# A NEW PTERASPIDID OSTRACODERM FROM THE DEVONIAN SENNI BEDS FORMATION OF SOUTH WALES AND ITS STRATIGRAPHIC SIGNIFICANCE

*by* E. J. LOEFFLER *and* R. G. THOMAS

ABSTRACT. A pteraspidid ostracoderm, *Althaspis senniensis* sp. nov., is described from the Senni Beds Formation of central south Wales. An associated assemblage of dispersed miospores indicates a mid Middle to lower Upper Siegenian age for this fossil. A typical Breconian macroflora is also present. The Dittonian aspect of the ostracoderm supports the suggestion that there is overlap between the Dittonian and Breconian Stages of the Lower Old Red Sandstone.

THE pteraspidid ostracoderm described herein was found by Dr. D. Goujet (Paris), in a fallen block of blue-grey mudstone on the floor of the disused Heol Senni Quarry, Powys, south Wales. This quarry was visited during the course of one of the post-symposium field excursions (Excursion B2) which formed part of the programme of the Palaeontological Association's Devonian Symposium (PADS), held in Bristol in September 1978. The quarry, which is situated on the north-eastern face of Fan Bwlch Chwyth (SN 9145 2210), 7 km south of Sennybridge, exposes a near flat-lying, sandstone-dominated sequence within the upper Middle part of the Senni Beds Formation; the succession is described by Edwards *et al.* (1978) in the field guide to the excursion.

The block containing the pteraspidid is of unlaminated, blue-grey mudstone and was found amongst other fallen debris at the base of the main quarry face; its original position in the sequence is uncertain. The pteraspidid plates, including a ventral disc, rostral plate, branchial plate, and some scales, were disarticulated but found in close proximity to one another on the same surface, within an area of 400 cm$^2$. Careful splitting of the block yielded a single, unidentifiable plant fragment, but no additional fish material.

### *Palaeontology of Heol Senni Quarry*

*Flora.* Plant fragments are common within the Senni Beds Formation at Heol Senni Quarry. Vegetative vascular macroplant axes several centimetres long are preserved as carbonaceous compressions in some blue-grey to grey-green coloured, very fine grained siltstone units. Examples of cf. *Psilophyton princeps* (Croft and Lang 1942) and *Hostinella* have been found in loose blocks of blue-grey, fine-grained sandstone and siltstone on the quarry floor. Additional fertile material collected during the PADS excursion has been identified by D. Edwards (pers. comm. 1979) as *Gosslingia breconensis* Heard and *Zosterophyllum* sp. She drew attention to the similarity between the Heol Senni flora and that of the Brecon Beacons Quarry, where all of these taxa are found, and of Llanover, where *Gosslingia* and cf. *P. princeps* occur.

In comparing the Cosheston Group of south-west Dyfed with the Senni Beds, Thomas (1978*a*) recognized over fifty taxa of dispersed miospores from Heol Senni. Important constituents of his assemblage include: *Calamospora atava* (Naum.) McGregor, 1964; *C. pannucea* Richardson, 1965; *Leiotriletes pagius* Allen, 1965; *Retusotriletes frivolus* Chibrickova, 1959; *R.* cf. *R. pychovii* Naumova, 1953; *R. triangulatus* (Streel) Streel, 1967; *Apiculatasporites* cf. *A. perpusillus* (Naum.) McGregor, 1973; *A. arenorugosa* McGregor, 1973; *A.* cf. *A. brandtii* Streel, 1964; *A.* cf. *A. plicata* (Allen) Streel, 1967; *A.* spp. nov.; *Dibolisporites* cf. *D. eifeliensis* (Lanninger) McGregor, 1973;

[Palaeontology, Vol. 23, Part 2, 1980, pp. 287-296, pls. 35-36.]

*D.* sp. nov.; *Emphanisporites* cf. *E. micrornatus* Richardson and Lister, 1969; *E. ?neglectus* (Vigran) *sensu* McGregor, 1973; *E. obscurus* McGregor, 1961; *E. rotatus* (McGregor) McGregor, 1973; *Aneurospora minuta* McGregor, 1973; *Aneurospora* comb. nov. et vars. nov.; *Camptozonotriletes* cf. *C. caperatus* McGregor, 1973; *Clivosispora torquata* McGregor, 1973 var. nov.; *?Lycospora* sp. nov.; and *Archaeozonotriletes chulus* vars. *chulus* and *nanus*. Other genera represented within these assemblages include: *Punctatisporites*; *Acanthotriletes*; *Anapiculatisporites*; *Apiculatisporis*; *Verrucosisporites*; *Convolutispora*; *Dictyotriletes*; *?Iberoespora*; *Stenozonotriletes*; and *Ambitisporites*. Several Heol Senni miospore samples contain derived Tremadocian and Wenlockian acritarchs.

On the basis of palynology and lithofacies, Thomas (1978*a*) considered the Senni Beds Formation to be the facies equivalent of the lower and middle portions of his Mill Bay Formation of the Cosheston Group, and its age to be mid Middle to lower Upper Siegenian.

*Fauna*. The ostracoderm fish which is described here is the best preserved and most complete yet recovered from the Senni Beds, and the first to have been found at Heol Senni Quarry. Vertebrates are extremely rare in the Senni Beds, having been recorded from only two other sites. The enigmatic *Pteraspis dixoni* White, considered by White (1938, 1950) to be a very primitive pteraspidid, occurs together with *Cephalaspis* sp. indet, low down in the Senni Beds near Ferryside in Carmarthenshire; *Rhinopteraspis cornubica* (McCoy) has been found high in the Senni Beds of Primrose Hill Quarry, near Crickhowell, Powys (White 1938).

## SYSTEMATIC PALAEONTOLOGY

Family PTERASPIDIDAE White, 1935
Subfamily PTERASPIDINAE Denison, 1970
Genus ALTHASPIS Zych, 1931

*Diagnosis*. See Dineley and Loeffler (1976, p. 129).

*Type species*. *Pteraspis elongata* Zych (non Alth) = *Althaspis samsonowiczi* Tarlo.

*Other species*. *A. anatirostra* Blieck, *A. kujdanowiensis* (Stensiö), *A. leachi* (White), *A. longirostra* (Zych), *A. spathulirostris* (Stensiö), *A. vimiensis* White.

### *Althaspis senniensis* sp. nov.

Plates 35 and 36

*Derivation of name*. From Heol Senni.

*Diagnosis*. Rostrum long and tapered (median length of rostral plate = 56 mm), with antero-lateral margins converging at approx. 35°. Subrostral surface covered in dentine ridges which are largely, but variably, deflected forward in the longitudinal mid-line.

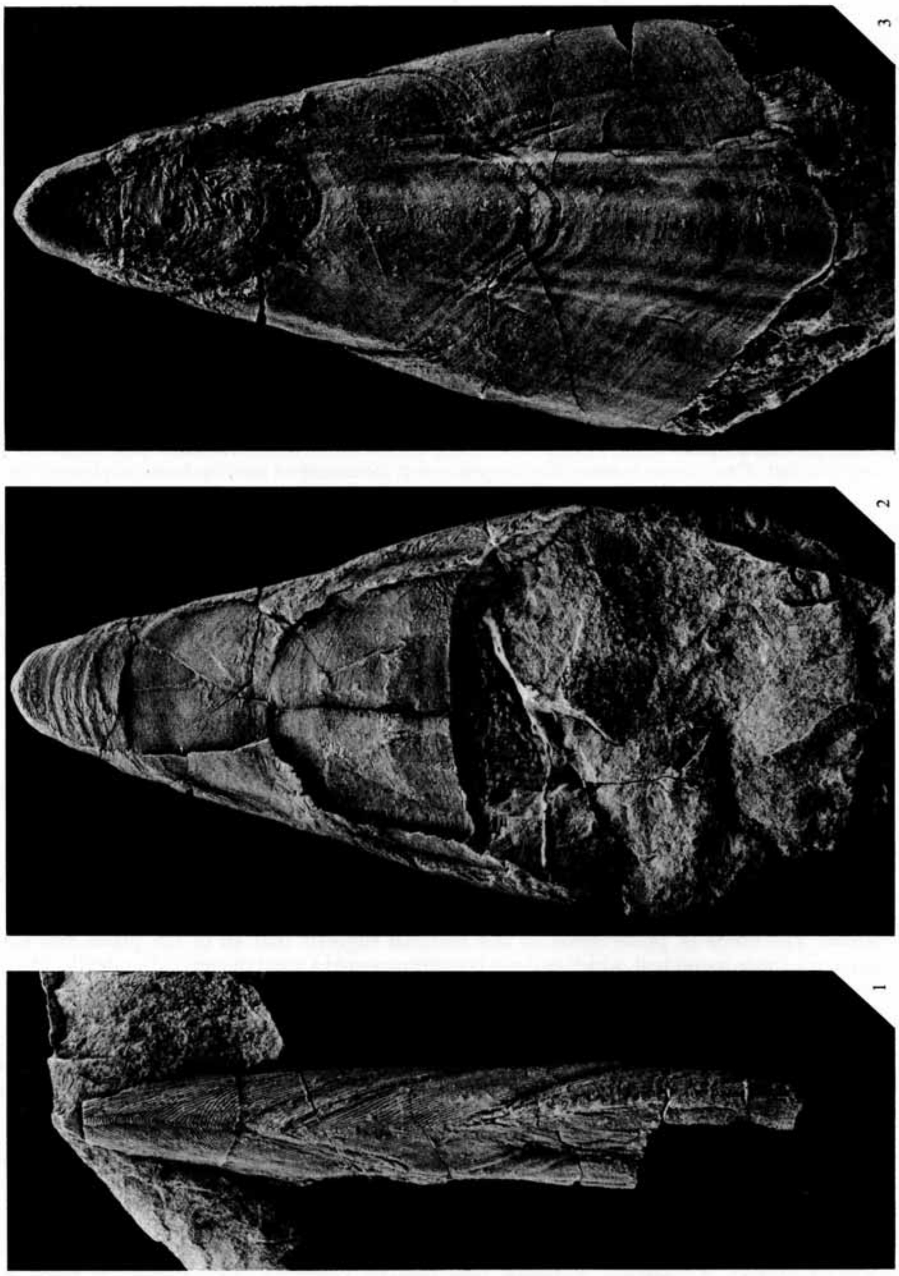
*Holotype*. A rostral plate, BMNH P.59744a, plate 35, figs. 2 and 3.

*Other material*. A ventral disc, BMNH P.59744b, pl. II, fig. 5. An incomplete branchial plate, BMNH P.59744c, pl. 35, fig. 1. Nine disarticulated scales, BMNH P.59744d-l, pl. 36, figs. 1–4.

---

EXPLANATION OF PLATE 35

Figs. 1–3. *Althaspis senniensis* sp. nov. 1, Incomplete branchial plate (BMNH P.59744c), ×2·5 approx. 2, Rostral plate in ventral view, showing subrostral surface (BMNH P.59744a, holotype), ×2·3 approx. 3, Rostral plate in dorsal view (BMNH P.59744a, holotype), ×2·3 approx.




LOEFFLER and THOMAS, Pteraspidid ostracoderm

*Description*

*Rostral plate* (Pl. 35, figs. 2, 3). The rostral plate has a median length of 56 mm and a maximum width of 28 mm. The free, antero-lateral margins converge at an angle of approximately 35°; the postero-lateral margins, which would presumably have been in contact with the orbital and pineal plates, converge at an angle of about 105°. On the dorsal surface of the rostrum, the dentine ridges have a density of approximately 7·5 mm; the surface of the plate is subdivided into three distinct areas by two deep grooves, which are interpreted as growth lines. Within the more posterior of these three divisions, ridges are concave forward (i.e. deflected backwards in the longitudinal mid-line), arranged parallel to the postero-lateral margins. Within the central division, the backward deflection of the ridges is increased, but reduced again at the rear of the anterior division. The curvature of the ridges increases toward the extremity of the rostrum, to become almost concentric around the tip.

On the underside of the rostrum the ventral preoral surface extends back some 30 mm (over half the total length of the rostral plate). This surface is covered with dentine ridges which are continuous with the dorsal ornament. The growth lines can also be traced ventrally, producing three slightly less distinct subdivisions. Posteriorly, the ridges are transverse to weakly convex forwards (i.e. deflected forwards medially), becoming more strongly convex in the central area. Anteriorly, the ridges change from being convex, to become transverse or slightly concave right at the tip of the rostrum.

There is no indication of an ascending lamella but, as the posterior margin of the preoral surface is discordant to the ridge pattern, it is possible that this is a broken edge. This is difficult to confirm, as the bone is crushed. The whole preoral part of the rostrum is rather thin, suggesting that the cancellous layer has been completely crushed.

*Branchial plate* (Pl. 35, fig. 1). The anterior 46 mm of the branchial plate is preserved; its maximum width is 7·5 mm. Dentine ridges, with a density of 6–8 mm converge on the longitudinal mid-line, toward the anterior end of the plate.

*Ventral disc* (Pl. 36, fig. 5). The ventral disc is approximately 87 mm long, with a maximum width of 50 mm being achieved about 25 mm behind the anterior margin, and a minimum width of 38 mm about 18 mm in front of the posterior margin. The plate is vaulted both longitudinally and transversely, most strongly at its narrowest part. The anterior margin is broadly rounded, the posterior margin is incomplete. Ornamentation is of rather flat-topped dentine ridges with weakly developed lateral crenulations; ridge density varies from 4·5 to 7·5 per mm, coarsest ornament being developed anteriorly and medially. The pores of the lateral line system are barely visible, but several growth lines are distinguishable.

*Scales*. Three distinct types of scale are recognized:

1. Lateral scales (Pl. 36, figs. 1, 2). Represented by seven specimens, these are flat, rhomb-shaped scales which are in the order of 4–5 mm long and 4–5 mm wide, and which have a narrow overlap brim anteriorly.
2. Fulcral scales (Pl. 36, fig. 3). Represented by a single specimen which is long (12 mm) and narrow (3 mm) and strongly arched about the mid-line.
3. Ridge scales (Pl. 36, fig. 4). Again strongly arched about the mid-line, this unique scale is of similar length to the fulcral scale, but almost twice as wide.

*Discussion*. The mode of preservation of this material suggests that all of the plates and scales belonged to a single individual, which had not been transported a great distance after death. The fact that the rostral plate is disarticulated suggests that it was weakly, or incompletely attached to the rest of the dorsal shield; these could be the remains of an immature, or recently mature individual.

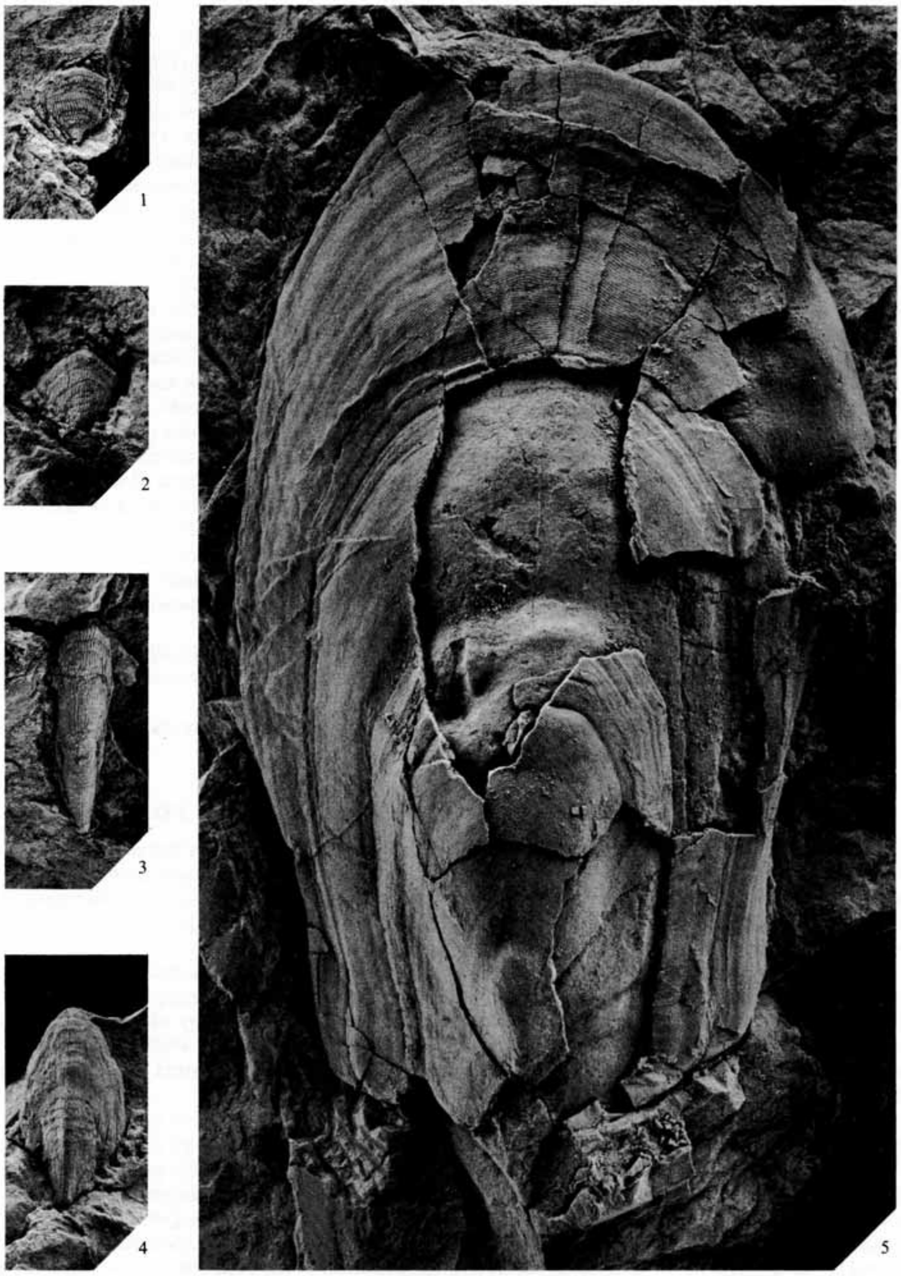
Pteraspidid classification relies heavily on the morphology of the subrostral surface (Tarlo 1961; Denison 1970; but see Novitskaya 1975, for an alternative view). The presence of an extensive subrostral surface covered in dentine ridges which are continuous with those of the dorsal surface is the basis for referring the Heol Senni specimen to the genus *Althaspis*.

---

EXPLANATION OF PLATE 36

Figs. 1–5. *Althaspis senniensis* sp. nov. 1, Lateral scale (BMNH P.59744d), ×3 approx. 2, Lateral scale (BMNH P.59744e), ×3 approx. 3, Fulcral scale (BMNH P.59744k), ×2·7 approx. 4. Ridge scale (BMNH P.597441), ×2·7 approx. 5, Ventral disc (BMNH P.59744b), ×2 approx.

PLATE 36



LOEFFLER and THOMAS, Pteraspidid ostracoderm

Only one species of *Althaspis* has previously been recorded from Britain, and that is the late Dittonian zonal form, *A. leachi* (White), now known from south-west Dyfed (White 1938), the Clee Hills (Ball and Dineley 1952), and the Forest of Dean (Allen *et al.* 1968). Rice (1967), describing them as *Rhinopteraspis cornubica*, recognized two forms of rostral plate amongst the specimens from Mitcheldean in the Forest of Dean: a long, narrow form and a squat form, in which the breadth to length ratios are 0·29–0·34 and 0·38–0·40 respectively (calculated from Rice's published data). Referring to additional material, but without publishing detailed palaeontological descriptions, Allen *et al.* (1968) re-identified the Mitcheldean pteraspidid as *A. leachi*; they agreed that two types of rostrum were present, figuring BMNH P.49119 (p. 146, fig. 2*d*) as an example of the squat form. Although it is approximately 1·3 times longer, this particular specimen is close in shape to the rostral plate from Heol Senni. Examination of material in the collections of the British Museum (Natural History), however, revealed the specimen to be somewhat atypical of the squat rostra from Mitcheldean; typical examples (e.g. P.49183, P.49186) are about 100 mm long and 40 mm wide (width ratio 0·40), while the specimen figured by Allen *et al.* (1968, fig. 2*d*) is about 75 mm long and 35 mm wide (width ratio 0·46). Ventral discs of *A. leachi* show little variation in shape and proportion (Rice 1967). At 136 mm, the median length of the ventral disc figured by Rice (1967, fig. 11) is approx. 1·6 times greater than that of the ventral disc from Heol Senni; the width ratios of the Mitcheldean and Heol Senni ventral discs are also quite different, being 0·42 and 0·57 respectively.

Other species of *Althaspis* are known from Belgium, Spitsbergen, and Podolia (Ukraine). On the basis of rostral shape alone, the Heol Senni material is readily distinguishable from *A. anatirostra* (Blieck 1975) and *A. spathulirostra* (Stensio 1964). The remaining species, all of which have rather long, tapered rostra, are more difficult to separate, largely because the Podolian species have not been adequately defined or described. In size, the rostrum from Heol Senni resembles a small, possibly juvenile, rostrum which White (1960) referred to *A. vimiensis*; in that species, however, the rostrum is more robust and has a more bluntly rounded tip.

A striking feature of the Heol Senni rostrum, and one in which it apparently differs from all of the other species except *A. leachi*, is the irregularity and curvature of the subrostral ridges; in other species, the ridges seem to be regular and more transverse.

As the pteraspidid from Heol Senni cannot readily be accommodated elsewhere, a new species, *A. senniensis*, has been established to receive it.

## DEPOSITIONAL ENVIRONMENT OF THE SENNI BEDS FORMATION

The Senni Beds Formation crops out from the head of Carmarthen Bay in the west to the Black Mountains in the east. It comprises a 150–450-m-thick (Allen 1974) sand-dominated sequence of fluvial and fluvio-lacustrine origin, which is distinguished from the sediments of the underlying Red Marls and overlying Brownstones by its primarily grey-green coloration, diagnostic macroflora and dispersed-miospore assemblages, and distinctive lithofacies associations.

Whilst the important Senni Beds Formation macroflora has been, and is still being, intensively studied, comparatively little is known about the sedimentology and provenance of the Formation. The most recent general account of the lithostratigraphy and sedimentology of the Senni Beds is contained in Allen's (1974) review of the Devonian rocks of Wales and the Welsh Borderland. To date, no detailed interpretations of the depositional environment(s) represented by the Senni Beds Formation have been published.

In central south Wales, where it attains a thickness of 300–380 m (Dineley and Williams 1978, fig. 31), the Senni Beds Formation consists of intraformational conglomerates (many of which are calcified) plus subordinate extraformational conglomerates, coarse to very fine grained sandstones, coarse to fine grained siltstones, some claystones, and occasional poorly developed calcretes. Whilst these lithologies are often rhythmically arranged (as, for example, in fining-upward cyclothems of variable complexity and completeness) there are many Senni Beds Formation sections, including that at Heol Senni Quarry, in which no over-all 'cyclic' organization of the constituent lithofacies units is discernible.

We interpret the Senni Beds Formation sequence of the Brecon Beacons area as having been deposited by a comparatively high discharge, mixed-load (but sand dominated), braided stream complex. Relatively high sedimentation rates and water-table levels during accumulation of the Senni Beds are indicated by the combination of the vertical succession of lithofacies units and the prevalence of grey-green colours within the Formation, plus the suites of stratification types and other sedimentary structures it contains.

In-channel and extra-channel sequences have been identified. In-channel facies recognized include: channel lags; channel-fill deposits; units formed by the migration of linguoid, transverse, lateral and ?rhomboid mid-channel bars, and low amplitude sand waves; bar delta wedges; and bar top sequences. Thick, multistorey sand bodies containing interbeds and/or lenses of intraformational conglomerate that overlie basal erosion surfaces imply repeated channel superimposition, filling and re-excavation. Many channel sand units are draped by thin mudstones deposited from suspension during waning flood stages. Local, comparatively rapid, channel shifting and consequent complete or partial channel abandonment, was common. Ponding of floodwaters occurred in channel cut-offs and (between flood stages) in parts of the secondary and tertiary distributaries of the active channel network. This local ponding, combined with decomposition of plant material (with the subsequent lowering of redox potentials), plus the presence of reworked calcrete glaebules and calcitized plant fragments (high pH and bicarbonate ion concentrations) resulted in the calcification of many channel-lag intraformational conglomerates.

Extra-channel and floodplain deposits of the Senni Beds Formation comprise proximal and distal crevasse splay sediments, some possible levee sediments, and thin, fine-grained, fluviolacustrine units laid down in temporary floodplain lakes. Sandstones interbedded with these mudstone-dominated fluviolacustrine units are thought to represent incursions of crevasse-splay sands deposited during major avulsion episodes. The Heol Senni pteraspidid may well have been carried from its habitat within the main channel system and deposited within a floodplain lake or channel-fill mud unit during one such flood event. Strongly reducing post-depositional conditions are indicated for the majority of these fluviolacustrine sediments by their typically blue-grey to grey-green coloration, and the preservation within them of pyrite nodules, macroplant cuticles, and miospores.

Vascular plants fourished along the shores of the temporary floodplain lakes, and colonized abandoned-channel fills and near-channel overbank deposits. High sedimentation rates and water-table levels, plus post-burial reducing conditions meant that the potential for preservation of these plants was comparatively good.

In the Brecon Beacons the Senni Beds Formation: Brownstones boundary has been drawn at the junction between the predominantly grey-green coloured sequence and the overlying red-brown succession, even though there are no major sedimentological differences between the lithofacies immediately below and above the contact. However, the Brownstones higher in the succession were laid down by sandy braided streams of a more shallow and ephemeral nature than those which deposited the Senni Beds.

The Senni Beds Formation is the lateral litho- and chronostratigraphic equivalent of the lower and middle portions of the 540–600-m-thick Mill Bay Formation (Cosheston Group) of south-west Dyfed, which Thomas (1978*a*, *b*) interpreted as the deposits of a braided-meandering river system (cf. Shelton and Noble 1974).

## STRATIGRAPHY

The Senni Beds, together with the Brownstones of central south Wales, constitute the Breconian, one of four Stages into which the Old Red Sandstone of the Anglo-Welsh area has been subdivided. The stages, in ascending order, are the Downtonian, Dittonian, and Breconian of the Lower Old Red Sandstone, which are unconformably overlain by the Farlovian of the Upper Old Red Sandstone. The foundations of this classification were laid by King (1925, 1934) who, using a combination of faunal (mainly ostracoderms) and lithostratigraphic evidence, recognized four discrete 'series' or 'divisions' in the Old Red Sandstone of Shropshire. These were, (I) Downtonian (or Anaspida Marls),

(II) Dittonian (or *Pteraspis* cornstones) followed by a group of 'false-bedded brown sandstones' which King (equating them with the Black Mountains sequence) termed (III) the 'Brownstones'. Together these comprised the Lower Old Red Sandstone, and were succeeded unconformably by (IV) the Farlow Sandstones (-Farlovian Stage of King 1934) of Upper Old Red Sandstone age. Although retained at formation level, the term 'Brownstones' is now no longer used *sensu* King (1925). Instead, the stage-name Breconian was proposed by Croft (1953) to circumscribe the highest Lower Old Red Sandstone of the Anglo-Welsh Basin, namely that part 'lying between the Dittonian and Farlovian Stages' of King (1934).

Attention has already been drawn to the difficulties of interpreting the Breconian Stage division, and to the possibility of its overlap with the preceding Dittonian Stage (Allen *et al.* 1968; Allen 1974). These difficulties arise essentially because the Downtonian and Dittonian Stages are defined on a largely biostratigraphical basis in the vertebrate-rich succession of the Clee Hills, whilst the Breconian Stage is defined on a largely lithostratigraphical basis in the Brecon Beacons where vertebrates are extremely rare. As a consequence, the Dittonian–Breconian boundary has never been satisfactorily fixed.

In the Clee Hills, refinement of King's (1925, 1934) original vertebrate stratigraphy by White (1950, 1961) and Ball and Dineley (1952, 1961) has resulted in the recognition of a number of ostracoderm zones which have proved to be of some value in correlation (White 1950, 1956). The Dittonian is characterized by its pteraspid faunas, the highest zone being that of *A. leachi* which is some 183 m (600 feet) thick (Ball and Dineley 1961), but which terminates well below the top of beds which are assigned on lithological grounds to the Dittonian Series (Ball and Dineley 1961). Biostratigraphically, the Dittonian Stage is 'regarded as being terminated by the appearance of *Rhinopteraspis cornubica*' (Allen *et al.* 1968). However, although *R. cornubica* (McCoy) (syn. *R. dunensis* (Roemer)) has come to be accepted as the 'Breconian zonal fossil' (Allen 1974), it has not yet been recorded from the Clee Hills and, in the whole of the south Wales Breconian, appears to be restricted to a single locality. This lack of evidence makes it impossible to determine the precise position of a faunal boundary between the *A. leachi* and *R. cornubica* zones. While it was long assumed that such a boundary would correspond to lithostratigraphical divisions, the discovery that the pteraspid from the Brownstones of Mitcheldean was *A. leachi* and not *R. cornubica* (Allen *et al.* 1968) demonstrated that this was not so.

In the Brecon Beacons, the Breconian Stage, as envisaged by Croft (1953), is characterized by its abundant and distinctive macroflora which includes *Drepanophycus* and *Gosslingia*, and by the presence of *R. cornubica*. Its junction with the Dittonian is drawn at a colour change (Allen 1974) in an area where ostracoderms are very rare. The flora occurs at many localities within the Senni Beds but the Brownstones appear to be unfossiliferous. The one locality at which *R. cornubica* has been found is a quarry high up in the Senni Beds, which are there in the region of 300 m (1000 feet) thick. This level would seem to be substantially above the highest appearance of *A. leachi* in the Clee Hills (Allen 1974). The macroflora of the Senni Beds, although probably the most extensive and representative Lower Old Red Sandstone flora in Britain, is of little stratigraphic value. The Breconian plants are relatively scarce and their distribution is facies controlled. Furthermore, owing to the lack of faunal control, it must be considered as a distinct possibility that they are Dittonian in age in terms of the ostracoderm zones.

## THE STRATIGRAPHIC SIGNIFICANCE OF THE HEOL SENNI PTERASPIDID

The discovery of pteraspidid material in association with a typical Breconian macroflora, and datable on the basis of a dispersed miospore assemblage, is a significant contribution toward resolving the dubious status of the Breconian Stage division. Unfortunately, the pteraspidid from Heol Senni cannot be referred either to *R. cornubica* or to *A. leachi*; it is a distinct species of *Althaspis*, showing similarities to forms from Podolia and France, as well as to the British species. It does, however, provide some support for the view that there is overlap between the Dittonian and Breconian Stages.

The fact that *A. senniensis* is smaller, and has a less attenuated rostrum than *A. leachi*, does suggest that it is more primitive. While this alone is insufficent evidence to suggest that it occurs at a lower stratigraphic level, it is relevant to note the stratigraphic distribution of other species of *Althaspis*. The rather similar *A. vimiensis* White, from Belgium (White 1960; Blieck 1977), there occurs only 17 metres above *Belgicaspis crouchi*; the latter is the characteristic pteraspidid of the zone immediately preceding that of *A. leachi* in Britain. The stratigraphic distribution of the species described by Stensiö (1958, 1964) was not given, but the range of *A. samsonowiczi* Tarlo (syn. *A. elongata* (Zych)) overlaps with that of *B. crouchi* in the Old Red Group of Podolia (Obruchev and Talimaa, 1967). In Spitsbergen, *A. anatirostra* Blieck is found at a level correlated with the base of the *B. crouchi* or top of the *Protopteraspis leathensis* zone of the Dittonian (Goujet and Blieck 1977).

Thus *A. senniensis* can be considered to be a pteraspidid of Dittonian aspect. Its presence in the Senni Beds indicates overlap between the Dittonian and Breconian Stages, as currently defined, but the extent of this overlap remains uncertain. In view of the scarcity of ostracoderms at this level in the Lower Old Red Sandstone, it seems unlikely that they, alone, will ever be of use in resolving the problem of the Dittonian–Breconian boundary; the eventual solution must involve choosing other organisms for zonal purposes. Work by Mortimer (1967), Chaloner and Streel (1968) and Richardson and Lister (1969) has drawn attention to the great potential of dispersed miospore assemblages for use in relative age determinations and stratigraphic correlations within the Anglo-Welsh Lower Old Red Sandstone. Thomas (1978*a*) has already used such assemblages to correlate between the Breconian of Pembrokeshire and Breconshire; it seems probable that they could eventually be used to define the Dittonian-Breconian junction.

In view of this, the discovery of a diverse, well-preserved and distinctive miospore assemblage, in association with an ostracoderm, is of great stratigraphic significance. It is noteworthy that the mid Middle to lower Upper Siegenian age of the Senni Beds Formation, as deduced from the miospore assemblage (Thomas 1978*b*), agrees well with the Middle to Upper Siegenian age suggested by White (1956) on the basis of *R. cornubica*, and is supported by Richardson and Rasul's (1979) comparison with the Apley Barn Borehole.

*Acknowledgements*. The authors would like to thank Dr. D. Goujet (Paris) for allowing them to work on this ostracoderm material, and Dr. Dianne Edwards (Cardiff) for providing unpublished information on the macrofloras from Heol Senni and neighbouring Breconian sites. Thanks are also due to Dr. Keith Allen (Bristol) who confirmed that the spore assemblage from the pteraspidid-bearing block was identical to that already recorded by Thomas (in Edwards *et al*. 1978) from Heol Senni, and to Dr. B. P. J. Williams (Bristol) for his constructive criticism of the manuscript. The photographs are the work of Mr. R. Godwin, University of Bristol.

## REFERENCES

ALLEN, J. R. L. 1974. The Devonian rocks of Wales and the Welsh Borderland. In OWEN, T. R. (ed.). *The Upper Palaeozoic and Post Palaeozoic Rocks of Wales*. University of Wales Press, Cardiff, pp. 47–84.

—— HALSTEAD (TARLO), L. B. and TURNER, S. 1968. Dittonian ostracoderm fauna from the Brownstones of Wilderness Quarry, Mitcheldean, Gloucestershire. *Proc. geol. Soc.* **1649**, 141–153.

BALL, H. W. and DINELEY, D. L. 1952. Notes on the Old Red Sandstone of the Clee Hills. *Proc. Geol. Ass.* **63**, 207–214.

—— —— 1961. The Old Red Sandstone of Brown Clee Hill and the adjacent area. Part 1. Stratigraphy. *Bull. Br. Mus. nat. Hist.* (Geol.), **5**, 177–242.

BLIECK, A. 1975. *Althaspis anatirostra* nov. sp., Ptéraspide du Dévonien inférieur du Spitsberg. *C.r. somm. Soc. géol. Fr.* **1975**, 74–77.

—— 1977. A propos d'*Althaspis vimiensis* White (Vertébrés, Agnathes, Hétérostracés) du Dévonien inférieur de Vimy-Fresnoy (France, P.-de-C.). Essai sur la répartition géographique et stratigraphique du genre *Althaspis*. *Annls Soc. geol. N.* **97**, 115–122.

CHALONER, W. G. and STREEL, M. 1968. Lower Devonian spores from South Wales. *Argumenta Palaeobotanica*, **1**, 87–101.

CROFT, W. N. 1953. Breconian: a stage name of the Old Red Sandstone. *Geol. Mag.* **90**, 4291432.

CROFT, W. N. and LANG, W. H. 1942. The Lower Devonian flora of the Senni Beds of Monmouthshire and Breconshire. *Phil. Trans. R. Soc.* **B231,** 131–163.

DENISON, R. H. 1970. Revised classification of Pteraspididae with description of new forms from Wyoming. *Fieldiana, Geol.* **20,** 1–14.

DINELEY, D. L. and LOEFFLER, E. J. 1976. Ostracoderm faunas of the Delorme and associated Siluro-Devonian formations, Northwest Territories, Canada. *Spec. Pap. Palaeontol.* **18,** 214 pp.

—— and WILLIAMS, B. P. J. 1978. Excursion B2: Introduction. *In* FRIEND, P. F. and WILLIAMS, B. P. J. (eds.). *Field guide to the Devonian of Scotland, the Welsh Borderland and South Wales. International Symposium on the Devonian System* (P.A.D.S. '78), Sept. 1978. The Palaeontological Association, pp. 55–61.

EDWARDS, D., RICHARDSON, J. B. and THOMAS, R. G. 1978. Locality B9. Heol Senni Quarry, Powys. Ibid., pp. 77–78.

GOUJET, D. and BLIECK, A. 1977. La faune de vertébrés de l'horizon 'Vogti' (Groupe de Red Bay, Spitsberg). Comparaison avec les autres faunes ichthyologiques du Dévonien inférieur européen. *Cr. Acad. Sci., Paris,* **284D,** 1513–1515.

KING, W. W. 1925. Notes on the Old Red Sandstone of Shropshire. *Proc. Geol. Ass.* **36,** 383–389.

—— 1934. The Downtonian and Dittonian strata of Great Britain and Northwestern Europe. *Q. Jl geol. Socl Lond.* **90,** 526–570.

MORTIMER, M. G. 1967. Some Lower Devonian microfloras from southern Britain. *Rev. Palaeobotan. Palynol.* **1,** 95–109.

NOVITSKAYA, L. I. 1975. A contribution to the revision of the Devonian pteraspids of Podolia. *Paleont. Jl* **1975,** 494–504.

OBRUCHEV, D. V. and KARATJUTE-TALIMAA, V. N. 1967. Vertebrate faunas and correlation of the Ludlovian-Lower Devonian in E. Europe. *J. Linn. Soc. (Zool.),* **47,** 5–14.

RICE, C. M. 1967. A discussion and description of the remains of the ostracoderm *Rhinopteraspis cornubica* (McCoy) found in the Lower Old Red Sandstone near Mitcheldean, Gloucestershire. *J. Univ. Sheffield Geol. Soc.* **5,** 2–9.

RICHARDSON, J. B. and LISTER, T. R. 1969. Upper Silurian and Lower Devonian spore assemblages from the Welsh Borderland and South Wales. *Palaeontology,* **12,** 201–252.

—— and RASUL, S. M. 1979. Palynological evidence for the age and provenance of the Lower Old Red Sandstone from the Apley Barn Borehole, Witney, Oxfordshire. *Proc. Geol. Ass.* **90,** 27–39.

SHELTON, J. W. and NOBLE, R. L. 1974. Depositional features of braided-meandering stream. *Bull. Am. Ass. Petrol. Geol.* **58,** 742–749.

STENSIÖ, E. A. 1958. Les cyclostomes fossiles ou ostracodermes. *In* GRASSÉ, P. P. (ed.). *Traité de Zoologie,* 13 (1), Masson, Paris, pp. 173–425.

—— 1964. Les cyclostomes fossiles ou ostracodermes. *In* PIVETEAU, J. (ed.). *Traité de Paléontologie,* 4 (1), Masson, Paris, pp. 96–385.

TARLO, L. B. 1961. *Rhinopteraspis cornubica* (McCoy), with notes on the classification and evolution of pteraspidids. *Acta palaeont. pol.* **6,** 367–400.

THOMAS, R. G. 1978*a*. *The stratigraphy, palynology and sedimentology of the Lower Old Red Sandstone Cosheston Group, S.W. Dyfed, Wales.* Unpublished Ph.D. thesis, University of Bristol, 552 pp.

—— 1978*b*. Locality B17. Mill Bay (West), near Cosheston, S.W. Dyfed. *In* FRIEND, P. F. and WILLIAMS, B. P. J. (eds.). *Field guide to the Devonian of Scotland, the Welsh Borderland and South Wales. International Symposium on the Devonian System* (P.A.D.S. '78). Sept. 1978. The Palaeontological Association, pp. 91–94.

WHITE, E. I. 1938. New pteraspids from South Wales. *Q. Jl geol. Soc. Lond.* **94,** 85–115.

—— 1950. The vertebrate faunas of the Lower Old Red Sandstone of the Welsh Borders. *Bull. Br. Mus. nat. Hist. (Geol.),* **1,** 49–67.

—— 1956. Preliminary note on the range of pteraspids in western Europe. *Bull. Inst. r. Sci. nat. Belg.* **32,** 1–10.

—— 1960. Notes on pteraspids from Artois and the Ardenne. Ibid. **36,** 1–15.

—— 1961. The Old Red Sandstone of Brown Clee Hill and the adjacent area. Part II. Palaeontology. *Bull. Br. Mus. nat. Hist. (Geol.),* **5,** 243–310.

ZYCH, W. 1931. *Fauna Ryb Dewonu i Downtonu Podola Pteraspidomorphi: Heterostraci.* 1A. 99 pp. Lwow.

E. J. LOEFFLER
Department of Geology
University of Bristol
Bristol BS8 1TR
England

R. G. THOMAS
Department of Geology
Oklahoma State University
Stillwater, Oklahoma 74074
U.S.A.

Typescript received 2 May 1979
Revised typescript received 20 June 1979