Ordovician trilobites from the inlier at Le Petit Fond d'Oxhe, Belgium

by William T. DEAN

Abstract

Ordovician rocks in the Oxhe inlier are assigned to two formations, the junction of which is not exposed and may be faulted. The older, unnamed formation resembles, but is younger than, part of the "Assise de Huy", farther west along the Meuse valley. Rare macrofossils include undetermined phyllocarid crustaceans, graptolites that suggest a Llandeilian age, and trilobites (*Corrugatagnostus morea* (SALTER, 1864), *Dionide jubata* RAYMOND, 1925, *Ellipsotaphrus monophthalmus* (KLOUČEK, 1916)) whose affinities are with faunas in the Llanvirn and Llandeilo of Bohemia, northern England and the Welsh basin. The younger unit, the Oxhe Formation, belongs to the Longvillian Stage (Caradoc). It contains the trilobites *Broeggerolithus nicholsoni* (REED, 1910) and *Brongniartella minor minor* (SALTER, 1852), part of a Longvillian assemblage widespread in northwestern England, North Wales, Shropshire and southeastern Ireland. Silurian rocks, assigned to the Llandovery on the basis of acritarchs, are seen in a small outcrop at the western end of the Oxhe inlier. Their junction with the Oxhe Formation is not exposed.

Key-words: Trilobites, Ordovician, Taxonomy, Stratigraphy, Belgium.

Résumé

Les dépôts ordoviciens de la boutonnière d'Oxhe appartiennent à deux formations; leur contact n'affleure pas et peut être faillé. La formation la plus ancienne n'est pas nommée; elle ressemble, tout en étant d'un âge plus récent, à une partie de l'Assise de Huy, localisée plus à l'ouest dans la vallée de la Meuse. De rares macrofossiles comprennent des crustacés phyllocarides indéterminés, des graptolithes suggérant un âge llandeilien et des trilobites (*Corrugatagnostus morea* (SALTER, 1964), *Dionide jubata* RAYMOND, 1925 et *Ellipsotaphrus monophthalmus* (KLOUČEK, 1916)). Ces derniers montrent des affinités avec les faunes du Llanvirn et du Llandeilo de Bohême, du nord de l'Angleterre et du bassin gallois. L'unité la plus jeune, la Formation d'Oxhe, appartient à l'Étage Longvillien (Caradoc). Elle contient les trilobites *Broeggerolithus nicholsoni* (REED, 1910) et *Brongniartella minor minor* (SALTER, 1852), faisant partie d'un assemblage longvillien étendu dans le nord-ouest de l'Angleterre, le nord du Pays de Galles et le sud-est de l'Irlande. Les dépôts siluriens, datés llandoveriens d'après l'examen d'acritarches, sont observés dans un affleurement limité à l'extrémité occidentale de la boutonnière d'Oxhe. Leur contact avec la Formation d'Oxhe n'est pas visible.

Mots-clefs: Trilobites, Ordovicien, Taxinomie, Stratigraphie, Belgium.

Introduction

The small valley known traditionally in geological literature as Le Petit Fond d'Oxhe lies about 1 km southeast of the small town of Ombret-Rawsa (sometimes, simply, Ombret) beside the River Meuse, between Huy and Liège in eastern Belgium (Fig. 1). The area falls within Sheet Nandrin 48/4 of the 1:10 000 topographic map of Belgium. In a recent account by MICHOT (1980) the spelling was changed to Le Petit Fond d'Ohe, to conform with that on the 1967 topographic map, though HOUET & CLEEVEN's (1968) dictionary of Belgian communes preferred Oxhe. The International Stratigraphic Guide (HEDBERG, 1976, p. 42) stated that "Change in the name of a geographic feature does not entail change of the corresponding name of the stratigraphic unit. The original name of the unit should be maintained; ...". In the present paper the original spelling is retained for both topographic and stratigraphic purposes.

Outcrops of what are now recognised as Ordovician rocks have long been known in the area and MALAISE (1894) recorded slaty shales from which he had collected *Lingula* sp., a trilobite pleuron, and debris resembling the phyllocarid crustacean *Caryocaris* SALTER, 1863 (see ROLFE, 1969, p. R316). MALAISE (1900b, p. 167) reiter-

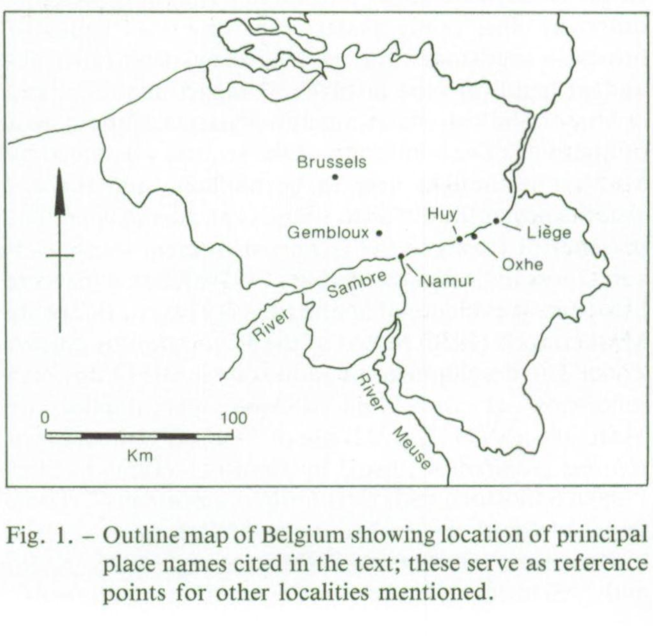

Fig. 1. – Outline map of Belgium showing location of principal place names cited in the text; these serve as reference points for other localities mentioned.

ated the record of *Caryocaris* when refuting an erroneous claim that fish-like fossils occurred in the easternmost outcrop of "Silurian (Arenig)" rocks on the road from Ombret to Yernée; this exposure corresponds to Locality A of the present paper (Fig. 2) where the presence of phyllocarids has been confirmed.

The Lower Palaeozoic rocks of Belgium have been subdivided geographically, on the basis of "massifs" (for example Massif de Dave) and "bandes" (for example Bande de Sambre-Meuse). Within each a number of "assises" has been recognised, based on both lithological and palaeontological features. For a review and relevant references see MICHOT (1976, 1980). Assises carry geographic names (for example the Assise de Fosse, composed of Ashgillian rocks), and their longitudinal margins may be faulted or marked by unconformities. Orientation is approximately ENE-WSW, a direction usually considered Hercynian, though the structural history may, as noted by MICHOT (1976), involve Caledonian movements.

The rocks noted here (summary in Fig. 4, p. 145) form part of the Assise d'Oxhe, introduced by MALAISE (1900a). As part of the Bande de Sambre-Meuse they were termed "Horizon d'Oxhe à *Trinucleus concentricus*" by MAILLIEUX (1926, p. 76). Also in the Bande de Sambre-Meuse, the Assise de Vitrival-Bruyère of MAILLIEUX (1926, p. 77) was interpreted by MICHOT (1954, pp. 54, 75) as a composite unit to include the "Zone à *Pionodema redux*" (presumably of Sart-Bernard) and the supposedly succeeding "Zone à *Cryptolithus gibbifrons*" (of Oxhe); these two "zones" have not been found in juxtaposition and are of very different ages within the Ordovician.

The first comprehensive account of the Oxhe inlier was published by MICHOT (1934a), whose map showed only Ordovician rocks, occupying an area 2 km long by 300 m wide, encircled by the conspicuous unconformity at the base of the Poudingue d'Ombret, of Lower Devonian, Gedinnian age. Using lithological criteria MICHOT divided the Ordovician rocks into three parts, in descending order: a) blue, sandy shales with some thin bands of brownish sandstone; b) dark blue shales with fairly abundant bands of blue or black, compact quartzite; and c) blue or blackish shales, finely micaceous, without beds of quartzite. The continuity of the sequence assumed by MICHOT is thought here to be unlikely, and the age significance of the different units is considered later. The presence of fossils in the vicinity of present localities F and G was indicated by MICHOT (1934a), but none were listed and as evidence of age he cited (1934a, p. B62) only MAILLIEUX's (1930) record of the *Pleurograptus linearis* Zone. The development of sandstone in the Ordovician succession at the Fond d'Oxhe was implied by MAILLIEUX's (1933, p. 32) use of "Grès d'Oxhe à *Cryptolithus gibbifrons*", listed by REGNÉLL (1951, p. 5) as "Oxhe Sandstone with *Cryptolithus gibbifrons*". These terms replaced the earlier usage of "Horizon d'Oxhe à *Trinucleus concentricus*" (MAILLIEUX, 1926, p. 76) and "Schistes d'Oxhe à *Cryptolithus gibbifrons*" (MAILLIEUX, 1930). Although exposure is incomplete, the present work suggests that sandstone is generally subsidiary to mudstone and siltstone apart from the exposure at Locality F, and in the vicinity of Locality E, where fragments of brown-weathering, fine-grained sandstone occur in abundance on the hillside.

The trilobites "*Cryptolithus gibbifrons* (MCCOY" and "*C. concentricus* EATON" (both unrecognisable species) and "*Homalonotus (Brongniartia) bisulcatus* SALTER" (now attributed to MCCOY *in* SEDGWICK & MCCOY, 1951) were recorded by MAILLIEUX (1926, 1930) who regarded their age as Caradocian, first (1926) as *Climacograptus peltifer* Zone and then (1930) as *Pleurograptus linearis* Zone. In a later paper MICHOT (1954, pp. 52, 60) considered the Oxhe fauna to be Caradocian; he noted also that below the beds with *Cryptolithus gibbifrons* were more than 100 metres of black shale that might belong to the Assise de Fosse (named for a town about 45 km WSW of Oxhe). The black shale may refer to both unit c) of MICHOT's 1934a and the unnamed formation at Locality A of the present paper. The use of the binomen *Cryptolithus gibbifrons* for material from southern Belgium by MAILLIEUX (1930, 1933) and MICHOT (1954) is of some historical interest as the name was employed earlier by BANCROFT (1929b, p. 75 and Table) for Lower Longvillian trinucleid trilobites now considered synonymous with *Broeggerolithus nicholsoni*. As shown by WHITTARD (1956, p. 68) the type material of *gibbifrons* is lost and the species is not recognisable.

MICHOT (1954, pp. 52-53) rightly emphasised the uniqueness of the Fond d'Oxhe fauna within Belgium, a conclusion still true today, and found difficulty in correlating the strata with allegedly contemporaneous rocks elsewhere in the country, many of which were equated with various zones in the Ordovician graptolitic scale. He drew attention to the fact that although MAILLIEUX (1926) had considered the "Schistes d'Oxhe" to be older than the "Schistes de Fosse" (and below what he termed the "Zone à *Plaesiomys porcata* et *Nicolella actoniae*"), in practice this could not be confirmed because the Fond d'Oxhe fauna is not known in the Bande de Sambre-Meuse *sensu stricto*.

The latest publication on the geology of the inlier is by MICHOT (1969), who modified slightly the western boundary of the Ordovician rocks as shown on his 1934a map and indicated an outcrop of apparently overlying Silurian rocks about 250 m W of the Ruisseau du Fond d'Oxhe. This area is poorly exposed and the stratigraphic relationships of the Caradoc strata with those of allegedly Silurian age are not clear. Part of MICHOT's Silurian outcrop appears to be occupied by Oxhe Formation but Llandoverian rocks dated by means of acritarchs are present (Francine MARTIN, personal communication).

Boundary of the Oxhe inlier

The Devonian rocks fringing the inlier form part of an

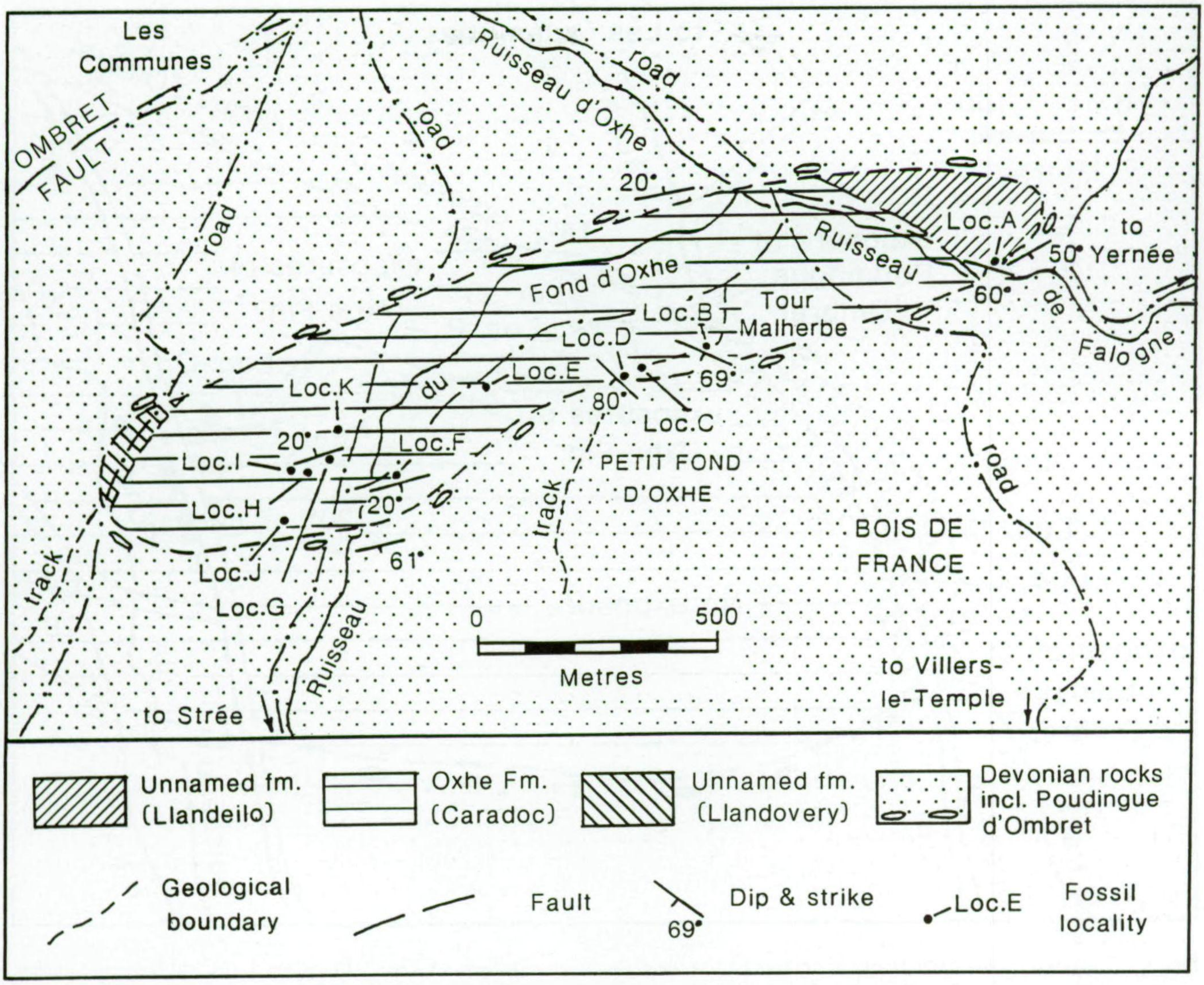

Fig. 2. – Geological map of the Oxhe inlier and adjacent area south of the Ombret Fault showing Ordovician macrofossil localities listed in text.

asymmetric anticline (axis approximately N. 70° E), the northern limb of which dips 14°-20° N and the southern limb dips 50°-61° S. Of the three Gedinnian units mapped by MICHOT (1969, fig. 2) the Poudingue d'Ombret is particularly resistant to erosion and forms a conspicuous feature that can be traced around most of the inlier, even though its unconformable contact with the underlying, less resistant Ordovician mudstone and siltstone is not exposed.

Thickly-bedded sandstone and conglomerate are especially well developed along the northwestern margin of the inlier, where they form a large, craggy exposure at least 150 m long in the wooded area about 300 m NW of the group of houses at Le Petit Fond d'Oxhe. The rocks dip 14° NNW and the feature may be traced eastwards, with occasional exposure, almost to the confluence of the Ruisseau du Fond d'Oxhe and the Ruisseau de Falogne (Fig. 2).

The eastern end of the inlier is poorly exposed and the next solid exposure of Poudingue d'Ombret is by the north side of the Ombret-Falogne road 25 m E of Locality A (Fig. 2). There, thickly-bedded conglomerate dips 50° SSE and marks the end of a feature that continues along the upper part of the high ground SE of the Ruisseau d'Oxhe. About 5 m of thickly-bedded sandstone, probably just above the basal conglomerate, are exposed 150 m S of Locality F (Fig. 2), in the eastern side of a track leading from the Ombret-Strée road. The sinuous outcrop of the Poudingue d'Ombret in this part of the inlier is due at least in part to the topography; small faults may also be present but could not be mapped with confidence owing to lack of exposure.

The outcrop of the Poudingue d'Ombret at the western end of the inlier is less clearly exposed, and on present evidence MICHOT's 1934a interpretation appears more convincing than that of 1969. The long exposure noted earlier, 300 m WNW of Le Petit Fond d'Oxhe, continues westwards to the side of the small road to Les Communes (Fig. 3), within 50 m of exposures in the Oxhe Formation. Three hundred metres S, along and on either side

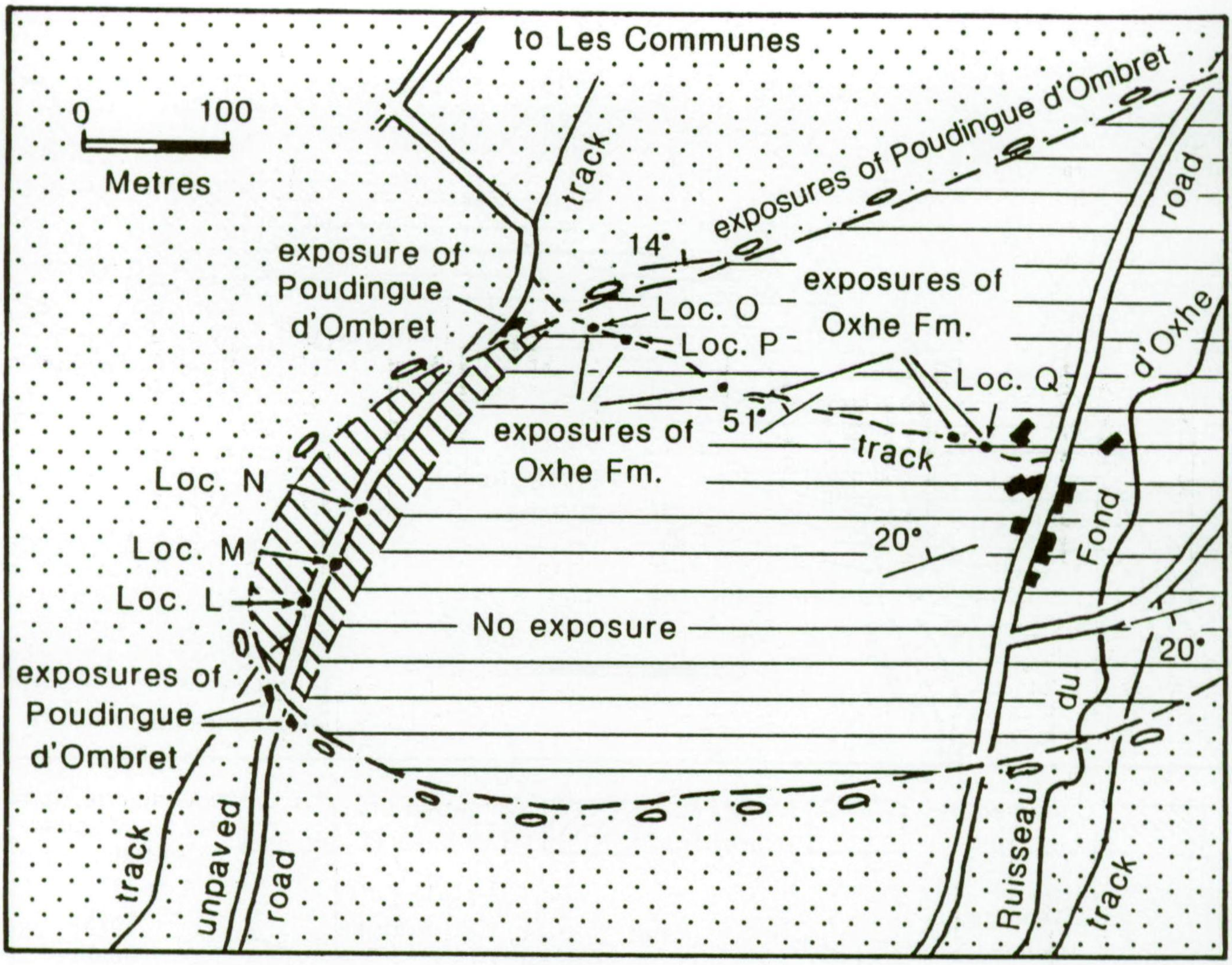

Fig. 3. – Enlarged geological map of the western end of the Oxhe inlier. For Key, see Fig. 2. Localities L, M and N are in Silurian (Llandovery) rocks, those at N being dated by means of acritarchs; Localities O, P and Q are in Oxhe Formation.

of the same road, conglomerate forms a low feature that runs NW; the eastern margin of the feature is interpreted tentatively as marking the base of the Poudingue d'Ombret. This boundary resembles the one shown first by MICHOT (1934a) rather than that on his 1969 map, in which Silurian mudstone occupies the same area and forms an outcrop extending still farther west for which no conclusive evidence has been found.

Ordovician rocks at Le Petit Fond d'Oxhe

UNNAMED FORMATION OF LLANDEILIAN AGE

The oldest rocks in the area correspond to part of MICHOT's (1934a) unit c) and were found only at the eastern tip of the inlier, by the NE side of the road from Ombret-Rawsa to Yernée (Fig. 2). Exposure is poor and the conjectured outcrop represents the area between the highest beds of the roadside section and the adjacent conglomerates at the base of the Poudingue d'Ombret (Lower Devonian) as mapped about 180 m to the north; on this interpretation the thickness of the formation could exceed 150 m. The apparently oldest strata are seen by the roadside at Locality A, where they dip 60° NNE; they are overlain unconformably at the southeastern end of the section by the Poudingue d'Ombret, which here dips 50° SE. Approximtely 4 m of dark grey micaceous mudstone, often soft and finely laminated, are visible and all the macrofossils were collected from a level 1.40 m above the base of the exposure. The lithology is quite distinct from that of the Oxhe Formation and the contact of the two formations is masked by Recent deposits and alluvium. The rocks resemble part of the argillaceous succession in the rail-cutting E of Sart-Bernard, 31 km WSW, near Naninne, as was noted by MICHOT (1934a, p. B62), and also shales in the railway cutting at Huy-Statte, 8 km W. Both the latter outcrops form part of the "Assise de Huy", within the Bande de Sambre-Meuse, and their graptolite fauna, reviewed by BULMAN (1950, pp. 2-4), indicates the presence of, respectively, lower Llanvirn and upper Arenig strata. A broad lithological comparison may also be made with the Hope Shales (lower Llanvirn) of the Shelve inlier in west Shropshire, on the border of England and Wales. It is evident that similar Ordovician sediments are widespread at different stratigraphic levels in western Europe and may contain similar genera. Although trilobites are uncommon at Locality A, they form a distinctive assemblage not yet reported elsewhere in Belgium. *Corrugatagnostus morea* (SALTER, 1864), *Dionide jubata* RAYMOND, 1925 and *Ellipsotaphrus monophthalmus* (KLOUČEK, 1916) all occur in the Hope Shales of the Shelve inlier, where the two first-named species range into the overlying Stapeley Volcanic Member (WHITTARD, 1966, pp. 299-301). Both British rock units are correlated with part of the *Didymograptus "bifidus"* Zone, considered by MAILLIEUX (1939, p. 8) and by MICHOT (1954, p. 47) to belong to the topmost Arenig Series but now classified as lower Llanvirn Series (WILLIAMS *et al.*, 1972).

In addition to the trilobites, described later, the grey mudstone at Locality A yielded a few fragments of unidentified inarticulate brachiopods, several crushed fragments of phyllocarid crustaceans, and four incomplete graptolites. The last have been examined by Isles STRACHAN, and the following is a summary of his comments. Specimen a: medium-sized *Climacograptus* very like *C. angulatus* BULMAN, 1953, now put in *Pseudoclimacograptus;* the Belgian example is narrower at the proximal end than *P. vestrogothicus* JAANUSSON & SKOGLUND, 1963, which also has strongly inclined thecal excavations. Specimen b: small, poorly preserved *Climacograptus* of the *C. brevis* ELLES & WOOD, 1906 type. Specimen c: large orthograptid of the *O. calcaratus* (LAPWORTH, 1876) type that lacks the proximal end and cannot be identified further. Specimen d: fragment of a dichograptid which, if correctly identified, would put the age as no higher than *Nemagraptus gracilis* Zone. Evidence for the latter is not positive, however, and Isles STRACHAN considers that all the forms present could occur in the *Glyptograptus teretiusculus* Zone [= lower Llandeilo as interpreted by WILLIAMS *et al.*, 1972]. *C. angulatus* was described first from strata claimed to belong to the *Didymograptus murchisoni* Zone [= upper Llanvirn], but Isles STRACHAN points out that orthograptids appear not to occur at such a low horizon.

Phyllocarid remains from Locality A are strongly compressed and poorly preserved, and correspond probably to material from the same locality recorded as *Caryocaris* by MALAISE (1894). The genus was reported (as *Lamprocaris micans* NOVÁK, a manuscript name) from Sart-Bernard, near Naninne, by MAILLIEUX (1939, p. 19), who noted the occurrence of the species at Huy and in the Llanvirn Series (Šarka Beds) of Bohemia. For the diagnosis of *Caryocaris* SALTER, 1863, and its junior subjective synonym *Lamprocaris*, see ROLFE (1969, p. R316).

OXHE FORMATION

The term corresponds to 'Horizon d'Oxhe à *Trinucleus concentricus*' of MAILLIEUX (1926, p. 76), and to units a), b) and part of unit c) of MICHOT (1934a). The most common rock types comprise micaceous mudstone and siltstone, sometimes cleaved, particularly in the south central part of the inlier. Occasional thin (up to 10 cm), impersistent beds of fine-grained sandstone occur within the mudstone, particularly in the vicinity of localities E and F. All the rocks are blue-grey when fresh but appear brown or brown-green on weathering. MICHOT's (1934a) assumption of a normal, ascending succession from east to west is broadly correct, but it has proved impractical to establish a detailed, measured sequence and no single section has been designated as stratotype. The area SW of the Ombret-Yernée road near Locality A (section in Unnamed formation of Llandeilian age) is covered with Recent deposits and alluvium that extend west from the Ruisseau de Falogne and along the Ruisseau du Fond d'Oxhe. Consequently it has proved impossible to define the formational base. Exposures are frequent along the wooded slopes SE of the main road from Ombret to Strée, and in this area the dip is generally SW or approximately S. In the area NW of the Ruisseau du Fond d'Oxhe, about 500 m NW of Tour Malherbe, MICHOT (1934a, p. B60) indicated exposures with a NW or NNW dip but none are now accessible.

The most characteristic part of the outcrop forms the hill slope immediately west of the road junction at Le Petit Fond d'Oxhe. Small exposures are common there but their lack of continuity makes estimates of thickness unreliable, though the available dips suggest a maximum of about 200 m. No graptolites were found in the Oxhe Formation but shelly fossils were collected from thin, lenticular, generally decalcified bands at several points, including localities G to J (Fig. 2). Groups represented include trilobites (*Broeggerolithus nicholsoni* (REED, 1910), *Brongniartella minor minor* (SALTER, 1852), beyrichiocope ostracods, brachiopods (*Dalmanella, Sowerbyella*), isolated machaeridian plates (*Lepidocoleus*) and pelmatozoan echinoderm fragments. The faunal diversity is low and the material is not generally well preserved, but the assemblage is of a type found commonly in the Longvillian Stage, middle Caradoc Series of the Welsh Basin and northern England.

The most continuous section in the lower part of the formation is on the west side of the high ground at Tour Malherbe (Fig. 2). The rocks, in the lower half of MICHOT's (1934a) unit b), are mostly micaceous, grey, sometimes pyritous mudstone and siltstone with minor beds of fine-grained sandstone that may show small-scale cross bedding. They crop out along the sides of a sunken track that descends the hill towards the main Strée to Ombret road; the dip is steep and variable to the WSW and some beds are strongly cleaved. Macrofossils were found at only two points in this track section: two distorted specimens of a bellerophontid gastropod (*Sinuites?* sp.) at Locality C; and a few fragments of *Broeggerolithus nicholsoni* at Locality D. No exposures were found on the highest ground W and SW of Le Fond d'Oxhe, but successively younger beds were seen in ascending the small track that runs WNW from the hamlet (Fig. 3), and were interpreted as a continuation of the Oxhe Formation. The rocks comprise brown-weathering, green-grey siltstone and fine-grained sandstone in which no macrofossils were found; a dip of 51° NW was measured at the midpoint of the track (Fig. 3). The contact with the overlying Poudingue d'Ombret was not seen. Sampling for microfossils at Localities O, P and Q (Fig. 3) yielded only very rare, badly preserved Ordovician acritarch taxa such as *Marrocanium* sp. and *Striatotheca* sp., and diacrodians; the detailed stratigraphic position of these within the interval "Arenig-Llandeilo" was not established (Francine MARTIN, personal communication).

Silurian rocks in the Oxhe inlier

The whole of the inlier was shown in MICHOT's (1934a) map as being occupied by Ordovician rocks. MICHOT (1969, fig. 2) modified the western boundary of the inlier so that a striplike outcrop of the Poudingue d'Ombret extended WSW, underlain by the elongated prolongation of a large outcrop of Silurian rocks. The latter strata were shown to overlie, apparently conformably, the Oxhe Formation, with the boundary between the two units running NNE subparallel to, and slightly less than 200 m W of, the road through the hamlet of Le Fond d'Oxhe. No details of the Silurian rocks were given, and no fossils were listed.

The present interpretation (Fig. 3) of the Oxhe Formation shows that unit occupying much of MICHOT's (1969) "Silurian" outcrop. The distribution of the latter is confined to a narrow, strip-like area running NNE along the minor, unpaved road that leads to Les Communes. A few exposures occur in and along the margin of the road but none were found to either side, and the boundary with the Oxhe Formation was not seen. The rocks comprise thin beds of micaceous, fine-grained sandstone with interbedded mudstone and laminated siltstone; at least some of the strata are almost vertical but the section is incomplete. The rocks are yellow-brown when weathered but some are grey or green-grey when fresh and there is a certain resemblance to the Oxhe Formation, though the higher beds of the latter appear to be darker and coarser grained; in both units the strike is comparable.

Samples from localities L, M and N (Fig. 3) were examined for microfossils by Francine MARTIN (personal communication). L and M proved barren, while N contained only rare, badly-preserved acritarchs, most of them reworked from the Ordovician (for example *Coryphidium* sp., *Frankea* sp., *Vogtlandia* sp. and diacrodians). A few specimens from locality N belong to species that appear in the Silurian; these include *Neoveryhachium carminae* (CRAMER) CRAMER, 1970 and *Elektoriskos williereae* (DEFLANDRE & DEFLANDRE-RIGAUD) VANGUESTAINE, 1979 emend. MARTIN 1990. The age is Llandoverian, probably excluding Rhuddanian.

Localisation of fossiliferous samples

UNNAMED FORMATION OF LLANDEILIAN AGE

Locality A. Exposure by NE side of road from Ombret-Rawsa to Yernée, 490 m ESE of "borne K6" and approximately 25 m W of the intersection of the road and the base of the Poudingue d'Ombret.

OXHE FORMATION (CARADOCIAN)

For convenience the position of most of the following localities is given with reference to a datum point situated on the N side of the main road from Strée to Ombret-Rawsa at its junction with the smaller side-road that runs NNE through the hamlet of Le Fond d'Oxhe.

Localities B, C and D are in the SE bank of a sunken cart-road that runs roughly NE from the Petit Fond d'Oxhe to meet the main road at Tour Malherbe. Cleaved grey mudstones with a few interbeds of uncleaved siltstone dip 69° SSW at Locality B (situated 785 m at N 070° E from datum point) where only traces of macrofossils (bellerophontid gastropods?) were found. Localities C and D form part of a long, almost continuous exposure of cleaved mudstone with minor beds of fine-grained sandstone, and are sited respectively 25 m and 15 m NE of the estimated base of the Poudingue d'Ombret.

Locality E. Brown-weathering, grey siltstone 280 m at N 061° E from datum point. The location is about 10 m above road level and 12 m S of the S edge of the road. The rocks correspond to the upper middle portion of Niveau b) of MICHOT (1934a) but do not differ significantly from his Niveau a). Higher beds in the section can be followed up to the feature formed by the basal Devonian rocks.

Locality F, situated 110 m at N 084° E from datum point. A large exposure at the junction of the SE side of the main road with a small but well defined track shows 4 m of brown weathering, micaceous silty mudstone and thin beds of sandstone. The rocks, which are well jointed, dip 20° SSW and the succession continues intermittently southwards along the track towards the base of the Poudingue d'Ombret.

Localities G, H, I and J represent thin (generally less than 3 cm), impersistent beds of decalcified, calcareous siltstone and fine-grained sandstone that crop out on the wooded hill slope SW of the houses at Le Fond d'Oxhe. Distance and direction from the datum point are as follows: Locality G, 65 m at N 030° W; Locality H, 85 m at N 066° W; Locality I, 110 m at N 073° W; Locality J, 145 m at N 119° W.

Locality K, 125 m due N from datum point. A small quarry, just W of the road from Le Fond d'Oxhe to Les Communes and Ombret-Rawsa, from which MALAISE obtained numerous trilobites in 1902. The section is no longer available and exposures in the immediately adjacent wooded area yielded no significant macrofossils.

Localities O, P and Q (Fig. 3). The track leading WNW from the houses at Le Fond d'Oxhe shows sporadic exposures. The localities correspond to samples taken, respectively, at points 52, 92 and 380 paces SSE of the track's junction with the road to Les Communes.

UNNAMED FORMATION OF SILURIAN AGE

Localities L, M and N (Fig. 3) are in the margins of the unpaved road leading to Les Communes, the junction of which with a well marked track from the SW is taken as a datum point. L, M and N are, respectively, 23 m, 51 m and 100 m NNE of the datum point.

Systematic descriptions of trilobites

Terminology is essentially that used in the Treatise on Invertebrate Paleontology (HARRINGTON *et al. in* MOORE, 1959, p. 0124), but glabella is taken to include the occipital ring. Figured specimens are in the Institut royal des Sciences naturelles de Belgique, Brussels, and their numbers carry the prefix IRScNB.

Family Diplagnostidae WHITEHOUSE, 1936
Subfamily Glyptagnostinae WHITEHOUSE, 1936
Genus ***Corrugatagnostus*** KOBAYASHI, 1939

Type species. *Agnostus perrugatus* BARRANDE, 1872, considered a junior subjective synonym of *Agnostus Morea* SALTER, 1864 (see below).

Corrugatagnostus morea (SALTER, 1864)
(Plate 1, Figure 1)

1864 – *Agnostus Morea* SALTER, p. 7, pl. 1, fig. 13.
1872 – *Agnostus perrugatus* BARRANDE, p. 143, pl. 14, figs. 14-16.
1939 – *Geragnostus (Corrugatagnostus) morei [sic]* (SALTER) – KOBAYASHI, p. 173, 187.
1955 – *Corrugatagnostus morea* (SALTER) – WHITTARD, p. 10, pl. 1, figs. 9-11, text-figs. 2b, c. Includes synonymy.
1977 – *Corrugatagnostus morea* (SALTER, 1864) – PEK, p. 27, pl. 6, figs. 1-7; pl. 5, figs. 6-8; pl. 9, fig. 1; text-figs. 2, 8. Includes synonymy.
1984 – *Corrugatagnostus morea* (SALTER, 1864) – PEK & PROKOP, p. 18, pl. 1, figs. 1, 2.

Figured specimen:
IRScNB No. a 2982.

Horizon and locality:
Unnamed formation of Llandeilian age, Locality A (Fig. 2).

Discussion:
The holotype came from the upper half of the Hope Shales of the Shelve Inlier, Shropshire, but the species was recorded (WHITTARD, 1955, p. 11) also from the upper half of the overlying Stapeley Volcanic Group in the same area; all these strata are correlated with the *Didymograptus bifidus* Zone, Llanvirn Series, and *C. morea* was said by WHITTARD (*loc. cit.*) to occur at a similar level in South Wales and Northern England. BARRANDE's type material of *A. perrugatus*, illustrated by WHITTARD (1955, text-fig. 2) came from the Dobrotiva Formation (Llandeilo) of Svatá Dobrotivá, Bohemia, where the species occurs also, though rarely, in the lower Caradoc (PEK & PROKOP, 1984). The single Belgian pygidium agrees with the numerous illustrations of British and Bohemian material but is preserved as an internal mould and the rugae are slightly less well defined.

Family Dionididae GÜRICH, 1908
Genus ***Dionide*** BARRANDE, 1847

Type species. *Dione formosa* BARRANDE, 1846

Dionide jubata RAYMOND, 1925
(Plate 1, Figure 2)

1925 – *Dionide jubata* sp. nov. RAYMOND, p. 25, pl. 1, figs. 12. 13.
1958 – *Dionide jubata* RAYMOND-WHITTARD, p. 98, pl. 14, figs. 1-5; text-figs. 5c, d. Includes synonymy.

Figured specimen:
IRScNB No. a 2983.

Horizon and locality:
Unnamed formation of Llandeilian age, Locality A (Fig. 2).

Discussion:
The species was founded (WHITTARD, 1958, p. 100, text-figs. 5c, d) on two syntypes from the Dobrotivá Formation (Llandeilo) of Svatá Dobrotivá, Bohemia. The Belgian pygidium, though incomplete and slightly distorted, agrees in essentials and one may note particularly both the faint interpleural furrows and the deep pleural furrows, which are straight adaxially and curve backwards abaxially, where there are traces of a marginal rim, perhaps exaggerated by compression. According to WHITTARD (*loc. cit.*) the species is rare in the Shelve inlier of west Shropshire, where it occurs in the Hope Shales and Stapeley Volcanic Group; both these units belong in the *Didymograptus bifidus* Zone of the Llanvirn Series.

Family Cyclopygidae RAYMOND, 1925
Genus ***Ellipsotaphrus*** WHITTARD, 1952

Type species. *Aeglina monophthalma* KLOUČEK, 1916

Ellipsotaphrus monophthalmus (KLOUČEK, 1916)
(Plate 1, Figure 3)

1916 – *Aeglina monophthalma* KLOUČEK, p. 13, plate, figs. 4-6.
1952 – *Ellipsotaphrus monophthalmus* (KLOUČEK) – WHITTARD, p. 312, pl. 32, figs. 10-16.
1961 – *Ellipsotaphrus monophthalmus* (KLOUČEK) – WHITTARD, p. 169, pl. 23, figs. 3, 4. Includes synonymy.
1983 – *Ellipsotaphrus whittardi* HÖRBINGER & VANÉK, p. 304, pl. 1, figs. 3, 4; pl. 2, fig. 3.
1987 – *Ellipsotaphrus monophthalmus* (KLOUČEK, 1916) – FORTEY & OWENS, p. 189, figs. 63a-e. Includes synonymy.

Figured specimen:
IRScNB No. a 2984.

Horizon and locality:
Unnamed formation of Llandeilian age, Locality A (Fig. 2).

Discussion:
The Belgian cranidium agrees very closely with the numerous published illustrations. KLOUČEK's holotype (WHITTARD, 1952, p. 312, pl. 32, figs. 10, 11) came from the Dobrotivá Formation (Llandeilo) of Bohemia. The species was described as "exceedingly rare" in the Hope Shales (lower Llanvirn) of Shelve, west Shropshire (WHITTARD, 1961, p. 169); in southwest Wales it occurs in the upper Arenig and lower Llanvirn (WHITTARD, 1961, p. 169; FORTEY & OWENS, 1987, p. 189).

Family Trinucleidae HAWLE & CORDA, 1847
Subfamily Cryptolithinae ANGELIN, 1854
Genus **Broeggerolithus** LAMONT, 1935 *ex* BANCROFT MS

Type species. *Cryptolithus broeggeri* Bancroft, 1929b

Broeggerolithus nicholsoni (REED, 1910)
(Plate 1, Figures 4-10, 14,15)

1910 – *Trinucleus nicholsoni* REED, p. 212, pl. 16, figs. 1-9.
1929b – *Cryptolithus gibbifrons* – BANCROFT, pp. 75, 76, table.
1938a – *Cryptolithus gibbifrons* (MCCOY) – WHITTINGTON, p. 52.
1938 – *Cryptolithus* cf. *gibbifrons* (MCCOY) – STUBBLEFIELD *in* MATLEY, p. 584, 588.
1962 – *Broeggerolithus nicholsoni* (REED) – DEAN, p. 79, pl. 6, figs. 7, 11?, 14?; pl. 7, figs. 1-12. Includes synonymy.
1963a – *Broeggerolithus nicholsoni* (REED) – DEAN, p. 4.
1966 – *Broeggerolithus nicholsoni* (REED) – WHITTINGTON, p. 86, pl. 26, figs. 16, 17, 19-22; pl. 27, figs. 2-16, 18, 19; pl. 28, figs. 2-5; text-fig. 5. Includes synonymy.
1975 – *Broeggerolithus nicholsoni* (REED, 1910) – HUGHES *et al.*, p. 580.
1977 – *Broeggerolithus* cf. *nicholsoni* (REED) – BRENCHLEY *et al.*, p. 82, pl. 1, figs. 7-9.
1979 – *Broeggerolithus nicholsoni nicholsoni* – RUSHTON *in* BURGESS & HOLLIDAY, pp. 12, 16.
1981 – *Broeggerolithus nicholsoni nicholsoni* – RUSHTON *in* ARTHURTON & WADGE, p. 19.
1984 – *Broeggerolithus nicholsoni* (REED) – THOMAS *et al.*, p. 33.
1988 – *Broeggerolithus nicholsoni* (REED, 1910) – MORRIS, p. 38.

Figured specimens:
IRScNB Nos. a 2985, a 2986, a 2987, a 2988, a 2989, a 2990, a 2991, a 2992.

Horizon and localities:
Oxhe Formation, localities D, F, I, J and K (Fig. 2).

Description and discussion:
A persistent difficulty when identifying trinucleids from structurally complex areas such as Oxhe, north Wales and northern England is the incompleteness of the cephalic fringe, a structure that is important at both generic and specific level. Ideally one should use complete cranidia, so that pit counts can be made for the entire fringe, which is sometimes slightly asymmetrical, but in most of the available material only half fringes can be used. *B. nicholsoni* was re-assessed by WHITTINGTON (1966, p. 86), whose combined data from four north Welsh localities showed that the pit counts for arcs (= concentric rows) E1 and E2 were in most cases 20-24 and 20-23 respectively, though the maximum numbers could be up to 27 and 26. Specimens from the type area exhibit similar variation. More than thirty pieces of mudstone from Oxhe yielded fragmentary cranidia of *Broeggerolithus*; less than ten could be used for pit counts, but the latter fall within the variation limits established by WHITTINGTON (1966). The most complete (Pl. 1, Fig. 8) has the following, estimated count: E2 22, E1 23, I1 22, numbers also in accord with those cited by OWEN (1983, p. 51) for *B. nicholsoni (sensu lato)*. The species is characterised by a marked development of radial rows of pits in I1 and E1-2 over the anterior and anterolateral parts of the fringe, a feature apparent even in small fragments (for example Pl. 1, Figs. 5, 9, 15). Both Belgian and British material shows the ventral fringe surface with a strongly developed girder, and pits of E1-2 set in narrow radial sulci, though the latter may be exaggerated by compression. Up to three pits of E2 may be absent near the genal angle, so that E1 forms the outermost arc there.

In England and Wales *B. nicholsoni* sensu stricto is apparently confined to the lower half of the Longvillian Stage. The upper Longvillian (or Woolstonian – see discussion of Oxhe Formation) contains the very closely related *Broeggerolithus longiceps* (BANCROFT, 1929b), which has a pit count similar to that for *B. nicholsoni* and differs only in having a few extra, so-called "auxiliary" pits (WHITTARD, 1955, p. 28) in the posterolateral part of E2. This feature may not prove to be a satisfactory specific character, but it has not yet been found in lower Longvillian material from Shropshire and northern England (DEAN, 1962, p. 81), nor has it been seen at Oxhe, though WHITTINGTON (1966, p. 88) reported it in occasional specimens from Bala, north Wales.

Family Homalonotidae CHAPMAN, 1890
Genus **Brongniartella** REED, 1918

Type species. *Homalonotus bisulcatus* MCCOY *in* SEDGWICK & MCCOY, 1851.

Brongniartella minor minor (SALTER, 1852)
(Plate 2, Figures 1-10; Plate 3, Figures 6, 7)

1852 – *Homalonotus bisulcatus* var. β *minor* SALTER, p. v.
1910 – *Homalonotus ascriptus* REED, p. 216, pl. 17, figs. 4-8.

1947 – *Brongniartella parva* HARPER, p. 165, pl. 6, figs. 7-8.
1961 – *Brongniartella minor* (SALTER) – DEAN, p. 351, pl. 54, fig. 6; pl. 55, fig. 11. Includes synonymy.
1962 – *Brongniartella ascripta* (REED) – DEAN, p. 106, pl. 15, figs. 1, 2, 5, 11 (*non* fig. 8); pl. 16, fig. 14?
1962 – *Brongniartella* sp. – DEAN, p. 105, pl. 15, figs. 3, 6, 7, 9, 10.
1963b – *Brongniartella minor* (SALTER) – DEAN, p. 62, pl. 5, figs. 3, 6, 10.
1966 – *Brongniartella ascripta* (REED) – WHITTINGTON , p. 66.
1966 – *Brongniartella minor* (SALTER) – WHITTINGTON, p. 65, pl. 19, figs. 3-20, figs. 1-9, 11-13. Includes synonymy.
1979 – *Brongniartella ascripta* (REED) – RUSHTON *in* BURGESS & HOLLIDAY, p. 16.
1981 – *Brongniartella ascripta* (REED) – RUSHTON *in* ARTHURTON & WADGE, p. 19.
1984 – *Brongniartella minor minor* (SALTER) – THOMAS *et al.*, p. 33.
1988 – *Brongniartella ascripta* (REED, 1910) – MORRIS, p. 39.
1988 – *Brongniartella minor* (SALTER, 1852) – MORRIS, p. 40.

Figures specimens:
IRScNB no. a 2995 – a 3004.

Horizon and localities:
Oxhe Formation, localities E, F, H, I, J and K (Fig. 2).

Description and discussion:
Brongniartella occurs in most stages of the Caradoc Series in England and Wales, where species and subspecies have proved of some stratigraphic value, and is found more rarely in the Ashgill. *B. minor (s.l.)* occurs first in the lower Soudleyan Stage of south Shropshire, where it is represented by *B. minor subcarinata* DEAN (1961, p. 352, pl. 55, figs. 6, 8), a small form with markedly subcarinate glabella, and fewer axial rings and pleural ribs on the pygidium. The former character may be of less systematic value than was first thought, and can be effaced in mechanically deformed specimens. *B. minor minor* was described from the Lower Longvillian of Bala, North Wales, and was reviewed in detail (as *B. minor*) by WHITTINGTON (1966), who considered *B. ascripta* (REED, 1910 – see synonymy above), from the Cross Fell inlier of northern England, to be a probable synonym, a conclusion with which I agree. Figured material of *B. minor minor* from North Wales (WHITTINGTON, 1966) and south Shropshire (DEAN, 1961) comprises only small specimens, with cranidia up to 1 cm in length, and large examples of the subspecies are generally fragmentary. On the other hand, the holotype cranidium of *B. ascripta*, which has a median glabellar ridge, possibly exaggerated by compression, is about 1.5 cm long, while a cranidium and pygidium from Cross Fell, previously assigned to *Brongniartella* sp. (DEAN, 1962, pl. 15, figs. 6, 7) and now placed in synonymy with *B. minor minor*, have a median length of 2.2 cm and >3 cm respectively. Usage of the name *B. minor minor* follows upon acceptance of *B. minor subcarinata* as a subspecies, for example by THOMAS *et al.* (1984, p. 33), though *subcarinata* has also been listed as a separate species by MORRIS (1988, p. 40).

Present evidence suggests that in the Lower Longvillian a single subspecies, *B. minor minor*, was present in England, Wales and the Oxhe area, being replaced in the Upper Longvillian (=Woolstonian) by *B. bisulcata* (McCOY *in* SEDGWICK & McCOY, 1851; description *in* DEAN, 1961, p. 346), a large species that attained a cephalic length of at least 5 cm. Features that may be used to distinguish *B. minor* from *B. bisulcata* were enumerated by WHITTINGTON (1966, p. 65) and include, *inter al.*, the following: the relatively larger eye lobe is sited on the highest part of the more convex cheek and stands as high as the lateral part of the glabella (in *B. bisulcata* it is lower); the pygidium is relatively shorter, and carries eight axial rings, compared with nine to twelve. WHITTINGTON's (*loc. cit.*) illustrations of the pygidium of *B. minor* show 6 or 7 pairs of pleural ribs, in addition to the anterior half ribs. The value of the supposed presence or absence of an occipital furrow, and of articulating and pleural furrows on the thoracic segments, a feature noted particularly by WHITTINGTON (*loc. cit.*), is less apparent, and in at least some *Brongniartella* species such furrows are faint or absent on the external surface of the exoskeleton, though well defined on internal moulds. A particularly characteristic feature of *B. minor* is the glabellar outline which, in both large and small specimens, is trapezoidal, subangular anterolaterally, with a transversely straight anterior margin, and straight axial furrows that converge forwards at approximately 20° from the ends of the occipital furrow; behind the latter, the axial furrows diverge strongly backwards. In these respects the resemblance between an almost uncrushed cranidium from Oxhe (Pl. 2, Figs. 1, 10) and the holotype of *Brongniartella ascripta* (REED, 1910), figured *in* DEAN (1962, pl. 15, fig. 11) is striking. The glabella of *B. bisulcata* is more rounded both frontally and anterolaterally, the lateral margins are sinuous in plan, and the outline is notably narrower over its anterior half. The value of the pygidium in separating the two species in less clear. WHITTINGTON's specimens of *B. minor* with 8 axial rings and 6 or 7 pairs of pleural ribs, were all small examples. Larger Oxhe pygidia, up to 40 mm (est.) wide, have 9 to 11 axial rings, plus a very small terminal piece, and 7 or 8 pairs of pleural ribs, plus the articulating half ribs. A similar number of ribs is seen in *B. ascripta*, while large, distorted pygidia of *Brongniartella* sp. (DEAN, 1962, pl. 15, figs. 3, 7, 9, 10), from the same area and possibly synonymous, have an estimated 11 axial rings and 8 pleural ribs. An assessment of the relative length of the pygidium in the two species will require additional, undistorted, large pygidia. WHITTINGTON (1966, p. 66) suggested that the hypostoma might be useful in distinguishing *B. bisulcata* and *B. minor*, but no example is yet known from Oxhe.

Family Illaenidae HAWLE & CORDA, 1847
Subfamily Illaeninae HAWLE & CORDA, 1847
Genus *Illaenus* DALMAN, 1827

Type species. *Entomostracites crassicauda* WAHLENBERG, 1821.

Illaenus? sp.
(Plate 1, Figures 11-13)

Figured specimens:
IRScNB Nos. a2993, a2994.

Horizon and localities:
Oxhe Formation, Localities I and K (Fig. 2).

Description and discussion:
Two poorly preserved, incomplete pygidia show the rounded outline and almost undefined axis that are typical of the family, and one (Pl. 1, Figs. 12, 13) retains traces of the doublure, the inner margin of which forms an apparently unbroken, even curve. The latter feature resembles that found in the «*Parillaenus*-Gruppe» of JAANUSSON (1954, p. 574), based on *Illaenus fallax* HOLM, 1882 from the Caradoc Series of Sweden. It has been reported also in specimens of Caradocian and Ashgillian age from England and Wales (DEAN, 1963a, p. 14; WHITTINGTON, 1966, p. 69). The other specimen (Pl. 1, Fig. 11) has suffered dorsal compression, which has fractured the exoskeleton to produce the superficially pleura-like structure on the left side; the small articulating halfring is visible, but there is almost no trace of axial furrows.

OTHER RECORDS OF *BRONGNIARTELLA* FROM BELGIUM
Excluding the material from the Fond d'Oxhe, the only published account of trilobites assignable to *Brongniartella* is based on material from Gembloux, 40 km SSE of Brussels (Fig. 1), where *Homalonotus Omaliusii* was described by MALAISE (1873, p. 81, pl. 1, figs. 4-9) from Grand-Manil, on the SW margin of the town. The species was illustrated by means of recognisable line drawings, but the name has been overlooked in primary palaeontological literature. MALAISE's type material is in the Institut royal des Sciences naturelles de Belgique, and the lectotype cranidium (IRScNB No. a2956, Pl. 3, Fig. 5, here selected) and two paralectotypes (Pl. 3, Figs. 1-4) are now illustrated under the binomen *Brongniartella platynotus* (DALMAN, 1929). The latter species, founded by DALMAN (1828, p. 135) on material from the *Dalmanitina* Beds (Ashgill Series) of Västergötland, Sweden, was revised by KIELAN (1960, p. 116, pl. 19, figs. 1-3) and its close resemblance to the Belgian specimens is evident. According to KIELAN (*loc. cit.*) the pygidium has ten to eleven transversely straight axial rings and "about seven" pleural ribs in addition to the anterior half ribs. The Belgian material is mostly compressed or distorted, but the number of ribs is similar. In all specimens ring furrows after the fourth are successively less well defined, and the hindmost difficult to discern, but pygidium IRScNB a2959 (Pl. 3, Fig. 4) may be compared with one figured by KIELAN (1960, pl. 19, fig. 2a).

One of the syntypes of *H. Omaliusii*, an enrolled individual, was said to come, not from Grand-Manil, but "Près Malonne" (MALAISE, 1873, pl. 1, fig. 6). An appropriate specimen (IRScNB a3005), collected by MALAISE and labelled as coming from between Malonne and Buzet, situated respectively 5 km WSW and 7.5 km SW of the centre of Namur (Fig. 1) has now been traced. The specimen is insufficiently well preserved to be certain that it is conspecific with the material from Grand-Manil, and for the present it is referred simply to *Brongniartella* sp. In any case, its place of origin is suspect.

The rest of MALAISE's (1873) type material came from the Carrière Lefèvre at Grand-Manil, once well known to collectors of Ordovician fossils but long overgrown and inaccessible. The fossiliferous strata form part of what MALAISE (1873, p. 14) termed the Assise de Gembloux, and their shelly fauna was said by MAILLIEUX (1926) to be Caradocian. The strata were later correlated (MAILLIEUX, 1930) with the Schistes de Fosse, named for a small town 15 km SW of Namur (Fig. 1); the latter unit was subsequently assigned to the Ashgill (MAILLIEUX, 1933). LEGRAND (1965) assigned the Grand-Manil brachiopod and trilobite faunas firmly to the Ashgill. LESPÉRANCE & SHEEHAN (1988, p. 100) stated that an Ashgillian age could be based only on the trilobites, but considered provisionally the brachiopod fauna to be upper Caradocian or Ashgillian.

Age and relationships of the trilobites

UNNAMED FORMATION OF LLANDEILIAN AGE
The small sample from Locality A (Fig. 2) includes only three trilobite genera and species, but these have a long stratigraphic range in dark-grey mudstones deposited in anoxic environments over a considerable area of northern Europe. All, particularly the cyclopygid genus *Ellipsotaphrus*, represent a deeper water biofacies than the Oxhe Formation and correspond broadly to the Olenid Community in the Arenig of south Wales (FORTEY & OWENS, 1978), later termed Olenid Biofacies (FORTEY & OWENS, 1987).

Cyclopygids are recorded only rarely from the Ordovician of Belgium. The sole examples illustrated are from the Llanvirn of Sart-Bernard, a village 9 km SE of Namur (Fig. 1), where *Cyclopyge rediviva* (BARRANDE, 1846) was described by MAILLIEUX (1939, p. 35). A single Caradocian occurrence was first reported as *Aeglina binodosa* by MAILLIEUX (1926, p. 71) from the Assise de Vitrival-Bruyère (account *in* MICHOT, 1934b, p. 24), named for a village 18 km WSW of Namur (Fig. 1, p. 135). The material was re-assigned to *Cyclopyge rediviva* by MAILLIEUX (1939, p. 37), and associated graptolites were said to indicate the *Climacograptus peltifer* Zone, equivalent to part of the *Diplograptus multidens*

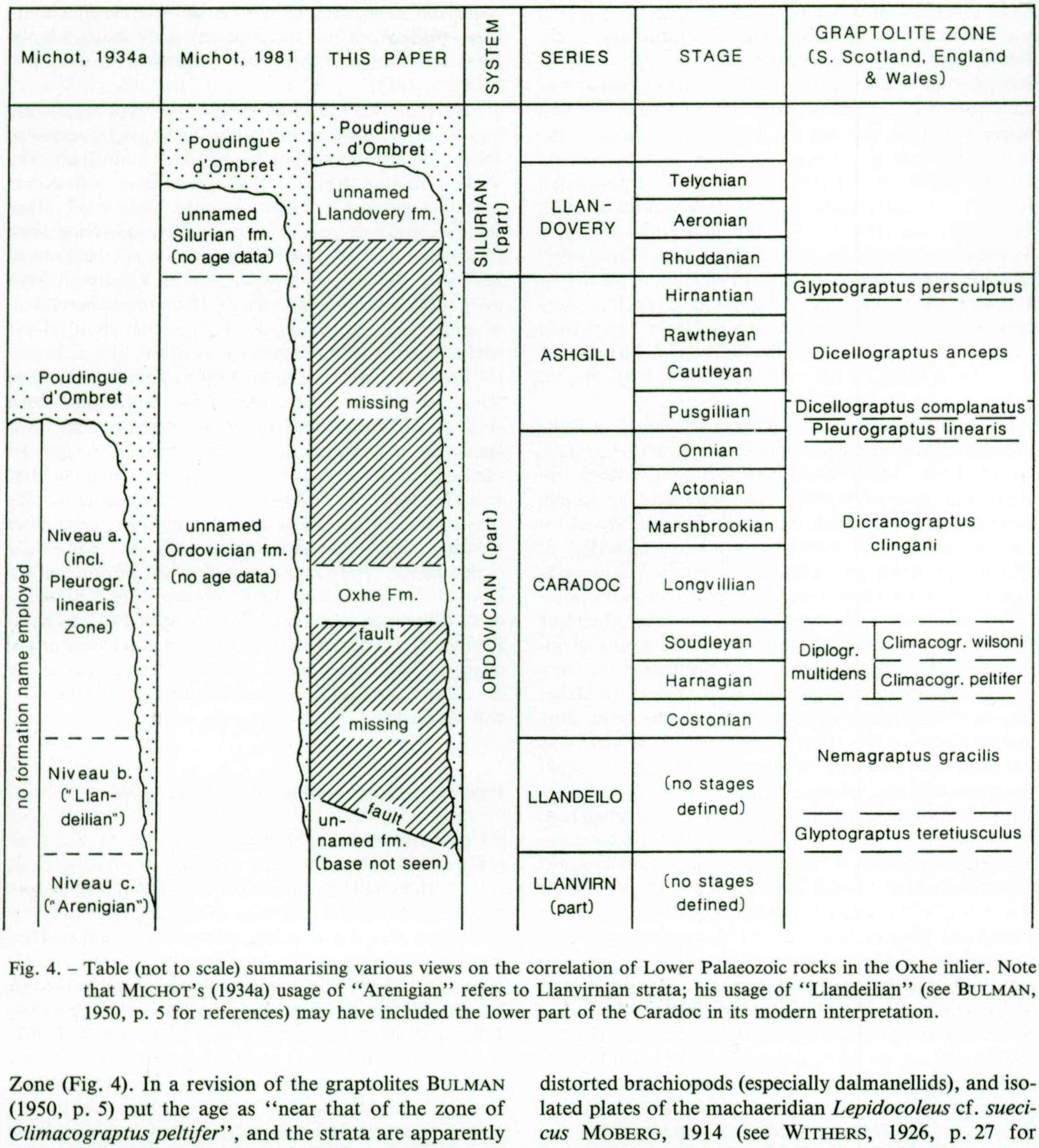

Fig. 4. – Table (not to scale) summarising various views on the correlation of Lower Palaeozoic rocks in the Oxhe inlier. Note that MICHOT's (1934a) usage of "Arenigian" refers to Llanvirnian strata; his usage of "Llandeilian" (see BULMAN, 1950, p. 5 for references) may have included the lower part of the Caradoc in its modern interpretation.

Zone (Fig. 4). In a revision of the graptolites BULMAN (1950, p. 5) put the age as "near that of the zone of *Climacograptus peltifer*", and the strata are apparently younger than the unnamed Llandeilian formation at Oxhe, though slightly older than the Oxhe Formation.

OXHE FORMATION

The assemblage exhibits little diversity and consists mainly of fragments, never abundant and often tectonically distorted, of *Broeggerolithus nicholsoni* and, less commonly, *Brongniartella minor minor*; only two examples of *Illaenus?* sp. were found. Trilobites, particularly trinucleids, proved most common in the mudstones but less so in some siltstone interbeds, which may also contain locally common beyrichiocope ostracods, often distorted brachiopods (especially dalmanellids), and isolated plates of the machaeridian *Lepidocoleus* cf. *suecicus* MOBERG, 1914 (see WITHERS, 1926, p. 27 for account of species). *B. nicholsoni* and *B. minor minor* are confined to the Longvillian Stage of the Caradoc Series in England and Wales but the other groups have a long range in the Caradoc and their distribution is influenced by changes in environment; in particular, brachiopods are more abundant and trilobites less common in the shallow, marginal facies of the Welsh basin, but in deeper water mudstone facies the reverse is true.

BANCROFT (1929a, p. 34) introduced the term Longvillian Stage on the basis of trilobites and brachiopods from mainly clastic strata (Horderley Sandstone, Alternata Limestone and Cheney Longville Flags) in south

Shropshire, an area whose palaeogeographic position was on the margin of the Midland Platform, east of the Pontesford-Linley Lineament and bordering the Welsh Basin (review *in* DEAN, 1985, p. 37). The Longvillian was later subdivided by BANCROFT (1933) into lower and upper substages (see DEAN, 1958 for discussion), the latter of which was given the name Woolstonian by HURST (1979, p. 206). Recognition of Woolstonian faunas is difficult outside the type Caradoc area of south Shropshire, and in a review of British trilobite faunas by THOMAS *et al.* (1984, p. 32) only the Longvillian (undivided) was employed. In the Cross Fell inlier of northwest England, where the relevant faunas have much in common with those of Oxhe, Lower and Upper Longvillian were retained by RUSHTON (*in* BURGESS & HOLLIDAY, 1979, pp. 6-12; *in* ARTHURTON & WADGE, 1981, pp. 18, 19).

Longvillian trilobite assemblages like that of the Oxhe Formation are widely distributed in northern England, North Wales, south Shropshire and southeastern Ireland, and *Broeggerolithus nicholsoni* may be locally common, particularly in mudstone facies. Typical locations, numbered 1 to 10, are shown on a map (Fig. 5, left half), together with relevant references. The assemblage has not yet been recorded from south and central Wales, where the appropriate strata are either absent or represented by graptolitic mudstone. The status of location 11 (Fig. 5) is uncertain but represents the only record of Caradocian strata between Wales and Oxhe, and may correspond approximately to the Oxhe Formation. The rocks, from a borehole, were dated as Caradocian by means of acritarchs (LISTER *et al.*, 1969) but associated macrofossils included, *inter al.*, one fragment of a homalonotid trilobite and one of a trinucleid.

The biofacies in which *B. nicholsoni* occurs most abundantly corresponds broadly to the Raphiophorid Community of FORTEY & OWENS (1978), which contains also trinucleids, located between their shallow water *Neseuretus* Community and the deeper water Olenid Community. However, even small changes in substrate may influence the composition of an assemblage, and whereas no raphiophorid has yet been found at Oxhe, the correlative Drygill Shales of northwest England (DEAN, 1963b) contain abundant *Broeggerolithus nicholsoni* together with small numbers of *Brongniartella minor minor, Flexicalymene* sp., *Kloucekia apiculata* (MCCOY *in* SEDGWICK & MCCOY, 1851) and *Lonchodomas* sp. *Broeggerolithus nicholsoni* has not been recorded below the Longvillian *sensu stricto*, though it extends upwards into the Woolstonian in the Cross Fell inlier. In the Woolstonian of south Shropshire *Broeggerolithus longiceps* (BANCROFT, 1929b) is considered to be at least closely related, and possibly no more than a local subspecies, if not a synonym. *Brongniartella minor minor* was described first from the Longvillian *sensu stricto* of Bala, North Wales, but occurs there also in the underlying Soudleyan (WHITTINGTON, 1966, p. 65). In south Shropshire (DEAN, 1961) *B. minor minor* occurs in Longvillian sandstones, but in lower Soudleyan mudstones the subspecies present in *B. minor subcarinata* DEAN1961; Woolstonian limestones and siltstones in the same area contain *B. bisulcata* (MCCOY *in* SEDGWICK & MCCOY, 1851).

Stages of the Caradoc Series in its type area were established by BANCROFT (1929a, 1929b, 1933; review *in* DEAN, 1958) and based on brachiopods and trilobites in shallow marine deposits; their correlation with corresponding graptolite zones, founded mainly on black shale sequences in southern Scotland, remains imprecise (discussion *in* DEAN, 1958; WILLIAMS *et al.*, 1972). Successive zones of *Nemagraptus gracilis, Climacograptus peltifer*, *Climacograptus wilsoni, Dicranograptus clingani* and *Pleurograptus linearis* occupy the whole of the Series together with the upper part of the Llandeilo and the lowest Ashgill. The base of the Longvillian has been tentatively equated with that of the *D. clingani* Zone (Fig. 4). A *Diplograptus multidens* Zone, named for a species from the Soudleyan of south Shropshire, replaced the combined *C. peltifer* and *C. wilsoni* zones in that area. The top of the Soudleyan is tentatively equated with that of the *D. multidens* Zone, though the graptolitic evidence in the upper half of the stage is less reliable than in the lower. The Oxhe Formation was correlated by MAILLIEUX (1926) with the *C. wilsoni* Zone, an assessment subsequently changed (MAILLIEUX, 1933) to basal *P. linearis* Zone. No reliable graptolitic evidence is yet available from the Fond d'Oxhe but a level low in the *D. clingani* Zone is suggested, by analogy with the British succession.

Palaeogeographic setting of the Oxhe inlier

Of the palaeogeographic maps published by SCOTESE (1986), that for the Middle Caradoc forms the basis (Fig. 5, right half) of the present discussion. In it Wales, southeastern Ireland and most of England and Belgium form part of a single region, subsequently termed East Avalonia (SCOTESE & MCKERROW, 1990, fig. 1), bounded to the NW by the Iapetus Suture and to the NE by the Tornquist Lineament (review *in* STROMBERG, 1981, a structural line considered by STØRMER (1967, p. 185) to date from the Permiam but probably of at least early Palaeozoic age. The southern boundary used by SCOTESE & MCKERROW (1990), which skirts the southwestern tip of England, is here moved slightly so as to include western Cornwall, where Ordovician trilobites from the Gorran Quartzites are of Armorican type (SADLER, 1974). Such a boundary lies well south of the line of the Hercynian Front as interpreted by KOKELAAR *et al.* (1990, text-fig. 1), which runs through south Wales.

SCOTESE (1986) showed East Avalonia and West Avalonia, comprising eastern Newfoundland, most of Nova Scotia, southern New Brunswick and part of New England, U.S.A., as a single assemblage, to which the name Avalonia Superterrane has been applied (review *in* GIBBONS, 1990). The term terrane has been in use for some

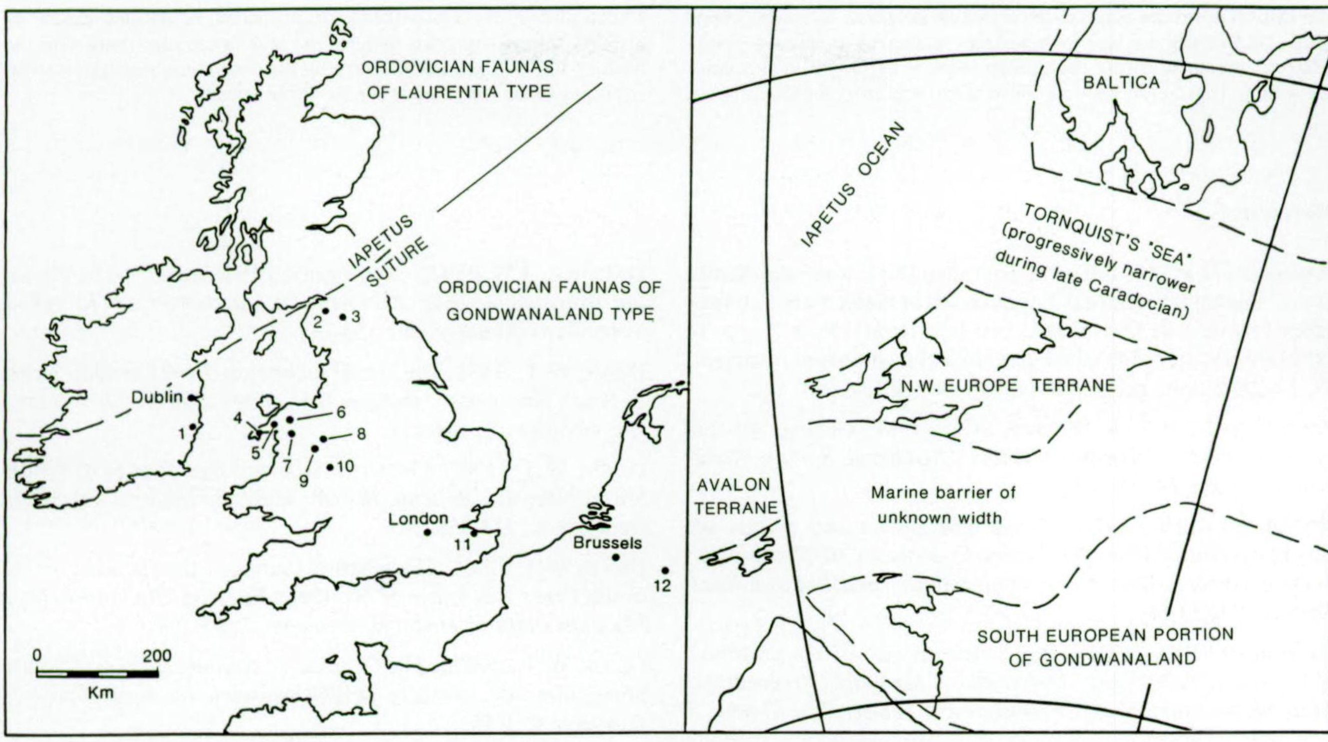

Fig. 5. – Left half: outline map of British Isles and Belgium showing occurrences of Longvillian faunas that include *Broeggerolithus nicholsoni* and *Brongniartella minor* or closely related trilobites. Numbered areas and relevant references are as follows: 1. Slieveroe, near Rathdrum (BRENCHLEY *et al.*, 1977); 2. Drygill, near Caldbeck (DEAN, 1963b); 3. Cross Fell inlier (DEAN, 1962; BURGESS & HOLLIDAY, 1979; ARTHURTON & WADGE, 1981); 4. Llŷn Peninsula, including Pwllheli and Llanbedrog (DEAN, 1963a; WHITTINGTON, 1966); 5. Ynys Galed, Dolbenmaen (HARPER, 1947); 6. Dolwyddelan, Snowdonia (ROMANO & DIGGENS, 1969); 7. Bala (WHITTINGTON, 1966); 8. Oswestry and 9. Meifod areas (WHITTINGTON, 1938a, 1938b); 10. Caradoc area, south Shropshire (DEAN, 1963a); 11. Unspecified part of Caradoc Series in the Bobbing borehole, near Sittingbourne, Kent (LISTER *et al.*, 1969); 12. Le Petit Fond d'Oxhe, Belgium (present paper).
Right half: palaeogeographic map, adapted from SCOTESE (1986) and SCOTESE & MCKERROW (1990), showing relationships of the terrane containing the above Caradoc faunas to Baltica, Laurentia and the southern European portion of Gondwanaland.

years and was applied (HORNE & HELWIG, 1969; HORNE, 1970) to fault-bounded areas of Lower Palaeozoic rocks, each with its own distinctive stratigraphy, in central Newfoundland and the so-called Magog-Belt of the Appalachians. Lower Ordovician rocks and faunas in each of the constituent parts of the Avalonia Superterrane are sufficiently different to suggest that they may not have been in juxtaposition originally, and for present purposes Avalon Terrane is restricted to the Avalon Platform of eastern Newfoundland; the more general name of Northwest Europe Terrane is applied to East Avalonia, which would encompass all the outcrops with Longvillian trilobites discussed in this paper and would in turn be divisible into smaller structural units.

The relationships of the Oxhe inlier are complex and imperfectly understood. About 0.7 km N of the Ordovician outcrop (Fig. 2) the Devonian rocks are truncated by an important structural line, the Ombret Fault (MICHOT, 1969, fig. 2), which runs almost NE near the top of the high ground at Les Communes. Immediately north of the Ombret Fault is an outcrop, elongated NE-SW, of shales whose Silurian (Telychian-Sheinwoodian) age was demonstrated by MARTIN (1969) on the basis of acritarchs. A little farther north a considerable area is underlain by the Ombret Flysch (MARTIN *et al.*, 1970), a unit that includes turbiditic rocks and was dated by means of acritarchs and chitinozoans as Upper Ordovician, Caradocian rather than Ashgillian. Such an age determination is too broad to justify any detailed comparison, or contrast, with the Oxhe Formation, and the two units may well have originated a considerable distance apart, judging from MICHOT's interpretation (*in* MARTIN *et al.*, 1970, fig. 5) of the Ombret Fault as a low angle structure that transported the Ombret Flysch northwards to its present position.

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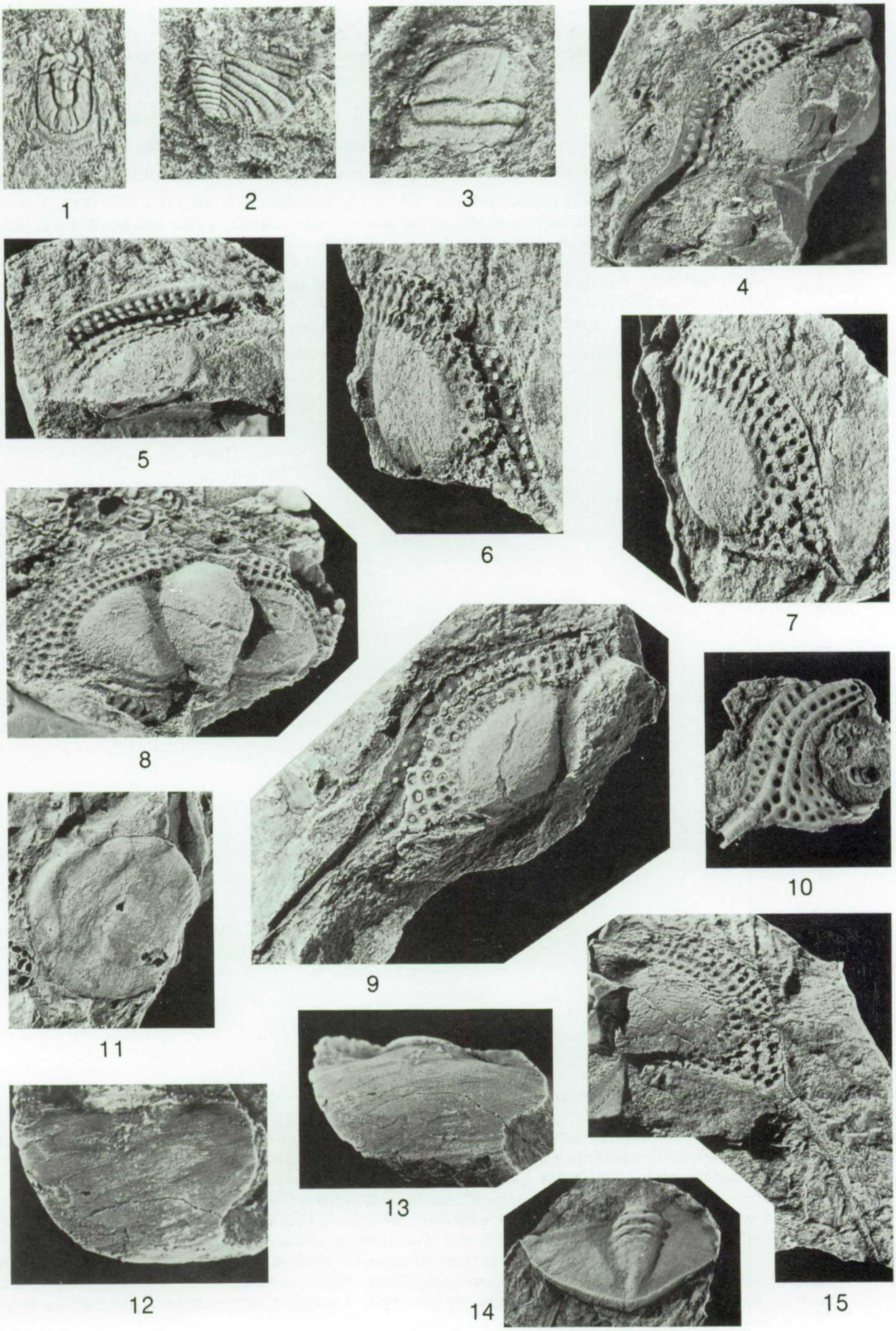
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◁ PLATE 1

All specimens are from Le Petit Fond d'Oxhe. Figs. 1-3 from the unnamed formation at Loc. A; Figs. 4-15 from the Oxhe Formation.

Fig. 1. – *Corrugatagnostus morea* (SALTER, 1864). Internal mould of pygidium and thorax. IRScNB No. a 2982 (8 ×).

Fig. 2. – *Dionide jubata* RAYMOND, 1925. Internal mould of incomplete pygidium. IRScNB No. 2983 (8 ×).

Fig. 3. – *Ellipsotaphrus monophthalmus* (KLOUČEK, 1916). Internal mould of cranidium. IRScNB No. a 2984 (8 ×).

Figs. 4-10, 14, 15. – *Broeggerolithus nicholsoni* (REED, 1910). 4, left half of cephalon, IRScNB No. a 2985 (3 ×), Loc. K; 5, external mould of ventral surface of part of left side of fringe, showing girder and pits of E1-2. IRScNB No. a 2986 (3 ×), Loc. K; 6, 7, mould and latex cast of right side of cephalon, IRScNB No. a 2987 (3 ×), Loc. I; 8. internal mould of cranidium, IRScNB No. a 2988 (4 ×), Loc. K; 9. left half of cephalon, IRScNB No. a 2989 (3 ×), Loc. I; 10. latex cast of ventral surface of right half of cephalic fringe, showing girder. IRScNB No. a 2990 (3 ×), Loc. K; 14. latex cast of pygidium. IRScNB No. a 2991 (3 ×), Loc. K; 15. latex cast of right half of cephalon. IRScNB No. a 2992 (3 ×), Loc. I.

Figs. 11-13. – *Illaenus?* sp. 11, internal mould of pygidium. IRScNB No. a 2993 (3 ×), Loc. K; 12, 13, dorsal and posterior views of incomplete internal mould of pygidium. IRScNB No. a 2994 (6 ×), Loc. I.

PLATE 2

All specimens are from the Oxhe Formation at Le Petit Fond d'Oxhe.

Figs. 1-10. – *Brongniartella minor minor* (SALTER, 1852). 1, 2, dorsal and anterior views of incomplete internal mould of cranidium, IRScNB No. a 2995 (2 ×), Loc. F; 10, latex cast from external mould of same specimen (2 ×); 3, internal mould of right librigena, IRScNB No. a 2996 (3 ×), Loc. K; 4, internal mould of cranidium, IRScNB No. a 2997 (4 ×), Loc. K; 5, internal mould of part of large cranidium, IRScNB No. a 2998 (1.5 ×), Loc. K; 6, internal mould of pygidium and part of enrolled thorax, IRScNB No. a 2999 (2 ×), Loc. K; 7, internal mould of small pygidium, IRScNB No. a 3000 (3 ×), Loc. K; 8, internal mould of fragment of large pygidium, IRScNB No. a 3001 (2.5 ×), Loc. K; 9, large pygidium preserved mainly as internal mould, IRScNB No. 3002 (3 ×), Loc. K. Note that in Fig. 5 the glabellar outline is asymmetrical, having been longitudinally compressed; the left side has an exaggerated, sinuous outline, but the surviving portion of the right side is straight. Associated, better preserved material, for example Fig. 4, shows the typical glabellar outline.

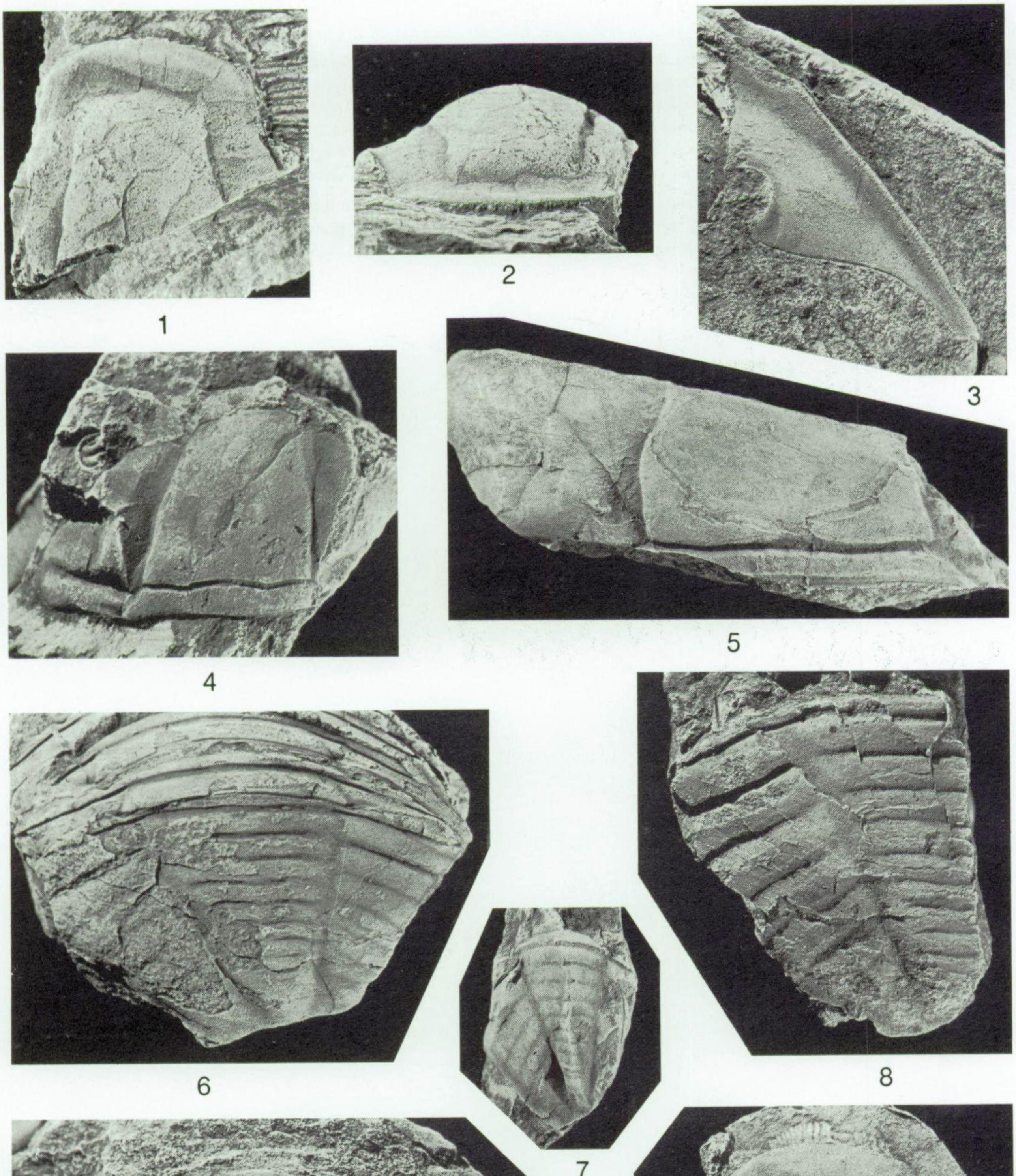
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PLATE 3

Figs. 1-5 – *Brongniartella platynotus* (DALMAN 1828). All are type specimens of *Homalonotus Omaliusii* MALAISE, 1873, from the Schistes de Gembloux at Grand-Manil, near Gembloux. 1, paralectotype, internal mould of incomplete cranidium and thorax, IRScNB No. a 2957 (1 ×), figured by MALAISE (1873, pl. 1, fig. 5); 2, front of same speciamen (1.5 ×); 3, paralectotype, internal mould of pygidium, IRScNB No. 2960 (1.5 ×), figured by MALAISE (1873, pl. 1, fig. 8); 4, paralectotype, internal mould of pygidium, IRScNB No. a 2959 (1.5 ×), figured by MALAISE (1873, pl. 1, fig. 7); 5, lectotype, internal mould of cephalon, IRScNB No. a 2956 (1 ×), figured by MALAISE (1873, pl. 1, fig. 4).

Figs. 6, 7.– *Brongniartella minor minor* (SALTER, 1852). Oxhe Formation at Le Petit Fond d'Oxhe. 6, right pleura of thoracic segment, IRScNB No. a 3003 (4 ×), Loc. K; 7, internal mould of axial ring and left pleura of thoracic segment, IRScNB No. a 3004 (2.5 ×), Loc. K.

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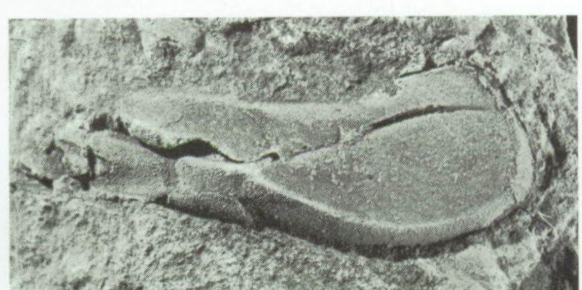

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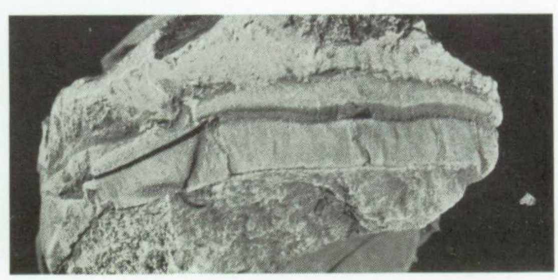

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