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Overview of the Transylvanian Paleogene sea cows' distribution records, with a focus on a new Oligocene locality

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Abstract. In the past, a fairly large number of Paleogene sirenian fossils were collected in the Transylvanian sedimentary basin, and although the study of these marine mammals has apparently decreased considerably in recent years, the data already resulting from these discoveries are important and deserve discussion. Such data refer to localities where these fossils were unearthed. Analyzing the papers belonging to various contributors, both old and recent, and performing our field studies, we made a list of these localities in Romania, where sirenian fossils have been unearthed. Except for a single find recorded outside the Carpathians, all others are directly related to the Transylvanian Basin, in various Paleogene marine formations. This work is related to these sites and highlights a few cases where such fossil sites can no longer be accessed, either due to natural or human influences. These fossils are useful markers of marine and even brackish shallow seas, allowing for paleogeographic reconstructions. We also report a new locality with Oligocene (Rupelian) sirenians in the Transylvanian Basin, at Bizuşa-Băi (Sălaj County). It is further evidence of the continuity of the group of marine mammals even after the "Grande Coupure", in Romania.

Keywords: Sirenia, Transylvania, Romania, Eocene, Oligocene, fossil record.

Introduction

The sirenians represent an order of fully adapted aquatic mammals, similarly to cetaceans; however, unlike cetaceans, sirenians are obligate herbivores (Domning 2001a, b, Domning et al. 2010). Although they have a rather terrestrial ancestry, with representatives as *Prorastomus sirenoides* Owen, 1855 (Owen 1855), *Pezosiren portelli* Domning, 2001 (Domning 2001a) or *Sobrarbesiren cardieli* Díaz-Berenguer, Badiola, Moreno-Azanza, Canudo, 2018 (Díaz-Berenguer et al. 2018) with amphibious lifestyle comparable to hippopotamus, as a result of a specific evolution relatively quickly on a geological timescale, these mammals have become completely dependent on aquatic environments. While their streamlined bodies, lack of hind limbs, and presence of flippers instead of front legs make them anatomically similar to pinnipeds, they are actually included in the clade of Tethytheria, making them more closely related to proboscideans (McKenna 1975, Gingerich et al. 1994, Domning 2001a, Uhen 2007, Voss et al. 2016, Berta 2020). Their skeletal structure can be recognized by the presence of pachyosteosclerosis, an osteological condition in which the bones become denser and devoid of internal marrow (e.g., Domning & de Buffrénil 1991, Romero 2009), enabling them to feed on seagrasses from the sea floor.

The evolution of sirenians began in the Eocene, and a fossil of one such early sirenian was unearthed in Jamaica, from rocks dating from the Early to Middle Eocene (Domning 2000, Berta 2020). It was classified as *Prorastomus sirenoides* and was described by Sir Richard Owen as the oldest sirenian. Some additional bones were found in 1989, completing the knowledge of this taxon (Savage et al. 1994). *Pezosiren portelli*, which is much better known, and later *Sobrarbesiren cardieli* were discovered to possess fully developed hind limbs, enabling a fully amphibious lifestyle (Domning 2001a, Díaz-Berenguer et al. 2018). These primordial sirenians, coupled with findings of other sirenian genera leading all the way up to the Holocene, enabled researchers to reconstruct a highly detailed evolutionary history, which is similar in many aspects to that of Cetaceans (Domning 2000, Berta 2020). Across the Oligocene – Miocene timespan the variations of sirenian taxa changed almost constantly, either dipping or rising, with the sirenians developing better and better adaptations to suit their environments: forelimbs turning into flippers, hind limbs becoming vestigial until they disappeared, their tails evolving flukes for better underwater locomotion, the entirety of their skeleton becoming denser to facilitate extended periods under water to eat sea grasses (Domning 2001a, b, Uhen 2007, Berta 2020).

Across the Cenozoic, sirenian diversity was quite high; however, only two families actually survived: Dugongidae (dugongs) and Trichechidae (manatees), both living in warm, tropical or subtropical waters (Domning 1994, Gingerich et al. 1994, Sagne 2001).

The single exception not too long ago to this trend was the giant sirenian *Hydrodamalis gigas* Zimmermann, 1780, commonly known as Steller's Sea Cow, which dealt solely with cold water of the northern Pacific Ocean, more specifically in the Bering Sea (Domning 1978, Mattioli & Domning 2006, Romero 2009). While modern sirenians have a much more limited dispersal, their fossil record reveals a much more widespread distribution across the globe, with their remnants being found on every continent, except Antarctica (Domning et al. 2010).

The present work represents an important step in the framework of reopening the process of researching sirenians in Romania's territory. The presented data contributes to a better understanding of Romania's sirenian fossil localities and reveals the potential for new ones, now and in the future.

Paleogene sirenians in Romania

In particular, the fossil record of Paleogene sirenians discovered in Romania shows that they are principally restricted to the inner Carpathian area, more precisely to the Transylvanian Basin (Fuchs 1971). A single locality is recorded outside the Carpathian belt, Albeşti Muscel in Argeş County (Grigorescu 1967, 2017). The latter finding concerns a single isolated, fragmentary rib. This distribution is related to the geographical extension of the Paleogene shallow marine outcrops (Rusu 1970, 1987, Popescu 1976, 1984) (Fig. 1).

Apart from the Paleogene localities, a more recent age find breaks the rule. It refers to an isolated rib fragment found in the Middle Miocene rocks at Zorlenţu Mare (Banat, Lugoj Middle Miocene sedimentary sub-basin; Florei 1962). The photograph published by Florei is of very poor quality. Unfortunately, the fossil was not preserved in the collection of the Babeş-Bolyai University in Cluj-Napoca, where the rest of the Miocene fossils (bivalves, gastropods, etc.) originating from this locality are stored. It is possible that Nicolae Florei entrusted it for study to Herman Fuchs, who did not return it to the finder. The fossil has no systematic value other than documenting the presence of these mammals in the Middle Miocene. What is bizarre is the uniqueness of this finding in deposits of this age, knowing that in the second half of the last century, such rocks were intensively investigated in many Neogene sedimentary sub-basins (Baia Mare, Şimleu, Vad-Borod, Beiuş, Zarand, Mureş corridor, Lugoj, Oraviţa, Strei, etc.), but no other similar mammalian remains were found. In these circumstances, we wonder: was it a sirenian bone, or another mammal's remains? Only a new discovery could correctly answer the question.

The purpose of this work is to highlight and present all of the Paleogene fossil localities in Romania, where sirenian fossils have been discovered. It should be mentioned, however, that the sites presented herein are only those known at the time of this article's writing, and it is possible that more may be discovered in the future. Already existing fossils from schools or private collections may increase the number of localities in question.

We also report a new locality with Oligocene (Rupelian) sirenians in the Transylvanian Basin, at Bizuşa (Sălaj County). It is further evidence of the continuity of the group of marine mammals even after the "Grande Coupure", in Romania.

Materials and methods

In order to indicate the fossil localities, we analysed two paleontological collections: one from the Paleontology – Stratigraphy Museum of the Babeş-Bolyai University, Cluj-Napoca, and another from Herman Fuchs' private collection, which was donated to the Bethlen Gábor College of Aiud. We also used scientific literature written by past authors on their discoveries. The two maps were created using Inkscape 1.4. The pictures were taken using a Sony DSC-RX100M5.

The rib fragments presented in this work were extracted from a limestone slab, dislodged, and collected from a small rock quarry in Bizuşa Băi, in Sălaj County. The cut surface of the rib was visible on the side of the slab. The limestone block was then transported to the Babeş-Bolyai University's Paleotheriology and Quaternary Geology Laboratory, where after carefully removing the matrix surrounding the bone, using an AIRBAG HP1 compressor, we proceeded to measure it according to Domning (1978) and Zalmout & Gingerich 2012, and using a Precise PS 7215, 150 mm digital caliper.

Abbreviations

BBU-PC: Museum of Paleontology-Stratigraphy Paleontological Collection of the Babeş-Bolyai University, Cluj-Napoca, Romania.
BCA-PC: Paleontological Collection of the Bethlen Gábor College.
BU-PC: Paleontological Collection of the University of Bucharest.
EME-PC: Paleontological Collection of the Society of Transylvanian Museums (Erdélyi Múzeum-Egyesület).
SNHM-PC: Paleontological Collection of the Brukenthal Natural History Museum, Sibiu.
BBU-PC BZ1: temporary inventory number for the rib fragment from Bizuşa that we have analysed.

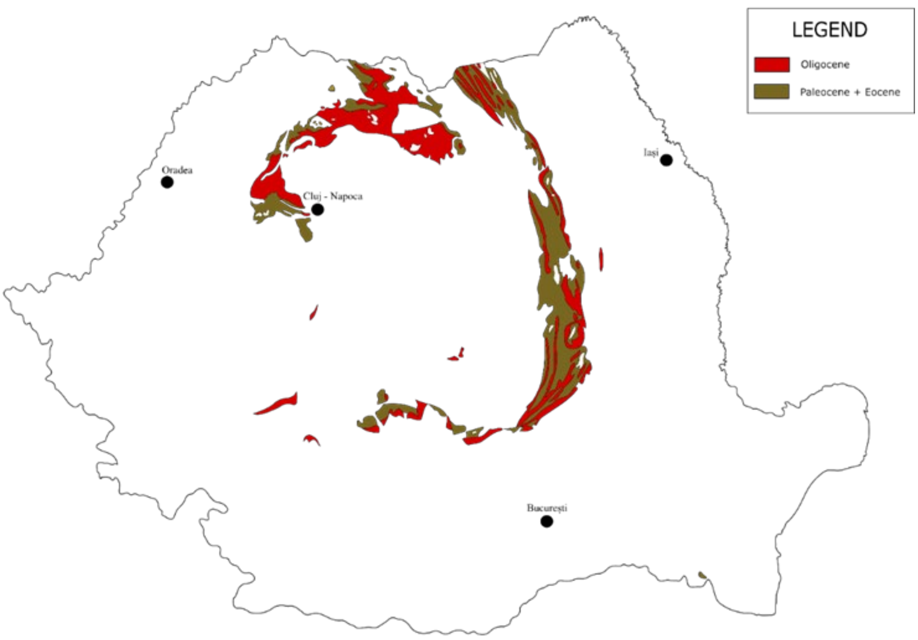


Figure 1. Map of Romania, highlighting the Paleogene formations (simplified, after Săndulescu et al. 1978)

Results

Mapping the sirenian fossil sites in Romania

Throughout the last two centuries, numerous sirenian fossil localities have been discovered all across the Transylvanian basin (Koch 1894, Tulogdy 1944, Florei 1962, Fuchs 1959, 1970, 1971, 1988, 1990, Macarovici 1978, Nicorici & Popovici 1981, Şuraru & Codrea 1988, Veress & Codrea 2023). As mentioned previously, the discovery of fossil sirenians has always been restricted to areas with Paleogene marine and marine-brackish formations, which can only be found within the basin. Nearly every sirenian fossil, fragmentary or more complete, has been classified as ″*Halitherium* sp.″, with one notable exception, the rib fragment discovered at Turnu Roşu (formerly Porceşti), which was first designated as ″*Halyanassa* von Meyer″, which was first thought to belong to a species of crocodile, but it was later reclassified as *Halitherium* sp. (Anonymous 1850, Koch 1891, Venczel et al. 2023). The fossil was once in the collection of parish priest Johann Michael Ackner; however, it has since been lost (Anonymous 1850, Koch 1894). What follows is a list of the fossil localities from the Transylvanian Basin (Fig. 2), based on the geological age of the rocks in which the fossils have been discovered.

List of Sirenian localities:

Eocene

1. Buciumi (= Gaura) (= Törökfalu) – slope of the Prosinel (Prosinyel) Mountain, Maramureş County, Preluca sedimentary area (Popescu 1978), (= *Perforata* layers in Koch 1894), Middle Eocene (Lutetian – Bartonian), ″*Halitherium* sp.″ rib fragments in the BCA-PC collection (Koch 1894; p. 205) (Veress & Codrea 2023; p. 79)
2. Iara (= Alsójára) – slope of the Râpona (= Ropó) Mountain, Cluj County, Căpuş Formation, Gilău sedimentary area (Popescu 1978), (= *Perforata* layers in Koch 1894), Middle Eocene (Lutetian – Bartonian), ″*Halitherium* sp.″ rib fragments in the BBU-PC collection (Koch 1894; pp. 203-205) (Mészáros et al. 1988; pp. 39-46)
3. Leghia (= Jegenye), Cluj County, slope of the Râpa (= Omlás) Hill, Mortănuşa Formation, Gilău sedimentary area (Bombiţă & Moisescu 1968) (= marls with *Ostrea* in Koch 1894), Middle Eocene (Bartonian), *Halitherium* sp. rib fragments in the BCA-PC collection (Koch 1894; p. 217)
4. Treznea (= Ördögkút), Sălaj County, Valea Şanţului, Mortănuşa Formation, Meseş sedimentary area (Vlad A. Codrea, personal observation, a small rib fragment), Middle Eocene (Bartonian)
5. Albeşti, Argeş County, Albeşti Limestone Formation, Late Eocene (Priabonian), Sirenia indet. single fragmented rib in the BU-PC collection (Grigorescu 1967; pp. 73 – 78) (Grigorescu 2017; pp. 81 – 82) (Fig. 3)
6. Baciu, Cheile Baciului rock quarry, Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), ″*Halitherium* sp.″ ribs and vertebrae in the BBU-PC and BCA-PC collections (Koch 1894; p. 246), ″Sirenia indet.″ molar in the collection of the EME-PC (Tulogdy 1944; pp. 57 – 58), ″*Halitherium* sp.″ proximal epiphysis of humerus (lost material) (Fuchs 1973; pp. 71 – 76), ″Sirenia indet.″ premolar in the BBU-PC collection (Şuraru & Codrea 1988; pp. 689 – 695), ″Sirenia indet.″ molar (lost material) (Fuchs 1990; pp. 89 – 92) (Fig. 4).
7. Cetea (= Csáklya) – Lupului stream, Alba County, (? = upper coarse limestone in Koch, 1894), ? Eocene (? Priabonian), Sirenia indet. fragmentary rib in the BCA-PC collection (Codrea & Mărginean 2007; p. 179). It is worth underlining once again that on the box label where the rib is preserved, it is mentioned "*Brachydiastematherium transilvanicum*″, but the geological age is ″Mediterranean″. We have valid reasons to consider that the specified age (Miocene) is the real one, because our explorations have not managed to locate any Paleogene rocks there, as it is also mentioned on the geological map 1:200000, Turda sheet (Giuşcă et al. 1967). Such a geological situation justifies the need to re-examine the fossil in question. It should be extracted from the plaster matrix in which it is fixed, and then examined in detail, especially to determine to what extent it belongs or does not belong to a sirenian. If it comes from a sirenian, and Paleogene rocks are absent from the Valea Lupului, we could consider it as a fossil originating from Middle Miocene (Badenian) rocks, thus providing evidence of the presence of these marine mammals in the Middle Miocene. It would be a second locality of such age in Romania, besides Zorlenţu Mare.
8. Cheile Babei, rock quarry, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), at the boundary of Sălaj and Maramureş counties, Preluca sedimentary area, Late Eocene (Priabonian), ″*Halitherium* sp.″ ribs and vertebrae (lost material) (Koch 1894; p. 246).
9. Ciurila, Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), ″*Halitherium* sp.″ ribs and vertebrae (lost material) (Koch 1894; p. 246).
10. Cluj Mănăştur (= Kolozsmonostor; currently a district of the municipality of Cluj-Napoca, formerly an independent locality), Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), ″*Halitherium* sp.″ ribs and vertebrae in the BBU-PC collection (Koch 1894; p. 246), ″*Halitherium* sp.″ scapula in the BBU-PC collection (Veress & Codrea 2023; p. 22).
11. Cluj Hoia (= Kolozsvár, Hója), Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), ″*Halitherium* sp.″ rib fragments (lost material) (Koch 1894; p. 246).
12. Cluj Someş-Dig (=Kolozsvár, Kisszamos gát), Cluj – Napoca, Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), ″Sirenia indet.″ skull roof in the BBU-PC and BCA-PC collections (Fuchs 1970), ulna and radius,

rib fragments in the BBU-PC collection (Fuchs 1988; pp. 49 – 60) (Veress & Codrea 2022; pp. 85 – 88; 2023; pp. 80 – 83).

13. Mera (= Méra) – the hills bellow and above the village, Cluj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), "*Halitherium* sp." ribs and vertebrae in the BCA-PC collection (Koch 1894; p. 246).
14. Jebucu (= Zsobok) – the hills surrounding the village, Sălaj County, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Late Eocene (Priabonian), "*Halitherium* sp." ribs and vertebrae (lost material) (Koch 1894; p. 246), sirenian pelvic bone described by Fuchs (an oral scientific communication), now lost.
15. Stana, Cluj Limestone Formation (Hofmann 1879) (= upper coarse limestone in Koch 1894), Gilău sedimentary area, Sălaj County, Late Eocene (Priabonian), endocranial natural cast in the BBU-PC collection (Nicorici & Popovici 1981; pp. 91 – 97), fragmentary skull in the BBU-PC collection (Veress & Codrea 2023; p. 20).
16. Turnu Roşu (=Porceşti, =Porcsesd),? Valea Nişului Formation (Mészáros 1996), Sibiu County, Late Eocene (Priabonian), "*Halitherium* sp." rib fragments in the BBU-PC and SNHM-PC collection (Koch 1894; p. 256) (Veress & Codrea 2023; p. 22).

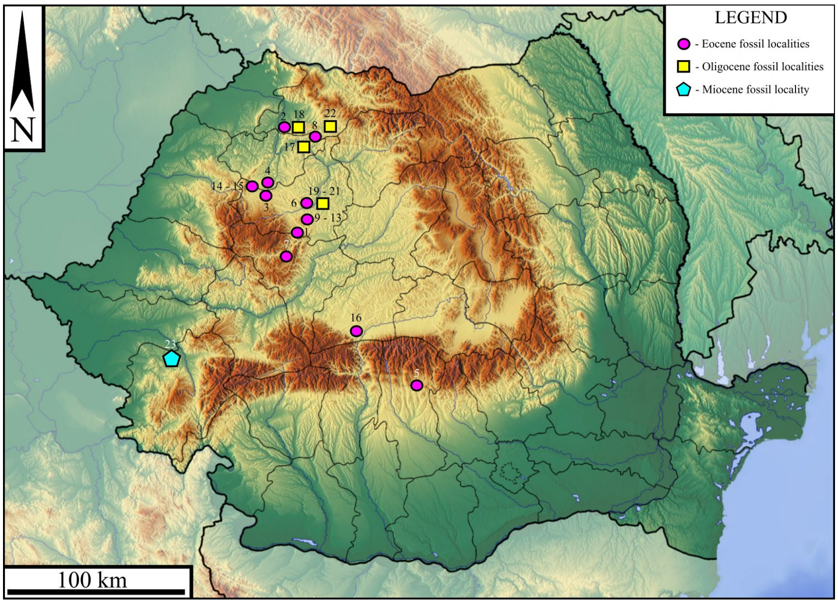


Figure 2. Map of Romania, showing the sirenian fossil localities (numbers, in text; based on Kordos 1976, modified)

Figure 3. Albeşti Limestone blocs from Argeş County (photo by Veress László)

Figure 4. Eocene limestone at Cheile Baciului (photo by Veress László)

Oligocene

17. Bizuşa-Băi – Secătura stream, Sălaj County, Cuciulat Formation (Mateescu 1938), Early Oligocene (Rupelian, Merian), Sirenia indet., ribs (BBU-PC BR1) – new sirenian fossil locality, herein presented (Fig. 5).
18. Buciumi (= Törökfalu) – Hovrilei Valley, Maramureş County, Brebi Formation (Koch 1880), Hoia Limestone Member (Hofmann 1879), Early Oligocene (Rupelian, Merian), "*Halitherium* sp." rib fragments (lost materials) (Koch 1894; p. 291).
19. Cluj Hoia (= Kolozsvár, Hója), base of the hill, Cluj-Napoca, Cluj County, Brebi Formation (Koch 1880), Hoia Limestone Member, Early Oligocene (Rupelian, Merian), Sirenia indet.., ribs (lost material) (Koch 1894; p. 310) (Fuchs, 1971; pp. 195 – 201).
20. Mera, Cluj County, Mera Formation (Koch, 1880), Early Oligocene (Rupelian, Merian), Sirenia indet., rib and various bone fragments in the BCA-PC collection (Koch, 1894; p. 310) (Fuchs 1971; pp. 195 – 201) (Veress & Codrea 2023; pp. 74 – 75).
21. Cluj Cordoş, Cluj County, Brebi Formation (Hofmann, 1879) Early Oligocene (Rupelian, Merian), "*Halitherium* sp." ribs and vertebrae (Koch 1894; p. 291).
22. Stoiceni (= Sztojkafalva), Maramureş County, Mera Formation (Koch 1880), Early Oligocene (Rupelian, Merian), Sirenia indet., ribs (lost material) (Koch 1894; p. 310; Barbu 1931; p. 16).

Miocene

23. Zorlenţu Mare, Caraş-Severin County. Middle Miocene (Badenian). This assignment (Florei 1962) is doubtful, as the fossil is lost.

Paleogene Sirenians of Romania

The very first sirenian fossils discovered in present-day Romania were a few rib fragments, found and collected by Johann Michael Ackner at Turnu Roşu (=Porceşti). He wrongly assigned these fossils to a crocodilian, but later, Hermann von Meyer related them to sea-cows (fide Koch 1894, in Şuraru & Codrea 1988). The main problem in this case is the beds from which the fossils originated because no indication of stratigraphy is available. In this locality, different Paleogene formations occur. Mészáros (1996) briefly described three formations (Valea Satului Formation, Cuisian; Strada Muntelui Formation, Lutetian-Priabonian; Valea Nişului Formation, Priabonian-lowermost Oligocene), all forming the Turnu Roşu Group. However, he didn't give a detailed description of each formation, as Venczel et al. (2023) underlined. It can be considered that the respective work was rather intended as a preamble to a more extensive work, which, however, never issued.

A larger number of sirenian fossils have been discovered soon after, many of them being mentioned in various works, beginning with Koch (1894) and related references. He mentioned several outcrops in Transylvania (see list above for details concerning the localities and geological ages). Eocene localities can be separated on one side, and Lower Oligocene on the other. It should be noted that post-Rupelian fossil sirenians are no longer found in Transylvania. An explanation can be found in the trends of the transition from marine to brackish water, with numerous emerging episodes in the marginal areas, as proven by the presence of continental formations. On the other hand, post-Eocene, there is a climatic degradation, with waters becoming colder and less salty (Mészáros et al. 1965, Rusu 1999, Chira & Igriţan 2004, Melinte-Dobrinescu & Brustur 2008, Sanjuan et al. 2023). Under such conditions, the seagrass that constituted the food for these marine mammals possibly vanished.

Separate from the NW area of the Transylvanian Basin, two localities were outlined: Turnu Roşu (=Porceşti), near Sibiu (Koch 1894, Simionescu & Barbu 1943, Şuraru & Codrea 1988), and in the Albeşti Limestone in Argeş County, outside the Carpathians (Grigorescu 1967, 2017, Veress & Codrea 2020). The geologically youngest locality, Florei (1962) mentioned, is Zorlenţu Mare, from the Banat region.

At Albeşti, Grigorescu (1967) found a single, fragmented sirenian rib extracted in seven pieces. The limestones of the Pietrei Hill, where this fossil was discovered, are part of the sedimentary filling of the Southern Carpathian Foredeep. While this is the single mention of sirenian fossils coming out of this area, this report enriched the list of taxa from the Pietrei Hill site. In a more recent work, Grigorescu (2017) reconstructed an eulittoral benthic ecosystem in warm, subtropical waters via the rich abundance of micro- and macrofaunal assemblages. These assemblages include foraminifera (*Nummulites*, *Assilina* and *Operculina*) and a high number of invertebrates, such as mollusks, crustaceans, bryozoans and crinoids, as well as a couple of vertebrate fossils, made up of bony fish and sharks.

Figure 5. Bizuşa-Băi, Cuciulat Formation. The sirenian bones originated from the limestone strata (photo by Marian Bordeianu)

Oligocene sirenian remains from Bizușa-Băi

Systematic paleontology

Class Mammalia Linneaus, 1758

Mirorder Tethytheria McKenna, 1975

Order Sirenia Illiger, 1811

Sirenia indet.

Material: a single fragmentary anterior rib (BBU-PC BR1) (Fig. 6).

Description: While a small handful of rib fragments were discovered, the most significant sirenian bone in the limestone block is one of the anterior ribs, possibly the second or third one. The single portion of this bone refers to proximal epiphysis and a very small portion of the shaft. The rest of the bone was lost, most likely when the limestone block detached from the layer of origin.

The rib can be recognized as an anterior one, as long as its *caput costae* (rib head) curls upwards, while at other ribs it is straight. Another morphological feature proving that this bone is an anterior rib is the slightly greater pronunciation of the *tuberculum costae*, which is visibly rounder, while in other ribs it is much more flattened and smoother. The tapering of the bone between the tubercle and the shaft indicates the presence of the rib neck.

Comparing it with a complete sirenian rib housed in the BBU-PC (devoid of inventory number and place of origin) (Fig. 7), it becomes evident that approximately 80% of the shaft is missing. The cross-section of the rib reveals a very thick and compact internal bone, indicative of advanced pachyosteosclerosis. The outer surface of the rib is a very dark, chocolate-brown color, indicative of slight phosphatization (Boessenecker et al. 2014) and that the "coloring oxides" haven't penetrated the bone very deeply, once again due to the pachyosteosclerosis (Fuchs 1971).

We also compared the measurements of our fossil with the analysis done by Fuchs (1971) on another rib proximal epiphysis that he unearthed in the Oligocene strata at Mera, in Cluj County (Table 1). The fossil collected by Fuchs is currently lost.

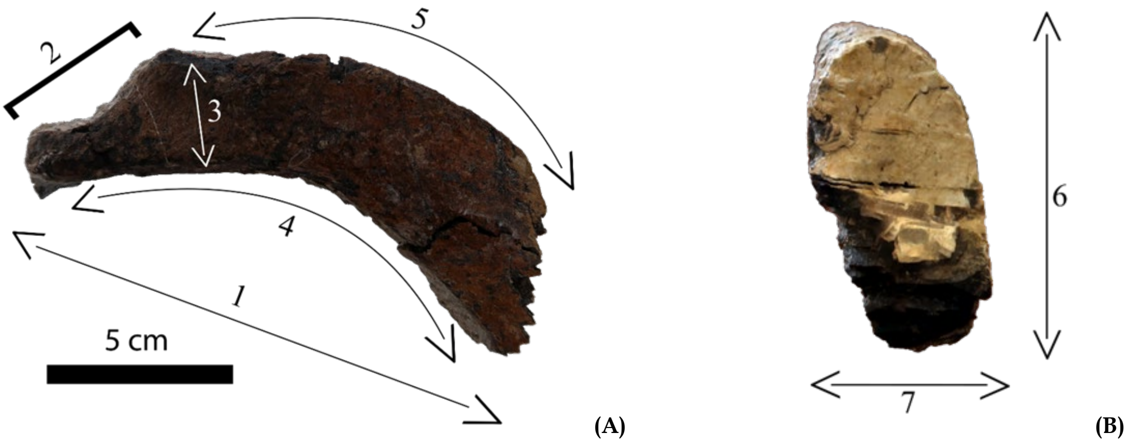


Figure 6. Proximal epiphysis of sirenian rib (BBU-PC BR1): (A) lateral view; (B) cross-section of the rib

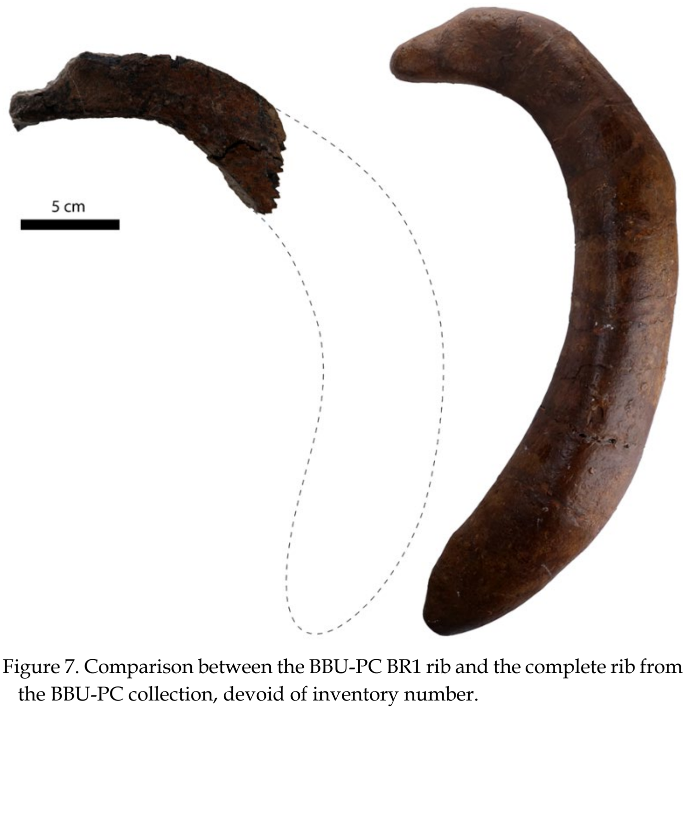


Figure 7. Comparison between the BBU-PC BR1 rib and the complete rib from the BBU-PC collection, devoid of inventory number.

Table 1. Measurements (mm) of the BBU-PC BR1 rib compared to a proximal rib fragment described by Fuchs (1971)

Measurement	Rib (BBU-PC BR1)	Fuchs (1971)
1. Total length	(+) 128.91	57.0
2. Capitulum to tubercule length	49.61	-
3. Neck diameter	25.84	29.0
4. Internal arc length	(+) 139.0	-
5. External arc length	(+) 123.0	-
6. Mediolateral width	46.53	29.0
7. Anteroposterior width	28.89	19.0

***Lithofacies*:** As mentioned previously in this work, we discovered several fragmentary sirenian ribs in the Oligocene (Rupelian) limestones from Bizuşa, which is now noted to be a new sirenian fossil locality (Fig. 8). The outcrop lies within the territory of Bizuşa-Băi, in Sălaj County, in the Preluca sedimentary area, on the left bank of Secătura Valley. The bioclastic limestones with brackish fauna are of Lower Oligocene (Rupelian) age and belong to the Cuciulat Formation, coeval with the Mera Formation, from the Gilău sedimentary area (Mészáros 2000, Codrea & Dica 2005). During our field research, we took one of the dislodged blocks of limestone, which displayed vertebrate fossils, and brought it to Babeş-Bolyai University's Paleotheriology and Quaternary Geology Laboratory, where the sirenian bones were extracted.

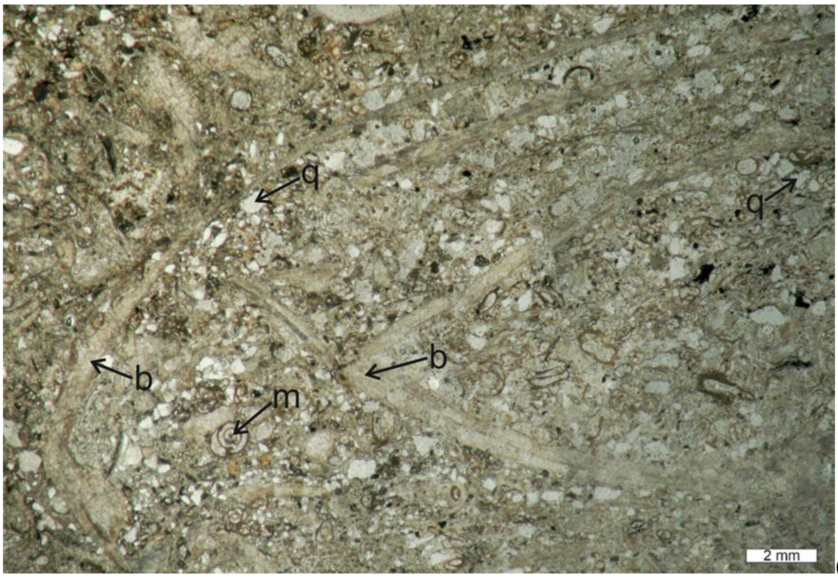
After analyzing thin sections of the rock matrix, we noted that the limestone is a compact, bioclastic packstone to rudstone type, containing fragments of bivalve mollusks and miliolid foraminifera. It also contains high amounts of extraclasts like angular quartz fragments, middle sorted (Fig. 9). These characteristics indicate the Oligocene (Rupelian) and reveal that the Cuciulat Formation was once a high-energy shallow coast area, where limestones were accumulated.

Taphonomy: The studied rib fragment and the rest of the unearthed rib fragments were accumulated in the limestone block, haphazardly disarticulated. The sea-cows died not far from the shore, their bones being carried around and scattered by the energy of the waves, long after soft tissue decomposition.

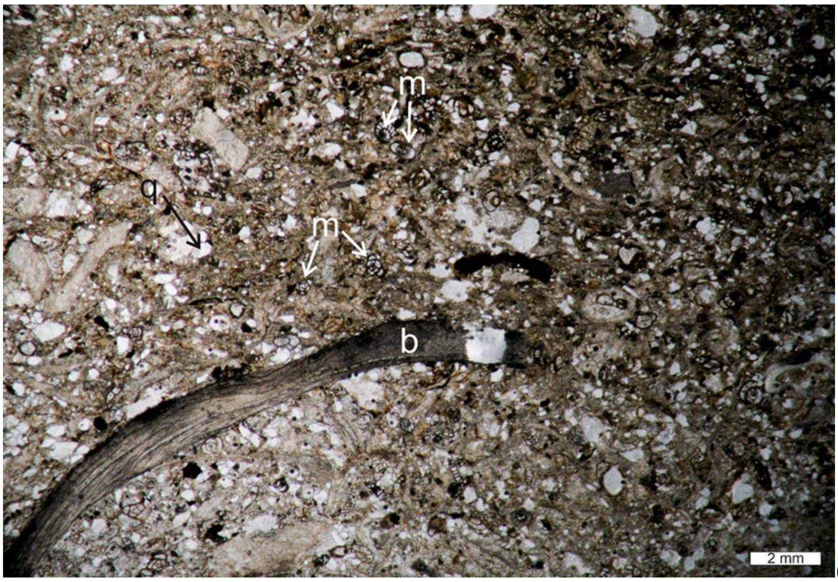

(A)


(B)

Figure 8. Studied limestone block from Bizuşa: (A) during its initial discovery in the field (photo by Marian Bordeianu); (B) in the laboratory (photo by Veress László)



(A)



(B)

Figure 9. Thin section samples (A, B): (b) section of bivalve shell; (m) miliolids; (q) quartz clasts.

Discussion

The study of sirenians extends into a relatively long period, beginning with the Jamaica discovery, i.e., the description by Sir Richard Owen in 1855 of the primitive *Prorastomus sirenoides* (Domning 1994, Sagne 2001). Since this landmark, the study of sirenians has continued constantly, and the list of sirenian localities has increased worldwide.

SE Europe is a region where, even though there are Eocene, Oligocene and Miocene geological formations, which are relevant due to the existence of marine mammals and the reports of sirenian fragments are particularly few: in Dobrogea and Bulgaria none have been discovered, in Moldova and Ukraine only a few ribs and vertebrae fragments have been found (Gol'din et al. 2018, Obadă 2020, Davydenko et al. 2023). Based on the fossil evidence from Romania's neighboring territories, such as Central and Western Europe, it can be seen that at least two sympatric species could have existed in the waters of Eocene Transylvania, supported by the works of Tulogdy (1944), Fuchs (1971) and Şuraru & Codrea (1988). Many studies have been conducted within Hungary's territories that revealed Eocene sirenian fossils. In the revision work of Kordos (2002), only four taxa are listed: *Sireniavus hungaricus* (small-sized primitive sirenian, closely related to *Eotheroides aegypticum* Owen 1875), *Anisosiren pannonica* (the taxonomic position is uncertain), Sirenia indet. I (small form) (formerly *Protosiren* cf. *fraasi* Abel (Kordos 1978)) and Sirenia indet. II (large form) (formerly *Eotheroides* sp. (Kordos 1980)). Kordos (2002) underlines the error in the description of *Paralitherium tarkanyense* Kordos (Kordos 1975), and after its revision in 2002, based on the morphological characteristics, included it into the genus *Sirenavus*, as *Sirenavus hungaricus*. In Serbia, no sirenian fossil evidence has been discovered.

In Romania, the highest number of sirenian localities concerns NW Transylvania. This can be explained by the specific paleogeography of this area, with shallow seas and marine platforms in the Middle-Late Eocene (Saulea et al. 1970a, b, c). The logic of the ecological requirements of current taxa can be easily verified for the Paleogene ones as well. It is clear that these marine mammals were confined to shallow water environments, as no traces of their existence have been found in deep waters. Therefore, we do not encounter them in deep bathymetry areas like the Eastern Carpathians (Săndulescu 1984).

To these, three other localities that yielded such fossils: Cetea (Alba County), Albeşti (Argeş County), and Turnu Roşu (= Porceşti) (Sibiu County). But, in none of them is there a very rich potential; the sea-cows' fossils are either unique finds or concern small samples of post-cranial bones. Cranial bones are missing, and a single tooth is known in Turnu Roşu (Nicolae Trif, pers. comm. to László Veress; unpublished).

All finds concern middle-late Eocene taxa. No find is reported from the Lower Eocene formations in Transylvania; therefore, we do not have any evidence of the presence of the basal most representatives in this region of Europe. Even the number of Middle Eocene finds is rather small and concerns scarce postcranial remains. This is surprising, as not very far, in Hungary, the number of finds and the variety of taxa are higher (Kordos 2002).

A particular problem that we will highlight, regarding these sites, is one that was already signalled by Koch in 1894 in his monographic work about the Paleogene of Transylvania, and then later by all other researchers who focused on the study of sirenians in Romania. We refer to the actuality of these sites: it has been stated that some of these can no longer be accessed due to the following reasons, explained as follows: I. covered by vegetation that spontaneously grew, possibly as a consequence of climatic changes, II. vanished, following the mining of rocks and III. become covered by construction works or by waters, following human activities (Koch 1894, Codrea et al. 1997)

If the sites that have been covered by vegetation can still be saved, although with high effort, the situation regarding items II. and III. is more drastic. In most cases, the material in which the fossils were preserved is limestone, highly valued for its importance in building and stone carving. Due to this reason, the mining of these rocks at open pits has deep roots in history since antiquity, in this region, possibly after the conquest of Dacia by the Roman Empire, the proof lies in the numerous archaeological vestiges that were carved from limestone mined from these sites. It is a well-known fact that much of the construction of the city of Cluj-Napoca was done using such limestones (Codrea et al. 1997), and in many villages, there were craftsmen who were well versed in polishing and ornamenting such rocks.

The limestones of the Călata Group, sedimented during the first Paleogene marine series, were mined at Viştea and Leghia, as well as from the left bank of the Someş River, at Gilău and North of Călata. It is a limestone based on organic accumulations, very rich in foraminifera, molluscs, and sea-urchin remains, being much coarser due to the high quartz content.

In the limestones belonging to the Turea Group of the second marine series, two parallel outcrop alignments can be easily noticed: the first one begins in Cluj-Napoca, from Mănăştur, Hoia Hill, the shoreline of the Someş River, continuing in the Nadăş Valley, Baciu and Suceagu; a second one, a limestone mixed with other types of rocks, starts in Mera, then follows towards Gârbău, Băgara and then unites with the first one and keeps extending through Aghireşu, Cuzăplac, Stana, Jebucu, Almaşului Valley (Koch 1894, Răileanu & Saulea 1956). These are particularly rocks suited for ornaments, materials for foundations and walling, with the most well-known open pits in Cheile Baciului (Mészáros & Clichici 1976, 1988).

In the last decades, with the appearance of modern building materials, the old rock quarries were no longer mined and have been covered by the new constructions of the extending Cluj-Napoca city, or vegetation. These limestones are still used in certain villages, but only for local needs (Mészáros & Clichici 1976, Codrea et al. 1997).

Koch reported at Turnu Roşu (= Porceşti) some small open-pits that lie south of the village. Throughout the centuries of mining or under the effects of flooding, the limestone vanished completely, leaving on Muntelui Street only a single outcrop, with a metamorphic (micaschist) bedrock (Koch 1894).

Another case of a vanished site concerns the bank of the Someşul Mic River, within the city of Cluj-Napoca, at Someş-Dig. Throughout time, numerous construction works were done in this area: in 1866, when the first dam was erected, explosives were used to break the rocks (Fig. 10). That is when the first sirenian fossil fragments were revealed (Fig. 11), along with other remnants of vertebrates (turtles, crocodiles, sharks, fish, etc.) and invertebrate fossils (molluscs, echinoids). Fortunately, Pávay managed to save a few of the fossils, but subsequent constructions have covered a large part of the site (Pávay 1871, Koch 1894). In 1962 when an attempt was made to make the Someş River navigable, the Garibaldi Bridge area, explosives were used once again (Mihály 2011) in 1988, when the Grigorescu microhydro power plant, the geological level was better revealed on the left bank as well, however it was later completely covered up.

Figure 10. First erection of the Someşul Mic dam. (Source: http://archivum2.szabadsag.ro/szabadsag/servlet/szabadsag/template/archive%2CPArchiveArticleSelectedScreen.vm/id/36952/mainarticle/false/web/false/quick/false/ynews/false;jsessionid=F5AA3CC5EF5A05EA7B29C816B904D2DE).

The last big construction work at the Someş Dam area took place between 2021 and 2024. The results, from our point of view, are that the Cluj Limestone Formation can no longer be studied, as the water level has risen considerably and has completely covered up the limestone 'island', from which sirenian fossils have been extracted (ribs, radius, ulna, pelvic bone). Even though our research group took steps towards the Cluj-Napoca city hall to protect this area, we never received any answer.

Because of these exposed causes and due to the Romanian legislation not mentioning the obligation to effectuate paleontological field work related to building construction, railways, roads and highways etc. as it happens in archaeology (Ordonnance nr. 43/2000, Law nr. 378/2001, Law nr. 462/2003) the paleontological sites are evolving in a bad way, becoming fewer and fewer and harder to value. In such circumstances, one may expect few to no relevant paleontological discoveries in our country, sirenians included.

Figure 11. The Cluj Limestone within the Someşul Mic River, when the Someş Dig fossil site could be accessed (photo by Veress László)

Conclusions

Evidence of the presence of sirenians in the Paleogene deposits of Romania dates back as early as the 19th century. The frequency of finds demonstrates that these marine mammals populated the current Transylvanian Basin much more densely, only a single fossil breaking the rule: the one (a rib) reported so far from the Paleogene limestones at Albeşti (Argeş County), outside the Carpathian belt. From other marine deposits, such as those in the extreme south of Dobrogea, such fossils have never been reported, but this does not mean there is no potential for such discoveries. Unfortunately, the limestone quarries that operated there in the past decades have ceased their activities, and under current conditions, the chances of any discoveries are greatly reduced.

In the Transylvanian Basin, most discoveries come from its northwestern area, where the most extensive outcrops of Paleogene deposits are known. At the same time, there are also marine vs. continental alternations, and the shallow water deposits have a large areal extent. The former proximal shelf areas are particularly favorable for accumulating fossil vertebrates (sirenids, other mammals, birds, reptiles, etc.). The carbonate platforms also experienced episodes of emergence, when the limestones were exposed to the surface. Such paleoenvironments were ideal for sirenians, who found favorable places for feeding and breeding.

If we are to synthesize the localities and geological ages from which these fossils are known in the specified area, it can be easily noted that the most frequent discoveries are those from the Upper Eocene rocks (Priabonian), followed by those from the Middle Eocene (Lutetian-Bartonian). There is a complete lack of evidence for the presence of these marine mammals in the Lower Eocene, a crucial period for understanding their origin. The explanation is strictly paleogeographic: in the Early Eocene, the entire area was covered only by red-beds continental deposits, where these mammals could not be present. A thick pile of ca. 1500 m (at the type-section), belonging to the Jibou Formation, is under discussion. It is the geological heritage of a fluvial plain, with small-extended lacustrine environments at Rona-Jibou or Horlacea. The attempt to demonstrate the existence of marine influences in the basal section of the ancient lake at Rona-Jibou, related to the evolution of the Maramures-Szolnok trench, has proven unsubstantiated (Mészáros 1995).

From the Early Oligocene (Rupelian) level, this work coins a new locality, Bizuşa-Băi (Sălaj County). There, fragmentary rib remains were found, and the most illustrative fragment is herein described and illustrated.

In the southern area of the basin, sirenian fossils are known from Turnu Roşu (= Porceşti), but since we are discussing old reports, the exact geological ages are not known to us, and the accompanying era labels, as well as the related papers, strictly mention the name of the locality.

Post-Paleogene, sirenians are only reported in Romania from a single locality, Zorlenţu Mare, in the Middle Miocene (Badenian). The fossil has been lost, and it is rather impossible to establish whether it was a sirenian bone.

The outcrops that provided sirenian fossils are currently on the verge of being covered, invaded by aggressive vegetation, or overtaken by the expansion of inhabited areas in various localities. On the other hand, the old open pits from which limestone was mined have mostly ceased their activities. Under these conditions, we anticipate that the number of discoveries in the future will be much lower.

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