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Additional data on the organic communities and facies development of the Korytnica basin (Middle Miocene; Holy Cross Mountains, Central Poland)

ABSTRACT: The results of new investigations on the diverse groups of fossils from the world-famous Korytnica Clays and associated deposits extend the previous recognition of the organic communities and its dependence upon environmental conditions that prevailed during the Middle Miocene (Badenian) development of the Korytnica basin, situated on the southern slopes of the Holy Cross Mountains, Central Poland. Within these limits, commented and/or discussed are the new data, obtained by the present authors or by the other students, on such animal groups as some foraminifers, boring bryozoans, some brachiopods and ostracodes, decapod crustaceans, some mollusks (chitons, gastropods, pelecypods), fish otoliths and some teeth or bone fragments, and finally some trace fossils attributable to the polychaetes. Ecological requirements and/or adaptations in some of these groups are also considered, the same as the biologic relationships between the particular groups, and composition of some organic communities. A special attention is paid to those fossils which are indicative of tropical and/or subtropical climatic conditions, as well as of their Indo-Pacific affinities.

INTRODUCTION

The aim of the present paper is to show some new results of investigations on the diversified fossils and their assemblages from the Middle Miocene (Badenian) Korytnica Clays developed within the Korytnica basin on the southern slopes of the Holy Cross Mountains, Central Poland. This paper opens a special issue of ACTA GEOLOGICA POLONICA (Vol. 29, No. 3; Warsaw 1979) devoted to the stratigraphy, paleontology and ecology of the Korytnica sequence, and it continues

the series which began in 1977 in the same journal (ACTA GEOLOGICA POLONICA, Vol. 27, No. 2). This former issue comprised a general paper on the organic communities and facies development of the Korytnica basin (Bałuk & Radwański 1977), and systematic descriptions of the calcareous nannoplankton (*by* Martini), some large-sized foraminifers (*by* Walkiewicz), free-living bryozoans (*by* Bałuk & Radwański), brachiopod assemblage (*by* Barczyk & Popiel-Barczyk), cuttlefish (*by* Bałuk), holothurian assemblage (*by* Walkiewicz), echinoids (*by* Mączyńska), and some fish (*by* Schultz); moreover, there were also presented reports on large pinnid pelecypods (*by* Jakubowski), burrows attributable to the ghost crabs (*by* Radwański), and on the synecology of macrobenthic assemblages recognized in the clays (*by* Hoffman).

This issue of ACTA GEOLOGICA POLONICA contains the results of the completed studies on the decapod crustaceans (Förster 1979 b), fish otoliths (Śmigielska 1979), fish teeth and bone material (Schultz 1979), and on the ecology of boring-inhabiting pelecypods *Sphenia anatina* (Basterot), their taxonomy and distribution in the Neogene deposits of Europe (Bałuk & Radwański 1979 a); moreover, presented are contributions on the boring ctenostomate bryozoans (Bałuk & Radwański 1979 b), on diverse trace fossils attributable to the polychaetes (Kern 1979, Bałuk & Radwański 1979 c), on the ecological analysis of the previously recognized macrobenthic assemblages (Hoffman 1979), and on the regional correlation of the Korytnica Clays with the other lithostratigraphic units of the Fore-Carpathian Depression (Alexandrowicz 1979).

Of the other groups of the invertebrate fossils collected from the Korytnica Clays by the present authors (*see* Bałuk & Radwański 1977, p. 86 and pp. 96—99), some remain still under investigation (small foraminifers, corals, tubular polychaetes, non-boring bryozoans, ostracodes, cirripedes, pelecypods, crinoids) or are ready to be taken for their research (starfish, and a scant material of ophiuroids). The completion of all these studies is expected in a few forthcoming years, and then it will be possible to present general considerations upon the character of the Korytnica fossils and their bearing upon the recognition of diverse environmental conditions prevailing during the Middle Miocene time in Europe.

The Korytnica fossils and their assemblages have recently been taken commonly for comparisons by the students of diverse Neogene faunas of Europe. The results of these studies (Benson 1976a,b; Davoli 1976, 1977; Laghi 1977) are commented and/or discussed in one of the following chapters. On the other hand, some special studies on the Korytnica fossils have also been undertaken in Poland, primarily on the ecology of selected groups or species, and their results are published elsewhere (Hoffman 1978a,b,c).

In this paper reminded is the general situation of the Korytnica basin, and it is followed by remarks on some newly investigated fossils, their ecology and paleogeographic significance. A special attention is paid to describe the history of the scientific investigations at Korytnica, as the 200th Anniversary of its discovery approaches soon.

GENERAL DATA ON THE KORYTNICA BASIN

The Korytnica basin is a small, *c* 5 sq km terminal part of a larger bay, the Korytnica Bay (*cf.* Text-fig. 1) which developed during the Middle Miocene (Badenian) transgression on the southern slopes of the Holy Cross Mountains in Central Poland. Its setting, development and history of its sedimentary sequence were analysed formerly (Bałuk & Radwański 1977). In this place, a short outline is given for the new readers to whom also the three paleogeographic sketchmaps from the previous report (Bałuk & Radwański 1977) are reproduced (Text-fig. 1).

The Middle Miocene (Badenian) transgression to which the Korytnica basin was confined, encroached the area of the Fore-Carpathian Depression in Southern Poland (*cf.* Text-fig. 1*B*)

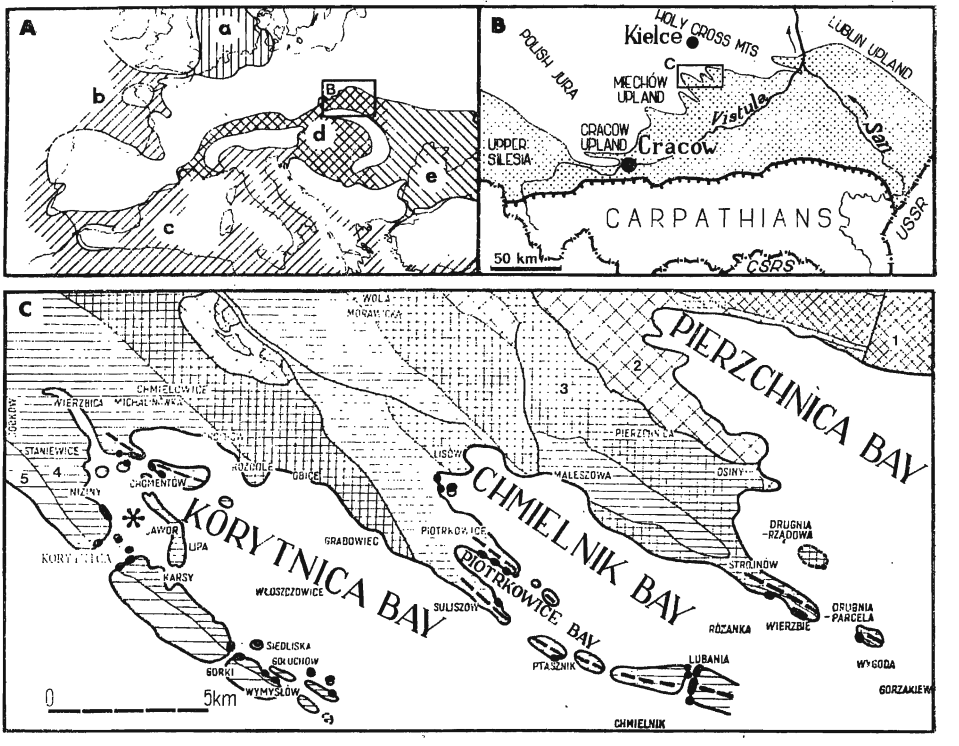

Fig. 1. Paleogeographic setting of the Korytnica basin

A — Marine basins in the Middle Miocene of Europe: *a* North Sea Basin, *b* Atlantic gulfs (Brittany, Touraine and Anjou Basin, Aquitanian Basin, Lisbon Basin), *c* Western Mediterranean Basin (=Tethys Basin), *d* Paratethys basins, *e* Euxinian Basin; rectangled is the area enlarged in Text-fig. 1*B*

B — Extent of the Middle Miocene (Badenian) sea in the Fore-Carpathian Depression (*stippled*); rectangled is the area enlarged in Text-fig. 1*C*

C — Middle Miocene (Badenian) shoreline and extent of the bays on the southern slopes of the Holy Cross Mountains; preserved localities of littoral structures are marked with black spots along the shoreline; asterisked is the Korytnica basin situated in the terminal part of the Korytnica Bay

Within the inland area distinguished are the occurrence zones of: *1* Cambrian (including locally Ordovician and Silurian), *2* Devonian, *3* Triassic, *4* Jurassic, *5* Cretaceous; marked with heavy dashes are the ridges in morphology that separate particular bays

having all the time good seaway connections with the Vienna Basin and the Mediterranean (*cf.* Text-fig. 1*A*). This transgression when reached the Holy Cross Mountains (*cf.* Text-fig. 1*B*) sculptured their southern slopes into a system of shallow bays which developed along the pre-Miocene valleys. The then-established Korytnica Bay was the largest and deepest of all the others, and the Korytnica basin itself became a protected, terminal part of this Bay (*cf.* Text-fig. 1*C*).

Within the so situated basin with the depths ranging maximum between 60 and 40 meters, the deposition of the Korytnica Clays took place primarily and the basin, being successively filled with the clay deposits, has become shallower and shallower up to almost sea level (*cf.* Bałuk & Radwański 1977, 1979c). The overlying members, i.e. marly sands and red-algal (lithothamnian) limestones complete the sedimentary sequence of the basin, and all these deposits lie horizontally being not disturbed by any tectonic movements except of a regional uplift of Late Badenian and/or Late Miocene age.

The general setting of the Korytnica basin and the development of its sedimentary sequence is recently discussed by Sellwood (1978) as an example of the facies establishment, development and decline presented in the casebook on "*Sedimentary Environments and Facies*".

DISCOVERY OF KORYTNICA AND ITS BICENTENNIAL

Formerly, it was believed (Kowalewski 1930, pp. 1—3; *cf. also* Bałuk & Radwański 1977, p. 96) that the fossiliferous clays at Korytnica were first recognized somewhere about the twenties of the last century. A year ago, however, an outstanding

DYSSERTACYA
NA PUBLICZNEY SESSYI
SZKOŁY GŁOWNEY KORONNEY
W PRZYTOMNOŚCI NAYJAŚNIEYSZEGO PANA
CZYTANA.
Przez
JANA JASKIEWICZA
Doktora Nadwornego J. K. MCi,
AKADEMII KRÓLEWSKIEY NAUK W PARYŻU KORRESPONDENTA,
HISTORYI NATURALNEY I CHEMII W SZKOLE GŁÓWNEY KORONNEY PROFESSORA.
W Krakowie Dnia 25. Czerwca 1787. Roku.

Fig. 2. Title page of Jaśkiewicz's *Dissertation at the public session of the Crown High School..., 1787*

student of the history of geology, and an advanced connoisseur of the old prints, Dr. S. Czarniecki of the Institute of Geological Sciences, Polish Academy of Sciences in Cracow, has kindly paid the present authors' attention that the first note on the ubiquitous fossils at Korytnica is included into a dissertation on the recognition of geological structures and petrifacts in Southern Poland, prepared by J. Jaśkiewicz and read before HM Stanislas August Poniatowski, The King of Poland, during the public session kept in the Crown High School (Jagiello University) in Cracow on Monday, June 25th, 1787; the text of this dissertation was published the same year (*cf.* Czarniecki 1978). Recently, due to promotion by Dr. S. Czarniecki, this text has been reprinted in 450 copies by the Society of the Bibliophiles in Cracow, and its title page and a part devoted to Korytnica are reproduced in the present paper (Text-figs 2—3).

obeszło, i że wszystkie części ziemi iedne po drugich iuż od morza były zalane, ponieważ na całym okręgu ziemi, znayduią się płody morskie, świadki niezawodne bytności tego elementu, w którym swoy początek wzięły. Nie zbywa na dowodach tey prawdy w kraiu naszym; Petryfikacye które się tu i w obfitości, i niepospolite znayduią, iaśnie nam także rzecz tę dowodzą. Przez petryfikacye zaś, rozumiem ciała skamieniałe, to iest: ostatki źwierząt i roślin, zachowuiące ieszcze swoy kształt, całkiem zaś iuż w kamień obrocone, albo ich części na kamieniach wypiątnowane, i wyciśnione; ciała te skamieniałe są to ślady rożnych nastąpionych odmian, które powierzchnia ziemi naszey poniosła, są to antyki czyli szacowne starożytności reszty, których pilne uważanie, i roztrząsanie, wiele bardzo światła przynieść może, co do Historyi naturalney ziemi naszey.

Co się tycze szczególniey petryfikacyi, ta bardzo iest różna, znayduią się czasem zupełnie ieszcze nieodmienione ciała te wykopane, tak dalece że ieszcze naturalny swoy glanc i kolor zachowuią, czasem się trafiaią iak gdyby zwapnione, straciwszy swoy glanc zupełnie, ziemi tylko postać maiące, i takie w kruchey ziemi na polach zaoranych, za pługiem się odkrywaią, mamy tego przykład w Woiewodztwie Sandomirskim w Korytnicy, gdzie w niezmierney mnogości się znayduią. Są także petryfikacye te w ziemiach i kamieniach wapiennych, i tam albo oddzielone są, i za ułupaniem kamienia wypadaią, postać zupełnie gatunku tego kamienia, kształt zaś ciała spetryfikowanego zachowuiące, albo też ziednoczone z kamieniem, iednę formuią massę, tego przykłady mamy w gorze kamienney Pinczowskiey, z którey kamień Pinczowski bardzo znany, nayzdatnieyszy do robot kamieniarskich wydobywa się;

Fig. 3. Part of the text of Jaśkiewicz's *Dissertation at the public session of the Crown High School..., 1787,* describing petrifacts that appear in immense plurality when the cropland is plowed at Korytnica

The paper by Jaśkiewicz (1787) contains a report from the geological expedition organized by himself in 1782 (*cf.* Czarniecki 1978), and presents the most important results of the field investigations. It is therefore obvious that this date of 1782 should be regarded as denoting the discovery of Korytnica. In the following years, the locality has soon become known to Polish naturalists and primary geologists, and it has also become famous all over Europe (*cf.* Pusch 1837, Murchison 1845, Eichwald 1853, Hörnes 1856, Hoernes & Auinger 1879). To exemplify this it is to remember that Sir R. I. Murchison when travelling to Russia took a special stop in Poland to make a trip to Korytnica, guided by Professor L. Zeuschner, to see and collect its famous seashells (*cf.* Murchison 1845, pp. 292—293).

The completion of systematic studies on diverse fauna of the Korytnica Clays, conducted by the present authors and collaborators, as indicated above, should therefore be done in 1982 to commemorate the Korytnica Bicentennial.

REMARKS ON THE RECENT INVESTIGATIONS OF SOME OF THE KORYTNICA FOSSILS

In a few last years, some of the Korytnica fossils have either been investigated or discussed by foreign students of the Neogene faunas who have used the Korytnica material for comparison and/or taxonomic revision. In such a way, some ostracodes, chitons, and gastropods have been taken upon consideration, as follows.

Ostracodes

Of the ostracodes, only the genus *Costa* Neviani, 1928, was analyzed by Benson (1976a, b) who investigated it by the means of both biological and mathematical methods. Within the Korytnica material, he recognized the presence of the species *Costa hermi* Witt, and *C. tricostata* (Reuss), the both of which have been regarded as ecologically important and used for environmental analysis (*cf.* Benson 1976a, Table 1; 1976b, Text-figs 1—2). The conclusion of Benson (1976a) that these two species are indicative of the boreal-type assemblage should however be objected as none of the hitherto recognized fossils within the Korytnica communities is of that type. On the contrary, all of them clearly indicate a strong influence of tropical and/or subtropical climate (*cf.* Bałuk & Radwański 1977, and this paper). It is therefore postulated that the discussed species should at most be regarded as very eurythermal, but never boreal. Although Korytnica was really situated the northernmost of all the Paratethys localities (as indicated by Benson 1976a, Text-fig. 4), but its seaway connections were evidently southbound (*see* Text-fig. 1*A*; the same *in* Bałuk & Radwański 1977).

Chitons

When studying the rich assemblage of the chitons from the northern Apennines, Laghi (1977) discussed all the forms hitherto reported from Korytnica, and he included most of the Korytnica species recognized by Bałuk (1971) into the synonymies of the present-day forms, as follows:

Lepidopleurus decoratus (Reuss, 1860) → *L. cajetanus* (Poli, 1791)
Lepidopleurus sulci Bałuk, 1971 → *L. cancellatus* (Sowerby, 1839)
Hanleya multigranosa (Reuss, 1860) → *H. hanleyi* (Bean, 1844)
Ischnochiton rudolticensis Sulc, 1934 → *I. rissoi* (Payradeau, 1826)
Lepidochitona subgranosa Bałuk, 1971 → *L. cinerea* (Linnaeus, 1766)

Callochiton rariplicatus (Reuss, 1860) → *C. laevis* (Montagu, 1803)
Chiton denudatus Reuss, 1860 → *C. corallinus* (Risso, 1826)
Acanthochitona faluniensis (Rochebrune, 1883) → *A. communis* (Risso, 1826)
Acanthochitona lacrimulifera Bałuk, 1971 → *A. fascicularis* (Linnaeus, 1766)

The same has been done by Laghi with a few other Neogene species established or determined by Reuss (1860), Šulc (1934), Bałuk (1971) and others from the Miocene of the Vienna basin, Bohemia and Moravia, and Poland (localities different from Korytnica; *cf.* Bałuk 1971).

The fact that the Miocene species are comparable to the present-day species was also known previously (*cf.* Šulc 1934, Malatesta 1962, Bałuk 1971), but it was generally accepted to name the Neogene species with separate names, although these species were regarded as direct ancestors of the present-day forms (*see* Malatesta 1962; and review and conclusions by Bałuk 1971, pp. 468—469).

Of the five new species established by Bałuk (1971) from Korytnica, only two have been left by Laghi unchanged as to their taxonomy, viz. *Ischnochiton korytnicensis* Bałuk, and *Craspedochiton minutulus* Bałuk, the latter being reported for the first time also from Montegibbio (Laghi 1977; Pl. 4, Figs 13—16).

The above discussion on the taxonomy of Neogene chitons does not influence the wealth of the Korytnica assemblage. Regardless their taxonomy, the components of the chiton assemblage from Korytnica remain in their total number of 17 species that make up the richest assemblage in the European Miocene. The comparable figure for the whole Vienna Basin is 14, but it is never so high for a particular locality (*cf.* Bałuk 1971). The richest assemblage of those studied by Laghi (1977) from the northern Apennines is that of Montegibbio which comprises 13 species documented, and two uncertain.

Gastropods

Of the gastropods, the genus *Terebra* Bruguière from the northern Apennines was studied by Davoli (1976, 1977) who presented some comparisons of the investigated assemblage to that from Korytnica. Indicating correctly the importance of the genus as an indicator of the tropical and/or subtropical climate, a series of mistakes has been set up when referring to the Korytnica specimens. Namely, Davoli (1976, Text-fig. 3; 1977, p. 139) mentions 5 species of *Terebra* from Korytnica and makes a reference with that number to the Friedberg's monograph. Friedberg (1911), however, reported from the Korytnica basin (localities Korytnica and Lipa) two species only, viz. *Terebra (Subula) fuscata* Brocchi, and *Terebra (Terebra) acuminata* Borson, the three others included into his monograph being found only in the Volhynia and Podolia regions in the Ukraine, Soviet Union. The third species from Korytnica, *Terebra neglecta* Michelotti, was additionally reported by Friedberg (1938, pp. 157—158) in his Catalogue in which *Terebra (Subula) fuscata* was renamed as *Terebra modesta* Tristan. A discussion upon the *fuscata/modesta* species, and description of the others, newly recognized species of *Terebra* from the Korytnica Clays will be presented by W. Bałuk elsewhere.

ECOLOGY OF SOME OF THE NEWLY INVESTIGATED ANIMAL GROUPS

In this chapter some particular problems on taphonomy, aut- and synecology, as well as composition of the organic communities are groupped under separate headlines to cover and indicate the subjects which have a special bearing upon the recognition of general life conditions within the Korytnica basin.

SHELL ENDOZOANS

The assemblage of diverse endozoans which have bored the gastropod shells embedded in the Korytnica Clays (*cf.* Bałuk & Radwański 1977, pp. 105—107) is enlarged by the borings *Helicotaphrichnus commensalis*, studied recently by Kern (1979) and attributed to the polychaete genus *Polydora*, presumably to the species related closely to such present-day ones as *Polydora commensalis* Andrews and/or *P. bioccipitalis* Blake & Woodwick (*see* Kern 1979, Kern & al. 1974).

The boring bryozoans, first announced by their genus *Spathipora* in the former report (Bałuk & Radwański 1977, p. 107 and Pl. 6, Fig. 4), are now described separately (Bałuk & Radwański 1979b). Besides *Spathipora*, there also occur commonly the genera *Terebripora* and *Penetrantia*, all of which have been colonizing the gastropod shells after the death of their hosts (*see* Bałuk & Radwański 1979b).

ECOLOGIC ADAPTATIONS

Ecologic adaptations have been studied by the present authors (Bałuk & Radwański 1979a) in the pelecypod species *Sphenia anatina* (Basterot) inhabiting empty borings of diverse polecypods (*Gastrochaena*, *Aspidopholas*, *Jouannetia*, *Lithophaga*) left in the littoral rubble of the Korytnica basin. Due to such a habitat, the shell of particular individuals of *Sphenia anatina* (Basterot) has acquired the shape of the occupied boring. Consequently, the four groups of the shell shape may be distinguished in this species, and the same groups are also recognizable in the other Neogene localities of Europe. It is therefore postulated that presumably this very species is the only one of the genus *Sphenia* that lived in the Neogene of Europe, and all specimens deviating in the shape and variously interpreted as to their taxonomy, are really its ecological variants (for further data *see* Bałuk & Radwański 1979a).

BIOLOGIC RELATIONSHIPS

To the examples of biologic relationships which are inferred from the presence of one species, the partner of which remained unpreserved, some new ones are added as compared to those presented in the former report (*cf.* Bałuk & Radwański 1977, pp. 110—111).

From the appearance of the gastropod genus *Thyca*, newly recognized by W. Bałuk in one of the nearshore biotopes and ready for description elsewhere, the presence of the starfish in the same biotope is inferred, as these very echinoderms are the hosts for ectoparasitic *Thyca*. In the present-day environments this relationship is well demonstrated along the offshores of the Island of Mahé, Seychelles, where *Thyca crystallina* parasitizes on *Linckia multifora*, the both living within the seagrass communities (*see* Taylor & Lewis 1970). It is noteworthy that in the Korytnica

basin a similar relationship has been inferred previously, viz. of the gastropod genus *Eulima* and of some holothurians being their hosts, the both living within the sea-grass beds (*see* Bałuk & Radwański 1977, pp. 101 and 111).

The other examples concern the hermit crabs and their activity, the results of which have been discussed in the former report (Bałuk & Radwański 1977, pp. 111—112).

At first, the presence of the hermit crabs in the Korytnica environment is additionally indicated by the above referenced borings *Helicotaphrichnus commensalis* which are commensals to the hermit crabs (*see* Kern 1979, Kern & al. 1974); the both above indicated species, *Polydora commensalis* and *P. bioccipitalis*, produce borings inside the columella of the gastropod shells occupied by hermit crabs which induce a water flow needed by the suspension-feeding polychaete. Of the Korytnica gastropods, the most frequently taken by the pagurid/spionid couple are the shells of *Ancilla glandiformis* (Lamarck) which are also frequently infected by the boring ctenostomate bryozoans; the discussion on the mutual relations of these three secondary dwellers of the *Ancilla* shells is undertaken separately (Bałuk & Radwański 1979b). It may be noted here, however, that the bryozoan-infected shells of the other gastropod species, *Ranella marginata* (Martini), often display the wearing marks resulting from the dragging of such a shell by the hermit crab over the sea bottom (*cf.* Bałuk & Radwański 1979b, Pl. 8, Fig. 2).

The former attribution of the damage of gastropod shells to the hermit crabs in the Korytnica environment (Bałuk & Radwański 1977) has recently been objected by Förster (1979b) and Cadée (*letter comm.*), who both indicate that the genus *Calappa* might have been much more responsible for that destruction. Especially Förster (1979b) expresses this evidently as he has recognized a high percentage of the *Calappa* remains within the whole crustacean decapod assemblage from the Korytnica Clays. One may agree with these authors, although a definite recognition will be possible in further investigations; nevertheless, the above presented evidences show that the hermit crabs really lived in the Korytnica basin and were the parts of its organic communities.

SEASONAL MIGRATIONS

When studying the ecology of the Korytnica sepioids, W. Bałuk was the first to recognize that these animals might have migrated into the shallows of the Korytnica basin for breeding by springtime (*see* Bałuk & Radwański 1977, p. 112). A similar conclusion is presently drawn by Śmigielska (1979) for bathypelagic and bathybenthic fish recognized in the Korytnica Clays by their otoliths (*cf.* Bałuk & Radwański 1977, p. 112). Śmigielska (1979) suggests that these fish (e.g. bathypelagic *Pterothrissus*, and bathybenthic *Physiculus* and *Coelorhynchus*), some of them represented by otoliths of juvenile specimens, have appeared within the Korytnica shallows when seasonally migrated from the deeper parts of the Fore-Carpathian sea (*cf.* Text-fig. 1*B—C*) to find the convenient breeding places and/or better trophic conditions.

SMALL-SIZED COMPONENTS OF THE ASSEMBLAGES

A few authors have recently concluded that the particular assemblages of the Korytnica fossils are dominated by small-sized forms.

Förster (1979b) stated that the decapod crustacean assemblage from the Korytnica Clays is dominated by small-sized remains coming from the juvenile individuals, and the fragments of adult specimens of *Calappa* are the only exception; he explained this by the selection prior to fossilization, which realized by an earlier burial of the more calcified dactyli which had dropped away from the carcass being furthermore destroyed i.a. by action of scavengers, and by post-mortem decalcification. Partly, it could have certainly happened so, but it seems that the more general factors there were two: (*i*) a supply of larger numbers of claws by younger individuals when they successively have moulted, (*ii*) unfavorable taphonomic conditions for the adults whose remains must have rested, at the slow sedimentation rate, much longer span of time on the sea bottom until they become buried.

The assemblage of the brachiopods, featured primarily of the small-sized forms was, on the other hand, regarded by Barczyk & Popiel-Barczyk (1977) as composed of juvenile specimens which could not find convenient environmental conditions for their turning adult, contrary to those conditions that prevailed outside the Korytnica Bay, wherefrom the brachiopod larvae had been floated by currents. The discussed assemblage is really dominated by the four *Argyrotheca* species, associated by one species of *Megathiris*, the small size of which is their specific or generic feature, and nothing is to indicate that only the early post-larval stages of these brachiopods could have developed well in the Korytnica environment. One cannot also accept an opinion presented for a similar assemblage from the Miocene deposits of Malta by Pedley (1976) that the small-sized species are neotenic.

The discussed assemblage of small-sized species of brachiopods should certainly be interpreted as resulting from an adaptation to live attached to diverse substrata within communities of seagrass and/or small, stalked animals (? bryozoans). It is evidently similar to that typical of Upper Cretaceous chalk facies (*cf.* Surlyk 1972, Bitner & Pisera 1979) in which it developed as an ecological response to the environmental conditions characterized, outside the indicated communities, by quaggy mud bottom and quiet water conditions.

TRACE FOSSILS

Apart from the above discussed borings *Helicotaphrichnus commensalis* which fall into the category of shell endozoans, the sediment-constructed trace fossils have first been recognized (Bałuk & Radwański 1979c) from the topmost parts of the Korytnica Clays sequence. These are the faecal pellets which are attributed to the polychaetes related closely to the present-day species *Heteromastus filiformis* (Claparède). Their bearing upon the recognition of the extreme shallow water and/or

intertidal, temporary at least, conditions during sedimentation of the topmost Korytnica Clays is discussed separately (Bałuk & Radwański 1979c), when following their description under a new ichnologic name, *Tibikoia sanctacrucensis*.

COMPOSITION OF THE ORGANIC COMMUNITIES

In this respect it is to note that some of the macrobenthic assemblages of the Korytnica Clays are recently reinterpreted as to their structure, development, and strategy of colonization of the sea bottom (Hoffman 1979).

On the other hand, it should be indicated that one of the most typical Korytnica communities, viz. that of rocky seashores covered by the oyster shellbed, that passes with interfingerings into the deepest parts of the Korytnica Clays (see: *os* and coeval Community *I* in Bałuk & Radwański 1977, Text-fig. 6*C*, and comparable section of the idealized shorescape in Text-fig. 5), is not of so unique character as it has previously seemed. After completing the previous report (Bałuk & Radwański 1977) a description of the similar facies arrived from New Zealand, where it was presented by Hayward (1976) from the Lower Miocene Waitakere Group exposed near Auckland. This facies of a gravel bank is characterized i.a. by the presence of the corals *Dendrophyllia* and *Caryophyllia*, gastropods of the *Tenagodus* type which presumably lived within alive sponges (*cf. also* Bałuk & Radwański 1977, p. 111), and other fauna comparable to that of Korytnica; this facies is interpreted (*see* Hayward 1976, Text-figs 3—4) as developed at depths ranging from sea level down to about 25—30 m where it changes into a sand-silt facies with solitary corals *Flabellum* and diverse tusk shells, mostly *Dentalium*, and other mollusks, all of them having counterparts in the Community *I* of the Korytnica basin (*cf.* Bałuk & Radwański, 1977, Text-fig. 5).

TROPICAL AND/OR SUBTROPICAL CLIMATE AND INDO-PACIFIC AFFINITIES OF THE FAUNA

The formerly drawn conclusions on the climatic conditions prevailing within the Korytnica basin as identical with those typical of the present-day tropical and/or subtropical zones (Bałuk & Radwański 1977) are supported by the newly obtained data, as follows.

Förster (1979b) stresses that within the decapod crustacean assemblage the high percentage of the genera *Calappa* (9%), and *Ozius* (52%), both the inhabitants of the tropical littoral zone, indicates similar environmental conditions for the Middle Miocene sea of Korytnica. The same may be said about some of the coeval facies far outside the Korytnica Bay where the genera *Dorippe* and *Macrophthalmus* become indicators of identical climate conditions (*cf.* Förster 1979a).

The same conclusion is offered from the analysis of the fish assemblage recognized from their otoliths (Śmigielska 1979), and from the analysis of environmental requirements of the gastropod genus *Terebra* widely distributed, but rarely occurring within the Miocene deposits of Europe (Davoli 1976, 1977).

Finally, the discussed climatic conditions are also indicated by the foraminifer genus *Amphistegina* which was briefly announced formerly (*see* Bałuk & Radwański 1977, p. 114). The new investigations of this genus by Rosenkrands Larsen (1977, 1978) demonstrate clearly that the species *Amphistegina lessonii* d'Orbigny, 1826, commonly reported although never paleontologically investigated from the Fore-Carpathian Miocene, has appeared not earlier than in the Pliocene, and ranges until now. On the other hand, however, the most commonly occurring species recognized in the Miocene deposits of Europe, viz. *Amphistegina mamilla* (Fichtel & Moll), and *A. hauerina* d'Orbigny are known, outside Europe, only from the Miocene tropical/subtropical regions of the Indo-Pacific province (Rosenkrands Larsen 1978). The species widely distributed in the Fore-Carpathian Miocene has been determined as *A. mamilla* (Fichtel & Moll), and recorded from the *Leithakalk* facies at Szczaworyż (Rosenkrands Larsen 1978, Table 1).

As it is apparent from the above review, the discussed fauna coming either from the Korytnica Clays, or from the coeval facies developed outside the Korytnica Bay, supports also the previous conclusions on its Indo-Pacific affinities (Bałuk & Radwański 1977). Besides the foraminifer species *Amphistegina mamilla* (Fichtel & Moll) reported by Rosenkrands Larsen (1978), this is evident from the occurrence of such crab genera as *Calappa*, *Mursia*, *Dorippe*, *Ozius*, and *Macrophthalmus*, reported by Förster (1979a,b).

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