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**AUI GEOLOGIE**

# Oligocene fish fauna and sedimentological particularities of the Bituminous Marls of the Vrancea Nappe, Eastern Carpathians, Romania

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**Abstract**

The study was conducted in the Bistriţa Half-Window, Vrancea Nappe, in the Bituminous Marls, which is an intriguing entity, both ichthyological and sedimentological. Formally considered a monotonous lithostratigraphic unit, at a closer look, this organic matter rich formation contains numerous lithofacies such as current and wave ripples, cross-bedding, hummocky and swaley-like cross-stratification, clastic dykes, intraformational slump folds among others. Therefore, the high level of bottom current activity seems somehow in contradiction with previous ideas about the cause for preservation of organic matter. In this study, we present the taxonomy of 13 fish fossils species. The palaeoecology of the fish assemblage is reconstructed based on present-day fish fauna bathymetrical comparisons. Furthermore, some palaeobathimetric observations were made in conjunction with sedimentary features.

**Keywords:** fish fossils, Bituminous Marls, Oligocene, Vrancea Nappe, Eastern Carpathians.

## 1. Introduction

The aims of this study are: 1) to present the taxonomic composition of fish fossils species discovered in the Bituminous Marls studied sections; 2) to reconstruct the palaeoecology and palaeobathimetry of fish assemblage based on ecology of recent fish fauna and sedimentological observations.

The studied outcrops are located in Vrancea Nappe (Marginal Folds Nappe, *sensu* Săndulescu, 1984), one of the outermost nappe of the Moldavide, which is a geostructural complex unit, consisting of several tectonic nappes, namely from west to est: Teleajen, Macla, Audia, Tarcău, Vrancea, and Pericarpathian. They represent the infilling of the Moldavide Basin, that was deformed in Miocene


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tectogeneses (Săndulescu, 1984). The Vrancea Nappe is cut into the outer margin of Tarcău Nappe, in tectonic half-windows, Bistriţa being the second one from north to south of the Eastern Carpathians (Băncilă, 1958; Dumitrescu, 1952). The structure of this nappe consists of many faulted folds, which are detached along the middle member of the Bisericani Formation, the grey-greenish mudstones. It is structurally interposed between Tarcău and Pericarpathian Nappes. Close to the nappe front, Doamna-Horaiţa Anticline exposes the oldest deposits of this unit.

## 2. Stratigraphic setting

The Moldavide Basin evolved after the closure of Ceahlău-Severin Ocean, from Cretaceous to Late Eocene, as part of the Tethys Ocean, and from Oligocene on, as part of the Paratethys Sea, its history being presented by Amadori et al. (2012) and Guerrera et al. (2012), based on existing literature. For Oligocene, Miclăuş et al. (2009) proposed a 2D cross section model showing a foreland basin system evolution after Cretaceous tectogeneses during which the easternmost branch of the Alpine Tethys (Schmid et al., 2008) was closed. The Vrancea Nappe sedimentation area was located on the basinward side of the forebulge area (Miclăuş et al., 2009).

The deposits accumulation, in the Moldavide Basin, lasted from Early Cretaceous to Middle-Late Miocene (Băncilă, 1958; Dumitrescu, 1952; Ionesi, 1971; Săndulescu, 1984, 1988; Grasu et al., 1988; Ştefănescu, 1995). The background black shale-type sedimentation was inprinted by two main events: Early Cretaceous Oceanic Anoxia Events (OAE) and Oligocene-Early Miocene isolation of the Paratethys from the Mediterranean Sea after the collision between Africa and Eurasia plates (Rögl, 1998; Steininger and Wessely, 1999; Popov et al., 2002), which is described as an anoxic, euxinic, or both event.

The Bituminous Marls Formation (BM) and their equivalents (Heller Mergelkalk, Dynow Marls) are considered to be sedimented during the maximum isolation of the Parathethys (NP23), being a marker level of Oligocene sedimentary succession (Rögl, 1998; Steininger and Wessely, 1999; Popov et al., 2002), although the age seems to be "not older than late Chattian" (Guerrera et al., 2012).

The Oligocene deposits from Vrancea Nappe are represented by Lower Menilites, Bituminous Marls, Lower Dyssodilic Shales with Kliwa Sandstone, Upper Dyssodilic Shales and Menilites, and Gura Şoimului Formation (known in the Romanian literature).

## 3. Sedimentological observations

The Bituminous Marls is a source rock succession laterally extensive in the Moldavide Basin of Romania, containing a wide variety of lithofacies, although was former described as a monotonous unit of pelagic origin. It is in fact a heterolithic deposit consisting of simple and composite bed-sets with different sedimentary structures from small scale fine lamination, hummocky and swaley-like cross stratification, wavy and lenticular bedding to large scale low angle cross stratification (Miclăuş et al., 2009; Miclăuş and Schieber, 2014). These structures are the results of different processes with low or high energy, from hemipelagic to tractive, and even debris flows. The full suite of

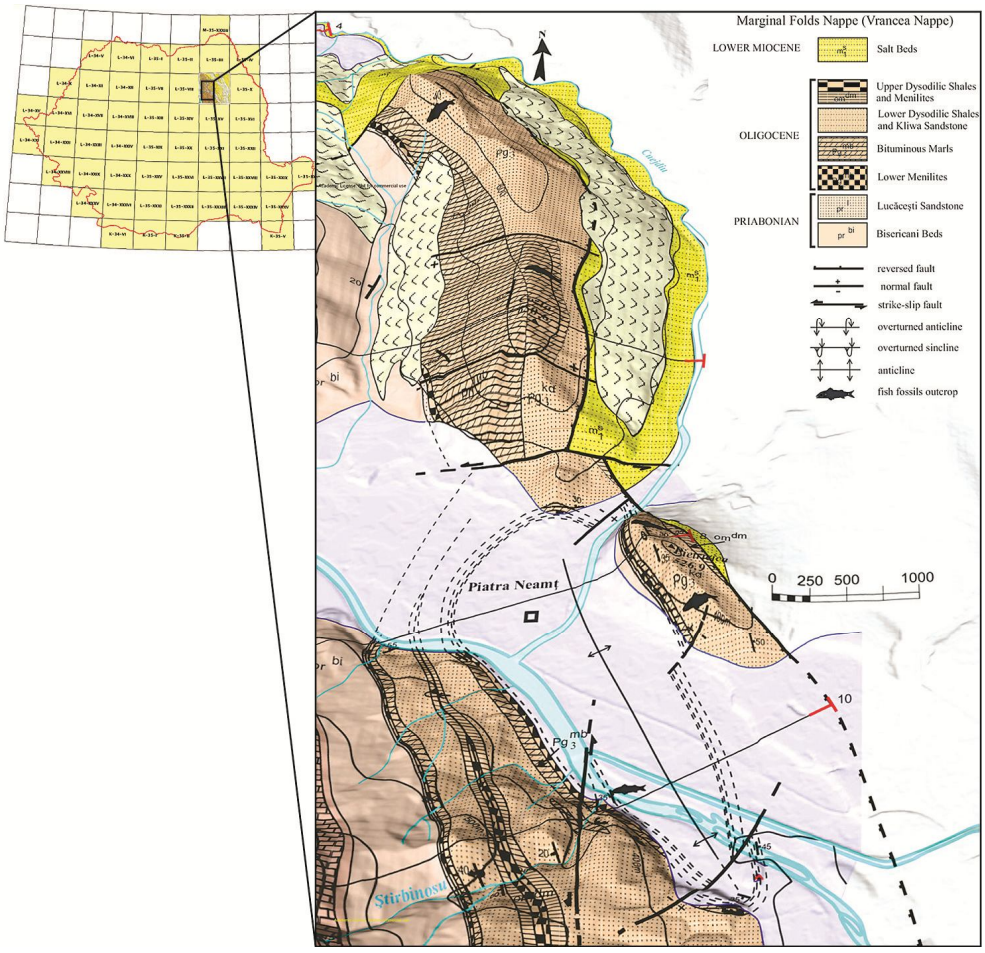


Fig. 1 Geological map of the Piatra Neamţ area with the locations of the fish outcrops (based on Baciu, 2017).

traction-produces muddy bedforms with cm-scale ripples and dm-scale megaripples led to the idea of reworking and bedload transport of sediment arrived at the seafloor via pelagic settling (Miclăuş and Schieber, 2014). The authors mentioned that the bottom current activity is incompatible with previous scenarios of anoxic bottom waters as the cause for preservation of lamination and organic matter.

Aside from primary sedimentary structures, there were also observed deformational meta-depositional structures such as convolute lamination, both in bituminous marls and sandstone interlayers, load casts and flames, and post-depositional structures such as clastic dykes and intraformational slump folds. Some facies are consistent with a slope and deeper water depositional setting, but others suggest that the seabed was from time to time within the reach of storm waves (Miclăuş and Schieber, 2014).

A significant Oligocene fish fauna has been collected from the Bituminous Marls of the Vrancea Nappe in Bistriţa Half-Window (Piatra Neamţ area) (Fig. 1).

Most of the type specimens as well as numerous additional materials from this area have been collected from the Lower Dysodilic Shales and are deposited in the paleontological collection of the Museum of Natural Sciences, Piatra Neamţ (MNSPN-PC).

The collection contains more than 1000 specimens which belong to about 50 species, representing about 20 families. The most important species include sardinas (Clupeidae), bristlemouth (Gonostomatidae), hachetfish (Sternoptychidae), lightfish (Photichthyidae), lanternfish (Myctophidae), codlets (Bregmacerotidae), squirrelfish (Holocentridae), dories (Zeidae), boarfishes (Caproidae), shrimpfish (Centriscidae), bigeyes (Priacanthidae), sharksuckers (Echeneidae), jaks and pompanos (Carangidae), pomfrets (Bramidae), snake mackerels (Gempylidae), cutlassfish (Trichiuridae), mackerels, and tunas (Scombridae), driftfish (Nomeidae), left-eye fluoders (Bothidae), triplespines (Triacanthidae) (Baciu, 2010).

During the geological investigations between 2003 and 2010, three outcrops were discovered. Two of them were situated in the main level of the bituminous marls, on the top of Cozla Mountain (46º 56' 56.19" N, 26º 22' 08.52" E, 640 m.) and Văleni Village (46º 54' 51.49" N, 26º 22' 39.11" E, 304 m.) and the third one, on the Pietricica Mountain, Piatra Neamţ (46º 55' 47.72" N, 26º 22' 51.80" E, 519 m.); the latter is situated in the second level of the Bituminous Marls, considered by Ionesi and Grasu (1993) to be an olistolith (Fig. 1).

## 4. Systematic Paleontology

Class CHONDRICHTHYES Huxley, 1880
Order LAMNIFORMES Berg, 1958
Family ODONTASPIDIDAE J.P. Müller & Henle 1839
Genus *Carcharias* Rafinesque, 1810
*Carcharias acutissima* (Agassiz, 1844)
Fig. 2

1977 *Odontaspis cuspidata* Agassiz, 1844, Ciobanu M., p. 43, pl. VI, fig. 5;
1991 *Carcharias acutissima* (Agassiz, 1844), Pharisat A., p. 21, figs 4 and 5.

Because of the taphonomical context, *Carcharias acutissima* teeths are actually rare in the Oligocene formations of the Vrancea Nappe. In the recent fauna the sand tiger sharks (*Carcharias taurus* Rafinesque, 1810) are worldwide distributed in tropical to temperate continental waters from Atlantic, Indian and Pacific Oceans (Nelson, 2006). Mostly an inshore species, found in shallow waters. However, this species was also recorded down to 191 m, close to the bottom, at the surface, or midwater (Grzimek's Animal Life Encyclopedia 2003).

Family CETORHINIDAE Gill, 1862
Genus *Keasius* Welton, 2013
*Keasius parvus* (Leriche, 1908)
Fig. 3

1977 *Cetorhinus parvus* Leriche, 1908, Ciobanu M., p. 43, pl. VI, figs 1, 2, 3;
1991 *Cetorhinus parvus* Leriche, 1908, Pharisat, p. 24, fig. 9;
2013 *Keasius parvus* (Leriche, 1908), Welton B., p. 39.

*Keasius parvus* gill rakers are frequently found in thin siltic layers of the Bituminous Marls from the Cozla Mountain (Piatra Neamț area).

Basking shark (*Cetorhinus maximus* (Gunnerus)) is the second largest living fish species being found worldwide in marine, warm (rarely subtropical) to cool temperate, continental and insular shelves, possibly oceanic (usually in shallow water); Atlantic (including the Mediterranean and western Barents Sea), Indian (only off western Australia), and Pacific Oceans (Nelson 2006). They are highly migratory, and several individuals may swim in tandem. A filter-feeding shark, capable of taking in massive amounts of zooplankton (Grzimek's Animal Life Encyclopedia, 2003).

Class ACTINOPTERYGII Klein, 1885
Subdivision TELEOSTEI s. Patterson and Rosen, 1977
Order CLUPEIFORMES Bleeker, 1859
Family CLUPEIDAE Bonaparte, 1831
Genus *Sardinella* Valenciennes, 1847
*Sardinella sardinites* (Heckel, 1850)
Fig. 4

1991 *Clupea sardinites* (Heckel, 1850), Pharisat, p. 27, figs 13, 14, 15
2003 *Clupea sardinites* (Heckel, 1850), Gregorovà Růžena and Požár M., p. 195, fig. 3
2006 *Sardinella sardinites* (Heckel), Carnevale et al., p. 686, figs 4.1, 4.2.

A considerable number of Clupeids are found, both in the Dysodilic Shales and Bituminous Marls. Hundreds of clupeids scales are preserved in the thin siltic layers of bituminous marls.

Primarily marine, some freshwater and anadromous; worldwide (mostly tropical). Coastal pelagic species. Found at depths ranging from near the surface down to 200 m. Schools in coastal waters (Nelson, 2006). Stays in deep water during the day but moves to the surface at night. Most migrate to coastal grounds at the onset of spawning seasons. Also migrates north and south, seasonally, to feeding areas and for over wintering.

The Atlantic herring (*Clupea harengus* Schnakenbeck, 1931) range is in Eastern Atlantic Ocean, from the northern Bay of Biscay, northward to Spitzbergen and Novaya Zemlya, and around Iceland and southern Greenland.

Also found in the western Atlantic, from southwestern Greenland, around Labrador, and south to South Carolina. This species is important as prey in the marine food chain, and it is consumed by larger fishes, squids, skates, whales, and seabirds (Grzimek's Animal Life Encyclopedia, 2003).

Order ARGENTINIFORMES Johnson and Patterson, 1996
Family ARGENTINIDAE Bonaparte,1846
Genus *Glossanodon* Guichenot, 1867
*Glossanodon musceli* (Paucă, 1929)
Fig. 5

1929 *Nemachilus musceli* Paucă, p 114;
1967 *Glossanodon musceli* (Paucă), Anna Jermanska, p. 200, figs. 2,4,6-7,9-10;
2003 *Glossanodon musceli* (Paucă), Gregorovà Růžena and Požár M., p. 196, fig. 4;
2005 *Austromallotus musceli* (Paucă, 1929), Prokofiev A.M., p. 10, figs 5, 6.

More than ten complete specimens of *Glossanodon musceli* (Paucă), were discovered in the Bituminous Marls. Small fish, average length between 30 to 40 mm; almost all the specimens are strongly affected by rigor mortis.

Argentinids prefer the outer shelf and upper slope. Marine, mesopelagic entering bathypelagic environments, demersal from 100 to 1400 m. Found on soft bottom, mud, gravel, sand, and rock. Feeds on planktonic invertebrates and euphausiids, small fishes. Only one species, *Argentina silus* (Ascanius, 1775) is important to fisheries, used fresh or in fish meal. Atlantic, Indian, and Pacific Oceans (Carpenter, 2002; Nelson, 2006).

Order STOMIIFORMES Fink and Weitzman, 1982
Family GONOSTOMATIDAE Gill, 1839
Genus *Scopeloides* Wettstein 1886
*Scopeloides glarisianus* (Agassiz, 1844)
Fig. 6

1997 *Scopeloides glarisianus* (Agassiz, 1844), Gregorovà Růžena, p. 123-136, pl. I, figs 1-5, pl. II, figs 1-6;
2005 *Scopeloides glarisianus* (Agassiz, 1844), Prokofiev A.M, p. 99, figs 5, 6;
2006 *Scopeloides glarianus* (Agassiz, 1844), Kotlarczyk et al., p. 28.

Frequently discovered in the Bituminous Marls from Pietricica Mountain and Văleni area. Elongated body with an average length between 100 and 250 mm. On the jaws, long canine teeths, between which considerably smaller and numerous intermediate teeths are positioned. Photophores (luminescent organs) are present.

The gonostomatids occurs throughout Atlantic, but confined to a band at 15–50ºS in Pacific and Indian Oceans. Depth distribution is age-specific: larvae occur

from 9 to 50 m. Adults occur from 250 to 900 m and juveniles in between. Stomiiforms are found over great depths throughout the world's oceans, including the Antarctic seas (but absent in the Arctic Ocean). Highest abundance and diversity is found in tropical seas. Distribution near landmasses is dictated by water depth and are rarely found in waters shallower than 500 m.

Most of the species are mesopelagic, while some others are bathypelagic. Most undergo diurnal migration, swimming from a daytime depth of 490 to 1000 m to near the surface at night, and then back down again before sunrise (Grzimek's Animal Life Encyclopedia, 2003).

Family PHOTICHTHYIDAE Weitzman, 1974
Genus *Eovinciguerria* Prokofiev, 2002
*Eovinciguerria obscura* (Daniltchenko, 1946)
Fig. 7

1977 *Vinciguerria macarovicii* Ciobanu, M. Ciobanu, p. 72, fig. 1, pl. XIX;
2000 *Vinciguerria obscura* (Daniltchenko, 1946), Gregorovà Růžena, p. 153;
2005 *Eovinciguerria obscura* (Daniltchenko, 1946), Prokofiev A.M., p. s123, figs 7,18.

Several small and complete specimens were discovered in the Bituminous Marls from Pietricica Mountain. Average length between 40 and 70 mm. Serial photophores are present and situated on the abdominal part and over the anal fin.

Marine species widely spread in the Atlantic, Indian, and Pacific Oceans; mesopelagic and bathypelagic (*Yarrella* and *Polymetme* may be benthopelagic). Diet consists mainly of zooplankton, crustaceans in particular (Carpenter, 2002).

Order MYCTOPHIFORMES Regan, 1911
Family MYCTOPHIDAE Gill, 1893
Subfamily *Lampanyctinae* Paxton, 1972
Genus *Oligophus* Ruzena Gregorova, 2004
*Oligophus moravicus* (Paucă, 1931)
Fig. 8

2004 *Oligophus moravicus* (Paucă, 1931), Gregorovà Růžena, p. 81-97;
2006 *Oligophus moravicus* (Paucă, 1931), Prokofiev A., p. 64, figs 10-15.

They are the most abundant fish species from the Bituminous Marls (more than 15 very well preserved specimens). On most of the specimens the photophores are visible.

Lanternfishes are small fishes, from 200 to 300 mm, as adults. Typically, the myctophids are widely spread in all oceans, from Arctic to Antarctic (Nelson, 2006). Most species are mesopelagic and found in the upper 1000 m of the water column. Few species are bathypelagic and

live at bigger depths. Some species are associated with continental and island slopes (pseudoceanic). Most species undergo a diurnal migration of several hundred meters. During the daytime, the peak abundance of most species is between 300 and 1,200 m, while at night it is between 10 and 100 m (Nelson, 2006). The only myctophid fisheries have been in the South Atlantic, Gulf of Oman, and Persian Gulf (Grzimek's Animal Life Encyclopedia, 2003).

Order GADIFORMES Goodrich, 1909
Family MERLUCCIIDAE Adams, 1864
Subfamily Merlucciinae Jordan et Gilbert, 1883
Genus *Palaeogadus* Rath, 1859
*Palaeogadus* sp.
Fig. 9

2006 *Palaeogadus* sp., Kotlarczyk J. et al., p. 30

In the Bituminous Marls olistolith from Pietricica Mountain, only one incomplete specimen of *Palaeogadus* sp., has been discovered.

They are marine fishes, Atlantic (both sides and including the Mediterranean Sea and parts of the Black Sea), southwesternmost Indian, eastern Pacific (from British Columbia to tip of South America), and New Zealand (Nelson, 2006), living on the shelf and upper continental slope, from shallow coastal waters to more than 1000 deep; most species, if not all, migrate vertically at night, to feed; seasonal onshore-offshore migrations are also documented. All species are voracious predators, the youngest ones feed predominantly on invertebrates (crustaceans, especially euphausiids and pandalids), while the adults feed mainly with fish and cephalopods (Grzimek's Animal Life Encyclopedia, 2003).

Order PERCIFORMES *sensu* Johnson and Patterson, 1993
PERCOIDEI *incertae familiae*
Genus *Oliganodon* Bannikov, 2010
*Oliganodon budensis* (Heckel, 1856)
Fig. 10

1991 *Serranus budensis* (Heckel, 1856), Pharisat A., p. 44, figs 32, 33;
2010 *Oliganodon budensis* (Heckel, 1856), Bannikov A.F., p. 86, pl. VII, figs 2, 3.

Several specimens were discovered in the Bituminous Marls from Pietricica Mountain.

The more or less elongated body of fossils specimens has small ctenoid scales, large mouth, and the caudal fin is generally straight-edged or rounded. The dorsal fin, a diagnostic feature, consists of a forward, spiny section and a hinder, soft-rayed section; the two portions are usually joined

but may be separated by a notch.

Mostly demersal (benthic or bottom-oriented) fishes of tropical and subtropical areas, ranging from shallow coastal waters to moderate depths, they are predators, feeding on invertebrates (mainly crustaceans and cephalopods) and fishes; some species have long, numerous gill rakers being thus adapted for feeding on zooplankton (Carpenter, 2002).

Suborder ACANTHUROIDEI
Family CAPROIDAE Lowe, 1843
Genus *Proantigonia* Gorjanovic-Kramberger, 1882
*Proantigonia cosmovicii* Baciu, Bannikov and Tyler, 2005
Fig. 11

2005 *Proantigonia cosmovicii* Baciu, Bannikov and Tyler, 2005a, p. 14, figs 1, 2.

Four specimens were discovered in the Bituminous Marls from Pietricica Mountain. Small fossil species with an average length between 15–25 mm. The body is covered with scales bearing needle-like laterally projecting spines on their surface.

Extant caproids (boarfishes) are benthopelagic, live near rocky bottom in depths of 65 to 600 m and occur in relatively small schools. Feed on plankton and benthic invertebrates (Carpenter 2002).

Suborder SCOMBROIDEI Bleeker, 1859
Family TRICHIURIDAE Rafinesque-Schmaltz, 1810
Genus *Anenchelum* de Blainville, 1818
*Anenchelum glarisianum* de Blainville, 1818
Fig. 12

1995 *Anenchelum glarisianum* Blainville, 1818, Bannikov and Parin;
2003 *Anenchelum glarisianum* Blainville, 1818, Gregorovà Růžena and Požár M., p. 200, fig. 5a.

Common species in the Bituminous Marls from the Piatra Neamț area. Complete specimens are very rare.

The fossil trichiurids has strongly elongated body with a very slender caudal peduncle. Greatest body depth contained 18–19 times in standard lenght. The trichiurids (cutlassfishes) are marine fishes, ussualy present in the Atlantic, Indian, and Pacific Oceans (Nelson, 2006); benthopelagic on continental shelves and slopes, and underwater rises from surface to about 1,600 m. deep. Voracious predators feeding on fishes, squids, and crustaceans (Carpenter, 2002).

Family SCOMBRIDAE Rafinesque-Schmaltz, 1815
Genus *Auxides* Jordan, 1919
*Auxides cernegurae* (Ciobanu, 1970)
Fig. 13

1970 *Pinulothunnus cernegurae* Ciobanu, p. 83, pl. V, fig. 1;
1977 *Pinulothunnus cernegurae* Ciobanu, Ciobanu M., p. 125, pl. XLVI, fig. 1.
1985 *Scombrosarda cernegurae* (Ciobanu, 1977), Bannikov A.F., p. 19, fig. 1;
2010 *Auxides cernegurae* (Ciobanu), Bannikov A.F., p. 136, pl. XX II, fig. 4.

Extremely rare species, discovered in the Bituminous Marls from the Văleni area. Marine (rarely freshwater), tropical and subtropical seas (Nelson, 2006). Typical scombrids with two dorsal fins and a series of finlets behind the rear dorsal fin and anal fin. The caudal fin is strongly divided and rigid.

The scombrids represent a diverse group of pelagic fishes. Some smaller species inhabit coastal waters while the larger ones, especially *Thunnus maccoyii*, *T. obesus*, *T. alalunga*, and *T. tonggol* carry out wide, transoceanic migrations (Carpenter, 2002).

Order PLEORONECTIFORMES Bleeker, 1859
Suborder PLEURONECTOIDEI Bleeker, 1859
Family SCOPHTHALMIDAE Chabanaud, 1933
Genus *Scophthalmus* Rafinesque, 1810
*Scophthalmus stamatini* (Paucă, 1931)
Fig. 14

2002 *Scophthalmus stamatini* (Paucă, 1931), Baciu and Chanet, p. 17-38, Fig. 3

Flatfish fossils are occasionally found in the Oligocene formations from the Piatra Neamt area. Baciu and Chanet (2002) described the oldest known scophthalmid, *Scophthalmus stamatini* (Paucă, 1931), from the Bituminous Marls (Lower Oligocene, Pietricica Mountain near Văleni). Nine specimens of *Scophthalmus stamatini* (Paucă, 1931), have been discovered.

Marine species (occasionally in brackish water), northern Atlantic and Baltic, Mediterranean and Black seas (Nelson, 2006). The Scophthalmids prefer shallow, inshore waters from the high tide line down to about 200 m, with the greatest numbers occurring at depths of less than 55 m. They occur most often on sandy bottoms but also can be found on softer and muddier sediments. Diurnally active. Often lie on or within sandy sediments (Grzimek's Animal Life Encyclopedia, 2003).

## 5. Conclusions

Palaeoichthyology is considered a relatively precise tool for determining the depth of deposition of ancient sediments (Gaudant, 1979). The comparative bathymetrical method uses the bathymetrical distribution of recent fishes most closely related to the fossils studied. Gaudant (1979)

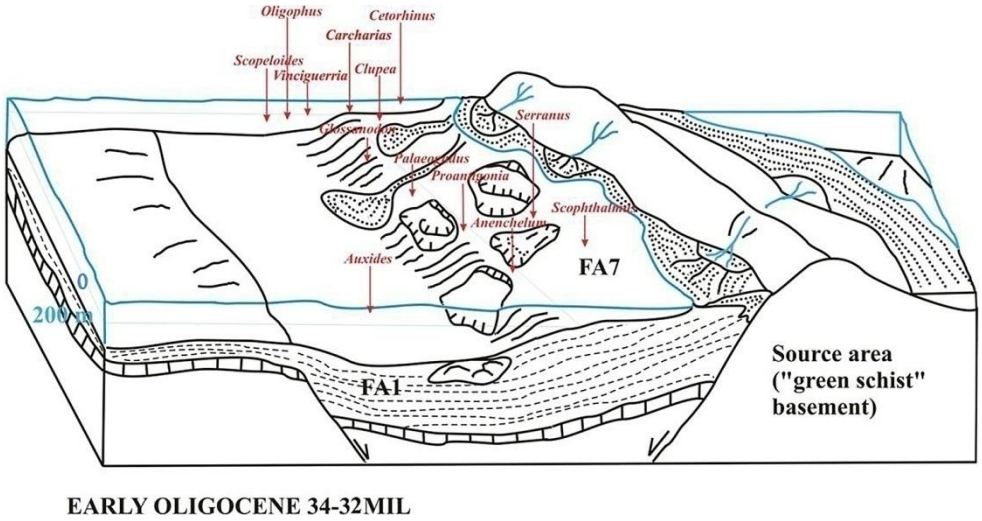


Fig. 15 The distribution of the fish genera in oceanic basin.

considers that it is possible to interpolate the ecological characters between recent and fossil fish fauna, until the level of the family. Palaeoecological analysis does not lead always to unequivocal solutions. Not all families have their representatives living exclusively in one, strictly defined ecological environment, for example deep-water pelagic or deep-water bentho-pelagic. There are some genera of the same family that inhabit one biotop while other one are confined to another biotope.

From Bituminous Marls, 13 species were identified; they belong to 13 families and 8 orders, among which: mesopelagic with vertical migration – *Scopeloides*, *Eovinciguerria*, *Oligophus*; shallow-water – *Cetorhinus*, *Clupea*; benthopelagic fishes living on the outer shelf and upper slope – *Glossanodon*, *Anenchelum*, *Palaeogadus*, *Proantigonia*; epipelagic zone – *Auxides*; associated with the sea bottom on continental shelf – *Carcharias*, *Oliganodon*, *Scophthalmus* (Fig. 15).

The sedimentary features of Bituminous Marls indicate a basin affected by tectonic deformations and gravitational collapses. This may be the source of coarse material, which supplied occasionally the muddy shelf system via hyperpicnal flows, induced by storm or turbiditic currents and started by floods or storms.

In such cases, the fish specimens do not provide precise ecological constrains, but together with sedimentological investigations and with the discovery of new fish fossils species, is possible to reconstruct the bathymetry of the sea floor during the sedimentation of the Bituminous Marls.

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Fig. 2 *Carcharias acutissima* (Agassiz, 1844), MSNPN-PC No. 96, Bituminous Marls, Pietricica Mountain.

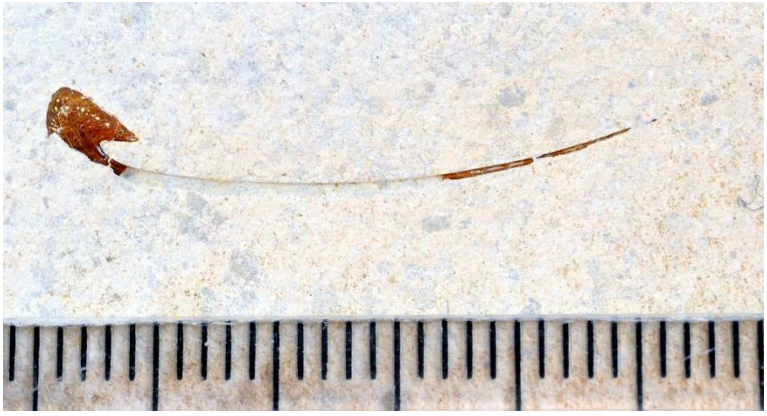

Fig. 3 *Keasius parvus* (Leriche, 1908), MSNPN-PC No. 893, Bituminous Marls, Văleni Village.

Fig. 4 *Sardinella sardinites* (Heckel), MSNPN-PC No. 894, Bituminous Marls, Văleni Village.

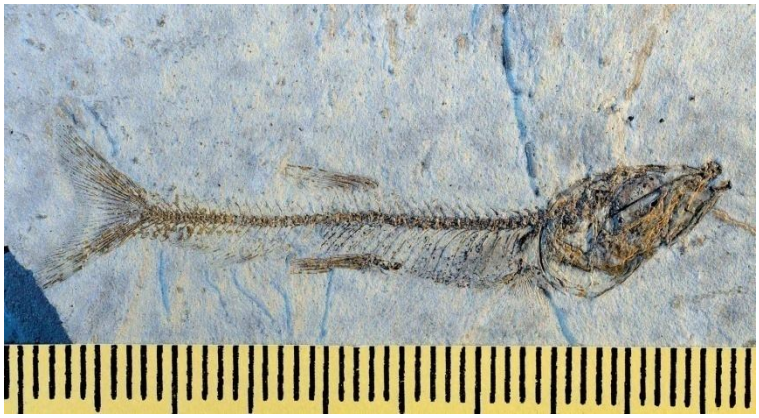

Fig. 5 *Glossanodon musceli* (PAUCĂ, 1929), MSNPN-PC No. 524, Bituminous Marls, Pietricica Mountain.

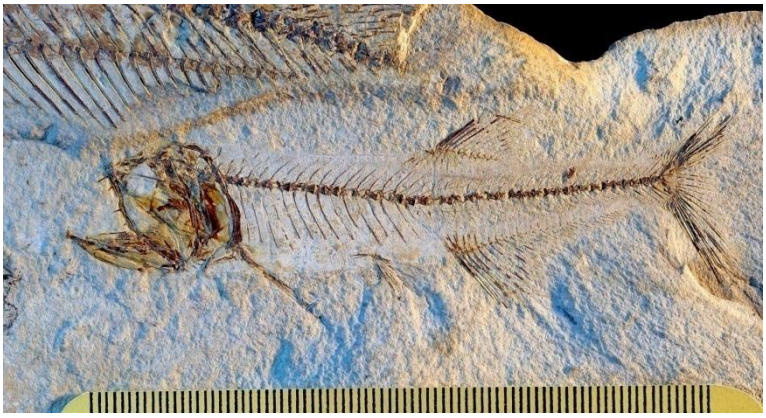

Fig. 6 *Scopeloides glarisianus* (Agassiz, 1844), MSNPN-PC No. 113, Bituminous Marls, Pietricica Mountain.

Fig. 7 *Eovinciguerria obscura* (Daniltchenko, 1946), MSNPN-PC No. 122, Bituminous Marls, Pietricica Mountain.


Fig. 8 *Oligophus moravicus* (Paucă,1931), MSNPN-PC No. 895, Bituminous Marls, Pietricica Mountain.

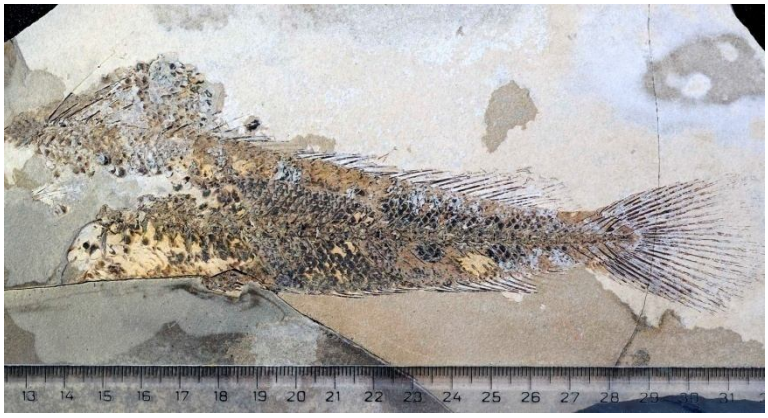


Fig. 9 *Palaeogadus* sp. Rath, 1859, MSNPN-PC No. 896, Bituminous Marls, Pietricica Mountain.

Fig. 10 *Oliganodon budensis* (Heckel, 1856), MSNPN-PC No. 892, Bituminous Marls, Pietricica Mountain.

Fig. 11 *Proantigonia cosmovicii* Baciu, Bannikov and Tyler, 2005, MSNPN-PC No. 577, Bituminous Marls, Văleni Village.

Fig. 12 *Anenchelum glarisianum* Blainville, 1818, MSNPN-PC No. 897, Bituminous Marls, Pietricica Mountain.

Fig. 13 *Auxides cernegurae* (Ciobanu, 1970), MSNPN-PC No. 158, Bituminous Marls, Văleni Village.

Fig. 14 *Scophthalmus stamatini* (Paucă, 1931), MSNPN-PC No. 227, Bituminous Marls, Pietricica Mountain and Văleni Village.