradoxus	Congeria praehomoboides	Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
11	Tortonian	C5r	MN7-8		Spiniferites paradoxus	Congeria praehomoboides	Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens
							Lymnocardium conjugens

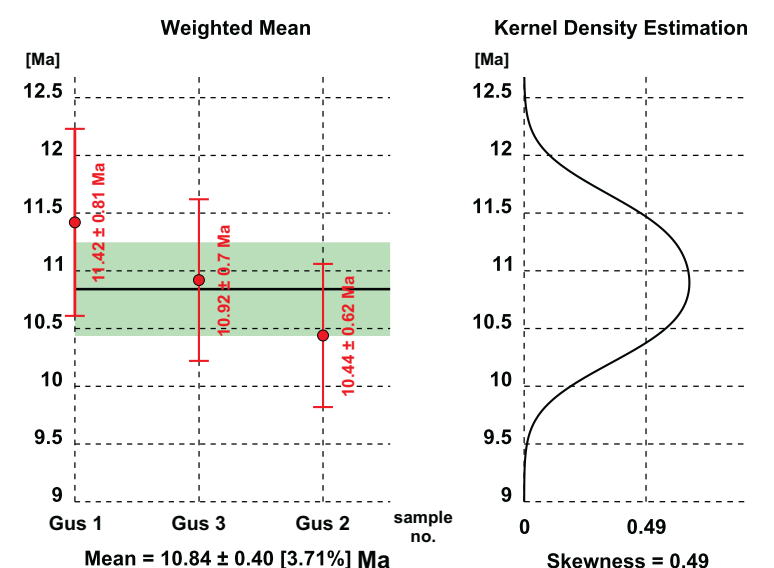
State-of-the-art stratigraphic chart of Lake Pannon deposits. Red zone and subzones are newly proposed, green area indicates time interval of all the studied Gușterița sections (modified after MAGYAR & GEARY 2012)

## Conclusions

**3 samples for authigenic <sup>10</sup>Be/<sup>9</sup>Be isotopic measurements: weighted mean value of 10.84 ± 0.4 Ma. Magnetostratigraphic samples: normal polarity, C5n.2n magnetic chron (11.056–9.984 Ma, ATNTS2012).**

**Taking into consideration all the age data: ~11.0–10.6 Ma age is suggested for the whole section**

## F Results of authigenic <sup>10</sup>Be/<sup>9</sup>Be dating from Gușterița 1, 2, & 3 samples (figured based on SPENCER et al. 2017)



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