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LATE DEVONIAN AND CARBONIFEROUS OSTRACODE ASSEMBLAGES AND THEIR RELATIONSHIP TO THE DEPOSITIONAL ENVIRONMENT

by M. J. M. BLESS (*)

ABSTRACT. - Four main depositional realms have been recognized in late Devonian and Carboniferous sediments. The boundaries between these entities are vague and transitional facies are known. The variations in the sedimentary environment have been clearly expressed in the ostracode faunas. In the late Devonian and Carboniferous strata around the Brabant Massif (Belgium and surrounding areas) the ostracode assemblages indicate the presence of marine near-shore to marine shallow off-shore environments during late Devonian and Dinantian times, and non-marine to marine near-shore facies during the Silesian period.

INTRODUCTION.

The distinction between a wide range of depositional environments, which may vary from non-marine to fully marine, is essential in the reconstruction of the tectonic evolution of sedimentary basins. Geochemistry, sedimentology and paleontology provide very valuable tools in a detailed interpretation of the conditions of deposition in the past. Ostracodes form one of the microfossil groups which have been applied successfully in the recognition of different sedimentary facies. Since Paleozoic times, they have adapted themselves to all kind of aquatic environments from the deep-sea to water-filled hollow tree-trumps and flowers, from hotwater springs to arctic seas, and from normal fresh-water to sulphuric, acid, alkaline or hypersaline water. Unfortunately, too often the papers on fossil ostracodes are limited to information on their systematics or stratigraphical distribution.

The potential of Paleozoic ostracodes for environmental interpretation has been clearly demonstrated in a large number of papers. An excellent review on the paleoecological distribution of Upper Devonian ostracodes has been published recently by LETHIERS (1982). He showed that ostracode assemblages can be used in the discrimination between several marine paleobiotopes, ranging from lagoonal to bathyal, in the Upper Devonian. Also in the Carboniferous sediments, a number of facies-controlled ostracode assemblages can be recognized. These permit to distinguish between four broad environmental realms which are termed here non-marine, marine near-shore, marine shallow off-shore and marine basin (figure 1). Within each of these realms, a number of distinctive ostracode groups may be recognized which enable to establish an even more detailed environmental zonation. A titre d'example, some characteristic late Devonian (late Famennian) and Carboniferous ostracode assemblages have been figured here (figures 2-11).

The recognition of some of these ostracode populations in late Famennian and Carboniferous deposits in the area around the so-called Brabant Massif (Belgium and surrounding areas of France, the Netherlands and the Federal Republic of Germany) has permitted to confirm the overall pattern of transgressions and regressions during that timespan (figures 13-23). These examples may serve in stimulating further paleoecological research on Devono-Carboniferous ostracodes.

NON-MARINE REALM.

Included are limnic and other fresh-water facies, as well as oligohaline, brackish-water and estuarine environments.

(*) Museum of Natural History Maastricht, Bosquetplein 6-7, 6211 KJ Maastricht, the Netherlands.

It should be realized that the latter are transitional to the true marine realm.

In Carboniferous times, the non-marine realm was characterized by representatives of only a few genera.

Carbonita (synonyms : *Gutschickia, Hilboldtina, Pruvostina, Whipplella*) seems to have been the predominant ostracode genus in many fresh-water paleobiotopes, but may have shown some tolerance for low salinites. *Carbonita* occurs in a variety of non-marine (clastic to carbonate) sediments, but seems to have preferred a clayey-silty substratum with often abundant organic matter. The presence of other ostracode genera - e.g. *Darwinula* - has sometimes been reported. Remarkable is the (rare) occurrence of the cypridinacean *Eocypridina* (synonym : *Radiicypridina*) in non-marine Upper Carboniferous strata of North America and Northwestern Europe.

Some species of *Geisina* (formerly often assigned to *Jonesina*) and *Sansabella* have been observed frequently in strata which have been interpreted as brackish-water deposits. These ostracodes may occur also in true fresh-water sediments (together with *Carbonita*) or in possibly marine, littoral deposits (with lingulid brachiopods, agglutinating foraminifers with arenaceous test and/or paraparchitacean or hollinellid ostracodes).

Non-marine ostracode assemblages have been described from both the Dinantian and Upper Carboniferous throughout the world. Identification of species or even genera is often difficult because of the poor preservation of non-marine ostracodes. Lateral outline, hingement, muscle scars and surface ornamentation may have been obscured on steinkerns or external molds of the frequently crushed, wrinkled, decalcified or recrystallized valves. This makes the discrimination between several genera and families of practically smooth-shelled, more or less bean-shaped ostracodes of *Carbonita* type by means of practically never observed details such as muscle attachment scars (as advocated by SOHN, 1977) to a merely academic problem, especially as long as no systematic review of muscle scars in all Late Paleozoic non-marine ostracode species has been carried out. However, one should be aware of the fact that possibly all the above genera are "sack-genera". This means that SOHN's (1977) criteria for splitting up *Carbonita* are valid, and may be applied also to *Geisina* and *Eocypridina*.

MARINE NEAR-SHORE REALM.

Included are several environments, which have been termed a.o. (eu-)littoral, supratidal to shallow subtidal, shallow neritic or epicontinental, inner shelf or platform, restricted marine, and lagoonal by different authors. Transitional facies to the non-marine and shallow marine off-shore realms are known.

The Carboniferous littoral paleobiotopes have been characterized by relatively monotonous, epi- or endobenthonic faubas, which flourished on a substratum of predominantly fine-grained clastic sediments. More diverse assemblages occurred in tide pools, lagoons and intertidal to shallow subtidal facies with sometimes varying salinity, water energy (turbulence) and oxygen contents, especially if the substratum consisted of fine-grained carbonates of calcareous clays and silts. The local occurrence of pyrite, pyritized or decalcified fossils suggests poorly aerated bottom conditions with low oxygen values below the sediment-water interface. Spineless, relatively large (up to several millimeters) paraparchitaceans have been the most common ostracodes in the littoral paleobiotope. Also *Beyrichiopsis* and some hollinellids have been recognized frequently in littoral deposits. A rather peculiar form is *Copelandella novascotica* from the Dinantian of southeastern Canada. The overall shape of this beyrichiacean ostracode strongly resembles that of the hollinellids. *Copelandella* may have occupied the same ecological niche as the latter ones, since it occurs in association with paraparchitaceans and the non-marine genus *Carbonita* (BLESS & JORDAN, 1971).

A characteristic inhabitant of the marine near-shore environment in late Devonian and Dinantian times was *Cryptophyllus*. This eridostracan genus disappeared at the beginning of the Dinantian in Canada, Northern Europe and the U.S.S.R. But in a more southern belt (Australia - JONES, 1974; Iran and Libya - BLESS & MASSA, 1982), *Cryptophyllus* has been found also in Lower and Upper Dinantian strata. *Cryptophyllus* and related genera have been reported also from much younger deposits (*Cryptophyllus* from Upper Jurassic of North America - SWAIN & PETERSON, 1951; *Ankumia* from late Cretaceous of the Netherlands - VAN VEEN, 1932).

Apart from the paraparchitaceans, hollinellids (or *Copelandella* in the Dinantian of southeastern Canada) and *Cryptophyllus*, most of the Carboniferous ostracodes in the marine near-shore realm have been relatively small (rarely over 1 mm). Many of these are smooth-shelled or possess a slightly ornamented carapace (punctate, granulose, striate). Spines are practically absent or very small (healdiids, *Rhadamesella*). Kloedenellaceans, cavellinids and healdiids are relatively frequent. Quasillitaceans (a.o. *Graphiadactyllis, Rhadamesella*) occur in some Dinantian near-shore assemblages. These groups may be common also in the marine shallow off-shore realm.

Low numbers of more ornamented ostracode genera are present in many near-shore deposits. The most frequent group is that of the kirkbyaceans. However, these may occur as well in the shallow off-shore and basin facies. Sometimes, small spinose, lobate or nodose forms occur. In the examples shown here, one should notice the presence of such ostracodes in the latest Devonian and Dinantian of Lybia (*Mammoides, Aechminella*) and Northwestern Europe (*Kellettina aculilobata*), and in the Silesian of Northwestern Europe (*Cornigella*). Presumably, these occupied a special niche within the nearshore realm.

Bairdiacean ostracodes are practically absent in typical near-shore environments.

MARINE SHALLOW OFF-SHORE REALM.

Included are several environments, which have been termed a.o. subtidal or infratidal, open marine neritic or epicontinental, open marine or outer stable shelf or platform, carbonate shelf or platform, and bathylittoral by different authors. Transitional facies to the marine near-shore and marine basin realms are known. For example, many biostromal paleobiotopes may be situated at the boundary between the marine near-shore and shallow off-shore realms.

Carbonate deposits predominate in the marine shallow off-shore realm, this in contrast to the marine near-shore environments where carbonates are practically absent or subordinate to the clastic sediments. The shallow off-shore facies are not necessarily deeper than those of the near-shore realm. This may be deduced from the presence of a.o. algal mats, corals and other organisms, which may have preferred shallow to extremely shallow paleobiotopes, and from sediments, which suggest turbulent depositional conditions (within the zone of wave energy).

Bairdiaceans (*Bairdia, Acratia, Bairdiacypris*) and *Bairdiocypris* (synonym : *Silenites*) are amongst the most characteristic ostracodes of the marine shallow off-shore realm, where they predominate in many assemblages. Also spinous paraparchitaceans (*Shishaella, Shivaella*) are typical representatives of these environments.

These and other ostracodes of the marine shallow off-shore realm are relatively large. The beyrichiacean *Pseudoleperditia* (lowermost Dinantian of the U.S.S.R., Northwestern Europe and North America) may be up to 4 mm, whereas some myodocopid genera (which have been common, possibly nektobenthonic inhabitants of this realm) may even attain 5 to 10 mm (e.g. *Cyprella, Entomoconchus*). Relatively large (over 1 mm), more or less ornamented ostracodes (e.g. *Coryellina*, kirkbyaceans, *Glyptopleura*) have been recorded regularly, usually however in low numbers. The predominance of relatively large ostracode species in marine shallow off-shore carbonates - as compared with the predominance of relatively small species in clastic-dominated near-shore facies - has been discussed earlier by BLESS et al. (1981).

Frequently, also vacellinids and healdiids occur, although these ostracodes have had their optimal distribution within the marine near-shore realm. Kloedenellaceans and quasillitaceans may be present in some marls or clay-dominated deposits.

MARINE BASIN REALM.

Included are several environments, which have been termed a.o. bathyal or abyssal, deep-sea or "deeper water", "Kulm", "Stillwasser", restricted basin, shale-dominated basin, pelagic, planktonic, oceanic, psychrospheric (= cold water), Thuringian or Entomozoan by different authors. Transitional facies to the marine shallow off-shore realm are known.

The sediments are clayey to silty with subordinate carbonates. The fossil assemblages are dominated ny nektonic or pelagic organisms (e.g. cephalopods). The marine basin in Devono-Carboniferous times is poorly defined, especially insofar as water depth and temperature are concerned. This problem has been enhanced with the rather vague definition of terms like "Kulm" and "restricted basin", which have been interpreted in different ways in the literature. For example, "Kulm" has been applied to a variety of clastic deposits, which range from greywackes to shales, and which may have been deposited at varying depths and water energy conditions. The term "psychrospheric" has been applied by some paleontologists (e.g. GRÜNDEL & KOZUR, 1975) for strongly ornamented, spinous ostracode assemblages of "Thuringian ecotype", because these resemble present-day psychrospheric assemblages (cf. BENSON & SYLVESTER-BRADLEY, 1971). Today, these preferably occur in deep-sea (below say 500 m) environments. But in regions of upwelling, these cold-water ostracodes may be found in shallower water. However, as already pointed out by LETHIERS (1982, 1983), ostracodes of Thuringian ecotype have predominated the assemblages in Devonian and Dinantian marine basins around the paleo-equator, at least according to the literature available thus far. OLEMPSKA (1979) correctly noticed that the morphological resemblance of present-day psychrospheric ostracodes and Paleozoic ones of Thuringian ecotype may not be sufficient for a reliable interpretation of Thuringian paleobiotopes. It is suggested, however, that the late Devonian and Carboniferous marine basin sediments have been deposited in water (considerably) deeper than that of the marine near-shore and shallow off-shore realms, and under very low energy conditions.

Two ostracode assemblages - which may, but do not necessarily, occur together - characterize the marine basin deposits.

The thin-shelled entomozoans with their striate "finger-print" ornamentation may have preferred a pelagic environment. Representatives of this group have sometimes entered the shelf facies. Entomozoans have been well preserved as molts in shale, but also occur in carbonates.

A benthonic or near-benthonic paleobiotope is suggested for a rather diverse group of (sometimes spinous) bairdiaceans and heavily ornamented, spinous ostracodes. These are rarely associated with marine shallow off-shore assemblages.

COMPARISON WITH OTHER OSTRACODE ASSEMBLAGES.

Four depositional realms have been distinguished in the Carboniferous. Their boundaries are flexible and only vaguely defined. Each of these realms might be subdivided into several smaller entities. The variations in the sedimentary environment have been clearly expressed in the ostracode faunas. In order to compare some general features observed in the course of the present study with the ideas of other authors, the principal ostracode associations and their corresponding facies have been summarized in figure 12. The data in this figure are easily compared with those of other reports.

The relationship between facies and ostracodes in the Upper Devonian has been reviewed by LETHIERS (1982). This author roughly distinguished between three paleobiotopes. The first one is comparable to our marine near-shore realm (termed "lagunaire et estuarine, supratidal, intertidal, marin restreint, marin ouvert" by LETHIERS). It is characterized by the presence of *Cryptophyllus*, *Beyrichiopsis*, kloedenellaceans, paraparchitaeans, quasillitaceans, cavellinids and barychilinids. The main difference with our assemblage is the practical absence of barychilinids and the rare occurrence of quasillitaceans in our populations. Moreover, LETHIERS included both spineless and spinous paraparchitaceans in these environments. The second paleobiotope of LETHIERS is comparable to our marine shallow off-shore realm (termed "marin restreint, marin ouvert, circalittoral" by LETHIERS). This paleobiotope was characterized by bairdiaceans and a group of usually ornamented ostracodes of so-called "Eifelian ecotype". Also paraparchitaceans and kloedenellaceans are frequent in this paleobiotope. LETHIERS' assemblage strongly resembles ours, with the exception that kloedenellaceans are rare in our shallow off-shore realm. The third paleobiotope (termed "circalittoral, bathyal" by LETHIERS) resembles our marine basin, and is characterized by spinous ostracodes of the "Thuringian ecotype". LETHIERS believes that entomozoans may have lived in practically all marine environments. In our opinion, entomozoans were pelagic inhabitants of the marine basin and only occasionally they have been swept into the shelf area because of storms or other accidents.

ROBINSON (1978) has made some observations on the ecological factors controlling the distribution of Dinantian ostracodes in Great Britain. He suggested that ostracode assemblages characterized by a low species diversity, and high number of individuals in the faunas of carbonaceous or ferruginous mudstones, might be "brackish-water" indicators. Representatives of such assemblages are *Cavellina*, and certain species of *Beyrichiopsis*, *Glyptopleura*, *Glyptolichvinella* and *Paraparchites* s.l. (according to ROBINSON). Except for *Cavellina* and *Glyptopleura* , this matches our own observations. However, in our opinion, these ostracodes should be termed marine near-shore (littoral), rather than brackish-water indicators because of their frequent association with the inarticulate brachiopod genus *Lingula*. In fact, these different views demonstrate that a reliable discrimination between these environments, which are transitional between true non-marine and marine near-shore, remains problematic and possibly also a matter of definition.

BLUMENSTENGEL (1975) has described some ostracode assemblages from the Dinantian of the northern German Democratic Republic (Rügen, Hiddensee). His assemblage "Saggard-1" bears some resemblance with our marine near-shore (transitional to shallow off-shore) assemblage, and is characterized by kloedenellaceans (10 to 50% of the populations), bairdiaceans and healdiaceans. His assemblage "Allgemeiner Typ" (general type) resembles our marine shallow off-shore populations because of the predominance of bairdiaceans and healdiaceans. His assemblage "Rügen-2" can be compared with our marine basin because of the presence of spinous ostracodes, bairdiaceans and healdiaceans. However, this latter fauna is aberrant insofar as quasillitaceans are abundant (20 to 60%).

LATE DEVONIAN AND CARBONIFEROUS OSTRACODE ASSEMBLAGES AROUND THE BRABANT MASSIF.

Two major depositional cycles can be distinguished in the Devonian and Carboniferous sediments of Belgium and surrounding areas (figure 13). Each of these shows a succession of strata which range from predominantly non-marine to marine near-shore clastics, through full marine carbonates into essentially non-marine to marine near-shore clastics. Both cycles are subdivided in a lower transgressive phase (the resultant of numerous more or less important transgressions which reached their acme during, respectively, the Eifelian-Frasnian and Dinantian), and an upper regressive phase (also composed of several major and minor regressions reaching their acme during, respectively, the late Famennian and Silesian).

These transgressions and regressions are recognized not only in the nature of the sediments, but also in the fossil contents of the same. Also ostracodes have proved to provide a valuable means in these investigations. This may be deduced from the example of the late Devonian and Carboniferous ostracode populations in the area around the Brabant Massif (figures 14-23).

The Brabant Massif is a - roughly East-West directed - complex tectonic unit of Cambro-Silurian rocks, extending from Southeastern England through Brussels into the area between Maastricht and Liège. It has acted as a positive horst area since the end of the Caledonian movements. At least important parts of the Brabant Massif must have been gradually overwhelmed by transgressing shelf seas during the acme of the Eifelian-Frasnian and Dinantian transgressions. During the Lower Devonian, late Famennian and Silesian, the Brabant Massif may have been - at least at intervals - a subordinate source area for the sediments deposited in the basins to the North (Campine-Brabant) and to the South (Dinant-Namur).

OSTRACODES OF THE TRANSGRESSIVE PHASE (STRUNIAN-DINANTIAN).

The gradual transgression of the sea over the flanks of the Brabant Massif during the late Famennian and early Dinantian (Fa2c-Tn2) can be recognized a.o. in the region South of Brussels (Feluy, Ecaussines, Onoz). In this area, the late Famennian sediments are either absent or very condensed and incomplete. The Strunian (Tn1a) and basal Dinantian (Tn1b) sediments have been deposited under marine near-shore conditions as has been deduced a.o. from the ostracode assemblages characterized by the presence of knoxiellids (and *Cryptophyllus* in the Strunian), and by the absence of bairdiaceans. The transgression has been completed only in the Middle Tournaisian (Tn2), when a marine shallow off-shore environment (with a more diverse fauna) becamed installed in this region. This is reflected in the ostracode population by the appearance of bairdiaceans.

In the Maastricht area, marine near-shore facies persisted only during the late Famennian and Strunian. Here, bairdiaceans and spinous paraparchitaceans appear in the basal Dinantian (Tn1b). Elsewhere (Aachen area, Ourthe Valley, Hoyoux Valley, Bocq Valley), marine shallow off-shore conditions are found already in Strunian times. Only in the southwestern part of the Dinant Synclinorium (Avesnois, Dinant region), the bairdiacean ostracodes, characterizing marine shallow off-shore facies, occur throughout the Famennian and Dinantian.

Evaporites (anhydrite, pallisade calcite), collapse breccias and some condensed sequences within the Dinantian carbonates indicate the existence of transitory restricted marine environments. In the ostracode assemblages, these restricted facies are reflected by the temporary disappearance of bairdiaceans and the predominance of paraparchitaceans and slightly ornamented ostracodes. However, in contrast to typical marine near-shore assemblages, knoxiellids are practically absent, whereas spinous paraparchitaceans persist in these populations.

The richest and most diverse ostracode assemblages have been recognized in the carbonates of the marine shallow off-shore realm in association with a prolific benthonic fauna (corals, brachiopods, bryozoans) and flora (algae). These assemblages not only consist of bairdiaceans and spinous paraparchitaceans, but also of (sometimes ornamented) myodocopids, some kirkbyaceans and certain species of the costate genus *Glyptopleura*.

OSTRACODES OF THE REGRESSIVE PHASE (SILESIAN).

The study of Silesian ostracodes around the Brabant Massif is far from being completed. No data exist for the Namurian. One may expect that bairdiaceans and spinous paraparchitaceans will be found in some Lower Namurian shallow off-shore deposits. In the younger Namurian strata, the ostracode assemblages are possibly dominated by either non-marine (*Carbonita, Geisina, Sansabella*), or marine near-shore forms of littoral type (spineless paraparchitaceans, hollinellids, *Beyrichiopsis*). More diverse ostracode populations, indicative of a marine near-shore environment sensu lato, will be restricted to a few marine bands, representing the most important (short-lived) transgressions. The same is known for the Westphalian, where ostracodes of the marine near-shore environment are restricted to some widespread marine horizons such as Finefrau Nebenbank and Aegir.

In the area discussed here, typical paralic conditions in Lower Westphalian times are indicated by the frequent occurrence of brackish-water representatives of the genus *Geisina*, whereas the almost exclusively fresh-water deposits of the Upper Westphalian have yielded only species of the genus *Carbonita*. It should be noticed that paralic facies persisted into the early Upper Westphalian of Great Britain, where brackish-water ostracodes of the genus *Geisina* have been reported from several horizons in the Upper Westphalian B and Lower Westphalian C. This matches the observation that the fossil assemblages of the Westphalian marine bands are more diverse in Great Britain than in Northern France, Belgium, the Netherlands and northern Germany, thus suggesting that the Westphalian marine transgressions overwhelmed the Northwestern European coal basin somewhere from the West. This believe is supported also by the presence of several ostracode species in a.o. the Aegir Marine Band, which had been described previously from Spain and North America.

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Fig. 1 - Cartoon showing the relationship between the main depositional environments and characteristic representatives of the ostracode assemblages occurring in the same during Silesian (upper row) and Dinantian (lower row) times (scale bar = 1 mm).

1. *Truyolsina truyolsi* BECKER & BLESS 1975 from cephalopod-bearing Lower Namurian (*Eumorphoceras* goniatite zone) shales of northern Spain (BECKER et al. 1975);
2. *Bairdia sp.* from Upper Westphalian marine shales (with pelecypods, gastropods, articulate brachiopods, fenestellid bryozoans and crinoids) of northern Spain (VAN AMEROM et al. 1970);
3. *Acratia cf. garrisonensis* (UPSON 1933) from the Upper Westphalian Aegir Marine Band (with articulate brachiopods, concodonts, and ostracodes belonging to the genera *Cypridina, Bairdia* and *Hollinella)* of southwestern Belgium (BLESS & WINKLER PRINS 1972);
4. *Hollinella (Hollinella) cristinae* BLESS 1965 from Upper Westphalian marine (pyritous and bituminous) shale (with articulate brachiopods, fusilinid foraminifers, and ostracodes belonging to the genera *Jordanites, Sansabella, Acratia* and *Bairdia*) of northern Spain (BLESS 1967);
5. *Beyrichiopsis lophota* COPELAND 1957 from Namurian brackish-water to marine littoral shale of southeastern Canada (COPELAND 1957);
6. *Chamishaella cf. brosgei* SOHN 1971 from Lower Namurian (*Eumorphoceras* goniatite zone) Assedjefar Formation (facies transitional between intertidal and subtidal; with *Hollinella, Amphissites, Shivaella, Graphiadactyllis, Cavellina, Healdia* and *Cribroconcha*) of Libya (BLESS & MASSA 1982);
7. *Sansabella carbonaria* COOPER 1946 from Lower Westphalian brackish-water (?) shale of southeastern Canada (COPELAND 1957);
8. *Carbonita humilis* (JONES & KIRKBY 1879) from Lower Westphalian non-marine shale (with non-marine lamellibranchs, fish-scales and the arthropod genus *Anthrapalaemon*) of the southern Netherlands (BLESS & POLLARD 1972);
9. *Tricornina (Bohemia) gracilis* RABIEN 1954, and
10. *Richterina (Maternella) cf. gyrata* (Reinh. Richter 1856) from Lower Dinantian (*Gattendorfia* goniatite zone) sequence of cephalopod-bearing shales with limestone nodules of Thuringia (German Democratic Republic; GRÜNDEL 1961, 1962);
11. *Bairdia sp.* from Lower Dinantian (*Gattendorfia* goniatite zone) limestone (with a.o. *Shishaella, Coryellina, Bairdiocypris, Acratia* and *Absina*) of Jablůnka-1 borehole, Czechoslovakia (this report);
12. *Shishaella sp.* from Lower Dinantian (Tn1b, *Gattendorfia* goniatite zone) sequence of shales and carbonates (with corals, crinoids, gastropods, conodonts and foraminifers) of the southern Netherlands (BLESS 1982);
13. *Acratia aff. rostrata* ZANINA 1956 from Lower Dinantian (Tn2a) shales (with brachiopods, crinoids, bryozoans and ostracodes belonging a.o. to the genera *Bairdia, Shishaella, Amphissites, Kummerowia, Coryellina*) of eastern Belgium (BECKER & BLESS 1974);
14. *Copelandella novascotica* (JONES & KIRKBY 1884) from the Lower Dinantian Horton Bluff Formation (with *Paraparchites, Carbonita*) of southeastern Canada (BLESS & JORDAN 1971);
15. *Beyrichiopsis ex. gr. chovanensis* (POZNER sensu GUREVICH 1966) from the Strunian (Tn1a) shales (with *Cryptophyllus* and *Knoxiella*) of the Southern Netherlands (BLESS 1982);
16. *Paraparchites sp.* from Upper Dinantian (Visean) shales and sandstones with intercalated evaporites (suggesting intertidal to supratidal deposits of Libya)(BLESS & MASSA 1982);
17. *Cryptophyllus sp.* from Upper Dinantian (V1) shales and sandstones (with a.o. *Aechminella, Monoceratina, Graphiadactyllis, Marginohealdia, Rhadamesella, Cavellina* suggesting intertidal deposits) of Lybia (BLESS & MASSA 1982);
18. *Carbonita subangulata* (JONES & KIRKBY 1879) from Dinantian marine limestone (presumably washed into this environment from non-marine facies) of Scotland (ANDERSON 1970).

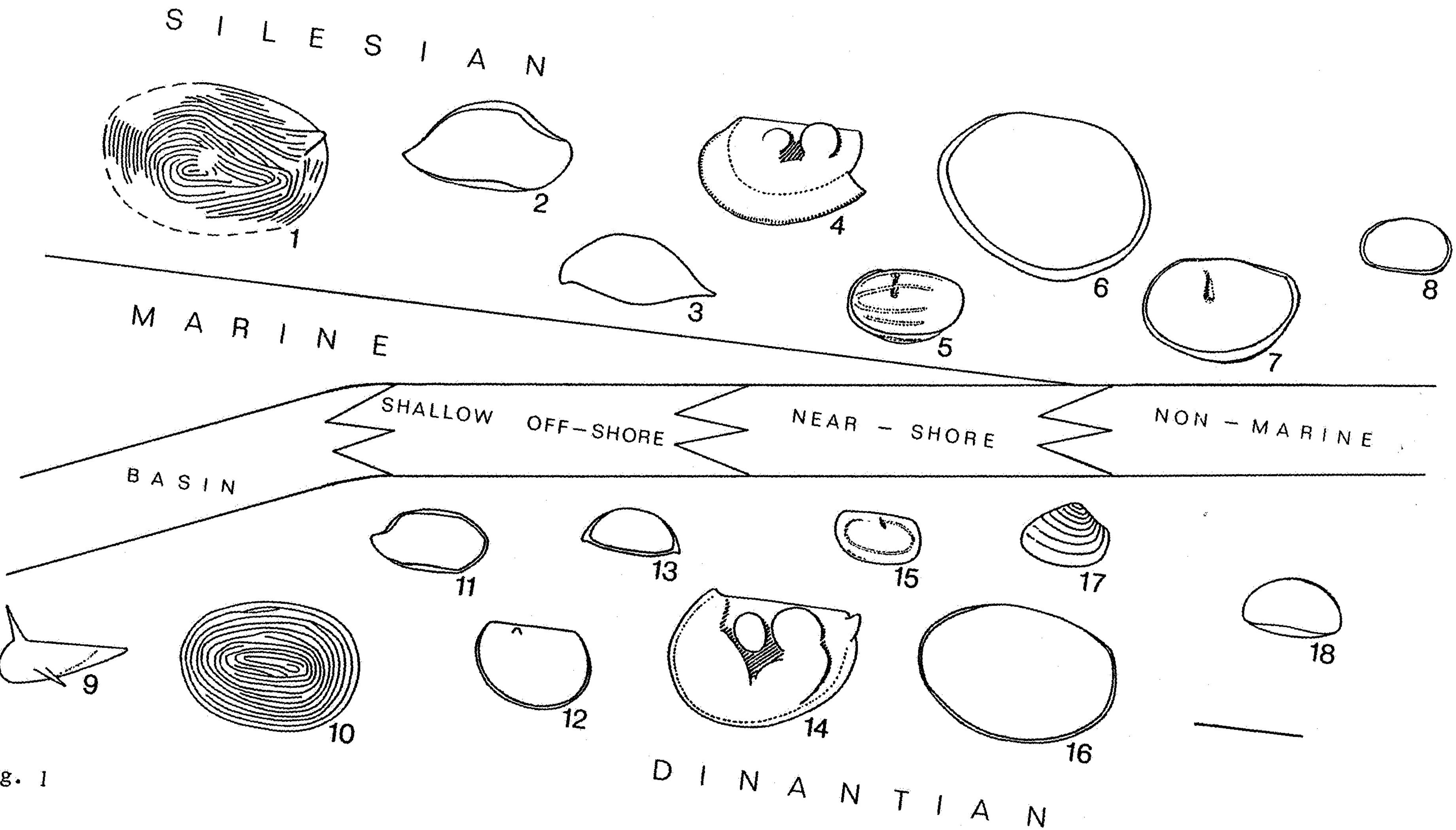
SILESIAN
MARINE
BASIN
SHALLOW OFF-SHORE
NEAR - SHORE
NON - MARINE
DINANTIAN
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Fig. 1

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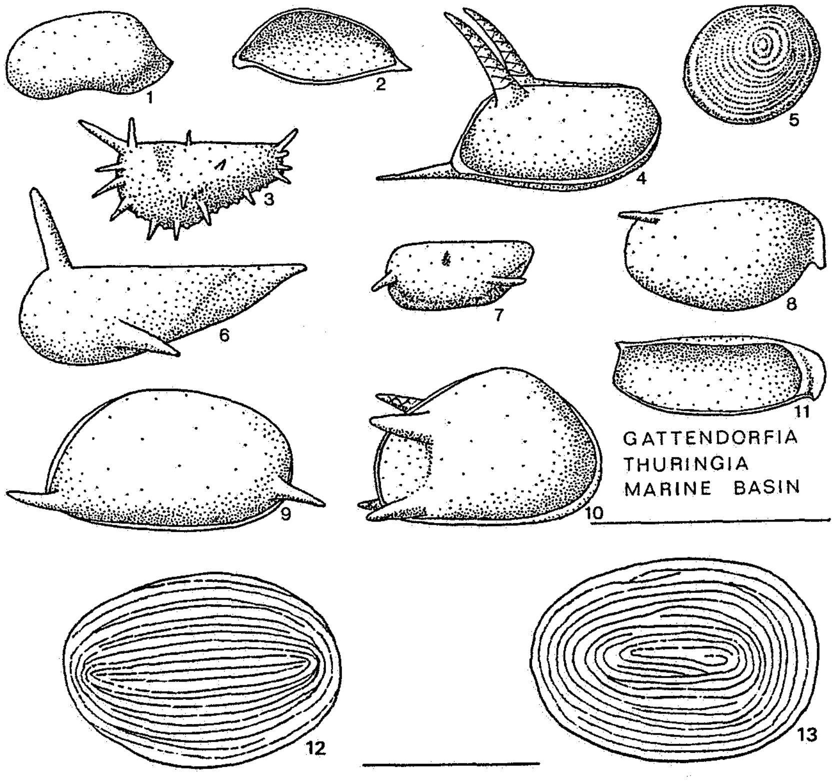

Fig. 2 - Lower Dinantian (Tn1b, Gattendorfia) ostracode assemblage from Thuringia (German Democratic Republic; after GRÜNDEL 1961, 1962). The (silicified) ostracodes have been derived from reddish-grey limestone nodules embedded in (dark) grey, sometimes green or red dyed, micaceous shale. Both the shale and limestones nodules may contain abundant pyrite. It is believed that originally the shales were calcareous, and that the limestone nodules have been the result of a complex of diagenetic and geochemical processes. Amongst the megafossils goniatites, trilobites, crinoids and the pelecypod genus *Posidonia* are frequent. The ostracodes figured here are characteristic of the many species with usually spinous carapaces occurring in this environment. Also figured are the representatives of the equally abundant and diverse group of Entomozoan ostracodes with their typical "finger-print" ornamentation. Normally, the Entomozoans have been preserved and studied as inner and outer molds in the shale. Silicified specimens are extremely rare. And it is practically impossible to prepare their tiny calcareous tests from the limestone.

The association of Entomozoans and ostracodes with spinous carapaces is characteristic of deposits with often abundant cephalopods, trilobites and conodonts, and a rather monotonous fossil assemblage of benthic organisms. This suggests a poorly aerated substratum with low oxygen content. The fossil assemblage is considered to be typical for the so-called "Thuringian paleobiotope" and has been interpreted by many authors as indicative for a relatively deep basin.

1. *Bairdia cf. compressa* GEIS 1932;
2. *Acratia (Cooperuna) ventriosa* GRÜNDEL 1961;
3. *Saalfeldella multispinosa* GRÜNDEL 1961;
4. *Rectonaria muelleri* GRÜNDEL 1961;
5. *Bertillonella sphaerula* GRÜNDEL 1961;
6. *Tricornina (Bohemia) gracilis* RABIEN 1954;
7. *Monoceratina saalfeldensis* GRÜNDEL 1961;
8. *Absina (Heterma) unispinosa* GRÜNDEL 1961);
9. *Gerodia ratina* GRÜNDEL 1962;
10. *Healdia thuringensis* GRÜNDEL 1961;
11. *Absina (Absina) ectina* GRÜNDEL 1962;
12. *Richterina (Richterina) latior* RABIEN 1961;
13. *Richterina (Maternella) cf.gyrata* (REINH. RICHTER 1856).

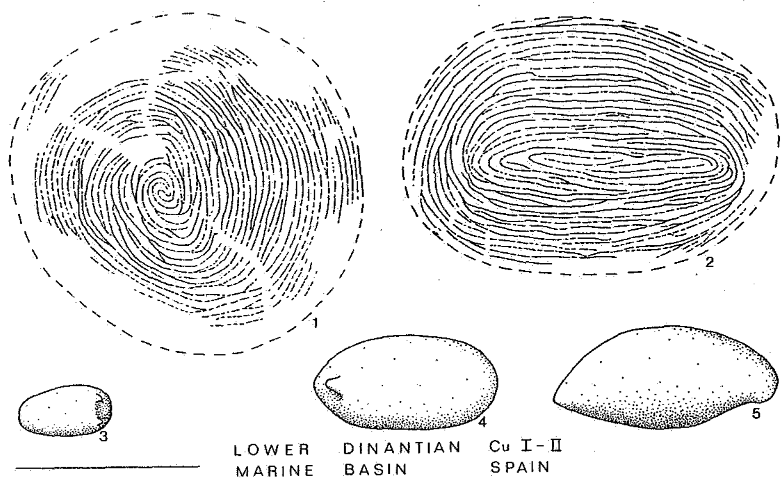

Fig. 3 - Lower Dinantian (CuI-II) ostracode assemblage from black (sometimes slightly calcareous), cephalopod-bearing shales of the Vegamian Formation (Leon, northern Spain; JORDAN & BLESS 1970). The ostracode assemblage also includes forms with a spinous test (e.g. *Tricornina*) and can be compared with those described from the "Thuringian paleobiotope".

1. *Maternella geniceraensis* JORDAN & BLESS 1970;
2. *Richterina (Richterina) aff. latior* RABIEN 1960;
3. *Healdia sp.*;
4. *Triplacera? sp.*;
5. *Acratia sp.*

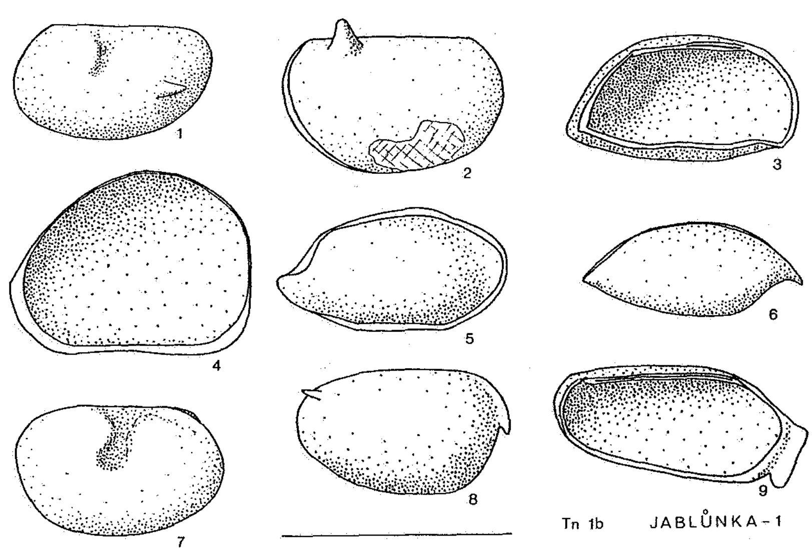

Fig. 4 - Lower Dinantian (Tn1b, Gattendorfia) ostracode assemblage from the Jablůnka-1 borehole (Moravia, Czechoslovakia), sample 5.601.50 m (this report).
The assemblage shows a mixture of elements which are characteristic of the shallow platform offshore environment (*Shishaella, Coryellina, Bairdiocypris*), representatives of the basinal, nodular limestones of the so-called Thuringian paleobiotope (*Absina*), and genera which may occur in both paleo-environments (*Acratia, Bairdia*).
This suggests that the depositional environment may have been located at the border between the shallow marine shelf and the relatively deeper(?) basin.

1. *Coryellina sp.*,
2. *Shishaella sp.*,
3, 6. *Acratia (Cooperuna) sp.*,
4. *Bairdiocypris sp.*,
5. *Bairdia sp.*
7. *Knoxiellid*,
8. *Absina (Heterma) unispinosa* (GRÜNDEL 1961),
9. *Absina (Absina) aff. ectina* GRÜNDEL 1962.

LATE FAMENNIAN–DINANTIAN IN BELGIUM, S. NETHERLANDS, AND F. R. G.

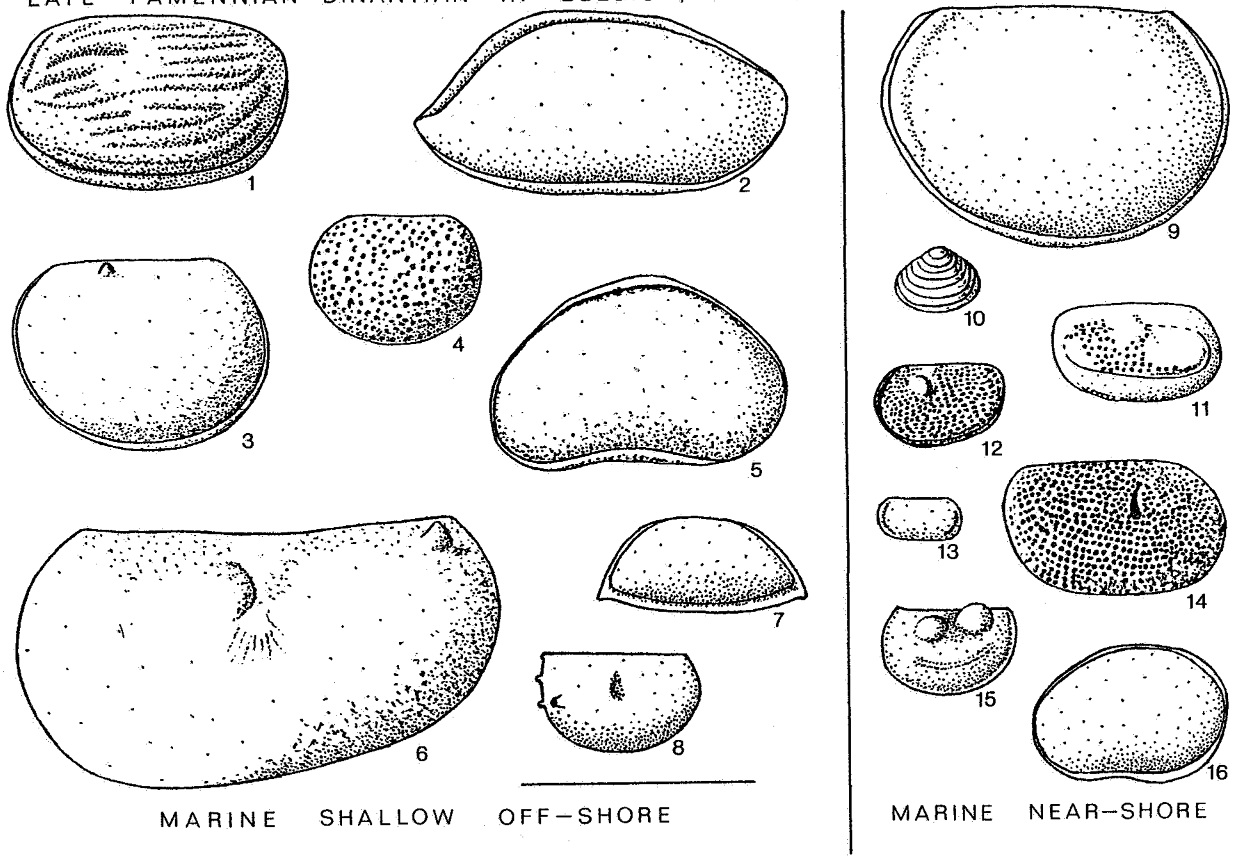

Fig. 5 – Late Famennian to late Dinantian ostracode assemblages from Belgium, the southern Netherlands and neighbouring parts of the Federal Republic of Germany (after BECKER & BLESS 1974, BECKER et al. 1974, BLESS et al. 1976, BLESS 1982, this report). Two assemblages, characterizing marine near-shore and shallow off-shore environments, have been distinguished. The near-shore facies of late Famennian to early Dinantian (Tn1b) times was the domain of sand-silt deposition in intertidal to even supratidal facies. The late Famennian to early Dinantian (Tn1b) near-shore facies around the so-called Brabant Massif (location indicated on figure 15-20) was the domain of alternating sand, silt and even (early diagenetic) dolomite deposition in intertidal to supratidal environments. In this area, there existed isolated ponds with a substratum of fine-grained carbonate mud, with practically no macro-organisms (apart from rare pelecypods and gastropods) and a rather diverse microfauna, almost exclusively consisting of ostracodes. Apart from large, smooth-shelled paraparchitaceans, practically all the species were relatively small (less than 1 mm), and many of these showed a finely ornamented carapace. Frequently coarse-grained carbonates with a prolific benthos (corals, brachiopods, crinoids) dominated in the shallow marine off-shore environments, where an equally diverse ostracode assemblage of predominantly smooth-shelled and relatively large (usually more than 1 mm) species flourished.

1. *Glyptopleura costata* (MC COY 1844) from DZH1 borehole near HEIBAART (Belgium), 1326.60 m;
2. *Bairdia sp.*;
3. *Shishaella sp.*;
4 *Libumella sp.*;
5. *Bairdiocypris aff. rudolphi* (KUMMEROW 1939);
6. *Pseudoleperditia venulosa* (KUMMEROW 1939);
7. *Acratia aff. rostrata* ZANINA 1956;
8. *Coryellina triceratina* POZNER in SAMOILOVA & SMIRNOVA 1960;
9. *Shemonaella sp.?*;
10. *Cryptophyllus sp.*;
11. *Beyrichiopsis ex gr. chovanensis* (POZNER sensu GUREVICH 1966);
12. *Knoxiella sp.*;
13. *Moorites sp.*;
14. *Knoxiella cf. complanata* (KUMMEROW 1939);
15. *Kellettina acutilobata* (ROME 1971);
16. *Cavellina coela* (ROME 1974).

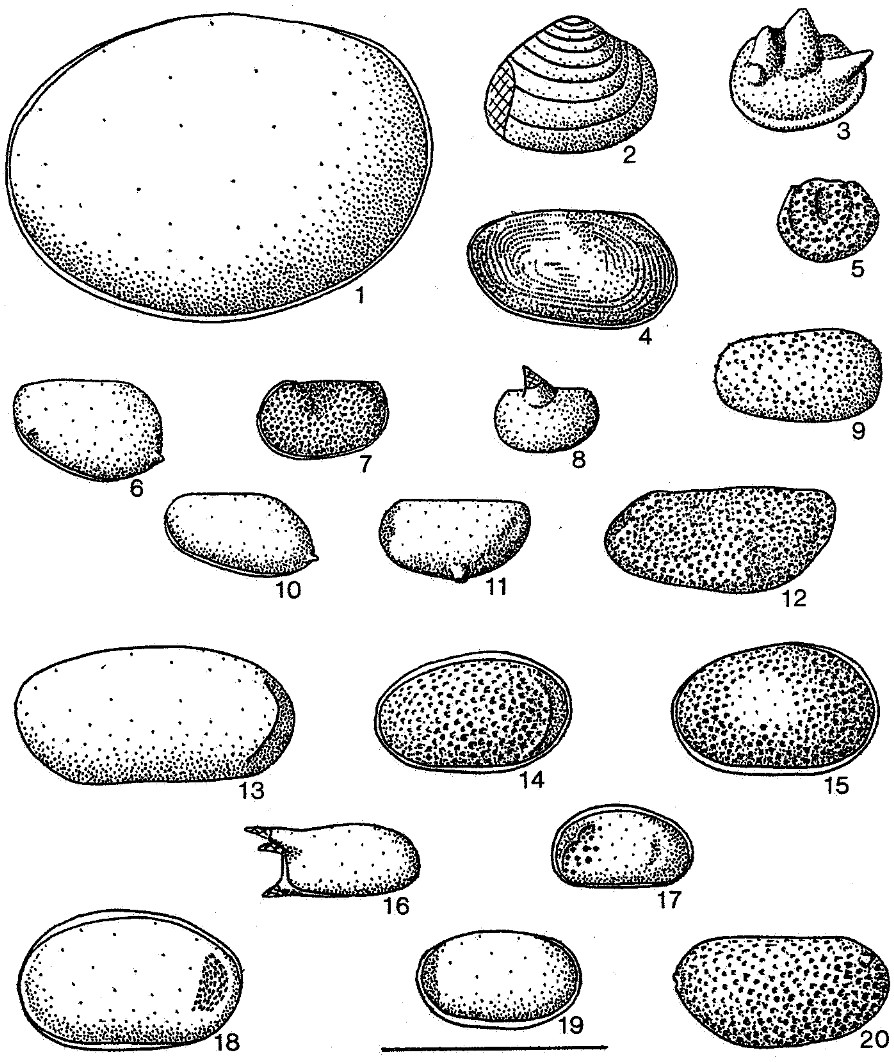

Fig. 6 - Dinantian ostracode assemblage from the Rhadames Basin (Libya; after BLESS & MASSA 1982). This marine near-shore microfauna has been extracted from the M'rar Formation, a shale-sandstone sequence with subordinate intercalations of evaporites (gypsum, anhydrite), and some stromatolites in the uppermost part of the section.
The sediments suggest intertidal to occasionally supratidal depositional environments. With the exception of *Paraparchites*, the ostracode species observed are relatively small (usually less than 1 mm). Many species show a slightly ornamented caparace. The assemblage can be compared with that from marine near-shore deposits of the late Famennian to early Dinantian in Belgium and the southern Netherlands (presence of paraparchitaceans, *Cryptophyllus*, knoxiellids, cavellinids; *Mammoides* may have occupied the same ecological niche as *Kellettina acutilobata; Rhadamesella* and/or *Graphiadactyllis* may have occupied the same niche as *Beyrichiopsis).*

1. *Paraparchites sp.;*
2. *Cryptophyllus sp.;*
3. *Mammoides bouckaerti* BLESS & MASSA 1982;
4. *Graphiadactyllis sp.;*
5. *Aechminella multiloba* (JONES & KIRKBY 1886);
6. *Rhadamesella rhadamesensis* BLESS & MASSA 1982;
7. *Knoxiella (?) sp.*
8. *Aechmina sp.;*
9. *Roundyella sp.;*
10. *Rhadamesella bourdoni* BLESS & MASSA 1982;
11. *Monoceratina sp.;*
12. *Monoceratina kockeli* BLESS & MASSA 1982;
13. *Marginohealdia africana* BLESS & MASSA 1982;
14. *Marginohealdia paprothae* BLESS & MASSA 1982;
15. *Eriella (?) courceyana* ROBINSON 1978;
16. *Rectonariid;*
17. *Cribroconcha streeli* BLESS & MASSA 1982;
18. *Paracavellina fernetae* BLESS & MASSA 1982;
19. *Cavellina sp.*
20 Ostracode indet.

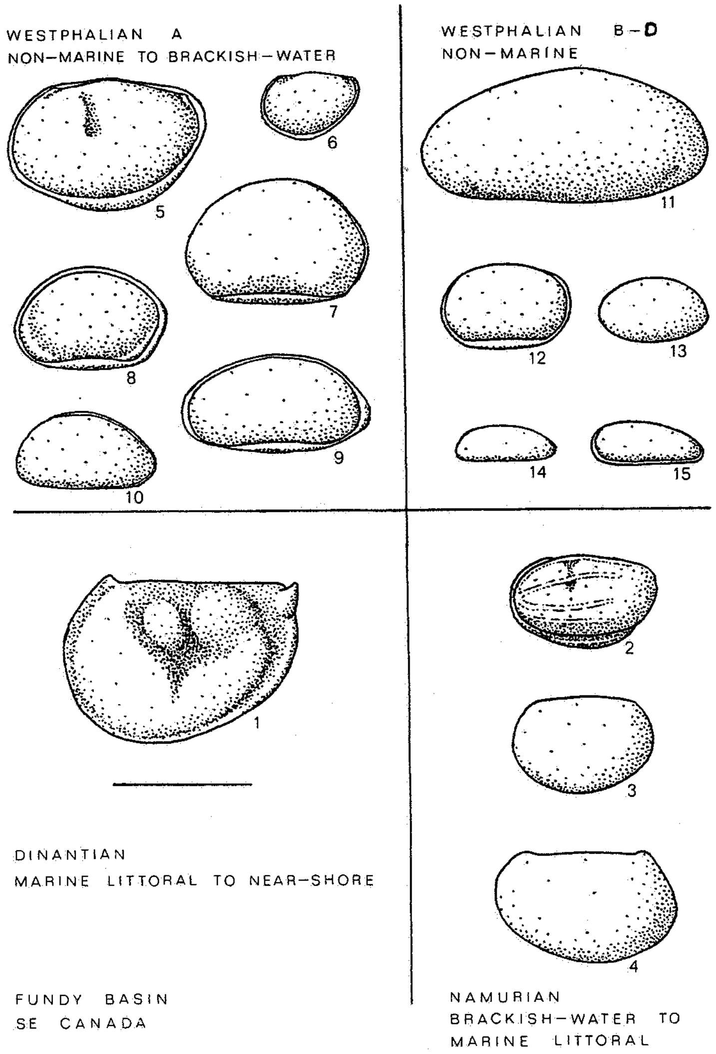

Fig. 7 - Carboniferous ostracode assemblages from the Fundy Basin (SE Canada; after COPELAND 1957, BLESS & JORDAN 1971).
Four assemblages, characterizing shallow marine near-shore to non-marine environments, have been observed. These suggest a gradual withdrawal of marine influence in the Fundy Basin from Dinantian into Wesphalian deposits. Of the Lower Dinantian (Horton Bluff Formation , Nova Scotia) ostracodes, only *Copelandella* has been figured.
This genus has been observed in shale together with other ostracodes of the genera *Paraparchites* and *Carbonita* (BLESS & JORDAN 1971). It is suggested that *Carbonita* had been washed into a marine littoral to near-shore facies, characterized by the occurrence of *Copelandella* and *Paraparchites*.
The presence of *Beyrichiopsis* and *Paraparchites* in the Namurian (Canso Group), sometimes associated with *Carbonita fabulina* and non-marine to brackish-water pelecypods (*Carbonicola cf aquilina*), suggests the presence of short-lived brackish-water to marine littoral environments. Presumably brackish-water ostracodes of the genus *Sansabella* are restricted to one horizon in the Westphalian A Riversdale group. The non-marine ostracode genus *Carbonita*, already present in the Dinantian, becomes quite prolific in the Westphalian strata, where several species have been recognized.
No marine or even brackish-water influence is known in the Westphalian B-D (Cumberland and Pictou Groups).

1. *Copelandella novascotica* (JONES & KIRKBY 1884);
2. *Beyrichiopsis lophota* COPELAND 1957;
3, 4. *Paraparchites spp.*;
5. *Sansabella carbonaria* COOPER 1946;
6. *Sansabella reversa* COPELAND 1957;
7. *Carbonita bretonensis* (COPELAND 1957);
8. *Carbonita altilis* (JONES & KIRKBY 1889);
9. *Carbonita agnes* (JONES 1870);
10. *Carbonita bairdioides* (JONES & KIRKBY 1879);
11. *Carbonita rankiniana* (JONES & KIRKBY 1879);
12. *Carbonita fabulina* (JONES & KIRKBY 1879);
13. *Carbonita inflata* (JONES & KIRKBY 1879);
14. *Carbonita scalpellus* (JONES & KIRKBY 1879);
15. *Carbonita secans* (JONES & KIRKBY 1879).

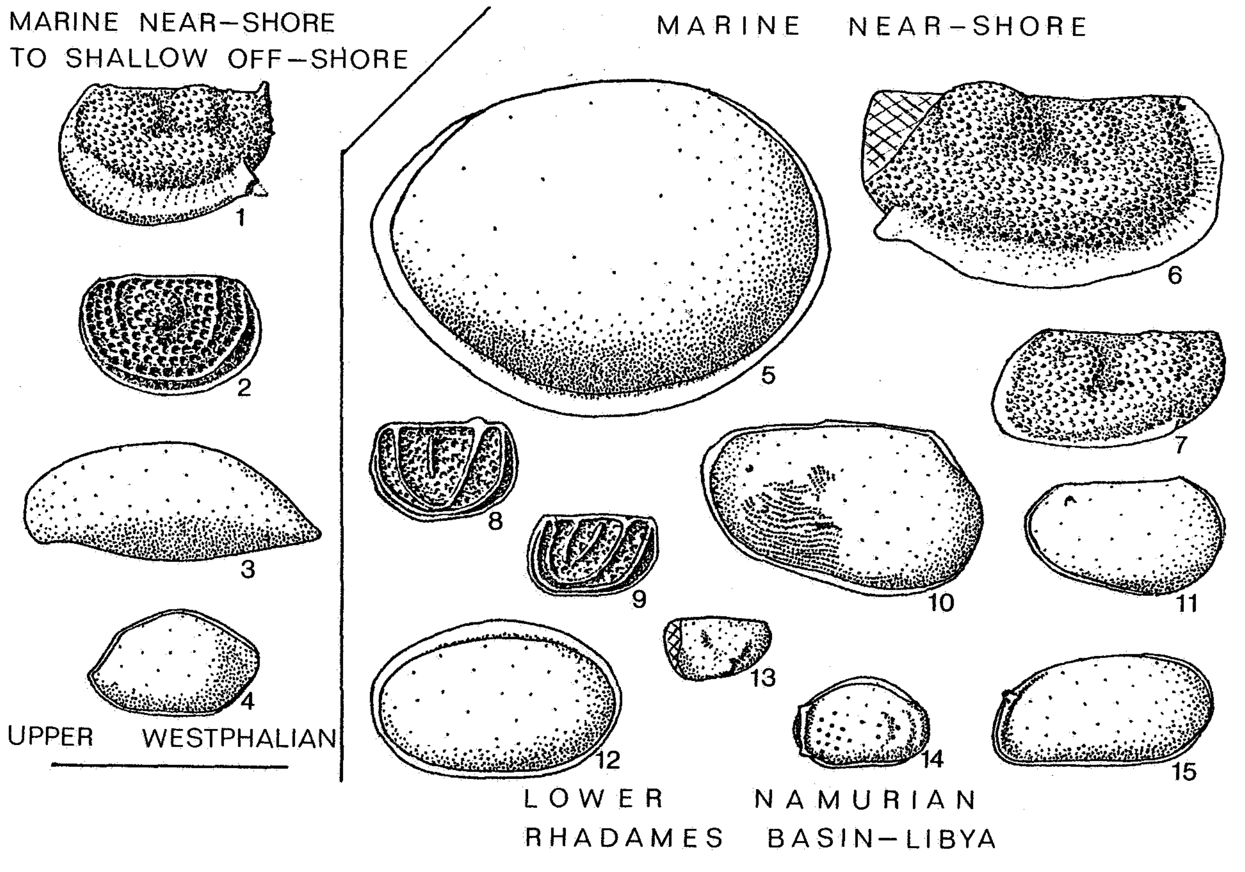

Fig. 8 - Silesian ostracode assemblages from the Rhadames Basin (Libya; after BLESS & MASSA 1982). The assemblages characterize marine near-shore deposits of Namurian age, and marine near-shore (transitional to shallow off-shore) deposits of Westphalian age. The Lower Namurian (*Eumorphoceras* goniatite zone) assemblage has been prepared from two shaly intervals in the predominantly sandstone sequence of the Assedjefar Formation.
Presumably, the sandstones represent intertidal near-shore deposits. In the uppermost portion of this formation, shales become more frequent and are intercalated by carbonates indicating a transition to more infratidal deposits. The ostracode assemblage may be compared with those from the Westphalian marine near-shore deposits in northern Spain and nortwestern Europe (paraparchitaceans, *Amphissites*, *Hollinella*, healdiids, cavellinids; *Graphiadactyllis* may have occupied the same ecological niche as *Jordanites*; *Cribroconcha* may have occupied the same niche as *Asturiella*). The Upper Westphalian assemblage from the Dembaba Formation has been extracted from a carbonate-dominated sequence with subordinate shale intervals, indicative of marine infratidal sediments. This assemblage is comparable to those of the Upper Westphalian marine near-shore transitional to shallow off-shore facies in northern Spain.

1. *Hollinella (Hollinella) ulrichi* (KNIGHT 1928);
2. *Amphissites centronotus* (ULRICH & BASSLER 1906);
3. *Acratia garrisonensis* (UPSON 1933) sensu COOPER 1946;
4. *Bairdia sp.*
5. *Chamishaella cf. brosgei* SOHN 1971;
6. *Hollinella (Keslingella) radiata* (JONES & KIRKBY 1886);
7. *Hollinella (Keslingella) sp.*;
8 and 9. *Amphissites urei* (JONES & KIRKBY 1859);
10. *Graphiadactyllis beckeri* BLESS & MASSA 1982;
11. *Shivaella sp.;*
12. *Cavellina sp.;*
13. *Monoceratina* sp.;
14. *Cribroconcha conspicua* (HARLTON 1929);
15. *Healdia sp.*

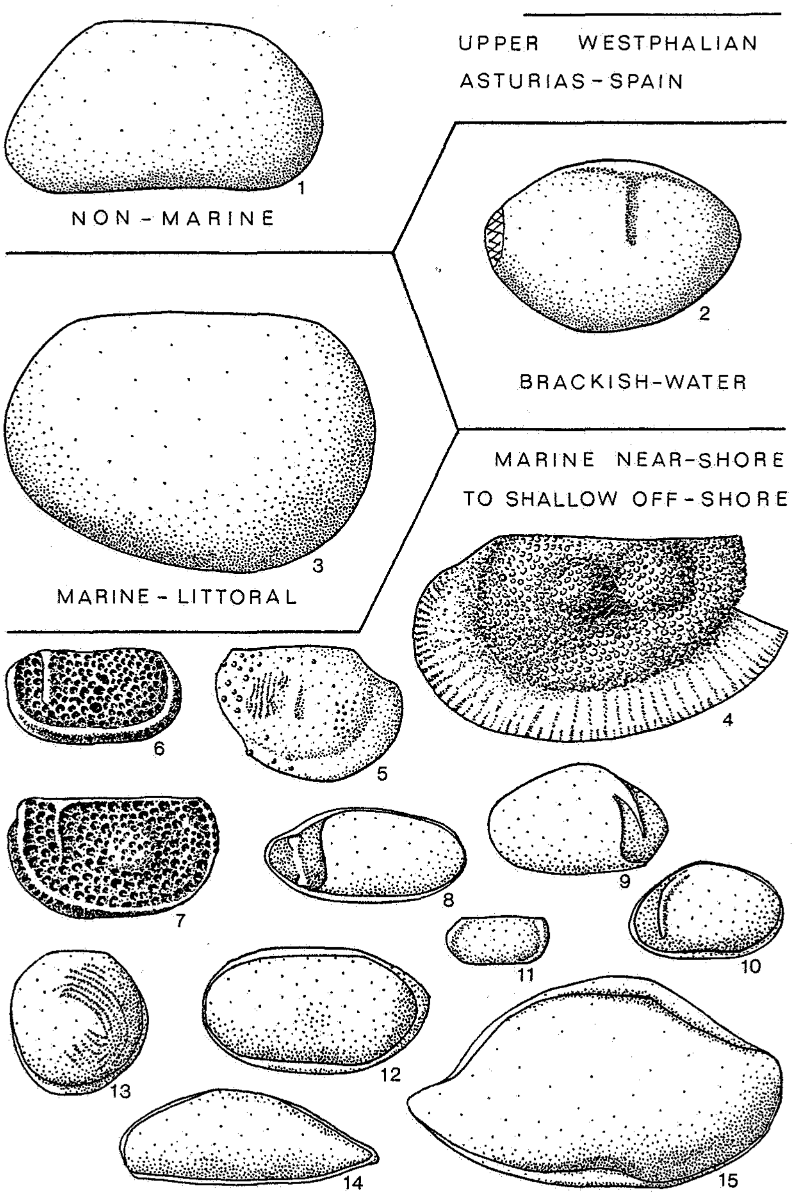

Fig. 9 - Upper Westphalian ostracode assemblages from the paralic coal basin of Asturias (northern Spain; after BLESS 1967, 1970, 1973, VAN AMEROM et al. 1970, SANCHEZ de POSADA & BLESS 1971).
Four assemblages characterizing paleo-environments ranging from non-marine to shallow marine near-shore (transitional to off-shore) have been distinguished. The non-marine ostracode genus *Carbonita* occurs in silty, sometimes carbonaceous shales with non-marine lamellibranchs. The presumably brackish-water representatives of the genus *Geisina* are often associated with *Paraparchites* and pelecypods. *Paraparchites* occurs either alone (along with *Lingula)*, or may be found in association with *Geisina, Hollinella* (e. g. *Hollinella (Praehollinella) aff. avonensis* (LATHAM 1932) and/or *Jordanites rawihinggili* BLESS 1967. An extremely rich and diverse assemblage occurs in many marine near-shore deposits (*Hollinella, Jordanites, Kirkbya, Amphissites, Healdia, Asturiella, Cavellina, Discoidella, Moorites*, etc.) along with lamellibranchs, subordinate articulate brachiopods and crinoids. In sometimes more calcareous shales, articulate brachiopods, fusilinid foraminifers and bryozoans become important elements of the megafossil assemblage, whereas the ostracode association is enriched by the frequent occurrence of the genera *Bairdia* (practically absent in true near-shore facies deposits) and *Acratia* (rare to absent in true near-shore facies deposits).

1. *Carbonita cf. bairdioides* (JONES & KIRKBY 1879);
2. *Geisina sp.;*
3. *Paraparchites sp.*;
4. *Hollinella (Hollinella) cristinae* BLESS 1965;
5. *Jordanites honeei* BLESS 1970;
6. *Kirkbya cf. waltheri* OMARA & GRAMANN 1966;
7. *Amphissites cf. centronotus* (ULRICH & BASSLER 1906);
8. *Asturiella fernandezi* BLESS 1970;
9. *Asturiella calveri* BLESS 1970;
10. *Healdia sp.;*
11. *Moorites sp.;*
12. *Cavellina cf. cumingsi* PAYNE 1937;
13. *Discoidella sp.;*
14. *Acratia garrisonensis* (UPSON 1933) sensu COOPER 1946;
15. *Bairdia sp.*

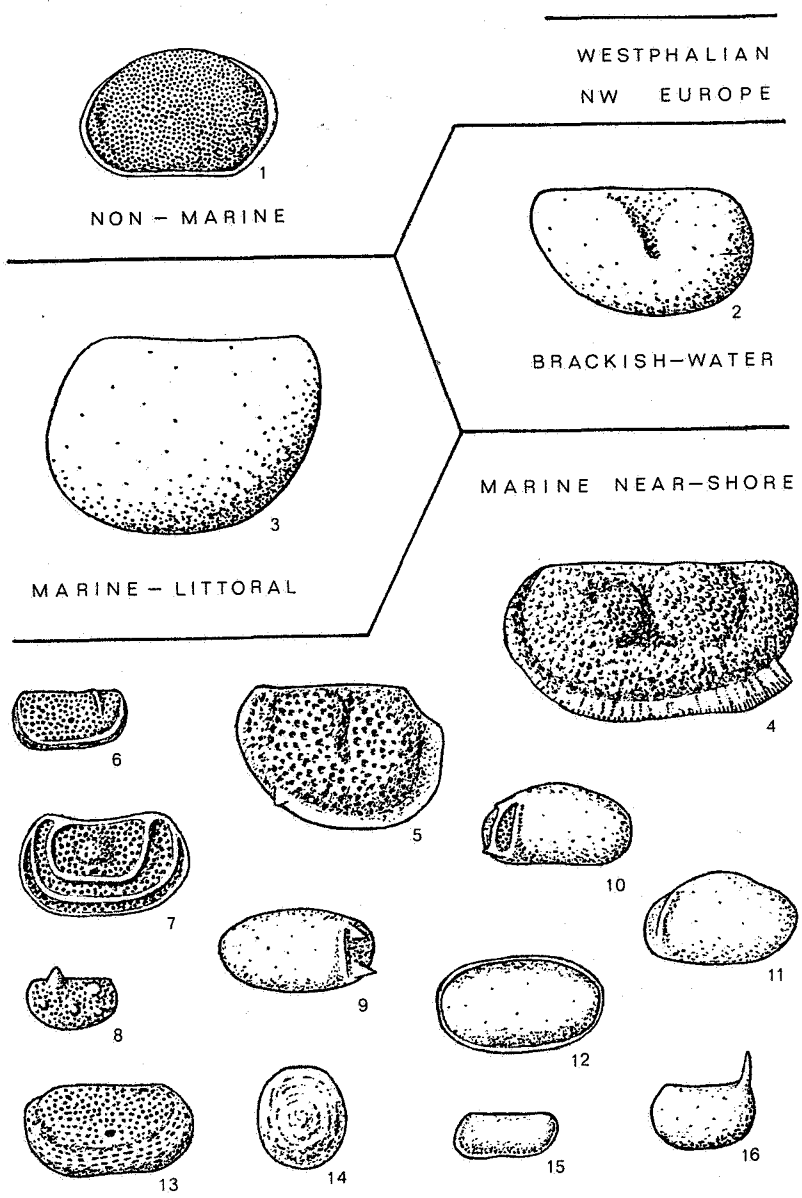

Fig. 10 - Westphalian ostracode assemblages from the paralic coal deposits of Northwestern Europe (after BLESS & POLLARD 1972, BLESS 1971, 1973, 1974).
Four assemblages, representing non-marine to marine near-shore paleo-environments, have been distinguished. The non-marine ostracode genus *Carbonita* occurs in (sometimes carbonaceous, bituminous or silty) shales, which may contain non-marine lamellibranchs, fish remains and subordinate arthropods (a.o. *Anthrapalaemon*). The genus *Geisina* may be associated with *Carbonita* and non-marine lamellibranchs, but also with agglutinating foraminifers (*Ammodiscus, Hyperammina*) and the inarticulate brachiopod *Lingula*. *Geisina* is believed to be most prolific in brackish-water facies. *Paraparchites* has been found in shales with agglutinating foraminifers, the coelenterate genus *Sphenothallus*, and *Lingula*. This assemblage has been interpreted as marine littoral, and may be considered as a variant of the marine near-shore facies. The marine near-shore environment (with lamellibranchs, articulate brachiopods, small (juvenile ?) goniatites) is frequently characterized by the ostracode genus *Hollinella*. In Great Britain, *Hollinella (Praehollinella) claycrossensis* BLESS & CALVER 1970 is common in several marine bands. *Hollinella* has also been observed in some marine horizons of Germany and the Netherlands. The most diverse ostracode assemblage occurs in the Aegir Marine Band (base Westphalian C) along with articulate brachiopods, lamellibranchs, and goniatites.
Ostracode genera like *Bairdia* and *Acratia*, indicative for shallow marine off-shore facies, are practically absent (exception figured by BLESS & WINKLER PRINS 1972, from southwestern Belgium).

1. *Carbonita humilis* (JONES & KIRKBY 1879);
2. *Geisina sp.*;
3. *Paraparchites sp.*;
4. *Hollinella (Hollinella) cristinae* BLESS 1965;
5. *Jordanites cristinae* (BLESS 1967);
6. *Kirkbya aff. kelletae* (BRADFIELD 1935) non HARLTON 1929;
7. *Amphissites rugosus* GIRTY 1910;
8. *Cornigella tuberculospinosa* (JONES & KIRKBY 1886);
9. *Asturiella fernandezi* BLESS 1970;
10. *Asturiella limburgensis* BLESS 1970;
11. *Healdia sp.;*
12. *Cavellina aff. lata* CORYELL 1928;
13. *Croftsendella giffordensis* BLESS 1974;
14. *Discoidella aff. convexa* SCOTT & BORGER 1941;
15. *Moorites aff. punctus* (WILSON 1933);
16. *Pseudoparaparchites aff. cornutus* (COOPER 1946).

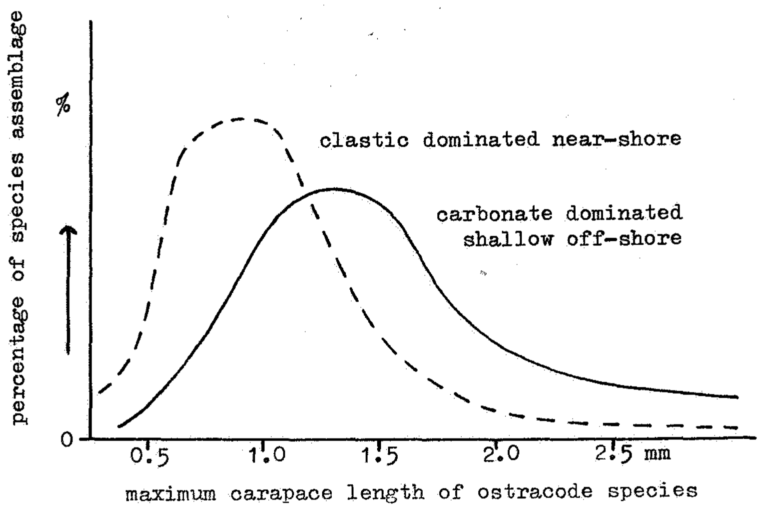

Fig. 11 - Relationship between Dinantian depositional environments and mean maximum lenght of caparace of ostracode species.

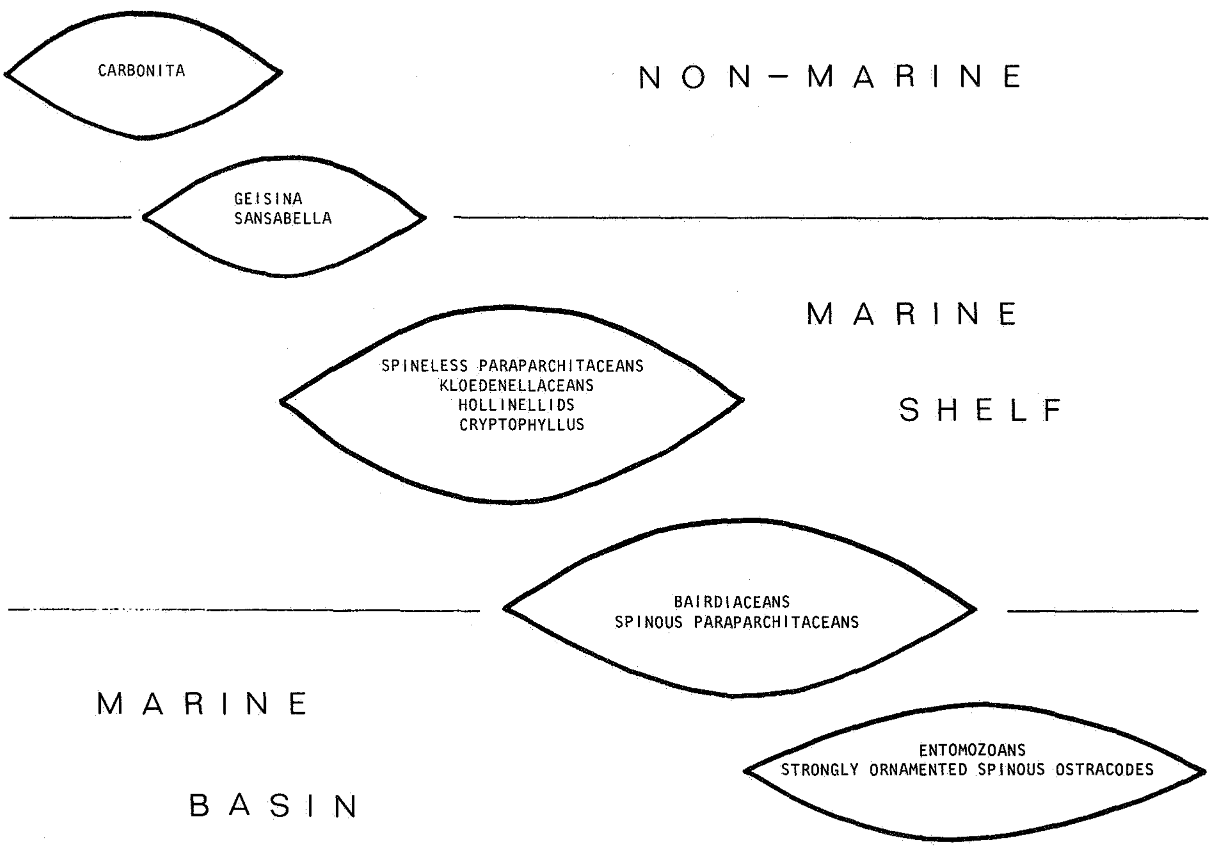

Fig. 12 - Scheme showing relationship between major late Devonian and Carboniferous environments and ostracode assemblages.

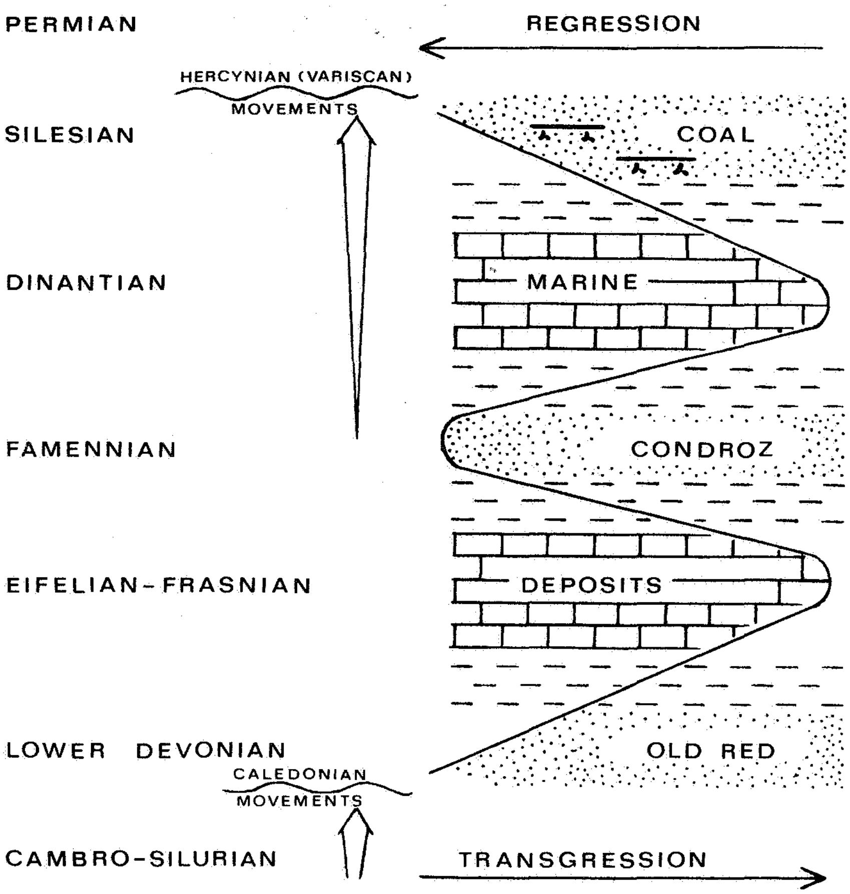

Fig. 13 - Simplified sedimentary history of the area around the Brabant Massif (Belgium and surrounding regions) during the Devonian and Carboniferous.

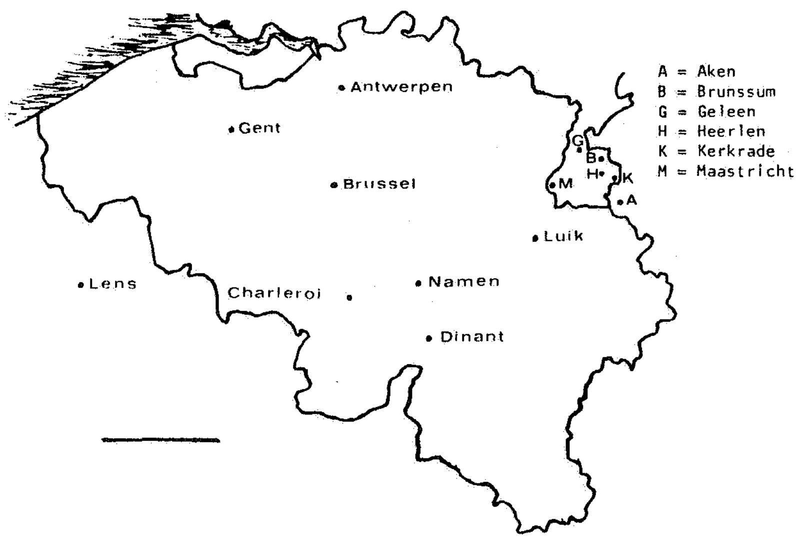

Fig. 14 - Map of Belgium and surrounding areas with indication of cities shown on the paleogeographical maps in figures 15-23. Scale bar is 50 km. Note that the paleogeographical maps have not been restored palinspastically.
Black stars on figures 15 to 23 indicate locations, which have yielded ostracodes of the time interval indicated on the map. The scale bar on these maps represents one millimeter.
The place, where the figured ostracode specimens had been discovered, is indicated in each case between brackets.

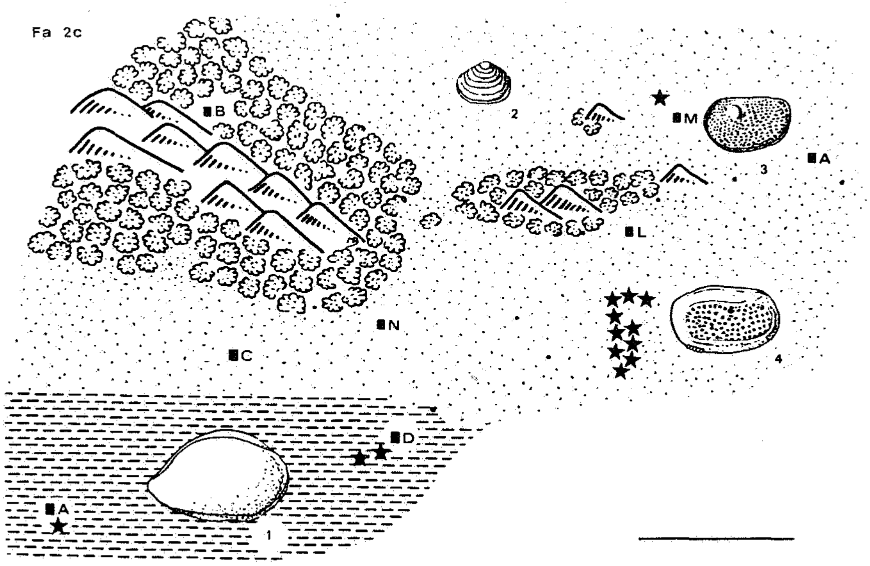

Fig. 15 - Paleogeography of the eastern part of the Brabant Massif and surrounding areas during the Upper Famennian (Fa2c). Positive (land) areas occurred around Brussels and the region west of the line Liège-Maastricht. These were bordered by a shallow near-shore sea with deposition of sand, silt, clay and subordinate carbonate sediments. Further to the south, a slightly deeper off-shore shelf sea existed with a more silty to clayey substratum. *Bairdia* (1, Hastière) was a characteristic element of the ostracode fauna in the off-shore environment, whereas *Cryptophyllus* (2, Kastanjelaan Maastricht), *Knoxiella* (3, Kastanjelaan Maastricht) and *Beyrichiopsis* (4, Chanxhe Ourthe Valley) were typical of the near-shore ostracode assemblage. Kloedenellaceans also occurred in the southern area, thus suggesting a transitional environment between marine near-shore and shallow off-shore facies. It should be noticed that this transitional environment seems to be linked to clayey or silty deposits.

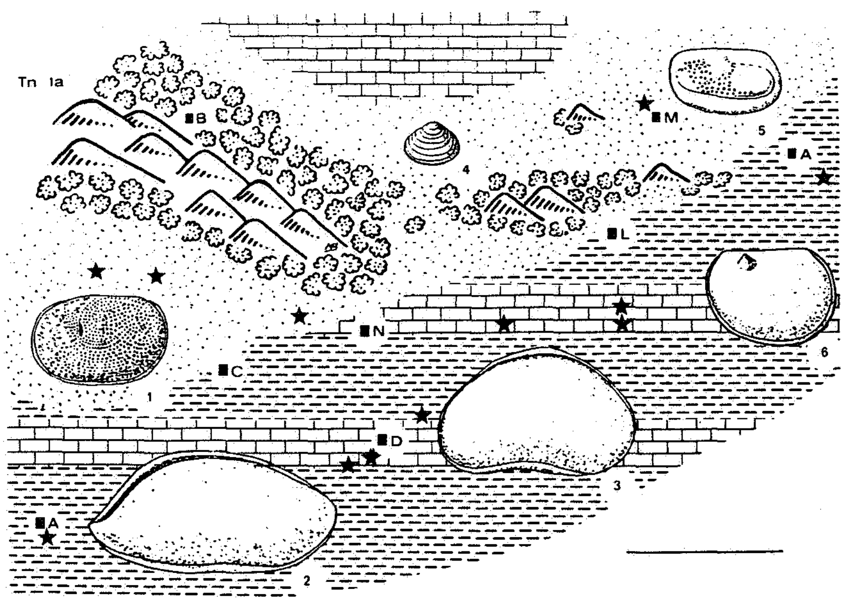

Fig. 16 - Paleogeography of the eastern part of Brabant Massif and surroundings during the latest Devonian (Tn1a, Strunian or Etroeungtian). The flanks of the islands have been covered by the sea during this period. At the same time, the shallow marine off-shore facies spreads across large parts of the shelf north and south of the Brabant Massif. This off-shore environment (with clays and carbonates) is characterized by ostracodes such as *Bairdia* (2, Spontin Bocq Valley), *Bairdiocypris* (3, Spontin Bocq Valley) and *Shishaella* (6, Rivage Ourthe Valley), whereas *Knoxiella* (1, Feluy), *Cryptophyllus* (4, Kastanjelaan Maastricht) and *Beyrichiopsis* (5, Kastanjelaan Maastricht) are practically restricted to the near-shore deposits.

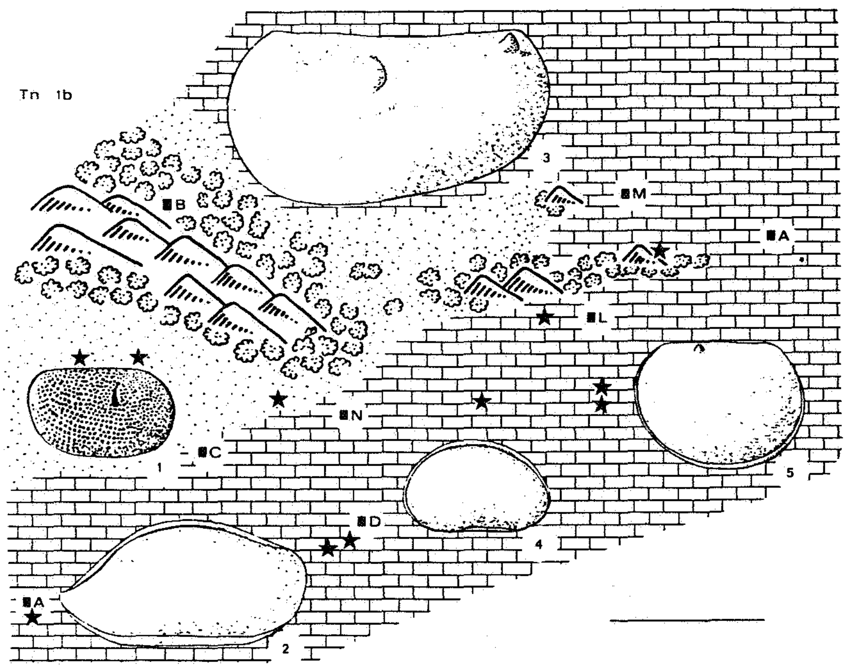

Fig. 17 - Paleogeography of the area around the eastern part of the Brabant Massif during the lowermost Dinantian (Tn1b). The shallow marine off-shore environment was characterized by widespread carbonate deposits and a.o. ostracodes belonging to the genera *Bairdia* (2, Kastanjelaan Maastricht), *Pseudoleperditia* (3, Kastanjelaan Maastricht), *Bairdiocypris* (4, Kastanjelaan Maastricht) and *Shishaella* (5, Kastanjelaan Maastricht). Ostracode assemblages characteristic of the marine near-shore environment have been recognized only in the region south of Brussels, and are represented here by the genus *Knoxiella* (1, Soignies).

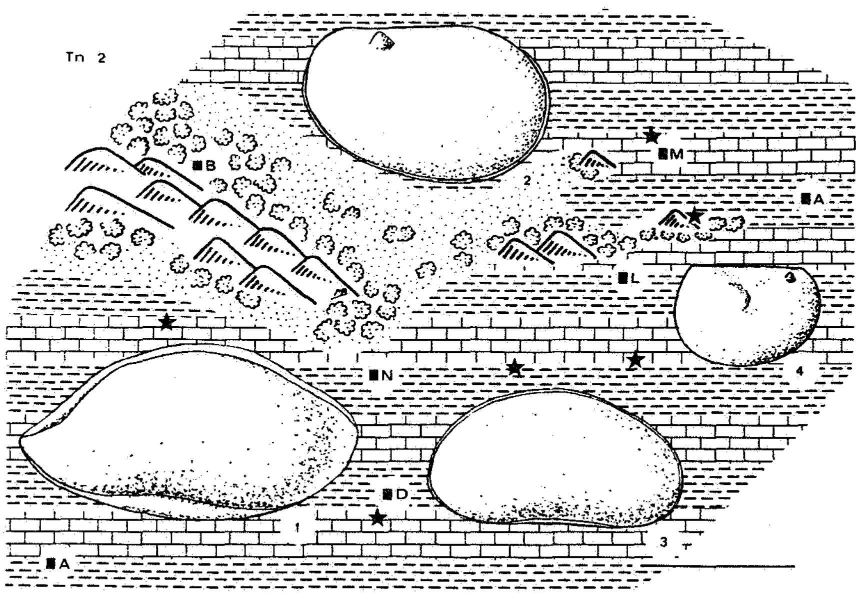

Fig. 18 - Paleogeography of the area around the eastern part of the Brabant Massif during the Middle Tournaisian (Tn2). The Dinantian transgression seems to have been completed at this time. True marine near-shore environments have not been observed. The shallow marine off-shore facies was characterized by the deposition of pelites at the beginning of the Middle Tournaisian (Tn2a). Later on (Tn2b-c), carbonates have been deposited throughout the area. The frequently quite diverse ostracode faunas include *Bairdia* (1, Feluy), *Shishaella* (2, Rivage Ourthe Valley), *Bairdiocypris* (3, Rivage Ourthe Valley) and *Pseudoleperditia* (4, Kastanjelaan Maastricht). Kloedenellaceans may be a subordinate element of the assemblage from the basal Middle Tournaisian (Tn2a) shales. This suggests that these have been deposited in a marine shallow off-shore transitional to near-shore environment.

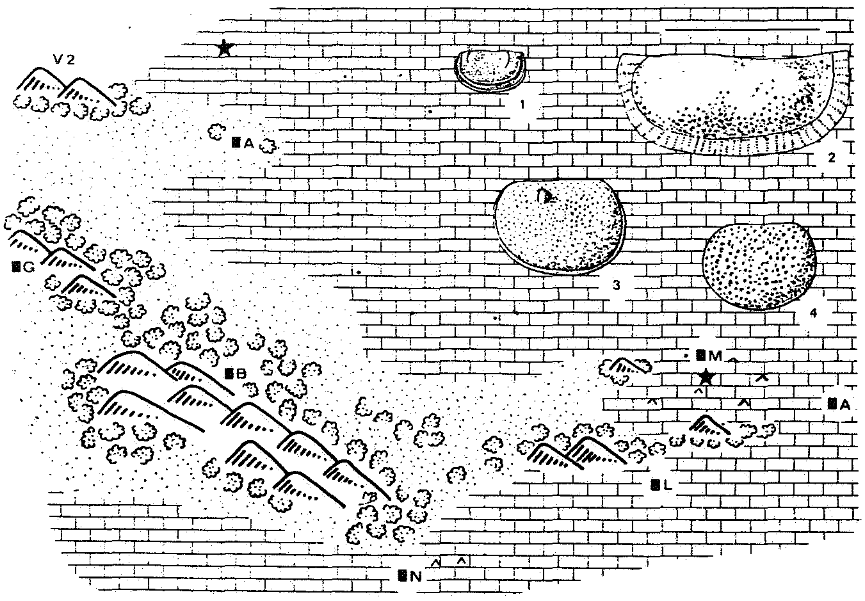

Fig. 19 - Paleogeography of the eastern part of the Brabant Massif and surroundings during the Middle Visean (V2). Widespread carbonate deposits with frequently rich and diverse fossil contents point to more or less open marine shelf conditions. However, ostracode assemblages from a.o. the southern Netherlands indicate the (local) existence of special environments. The presence of slightly ornamented ostracodes evokes facies conditions similar to those of the Upper Famennian to lowermost Dinantian near-shore sediments. The local occurrence of evaporites (for example at Heugem-Maastricht, Vedrin-Namur and St-Ghislain) suggests the temporary installation of restricted environments on an extremely shallow shelf. Characteristic ostracodes are *Amphissites* (1, Heugem Maastricht), *Kummerowia* (2, Heugem Maastricht), *Shivaella heugemensis* (3, Heugem Maastricht) and *Libumella* (4, Heugem Maastricht).

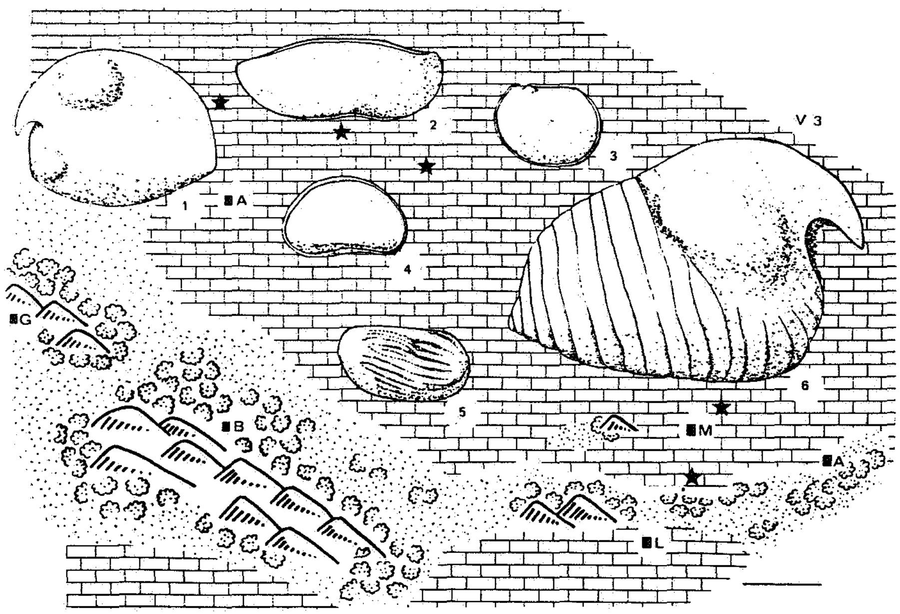

Fig. 20 - Paleogeography of the area around the eastern part of the Brabant Massif during the Upper Visean (V3). The shallow marine shelf with widespread carbonate deposition was colonized by many cosmopolitic organisms coming from Asia and Africa through Central England, and from the U.S.S.R. The ostracode assemblages indicate optimal shallow marine off-shore conditions, and are characterized by relatively large (well above 1 mm, sometimes up to 10 mm) forms, which may be well ornamented. Examples are *cf. Cypridella* (1, Houthem), *Bairdia* (2, Heibaart), *Shishaella* (3, Heibaart), *Bairdiocypris* (4, Heibaart), *Glyptopleura* (5, Houthem) and *Cyprella* (6, Houthem).

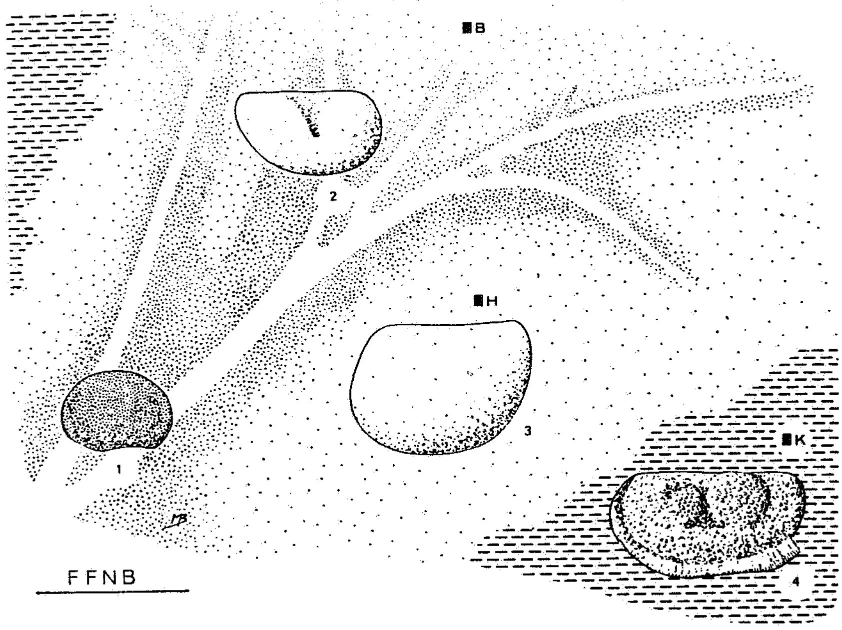

Fig. 21 - One of the short-lived marine transgressions during the Silesian has been the Finefrau-Nebenbank (FFNB) transgression in early Westphalian A times. This transgression has been well documented in the former coal mining area of South Limburg (the southern Netherlands), around Brunssum, Heerlen and Kerkrade. The depositional environment varied from non-marine to marine near-shore conditions. Non-marine facies are characterized by the ostracode genus *Carbonita* (1), brackish-water by *Geisina* (2), marine littoral by *Paraparchites* (3), and marine near-shore by *Hollinella (4)*.

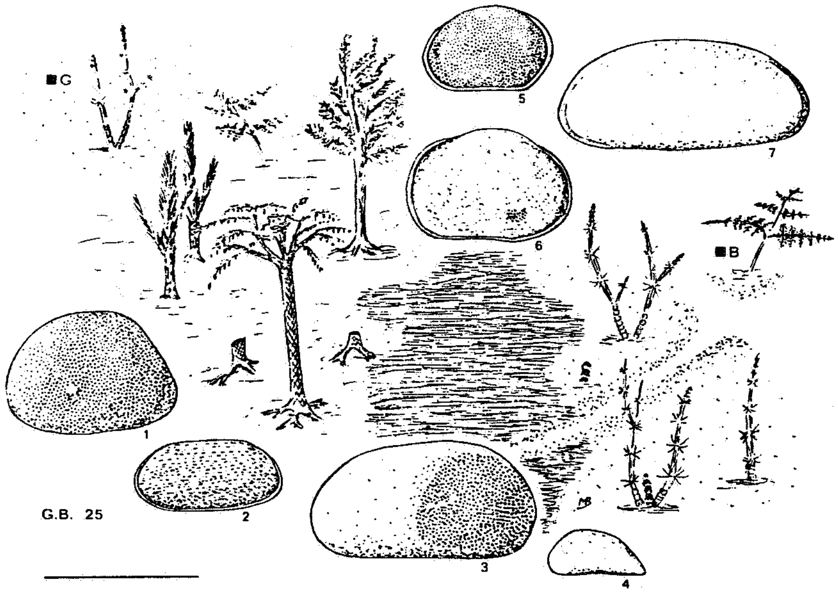

Fig. 22 - A titre d'example, a paleogeographic map of part of the former mining district of South Limburg, between Geleen and Brunssum, during a short interval of the Upper Westphalian A period (G.B. 25 time), is presented. This map shows that several subfacies can be distinguished in the non-marine environment. Swamps were characterized by giant horse-tails (*Calamites*), whereas ferns and fern-like trees (a.o. *Lepidodendron* and *Sigillaria*) may have flourished in slightly drier areas. Non-marine ostracodes of the genus *Carbonita* were abundant in streams and pools with stagnant water. In the former coal mine Emma, between Geleen and Brunssum, several species of Carbonita have been studied from a pool deposit. Some species, such as *Carbonita sp.* (1), *Carbonita evelinae* (2), *Carbonita aff. salteriana* (3) and *Carbonita secans* (4), predominated in silty sediments, whereas other forms, such as *Carbonita humilis* (5), *Carbonita sp.* (6) and *Carbonita cf. scalpellus* (7), seem to have preferred a pelitic substratum with relatively high contents of organic matter.

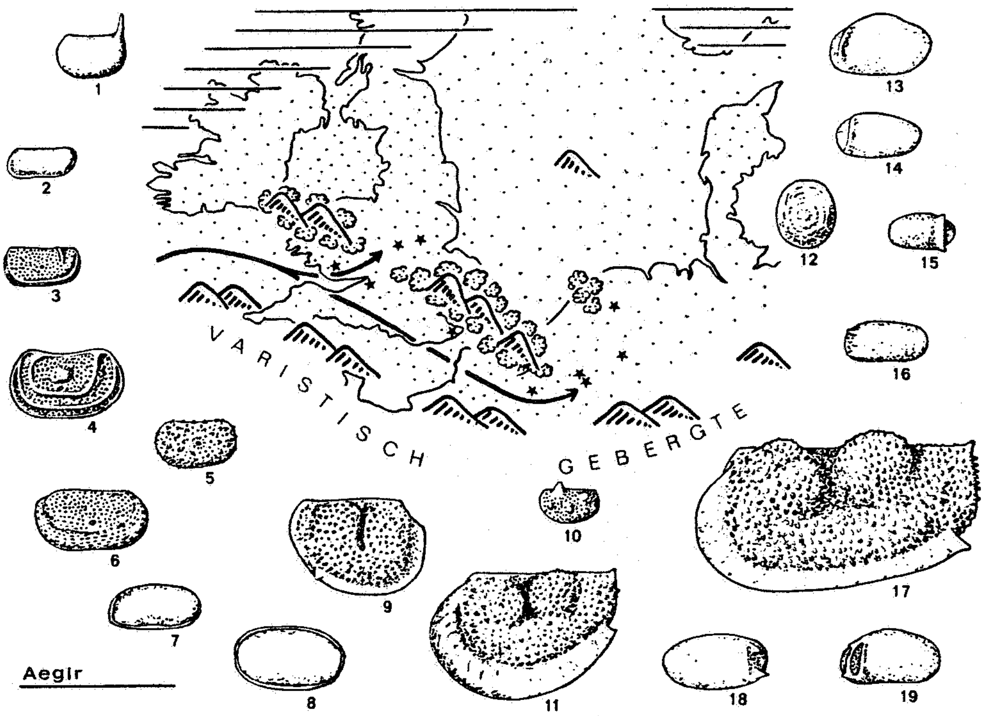

Fig. 23 - Paleogeographic map of Northwestern Europe during the marine transgression of the Aegir Sea, at the beginning of the Upper Westphalian. Silty to clayey sediments have been deposited in shallow sea. The most prolific faunas have been entered the area from the west, as may be deduced from the many species which show close relationship with e.g. Spanish and North American forms. The most diverse fossil assemblages have been found along the southern and eastern flanks of the Wales-London-Brabant Massif. Nevertheless, the facies was not optimal. Ostracodes, characteristic of shallow marine off-shore environments, such as *Bairdia* and *Acratia*, are rare or absent. The specimens figured here are all from Stoke Gifford, near Bristol in Great Britain. Almost identical assemblages have been recorded from the coal basins of the Ruhr, South Limburg and Campine. These belong to the genera *Pseudoparaparchites* (1), *Moorites* (2), *Kirkbya* (3), *Amphissites* (4), *Roundyella* (5), *Croftsendella* (6), *Pseudobythocypris* (7), *Cavellina* (8), *Jordanites* (9), *Cornigella* (10), *Hollinella* (11, 17), *Healdia* (13, 14, 15, 16), *Discoidella* (12) and *Asturiella* (18, 19).