

## *Ophiurites eocaenus* Leriche, 1931 (Ophiuroidea, Eocene, NW Belgium) revisited

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### Abstract

The ophiuroid species *Ophiurites eocaenus* LERICHE, 1931 from Eocene ("Paniselian") strata in northwestern Belgium is redescribed on the basis of the four specimens that constitute the type lot from Zeebrugge and two additional specimens on a slab recently collected from the beach near Cadzand (province of Zeeland, The Netherlands), some 15 km north of Zeebrugge. Details of disc and arm plating are better preserved in the Cadzand specimens than in the type lot. The species cannot be assigned to *Stegophiura* MATSUMOTO, 1915; it is here tentatively referred to *Ophiozona* LYMAN, 1865 and compared with other Tertiary species from NW Europe and elsewhere. Some remarks on the stratigraphic provenance of this species are added.

**Key-words:** Echinodermata, Ophiuroidea, Eocene, systematics, comparisons, stratigraphy

### Résumé

L'Ophiure *Ophiurites eocaenus* LERICHE, 1931 des dépôts éocènes ("Panisélien") du nord-ouest de la Belgique, est redécrite sur la base des quatre exemplaires de la série type en provenance de Zeebrugge et de deux spécimens récoltés récemment sur la plage près de Cadzand (province de Zélande, Pays-Bas), à environ 15 km au nord de Zeebrugge. Des détails de plaques discales et brachiales sont mieux préservés sur les spécimens de Cadzand que sur ceux de la série type. L'espèce ne peut pas être attribuée au genre *Stegophiura* MATSUMOTO, 1915; à titre d'essai, elle est placée ici dans le genre *Ophiozona* LYMAN, 1865 et comparée à d'autres espèces tertiaires du NW de l'Europe et d'ailleurs. Quelques remarques concernant la position stratigraphique de l'espèce sont jointes.

**Mots-clés:** Echinodermes, Ophiures, Eocène, Systématique, Comparaisons, Stratigraphie.

### Introduction

Ophiuroids constitute only a minor part in the echinoderm faunas of the northwest European Tertiary (North Sea Basin). LERICHE (1931, p. 109) pointed out that Tertiary ophiuroids are extremely rare and that Tertiary as well as Mesozoic strata in Belgium had not yet yielded any. As far as Mesozoic (Late Cretaceous in particular) occurrences are concerned a number of important discoveries during the past few years should be noted (JAGT,

in prep. a, b). In view of the fact that ophiuroids are generally preserved as dissociated ossicles, and that more or less complete specimens (*i.e.* with disc and arms preserved) are exceptional, these echinoderms have received only scant attention in the palaeontological literature, with a few exceptions of which RASMUSSEN (1972) is the most important.

*Ophiurites eocaenus* was introduced by LERICHE (1931) for four specimens and some arm fragments on a slab found at the mole of Zeebrugge harbour (province of West Vlaanderen, Belgium). It appears to be a distinct species which does not correspond with British Eocene taxa introduced and described by RASMUSSEN (1972), who referred it to the genus *Stegophiura* MATSUMOTO, 1915. This genus, however, is utterly different, and, for reasons outlined below, it seems best, at least for the time being, to tentatively refer *O. eocaenus* to *Ophiozona* LYMAN, 1865 *sensu* MATSUMOTO, 1915. LERICHE's original and RASMUSSEN's subsequent descriptions are here complemented using the Cadzand specimens, which undoubtedly belong to the same species and show more details of disc and arm plating. Some remarks on the stratigraphic provenance of these ophiuroids and on the use of the term Paniselian are added.

### Systematic description

Order Ophiurida MÜLLER & TROSCHEL, 1840

Suborder Chilophiurina MATSUMOTO, 1915

Family Ophiuridae LYMAN, 1865

Subfamily Ophiolepidinae LJUNGMAN, 1867 *sensu* MATSUMOTO, 1915

Genus *Ophiozona* LYMAN, 1865 *sensu* MATSUMOTO, 1915

Type species *Ophiolepis impressa* LÜTKEN, 1859, by the subsequent designation of CLARK (1915, p. 337)

*Ophiozona ? eocaena* (LERICHE, 1931)  
(Pl. 1, Figs 1-3)

- v\* 1931 *Ophiurites eocaenus* nov. sp. – LERICHE, p. 109, text-figs 1, 3, 4; pl. 6.  
 . 1953 *Ophiurites eocaenicus* Leriche – SIEVERTS-DORECK, p. 278.  
 v. 1972 *Stegophiura eocaenus* (Leriche, 1931) – RASMUSSEN, p. 77.  
 ? 1973 *Ophiurites eocaenicus* Leriche, 1931 – ROMAN & PERREAU, p. 108, pl. 1, figs 1-3; text-fig. 1.

#### TYPES

RASMUSSEN (1972, p.77) designated the specimen marked A by LERICHE (1931, text-fig. 1; pl. 6) lectotype of the species. The type lot (Pl. 1, Fig. 1) comprises four specimens and several fragments of arms on a slab now housed in the collections of the Institut royal des Sciences naturelles de Belgique at Brussels, catalogue number IST 6020 (ex geological collections of the Université de Bruxelles).

#### LOCUS TYPICUS AND STRATUM TYPICUM

The original label with the type specimens reads as follows:

*Ophiurites eocaenus* Ler. Type.

Age: "Panisélien".

Gisement: Dans un galet en grès glauconifère échoué au pied du môle de Zeebrugge.

Don.: M. Henri Pohl 1929

Bull. Soc. belge de Géol., de Paléont. et d'Hydrol., t. XL (1930), pp. 109-119, pl. VI.

For a discussion of the stratigraphic provenance the reader is referred to the section on stratigraphy.

#### MATERIAL STUDIED

In addition to the type lot (Pl. 1, Fig. 1), a slab with two specimens, one showing the dorsal (aboral) side, the other the ventral (oral) side of disc and arms, collected from the beach near Cadzand (province of Zeeland, The Netherlands) by J.J. de Klerk (collections of the Institut royal des Sciences naturelles de Belgique, no. IST 6041) was studied. These specimens (Pl. 1, Figs 2, 3) are undoubtedly conspecific with the type lot and are preserved in a similar glauconitic sandstone of "Paniselian" age.

#### DESCRIPTION

Disc low and flat, pentagonal with straight or slightly concave interradial margins, rather than round as stated by RASMUSSEN (1972, p. 77). Disc diameter varying between 11 and 14 mm; arms reaching a length of at least 35 mm (*i.e.* more than 3 times the diameter of the disc). Width of arms near disc between 3 and 3.5 mm, being widest within the disc. Dorsal face of disc covered with smooth plates or scales, amongst which three series of primaries can be recognised. Central plate somewhat smaller than plates of the first series in radial position, and rather inconspicuous; outline circular. Second series in interradial position, plates more or less pear-shaped and *c.* 1.3 mm long. Third series again in radial position, consisting of plates somewhat smaller than those of the

second series, rounded distally, pointed proximally and somewhat swollen, and longer than wide. Radials moderate sized, *c.* 3 mm long, distinctly longer than wide, rounded with blunt proximal end and more or less straight interradial margins. Overall aspect rather angular. Between the three series of primaries numerous smaller plates varying in size and shape are seen, but generally their exact shapes cannot be made out satisfactorily. There are two larger plates between the second (inter-radial) and third (radial) series, the proximalmost of which is the larger; the smaller is separated from the radial plates by a row of very small plates. Interradially, between the radial plates is one larger, pear-shaped plate surrounded by a number of smaller scales that become larger at the disc margin. Marginal plates are at least three in number, rather massive, the one in contact with the radial plates especially so at its distal margin. Radial shields separated by at least four small plates that are distinctly wider than long and join a ring of small scales around the third series primaries. Four trapezoidal plates that vary strongly in size and shape are seen between the first dorsal arm plates and the distal margin of the radial shields. The outer one is the largest and is squeezed in between the marginal plate that is in contact with the radial shield and three (possibly four) scythe-shaped plates, of which the outer one is the largest. No arm comb seen. Dorsal arm plates wider than long in proximal and middle portion of arms, in distal portion nearly equally wide as long. Plates sharp-angled, line of contact straight or nearly so; plates show lateral and distal rims and a depressed central area, lateral tips acute. Lateral arm plates do not meet over the entire length of arm, but are closer together in middle and distal portion of arm. Lateral arm plates relatively massive, with acute angles dorsally, rather swollen, especially there where arm spines articulate. At least two spines (not preserved), appressed, on the lower half of the plate, the lower one apparently being the larger.

Genital cleft on ventral face rather inconspicuous, but long. Genital scale long and narrow, no papillae seen. Interbrachial area covered with a few large plates, amongst which is a marginal plate that borders on a large plate which is widest in its distal part and blunt at the proximal end, with two elongate plates between it and the oral shield. The marginal plate is separated from the ventral ends of the scythe-shaped plates by a fairly large, round plate to the right and left. Oral shield longer than wide, rounded distally, pointed proximally and with faint notches medially. Adoral plates comparatively massive, meeting within, wider at the outer ends. Oral plates apparently much smaller, one large infradental papilla. At least two stout oral papillae. Second oral tentacle pore apparently opening entirely inside the oral slit (It must be stressed that the oral frame of the Cadzand specimen (Pl. 1, Fig. 3) is unfortunately rather worn, so that details cannot be fully appreciated). First ventral arm plate markedly wider than long, with rounded margins. All ventral arm plates in contact over the entire length of arm, in the middle portion as wide as long, in the distal

portion longer than wide. Plates massive, quadrangular, with strongly pointed distal margins. Tentacle scales two, the inner one being twice or nearly twice as large as the outer.

#### DISCUSSION

Originally described as *Ophiurites*, a collective name coined by BÖHM (1889, p. 252 (21)) for fossil ophiuroids that cannot be referred to modern genera with any certainty, the present species was subsequently assigned to *Stegophiura* by RASMUSSEN (1972), mainly on account of the similarly large arm plates. MATSUMOTO (1915, p. 78) defined the genus *Stegophiura* as follows:

“Disk high, covered with plates and scales, among which the primaries are prominent. Radial shields stout, joined distally. Arm combs and genital papillae present. Oral shields oval or pyriform. Second oral tentacle pores open more or less, or entirely, outside oral slits, large, provided with numerous scales. Arms very short, very stout at base, higher than wide, rapidly tapering distally, with acute tip. Dorsal and ventral arm plates well developed, successive plates widely in contact with each other. Lateral arm plates high, with numerous arm spines, often unequal and arranged in two series. Tentacle pores large, with numerous scales.”

A comparison of the above description of *O. eoacaenus* with this diagnosis and with the discussion of this genus and the illustrations in MATSUMOTO (1917) contradicts reference to *Stegophiura*. Alternatively, *O. eoacaenus* might be assigned to *Ophiura* in its broadest sense, as has been the case for many Mesozoic (as well as Cainozoic) forms (SPENCER & WRIGHT, 1966, p. U95). This course of action, however, presents problems as well, since several features of this and closely related genera clearly differ from what can be seen in *O. eoacaenus*. *Ophiura* LAMARCK, 1801 as restricted by MATSUMOTO (1915; see also FELL, 1960) contains species in which the second oral tentacle pores open nearly or entirely outside the oral slits, genital papillae and usually also arm combs are present and in which lateral arm plates meet over the arms (ventral arm plates not in contact). Moreover, the tentacle pores show rather many scales. As pointed out above, *O. eoacaenus* is a species in which the second oral tentacle pores apparently open inside the oral slits, and should consequently be referred to the subfamily Ophiolpidinae LJUNGMAN, 1867. Making use of FELL's (1960) synoptic key the following features may be seen in *O. eoacaenus*:

- tentacle pores well developed throughout arm,
- tentacle scales present,
- tentacle scales well developed throughout the arm,
- dorsal arm plates entire, not fragmented nor divided into supplementary plates,
- no papillae skirting genital scales or radial shields,
- adoral shields meeting on midline proximal to oral shield, 1 or 2 tentacle scales,
- first lateral arm plate not enlarged,
- marginal plates not swollen,
- disc covered with numerous small plates and scales, the

larger ones surrounded by the smaller: radial shields small, widely separated by intervening plates and scales: three conspicuous plates lie between, and distal to, the shields: 4 or 5 short arm spines: 2 tentacle scales: dorsal and ventral arm plates broadly contiguous throughout.

The end result is the genus *Ophiozonia* LYMAN, 1865 as restricted by MATSUMOTO (1915, p. 82), who provided the following diagnosis:

“Disk covered with very numerous small plates and scales, the larger surrounded by belts of smaller. Radial shields small, widely separated from each other by several plates and numerous scales. A noticeable trio of plates is distinguishable just outside and between each pair of radial shields. Oral and adoral shields small. Teeth and oral papillae present, latter very thick and close-set. Genital slits rather long. Arms long, rather slender, very gradually tapering distally, with blunt tips. Dorsal, as well as ventral, arm plates well developed, quadrangular, successive plates widely in contact with each other throughout the entire length of the arm. Four or five short, peg-like arm spines. Two tentacle scales to each pore, more or less oval in common outline.”

In addition, MATSUMOTO (1915, pp. 82, 83) remarked that the Ophiolpidinae comprises two groups one of which includes forms with well-developed, quadrangular dorsal and ventral arm plates. This group is again divided into two sections, one of which includes *Ophiozonia* and is characterised by the presence of a distinct trio of plates just outside and between each pair of radial shields and by the presence of two oval tentacle scales.

Comparison of the above diagnosis of the genus *Ophiozonia* and the figures of three of its representatives in CLARK (1911, figs 6-8), shows that *O. eoacaenus* corresponds rather well with these. It must be stressed however, that MATSUMOTO (1915, p. 82) referred *Ophiozonia elevata* CLARK, 1911, *O. longispina* CLARK, 1908 (type species), *O. platydisca* CLARK, 1911 and *O. polyplax* CLARK, 1911 to his new genus, *Ophiozonella*, which differs in several aspects. Despite this, *Ophiurites eoacaenus* appears to be related to this group, and is therefore here referred to as *Ophiozonia ? eoacaena*. Seeing that this species differs from typical representatives of *Ophiozonia* in having fewer arm spines, a different disc plating, characteristic scythe-shaped plates at arm bases and comparatively large adoral shields, this assignment is tentative at best. Examination of the oral frame (dental plates in particular) is not possible: the diagnostic features (see MURAKAMI, 1963) of this structure cannot be determined.

#### COMPARISONS

SIEVERTS-DORECK (1953) presented a valuable general survey of Cainozoic ophiuroids. In recent years, the number of species has increased considerably, many of them being known only as dissociated ossicles. In order to show that *Ophiozonia ? eoacaena* is indeed a distinct species, a number of Tertiary taxa from northwest Europe and elsewhere are here briefly discussed.

ARNOLD (1908) described *Amphiura sanctaecrucis* ARNOLD from the Santa Margarita Formation (Late Miocene) of the Santa Cruz Mountains, California. This species is immediately distinguished from *O. ? eocaena* by its disc and arm plating and the character of the arm spines. BERRY's (1935) Pliocene species *Ophioderma* sp. has distinctive lateral and ventral arm plates which are quite unlike those of the species under discussion. *Amphiophiura oligocenica* BERRY (1937) from the Oligocene of Mississippi was introduced for dissociated ossicles; they do not show any similarity to those of the Belgian species here described. Complete individuals of *Ophiura marylandica* BERRY, 1934 (see BERRY, 1939) from the Upper Miocene of Maryland show this species to be different in several respects from *O. ? eocaena*: the radial shields meet over one third of their length, disc plating shows several distinct series of plates, arm combs are present, ventral arm plates and tentacle pores are quite different as is the oral frame. From the Middle Oligocene of Hungary KOLOSVÁRY (1941) described a new genus and species, *Pseudaspidura hungarica*, which is in fact a very poorly known species based on a specimen that does not really display any diagnostic features to permit introduction of new taxa on the generic and specific levels. The radial shields and lateral and ventral arm plates of *Ophiomusium stephensoni* (BERRY, 1942) are easily distinguished from those of the present species from the North Sea Basin. RASMUSSEN (1952) described several species from the Lower Tertiary of New Jersey all of which are very distinctive. Amongst the various new species described and illustrated by KÜPPER (1954) from the Tortonian of Austria are two taxa that are provisionally referred to the Ophiolepididae. Both show characteristic arm spine bases separating them readily from *O. ? eocaena*.

*Ophiurites (Ophiomusium ?) lamberti* of ROMAN (1956) is again a rather poorly known species that is easily distinguished from the taxon under discussion by its ventral disc and arm plating (see also ROMAN, 1956, p. 430). From the Upper Cretaceous of southeast England, Hess (1960) described several species amongst which are *Ophiotitanos tenuis* SPENCER (1907, p. 104, pl. 28, figs 1, 2) and *Ophiura ? serrata* F.A. ROEMER, 1840. Both species are assigned to the Ophiolepidinae *sensu* MATSUMOTO and *O. tenuis* is compared with *Ophiozona* but left in the genus *Ophiotitanos* SPENCER, 1907. This species has more arm spines than *O. ? eocaena* and shows disc granulation. The late Miocene *Amphiura ? kuehni* from Austria (BINDER & STEININGER, 1967) shows very distinctive disc plating and arm structure which set it apart from the present species immediately. *Ophiomusium danicum* BRÜNNICH NIELSEN, 1926 is described from the Polish lowermost Tertiary by MARYAŃSKA & POPIELBARCZYK (1969); this species, with characteristic lateral arm plates that meet over the arm both dorsally and ventrally, is also known from coeval strata in Denmark (BRÜNNICH NIELSEN, 1926; RASMUSSEN, 1950). The West American Eocene and Miocene *Ophiocrossota baconi* and *O. oweni* (BLAKE & ALLISON, 1970; BLAKE,

1975) are immediately distinguished from the Belgian species by their distinctive disc and arm plating, while there are also considerable differences in their oral frames. The undoubtedly most thorough study of Tertiary ophiuroids from Europe and Greenland was based on rich faunas of occasionally exceptionally well-preserved specimens and was authored by RASMUSSEN (1972). Amongst the various species described there are eight that are referred (provisionally no doubt) to *Ophiura*. *Ophiura achatae* RASMUSSEN (Late Danian of Greenland) is compared with *Ophiurites eocaenus* (referred to *Stegophiura* by RASMUSSEN) and is stated to differ in having short arm joints and plates and different dorsal arm plates. The ventral arm plates are also quite unlike those of *O. eocaenus*. In *Ophiura furiae* RASMUSSEN (1972, pl. 6, figs 4, 5) from the Ypresian of Denmark the radial shields meet distally, the dorsal arm plates are separated at the eighth arm joint and the ventral arm plates are separated over the entire length of the arm. Differences exist also in the oral frame. *Ophiura wetherelli* of FORBES (1852, p. 32, pl. 4, fig. 7; see also RASMUSSEN, 1972, p. 64, pl. 7, figs 1-5; pl. 13, figs 2, 3) appears to be the commonest species of ophiuroid in the Ypresian of southeast England. It is distinguished from *O. ? eocaena* by its distinctive disc plating, the structure of its oral frame and of the arms, in which the ventral as well as the dorsal arm plates are separated, the former over the entire length of the arm. The lateral arm plates are also less massive. Another British Ypresian species is *O. bogneriensis* RASMUSSEN (1972, p. 66, pl. 8, figs 1-10; pl. 14, fig. 1), which differs from LERICHE's species in its disc plating with comparatively large radial shields and little or no variation in shape and size of the smaller disc scales. A well-developed arm comb is present and the oral shield, the lateral arm plates and the dorsal arm plates clearly differ from those of *O. ? eocaena*. *Ophiura bartonensis* RASMUSSEN (1972, p. 68, pl. 9, figs 1-9; pl. 14, figs 2-4) from the Bartonian (Late Eocene) of England is a distinct species as well, differing from *O. ? eocaena* in details of disc and arm plating. Three additional Bartonian species from England, *Ophiura carpelloides* RASMUSSEN (1972, p. 71, pl. 10, figs 1-9), *O. davisii* RASMUSSEN (1972, p. 75, pl. 10, figs 10-15) and *O. costata* RASMUSSEN (1972, p. 70, pl. 6, figs 8, 9) are based on dissociated ossicles, amongst which are lateral arm plates that are markedly different from those of the species here described. To summarise, *O. eocaena* proves to be a distinct species that does not occur in British Eocene strata. A record of this species from the Bartonian of Ezanville (Val-d'Oise, France) by ROMAN & PERREAU (1973, p. 108, text-fig. 1; pl. 1, figs 1-3) is based on several arm fragments which closely resemble the structure seen in the Belgian species, but in which the lateral arm plates appear even more tumid (especially distally) and the outer tentacle scale is larger than the inner. Whether these, admittedly small, differences permit this French species to be differentiated from the Belgian one can only be determined on the basis of discs or disc plates of the former. For the time being it is here

referred to *O. ? eocaena* with a query. ROMAN & PERREAU (1973, p. 111) retain the generic denomination *Ophiurites*, arguing that, "... l'attribution à un genre précis ne paraît pas possible, les caractères sur lesquels est fondée principalement la systématique des Ophiures (disposition de l'armature buccale) n'étant pas connus." *Ophiurites* sp. (ROMAN & PERREAU, 1973, p. 111, text-fig. 2; pl. 1, fig. 4) from the Bartonian of the same area is apparently different judging from the ventral disc plating and the structure of the oral frame. In addition, in *O. ? eocaena* the arms are widest within the disc, which does not seem to be the case for *Ophiurites* sp. *Ophiura ? sternbergica* of KUTSCHER (1980, p. 226, pl. 2, figs 4-7; pl. 3, figs 4, 5; pl. 4, figs 1-7) from the Upper Oligocene of NE Germany can easily be distinguished from *O. ? eocaena* especially by its small ventral arm plates and the structure of the lateral arm plates. Of *Ophiura ?* sp. (KUTSCHER, 1985, p. 8, pl. 3, fig. 1) from the Middle Oligocene of the GDR only a single lateral arm plate is known, which is easily distinguished from the plates seen in the Belgian species under discussion (fragility and arrangement of arm spine bases). From the Upper Eocene of Germany LIENAU (1984, p. 50, pl. 3, fig. 13) illustrated a fragmentary ophiuroid under the name *Chilophiurina* gen. et sp. indet. The rather poor illustration does not allow any comments to be made on this form. A diminutive species from the Palaeocene of the Paris Basin was described and figured by BIGNOT *et al.* (1987) as *Bibophiura opercularis*. This form has very distinctive lateral arm plates, large arm spines and a characteristic disc plating.

To summarise, LERICHE's species (here referred to as *Ophiozonia ? eocaena*) appears to be a well-defined taxon which is probably endemic to the Eocene of Belgian Flanders, with the possible exception of a French occurrence (ROMAN & PERREAU, 1973, see above).

#### STRATIGRAPHY

*Ophiozonia ? eocaena* was first described from a slab of grès "panisélien" as they are commonly found on the beaches along the Belgian coast. They originate from submarine outcrops some distance away from the shoreline. The find of additional specimens of this species of ophiuroid in a similar slab on the beach near Cadzand, some 15 km north of Zeebrugge where the type lot was found, demonstrates the degree of dispersal of these boulders. Eocene fossils, molluscs in particular (VAN REGTEREN ALTENA *et al.*, 1965; JANSSEN & VAN DER SLIK, 1974, 1978; JANSSEN *et al.*, 1984) are commonly washed ashore near the Belgian-Dutch border (Het Zwin). In most cases, these species can be readily matched with inland occurrences and thus their stratigraphic provenance can be precisely determined. Boulders without such typical fossils, like the one yielding the type lot of *O. ? eocaena* and the Cadzand find, present problems as far as their stratigraphic age is concerned. LERICHE (1931, pp. 109-114) discussed the stratigraphic provenance of these slabs and boulders. He distinguished a greenish-grey, glauconitic sandstone similar to the one found

intercalated in Paniselian strata of authors. The commonest fossil found in these boulders is the bivalve *Megacardita (Venericor) planicosta lerichei* GLIBERT & VAN DE POEL, 1970, which is a typical fossil of the Aalter Sands, but which is not confined to that unit (see GLIBERT, 1985). LERICHE stressed that lithological features of these boulders show them to be derived from various distinct horizons, yielding silicified fossil assemblages (*M. planicosta*, *Turritella solanderi* MAYER-EYMAR, 1877) identical to those known from the Aalter Sands. Because of this rather wide range of lithologies, LERICHE (1931, p. 110) was unable to determine the exact stratigraphic provenance of these boulders. He therefore gave as stratigraphic age for his new species of ophiuroid: "Panisélien". The term Panisélien was introduced by DUMONT (1851) to encompass the sandy clays between the Ypresian and the Bruxellian, by implication those exposed at Mont Panisel, near Mons, southern Belgium. A number of important contributions have been published over the past few decades, concentrating mainly on regional stratigraphy of the Ypresian and related strata in the French-Belgian basin, but also on the chronostratigraphic position of the various stages recognised. Some of these contributions will here be focussed on with the aim of determining the stratigraphic age (if at all possible) of *Ophiozonia ? eocaena*.

LERICHE (1912, pp. 796, 800) mentioned a "faciès panisélien du Bruxellien" and referred "les couches dites d'Aeltre" to the Bruxellian as a separate facies. In addition, he mentioned in a footnote on page 800 that, "Les couches d'Aeltre affleurent en mer. Le flot ramène fréquemment sur la côte des blocs d'un grès grossier et glauconifère, panisélien, et de grosses *Cardita planicosta*." A more detailed account of these boulders can be found in LERICHE (1932). In 1942 LERICHE provided a detailed picture of the Paniselian and its various interpretations, together with a discussion of the Ypresian-Lutetian boundary. An exhaustive discussion of the Ypresian in France and Belgium, and of the stratigraphic age of the Aalter Sands was presented by FEUGUEUR (1951), indicating the twofold division of the Paniselian into a lower part VI (of Ypresian age) and an upper part VII-VIII (of Lutetian/Bruxellian age). FEUGUEUR's plates clearly show the stratigraphic relationship of the various units, indicating the occurrence of sandstone boulders in the Panisélien inférieur (Y 2) in the Belgian basin. A similar treatment of the subject, this time with additional micropalaeontological data is found in LE CALVEZ & FEUGUEUR (1956), who correlate the Paniselian with the upper Cuisian of the Paris Basin and who refer to the former unit "sable, grès, argile" and "Sable d'Aeltre" to be ultimately correlated with the upper Ypresian. De HEINZELIN & GLIBERT (1957) pointed out that the Paniselian Stage as formerly recognised had been subdivided into a lower part incorporated into the Ypresian and an upper part referred to the Lutetian (Bruxellian, B1). In GULINCK (1965) the Paniselian is also retained with in its uppermost part the Aalter Sands, while pointing out the problems that exist in unravelling the Paniselian strata

and their stratigraphic relationships. BLONDEAU *et al.* (1965) presented a comparable picture, with the Paniselian overlain by the Aalter Sands, and referred to the upper Ypresian (Cuisian). MOORKENS (1968) however, distinguished the Paniselian (as a local term only) spanning the Ypresian-Lutetian boundary, with the rank of formation, overlying the Ypresian *s. str.* and being subdivided into a lower and an upper part, the latter corresponding with the Aalter Sands. BRÖNNIMAN *et al.* (1968) based their correlations in the Palaeogene of the French, Belgian and English basins on planktonic foraminifers, with the Paniselian incorporated into the upper part of the Ypresian. In CURRY *et al.*'s (1969) view the complex of the Sable d'Aalter, Sables de Vlierzele et du Mont Panisel and the Sable de Mons-en-Pévèle should be referred to the upper Ypresian (Cuisian). DE CONINCK (1971), on the basis of organic walled microfossil assemblages, pointed out that a twofold division of the Belgian Ypresian into an Ypresian *s. str.* and a Paniselian *pro parte* is possible. To the former are referred the Argile d'Ypres and the Sables de Mons-en-Pévèle and to the latter the Argile de Merelbeke, Argile sableuse d'Anderlecht, Sables de Vlierzele and the Sédiments d'Aalter-canal or the Complexe d'Aalterbrugge. NOLF (1972a) presented a lucid account of the stratigraphy of the Panisel and Den Hoorn Formations, introducing the term Oedelem Sands and favouring a reinstallation of the Panisel Formation as originally intended by DUMONT (1851). This formation comprises in NOLF's view the P1 beds, but without unit P1 m and the Aalter Sands. NOLF distinguished three different facies within the Panisel Formation, which are underlain by the Ypres Formation (Argile de Merelbeke (P1 m), Sables de Mons-en-Pévèle and Argile de Flandres), and overlain by the Den Hoorn Formation (Sables d'Aalter and Sables d'Oedelem) and the Bruxelles Formation (Sables de Bruxelles). NOLF pointed out that the Paniselian of authors had been erroneously given chronostratigraphic rank, whereas this term can only be used in a lithostratigraphic sense. NOLF (1972b), as a sequel to the lithostratigraphy outlined in his earlier paper, analysed the fish assemblages of the Panisel and Den Hoorn Formations. He indicated (p. 114) that, especially near Cadzand, large numbers of remanié Panisel Formation sediments are found. His stratigraphic analysis of the fish faunas is especially interesting since these comprise the first representatives of typically Lutetian assemblages at the Ypresian/Lutetian boundary. The Den Hoorn Formation yields assemblages the majority of which are typically Lutetian in character and in which no typical Ypresian species has yet been found. NOLF's main conclusion (p. 131) is that,

“... nous pouvons seulement dire que la base des Sables d'Oedelem est la limite Yprésienne-Lutétienne, la plus haute admissible, mais comme la faune de la Formation du Panisel (sensu Dumont) est pour ainsi dire inconnue, il n'est pas exclu que cette limite puisse encore tomber plus bas dans la séquence.”

BERGGREN (1972) provided a detailed discussion of a Cainozoic time-scale, with data on calcareous nannop-

lankton and planktonic foraminifers, and with suggested time-stratigraphic boundaries. Incorporated are data obtained by potassium argon glauconite analyses (ODIN *et al.*, 1969), e.g. for the Aalter Sands.

ROBASZYNSKI (1979) discussed correlations in the Palaeocene and Lower Eocene of the Mons basin and northern France, retaining the Sables du Mont-Panisel (Argile de Merelbeke, Y2) as local unit, to be classified in the upper part of the Ypresian. CURRY *et al.* (1978) in their discussion of British Tertiary correlations naturally reviewed correlations with the European continent, and classified in the early Eocene (Ypresian) the Ypres Clay, Mons-en-Pévèle Sands, Vlierzele, Forest, and the Aalter Sands, with the Paniselian comprising the latter four units (CURRY *et al.*, table 2). Important data on planktonic foraminifers and calcareous nannoplankton are furnished by BIGG (1982). Unfortunately, the Panisel Beds (BIGG, 1982, fig. 7) have not yielded any planktonic foraminifers, nor any calcareous nannoplankton (fig. 8), rendering interregional correlations impossible. CAVELIER & POMEROL (1986, p. 258) include the Paniselian in the Ypresian as originally defined (DUMONT, 1849), which corresponds to nannoplankton zones NP11, NP12 and NP13 of MARTINI (1971), and which is accepted as a standard early Eocene stage.

The type area of the Paniselian in the Mons basin was briefly discussed by DUPUIS & ROBASYNSKI (1986), who stressed that the Mont-Panisel and Bois-là-Haut hills (the stratotype of the Paniselian) remains poorly known in the absence of detailed biostratigraphic data, but that unpublished analyses of calcareous nannoplankton indicate placement of the calcareous sand with *Nummulites planulatus* LAMARCK, 1804 at the top of nannozone NP11. A detailed analysis of the Paniselian facies in its type area by means of a borehole should conclude the discussion on this topic. The most thorough revision of Ypresian stratigraphy in Belgium and northwestern France to date is by STEURBAUT & NOLF (1986). A formal lithostratigraphic scheme is proposed, a new nannofossil zonation established and correlated with the standard zonation of MARTINI (1971) and various aspects of sedimentation and tectonics are discussed. In northwest Belgium the Ypresian consists of a lower clayey sequence (Yc on the Belgian geological map), overlain by very fine sands (Yd), in turn overlain by rather coarse, more or less clayey, glauconitic sands with bands of sandstone (P1, or “Lower Paniselian”), with the Merelbeke Clay (P1m) marking the boundary between units Yd and P1. The redefined Ieper Formation includes several members, amongst which is the Panisel Sand Member, which represents the upper Ieper Formation in the southern part of the Belgian basin. The lowermost part of this member yields nannofossil assemblages referable to unit VII, the uppermost part is assignable to unit VIII (both are within NP12, see STEURBAUT & NOLF, 1986, fig. 10). In the northwest part of the Belgian basin the Egem Sand Member is the equivalent of the Panisel Sand. Lithostratigraphic and biostratigraphic relationships of the various units recognised (STEURBAUT &

NOLF, 1986, fig. 10) show the Panisel Sand to be within nannozone NP12. An equally detailed picture of the Aalter Sands in their stratotype can be found in STEURBAUT & NOLF (1989), who presented lithostratigraphic as well as biostratigraphic (nannoplankton) analyses. The larger part of this unit can be referred to NP14 of MARTINI (1971) (*Discoaster subloedoensis*, spanning the upper Ypresian-Lutetian boundary and embracing the Bruxellian, see CAVELIER & POMEROL, 1986, table 1). The Aalter Sands sequence is subdivided into twelve lithologically distinct beds in turn to be grouped into four major intervals characterised by particular molluscan assemblages, the middle two of which are typified by the occurrence of *Megacardita planicosta lerichei* and *Turritella solanderi*. As pointed out above, this bivalve subspecies is especially common in the Aalter Sands, but it has also been reported from the Oedelem Sands (GLIBERT, 1985, p. 285, table on p. 347), as well as from the Brussels Sands (upper Bruxellian = B2, Brussels Formation). *Turritella solanderi* is also very common in the Aalter Sands, but has also been recorded for the Ypresian of the Paris Basin (GLIBERT, 1985; DHONDT in MOORKENS *et al.*, 1967, p. 220). From the above it appears that the Panisel Beds as now restricted are decidedly Ypresian in age, but that the

lithologic similarity between the boulders washed ashore on the Belgian and Dutch (Zeeland) beaches and the sandstone intercalations in the Mons Basin Paniselian cannot be automatically put forward as evidence of an Ypresian age of the former. The common occurrence of such distinctive molluscan species as *M. planicosta lerichei* and *T. solanderi* amongst the boulders would suggest correlation with the Aalter Sands, and, by definition, a Lutetian age. However, as both species have been recorded from strata underlying and overlying the Aalter Sands, this is not absolute proof. In fact, in the absence of any molluscs in the slabs yielding the only specimens of *Ophiozona ? eocaena* recorded hitherto and described here, this age assignment is tentative at best.

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#### PLATE I

*Ophiozona ? eocaena* (LERICHE, 1931). All specimens are in the collections of the Institut royal des Sciences naturelles de Belgique, Brussels.

Fig. 1 : The type lot, the specimen marked with an arrow being the lectotype, preserved on a slab collected near the mole of Zeebrugge harbour. Paniselian of authors, most probably Lutetian (equivalents of the Aalter Sands) in modern stratigraphic terms; x 2.

Figs 2, 3: The Cadzand specimens, preserved on a lithologically similar slab, showing the dorsal (adoral) side of disc and arms (Fig. 2) and the ventral (oral) side of the same (Fig. 3). Paniselian of authors, most probably Lutetian (equivalents of Aalter Sands) in modern stratigraphic terms. Leg./don. J.J. de KLERK; x 2.

