PS Middle Miocene Micropaleontological and Sedimentary Aspects within a Piggy-Back Basin, Carpathian Bend Zone, Romania*

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Abstract

The studied outcrop is located along the Bizdidel River, close to Pucioasa town, in the Carpathian Bend Zone. The main investigated Pucioasa section is found on the northernmost extension of a syncline limb, part of a wedge top piggy-back basin and partly to some deformed foredeep related thrust sheets.

The current investigation focuses on the relative age dating and paleoecological conditions using calcareous nannoplaknton and foraminifera associations. Also, a sedimentological analysis was performed, necessary for the depositional environment interpretation. For the qualitative and quantitative study of the calcareous nannoplankton and foraminifera assemblages, 55 rock samples were collected and analyzed. Sample preparations for the calcareous nannoplankton analysis were made using standard methods. Foraminifera samples were processed by standard micropaleontological methods, the specimens were recovered from the 63 µm sieve and studied under stereomicroscope. Sedimentological studies included grain size analysis, sedimentary structure descriptions, and nature of bed contact analysis, measured on a cm – dm scale.

The calcareous nannoplankton assemblages from the Pucioasa section are characterized by low diversity (30 species), fluctuating abundance, and poor to moderate preservation. Along the studied sections, some changes into the calcareous nannoplankton assemblages can be observed. All the changes are due to variations of paleoecological conditions related to the regional or local tectonics. The studied deposits can be assigned to NN4 - NN5 Biozones (Badenian). The foraminiferal analysis shows an age ranging from Badenian to Sarmatian. The syn and pre-tectonic ages relates to the Middle Miocene thrusting events in the Carpathians.

From a sedimentological point of view, the investigated pre-tectonic units consist of dark-gray mudstones with rare gray-yellow sandstones and siltstones. They were interpreted as part of an unconfined fan fringe. The sedimentary succession from the syn-tectonic basin consist of

mudstones, siltstones with different colors (gray, brown, green) and fine – medium sandstones and sandy granules beds with various sedimentary structures. Gypsum and volcanic tuffs are intercalated. The gross depositional environment is interpreted as shallow marine/medial shoreface/delta front to offshore settings. The deposition of evaporites relates to the piggy-back basin isolation (tectonic/eustatic effects) which formed a ponded basin that permitted salinas to be formed.

This study results offers an informative view on foredeep to wedge top piggy back evolution during Middle Miocene times in the Carpathian Bend Zone.

Selected References

Botond, S., 2012, Reconstruction of the Paleogene and Neogene Marine Paleoenvironments in the Southernmost Part of the Tarcău Nappe (East Carpathians) Based on Fossil Foraminifera Assemblages: Ph.D. Thesis, Babes-Bolyai University, Cluj-Napoca, Romania, 182 p.

Krezsek, C., and S. Filipescu, 2005, Middle to Late Miocene Sequence Stratigraphy of the Transylvanian Basin (Romania): Tectonophysics, v. 410, p. 437-463.

Middle Miocene micropaleontological and sedimentary aspects within a piggy-back basin, Carpathians bend zone, Romania

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The studied section crops along the Bizdidel River, close to Pucioasa town, in the Carpathians bend zone (Fig.1).

This section reflects very well the deep marine foredeep (?piggy-back) - lower part of outcrop and upstream (Fig.3-5,12f) - to shallow marine piggy-back transition (Fig.3-6,12a-e). This shallowing upward is interpreted to be related to the tectonic uplift (Fig.5) of the Middle Miocene main thrusting events in the Carpathians Bend Zone.

The sin-kinematic evidence of the piggy back deposits can be seen by the thickness variations (Fig. 5) and wedge type geometries of the Badenian gypsum seen in the Pucioasa quarry (Fig. 2 & 6)

Also, the Badenian/Sarmatian transition was found within the piggy-back deposits (Fig.3). Interestingly thick coarse deposits were found around base Sarmatian, a feature also observed in the Transylvanian Basin (Krezsek&Filipescu,2005).

Fig. 1: Pucioasa outcrop location

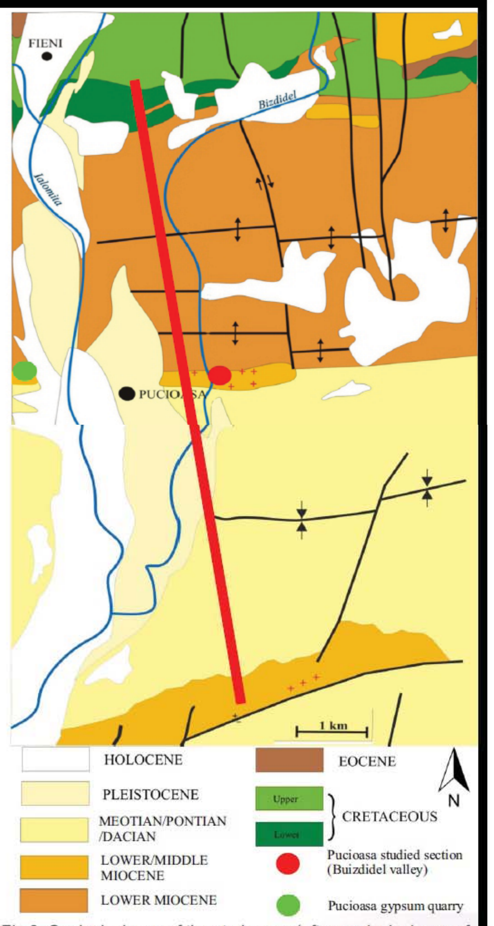
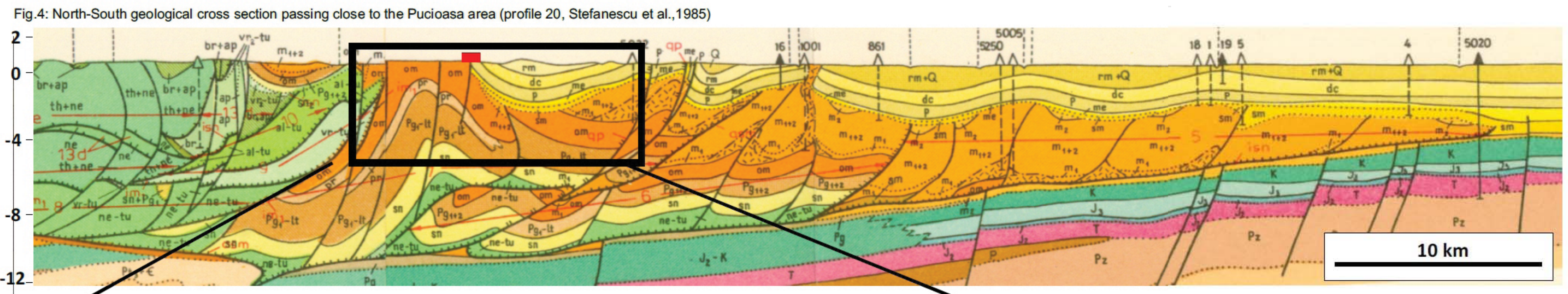


Fig.2: Geological map of the study area (after geological map of Romania, 1:50000, Pucioasa sheet, fide Szabo, 2012). Cross section orientation (red line) - Fig. 5.

Fig.4: North-South geological cross section passing close to the Pucioasa area (profile 20, Stefanescu et al.,1985)



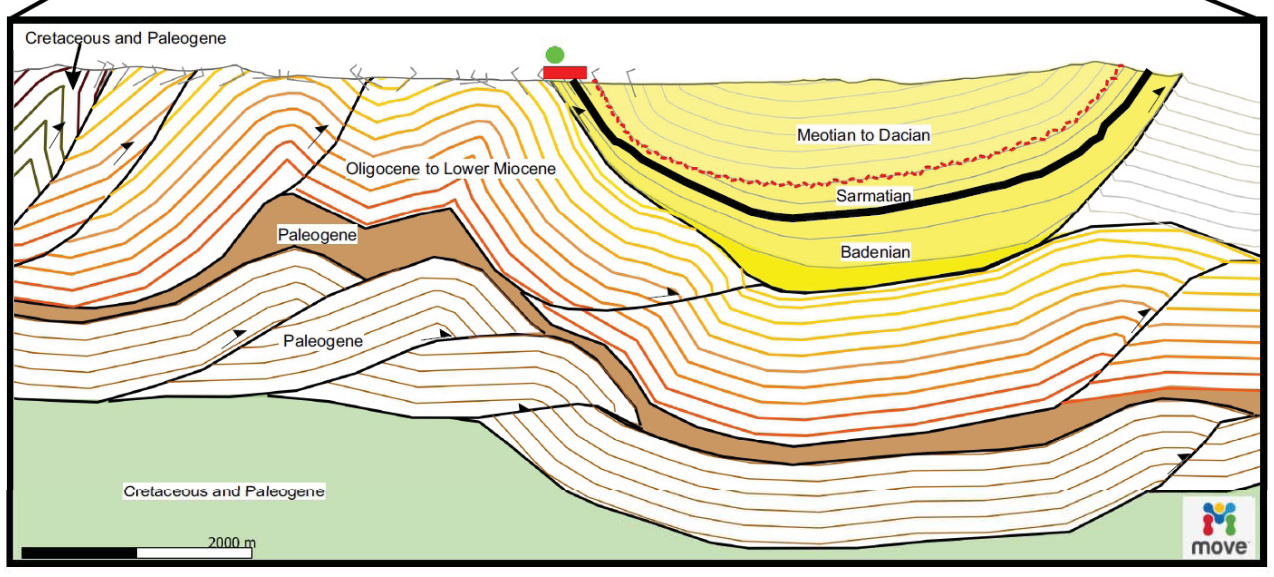


Fig.5: Simplified geological cross section constructed in Move 2016 on a 2D seismic line (**work in progress**). The thick red line is the studied outcrop position. The green circle marks the gypsum quarry projection on the geological cross section (see Fig. 2 for lcoation). One can noticed the Middle Miocene piggy-back setting with the thickness variations (sin-kinematic sedimentation, see Fig. 6). This piggy-back basin is situated on top of some thrust sheets made of Oligocene to Lower Miocene foredeep deposits. An unconformity (dashed red line-seen, visible in outcrop and seismic data) exists between the Meotian and Sarmatian deposits. Black thick line should be the limit between Badenian and Sarmatian deposits. Above the boundary there should be an erosional contact (See fig. 3).

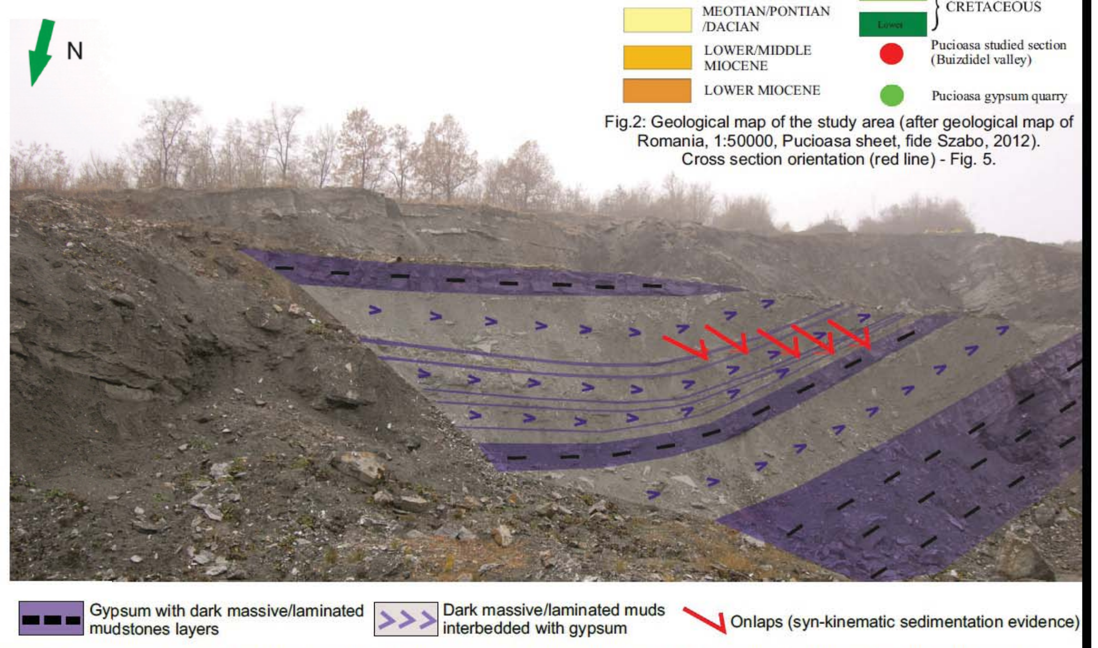


Fig. 6: Gypsum quarry at Pucioasa (location at Fig. 3). Wedge type geometries with onlap strata termination that can be interpreted as a sin-kinematic sedimentation evidence related to the onset of piggy-back tectonics.

For the qualitative/quantitative study of the calcareous nannoplankton and foraminiferal assemblages, 55 rock samples were collected and analyzed.

Sample preparations for the calcareous nannoplankton analysis were made using standard methods (total >300 species).
Foraminifera samples were processed by standard micropaleontological methods, where the specimens were recovered from the 63 μm sieve and studied under stereomicroscope.

Foraminifera results:

Even tough the majority of the samples contain foraminifera assemblages of Lower to Middle Miocene range, some samples had (see below) distinct species that confirmed the Middle Miocene age of the deposits (Fig.2):

Biozones (fora.samples: Fig. 3):

- *Orbulina suturalis* Zone (early Badenian) – samples 1-16 (index taxa found in sam. 3-4).
- *Obandyella transsylvanica* (middle Badenian) – samples 24-30.
- *Tenuitellinata* Zone (terminal Badenian)/*Anomalinoides divides* Zone (base of Sarmatian – sample 37.
- ?*Varidentella reussi* to *Dogielina sarmatica* zones (mid Sarmatian) - samples 39-48.

Calcareous nannoplankton results:

Biozones (nanno.samples: Fig. 3):

- NN4 Zone (early-middle Badenian): *Helicosphaera ampliaperta* (Fig. 7a) together with *Sphenolithus heteromorphus* (Fig. 7b). Some other species (e.g. *Discoaster deflandrei* (Fig. 7c), *Helicosphaera euphratis* (Fig. 7d) and *Helicosphaera scissura*, Fig. 7e)) support the above mentioned biozone.

- NN5 Zone (middle-?upper Badenian): LO of *H. ampliaperta* (Fig.7a),(in sample_nanno 14) indicates the boundary between NN4 - NN5 Biozones. Into the NN5 Biozone it has been identified a single specimen of *H. waltrans* (Fig. 7g), a very rare species for Middle Miocene. *Discoaster variabilis* (Fig. 7h) was found in the NN5 biozone.

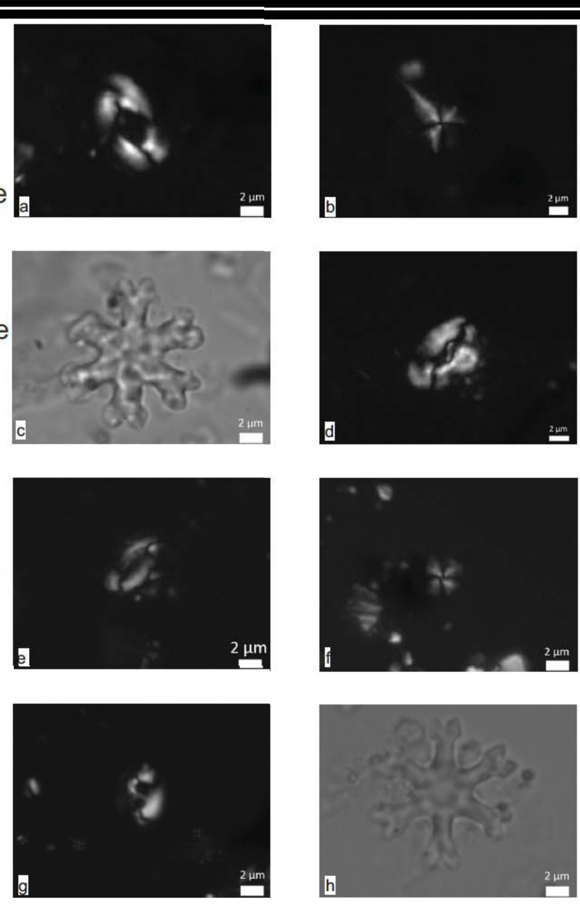


Fig 7: a) *Helicosphaera ampliaperta*; b) *Sphenolithus heteromorphus*; c) *Discoaster deflandrei*; d) *Helicosphaera euphratis*; e) *Helicosphaera scissura*; f) *Calcidiscus leptoporus*; g) *Helicosphaera waltrans*; h) *Discoaster variabilis*;

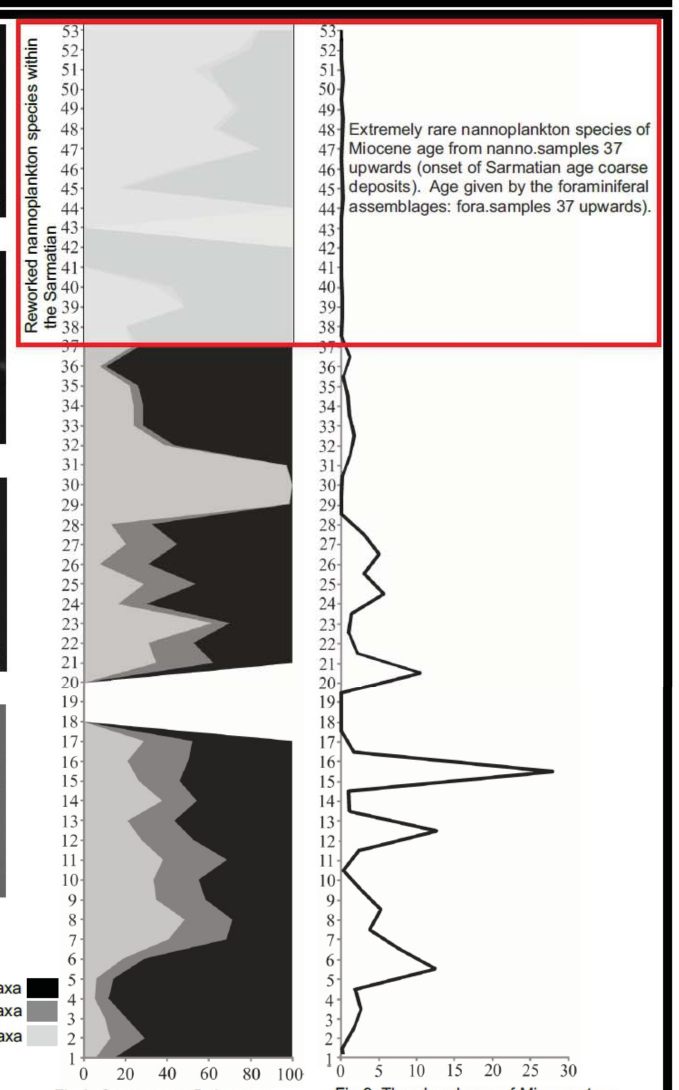


Fig.8: Cretaceous, Paleogen, Miocene taxa abundance. The K/Pg taxa comes from the K/Pg thrust nappes that where uplifted in the hinterland (Fig. 4,5), (% of all taxa counted).

Fig.9: The abundance of Miocene taxa registers a decrease in the upper part of the section, where the reworked taxa exceed the autochthon species. A peak of abundance have been identified immediately above the LO of Helicosphaera ampliaperta, into the lower part of NN5 Zone (Miocene specimen/FOW).

Extremely rare specimens of nannoplankton occur from sample_nanno 37 (or fora_sample 38) upwards. As the foraminiferal assemblages are of Sarmatian age, the identified Badenian nannoplankton specimens must have been reworked. Also, given the erosional thick and coarser conglomerates around samples [(38-41),(37-40)], it can suggest a tectonic event in the Sarmatian (hinterland uplift) that lead to the restricted connections of the basin. Therefore the paleoecological conditions changed due to brackish waters.

From a sedimentological point of view 6 lithotypes (facies) have been defined (see Fig. 3 legend). It stack up into several progradational CUS and FUS sequences (Fig. 3, Fig. 10). The EOD interpretation (Fig. 3, Fig. 11) consists of: slope/offshore (distal shelf) - lower part of the outcrop (transition from inner foredeep slope to piggy back setting); offshore (distal shelf)/bay/prodelta - offshore transition - delta front/lower shoreface (+storm reworked delta front/shoreface) and deltaic distributary channels (+/- interchannel/abandomnent intervals). This suggest an overall shallow marine sedimentation. Besides the regional causes for the evaporites deposition, a tectonic reason can be inferred also (thrust activity which isolated the piggy back basin - see Fig. 6).

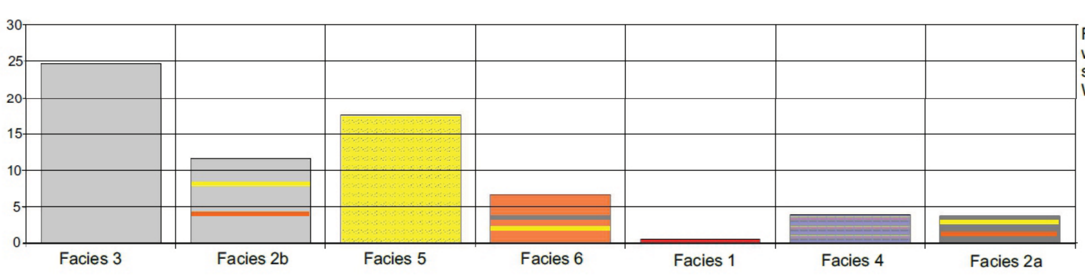


Fig.10: Facies distribution within the length of the studied outcrop (done in WellCad 5.1)

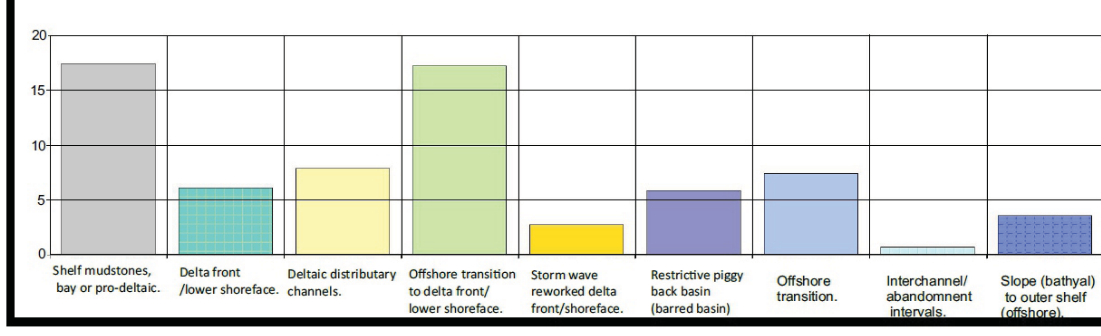


Fig.11: EOD distribution within the length of the studied outcrop (done in WellCad 5.1)

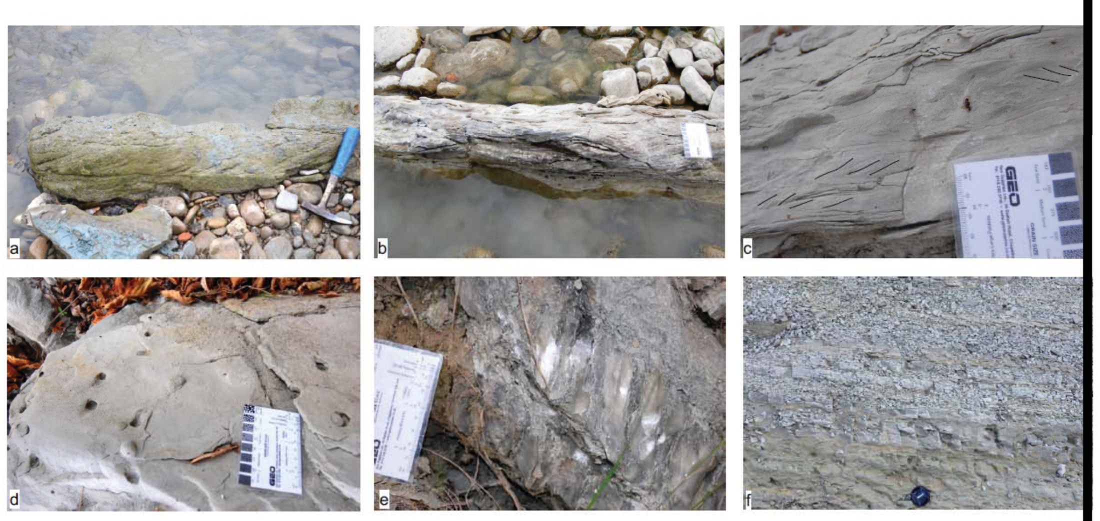


Fig. 12: a) planar cross bedded sandstones; b) Storm events (HCS-SCS) in sandstones; c) Bioturbated stacked wave related ripples in fine sandstones; d) Vertical burrows in fine sandstones (*Lockeia* sp.); e) Prismatic crystal twins - gypsum; f) Silty mudstones/shalestones (some fissility) - lower part of outcrop (and upstream) ;

Sedimentary structures
- Planar parallel lamination
- Flames
- Assimetrical ripples
- Mud drapes
- Soft sediment deformation
- Load casts
- Cross bedded
- Hummocky like
- Oscillation/wave ripples
- Dish and pillars
- Clast imbrication
- HCS/SCS
- Horizonthal bedding
- Planar cross stratificatom
- Flaser lamination

Ichnofossils
- Lockeia sp.
- Conichnus sp.

Lithotypes
- Facies 1: Vulcanic tuff.
- Facies 2a: Interbedded dark shalestones/mudstones with siltstones and sandstones intercalations.
- Facies 2b: Interbedded light grey or brown-reddish mudstones, silstones, sandstones intercalations.
- Facies 3: Mustones (very rare/thin to none siltstones and sandstones intercalations).
- Facies 4: Interbedded gypsum with silicilastics intercalations.
- Facies 5: dm/m thick sandstones, gravelly sanstones, sandy conglomerates.
- Facies 6: Siltstones with rare thin sandy siltstones, sandstones and mudstones.

Depositional Environment
- Slope (bathyal) to outer shelf (offshore).
- Shelf mudstones, bay or pro-deltaic.
- Offshore transition.
- Offshore transition to delta front/lower shoreface.
- Delta front/lower shoreface.
- Restrictive piggy back basin (barred basin)
- Interchannel/abandomnent intervals.
- Storm wave reworked delta front/shoreface.
- Deltaic distributary channels +/- deltaic lobes.

Litho. qualifiers
- Bioclasts (undifferentiated)
- Coal clasts
- Gypsum with sand size rounded gypsum clasts (algal origin?)

Sedimentary structure qualifiers
- Faults
- Rip-up clasts
- Vertical burrows
- Horizonthal burrows
- Reverse fault
- Compresional shear zone

Selected Literature
Botond, S. (2012): Reconstruction of the Paleogene and Neogene marine paleoenvironments in the southernmost part of the Tarcău Nappe (East Carpathians) based on fossil foraminifera assemblages, Unpublished Ph.D. Thesis, Cluj-Napoca, 182 pp.
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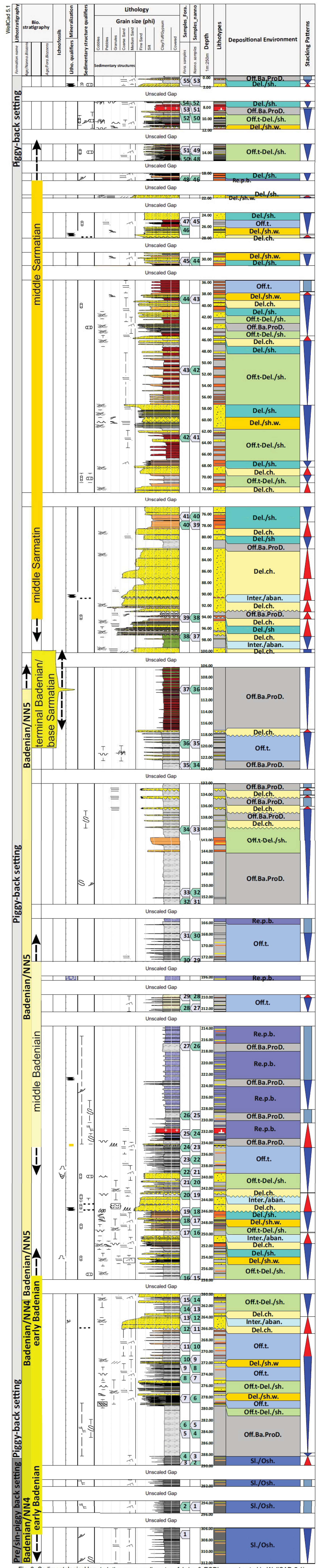

Fig. 3: Sedimentological log (relative ages, sedimentary fabrics & EOD's, constructed in WellCAD 5.1)