BABEȘ-BOLYAI UNIVERSITY
FACULTY OF BIOLOGY AND GEOLOGY
PHD SCHOOL OF THEORETICAL AND APPLIED GEOLOGY

PALEOGENE SIRENIANS OF ROMANIA

THESIS SUMMARY

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Cluj-Napoca

2025

Key words:

Sirenians, Paleogene, NW Transylvanian Basin, Museums, Romania

Note: This doctorate thesis was made based on the following articles:

CODREA V.A., **VERESS L.** 2024, János Tulogdy's first study attempt about an Eocene Sea cow tooth from Transylvania, *NYMPHAEA FOLIA NATURAE BIHARIAE*, *Oradea*, 51, pp. 21-36

VERESS L., CODREA V.A. 2020, A freshwatersoft-shelled turtle in the Albești Limestone, *Muzeul Olteniei Craiova. Oltenia. Studii şicomunicări. Ştiinţele Naturii,* 36(1), pp. 7–20

VERESS L., CODREA V.A. 2021, Istoria geologică a sirenienilor: între realitate, mituri şi legend, *ELANUL*, 1(227): pp. 59-79

VERESS L., CODREA V.A. 2022a, Istoria clasificărilor sistematice în biologie, *ELANUL*, 1-2(231-232), pp. 64-77

VERESS L., CODREA V.A., BORDEIANU M. 2022b, Mapping the Paleogene sirenians in Transylvania, *XXII Congress of Carpathian-Balkan Geological Association (CBGA), Plovdiv, Bulgaria*, pp. 71

VERESS L., BORDEIANU M., CODREA V.A. 2022c, Some new data on the Eocene sirenians from Cluj-Napoca Someș-Dig (Transylvanian Basin, Romania), *MARISIA, Natural Sciences II*, pp. 81-95

VERESS L., CODREA V.A. 2023a, A catalogue of fossil sirenians housed in the Museum of Paleontology – Stratigraphy, "Babeș - Bolyai" University, Cluj – Napoca, *Oltenia. Studii şi comunicări. Ştiinţele Naturii*, 39(1): pp. 19-29

VERESS L., CODREA V.A. 2023b, List of sirenian fossils housed in the "Bethlen Gábor" College in Aiud, Romania, *NYMPHAEA Folia naturae Bihariae*, XL, pp. 67-88

VERESS L., CODREA V.A., VENCZEL M. 2024, Overview on the Transylvanian Paleogene sea-cows' localities, with focus on a new Oligocene locality, *North Western Journal of Zoology* (in press, accepted for publication)

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Introduction

Paleontology is the scientific field that deals in the study of life that existed on our planet millions of years before the first human civilization was established. It involves the discovery, analysis and classification of fossil organisms, how they interacted with each other as well as their relationship with their environment. The widely known field of vertebrate paleontology is the study of fossil marine mammals, which involves the research of pinnipeds (seals, sea lions and walruses), cetaceans (whales and dolphins), as well as sirenians (sea cows).

Sirenians, by their very nature are a unique order of mammals, being the only living aquatic mammals that are obligate herbivores, and as newer fossils of them are being discovered, the information surrounding these amazing creatures becomes greater with each passing year. However, the study of fossil sirenians has stagnated greatly in Romania, with no continuity on their research. Often times when sirenian fossils are discovered in Romania, they are generally deposited and catalogued in museums, however, many such materials were lost and we only know of them through the scientific literature in which they were reported and described. While the majority of these remains consist of ribs (complete or fragmentary), certain fossils, such as skull fragments, would provide a good starting point with which to identify the systematic assignation of these sirenians.

This thesis represents an absolute novelty in the domain of Romanian paleontological research, through the theme that was addressed. Currently there are numerous well-documented studies on paleoenvironmental reconstructions or on the biostratigraphy of sedimentary basins, from the micropaleontological point of view, not however referencing the marine mammal fauna, in particular the sirenians.

The primary aim of the thesis’ research is to provide clearer and more precise information regarding the sirenian fossils discovered in Transylvania, as well as on the associated paleoenvironments. In order to reach this goal, a series of detailed analyses were conducted on the sirenian fossils that were collected from the riverbed of the Someșul Mic, by the scientific team of the Paleotheriology and Quaternary Geology Laboratory, as well as on the fossils housed in the collection of the Paleontology Stratigraphy Museum of the Babeș-Bolyai University and from other Transylvanian museums. The objectives of this work are the following:

- Inventory and updated taxonomic evaluation of the fossils from museum and private collections in Transylvania.
- Collecting fossils from paleontological sites, which bear Paleogene sedimentary rocks.
- Paleoenvironmental reconstructions.
- Taphonomic interpretation of the fossil remains.
- Comparing the results with other sirenian fossils from the Romanian and European territory, based on the bibliographic references and their publications.

Acknowledgements

I would first and foremost wish to voice my gratitude towards my mentor and scientific advisor Prof. Dr. Vlad Aurel Codrea, for his extensive knowledge and wisdom on all of the aspects of this thesis, the subject of which he himself proposed at the beginning of this research. Without his guidance and expertise much of the data featured in this thesis would have remained unknown to me.

I would like to thank the members of the doctoral guidance committee, Prof. Dr. *habil.* Ioan Tanțău, Conf. Dr. *habil.* Ferenc Forray and Lect. Dr. George Pleș for offering me the chance to present my work before them, as well as provide me with useful comments and ideas during the course of my studies.

I would also like to thank Senior Researcher Dr. Venczel Márton for assisting us in deciphering the taxonomic assignation of an Eocene fossil sirenian skull.

I would like to express my deepest gratitude towards Dr. Daryl Domning of Howard University, from Washington D.C. and towards Dr. Claire Sagne of the Natural History Museum of Paris, for their kindness in helping me with the bibliographic suport and for their support.

I would also like to thank the following people who helped me, in one form or another, during my years if study: I would like to extend my gratitude towards Dr. Liana Săsăran, curator of the Museum of Paleontology-Stratigraphy of the Babeș-Bolyai University, who gave me access to the numerous sirenian fossils that are currently housed within the museum's storage, as well as helping me with the administrative problems; Lect. Dr. Cristian Victor Mircescu for providing us with the thin sections of the limestone slab from Bizușa Băi, as well as for assisting us in analyzing it; Lect. Dr. Silye Lóránd and Dr. Kövecsi Szabolcs Attila for making us aware of and gave us access to a second collection of fossils that have been collected by Herman Fuchs and then donated to the Babeș-Bolyai University by his nephew; museum curator Dr. Alexandru Solomon of the Mureș County Museum – Natural Sciences branch, and museum curators Dr. Nicolae Trif of the Natural History Museum of Sibiu, for enabling us access to the fossil sirenian material from their respective museums' collection.

I would like to thank all of the teachers of the Babeș-Bolyai University for imparting their knowledge to me over the years and helping me understand the complexities of geosciences and the connections between them.

As this thesis was created in collaboration with the Bethlen Gábor National College of Aiud, I wish to extend my gratitude to the principal of the school, Prof. Dr. Szőcs Ildikó, as well as to professor Dvoracsek Ágoston, for providing us with the opportunity to access and study sirenian fossil remains housed in the collection, known as the 'Hermann Fuchs Collection 1'.

I would like to also thank my good friend, geological engineer Marian Bordeianu, who not only presented to me key locations from which to collect the materials needed for this study, but who also lent me his technical expertise and taught me how to utilize a variety of programs which were needed for the making of this thesis.

Last but not least, I would like thank my family for all of their love and support for me and my work over the past few years.

This research was financially supported by the grant of the Ministry of Research, Innovation and Digitization CNCS – UEFISCDI, project number PN-III-P4-PCE-2021–0351, within PNCDI III.

1. Geology of the Marine Paleogene Formations of Romania

1.1. The Paleogene

The Paleogene is an important period in Earth's history, meaning a kind of 'aftermath', following the Cretaceous/Paleogene (K/Pg) Mass Extinction event, otherwise known as the age of mammals (Janis, 1993). Off, course an age of primitive, "old" mammals. In other words, the ecological niches vacated by the disappearance of the great reptiles, became occupied by mammals which showed remarkable diversifications and radiations.

The Paleogene is a chronostratigraphic Period/System which, according to the latest chronostratigraphic readings, began 66 Ma and ended 23 Ma. It spanned for 43 million years and it is subdivided into three Epochs: Paleocene (66 Ma – 56 Ma), Eocene (56 Ma – 33.9 Ma) and Oligocene (33.9 Ma – 23.03 Ma) (Speijer et al., 2020).

At the end of the Mesozoic and beginning of the Paleogene, several tectonic events took place. The most significant is connected to the continual fragmentation of the supercontinent, Pangea. An important thing to note, is that while Pangea's gradual breakup began in the Lower Jurassic (cca. 205 Ma) (Guan et al., 2021) and by the end of the Upper Cretaceous the separated continents looked somewhat similar to their present-day forms (Rasser et al, 2008; Ziegler, 1988).

At this time, Africa was showing signs of moving northward, in the direction of Eurasia and with a counterclockwise rotation (Rasser et al., 2008). Europe was still an archipelago, with portions of the continent being submerged into epicontinental seas, although the continent itself was unitary (Rögl, 1999). The Tethys Ocean, which has existed since the Mesozoic, had almost disappeared by the end of the Eocene, due to changes in oceanic circulations, caused by the movement of the lithospheric masses. The present-day Mediterranean Sea is all that remains of the Tethys Ocean (Rögl, 1999; Schmiedl et al., 2002; Olteanu & Jipa, 2006). Orogenic activities of the Alpine thrust belt that were happening during the Upper Eocene, made it possible for the Lower Oligocene Paratethys to become a largely isolated sea (İslamoğlu et al., 2010).

1.1.1. Paleogene climatic changes

At the beginning of the Paleogene the world went through several climatic events, which determined the evolution of the paleofauna (Speijer et al., 2020). The cause of the rises in temperature is often cited as a great release of greenhouse gasses, which may have been caused by the following events: rise in global sea level, deoxygenation, hydrological cycles, etc. This sudden rise in global temperatures is known as the Paleocene-Eocene Thermal Maximum (PETM) or the Late Paleocene Thermal Maximum (LPTM) (Zachos et al., 2001). At this period, global temperatures kept rising by about 5°C between 4000 and 20000 years. An interesting thing to note, is that current global warming is often compared to the PETM, particularly due to the rising in greenhouse gasses (Remmelzwaal et al., 2019). Following the Paleocene-Eocene Thermal Maximum was a period, when the Earth underwent the warmest climatic temperatures recorded in the Cenozoic, which came to be known as the Early Eocene Climatic Optimum (EECO) (Slotnick et al., 2015; Payros et al., 2015).

All of these climatic and tectonic changes caused major faunal and floral turnovers throughout the Paleogene (Behrensmeyer et al., 1992; Solé et al., 2019), and have led to some major extinction phases of the Cenozoic.

1.1.2. Paleogene faunal turnovers

In regards to the fauna, during the Paleogene three major faunal turnovers have occurred. The first of these happened at the beginning of the Paleocene, which in addition began the processes of rapid evolutionary radiation and continental endemism of mammals, filling the ecological gaps left after the K/Pg Mass Extinction. Most of the Paleocene mammal radiation began in North America, and as such the faunal turnover in question is known as the North American Land Mammal Age (NALMA) (Speijer et al., 2020). The second major faunal turnover coincided with the PETM and involved similar evolutionary innovations, mostly in the northern continents. This event is known as the Mammalian Dispersal Event (MDE) which led to the appearance of many modern mammalian forms, particularly primates, chiropterans, artiodactyls, perissodactyls and proboscideans. Later on, the time span between the late Eocene and the early Oligocene is a period of significant importance in terms of systematic biota development.

During this time period, the third global fauna turnover of component continental vertebrates occurred, known as the *Grand Coupure* (Stehlin, 1909; Brunet, 1979; Fărcaș & Codrea, 2005; Mennecart et al., 2018; Tissier et al., 2019; Speijer et al., 2020; Codrea & Venczel, 2020; Codrea et al., 2022; Maridet et al. 2023).

It is still unclear as to what could have been the cause of the *Grand Coupure*, although a number of causes have been put forward as possibilities, such as: sudden shift in climate at the Eocene-Oligocene boundary, water/dry land distribution which caused certain significant changes (ex. the separation of Europe from Asia) and it was during this event that large portions of mammal fauna from Europe began to go extinct, and subsequently be replaced by immigrant mammal faunas from Asia (Brunet, 1979; Costa et al., 2011).

During the Paleogene mammals have also claimed dominance over the marine environments as well, due to the fact that the K/Pg Mass Extinction wiped out all of the large bodied marine reptiles of the Late Cretaceous. Having little competition in this new domain, mammals began their morphological development to become better suited for marine life, thereby forming the major groups of marine mammals that still exist to this day: cetaceans, pinnipeds and sirenians (Mészáros & Petrescu, 1976; Berta, 2020). Plants were also present in marine environments, from which seagrasses, which have existed since the Cretaceous and extensively developed in the Eocene (Philips & Meñez, 1988), were of great importance, as they were the primary source of food for the sirenians.

1.2. The Geology of the Paleogene formations of NW Transylvanian Basin

The Transylvanian Basin represents an intramountain basin, which functioned as a major deposition center at the end of the Mesozoic and during the Cenozoic (Săndulescu, 1984; Krézsek & Bally, 2006).

Studies conducted throughout the decades on the sedimentation around the Gilău Mountains, with an extension into the whole Transylvanian Basin, have revealed the presence of three sedimentary megacycles (Codrea & Dica, 2005; Codrea & Venczel, 2020):

1) Upper Cretaceous – Lower Miocene
2) Lower Miocene – Middle Miocene
3) Middle Miocene – Upper Miocene

These megacycles were also shown to include marine and continental interbedding (e.g. Mészáros & Moisescu, 1991; Mészáros, 2000; Codrea & Hosu, 2001; Krézsek & Bally, 2006; Filipescu, 2011; Sabău et al., 2021). The Paleogene deposits in particular represent a post-tectogenetic cover of the Carpathian area, with a thickness ranging between 500 m to over 1800 m in the northern areas (Fărcaș & Codrea, 2004; Krézsek & Bally, 2006).

In our area of interest, the NW part of Transylvania, Popescu (1984) presents three sedimentary areas, which begin their formation during the Eocene (unlike the other two – Cluj and Jibou – presented by Hofmann (1879), Koch (1891) and Răileanu & Saulea (1956)). These three areas (Popescu, 1984) are:

- The Gilău area (in the southern part of NW Transylvania)
- The Meseș area (in the central/western part of the same territory)
- The Preluca area (in the northern part of the same territory)

We will now present the Paleogene formations, which are the most important for the purposes of our studies of the sirenians from Romania's territories, placing a greater focus onto the Gilău sedimentary area (Răileanu & Saulea, 1956; Popescu 1984; Mészáros, 2000):

- **The Jibou Formation (Hofmann, 1879) Late Maastrichtian – Early Eocene (NP8 – NP14) (continental)**
- **The Călata Group (Rusu, 1995) (NP15 – NP17):** represents the first Paleogene marine episode, also known as the former „Lower marine series" (Răileanu & Saulea, 1956).
    - **The Foidaș Formation (Mészáros & Moisescu, 1991) Upper Lutetian**
    - **The Căpușu Formation (Popescu, 1978) Late Lutetian – Bartonian (NP15 – NP17):** this is known as "Marly-limestones", which contain *Ostrea* remains, as well as Nummulitids (*N. striata, N. perforatus*). This formation, coupled with the Foidaș Formation, form banks that are associated with the *Inucu* and *Văleni* members, which are characterized by the NP 15, 16 and 17 nannozones (Filipescu, 2011).
    - **The Mortănușa Formation (Bombiță & Moisescu, 1968) Bartonian – Priabonian (NP17 – NP18):** being made of clays and marls, it is characterized as being regressive, particularly where the formation becomes extremely sandy, thereby forming an offshore open marine facies 80 m thick. This formation is also rich in mollusks, large foraminifera, sirenians and sharks (Filipescu, 2011).
    - **The Viștea Limestone (Rusu, 1995) (NP18):** it is the uppermost unit of the Călata Group and was described by Koch (1894) as „lower coarse limestone beds" and by Popescu (1984) as „Leghia Limestone". It is a normal marine calcarenite which contains traces of bioclast (alveolinids, miliolids, coralinaceans and macroforaminifera-Nummulites fabianii etc.), dolomicrites and siliciclastes. It then made the transition to the overlying continental Valea Nadășului Formation (Mészáros, 2000).
- **The Valea Nadășului Formation (Popescu, 1978) (continental)**
- **The Turea Group (Rusu, 1995) Upper Eocene (Priabonian) – Lower Oligocene (Rupelian) (NP19-NP21)**: it is a new marine cycle and the second Paleogene marine episode, formerly known as the „Upper marine series" (Răileanu & Saulea, 1956).
    - **The Jebucu Formation (Bombiță, 1984)**

    - **The Cluj Limestone Formation (Hofmann, 1879):** consists of shallow-water platform carbonates with porous bio-skeletal wackestone/packstone facies. Remnants of *Crassostrea transilvanica* are common. Additionally, it may contain coarser carbonate levels (such as those located in the edges of Cluj-Napoca) with various types of marine invertebrates (echinoids, gastropods, bryozoans) and vertebrates (turtles, crocodiles, bony fish, selachians, sirenians). Short emersions occurred during the limestone deposition (Popescu, 1984).
    - **The Brebi Formation (Hofmann, 1879) (NP21 – 22):** is an offshore siliciclastic formation with two levels: (I) one of these levels formed through the deepening of the sea and the related marls primarily contain *Nummulites fabianii*. (II) the second is an upper level that bears a rich number of bryozoans. Within this formation, what is known as the *Pycnodonta gigantea* level marks two distinct boundaries: the Eocene-Oligocene boundary and the boundary between the NP21 and NP22 nannozones (Răileanu & Saulea, 1956).
    - **The Mera Formation (Koch, 1880) Lower Oligocene (Rupelian) (NP22-NP23):** it is a normal marine, locally brackish formation, containing a succession of facies: marno-calcareous sandstone, marno-clays, marine sandstones with mollusks, bioclastic limestones, marly sands with brackish mollusks. The fossiliferous content is rich in mollusks, foraminifera and nanoplankton. It was deposited in a coastal area, which in the Gilău area periodically suffered reductions in salinity, with a subtropical climate with cooling tendencies, It corelates with the Cuciulat Formation from the Preluca Area. This formation represents the end of the Paleogene normal marine, carbonate sedimentation in NW Transylvania (Popescu, 1984).
    - **The Hoia Limestones (Hofmann, 1879):** a carbonate unit deposited on the base of the previous formation, as carbonate levels with bio-skeletal packstone facies. *Scutella* fragments are common (Mészáros, 2000).
- **The Moigrad Formation (Rusu, 1970) (NP24)**
- **The Dâncu Formation (Rusu, 1972)**
- **The Gruia Formation (Rusu, 1989)**

- **The Var Sandstones (Răileanu & Saulea, 1956)**
- **The Cuzăplac Formation (Moisescu, 1972)**
- **The Cubleșu Formation (Moisescu, 1972)**
- **The Vima Formation (Rusu, 1969) (NP25-NN1):** it was deposited particularly into the Preluca area. It is presented in the form of marls with rare sandstone intercalations that may contain mollusk fragments and calcareous nannofossils. It is a marine formation that comprises the Oligocene-Miocene boundary and together with the Cubleșu Formation marks the end of the Paleogene sedimentation in Transylvania (Mészáros, 2000).

2. History of research

2.1. History of research of the Paleogene deposits of NW Transylvanian Basin

Research of NW Transylvanian Basin encompasses many chronological stages. The very first studies' primary objective revolved around economic targets, as in the supply of raw materials during an epoch related to the already-unfolding industrial revolution. Such works, however, only referred to scarce mentions related to paleontology. The first geological study with modern character, which actually refers to the salt deposits of Ocna Dej, was conducted by J. E. von Fichtel and was issued in 1780.

Valuable geological data were included also by Beudant (1822) in his books related to his voyage in Eastern Europe. He carefully noted a series of details learned from others (as he himself never made it to Transylvania) about its geology. The map he created of NW Transylvania Basin, while lacking a few details, still displays some interesting features; he noted the presence of course limestone ("calcaire grossier parisien") formations in areas near and around Cluj-Napoca (Fărcaș & Codrea, 2004).

The first synthesis work referring to the stratigraphy of Transylvania was drafted by Franz von Hauer and Guido Stache in 1863, who realized a true monography which included all of the previously published geological studies, as well as observations of their own.

Pávay (1871) published the results of his studies conducted on the areas around Cluj-Napoca, at the behest of the Ministry of Hungarian Industry and Research, based on which the railway connecting Cluj-Napoca with Oradea was built. What is important is the fact that he revealed the first paleontological information (ex. vertebrate remains from the locality of Rădaia (Priabonian)).

An important stage from the first hundred years of geologic research in Transylvania, is represented by two geologists, who worked and published separate from each other. Karl Hofmann through his publications in the years 1879, 1883, 1887, brought fundamental contributions especially to the Meseș and Preluca areas, even drawing a 1:75000 geological map, titled „Gaura und Galgo”, which is current even today. Antal Koch, in his monumental classical monography which issued in two parts (1894, 1900), conceived a synthesis of the stratigraphic successions and of the Transylvanian Depression’s formations, as well as of the paleontological discoveries, thereby realizing the inventory of the collected fossils and of the fossil sites. Additionally, Koch realized a detailed geological map of the Transylvanian Basin, which earned him a great deal of prestige at the World Exhibition in Paris, towards the end of the 19th century.

The works done in the first half of the 20th century, even though they are important, essentially did not modify the stratigraphy established by Hofmann and Koch.

The second half of the 20th century brought forth the contributions of more generations of geologists who have published numerous data about the stratigraphy, geomorphology and paleontology of the Paleogene deposits, after the research conducted under the aegis of the Geological Committee, the Romanian Geological Institute or within the universities where they studied at.

2.2. History of research of fossil sirenians from Romania

Even though the number of sirenian fossils is relatively high, the vast majority of them are rib fragments, which have modest systematic value. The reports of such pieces are only valued for the signaling of this group of marine mammals in marine deposits with various stratigraphic ages, although with a visible majority in Late Eocene (Priabonian). The first reports belong to Hofmann, Koch and Pávay.

This is why the published works which refer to these discoveries are relatively few, but valuable in terms of their context: Tulogdy (1944), Florei (1962), Fuchs (1959, 1970, 1971, 1973, 1988, 1990), Nicorici and Popovici (1981), Șuraru and Codrea (1988), Grigorescu (1967, 2017), Veress et al. (2022b, 2022c), Veress & Codrea (2023a, b), Codrea & Veress (2024).

It can be readily noticed, that the preoccupation towards the Paleogene sirenians of Transylvania and the role they had in their environments, can be divided into two stages: the first between the years 1944 and 1988 and the second beginning in 2020.

3. Sirenians

3.1. Main features of sirenians

Sirenians are marine mammals adapted to aquatic environments. With the extinction of the dinosaurs at the end of the Mesozoic Era, mammals have diversified and occupied every ecological niche, including the ones of the marine environment. This peculiar category of mammals known as marine mammals, was able to drastically diversify, forming many and sometimes unique groups of animals. These include sea otters *(Enhydra lustris)*, pinnipeds (seals, sea lions and walruses), cetaceans (dolphins, whales, porpoises), sirenians (dugongs and manatees) (de Muizon & McDonald, 1995; Berta et al., 2006; Uhen, 2007; Romero, 2009).

Sirenians, popularly known as ‘sea cows’, are members of an Order of fully aquatic mammals, aptly named ‘Sirenia’. An important piece of information to note is to not confuse the order name ‘Sirenia’ with the name ‘Sirenidae’, which is a family (or suborder) of salamanders with external gills, possessing only a front pair of limbs, and they are also referred to as ‘Sirens’ (Fig. 10) (Gray, 1825; Cogger & Zweifel, 1998). Sirenians are known to live in near-shore, shallow-water tropical and subtropical environments, in the Atlantic and Indo-Pacific oceans (Romero, 2009; Voss, 2014). These animals are unique, because they are the only marine mammals that are obligate herbivores (Domning 1978; Domning et al., 2010; Berta, 2020), while most other marine mammals are either macro-carnivorous or filter feeders (whales). Their teeth have evolved to enable them to feed on marine angiosperms, sea grasses and freshwater macrophytes (Domning, 1978; Voss, 2014). In order to feed more efficiently and to reduce the buoyancy of their bodies, the bones of sirenians display an osteological phenomenon, known as pachyosteosclerosis (a combination of pachyostosis and osteosclerosis), in which the bones are thicker and denser (Domning, 1978; Romero, 2009). Other characteristics, distinct to sirenians include large yet streamlined bodies, forelimbs that were modified into flippers, hindlimbs that have been reduced into vestigial pelvises, down-turned snouts with certain angles and powerful horizontal tails in the shape of a fluke or a paddle. The skull of sirenians have a distinct downturn at the premaxilla, however it tends to differ between extant families: in Dugongs the downturn is very sudden, while with Manatees the downturn is less pronounced. The external nares are dorsally retracted and enlarged in extant species and also extend to or beyond the anterior margin of the orbits (Domning, 1978; Berta, 2020).

3.1.1. Mythology relating to sirenians

The earliest facts regarding sirenians originated mostly from the stories told by antique sailors, who were able to get a glimpse of these marine mammals. From these stories sirenians began to be associated with the mermaids of antiquity, mythical beings that are half human and half fish (a successful statuary representative of such a character is the Little Mermaid, from the port of Copenhagen, Denmark).

Members of the mammals' Order 'Sirenia' are commonly referred to as 'sirens' ('sirenians'), a name which derives from the creatures of Greek mythology of the same name. Sirens were believed to have been bizarre creatures that used their enchanting songs to lure traveling sailors to the rocky coasts of their islands (Orchard, 1995; Mittman & Dendle, 2013). Originally the poets Vergil and Ovid wrote that the sirens lived on a group of small islands, at the time known as *Sirenum scopuli*. Pliny the Elder, in chapter seventeen of his *Naturalis Historia*, mentions Greek historian Dinon of Colophon (c. 360–340 BC), who stated that sirens are aggressive predatorial creatures which originate from India (Rackham, 1967).

The most well-known appearance of sirens in literature is in Homer's Odyssey, where the hero Odysseus (Ulises), who following sorceress Circe's advice, under the temptation of his own curiosity to hear the unequal songs of the sirens, ordered his men to tie him to the mast of their ship and continue sailing, their ears being filled with wax (Pope, 1880).

Later on, sirens were described as having fully human bodies with the addition of a pair of avian wings on their backs (Austern & Naroditskaya, 2006). Interestingly enough this 'bird-person' image also appears in Egyptian mythology as well, called a *ba*, as a way of explaining the soul's departure from the body.

In the Early Modern Period the image of the sirens changed completely. Isidore of Seville (c. 560 – 636) mentions in his *Etymologiae* that sirens ‘live in the waves’ (Barney et al., 2006). It is possible that the association of the name ‘siren’ and half fish women might have begun from here.

While the image of half human half fish creatures was prevalent during the ancient times, such creatures were mostly shown as ‘mermen’ (ex. Dagon, Oannes, Ea) (Waugh, 1960; Kernbach, 1989). With the passage of time however, mermen were described more and more as ugly and bestial.

Female versions of mermen, known as ‘mermaids’, also occasionally appeared as protective figures: Kuliltu (Mesopotamia), Atargatis (Assyria), Ningyo (Japan) (Yoda & Alt, 2008; Dell, 2010). There is even a legend about the sister of Alexander the Great, Thessalonike, who transformed into a mermaid after her death.

In the Polish city of Warsaw, there are several legends pertaining to a mermaid by the name of Syrenka. She is the city’s protector and appears on its coat of arms. A similar coat of arms can be found in the Reformed Church from Cluj-Napoca. It belonged to countess Bethlen, born Sarolta, baroness Wesselényi of Hadad. The coat of arms depicts a mermaid with crown on her head, holding three flowers. The family has its roots in Poland (Nagy, 1865).

Alchemist Paracelsus von Hohenheim also describes mermaids, which led to the writing of de la Motte Fouqué’s novella *Undine*, and eventually to Hans Christian Andersen’s famous mermaid fairy tale *The Little Mermaid*.

Sometimes mermaids were said to inhabit freshwater environments as well: the Naiads (Greek mythology), the Rusalkas (Slavic folklore), the Lostrița (Romanian folklore), Selkie (Norwegian, Scottish folklore) (Ivanits, 1992). In Romanian mythology the Ştima apei or Vâlva apei is an evil spirit (Antonescu, 2009). Mermaids also appear in many other Asian and African cultures.

In the medieval period, mermaids are described in bestiaries and Christopher Columbus would describe for the first time three ‘mermaids’, which were in fact the first observations of North American Manatees (Haase & Reinhold, 1993).

From a morphological standpoint, it is easy to see why Sirenians have such a strong connection to the mythological side of natural history. Like mermaids, Sirenians have streamlined bodies with only a pair of front limbs, no hind limbs and a fish-like horizontal tail fluke similar to cetaceans (with manatees being the exception since they have round, paddle-like flukes).

3.1.2. Scientific approach

In 546 BCE, Milesian philosopher Anaximander was the first to speculate the evolutionary origin of humans from water (Bell, 2019). Later on, Aristotle (384 – 322 BCE) made the distinction between the disciplines of botany and zoology and establishing biological classifications of various animals through natural observations, and not base his finds on the mystical. Later on, Pliny the Elder (23/24 – 79 CE) also classified animals, but based on by the environments they lived in. This was how marine mammals were considered fish at the time (Romero, 2009).

In the 18th century the 'father of ichthyology', Swedish naturalist Peter Artedi (1705 – 1735 CE), separated the cetaceans from fish, putting together the basic classifications of animals: Class, Family, Genera and Species. After his death, his good friend Carl Linnaeus (1707 – 1778 CE) continued his work, being the first to classify all plants, animals and minerals (Calisher, 2007), in his books, titled 'Systema Naturae' and being named as the 'father of modern taxonomy'. He introduced the binomial classification system and the term *Mammalia*. If in the first edition of his book (which had 11 pages) cetaceans and sirenians were still considered fish, in his tenth edition (which had 3000 pages) they were considered mammals (Schiebinger, 1993).

Charles Darwin (1809-1882), in his book *'The Origin of Species'*, realized a short description of sirenians, including them in the Order *Ungulate* (Darwin, 2003), and Illinger in 1811 gave the Order name *Sirenia*.

The first adequately formulated cladogram of the Order Sirenia was first put together by Savage (1976), followed by a detailed phylogenetic analysis by Domning (1994), who included all of the extinct and extant sirenian species.

3.1.3. Systematic classifications

The Order Sirenia is divided into four families, from which two families are known only from the Eocene and are extinct, and two have survived into historic times (Bajpai et al., 2009).

The two extant families are: the Trichechidea which includes the West Indian Manatee (*Trichechus manatus* Linnaeus, 1758), the African Manatee (*T. senegalensis* Link, 1795) and the Amazonian Manatee (*T. inunguis* Natterer, 1883), with the second family being the Dugongidae which includes the Dugong (*Dugong dugon* Müller, 1776). The West Indian Manatee is further classified into two subfamilies, consisting of the Florida Manatee *(Trichechus manatus latirostris* Harlan, 1824*)* and the Caribbean or Antillean Manatee *(Trichechus manatus manatus* Linnaeus, 1758*)*. The *Dugongidae* also includes the largest known sirenian, the Steller's Sea Cow (*Hydrodamalis gigas)*, however due to human predation it is now extinct (Berta, 2020; Walker, 2015).

The two extinct Families of Sirenia from the Eocene are Prorastomidae and Protosirenidae.

3.2. Evolution of Sirenia

Similarly to cetaceans, sirenians have a very rich fossil record, which presents the transition they have made from land and back into the water. Their evolutionary history is currently traced back to the Eocene, followed by a high taxonomic diversification in the Oligocene and then a sudden decline in the Upper Miocene.

3.2.1. Family Prorastomidae

Prorastomus sirenoides is the earliest known ancestor of sirenians, found in deposits in Jamaica, which date back to the Early to Mid-Eocene, approximately 50 Ma (Reinhart, 1976; Savage, 1976; Romero, 2009; Domning et al., 2010; Berta, 2020). The only known fossil remains of *P. sirenoides* are a skull together with mandibles and the atlas, which were described by sir Richard Owen in 1855 after their discovery at the Yellow Limestone Formation (Savage, 1976). It was a species which, similarly to primitve whales, had fully developed hind legs which were used for both land and aquatic locomotion.

Members of this family were already displaying characteristics similar to extant sirenians, such as dorsally retracted nasal openings, heavy pachyosteosclerotic ribs and dental morphology which indicates a seagrass-based diet. The rostrum is elongated, but it doesn't deflect like in later species, instead forming a forceps-like structure (Voss, 2014).

3.2.2. Family Protosirenidae

Another family of primitive sirenians found in the Eocene, are the Protosirenidae. This Family has only one known genus, *Protosiren.* Fossils of this sirenian were discovered in Egypt, as well as Pakistan (Zalmout et al., 2003), within Lutetian and Priabonian deposits. Post-cranial remains indicate that *Protosirenids* still poses hind limbs, however both anterior and posterior limbs more closely resemble flippers, which indicate that they are no longer capable of supporting their mass on dry land (Zalmout & Gingerich, 2012).

3.2.3. Family Dugongidae

The Family Dugongidae, unlike today, were far more diverse in the past, their evolutionary line beginning in Middle and Late Eocene, in the Old-World Tethys. The three genera that were prominent during the Eocene – *Eotheroides, Eosiren* and *Prototherium* –, which together formed the paraphyletic subfamily *Halitheriinae*. They coexisted with the Protosirenids, which is well illustrated from the discoveries made in the Priabonian deposits from the Fayum Basin in Egypt (Zalmout & Gingerich, 2012).

The type species of the Genus *Eotheroides*, *Eotheroides aegyptiacum,* was first described by Richard Owen in 1875, by examining a Lutetian cranial endocast from Egypt (Domning et al., 2010). Since then, while a number of skull fragments have been discovered, as well as a number of pachyosteosclerotic ribs, other morphological elements such as cranial rostra and caudal vertebra are still missing, which complicates the better understanding of this species' paleobiology. Other species of *Eotheroides* were also discovered in other countries around the world, including a possible but uncertain find in Romania (Zalmout & Gingerich, 2012).

3.2.3.1. Subfamily Hydrodamalinae

The Subfamily Hydrodamalinae is comprised of two genera: *Dusisiren* and *Hydrodamalis,* with the former first appearing in the Miocene and persisted towards the Holocene (Voss, 2014). *Dusisiren* displayed unique characteristics: enlarged bodies, decreased snout deflection, reduction of teeth and finger bones and the loss of its tusks. These characteristics suggest that the genus fed on kelp, due to the climate becoming colder and seagrasses being replaced by kelp (Domning et al., 2010; Berta et al., 2006).

The genus *Hydrodamalis gigas* stands out as the most unique, not just within its genus, but within the Order Sirenia, being the only species of sirenian that was capable of living and thriving in the cold waters of the North Pacific (Domning, 1976). This was possible, in large part due to its massive size: reaching sizes of up to 7 to 9 m in length with a weight of 4 to 10 tons (Berta et al., 2006), making it the largest sirenian to ever exist.

3.2.4. Family Trichechidae

Manatees are a Family of sirenians, who’s fossil record is scantly known and isn’t as diverse that of dugongs. According to analyses done by de Souza et al. (2021). Trichechids first appeared in the Late Miocene and then diversified during the Plio-Pleistocene. There exist a few morphological aspects that differ from dugongs: they have smaller bodies with circular, paddle-shaped tails; their skulls are broader, with their premaxilla only slightly downturned and because the premaxilla is much smaller, manatees don’t possess tusks; they also possess a series of nails on their flippers, marking their lineage with *Tethytheria*; they have unique molar teeth, in the sense that they have evolved to continuously replace them throughout their lives; they have also adapted to freshwater environments (Domning et al. 2010; Berta et al. 2006).

4. Materials and Methods

4.1. Institutional abbreviations

BBU-PC: Museum of Paleontology-Stratigraphy Paleontological Collection of the Babeș-Bolyai University, Cluj-Napoca, Romania
BCA-PC: Paleontological Collection of the Bethlen Gábor National College, Aiud
SPAL: Science Paleontology, Paleontology Collection, Mureș County Museum, Târgu Mureș

4.2. Materials

For this study, we have labelled, measured and studied up to 254 fossil pieces that are currently present and accounted for. From this sample, 33 items concern either isolated pieces that are impossible to assign to one bone or another, but with clear Sirenian origin, or of clusters of very small bone splinters.

Concerning their origin, the fossils studied within this work are a mix of teeth and bones either curated in university and museum collections, or fossils unearthed during field researches.

The paleontology collection of the Paleontology – Stratigraphy Museum of the Babeș-Bolyai University, Cluj-Napoca, has very few cranial materials, being comprised mainly of a fragmentary skull and a cranial roof, along with two fragmentary mandibles. The rest of the collection is made up of post-cranial remains, the majority being ribs (31 items), most being fragmentary and few being complete. Due to the fact that sirenian ribs are the most common types of fossil bones to be discovered, the greater abundance of such remains being in the museum's collection is to be expected. The collection also contains six vertebrae, four fragmentary humeri, a single scapula bone within a block of limestone and a single radius bone which was left inside a small matrix of rock.

Within the museum's storage we have found several bags that contained fossils from Herman Fuchs' personal collection, which included sirenian remains, however this collection comprises only of ribs (11 items), vertebrae (6 items) and a number of fragmentary bone shards (12 items).

The small museum of the Bethlen Gábor National College from Aiud, houses another, much large part of the Fuchs Collection, with 49 rib fragments, 5 vertebrae and numerous bone fragments, the most interesting being a glenoid of a scapula, a sternum fragment, a complete jugal and a possible skull fragment.

Secția de Științele Naturii a Muzeului Județean Mureș are în colecția sa patru fragmente de coaste provenite din Calcarul de Cluj, din județul Cluj.

Muzeul de Isotrie Naturală din Sibiu ne-a pus la dispoziție două vertebre, 15 fragmente de coasă și un fragment de molar.

Senior lecturer Dr. Viorel Arghiuș of the Faculty of Environmental Sciences and Engineering, granted us access to the university's fossil collection. It contains a fragmentary skull made up of 3 parts, 43 ribs, 19 vertebrae and two humeri.

We have also collected from the fields seven rib fragments, one radius, one ulna and one pelvic bone. Additionally, four more fossils (three rib fragments and one fragmentary rib) were discovered recently and donated to us by first year geology student Turinovici Matei.

4.3. Methodology

For our field work, we utilized a GBH 18V-26 F Bosch percussion hammer to penetrate the bulk of the rock matrix the bones were in. For more precise works, we used an Estwing Pointed Tip Rock Pick, along with a simple hammer and chisel to extract the bones themselves.

We later brought the rocks including the fossils to the Babeș-Bolyai University's Paleotheriology and Quaternary Geology Laboratory, and restored them. In the case of fossils contained within a rock matrix, the removal of matrix was done using an AIRBAG HP1 compressor, which needed to be done carefully, so as to minimize damage to the bones themselves as best as possible. This procedure is never clean however, with parts of the bones themselves falling off almost constantly. In order to prevent even further destruction of the bones, we dowsed them with mowillite. For the broken pieces, we used professional adhesives (e.g. cyanoacrylate etil2 adhesive).

Photographs of the fossils were taken using a Sony DSC-RX100M5 camera that was mounted on a professional tripod, as well as a Nikon d90 with 18-55 mm objective. The photographs were processed using Adobe Photoshop CC 2017 and GNU Image Manipulation Program (GIMP), while the maps were created using Adobe Illustrator CS6 and Inkscape 1.4. The tables and diagrams were created using Office Word. In addition, we also performed a computed tomography scan (CT scan), with help from the University of Agricultural Sciences and Veterinary Medicine (USAMV) Cluj-Napoca.

For the analysis of the Bizușa-Băi limestone, we made thin sections, via preliminary cutting into slices with a diamond saw, then the sections were cleaned using distilled water and finally analyzed using a polarizing microscope, with Cannon Powershot A640 camera mounted onto it.

The taxonomic analysis of the V115/1 skull was realized in two steps: in the first one we used the character matrix for sirenian taxa created by Domning (1994), with later additions. In the second step, the parsimony (cladistic) analysis was conducted with the phylogenetic software package TNT version 1.6 of Goloboff and Morales (2023). In the parsimony analysis, the character–taxon matrix (CTM) was first analyzed using the "New Technology search" option with the sectorial search and tree fusing options as default parameters. A search for suboptimal trees ten steps longer than that of the most parsimonious tree was also completed in order to calculate the decay indices of Bremer (1994), and the common synapomorphies for all trees were also identified. In the parsimony analysis all characters were treated as unordered.

The morphometric data, which were all done in millimeters, were acquired using a measuring tape and a Precise PS 7215, 150 mm digital caliper as well as 250 mm basic caliper and the techniques utilized in these measurements follow those employed by Domning (1978) and Zalmout and Gingerich (2012). Further analysis of the bones was carried out by comparing our material with the ones described in scientific literatures and private collections.

5. Results and discussions

Of the 254 fossils that we have studied, 63% of these are ribs, either complete or fragmentary, followed by vertebrae with 14%. Alarmingly, 13% of the sirenian fossil material is comprised of small fragments or shards that cannot be identified in any sort of way. However, one percent of the materials is comprised of cranial materials, which is very useful for us in our systematic assignation (Fig. 1).

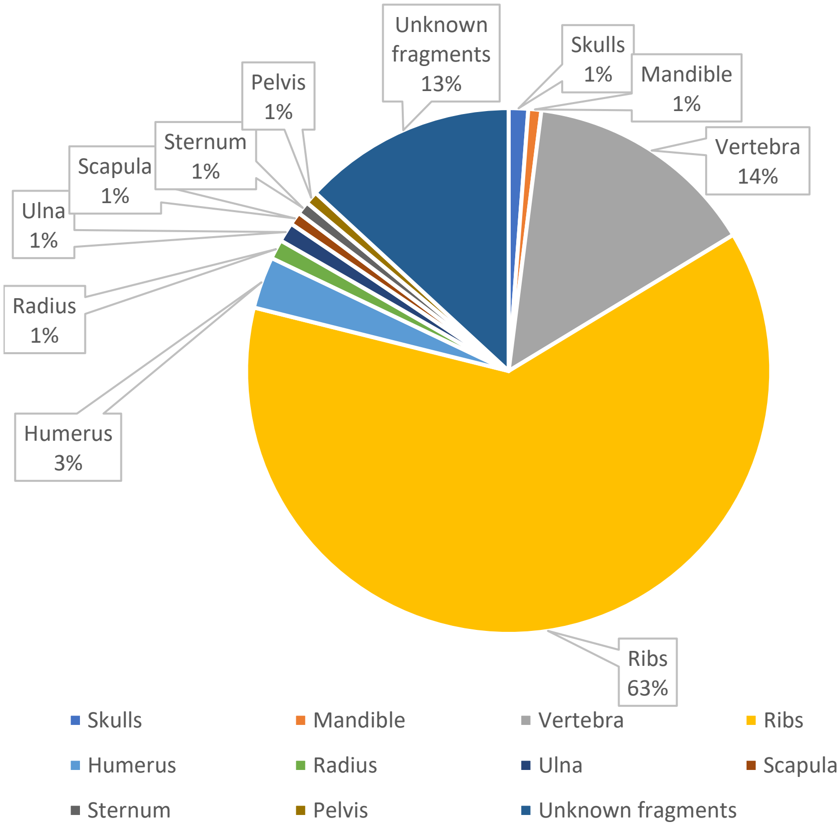

Figure 1: *Percentage of sirenian fossil bones discovered in Romania and studied by us or described in scientific literature*

5.1. Localități cu fosile de sirenieni

Throughout the decades, numerous sirenian fossil localities have been discovered all across Romania's territories (Fig. 2).

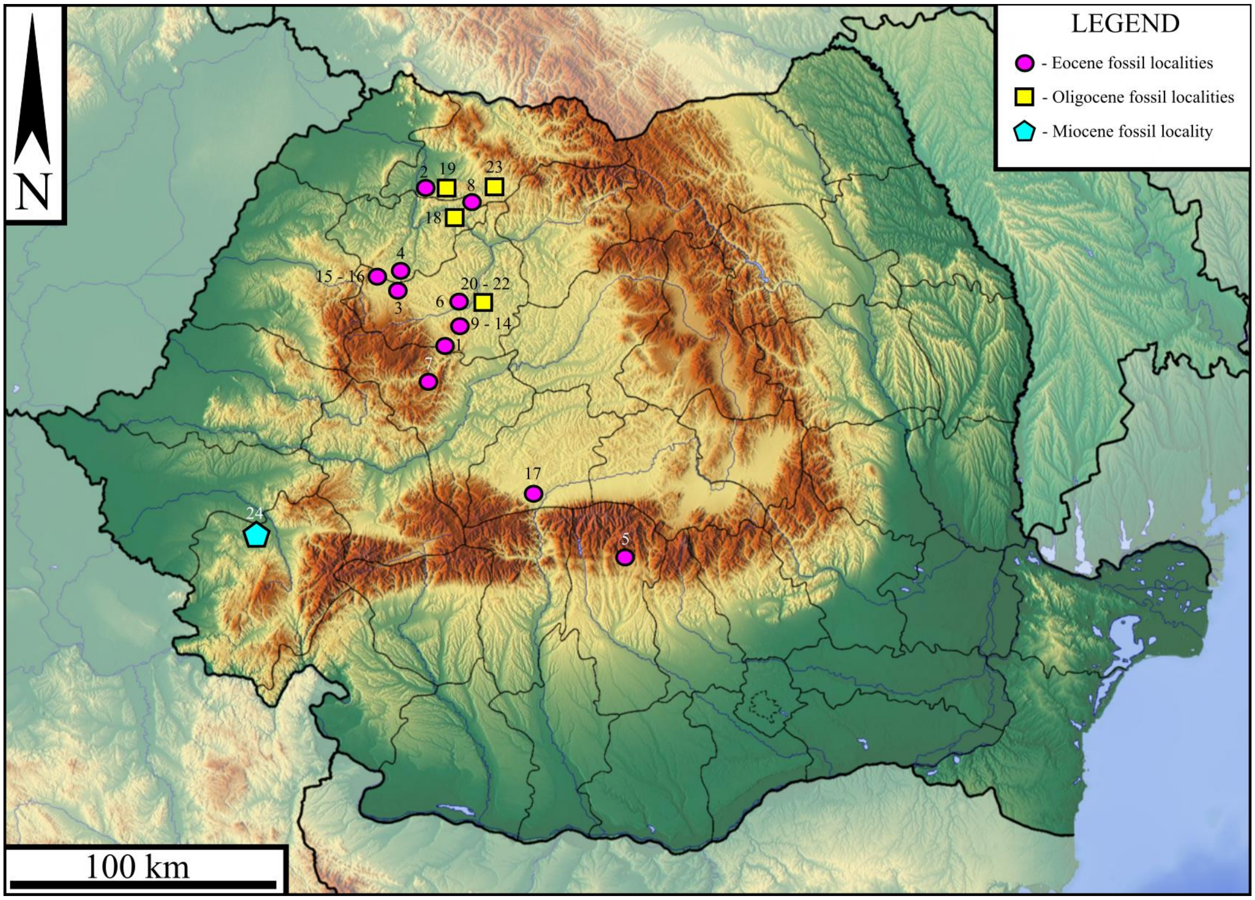

Figure 2: *Map of Romania, showing the locations of sirenian fossil localities (based on Kordos, 1976)*

List of the sirenian fossil localities (Fig. 2):

Eocene:

1. Buciumi (= Gaura) – slope of the Prosinel (Prosinyel) Mountain, Maramureș County, Căpuș Formation (Popescu, 1978) (= *Perforata* layers in Koch, 1894), Preluca sedimentary area, Middle Eocene (Lutetian – Bartonian)
2. Iara – slope of the Râpona (= Ropó) Mountain, Cluj County, Căpuș Formation (Popescu, 1978) (= *Perforata* layers in Koch, 1894), Gilău sedimentary area, Middle Eocene (Lutetian – Bartonian)
3. Leghia, slope of the Râpa (= Omlás) Hill, Cluj County, Mortănușa Formation (Bombiță & Moisescu, 1968), member of the Viștea Limestone (Răileanu & Saulea, 1956) (= marls with *Ostrea* in Koch, 1894), Gilău sedimentary area, Middle Eocene (Bartonian)

4. Treznea, Valea Șanțului, Sălaj County, Mortănușa Formation (Bombiță & Moisescu, 1968), Meseș sedimentary area (Vlad A. Codrea, *personal observation*, a small rib fragment), Middle Eocene (Bartonian)
5. Albești, Argeș County, Albești Limestone Formation, Late Eocene (Priabonian)
6. Baciu, Cheile Baciului rock quarry, Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
7. Cetea – Lupului stream, Alba County, (? = upper course limestone in Koch, 1894),? Eocene (? Priabonian)
8. Cheile Babei, rock quarry, between Sălaj County and Maramureș County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Preluca sedimentary area, Late Eocene (Priabonian)
9. Ciurila, Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
10. Cluj Mănăștur (currently a district of the municipality of Cluj-Napoca, formerly an independent locality), Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
11. Cluj Hoia, Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
12. Cluj Someș-Dig, Cluj – Napoca, Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
13. Cluj-Napoca Someșeni (currently a district of the municipality of Cluj-Napoca, formerly a distinct locality) Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian).
14. Mera – the hills bellow and above the village, Cluj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)
15. Jebucu – the hills surrounding the village, Sălaj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Late Eocene (Priabonian)

16. Stana, Sălaj County, Cluj Limestone Formation (Hofmann, 1879) (= upper course limestone in Koch, 1894), Gilău sedimentary area, Sălaj County, Late Eocene (Priabonian)
17. Turnu Roșu (=Porcești), Sibiu County, (?) Valea Nișului Formation (Mészáros, 1996), Late Eocene (Priabonian)

Oligocene:

18. Bizușa-Băi – Secătura stream, Sălaj County, Cuciulat Formation (Mateescu, 1938), Early Oligocene (Rupelian, Merian) – new sirenian fossil locality, herein presented.
19. Buciumi (= Gaura) – Hovrilei Valley, Maramureș County, Brebi Formation (Hofmann, 1879), Hoia Limestone Member (Hofmann, 1879), Early Oligocene (Rupelian, Merian)
20. Cluj Hoia, base of the hill, Cluj-Napoca, Cluj County, Brebi Formation (Hofmann, 1879), Hoia Limestone Member (Hofmann, 1879), Early Oligocene (Rupelian, Merian)
21. Mera, Cluj County, Mera Formation (Koch, 1880), Early Oligocene (Rupelian, Merian)
22. Cluj Cordoș, Cluj County, Brebi Formation (Hofmann, 1879) Early Oligocene (Rupelian, Merian)
23. Stoiceni, Maramureș County, Mera Formation (Koch, 1880), Early Oligocene (Rupelian, Merian)

Miocene:

24. Zorlențu Mare, Caraș-Severin County. Middle Miocene (Badenian). This assignation (Florei, 1962) is doubtful, as the fossil is lost.

5.2. Systematic paleontology

Order Sirenia ILLIGER, 1811

Family Dugongidae GRAY, 1821

Subfamily Halitheriinae CARUS, 1868

"Distinct species"

Sirenians within Romania are very poorly known. Domning (1994) was the first who pointed out and vehemently emphasized at the end of the 20th century the importance of a substantial revision that would dramatically change the sirenian evolutionary tree. We attempted to perform a systematic analysis of the V115/1, by analyzing every morphological characteristic of the skull and using the sirenian character matrix created by Domning (1994) and updated by Diáz – Berenguer.

5.2.1. Fossils discovered during field expeditions

Bizușa Băi

The fragmentary sirenian fossils that have been discovered at the limestone quarry at Bizușa Băi represent a fairly recent addition to the list of sirenian fossil localities within Transylvania. The outcrop itself lies within the territory of 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 (Mészáros, 2000; Codrea & Dica, 2005).

Cluj-Napoca – Someș-Dig

Other fossils that we were able to discover in the field, were the ones from Cluj-Napoca, from the Someș Dig fossil locality. While the discovery of fragmentary ribs, in our case four in total, is a fairly common occurrence at this point in time, our search yielded three very unique bones. We are referring to the radius and ulna bones (Fig. 42) and the fragmentary innominate bone. Interestingly, the ulna and radius were discovered imbedded in their natural, anatomical connection, which is very rare. We also compared the three fossils that we have discovered with the ones found by Fuchs (1988) at the same fossil locality. Unfortunately, these latter ones are lost, and we based our comparisons on the data and photographs from published articles.

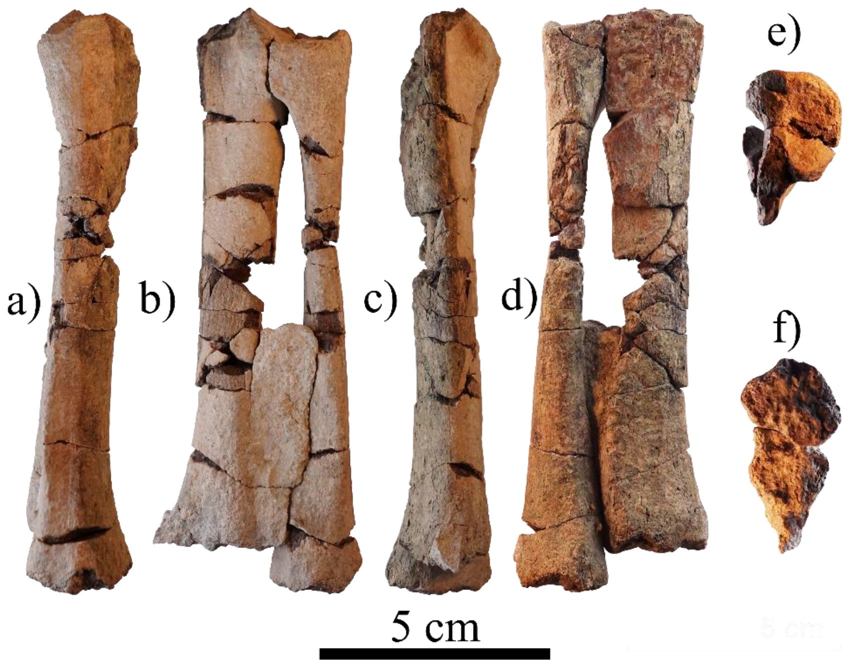

Figure 42: *BBU-PC SDRU1, radius and ulna in anatomical connection: (a) anterior view; (b) lateral right view; (c) posterior view; (d) lateral left view; (e) proximal view; (f) distal view*

Cheile Baciului

Cheile Baciului, represents an area another site of interest for vertebrate paleontologists. Recently, student Turinovici Matei discovered a few rib fragments and a well-preserved rib, from which only the proximal end of the epiphysis is missing.

5.2.2. Museum collections

Museum of Paleontology-Stratigraphy of the Babeş-Bolyai University, Cluj-Napoca, Romania

The following section of this chapter will showcase the inventory and description of the fossils housed in the Paleontology Stratigraphy Museum. The methodology used to describe the bones from the collection, was the same one employed by Codrea (2000 and references therein), which includes: the material itself, the geological site where the bones were discovered along with the age of the site, the name of the person(s) who donated the find to the museum (if said information is available) and reference to any scientific document in which these fossils were described (if there are any).

CRANIAL MATERIAL

Material: skull missing the rostrum and right jugal and squamosal

Inventory nr.: BBU-PC V115/1

Geological site: Stana, Sălaj County, Cluj Limestone Formation

Geological age: Late Eocene (Priabonian)

Donor: unknown (according to some information, it would have been Prof. Dr. Ștefan Mateescu, assistant of Prof. Ion Popescu-Voitești), as the fossil was extracted from a block of limestone that was housed in the museum. It was prepared and included into the Museum's collection by Prof. Dr. Vlad Codrea in 1977.

Description: The cranium for the most part is complete, however the right jugal and squamosal were missing, being displaced from the skull before burial into sediment. The rostrum of the premaxilla is also absent from this fossil, being eroded by weathering. Without the rostrum, the condylobasal length of this fossil piece is 302 mm long. The zygomatic width of the cranium is estimated to be 138.76 mm. This measurement was done based on the methodology employed by Balaguer & Alba (2016) (Table I), who examined a similarly preserved sirenian skull in their work.

The interior of the skull is filled with remnants of the limestone matrix from which it was extracted from. This interior matrix wasn't removed at the time of its preparation in order to avoid any damage to the fossil itself. This prevents us from examining the interior of the interior of the skull. The occipital region broke off at one point, which revealed an intact endocranial cast within, however only the postero-dorsal portion of the cast was visible. The dental formula of this fossil is presented only by the molars M_2 and M_3, as the rest of the teeth are missing and only the alveoli are present.

An unusual feature of our skull, is the presence of a long divot located on the lower lateral sides of the cranium, on the lower portions of the parietals, just above the alisphenoids and reaching the ocular cavities. On the lateral right side of the skull, this structure is more clearly seen and much more pronounced. At the moment we are unsure as to what this structure could be, although presently it could be an area where cranial muscles were firmly held in place.

Material: skull roof

Inventory nr.: 17134

Geological site: Cluj-Napoca, Someșul Mic riverbed, Cluj Limestone Formation

Geological age: Late Eocene (Priabonian)

Donor: Hermann Fuchs, 1960

Reference: Fuchs (1970)

Material: endocranial natural cast in limestone

Inventory nr.: 21552

Geological site: Stana, Sălaj County, Cluj Limestone Formation

Geological age: Late Eocene (Priabonian)

Donor: Eugen Nicorici, 1980

Reference: Nicorici & Popovici (1981)

Material: fragmentary mandible

Inventory nr.: V114

Geological site: Cluj-Napoca, Someș-Dig, Cluj Limestone

Geological age: Late Eocene (Priabonian)

Donor: Robert Strusievici in 1988 gave the fossil to Vlad Codrea (VAC), then former paleontologist of the Țării Crișurilor Museum in Oradea, Tiberiu Jurcsák prepared and reconstructed the mandible.

POST CRANIAL MATERIAL

Is made up of fragmentary vertebrae, ribs, scapula, humeri and radius. On June 5th 2020, grandson of Herman Fuchs, Tósa András donated a portion of his grandfather's collection to the Babeș – Bolyai University. Recently, I was given access to this collection and many other materials, and inventoried and measured 29 sirenian fossils, all of them being fragmentary ribs and vertebrae, packeted in newspapers, on which in some cases the location of origin and a provisional inventory number is written.

The Aiud Museum of Natural Sciences of the Bethlen Gábor College, Aiud, Romania

It is the oldest natural sciences museum in the country, as it was opened to the public in 1796 (Codrea & Mărginean, 2007; Veress & Codrea, 2021). It houses a single sirenian fossil, assigned with the inventory number AiM 1027, discovered in Cetea, Alba County.

Within the same building of the Bethlen Gábor National College, there is a small museum, which was founded after the primary museum became a suborder to the Aiud town hall. In 2006, the family of the late Prof. Fuchs Hermann, donated several items from his paleontological collection. A part of this material is already exposed and the other part remained in boxes. I was able to identify numerous sirenian fossils, mostly post-cranial materials and a jugal fragment and possible basisphenoid.

Mureș County Museum

In the museum's paleontological collection there are four rib fragments which were discovered in the Cluj Limestone Formation. A notable aspect regarding these fragments is that, upon their introduction into the museum's collection they were classified as belonging to *Rhytina gigas(!)*. This would indicate that further studies are needed to better determine the species these bones belonged to.

Natural History Museum of Sibiu

It is one of the oldest museums in the country. Its paleontological collection houses sirenian fossils as well, which are: two fragmentary vertebrae, 15 rib fragments and a fragmentary molar tooth. It is known that the originate from Turnu Roșu (=Porcești), without any other supplementary information.

Paleontological collection of the Faculty of Environmental Sciences and Engineering, Babeș-Bolyai University, Cluj-Napoca

Lect. Dr. Viorel Arghiuș of the Faculty of Environmental Sciences and Engineering, was able to collect a variety of fossils from various sites in Romania. These fossils are part of the faculty's collection and we were given permission to study them.

Among the numerous ribs, vertebrae and two humeri, the collection also houses a skull, which unfortunately is very fragmentary, and we were able to analyze it and later compare it with the V115/1 sirenian skull.

5.3. The Paleogene and evolution of the paleoenvironments from the NW Transylvanian Basin, based on the interpretation of the Sirenian record

From the Tethys to the Paratethys Sea

The great tectonic events took place around the Eocene – Oligocene boundary and which continued throughout the Lower Oligocene (Rupelian) have deeply modified the geography and environments. In the southern hemisphere, the most important event was the Australia's and South

America's split from Antarctica, which generated the first circum-Antarctic current and formation of the first Antarctic ice caps (Berggren & Prothero, 1992; Zachos et al. 1992). Along with these paleogeographic changes, a significant cooling of the climate occurred in a lot of regions of the Earth. In the northern hemisphere, the series of great collisions that took place (India vs. Asia, Africa vs. Europe) brought forth in the norther hemisphere the formation of the active mountain ranges via horizontal compression of the continental lithosphere (Scotese, 2004; Rasser et al., 2008), the closing of the Tethys Ocean and the birth of the two new marine domains: to the north, the intercontinental Paratethys Sea and to the south also intercontinental, the Mediterranean Sea (Rögl, 1998; Olteanu & Jipa, 2006).

In 1924, Laskarev proposed separating the Paratethys bioprovinces from the Mediterranean ones, recognizing the evolution of the endemic mollusk faunas from the Vienna, Pannonian, Styrian, Dacian and Euxinian basins. Currently, the birth of the Paratethys is considered to have occurred around the Eocene-Oligocene boundary and this lost sea is subdivided into three sub-domains: Western, Central and Eastern Paratethys (Steiniger & Wessely, 2000; Olteanu & Jipa, 2006).

In the time span between the middle of the Eocene and the beginning of the Oligocene, approximately across 10 Ma, the great gateways, which formed the connection between the Arctic Ocean, the Indian Ocean, the North Sea, the Mediterranean Sea and the Paratethys, became closed off one after the other, effectively interrupting the marine exchange between the polar and tropical regions (Berggren & Prothero, 1992; Palcu & Krijgsman, 2021).

Eocene

Over time, many paleobiogeographic reconstructions have been presented, through which the correct positioning of each continent during different geologic times was attempted, as well as demonstrating the relationship between the marine fauna and the migration of the continents (Rögl, 1998; Scotese, 2004).

In NW Transylvania, a part of the Transylvanian Basin presents itself during the Upper Eocene (Priabonian) in the form of an archipelago with epicontinental areas, especially coastal and subcoastal (Steiniger & Wessely, 2000; Olteanu & Jipa, 2006), with a warm, tropical climate (Tulogdy, 1944; Bombiță, 1963; Dumitrescu, 1968; Fuchs, 1970; Petrescu, 2003) and developed in the nannoplankton zones, between the NP18 and NP21, which correspond with the planktonic foraminifera zones between P15 and P17 (Rögl, 1998).

Such conditions were favorable for the formation of faunistic assemblages typical in warm marine environments: foraminifera: miliolids (e.g *Biloculina, Quinqueloculina* etc), nummulites (e.g. *Nummulites striatus, N. fabianii* etc), mollusks (e.g. *Crassostrea transsilvanica, Campanile, Vulsella* etc), echinoderms (e.g. *Echinolampas, Scutellina* etc), colonial and solitary corals and calcareous algae (Koch, 1894; Vlaicu-Tătărîm, 1963), crustaceans – decapods (*Harpactoxanthopsis bittneri, Micromaia tuberculata)* (Mihály, 2011), crocodilians *(Diplocynodon, Crocodylia* indet.) (Codrea & Venczel, 2020; Sabău et al., 2021). The ichthyofauna is represented by benthic (e.g. *Dasyatis, Myliobatis, Scaroides*) and pelagic (e.g. *Charcarocles, Charcarias)* representatives. The existence of these latter fish was conditioned by the presence of sirenians, the main food source of sharks (Codrea et al. 1997; Ciuclea et al. 2017). On their turn, Sirenians themselves also indicate a rich sea grass presence.

Unfortunately, the preservation of these marine angiosperm plants is very low (Domning, 2001). In order to indicate the areas in which they populated, a list of seagrass indicators was put together – Indirect paleo-seagrass indicators (herein abbreviated as IPSIs) –, which include benthic foraminifera, gastropods, echinoderms, as well as arguably the best markers: the sirenians (Reich et al., 2015; Tuya et al. 2018). Even if no fossils of these plants have been signaled yet in the studied region, it can be theorized that they existed in abundance (Codrea et al. 1997), especially if we take into consideration the daily required intake of seagrasses in the case of modern species.

The Eocene faunal assemblage from the marine formations, in the Călata Group, as well as in the Turea Group (Kovács & Arnaud-Vanneau, 2004), the nummulitid foraminifera, corals gastropods and echinoderms, along with the sirenian population, provide an indication as to the shallow Eocene marine water depth within the studied region, which is actually similar to the with modern Indo-Pacific areas. All of these organisms developed in warm waters, with depths of around 50-150 m, and with normal salinity, in a tropical or subtropical climate (Vlaicu-Tătărîm, 1963; Popescu, 1984).

Eocene – Oligocene boundary

These great tectonic and climatic events which favored the diversification of terrestrial faunas, through the possibility of migrations around the geologic event known as *"Grande*

Coupure", have disadvantaged the migration of marine fauna, which could no longer find pathways between the cold and warm regions.

In the NW territories of the Transylvanian Basin, the Brebi Formation was deposited, later on named by Koch (1894) as "intermedia", a siliciclastic formation with a rich bryozoan and limestone content (Chira & Igrițan, 2004). The reticulate *Nummulites fabianii* and *Pycnodonte gigantica* mollusk are biostratigraphic markers of the Eocene – Oligocene boundary between the NP21 and NP22 nannoplankton zones (Mészáros et al. 1989; Mészáros, 2000; Rasser et al. 2008). *Globigerina tapuriensis/G. ampliapertura* also appears in such areas (Rögl, 1998), as well as the remains of *Clamys, Spondylus* and *Cardita laurae* casts (Mészáros and Clichici, 1976). The nannoplankton assemblage contains a large number of around 40 species, from which the most frequent are the following: *Istmolithus recurvus, Sphenolithus predistentus, Reticulofenestra umbilica, Coccolithus pelagicusș* (Chira & Ingrițan, 2004). Crustaceans have also been identified from the same species reported from the Cluj Limestone Formation as well: *Harpactoxanthopsis bittneri, Paleocarpilius macrocheilus* (Mihály, 2011). Koch (1894) reported sirenian rib fragments from the Hoia Limestone Formation (= Hoia Layers).

The Eocene – Oligocene boundary can be found in in the Brebi Formation marls, over which sedimentation happened in marginal areas of the Hoia Limestone, with interpenetrations of these stratigraphic units in certain areas. The transition was gradual, with the Hoia Limestone being the last normal marine carbon sedimentation of the Paleogene from the NW Transylvanian Basin (Popescu, 1984).

Oligocene

The lowermost stage of the Oligocene is the Rupelian. It is generally accepted that the transition from greenhouse to icehouse conditions, marked by glaciation pulses, took place during the Rupelian (Speijer et al. 2020). The response of the marine biotas to this climatic deterioration, was similar at all of the other groups of benthic phytoplankton, zooplankton and microfauna, leading to a decrease in global diversity (Berggren & Prothero, 1992).

In the NW Transylvanian Basin, the Lower Oligocene (Rupelian) means the sedimentation of the Mera Formation (in the stratigraphy of the Central Paratethys, constitutes the stratotype of the unit, known as Merian), represented by clays, sands, sandstones and bioclastic limestones (Chira & Igrițan, 2004). At the basal section of the formation Mészáros & Ianoliu (1977) described a very rich nannoplankton association: *Sphenolitus predistentus, Ericsonia subdisticha, Braarudosphaera bigelowi* etc. belonging to the standard NP22 zone. A series of nannoplankton species then gradually disappear: *Coccolithus formosus, Istmolithus recurvus, Clausicoccus subdistichus*. A rich fauna of mollusks *(Clamys bellicostata, Pitar incrassata, Turitella biarritzensis)*, echinoids *(Scutella subtrigona)*, miliolids, nummulites *(Nummulites retianus)* (Rögl, 1998), as well as numerous sirenian ribs (Fuchs, 1970; Veress & Codrea, 2023a, b) were found.

In the upper part of the Mera Formation, the nannoplankton populations disappear completely. The presence of Charophyte flora assemblages from the Dâncu Formation, from the Suceag fossil locality, near Cluj (Transylvanian Basin), confirms salinity fluctuations and indicates a depositional environment that transitions between fresh and marine water sources, forming an estuary fed by a river originating form Gilău Mountains, which were already elevated (Sanjuan et al. 2023).

The Mera Formation is equivalent to the Lower Cuciulat Formation (Codrea & Dica, 2005), from the Preluca sedimentary area (Popescu, 1984; Rusu, 1989). Rusu (2000) underlines that the Cuciulat Formation presents the same bioclastic limestone facies with brackish fauna and was deposited in a coastal area with brackish episodes, with a subtropical climate with cooling episodes. This fact is confirmed from the thin sections collected from the studied limestone block from Bizușa-Băi. We speak of a compact bioclastic packstone to rudstone type limestone, containing bivalve shells miliolid type foraminifera. It also contains extraclasts, in the form of angular quartz fragments, middle sorted. It is most likely a limestone that accumulated in a shallow coastal zone with high wave energies.

5.4. Taphonomy

Taphonomy encompasses two stages: biostrationomy, between the death of an organism and its final burial; and diagenesis, from the final burial to its discovery by paleontologists (Lyman, 2010). This differentiation was made in order to separate the preburial processes from the postburial geological and chemical processes.

The taphonomic analysis was carried out using the traditional method, through which certain parameters were considered: the lithofacies, the articulation, the abrasion, the luster, the phosphatization, all based on the work done by Boessenecker (2011) and Boessenecker et al. (2014).

1) Lithofacies

The principal sedimentary facies in which the fossils were found in the sites from areas located around Cluj-Napoca (Someș-Dig, Someș riverbed, Cluj-Mănăștur, Cheile Baciului, Stana) is represented by Eocene marly-limestone banks of the Cluj Limestone, with a geological structure comprised of a "porous skeletal wackestone to packestone with terrigenous grains" (Codrea & Hosu, 2001).

2) Articulation

After discomposure of the soft tissues, in the absence of transport agents, the bones can remain in their initial positions until the burial in the area of origin. In the case of marine environments, the energy of the waves facilitates the transportation of the bones to the burial location, their orientation indicating usually the direction of the depositional paleocurrents.

In the studied area, sirenian fossils have been discovered in two taphonomic ways: rare bone accumulations, in large part rib and vertebra fragments, or isolated bones, in the majority of cases. No complete skeleton has been discovered thus far. In the case of accumulations, the bones lied in disarticulated disorder, some laying over others, from which we can deduce that they were buried nearby shore, after being carried by the energetic waves, long after their carcasses were decayed.

3) Fragmentation

Modifications to the bones can take place in any taphonomic stage: trauma during its life, post-mortem deterioration caused by predators and transport, or could be effects caused by the effects of diagenesis and post-depositional processes, when following high pressures, the bones can either be deformed or even broken.

The majority of the studied fossils are very fragmentary. We refer to fully conserved pieces only in the case of a few ribs, less fragile due to the high grade of pachyosteosclerosis, as well as certain vertebrae.

4) Abrasion

Abrasion marks on the bones' surfaces, suggest that these were exposed on the sea floor for a while prior to the burial, the sedimentation rate possibly being reduced, or that transportation took place in highly energetic conditions, among rocks or other obstacles.

In the rare cases of molar descriptions, advanced abrasion of the crown has been observed, possibly due to their intense use, especially in the case of adult specimens, as in the case of the molar teeth of the V115/1 skull. It has also been noted, that smaller teeth have a much higher conservation rate than the bigger ones (Behrensmeyer, 1975). The advanced weathering can be explained by the mixing of seagrass with carbon sediments. In the history of the group, this aspect explains the substitution of the actual dentition with horned abrasive plates, in the case of modern, oceanic forms.

Other forms of abrasions are represented by bitemarks left by carnivores (Domning, 1978, 2000). On a some of the studied bones from the Transylvanian Basin, we noticed visible bite marks on their surfaces, which appear as Two small marks appear as two shallow, round pits, indicating a clear sign of predation, although it is currently not clear as to whether these marks were left by a crocodilian or a selachian. The long, narrow cuts, which are similar to the ones left by shark teeth, reveals their attack on the sirenians. In other cases, we noticed many small holes, which could indicate signs of bioerosion, caused by bone eating worms.

5) Polish

Sirenian bones are rarely polished, unlike the ones from odontocetes, mysticetes and pinnipeds (Boessenecker et al., 2014). Our analyzed fossils generally have a very dull aspect and only those that have much deeper colors present a weak luster.

6) Phosphatization

Phosphatization is an early diagenetic process through which, during fossilization, the organic material is replaced by calcium-phosphate minerals (Boessenecker, 2011).

The change of color in bones, follow-up of mineralization, is also associated with phosphatization, these becoming black or dark brown (Boessenecker et.al, 2014).

The fossils that make up the bulk of our study, present weak signs of phosphatization, the only proof being the color of the bones themselves, particularly the color of the ribs, which varies between multiple shades of dark brown, especially at the external parts of the bones, where the coloring oxides were able to much more easily penetrate and in a much higher measure.

5.5. Disappearance of sirenians from the NW Transylvanian Basin

The existence of sirenians in the NW Transylvanian Basin for millions of years, has to be observed from a wider context involving their first appearance, development and disappearance in the European realm. In Romania the earliest sirenians are Lutetian – Bartonian (Koch, 1894) and the last ones are from the Middle Miocene (Badenian), but for these last ones, more hard evidence is needed (Florei, 1962).

In the wider European area, the duration of their existence is much longer. The first adequately described quadrupedal sirenian, *Sobrarbesiren cardieli*, from the Middle Lutetian from Huesca province (northeastern Spain), is known as the oldest quadrupedal sirenian in western Europe (Díaz-Berenguer et.al., 2018).

After the Messinian event, only two species existed in this area: *Metaxytherium serresi* and *M. subappeninum*. The latter of the two was the last sirenian species to exist in the Mediterranean Sea, all the way to its extinction at the end of the Pliocene (Sorbi et al, 2012; Heritage & Seiffert, 2022).

All of the data regarding adaptability is important in the problem of elucidating the causes for the extinction of the sirenians from the NW Transylvanian Basin. Only possessing two fragmentary skulls, we cannot produce any true statistics. Although, we can remark the fact that the presented Eocene sirenians were presumed to have had lengths reaching between 1,75 and 2,6 m, a relatively normal size during the Eocene, but still small when compared to examples, such as *Dusisiren*, which could reach up to 4 – 5 m, and *Hydrodamalis* with a doubled length of up to 8 – 9 m.

In the end, the reduction of seagrass biodiversity, distribution and abundance and the cooling of the deep waters, along with glacial growth at the northern hemisphere 2.7 Ma have contributed, together with the cooling of the climate to the disappearance of the last sirenian species from the European region.

This was most definitely a series of events which took place simultaneously or close to one another at the beginning of the Oligocene: (1) The sudden cooling following the initiation of the circum-Antarctic Ocean circulation (Zachos et al., 1992, 2001; Speijer et al. 2020); (2) Changes in marine gateway configuration and connectivity with global oceans, which led to the transformation of the Paratethys sea into an anoxic giant (Olteanu & Jipa, 2006; Palcu & Krijgsman, 2021); (3) Fluctuations in sea levels and the intense continentization phase, which led to the restriction of the Transylvanian Basins and the reduction of habitable surface space for sirenians; (4) Reduction of marine water salinity; (5) Disappearance of the food source, seagrasses, which could no longer grow in such environmental conditions.

The total disappearance of the sirenians from the NW Transylvanian Basin during the Lower Oligocene (Rupelian), took place as these species could not adapt fast enough to these rapidly occurring events.

As for Florei's (1962) finding regarding the "presence of sirenians" at Zorlențu Mare (Banat), even though the fossils to prove this aspect were lost, going by the description of the paleoecology and fauna of the region, we can affirm that there truly were optimal conditions for these marine mammals to exist during the Middle Miocene. The sirenians have disappeared definitively from the seas that covered Romania's present territories.

The relics of the Paratethys, Caspian- and Black Sea remained isolated, the latter opening through the Bosphorus- and Dardanelles Strait towards the Mediterranean only during the Holocene. Favorable living conditions for sirenians were never created again.

5.6. Discussions

In the course of our research, we noticed several problems that influence the study of sirenians from the area. In SE European region, while the existence of Eocene, Oligocene and Miocene geological formations has been demonstrated in the past, signs of sirenian fossils are very few.

In Romania, many sirenian fossil sites can no longer be accessed, because: (1) they become covered by vegetation or became forested; (2) they vanished, following various mining operations at the rock levels in which they were; (3) they become covered by construction works or by waters, following human works (Koch, 1894; Codrea et al. 1997).

Another problem is the works done at rock quarries which house sirenian fossils. These limestones are very good for construction and ornamentation works. Similarly, was most of the outcrop from the banks of the Someșul Mic River destroyed.

Another aspect of our research refers to the naming systematic classification correction of the sirenian fossils that exist in museum collections.

Regarding the fossils from the territories of Romania, many of these have been wrongly classified into the genus *Halitherium*, which are, systematically sirenia indet. We affirm this theory due to two reasons: first of all, we are talking about post-cranial fragments, which cannot be used for systematic analysis. Another reason for which we consider the classification wrong, is that the genus *Halitherium* as it has been known up until now, is specific only to the Oligocene, meaning the Eocene fossils cannot belong to this genus, which is why we recommend a revision of these materials. Such revisions are done all over the world. Presently, while classic systematics offers a stable placement for sirenians, the situation is much more complicated in the realm of cladistics. For the same species different cladograms can be produced, based on the types and number of introduced characters. In light of this information, the problem of systematically identifying sirenians from the NW Transylvanian Basin remains real and present.

Another gap in our knowledge of sirenians, is a complete inventory of such fossils, discovered within the territories of Romania and housed within museum collections. A database that can be accessed from any corner of the world by those interested in sirenian research, is also missing. This would have facilitated research, for example during the pandemic, when transportation was no longer possible and we were limited only to online studies.

As for the museum collections, we are presently confronted with a grave problem: many sirenian fossils, which, after their discovery, were described in the publications of the time, disappeared, preventing any further studies and comparisons with newer discoveries. The reverse of this situation is when new collections suddenly appear, that have been unknown until recently. Here we mention the two studied Fuchs Collections: Fuchs Collection 1 from the BCA-PC and the Fuchs Collection 2 from the BBU-PC. They were both donated by Herman Fuchs' descendants, the first one in 2006 and the second one in 2020.

6. Conclusions

Throughout time, sirenians represented the basis of myths and tales of mermaids, inspired numerous artists, painters, sculptors, composers, writers and have created controversies in regards to their placement in the animal kingdom. In 1811, Carl Illinger introduced the name ‘Sirenia’ for the family of living sea cows, based on their resemblance to the mythical creatures. Later, numerous studies managed to clarify *how* the great mammal groups managed to adapt to semi-aquatic or fully aquatic lifestyles in the aquatic environments (fresh, brackish and marine). The most difficult question, to this day, remains *why* did they choose the aquatic environment.

The subject of study for this doctorate thesis represents a novelty and refers to the sirenian fossils discovered in Romania. Until the present, no synthesis material existed, which could encapsulate all of the research results of this subject. The aim of this work was to bring to light new information regarding their appearance, existence and disappearance, about the distribution and evolution of their habitats in the NW Transylvanian Basin and to integrate this information into the wider context of knowing these marine mammals in a European and global scale.

The research centralized around the north-western region of the Transylvanian Basin, particularly on the Gilău sedimentary zone, as this is the area where Paleogene marine epicontinental deposits are the most well represented.

The most well represented and important geologic formations in regards to sirenian fossil occurrences, are the ones in which marine deposit sedimentation occurred during the Paleogene. We are primarily referring to the formations of the two marine sequences: the Călata Group and the Turea Group. The result of our research revealed that in the following formations sirenian fossils were discovered: Căpușu, Mortănușa, Viștea Limestone, Cluj Limestone, Brebi, Hoia Limestone, Mera, Cuciulat. **For the first time we signal a new sirenian fossil locality, which is Bizușa Băi, where the Cuciulat Deposits can be found and from which we described sirenian rib fragments.**

Since until the present, there hasn’t been a material that encompasses all of the localities with sirenian fossil occurrences in Romania, **we have put together, for the first time, a synthesis of the deposits from which sirenian fossils were reported, by creating a list of sirenian fossil localities and a map where we highlighted these localities.**

During our research, we tried to identify from a systematic perspective at least one sirenian via a well-preserved skull, in order to conduct a phylogenetic analysis. Unfortunately, in the case of the AS1 skull, similarly to the V114 mandible, we could only realize a morphological analysis, because certain characters necessary for the phylogenetic analysis were not preserved. **Despite these afore mentioned issues, we managed to conduct for the first time in the study of Romanian sirenians, a detailed morphological analysis, followed by a phylogenetic analysis and a cladogram, in which the V115/1 skull can be identified as a *'distinct species'*.** The result of the Stana specimen being a sister taxon with *Eotheroides lambondrano* represents a novelty and at the same time a surprise, as the preliminary analysis conducted by Sagne (2001) placed it into the genus *Protootherium*.

From the numerous post-cranial fossils inventoried and measured, the most important ones in terms of value, are the ones personally collected by me and drd. Marian Bordeianu from the bank of the Someșul Mic River, in the Someș Dig fossil site, designated with the temporary inventory numbers BBU-PC SDRU1 and BBU-PC SDP1. **It is the first time when in Romania's territory a radius and ulna of a juvenile sirenian have been discovered, collected and analyzed, in their natural anatomical connection. Another unique discovery was the fragmentary pelvic bone, as it is a bone that is very rarely preserved in the sedimentary deposits of our country.**

Up to the present the situation regarding the number of sirenian fossils discovered in Romania's territory wasn't clear, neither was the exact place where they are kept. **Through personal research I managed to inventory and measure every sirenian fossil fragment housed in the collections of the museums of Transylvania and published the lists which contain the measurement data, locality, age and geologic formation and, where it was possible, systematic assignation.** It is about the Paleontology – Stratigraphy Museum of the Babeș-Bolyai University, the Natural History Museum of Sibiu, the Mureș County Museum from Târgu Mureș, the Natural Sciences Museum from Aiud and the Bethlen Gábor College Small Museum. All of the inventoried fossils originate from the Paleogene deposits from the Transylvanian Basin, the majority from the NW region, from the areas around Cluj and most of them can be found in the museums from Cluj-Napoca and Aiud.

I have firstly catalogued and analyzed the sirenian fossils from three different collections: the 'Arghiuș collection' from the Faculty of Environmental Sciences and

Engineering of the Babeș-Bolyai University, the Fuchs Collection 1 from the Bethlen Gábor College and the Fuchs Collection 2 (unregistered) from the Faculty of Biology – Geology of the Babeș-Bolyai University, Cluj-Napoca.

At the Results chapter, we included the evolutionary reconstruction of the sirenians' paleoenvironment in the NW Transylvanian Basin, presenting them chronologically, beginning with the Upper Eocene and ending with the Lower Oligocene. We underlined the area where the Eocene–Oligocene boundary can be found, in the continental environment, via the *Grande Coupure* event, as well as in the marine environment. The repeated changes of the climate, salinity, temperature and eustatic sea level have directly influenced the evolution of the paleoenvironment, as well as the evolution of the sirenians. **Presenting these environmental conditions, we highlighted for the first time a model of the disappearance of the sirenians from the waters of the Transylvanian Basin. In a relatively short period of time an entire series of geologic and biologic events took place, which lead to their disappearance.** The sudden cooling that followed the beginning of the circum-Antarctic oceanic circulation, the changes regarding the marine access paths and their connectivity to the planetary oceans, transforming the Paratethys Sea into an anoxic giant, the fluctuations of the sea level and continentalization, the reduction of sea water salinity and lastly the disappearance of their food source have equally contributed to the disappearance of the sirenians from the waters of the Transylvanian Basin.

Another new element in this work is represented by the taphonomic analysis of the sirenian remains, realized with the following parameters: lithofacies, articulation, fragmentation, abrasion, polish and phosphatisation, according to Boessenecker (2011). Almost every studied fossil was found disarticulated and deposited in two taphonomic ways: bone accumulations and isolated bones, with no complete skeleton. Fragmentation is very high, caused by trauma inflicted during their lives, post-mortem deterioration via predation and transportation, as well as pressure of the rock layers over the fossils during diagenesis. Some of the studied fossils present abrasion marks left by transportation in high energy conditions, predators or bone eating worms or mollusks.

In modern times, all sirenians are rated as vulnerable on the IUCN Red List of Threatened Species. Even if humanity cannot be blamed for the prehistoric decrease in sirenian species numbers and habitats, the endangering of extant sirenians is caused, primarily by their interactions with humans. Efforts are being made to reduce their hunting and capture and for extending and protecting their habitats. We can help them and give them a chance at a future, by knowing their past.

The present doctoral thesis represents an important first step in the framework of reopening the process of researching sirenians in the territory of Romania and of the environment in which they existed. The presented information contributes to a better understanding of the events caused by the paleoclimatic and paleogeographic changes in the studied area and offers an overall vision of the influence of these changes over the existence and evolution of sirenians in the European and global context.

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