Basal Carboniferous Strata in Part of Northern León, NW. Spain : Stratigraphy, Conodont and Goniatite Faunas,

by A. C. HIGGINS, C. H. T. WAGNER-GENTIS and R. H. WAGNER

(Geology Department, University of Sheffield, England).

SOMMAIRE. — *Les premières couches d'une série extrêmement condensée d'âge surtout carbonifère inférieur, quoique comprenant aussi du Famennien le plus supérieur, sont décrites d'une région dans le Nord de la province de Léon (Nord-Ouest de l'Espagne), qui se trouve sur le versant sud de la Cordillère Cantabrique. Quelques coupes bien exposées en affleurement ont été étudiées aux points de vue de la stratigraphie détaillée et des faunes pélagiques de conodontes et de goniatites. Les coupes sont représentées par des dessins schématiques des figures 2 et 3 dans le texte, tandis que la situation géographique des localités est indiquée dans la figure 1 dans le texte. La répartition des espèces de conodontes trouvés dans les localités différentes est donnée dans la figure 4 dans le texte et la succession des faunes de conodontes ainsi que les espèces de goniatites ont été indiquées dans la figure 2 dans le texte.*

Les résultats de l'investigation réalisée peuvent être résumés comme suit :

1. La sédimentation était continue depuis le Famennien supérieur jusqu'au Tournaisien supérieur.

2. Un soulèvement pendant le Tournaisien supérieur éliminait une partie considérable de la série tournaisienne dans la partie méridionale de la région étudiée, ainsi que la totalité du Tournaisien déposé dans la partie septentrionale. Une représentation plus complète du Tournaisien restait intacte dans la partie centrale.

3. Une transgression d'âge tournaisien très supérieur venait ensuite déposer une mince bande de grès à nodules phosphatés dans les parties méridionales et septentrionales de la région, la datation étant établie au moyen de conodontes. Ils suivent des schistes noirs (« couches de Vegamián » de COMTE, *1959), qui contiennent une faune benthonique à* Lingula, *etc. au sommet dans la partie septentrionale de la région.*

4. Une seconde transgression venait s'inscrire dans la série méridionale par une autre mince bande de grès, localement conglomératique, à nodules phosphatés et montrant des traces de vers sur la surface inférieure. Cette transgression est aussi indiquée par une lacune stratigraphique avec des poches de dissolution dans la partie centrale de la région. Dans la partie septentrionale, au contraire, la série est ininterrompue, les schistes noirs se passant par moyen des schistes compacts, calcareux, à des calcaires premièrement gris, puis rouges, de faciès griotte.

5. Des calcaires noduleux, de faciès griotte, suivent partout. Ils correspondent au Viséen inférieur de la zone anchoralis *(conodontes) ou II* β/γ *(goniatites).*

Ils sont surmontés par des schistes silicieux rouges, constants sur les parties septentrionale et centrale de la région, mais absents dans la partie méridionale.

6. Des rides basses paraissent être établies très temporairement pendant le Tournaisien le plus supérieur et le Viséen le plus inférieur, respectivement, dans les parties septentrionale et centrale de la région. Une terre émergée, à relief bas probablement, se situait vers le Sud d'une façon plus ou moins permanente.

Des discussions sur les conodontes et goniatites sont présentées, respectivement, par A. C. Higgins *et* C. H. T. Wagner-Gentis *dans les chapitres V et VI.*

Summary. — *The earliest strata of a strongly condensed succession of Lower Carboniferous (and including some high Famennian) ages are described from an area of Palaeozoic outcrops in the northern part of the province of León, NW. Spain, on the southern flank of the Cantabric Mountain Chain. Certain well-exposed sections in this region have been investigated with regard to detailed stratigraphy and faunal contents, particularly conodonts and goniatites. The sections are diagrammatically reproduced in textfigures 2 and 3, whilst the location of the sections is indicated in textfigure 1. Textfigure 4 combines the evidence of conodont faunas, whilst the succession of conodont faunas and more occasional goniatite finds are also indicated in textfigure 2.*

The results of the investigation can be summarised as follows :

1. Sedimentation was continuous from the Upper Famennian into the Tournaisian.

2. Uplift during late Tournaisian times eliminated a considerable part of the Tournaisian succession in the southern part of the area investigated and virtually all of the Tournaisian in the northern part, whilst a more complete representation remained in the central part.

*3. Subsequent transgressive deposits consist of a thin basal sandstone with phosphatic nodules, which are dated as late Tournaisian in the north and south of the area. They are followed by black shales which contain a benthonic fauna (*Lingula*, etc.) in the top part of the formation as recorded in the northern part of the region.*

4. A second Carboniferous transgression is recorded in the southern part, where a basal transgressive sandstone (locally conglomeratic) with phosphatic nodules and casts of worm-tracks occurs above the black shale formation. This transgression also extended over the central part, but is not marked as a non-sequence in the northern part, where the black shales pass gradually into overlying limestones.

5. Succeeding nodular limestones, sometimes grey at the base, but mainly coloured a vivid red (Griotte), are found all over the area and correspond in age to Lower Visean anchoralis *zone (conodonts) or II* β/γ *(goniatites).*

6. Low-lying ridges seem to have been briefly established during late Tournaisian and early Lower Visean times in the northern and central parts of the region, respectively. A landmass was situated towards the south.

Specialist remarks on the conodont and goniatite faunas are given in chapters V and VI which are due, respectively, to the first and second authors of the present paper.

I. — INTRODUCTION.

Until recently the full stratigraphic succession and the various ages of Lower Carboniferous rocks in NW. Spain were very incompletely known. BARROIS (1881, 1882) first proved the existence of Lower Carboniferous rocks in the Cantabric-Asturian area of NW. Spain, but a more precise dating was only introduced when DELÉPINE (1943) described several Upper Visean goniatite faunas from this area. The goniatites were obtained from red-coloured nodular limestones of « Griotte » facies, which were considered to form the basal Carboniferous deposits. However, an earlier Carboniferous formation of black shales with occasional silico-phosphatic nodules was subsequently described as the Vegamián formation by COMTE (1959, pp. 330 and 331). These black shales were recorded from the northern part of the province of León. COMTE also recorded that the black shales formed a gradual transition with overlying « Griotte » limestone, whilst being more clearly separated from underlying Upper Devonian rocks. COMTE (1959, p. 316) further observed that the Lower Carboniferous strata usually rested on Upper Devonian (Famennian) rocks and did not cut obliquely through the pre-Carboniferous succession, as could be expected if an important unconformity existed below the Lower Carboniferous deposits. He remarked that « Cette particularité n'est pas en faveur d'une transgression du Viséen en Léon, transgression qui a été reconnue dans une grande partie de l'Europe occidentale. De nouvelles études, très minutieuses, portant sur les couches voisines du contact seraient nécessaires pour trancher ici la question ». It may be added that COMTE (1938, 1959) proved the presence of an important regional unconformity below the Upper Famennian strata in northern León, which thus tended to occupy a predominant position with regard to the pre-Carboniferous unconformity or non-sequence as recorded by DELÉPINE.

The goniatite faunas in the « Griotte » limestone formation in the early Carboniferous succession have recently been re-examined by the second author (WAGNER-GENTIS, *in* WAGNER, 1955, 1957; WAGNER-GENTIS, 1960, 1963), who found that they ranged from Lower Visean (IIγ zone) to middle Namurian A (E_2 zone). A description of the earliest goniatite fauna available (see chapter VI of the present paper) now shows that the

« Griotte » limestone commenced to be formed even during early Lower Visean times (II β/γ zone). In an independent investigation by KULLMANN (*in* SCHINDEWOLF and KULLMANN, 1958; KULLMANN, 1961, 1962), which was undertaken while the second author's studies were in progress, a series of Visean and Lower Namurian goniatites were described, ranging from Pe γ to Go γ and E_2. The « Griotte » limestone formation, which spans the entire Visean as well as a large part of the Lower Namurian in some parts of the area (the top of the formation is diachronous), has a total thickness of about 20 m. on the average. It therefore represents an extremely condensed succession which at first yielded a mixed goniatite fauna of various ages when sampled from weathered outcrop material (see the list published *in* WAGNER, 1955, p. 153). The second author is grateful to Professor H. SCHMIDT (Göttingen) for kindly pointing to this fact in a letter received in 1956. Subsequent collecting at specific levels of the « Griotte » formation proved the successive goniatite faunas as mentioned above. Well-preserved specimens « *in situ* » were mainly hard to find, however, so that successions of more or less complete assemblages could only be built up after several years of arduous collecting. For this reason it was found extremely rewarding that the « Griotte » proved rich in conodont remains (LYS et SERRE, 1958; HIGGINS, 1962). Detailed sampling of the « Griotte » and the underlying earlier Carboniferous and immediately preceding Upper Devonian rocks has now provided the first author with an almost complete succession of conodont faunas from the highest Famennian through Tournaisian to Visean. The presence of Tournaisian deposits in NW. Spain has been the subject of much speculation in the literature, but has now been proved for the first time. There is reason to suspect that Tournaisian deposits only occur in some parts of the Cantabric-Asturian area, whilst in some other parts Lower Visean strata rest immediately on Devonian or older rocks. This matter is here explored in a fairly large area in the northern part of the province of León, which mainly corresponds to the region described by WAGNER, 1963.

Six well-exposed stratigraphic sections (see textfig. 2) have been investigated in detail. They respectively represent outcrops in the northern and southern parts of the region (Genicera and Santiago-Olleros sections), with an intermediate part in between (Pola de Gordón — Beberino and Aviados sections).

The sections occur in east-west striking outcrops of strata belonging to a series of thrust slices. Facies variations in these slices are usually found in a north-south direction. The Lower Carboniferous deposits form no exception to this rule. Only the early part of the Lower Carboniferous succession is discussed in detail in the present paper.

In successive chapters the stratigraphy and fossil contents of the various sections as well as the overall stratigraphic and palaeogeographic implications will be discussed. Subsequently, a description of some elements of conodont fauna is given by the first author and a description of Lower Visean goniatites provided by the second author.

ACKNOWLEDGEMENTS.

The authors are grateful to Professor L. R. MOORE for facilities in the Department of Geology, University of Sheffield. The first author also acknowledges the use of photographic facilities at the « Service géologique de Belgique » in Brussels. The second two authors wish to record their indebtedness to the Research Fund of the University of Sheffield for a grant in aid for fieldwork during one year of collecting (1961). Many thanks are due to Professor L. R. MOORE and Dr. R. NEVES for assistance with collecting an early Lower Visean fauna at the locality of Olleros de Alba. The second author further wishes to record her indebtedness to Dr. W. S. BISAT, F.R.S. for helpful discussion on goniatite faunas. The field investigations were carried out in agreement with the Institute « Lucas Mallada » of the « Consejo Superior de Investigaciones Científicas » in Madrid and the « Comisión Nacional de Geología » in Madrid.

II. — LITHOLOGY AND FAUNAL CONTENTS OF STRATIGRAPHIC SECTIONS.

A number of sections in the Porma-Bernesga region and adjacent areas in the northern part of the province León have been measured by the third author (cf. WAGNER, 1963) and sampled for goniatite and conodont investigation. Six of the most important sections have subsequently been examined in detail with regard to conodont faunas studied by the first

author. Goniatite evidence has been studied by the second author. In the following description of the various sections an analysis of the conodont faunas (listed in textfig. 4) is made by the first author and the relevant goniatite evidence discussed by the second author. Ultimately, the sections have been revisited by all three authors together and re-examined with regard to doubtful points in the stratigraphic succession.

The location of the sections discussed in detail is indicated in textfigure 1. Textfigure 3 shows the broad outline of the stratigraphic succession with lines of correlation. The detailed lithological succession and faunal evidence in each of the sections are represented in textfigure 2.

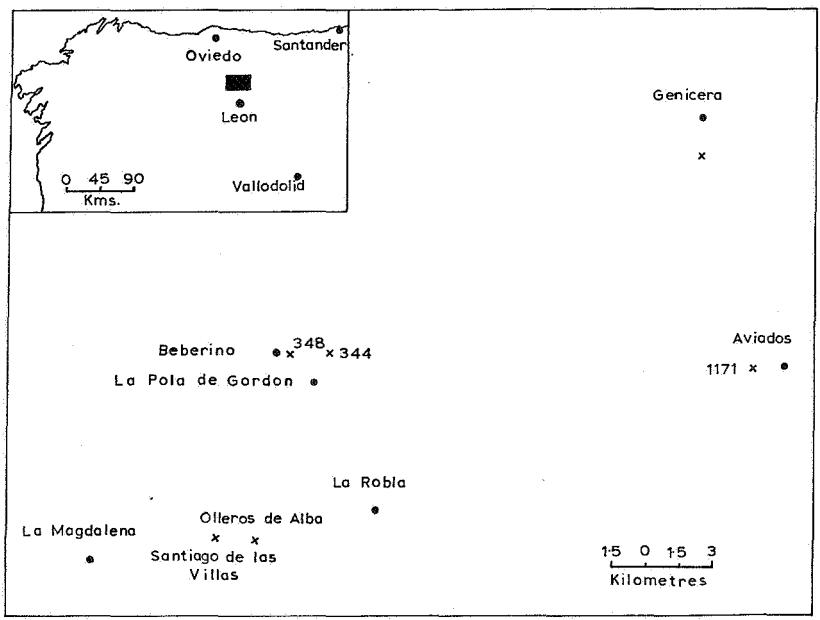


FIG. 1.

The general succession of Lower Carboniferous rocks in the Porma-Bernesga region has recently been described by WAGNER (1963). He described a very condensed lithological succession which, at its most complete development, consists of a black shale formation overlain by cream or grey, fine-grained nodular limestones passing into red nodular limestones, cherts and fine-

grained, red and grey, somewhat nodular limestones which are succeeded in turn by dark grey, fetid limestones. The cream nodular limestones at the base of the limestone formation in some parts of the area may be due to decoloration of the red limestone which is generally known as « Griotte ». Non-sequences are indicated by thin basal sandstone layers with phosphatic nodules which, in the southern part of the area, exist at two different levels of the Lower Carboniferous succession.

Goniatite faunas were almost exclusively found in the nodular limestones, where they occur in abundance, although well-preserved specimens are usually hard to find. Conodonts were extracted from more varied lithologies. The best preserved specimens were obtained from the « Griotte » limestone formation which contained conodonts in profusion. A lesser density of specimens was found in underlying high Upper Devonian limestone. The black shales of the Vegamián formation proved difficult to break down and thus yielded only very incomplete evidence due mainly to severe breakage. The most prolific conodont fauna was obtained from a thin weathered sandstone with phosphatic nodules (sample 1311 : Santiago section). Abundance of conodont specimens varies with the lithology and it seems quite obvious that the rate of sedimentation is the main controlling factor. Faunas of Lower Carboniferous age were more abundant than those of Upper Devonian age and reflect the very slow rate of deposition during Lower Carboniferous times. Extreme examples of slow deposition are the phosphatic nodules in basal sandstone deposits which are relatively the richest in conodonts. However, difficulties of extraction from the phosphatic nodules made the nodular limestone faunas the most attractive.

1. Santiago de las Villas.

This section was mentioned in WAGNER (1963) but was not described in detail. It occurs in a gully at about 600 m. NNE. of the village. The details of the lower part of the succession are as follows :

3,00 m. of red nodular limestone (1111). A goniatite, *Merocanites subhenslowi* nov. sp. was found at about 0,60 m. above the base of this formation (1354).

1,40 m. of grey nodular limestone (1110 at the base, 1315 at the top).

0,40 m. of grey limestone, somewhat nodular, intercalated with olive green shales (1109).

0,05 m. of sandy shales with phosphatic nodules.

0,20 m. of conglomeratic sandstone.

0,05 m. of black carbonaceous shale.

0,25 m. of sandstone with a conglomeratic base becoming finer towards the top. The conglomeratic base is irregular and rests on a worm-tracked surface. The conglomerate contains phosphate pebbles.

2,40 m. of black and grey shales.

0,02-0,05 m. of sandy shales with phosphate nodules (1311).

0,25 m. of fine-grained limestone (1310).

1,10 m. of sandstone with carbonaceous inclusions. In the top part the sandstone is thinly bedded.

0,80 m. of grey sandy shales with cherty bands.

0,50 m. of calcareous sandy shales (1353 — not yet examined).

1,10 m. of dark grey, cherty sandy shales.

5,10 m. of well bedded grey sandy shales with cherty intervals.

6,00 m. of grey shales.

3,00 m. of brown sandstones.

The lowest conodont sample examined (1310) is a fine-grained, grey limestone lentil containing conodonts in moderate abundance. Included in the fauna are *Gnathodus kockeli*, *Gnathodus* sp. A, *Angulodus walrathi*, *Polygnathus communis*, *Polygnathus inornata* and *Ozarkodina regularis*. The latter three species mentioned have been recorded from both the Devonian and Tournaisian of Germany by BISCHOFF (1957), but *Gnathodus kockeli* is known only from the Tournaisian, *Gattendorfia*-Stufe, in Europe (BISCHOFF, 1957; VOGES, 1959; ZIEGLER, 1959). Recently, however, it has been recorded from the highest Devonian of the Mississippi Valley (SCOTT and COLLINSON, 1961; COLLINSON, SCOTT and REXROAD, 1962), but is extremely rare in these beds and is abundant only in the lowest Mississippian strata. Occurring with *Gnathodus kockeli* in America are two species which they referred to as *Gnathodus* n. sp. A

and *Gnathodus* n. sp. B. The first species is recorded here as *Gnathodus* sp. A and was extracted from sample 1310. In Europe, *Gnathodus kockeli* is restricted to the *Gattendorfia*-Stufe and, despite its rare occurrence in the highest Devonian of North America as well, its presence here in NW. Spain in association with an abundance of *Polygnathus communis*, is interpreted as indicating the presence of Tournaisian beds.

Sample 1311 contains a very abundant conodont fauna but its specimens are badly broken. Included in this fauna are *Polygnathus communis*, *Polygnathus inornata*, *Polygnathus* cf. *flabella*, *Siphonodella cooperi* and fragments of many other species. This sample could be attributed to the Middle Tournaisian because of its abundance of *Siphonodella* and *Polygnathus*, but its exact position in the Tournaisian succession is doubtful. The absence of *Gnathodus* suggests that the fauna belongs to the « zone of few gnathodids », of Kinderhookian age, in the Upper Mississippi Valley (COLLINSON, SCOTT and REXROAD, 1962). Moreover, *Polygnathus* cf. *flabella*, ranging from the Middle to Upper *Gattendorfia*-Stufe in Germany (VOGES, 1959), indicates a similar age. *Siphonodella cooperi* occurs in beds of both Tournaisian and Lower Visean age in North America (HASS, 1959), but it is rare in the latter strata where it is also associated with abundant specimens of *Gnathodus*. Its range in Europe is not yet known. The association of genera and species in sample 1311 thus indicates a Middle or Upper Tournaisian age.

Sample 1109, forming the base of the Griotte limestone formation, contains a very distinctive conodont fauna consisting of many genera and species, but dominated by the genera *Pseudopolygnathus* and *Gnathodus*. The association of *Pseudopolygnathus triangula pinnata*, *Doliognathus lata*, *Scaliognathus anchoralis*, *Gnathodus delicatus* and *Geniculatus claviger* is diagnostic for the *anchoralis* zone. This sample is therefore of Lower Visean, cu II β/γ, age.

The grey nodular limestone above sample 1109 contains fewer conodonts than the previous bed. Sample 1110, at the base of the limestone, contains only *Pseudopolygnathus triangula pinnata*, but sample 1315, at the top of the limestone, has a moderately abundant fauna including many specimens of *Scaliognathus anchoralis* and *Hindeodella segaformis*, which belong to the *anchoralis* zone. Therefore, the *anchoralis* zone is at least 1,50 m. thick in this section. The red nodular

limestone immediately above contains a few conodonts at the base, but only *Gnathodus* cf. *texanus* has been identified.

At 0,60 m. above the base of the red Griotte (i.e. at about 2,00 m. above the base of the total limestone formation) two specimens of *Merocanites subhenslowi* nov. sp. have been found (loc. 1354). This species is considered a precursor of *Merocanites henslowi* (SOWERBY) and may indicate basal B zone (BISAT) or II γ-δ zones (H. SCHMIDT).

2. **Olleros de Alba.**

This section was described by WAGNER, 1963. The locality is immediately north of the village of Olleros de Alba on the road from La Robla to La Magdalena. The section is further extended downwards from the black shale formation by more recent observations.

6,00 m. of red nodular limestone (OL-B at 1 m., OL III at the extreme base).

0,40 m. of grey nodular limestone (OL II at the extreme base).

1,30 m. of cream coloured nodular limestone (OL-A, OL t5, OL I).

0,12 m. of hard, quartzitic sandstone.

2,20 m. of black shale (1347 at extreme base).

0,10 m. of mudstone.

0,60 m. of limestone (1348 at the top) grading into :

6,60 m. of sandstone.

14,70 m. of dark grey sandstone, thinly bedded with disturbed laminae. Dark sandy shales are intercalated in places.

1,90 m. below the top of the sandstone formation a limestone rib of 0,10 m. thickness occurs (1349).

1,20 m. of brownish grey, sandy shales.

0,05 m. of limestone (1350).

1,30 m. of calcareous ? shales.

0,05 m. of limestone (1351).

3,30 m. of sandy calcareous shales.

0,05 m. of limestone (1352).

— preceded by calcareous shales.

These samples (1347-1352) have not yet been investigated. By analogy with the section near Santiago de las Villas, they should correspond mainly to the Devonian and partly to the Tournaisian.

The lowest sample examined, OL t5, was taken at the extreme base of cream coloured nodular limestone immediately above the black shale formation and it contains an abundant conodont fauna. The genera *Gnathodus* and *Pseudopolygnathus* are the commonest ones present. *Gnathodus delicatus* and *Pseudopolygnathus triangula pinnata* are common constituents and diagnostic forms include *Doliognathus lata*, *Scaliognathus anchoralis*, *Hindeodella segaformis* and *Geniculatus claviger*. This association belongs to the *anchoralis* zone and it is remarkably similar to that of sample 1109 in the Santiago de las Villas section.

Sample OL I, taken a few centimetres above OL t5, contains a prolific conodont fauna. *Gnathodus*, represented by a greater variety of species than in the previous sample, constitutes 31 % of the assemblage. In contrast to the previous fauna the commonest species are *Gnathodus* cf. *texanus* and *Gnathodus* sp., whilst *Gnathodus delicatus* is rare. *Pseudopolygnathus* (16 %) and *Spathognathodus* (5 %) are the other common constituents. The association of *Pseudopolygnathus triangula pinnata*, *Scaliognathus anchoralis*, *Hindeodella segaformis* and *Doliognathus lata* in the sample is indicative of the *anchoralis* zone. From this bed the following goniatites are determined : *Pericyclus* sp. (= *P. hauchecornei* DELÉPINE, *non* HOLZAPFEL), *Munsteroceras browni* (MCCOY) and *Munsteroceras* cf. *crassum* FOORD (cf. WAGNER-GENTIS, *in* WAGNER, 1963). These species are indicative of a II β/γ age. Conodont samples OL II and OL III contain faunas lacking the distinctive forms found in the preceding beds and consisting mainly of species of *Gnathodus*, such as *Gnathodus* cf. *texanus*, *Gnathodus girtyi* and *Gnathodus semiglaber*. Additional forms include *Spathognathodus stabilis* and, in sample OL III, two specimens of *Polygnathus inornata*. The absence of typical conodonts of the *anchoralis* zone suggests strongly that these samples belong to the *anchoralis-bilineatus* interregnum (cu II γ/δ). At 2,70 m. above the base of the Griotte, *Munsteroceras subglobosum* LIBROVITCH and *Merocanites subhenslowi* n. sp. are recorded (OL-B). At 3,00 m. from the base *Merocanites subhenslowi* also occurs. A composite list of goniatites from this locality has already been mentioned in WAGNER-GENTIS, 1960.

3. **Pola de Gordón.**

This locality is a quarry on the eastern bank of the Bernesga river about 1 km. north of Pola de Gordón. The section has been described by WAGNER (1963), who listed it as locality 344.

At the base of the section grey massive limestones of Givetian age are followed by quartzite which has been indicated as Upper Devonian by COMTE (1959). Sample 1206 from the overlying coarsely crystalline limestone contains few conodonts but they include a number of forms with restricted ranges. *Spathognathodus aculeatus*, for example, is restricted to the *costatus* zone (upper toV-toVI) of Germany (ZIEGLER, 1962) and *Spathognathodus strigosus* appears to be restricted to Upper Devonian strata in Germany. *Polygnathus communis* originates in the *styriaca* zone (toIV) but also occurs in the Lower Carboniferous. Though the fauna is small, its general aspect indicates Upper Devonian. It probably belongs to the *costatus* zone.

The succeeding red nodular limestones have an irregular contact with the underlying beds and this apparent non-sequence is confirmed by the conodont fauna of sample 1207 A at the base of these limestones. This fauna, consisting mainly of *Gnathodus* (33 %), *Pseudopolygnathus* (10 %) and *Spathognathodus* (9 %), includes *Scaliognathus anchoralis*, *Pseudopolygnathus triangula pinnata* and *Hindeodella segaformis*, which are all indicative of the *anchoralis* zone, Lower Visean. Consequently, the Tournaisian is not represented in this section.

Sample 1207 B, a short distance below a chert bed, contains a fauna dominated by *Gnathodus*, but, with the possible exception of *Gnathodus punctatus* ?, it lacks diagnostic genera and species. *Gnathodus punctatus* ? has not been recorded from post-*anchoralis* beds in Europe and in this instance it may indicate an horizon near the top of the *anchoralis* zone. Upper Visean goniatites have been recorded (WAGNER-GENTIS *in* WAGNER, 1963) from scree material of Griotte Limestones succeeding the chert bed. It also yielded conodonts (HIGGINS, 1962).

4. **Beberino.**

This is a riverside exposure at the village of Beberino. The section is listed as locality 348 in WAGNER, 1963. It forms the westward continuation of the section north of Pola de Gordón. At the base of the section there are several metres

of yellow-brown sandstone which pass upwards into sandy limestone. The latter are followed by a grey siliceous limestone bed with highly ferruginous red bands, one of which has been sampled (1200 B), but which does not contain conodonts. Twenty-five centimetres above the top of this limestone a rich conodont fauna was recovered (sample 1200 C), containing *Scaliognathus anchoralis*, *Pseudopolygnathus triangula pinnata* (18 %), *Hindeodella segaformis* and abundant specimens of *Gnathodus* (37 %). This fauna dates the sample as *anchoralis* zone.

Immediately above the siliceous limestones are red nodular limestones yielding an association of Middle and Upper Visean goniatites from scree samples (WAGNER-GENTIS *in* WAGNER, 1963). Half a metre above the base of these limestones, a conodont sample (1201 A) yielded species of *Gnathodus*, such as *Gnathodus semiglaber*, *Gnathodus* cf. *texanus* and *Gnathodus girtyi*. None of these conodont species dates the bed accurately. However, the absence of the diagnostic *anchoralis* zone genera and species suggests an *anchoralis-bilineatus* age. It is certainly not older than Lower Visean.

5. **Aviados.**

This section is situated about 1 ½ km. west of the village of Aviados. The lower part of the succession is as follows :

1,60 m. of red chert.

2,40 m. of red Griotte (locally decoloured and including samples 1171 III and IV).

0,50 m. of grey, highly nodular, fine-grained limestone forming a gradual transition with the overlying Griotte, but having an irregular contact with the underlying formation.

3,20 m. of coarsely crystalline limestone grading downwards into coarsely calcareous sandstone. The latter bed includes samples 1171 I (1365) and II (1367) and sample 1366.

The lowest sample (1171 I) contains a small fauna consisting of *Polygnathus* and fragments of *Ligonodina*, *Spathognathodus* and *Hindeodella*. The majority of the specimens were referable to *Polygnathus communis* and *Polygnathus inornata*, two species which occur in both the Devonian and Carboniferous

in Germany and North America. However, VOGES (1959) noted that these species are particularly abundant in the Tournaisian. This fact, together with the absence of typical later Carboniferous forms, suggests an early Carboniferous age for the sample, although it could also be of late Devonian age. At the top of the limestone (sample 1171 II) is a rich fauna consisting of abundant specimens of *Siphonodella* and *Polygnathus* with a few specimens of *Gnathodus*. Amongst the fragmented specimens *Siphonodella cooperi*, *Polygnathus communis*, *P. inornata*, *Gnathodus* cf. *texanus*, *G. girtyi* and *G. delicatus* have been identified. The abundance of *Siphonodella* and *Polygnathus* and the rarity of *Gnathodus* suggest a high Tournaisian age for this sample.

At the base of the red nodular limestones occurs a moderately rich fauna (sample 1171 III) including *Scaliognathus anchoralis*, *Pseudopolygnathus triangula pinnata* and abundant specimens of *Spathognathodus stabilis*. *Gnathodus* is poorly represented but the presence of *Scaliognathus anchoralis* dates this sample as *anchoralis* zone. The highest sample in the limestone (1171 IV) contains mainly species of *Gnathodus*, such as *Gnathodus* cf. *texanus* and *Gnathodus punctatus* ?. Although all specimens of the latter species are fragmentary and therefore difficult to identify, they may indicate an *anchoralis* age for the sample. It is not older than Lower Visean.

6. **Genicera.**

This section has been described in WAGNER, 1963. It is situated about 2 km. south-west of Genicera. In this section a gradual transition has been recorded from the black shale formation upwards into limestones of the Griotte succession. This transition is effected through mudstones and fine-grained limestones. In the top part of the black shales and mudstones a benthonic fauna has been found. The red nodular limestones of Devonian age at the base of the section are not exactly dated. The succeeding brown decalcified sandstones apparently correspond to the La Ermita sandstone formation of COMTE (1959, see map), which is considered to be of upper Famennian age. The coarsely crystalline limestone above them contains conodonts (samples 1164 and 1339). The lower sample (1164) yields *Spathognathodus aculeatus*, *Spathognathodus inornatus*, *Polygnathus nodomarginata* and *Spathognathodus costa-*

tus costatus, an association characteristic of the *costatus* zone of the Upper Devonian. The upper sample (1339) contains *Spathognathodus costatus spinulicostatus* and *Spathognathodus costatus costatus*. Other genera present in both samples include fragments of *Ligonodina*, *Hindeodella* and *Roundya*. In Germany and the Pyrenees (ZIEGLER, 1959, 1962) this association of genera and species indicates a late Devonian age. Therefore, they are considered to be Devonian rather than Carboniferous.

At the extreme base of the overlying black shales occurs a thin sandy bed containing phosphate nodules (1338). This bed contains abundant though extremely fragmented conodonts amongst which *Siphonodella*, *Polygnathus* and *Pseudopolygnathus* have been identified. This fauna is undoubtedly of Carboniferous age and the association of genera is comparable to that of the Tournaisian fauna at the base of the black shale formation at Santiago. However, the fragmentation of the specimens is too severe to allow firm specific determinations and therefore accurate zonation.

For reasons stated elsewhere, the black shales have not been examined in detail. However, one sample in the top part of the formation, which shows conodonts on its bedding planes, has yielded *Pseudopolygnathus triangula pinnata* which indicates a late Tournaisian or lower Visean age. A few centimetres above this sample a thin limestone (1166 B) contains *Scaliognathus anchoralis*, *Pseudopolygnathus triangula pinnata* and *Hindeodella segaformis*, which belong to the *anchoralis* zone. Immediately above this bed is a grey nodular limestone band (1166 C) which yields a small conodont fauna consisting mainly of species of *Gnathodus* which are not older than *anchoralis* age. At 1,10 m. above the base of the grey limestone a specimen of *Munsteroceras hispanicus* DELÉPINE, *non* CRICK and FOORD, has been found by Mr. NEPVEU and was kindly submitted to the second author. A well-preserved example of *Merocanites subhenslowi* nov. sp. was furthermore encountered in the top part of the succeeding red nodular limestone formation (0,75 m. thick). It apparently represents a form precursory to *Merocanites henslowi* (SOWERBY) and thus seems to indicate an horizon at the base of the B-zone of BISAT's classification (i.e. late II γ ?). The red nodular limestone yielded only a poor conodont fauna.

III. — STRATIGRAPHIC AND PALAEOGEOGRAPHIC IMPLICATIONS.

The sections examined in the present paper correspond to three different belts in roughly E-W striking units in the Porma-Bernesga region of northern León. Each of these belts seems to have had a somewhat different stratigraphic history due to slightly different palaeogeographic positions.

The earliest Carboniferous strata (corresponding to the Lower Tournaisian *kockeli* zone) have been found in the Santiago section in the southernmost part of the area. They follow in a probably uninterrupted succession on still undated strata which may well belong to the highest Devonian. No stratigraphic break with the underlying beds has been observed. In fact, the first break in the succession occurs above the *kockeli*-bearing strata in the Santiago section, where a thin basal transgressive sandstone with phosphatic nodules is found. This transgression is of late Tournaisian age, as follows from a conodont fauna belonging to the *Siphonodella* zone.

A slightly younger *Siphonodella* fauna occurs in the top part of a coarsely crystalline limestone in the Aviados section, to the east and probably corresponding to a somewhat more northerly palaeogeographic position. This limestone extends downwards over a relatively considerable stratigraphic thickness and may well correspond to the greater part of the Tournaisian. It forms a gradual transition with underlying quartzitic sandstone which may form part of the highest Devonian succession. It is also observed that the coarsely crystalline limestone of Aviados is similar in lithology and stratigraphic position to a formation in the sections of Pola de Gordón, Beberino and Genicera, which has yielded conodonts of the highest Famennian *costatus* zone. Although the evidence is still incomplete, it seems likely that the Famennian and the Tournaisian follow on each other without stratigraphic break.

Uplift during Tournaisian times subsequently eliminated a considerable part of the Tournaisian sequence in the southerly exposures of Santiago de las Villas and Olleros de Alba, where a transgression of Upper Tournaisian age set in at a time when concordant sedimentation was still in progress further north in the Aviados region. This creates the impression that the transgression moved from north to south. On the other hand, a basal transgressive sandstone is found in exactly the same

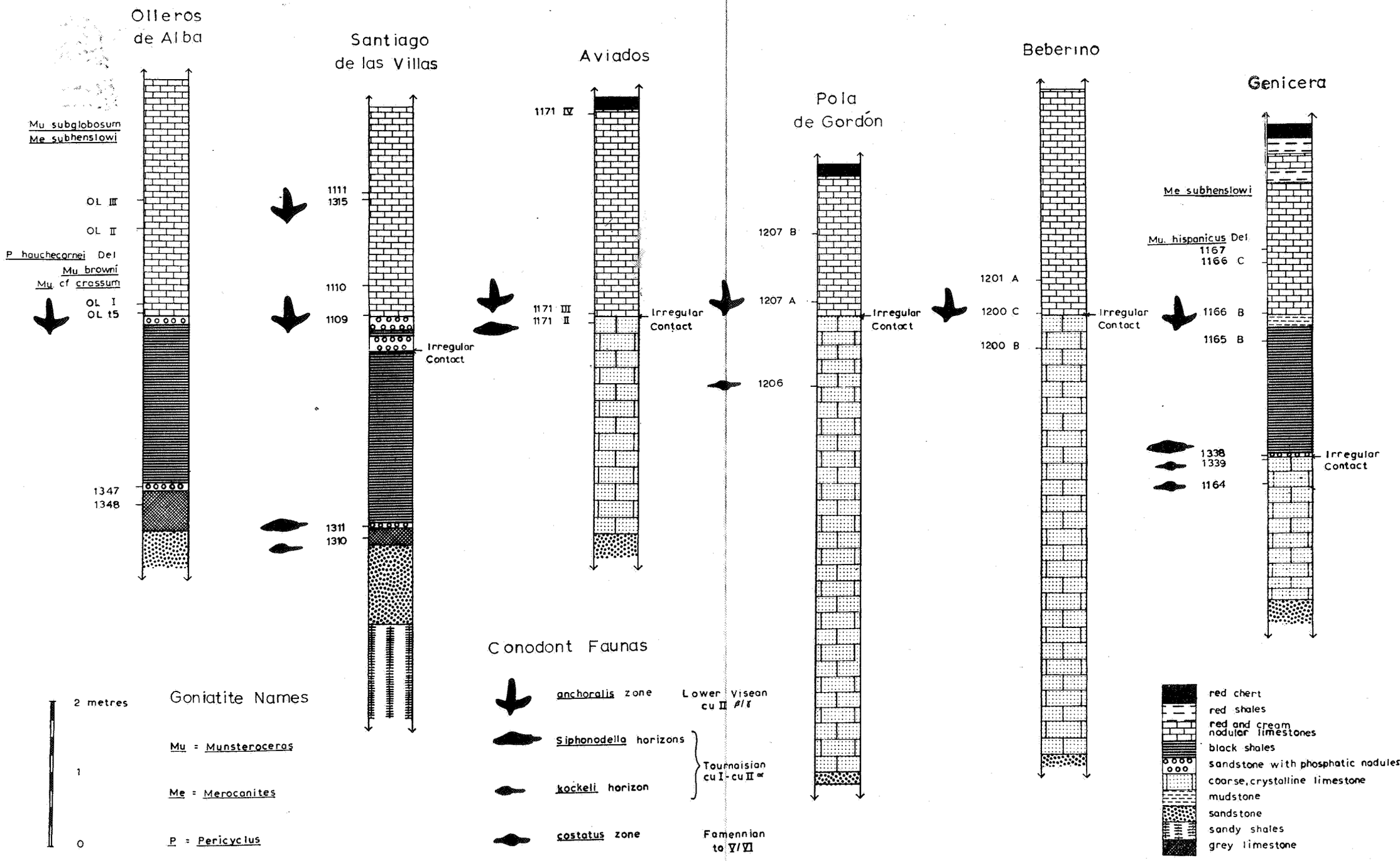

Olleros de Alba
Mu subglobosum
Me subhenslowi
OL III
OL II
P hauchecornei Del
Mu browni
Mu cf crassum
OL I
OL t5
1347
1348
Santiago de las Villas
1111
1315
1110
1109
Irregular Contact
1311
1310
Aviados
1171 IV
1171 III
1171 II
Irregular Contact
Pola de Gordón
1207 B
1207 A
1206
Irregular Contact
Beberino
1201 A
1200 C
1200 B
Irregular Contact
Genicera
Me subhenslowi
Mu. hispanicus Del
1167
1166 C
1166 B
1165 B
1338
1339
1164
Irregular Contact
2 metres
1
0
Goniatite Names
Mu = Munsteroceras
Me = Merocanites
P = Pericyclus
Conodont Faunas
anchoralis zone
Lower Visean cu II β/γ
Siphonodella horizons
kockeli horizon
Tournaisian cu I - cu II α
costatus zone
Famennian to V/VI
red chert
red shales
red and cream nodular limestones
black shales
sandstone with phosphatic nodules
coarse, crystalline limestone
mudstone
sandstone
sandy shales
grey limestone

FIG. 2.

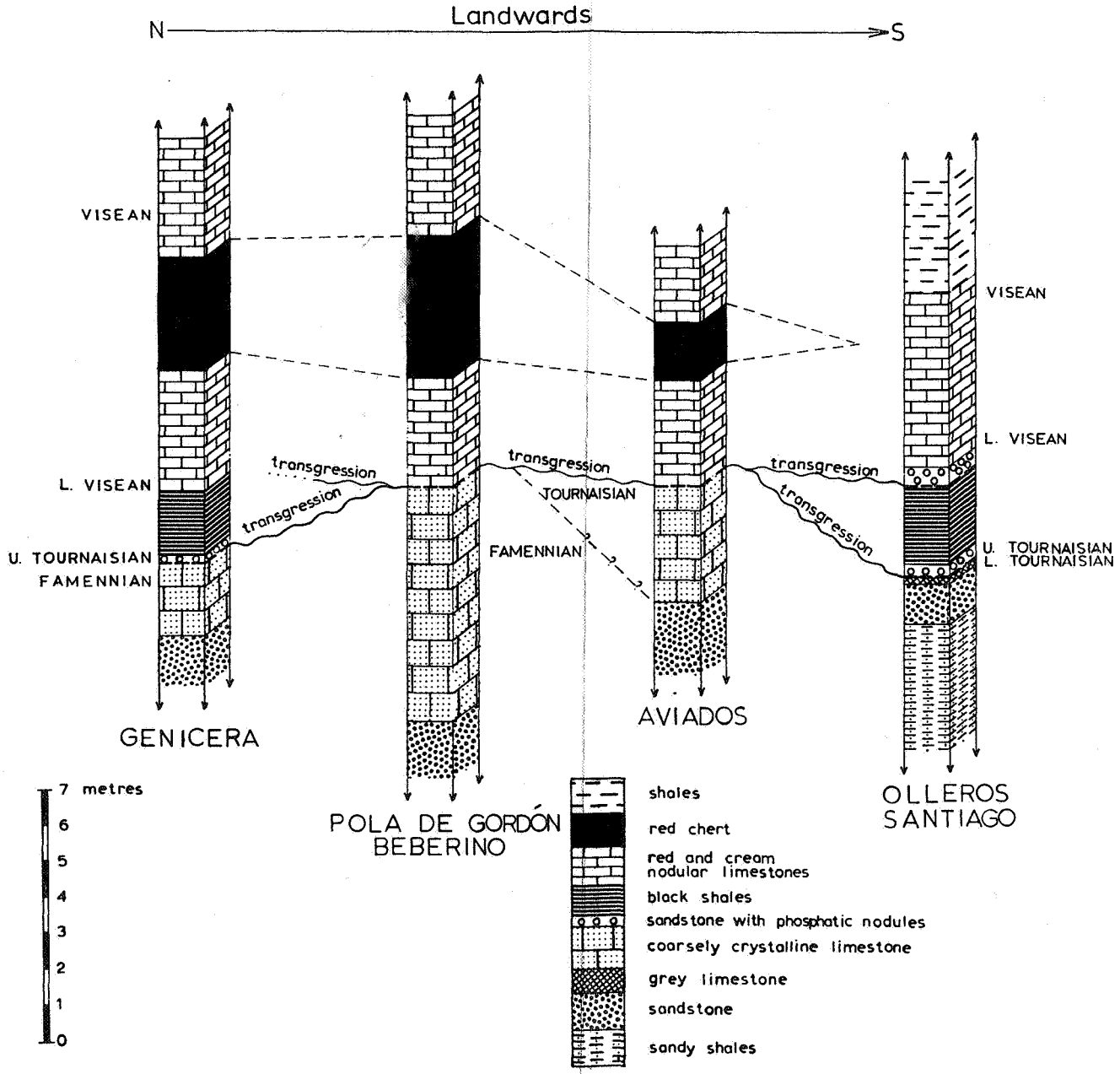

N
Landwards
S
VISEAN
L. VISEAN
U. TOURNAISIAN
FAMENNIAN
transgression
transgression
transgression
TOURNAISIAN
FAMENNIAN
transgression
transgression
VISEAN
L. VISEAN
U. TOURNAISIAN
L. TOURNAISIAN
GENICERA
POLA DE GORDÓN
BEBERINO
AVIADOS
OLLEROS
SANTIAGO
7 metres
6
5
4
3
2
1
0
shales
red chert
red and cream
nodular limestones
black shales
sandstone with phosphatic nodules
coarsely crystalline limestone
grey limestone
sandstone
sandy shales

FIG. 3.

stratigraphic position in the section near Genicera, further north. Possibly, a ridge existed in the northern part of the area, so that local transgressions spread both south- and northwards from a sea established in the middle part of the area examined.

The position of this ridge was impermanent, since the Genicera section shows a subsequent history of continuous sedimentation throughout the Visean. Instead, a ridge may have become established later in the central part of the area examined.

The history of the first transgression of Carboniferous age in northern León can be followed quite well in the exposure SW. of Genicera. A basal transgressive sandstone with phosphatic nodules is followed here by black shales carrying fish scales, lamellibranchs, ostracodes, horn brachiopods (*Lingula*, *Orbiculoidea*), calcareous brachiopods and badly preserved, squashed goniatites resembling *Pericyclus* ? sp., which all occur in the top part of the formation. They indicate a shallow, muddy sea which apparently spread all over the area, since the black shales also occur in the southern exposures of Olleros de Alba and Santiago de las Villas.

The black shales (Vegamián formation of COMTE, 1959) pass gradually upwards through calcareous mudstones into limestones at the base of the Griotte formation in the Genicera section, but a stratigraphic break is indicated near Olleros and Santiago de las Villas, where the black shale formation is followed by transgressive sandstone (c.q. conglomerate) with phosphatic nodules and casts of worm-tracks. This second Carboniferous transgression therefore also operated from north to south, overstepping a southern landmass. The limestone beds immediately following on the thin basal transgressive deposits are invariably dated as Lower Visean *anchoralis* zone (= II β/γ zone on goniatites) throughout the area.

The *anchoralis* zone limestones rest without basal sandstone deposit immediately on coarsely crystalline limestone of variously uppermost Famennian (*costatus*-zone) or high Tournaisian (*Siphonodella* zone) ages in the central part of the area. The biggest stratigraphic gap is recorded in the sections near Pola de Gordón and Beberino, corresponding to one and the same E-W striking structural unit. Another section near Pola de Gordón, which has not yet been examined for microfauna, shows the presence of erosion pockets in presumed Devonian coarsely crystalline limestone immediately below the Griotte

limestone. The conclusion seems warranted that the region of Pola de Gordón and Beberino was situated on a ridge during lowermost Visean times (pre-*anchoralis* zone), from which Tournaisian strata were taken off by erosion. In the region of Aviados, which may have occupied a slightly more southerly position, a large part of the Tournaisian is still present, although the black shale formation is absent. Probably, it corresponds to a position on the southern flank of the Pola de Gordón-Beberino ridge of early Lower Visean times.

Conditions apparently became more stabilised from the Lower Visean *anchoralis* zone onwards, since nodular limestones (at first grey in some parts of the area, but rapidly passing to red everywhere) were subsequently formed all over the region examined. They correspond in age to Lower Visean high II γ and possible Middle Visean lower B zone (II γ-δ ?), as indicated by successive stages of evolution in goniatites of the *Merocanites henslowi* complex (i.e. including its apparent precursor *Merocanites subhenslowi* nov. sp.). These limestones of typical Griotte facies are followed by a constant horizon of red cherts in the northern and central parts of the area. The cherts are absent in the southern part, where red nodular limestones are formed in an uninterrupted succession. After the cherts a return to red nodular limestone with alternating grey, less nodular bands is recorded in the northern and central parts, where the Griotte formation passes gradually upwards into dark grey, well-bedded fetid limestones. The basal part of the fetid limestone formation has yielded E_1 and E_2 goniatites and conodonts (HIGGINS, 1962; WAGNER-GENTIS, 1963), indicating Lower Namurian age. In the southern part of the area (Santiago and Olleros sections) a terrigenous facies of red, green and grey shales is found immediately above the Griotte limestone, the top part of which has not yet been dated exactly. This terrigenous facies certainly corresponds mainly to a Namurian age, but it is still uncertain whether also a part of the Upper Visean is represented in this manner. The top of the Griotte formation is certainly diachronous.

The distribution of strata and its palaeogeographic implications have been summarised in textfigure 3.

IV. — CONCLUSIONS.

The detailed examination of lithological formations and pelagic faunas contained by the extremely condensed succession of mainly Lower Carboniferous ages over a large area in the northern part of the province of León has yielded a number of stratigraphic and palaeogeographic results. Especially the conodont faunas proved extremely important, since identifiable goniatites are not always easy to find.

Contrary to usually accepted opinions in the literature, there seems to be an uninterrupted succession from the highest Famennian upwards into the Tournaisian. This result obtained for a part of the Cantabric Mountain Chain closely matches ZIEGLER's (1959) report on Tournaisian beds in the Pyrenees.

The first Carboniferous transgression occurred in fairly late Tournaisian times, corresponding to the *Siphonodella* zone (conodont zonation). This transgression has been clearly demonstrated in the southern and northern parts of the area investigated, but has not been proved in the central part, where a more continuous Tournaisian succession may have been formed (Aviados section).

A second Carboniferous transgression is dated as early Lower Visean (immediately pre-*anchoralis* zone = II β/γ of the goniatite zonation) as regarded in this area. It is restricted to the southern and central parts of the area, since a continuous succession from the highest Tournaisian onwards is found in the northern exposures.

The two Lower Carboniferous transgressions and the immediately preceding periods of uplift seem less important than the earlier movements with subsequent transgression of the La Ermita sandstone formation, of Upper Famennian age, which have been recorded by COMTE (1938, 1959). The uplifts of Carboniferous age seem to have resulted in comparatively little erosion of strata (only a few metres), whereas the Famennian and all preceding deposits down to Cambrian (see COMTE, 1959) were affected by the Upper Famennian uplift.

Both the evidence of Lower Carboniferous non-sequences and subsequent transgressive deposits and the presence of possible high Upper Visean and Namurian terrigenous strata in the southern part of the region indicate the proximity of a landmass

to the south (see also WAGNER, 1963). More or less shallow ridges may also have existed at first during late Tournaisian times in the northern part of the area and later during early Lower Visean times in the central part (Pola de Gordón-Beberino ridge). Although important stratigraphic gaps exist in the successions on these ridges, their importance may not be exaggerated, since the removal of only a few metres of strata in this very condensed succession already results in considerable time gaps. The ridges may have been in existence only during very short times.

The black shale formation (Vegamián formation of COMTE, 1959), which is almost at the base of the first Carboniferous transgression, probably straddles the Tournaisian-Visean boundary.

The conclusions given above only apply to the region investigated and cannot be generalised over the entire Cantabric-Asturian area. For example, the Tournaisian is certainly absent in northeastern Palencia, where the Lower Carboniferous succession commences with Lower Visean deposits (WAGNER-GENTIS, 1960, 1963). The present authors' investigations are being continued both over a larger part of the Cantabric-Asturian area in NW. Spain and further upwards into the Carboniferous succession.

V. — CONODONT DESCRIPTIONS.

(A. C. HIGGINS.)

The figured specimens have been placed in the collections of the Micropalaeontology Laboratory at the University of Sheffield. Under the heading occurrence are included only those beds in which the species occur in NW. Spain. The total number of conodont species recorded has been listed in figure 4. A few comments on certain systematic problems have been included below.

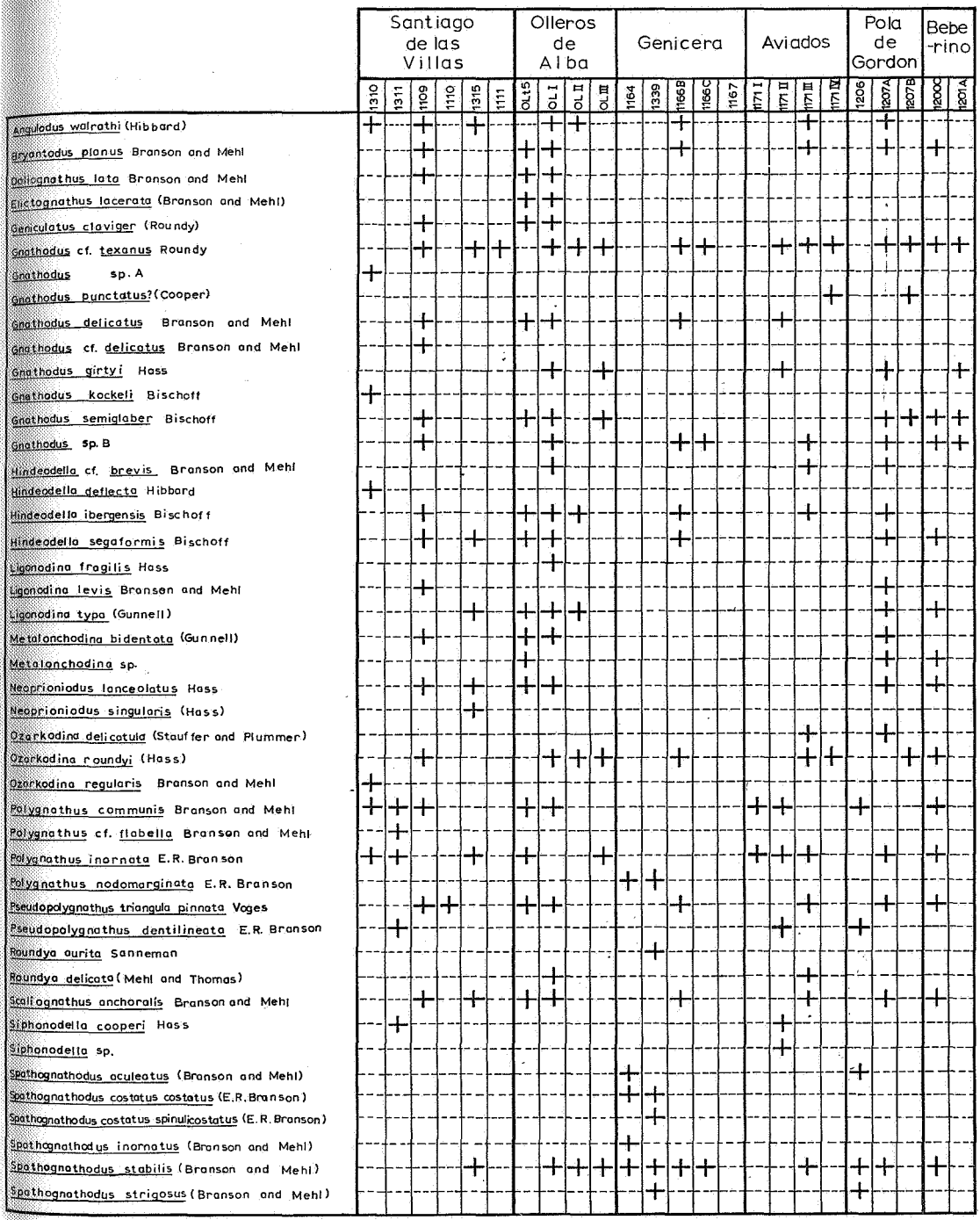

Santiago de las Villas
Olleros de Alba
Genicera
Aviados
Pola de Gordon
Bebe-rino
1310
1311
1109
1110
1315
1111
OLt5
OL I
OL II
OL III
1164
1339
1166B
1166C
1167
1171 I
1171 II
1171 III
1171 IV
1206
1207A
1207B
1200
1201A
Angulodus walrathi (Hibbard)
Bryantodus planus Branson and Mehl
Deliognathus lata Branson and Mehl
Elictognathus lacerata (Branson and Mehl)
Geniculatus claviger (Roundy)
Gnathodus cf. texanus Roundy
Gnathodus sp. A
Gnathodus punctatus? (Cooper)
Gnathodus delicatus Branson and Mehl
Gnathodus cf. delicatus Branson and Mehl
Gnathodus girtyi Hass
Gnathodus kockeli Bischoff
Gnathodus semiglaber Bischoff
Gnathodus sp. B
Hindeodella cf. brevis Branson and Mehl
Hindeodella deflecta Hibbard
Hindeodella ibergensis Bischoff
Hindeodella segaformis Bischoff
Ligonodina fragilis Hass
Ligonodina levis Branson and Mehl
Ligonodina typa (Gunnell)
Metalonchodina bidentata (Gunnell)
Metalonchodina sp.
Neoprioniodus lanceolatus Hass
Neoprioniodus singularis (Hass)
Ozarkodina delicatula (Stauffer and Plummer)
Ozarkodina roundyi (Hass)
Ozarkodina regularis Branson and Mehl
Polygnathus communis Branson and Mehl
Polygnathus cf. flabella Branson and Mehl
Polygnathus inornata E.R. Branson
Polygnathus nodomarginata E.R. Branson
Pseudopolygnathus triangula pinnata Voges
Pseudopolygnathus dentilineata E.R. Branson
Roundya aurita Sanneman
Roundya delicata (Mehl and Thomas)
Scaliognathus anchoralis Branson and Mehl
Siphonodella cooperi Hass
Siphonodella sp.
Spathognathodus aculeatus (Branson and Mehl)
Spathognathodus costatus costatus (E.R. Branson)
Spathognathodus costatus spinulicostatus (E.R. Branson)
Spathognathodus inornatus (Branson and Mehl)
Spathognathodus stabilis (Branson and Mehl)
Spathognathodus strigosus (Branson and Mehl)

FIG. 4.

Genus **GNATHODUS** PANDER

(type species : *Gnathodus mosquensis* PANDER).

Gnathodus delicatus BRANSON and MEHL.

(Pl. V, fig. 24.)

Remarks. — The majority of the specimens of this species are characterised by the presence of a prominent node or nodes at the extreme anterior end of the inner side of the platform. In this respect, these specimens from NW. Spain differ from the more typical examples of the species. However, this difference is considered to fall within the limits of variability of the species.

Occurrence. — Upper Tournaisian ?, *anchoralis* zone.

Gnathodus cf. **delicatus** BRANSON and MEHL.

(Pl. V, fig. 23.)

Remarks. — This small group of specimens is characterised by the presence of a broad noded band on the oral surface of the inner side of the cup which is approximately equal in width to that of the outer side. The cup, and its ornamented areas, are therefore more symmetrical than those of more typical members of the species.

Occurrence. — *Anchoralis* zone.

Gnathodus cf. **texanus** ROUNDY.

1962. *Gnathodus texanus* HIGGINS, *non* ROUNDY : Not. Com. Inst. Geol. Min. España, 65, pl. 3, fig. 28 (*non* fig. 30 = *Gn.* sp. B).

Remarks. — The large number of specimens referred to *Gnathodus* cf. *texanus* in the present paper possess larger aboral cavities than occur in the type specimen of this species and appear to be closely comparable to *Gnathodus* n. sp. aff. *G. texanus* COLLINSON, SCOTT and REXROAD (1962), as recorded

from probable Visean beds in North America. According to the cited authors, *G.* n. sp. aff. *G. texanus* appears before *G. texanus* s. s. in North America, but the difference in stratigraphic range between these two species has not yet been demonstrated in Europe. It is found that *Gnathodus* cf. *texanus* ranges throughout the Visean in NW. Spain, but *G. texanus* s. s. has not yet been observed here.

Occurrence. — Upper Tournaisian ? to Upper Visean.

Gnathodus sp. A.

(Pl. V, fig. 28.)

1961. *Gnathodus* cf. *G. commutatus* (BRANSON and MEHL) SCOTT and COLLINSON : Kansas Geol. Soc. 26th Ann. Field Conf. Guidebook, pp. 123 and 124, pl. 1, figs. 23-27.

1962. *Gnathodus* sp. A COLLINSON, SCOTT and REXROAD : Illinois Geol. Survey Circular, 328, p. 8, fig. 3.

Remarks. — This species is morphologically identical to *Gnathodus commutatus commutatus* BRANSON and MEHL, but, as it is noted by COLLINSON, SCOTT and REXROAD, the two species are separated by a considerable gap. For this reason *Gnathodus* sp. A is regarded as a homeomorph of *G. commutatus commutatus.* In NW. Spain a few specimens of *Gnathodus* sp. A occur in association with abundant specimens of *Gnathodus kockeli* in beds which are regarded as early Tournaisian in age. *Gnathodus commutatus* on the other hand does not occur below the Visean.

Gnathodus sp. A is being described by SCOTT in a forthcoming paper.

Occurrence. — Lower ? Tournaisian.

Gnathodus sp. B.

(Pl. V, fig. 26.)

1962. *Gnathodus texanus* HIGGINS, *non* ROUNDY : Not. Com. Inst. Geol. Min. España, 65, pl. 3, fig. 30.

Description. — The length of the blade is unknown. The carina, consisting of laterally thickened nodes narrowing posteriorly and anteriorly, diminishes in height towards the

posterior extremity of the unit. The cup is greatly expanded on the outer side, but is long and narrow on the inner side. On the latter side, high above its surface and adjacent to the carina, is a row of nodes which are greatly expanded at the anterior end of the cup. On the outer side one or two nodes occur on the oral surface adjacent to, but usually much lower than, the carina.

The aboral side of the cup is excavated and is crossed by a longitudinal groove which is continued along the blade.

Comparison. — This species is closely comparable to *Gnathodus* cf. *texanus*, the major difference being the extension of the inner side of the platform to the posterior end of the unit.

Occurrence. — *Anchoralis* zone to *anchoralis-bilineatus* interregnum.

Gnathodus punctatus ? (COOPER).

1939. *Dryphenotus punctatus* COOPER : Journ. Paleontology, 13, nº 4, p. 386, pl. 41, figs. 42 and 43; pl. 42, figs. 10 and 11.

Remarks. — A few fragmentary specimens have been doubtfully referred to this species, because they possess a cup which is broadly expanded on the outer side and ornamented with radiating rows of nodes. The ornamentation of the inner side however more closely resembles that of *Gnathodus semiglaber* and it appears probable that these are transitional specimens.

Occurrence. — *Anchoralis* ? zone.

VI. — DESCRIPTION OF GONIATITES.

(C. H. T. WAGNER-GENTIS.)

Within the area discussed in the present paper only one locality yielding goniatites of early Lower Visean age (II β-γ zone in H. SCHMIDT's classification) has been found. It occurs at the base of the nodular limestone formation in the section

immediately north of Olleros de Alba (OL-A). The fauna corresponds in age with the *anchoralis* zone fauna of conodonts recorded by A. C. HIGGINS in this paper.

At a somewhat higher level in the succession, in red nodular limestones, rather well preserved remains of Prolecanitids are found in various localities. They usually belong to a species representing a possible precursor of *Merocanites henslowi* (SOWERBY), of the lower B zone in England (BISAT, 1934). This species is here described as *Merocanites subhenslowi* nov. sp. It apparently indicates a stratigraphic level at the base of the B zone (i.e. high II γ zone ?).

The specimens described here will be deposited in the collection of the Institute « Lucas Mallada » in the « Museo Nacional de Ciencias Naturales », Madrid.

Genus **PERICYCLUS** MOJSISOVICS.

Pericyclus sp. (= **P. hauchecornei** DELÉPINE, **non** HOLZAPFEL).

(Pl. I, figs. 1-4.)

1941. *Pericyclus hauchecornei* DELÉPINE, *non* HOLZAPFEL : Not. Mém. Serv. géol. Maroc, 56, pp. 50-52, pl. 1, figs. 5 et 6.

1963. *Pericyclus* cf. *hauchecornei* WAGNER-GENTIS, *non* HOLZAPFEL : Not. Com. Inst. Geol. Min. España, 69, p. 7.

Description. — A single, rather badly preserved specimen is available for description from the basal part of the Griotte limestone at Olleros de Alba (León). It is considered identical with a specimen illustrated from the Carboniferous of Morocco by DELÉPINE (1941).

Shape : Thick, discoid, evolute shell with a broadly rounded venter and short, rounded sides; umbilical wall narrow and rounded, nearly perpendicular to the sides. The cross-section of the shell is kidney-shaped.

Ornamentation : The sides and the venter are crossed by strong, undivided ribs which are almost straight. They form only a shallow sinus on the venter. No intercalated ribs are present. The width of the ribs approximately equals the separation of the ribs. They seem to be triangular in cross-section and, when slightly worn, appear to consist of a bundle

	Olleros de Alba (León)		Bordj d'Erfoud, Morocco (DELÉPINE, 1941)
	Last whorl	Penultimate whorl	
Diameter (D)	ca 38 (1)	25–26	46
Width (W)	20	ca 14,5	24–25
Height of whorl (H)	ca 13?	9?	—
Height of opening (h)	ca 9	—	—
Umbilicus (O)	13?	—	16
Ribs per centimetre on the middle of lateral side ...	4	10	5–6
W/D ratio	0,52	0,55	0,54
O/D ratio	0,40	—	0,35
H/D ratio	0,40	—	—

(1) Measurements in millimetres.

of thin lirae. There is a noticeable difference between the width of the ribs on the ultimate and penultimate whorls (respectively, 4 and 10 per centimetre on the middle of the sides, when D = 38 and 25-26).

Constrictions are faintly visible on the last whorl only.

Suture-lines are not preserved on the specimen described.

Comparisons. — The specimen from Olleros de Alba (León) is identical in most of its visible characteristics with the specimen figured and described by DELÉPINE (1941) from Bordj d'Erfoud in Morocco under the name of *Pericyclus hauchecornei* HOLZAPFEL. Both specimens differ from HOLZAPFEL's species as originally described from Liebstein in the Erdbach-Breitscheid region of Germany, because they possess about half the number of ribs per centimetre in specimens of the same diameter (compare SCHINDEWOLF, 1951, p. 93).

They are quite similar to *Pericyclus grandicostatus* LIBROVITCH (1927, pp. 23-25, 46, Tab. III, figs. 1-4), but differ in possessing a slightly larger umbilicus (O/D = 0,26 at D = 40 mm. and

O/D = 0,30 at D = 21 mm. for *P. grandicostatus*). LIBROVITCH does not mention any pronounced difference in the number of ribs per centimetre on the penultimate and last whorls whereas this forms one of the salient characteristics of the specimen here described. The number of ribs in *P. grandicostatus* has been given as 6 per centimetre when D = 40 and 8 per centimetre when D = 21 mm.

Pericyclus (*Ammonellipsites*) *funatus* (SOWERBY), as drawn by FOORD (1901, pl. XXXVIII, fig. 5; pl. XXXIX, figs. 1 *a-b*), differs in having a somewhat larger umbilicus (O/D = 0,46 at D=78 mm.) and stronger ribs (3 per centimetre at D=78 mm.).

Pericyclus (*Ammonellipsites*) *kochi* HOLZAPFEL, as figured by SCHINDEWOLF (1951, pl. VI, fig. 10) from Winterberg in Germany, shows the same number of ribs per centimetre as occur on whorls of comparable diameter in the specimens here described. However, the umbilicus of *P. kochi* is markedly smaller than that of *P. hauchecornei* DELÉPINE, *non* HOLZAPFEL. The original specimens of *Pericyclus kochi*, from Liebstein in the Erdbach-Breitscheid region (HOLZAPFEL, 1889-1894, pp. 35-36, Taf. III, figs. 3-7), show a more globoid shell, with a smaller umbilicus (D/W=0,68; D/H=0,48; D/O=0,23 at D=35 mm.). HOLZAPFEL mentions that the strength and density of ribbing varies from one whorl to another in *Pericyclus kochi*. This characteristic is shared by the specimen in hand.

Discussion. — It seems most likely that the specimen from Olleros as well as the example figured by DELÉPINE from Morocco represent a still unnamed species of *Pericyclus*, which is different from *Pericyclus hauchecornei* HOLZAPFEL and the other species mentioned under comparisons. However, the specimen in hand is not well enough preserved to serve as a holotype and it is therefore preferred to describe the species provisionally as *Pericyclus* sp. (cf. *hauchecornei* DELÉPINE, *non* HOLZAPFEL) until better preserved material becomes available.

DELÉPINE's specimen from Bordj d'Erfoud in Morocco has already been excluded from *Pericyclus hauchecornei* HOLZAPFEL by SCHINDEWOLF (1951, p. 93).

Occurrence :

Morocco : Bordj d'Erfoud, niveau *a* (DELÉPINE, 1941, p. 8 : list), in strata of lower Visean age (S1b = II β-γ according to PAREYN, 1961, Tabl. IV).

NW. Spain : At the base of the Griotte limestone outcropping at Olleros de Alba (prov. León), in strata of II β-γ age; together with *Munsteroceras browni* (McCoy) and *Munsteroceras* cf. *crassum* Foord (loc. OL-A).

Genus **MUNSTEROCERAS** Hyatt.

Munsteroceras browni (McCoy) Delépine.

(Pl. 2, figs. 5-8.)

1844. *Goniatites Browni* McCoy : Synopsis Carboniferous Fossils of Ireland, p. 12, pl. IV, fig. 17.

1897. *Glyphioceras Browni* Foord and Crick : Catalogue Fossil Cephalopoda British Museum, pt. 3, p. 183.

1903. *Glyphioceras* (*Beyrichoceras*) *Browni* ? Foord : Palaeont. Soc. London, 55, pp. 175 and 176, pl. XLVI, figs. 4 *a-c.*

1941. *Munsteroceras* cf. *browni* Delépine : Not. Mém. Serv. géol. Maroc, 56, pp. 56 et 57, pl. I, fig. 11.

?1941. *Munsteroceras corpulentum* Delépine : Not. Mém. Serv. géol. Maroc, 56, p. 56, pl. II, figs. 10-12, *non* pl. II, figs. 7-9 (= *M. corpulentum* Crick).

1951. *Munsteroceras* cf. *corpulentum* Smyth form Ø : Proc. Royal Irish Acad., pp. 297 and 298, textfig. 1 m, pl. XI, fig. 4.

Description. — Only one specimen is available for description. It comes from the basal layer of Griotte limestone at Olleros de Alba (León) (OL-A).

D	ca 30 (1)
W	ca 20
H	10
h	8 ?
O	10
W/D	0,69
H/D	0,33
h/D	0,27
O/D	0,33

(1) Measurements in millimetres.

Shape : The shell is almost cadicone, with a very wide, arched venter and narrow, arched sides. The umbilicus is wide and has an acute shoulder. The umbilical wall is perpendicular to the side of the shell.

No *ornamentation* has been preserved.

No *constrictions* are preserved on the specimen in hand, which is rather worn.

The *sutures* are wide apart (about 6 per half whorl). The ventral lobe consists of straight, subparallel sides with a low median saddle which, at the bottom of the lobe, forms a serrated edge. The first lateral saddles are rounded, whilst the first lateral lobes are pointed. The ventral cheeks of the first lateral lobes are straight, whereas the umbilical sides are slightly bent outwards in the lower middle part of the lobes. The second lateral saddles are rounded and terminate on the umbilical shoulder at 1/3 the depth of the lateral lobes.

Comparisons. — The specimen in hand may be compared with *Munsteroceras sphaeroidale* (McCoy) and *Munsteroceras corpulentum* (Crick), but has a wider umbilicus than either one of these species. It is also more cadicone and thus agrees with *Munsteroceras browni* (McCoy), as figured and described by Foord (1903) and Delépine (1941).

Remarks. — The specimen figured by Delépine (1941, pl. II, figs 10-12) from the Lower Visean of Morocco has a D/O ratio of 0,35 which seems to agree better with *Munsteroceras browni* than *Munsteroceras corpulentum.* It is also slightly wider than may be admitted for *M. corpulentum.*

Also in the case of *Munsteroceras* cf. *corpulentum* Smyth form Ø it seems that the rather wide umbilicus and the relatively globoid shell invite comparison with *Munsteroceras browni* rather than *Munsteroceras corpulentum.* It is further observed that the suture line drawn by Smyth (1951, p. 307, textfig. 1 q) from the topotype of *Munsteroceras corpulentum* Crick as figured by Foord from St. Doulagh, Co. Dublin, is identical with that of *Munsteroceras browni* from Olleros, Spain. The two species differ in the shape of the shell.

Occurrence :

Ireland : County Limerick, exact locality unknown (Foord, 1903); Rush Slates, County Dublin (Smyth, 1951, p. 289), belonging to the Lower Visean.

Morocco : Bordj d'Erfoud, niveau *a* (Delépine, 1941, pp. 8 and 9), in an assemblage of Lower Visean age (S1b : cf. Pareyn, 1961, Tabl. IV).

NW. Spain : Base of the Griotte limestone at Olleros de Alba (prov. León), corresponding to II β/γ (together with *Pericyclus hauchecornei* DELÉPINE, *non* HOLZAPFEL and *Munsteroceras*. cf. *crassum* FOORD).

Munsteroceras cf. **crassum** FOORD.

1903. *Glyphioceras* (*Munsteroceras*) *crassum* FOORD : Palaeont. Soc. London, pp. 193-194, pl. XLII, figs. 10 a-c.
1927. *Munsteroceras crassum* LIBROVITCH : Comité Géol. Leningrad, Matériaux, 74, p. 34, pl. VI, fig. 6.
1941. *Munsteroceras crassum* DELÉPINE : Not. Mém. Serv. géol. Maroc, 56, p. 58, pl. II, figs. 4-6.
1961. *Munsteroceras crassum* PAREYN : Publ. Centre Recherches Sahariennes, Sér. Géol., 1, t. II : Paléontologie, pp. 100 et 101, pl. VIII, figs. 11-16, textfig. 6 A.

Description. — Only a fragment of an internal cast has been found in the locality near Olleros de Alba, at the base of the Griotte formation (OL-A). The dimensions of this specimen are compared below with those of various examples of *Munsteroceras crassum* recorded in the literature.

	Olleros de Alba	Hassi Sguilma, Algeria (PAREYN, 1961)		Bordj d'Erfoud (DELÉPINE, 1941)	Ballinacarriga, Eire (FOORD, 1903)
D	ca 40 (1)	32	41	55	75
W	22	20	25	32	35
H	17	17	19	31	45
h	9	8	12	15	—
O	ca 7 (2)	7	12	8	12
W/D	0,55	0,6	0,6	0,58	0,46
H/D	0,4	0,46	0,44	0,58	0,6
O/D	0,1–0,2	0,2	0,3	0,15	0,1–0,2

(1) Measurements in millimetres.

(2) Reconstructed from a part of the whorl.

Shape : The specimen from Olleros de Alba is quite fragmentary (less than 1/2 of a whorl). A reconstruction of the specimen may show a sphaerocone shell with a small umbilicus and low sides. The transverse section of the whorl has a horseshoe shape. The opening is about half the total height of the whorl. The greatest width of the whorl is at the umbilicus. The venter is strongly arched, whilst the rather short sides are only slightly curved. The sides are slightly converging towards the venter. The lateral sides pass with rounded edges into the narrow umbilical wall. There is an angle of about 90° between the sides and the umbilical wall.

Neither the *constrictions* (if present) nor the *ornamentation* have been preserved.

The *suture-line* consists of a deep ventral lobe with straight parallel sides, which diverge slightly at the top of the lobe. The first lateral saddle is rounded and of medium width. The succeeding lateral lobe is pointed and has straight cheeks, so as to give the lobe the appearance of a capital V. The bottom of this lobe reaches the same depth as the base of the ventral lobe. The second lateral saddle is rounded. It reaches the umbilical wall at about the depth of the preceding lobe. Furthermore, a shallow lobe is formed on the umbilical wall. The sutures appear rather crowded, which may be due to the fact that the specimen described here consists partly of the living chamber, so that suture lines are shown close to the living chamber. The sutures fit each other in a similar way to those in *Munsteroceras rotella* (DE KONINCK).

Remarks. — The specimen described here shows approximately the same dimensions as *Munsteroceras crassum* described from North Africa by DELÉPINE (1941) and PAREYN (1961). It differs slightly from the type specimen as described by FOORD (1903) from Ireland, in which the height of the whorl is greater than the width. However, this may be due to the Irish specimen being twice as large as the Spanish one. At a diameter of about 55 mm. (e.g. the specimen figured by DELÉPINE, 1941, pl. II, figs. 4-6) the height of the whorl equals the width.

Comparisons. — The specimen from Olleros has approximately the same shape as *Munsteroceras ellipsoidale* CRICK and *Munsteroceras obesum* FOORD, as figured in FOORD (1903). In

both species the height equals the width, which may again be due to the large size of the specimens. A more fundamental difference is found in the more slender aspect and wider umbilicus in both species mentioned above as compared with *Munsteroceras crassum* FOORD.

Munsteroceras euryomphalum SCHINDEWOLF (1926, pp. 87-89, figs. 10 a-b) is characterised by an extremely wide ventral lobe with a slightly raised median saddle and clearly differs in this respect from the specimen in hand. The shape of the preserved whorl fragment of the Olleros specimen could fit one of the whorl sections of *M. euryomphalum*.

Occurrence :

Ireland : Ballinacarriga, Co. Limerick (FOORD, 1903).

North Africa : Bordj d'Erfoud, niveau *a* (Morocco), in a fauna of Lower Visean age (DELÉPINE, 1941, p. 8); Hassi Sguilma (Sth. Algeria), in a fauna of the S1b zone of the Lower Visean (PAREYN, 1961, Tabl. IV).

U.S.S.R. : Son Kul region in the Tian-Shan Mountains of Turkestan, where it occurs in a fauna of lower Visean age (LIBROVITCH, 1927).

NW. Spain : Base of the Griotte formation at Olleros de Alba (OL-A), in the province of León, together with other elements of II β/γ age.

Munsteroceras cf. **subglobosum** LIBROVITCH.

(Pl. 3, figs. 9 and 10.)

1927. *Munsteroceras subglobosum* LIBROVITCH : Comité géol. Leningrad, Matériaux, 74, pp. 35 and 36, fig. 17, p. 53, pl. VI, fig. 7, pl. VII, figs. 1 and 2.

1941. *Munsteroceras* cf. *subglobosum* DELÉPINE : Not. Mém. Serv. géol. Maroc, 56, pp. 60 et 61, pl. III, figs. 20 et 21, textfig. 10.

Specimen excludendum :

1961. Cf. *Munsteroceras subglobosum* PAREYN : Publ. Centre Recherches sahariennes, Sér. Géol., 1, t. II : Paléontologie, p. 104, pl. VIII. figs. 27 et 28.

Description. — Only one rather badly preserved specimen from Olleros de Alba (OL-B) is available for description.

D	51 (1)
W	ca 30
H	29
h	ca 15
O	5
W/D	0,58
O/D	0,09
H/D	0,56

(1) Measurements in millimetres.

Shape : Thick, discoid, involute shell, with a narrowly rounded venter and curved sides. The latter converge slightly towards the venter. The greatest thickness occurs near the umbilicus. The contour of the whorl has a parabolic shape. The umbilicus is very small.

No *ornamentation* has been preserved.

No *constrictions* are present.

The *suture-lines* are widely separated (about 10 to 12 per whorl). The suture possesses a deep, narrow ventral lobe with a median saddle which has about 1/5 of the depth of the lobe. The sides of the ventral lobe are parallel and an apparent slight inflation in the middle may be due to erosion of the specimen in hand. The first lateral saddle, which is situated on the lateral-ventral area, is broadly rounded and has nearly parallel sides. The first lateral lobe is shaped like a large pointed V, which reaches just a little deeper than the ventral lobe. The second lateral saddle is wide and rounded. It reaches the umbilical wall. No more of the suture-line is visible on the specimen in hand.

Remarks. — *Munsteroceras* cf. *subglobosum* Librovitch from Olleros de Alba is reminiscent of *Nautellipsites hispanicus* (Crick and Foord) which has a suture-line of similar shape. However, the former has a more globular shell and its sutures are farther apart.

The specimen in hand is very close to *Munsteroceras subglobosum*. For example, the rather globular shell with a small umbilicus, the parallel sides of the ventral lobe and the

parallel sides of the first lateral saddle are all characteristics which coincide very well in the specimen in hand and LIBROVITCH's species. In fact, the only apparent difference is found in the outline of the whorl which shows somewhat converging sides in our specimens, whereas they are parallel in *Munsteroceras subglobosum* LIBROVITCH.

The specimen of *Munsteroceras* cf. *subglobosum* which has been figured from North Africa by PAREYN (1961, pl. VIII, figs. 27 et 28), has a larger umbilicus.

Occurrence :

Russian Turkestan : Tian Shan Mountains, where it occurs in a fauna of the middle and upper « *Pericyclus* Stufe », according to LIBROVITCH (1927, p. 42).

Morocco : Bordj d'Erfoud, niveau *b*, Lower Visean (DELÉPINE, 1941, p. 9).

NW. Spain : At Olleros de Alba (prov. León), at 2,70 m. from the base of the Griotte limestone (loc. OL-B), where it occurs together with *Merocanites subhenslowi* nov. sp. and cf. *Munsteroceras djaprakense* ? LIBROVITCH in strata which probably correspond to high II γ zone (at the base of the B zone of BISAT's classification).

Genus **MEROCANITES** SCHINDEWOLF.

Merocanites subhenslowi nov. sp.

(Textfigs. A-C; pl. III, figs. 11-13; pl. IV, fig. 14.)

1963. *Merocanites henslowi* var. WAGNER-GENTIS, *in* WAGNER : Bol. Inst. Geol. Min. España, 74, p. 60.

Description. — Two specimens (holotype and paratype) are available from Olleros de Alba (OL-B), at 2,70 m. above the base of the Griotte limestone; one specimen from the section SW. of Genicera, at about 1,95 m. above the base of the Griotte limestone (1167); furthermore one fragment, representing a part of the living chamber, which has been found in the Barruelo region, province of Palencia, exact level in the Griotte limestone unknown.

	Holotype (OL-B)	Paratype (OL-B)
D	ca 90 (1)	—
H	27	36
h	ca 26	—
W	15	—
O	44	—

(1) Measurements in millimetres.

Shape : The shell is a very flat serpenticone, the involution being almost nil. The widest part of the whorl is near the umbilicus. The umbilical shoulder is rounded and the sides are nearly flat or slightly convex. The lateral-ventral area is smoothly rounded and passes into the narrowly rounded venter. The lateral-ventral area of the living chamber appears to be smoothly rounded as well.

The *ornamentation* is not preserved.

No *constrictions* are present.

The *suture-line* has a short V-shaped ventral lobe with a siphonal opening. The sides of the ventral lobe are convex towards the siphon. The 1st lateral saddle is rounded and the following 2nd and 3rd lateral saddles are clavate, the 2nd lateral saddle reaching somewhat higher than the 1st and 3rd ones. The 1st, 2nd and 3rd lateral lobes are lanceolate, the 2nd lateral lobe being longer than the other ones. The 2nd and 3rd lateral saddles as well as the 1st, 2nd and 3rd lateral lobes are all very narrow and long. The 4th lateral saddle is rounded and lower than the 3rd lateral saddle. The umbilical side of the 4th lateral saddle is more or less horizontal, slightly sinuous and bends downwards halfway on the umbilical wall. The 4th lateral lobe has a narrow V-shape and extends to about 1/3 of the depth of the 3rd lateral lobe. It is situated on the umbilical wall just outside the whorl suture, when the height of the whorl is ca 27 mm. One fragment of a whorl (paratype : pl. III, fig. 13), which has a height of 36 mm., shows the rounded 4th lateral saddle on the lateral side of the

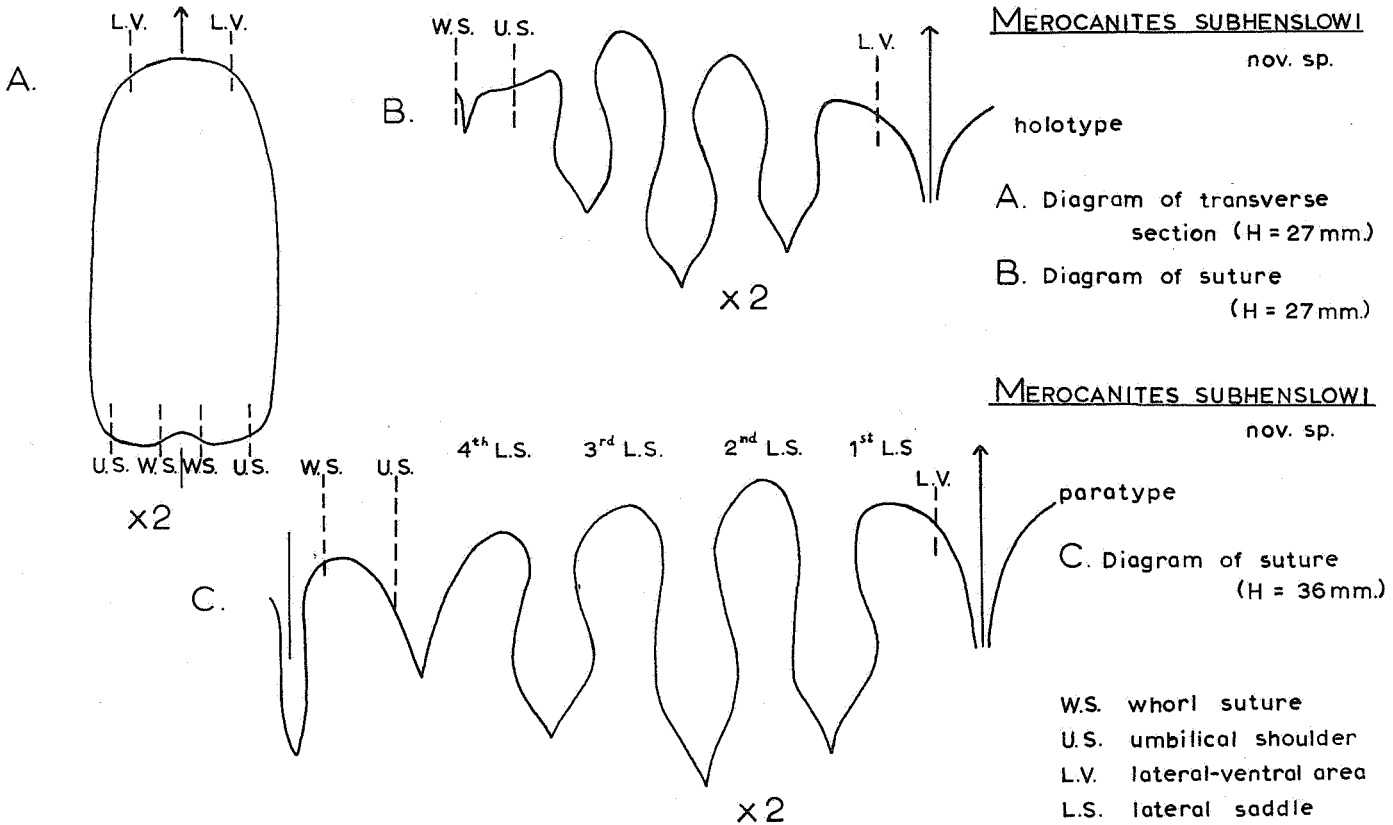

A.
L.V.
L.V.
U.S. W.S. W.S. U.S.
x2
B.
W.S. U.S.
L.V.
x2
MEROCANITES SUBHENSLOWI
nov. sp.
holotype
A. Diagram of transverse section (H = 27 mm.)
B. Diagram of suture (H = 27 mm.)
MEROCANITES SUBHENSLOWI
nov. sp.
paratype
C. Diagram of suture (H = 36 mm.)
C.
W.S. U.S.
4th L.S.
3rd L.S.
2nd L.S.
1st L.S
L.V.
x2
W.S. whorl suture
U.S. umbilical shoulder
L.V. lateral-ventral area
L.S. lateral saddle

FIG. 5.

shell. The dorsal saddle is rounded and its highest part coincides with the whorl suture. The dorsal lobe is long and narrow, pointed (not spiked) and constricted at its opening.

Diagnosis. — A species of the group of *Merocanites henslowi* (SOWERBY) which is characterised by the presence of the 4th lateral lobe in a position just outside the whorl suture on the umbilical wall, when the height of the whorl is about 27 mm.

Types. — The holotype (pl. IV, fig. 14; textfig. 5 A-B) is a fairly well-preserved specimen which shows a number of whorls up to a height of 27 mm. The paratype (pl. III, figs. 12 and 13; textfig. 5 C) consists of a part of a whorl which is reasonably well-preserved and in which the height of the whorl is 36 mm. Both type-specimens have been obtained from the red Griotte near Olleros de Alba, at about 2,70 m. above the base of the limestone formation (loc. OL-B). They will be deposited in the collections of the Institute « Lucas Mallada » at the « Museo Nacional de Ciencias Naturales », Madrid.

Comparisons. — *Merocanites subhenslowi* nov. sp. belongs to a group of species with closely comparable suture-lines which show a certain development expressed in the changing position of the 4th lateral lobe. Another difference can be found in the size and shape of the 3rd lateral lobe. Immediately comparable species are *Merocanites henslowi* (SOWERBY) and *Merocanites subapplanatus* SMYTH. The differences and resemblances are outlined in the table given on the next page.

It is indicated in the table that the 4th lateral lobe of *Merocanites subhenslowi* moves from a position near the whorl suture towards the lateral sides with increasing diameter (expressed as the height of the whorl) of the specimen. It is also shown that the 4th lateral lobe, which, at a 27 mm. height of the whorl, is situated just outside the whorl suture in *M. subhenslowi*, occupies a position on the umbilical shoulder in specimens of *M. henslowi* with a comparable height of the whorl (respectively ca 23 mm. and 24 mm. height). This seems to indicate that equivalent positions of the 4th lateral lobe are obtained at relatively earlier stages in the development of *M. henslowi* which thus appears to be slightly further evolved than *M. subhenslowi*. From a comparison between the para-

M. subhenslowi (Olleros-B, Spain)	*M. subhenslowi* (Genicera 1167, Spain)	*M. henslowi* (Rylstone, central England — BISAT, 1934, fig. 22)	*M.* cf. *henslowi* (Djebel Ioucha, SW. Algeria — PAREYN, 1961, p. 83)	*M. subapplanatus* (Rush Slates, Co. Dublin, Ireland — SMYTH, 1951, textfigs. 1 a, c)
Height of whorl 15 mm. (holotype) 4th lateral lobe on the dorsal side of whorl suture				Height of whorl 15 mm. (paratype) 4th lateral lobe on the dorsal side of whorl suture
Height of whorl 27 mm. (holotype) 4th lateral lobe just outside whorl suture, on the umbilical wall	Height of whorl 23 mm. 4th lateral lobe just outside whorl suture, on the umbilical wall	Height of whorl ca 23 ? mm. 4th lateral lobe near the umbilical shoulder, on the umbilical wall	Height of whorl 24 mm. 4th lateral lobe near the umbilical shoulder, on the umbilical wall	
Height of whorl 36 mm. (paratype) 4th lateral lobe just on lateral side			Height of whorl 36 mm. 4th lateral lobe just on lateral side	
3rd lateral lobe is deeper than 1/2 depth of the 2nd lateral lobe and is constricted at the opening	3rd lateral lobe is deeper than 1/2 depth of the 2nd lateral lobe and is constricted at the opening	3rd lateral lobe is deeper than 1/2 depth of the 2nd lateral lobe and is constricted at the opening	3rd lateral lobe is deeper than 1/2 depth of the 2nd lateral lobe and is constricted at the opening	3rd lateral lobe is shorter than 1/2 depth of the 2nd lateral lobe and is not constricted at the opening

type of *M. subhenslowi* (height of the whorl 36 mm.) and the examples of *M.* cf. *henslowi* given by PAREYN (1961, p. 83), it seems to follow that the ultimate position of the 4th lateral lobe in the later stages of ontogenetic development are approximately equal in both species. The same impression is gained from a large whorl fragment of *M. henslowi* from Scarlet (Isle of Man), which Dr. W. S. BISAT and Dr. J. S. TURNER kindly showed me and which also had the 4th lateral lobe just on the lateral side when the height of the whorl equalled approximately 36 mm. However, no complete specimen with coils reaching a 36 mm. height of the whorl has been seen as yet, so that the full ontogenetic development of the suture still remains more or less conjectural.

All the other characteristics of the shape of the shell and the suture-line are the same in both *Merocanites subhenslowi* and *Merocanites henslowi.*

Merocanites subapplanatus SMYTH, as described from the Lower Visean of Ireland, shows the same position of the 4th lateral lobe of specimens of comparable diameter (15 mm. height of whorl as indicated in the table). However, it differs from *Merocanites subhenslowi* nov. sp. in the shape of the 3rd lateral lobe which is shorter and not constricted at the opening.

The recorded specimens of *Merocanites subapplanatus* are all of a small size and the later ontogenetic stages of suture development in this species are still unknown.

Remarks. — It should have been possible to consider *Merocanites subhenslowi* nov. sp. and *Merocanites henslowi* (SOWERBY) as varieties of one and the same species. However, since the later form has been first described, it cannot be recorded as a variety of the earlier form which is described in the present paper. The two forms are therefore regarded as separate species for taxonomic purposes.

The relative stratigraphic position of the three species mentioned under comparisons warrants some comment. The earliest form seems to be *Merocanites subapplanatus* SMYTH from the Rush Slates in County Dublin, Ireland, which has a somewhat less evolved 3rd lateral lobe, all the other characteristics being equal to those of *Merocanites subhenslowi* nov. sp. from Spain. It occurs together with *Pericyclus* cf. *kochi* HOLZAPFEL and *Munsteroceras browni* (MCCOY) (recorded as

M. cf. *corpulentum* form Ø by SMYTH). This assemblage has been referred to Lower Visean, without further precision.

Merocanites subhenslowi nov. sp. apparently represents a precursor of *Merocanites henslowi* (SOWERBY) which shows a more advanced position of the 4th lateral lobe. *M. henslowi* has been recorded from England in a stratigraphic position which is higher than those occupied by *Merocanites compressus* (SOWERBY) and *Merocanites applanatus* (HOLZAPFEL) (according to BISAT, 1934, p. 305). Consequently, *Merocanites subhenslowi* nov. sp. may correspond to the lowest B zone.

Merocanites cf. *henslowi* of SW. Algeria was recorded by PAREYN (1961) from the Djebel Ioucha in association with *Beyrichoceras hodderense* BISAT, *Munsteroceras euryomphalum* SCHINDEWOLF (= *Munsteroceras latumbilicatum* KULLMANN, 1961, p. 266) and *Munsteroceras* (*Nautellipsites*) *pseudoparallelus* DELÉPINE. This fauna was attributed to the S2b zone of PAREYN, i.e. approximately the base of the B zone or top II γ (= II δ ?), according to PAREYN (1961, tabl. IV).

Apparently, *Merocanites subhenslowi* nov. sp. belongs to lower B zone (BISAT) or II γ-δ zones (H. SCHMIDT).

Occurrence. — *NW. Spain* : At 2,70 m. above the base of the Griotte limestone at Olleros de Alba, prov. León, loc. OL-B (holotype and paratype), where it occurs together with *Munsteroceras* cf. *subglobosum* LIBROVITCH and a badly eroded specimen similar to *Munsteroceras djaprakense* LIBROVITCH; at 1,95 m. above the base of the Griotte limestone SW. of Genicera, prov. León (loc. 1167); furthermore at 1,50 to 2,50 m. above the base of the Griotte limestone (Villabellaco formation) ESE of Villabellaco in the Barruelo region of northeastern Palencia, NW. Spain, where it occurs immediately above *Pericyclus* (*Ammonellipsites*) *kayseri* H. SCHMIDT.

Addendum. — In J. KULLMANN's (1963), « Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien). II : Paläontologie der U.O. Prolecanitida MILLER und FURNISH. Die Altersstellung der Faunen » (*Abh. Neues Jahrb. Geol. Pal.*, 116, 3, pp. 269-324, Tafn. 17-20), which appeared after this paper had been written, several specimens of *Merocanites subhenslowi* are figured and described under the name of *Merocanites applanatus* FRECH (pp. 274-276, Taf. 17, figs. 1-2).

The latter identification seems incorrect, because the group of *Merocanites applanatus* is characterised by a more rectangular cross-section than occurs in the group of *Merocanites henslowi.* Even more important is the fact that the lobes are markedly shorter in the *M. applanatus* group.

REFERENCES.

BARROIS, CH., 1881, El mármol amigdaloide de los Pirineos Cantábricos. (*Bol. Inst. Geol. España,* VIII, pp. 131-155, láms B-G.)

— 1882, Recherches sur les terrains anciens des Asturies et de la Galice. (*Mém. Soc. géol. Nord,* II, 1, pp. 1-630, pls. I-XX.)

BISAT, W. S., 1934, The Goniatites of the Beyrichoceras Zone in the North of England. (*Proc. Yorkshire Geol. Soc.,* XXII, pt. IV, pp. 280-309, text-figs. 1-27, pls. XVII-XXIV.)

BISCHOFF, G., 1957, Die Conodonten-Stratigraphie des rhenoherzynischen Unterkarbons mit Berücksichtigung der *Wocklumeria*-Stufe und der Devon/Karbon-Grenze. (*Abh. hess. L-A. Bodenforschung,* 19, 64 p., 6 Tafn.)

BRANSON, E. B., 1938, Stratigraphy and paleontology of the Lower Mississippian of Missouri. Part II. (*Univ. Missouri Studies,* 13, nº 4, pp. 1-242.)

BRANSON, E. B. and MEHL, M. G., 1934 *a*, Conodonts from the Grassy Creek Shale of Missouri. (*Ibid.,* 8, nº 3, pp. 171-259, pls. 13-21.)

— 1934 *b*, Conodonts from the Bushberg sandstone and equivalent formations of Missouri. (*Ibid.,* 8, nº 4, pp. 265-300, pls. 22-24.)

— 1941, New and little known Carboniferous conodont genera. (*Jour. Paleontology,* 15, pp. 97-106, pl. 19.)

BRANSON, E. R., 1934, Conodonts from the Hannibal Formation of Missouri. (*Univ. Missouri Studies,* 8, nº 4, pp. 301-343, pls. 25-28.)

COLLINSON, C., SCOTT, A. J. and REXROAD, C. B., 1962, Six charts showing biostratigraphic zones and correlations based on conodonts from the Devonian and Mississippian rocks of the Upper Mississippi Valley. (*Illinois Geol. Survey Circ.,* 328, 32 p.)

COMTE, P., 1938, La transgression du Famennien supérieur dans la Cordillère Cantabrique. (*C. R. Acad. Sci. Paris,* 206, pp. 1741-1743.)

— 1959, Recherches sur les terrains anciens de la Cordillère Cantabrique. (*Mem. Inst. Geol. Min. España,* LX, 404 p., carte géol. en couleurs, 5 coupes.)

COOPER, C. L., 1939, Conodonts from a Bushberg-Hannibal horizon in Oklahoma. (*Jour. Paleontology,* 13, nº 4, pp. 379-422, pls. 39-47.)

DELÉPINE, G., 1941, Les Goniatites du Carbonifère du Maroc et des confins algéro-marocains du Sud (Dinantien-Westphalien). (*Not. Mém. Serv. géol. Maroc*, 56, pp. 1-111, pls. I-VIII.)

— 1943, Les faunes marines du Carbonifère des Asturies (Espagne). (*Mém. Acad. Sci. Inst. France*, 66, pp. 1-122, pls. I-VI.)

FOORD, A. H., 1903, Monograph of the Carboniferous Cephalopoda of Ireland. (*Pal. Soc. London*, 55, pt. V, pp. 147-234, pls. XL-XLIX.)

GUNNELL, F. H., 1931, Conodonts from the Fort Scott limestone of Missouri. (*Jour. Paleontology*, 5, n° 3, pp. 244-252, pl. 29.)

— 1933, Conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee groups of Missouri and Kansas. (*Ibid.*, 7, n° 3, pp. 261-298, pls. 31-33.)

HASS, W. H., 1953, Conodonts of the Barnett formation of Texas. (*U. S. Geol. Survey Prof. Paper*, 243-F, pp. 69-94, pls. 14-16.)

— 1959, Conodonts from the Chappel Limestone of Texas. (*Ibid.*, 294-J, pp. 365-399, pls. 46-50.)

HIBBARD, R. R., 1927, Conodonts from the Portage group of western New York. (*Am. Jour. Sci.*, [5], 13, n° 75, pp. 189-208, pls. 1-4.)

HIGGINS, A. C., 1962, Conodonts from the Griotte Limestone of NW. Spain. (*Not. Com. Inst. Geol. Min. España*, 65, pp. 5-22, pls. 1-3.)

HOLZAPFEL, E., 1889, Die Cephalopoden-führenden Kalke des unteren Carbon von Erdbach-Breitscheid bei Herborn. (*Paläont. Abhandlungen*, [N. F.], V, 1, pp. 3-74, Tafn I-VIII.)

KULLMANN, J., 1961, Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien). I. Stratigraphie. Paläontologie der U. O. Goniatitina HYATT. (*Abh. Neues Jahrb. Geol. Paläont.*, 113, n° 3, pp. 219-326, Abb. 1-12, Tafn 19-23.)

— 1962, Die Goniatiten der Namur-Stufe (Oberkarbon) im Kantabrischen Gebirge. (*Abh. Math.-Naturwiss. Kl. Akad. Wiss. Lit.*, Jahrg. 1962, n° 6, pp. 261-377, Tafn 1-7.)

LIBROVITCH, L. S., 1927, Lower Carboniferous Cephalopods from the Son-Kul region (Tian Shan). (*Comité Géol., Leningrad, Matériaux*, 74, pp. 1-55, pls. 1-7.)

LYS, M. et SERRE, B., 1958, Contribution à la connaissance des microfaunes du Paléozoïque. Études micropaléontologiques dans le Carbonifère marin des Asturies (Espagne). (*Revue Inst. français du Pétrole et Ann. Comb. liquides*, XIII, n° 6, pp. 879-916, pls. I-XI, tabl. I et II.)

MEHL, M. G. and THOMAS, L. A., 1947, Conodonts from the Fern Glen of Missouri. (*Denison Univ. Jour. Sci. Labs*, 40, art. 2, pp. 3-19, pl. I.)

PAREYN, CL., 1961, Les massifs carbonifères du Sahara sud-oranais. (*Publ, Centre Recherches sahariennes*, [Ser. géol.], I, t. II : Paléontologie, pp. 1-244. pl. I-XXVIII.)

ROUNDY, P. V., 1926, Part 2 : The microfauna, *in* ROUNDY, GIRTY and GOLDMAN, Mississippian formations of San Saba County, Texas. (*U. S. Geol. Survey Prof. Paper*, 146, pp. 5-23, pls. 1-4.)

SANNEMAN, D., 1955, Oberdevonische Conodonten (to II). *Senckenbergiana Lethaea*, 36, pp. 123-156, 6 Tafn.)

SCHINDEWOLF, O. H., 1926, Beiträge zur Kenntnis der Cephalopodenfauna des oberfränkisch-ostthüringischen Unterkarbons. (*Senckenbergiana*, 8, pp. 63-96, Abb. 1-11.)

— 1951, Über ein neues Vorkommen unterkarbonischer *Pericyclus*-Schichten im Oberharz. (*Abh. Neues Jahrb. Geol. Paläont.*, 93, pp. 23-116, Abb. 1-36, Tafn 3-7.)

SCHINDEWOLF, O. H. und KULLMANN, J., 1958, Cephalopoden-führendes Devon und Karbon im Kantabrischen Gebirge (Nordspanien). (*Mh. Neues Jahrb. Geol. Paläont.*, 1958-1, pp. 12-20.)

SCOTT, A. J. and COLLINSON, C., 1961, Conodont faunas from the Louisiana and McCraney Formations of Illinois, Iowa and Missouri. (*Kansas Geol. Soc. 26th Ann. Field Conf. Guidebook*, pp. 110-141, 2 pls.)

SCHMIDT, H., 1925, Die carbonischen Goniatiten Deutschlands. (*Jahrb. Preuss. Geol. L. A.*, XLV [1924], pp. 489-609, Tafn 19-26.)

SMYTH, L. B., 1951, A Visean Cephalopod fauna in the Rush Slates of Co. Dublin. (*Proc. Roy. Irish Acad.*, 53, section B, nº 15, pp. 289-308, textfig. 1, pl. XI.)

STAUFFER, C. R. and PLUMMER, H. J., 1932, Texas Pennsylvanian conodonts and their stratigraphic relations. (*Univ. Texas Bull.*, 3201, *Contr. to Geology*, pt. I, pp. 13-50, pls. 1-4.)

VOGES, A., 1959, Conodonten aus dem Unterkarbon des Sauerlandes (*Gattendorfia*- und *Pericyclus*-Stufe) (*Paläont Z*, 33, nº 4, pp 266-314, Tafn 33-35.)

— 1960, Die Bedeutung der Conodonten für die Stratigraphie des Unterkarbons I und II (*Gattendorfia*- und *Pericyclus*-Stufe) im Sauerland. (*Fortschr. Geol. Rheinld. u. Westf.*, 3, Teil 1, pp. 197-228, Abb. 1-5, Tab. 1-5.)

WAGNER, R. H., 1955, Rasgos estratigráfico-tectónicos del Paleozoico Superior de Barruelo (Palencia). (*Estudios Geológicos*, XI, 26, pp. 145-202, láms XXVIII-XXXI.)

— 1957, Nota sobre la estratigrafía del terreno hullero de Sabero (León). (*Estudios Geológicos*, XIII, 35-36, pp. 229-239, láms XXXI-XXXV.)

— 1962, A brief review of the stratigraphy and floral succession of the Carboniferous in NW. Spain. (*C. R. IVe Congr. Carbon. Heerlen 1958*, III, pp. 753-762, pls. 29-33.)

— 1963, A general account of the Palaeozoic Rocks between the Rivers Porma and Bernesga (León, NW. Spain). (*Bol. Inst. Geol. Min. España*, 74, 163 p., figs. 1-35, geol. map.)

WAGNER, R. H. and WAGNER-GENTIS, C. H. TH., 1963, Summary of the Stratigraphy of Upper Palaeozoic Rocks in NE. Palencia, Spain. (*Proc. Kon. Ned. Akad. Wetenschappen*, Amsterdam, [B], LXVI, 3, pp. 149-163.)

WAGNER-GENTIS, C. H. TH., 1960, On *Nautellipsites hispanicus* (FOORD and CRICK). (*Estudios Geológicos*, XVI, nº 1, pp. 43-51, figs. 1-4.)

— 1963, Lower Namurian goniatites from the Griotte limestone of the Cantabric Mountain Chain. (*Not. Com. Inst. Geol. Min. España*, 69, pp. 5-42, pls. I-VIII.)

ZIEGLER, W., 1959, Conodonten aus Devon und Karbon Südwesteuropas und Bemerkungen zur bretonischen Faltung. (*Mh. Neues Jahrb. Geol. Paläont.*, 1959-7, pp. 289-309.)

— 1962, Taxionomie und Phylogenie oberdevonischer Conodonten und ihre stratigraphische Bedeutung. (*Abh. Hess. Landesamt f. Bodenforschung*, 38, 166 p., 14 Tafn.)

EXPLANATION OF PLATES.

The conodonts are figured × 40 or × 30. Photographs by the author. The specimens are stored in the Micropalaeontological Laboratory of the Department of Geology, University of Sheffield, England.

Goniatites are figured natural size and × 3. The photographs are due to Mr. B. PIGOTT (Department of Geology, University of Sheffield). The specimens are to be deposited in the collections of the Institute « Lucas Mallada » in the « Museo Nacional de Ciencias Naturales », Castellana 84, Madrid.

PLATE I

EXPLANATION OF PLATE I.

Goniatites.

FIG. 1. — *Pericyclus* sp. (=*P. hauchecornei* DELÉPINE, non HOLZAPFEL), nat. size.

Ventral view of ultimate whorl, showing the coarse transverse ribbing. Locality OL-A, Olleros de Alba (León), basal Griotte limestone, Lower Visean, II β-γ zone.

FIG. 2. — Same specimen, nat. size.

Ventral view of penultimate whorl, which is less coarsely transversely ribbed than the ultimate whorl.

FIG. 3. — Same specimen, ×3.

Ventral view of penultimate whorl. It shows faintly several thin lirae forming one transverse rib which is rather worn.

FIG. 4. — Same specimen, ×3.

Lateral view of penultimate whorl.

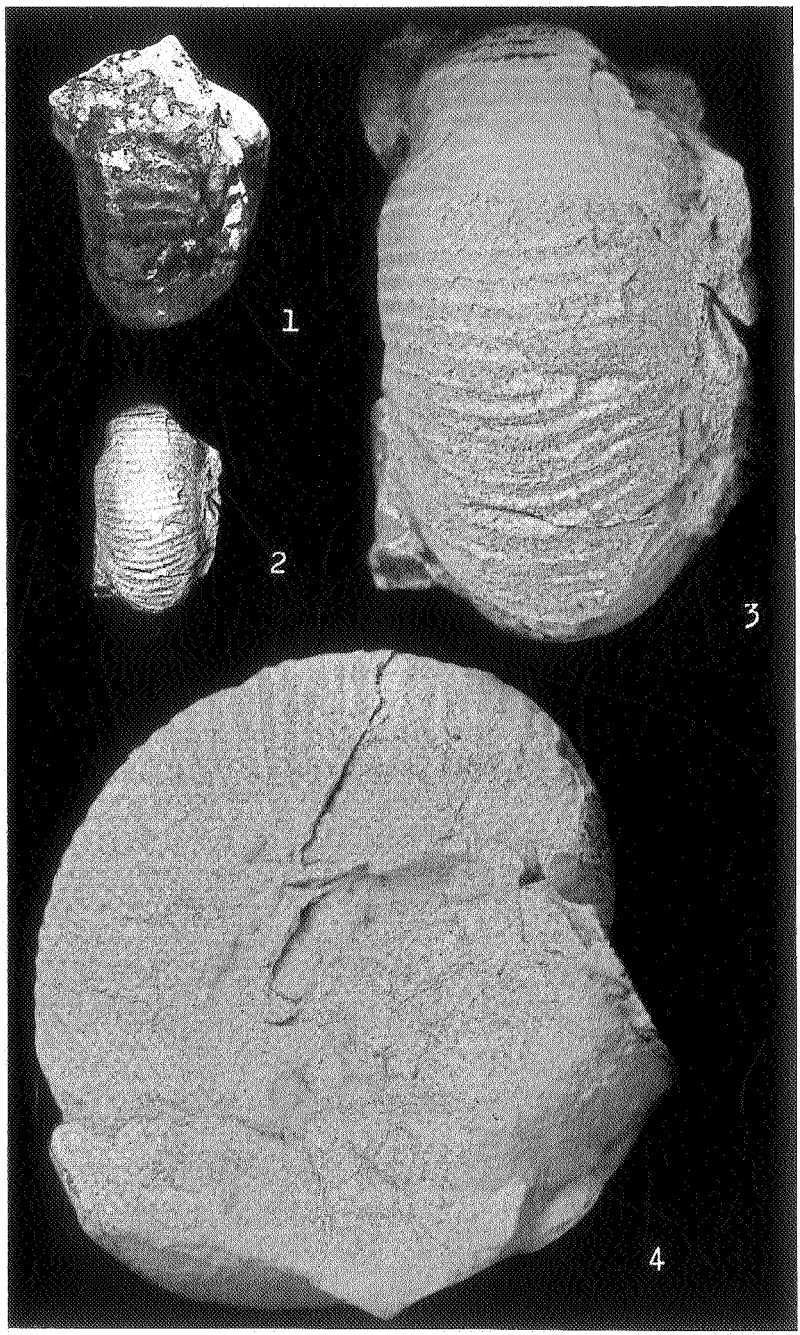

1
2
3
4

PLATE II

EXPLANATION OF PLATE II.

Goniatites.

FIG. 5. — *Munsteroceras browni* (McCOY) DELÉPINE, nat. size.
Ventral view. Locality OL-A, Olleros de Alba (León), basal Griotte limestone, Lower Visean, II β-γ zone.

FIG. 6. — Same specimen, ×3.
Ventral view, showing straight sides of ventral lobe with the siphonal notch at the base of the lobe and the parallel sides of the 1st. lateral saddle.

FIG. 7. — Same specimen, nat. size.
Lateral view.

FIG. 8. — Same specimen, ×3.
Lateral view, which shows the wide umbilicus and, in one place. the acute umbilical shoulder.


5
7
6
8

PLATE III

EXPLANATION OF PLATE III.

Goniatites.

(All figures natural size.)

FIG. 9. — *Munsteroceras* cf. *subglobosum* LIBROVITCH.

Lateral view, which shows traces of two succeeding lateral lobes. They are shaped like large pointed V's. Locality OL-B, Olleros de Alba (León). Red Griotte at 2.70 metres above the base of the limestone formation.

FIG. 10. — Same specimen.

Ventral view, which shows traces of two succeeding sutures. The flexuous sides of the ventral lobes may be due to erosion.

FIG. 11. — *Merocanites subhenslowi* nov. sp.

Lateral side. Locality 1167, SW. of Genicera (León). Red Griotte, at 1.95 metres above the base of the limestone formation.

FIG. 12. — *Merocanites subhenslowi* nov. sp.

Paratype. Lateral view. The 2nd. of the three sutures shows quite clearly the 4th. lateral lobe, situated on the lateral side near the umbilical shoulder. Locality OL-B, Olleros de Alba (León). Red Griotte at 2.70 metres above the base of the limestone formation.

FIG. 13. — Same specimen.

Dorsal view of a whorl fragment.

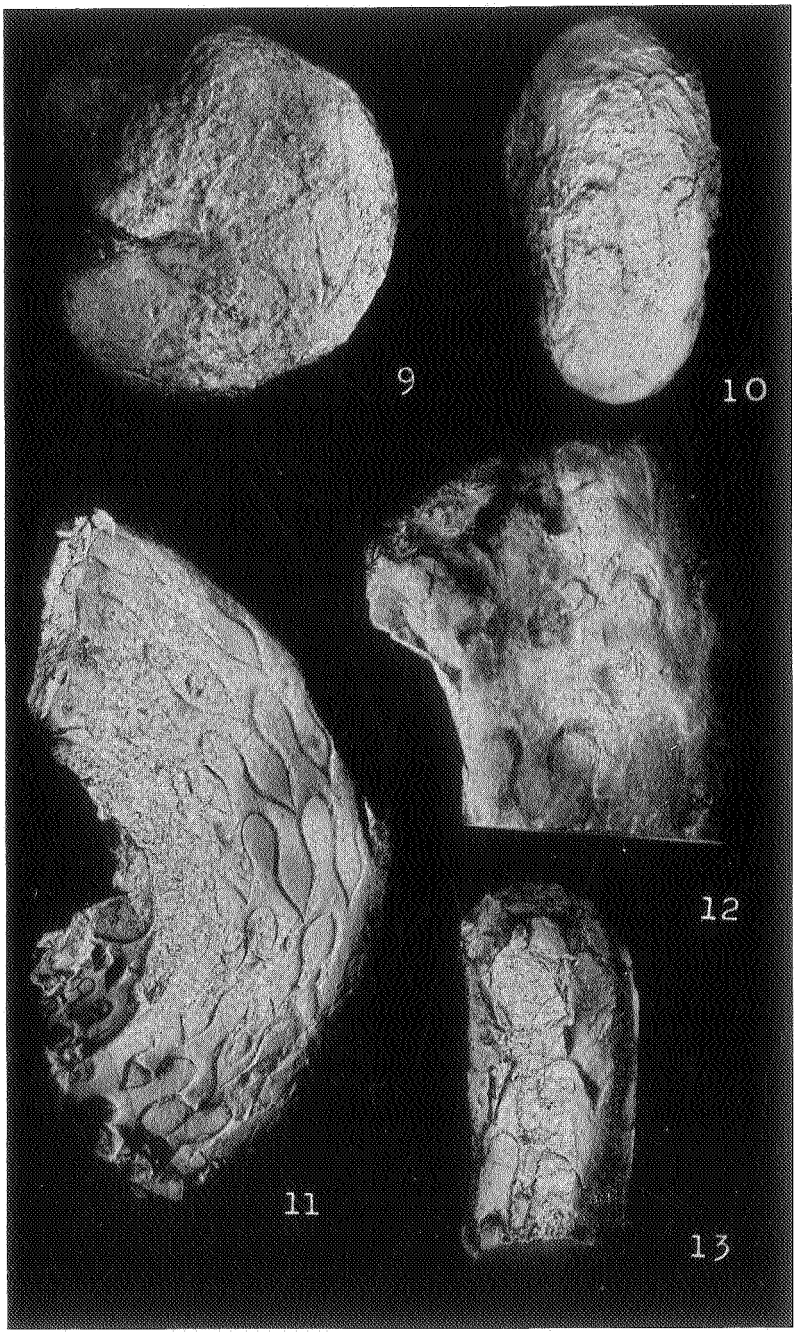

9
10
12
11
13

PLATE IV

EXPLANATION OF PLATE IV.

Goniatites and Conodonts.

FIG. 14. — *Merocanites subhenslowi* nov. sp., nat. size.
Holotype. Lateral view. Locality OL-B, Olleros de Alba (León). Red Griotte at 2.70 metres above the base of the limestone formation.

FIG. 15. — *Polygnathus* cf. *flabella* BRANSON and MEHL, ×40.
Oral View. Cat. No. 1171 II (1).

FIG. 16. — *Pseudopolygnathus triangula pinnata* VOGES, ×40.
Oral View. Cat. No. OL I (1).

FIG. 17. — *Scaliognathus anchoralis* BRANSON and MEHL, ×40.
Oral View. Cat. No. OL I (2).

FIG. 18. — *Spathognathodus inornatus* (BRANSON and MEHL), ×40.
Lateral View. Cat. No. 1164 (1).

FIG. 19. — *Doliognathus lata* BRANSON and MEHL, ×40.
Oral View. Cat. No. OL I (3).

FIG. 20. — *Doliognathus lata* BRANSON and MEHL, ×40.
Oral View. Cat. No. OL I (4).

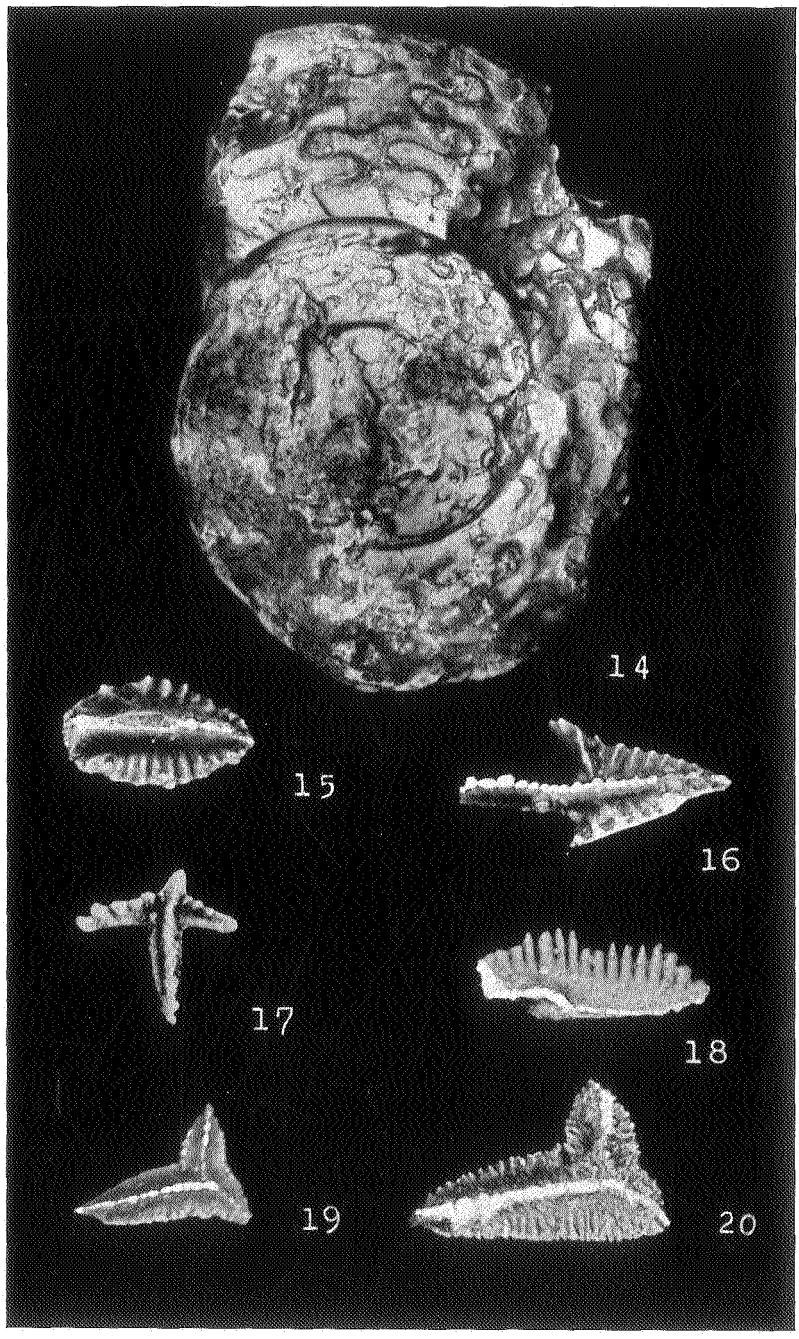

14
15
16
17
18
19
20

PLATE V

EXPLANATION OF PLATE V.

Conodonts.

FIG. 21. — *Spathognathodus costatus costatus* (E. R. BRANSON), ×40.
Oral View. Cat. No. 1164 (2).

FIG. 22. — *Spathognathodus costatus spinulicostatus* (E. R. BRANSON), ×40.
Oral View. Cat. No. 1339 (1).

FIG. 23. — *Gnathodus* cf. *delicatus* BRANSON and MEHL, ×30.
Oral View. Cat. No. 1109 (1).

FIG. 24. — *Gnathodus delicatus* BRANSON and MEHL, ×30.
Oral View. Cat. No. 1109 (2).

FIG. 25. — *Gnathodus* sp., ×40.
Oral View. Cat. No. 1207 A (1).

FIG. 26. — *Gnathodus* sp. B, ×40.
Oral View. Cat. No. OL I (5).

FIG. 27. — *Gnathodus kockeli* BISCHOFF, ×40.
Oral View. Cat. No. 1310 (1).

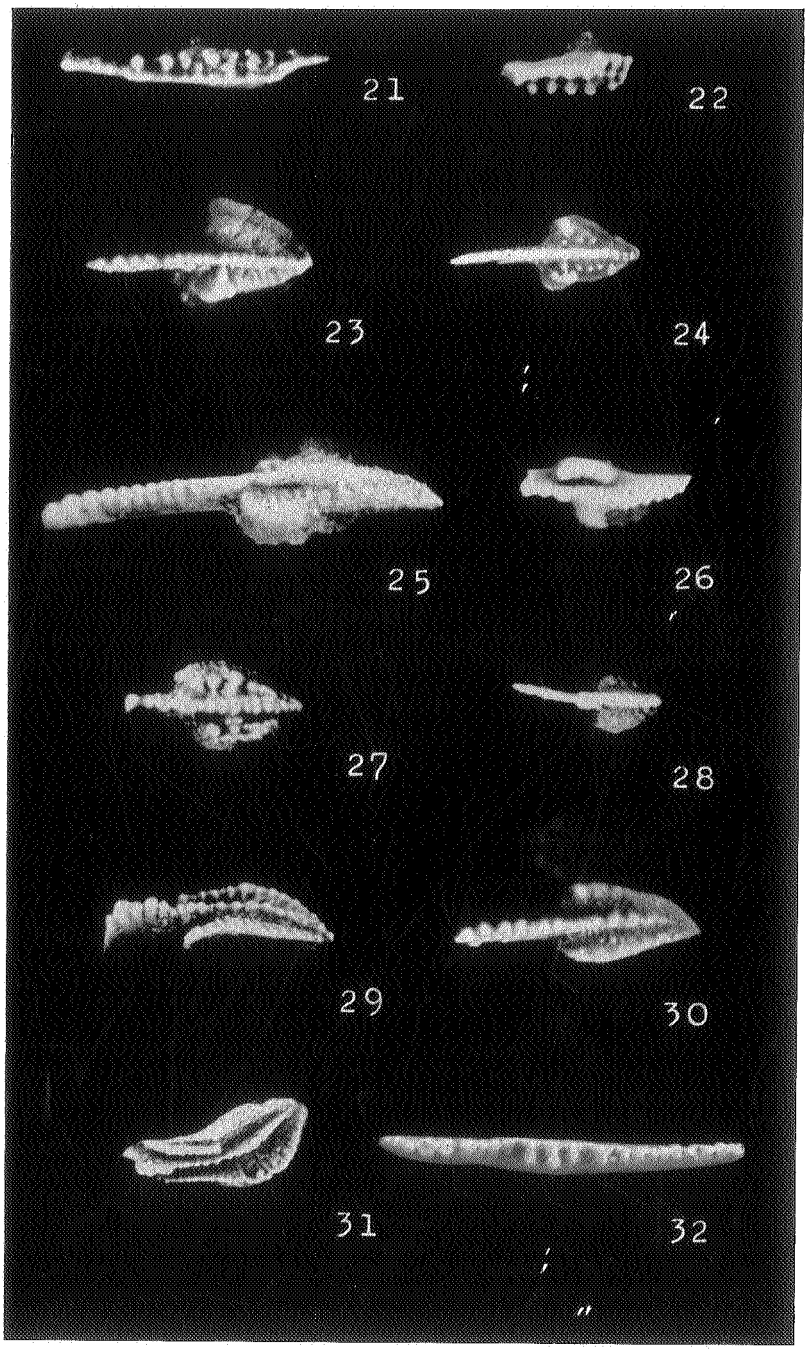
FIG. 28. — *Gnathodus* sp. A, ×30.

FIG. 29. — *Polygnathus inornata* E. R. BRANSON, ×40.
Oral View. Cat. No. 1207 A (2).

FIG. 30. — *Polygnathus communis* BRANSON and MEHL, ×40.
Oral View. Cat No. OL I (6).

FIG. 31. — *Siphonodella cooperi* HASS, ×40.
Oral View. Cat. No. 1311 (1).

FIG. 32. — *Spathognathodus aculeatus* (BRANSON and MEHL), ×40.
Oral View. Cat. No. 1164 (3).


21
22
23
24
25
26
27
28
29
30
31
32