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Paleogeographic meaning of psychrospheric Miocene ostracodes from the Fore-Carpathian Depression

ABSTRACT: In the early Middle Miocene (Early Badenian) of the Fore-Carpathian Depression in Poland, a psychrospheric ostracode assemblage has been identified. Pre-Miocene and Miocene distribution of particular species of the assemblage, and particularly *H. asperrima* (associated with warm-water foraminifera) suggests that in the early Middle Miocene a deep and stratified basin extended from the Mediterranean to the northernmost part of the Central Paratethys, that was influenced by waters from the Atlantic Ocean, via the Iberian Portal. This probably allowed the psychrospheric *Cluthia miocenica* and *Pseudocythere* cf. *caudata* to invade later, in the Late Badenian, the northern part of the Central Paratethys, i.e. the Roztocze region, southern part of the Lublin Upland, southeastern Poland. Climatic deterioration and/or change of circulation, proposed by various authors for the Middle Miocene, enabled these species to survive in shallow waters of the Late Badenian of Poland.

INTRODUCTION

Together with the neritic ostracodes of the late part of the Middle Miocene, i.e. Late Badenian (corresponding to Serravallian) of the Roztocze region, southeastern Poland, there occur species which are exotic not only to the hitherto known Middle Miocene ostracodes of the Central Paratethys but also to the southern areas of Europe, including the Mediterranean. These species are represented, among others, by *Cluthia miocenica* SZCZUCHURA (see SZCZUCHURA 1986, 1994) and *Pseudocythere* cf. *caudata* SARS (see SZCZUCHURA & PISERA 1986, SZCZUCHURA 1994). Both *Cluthia* and *Pseudocythere* are mainly deeper- and cold-water ostracodes (CRONIN 1983, WHATLEY & AYRESS 1988, WHATLEY & COLES 1991, AYRESS & DRAPALA 1994).

The *Cluthia* and *Pseudocythere* species typical of the Roztocze region occur in marly sediments containing planktic foraminifera, mostly *Globigerina* and *Velapertina* representatives, and are most probably of neritic origin (SZCZUCHURA 1982, SZCZUCHURA & PISERA 1986); they belong to the *Globigerina* ecozone.

In the present paper another psychrospheric ostracode assemblage is reported from sediments of the early part of the Middle Miocene, *i.e.* Early Badenian (corresponding to Langhian) of the Fore-Carpathian Depression in Poland. It includes species of the genera: *Cytherella*, *Bythocypris*, *Henryhowella*, *Agrenocythere*, and *Krithe*. The stratigraphic and geographic distribution of these ostracodes is hereafter discussed in connection with the Middle Miocene paleogeography of Europe, including the Mediterranean areas.

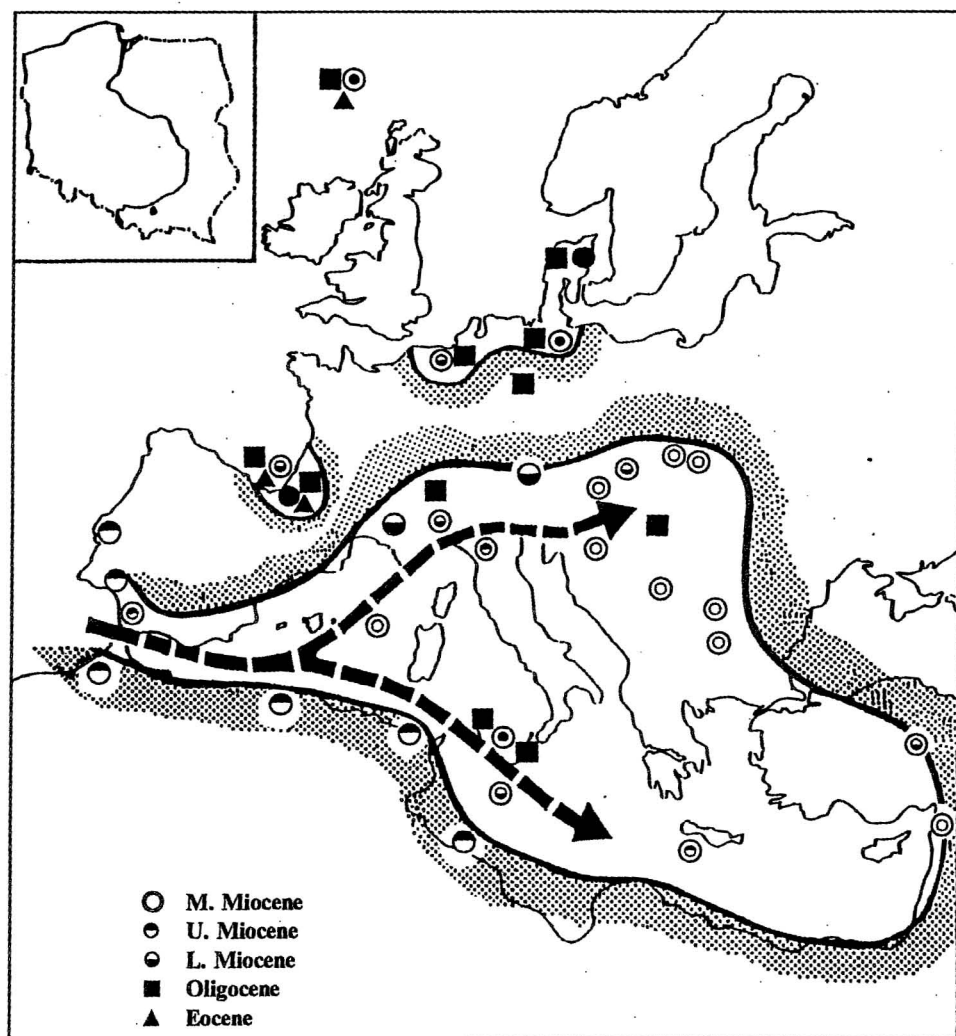


Fig. 1. Pre-Miocene and Miocene distribution of *Henryhowella asperrima* (REUSS, 1850) in Europe and the adjacent areas; insert shows location of the borehole Łapczyca-1 in Poland

Thick line denotes the extent of the Middle Miocene deeper basins in Europe and the Mediterranean with an influence of the Atlantic waters

Middle Miocene (Badenian) ostracodes recognized so far in Poland (SCHILLER 1973, 1976; SZCZUCHURA 1986, 1987, 1994; SZCZUCHURA & PISERA 1986, PARUCH-KULCZYCKA 1992) are very diverse and consist mostly of the neritic forms known from the synchronous, as well as from younger or (rarely) older strata of Europe (including the Mediterranean) and from outside that area. In comparison with these ostracodes, the ostracode assemblage found in the Fore-Carpathian Depression in the Łapczyca-1 borehole, close to Bochnia near Cracow (see Text-fig. 1), is exceptional. The taxonomic structure of that ostracode assemblage suggests their psychrospheric origin (cf. BENSON 1978, STEINECK 1981, BENSON & al. 1991). The ostracode fauna contains *Henryhowella asperrima* (REUSS) (see Pl. 1, Figs 9-12; 22 specimens), *Agrenocythere* sp. (see Pl. 2, Fig. 9; 1 specimen), *Bythocypris* cf. *lucida* (SEGUENZA) (see Pl. 1, Figs 7-8; 2 specimens), *Bythocypris* sp. (see Pl. 1, Figs 1-6; 11 specimens), *Krithe* cf. *citae* OERTLI (see Pl. 2, Fig. 12; 2 specimens), *Krithe* sp. (see Pl. 2, Figs 10-11; 3 specimens), and *Cytherella* cf. *vulgata* RUGGIERI (see Pl. 1, Figs 13-14; 2 specimens). They were found in the Łapczyca-1 core at depth 346 m, within the microfauna consisting, besides ostracodes, almost exclusively of planktic foraminifera. These latter are represented (see Pl. 2, Figs 1-6) by *Orbulina* cf. *suturalis* BRÖNNIMANN, *Praeorbulina* cf. *glomerosa* (BLOW), *Globigerinoides quadrilobatus* (D'ORBIGNY), and *Globigerinoides trilobus* (REUSS). Only one specimen of the benthic foraminifera *Haplophragmoides* sp. (see Pl. 2, Fig. 8) co-occurs. ŁUCZKOWSKA (1958), who studied the foraminifera from the core, referred the sediments discussed here to the basal part of the silty series, directly overlying the Mesozoic strata, and she dated them as the earliest "Tortonian", now they are referred to the earliest Badenian. The area represents the deepest part of the Fore-Carpathian Miocene basin. SZCZUCHURA (1982) and SZCZUCHURA & PISERA (1986) assigned the Middle Miocene sediments containing (among others) representatives of *Praeorbulina* and *Globigerinoides* to the *Globigerinoides* ecozone within the lower part of the Middle Badenian.

In the present paper it is attempted to trace the biogeographic ties of the Łapczyca and Roztocze exotic ostracode species.

SPATIO-TEMPORAL DISTRIBUTION OF THE ŁAPCZYCA OSTRACODES

Henryhowella asperrima

Among the ostracodes from the Łapczyca borehole *Henryhowella asperrima* (REUSS 1850) is particularly interesting. This is a species of rather well established taxonomy, with a wide distribution in space and time but preferring deeper environments. REUSS (1850) identified this species for the first time in the Middle Miocene of the Vienna Basin, but also reported it from coeval strata of the salt-mine in Wieliczka, geographically close to Łapczyca.

In Poland, *H. asperrima* occurs in the Early Badenian as well as the Late Badenian sediments, mostly those of at least deeper neritic origin (cf. SZCZUCHURA & PISERA 1986, SZCZUCHURA 1994).

In Europe, outside Poland, *H. asperrima* ranges from the Eocene to the end of Miocene (see Text-fig. 1). It is known from the Eocene and/or Oligocene of western border of the continent (Aquitainian Basin and Gulf of Gascony: DUCASSE & PEYPOUQUET 1979) as well as from the French Alps (CHAROLLAIS & al. 1980), northern (UFFENORDE 1981) and central Germany (FAUPEL 1975), Belgium (KEU 1957), Denmark (UFFENORDE 1979), and Hungary (MÉHES 1941). In the Early Miocene *H. asperrima* area of distribution extends from southern France (Aquitainian Basin: MOYES 1965 and Rhone Basin: CARBONNEL 1969) up to Belgium (KEU 1957), Denmark (UFFENORDE 1979), and northwestern Germany (UFFENORDE 1980), Bavaria (WITT 1967), Bohemia (ŘIHA 1983), northwestern (OERTLI 1961) and southern Italy (CIAMPO 1981), Malta (RUSSO & BOSSIO 1976), and central Turkey (BASSIOUNI 1979).

Not earlier than in the Middle Miocene (as far as it is known) *H. asperrima* appeared in the most northern part of the Central Paratethys, i.e. in the Fore-Carpathian Depression of Poland (SZCZUCHURA & PISERA 1986). It is also known that time from the Vienna Basin (REUSS 1850), Bohemia (ŘIHA 1983), Romania (OLTEANU 1971), Bulgaria (STANCHEVA 1962), northwestern (BLAŠKOVIČ & al. 1975) as well as from northeastern Yugoslavia (KRSTIĆ 1978), northern Appenines (OERTLI 1961, RUSSO 1964) and Sicily (CIAMPO 1981), southern Spain and the Balearic Basin (BENSON 1976a), and Malta (RUSSO & BOSSIO 1976). The Aquitainian Basin (DUCASSE 1974) and northwestern Germany (DANIELS & al. 1990) are within the northern limits of its distribution.

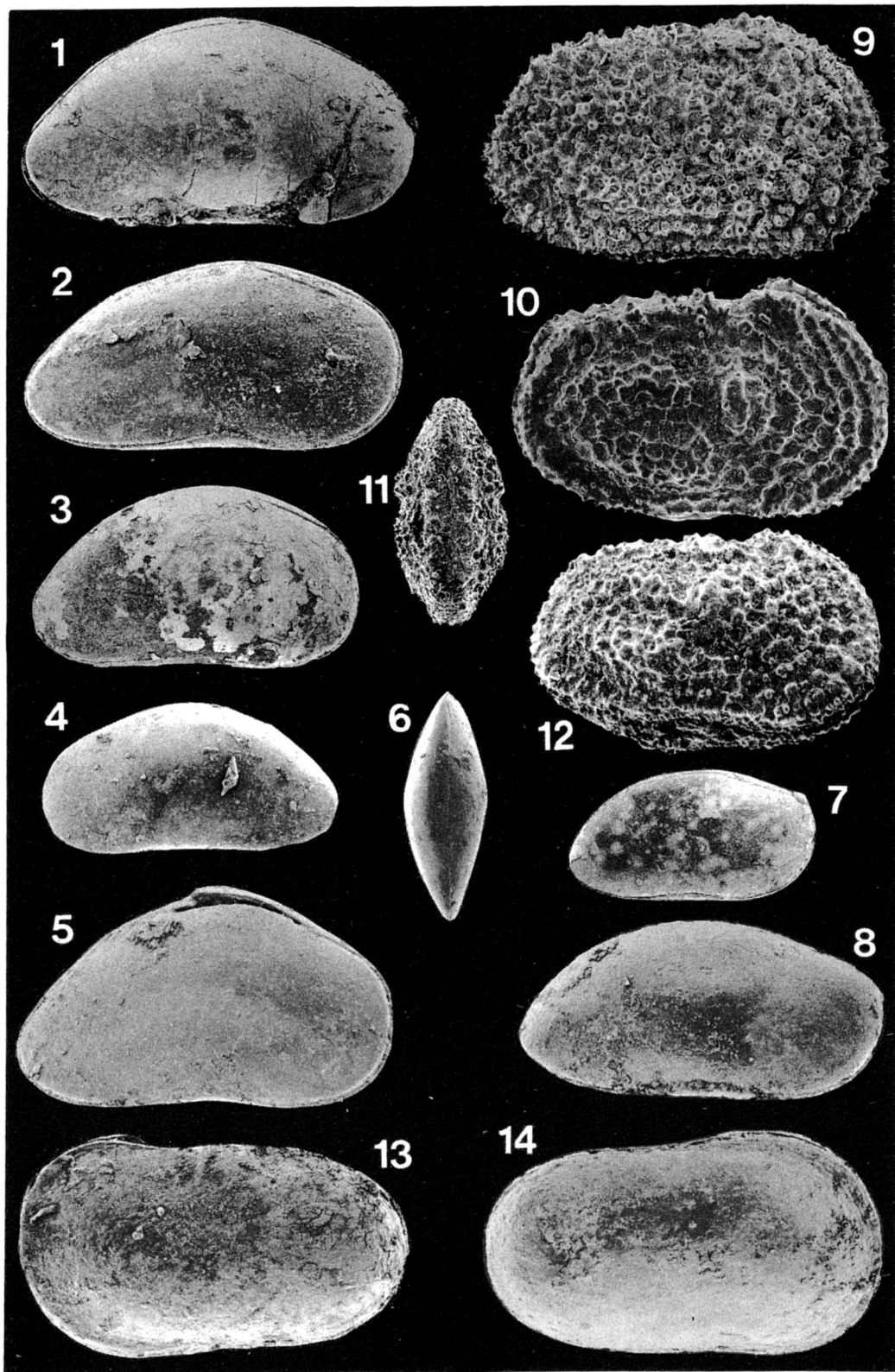
In the Late Miocene *H. asperrima* continued to occur in Portugal (NASCIMENTO 1983), the Aquitainian Basin (MOYES 1965), Denmark (UFFENORDE 1979), Germany (UFFENORDE 1981), southern Spain (BENSON 1976a), northern Italy (DIECI & RUSSO 1964, RUSSO 1968), Sicily (RUGGIERI 1962), and Greece (SISSINGH 1972a). This species is also recorded at that time from the southern areas of the Mediterranean basins, i.e. MOROCCO (CARBONEL & CIRAC 1978), Algeria (SISSINGH 1972b), Tunisia (BONADUCE & al. 1992), and the area adjacent to Libya (VAN HINTE & al. 1980).

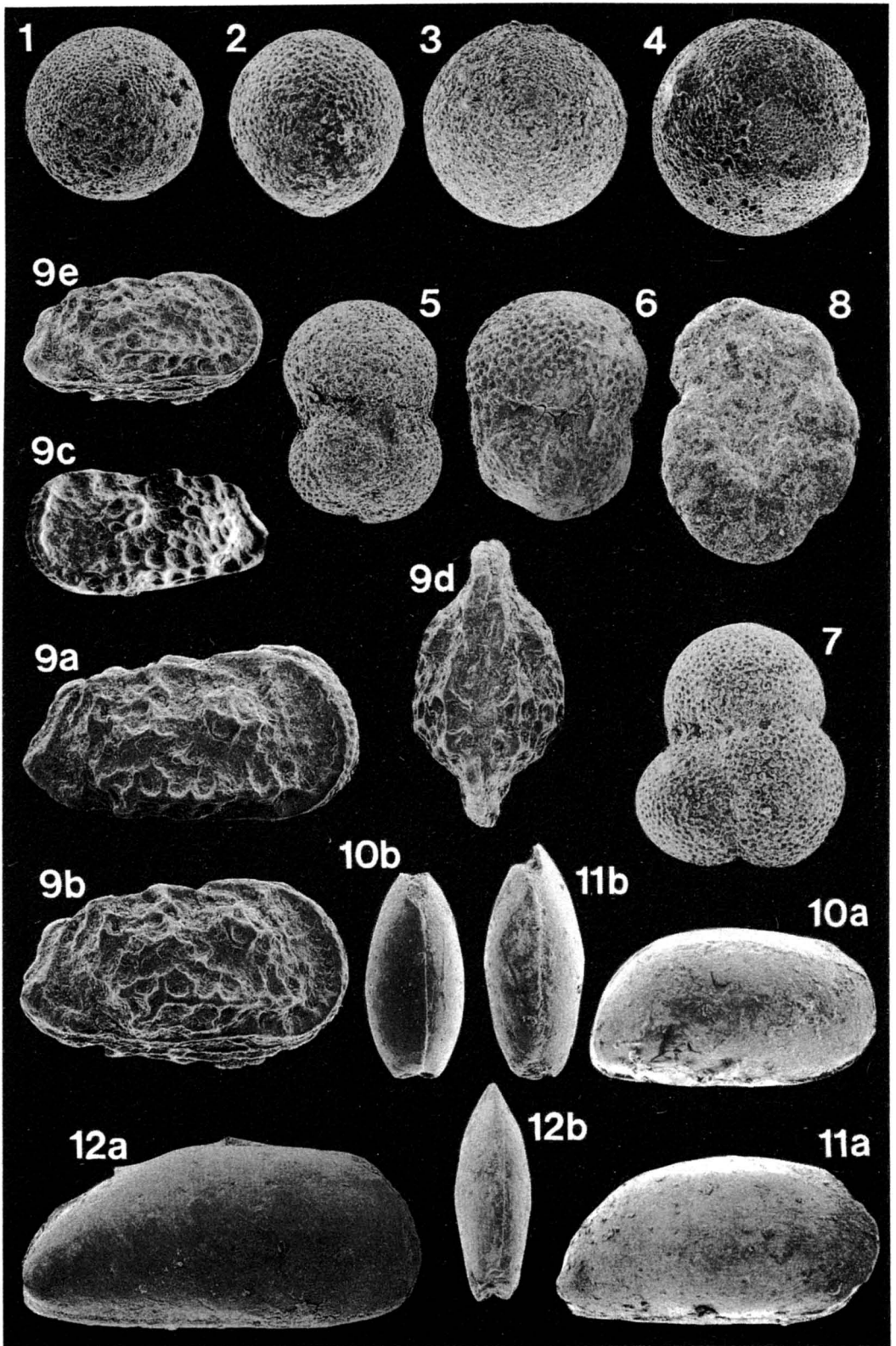
It is worth noting that in the southeastern part of the Mediterranean, in Turkey (BASSIOUNI 1979), *H. asperrima* was associated with Middle Miocene shallow-water ostracodes, including brackish-water ones. At the same time in northeastern Egypt and northern Libya ostracode assemblages were dominated by endemic ostracode species typical of the Mediterranean, and particularly north African, areas (SZCZUCHURA & ABD-ELSHAFY 1988). Similarly, the Middle Miocene ostracodes from Iraq are quite different from those of Europe (KHALAF 1988, 1993; according to this author the ostracode biofacies recognized by him extend as far as to southern Turkey, Syria, and Saudi Arabia). In the Eastern Tethys, including the Ukraine, the Middle

PLATE 1

Ostracodes from the Łapczyca-1 borehole (depth 346 m), early part of the Middle Badenian

- 1-6 — *Bythocypris* sp.: 1, 2 — adult carapaces, seen from right side, ZPAL O. XXXVI/1, 2 (× 50, × 60 respectively); 3, 5 — juvenile carapaces, seen from right side, ZPAL O. XXXVI/3, 4 (× 50, × 40 respectively); 4 — adult carapace, seen from left side, ZPAL O. XXXVI/5, × 60; 6 — adult carapace, seen from above, ZPAL O. XXXVI/6, × 25
- 7-8 — *Bythocypris* cf. *lucida* (SEGUENZA): (?)adult carapaces, seen from right side, ZPAL O. XXXVI/7, 8 (× 50, × 60 respectively)
- 9-12 — *Henryhowella asperrima* (REUSS): 9 — adult right valve, ZPAL O. XXXVI/9, × 45; 10, 12 — adult carapaces, seen from right side, ZPAL O. XXXVI/10, 11 (× 70, × 90 respectively); 11 — adult carapace, seen from above, ZPAL O. XXXVI/12, × 50
- 13-14 — *Cytherella* cf. *vulgata* RUGGIERI: 13 — (?)adult carapace, seen from left side, ZPAL O. XXXVI/13, × 70; 14 — (?)adult carapace, seen from right side, ZPAL O. XXXVI/14, × 70





Miocene ostracodes were rather shallow-water, dominated by forms unknown from Europe (SCHNEIDER 1949, 1953, 1975). Contrasting with the above reviewed Middle Miocene ostracode faunas are those known from the coeval sediments of western Europe, including the western part of the Mediterranean, e.g. from southern Spain (BENSON 1976, 1978) as well as northern Italy (OERTLI 1961, RUSSO 1964) and Sicily (CIAMPO 1981); they are obviously deeper-water and are composed of species broadly distributed in Europe and outside it.

Outside Europe and the Mediterranean, *H. asperrima* is known from both the Atlantic Ocean and the Indo-Pacific, where it is an element of the psychrospheric faunas. COLES & al. (1990) mentioned this species as existing in these oceans from the Eocene to Recent. In the Middle Miocene *H. asperrima* occurred (among others) in the northwestern (Jamaica: STEINECK 1981) and northeastern Atlantic (Rockall Bank area), as well as in the southwestern (Rio Grande Rise) and southeastern Atlantic (Walvis Rise: BODEGART 1983).

Agrenocythere sp.

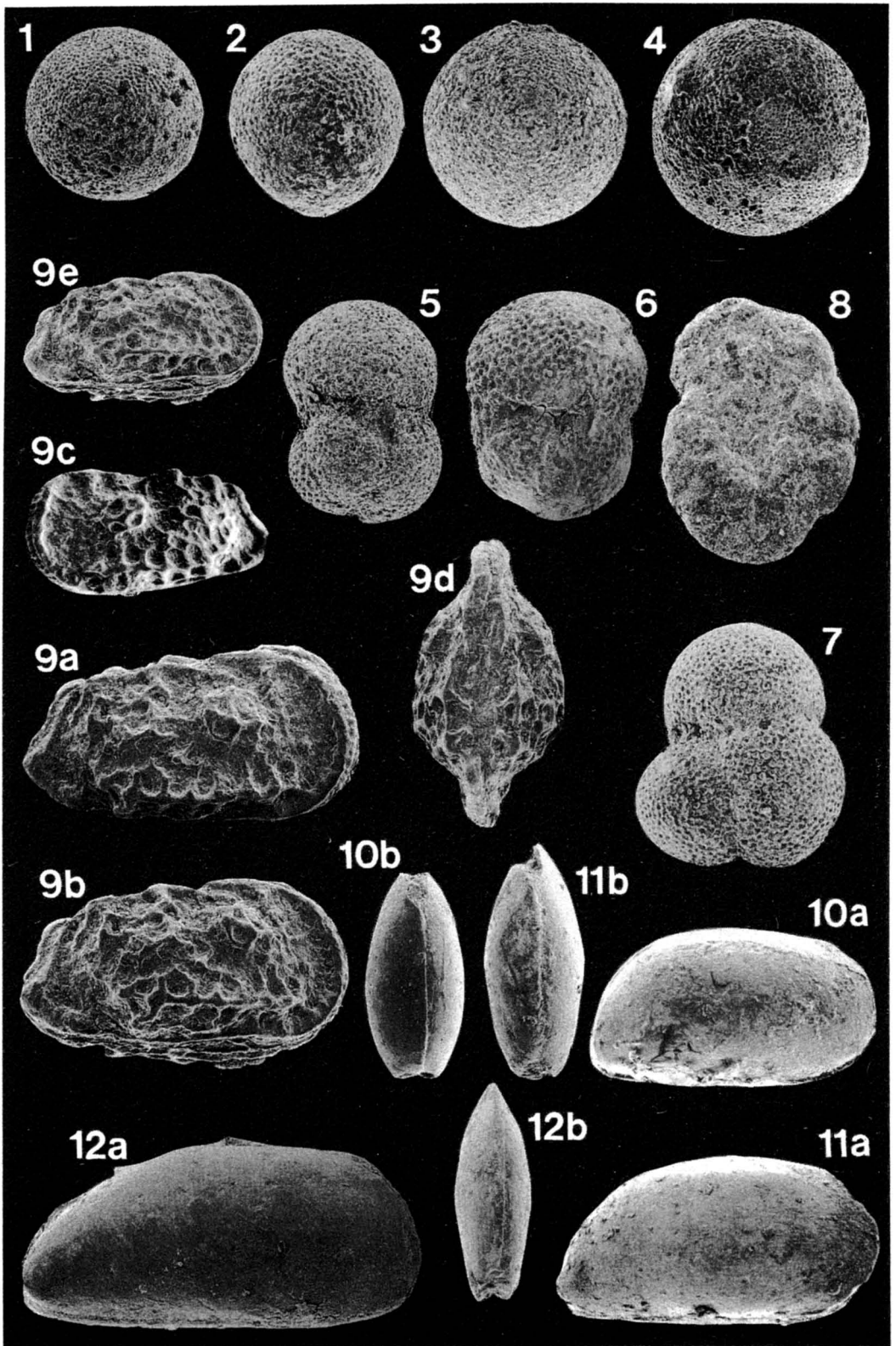
The species co-existing with *H. asperrima* in the sample from the Łapczyca borehole, belongs to a genus whose species are less frequent than *H. asperrima* in the ostracode assemblages so far known from the Cenozoic sediments, being usually represented by only a few specimens in samples. It is typical mostly of deep-water environments.

In Europe, including the Mediterranean, species belonging to *Agrenocythere* are known already in the Paleogene of the Carpathians (Moravia: POKORNÝ 1977) as well as from the Paleogene of southwestern France (Aquitainian Basin: DELTEL 1964), French Alps (CHAROLLAIS & al. 1980) and southern Italy (CIAMPO 1981). In the Early Miocene, *A. hazelae* occurs in western basins of the Mediterranean, where it extends up into the Middle Miocene (BENSON 1978); from the Middle Miocene it is recorded from southeastern Spain (BENSON 1976a, STEINECK 1981) and Sicily (RUGGIERI 1962, CIAMPO 1981). In the early part of the Middle Miocene the *Agrenocythere* representatives appeared in the Central Paratethys, in the Fore-Carpathian Depression, i.e. in Moravia (ŘIHA 1993) and in Poland (present work). From the Late Miocene, *A. pliocenica* is known from the western Mediterranean (BENSON 1978) and northern Apennines (DIECI & RUSSO 1964).

PLATE 2

Ostracodes and foraminifera from the Łapczyca-1 borehole (depth 346 m), early part of the Middle Badenian

- 1, 3-4 — *Orbulina* cf. *suturalis* BRÖNNIMANN; ZPAL F. XL/1, 3, 4 (× 60, × 65, × 70 respectively)
- 2 — *Praeorbulina* cf. *glomerosa* (BLOW); ZPAL F. XL/2, × 65
- 5 — *Globigerinoides quadrilobatus* (D'ORBIGNY); ZPAL F. XL/5, × 60
- 6 — *Globigerinoides trilobus* (REUSS); ZPAL F. XL/6, × 40
- 7 — *Globigerinoides* sp.; ZPAL F. XL/7, × 80
- 8 — *Haplophragmoides* sp.; ZPAL F. XL/8, × 70
- 9 — *Agrenocythere* sp.: 9a, 9b, 9e — adult carapace, seen from right side in somewhat different magnification and view, ZPAL O. XXXVI/15 (× 50, × 50, × 40 respectively); 9c — seen from left side, × 40; 9d — seen from above, × 45
- 10-11 — *Krithe* sp.: 10a, 11a — adult carapaces, seen from right side, ZPAL O. XXXVI/16, 17, both × 80; 10b, 11b — seen from above, both × 50
- 12 — *Krithe* cf. *citae* OERTLI: 12a — adult carapace, seen from right side, ZPAL O. XXXVI/18, × 80; 12b — seen from above, × 40



Outside Europe, *Agrenocythere* (*A. pliocenica*) is known from the Upper Miocene sediments of northwestern Africa (Morocco) (CARBONEL & al. 1980, BENSON & al. 1991). It is known, moreover, from the Eocene up to Recent times, from both the Atlantic as well as the Pacific Ocean (COLES & al. 1990). The species *A. hazelae* is recorded from the Middle Miocene of the western Atlantic (Jamaica) as well as southeastern Spain (STEINECK 1981). It seems worth mentioning, that NIKOLAEVA (1993) found deep-water ostracodes, including *Agrenocythere* representatives, in the early Paleogene sediments of the Caucasus.

OTHER LAPCZYCA OSTRACODES

Besides *Agrenocythere* and *H. asperrima*, some tentatively determined species occur in the sample that seem to be less important as stratigraphic and paleoecologic markers. However, it is known, that *Bythocypris*, *Krithe*, and *Cytherella* (especially its particular morphotypes) prefer deeper-water environments. Moreover, *Bythocypris lucida* (SEGUENZA, 1880), *Cytherella vulgata* RUGGIERI, 1962, and/or *Krithe citae* OERTLI, 1961, are known from the Middle Miocene of Spain and western, deeper basins of the Mediterranean (BENSON 1978), southern (CIAMPO 1981) and northern Italy (OERTLI 1961), as well as the Central Paratethys (BRESTENSKÁ & JIŘIČEK 1978). COLES & al. (1994) treated *K. citae* (males) as conspecific with *K. morkhoveni morkhoveni* VAN DEN BOLD, 1960, the subspecies known from the Paleocene up to Recent times, and indicated its North Atlantic origin.

EXOTIC LATE BADENIAN OSTRACODES FROM ROZTOCZE AND THEIR PRE-MIOCENE AND MIOCENE DISTRIBUTION

The species *Cluthia miocenica* SZCZUCHURA, 1986, from the Upper Badenian of Roztocze (southeastern Poland) was considered (SZCZUCHURA 1986) to be the oldest species of *Cluthia* and the only species of that genus in Europe. Now it is known that *Cluthia* occurs in the Upper Miocene of northwestern Italy (CIAMPO 1986), and it is recorded, moreover, from Eocene to Recent times in the southern hemisphere (AYRESS & DRAPALA 1994). It is a deep- and cold-water indicator.

The species *Pseudocythere caudata* SARS, 1866, is probably represented in the Late Badenian of Roztocze. This may be one of the oldest populations of that species in Europe. The species *P. caudata* was recorded from the Middle as well as Late Miocene of southern Italy (CIAMPO 1981, 1986). Outside Europe species of *Pseudocythere* (including *P. caudata*) are known from Eocene up to Recent times and are members of the psychrospheric ostracode faunas living in the Atlantic (WHATLEY & COLES 1991).

PALEOGEOGRAPHIC IMPLICATIONS

The geographic and stratigraphic distribution of *Henryhowella asperrima* and other ostracode species discussed above, seem to indicate the extent of the pre-Miocene and particularly the Middle Miocene deeper basins in Europe,

including the Mediterranean in the south and Central Paratethys in the north (see Text-fig. 1). It also suggests, that in the Middle Miocene (except its uppermost part) exchange of faunas within these basins followed mostly peri-Alpine and peri-Carpathian foredeeps. Moreover, it suggests that even the most northern basins were influenced by waters from the Mediterranean as well as (indirectly) from the Atlantic; this happened *via* the Iberian Portal then the Alpine-basins. The geographic barriers, *i.e.* the land masses adhering to the Alpine-Carpathian foredeep (*cf.* BENSON 1976b, STEININGER 1977), mainly in the Middle Miocene, separated these deeper European basins from those situated in northwestern and western Europe; these latter basins were under direct influence from Atlantic. Earlier, *i.e.* in the Paleogene and Lower Miocene the distribution of *H. asperrima* in Europe could profit by the then existing remnant basins which allowed the exchange of faunas even longitudinally.

The geographic and stratigraphic distribution of *H. asperrima* indicates also that not later than in the Middle Miocene the Tethys was closed in the east and southeastern part and that at this time the Mediterranean basins were more shallow in the east than in the west. This variation concerning the depth of the Mediterranean in the Miocene was stated also by SINGH (1976) as well as by BENSON (1978). The exchange of faunas between the Central Paratethys and Eastern Paratethys as well as between the Mediterranean and Indo-Pacific was rather poor and concerned the shallow-water forms only.

The above opinion concerning the Middle Miocene paleogeography of the area discussed is somewhat different from that proposed by other authors, *e.g.* BENSON (1976b), STEININGER & *al.* (1978), RÖGL & STEININGER (1984) or STEININGER & RÖGL (1985). All they suggested that in the Middle Miocene there was a greater connection between Central Paratethys and Eastern Paratethys than with the Mediterranean, and, moreover, that there was a large connection between the Mediterranean and the Indo-Pacific. BENSON (1976a, 1976b, 1978) was the opinion that in the Middle Miocene there was an influence of the Atlantic waters to the Mediterranean, however, it was restricted mostly to its central part as well as southern areas of Western Paratethys.

The afore-mentioned Iberian Portal, then peri-Alpine "corridor", was certainly used to transfer the Atlantic psychrospheric "guests" known from the Łapczyca borehole as well as the Roztocze region into the Fore-Carpathian Depression; according to AYRESS & DRAPALA (1994) the worldwide dispersion of *Cluthia* was achieved in the early Neogene *via* deep water pathways. It is difficult, however, to say whether this corridor transferred similar or different waters during the entire Middle Miocene, or only during its lower part, *i.e.* whether these Middle Miocene psychrospheric ostracodes (of different age, different habitat and different taxonomic structure) from northern Paratethys are of common origin but adapted to different environment, or are of different origin. The first possibility seems to be more probable since *Pseudocythere cf.*

caudata Sars is known from the lower part of the Middle Miocene (Langhian) of Sicily (CIAMPO 1981) and, moreover, representatives of *Cluthia* are unusually small-sized and thin-shelled forms, *i.e.* difficult to be found and/or preserved as fossils.

STEININGER & RÖGL (1979) suggested that there were two transgressions in the Middle Miocene of the Central Paratethys, separated by distinct shallowing connected with the deposition of evaporites. In the present Author's opinion this shallowing can be observed mostly in the peripheral areas of the Central Paratethys and the deposition of evaporites was not restricted to these shallow-water areas.

The warm-water foraminifera associated with the Early Badenian psychrospheric ostracodes in the Fore-Carpathian Depression, indicate that there was a stratification of waters, and (at the same time), there existed a warm surface layer. The lack of warm-water foraminifera in the later Badenian may correspond to the disappearance of this warm surface layer, enabling otherwise deep-water psychrospheric forms to live in shallower waters.

The disappearance of the warm, surface layer in the Late Badenian sea in the Fore-Carpathian Depression (particularly in its northern part), may be a consequence of a change of circulation of the oceanic waters and/or deterioration of climate, as it is known that both depend on each other. Both these events are recognized in the Middle Miocene of different parts of the world. BENSON (1978, 1991), VAN DER ZWAAN (1979, 1982), TROELSTRA & *al.* (1980), ZACHARIASSE & SPAAK (1983) and CHAMLEY & *al.* (1986) recorded similar (as in Poland) changes in the distribution of the Middle Miocene and/or Late Miocene microfauna in the Mediterranean area and explained it as the result of climatic fluctuation as well as a change of circulation. At the same time SHACKLETON & KENNETT (1975), SAVIN & *al.* (1981), and HODELL & KENNETT (1985) proved the Middle Miocene global change of climate, while VERGNAUD-GRAZZINI (1983) stated that from the Serravallian up to the Late Tortonian/Early Messinian the deep waters circulation in the Mediterranean varied from that previously and became more sluggish. This sluggish circulation, when it reached the Central Paratethys, could have been strengthened by the then arising Carpathians.

Thus the afore-mentioned changes of microfauna, particularly foraminifera, in the Middle Miocene of the northern part of the Central Paratethys, as well as the causes of these changes, seem to be comparable to those in the synchronous and younger (Late Miocene) sediments of the Mediterranean. The analogy seems to apply also to the evaporites associated with these events in all the cases mentioned.

The disappearance of the open marine environment in the latest Badenian of the Central Paratethys caused some elements of its ostracode biofacies (*e.g.*

Cluthia) to be restricted in their geographic distribution in Europe and to persist (some up to the present day) only in its southern region. It is not ruled out, however, that they (e.g. *Cluthia*) invaded the Mediterranean basins in the Upper Miocene from the Atlantic *via* the Rifian Corridor.

TAXONOMIC NOTES ON OSTRACODES
FROM THE ŁAPCZYCA BOREHOLE

Henryhowella asperrima (REUSS, 1850)

In the Badenian sediments of Poland the species is very variable in carapace size, shape and ornamentation (see Pl. 1, Figs 9, 10, 12). Specimens found in the Łapczyca borehole are blind. In the present Author's opinion, which agrees with that of RUGGIERI (1962) and UFFENORDE (1981), *H. asperrima* is conspecific (at least) with *H. ruggierii* OERTLI, 1961. KEMPF & NINK (1993) consider *H. evax* ULRICH & BASSLER (1904) as conspecific with *H. asperrima*.

Cytherella cf. *vulgata* RUGGIERI, 1962

It is difficult to say if specimens referred to this species are adult or juvenile forms. Their lateral outline as well as the narrow, rough anterior marginal list and posterior part of the carapace covered by papillae suggest that they may belong to *C. vulgata*. Similar ornamental features occur, however, in *C. robusta* COLALONGO & PASINI, 1980.

Bythocypris cf. *lucida* (SEGUENZA, 1880)

The size, as well as general appearance of specimens, if adult, is close to those known from the Middle Miocene of the Central Paratethys as *B. lucida*. In comparison with specimens referred to this species by various authors (e.g. SISSINGH 1972a, RUSSO 1968, COLALONGO & PASINI 1980) they are more or less different in their lateral outline.

Bythocypris sp.

Unknown internal features of specimens referred to this species as well as the equivocal determination of species belonging to *Bythocypris* (as mentioned above) make its systematic position difficult to recognize. It is worth noting, that in comparison with the associated specimens, those referred to *Bythocypris* sp. are much larger.

Krithe cf. *citae* OERTLI, 1961

The general, external appearance of specimens of this species, especially as seen from above, allows comparison with those described by OERTLI (1961) as *K. citae*. COLES & al. (1994) included *K. citae* (its male representatives only) into the synonymy of *K. morkhoveni* morkhoveni VAN DEN BOLD 1960.

Krithe sp.

Specimens assigned to this species differ somewhat in general appearance. Thus it cannot be ruled out that they belong to various species. They seem similar to those described by OERTLI (1961) as *K. langhiana*, and to those described as *Krithe* sp., by BENSON & PEYPOUQUET (1983), from the deep-sea, late Tertiary sediments of the Rio Grande Rise.

Agrenocythere sp.

This specimen, according to its general, heavy and rather sparse ornamentation, seems similar to those assigned to *A. antiquata* BENSON, 1972. The differences in ornamentation, however, exclude a common origin.

CONCLUSIONS

Psychrospheric ostracodes representing the genera *Cytherella*, *Bythocypris*, *Krithe*, *Henryhowella*, and *Agrenocythere*, coexisting with warm-water planktic foraminifera, found in the early Middle Miocene (Early Badenian) of the Polish part of the Fore-Carpathian Depression, indicate that deep and stratified basins existed therein.

Pre-Miocene and Miocene distribution of these ostracodes, and especially *H. asperrima*, that is long-lasting and cosmopolitic species preferring deeper-water environments, allows to suppose, that these ostracodes invaded the Central Paratethys in the Middle Miocene from the Atlantic *via* the Iberian Portal and then the peri-Alpine foredeeps.

In the Middle Miocene there existed large exchange of ostracodes between the Central Paratethys and the Mediterranean while between the Central and the Eastern Paratethys as well as between the Mediterranean and the Indo-Pacific it was rather weak; the exchange of ostracodes between the latter areas concerned mostly shallow-water forms.

The Iberian Portal probably allowed the psychrospheric species *Cluthia miocenica* SZCZUCHURA and *Pseudocythere* cf. *caudata* SARS to invade later, in the Late Badenian, the northern part of the Central Paratethys, *i.e.* southeastern Poland (Roztocze region).

The shallow-water habitat of ostracodes from the Roztocze region, associated with planktic foraminifera preferring cold-water environment, could be the result of the Middle Miocene climate deterioration and/or change of water circulation, *i.e.* the events recognized in that time in different parts of the world, the Mediterranean including.

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**ZNACZENIE PALEOGEOGRAFICZNE MIOCENSKICH MAŁŻORACZKÓW
PSYCHROSFERYCZNYCH Z ZAPADLIKA PRZEDKARPACKIEGO**

(Streszczenie)

W dolnobadeńskich osadach Zapadlika Przedkarpackiego, napotkanych w wiercieniu Łapczyca-1 koło Bochni (patrz fig. 1) znaleziono charakterystyczny zespół małżoraczków psychrosferycznych, t.j. preferujących wody zimne i głębokie (patrz pl. 1-2). Zespół ten obejmuje gatunki: *Henryhowella asperrima* (REUSS), *Cytherella* cf. *vulgata* RUGGIERI, *Bythocypris* cf. *lucida* (SEGUENZA), *Bythocypris* sp., *Krithe* cf. *citae* OERTLI, *Krithe* sp. oraz *Agrenocythere* sp. Znaleziony zespół wyraźnie różni się pod względem struktury taksonomicznej od poznanych dotąd małżoraczków badanu Polski, reprezentowanych zwykle przez formy nerytyczne.

Współwystępujące w badanym zespole ciepłolubne otwornice planktoniczne określają wiek mikrofauny, a nadto wskazują, iż wody zasiedlanego przez nie basenu były stratyfikowane.

Analiza rozprzestrzenienia w czasie i przestrzeni omawianych małżoraczków, a zwłaszcza *H. asperrima*, sugeruje, iż przedostały się one do zapadlika przedkarpackiego (Paratetydy Centralnej) w środkowym miocenie z Atlantyku, poprzez "korytarz iberyjski", a następnie — zapadlika przedalpejskie (patrz fig. 1).

Zapewne także inne gatunki środkowomiocenijskich małżoraczków psychrosferycznych z obszaru Polski, w tym *Pseudocythere* cf. *caudata* Sars i *Cluthia miocenica* SZCZUCHURA, znane z górnego badenu Rostocza (SZCZUCHURA & PISERA 1986, SZCZUCHURA 1994), wykorzystwały podobną drogę migracji. Tym ostatnim gatunkom towarzyszą małżoraczki i otwornice (bez form ciepłolubnych) pochodzenia nerytycznego. Być może, zmiany klimatyczne i/albo zmiana cyrkulacji w basenach morskich w młodszym badenie umożliwiły płytkowodne występowanie psychrosferycznych małżoraczków na obszarze Rostocza.

Zmiany środowiska morskiego w środkowym miocenie Paratetydy Centralnej i innych obszarów Europy, w tym obszaru śródziemnomorskiego, stwierdzone m.in. w oparciu o badania mikrofaunistyczne, wykazują znaczne analogie.