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THE BEGINNINGS OF THE SARGASSO ASSEMBLAGE IN THE TETHYS?

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ABSTRACT

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An assemblage of organisms, here termed "quasi-Sargasso", occurs in the Oligocene menilite beds of the Carpathian flysch. It is suggested that this assemblage migrated into the Atlantic Ocean, probably during the Miocene. Its further evolution, which gave rise to the present-day Sargasso assemblage, took place in the middle Atlantic area.

INTRODUCTION

The menilite beds of Late Eocene to Early Miocene age in the Carpathian flysch have yielded rich ichthyofaunal assemblages. Together with palaeontologically similar Iranian, Caucasian, Swiss, Bavarian, Italian, and Algerian material, these assemblages record the development of the Tertiary ichthyofauna of the Tethys over a wide area.

The term *menilite beds* is commonly used as the name of the informal lithostratigraphic division unit. The menilite beds consist of brown/black siliceous—argillaceous shales, siltstones and banded cherts. Thick-bedded sandstones are less frequent. As a result of systematic sampling of the menilite beds layer by layer over a number of years, investigations of the Carpathian ichthyofauna of Poland have provided new and interesting results. It has been shown that particular layers (fish horizons) contain assemblages of bathypelagic or sublittoral-neritic genera with definite ecological requirements. These assemblages vary in composition in a systematic manner, which suggests that the ecological changes may have been caused by changes in basin depth. The results of previous studies permit formulation of a hypothesis of two bathymetric changes within the basin of menilite deposition, in view of the succession of assemblages from bathypelagic to neritic-sublittoral and back again to bathypelagic (Jerzmańska, 1968; Jerzmańska and Kotlarczyk, 1968).

Geographic change in the ichthyofaunal assemblages is somewhat complicated by facies change, whereby the upper part of the menilite beds (contain-

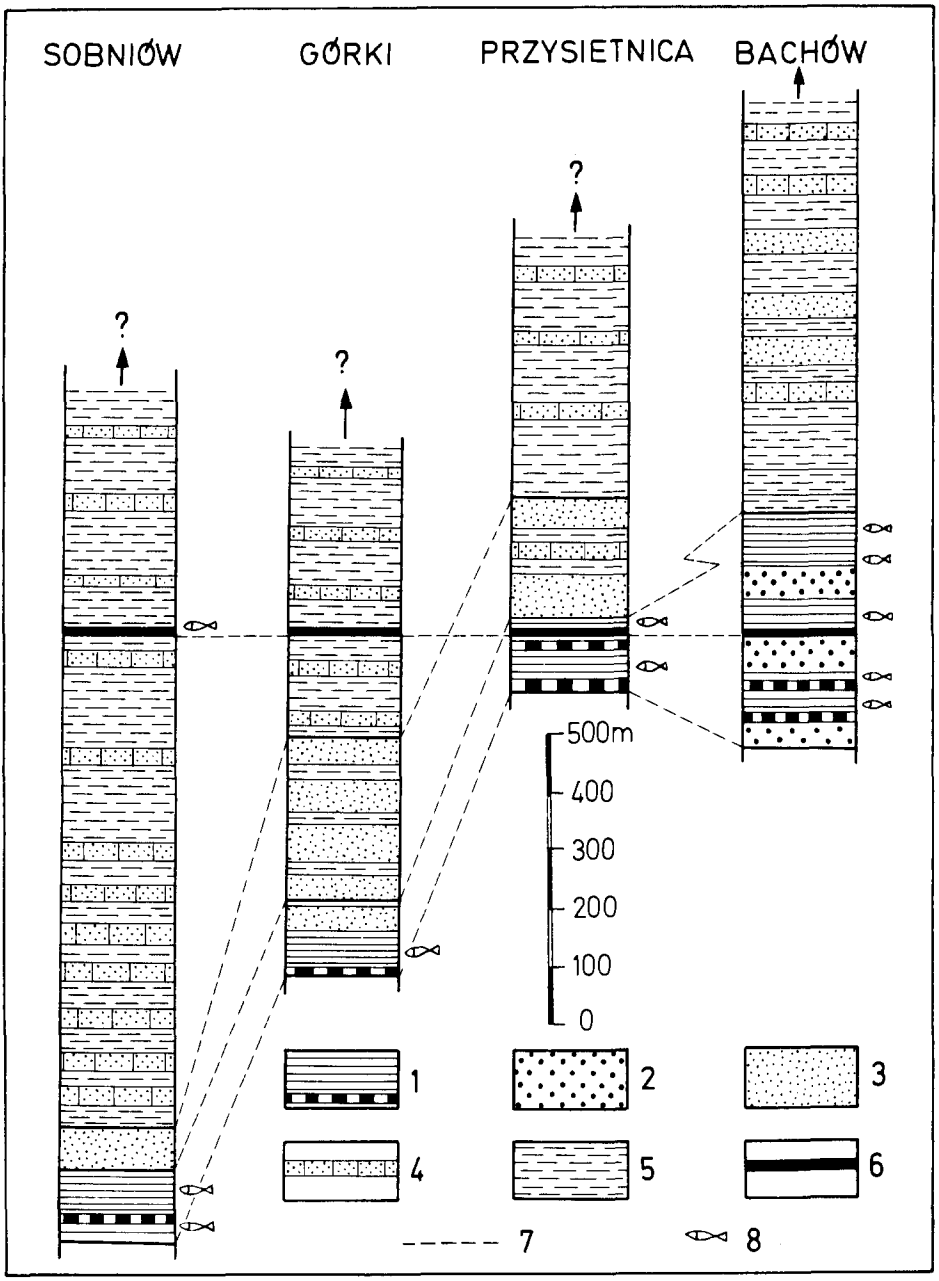

Fig. 1. Thickness changes of the menilite beds and the Krosno beds in the Polish Carpathians from the marginal (right) to the central (left) part of the sedimentary basin. Legend: non-flysch menilite beds — *1* = brown siliceous-argillaceous shales with cherts; *2* = thick-bedded white Kliwa quartzarenites (fluxoturbidities); flysch Krosno beds — *3* = thick-bedded calcareous sandstones; *4* = thin-bedded calcareous sandstones (turbidities); *5* = grey marly shales; *6* = key bed: horizon of the Jasło shales (laminated limestones); *7* = correlation lines of lithostratigraphical members; *8* = layers with ichthyofauna.

ing the upper bathypelagic assemblages) in the outer part of the basin is replaced by a thick sandstone—shale complex (Krosno beds) in the central part of the basin. These facies have in common the calcareous Jasło shales, which were recognized as an excellent isochronous key bed (Fig.1) (Jucha and Kotlarczyk, 1961; Koszarski and Żytko, 1961; Jucha, 1969). This horizon contains a rich, bathypelagic ichthyofauna (Jerzmańska, 1960; Jerzmańska and Jucha, 1963). The lower bathypelagic assemblage, frequently encountered in the thin sequence of shales with cherts, and the neritic-sublittoral assemblage have a wide distribution in the menilite beds of the Polish Carpathians.

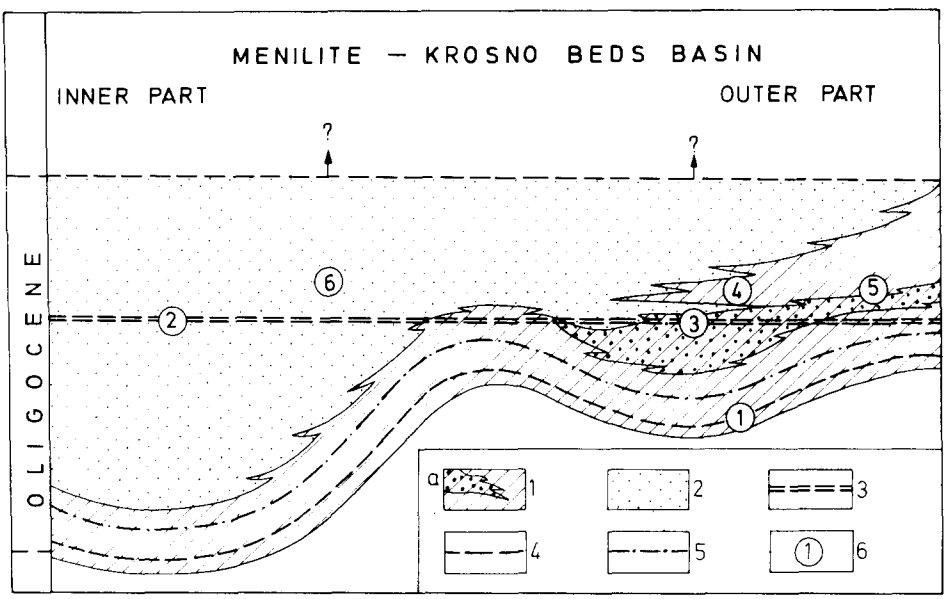

Fig.2. Ideogram of the facies changes in the Oligocene sedimentary basin of the outer Carpathian flysch.
Legend: *1* = menilite shales with the Kliwa sandstones (*a*); *2* = Krosno beds (Ždanice beds); *3* = Jasło shales, chronohorizon; *4* = limit between lower bathypelagic and sublittoral-neritic fish assemblages; *5* = limit between sublittoral-neritic and upper bathypelagic fish assemblages; *6* = encircled numerals indicate the stratigraphic position of important exposures with fish assemblages in sections at *1*, Jamna, *2*, Sobniów, *3*, Łubno, *4*, Bachów, *5*, Piatra Neamţ, and *6*, Krumvíř.

However, the upper bathypelagic assemblage can be traced mainly in those places where younger deposits, belonging to the menilitic facies, occur. Where the siliceous shale of the menilitic facies is replaced by the sandstone—shale Krosno facies, the upper bathypelagic assemblage is represented mainly in the Jasło shales (Fig.2). Because the age of the Jasło shales was earlier determined as Lattorfian (Tongrian), it follows that the upper bathypelagic assemblage cannot be older than Lattorfian; its upper limit may reach to the Early Miocene.

The upper bathypelagic assemblage has been the subject of detailed study in recent years. It consists of representatives of bathypelagic fish families (Gonostomatidae, Sternoptychidae, Myctophidae, Gempylidae) and pelagic fishes (Clupeidae, Trichiuridae). This assemblage undergoes certain changes with time. The greatest surprise was provided by the fact that in the upper part of the menilite beds there is a mixed ecological assemblage with a high proportion of shallow-water fishes of the family Syngnathidae, comprising up to 1/3 of all fish skeletons found.

The present authors had previously noted that only a small proportion of fishes belonging to shallow-water genera (mainly juvenile individuals) were mixed with the bathypelagic assemblages. Only 5 out of 166 specimens collected in the deposits of the lower bathypelagic horizon (at the Jamna locality) (Figs. 2, 3), were represented by shallow-water fishes, the remainder

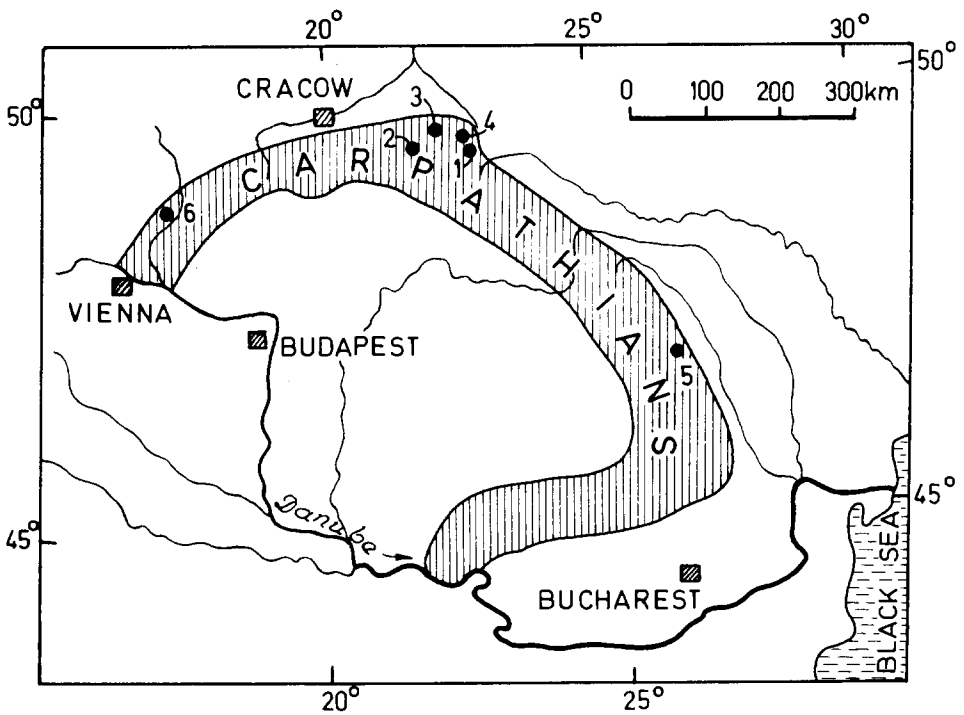

Fig.3. Distribution of localities (black dots) with important fish assemblages in the Carpathian belt: *1*, Jamna; *2*, Sobniów; *3*, Łubno; *4*, Bachów; *5*, Piatra Neamț; *6*, Krumvíř.

being bathypelagic and pelagic (Jerzmańska and Kotlarczyk, 1968). In the Jasło shales at the Sobniów locality (Fig.3), only one specimen out of 261 fishes collected represented a shallow-water form, the rest belonging to pelagic and bathypelagic forms (Jerzmańska, 1960). The samples are considered representative (Jerzmańska et al., 1973), and it may be assumed that

the occurrence of shallow-water fishes is accidental and atypical for the assemblage. Probably living individuals were carried away from their normal environment by marine currents.

In the material of the upper part of menilite beds, the possibility of accidental mixing of the skeletons of shallow-water and bathypelagic fishes forming the fossil assemblages, should be excluded (Jerzmańska et al., 1973). The discovery of numerous brown algae (Phaeophyta), occurring together with the fish skeletons, suggests a possible explanation of this phenomenon. The algae probably formed large concentrations, that included different genera, at the surface of the sea (Jerzmańska and Kotlarczyk, 1975). Some of these algae had air bladders without stems, inserted in the branches (Fig.4).

Fig.4. Fossil brown algae from fish-bearing Oligocene beds of the Carpathians (parts of thallus showing air bladders without stems) and a fragment of *Lepidopus isopleurus* Ag. skeleton; ca. × 1·5. (Photo by Z. Staniewski.)

Other algae are similar, in outline of the thallus, to certain pelagic forms belonging to the modern genus *Sargassum* (Fig.5). In the material studied no signs of holdfasts or attachment devices were observed.

Comparison of the fish genera in fossil assemblages, belonging to the top part of the upper bathypelagic horizon, with those from recent marine biocoenoses shows that the similar, net faunal compositions occur only in the Sargasso Sea, where there is a depth zonation of genera (Timmermann, 1932; Beebe, 1937). The ichthyofauna, associated with the floating weeds, drifts

above the depths of a few thousand metres, occupied by various deep-water forms. It follows that in the thanatocoenoses, which might be formed at present on the bottom of the Sargasso Sea, brown algae (*Sargassum*), pelagic and bathypelagic fishes as well as crabs and fishes of shallow-water types could be expected to be present. It is known that the species *Syngnathus pelagicus*, otherwise known from the shallow, coastal waters of Africa and America (Fowler, 1936), is prominent among the shallow-water fishes of the Sargasso Sea (Timmermann, 1932). In the deeper waters of the Sargasso Sea the bathypelagic fishes belong to families such as the Gonostomatidae, Myctophidae and Sternoptychidae (Beebe, 1937). The possibility of deposition of weed on the sea floor at depths down to 5000 m was demonstrated by the research of Schoener and Rowe (1970).

Fig.5. Fossil brown algae from fish-bearing Oligocene beds of the Carpathians (outline of the thallus similar to certain pelagic forms of the genus *Sargassum*); ca. × 0·75. (Photo by Z. Staniewski.)

The conclusion that the association of fossil brown algae with shallow-water, pelagic and bathypelagic fishes is not an accident, but reflects conditions comparable to those in the present-day Sargasso Sea, was based on material from a few localities in the eastern part of the Polish Carpathians. We have termed this assemblage "quasi-Sargasso" (Jerzmańska and Kotlarczyk, 1975). The most representative locality is at Bachów (Fig.3), where out of 1193 fishes found in seven layers in a packet about 1.5 m thick, 390 belong to the species *Syngnathus incompletus* Cosmovici. The latter shows some morphological similarities to the living species *Syngnathus pelagicus* (Jerzmańska and Kotlarczyk, 1975).

OLIGOCENE FISH/ALGAE ASSEMBLAGES ELSEWHERE IN THE CARPATHIANS

In spite of the lack of quantitative studies of fishes described in detailed accounts of sections in other parts of the Carpathians, it seems probable that similar assemblages occur at Piatra Neamt, Rumania, and Krumvíř, Czechoslovakia (Fig.3).

A few sections of the menilite beds at Piatra Neamţ (Cozla, Petricica) are

characterized in the upper part by the presence of numerous individuals of *Syngnathus incompletus* Cosmovici (Simionescu, 1905). From this locality, numerous bathypelagic fishes were later described. According to Paucă (1931), Cosmovici and Paucă (1943) and Ciobanu (1969), the following families are represented in the upper menilite shales: Clupeidae, Gonostomatidae, Sternoptychidae, Myctophidae, Trichiuridae, Carangidae, Echeneidae, and Syngnathidae. Therefore, this assemblage is in general terms similar to the upper bathypelagic assemblage defined by the present authors. In Simionescu's (1905) account of the Rumanian assemblage, it is significant that he illustrates an association of fish with unnamed algae.

In the Oligocene marls at Krumvíř (Moravia), also numerous individuals of *Syngnathus incompletus* occur together with algae (Kalabis, 1957), as well as bathypelagic fishes with light organs (V. Kalabis, pers. comm., 1968). These marls belong to the Ždánice beds (lithological equivalents of the Krosno beds), and are taken to be a facies variant of the upper part of the menilite beds and as the equivalent of strata containing the top part of the upper bathypelagic assemblage. Picha and Stranik (1963) recognized the local representatives of the Jasło shales among the beds mentioned above. It should be pointed out that the marls containing the fauna exhibit very thin, parallel lamination and, from a sedimentological point of view, resulted from tranquil pelagic sedimentation, as do the Jasło shales.

BIOGEOGRAPHIC SIGNIFICANCE OF THE "QUASI-SARGASSO" ASSEMBLAGE

The facts presented above permit formulation of the hypothesis that probably in the Middle Oligocene, when the deposits of the upper part of the menilite beds and equivalent facies were being formed, a new assemblage of organisms appeared within the upper bathypelagic assemblage in the Carpathian basin. This assemblage was similar in composition and character to the one presently existing in a few vertical zones in the Sargasso Sea (Table I). The question arises as to whether this Oligocene "quasi-Sargasso assemblage" could help provide an explanation for the genesis of the present-day Sargasso assemblage.

The fauna discussed above belongs to a typical Oligocene ichthyofauna, almost half of which comprises genera existing at present in the Mediterranean, and in the middle Atlantic (Arambourg, 1965). However, it is necessary to take into account the difficulty or even impossibility of establishing specific identities of Oligocene fossils and living forms. Besides evolutionary changes, which must have occurred in the period of 36 million years, a great obstacle to identifications of this kind is the absence of taxonomic criteria relating to the soft parts of fishes. On account of these difficulties, our considerations will be of a hypothetical nature. Nevertheless, it is fascinating to look for the beginnings of the Sargasso assemblage in such distant times. For years, the coasts of America were taken as the source of the drifting algae and the fauna accompanying them. It was thought that currents played a

major role in continuously supplying algae, torn from the Central American coast, and in making up losses, caused by the decay of thalli. This hypothesis was invalidated by the work of Winge (1923) and Parr (1939). Parr's main objections related to the absence of large areas which could be the potential source of the drifting populations, and the absence from the littoral zone of the drifting species *Sargassum fluitans* and *S. natans*, which form the major part of the Sargasso Sea flora.

TABLE I

Comparison of the ichthyofaunal composition in the Sargasso Sea and the Carpathian upper menilite basin

	Sargasso Sea assemblage	Quasi-Sargasso assemblage[3]
Typical shallow-water fishes		
Syngnathidae	present[1]	present
Antennariidae	present[1]	absent
The most abundant deep-water fishes		
Gonostomatidae	present[2]	present
Myctophidae	present[2]	present
Sternoptychidae	present[2]	present

[1] After Timmermann (1932); [2] after Beebe (1937); [3] after Jerzmańska and Kotlarczyk (1975).

Of course, these arguments cannot be extended back through geological time, and the possibility that the Sargasso assemblage started to form in this manner, e.g. during Oligocene times, cannot be excluded. Indeed the occurrence of the vegetatively reproduced algae (Parr, 1939) in the Sargasso Sea proved the long-time evolution of the Sargasso assemblage. One could accept the hypothesis that the Sargasso assemblage is of North Atlantic origin. No fossil records of the earliest evolutionary link, however, were found in this area. It seems correct to consider the alternative hypothesis that the Sargasso-like assemblage has appeared in another vicinity, i.e. in the Tethys Sea. Most probably, favorable paleogeographic and climatologic conditions occurred in the Carpathian sector of the Tethys. The coasts of the Carpathian basin and its cordilleras supplied different genera of algae, which were torn loose from the sea bottom, prior to transport by the currents. Some algae probably underwent change into forms capable of existing in new pelagic conditions. Simultaneously, the pelagic waters could have been colonized by the littoral fauna accompanying the algae. This evolution lasted for at least 12 million years.

The next trace of the occurrence of the quasi-Sargasso assemblage in the Tethys Sea is to be found in the Upper Miocene of Sicily. The calcareous dia-

tomites (tripoli) at Bessima contain predominantly bathypelagic and pelagic fishes (e.g., Myctophidae, Sudidae, Trichiuridae) and a marked "admixture" of Syngnathidae (over 10%: Leonardi, 1959). J. Kotlarczyk, during field work with Dr. Di Geronimo at Bessima in 1972, found hitherto unnoted fossil algae, similar to the ones occurring in the Carpathians, associated with numerous fishes.

It is suggested that the quasi-Sargasso assemblage migrated into the Atlantic Ocean before its primary habitat was destroyed by the final Alpine folding at the end of the Miocene. In the centre of the North Atlantic circular current further evolution could have taken place, resulting in the present-day Sargasso assemblage. Our hypothetical explanation of the genesis of the Sargasso assemblage is in accordance with the fossil records of the immigration of the Tethyan forms to the Caribbean region (Fell, 1967).

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