

Upper Cretaceous - lowermost Miocene lithostratigraphic units exposed in Alba Iulia – Sebeş – Vinţu de Jos area (SW Transylvanian basin)

Vlad CODREA* & Emanuel Paul DICA

Department of Geology, “Babeş-Bolyai” University, Kogălniceanu 1, 400084 Cluj-Napoca, Romania

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ABSTRACT. A main area where several Uppermost Cretaceous-Lower Cenozoic formations are exposed in the SW Transylvanian Depression is the region outlined by the localities Alba Iulia, Sebeş, Vinţu de Jos (Alba district). In Maastrichtian, continental formations belonging to the post-Laramian cover began their deposition. In Early Cenozoic, the dominance of continental formations continued, but some short marine transgressions occur too, with specific marine and brackish deposits interbedded into the continental successions. Some new lithostratigraphic units are proposed: Vurpăr (Maastrichtian), Şard (Maastrichtian-Late Eocene), Bărăbanţ (Oligocene) and Sântimbru (Aquitanian) formations. Ighiu Fm. (Late Eocene-Early Oligocene) is also reinterpreted. This region is an outstanding one for the fossil vertebrate heritage too due to the Uppermost Cretaceous (Maastrichtian) dinosaur fauna discovered into Vurpăr and Şard formations, very similar with the famous faunas described by Nopcsa from Haţeg Basin. The autochthony of these fossils is obvious. In this context, some corrections should be done on several older geological maps, where these deposits correspond to erroneous geological ages.

Key words: Transylvanian Basin, lithostratigraphic units, Late Cretaceous-Earliest Miocene, Romania.

INTRODUCTION

On its SW side, the Transylvanian Depression advances through an embayment towards its connection with Strei Depression and Mureş passageway. Among the various sedimentary formations exposed in this region, the Upper Cretaceous-Lower Miocene successions cropping out in Alba Iulia-Sebeş-Vinţu de Jos (Alba district) area are of peculiar interest, illustrating the transition that took place at the K/T boundary, as well as the sedimentary environments evolution in the Early Cenozoic. The area is outstanding for its dinosaur-bearing strata, pointed out since the early 20th century, due to Nopcsa (1905) contribution. For instance, it is the second most representative region bearing Uppermost Cretaceous dinosaur fauna from our country, after the Haţeg Basin.

GEOLOGICAL SETTING

In this region are exposed several formations belonging from structural viewpoint to Apuseni Mts. and Transylvanian Basin.

The firsts can be followed in Metaliferi Mts., where form the Bozeş Nappe, a constituent of the Transylvanids (Bleahu et al., 1981; Săndulescu, 1984).

The second, belongs to the post-Laramide sedimentary cover which marks the beginning of the Uppermost Cretaceous-Paleogene Transylvanian Basin

evolution (Balintoni et al., 1998; Codrea et al., 2001a, c; 2003). On some older geologic maps, as 1: 200 000 (Turda sheet) published by the Romanian Geological Institute, all these formations had been allocated to the Oligocene, in spite of clear evidence of older deposits.

On the other hand, some geologists proposed a different sedimentary paradigm in Transylvanian Depression, suggesting even the complete absence of the Paleocene and a gap and discontinuity between the Late Cretaceous and Eocene (Ciupagea et al., 1970; Ciulavu et al., 2000). This point of view falsifies the stratigraphic evolution, because the presence of Paleocene deposits is enough clear, as well as the role they played in the basin geological history (Gheerbrant et al., 1999; Hosu, 1999; Codrea & Fărcaş, 2001c).

The main peculiar feature of the Lower Cenozoic formation from the area refers to the trenchant dominance of the land formations (red beds). Compared to the classic successions from the NW Transylvanian Depression, here the marine sequences are subordinate and concern only thin strata interbedded into the thick land piles of red beds, pointing out episodic transgressions that occurred in the Priabonian-Early Rupelian and Late Egerian (Aquitanian).

A historical overview on the various interpretations concerning the geological ages of the different deposits, could also explain the wide discrepancies between the geological maps published until now (details in Codrea et al., 2001a; 2003).

*Correspondence: V. Codrea (vcodrea@bioge.ubbcluj.ro)

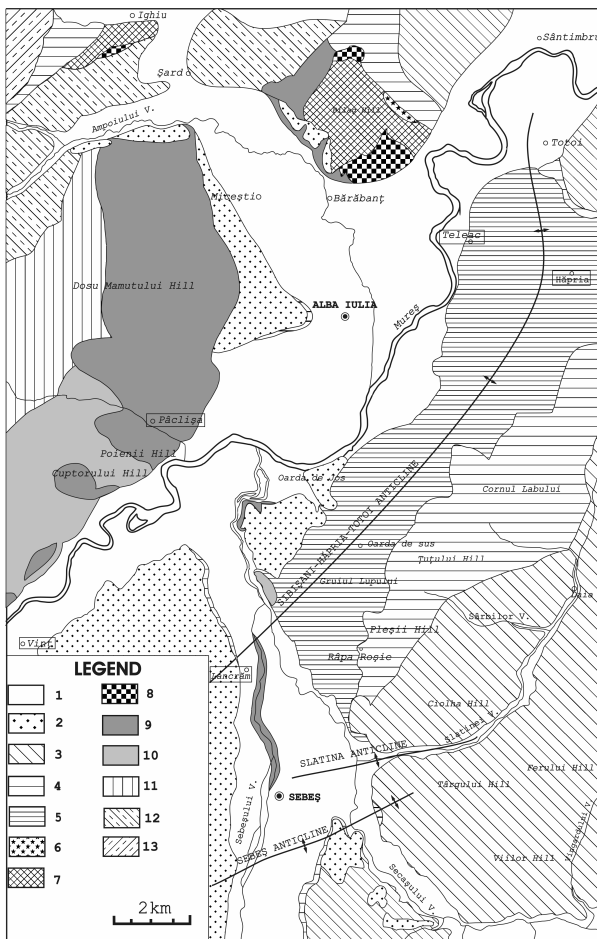


Fig. 1. Geological map of Alba Iulia-Sebeș-Vințu de Jos (according Ilie, 1959, modified).

1- alluvia; 2- lower terrace; 3- Pannonian s. str.; 4- Badenian; 5- Sebeș Fm., ?Burdigalian; 6- Sântimbru Fm., Aquitanian; 7- Bărâbaș Fm., Rupelian-Chattian; 8- Ighiu Fm., Late Priabonian-Early Rupelian; 9- Șard Fm., Maastrichtian-Priabonian; 10- Vurpăr Fm., Early Maastrichtian; 11- Bozeș Formation, Santonian-Maastrichtian; 12- Aptian-Albian; 13- Barremian-Aptian

LITHOSTRATIGRAPHIC UNITS

The extension of the Upper Cretaceous-Lower Miocene formations exposed into the area is illustrating by the herein map (Fig. 1).

Bozeș Formation (GHIȚULESCU & SOCOLESCU, 1941)

Inoceramus Strata (Pálffy, 1902)
Bozeș Strata (Ghițulescu & Socolescu, 1941)
Inoceramus cripsi Strata (Iacob, 1943)
Inoceramus Strata (Gherman, 1943)
Flysh facies (Dimian & Dimian, 1963)
Bozeș Strata (Tomescu et al., 1969)
Bozeș Strata (Ianovici et al., 1969)
Bozeș Strata, flysh facies (Mantea et al., 1971)
Bozeș Strata (Antonescu, 1973)
Bozeș Formation (Lupu, in Bleahu et al., 1981)
Cretaceous (marine facies) (Grigorescu, 1987)
Bozeș Flysch (Schuller, 2004)

On the studied area, only the top of this formation occurs. It consists on a thick pile of marine basin plain and slope turbidites, forming a typical flysh (Schuller, 2004).

According the same a considerable part from Bozeș

Fm. top (around 4000 m) has been eroded after its deposition.

The formation belongs to Santonian - Early Maastrichtian, as evidence by molluscs and foraminifers (Dimian & Popa-Dimian, 1963; Tomescu et al., 1969; Codrea et al., 2001a), nannoplankton (Bălc & Chira, 2002; Chira et al., 2004) or microflora (Antonescu, 1973).

It worth to be stressed that some contributors as Lupu (in Bleahu et al., 1981) included into the Bozeș Fm. also the Maastrichtian molass.

The same interpretation can be found in Grigorescu (1987) or Grigorescu et al. (1990). The most reasonable point of view in our opinion belongs to Antonescu (1973) who considered that Bozeș Fm. should include the flysch successions only without molass, as Ghițulescu & Socolescu (1941) suggested as a matter of fact from the beginning.

Vurpăr Formation *nom. nov.*

“Actaeonella gigantea Beds”, Cerithium Beds”, “Sabal major Beds” (Pálffy, 1902)

“Actaeonella gigantea Strata”, Cerithium Strata”, “Sabal major Strata” (Gherman, 1943)

“Cerithium Beds” and “Actaeonella Beds” (Iacob, 1943)

Littoral-proximal facies (Dimian & Dimian, 1963)

Bozeș Strata (Bleahu & Dimian, 1967)

Bozeș Strata (Tomescu et al., 1969)

Bozeș Strata, southern area proximal littoral facies (Ianovici et al., 1969)

Bozeș Strata, molass facies (Mantea et al., 1971)

Coarse proximal-clastic facies (Antonescu, 1973)

Bozeș Formation (Lupu, in Bleahu et al., 1981)

Cretaceous (marine facies) (Grigorescu, 1987)

Definition: yellowish silty sandstone, with polygenetic conglomerate and silts interbedded, sometimes with coal forming thin lens-like accumulations, indicating a clastic coast environment, with fan delta successions and several invasive marine episodes interbedded. In certain levels, the wood fragments and leaf imprints are numerous.

Detailed litho-stratigraphic chart of this formation between Băcăinți-Vurpăr-Pâclișa belongs to Tomescu et al. (1969).

The thickness of these deposits reaches 250 m.

Lower boundary: unconformity marking the end of the Bozeș Fm.

Upper boundary: disconformity between the yellowish sandstone and the red beds located above.

Type section: on middle hydrographic basin of Vințu Valley (on Cetății Creek), a right Mureșului Valley tributary, debouching into at Vurpăr.

Other representative exposures: on Stăuinii Valley.

Age: Lowermost Maastrichtian. Rich ammonite and mollusc assemblages, as well as macro- and microflora occurring on Stăuinii and Pâclișa valleys support this allocation (Pálffy, 1902; Nopcsa, 1905; Iacob 1949, 1953; Dimian & Popa-Dimian, 1964; Tomescu et al., 1969; Antonescu, 1973).

A dinosaur footprint has been mentioned from Sebeșului Valley in deposits probably belonging to this formation (Vremir & Codrea, 2002).

Șard Formation *nom. nov.*

Red clastic complex (Ilie & Mamulea, 1958)
Red continental formation (Dimian & Dimian, 1963)
Continental complex with reddish variegated deposits (Bleahu & Dimian, 1967)
Old variegated complex (Mészáros et al., 1969)
Red clastic facies (Antonescu, 1973)
Bozeş Formation (Lupu, in Bleahu et al., 1981)
Red Clastic Formation (Antonescu et al., 1983)
Upper Maastrichtian (continental facies) (Grigorescu, 1987)
Bozeş Strata (Grigorescu et al., 1990)
 "Bozeş Strata" (Weishampel et al., 1991, 2003; Grigorescu, 1992)
Vinţu de Jos Strata (Therrien et al., 2002)
Red Continental Strata, Vurpăr (Therrien, 2005)

Definition: this continental formation with peculiar red-beds is superposed on various older units. Descriptions of the sedimentary environments and architecture of deposits belongs to Codrea et al. (2001a), Therrien et al. (2002) and Therrien (2005). The last contribution contains also representative charts from Vurpăr and Valea Stăuinii.

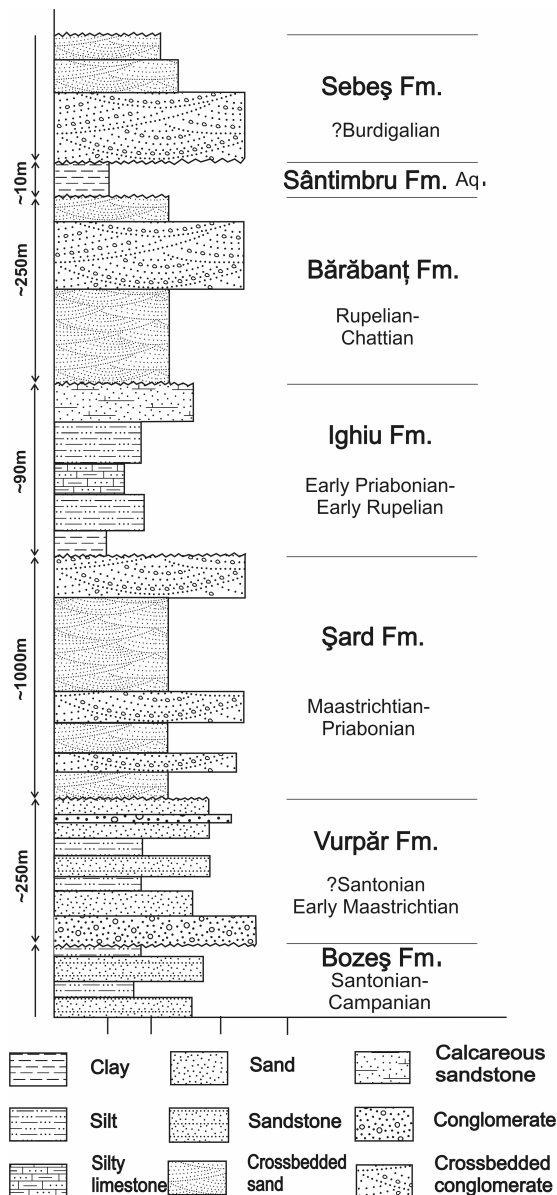


Fig. 2. Lithostratigraphic units chart from Metaliferi area.

As a whole, this succession refers to a braided fluvial system, numerous internal bars, where the sediments were temporary stocked. Sand and gravel represent the channel-fills. The red silt, with pedogenic levels documented by root-marks represents overbank accumulations. Sometimes, towards its base mainly at Oarda de Jos, the fluvial system developed pond-like deposits, even with small lake developing tendencies. Grey-blackish silt clay and calcrete document this kind of environment. Towards the formation top, near Bărbănt, charophyte flora documents lacustrine episodes too (Mészáros et al., 1969).

The succession thickness in this area surpasses 1000 m. The formation pitching toward SE is monocline, with greater values towards its base and attenuates at the top. Lower boundary: disconformity or even angular-unconformity marking the contact between the Şard Formation base and the older units.

Upper boundary: disconformity marking the contact between the Şard Fm. top and the transgressing marine Upper Eocene (Priabonian).

Type-section: on Tuiuşului Valley, near Şard (an illustrating section belongs to Mészáros et al., 1969).

Other representative exposures: on Ampoiului Valley SW from Şard, N-NE from Bărbănt, NE from Vurpăr, at Pâclişa, as well as on the right bank and the riverbed of Sebeşului Valley, between Sebeş and Lancrăm and Oarda de Jos.

Age: the fossils are rare in these red-beds. However, the succession base at Vurpăr, Valea Stăuinii, Oarda de Jos, Lancrăm or Sebeş, yielded several vertebrate remains (Nopcsa, 1905; Codrea et al., 2001a, 2002a, 2003; Weishampel et al., 2003), belonging to dinosaurs, crocodylians and turtles: *Zalmoxes shqiperorum* WEISHAMPEL, JIANU, CSIKI & NORMAN, 2003, *Z. robustus* (NOPCSA, 1902), *Telmatosaurus transylvanicus* (NOPCSA, 1900), "*Strutiosaurus*" *transylvanicus* NOPCSA 1915, *Magyarosaurus dacus* (NOPCSA, 1915), as well as by crocodylians (*Allodaphosuchus*) and turtles (*Kallokibotia* and another undetermined taxon). All the bones, document an autochthonous status, *in situ*, of the fossils. As a whole, the assemblage is somewhat similar with the famous Uppermost Cretaceous (Maastrichtian) fauna from the Haţeg Basin, firstly described by Baron von Nopcsa. In this manner, one can suppose that the Şard Fm. base is coeval with the Uppermost Cretaceous formations from Haţeg.

According to latest paleomagnetic and paleontologic studies, Sânpetru Fm. from Haţeg Basin can be related to Early Maastrichtian (Codrea et al., 2002b; Smith et al., 2002; Panaiotu & Panaiotu, 2002; Van Itterbeek et al., 2004), in spite of different interpretations (Lopez-Martinez et al., 2001).

Antonescu (1973) and Antonescu et al. (1983) allocate also to Late Maastrichtian the rocks exposed on Pâclişa Valley, south of Alba Iulia, on pollen assemblages with *Pseudopapillopollis praesubhercynicus* (GÓCZÁN, GROOT, KRUTZCH & PACLTOVA, 1967) correlative with the similar deposits from Haţeg Basin and Poiana Ruscă. One can consider that the beginning of Şard Fm. deposition started in the Early Maastrichtian and probably continued until the Late Eocene (Priabonian) when the marine invasive deposits overlay the continental red-beds.

Compared with the NW side of the Transylvanian Depression, Şard Fm. represents a comprehensive pile of sediments corresponding to Jibou Fm. (Maastrichtian-Bartonian), the whole lower marine series (Bartonian-Priabonian) the continental Valea Nadăşului Fm. and the base of Cluj Limestone (Priabonian).

Ighiu Formation (GHERMAN, 1943; emended)

Carpathensandstein (Hauer & Stache, 1863)

Middle Eocene block (Herepey, 1865)

Intermedia Strata (Koch, 1894)

“*Eocene*” and “*Upper Oligocene Strata*” (Telegdi Róth, 1904)

Ighiu Strata and “*Num. Fabiani Strata*” (Gherman, 1943)

“*Flysch facies (Şotrile type)*” (Ilie, 1943, 1952, 1955)

Upper Eocene and Lower Oligocene marine deposits (Mészáros et al., 1969)

Eocene (marine facies) (Grigorescu, 1987)

Ighiu Beds (Moisescu & Mészáros, 1995)

Emended definition: this formation comprises marine-brackish sediments, with lacustrine episode towards the top. Lithology involves nummulite limestone, marl limestone, marl (V. Tuiuşului), lumachelle (Ighiu, BărăbaŃ), sandstone and quartz sand (Ighiu, Şard, BărăbaŃ; Mészáros et al., 1969).

Lithologic and stratigraphic charts and sections belong to Mészáros et al. (1969) and Băluţă (1972, 1987). The maximum thickness of these deposits reaches 90 m.

Gherman (1943) considered the “Ighiu Strata” as including the Early Oligocene only. However, the Early Oligocene cannot be mapped apart from the Late Eocene. Lower boundary: disconformity contact between the Ighiu Fm base and the top of Şard Fm.

Upper boundary: disconformity between the top of the marine or brackish succession and the base of continental deposits belonging to BărăbaŃ Fm.

Type section: south of Ighiu, at “Dealul Viilor” (Măguli).

Other representative exposures: NE from Şard on Tuiuşului Valley, N from BărăbaŃ at Coasta Caldă (eastern Bilag Hill slope).

Age: rich alga, foraminifers (Bombiţă, 1963), bryozoans, mollusca, echinoderms or ostracoda have been mentioned and/or described from this succession (Băluţă, 1973, 1987; Moisescu & Mészáros, 1995). The assemblages are indicative for the Late Priabonian-Early Rupelian (Merian).

BărăbaŃ Formation *nom. nov.*

Upper Oligocene Strata (Telegdi Róth, 1905)

Red Complex (Gherman, 1943)

Red clastic complex (Ilie & Mamulea, 1958)

Continental complex with reddish variegated deposits (Bleahu & Dimian, 1967)

New variegated complex (Mészáros et al., 1969)

Oligocene (continental facies) (Grigorescu, 1987)

Description: the Upper Eocene-Lower Oligocene marine deposits are covered in all this area by a continental formation, similarly dominated by red-beds as the Şard Fm, belonging to fluvial system environment.

However, the main difference between these successions consists on a lower proportion of the channel filling rough clasts in BărăbaŃ Fm. As a whole, the silt and fine sand are the dominating rocks.

The thickness of these continental deposits is lower compared to Şard Fm., at least exceeding 250 m.

According to Mészáros & Dudich (1968), the BărăbaŃ Fm. continental episode occurred as a consequence of the pirenian tectogenesis. In this manner, a part of the previous Eocene-Oligocene marine sediments already accumulate had been eroded.

Lower boundary: disconformity or even angular-unconformity between the BărăbaŃ Fm. continental red-beds and the subjacent eroded Upper Eocene-Lower Oligocene marine-brackish and lacustrine successions, or even older units as the ones belonging to the Late Jurassic or Early Cretaceous (south of Ighiu).

Upper boundary: disconformity between the continental red-beds and the superjacent Aquitanian marine transgressing episode of Sântimbru Fm.

Type-section: on the Iovului Creek (“Dracului Valley”) left bank.

Other representative exposures: Pantei, Pilişcului, Crişeni creeks.

Age: for instance, the age of BărăbaŃ Fm. can only be supposed on its geometric relationship with the lower and upper adjacent formations, due to its scarcity of fossils. However, a limb bone belonging to an undetermined tetrapode had been mentioned long time ago (Koch, 1894; 1900 a, b).

The fossil is curate at the Aiud Science Nature Museum but until now, nobody could revise it. In these circumstances, the red beds can be related to the Early Oligocene-Uppermost Oligocene, or even maybe the Earliest Miocene (Late Egerian; - Early Aquitanian), as the base of Aquitanian cannot be excluded.

Sântimbru Formation *nom. nov.*

Upper Oligocene Strata (Telegdi Róth, 1905)

Upper stage (Gherman, 1943)

Red clastic complex (Ilie & Mamulea, 1958)

New variegated complex (Mészáros et al., 1969)

Definition: marine sediments, including a sequence of marls with oyster lumachelle {*Crassostrea gryphoides gryphoides* (SCHLOTHEIM, 1813) and *Ostrea fimbriata crassa* SCHAFFER, 1910}. This marine episode refers to very thin succession (around 10 m only).

However, one can presume that these deposits could exist on subsurface on higher thickness, as it seems to be evidence by borehole data on Secaşului Valley (Nicolae Mészáros, personal communication).

Lower boundary: disconformity with the subjacent BărăbaŃ Fm. red beds.

Upper boundary: unconformity between the Sântimbru Fm. and the superjacent Sebes Fm.

Type section: on Iovului Creek (Dracului Valley).

Age: the studies carried on by Şuraru & Băluţă (1983), pointed out the Upper Egerian (Aquitanian) appurtenance for these deposits.

Comments: actually, Iovului Creek is transformed into a cesspool for Alba Iulia town. Unfortunately, in this way a representative section of Alba district geological heritage was annihilated (Chira & Popa, 2004).

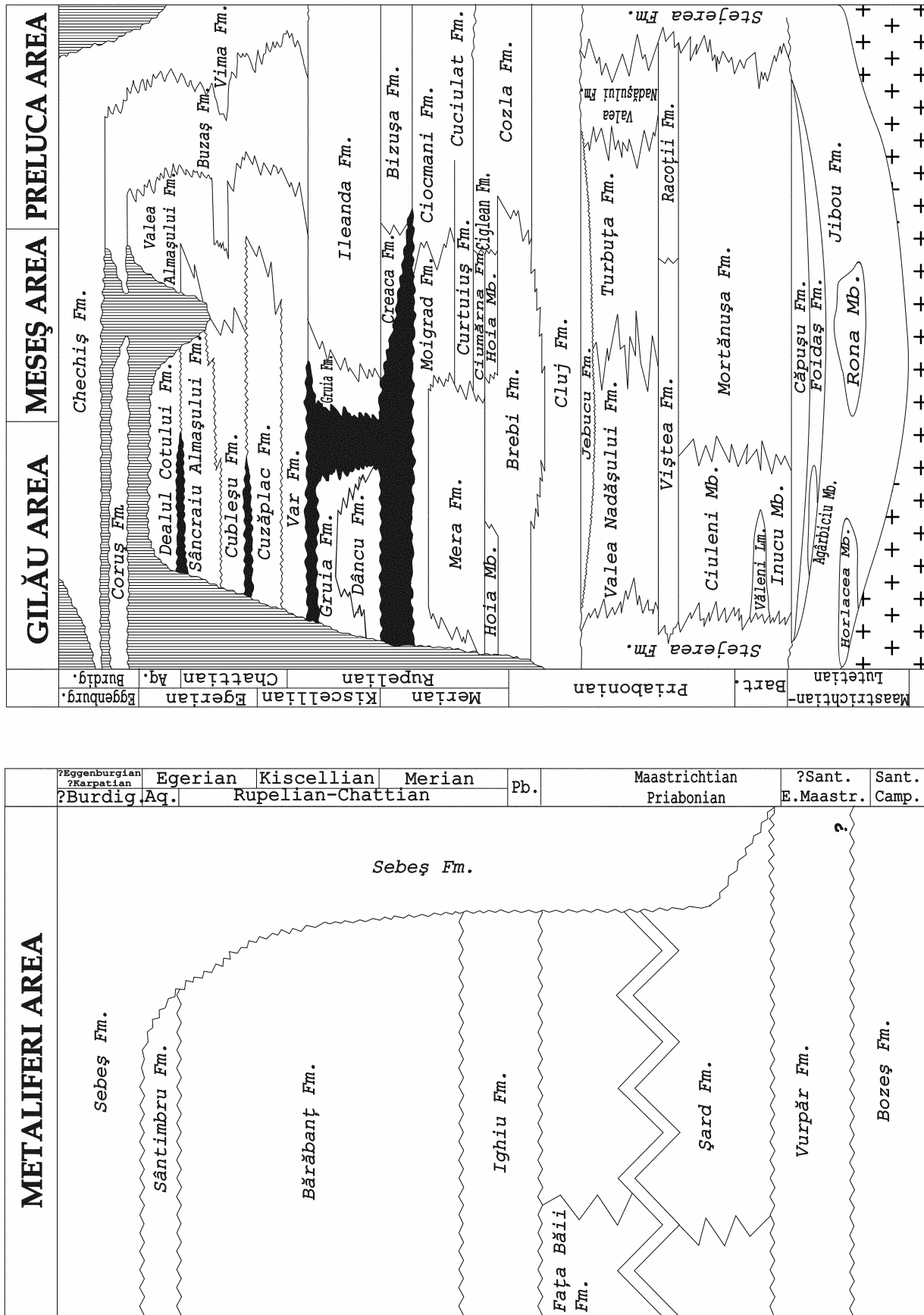


Fig. 3. Correlation chart of Metaliferi area and the latest Cretaceous-Early Miocene formations from NW Transylvania (the last ones, according to Rusu 1987, 1989 refined by Filipescu, 2001).

POST AQUITANIAN HISTORY

On the Mureş left bank, as well as on its tributaries, Sebeşului and Secaşului valleys, these formations are covered by the red beds belonging to Sebeş Fm. (Marinescu et al., 1998). This formation represents nothing else but a very aggressive erosion episode that eroded considerable amounts of the already accumulated formations. The age of Sebeş Fm. was for a long time rather unclear, due to the lack of indicative fossils. The only fossils ever found into this pile of sediments are all reworked: dinosaur and other reptilian bones originating from Şard and possibly from Vurpăr formations (Codrea & Vremir, 1997; Jianu et al., 1997); nummulite limestone blocks originating from Ighiu Fm.; oyster fragments probably originating from the Sântimbru Fm. In these circumstances, one can only presume that the Sebeş Fm. red beds started to accumulate in the Lower Miocene, probably between (?) Eggenburgian-Ottangian. One cannot exclude even an earlier beginning for the accumulation of these continental deposits (? Latest Egerian). The marine Lower Badenian succession covers this pile of continental deposits, as it can be clearly observed at Râpa Roşie type section, near Sebeş.

CONCLUSIONS

Referring to the red beds exposed along Mureşului Valley, Saulea (1967) stressed: "one can presume that into the red clay pile, besides thick, several series should be comprised, but their identification is difficult due to resembling facies". Our research proves that this assertion avers true.

In the studied area, three red beds formations are exposed: Şard (Late Maastrichtian-Priabonian), Bărăbant (Rupelian-Late Egerian) and Sebeş (? Latest Egerian-Ottangian), sandwiching between two marine formations: Ighiu (Late Priabonian - Early Rupelian; *i.e.*, Merian) and Sântimbru (Late Egerian - Aquitanian).

On its turn, Şard Fm. is laying on Upper Cretaceous successions, *i.e.* Bozeş Fm. flysh (Santonian- ? Earliest Maastrichtian) and Vurpăr Fm. molass (Maastrichtian), but also on older units.

In the Transylvanian Depression, the Alba Iulia-Sebeş-Vinţu de Jos region represents a distinct Uppermost Cretaceous-Lower Miocene sedimentary area, that we named "Metaliferi area" (Fig. 3). In some degree, some resemblances with the NW sector of the Transylvanian Depression exist, with same alternate continental and marine successions. But if in NW the marine and brackish formations assert the dominance on the continental successions, here the situation is completely reversed, as the marine sequences are strictly episodic ones.

It worth to be mentioned that in 1 Aiud borehole (near Rădeşti), a succession of red beds with Eocene marine deposits interbedded had been encountered (Băluţă, 1973; N. Mészáros, *written communication*). It evidence that the Ighiu Fm. marine ingression probably arrived from northern areas, thus explaining the resemblance between the Priabonian and Merian faunal assemblages from Metaliferi area and NW Transylvanian Depression ones (Gilău, Meseş).

For the continental successions, for instance, indicative *in situ* fossil assemblages including plants and vertebrates

(dinosaurs, crocodilians, turtles) are coming only from Vurpăr and Şard formations, documenting the Maastrichtian. For the other land deposits this kind of evidence are be long in coming.

Acknowledgements. This contribution is a tribute to the memory of two of our late colleagues and mentors: Prof. Nicolae Mészáros and Senior Lecturer Crişan Băluţă. Both, they let us a lot of unpublished data, but also a rough legacy: to clarify the stratigraphy of the continental deposits from the area. We tried to do our best.

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