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SOME SPANISH UPPER CARBONIFEROUS NON-MARINE BIVALVE FAUNAS: A PRELIMINARY STATEMENT WITH EMPHASIS ON FACIES IN NORTH-WEST SPAIN AND IN BRITAIN

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ABSTRACT

Pioneer collecting by R. H. WAGNER and others of non-marine bivalve faunas from N. W. Spanish measures attributed to Westphalian A, A-B and D and from Stephanian beds of Cantabrian, A, B and C Stages has revealed only myalinid genera, a result which is paralleled by recent work on the Pennsylvanian of the Appalachian coalfield, south and west of Nova Scotia. In the Appalachians and in north-west Spain the genera include *Naiadites*, *Curvirimula*, *Anthraconauta* and *Anthraconaia*. On floral evidence the first two appear to have survived in Spain to a considerably later date than that of their last appearance in Britain and north-west Europe in general. Some of the paralic bivalve species of north-west Spain occur in Britain on horizons of earlier date, their upward range there being very probably limited by the change to limnic conditions, as exemplified by the British Morganian facies, characterised essentially by *Anthraconauta* with *Carbonita*. Aspects of the palaeoecology and facies of Carboniferous non-marine bivalves in European paralic and limnic successions are briefly discussed and it is emphasised that *Anthraconauta-Carbonita* assemblages and those characterised by *Curvirimula*, with and without elongate *Naiadites*, are mutually exclusive. *Curvirimula* survived, in the Villablino coalfield, possibly to early Stephanian C times.

It is concluded that in the times following the deposition of respectively the Top Marine Band in Britain (of Westphalian mid-C age) and of the Sabero Marine Band of N. W. Spain (probably of Stephanian late-A or early-B age) comparable limnic faunas predominated in both provinces. Bivalves were represented by *Anthraconaia*, in the main probably as near-vertical burrowers, or by gregarious *Anthraconauta* with, or without, the association of the ostracod *Carbonita* and the branchiopod crustaceans, *Leaia* and *Euestheria*.

RESUMEN

Recolecciones recientes de R. H. WAGNER y otros de lamelibranquios de agua dulce en rocas del Westfaliense A, A-B y D, y del Estefaniense (pisos Cantabriense, A, B y C), en el noroeste de España, han proporcionado solamente géneros myalínidos, un resultado comparable al obtenido recientemente en el Pennsylvaniense de los Apalaches, al sur y al oeste de Nueva Escocia. Tanto en los Apalaches como en el noroeste de España interesan los géneros *Naiadites*, *Curvirimula*, *Anthraco-*

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nauta y *Anthraconaia*. Según la datación proporcionada por floras fósiles, parece que los dos géneros primeramente mencionados han durado más en España que en Gran Bretaña y el resto de Europa noroccidental. Algunos de los géneros bivalvos de facies parálica, que se han encontrado en el noroeste de España, existen en Gran Bretaña en niveles de edad mas antigua, y resulta muy probable que su distribución estratigráfica esté condicionada por el cambio a facies límnicas que se manifestó en Gran Bretaña con el «Morganiense». La facies morganiense se caracteriza esencialmente por *Anthraconauta* asociada al ostrácodo *Carbonita*.

Se comenta sobre aspectos de la paleoecología y la facies de los lamelibranquios de agua dulce en las secuencias parálicas y límnicas europeas, haciendo notar que las asociaciones de *Anthraconauta* y *Carbonita* se encuentran precisamente donde no existen las caracterizadas por *Curvirimula* y *Naiadites* de forma alargada. Estas dos clases de asociaciones son de facies mutuamente exclusiva. Resulta interesante que el género *Curvirimula*, de facies parálica, se encuentra aún en Villablino (León), en estratos del Estefaniense B superior o C inferior.

Es de notar que al último nivel marino del Carbonífero británico (es decir, el «Top Marine Band», de edad westfaliense C medio), tanto como al nivel marino más alto del Carbonífero en el noroeste de España (de edad estefaniense A superior, o B inferior, de la cuenca minera de Sabero), los siguen faunas límnicas comparables. Están caracterizadas por *Anthraconaia*, bivalvos perforantes generalmente en un sentido casi vertical, o por *Anthraconauta*, lamelibranquio gregario al que se asocia a menudo el ostrácodo *Carbonita* y, menos frecuentemente, los crustáceos branquiópodos *Leaia* y *Euestheria*.

INTRODUCTION

Non-marine bivalves collected from Upper Carboniferous beds in north-west Spain have been occasionally reported and figured, for example by BARROIS (1882, Pl. XVII), by GÓMEZ DE LLARENA (1950, lám. XXI), HERNÁNDEZ-SAMPELAYO (1947, 1949), TEIXEIRA (1950, láms. XXV-XXVI), by CALVER (*in* WAGNER *et al.* 1969, Pl. 5, figs. 18-20) and by WAGNER & ARTIEDA (1970, lám. XIX). TEIXEIRA (1943, Est. III, fig. 1; 1944, p. 68, Est. VIII) noted similar shells in North Portugal. Non-marine Spanish myalinid genera may possibly have been recorded under the name of *Sanguinolites* (e. g. by GÓMEZ DE LLARENA 1950, lám. XXI, bottom right) and as *Posidonia* by HERNÁNDEZ-SAMPELAYO (1947)*

One of us (R. M. C. E.) has recently examined non-marine bivalve material, comprising collections of one to more than twenty specimens, obtained from thirty-three horizons, of which nearly all lie in measures of Stephanian and late Westphalian age. These fossiliferous localities (listed on p. 94) have been found within separate basins which are distributed on an E-W belt of some 80 kilometres, each having its distinctive relationship to the Leonian and Asturian movements that affected the region and, in accordance with their particular relationship, incorporating floras of Westphalian D and Stephanian A, B and C, as well as WAGNER's transitional Cantabrian Stage. From Westphalian measures laid down before the Leonian movements we have seen material only from two horizons in the La Camocha Mine, near Gijón, Asturias. In this locality, in beds attributable on floral evidence to Westphalian A and A-B (NEVES 1964), one of us (*in* WAGNER 1970) has already reported the presence of *Curvirimula* of the *C. belgica* (HIND) group and small *Naiadites* sp. (text-fig. 1, bottom right).

(*) We interpret nearly all the figured specimens of HERNÁNDEZ-SAMPELAYO (1947, láms I-IV) as *Curvirimula*, but the possibility that small *Myalina* is also represented cannot be excluded.

DISCUSSION OF THE FAUNAS SEEN BY THE WRITERS

We take the opportunity of briefly reviewing and discussing some stratigraphical and palaeoecological aspects of certain Spanish and some other non-marine bivalve faunas which have been found recently elsewhere within late Carboniferous paralic and limnic measures in Spain, Britain and north America.

The fauna from Casavegas and from some higher horizons

WAGNER & VARKER (1971, text-figs. 3, 5) record four horizons yielding elongate shells in the Casavegas-Caloca-road section, northern Palencia, between the measured intervals of 325 and 335 metres in strata assigned to late Westphalian D. On the lower two horizons the shells, which we have not seen, have been referred to *Anthraconaia* and are preserved in siltstone. Of the upper two horizons, on which shells occur in dark silty mudstones containing a number of land plants (see WAGNER & VARKER 1971), Locality 1910 has yielded fairly abundant *Anthraconaia* with conjoined open valves. The shells include *Anthraconaia spathulata* WEIR (Pl. 1, figs. 1, 2), *A.* sp. cf. *persulcata* WEIR (Pl. 1, fig. 3) and *A.* sp. cf. *arenacea* (DAWSON) ROGERS 1965 (Pl. 1, fig. 4). From the top horizon (Locality 1929), in which the sediment appears identical to that of Locality 1910, a single *Anthraconaia* only was found (Pl. 1, fig. 5), a shell comparable with that of Pl. 1, fig. 4, but having greater posterior expansion and a greater curvature of the ventral margin. The remainder of the fauna from the top horizon consists of *Naiadites obliquus* TRUEMAN & WEIR (Pl. 2, fig. 1) and related forms (Pl. 2, figs. 2, 3), a large myalinid which may possibly be referable to the group of *Naiadites productus* (BROWN) (Pl. 2, fig. 4) and a number of incomplete fragments of still larger shells, suggestive of a more obliquely elongate triangular lateral outline (e. g. Pl. 2, fig. 5) but with anterior ends too incomplete for generic determination. The fossils of both bands are mostly flattened but not greatly distorted and, except in the case of the large fragmentary *?Myalina*, afford few difficulties in identification.

Anthraconaia spathulata, *A. persulcata* and its less sulcate variants occur in North Staffordshire, Nottinghamshire and Scotland at the base of British Westphalian D, in association with and immediately overlying the Top Marine Band and its equivalents. In Scotland the former occurs also in the Barren Red Measures of Ayrshire at a horizon which may be somewhat higher in Westphalian D. *Naiadites obliquus* is a species of Westphalian B, met with in Britain at about the start of the succession of marine and *Lingula* bands that characterise the upper part of the lower Similis-Pulchra Zone (below the Mansfield-Aegir Marine Band) in the Pennine coalfields. *Anthraconaia arenacea* is a species of the Pictou Group in Nova Scotia, which ROGERS (1965, p. 685) equates with upper Westphalian C-Westphalian D (see also EAGAR 1970, fig. 1).

We figure also shells of the *Anthraconaia pruvosti - prolifera* group collected from Stephanian B and C measures (Pl. 1, figs. 6-9), where there is no associated evidence of marine fossils. This group ranges upwards from Westphalian D in NW Europe into the highest Stephanian.

Discussion

In the intermediate Cantabrian Stage non-marine bivalves are recorded on three horizons, all in the lower part of this stage in NW Spain (WAGNER *et al.* 1969, fig. 2). We have noted that these occurrences consist of relatively elongate *Anthraconaia* and that *A.* aff. *pruvosti* (TCHERNYCHEV), on two of these horizons, immediately overlies marine beds of the Barranquito Formation, a point made by CALVER (*in ibid.*, p. 127). We note furthermore that in both cases the valves of the specimens lie open and conjoined, as at Casavegas, and that this condition of burial usually obtains in the *Anthraconaia prolifera* group not only in Stephanian measures of the Saar, but also in older occurrences of shells of this group and allied forms in the Westphalian of other coalfields (WEIR 1967, pp. 409-10*). Moreover, we have examined some small detached valves of young or stunted *Anthraconaia* sent to us by Mr. J. A. Knight who found them in the upper part of shell-bearing measures including very small *Myalina* closely associated with *Curvirimula* and therefore suggestive of phases of restricted marine conditions. These beds were found in basal deposits of the Sabero sequence, N. E. León (KNIGHT 1971, text-fig. 3) in measures attributed on floral evidence to late Stephanian A or early Stephanian B. The horizon is indicated in Text-fig. 1, marked «Sabero Marine Band».

We consider it hardly fortuitous that elongate *Anthraconaia* has been found in strata associated with, or immediately following marine deposits in Britain and Spain (in upper Westphalian and in upper Westphalian and Stephanian rocks respectively). Detailed studies on shell variation with respect to lithology and periodicity in sedimentation (EAGAR 1947, 1952, 1953) have already led to the conclusion that elongate *Anthraconaia*-like forms, the *Carbonicola bellula - lenisulcata* group, were probably invaders of the British deltaic area in late Namurian times, following in the wake of marine incursions; furthermore that these elongate shells probably provided the root stock from which rich faunas of highly variable bivalves may have evolved in more restricted non-marine environments in lowest Westphalian times. The recent discovery of shells of the *Carbonicola bellula* stock associated with near-vertical burrows in

(*) In this context it was pointed out that the opened condition of the conjoined valves of this species, which lie approximately parallel to planes of bedding, was found also in several other elongate non-marine species of earlier Westphalian times. This condition presented certain difficulties if it were to be reconciled with reasonable inferences, drawn mainly from external shell morphology, that such bivalves burrowed for most of their lives, possibly steeply like their supposed modern analogues among the living Unionidae (WEIR 1967, p. 410, footnote). Recently one of us (EAGAR 1971) has found a closely similar case in British late Namurian and early Westphalian measures where direct evidence of shell burrowing is preserved abundantly, on numerous horizons, notably in siltstone partings in the upper part of the Haslingden Flags (late Namurian C) of the Pennine region. The slab bearing the holotype of the elongate *Anthraconaia*-like species *Carbonicola bellula* (BOLTON) was obtained from near the top of the Haslingden Flags and bears a number of burrows, referred to *Pelecypodichnus* SEILACHER, with preferred orientation on its reverse (uppermost) side. Lying immediately below the burrows (and by inference from the quarry section, above numerous bands of *Pelecypodichnus* of lower siltstone bands) are two pairs of conjoined valves, both current-orientated in the same direction as the long axes of the succeeding sandstone-filled burrows. The shells fit the burrows if placed in them in a near-vertical position. Moreover on a higher horizon, within the upper part of the Lenisulcata Zone in the Wigan area, a shell associated with small *Carbonicola* cf. *bellula* may be seen in cross section within a burrow orientated in an approximately vertical position (*ibid.*, pl. 1 G, pl. 2).

relatively coarse-grained measures (see footnote* p. 90) has provided suggestive evidence of the way in which colonisation of the deltaic area was then achieved in the face of strong seaward-moving currents. Bearing these facts in mind, together with the comparisons which we have already made between non-marine myalinid species of British Westphalian C and D beds and those of the Casavegas fauna (of late Westphalian D age), we consider the latter to be quite possibly of pro-deltaic origin. As such the Casavegas bivalves may have lived at times in partly saline water. However, there is no evidence to suppose that faunas of *Anthraconaia* from Stephanian B and C measures in north-west Spain had the same habitat. The environment of *A. prolifera* in the Saar-Lorraine area appears to have been limnic.

Whereas *Anthraconaia*, and less commonly certain groups of elongate *Carbonicola* with *Anthraconaia*-like outline, have tended to appear above marine bands and to persist upwards into paralic and limnic facies in which there is often no direct evidence of the proximity of former marine influence, the genus *Curvirimula*, even without the association of *Lingula* and *Myalina*, is invariably a useful pointer to brackish tendencies in the palaeoenvironment (WEIR 1960, p. 298; EAGAR 1971, fig. 4). As earlier evidence suggested, *Curvirimula* has a long range upward from Goniatite Zone P. We now know that this genus ranges into the post-Asturian sequence in north-west Spain. In the Villablino coalfield, on the basis of floral evidence, *Curvirimula* is of late Stephanian B or early C age (text-fig. 1). This very provisional range diagram of Spanish non-marine paralic and limnic genera placed vis-à-vis the established ranges* of the same genera in Britain and north-west Europe, shows some interesting parallels in relation to the last marine invasions of the two regions, in the middle of Westphalian C times in Britain and very much later in Spain, probably near the commencement of Stephanian B. In both regions *Naiadites* and *Curvirimula* came in early, and in both *Anthraconauta* and *Anthraconaia* survived for some time after the last marine beds were laid down. *Anthraconaia* outlasted *Anthraconauta* in the British-north European region and may also have done the same in north-west Spain. *Anthraconauta* is much more common in the limnic Stephanian B-C than *Anthraconaia* (WAGNER, pers. comm.), a situation which again finds a parallel in the British Phillipsii and Tenuis Zones. The main difference, on present available evidence, is the long persistence of *Curvirimula* in parts of north-west Spain. Paralic facies extends into post-Asturian measures in the Sabero coalfield and in that of Villablino, in the latter case on the evidence of *Curvirimula* only. *Curvirimula* in the Villablino coalfield includes at least one new species (Pl. 1, fig. 13). In the Ciñera-Matallana coalfield some new species of *Anthraconauta* are associated with others familiar to British workers including *A.* aff. *phillipsii* (WILLIAMSON) (Pl. 1, fig. 12), *A.* aff. *phillipsii* showing a trend towards A. *wrighti* (DIX & TRUEMAN) *(ibid.*, fig. 11), and occasional shells trending towards *A. tenuis* (DAVIES & TRUEMAN). The British Morganian, which comprises the Phillipsii and

(*) There is some uncertainty regarding the upward limits of the species of *Anthraconauta* and *Anthraconaia* in north-west Europe.

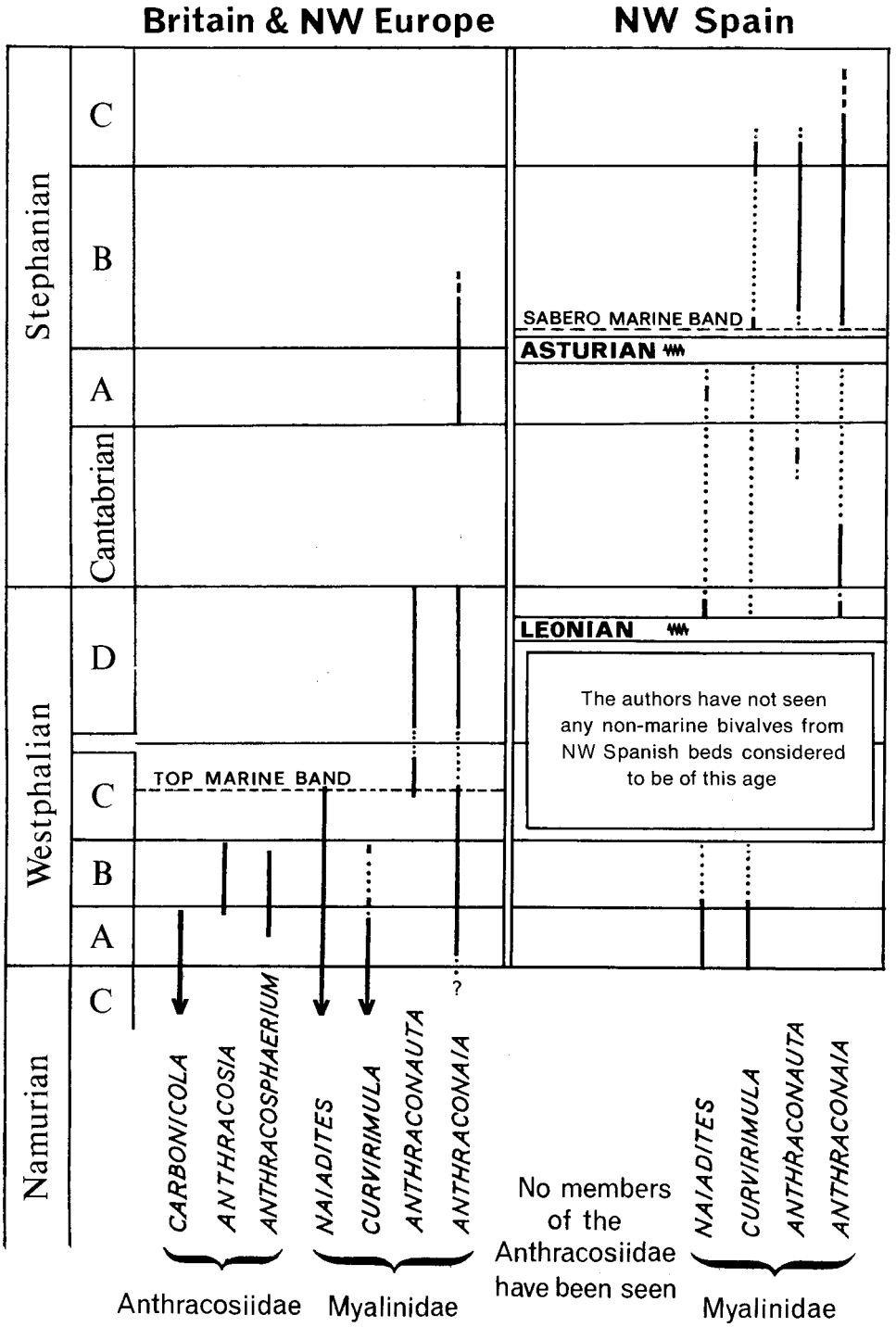
Tenuis Zones, is equated with the upper half of Westphalian C and the whole of Westphalian D. On floral evidence in South Wales (WAGNER 1964, p. 844) the Morganian lies wholly below the Stephanian of N. W. Spain. The Morganian zones, however, are inapplicable to brackish facies. In the Ciñera-Matallana coalfield bands of *Anthraconauta* associated with *Carbonita* ostracod facies, suggestive of fresh water (BLESS 1970), are exceedingly common (WAGNER & ARTIEDA 1970), as are the further associations with this genus of the branchiopod crustaceans *Leaia* and *Euestheria* (see the list of localities, p. 94). These latter bands are of Morganian facies, characterised essentially by *Anthraconauta*, with or without *Carbonita*, *Leaia*, and other branchiopod crustaceans, and with *Anthraconaia* rare and sporadic. This facies is to be contrasted with that of measures yielding *Curvirimula*, with or without the association of elongate *Naiadites* and with beds yielding certain *Anthraconaia* species. Provisionally, and for convenient brevity, the latter may be called the *Curvirimula* facies. The two facies would appear to be incompatible and mutually exclusive, the latter indicating a brackish and the former being suggestive of a limnic environment.

Further work on ostracods, and perhaps on *Anthraconauta* and *Anthraconaia*, as more material becomes available, may eventually lead to a better established correlation between the two provinces. We may anticipate longer stratigraphical ranges for certain non-marine myalinid genera *(Naiadites* and *Anthraconaia)* of Westphalian B than Morganian environments apparently permitted in Britain. This we have already suggested in text-fig. 1 and we have noted the particular case of *N. obliquus* DIX & TRUEMAN of which the stratigraphic range may have been terminated by environmental conditions prevalent in Britain and N. W. Europe. The gaps, indicated by the dotted lines in the ranges of these genera, are likely to be filled with further collecting.

Although it should be stressed that very few non-marine bivalves have been collected as yet from Spanish paralic facies of Westphalian age, the absence of any representatives of the Family Anthracosiidae*, if not attributable to collection failure, finds a parallel in the non-marine succession of the Pennsylvanian of North America. It seems to us significant that fairly intensive collecting in Pennsylvanian beds of coal measure facies south and west of Nova Scotia, that is throughout the Appalachian coalfield, has failed to reveal any anthracosiid genera, although *Naiadites*, *Curvirimula*,

(*) At present we exclude from consideration «*Anthracosia carbonarius*» (BARROIS 1882, Pl. XVII, fig. 17), a shell of very doubtful affinities.

Text-fig. 1.—Stratigraphical ranges of non-marine bivalve genera in the Upper Carboniferous of Britain and N. W. Europe compared with the probable ranges of the same genera in N. W. Spain, as suggested by a first sample from thirty-five horizons in various coalfields (see the list of localities, p.94). The correlation of the Spanish and West European sequences and the spacing of the stage divisions (which are not to scale for Britain and N. W. Europe) are after WAGNER (1970). The left hand part of the figure is intended to replace text-fig. V in TRUEMAN & WEIR (1946), which refers only to the British succession and pre-dates the proposition of the genus *Curvirimula*. On the basis of recent work by KNIGHT (1971), floral evidence suggests that the Sabero Marine Band may be of either late Stephanian A or early Stephanian B age.


Britain & NW Europe
NW Spain
Stephanian
Westphalian
Namurian
C
B
A
Cantabrian
D
C
B
A
C
SABERO MARINE BAND
ASTURIAN
LEONIAN
The authors have not seen any non-marine bivalves from NW Spanish beds considered to be of this age
TOP MARINE BAND
?
CARBONICOLA
ANTHRACOSIA
ANTHRACOSPHAERIUM
NAIADITES
CURVIRIMULA
ANTHRACONAUTA
ANTHRACONAIA
Anthracosiidae
Myalinidae
No members of the Anthracosiidae have been seen
NAIADITES
CURVIRIMULA
ANTHRACONAUTA
ANTHRACONAIA
Myalinidae

Anthraconauta and *Anthraconaia* have all proved to be present (EAGAR 1970). Northward however, in Nova Scotia, small *Carbonicola* is also found with these myalinids, although this genus is restricted to the Canso Series, attributed to the Namurian and the earliest part of Westphalian A (ROGERS 1965). Recent restorations of the mid-Atlantic area before major westward continental drift took place (BULLARD *et al.* 1965, figs. 7,8), with due allowance for the width of the continental shelf and the fit of certain earlier formed structures found on both sides of the Atlantic, tend to associate north-west Spain more nearly with the Appalachian Trough than with Nova Scotia, which is aligned in a more northerly direction, towards the paralic area of Britain, and north-western Europe in general.

LOCALITIES FROM WHICH NON-MARINE BIVALVES HAVE BEEN SEEN

(a) Asturias

Localities 112 and 120. Coll. JONGMANS/WAGNER. La Camocha Mine, near Gijón, Asturias. Two horizons have been collected, the roof shales of Seam 3 (112) and those above Seam 19 (120). The horizons appear referable on floral evidence (NEVES 1964) to Westphalian A and Westphalian A-B respectively. Both horizons have yielded *Curvirimula* spp. of the *C. belgica* (HIND) group and small *Naiadites* sp.

(b) Northern Palencia.

Loc. 1910. Coll. JONES/MORRIS/WAGNER. Casavegas-Caloca road section near Casavegas village, northern Palencia (WAGNER & VARKER 1971, text-figs. 3, 5). Shells lie 323.40 m above the Leonian disconformity and are dated as of upper Westphalian D age on the basis of floral evidence. They include *Anthraconaia spathulata* WEIR (Pl. 1, figs. 1, 2), *Anthraconaia* sp. cf. *persulcata* WEIR *s. l.* (Pl. 1, fig. 3), *A.* sp. cf. *arenacea* (DAWSON) ROGERS (Pl. 1, fig. 4) and *Naiadites* sp.

Loc. 1929. Coll. JONES/MORRIS/WAGNER. Casavegas-Caloca road section, as for Locality 1910, above, but at 324.80 m above the Leonian disconformity (WAGNER & VARKER, text-figs. 3, 5). The shells include *Anthraconaia* sp. cf. *arenacea* (DAWSON) ROGERS (Pl. 1, fig. 5), *Naiadites obliquus* DIX & TRUEMAN (Pl. 2, fig. 1) and related forms (Pl. 2, figs. 2, 3) and *?Myalina* (or *Naiadites)*, probably two distinct forms (Pl. 2, figs. 4, 5).

Loc. 1703. Coll. WAGNER. Section halfway along the road to Mina Carmen, north-east of Santa María de Redondo, northern Palencia. The measures are of upper Cantabrian age and yield very small, poorly preserved *Anthraconauta* sp.

Loc. 115. Coll. WAGNER. Roof shales of Seam VI, San Rafael Mine, near Orbó, Barruelo coalfield, Palencia. The horizon is in the Calero Member of the Barruelo Formation and is attributed to Stephanian A *(s.s.) (cf.* WAGNER & WINKLER PRINS 1970). Large *Naiadites* spp., including shells comparable with *N. obliquus* DIX & TRUEMAN and the large *?Myalina* of Pl. 2, fig. 5, are abundant.

(c) Sabero coalfield (León)

Loc. 68. Coll. KNIGHT. Section on the northern flank of the Sabero Syncline (KNIGHT 1971, text-fig. 2). Three fossiliferous horizons have been found about 30 m above the Asturian unconformity lying close together in KNIGHT's Unit 1. They are referable to either uppermost Stephanian A or basal Stephanian B and have yielded *Myalina, Curvirimula* and a small *Anthraconaia*, the latter on a horizon higher than that of a band containing a marine bivalve. These horizons are referred to collectively in text-fig. 1 as the «Sabero Marine Band» and indicate phases of restricted marine conditions.

Loc. 95. Coll. KNIGHT. Mine «Pozo Herrera 2» at Sotillos. A single slab, with *Anthraconaia pruvosti* (TCHERNYCHEV) (Pl. 1, fig. 6) and *A.* sp. nov. 1, was collected by Mr. J. A. Knight in cross- cut 4E - 3S of the fourth level. The horizon lies between seams «A» and «C y D», being close above the roof of the former seam, in the Paquete Central of the Sabero Syncline. On floral evidence the horizon lies in Stephanian B.

(d) Ciñera-Matallana coalfield (León).

Loc. 339. Coll. WAGNER. Tip of the Santa Lucía coal mine, zone of Mediavilla, in workings of the Seam Pastora, of Stephanian B age. *Anthraconaia* aff. *puella* (WATERLOT) (Pl. 1, fig. 8), a single specimen.

Loc. 1845. Coll. WAGNER/VILLEGAS. Cross-cut (Transversal) from San José to Amézola, at *c.* 80 m below seam 5 of the San José Formation; probably corresponding to the upper part of the Cascajo Formation, Stephanian B. *Anthraconaia prolifera* (WATERLOT) *s. l*, a single specimen, figured in WAGNER & ARTIEDA (1970, lám. XIX).

Loc. 953. Coll. WAGNER. Specimens found loose at *c.* 300 m SE of Pozo Ibarra, among rocks of the Roguera Formation, Stephanian B. *Anthraconaia* sp. including *A.* aff. *pruvosti* (TCHERNYCHEV) (Pl. 1, fig. 9).

Loc. 1147. Coll. WAGNER. Roof shales of the Picalín coal seam in the San Nicolás Mine, El Barrero mining group, Matallana Formation. Middle to upper Stephanian B. *Anthraconauta* aff. *phillipsii* (WILLIAMSON) (Pl. 1, fig. 12), *A.* aff. *phillipsii* trending towards *A. wrighti* DIX & TRUEMAN), *A.* cf. *wrighti* and *A.* cf. *tenuis* (DAVIES & TRUEMAN). The shells are associated with *Carbonita* spp. and are regarded as of middle to upper Stephanian B age.

Loc. 1134. Coll. WAGNER. Horizon approximately 10 m below seam 0 of the Competidora complex, in collapsed workings at Alto de Tabliza, Pastora Formation, Stephanian B. *Anthraconauta* sp. is present with abundant *Carbonita, Euestheria*, insect wings and very rare *Leaia.*

Loc. 1244. Coll. WAGNER. Shell-bearing shales commence 0.60 m above seam Roguera and extend upward for 3.70 m in the Esperanza Valley section, Roguera Formation, east of Santa Lucía. The horizon lies in Stephanian B. Collection made from the basal 0.50 m includes somewhat distorted *Anthraconauta* cf. *phillipsii* (WILLIAMSON) and *A.* sp. with *Carbonita* and rare *Leaia.*

Loc. 1245. Coll. WAGNER. Shell-bearing shales commence 23.25 m above seam Roguera in the Esperanza Valley section, Roguera Formation, and extend upward for 0.45 m. They yield *Anthraconauta* aff. *phillipsii* and *A.* sp. nov. 1.

Loc. 1246. Coll. WAGNER. An *Anthraconauta* - *Carbonita* band with very rare *Leaia* at 28.00 m above seam Roguera, Esperanza Valley section. Non-marine bivalves include *Anthraconauta phillipsii*, *A.* cf. *phillipsii* (a shell with a shorter anterior end than is typical of this species), and *A.* sp. nov. 2.

Loc. 1254. Coll. WAGNER. Collapsed working in the 3rd seam of the Pastora Formation in the thrust anticline separating Bardaya Syncline from the next syncline to the south; near the Bardaya coal mine, along the path to the mine buildings. Stephanian B. *Anthraconaia* sp. nov. 2 occurs in ironstone.

Loc. 1297. Coll. WAGNER. Shell-bearing beds through 1.60 m commencing 1.80 m above seam Miñon (= Picalín) in the railway cutting east of Serrilla, Hulano Syncline, Matallana Formation. Stephanian B. With uncommon *Carbonita*, the beds yield *Anthraconauta* aff. *phillipsii* (WILLIAMSON) including some shells very near the type of this species. *A.* aff. *wrighti* (DIX & TRUEMAN) and forms lying between *A. tenuis* (DAVIES & TRUEMAN), *A. phillipsii* and *A. wrighti* (e. g., Pl. 1, fig. 10).

Loc. 1299. Coll. WAGNER. Section east of Matallana de Torío, Bienvenidas Formation. Stephanian B. *Anthraconauta* spp.

Loc. 1301. Coll. WAGNER. Band at about 3 m above the marker band with *Leaia baentschi* at the base of the Cascajo Formation, outcropping in the road from Villalfeide to Correcillas. The locality is shown in WAGNER & ARTIEDA 1970, fig. 19-A. Stephanian B. *Leaia* with small poorly preserved *Anthraconauta* sp.

Loc. 1324. Coll. WAGNER. Roof shales of a seam of the San José Formation in the closely compressed syncline north of Orzonaga. Stephanian B. *Anthraconauta* sp., poorly preserved, and *Carbonita*.

Loc. 1327. Coll. WAGNER. Section towards the south in the railway cutting east of Serrilla, 92.50 m above seam Miñon (= Picalín), Matallana Formation. Stephanian B. *Anthraconauta* cf. *phillipsii* (WILLIAMSON) with anterior end shorter than the type of this species, *A.* sp. nov. 3. Compare loc. 1297.

Loc. 1331. Coll. WAGNER. Second marker band with *Leaia* and *Anthraconauta* near the base of the Cascajo Formation, 6 m above the 1st band with *Leaia* which marks the base of this Formation. The locality is about 350 m north-east of the village of Villalfeide. Stephanian B. Shells include *Anthraconauta* aff. *wrighti* (DIX & TRUEMAN), *A.* cf. *tenuis* (DAVIES & TRUEMAN) and large *Anthraconauta* sp.

Loc. 1543. Coll. WAGNER. Shell band in the roof of seam Carmondina, in Arroyo Regueras, east of Matallana, either in San José Formation or the basal part of the Bienvenidas Formation, Stephanian B. *Anthraconauta* aff. *tenuis* (DAVIES & TRUEMAN), near the type.

Loc. 1735. Coll. WAGNER. Shell band with *Leaia* and *Euestheria* between seams 4 and 5 in the San José Formation; a trench in the southern slope of Faedo Mountain. Stephanian B. *Anthraconauta* sp. between *A. phillipsii* (WILLIAMSON) and *A. calciferus* (HIND).

Loc. 1736. Coll. WAGNER. Shell band with *Carbonita*, a second band between seams 4 and 5 in the San José Formation; further details as for Locality 1735, above. *Anthraconauta* sp., poorly preserved.

Loc. 1737. Coll. WAGNER. Shell band with *Leaia* and *Carbonita*, a third band between seams 4 and 5 in the San José Formation; as for Loc. 1735. *Anthraconauta* sp. between *A. phillipsii* and *A. wrighti*.

Loc 1871. Coll. WAGNER. Band outcropping at the base of a tip adjoining the mining railway of Piso 1 (first level) in Picalín Valley, Matallana Formation, Stephanian B. *Anthraconauta* cf. *tenuis* (DAVIES & TRUEMAN), trending towards *A. wrighti*.

Loc. 2147. Coll. WAGNER. Shell band opposite the washery of the La Gamonera Mine, in a measured section in Tabliza Valley, Roguera Formation, Stephanian B. *Anthraconaia* sp. nov. (Pl. 1, fig. 14).

(e) Villablino coalfield.

Loc. 173. Coll. JONGMANS/KIMPE. Tip at Lumajo east of Villablino. Material corresponding to Paquete Orallo, of late Stephanian B age. *Curvirimula* spp., including *C.* sp. nov. (Pl. 1, fig. 13). Geol. Bureau Cat. N.º 342.

Loc. 278. Coll. JONGMANS/KIMPE. Mine Villablino, cross-cut n.º 2 at 478 m, Horizon at 10 m above seam 4, Paquete Calderón, early Stephanian C. *Curvirimula* sp. Geologisch Bureau, Heerlen (L.), Netherlands, Cat. N.º 28.

Loc. 157. Coll. JONGMANS. Roof shales of seam 4. Piernavieja cross-cut, Calderón beds, lower Stephanian C. *Anthraconaia spathulata* WEIR (Pl. 1, fig. 7). Geologisch Bureau, Heerlen (L.), Netherlands, Cat. N.º 329.

Loc. 155. Coll. JONGMANS. Tip at Caboalles, from Maria Bolsada beds, Stephanian C. *Anthraconaia* sp. Geologisch Bureau, Heerlen (L.), Netherlands.

Loc. 372. Coll. KIMPE. Tip of Mina Constantina, from Paulina beds, Stephanian C. *Anthraconaia* sp. Geologisch Bureau, Heerlen (L.), Netherlands, Cat. N.º 61.

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POSTSCRIPT

Since this paper went to press we have received information from Dr. W. F. M. KIMPE, of the Geologisch Bureau, Netherlands, concerning the precise provenances of

two small collections of *Curvirimula* from Stephanian B and C measures of the Villablino coalfield, viz.

Loc. 293. Coll. JONGMANS/KIMPE, Mine El Castro, cross-cut south, 9 m below seam ϒ , Paquete Orallo, late Stephanian B. *Curvirimula* sp., fragments only. Geol. Bureau Heerlen, Netherlands, Cat. N.º 15.

Loc. 279. Coll. JONGMANS/KIMPE. Mine Villablino, 18 m above seam 1, at the top of Paquete Calderón, early Stephanian C. *Curvirimula* sp., cf. *C. trapeziforma* (DEWAR). Geol. Bureau Heerlen, Netherlands, Cat. N.º 24.

When these horizons are added to those listed on p. 97, it will be seen that *Curvirimula*, a near-marine genus, has been found on three different horizons within the Stephanian B and C of the Villablino coalfield, and that there exists the possibility of its occurrence on a fourth horizon (locality 173).

PLATE 1

Non-marine myalinid bivalves from the Upper Carboniferous of northwest Spain. All the specimens are shown at a magnification of 1. 2, unless it is otherwise stated.

«M. M.» denotes material registered in the Manchester Museum, University of Manchester, England. «G. B.» denotes denotes material in the Geologisch Bureau, Heerlen (L.), Netherlands. Locality numbers, followed by the names of the collectors, are listed on p. 94.

Fig. 1.—*Anthraconaia spathulata* WEIR. Locality 1910, Casavegas/Caloca road section, near Casavegas (northern Palencia). The horizon lies 323.40 m above the Leonian disconformity and, on floral evidence, is placed in the upper part of Westphalian D. M. M. LL. 3949.

Fig. 2.—*Anthraconaia spathulata* WEIR, a smaller, probably younger shell (cf. WEIR 1967, pl. XLVI, figs. 26, 27). Provenance as for Fig. 1, above. M. M. LL. 3950.

Fig. 3.—*Anthraconaia* sp. cf. *persulcata* WEIR *s. l.* As for Fig. 1. M. M. LL. 3951.

Fig. 4.—*Anthraconaia* sp. cf. *arenacea* (DAWSON) ROGERS. As for Fig. 1. M. M. LL. 3952.
In Figs. 2, 3, & 4 the margins of the valves have been restored with a continuous line where we are confident of our interpretation and by a broken line where there is room for differences of opinion.

Fig. 5.—*Anthraconaia* sp. cf. *arenacea* (DAWSON) ROGERS. Locality 1929, adjacent to that of Fig. 1, in the Casavegas/Caloca road section, near Casavegas (northern Palencia). The horizon is 324.8 m above the base of the Leonian disconformity; upper Westphalian D. M. M. LL. 3953.

Fig. 6.—*Anthraconaia pruvosti* (TCHERNYCHEV), a shell lacking the radial riblets which sometimes characterise the posterior dorsal region of this species. Locality 95, Sotillos, Paquete Central, Sabero coalfield. On floral evidence the horizon lies in Stephanian B. M. M. LL. 3983A.

Fig. 7.—*Anthraconaia spathulata* WEIR, a rather small specimen from Locality 157, roof shales of Seam 4, Calderón beds, Villablino coalfield (León), lower Stephanian C. G. B. N.º 329.

Fig. 8.—*Anthraconaia* aff. *puella* (WATERLOT) (of. WEIR 1967, pl. XLV, fig. 19). Locality 339, tip of the Santa Lucía coal mine, Ciñera-Matallana coalfield (León). Stephanian B. G. B. N.º 337.

Fig. 9.—*Anthraconaia* aff. *pruvosti* (TCHERNYCHEV) (cf. WEIR 1967, pl. XLV, figs. 8, 11). Locality 953, near Pozo Ibarra, Roguera Formation, Ciñera-Matallana coalfield. Stephanian B. M. M. LL. 3954.

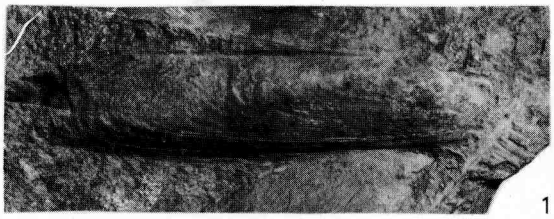
Fig. 10.—*Anthraconauta* aff. *phillipsii* (WILLIAMSON) × 2.3. Locality 1297, 1.80 m above seam Miñón (= Picalín) in the cutting west of Serrilla, Hulano Syncline, Ciñera-Matallana coalfield. Stephanian B. M. M. LL. 3955A.

Fig. 11.—*Anthraconauta* aff. *phillipsii* (WILLIAMSON), with slight trend towards *A. wrighti* (DIX & TRUEMAN) × 3.5. The margins of the valve, which are clear on the specimen, have been outlined in white. Locality 1147, roof shales of the Picalín coal seam in the mine of San Nicolás, Matallana Formation, Ciñera-Matallana coalfield. Middle to upper Stephanian B. M. M. LL. 3980.

Fig. 12.—*Anthraconauta* aff. *phillipsii* (WILLIAMSON) × 2.9. A small shell. The broken line on the dorsal part of the posterior margin indicates the edge of the valve which was cleared of matrix after the photograph was taken. A small part of the shell is missing in the umbonal region where the margin has been restored. Locality as for fig. 11. M. M. LL. 3981A.

Fig. 13.—*Curvirimula* sp. nov. × 5.2. Possibly a young shell. Compare with the form figured by PASTIELS (1960, pl. I, fig. 4). The continuous line indicates the posterior ventral and posterior margin of the valve which is clear on the specimen. The broken line shows our interpretation of the ventral portion of the anterior margin. The photograph has been re-touched over a small area (corresponding to about 1 sq. mm on the specimen) immediately above the point of maximum depth. Locality 173, a colliery tip at Lumajo, Villablino coalfield. Late Stephanian B. G. B. N.º 342.

Fig. 14.—*Anthraconaia* sp. nov., cf. *A. spathulata* WEIR × 2. 3. The continuous and broken lines show parts of the dorsal margin where it is clear and inferred respectively. Locality 2147, opposite the washery of the La Gamonera Mine, Roguera Formation, Tabliza, Ciñera-Matallana coalfield. Stephanian B. M. M. LL. 3982.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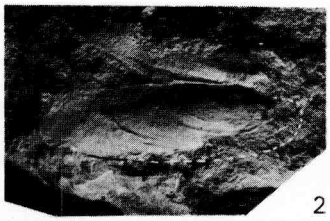
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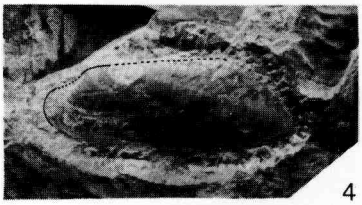
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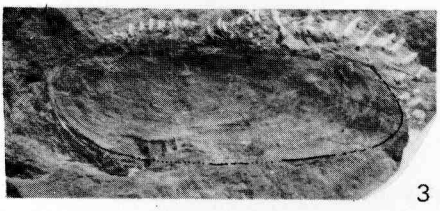
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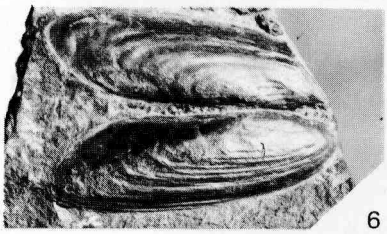
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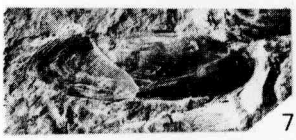
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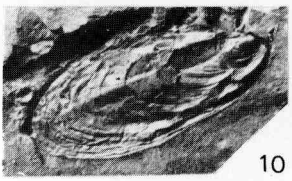
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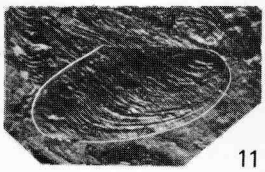
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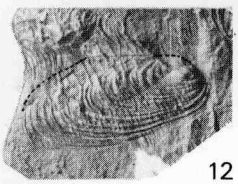
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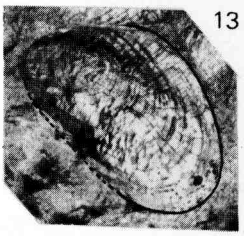
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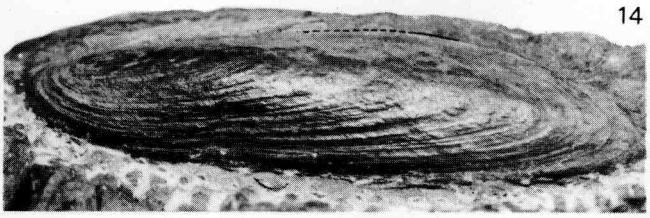
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PLATE 2

Non-marine myalinid bivalves from upper Westphalian D beds near Casavegas, northern Palencia. The specimens are shown at a magnification of 1. 2, unless it is otherwise stated.

All the shells have been collected from Locality 1929, a band 324.80 m above the Leonian disconformity in the region (see the list of localities, with further details, on p. 94). Registered numbers, prefixed by «M. M.» denote collections in the Manchester Museum, University of Manchester, England.

Fig. 1A.—*Naiadites obliquus* DIX & TRUEMAN. M. M. LL. 3956.

Fig. 1B.—The same shell × 2.4 and with restored margins.

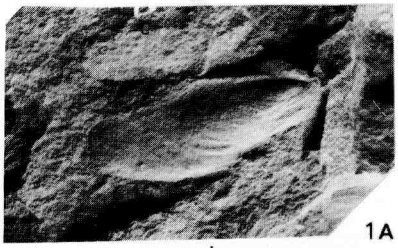
Fig. 2A.—*Naiadites* sp. aff. *obliquus* DIX & TRUEMAN. M. M. LL. 3957.

Fig. 2B.—The same shell × 2.4. The specimen is an impression of the shell. The oblique light in which it has been photographed does, however, give a true indication of the gentle convexity of the valve.

Fig. 3.—*Naiadites* sp. aff. *N. obliquus* DIX & TRUEMAN. M. M. LL. 3958.

Fig. 4.—*?Myalina* or *Naiadites* sp. (cf. *N. productus* (BROWN) group). A white line has been drawn on the specimen, which is an impression of the valve. Where the line is continuous, its inner edge indicates the margin of the valve; where the line is broken the margin of the valve is inferred. The anterior end of the impression is incomplete. M. M. LL. 3959.

Fig. 5.—*?Myalina* sp., or possibly a large *Naiadites*. The anterior end and some of the dorsal margin is missing. M. M. LL. 3960.



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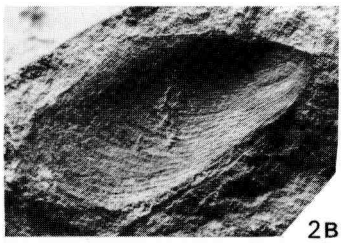

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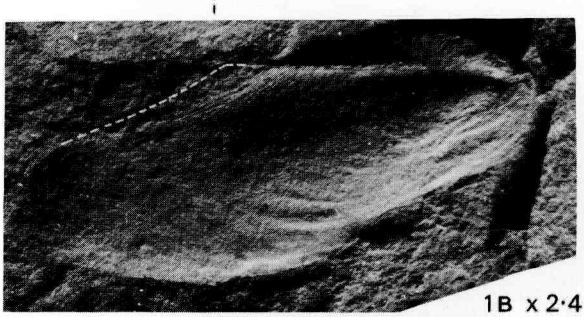

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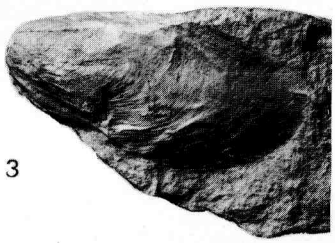

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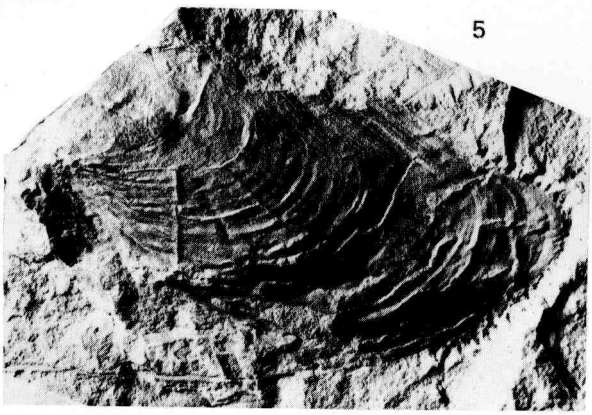

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