

THE STRATIGRAPHY OF NAMURIAN AND WESTPHALIAN ROCKS IN THE VILLAMANÍN AREA OF NORTHERN LEÓN, N. W. SPAIN

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ABSTRACT

Some 2,400 metres of sediments, ranging from Tournaisian to Westphalian C in age, are recorded from the northern flank and the folded core of the Cármenes Syncline in the Villamanín area, northern León (text-fig. 1). Incompletely developed Tournaisian is followed by a full succession of Viséan and Namurian rocks, commencing with highly condensed nodular limestones (20-25 m, corresponding to Viséan and Lower Namurian), which pass gradually into several hundred metres of fetid limestone (ca. 350 m, corresponding to late Namurian A and Namurian B) and more massive limestones wedging into terrigenous rocks (up to 750 m thick, and corresponding to late Namurian B, Namurian C and basal Westphalian A). The Namurian A (upper), B and C limestones form the «caliza de montaña» (text-fig. 1), and the two units mentioned are the Barcallente and Valdeteja formations, respectively (cf. WINKLER PRINS 1971).

Uplift during Westphalian A times produced non-sequences in a thin terrigenous succession (text-fig. 2: between R 22 and R 25) below a prominent limestone («caliza masiva») of Westphalian B (also Kashirian) age. A mainly terrigenous basin fill succession, some 600 m thick, leads to lower Westphalian C regressive marine, rhythmic units with seat-earths and thin coals at the top. Foraminiferal and algal limestones figure characteristically in this part of the succession, which also dates as Kashirian (text-figs. 3, 4, 5).

Dating in terms of N. W. European chronostratigraphic units is based on miospore assemblages, viz. (1) a *Raistrickia fulva* Zone (Namurian B-C), (2) *Dictyotrites bireticulatus* Zone (lower Westphalian A), (3) *Vestispora pseudoreticulata* Zone (Westphalian B), (4) a *Triquitrites additus* Zone (lower Westphalian C). These spore assemblages are summarized in Table 2 and their significance is discussed. Sporadic plant impression floras are figured (Pls 7-8) and discussed.

Occasional finds of goniatites (Pls. 2-6) in terrigenous strata, ranging from Namurian B to Westphalian B, span the Morrowan of the North American Mid-Continent region. These cephalopods are described in conjunction with goniatites found elsewhere in N. W. Spain from similar horizons. A new genus and species, *Rodiezmoceras bisati*, is described from the Villamanín area, and a new species, *Retites merensis*, is recorded from eastern Asturias.

The occurrence of miospores, plant impressions, cephalopods and foraminifera (including fusulinids), in one and the same succession of strata allows certain correlations to be admitted. The lower limit of the Morrowan in Arkansas, U. S. A., may lie within or just below the upper Namurian B. The Lower Bashkirian of the Russian sequence correlates with Namurian C and basal Westphalian A, which also compares with the Middle Morrowan. The lower limit of the Moscovian may be sought within lower Westphalian B or even in the upper Westphalian A, since the Westphalian B and lower Westphalian C are found to equate with Kashirian. The correlations obtained are summarized in Table 1.

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RESUMEN

Alrededor de 2.400 m de sedimentos, abarcando edades entre el Tournaisiense y el Westfaliense C, son descritos del flanco septentrional y del núcleo plegado del Sinclinal de Cármenes en la región de Villamanín, provincia de León (Fig. 1). A un Tournaisiense incompleto se le superpone un Viséense y Namuriense completos. El Viséense comienza con calizas nodulares de facies condensada (20 a 25 m) que llegan al Namuriense inferior. Pasan gradualmente a varios centenares de metros de calizas fértidas, con espesor aproximado de 350 m, y que corresponden al Namuriense A alto y Namuriense B. Encima se encuentran calizas más masivas que se acuñan en estratos terrígenos. Estas calizas llegan a tener un espesor del orden de 750 m, y corresponden al Namuriense B alto, Namuriense C y Westfaliense A más inferior. Las calizas del Namuriense A alto, Namuriense B y C, y base del Westfaliense A constituyen el complejo de la «caliza de montaña» (Figs. 1,4), distinguiéndose dos unidades llamadas Formación Barcaliente y Formación Valdeteja, respectivamente (WINKLER PRINS 1971).

Un levantamiento durante el Westfaliense A dió lugar a hiatos estratigráficos en una secuencia terrígena delgada (Fig. 2: entre las localidades R 22 y R 25), y antes de formarse una caliza potente («caliza masiva») de edad Westfaliense B ó Kashiriense. Después la cuenca se rellenó con sedimentos principalmente terrígenos, con un espesor de 600 m, a cuyo techo se encuentran ritmos sedimentarios regresivos de edad Westfaliense C inferior, que comienzan con estratos marinos y que terminan con suelos de vegetación y carbones delgados. En la parte alta de esta sucesión se encuentran a menudo calizas con foraminíferos y algas, que pertenecen al Kashiriense (Figs. 3, 4, 5).

La secuencia se ha datado en términos de la cronoestratigrafía del NW de Europa mediante las siguientes asociaciones de miosporas: (1) Zona de *Raistrickia fulva* (Namuriense B-C), (2) Zona de *Dictyotrites bireticulatus* (Westfaliense A inferior), (3) Zona de *Vestispora pseudoreticulata* (Westfaliense B), (4) Zona de *Triquitrites additus* (Westfaliense C inferior). Estas asociaciones se han representado en el Cuadro 2, presentándose además un comentario sobre su significado estratigráfico. La escasa microflore encontrada se comenta y se figura en las láminas 7 y 8.

Se presenta una descripción sistemática de los goniatítidos esporádicos que han sido encontrados en estratos terrígenos de la secuencia Namuriense B-Westfaliense B, tanto de la zona de Villamanín como de otros lugares del NW de España (láminas 2 a 6). Se trata de especies encontradas en el Morrowiense de EE. UU. y en el Bashkiriense de la URSS. Además, se describen un género y especie nueva, *Rodiezmoceras bisati*, de la región de Villamanín, y una nueva especie, *Retites merensis*, de la región oriental de Asturias.

La presencia simultánea de miosporas, impresiones de plantas, cefalópodos y foraminíferos en una sola sucesión de estratos permite establecer ciertas correlaciones. Se constata que el límite inferior del Morrowiense de Arkansas (EE. UU.) se sitúa dentro o justamente por debajo del Namuriense B superior. El Bashkiriense inferior de la cronoestratigrafía rusa, basada en la secuencia de la cuenca del Donetz, se equipara al Namuriense C y Westfaliense A más bajo, que equivale igualmente al Morrowiense medio de EEUU. El límite inferior del Moscoviense puede encontrarse dentro del Westfaliense B o en el Westfaliense A superior, ya que el Westfaliense B y el Westfaliense C inferior se correlacionan con el Kashiriense (es decir, la parte alta del Moscoviense inferior). Estas correlaciones están representadas en el Cuadro 1.

INTRODUCTION

A photogeological and field reconnaissance of Palaeozoic strata in the area between the Orma and Bernesga rivers (WAGNER 1963) has been followed by more detailed partial investigations (eg. HIGGINS *et al.* 1964). Among the latter is a stratigraphic investigation of the region immediately west and east of the Bernesga river, in the area of Villamanín (text-fig. 1), where rocks of Namurian and Westphalian ages crop out in the Cármenes Syncline. Field work for this investigation was mainly done during the summer of 1961, with some additional collecting and palaeontological work extending throughout more recent years.

A reasonably full stratigraphic section was measured by L. R. M., with the assistance of R. N. and R. H. W., in the Valle El Ejío, N. N. W. of Rodiezmo (text-figs 1, 2). Two additional, less complete sections were measured by R. H. W. in the railway cutting south of Villanueva de la Tercia (text-figs 1, 3) and near Barrio de la Tercia (text-figs 1, 4). Furthermore, a general sequence of strata in the vicinity of Viadangos de Arbas (text-fig. 1) was established by R. N. and R. H. W. The relative position of the measured sections is indicated in the general stratigraphic column of text-fig. 5. Stratigraphic dating is based mainly on palynological investigations effected by R. N., in combination with cephalopod identifications by C. H. T. W.-G., the classification of fusulinid and other foraminiferal faunas by Mr. G. SCHMERBER (Institut Français du Pétrole), brachiopod faunas by Dr. C. F. WINKLER PRINS (Rijksmuseum van Geologie en Mineralogie, Leiden), and some impression floras by R. H. W.

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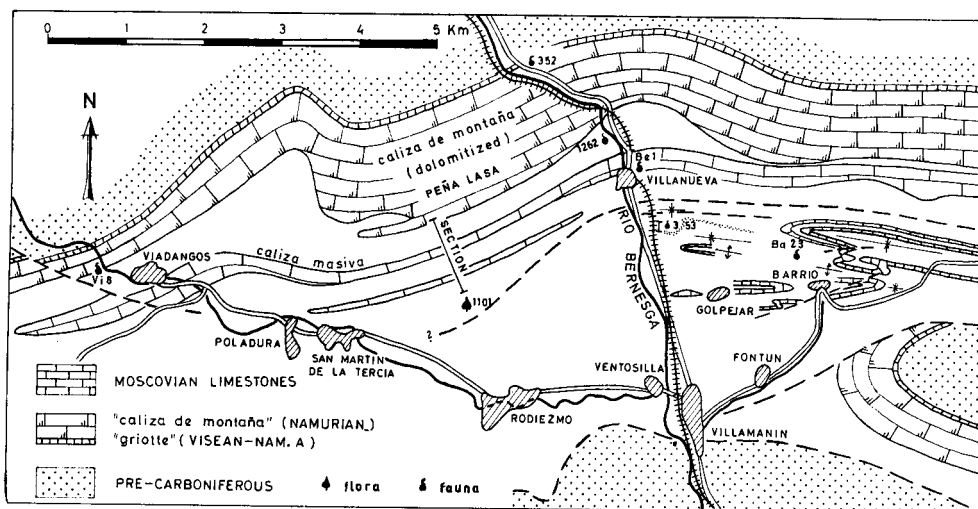
In the years that elapsed since this investigation commenced, some independent work was published by DE SITTER (1962), RÁCZ (1965), EVERS (1967) and MARCOS (1968), dealing with the general structure of the area and bringing further information on its stratigraphy. Previous work includes BARROIS' (1882, p. 577) record of brachiopods, gastropods and echinoderms from a locality near Villanueva de la Tercia.

GEOLOGICAL SETTING

The area investigated forms a small part of the Cármenes Syncline (WAGNER 1963) which is a large isoclinal structure with a heavily crumpled core. It can be followed along the strike for at least 60 km, and is generally about 3 to 4 km wide. The eastern end of this structure lies in the vicinity of Valdeteja (cf. WINKLER PRINS 1971) and its western continuation is found in the area south of San Emiliano (GÓMEZ DE LLARENA & RODRÍGUEZ ARANGO 1948, VAN DEN BOSCH 1969, MARCOS 1968). The northern and southern limits of the E-W striking syncline are determined by thrust faults which are presently found to be dipping almost vertically, but which were originally formed as southward dipping overthrusts, with movement from south to north. The steepening of the dip of the thrust planes was accompanied by a reversal of the regional dip of strata which are now inclined *ca.* 60° N., but which probably dipped originally a similar amount to the south. The magnitude of the thrusting induced

DE SITTER (1962) to postulate nappes, and according to this interpretation the Cármenes Syncline belongs to the «Bodón Nappe» unit. DE SITTER's interpretative section through this unit shows southward dipping strata (which, in fact, dip approximately 60° N) with flat overthrusts which are drastically steepened at outcrop. Although there is general agreement about the northward movement of thrusting, the extreme flattening of the overthrusts at depth is not proven, and it may be that the structure should be interpreted as isoclinal thrust slices rather than fully developed nappe structures. The same general style of folding and thrusting is envisaged, but the area does not seem to be sufficiently developed structurally to be interpreted as consisting of first order nappes.

In keeping with the general interpretation of thrusts moving from south to north, it is found that the southern flank of the Cármenes Syncline is heavily disturbed. The thrust area constituting the southern boundary fault of the syncline shows considerable complexity. A steepened, nearly vertical thrust plane has been bent into a cross-fold S.S.E. of Rodiezmo (text-fig. 1), and it appears that more than one plane of movement coincides in this area. Obviously, the southern flank is too disturbed tectonically for detailed stratigraphic work to be effective. The core of the syncline is quite intensively deformed and crumpled into a number of small, accessory synclines and anticlines. A good deal of detailed mapping would be necessary in order to link up lithological units in the core of the Cármenes Syncline. Only a general succession



Text-fig. 1.—General map of the Villamanín area showing the main units of Carboniferous rocks. The «caliza de montaña» consists of two formations, viz. the Barcaliente Formation below and the Valdeteja Formation above. The latter is strongly wedging and is not represented near Viadangos de Arbas, where a terrigenous sequence is developed instead. Some of the more important fossil localities are marked on this map which also shows the location of the two main sections, i. e. the Valle El Ejío section N. N. W. of Rodiezmo and the railway section south of Villanueva de la Tercia. It seems likely that a minor fault separates the northern flank of the Cármenes Syncline from the folded core which shows the presence of a number of small synclines and anticlines near Barrio de la Tercia and Golpejar.

has been established here. This leaves the relatively undisturbed northern flank of the main syncline as the only suitable location for a measured section. Fortunately, a number of north-south oriented gullies and streams as well as the Bernesga river (text-fig. 1) provide natural sections through the E-W striking strata. One reasonably long section has been measured in the Valle El Ejío N. N. W. of Rodiezmo (text-fig. 2).

The Carboniferous rocks in the northern flank of the Cármenes Syncline show a disconformable contact with the underlying Devonian rocks (see the maps published by COMTE 1959, DE SITTER 1962, WAGNER 1963, MARCOS 1968). The importance of this disconformity has been shown through the work of COMTE (1938), who proved it to be related to strong uplift of the Cantabrian Block in the central part of the Cantabric-Asturian area. The Cármenes Syncline was apparently situated on the southern edge of the Block, and the severity of the uplift in this region is shown by the absence of Middle and Upper Devonian as well as the top part of the Lower Devonian, whereas these rocks are preserved only a few kilometres further south. Above the disconformity a few metres of sandstone (Ermita Formation) are followed by *ca.* 2 m of coarsely crystalline, mainly crinoidal limestone of Strunian age (cf. HIGGINS *et al.* 1964, WAGNER *et al.* 1971). After another stratigraphic gap, due to uplift, a renewed transgression took place with a few metres of black shales (Vegamián Formation), of Upper Tournaisian age, being formed before nodular limestones with a chert band (Genicera Formation - see WAGNER, WINKLER PRINS & RIDING 1971) were deposited as a continuous horizon throughout the Cantabric-Asturian area. The latter has usually been recorded as «griotte» (Marbre griotte of BARROIS 1882, or Mármol grioto of Spanish authors). Despite its very reduced thickness (20-25 m), it represents a great deal of time, from Lower Viséan to Lower Namurian. The «griotte» forms a gradual transition with a thick unit of limestones, usually recorded as «caliza de montaña» (a translation of Mountain Limestone) or as «calcaire des cañons» (BARROIS 1882). In the region discussed here, the «caliza de montaña» consists of two units, viz. well bedded, dark grey, fetid limestones at the base and more massive, lighter grey limestones at the top. The latter contain reefs and can be strongly wedging. The two units are distinguished as separate formations, viz. the Barcaliente and Valde-teja Formations, as described by WINKLER PRINS 1971 and WAGNER *et al.* 1971. Above the «caliza de montaña», and partly as a lateral equivalent of the top unit, a sequence of mudstones and sandstones with occasional bands of limestone is developed. This is the «assisè de Lena» of BARROIS (1882), and the San Emiliano Formation (*sensu lato*) of BROUWER & VAN GINKEL (1964), RÁCZ (1965), VAN GINKEL (1965), EVERS (1967) and WINKLER PRINS (1968). Reasons are given in the present paper to indicate that the San Emiliano Formation, as known from its type area near San Emiliano (León), is probably absent or extremely reduced in the Villamanín area discussed here.

The Carboniferous succession in the Villamanín area has been studied in a number of sections, some of which have been measured in detail, whilst others have only been generally investigated. These sections are discussed overleaf.

BERNESGA VALLEY SECTION

The valley of the Bernesga river cuts the northern flank of the Cármenes Syncline in a gorge excavated in mainly dolomitized «caliza de montaña» which is followed by a terrigenous sequence surmounted by a prominent limestone passing through the village of Villanueva de la Tercia (text-fig. 1). South of Villanueva the folded core of the syncline is exposed along the León-Gijón railway. Only small parts of the total succession have been measured, and the following account will be restricted to the sequence of «griotte» and «caliza de montaña» north of Villanueva.

The «griotte» limestone is worked in a quarry at 2 km N. W. of Villanueva de la Tercia, just off the eastern side of the Bernesga Valley (loc. 352—see text-fig. 1). Viséan and Lower Namurian goniatite and conodont faunas were collected from different points in the quarry. The Viséan faunas were recovered from scree samples and occur in red nodular limestone. *Goniatites* ex gr. *striatus-granosus* SOWERBY-PORTLOCK, Pronoritidae, *Geniculatus claviger* (ROUNDY), *Gnathodus bilineatus* (ROUNDY), *Gn. commutatus commutatus* (BRANSON & MEHL), and *Gn. girtyi* HASS (C. H. T. WAGNER-GENTIS and A. C. Higgins det.) were mentioned in WAGNER 1963 (p. 220). The following Lower Namurian goniatites were subsequently collected from red and cream coloured nodular limestones at unspecified horizons in the quarry (C. H. T. W.-G. det.): *Mesoglyphioceras granosus* var. *aciculare* PAREYN, *Delepinoceras eothalassoide* WAGNER-GENTIS, *Delepinoceras thalassoide* (DELÉPINE), *Gonioboceras declive* WAGNER-GENTIS (see WAGNER-GENTIS, in WAGNER, WINKLER PRINS & RIDING 1971), *Kazakhoceras hawkinsi* (MOORE), *Pronorites arkansasensis* (SMITH), *Prionoceras* cf. *stevanovici* KULLMANN. The first two species mentioned are indicative of the basal Lower Namurian goniatite zone in Spain (equivalent to E₁) and the latter five belong to the E₂ Zone recorded in the Mediterranean area (PAREYN 1961, KULLMANN 1962, 1963b, WAGNER-GENTIS 1963). The exact position of the E₂ horizon in the quarry of loc. 352 could be determined later in a measured section which shows the following units, as recorded by R.H.W.

- 13.—ca. 800 m of dolomitic limestone («caliza de montaña»).
- 12.—5.00 m of well bedded, dark grey, fetid limestone.
- 11.—marly layer (cream coloured) with E₂ goniatites: *Delepinoceras thalassoide*,
Pronorites arkansasensis (loc. 352-0, C. H. T. W.-G. det.)
- 10.—0.90 m of well bedded, dark grey, fetid limestone.
- 9.—marly layer (cream coloured) with unidentified goniatites.
- 8.—10.75 m of well bedded, dark grey, fetid limestones with occasional marly bands and partings of calcareous mudstone.
- 7.—2.65 m of dolomitic limestone.
- 6.—4.60 m of well bedded, dark grey, fetid limestones.
- 5.—0.80 m of pink and grey nodular limestones.
- 4.—1.20 m of dolomitic limestone.
- 3.—0.70 m of pink nodular limestone.
- 2.—1.00 m of red nodular limestone with red shale partings.

1.—6.30 m of red chert with bands of red shale.

The base of the succession is not exposed in the quarry, but up to 7 m of nodular limestones of Lower Viséan age may be present below the chert horizon (as follows from exposures further along the strike).

Beyond unit 5, as measured in the quarry of loc. 352, a gradual passage is found between nodular limestones (still represented in the thin goniatite bands) and dark grey, fetid limestones of the Barcaliente Formation (lower part of «caliza de montaña»). Extensive dolomitization affects the Barcaliente Formation as well as the overlying Valdeteja Formation in the Bernesga Valley. Its irregularity shows it to be secondary, and further along the strike dolomitization is found to be less common or even absent, though recurring elsewhere. The type localities for the Barcaliente and Valdeteja formations occur 23 km eastwards along the strike from the Bernesga Valley section. There, in the Arroyo de Barcaliente and near Valdeteja, ca. 300 m of well bedded, dark grey, fetid limestones of the Barcaliente Formation are separated by an erosional breccia from 675 m of lighter grey and generally more massive limestones of the Valdeteja Formation (WINKLER PRINS 1968, 1971; WAGNER *et al.* 1971). The probable disconformity associated with this breccia at the boundary of the two formations does not appear to involve a measurable time gap. It is likely, however, that more important movements took place at this horizon elsewhere in the Cantabric-Asturian area.

Several hundred metres of terrigenous deposits with occasional limestone bands follow onto the dolomitized «caliza de montaña» in the Bernesga Valley section (text-fig. 1). Within this terrigenous unit, which has not been studied in detail, a large specimen of *Branneroceras branneri* (SMITH) has been found and identified by C. H. T. W.-G. This is a characteristic species of the Lower Bashkirian (U. S. S. R.) and of the basal Upper Morrowan (U. S. A.). Miospores from the *Branneroceras* locality (1262) indicate basal Westphalian A (R. N. *det.*): *Anapiculatisporites spinosus* (KOSANKE) POTONIE & KREMP, *Apiculatisporis variocorneus* SULLIVAN, *Calamospora pallida* (LOOSE) SCHOPF, WILSON & BENTALL, *Cirratriradites* sp., *Crassispora kosankei* (POTONIE & KREMP) BHARADWAJ, *Densosporites* sp., *Dictyotriletes bireticulatus* (IBRAHIM) POTONIE & KREMP, *Florinites pumicosus* (IBRAHIM) SCHOPF, WILSON & BENTALL, *F. similis* KOSANKE, *F. visendus* (IBRAHIM) SCHOPF, WILSON & BENTALL, *Laevigatosporites desmoinesensis* (WILSON & COE) SCHOPF, WILSON & BENTALL, *Lophotriletes microsaetosus* (LOOSE) POTONIE & KREMP, *Lycospora pellucida* (WICHER) SCHOPF, WILSON & BENTALL, *Schulzospora rara* KOSANKE. Preservation of the assemblage was poor.

VALLE EL EJIO SECTION N. N. W. OF RODIEZMO

This section has been measured in some detail (text-figs 1, 2), using exposures in the Valle El Ejío and on adjoining hill tops and in nearby gullies. The measured section starts at the top of the «caliza de montaña» at Peña Lasa, which represents the fullest development of limestone (dolomitized) in the area. The succession is overturned and dips steeply northwards (60° N on the average).

The first deposit after the limestone is a wedging, massive calcareous sandstone occurring as a lens in olive brown calcareous shales and mudstones. The contact between the limestone and the sandstone/shale unit appears somewhat tectonized, a fairly usual phenomenon where the relatively competent limestone and dolomite are in contact with less competent mudstones and shales. A spiriferid brachiopod has been observed in the shales, together with comminuted plant fragments. A poorly preserved spore flora was obtained from this locality (R 20 - R. N. det.): *Ahrensisporites beeleyensis* NEVES, *Cingulizonates loricatus* (LOOSE) BUTTERWORTH & SMITH, *Densosporites anulatus* (LOOSE) SMITH & BUTTERWORTH, *Dictyotriletes karadenizensis* (ARTÜZ) SMITH & BUTTERWORTH, *Lycospora pellucida*, *Radiizonates striatus* (KNOX) STAPLIN & JANSONIUS, *Raistrickia fulva* ARTÜZ, *Potonieisporites elegans* (WILSON & KOSANKE) WILSON & VENKATACHALA. In addition, a number of reworked Devonian elements, including *Emphanisporites* sp., were found as well.

The reworking of Devonian spores shows that nearby land was being eroded to considerable depth. The position of this land mass is conjectural, but cannot have been very near since «caliza de montaña» and its correlatives are developed everywhere in northern León and Asturias, apart from the westernmost area where no Carboniferous is known below Stephanian B and C.

The shales and mudstones of loc. R 20 are followed by 3 m of calcareous sandstone in units of 30-50 cm thick, which are separated by dark, micaceous, silty shales. Within the sandstone small scale current bedding has been found. It also contains occasional small pebbles. The entire unit wedges eastwards. Some of the outcrop has been obscured by hill creep.

About 12.5 m of olive green mudstones and shales (weathering to a brown colour) follow in succession. They contain comminuted plant debris and broken shell remains. A thin calcareous sandstone with comminuted plants separates this horizon from fine, silty, micaceous shales which are followed in turn by sandstone with drifted plant remains at the base. Towards the top this sandstone becomes calcareous. It is succeeded by 8 m of olive green and bluish grey, fine-grained shales with occasional calcareous nodules and containing thin ribs of micaceous sandstone. Spores from this horizon (R 22) comprise the following species (R. N. det.): *Bellisporites bellus* ARTÜZ, *Cirratridites* sp., *Crassispora kosankei*, *Florinites mediapudens* (LOOSE) POTONIE & KREMP, *F. pumicosus* (IBRAHIM) SCHOPF, WILSON & BENTALL, *Limitisporites* sp, *Lophotriletes microsaetosus*, *Lycospora pellucida*, *Mooreisporites fustis* NEVES, *Potonieisporites elegans*, *Radiizonates striatus* (KNOX), *Schopfipollenites ellipsoides* (IBRAHIM) POTONIE & KREMP, *Schulzospora rara*. Moreover, recycled Devonian spores were found. Some evidence of reworked Upper Viséan-Namurian A material is provided by the presence of *Tripartites* cf. *trilinguis* (HORST) POTONIE & KREMP.

Both localities R 20 and R 22 present lower Westphalian A assemblages, but the latter contains the better preserved and more characteristic spore flora. The presence of reworked Devonian and Viséan-Namurian spores in both localities provides a strong indication for movements of uplift taking place during lower Westphalian A times in a nearby area. This indication is emphasized by the evidence of local erosion in the deposits overlying the shales and mudstones of locality R 22.

Immediately above the fine-grained deposits of loc. R 22 lies a calcareous, gritty sandstone, well bedded, with comminuted plant fragments (showing coaly remains in places), flute casts and pebbles at the base which also shows signs of erosion. Among the plant debris a cast of *Stigmara* was observed. Olive green, micaceous shales follow. Above these a thin (60 cm), gritty sandstone is recorded. It wedges into black, micaceous shales alternating with gritty sandstones, showing erosional features at the base. This sequence is overlain by a limestone lens, approximately 3 m thick, in calcareous fossiliferous sandstone, compacted around the limestone. Rubbly limestone in a sandy matrix follows; thus creating the impression of shallow water deposits above wave base. Abundant fossil remains (brachiopods, trilobites, goniatites, etc.) were collected from overlying calcareous shales which also yielded abundant and well preserved plant spores (loc. R 25 - R. N. det.): *Alatisporites pustulatus* IBRAHIM, *Alisporites* sp., *Crassispora kosankei*, *Cingulizonates loricatus*, *Densosporites* cf. *sphaerotriangularis* KOSANKE, *Dictyotriletes bireticulatus*, *Florinites mediapudens*, *Laevigatosporites desmoinesensis* (WILSON & COE) SCHOPF, WILSON & BENTALL, *Limitisporites* sp., *Lycospora pellucida*, *Mooreisporites fustis*, *Reticulatisporites polygonalis* IBRAHIM, *Raistrickia saetosa* (LOOSE) SCHOPF, WILSON & BENTALL, *Schulzospora rara*, *Vestispora pseudoreticulata* SPODE, *Wilsonites delicatus* KOSANKE.

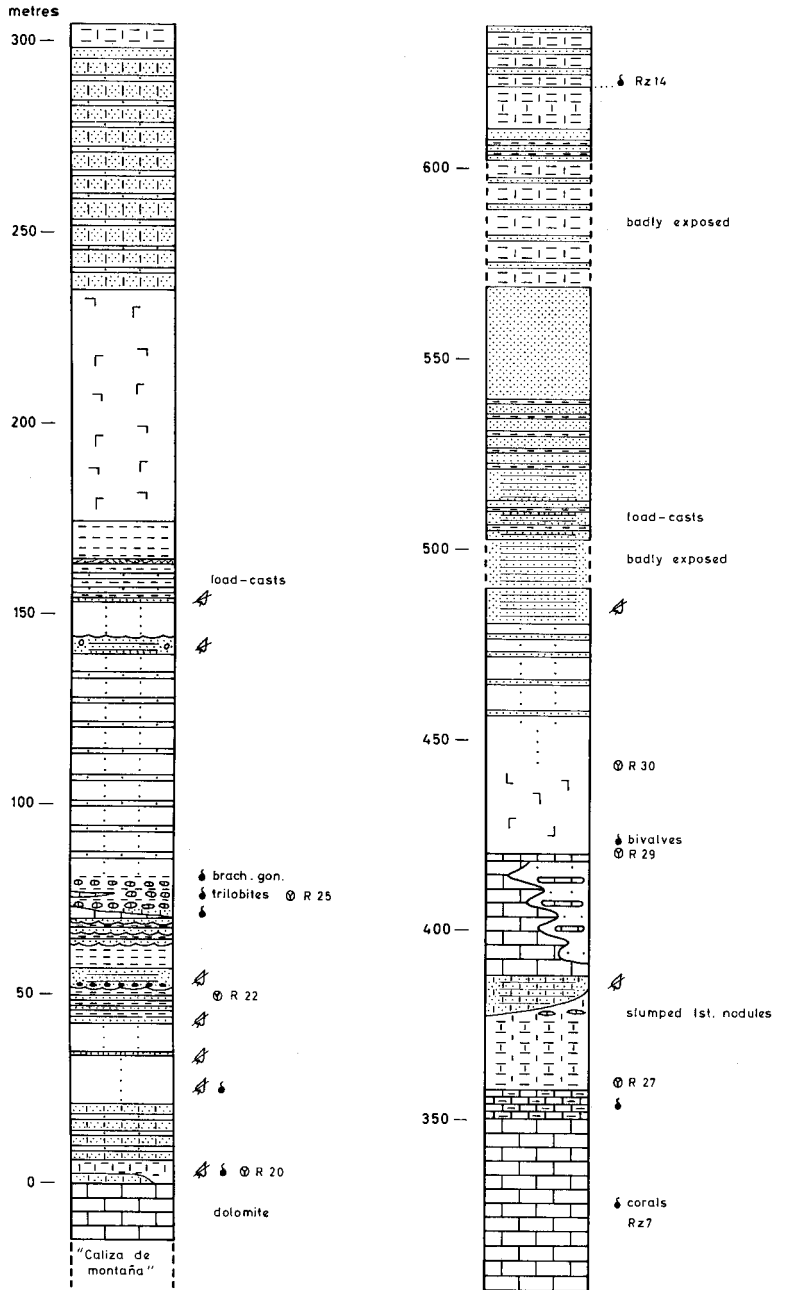
This assemblage is considered to be of lower Westphalian B age, but is unusual in that the disaccate genera *Alisporites* and *Limitisporites* are fairly frequent (2-3 %). There is an appreciable time gap between R 22 and R 25, and this may well mean that movements of uplift reached the area investigated. The absence of reworked Devonian and early Carboniferous material in loc. R 25 may indicate that the movements of uplift had ceased in lower Westphalian B times.

Goniatites collected in loc. R 25 proved to belong to a new genus and species, *Rodiezmoceras bisati* WAGNER-GENTIS, which is regarded as a successor to *Branneroceras branneri* (compare page 351). The trilobites from loc. R 25 have been described as *Gitarra leonensis* sp. nov. by ROMANO (1971).

Succeeding dark brown shales contain an horizon, 60 cm thick, of calcareous nodules passing upwards into a limestone breccia. This changes westwards into a crinoidal limestone. A further band of limestone nodules is found at the top of the shales. This is followed by about 15 cm of shales with brachiopods (*Buxtonia*) and goniatites.

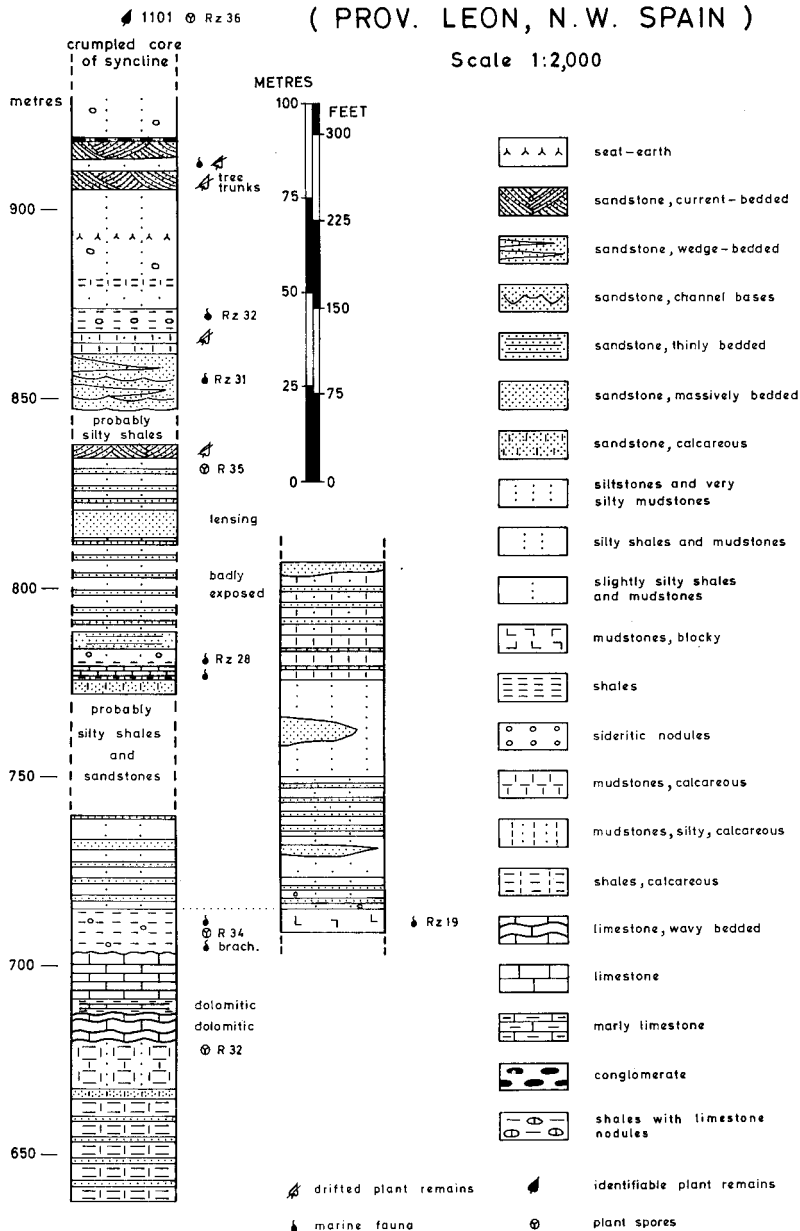
The fossil band is succeeded by ca. 60 m of silty, micaceous shales with sandstone ribs, and 5 m of uniformly bedded, calcareous sandstone (bedding interval 30-50 cm) with plant debris. The latter passes upwards into flaggy, micaceous black shales containing ironstone nodules near the top. There are signs of erosional contacts in the top units, before they pass into silty, micaceous shales, olive green in colour, which are fining upwards.

The next unit commences with 1 m of thinly bedded, micaceous, siltstones and sandstones with carbonaceous matter on the bedding planes. Alternating shales, siltstones and thin sandstones with occasional load casts form the main part of this



SECTION OF MOSCOVIAN AND LOWER WEST-PHALIAN ROCKS NORTH OF RODIEZMO.

(PROV. LEON, N.W. SPAIN)



Text-fig. 2.—Stratigraphic section measured in the Valle El Ejío N. N. W. of Rodiezmo, and representing strata of Westphalian A, B and basal C ages. An important disconformity is developed between localities R 22 and R 25, within rocks of Westphalian A age.

unit which is terminated by 1 m of stratified, micaceous sandstone, load casted at the base, and cross bedded higher up.

Micaceous shales, 10 m thick, are then followed by 60 m of blocky mudstone showing spheroidal weathering in the upper part. It is succeeded by a major unit of calcareous sandstone, in bands of 30-50 cm thickness, with thin partings of micaceous siltstones to silty shales (in intervals of *ca.* 30 cm). A band of felspathic sandstone at the top is followed by calcareous mudstone which leads upwards into a generally massive, light grey limestone, with a tendency to lensing, and containing crinoid debris as well as corals among the few macrofossils observed.

Then follows a yellow weathering, compact, dark limestone with calcareous shale bands. It contains crinoids and brachiopods. The next unit is terrigenous, consisting of calcareous shales, olive green to ochreous in colour, and coarsening upwards to silty mudstone. Limestone nodules occur in the top part of this unit which has yielded a good spore flora (R 27) of Westphalian B age (R. N. *det.*): *Acanthotriletes* sp., *Ahrensia* cf. *guerickei* (HORST) POTONIE & KREMP, *Anapiculatisporites* sp., *Calamospora ferrugosa* (LOOSE) SCHOPF, WILSON & BENTALL, *Cirratriradites saturni* (IBRAHIM) SCHOPF, WILSON & BENTALL, *Densosporites belliatius* ARTÜZ, *D. microanatolicus* ARTÜZ, *Dictyotriletes bireticulatus*, *Endosporites globiformis* (IBRAHIM) SCHOPF, WILSON & BENTALL, *Florinites mediapudens*, *F. similis* KOSANKE, *Illinites* sp., *Knoxia* cf. *dissidius* NEVES, *K. stephanephorus* LOVE, *Leiotriletes adnatus* KOSANKE, *L. sphaerotriangulus* (LOOSE) POTONIE & KREMP, *Laevigatosporites desmoinesensis*, *Limitisporites* sp., *Lycospora pusilla* (IBRAHIM) SCHOPF, WILSON & BENTALL, *Mooreisporites* sp., *Potonieisporites elegans*, *Raistrickia fulva* ARTÜZ, *Reinschospora fimbriata* ARTÜZ, *Savitrissporites nux* (BUTTERWORTH & WILLIAMS) SULLIVAN, *Triquirites* sp., *Verrucosiporites microtuberosus* (LOOSE) SMITH & BUTTERWORTH.

A strongly wedging flaggy, calcareous sandstone (thickening westwards), with drifted plant debris, separates the mudstone horizon from another massive limestone which thins quickly eastwards where it passes into silty shales and sandstones with large limestone nodules. The massive, lensing limestone is capped by a thin band of bedded limestone.

The combined limestone unit can be traced eastwards into the Bernesga Valley, where it passes along the northern edge of the village of Villanueva de la Tercia (text-fig. 1). Here, it lies above the terrigenous unit containing loc. 1262 with *Branneroceras branneri* (compare p. 313). A rubbly horizon at the top of the limestone at Villanueva de la Tercia proved to be quite fossiliferous. A foraminiferal fauna collected from this locality (Be 1) has been examined by Mr. G. SCHMERBER (*in litt.* 21. V. 63): *Profusulinella prisca* (DEPRAT), *Schubertella obscura* LEE & CHEN, *Tuberitina maljavkini* MIKHAILOV, *Haplophragmina kashirica* REITLINGER, *Endothyra* ex gr. *bradyi* MIKHAILOV, *Bradyina magna* ROTH & SKINNER, *Climacammina* cf. *inperta* REITLINGER, *Palaeotextularia vulgaris* (REITLINGER), *P. eofragilis* (REITLINGER), *Spiroplectammina conspecta* REITLINGER, *Eolasciodiscus?* cf. *donbassicus* REITLINGER, *Tetrataxis conica* (EHRENBERG) emend. MOELLER, *Globivalvulina*

scaphoidea REITLINGER, *Eostaffella* sp.; an association of Kashirian age. This is the first direct information in Northwest Spain linking Westphalian B in the N. W. European chronostratigraphic succession with Kashirian of the Russian Moscovian.

Above the limestone, both in the Valle El Ejío section and near Villanueva, a mudstone unit is found. Exposures are discontinuous in the Villanueva area, and the following account refers to the Valle El Ejío. In this section olive green mudstones with marine bivalves are first encountered. They pass gradually upwards into darker, silty shales with thin sandstone ribs and ironstones. Eventually, a fine-grained, well bedded sandstone (bedding interval 15-20 cm) with very thin, micaceous shale partings (only a few mm thick) is reached. The sandstone contains comminuted plant remains. Further flaggy sandstones are poorly exposed, until an horizon of well bedded to flaggy, micaceous sandstones is found, with load casts extending down into shale partings. The load casts show the sequence to be continuous by younging southwards. Thinly bedded, flaggy sandstones and shales follow in a partly not very well exposed succession, leading on towards more massively bedded, fine-grained, feldspathic sandstones, weathering to a yellowish colour. The beds are approximately 30 cm thick in this part of the unit.

Probably calcareous shales, with thin sandstone ribs, follow in a badly exposed part of the succession, and before a flaggy sandstone with thin laminae of micaceous shale is reached. This is succeeded by olive green mudstones and yellow calcareous shales with thin calcareous sandstone bands. A fossil band in this unit yielded *Pterinopecten*. The mudstone/shale unit becomes gradually silty upwards and contains an increasing proportion of darker siltstone and sandstone bands in the higher part. A thin, massive, reddish weathering, calcareous sandstone separates the foregoing unit from another, slightly silty unit of very calcareous mudstones, almost a limestone. This unit yielded a spore flora of upper Westphalian B age (R 32 - R. N. det.): *Acanthotriletes* sp., *Alatisporites pustulatus* IBRAHIM, *Cirratriradites saturni*, *Crassispora kosankei*, *Dictyotriletes bireticulatus*, *Endosporites globiformis*, *E. zonalis* (LOOSE) KNOX, *Florinites mediapudens*, *F. millotti* BUTTERWORTH & WILLIAMS, *Laevigatosporites desmoinesensis*, *Lycospora pellucida*, *Illinites* sp., *Savitrisporites nux*, *Triquitrites bucculentus* GUENNEL, *T. cf. sculptilis* (BALME) SMITH & BUTTERWORTH, *Vestispora cf. costata* (BALME) SPODE, *V. pseudoreticulata* SPODE.

The very calcareous mudstones pass upwards into a dolomitic, irregularly bedded limestone of somewhat nodular appearance, and without visible fossil remains. There follow 4 m of shales with ribs of yellow, dolomitic limestone, which are succeeded by a light grey, regularly bedded limestone, shaly at the base, and more massive in the upper part. Dark fossiliferous shales follow immediately upon the limestone, in a thin band and before a larger unit of olive green mudstones with small ironstone layers is reached. These mudstones are also fossiliferous and contain mainly brachiopods. A sample of mudstone from this horizon (R 34) yielded spores of upper Westphalian B age (R. N. det.): *Ahrensia sporites guerickei* (HORST), *Cingulizonates loricatus*, *Crassispora kosankei*, *Densosporites sphaerotriangularis*, *Dictyotriletes bireticulatus*, *Florinites mediapudens*, *F. pumicosus*, *F. millotti* BUTTERWORTH & WILLIAMS, *Laevigatosporites desmoinesensis*, *Lophotriletes microsaetosus*, *Lycospora pellucida*, *Rais-*

trickia saetosa, *Savitrisporites nux*, *Schopfipollenites ellipsoides*, *Triquitrites sculptilis*, *Vestispora costata*, *V. pseudoreticulata*.

Tracing the top of the limestone eastwards from the valley floor to a path near the hill top, a locality of fossiliferous, blocky, olive green mudstones was explored. These mudstones are calcareous and yield an interesting fauna, mainly of brachiopods but also of other marine animals, including goniatites (Rz 19). The latter belong to the following taxa (C. H. T. W.-G. *det.*): *Proshumardites primus* PLUMMER & SCOTT, *Proshumardites* sp., ?*Diaboloceras* sp., ?*Rodiezmoceras bisati* sp. nov.; an assemblage comparable to that found in the Smithwick Formation of Texas, U. S. A., of Lower Pennsylvanian age. Brachiopods from loc. Rz 19 were examined by Dr. C. F. WINKLER PRINS, who reported the following elements (pers. comm.): chonetids, marginiferid, *Rhipidomella* sp., rhynchonellid.

The section continues with silty, micaceous shales with sandstone ribs, followed by a generally more sandy unit, virtually unexposed in the Valle El Ejío but visible on the hill (section in right hand column of text-fig. 2). A calcareous sandstone, brownish weathering, occurs after the unexposed interval in the valley, and this is followed by calcareous shales and a crinoidal, shaley, detrital limestone which appears to be somewhat dolomitic, and which contains *Chaetetes*. One band, 30 cm thick, with abundant crinoids, forms the top of the limestone. It is followed by blue-grey shales with marine fossils (Rz 28), and this grades upwards into dark, silty shales with ironstone nodules. The fossil locality yielded the following brachiopods (C. F. WINKLER PRINS *det.*): *Linoproductus* sp., *Cancrinella* sp., strophomenid, rhynchonellid.

This limestone horizon appears to be represented by calcareous shales in the section measured on the hill (right hand column, text-fig. 2).

A thinly bedded, micaceous and calcareous sandstone follows in the valley section, and this is succeeded by poorly exposed sandy shales with sandstone ribs, 2-5 cm thick. The section on the hill shows a similar alternation of shales and sandstones, the shales being calcareous. A massive, felspathic sandstone with a hard weathering lenticular quartzose inclusion, 1 m thick, is followed by 1 m of coarse, silty, micaceous shale, which is succeeded by almost 8 m of massive, unbedded sandstone, forming a lensing band across the hill. This is followed by sandy shales with sandstone ribs, and another massive sandstone (*ca.* 4 m thick). The latter is current bedded, coarse-grained, and contains coaly fragments of driftwood. After an unexposed interval, probably occupied by silty shales, a thick horizon of coarse-grained, felspathic and probably somewhat calcareous sandstone occurs. It shows wedge bedding and channel bases, and probably reflects a shallowing of the basin, even though the presence of marine fossils shows that subaerial conditions were not attained. Silty, micaceous, calcareous shales are then followed by calcareous siltstones with micaceous shale partings showing the presence of comminuted plant debris. The next unit consists of dark mudstones and shales with paler, thin, calcareous shales and abundant ironstone layers and nodules packed with fossils (Rz 32). Among the brachiopods Dr. C. F. WINKLER PRINS (pers. comm.) recognized chonetids and a strophomenid.

Silty shales with thin bands of siltstone are subsequently followed by a thin layer of calcareous mudstone and by silty shales with ironstone ribs and nodules.

Then, for the first time, an unmistakably subaerial facies developed in the shape of a lepidophyttalean root bed with abundant rootlets of *Stigmara*. Silty, micaceous shales with sandstone layers follow above the root bed, and these are succeeded by current bedded sandstone, calcareous, with large carbonized trunks of fossil trees. After an interval of micaceous siltstone, a similar current bedded sandstone with driftwood is encountered. The entire unit contains brachiopod shells and is marine, despite the current bedding and the amount of driftwood present. On top of the sandstone a band of coarser sandstone with quartzite and ironstone pebbles occurs. There is a lateral passage to 15 cm of dolomitic limestone which forms a lens. Greenish, silty shales with sandstone ribs and ironstone nodules and bands close the measured sequence.

At this horizon commence a number of small synclines and anticlines representing the core of the Cármenes Syncline. No obvious faulting has been encountered, and it would seem likely that the succession continues normally until an horizon of seat-earths, roof shales and coal is reached at approximately 1,250 metres N. N. W. of Rodiezmo (text-fig. 1). This horizon may be only tens of metres above the last measured deposits. The coal and a seat-earth yielded a well preserved microflora which was dominated by the genera *Lycospora* and *Vestispora*. The presence of small, sculptured *Triquitrites* spp., *Microreticulatisporites nobilis* and *Vestispora* cf. *magna* is considered to indicate a low Westphalian C age, when taken in conjunction with the general assemblage composition, and this locality certainly belongs to an horizon near the Westphalian B/C boundary. The total assemblage is as follows (loc. Rz 36 - R. N. det.): *Ahrensia* cf. *velensis* BHARADWAJ, *Apiculatisporis irregularis* (KOSANKE) POTONIE & KREMP, *Calamospora microrugosa* (IBRAHIM) POTONIE & KREMP, *Camptotriletes bucculentus* (LOOSE) POTONIE & KREMP, *Cirratriradites saturni*, *Crassispora kosankei*, *Densosporites sphaerotriangularis*, *Dictyotriletes* sp., *Endosporites globiformis*, *Florinites mediapudens*, *F.* cf. *millotti*, *Laevigatosporites desmoinesensis*, *Leiotriletes adnatus* KOSANKE, *Lycospora pellucida*, *Microreticulatisporites nobilis* (WICHER) KNOX, *Reticulatisporites polygonalis* IBRAHIM, *Savitrissporites nux*, *Schopfipollenites ellipsoides*, *Triquitrites bucculentus*, *T. exiguus* WILSON & KOSANKE, *Vestispora* cf. *magna* (BUTTERWORTH & WILLIAMS) WILSON & VENKATACHALA, *V. pseudoreticulata*.

The coal has been the subject of small scale workings (mentioned by MALLADA 1898, 2nd edition 1927, p. 206). Plant fragments found on the tip (loc. 1101) are combined with those collected from a silty mudstone above a seat-earth outcropping in the hillside (Rz 36) in order to present the following list (R. H. W. det.): *Paripteris linguaeformis* (P. BERTRAND) GOTHAN, *Neuropteris tenuifolia* (VON SCHLOTHEIM) STERNBERG, *Alethopteris davreuxi* (BRONGNIART) GOEPPERT, *Sphenopteris (Tetratema) alata* BRONGNIART, ? *Mariopteris* sp., *Pecopteris plumosa* (ARTIS) BRONGNIART, *Sphenophyllum* sp. indet., *Annularia microphylla* SAUVEUR, *Cordaites* sp., *Samaropsis* sp. This is an assemblage which could be found in either Westphalian B or early Westphalian C in N. W. Europe.

VIADANGOS DE ARBAS

Near the village of this name (text-fig. 1) a partly different succession of strata is developed. Exposure is continuous up to the top of the «caliza de montaña» which only comprises the Barcaliente Formation in this area. The higher part of the succession is patchily exposed and only a general sequence of strata has been established. The following units are recorded.

- 21.—prominent limestone with reef bodies (continuation of the Kashirian = lower Westphalian B limestone at Villanueva de la Tercia).
- 20.—ca. 25 m blue-grey calcareous mudstones (incompletely exposed).
- 19.—ca. 70 m calcareous mudstones with minor contortions (partly exposed).
- 18.—ca. 35 m grey, silty shales with siltstones and sandstone ribs containing comminuted plant fragments; minor contortions in the shales which are patchily exposed.
- 17.—34 m coarse-grained, dirty sandstones alternating with silty shales with abundant comminuted plant remains and a few identifiable fragments (loc. 1095 - R. H. W. det.): *Paripteris gigantea* (STERNBERG) GOTHAN, *Sphenopteris* sp. indet., *Calamites suckowi* BRONGNIART, *Lepidodendron obovatum* STERNBERG. From an exposure of the same unit immediately east of the village a fragment of *Mariopteris acuta* (BRONGNIART) was recorded (WAGNER 1963, p. 233). The facies of this unit is turbiditic.
- 16.—ca. 15 m grey shales with silty ribs; ironstone nodules in the upper part; badly exposed.
- 15.—ca. 0.30 m grey, calcareous mudstone with bands of algae, brachiopods and crinoids, and cephalopods (loc. Vi 8 - C. H. T. W.-G. det.): *Retites semiretia* MCCAULEB, ?*Gastrioceras* sp., prolecanitid, *Metacanites* spp. (2 species). *Retites semiretia* is a characteristic element of the basal Morrowan in Arkansas, U. S. A. Spores from the *Retites* Band at Viadangos form an assemblage of upper Namurian B age (see opposite page).
- 14.—ca. 12 m thin, crinoidal limestones with grey calcareous mudstone intercalations.
- 13.—ca. 75 m well bedded, dark grey (almost black), fetid limestones (bedding interval approx. 15-30 cm) alternating with very thinly bedded, fetid calcareous shales and occasional bands of detrital crinoidal limestone containing pebbles of black limestone; some of the shaly bands show signs of minor slumping.
- 12.—2 m dark grey, fetid limestone, with numerous calcite veins.
- 11.—17 m unexposed.
- 10.—204 m secondary dolomite.
- 9.—27 m grey, massive-bedded limestone with chert patches.
- 8.—ca. 20 m well bedded, dark grey, fetid limestone.
- 7.—ca. 10 m thinly bedded, fine-grained, grey limestones with reddish tinted nodular bands (upper part of «griotte»).

- 6.—0.20 m red nodular limestone («griotte»).
- 5.—1 m red chert.
- 4.—5 m red nodular limestone («griotte»).
- 3.—2.05 m grey, slightly nodular limestone (basal «griotte»).
- 2.—0.75 m black shales (Vegamián Formation).
- 1.—coarsely crystalline, white limestone (thickness not measured).

Between units 1 and 2 a disconformity exists which separates Lower Tournaisian from Upper Tournaisian in this part of northern León (WAGNER *et al.* 1971). Units 3 to 7 represent the Genicera Formation («griotte») and from unit 8 to unit 14 the well bedded, fetid limestones of the Barcaliente Formation are represented. The top of the Barcaliente Limestone Formation near Viadangos is determined by the *Retites* Band (unit 15) which contains basal Morrowan goniatites as well as a spore flora characteristic of the upper Namurian B Marsdenian Stage of N. W. Europe (loc. Vi 8 - R. N. *det.*): *Alatisporites pustulatus*, *Anapiculatisporites spinosus*, *Armatissporites* spp., *Calamospora microrugosa*, *C. ferruginea*, *C. pallida*, *Cingulizonates loricatus*, *Cirratiradites specus* NEVES, *Crassispora kosankei*, *Densosporites anatolicus* ARTÜZ, *Dictyotriletes* cf. *mediareticulatus* (IBRAHIM) POTONIE & KREMP, *Florinites visendus*, *Laevigatosporites desmoinesensis*, *Leiotriletes* sp., *Lophotriletes* sp., *Lycospora pellucida*, *L. subtriquetra* (LUBER & WALTZ) POTONIE & KREMP, *Mooreisporites trigallerus* NEVES, *Neoraistrickia inconstans* NEVES, *Potonieisporites elegans*, *Raistrickia fulva*, *Reticulatisporites polygonalis*, *Rotaspora* sp.

The presence of *Armatissporites* spp., *Cirratiradites specus*, *Crassispora kosankei*, *Mooreisporites trigallerus* and *Neoraistrickia inconstans* in an assemblage lacking *Dictyotriletes bireticulatus*, *Florinites mediapudens* and *Vestispora* spp. indicates this to be the oldest horizon examined in the Villamanín area. Recycled Devonian elements also present in loc. Vi 8, include *Ancyrospora* sp., *Emphanisporites* sp. and various acritarch species. It is tempting to relate this evidence of erosion to the signs of tectonic movement as found at the top of the Barcaliente Formation in its type section near Valdeteja (WINKLER PRINS 1971, WAGNER *et al.* 1971), where an erosional breccia occurs at this horizon.

Near Viadangos, there is a rather clearly marked change in the sedimentary environment with unit 16 and, particularly, unit 17 which apparently marks an increase in the rate of sedimentation, possibly accompanied by an increase in the basin slope. However, there is no apparent time gap involved, since a spore assemblage obtained from the sandstone unit (17) contains essentially the same taxa as recorded in the *Retites* Band. The sandstones of unit 17 are therefore still regarded as being of Namurian B age. Above the sandstone unit, the succession is essentially shaly with subordinate, thin sandstones near the base and progressively becoming more marly in unit 19. Preliminary palynological examination of this sequence, which is patchily exposed in the stream to the south-west and south of Viadangos de Arbas, indicates the presence of a full Namurian C and basal Westphalian A sequence. The first appearance of *Dictyotriletes bireticulatus* and *Florinites mediapudens* is recorded in the calcareous

mudstones (unit 19) exposed in the right bank of the stream, at 100 m below the small bridge due west of Viadangos.

The completeness of this succession makes it clear that the dolomitized limestone of the Valdeteja Formation in Peña Lasa, which underlies the measured section in the Valle El Ejío, has fully wedged out into a terrigenous sequence near Viadangos. It is also clear from the map (text-fig. 1) that the upper part of the «caliza de montaña» is strongly wedging, and that the terrigenous lens north of Villanueva de la Tercia may correspond to an appreciable part of the terrigenous Namurian C and basal Westphalian A at Viadangos. The apparent difference in thickness between the carbonate sequence at Peña Lasa and the equivalent terrigenous strata at Viadangos may be explained by the compaction factor of mudstones, which are strongly represented near Viadangos.

RAILWAY SECTION SOUTH OF VILLANUEVA DE LA TERCIA

In the village of Villanueva de la Tercia (text-fig. 1) the limestone yielding foraminifera of Kashirian age is followed by a fairly monotonous mudstone sequence, of which only the basal part is well exposed. After an unexposed hollow, the first wrinkle in the folded core of the Cármenes Syncline is reached in a mudstone sequence which, apparently, precedes an undisturbed succession of 190 m thickness, which is exposed in the León-Gijón railway cutting. This succession, which youngs southwards and which is overturned, has been represented in main outline in text-fig. 3.

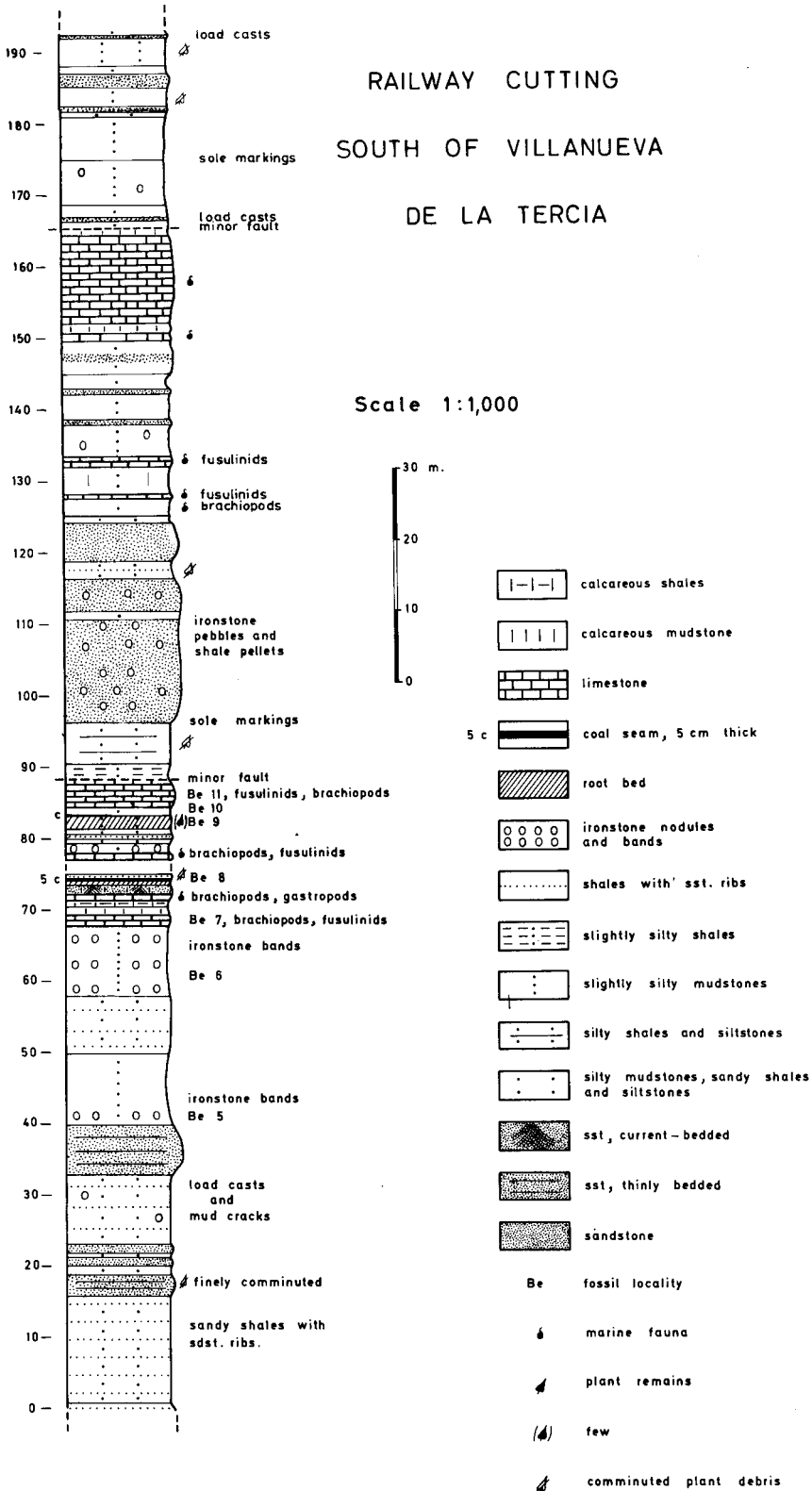
The measured sequence commences with a sandstone followed by sandy shales with sandstone ribs, a flaggy sandstone with comminuted plant debris, more sandy shales and bands of massive sandstone. Then, a 10 m unit of sandy shales with sandstone ribs and ironstone bands shows load casting and mud cracks. It is followed by 7 m of bedded sandstone, distinctly flaggy at the base. Ten metres of dark mudstones with numerous ironstone bands in the lower part are separated by 8 m of sandy shales with sandstone ribs from another 10 m of dark mudstones with ironstone bands. Spore samples from the two mudstone horizons (Be 5 and Be 6—see text-fig. 3) yielded a badly preserved microflora (R. N. det.): *Cirratriradites flabelliformis* WILSON & KOSANKE, *Crassispora kosankei*, *Densosporites sphaerotriangularis*, *Florinites mediapudens*, *F. similis*, *Laevigatasporites vulgaris*, *Lycospora pellucida*, *L. torquifer* (LOOSE) POTONIE & KREMP, *Potonieisporites elegans*, *Rathizonates tenuis* (LOOSE) BUTTERWORTH & WILLIAMS, *Schopfipollenites ellipsoides*, *Triquitrites* sp., *Verrucosisporites compactus* HABIB. The age of this microflora should be considered in conjunction with the assemblages found a little higher in the same succession (localities Be 8 and Be 10), which are better preserved and which are clearly of lower Westphalian C age. There is nothing in the association of spores quoted, which would militate against this age.

→

Text-fig. 3.—Stratigraphic section measured in the railway cutting at 500 m south of Villanueva de la Tercia. Only a general impression is presented of this sequence of lower Westphalian C age, which also contains fusulinid faunas referable to the Lower Moscovian (Kashirian).

RAILWAY CUTTING SOUTH OF VILLANUEVA DE LA TERCIA

Scale 1:1,000



The mudstones of loc. Be 6 are succeeded by calcareous mudstone and muddy limestone with brachiopods and fusulinid foraminifera (Be 7) which have not been studied. They are followed by calcareous mudstones and shales with muddy limestone containing brachiopods and gastropods. Presumably, the basin of sedimentation became shallower, since fusulinids are apparently present only in the lower part of this calcareous unit. Also, the unit is succeeded by 1.20 m of current bedded, probably calcareous sandstone with ripplemarks and worm tracks at the top; probably representing a near shore facies. A thin limestone (muddy) was deposited at the top of this bed. The presence of a seat-earth followed by 5 cm of coal indicates the final stage of regression. From the coal a good microflora was obtained (Be 8—R. N. det.): *Calamospora perrugosa*, *Calamospora* sp., *Cingulizonates* sp., *Endosporites globiformis*, *Florinites mediapudens*, *F. millotti*, *F. pumicosus*, *Laevigatosporites desmoinesensis*, *Lycospora pellucida*, *Microreticulatisporites nobilis*, *Punctatisporites* sp., *Reticulatisporites polygonalis*, *Spencerisporites radiatus* (IBRAHIM) FELIX & PARKS, *Triquitrites exiguus*, *T. novicus* BHARADWAJ, *Vestispora* cf. *magna*, *V. pseudoreticulata*. This assemblage is similar to that obtained from the coal horizon N. N. W. of Rodiezmo (loc. R 36), and should also be regarded as being of early Westphalian C age. This does not necessarily imply a direct correlation between the two coals.

The roof of the coal seam is constituted by a quartz sandstone with fairly large, drifted plant remains. The irregular base of the sandstone and the drifted plants both point to a channel fill, possibly of fluvial origin.

The first two metres above the sandstone are unexposed, but renewed transgression is proved by the presence of 0.80 m of muddy limestone containing fusulinid and other foraminifera, as well as brachiopods. It is followed by calcareous mudstone (0.30 m), mudstone with occasional ironstone nodules (1.20 m), sandy shales (0.60 m), fine-grained sandstone (0.60 m), sandy shales (0.60 m) and silty mudstones with abundant Stigmairian rootlets constituting another seat-earth (ca. 2 m). The overlying coal is only a smut which has been sheared out along the strike. This succession represents a regressive sequence, with the least shallow marine deposits (with fusulinid foraminifera) at the base of the succession.

Another transgression is indicated by blue grey mudstones (1 m) followed by hard limestone (4 m). Both deposits contain fusulinid foraminifera and the limestone is also fairly rich in brachiopods. A sample of the mudstone proved to contain a rich spore flora (Be 10 - R. N. det.): *Ahrensiporites* sp., *Apiculatisporites setulosus* (KOSANKE) POTONIE & KREMP, *Calamospora* sp., *Crassispora kosankei*, *Densosporites triangularis* KOSANKE, *Florinites mediapudens*, *F. millotti*, *F. similis*, *Laevigatosporites vulgaris* IBRAHIM, *L. desmoinesensis*, *Limitisporites* sp., *Lophotriteles pseudoaculeatus* POTONIE & KREMP, *Lycospora pellucida*, *L. torquifer*, *Mooreisporites inusitatus* (KOSANKE) NEVES, *Reticulatisporites lacunosus* KOSANKE, *Triquitrites additus* WILSON & HOFFMEISTER, *T. bransonii* WILSON & HOFFMEISTER, *T. subspinosus* PEPPERS, *Vesicaspora wilsonii* (SCHEMEL) WILSON & VENKATACHALA, *Vestispora* sp., *Wilsonites delicatus* KOSANKE. The absence of *Torispora*, *Thymospora* and *Vestispora fenestrata* indicates an horizon still below mid-Westphalian C.

The foraminifera of Be 10 and Be 11 were studied by Mr. G. SCHIMMERBER (*in litt.* 21. V. 1963), who recognized the following species: *Fusulinella bocki* var. *delepinei* GÜBLER, *F. praebocki* RAUSER, *Schubertella* ex gr. *obscura* LEE & CHEN, *Profusulinella librovitchi* (DUTKEVITCH), *P. aljutovica* (RAUSER), *Ozawainella angulata* (COLANI), *Ammodiscus variabilis* REITLINGER, *A. multivolutus* REITLINGER, *Brunsiella densa* REITLINGER, *Eostaffella* sp., *Millerella* sp. This assemblage was referred to either late Kashirian or early Podolskian (SCHIMMERBER pers. comm.).

Another sample, collected from one of the carbonate beds in the interval between 68 m and 88 m in the same section (loc. 353), yielded the following species to G. SCHIMMERBER (*in litt.* 21. V. 1963): *Fusulinella bocki* var. *delepinei* GÜBLER, *Ozawainella pseudorhomboidalis* RAUSER, *Millerella carbonica* (GROZDILOVA & LEBEDEVA), *Eostaffella acuta* GROZDILOVA & LEBEDEVA, *Planoendothyra aljutovica* (REITLINGER), *Endothyranella* cf. *mordovica* REITLINGER, *Globivalvulina scaphoidea* REITLINGER.

Brachiopods from the same general locality, identified by C. F. WINKLER PRINS, also point to a late Kashirian or a Podolskian age. The following comments are made by Dr. WINKLER PRINS (personal communication): «Most localities of this section give no good age indication, since the fauna generally consists of spiriferids (i. e. *Choristites* sp., and specimens provisionally assigned to *Choristites asturicus* (DELEPINE 1943)), which have not been sufficiently studied (e. g. the relation of *C. asturicus* to the Russian species of *Choristites*, which are highly useful for stratigraphic purposes, is unknown). The presence of *Isogramma davidsoni* (BARROIS) may indicate an age at least as young as the Moscovian, since there is a close affinity with *L. paotchowensis* (GRABAU & CHIAO). The occurrence of *Pulsia* sp. and *Orthotetes radiata* (FISCHER DE WALDHEIM) indicates a Moscovian age or younger. Then, there are *Levipustula* cf. *breimeri* WINKLER PRINS and *Kozlowskia* cf. *aberbaidenensis* RAMSBOTTOM, both characteristic elements of the *Kozlowskia/Karavankina* Zone (WINKLER PRINS 1968), of Moscovian age (probably Podolskian, but possibly upper Kashirian). *K. aberbaidenensis* was first described from the basal Westphalian C Cefn Coed Marine Band in South Wales (RAMSBOTTOM 1952). *Kozlowskia* has, to my knowledge, never been recorded below either upper Kashirian or lower Westphalian C in Europe. In this respect, it is necessary to recall that the specimens of *Marginifera* (= *Kozlowskia*) *pusilla* SCHELLWIEN, described by DELEPINE (1943) from the «calcaire des cañons» (Valdeteja Formation?) near Entrago (Asturias), cannot be reliably referred to *Kozlowskia* in the absence of described internal structures. For the time being, these specimens should be regarded as indeterminate marginiferids (compare WINKLER PRINS 1968, p. 61)».

The combined evidence of plant spores, foraminifera and brachiopods in the railway section south of Villanueva seems to indicate the probable equivalence of late Kashirian (or early Podolskian) and lower Westphalian C. This correlation tends to modify GORSKI & STEPANOV'S (1960) conclusion that the Kashirian would be correlatable with upper Westphalian C and the Podolskian with lower Westphalian D.

A collection of foraminifera from the same general locality (353) was earlier

made available to VAN GINKEL (*in* WAGNER 1963, p. 233; VAN GINKEL 1965, appendix 1, L 353), who concluded upon a late Bashkirian age. His conclusion is obviously at variance with the results reported above.

Above the limestone of loc. Be 11 (text-fig. 3) a small fault occurs, which apparently eliminates a few metres of strata. Then, 2 m of slightly silty shales are recorded. They are followed by 6 m of sandy shales and siltstones with comminuted plant debris (also *Calamites* sp.) and mica flakes on the bedding planes. A sharp contact is observed between these shales and an overlying, coarse-grained, massive sandstone (14.30 m thick), with sole markings at the base. The latter contains ironstone pebbles and shale pellets, particularly in the first 20 cm at the base, and probably marks an increase in the basin slope and, presumably, a deepening of the basin. It also shows the presence of channel bases, possibly due to submarine channelling as the result of sand transport «en masse». A brecciated lens is also observed. Slightly silty shales, 1.30 m thick, and containing a lens of brecciated sandstone, are followed by another sandstone, 4.40 m thick, with load casts at the base. This sandstone is also characterized by the presence of sideritic ironstone pebbles, channel bases, and its coarse-grained and massive aspect. Ripplemarks are found at the top of this unit. Sandstone bands with probable sole markings at the base and ripplemarks at the top (0.30 m thick) are followed in succession by 0.45 m of silty shales; 0.30 m of medium-grained sandstone with probable sole markings at the base and ripplemarks at the top, and comminuted plant debris; another 0.30 m of sandstone bands with ripplemarks at the top and comminuted plants; and a further unit of 1.30 m of sandstones and siltstones with plant debris and a few ripplemarks at the top of sandstone bands. A sharp contact is observed between this unit and 5.80 m of coarse-grained, massive sandstone with drifted stem remains (e. g. *Calamites*) at the top. 1.80 Metres of silty shales and mudstones, with cross-laminated siltstone bands showing vertical burrows, follow in succession. A layer with shell debris is observed near the top of this unit. A further 2.50 m of slightly silty mudstone contains limestone bands with brachiopods, after which 0.30 m of detrital limestone with fusulinid foraminifera and brachiopods are found. Some 3.70 m of slightly silty mudstones, which are somewhat calcareous, are found subsequently and before another detrital limestone band (0.30 m thick) is reached. The latter contains fusulinids, crinoids, brachiopods and other marine fossils, and is strongly lensing. After 0.55 m of silty shales and mudstones, a similar lens of 0.35 m of detrital limestone occurs. It contains fusulinids throughout and a brachiopod layer at the top. Then, a unit of 4.50 m of slightly silty, dark grey shales with ironstone bands is encountered. This is followed by 0.60 m of sandstone; 3.50 m of slightly silty, dark grey shales; 0.90 m of sandstone (in three bands) showing sharp contacts at the base and ripplemarks and tracks at the top; 2.10 m of slightly silty mudstone; 4.60 m of slightly silty shales with sandstone ribs showing ripplemarks and, in some cases, sole markings at the base.

Subsequently, a major limestone unit is encountered. It consists of 0.90 m of limestone and dirty limestone with gastropods, crinoids, algae, etc.; 1.50 m of calcareous mudstone; 12.40 m of fossiliferous limestone; and 0.70 m of calcareous

mudstone. A probably minor strike fault occurs between this unit and 1.10 m of slightly silty shales; 0.60 m of sandstone with load casts; 1.80 m of slightly silty shales with sandstone ribs (load casted); 6.50 m of slightly silty mudstones with sideritic ironstone layers; and 6 m of slightly silty mudstones. Between the latter two units occurs a thin band of sandstone with sole markings at the base. Then, 0.70 m of silty shales with sandstone ribs, showing mica and comminuted plant debris, are followed by 0.60 m of fine-grained sandstone with load casts and comminuted plants; 2.70 m of slightly silty mudstones and siltstones with plant debris; 1.90 m of medium-grained, well bedded sandstone (intervals varying from 7 to 50 cm) with plant debris throughout and ripplemarks at the top; 1.10 m of slightly silty shales, dark grey in colour, with very finely comminuted plants; 4 m of light brown, micaceous, silty shales with plant debris; 0.50 m of sandstone with load casts and rare, vertical burrows; and 0.60 m of exposed slightly silty shales with thin sandstone partings showing sole markings.

Here the section ends. Among the fossil debris found loose in the railway cutting, a small plant fragment proved to be identifiable as *Alloiopteris* sp. (Pl. 8, fig. 28). Another plant fragment is tentatively assigned to *Pecopteris pennaeformis* BRONGNIART.

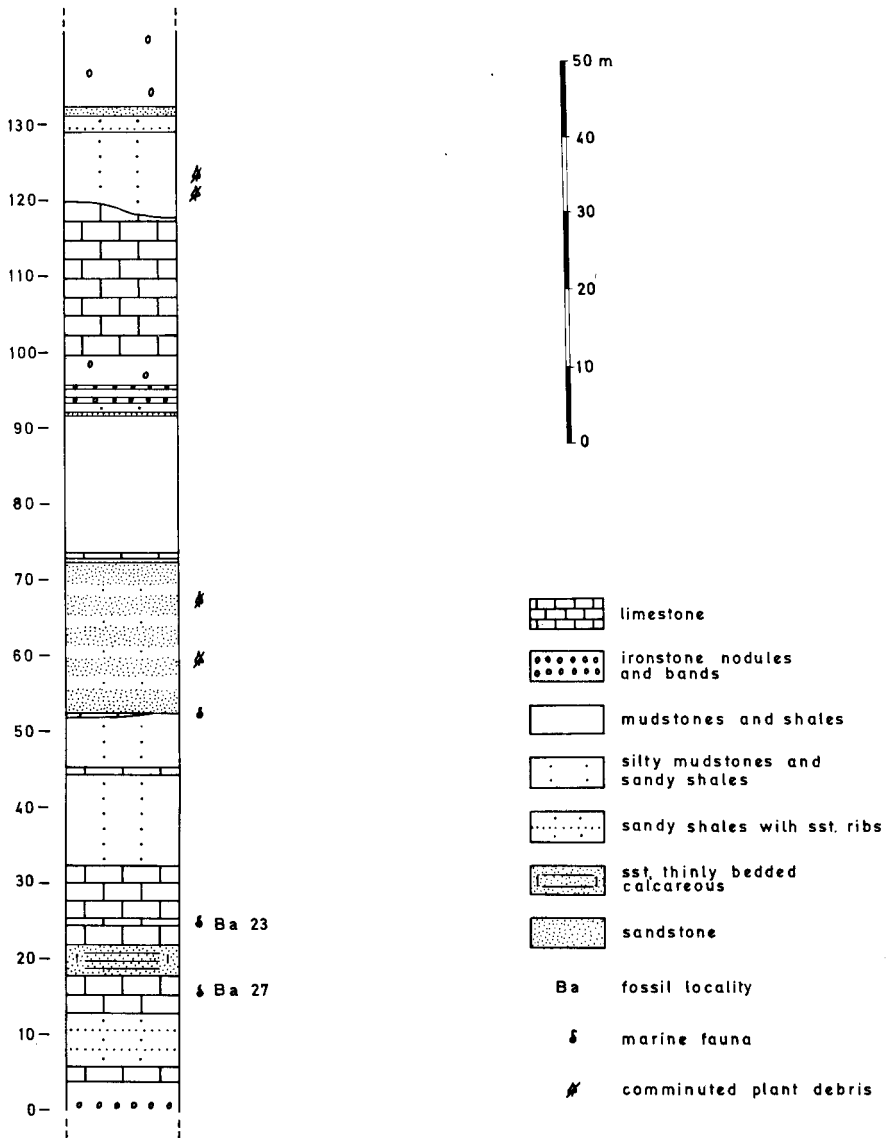
SECTION MEASURED NEAR BARRIO DE LA TERCIA

Near the village of Barrio de la Tercia (text-fig. 1) the folded core of the Cármenes Syncline shows the presence of several small synclines and anticlines in limestones, shales, mudstones and sandstones. A succession of these strata has been measured in the northern flank of a small syncline which passes through Barrio itself, and this succession has been continued downwards in structures north of the village. The stratigraphic position of this succession, in relation to that measured in the railway cutting south of Villanueva, is not known in detail. On field evidence, it may be a little younger, and this may be so, although a fusulinid fauna collected near Barrio de la Tercia (loc. Ba 23—see text-fig. 4) has been dated as Kashirian and is, therefore, not apparently younger than the late Kashirian (or early Podolskian) assemblages from the railway cutting.

The following sequence has been recorded (general sequence only—see text-fig. 4): - grey shales with ironstone bands (basal part of section, no thickness measured); -detrital limestone (2 m); -sandy shales with sandstone ribs (7 m); -detrital limestone with foraminifera, *Chaetetes*, etc. (5 m, loc. Ba 27 - G. SCHMERBER *det.*, pers. comm. 21. V. 1963); *Pseudostaffella ozawai* (LEE & CHEN), *P. topilini* PUTRJA, *P. sphaeroidea?* MOELLER, *Schubertella* ex gr. *obscura* LEE & CHEN, *Tuberitina maljavkini* MIKHAILOV, *Haplophragmina kashirica* REITLINGER, *Bradyina magna* ROTH & SKINNER, *Spiroplectammia conspecta* REITLINGER, *Endothyranella mordovica* REITLINGER, *Plectogyra inusitata* (REITLINGER), *Globivalvulina scaphoidea* REITLINGER; an assemblage which SCHMERBER assigns a Kashirian or lower Podolskian age; -flaggy sandstone and calcareous sandstone (4 m); -detrital, largely foraminiferal limestone (1 m); -dark, muddy limestone with gastropods (0.80 m); -nodular limestone (partly algal?) (0.70 m);

COMPOSITE SECTION OF MOSCOVIAN STRATA NEAR BARRIO DE LA TERCIA

Scale 1:1,000



Text-fig. 4.—A composite section of the strata exposed near Barrio de la Tercia. Only a general impression of the sequence is presented.

-foraminiferal limestone (1 m, loc. Ba 23 - G. SCHMERBER *det.*, pers. comm. 21. V. 1963); *Profusulinella librovitchi* (DUTKEVITCH), *P. prisca* (DEPRAT), *P. aljutovica* (RAUSER), *Aljutovella aljutovica* (RAUSER), *Schubertella obscura* LEE & CHEN, *Tuberitina maljavkini* MIKHAILOV, *Haplophragmina kashirica* REITLINGER, *Tetrataxis minima* var. *latispiralis* REITLINGER; an assemblage which SCHMERBER refers to the Kashirian; -dark grey limestone (7 m); -sandy shales (12 m); -detrital limestone (1 m); -sandy shales (7 m); -limestone lens (not measured); -coarse-grained sandstone alternating with sandy shales (20 m), and calcareous at the base where it shows the presence of brachiopods as internal casts; comminuted plant debris is common in this sandy unit.

Within the sandstone/shale unit, mentioned above, a synclinal and an anticlinal hinge are found in quick succession, and before the sequence continues in the northern flank of the small syncline passing through Barrio de la Tercia. This continuation is as follows (text-fig. 4): -shales (0.50 m); - limestone (0.70 m);-grey shales (18 m); -sandstone (0.40 m); - sandy shales (1.30 m);-sandy ironstone band (0.70 m); -grey shales (1 m); -clay ironstone bands (0.40 m); -grey shales with occasional ironstone nodules (3.50 m); -irregularly bedded, muddy limestone with decalcified brachiopods in calcareous mudstone at the top, and probable algal structures throughout, together with less common brachiopods (20 m); -sandy shales (10 m), showing finely comminuted plant debris at 2.10 m and 3.80 m from the base, respectively; - sandy shales with sandstone ribs (2 m); -massive sandstone (1.20 m); -grey shales with occasional ironstone nodules (over 10 m thick).

Neither the detailed mapping, necessary to link up parts of the local succession, nor the level of recording of the stratigraphic section are wholly satisfactory, and more work needs to be done in the vicinity of Barrio de la Tercia. The record, as stated above, will therefore have to be regarded as provisional.

The limestones near Barrio de la Tercia have been the subject of a study by RÁCZ (1965), who found both fragmental and skeletal limestones, the latter being mainly banks, with a lesser proportion of reefs. Algae proved to be important constituents.

REGIONAL STRATIGRAPHY

Text-fig. 5 provides an impression of the general stratigraphic succession in the Villamanán area. The main column has been built up from exposures in the Valle El Ejío which are continued downwards into the «caliza de montaña» of Peña Lasa (text-fig. 1). The latter is heavily dolomitized and the distinction between thinly bedded, fetid limestone (Barcaliente Formation) and more massively bedded and massive limestone (Valdeteja Formation) cannot be made here. However, the left hand column, corresponding to the succession at Viadangos de Arbas, shows the Barcaliente Formation to be restricted to the basal 360 m, above which a terrigenous sequence is developed at Viadangos. This succession, which has been dated as top Namurian B,

Namurian C and basal Westphalian A, corresponds in time with the upper part of the «caliza de montaña» in Peña Lasa and the basal terrigenous beds (below the disconformity) in the Valle El Ejío. Since the Barcaliente Formation represents a quiet marine facies of generally micritic limestones (compare WINKLER PRINS 1971, which are continuous over large areas, it seems likely that the strongly wedging top part of the «caliza de montaña» in Peña Lasa belongs to the Valdeteja Formation. The latter contains reef bodies and is generally variable in thickness.

If it may be accepted that the limestones of the Barcaliente Formation show no appreciable variation in thickness within the area considered (text-fig. 1), i. e. in 4 kilometres, the *Retites* Band of the Viadangos section should correspond to a position at ca. 360 m above the base of the «caliza de montaña» in Peña Lasa. Since the *Retites* Band has been dated as upper Namurian B, it follows that the main thickness of «caliza de montaña» in Peña Lasa corresponds to Namurian C, in conjunction with the basal part of lower Westphalian A. This is interesting, because Namurian C is usually regarded as representing only a short spell of Namurian time, shorter in fact than either Namurian A or B. Evidently, the rate of sedimentation increased with the Valdeteja Formation; thus continuing a general trend which leads from the extremely condensed facies of «griotte» limestone (ca. 17 m corresponding to the entire Viséan) through slowly deposited fetid limestones of the Barcaliente Formation (19 m of lower and middle Namurian A, and some 340 m of upper Namurian A and Namurian B) to the more rapidly formed Valdeteja limestones (some 730 m corresponding to top Namurian B, Namurian C and basal Westphalian A).

From a maximum thickness of ca. 1,100 m of «caliza de montaña» in Peña Lasa there is rapid wedging of the Valdeteja Formation both eastwards and westwards. In the Bernesga Valley (text-fig. 1) a mudstone/sandstone succession with occasional limestones replaces the top part of the «caliza de montaña». This includes the locality with *Branneroceras branneri* (loc. 1262), of the early Upper Morrowan and Lower Bashkirian, which has also been dated as basal Westphalian A. Westwards, in the direction of Viadangos de Arbas, the upper part of the «caliza de montaña» very rapidly develops mudstone wedges, whilst the limestone shows the presence of a rubbly facies prior to wedging into a mudstone/sandstone succession. This lateral rubbly facies, containing some quite large boulders, suggests wave action on the Valdeteja Limestone Formation, the debris of which flanked contemporary terrigenous deposits dated as top Namurian B, Namurian C and early Westphalian A at Viadangos de Arbas (left hand column of text-fig. 5). The extremely reduced thickness of Namurian C at Viadangos, in contrast to the large amount of limestone formed at the same time in the nearby locality of Peña Lasa, cannot be explained entirely by a difference in compaction (even though this may have played a rôle) and may be due in part to a primary difference in thickness between an upstanding mound of limestone and adjacent deposits. A detailed sedimentological analysis of these deposits may further elucidate this question.

At ca. 50 m above the «caliza de montaña» in the Valle El Ejío section (text-fig. 2) there are signs of erosion which correspond approximately with the rapid change from lower Westphalian A to basal Westphalian B recorded by the spore floras of

R 20 and R 22 on the one hand, and that of R 25 on the other. The floras of R 20 and R 22 are also characterized by reworked Devonian material, indicating the presence of a nearby landmass being eroded down to the level of Devonian strata. Signs of reworked Devonian spores and acritarchs cease with the locality R 25. There is reason to interpret the evidence as a disconformity, or perhaps a succession of disconformities in the interval between R 20 and R 22.

In this context, it is interesting to compare with a presumably more complete succession of Lower Westphalian strata in the region of San Emiliano, some 20 km W. N. W. of Viadangos. This succession, originally described by GÓMEZ DE LLARENA & RODRÍGUEZ ARANGO (1948) and GARCÍA FUENTE (1952) and, most recently, by VAN DEN BOSCH (1969), consists of terrigenous clastics with intercalated limestone bands and occasional coal seams with seat-earths in the upper part. The total thickness of this San Emiliano Formation (BROUWER & VAN GINKEL 1964, VAN GINKEL 1965) has been estimated as 2,400 m or more (VAN DEN BOSCH 1969, p. 179). Two fusulinid faunas from the San Emiliano Formation proved to belong to the Bashkirian (VAN GINKEL 1965, p. 187) and some plant fossils recorded by JONGMANS (*in* WAGNER 1959, pp. 399-400) and by STOCKMANS & WILLIÈRE (1966, Pl. I) indicated Namurian C/ lower Westphalian A and Westphalian A, respectively. These data are still inadequate (no measured section is available as yet), but it appears likely that a rather more complete succession of Westphalian A strata is available in the region of San Emiliano than there is in the Villamanín area discussed in the present paper. A cursory examination of strata in the San Emiliano Formation has tended to suggest the presence of rhythmic sedimentation, with marine shales and limestones directly overlying coal seams in the pattern of a sudden transgression at the base of more gradually regressive units such as have been reported elsewhere in the Cantabrian Mountains (BLESS 1971, WAGNER & VARKER 1971). Such rhythmic units have not been found in the very much reduced succession of Westphalian A rocks in the Villamanín area, where they may be absent as the result of uplift and subsequent erosion in late Westphalian A times.

The total area affected by these movements of uplift may well coincide, in general outline, with the Cantabrian Block of RADIG 1962 (= Cantabrian Zone of LOTZE), in the central part of the Cantabric-Asturian area of Palaeozoic sedimentation (compare WAGNER 1970, text-fig. 2). The stratigraphic succession in this central area, in the regions east of the central Asturian coalfield, has been described most recently by JULIVERT (1961, 1967, p. 61) and by SJERP (1967). Both authors draw attention to a thin unit of red and green mudstones with chert, limonite- and manganese-bearing nodules (Ricacabiello Formation of SJERP), which overlies the «caliza de montaña», and which represents a facies of condensed sedimentation. This unit, only a few tens of metres thick, contains goniatites and nautiloids which are still unidentified in the area east of the central Asturian coalfield. However, a little north of this area, in eastern Asturias, a comparable facies of mudstones above the «caliza de montaña» has yielded two species of *Retites* to E. MARTÍNEZ (1971), one of which has been identified as *Retites semiretia* McCALEB, i. e. the same basal Morrowan species as has been found above the «caliza de montaña» (Barcaliente Formation) near Viadangos de Arbas,

in rocks of late Namurian B age. The Asturian specimens of *Retites* are described with the material from Viadangos in the present paper (pp. 345-347, Pl. 2). It is interesting to note that the «caliza de montaña» east of the central Asturian coalfield and further north is composed of well bedded, fetid limestones comparable to those of the Barcaliente Formation in northern León. The Valdeteja Formation seems to be absent in this area, although there is a possibility that this higher part of the «caliza de montaña» reappears just north of the Picos de Europa, in the gorge of the Río Cares. The Valdeteja Formation is also present west of the central Asturian coalfield, in the continuation of the tectonic unit discussed here from the Villamanín area.

Both JULIVERT and SJERP describe a few hundred metres of terrigenous clastic deposits succeeding the condensed facies of the Ricacabiello Formation, and the latter reports the presence of probably Vereyan (early Moscovian) fusulinids and algae in a limestone lens at some 250 m above the Ricacabiello Formation. This terrigenous unit (called the Beleño Formation by VAN GINKEL 1965, p. 190) is followed by 80-300 m of limestone which has been recorded as «caliza masiva» (JULIVERT 1957, 1961; J. A. MARTÍNEZ 1962). VAN GINKEL (1965) calls this the Escalada Formation and reports fusulinid assemblages of either upper Kashirian or lower Podolskian age. The first limestone found in the Valle El Ejío section has yielded Kashirian foraminifera in its lateral continuation at Villanueva de la Tercia (loc. Be 1, compare page 318). This limestone shows great lateral continuity, despite obvious changes in thickness, and forms a clearly traceable marker horizon at 250 metres above the intra-Westphalian A disconformity. It seems likely that this limestone represents the «caliza masiva» in the Villamanín area, which thus shows a stratigraphic development closely similar to that of the area east of the central Asturian coalfield, the only major difference being found in the presence of the Valdeteja Formation and equivalent terrigenous deposits. This may merely signify that the uplift and erosion of Westphalian A times did not affect the Villamanín area quite as much as it did the area east of the central Asturian coalfield, which appears to have been eroded down to the level of the Barcaliente Formation. One might assume that the Villamanín area, south of the central Asturian coalfield, occupied a position on the margin of the Cantabrian Block, whereas the area east of the central Asturian coalfield would correspond to the Block itself. West of the central Asturian coalfield, i. e. in the region of Teverga and in its continuation southwards into the valley of San Emiliano, the disconformity between lower Westphalian A and lower Westphalian B may not have been developed, and this may indicate a position off the Cantabrian Block.

A problem is posed by the presence of Devonian spores as recycled elements in the lower Westphalian A spore floras of localities R 20 and R 22 of the Valle El Ejío section. The consistent presence of the Namurian «caliza de montaña» in the area east of the central Asturian coalfield and the knowledge of an even more complete succession of Namurian age west of this coalfield, makes it rather difficult to accept the Cantabrian Block as a source for reworked Devonian. Of course, it is theoretically possible to assume the removal of Namurian and Lower Carboniferous from the area presently occupied by the Westphalian rocks of the central Asturian coalfield, but such a solution is

entirely hypothetical and not very likely. It thus remains to assume a derivation of reworked Devonian spores from a hinterland which, for the Villamanín area, would be situated towards the south. It is possible and, indeed, quite likely that the Westphalian A uplift of the Cantabrian Block would have been linked to a corresponding uplift of this southern hinterland, the latter being the more important one. Probably, the uplift of the southern hinterland would have occurred at a slightly earlier date than that operating on the Cantabrian Block, since the evidence of reworked Devonian material is found *below* the stratigraphic gap (between localities R 22 and R 25) ascribed to uplift of the Cantabrian Block. The interplay of movements acting on the southern hinterland and the Cantabrian Block (which later acted as a tectonic foreland) is a recurrent theme of the stratigraphic development of the Cantabric-Asturian area in Palaeozoic times.

It is an interesting conjecture to speculate on the distance which the reworked Devonian spores would have had to travel from a southern hinterland, subjected to erosion. Very likely, this distance was in excess of 35 km, for at half this distance the Devonian rocks are still covered by Viséan and Namurian strata (as the outcrops of these rocks show) and the tectonic structure is such as to assume a minimum of 50 % shortening.

An unbroken succession of strata seems to have been deposited from early Westphalian B onwards, i. e. from the horizon of loc. R 25 which does not show any evidence of reworked Devonian spores. This locality also contains the goniatite *Rodiezmoceras bisati*, a probable descendant of *Branneroceras branneri* which was found in basal Westphalian A strata. Westphalian B may be represented by 900-1,000 m of strata, since the earliest Westphalian C is reached at some 940 metres above the disconformity (see text-fig. 5, middle column) at the horizon of the coal which was mined N. N. W. of Rodiezmo (loc. Rz 36 = loc. 1101). This coal and the root bed found at ca. 90-100 m lower down the succession (Valle El Ejío) constitute the earliest evidence for non-marine strata in the Villamanín area. The rate of sedimentation of the Westphalian B strata in the unbroken succession measured in the Valle El Ejío appears to have been rather low. This sequence consists mainly of mudstones with strongly wedging sandstones (only a few sandstone partings in mudstone remain in the Bernesga Valley, at a very short distance to the east) and three limestone horizons. The most constant horizon in this succession is the «caliza masiva» which is found as a continuous marker band from Viadangos and beyond, to Villanueva de la Tercia and further eastwards (text-fig. 1). There is neither any evidence for rhythmic sedimentation nor of turbidites, and it seems that the Westphalian B succession of strata represents the steady infilling of a basin with shallow marine deposits. Towards the top of the succession in the Valle El Ejío current bedded sandstones are encountered, and these are interpreted as representing a deltaic marine environment. The corresponding shallowing of the basin culminated in a thin bed with Stigmairian rootlets at 840 m above the Westphalian A disconformity. This temporary emergence of the basin was followed by renewed transgression and no further emergence has been recorded until the coal horizon of loc. Rz 36 was reached. A short interval of poorly exposed strata

separates this coal horizon from the measured section, and its exact distance from the top of the measured section cannot be ascertained without very detailed mapping. However, there can be no doubt about its relative position, right at the top of the section recorded in the Valle El Ejío.

A general correlation of the coal horizon N. N. W. of Rodiezmo with the coals of the railway section south of Villanueva de la Tercia (text-fig. 3) is indicated by the lower Westphalian C age of both localities. However, the coals in the railway section form part of rhythmic units incorporating fusulinid limestones. No such facies has been recorded in the Valle El Ejío section N. N. W. of Rodiezmo, and it therefore seems likely that the railway section comes slightly higher in the local succession than the coal near Rodiezmo. The sequence measured in the railway section has been placed in its probable position with regard to the Valle El Ejío sequence and that of the Bernesga Valley near Villanueva in text-fig. 5. Probably, the rhythmic units of the railway section represent the next stage in the development of the basin, with intermittent downwarp maintaining the marine character of the basin which was subsequently filled by gradually more shallow marine deposits until emergence took place.

Fusulinid assemblages of either Kashirian or Podolskian age were recorded from the railway section. Similar assemblages, of which Be 23 gave a clear indication of Kashirian, were found in the short succession measured near Barrio de la Tercia (text-fig. 4). This succession is characterized by foraminiferal, algal and brachiopod limestones which occur in a rock sequence devoid of coal. A similar facies occurs in the top part of the railway section south of Villanueva, and on field evidence it appears that the sequence near Barrio de la Tercia may be generally a little younger than that measured in the railway cutting. The succession at Barrio has been placed in its probable position with regard to that of the railway cutting in text-fig. 5.

The sedimentary sequence found in the Valle El Ejío, the railway section south of Villanueva, and near Barrio de la Tercia, has been deposited rather slowly, since approximately 1,300 metres of strata correspond to Westphalian B and lower Westphalian C. The general facies is that of a shallow marine basin which became emergent at certain intervals during lower Westphalian C times and which, subsequently, continued to subside. There is no reason to admit a syntectonic flysch facies as stated by EVERS (1967), whose observations were inadequate. For example, EVERS mentioned that the coal seams in the railway cutting south of Villanueva lacked a seat-earth, and this observation is obviously incorrect. His flysch interpretation was used to illustrate a theory of syntectonic sedimentation in front of advancing thrust sheets. The rather slow deposition as mentioned above seems to be out of character with the type of sedimentation envisaged by EVERS.

One of the most interesting results obtained by the present investigation is the large degree of comparison possible with the stratigraphic sequence developed east of the central Asturian coalfield. DE SITTER, in a series of papers (e. g. DE SITTER 1962), postulated that a fundamental tectonic line, the «León Line», would separate the development of Carboniferous strata in most of northern León (and including the

Villamanín area) from that in Asturias and some of the adjacent part of northern León. The close relationship existing between the Carboniferous strata in the Villamanín area and those of the Asturian region provides no support for DE SITTER's concept, which has been increasingly criticized in recent years (MARCOS 1968, WAGNER 1970).

Recent workers (RÁCZ 1965, VAN GINKEL 1965, EVERS 1967, WINKLER PRINS 1968) have attributed the post- «caliza de montaña» succession of terrigenous strata in the Cármenes Syncline to the San Emiliano Formation. The recognition of a different age and the absence, due to disconformity, of strata corresponding to the type San Emiliano, make the application of this formational name unwarranted in the Villamanín area.

LONG-RANGE CORRELATION

The Carboniferous of Northwest Spain is well known for the opportunity it provides to compare the various zonations based on different kinds of marine and continental fossils. Marine strata, containing varied marine faunas and floras, are found throughout the succession, up to and including the lower Stephanian (*sensu lato*). Such a development of marine strata, generally predominating over non-marine deposits, is very different from that prevailing in N. W. Europe where shallow marine transgressions laid down thin marine bands in the context of a predominantly continental sequence. The variety and scope of marine faunas is therefore much greater in Northwest Spain than it is in N. W. Europe, a case in point being the presence of fusulinid faunas which are absent in the more restricted facies of the marine bands in the Upper Carboniferous of N. W. Europe. At the same time, standard N. W. European macro- and microfloras occur in Northwest Spain.

The Upper Carboniferous marine faunas of Northwest Spain invite comparison with those of the Donbass, Moscow Basin and South Urals areas of the U. S. S. R.; the North African region; the Austrian, Italian and Yugoslavian Alps; and the Mid-Continent area of the U. S. A. They obviously belong to the equatorial «Tethyan» sea of the time.

In Russia as well as in North America the evolutionary sequence of fusulinid foraminifera has provided the means for a «standard» zonation which can also be applied in Northwest Spain (LYS & SERRE 1958, VAN GINKEL 1965, C. MARTÍNEZ DÍAZ 1969). Brachiopods provide another link with Russia, the Alps and North America (DELÉPINE 1943, WINKLER PRINS 1968), and goniatites show relations with Russia, North Africa and North America, as well as with N. W. Europe (DELÉPINE 1943, WAGNER-GENTIS 1960, 1963, 1971, and *in* HIGGINS *et al.* 1964, KULLMANN 1961, 1962, 1963). Non-marine plant fossils, i. e. impression floras as well as spores, furnish the elements of a direct correlation with N. W. Europe (compare WAGNER 1962, 1964, NEVES 1964), Central Europe, Russia and North America; in fact, they compare with all the other Euramerican floras recorded.

The rather restricted marine facies present at only a few intervals in the Westphalian of N. W. Europe has made a correlation with the predominantly marine successions of similar age in Russia and North America fairly difficult. The rôle

of Northwest Spain as a possible intermediary was fully recognized by DELÉPINE (1938, 1943, 1951), who proposed the first general correlation between Russia, Northwest Spain and N. W. Europe. Only a few elements of fauna could be used at that time, and DELÉPINE's correlation has remained a tentative one.

A correlation, based on more comprehensive faunas and floras, has been proposed recently by VAN GINKEL (1965), mainly on the basis of fusulinid faunas, and impression floras as published by WAGNER 1962. This correlation modifies the scheme of correlation between Russia, N. W. Europe and North America, as proposed by Russian workers in the *Compte rendu* of the 4th Carboniferous Congress, held in Heerlen, 1958 (AIZENVERG *et al.* 1960, GORSKY, STEPANOV *et al.* 1960, STEPANOV *et al.* 1962). The evidence of Spanish faunas and floras differs with the Russian proposals mainly with regard to the boundaries of the Bashkirian which, naturally, involve the Lower Moscovian and the Namurian in the Russian sense. The lower limit of the Bashkirian was drawn by the Russian workers at the boundary between Namurian B and Namurian C of N. W. Europe, and the upper limit of the Bashkirian was drawn between Westphalian B and C. A paper by EINOR (1957) draws attention to different opinions existing in Russia on the subject of the lower limit of the Bashkirian, and the Russian proposals of 1958 may therefore be regarded as reflecting a majority opinion rather than a unanimous one based on incontrovertible fact. WAGNER & WAGNER-GENTIS (1963) mentioned some apparent contradictions in the distribution of fossils in Northwest Spain with regard to the Russian correlation, and VAN GINKEL (1965) examined this question more closely by reviewing all the available information from Northwest Spain. In conclusion, he suggested that «the lower limit of the Bashkirian might correspond to the boundary between the Namurian A and B» or even lie within Namurian A, whilst the upper limit of the Bashkirian appeared to correlate approximately with the Namurian/Westphalian boundary (VAN GINKEL 1965, p. 210 and p. 211, respectively). VAN GINKEL's proposals are based almost entirely on spot samples in successions which are not always fully investigated stratigraphically and structurally, and which do not usually show different kinds of zonal fossils in close association within one and the same succession. Inevitably, this imposes a certain degree of doubt until more closely sampled, continuous successions are reported (see comments in WAGNER 1970).

Perhaps the Villamanín area shows the first example of a reasonably complete succession of Viséan, Namurian, lower Westphalian A, and Westphalian B and C strata which has yielded evidence of diverse biostratigraphic elements capable of providing a correlation with N. W. European, Russian and North American chronostratigraphic units. This evidence will be examined below.

The first horizon combining the evidence of two different zonations lies at the *Retites* Band, forming the top of the «caliza de montaña» (Barcaliente Formation only) at some 380 m above the base of the Carboniferous in the Viadangos section (text-fig. 5). It contains *Retites semiretia*, a goniatite species hitherto known only from the Hale Formation of the Lower Morrowan in Arkansas, U. S. A. *Retites semiretia* is regarded as stratigraphically significant, not only because of its stratigraphically restricted occurrence in Arkansas, but also in view of the fact that McCALEB (1968,

p. 64) finds it to be the direct progenitor of *Branneroceras branneri* which occurs immediately above the Hale Formation in the Brentwood Member of the Bloyd Formation. According to McCaleb (1964), *Retites semiretia* still occurs in the Prairie Grove Member (upper part of the Hale Formation), but it seems generally restricted to the Cane Hill Member (lower part of the Hale Formation). It may be recalled that the Morrowan represents the basal Pennsylvanian, and this adds further interest to the find of *Retites semiretia*, a goniatite occurring at the very base of the Pennsylvanian (sub)system.

FELIX & BURBRIDGE (1967) examined the miospore assemblages from three successive Mississippian and Pennsylvanian units in Oklahoma, viz. the Goddard, Springer and Morrow. Their range chart (*loc. cit.*, p. 44) shows an abrupt change in microflora from Springer to Morrow. It is noted that *Tripartites vetustus* and *Schulzospora rara* disappear at the Springer/Morrow boundary, whilst *Florinites antiquus*, *Mooreisporites inusitatus*, *Endosporites formosus* (= ?*E. globiformis*) begin at this boundary. There does not appear to be evidence for typical Namurian B-C assemblages in the succession dealt with by FELIX & BURBRIDGE, and a substantial time gap seems to be present at the Springer/Morrow boundary in the area which they examined.

The *Retites* Band at Viadangos yielded an association of miospores which is directly comparable to that of the upper Namurian B Marsdenian in Britain. The question arises whether the lower limit of the *Retites* range in North America is well enough known to conclude on a correlation between basal Morrowan and Marsdenian. In view of the widespread Mississippian/Pennsylvanian disconformity in the United States Midcontinent region, it is just conceivable that the *Retites* occurrence in Spain represents the lower part of its range, and that this occurrence lies below the basal Morrowan. It is also possible, of course, that the Morrowan in the area studied palynologically by FELIX & BURBRIDGE begins later in the Lower Pennsylvanian than the Morrowan of Arkansas.

GORDON (1964, Table 11) tentatively correlated the basal Morrowan with the Kinderscoutian R₁ (lower Namurian B) of the British succession, but the adduced evidence is wholly circumstantial. BOUCKAERT & HIGGINS (1970) also suggested a correlation between the Cane Hill Member and basal Kinderscoutian, and based this on a comparison between the ornamentation of *Retites semiretia* and that of *Reticuloceras* of the *circumplicatile-paucicrenulatum* group. It would seem that the direct correlation between basal Morrowan and Marsdenian, via the *Retites* Band at Viadangos, carries more weight.

The next horizon at which spore evidence coincides with a goniatite occurrence in the Villamanín area, is that where *Branneroceras branneri* has been found in mudstone which also yielded basal Westphalian A miospores. This occurrence lies at some 1,070 m above the base of the Carboniferous succession in the Bernesga Valley section (text-fig. 5). Another find of *Branneroceras branneri* was made by C. F. WINKLER PRINS in limestone of the Valdeteja Formation north of Cármenes. This locality has been marked by WINKLER PRINS (1968, text-fig. 8) as lying some 600 m above the local

base of the Carboniferous, and apparently represents a slightly lower horizon than that quoted from the Bernesga Valley.

Both GORDON (1964, p. 76) and McCALEB (1968) agree that typical *Branneroceras branneri* is restricted in Arkansas (its type area) to the Brentwood Member of the Bloyd Formation, of lower Upper Morrowan age. The restricted range of this species confers it considerable stratigraphic significance, particularly since it occurs in Arkansas in a closely sampled succession from which both its progenitor (*Retites semiretia*) and its successor (*Diaboloceras*) are known (McCALEB 1968). The exact base of the zone of *Branneroceras branneri* has not yet been established, according to McCALB (1968, p. 65), but cannot be lower than the Prairie Grove Member of the Hale Formation. The top occurrence of this species is below the cap rock of the Baldwin Coal, which contains the first examples of its descendant, *Diaboloceras* (McCALEB *loc. cit.*). The Brentwood Member is correlated with the lower Westphalian A by McCALB (1968, text-figs. 2, 3) but no reasons are given. GORDON (1964, Table 11) correlates his zone of *Branneroceras branneri* s. l. with the top of Namurian B (R_2) and the Namurian C (G_1), apparently using the occurrence of *Gastrioceras branneroides* BISAT from the base of the *Gastrioceras cancellatum* Zone (G_1) in North Wales (BISAT 1940) as a possible link. *G. branneroides* may, however, compare more closely to *Retites*, and this may tend to indicate a higher position for the base of the *Branneroceras branneri* Zone. The lower one of the two Spanish occurrences of *Branneroceras branneri*, corresponding to an horizon in the Valdeteja Formation well above that of the *Retites* Band marking the top of the Barcaliente Formation near Viadangos, does apparently suggest a (late?) Namurian C age. The second occurrence has been directly dated as basal Westphalian A. An upper Namurian C and basal Westphalian A age seems to be quite likely for *Branneroceras branneri*.

GORDON (1970) erected a more restricted *Branneroceras branneri* Zone, which «approximates to but may not fully encompass the range zone of *B. branneri*». He noted this zone as coincident with the Brentwood Limestone Member of the Bloyd Formation in Arkansas. In his correlation chart (GORDON 1970, fig. 2) he equates the *Branneroceras branneri* Zone, as defined above, with R_2 (Marsdenian) in Great Britain, basing this correlation on the presence of *Branneroceras branneroides* (BISAT) GORDON in the uppermost R_2 Zone of North Wales, and on the presence of early forms of *Gastrioceras* both in the *Branneroceras branneri* Zone and in the R_2 Zone. Reasons have been given already for regarding this correlation as unsatisfactory.

Branneroceras branneri has also been recorded from the C_2^{ba} division of the Donetz Basin, i. e. from Lower Bashkirian strata (AIZENVERG *et al.* 1960), where it occurs together with other Namurian C goniatites and plants. *Branneroceras* is also mentioned as marking the base of the Bashkirian in the Tian Shan, U. S. S. R. (SERGOUGNKOVA 1963).

The presence of *Branneroceras branneri* in a succession dated as Namurian C and basal Westphalian A in Northwest Spain agrees with the correlation between Lower Bashkirian and Namurian C, as proposed by AIZENVERG *et al.* 1960, GORSKY & STEPANOV *et al.* 1960, and STEPANOV *et al.* 1962, on the basis of ammonoids and plants

occurring in the same beds as do the characteristic foraminifera. On the other hand, the Russian workers also equated the Lower Bashkirian with the Lower Morrowan, and this correlation may have to be modified in the light of upper Namurian B spores coinciding with a basal Morrowan index goniatite in Northwest Spain.

VAN GINKEL (1965, pp. 209-210) discussed the probable position of the lower limit of the Bashkirian in Northwest Spain, and presented the tentative conclusion that it might correspond to either the Namurian A/B boundary or to a position within Namurian A. This conclusion, based on circumstantial evidence, is wholly unsubstantiated, and can be discarded in the light of the information gained from the Villamanín area, where the Lower Bashkirian *Branneroceras* Zone is undoubtedly later than Namurian B.

The incomplete succession of Westphalian A rocks in the Villamanín area is probably to be compared with at least part of the better developed San Emiliano Formation at some 20 km westwards in northern León. Although the San Emiliano Formation in its *locus typicus* has not yet been studied in detail, it seems that fusulinid faunas of Upper Bashkirian age may occur in the same succession as Westphalian A floras (compare VAN GINKEL 1965, JONGMANS *in* WAGNER 1959, STOCKMANS & WILLIÈRE 1966).

At the horizon of the «caliza masiva» in the Villamanín area (at Villanueva de la Tercia and in the Valle El Ejío section—text-fig. 5), a Westphalian B spore flora coincides with a Kashirian (late Lower Moscovian) foraminiferal assemblage. This apparently modifies the Russian correlation of Kashirian with upper Westphalian C (STEPANOV *et al.* 1962) and corresponds more closely to correlations published by SJERP (1967, p. 85) and WINKLER PRINS (1968, p. 63). The absence of identified Vereyan assemblages in the Villamanín area, where a reasonably full succession of Westphalian B strata appears to be present, makes it impossible at this moment to contribute to the correlation of the Bashkirian/Moscovian boundary, apart from the observation that it could correspond to a position within upper Westphalian A or even to the base of Westphalian B. VAN GINKEL (1965, p. 210), however, reported an upper Vereyan fusulinid fauna from rocks in northern Palencia which are overlain by conglomerates of probable Westphalian A age. This tends to suggest a position within Westphalian A rather than at the base of Westphalian B. The Russian correlation of the Lower Moscovian boundary with the base of Westphalian C appears to be out of the question.

The lower Westphalian B spore assemblage of loc. R 25 in the Valle El Ejío section is associated with the goniatite *Rodiezmoceras bisati*, a successor to *Branneroceras branneri*, whose range has not yet been established. FELIX & BURBRIDGE'S (1969) record of *Vestispora profunda* occurring for the first time in the Upper Morrowan, tends to indicate that the Westphalian A/B boundary lies above the Morrowan of North America (compare Table 1). In Illinois this boundary coincides approximately with the limit between the Caseyville and the Tradewater Groups, as studied palynologically by KOSANKE (1950). R. C. MOORE *et al.* (1944, correlation chart) agree with this correlation, but also equate the Caseyville/Tradewater boundary with that between

WESTERN EUROPE	MID-CONTINENT U. S. A.	
WESTPHALIAN D		Myachkovian
		Podolskian
WESTPHALIAN C		Kashirian
WESTPHALIAN B	ATOKAN Winslow Fm	MOSCOVIAN ↓ Vereyan
WESTPHALIAN A	MORROWAN Bloyd Formation	? ? ? ? ?
NAMURIAN C		BASHKIRIAN ↑
	Hale Formation	
NAMURIAN B	stratigraphic gap?	
NAMURIAN A	SPRINGERIAN	
	CHESTERIAN	

Table 1.—Proposed correlations between major stratigraphic units of the Carboniferous in Western Europe, North America (Mid-Continent), and Russia, as discussed in the present paper.

the Morrow and the overlying Lampasas (Atoka), which does not seem to fit the evidence quoted above. KOSANKE's evidence shows *Florinites antiquus*, *Laevigatosporites* and *Wilsonia* appearing in the upper Caseyville, and *Vestispora (Reticulatisporites) irregularis* starting at the base of the overlying Tradewater Group, whilst *Schulzospora* is restricted to the Caseyville Group. The Tradewater/Carbondale boundary (adjusted to R. C. MOORE *et. al.*'s chart) shows the incoming of many species of small *Triquitrites*, which suggests the Westphalian B/C boundary (in agreement with R. C. MOORE *et al.*).

At an horizon corresponding to upper Westphalian B (text-fig. 5), another assemblage of goniatites was found in the Valle El Ejío section. The only well defined species in this assemblage is *Proshumardites primus* which was previously recorded from the *Gastrioceras listeri* Zone in Texas (PLUMMER & SCOTT 1937, p. 25). This would point to a Westphalian A age. It is possible that the specimens identified as *Proshumardites morrowanus* by McCaleb (1968) can be assigned to *P. primus*, and in this case an Upper Morrowan occurrence could be added. The comparable

Proshumardites karpinskyi var. *becharensis* PAREYN has been recorded in association with *Gastrioceras crenulatum* BISAT, *G. marianum* DE VERNEUIL, *Homoceratoides* ex gr. *divaricatum* (HIND), *Anthracoceras vanderbecki* LUDWIG, *Wiedeyoceras lineolatum* A. K. MILLER and *Reticuloceras superbilingue* BISAT; an assemblage which PAREYN (1961, p. 164) ascribes to *Reticuloceras* Zone or higher. It seems that *Proshumardites primus* and comparable species have generally been found in Westphalian A rocks, and the presence of this species in upper Westphalian B strata in Northwest Spain appears to extend its known range.

Westphalian B spores have been found at the horizon of the «caliza masiva» (text-fig. 5), which contains Kashirian fusulinids.

The simultaneous occurrence of lower Westphalian C plant spores and (upper?) Kashirian fusulinid and brachiopod faunas in the railway cutting south of Villanueva de la Tercia (text-fig. 5) provides evidence of direct correlation which, in conjunction with the evidence from the «caliza masiva», modifies the Russian correlation of Kashirian with upper Westphalian C. It appears from the evidence in the Villamanín area that the Kashirian corresponds to (middle to upper?) Westphalian B and lower Westphalian C.

No evidence for strata higher than lower Westphalian C has been found in the Villamanín area which may also fail to reach the Upper Moscovian Podolskian.

DESCRIPTION OF GONIATITES

(C. H. T. WAGNER-GENTIS)

The goniatites collected in the Villamanín area belong to four different assemblages. The oldest assemblage is that of the *Retites* Band near Viadangos. Apart from abundant *Retites semiretia* McCaleb it contains an unidentifiable prolecanitid, ?*Gastrioceras* sp., and two species of the nautiloid *Metacanites*. The *Retites* Band (loc. Vi 8) has been dated on plant spores as upper Namurian B. The second horizon at which goniatites were found is that represented by *Branneroceras branneri* (SMITH), occurring at an appreciably higher level than the *Retites* Band (compare text-fig. 5). *Branneroceras branneri* appears in a mudstone in the Villamanín area (loc. 1262), but 8 km to the east the same species has been collected from a muddy limestone band in «caliza de montaña» (Valdeteja Formation) at ca 1 km north of Cármenes (Coll. C. F. WINKLER PRINS, loc. 10' - see WINKLER PRINS 1968, text-fig. 8, column B: *Eomarginifera setosa* Band). Loc. 1262 has also yielded spores of early Westphalian A age. It is possible that loc. WP 10' is somewhat lower in the local stratigraphic succession.

Both the *Retites* Band and the *Branneroceras* occurrences are below the disconformity which eliminated most of Westphalian A in the Villamanín area. Immediately above the disconformity, in loc. R 25, dated on spores as basal Westphalian B, *Rodiezmoceras bisati* gen. et sp. nov. occurs. This goniatite is regarded

as a probable descendant of *Branneroceras*, since it shows an identical suture but for the position of the umbilical lobe which has moved onto the lateral side in the later form. At some 650 m higher in the succession (loc. Rz 19 in the Valle El Ejío section—see text-fig. 2) another goniatite assemblage is recorded. It contains *Proshumardites primus* PLUMMER & SCOTT, *Proshumardites* sp., and fragments which have been tentatively identified as *Diaboloceras* sp. and *Rodiezmoceras bisati*. The absence of a suture makes the latter two identifications particularly hazardous. Plant spores at this horizon indicate an upper Westphalian B age which may be higher than any age previously recorded for *Proshumardites primus*.

Next to the assemblages recorded in sequence from the Villamanín area and the adjacent region of Cármenes, two species of *Retites* are described from an exposure at 50 m above the «caliza de montaña» at Meré, eastern Asturias. These specimens from the collection of E. MARTÍNEZ-GARCÍA (compare MARTÍNEZ-GARCÍA 1971) belong to *Retites semiretia* and a new species described here as *Retites merensis*. The assemblage occurs in a similar stratigraphic position to that of the *Retites* Band near Viadangos de Arbas in the Villamanín area.

The specimens illustrated from the Villamanín area (Coll. MOORE, NEVES, WAGNER & WAGNER-GENTIS) are stored in the British Museum (Natural History), London, whilst the specimen of *Branneroceras branneri* from the exposure north of Cármenes (Coll. C. F. WINKLER PRINS) is in the Rijksmuseum van Geologie en Mineralogie (National Museum of Geology and Mineralogy), Leiden, the Netherlands. The material from Meré (Coll. E. MARTÍNEZ-GARCÍA) is in the Departamento de Paleontología, Facultad de Ciencias, Universidad de Oviedo.

Family Gastrioceratidae HYATT

Genus *Retites* McCALEB 1964

Retites semiretia McCALEB

Pl. 2, figs. 2-4

M a t e r i a l.—Numerous fragments of shell ornament, two of which have been retained (Pl. 2, fig. 3), were collected from loc. Vi 8, in mudstone immediately above the «caliza de montaña» (Barcaliente Formation) at 350 m west of Viadangos de Arbas (León). Two more specimens came from a marly, weathered mudstone at 50 m above the «caliza de montaña» in the road section near Meré (eastern Asturias). Both these specimens are figured (Pl. 2, figs. 2, 4).

D e s c r i p t i o n.—The specimens obtained are only fragments of a whorl. However, the shape of the available whorl segments indicates a short, rounded lateral side and an arcuate venter. Ornament consists of plications around the umbilical edge. Crossing the whorl are transverse lirae, joined loosely on top of the plications and, after leaving the plications, diverging clearly into two or three separate lirae. Between the plications one to two lirae are intercalated. Together, the lirae form a salient on the latero-ventral side and a sinus on the venter. A spiral ornament is visible on the lateral side beyond the plications, latero-ventral side and venter. It is only developed strongly over the latero-ventral salient of transverse ornament, where a reticulate pattern is produced. Deep constrictions are found, following the transverse lirae.

C o m p a r i s o n s.—*Retites semiretia* is comparable with *Gastrioceras bran-neroides* BISAT 1940 (see, in particular, figs. 2 and 3 of Pl. XIV in RAMSBOTTOM & CALVER 1962). Especially the joining of transverse lirae on the plications around the umbilical edge is a comparable feature. *R. semiretia* differs from *G. bran-neroides* because the latter has a much finer and denser spiral ornament. *Branneroceras bran-neri* (SMITH 1896), another comparable species, differs in the presence of a reticulate pattern on the umbilical plications. According to McCALB (1964), *Retites semiretia* usually possesses very deep and clear constrictions, which are absent in *Branneroceras bran-neri* and *Gastrioceras bran-neroides*.

R e m a r k s.—McCALB (1964) described *Retites semiretia* as a precursor of *Branneroceras bran-neri*. In the Villamanín area the former is found at a stratigraphic horizon which appears to be lower in the local succession than that which yielded a specimen of the latter (i. e. at loc. Vi 8 and loc. 1262, respectively - see text-fig. 1). Loc. Vi 8, containing *Retites semiretia*, yielded a spore flora of late R₂ (upper (Namurian B) to R. NEVES (see page 323). This age closely compares with the basal Namurian C age of *Gastrioceras bran-neroides*, which has been recorded from the base of the *Gastrioceras cancellatum* Zone in North Wales (BISAT 1940).

D i s t r i b u t i o n.—The only hitherto described occurrence of *Retites semiretia* was in the Cane Hill and Prairie Grove members of the Hale Formation (Lower Morrowan) in Arkansas, U. S. A. (McCALEB 1964), where it occurs in association with *Syngastrioceras globosum* (EASTON) and *Pronorites arkansasensis* (SMITH). In Spain, it occurs together with *Retites merensis* sp. nov. in mudstones at 50 m above the local top of «caliza de montaña» near Meré (Asturias) (E. MARTÍNEZ loc. 75), and together with *Metacanites* spp., a prolecanitid?, *Gastrioceras?* sp. indet., and possible *Proshumardites*, in mudstones above the «caliza de montaña» near Viadangos de Arbas (León) (loc. Vi 8), where dating on spores indicates late Namurian B.

Retites merensis sp. nov.

Pl. 2, fig. 5.

M a t e r i a l.—One specimen (part and counterpart), preserved as an imprint in mudstone at 50 m above the «caliza de montaña» in the road section near Meré, eastern Asturias.

R e p o s i t o r y o f t y p e.—Departamento de Paleontología, Facultad de Ciencias, Universidad de Oviedo, Spain (Coll. E. MARTÍNEZ loc. 75).

D i a g n o s i s.—Shell serpentinecone; whorls at first hexagonally to rectangularly coiled, and later whorls ellipsoidally wound. Large umbilicus. Ornament consisting of small ribs forming occasional nodes on the umbilical edge. Ribs carry straight over the lateral side, and bend strongly forwards over the latero-ventral side where bifurcation to the front of the main ribs sometimes occurs. The ribs form a shallow sinus on the venter. A very fine spiral ornament is found only on the latero-ventral and ventral parts of the whorl, forming tiny bead-like protuberances where they cross the ribs. No longitudinal ornament occurs on the umbilical area and lateral sides. Fairly deep constrictions occur on the outer whorl, following the transverse ornament.

Description.—Of the widely umbilicated serpentinocone shell the following measurements have been made: Diameter - 8 to 9 mm; Height of outer whorl - 2.5 mm; Width of umbilicus - *ca.* 6 mm.

The specimen is flattened but, nevertheless, appears to possess a widely rounded venter and short rounded sides. The coiling of the first few whorls is angular and in later whorls rounded ellipsoidal. The ornament shows small tubercles along the umbilical edge, but these are not always formed. Bifurcation of the small ribs of the transverse ornament takes place where the ribs start bending forwards, but is not invariably present.

The number of ribs on one third of the whorl is *ca.* 12 along the umbilical border and *ca.* 18 along the venter on the last (5th) whorl. There are 10 ribs along the umbilical border on one third of the 4th and 3rd whorls.

A very fine spiral ornament crosses the transverse ornament and forms tiny bead-like protuberances on the crossing points. These spiral lirae do not occur along the umbilical edge or on the lateral sides; they commence where bifurcation of the ribs takes place or just beyond it. The spiral ornament is more crowded than the transverse. A deep constriction following the transverse ornament is present on the outer whorl.

Discussion.—The specimen described is similar in shape to *Retites* and *Branneroceras*. An angular coiling is also recorded occasionally for *Branneroceras* (McCaleb 1966). It has the design of transverse ornament and the elongate nodes along the umbilical edge that occur also in *Branneroceras* and *Retites*. It also coincides with *Branneroceras* in possessing spiral lirae which form tiny bead-like protuberances by interference with the transverse ornament. The specimen in hand agrees with *Retites* in the absence of spiral lirae near the umbilical edge and on part of the lateral side, as well as by the commencement of spiral ornament where the transverse ribs start to bifurcate. *Retites* also shows deep constrictions.

However, the specimen from Meré differs from the only hitherto described species, *Retites semiretia* McCaleb, in the absence of bundles of transverse lirae, superimposed on the umbilical plications, which fan out beyond the plications. Instead, it possesses small transverse ribs which occasionally bifurcate. The nodes around the umbilical edge are inconsistently present, and the longitudinal ornament is weaker. These differences may eventually warrant recognition of a new subgenus in the *Retites/Branneroceras* group, but one should want to see the suture before making a decision to this effect.

Occurrence.—*Retites merensis* was found at 50 m above the «caliza de montaña» near Meré, in eastern Asturias, where it occurs together with *Retites semiretia* McCaleb, of Lower Morrowan (late Namurian B) age.

Genus *Branneroceras* PLUMMER & SCOTT 1937
Branneroceras branneri (SMITH) PLUMMER & SCOTT
Pl. 5, fig. 16; Pl. 6, fig. 17

M a t e r i a l.—One specimen collected by Dr. C. F. WINKLER PRINS at 1 km, approximately, to the north of Cármenes (León), in the Torío Valley (east of the Villamanín area, in the continuation of the same structures) (W. P. loc. 10'); and two specimens from the western bank of the Bernesga river, ca. 500 m north of Villanueva de la Tercia (loc. 1262). The specimen from the Cármenes area is a flat shell impression preserved in thinly bedded, black calcareous shale. The inner whorls are not preserved. The specimens from the Bernesga valley are preserved in greyish silty mudstone. One is extremely large (150 mm diameter) but, unfortunately, rather badly shattered as a result of weathering. The other specimen is a small, flat imprint in poor preservation.

D e s c r i p t i o n.—Shell serpentinocone. Diameter of Cármenes specimen 55 mm, Villanueva specimens 150 mm and ca. 23 mm. Ornamentation consists of strong plications around the umbilical edge. On the specimen from Cármenes (Pl. 6, fig. 17) these plications are seen to fade away on the outer volutions. The large specimen from the Bernesga Valley, north of Villanueva, has tubercles on the umbilical edge, as culminations of the plications. The number of plications per half whorl in both specimens is 17 to 18. Superimposed on the plications and tubercles are transverse lirae, starting on the plications and tubercles, bending forwards over the latero-ventral side (where they form a salient), and then bending back over the venter (forming a sinus). There are ca. 3 lirae on each plication and 2 per interspace. Apparently, there are neither bifurcations nor intercalations of transverse lirae. A spiral ornament is present from the umbilical edge onwards. It crosses the plications to form a reticulate pattern with the transverse ornament. The spiral ornament becomes stronger where the latero-ventral salient of transverse lirae sets in, and it continues strongly marked over the venter. Where the longitudinal lirae are strongly developed, they appear to form tiny bead-like protuberances on the crossing points with transverse lirae. No constrictions are preserved on the specimens in hand, which do not show a suture line either.

D i s t r i b u t i o n.—In Arkansas, U. S. A., *Branneroceras branneri* has been recorded from the Brentwood Member of the Bloyd Formation (basal Upper Morrowan), together with *Gastrioceras fittsi* MILLER & OWEN, *Syngastrioceras oblatum* (MILLER & MOORE), *Pronorites arkansasensis* (SMITH), *Cymoceras miseri* McCALEB, *Bisatoceras secundum* MILLER & MOORE, *Pygmaeoceras morrowense* (MILLER & MOORE), *Proshumardites morrowanus* GORDON (after McCALEB 1968). In Oklahoma *Br. branneri* is known from the Union Valley and Wapanucka formations, of Morrowan age (UNKLESBAY 1962, McCALEB 1968), where it occurs in association with *Gastrioceras fittsi*, *G. adaense* MILLER & OWEN, *Syngastrioceras oblatum*, *Pseudoparalegoceras compressum* (HYATT), *Pronorites arkansasensis*, *Bisatoceras secundum*, *Pygmaeoceras morrowense*, *Eoasianites globulosus* (MEEK & WORTHEN). From the same formations MILLER & OWEN (1944) also mention *Gastrioceras grileyi* MILLER & OWEN.

From China, YIN (1935) has recorded *Gastrioceras reticulatum* YIN (a junior synonym of *Branneroceras branneri* —see McCALEB 1968, p. 60), together with

Shuichengoceras yohi YIN, *Syngastrioceras kueichowense* (YIN) LIBROVITCH (originally described under *Gastrioceras*), *Syngastrioceras suborientale* (YIN) LIBROVITCH (described under *Gastrioceras*) and *Syngastrioceras orientale* (YIN) LIBROVITCH (described under *Gastrioceras*); all occurring in the Wangchiappa Limestone, at Shuichenghsien, Kueichow.

In Russia, AISENBERG *et al.* (1960) mentioned *Branneroceras branneri* from Bashkirian (C₂^b_a) deposits in the Donetz basin.

From Central Asia (Tian Shan), *Branneroceras* has been mentioned by SERGOUENKOVA (1963) as marking the base of the Bashkirian Stage. She correlates these deposits in the Tian Shan with Namurian C.

KULLMANN (*in* STEVANOVIĆA & KULLMANN 1962, Taf. 2, fig. 1) figured a goniatite from Lower Namurian (E₂) deposits in Yugoslavia, under the name of *Gastrioceras (Branneroceras) branneri branneri* SMITH, thus apparently providing an early record of this species. However, his illustration is unconvincing and the identification is subject to reservation.

Rodiezmoceras gen. nov.

Diagnosis.—Conch discoidal with large umbilicus. Venter and flanks rounded; umbilical shoulder narrowly rounded and umbilical wall inverted. Ornament with undivided, coarse, transverse ribs directed forwards on the lateral side, forming a salient on the ventro-lateral side and a sinus on the venter. Dorsally, transverse ribs are present as well as more closely spaced fine, longitudinal lirae. Faint traces of fine spiral lirae occur on the ventro-lateral and ventral sides. Umbilical wall smooth. No constrictions. Suture line as in *Branneroceras branneri*, but differing in the position of the umbilical lobe which is on the lateral side.

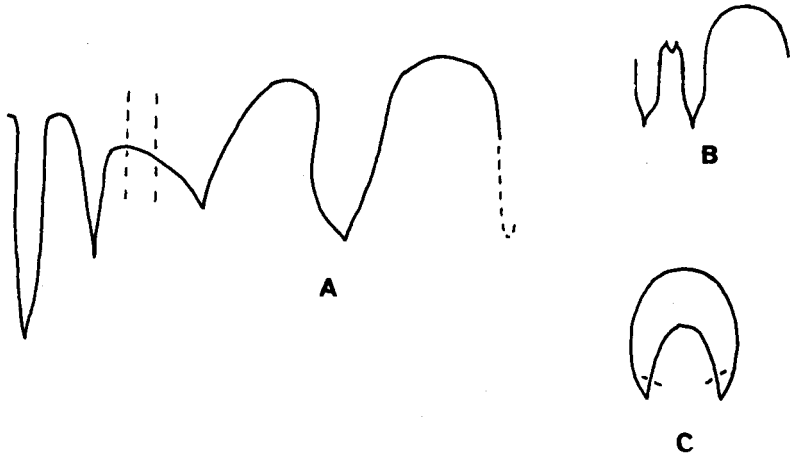
Type of genus.—*Rodiezmoceras bisati* sp. nov.

Discussion.—*Rodiezmoceras* differs from *Branneroceras* in having its umbilical lobe on the lateral side instead of on the umbilical wall. The ornament does not show any transverse lirae on the transverse ribs and interspaces, as in *Branneroceras*, but has the transverse ribs continuing over the lateral, ventro-lateral and ventral sides. The spiral ornament is very subdued, and is present only on the latero-ventral and ventral sides. The shape of the whorl seems to be less squat than in *Branneroceras*, but the type specimen is slightly distorted.

Rodiezmoceras bisati sp. nov.

Pls. 2-4, figs. 9, 11; ? figs. 12-13; text-fig. 6

Material.—One specimen (holotype) preserved as a solid in yellowish brown, marly mudstone at 75 m above the «caliza de montaña» in the Valle El Ejio section (loc. R 25), north of Rodiezmo (text-fig. 2). Two additional, rather fragmentary specimens from loc. Rz 19 (text-fig. 2) are tentatively assigned to this species.



Text-fig. 6.—*Rodiezmoceras bisati* gen. et sp. nov. (a) internal and external suture of outer whorl; (b) ventral suture of previous whorl; (c) cross section of whorl. Sutures $\times 3$, section $\times 1$. Holotype: Brit. Mus. Nat. Hist. C 76353.

Repository of holotype.—British Museum (Nat. Hist.), Dept. of Palaeontology, Cat. No. C 76353.

Diagnosis.—As for the genus.

Description.—Shell evolute, discoidal. Dimensions: Diameter - 50? mm; Width - ca. 10 mm; Height of outer whorl - 16 mm; Height of opening outer whorl - 11 mm; Width of umbilicus - 20? mm. The outer whorl is not distorted, but only preserved up to the mid-venter. The whorl is higher than it is wide, and the outer side is rounded. The umbilical wall bends inwards and upwards. For cross-section of whorl see text-fig. 6 c.

Ornament consists of 6 ribs at 10 mm diameter near the umbilical edge, at a whorl height of 15 mm. On the flanks the interspaces between ribs are slightly wider than the ribs themselves. The ribs are undivided and without intercalations. Worthy of note is the leaning forwards of ribs on the flanks.

Suture (text-fig. 6) has two pointed ventral lobes, with a median saddle reaching up to two thirds the height of the widely rounded ventro-lateral lobes. The lateral lobe is asymmetrical, pointed and inflated towards the umbilical side. It is twice as wide as the ventral lobes. The second lateral saddle is rounded, and the small, pointed umbilical lobe lies on the lateral side. On the dorsal side are three long, narrow and pointed lobes, the middle one of which is the longest. The link between the inner and the outer suture is effected by a loop between the umbilical lobe and the first dorsal lobe.

Comparison.—Besides comparisons as stated for the genus, *Rodiezmoceras bisati* is somewhat comparable to *Paralegoceras percostatum* H. SCHMIDT (1955, p. 50, Taf. A, figs 1 a-b). *P. percostatum* has a lower ventral saddle and possesses a second lateral lobe. The internal suture is not visible in the only known specimen

of *P. percostatum*, and if it would prove to have no umbilical lobe, it could well turn out to be the *Rodiezmoceras* type suture. It should be noted that the suture of *P. percostatum* is different from that normally present in *Paralegoceras*. The ornament differs in that *P. percostatum* has more sharply edged ribs which show a slightly sigmoid course on the flanks of the outer whorl, and which are not leaning forwards as distinctly as in *R. bisati*.

D I S C U S S I O N.—*Rodiezmoceras* shows the same kind of suture as in *Branneroceras*, with the sole difference that the umbilical lobe lies on the lateral side. It may be that this reflects an evolutionary trend and that *Rodiezmoceras* issued from *Branneroceras* stock.

O C C U R R E N C E.—At 75 m above «caliza de montaña» in Valle El Ejío section north of Rodiezmo, Villamanín area (León). This locality (R 25) has been dated on miospores as early Westphalian B (cf. page 315). Also, doubtfully, at 710 m above the «caliza de montaña» in the same section (loc. Rz 19—text-fig. 2), in rocks of upper Westphalian B age.

?*Gastrioceras* sp.

Pl. 2, fig. 8

M A T E R I A L.—One specimen from the *Retites* Band west of Viadangos de Arbas (León) (loc. Vi 8).

D E S C R I P T I O N.—Fragment of a whorl, probably representing a little less than half the whorl, with 10 tubercles around the umbilicus as preserved; most likely some 12 tubercles existed per half whorl. A very deep and wide constriction is present. No ornamentation has been preserved. The diameter was probably 24 to 25 mm, and that of the umbilicus between 9 and 10 mm.

Family Schistoceratidae SCHMIDT

?*Diaboloceras* sp.

Pl. 3, fig. 10

M A T E R I A L.—A negative imprint in mudstone from loc. Rz 19 (upper Westphalian B), at 710 m above the «caliza de montaña» in the Valle El Ejío section north of Rodiezmo (León).

D E S C R I P T I O N.—Probable diameter *ca.* 20 mm, umbilicus *ca.* 9 mm. Around the umbilical edge it shows plications, and from the umbilical edge to the ventro-lateral side a reticulate ornament is visible, the tranverse striae being as strongly developed as the longitudinal ones.

Family Agathiceratidae ARTHABER
Genus *Proshumardites* RAUSER-CHERNOUSSOVA 1928
Proshumardites primus PLUMMER & SCOTT
Pl. 4, fig. 14; text-fig. 7

M a t e r i a l.—One specimen from loc. Rz 19 in the upper part of the Valle El Ejio section north of Rodiezmo (León). Only half of the shell is preserved in greyish mudstone.

D e s c r i p t i o n.—Shell ellipsocone and involute. Diameter probably 12 mm, width 8 mm. Transverse circumference of outer whorl semilunar (text-fig. 7).

Ornament consists of *ca.* 21 spiral ridges between the umbilicus and the mid-venter; spiral ridges flat-topped, with interspaces approximately $1\frac{1}{2}$ times the width of the ridges. A deep, straight constriction runs underneath the ornament.



Text-fig. 7.—*Proshumardites primus* PLUMMER & SCOTT. (a) suture, $\times 3$; (b) contour of whorl, $\times 3$. Brit. Mus. Nat. Hist. C 76357.

Suture-line characterized by a rather broad ventral saddle, lanceolate ventral lobes with parallel sides, a large, asymmetrical and bluntly pointed latero-ventral saddle, and a trifold lateral lobe consisting of a small ventrally positioned secondary lobe, a long, lanceolate and pointed central secondary lobe, and an umbilically positioned secondary lobe which is longer and wider than the ventrally positioned one; the umbilically positioned saddle of the trifold lobe being wider and higher than the ventrally positioned one. After the trifold lobe the suture is not very well visible, but gives the impression of a large, wide saddle, as high as the ventro-lateral saddle.

C o m p a r i s o n s.—The specimen in hand is very similar to *Proshumardites karpinskyi* var. *becharensis* PAREYN (1961, p. 163, Pl. XIX, figs. 14-15), but differs in the number of spiral ridges between umbilicus and mid-venter (21 as against 33 in PAREYN's variety). On the other hand, the suture, as shown on PAREYN's Pl. XIX, figs 14-15, is identical to that described here.

The specimen in hand differs from *Pr. morrowanus* GORDON in the shape of the secondary lobes of the trifold lateral lobe, as drawn by GORDON (1964, p. 277, text-fig. 90), but shows the same suture as in *Pr. morrowanus* as figured by McCaleb (1968, text-fig. 5). It is difficult to decide whether GORDON's specimen had a weathered suture or McCaleb's should be regarded as belonging to *Pr. primus*.

D i s t r i b u t i o n.—*Proshumardites primus* was first recorded from the Smithwick Formation in Texas, attributed to the *Gastrioceras listeri* Zone (PLUMMER

& SCOTT 1937, p. 25). It occurred together with *Praedaraelites sandbergeri* (PLUMMER & SCOTT) (originally named *Paraprolecanites*), *Glaphyrites raymondi* PLUMMER & SCOTT, *Pseudoparalegoceras lenticulare* (PLUMMER & SCOTT) (originally named *Phaneroceas*), *Gastrioceras smithwickense* PLUMMER & SCOTT (similar to *Branneroceras branneri*), *Gastrioceras occidentale* MILLER & FABER, and *Bendoceras shumardi* PLUMMER & SCOTT (i. e. their Pl. 11, figs. 8-9, which show the ornament, and not the specimens showing the *Bendoceras* suture, which are from a different locality).

The specimens identified as *Proshumardites morrowanus* GORDON by McCALB (1968) may well belong to *Pr. primus*. These were found in the lower and middle parts of the Boyd Formation (Upper Morrowan) of Arkansas, U. S. A., in association with *Wiedeyoceras smithi* McCALB, *Gastrioceras attenuatum* McCALB, *G. araium* McCALB, *Syngastrioceras oblatum* (MILLER & MOORE), *Pseudoparalegoceras compressum* (HYATT), *Diaboloceras neumeieri* QUINN & CARR, *Axinolobus modulus* GORDON, *A. quinni* McCALB & FURNISH, *Bisatoceras secundum* MILLER & MOORE, *Gastrioceras fittsi* MILLER & OWEN, *Branneroceras branneri* (SMITH), *Pronorites arkansasensis* (SMITH), *Pygmaeoceras morrowense* MILLER & MOORE, and *Cymoceras miseri* McCALB.

The species was recorded from Morocco by DELÉPINE (1941, p. 24), who found it in association with *Gastrioceras*.

From Algeria (Sud-Oranais), *Proshumardites karpinskyi* var. *becharensis* PAREYN (1961, p. 164) was mentioned with an undescribed goniatite fauna, which indicates a wide stratigraphic range.

Proshumardites sp.

Pl. 4, fig. 15

This specimen, found in loc. Rz 19 of the Valle El Ejío section near Rodiezmo (León), only shows the ornament consisting of ca. 24 spiral ridges between the umbilicus and the venter. The ridges are crossed by a very fine transverse ornament which is hardly visible. Crossing the whorl, wide constrictions are found, with an angle of 60° between them. No suture line is visible.

Prolecanitidae?

Pl. 2, fig. 1

A specimen, found in the *Retites* Band at Viadangos de Arbás (León) (loc. Vi 8), is serpenticone with a rapidly increasing whorl height. For this reason it might equally well belong to the Daraelitidae. The lack of a suture makes a definite identification impossible.

MACROFLORAL ELEMENTS

(R. H. WAGNER)

Identifiable plant macrofossils are rare in the generally marine succession of Namurian and Westphalian strata in the Villamanín area. Apart from incidental remains of drifted plants, which are usually too decayed or too heavily comminuted to be identifiable, but which occasionally comprise recognizable genera and species, there are only two localities yielding plant macrofossils.

1. Viadangos de Arbas.

The older locality occurs in sandstones and silty shales of unit 17 of the succession at Viadangos de Arbas (compare page 322). Abundant comminuted plant remains are accompanied by occasional fragments of foliage and casts and molds of trees (loc. 1095). Most common are detached pinnules of *Paripteris gigantea* (STERNBERG) GOTHAN. They show the usual aspect of falcate, fairly broad pinnules with parallel borders tapering towards a broadly rounded apex, and possessing a cordate base. The midvein is thin but its position is distinct, and the midvein seems to reach generally about halfway up the pinnule. Lateral veins are broadly arching and moderately close. Although the preservation of the venation is inadequate, the lateral veins are assumed to be free, non-anastomosing. LAVEINE (1967, p. 257) has recently reviewed the stratigraphic distribution of *P. gigantea* which ranges from Namurian B to lower Westphalian C.

The pith casts of *Calamites* are not usually diagnostic unless branch scars are present. The fragmentary remain in loc. 1095 shows blunt, alternating ribs on the single node preserved. *Calamites suckowi* BRONGNIART, which is characterized by blunt, alternating ribs, occurs from Namurian B to late Stephanian.

Lepidodendron obovatum STERNBERG, which is represented with an external mold (Pl. 8, fig. 23), is a common species throughout the Namurian and the Westphalian of Europe.

Mariopteris acuta BRONGNIART, which was recorded in 1963 (p. 233) from a locality in the same sandstone unit at the north-eastern tip of the village of Viadangos, ranges from Namurian B to Westphalian A (according to STOCKMANS & WILLIÈRE 1954).

The four species mentioned are insufficient as an assemblage to provide an accurate age determination. On the evidence of miospores, the sandstone unit at Viadangos should be regarded as late Namurian B in age, and this is within the range indicated by the plant macrofossils.

2. Coal tip and exposures N.N.W. of Rodiezmo.

This is the only locality which yielded plant macrofossils from non-marine strata. Most specimens were obtained from the tip of a small coal working at 1,250 m

N. N. W. of Rodiezmo (loc. 1101, text-fig. 1), yielding material from fine-grained roof shales and from more silty mudstones, probably representing the seat-earth. Further remains from the same horizon were collected from silty mudstones outcropping near the coal tip (loc. Rz 36).

The most common element of this flora is *Paripteris linguaefolia* (P. BERTRAND) GOTHAN (Pls. 7-8, figs. 21, 22, 25), which is recognizable by its pinnules showing a broadly rounded apex, an extremely short midvein (which is hardly developed at all) and closely spaced, broadly arching, fine lateral veins. This species is characteristic of upper Westphalian B and Westphalian C. It has previously been recorded in Spain from late Westphalian B strata in northern Palencia (WAGNER 1960, 1966).

Neuropteris tenuifolia (VON SCHLOTHEIM) STERNBERG (Pl. 7, fig. 19) is a well known element of Westphalian B and C strata, which appears in late Westphalian A and still occurs sporadically in early Westphalian D rocks (compare LAVEINE 1967, pp. 171-172). Its slightly triangular pinnules with a moderately wide nervation are characteristic.

Alethopteris davreuxi (BRONGNIART) GOEPPERT is well represented in the locality N. N. W. of Rodiezmo. Its broadly confluent, slender pinnules with a wide nervation (Pl. 8, fig. 24) are very characteristic. This species is distinguished from the comparable *Alethopteris ambigua* LESQUEREUX (= *A. friedeli* P. BERTRAND) by its more thinly limbed pinnules, those of the latter being markedly coriaceous. *A. davreuxi* occurs throughout Westphalian A, B, C and lower D, but appears most commonly in Westphalian B and lower Westphalian C strata (compare BUISINE 1961, p. 154).

The specimen identified as *Sphenopteris (Tetratmema) alata* BRONGNIART (Pl. 7, fig. 18) shows the winged rachis and rather widely spaced pinnules of this species which is mainly distinguished from *Sphenopteris (Palmatopteris, Tetratmema) furcata* BRONGNIART by its less deeply dissected pinnules with more bluntly pointed lobes (compare KIDSTON 1923, p. 93). There is also a resemblance to *Diploptemum patens* NĚMEJC (see NĚMEJC 1937, Plate fig. 12). *S. alata* has been recorded from the upper Westphalian D (Radstockian) in Britain, but is too uncommon to be important stratigraphically.

The small fragment recorded as *?Mariopteris* sp. (Pl. 7, fig. 20) is somewhat comparable to *Mariopteris dertoncourti* ZEILLER, but cannot be reliably identified with any species.

Pecopteris plumosa (ARTIS) BRONGNIART (Pl. 8, fig. 26) is represented by a totally characteristic fragment. Unfortunately, this species ranges throughout the Westphalian and also occurs in Namurian B-C. Perhaps, the typical form of *P. plumosa* becomes less common in Westphalian D strata.

Only a single verticil of *Annularia microphylla* SAUVEUR (Pl. 8, fig. 27) has been found, but the stiff, curved leaves of small dimensions are characteristic. This species is regarded as a Westphalian A and B element, which is generally rare, but most common in Westphalian B (GOTHAN, LEGGEWIE & SCHONEFELD 1959, p. 51).

The same locality also contains specifically unidentified fragments of *Cordaïtes* leaves and a doubtful *?Lepidostrobis* sp.

The total assemblage is generally indicative of Middle Westphalian, and the presence of *Annularia microphylla* would tend to exclude most of Westphalian C and therefore provide an indication for Westphalian B rather than C. The more complete miospore assemblage recorded by R. NEVES dates the locality as approximately coinciding with the Westphalian B/C boundary.

3. Railway cutting south of Villanueva de la Tercia.

A fragment of *Alloiopteris* sp. (Pl. 8, fig. 28) has been found in the scree of this exposure, which also yielded *Pecopteris* cf. *pennaeformis* BRONGNIART.

MIOSPORE ASSEMBLAGES

(R. NEVES)

The basis for the palynological dating suggested in this paper is traditional in the sense that it is based on the qualitative features of the assemblages which are compared with the stratigraphic ranges of species recorded in other documented basins. First appearances of certain, often structurally complex species, are considered significant when they occur in a recognizable order. These are considered against the more general changes which take place in the overall composition of the assemblages as a result of the evolution of the longer ranging species.

Application of this method to the essentially clastic Upper Carboniferous succession of the Cármenes Syncline meets certain difficulties. For example, very few publications dealing with Upper Carboniferous microfloras provide miospore ranges for clastic sequences. Secondly, the range charts provided for most basins outside Europe, including North America and the U. S. S. R., do not give sufficient detail as to allow close comparisons. Similarly, the paucity of published data on the microfloras of northern Spain restricts comparison of the current succession to that described from the La Camocha Mine in Asturias by NEVES (1964). The present discussion is limited therefore to effecting a correlation with the Upper Carboniferous successions of N. W. Europe.

Samples from the three main sections examined —Bernesga, Valle El Ejío and Viadangos de Arbas— have yielded miospore assemblages which varied widely in terms of preservation and diversity of composition. In the majority of samples it was possible to determine species with confidence and based on qualitative criteria five main assemblages have been recognized:—

- I. *Raistrickia fulva* assemblage.
- II. *Dictyotriletes bireticulatus* assemblage.
- III. *Florinites mediapudens* assemblage.
- IV. *Vestispora pseudoreticulata* assemblage.
- V. *Triquitrites additus* assemblage.

Many species of long ranging genera including *Apiculatisporis*, *Calamospora*, *Densosporites*, *Granulatisporites*, *Laevigatosporites*, *Lophotriletes* and *Lycospora* persist throughout and constitute the background microflora. The restricted range species which distinguish the various assemblages are shown in Table 2. In certain instances, i. e. *Schulzospora*, the upper limit of the biozone is included in the assemblage criteria where regional evidence warrants this. The relationships of the sections examined to the sequence of miospore assemblages is also indicated in Table 2. together with the suggested marine correlatives of N. W. Europe. The latter conclusions have been reached following a comparison with the ranges of 14 taxa as recorded in various European basins which are plotted on Table 3.

Quite clearly the absence of a typically Namurian A assemblage comprising such genera as *Chaetosphaerites*, *Grandispora*, *Remysporites*, *Rotaspora* and *Tripartites* in the examined sequence, places a maximum possible age of Namurian B on the lowest horizons. Similarly the absence of *Torispora*, *Vestispora fenestrata*, *Microreticulatisporites sulcatus*, etc. in the higher assemblages, restricts their age to pre-middle Westphalian C.

The oldest horizons examined occur in the Viadangos de Arbas section in proximity to the *Retites* Band (text-fig. 5). The absence of such elements as *Spelaeotriletes* and *Krauselisporites* at these horizons favours a Marsdenian (R_2) rather than a Kinderscoutian (R_1) age. *Dictyotriletes bireticulatus* precedes *Florinites mediapudens* in both the upper part of the Viadangos section and the lower part of the sequence examined from the Valle El Ejío. The sequence of changes which occur in the higher assemblages and are outlined in Table 2 can be compared closely with those recorded by NEVES (1964) from the coal seam succession of the La Camocha mine in Asturias. One significant difference however is the absence of the *Vestispora costata* assemblage from the Valle El Ejío section. Assemblages of the *Vestispora pseudoreticulata* Zone occur immediately above the «caliza masiva» and on comparison with other European successions are clearly of Westphalian B age. One unusual aspect of these assemblages is the considerable presence (1 - 3 %) of species of the disaccate genera *Alisporites*, *Illinites* and *Limitisporites* in assemblages of Westphalian B age. It is of interest to note that disaccate pollen of the genus *Complexisporites* was present in the La Camocha coals at certain horizons (recorded as *Kosankeisporites* by NEVES 1964, Table I, Plate III, figs. 5 - 8).

Minor changes in the assemblages occur as the section in the Valle El Ejío is mounted. Species including *Endosporites globiformis*, *Florinites millotti*, *Microreticulatisporites nobilis*, *Vestispora* cf. *magna* and *Wilsonites delicatus* appear and occur in small numbers. Small, often ornamented species of *Triquitrites* appear at the top of the section near the horizon of the coal seam and are considered to indicate an age near the Westphalian B/C boundary.

Table 2: Miospore Assemblages of the Cármenes Syncline and their N. W. European correlatives.

Miospore Assemblage	Diagnostic Miospore Taxa	Cármenes Syncline Successions	Proposed Age Equivalent
Triquirites additus	<i>Triquirites additus</i> , <i>T. exiguus</i> , <i>T. bucculentus</i> , <i>Ahrensisporites</i> <i>vetensis</i> , <i>Apiculatisporis irregularis</i> , <i>Microreticulatisporites nobilis</i> .	Bernesga Be 10 Be 5 Rz 36	WESTPHALIAN C (basal part)
Vestispora pseudoreticulata	<i>Endosporites globiformis</i> , <i>Florinites</i> <i>milloti</i> , <i>Vestispora pseudoreticulata</i> , <i>Disaccites</i> .	El Ejo R 25	WESTPHALIAN B
Florinites mediapudens	<i>Florinites mediapudens</i> , <i>F. pumicosus</i> , <i>Bellispores bellus</i> , <i>Radizoonates</i> <i>striatus</i> , <i>Wilsonites delicatus</i> , <i>Schulzospora</i> spp.	Valle Vi 17 R 22 1262	WESTPHALIAN A (middle & lower)
Dictyotriletes bireticulatus	<i>Dictyotriletes bireticulatus</i> , <i>Apiculatisporis varicornis</i> , <i>Cirratriradites saturni</i> , <i>Florinites</i> <i>similis</i> , <i>Mooreisporites fustis</i> .	Vi 14 R 20 de Arbas	NAMURIAN C
Raistrickia fulva	<i>Raistrickia fulva</i> , <i>Alatisporites</i> spp., <i>Armatisporites</i> spp., <i>Crassispora kosankei</i> , <i>Schulzospora</i> spp., <i>Ahrensisporites guerickei</i> .	Vi 8 Viadangos	NAMURIAN B (Marsdemian, R ₂)

These upper assemblages of the Valle El Ejío section compare closely with those obtained from the railway cutting south of Villanueva and which are therefore considered to be of basal Westphalian C age.

Long range correlations with the lower Pennsylvanian in the United States are difficult due to lack of detailed published data. However, based on the publications of KOSANKE (1950) and FELIX & BURBRIDGE (1967), the following tentative conclusions are possible.

KOSANKE, in his comprehensive account of the Pennsylvanian of Illinois, records the presence of *Florinites antiquus*, *Laevigatosporites* spp., and *Wilsonites delicatus* in the upper Caseyville. *Schulzospora* was restricted to the Caseyville, whilst *Vestispora* (*Reticulatisporites*) *irregularis* first appears at the base of the overlying Tradewater. These few facts, providing that the succession is complete, would indicate a correlation between the upper Caseyville and the upper Westphalian A. This correlation agrees with that proposed by MOORE *et al.* (1944, Chart 6).

FELIX & BURBRIDGE (1967), in their account of the palynology of the Springer Formation of Oklahoma, give generalized ranges of selected miospore species through the Goddard and Springer formations of Oklahoma and the Morrow Formation of Arkansas. Species restricted to the Morrow include *Dictyotriletes bireticulatus*, *Florinites antiquus*, *Endosporites formosus*, *Wilsonites vesicatus* and *Vestispora profunda*. This total association occurs in the upper part of the Morrow and compares favourably with that present in the *Vestispora costata* Zone of La Camocha. A correlation of upper Westphalian A with upper Morrow is indicated.

Consideration of the assemblages at the Springer-Morrow boundary as plotted by FELIX & BURBRIDGE, clearly indicates a major change in species composition. The ranges of some 15 taxa including *Schulzospora rara*, *Propriisporites rugosus* NEVES, *Reticulatisporites peltatus* PLAYFORD, *Tripartites vetustus*, *Rotaspora fracta*, and *Bellisporites* (*Lycospora*) *nitidus* terminate whilst 6 others including *Florinites antiquus*, *Mooreisporites inusitatus* and *Endosporites formosus* begin. A natural evolutionary change of this magnitude is remarkable. Compared with the European succession, several aspects of this change are unusual. For example, there is no range overlap between species such as *Florinites antiquus*, *Schulzospora rara* and *Dictyotriletes bireticulatus* as would be expected in lower Westphalian A. The Marsdenian-Yeadonian association of *Armatisporites*, *Crassispora*, *Ahrensisporites* and *Schulzospora* is not apparent in the FELIX & BURBRIDGE chart. Finally, the juxtaposition of *Tripartites* and *Rotaspora* with *Florinites antiquus* at the Springer-Morrow boundary is not known in Europe, even in the Bug Basin.

Consequently, it would appear possible that some part of the succession, corresponding to upper Namurian B, Namurian C and lower Westphalian A, is missing from the section as plotted by FELIX & BURBRIDGE.

In conclusion, a correlation between Springer and some part of Namurian A and lower B seems probable; the basal equivalent of the Morrow is not apparent whilst the upper Morrow resembles uppermost Westphalian A.

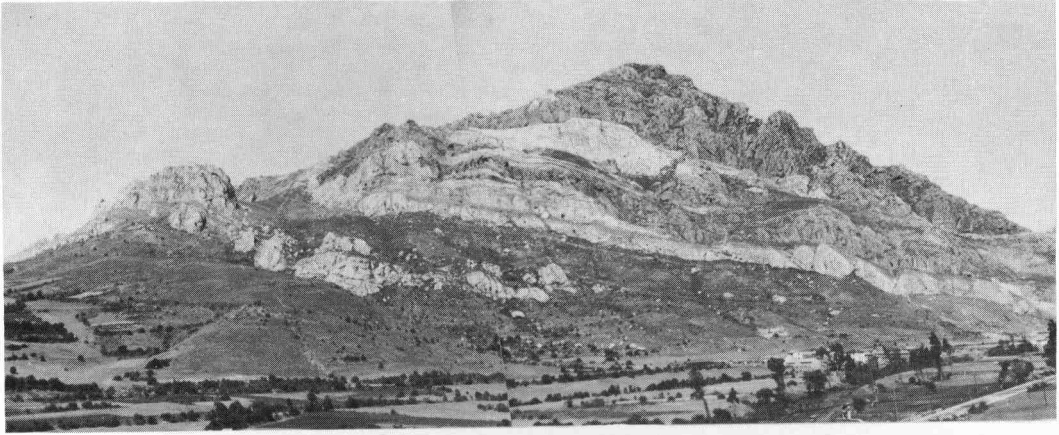
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A view of the two main limestone units in the Carboniferous of the Villamanín area of northern León, taken from a position E. S. E. of Villanueva de la Tercia. The «caliza de montaña» (Namurian) in the background is largely dolomitized, showing up as dark dolomitic limestone with lighter, undolomitized patches. The «caliza masiva» (Westphalian B) is separated from the «caliza de montaña» by a terrigenous sequence which contains an important stratigraphic gap, eliminating most of Westphalian A.

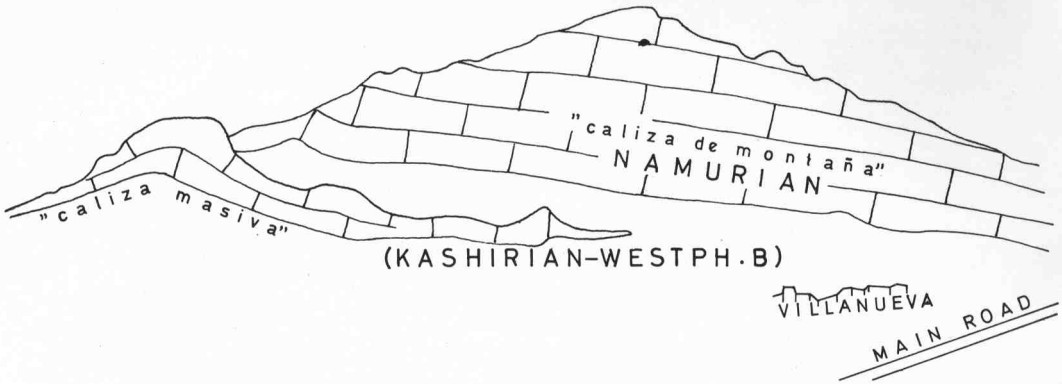


PLATE 2

- Fig. 1.—Prolecanitid, probably belonging to the Daraelitidae, $\times 3$. Lateral view, showing manner of coiling.
 Locality Vi 8, *Retites* Band at the top of the «caliza de montaña» at Viadangos de Arbas (León). Age: upper Namurian B, also Lower Morrowan. Repository: British Museum (Nat. Hist.) Cat. N.º C 76349.
- Fig. 2.—*Retites semiretia* McCaleb, $\times 3$. Ventro-lateral view, showing the ornament.
 Locality AC-75 (Coll. E. MARTÍNEZ-GARCÍA), at 50 m above the «caliza de montaña» near Meré, eastern Asturias (specimen collected by Dr. J. GANDL). Age: Lower Morrowan. Repository: Departamento de Paleontología, Universidad de Oviedo.
- Fig. 3.—*Retites semiretia* McCaleb, $\times 3$. Ventro-lateral view, showing the ornament.
 Locality Vi 8, *Retites* Band at Viadangos. Age: upper Namurian B. Brit Mus. Nat. Hist. Cat. N.º C 76348.
- Fig. 4.—*Retites semiretia* McCaleb, $\times 3$. Fragment showing venter with constrictions and another fragment showing ventro-lateral side with reticulate ornament.
 Locality AC-75 (Coll. E. MARTÍNEZ-GARCÍA), near Meré (specimen collected by Dr. J. GANDL). Age: Lower Morrowan. Repository: Depto. de Paleontología, Univ. Oviedo.
- Fig. 5.—*Retites merensis* sp. nov., $\times 6$. Holotype. Lateral view showing the extremely evolute coiling, the transverse ribs, one constriction, and the fine longitudinal lirae crossing transverse ribs on the venter.
 Locality AC-75 (Coll. E. MARTÍNEZ-GARCÍA), at 50 m above the «caliza de montaña» near Meré, eastern Asturias. Age: Lower Morrowan. Repository: Depto. de Paleontología, Univ. Oviedo.
- Fig. 6.—*Metacanites* sp., $\times 1$. Lateral view showing five elongate ribs per quarter volution.
 Locality Vi 8, *Retites* Band at Viadangos. Age: upper Namurian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76350.
- Fig. 7.—*Metacanites* sp., $\times 1$. Lateral view showing five protuberances at mid-flank in a quarter volution.
 Locality Vi 8, *Retites* Band at Viadangos. Age: upper Namurian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76351.
- Fig. 8.—*Gastrioceras?* sp., $\times 3$. Lateral view showing 6 nodes in a quarter volution along the umbilical edge, and a constriction.
 Locality Vi 8, *Retites* Band at Viadangos. Age: upper Namurian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76352.
- Fig. 9a.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 1$, Holotype. Ventro-lateral view showing transverse ribs and part of the suture line.
 Locality R 25, at 75 m above the «caliza de montaña» in Valle El Ejío section, N. N. W. of Rodiezmo. Age: basal Westphalian B. Repository: Brit Mus. Nat. Hist. Cat. N.º 76353.

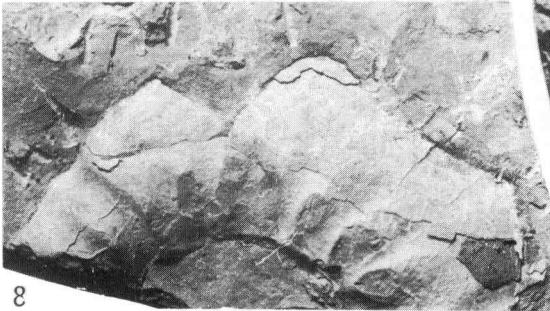
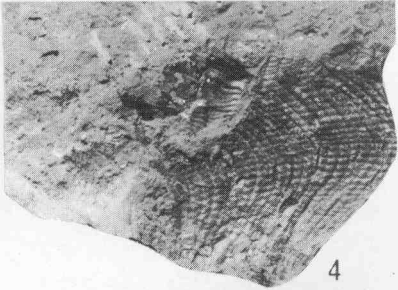
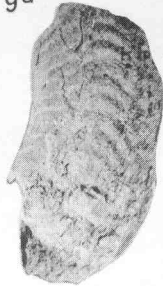
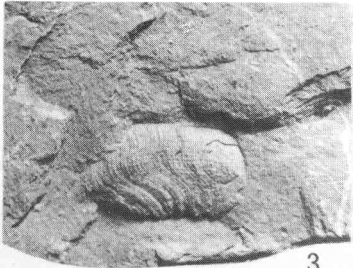
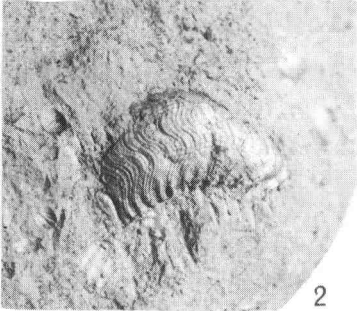


PLATE 3

Fig. 9b.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 3$, Holotype. Dorsal view showing internal suture and ornamentation.

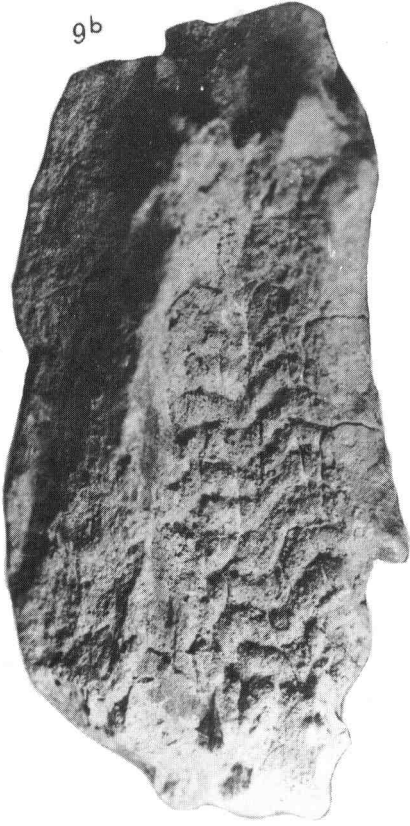
Locality R 25, at 75 m above the «caliza de montaña» in Valle El Ejío section, N. N. W. of Rodiezmo. Age: basal Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76353.

Fig. 9c.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 3$, Holotype. Ventro-lateral view showing transverse ribs and part of the suture (same as Pl. 2, fig. 9a). Loc. R 25, Valle El Ejío.

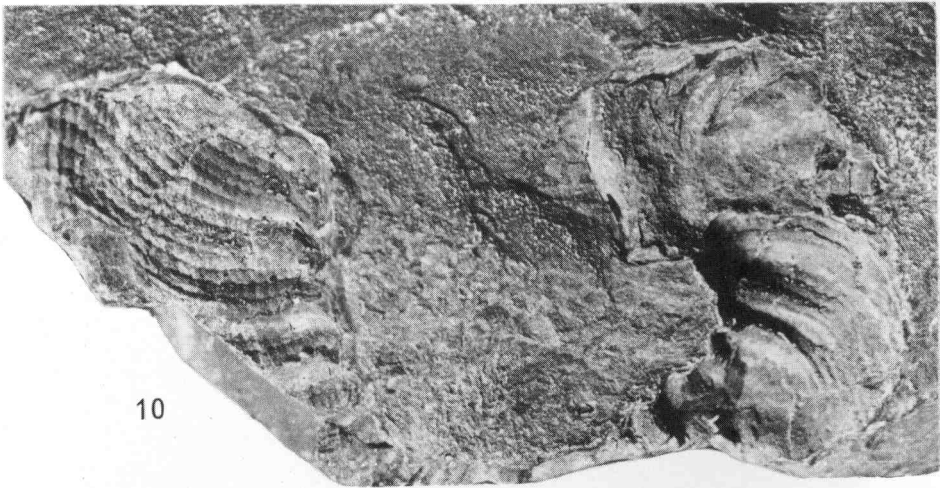
Fig. 10.—*Diaboloceras?* sp., $\times 3$. Lateral view showing plications around the umbilicus, and the reticulate ornament.

Locality Rz 19, at 710 m above the «caliza de montaña» in Valle El Ejío section, N. N. W. of Rodiezmo. Age: upper Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76356.

9b



9c



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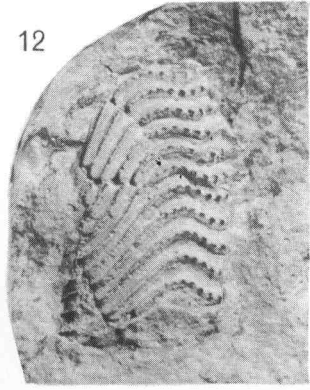
PLATE 4

- Fig. 11.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 3$. Ventro-lateral view of holotype with the outer whorl removed. Whorl showing the ornament of transverse ribs.
Locality R 25, at 75 m above the «caliza de montaña» in Valle El Ejío section, N. N. W. of Rodiezmo. Age: basal Westphalian B. Repository: Brit. Mus. Nat. Cat. N.º C 76353.
- Fig. 12.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 3$. Ventro-lateral view showing transverse ribs and the crossing points of the longitudinal lirae (showing up as black dots) on the ventral part of the specimen.
Locality Rz 19, at 710 m above the «caliza de montaña» in Valle El Ejío section, N. N. W. of Rodiezmo. Age: upper Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76354.
- Fig. 13.—*Rodiezmoceras bisati* gen. et sp. nov., $\times 3$. Ventro-lateral view showing the ornament of transverse ribs.
Locality Rz 19, Valle El Ejío. Age: upper Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76355.
- Fig. 14.—*Proshumardites primus* PLUMMER & SCOTT. $\times 6$. Ventral view showing the striate ornament, three constrictions, and the suture.
Locality Rz 19, Valle El Ejío. Age: upper Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76357.
- Fig. 15.—*Proshumardites* sp., $\times 3$. Lateral view showing the striate ornament and prominent constrictions.
Locality Rz 19, Valle El Ejío. Age: upper Westphalian B. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76358.

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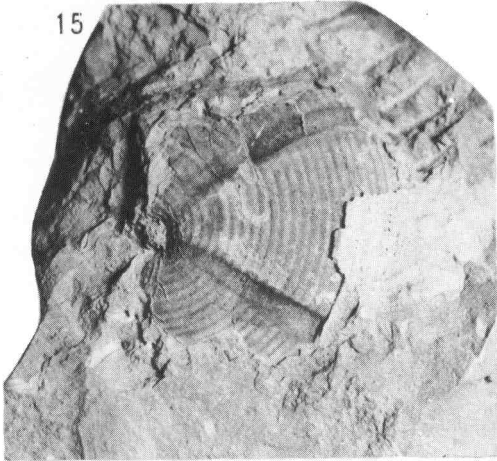
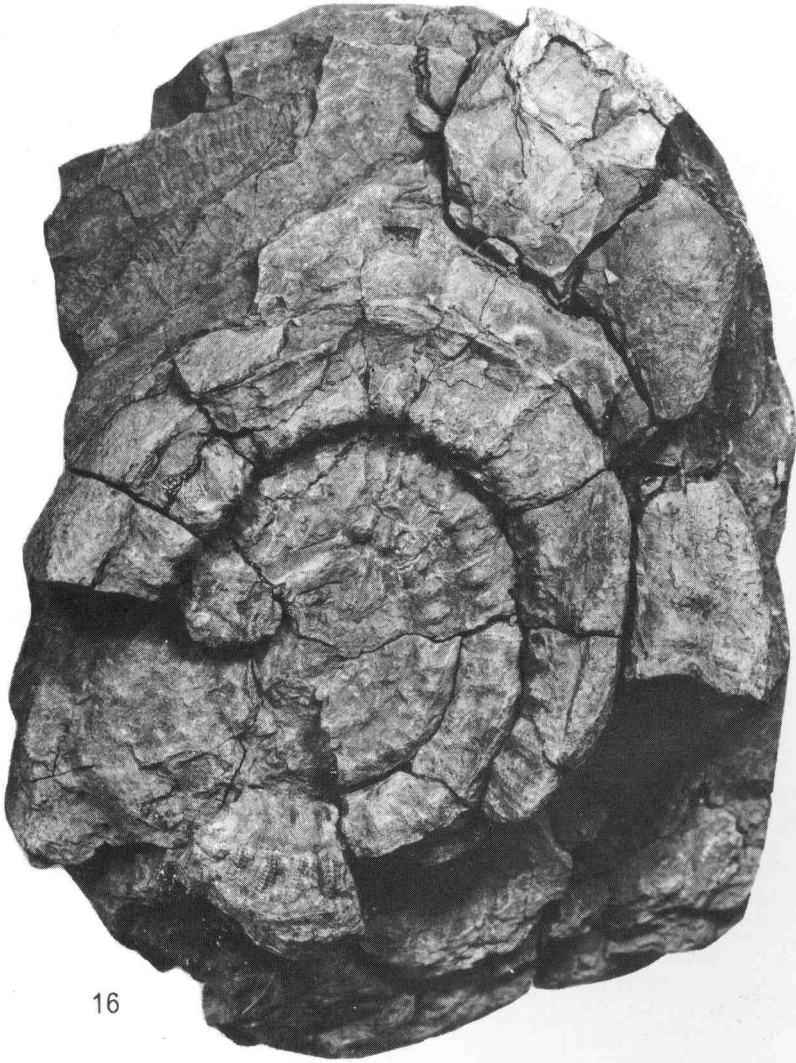


PLATE 5

Fig. 16.—*Branneroceras branneri* (SMITH) PLUMMER & SCOTT, $\times 1$. Lateral view showing nodes around the umbilical edge. The reticulate ornament overlying the ribs is visible in the lower part of the photograph.
Locality 1262, ca 500 m north of Villanueva de la Tercia, mudstone outcropping on the western bank of the Río Bernesga. Age: basal Westphalian A. Repository: Brit. Mus. Nat. Hist. Cat. N.º C 76359.



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PLATE 6

Fig. 17.—*Branneroceras branneri* (SMITH) PLUMMER & SCOTT, $\times 3$. Lateral view of a squashed specimen showing the evolute way of coiling and the characteristic ornamentation.
Locality 10' (Coll. WINKLER PRINS), in «caliza de montaña» (Valdeteja Formation) at ca 1 km north of Cármenes (León), in the Torío Valley. Age: Lower Bashkirian or basal Upper Morrowan, either Namurian C or basal Westphalian A. Repository: Rijksmuseum van Geologie en Mineralogie (National Museum of Geology and Mineralogy) at Leiden, the Netherlands, RMC-St. 167507.



PLATE 7

Basal Westphalian C flora N. N. W. of Rodiezmo.

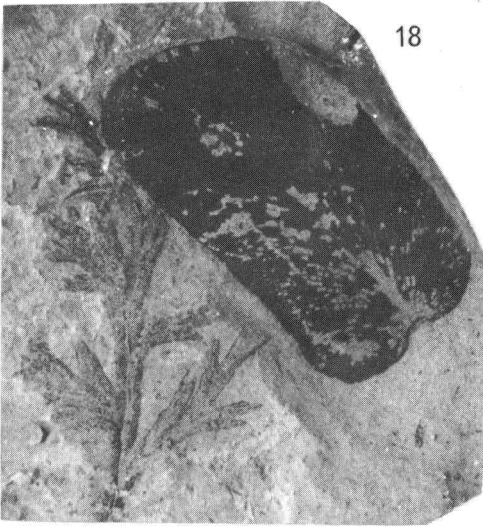
Fig. 18.—*Sphenopteris alata* BRONGNIART and *Paripteris linguaefolia* (P. BERTRAND) GOTHAN, × 3.
Loc. 1101.

Fig. 19.—*Neuropteris tenuifolia* (VON SCHLOTHEIM) STERNBERG, × 3. Loc. Rz 36.

Fig. 20.—? *Mariopteris* sp., × 3. Loc. 1101.

Fig. 21.—*Paripteris linguaefolia* (P. BERTRAND) GOTHAN, × 3. Loc. 1101.

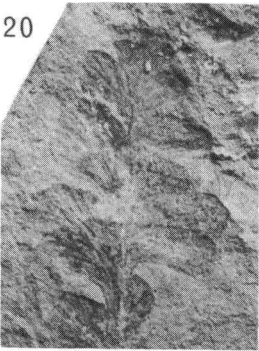
Fig. 22.—*Paripteris linguaefolia* (P. BERTRAND) GOTHAN, × 3. Loc. 1101.



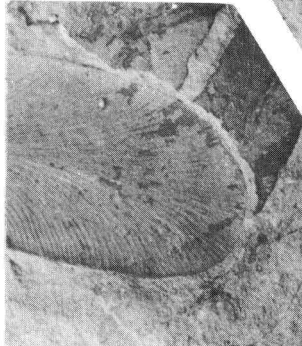
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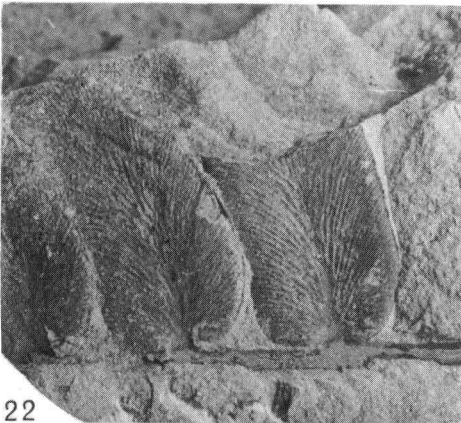
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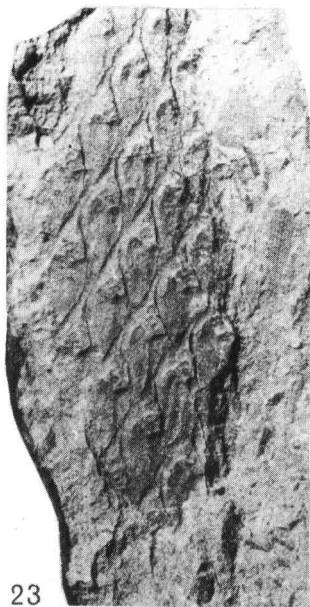


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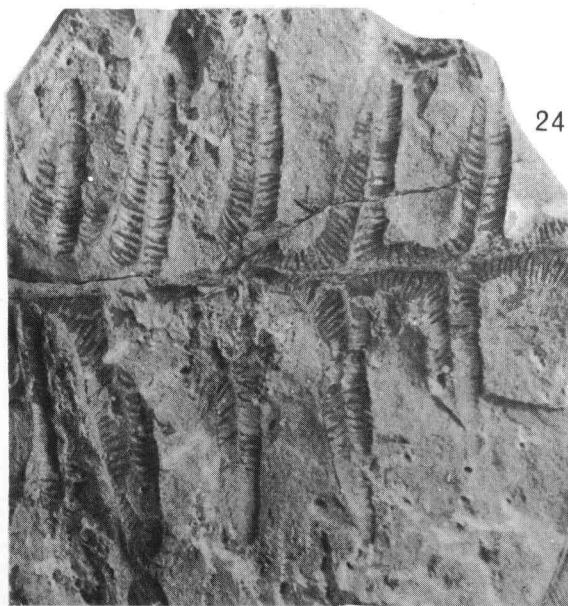


PLATE 8

- Fig. 23.—*Lepidodendron obovatum* STERNBERG, × 1. Loc. 1095. Late Namurian B sandstones and sandy shales west of Viadangos de Arbas.
- Fig. 24.—*Alethopteris davreuxi* (BRONGNIART) GOEPPERT, × 3. Loc. Rz 36. Exposures in basal Westphalian C shales near the coal tip N. N. W. of Rodiezmo.
- Fig. 25.—*Paripteris linguaefolia* (P. BERTRAND) GOTHAN, × 3. Loc. 1101. Tip of basal Westphalian C coal-measures N. N. W. of Rodiezmo.
- Fig. 26.—*Pecopteris plumosa* (ARTIS) BRONGNIART, × 3. Loc. 1101. Tip of basal Westphalian C coal-measures N. N. W. of Rodiezmo.
- Fig. 27.—*Annularia microphylla* SALVEUR, × 6. Loc. 1101. Basal Westphalian C, N. N. W. of Rodiezmo.
- Fig. 28.—*Alloiopteris* sp., × 6. Loc. 353. Scree in the railway cutting south of Villanueva de la Tercia. Lower Westphalian C.



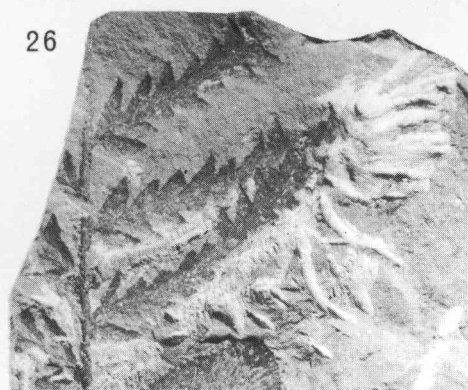
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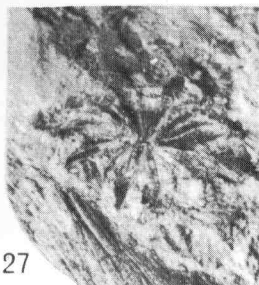
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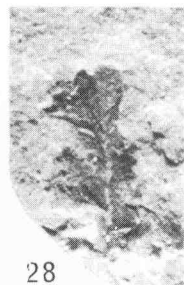
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