TRABAJOS DE GEOLOGÍA, 3, Fac. Ci. Univ. Oviedo,
«The Carboniferous of Northwest Spain»
pp. 1-39, text-figs 1-6, pls 1-5.

ACCOUNT OF THE INTERNATIONAL FIELD MEETING ON THE CARBONIFEROUS OF THE CORDILLERA CANTABRICA. 19-26 SEPT. 1970

R. H. WAGNER*

(With contributions by A. GARCIA- LOYGORRI** and J. A. KNIGHT*)

This field meeting was jointly organized by the IUGS Subcommission on Carboniferous Stratigraphy and the Comisión Nacional de Geología, with the active support of the Universities of Madrid and Oviedo, the Empresa Nacional «Adaro» de Investigaciones Mineras, and the mining companies S. A. Hullera Vasco-Leonesa and Hulleras de Sabero y Anexas S. A. Additional financial support for the organization has been given by the International Union of Geological Sciences.

Organizing Committee.

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Co-President: Professor B. MELÉNDEZ —Vocal de la Comisión Nacional de Geología; Catedrático de la Universidad de Madrid.

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The Organizing Committee gratefully acknowledges the considerable assistance given to the local organization by Mr. F. J. VILLEGAS, of Santa Lucía de Gordón (S. A. Hullera Vasco-Leonesa).

Excursion Leaders.

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A. GARCÍA LOYGORRI (Empresa Nacional «Adaro»).
M. GERVILLA (Empresa Nacional «Adaro»).
Ch. GREBER (Bureau de Recherches Géologiques et Minières).
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W. J. VARKER (University of Leeds).
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R. H. WAGNER (University of Sheffield).
C. F. WINKLER PRINS (Rijksmuseum van Geologie en Mineralogie, Leiden).

Summary Programme.

Saturday, 19th: Arrival at the Hotel Valgrande (Parador Nacional de Pajares) on the watershed between the provinces of Oviedo (=Asturias) and León.

Sunday, 20th: Tournaisian, Viséan and Namurian rocks in the Bernesga Valley and in the general region of La Robla (León); some Stephanian B in the Bernesga Valley (at Pola de Gordón) and north of La Magdalena (León).

Monday, 21st: Namurian and Westphalian (also Bashkirian and Lower Moscovian) strata in the Curueño, Torío and Bernesga valleys (León). An introductory lecture to «The Stratigraphy of the Central Asturian Coalfield» was given in the evening by A. GARCÍA-LOYGORRI.

Tuesday, 22nd: Westphalian C and D (also Upper Moscovian) strata in the central Asturian coalfield; exhibition of maps, sections, rock samples and fossils in the collection of the E. N. Adaro at Ujo; reception by the Empresa Nacional «Adaro» in Oviedo.

Wednesday, 23rd: Stephanian B of the Ciñera-Matallana coalfield (León); reception by the S. A. Hullera Vasco-Leonesa. An informal lecture was given by Dr. J. I. ARTIEDA on the method of working the thick coal of the Pastora Seam. In the evening a discussion on the probable correlation of the Ciñera-Matallana and Sabero coalfields was introduced by J. A. KNIGHT.

Thursday, 24th: Late Stephanian A and early Stephanian B of the Sabero coalfield; reception by Hulleras de Sabero y Anexas S. A.; Viséan and Namurian rocks with unconformable upper Westphalian D in the area east of Sabero (León).

Friday, 25th: Disconformable upper Westphalian D and lower Stephanian *(sensu lato)* in northern Palencia. This excursion was followed in the evening by a general discussion on the lower Stephanian and on the merits of a «Cantabrian» Stage or Substage, between the Westphalian D Stage and Stephanian A *(sensu stricto)*.

Saturday, 26th: Westphalian C (or Upper Moscovian) rocks north of Prioro (León) and lower Cantabrian strata at Tejerina (León).

This programme differed from the advertised one in containing one day in the province of Palencia which was unforeseen (text-fig. 1), and which replaced a second day in the central Asturian coalfield where recent road building had altered a vital exposure studied specially for the field meeting (see WAGNER & WINKLER PRINS, *in* BLESS 1971). At the request of certain participants, and following a majority decision, an excursion in northern Palencia was substituted.

During the days of 19-24 September the field meeting was based on the Parador Nacional de Pajares (Hotel Valgrande) which was made available in its entirety by the Ministry of Information and Tourism. It proved an excellent base for the meeting, with adequate facilities for lectures and discussions in the evening, and comfortable accommodation. Unfortunately, however, it was too small to provide accommodation for all the participants in the field meeting, so that a number were lodged in the smaller hotels in the vicinity. On 24th September the centre was moved to the provincial capital of León.

The excellent weather, which was exceptionally good for the time of the year, added to the enjoyment of the meeting. The Parador Nacional de Pajares, built on a site of great scenic beauty, offered wide vistas of the contrasting landscape in Asturias and in León. These were unmarred by the mists which so often swirl around the Pass of Pajares, at 1,400 metres altitude.

Despite the large number of participants (see page ix), a single coach proved adequate for most excursions, an achievement due entirely to the skill of Mr. REYERO, driving one of his own coaches. Some additional service from Land Rovers proved invaluable in the mountainous area visited.

FIRST DAY OF THE MEETING (19h SEPT.): ARRIVAL AT PAJARES

Apologies for absence were received from Professor G. MORTELMANS, Dr. J. DANZÉ* and Mr. L. LAMBRECHT, who also sent their good wishes for the success of the meeting.

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* The sudden and premature death of Dr. DANZÉ during the late autumn of 1970 has saddened his many friends among the participants in the field meeting.

A field guide with printed maps and sections was distributed to the attending members. It was regretted that the printed papers, as represented in the present volume, were not yet available, but galley proofs of eight papers and page proofs of one were available for consultation. Furthermore, the S. A. Hullera Vasco-Leonesa generously distributed the volume by R. H. WAGNER & J. I. ARTIEDA on «La Cuenca Minera Ciñera-Matallana». As a most extraordinary gesture, which was immensely appreciated, Ing. I. PATAC presented to all the attending members a set of papers published by his father, the late Asturian geologist and mining engineer of the same name, whose pioneer work on the Carboniferous of Northwest Spain remains of great interest. Mr. PATAC also put on display the unique specimen of *Callipteris conferta* which was obtained from the only proved Autunian in NW. Spain, and which was figured by I. PATAC (1920) in «La Formación Uraliense Asturiana».

Professor T. N. GEORGE and Professor B. MELÉNDEZ, Co-Presidents of the meeting, welcomed the attending members and thanked the S. A. Hullera Vasco-Leonesa (as represented by Ing. R. GARCÍA DE LAS PEÑAS) and Ing. I. PATAC for their generosity. The meeting was declared open.

SUNDAY 20th SEPT: BERNESGA VALLEY AND GENERAL AREA OF LA ROBLA (LEON)

(Excursion leader: R. H. WAGNER)

The members of the field meeting travelled down the Bernesga River Valley along the main road from the Puerto de Pajares to La Robla (see text-fig. 1), which cuts through a succession of isoclinal folds and thrust slices in strata ranging in age from Middle Cambrian to Westphalian C.

Las Baleas Quarry.

The first stop was at the Las Baleas Quarry, at *ca.* 1 km north of Pola de Gordón, where the owner, Sr. A. DE CELIS, kindly provided for access to a succession of Tournaisian, Viséan and Namurian rocks, which belong to the highest formations in the overturned northern flank of an E-W striking isoclinal syncline. The core of this syncline is exposed in the quarry, towards its southern end. The southern limb of the syncline is eliminated by thrusting, and the southern end of the Las Baleas Quarry contains the anomalous, tectonic contact between Namurian A-B limestone and Devonian limestone, belonging to another thrust slice.

At the northern end of the quarry the Carboniferous rocks are preceded by 1.40 m of limestone grading downwards into some 15 m of calcareous sandstone belonging to the Upper Devonian Nocedo Formation. The Carboniferous strata belong to the Ermita (late Famennian?-Lower Tournaisian), Baleas (Upper Tournaisian),

Text-fig. 1.—General map showing the main roads of the area visited in León and Asturias, and indicating the position of the villages near localities examined. Provincial boundaries are shown as well as the capitals of León and Oviedo.

Genicera (Viséan-Lower Namurian) and Barcaliente (Namurian A-B) formations. A major disconformity separates the Ermita Formation from the preceding Devonian; another important disconformity occurs below the Baleas Formation; and a less important disconformity (without a datable time gap) separates the latter from the Genicera Formation, which grades upwards into the Barcaliente Formation. The Baleas Quarry, in nearly vertical strata, provides an excellent stratotype for the Baleas Limestone Formation and a completely exposed hypostratotype for the Ermita Sandstone Formation which was originally described from the Ermita del Buen Suceso, a few kilometres south of the quarry in the same Bernesga River Valley (see WAGNER, WINKLER PRINS & RIDING 1971). The Genicera Limestone Formation in the Las Baleas Quarry was described as «Marbre griotte» by BARROIS (1882, p. 577), who recorded Upper Viséan goniatites. Further records of Upper Viséan goniatites, conodonts and corals are given in WAGNER 1963 (pp. 217-218). Red and grey nodular limestones and shales of the upper part of the Genicera Formation (Canalón Member) show a gradual passage to thinly bedded, dark grey limestones of the Barcaliente Formation, at least 120 m thick, which constitute the principal formation worked in the Las Baleas Quarry.

A detailed succession was measured and reads as follows (compare WAGNER, WINKLER PRINS & RIDING 1971, text-fig. 2):

Barcaliente Formation.

—120 m dark grey, thinly bedded (5-10 cm intervals), fetid limestone (up to the synclinal core and thus representing a minimum thickness).
—0.35 m dark grey limestone, somewhat breccious.

Genicera Formation (Canalón Member).

—0.75 m reddish grey limestone, somewhat nodular, with crinoid debris.
—2.50 m greenish calcareous mudstone with squashed goniatites, pectinoid and other lamellibranchs, crinoids and trilobites (loc. 2053).
—0.50 m calcilutite, slightly nodular.
—0.95 m calcareous mudstone (greenish) with some nodular limestone.
—0.30 m light grey, slightly nodular calcilutite, with a few remains of crinoid calices.
—0.10 m greenish calcareous mudstone, with some crinoid debris.
—0.07 m grey limestone, slightly nodular.
—9.70 m thinly bedded, dark grey, fetid limestone.
—0.10 m thinly bedded, dark grey, fetid limestone with small chert nodules.
—2.10 m thinly bedded, dark grey, fetid limestone.
—0.40 m thinly bedded, dark grey, fetid limestone with chert nodules.
—0.75 m grey calcilutite, slightly nodular, with crinoids.
—0.28 m green mudstone.
—1.60 m grey calcilutite, slightly nodular.
—0.10 m greyish to greenish marl.
—1.65 m grey calcilutite, slightly nodular, with crinoids.
—0.20 m red shales.
—0.80 m grey calcilutite, slightly nodular.
—0.12 m red shales.
—0.35 m grey calcilutite, slightly nodular, with chert nodules.
—0.08 m red shales.
—0.35 m alternating grey calcilutite and reddish, slightly nodular calcilutite.

—0.03 m reddish marl.
—5.05 m reddish grey calcilutite.
—0.03 m reddish marl.
—0.90 m reddish grey calcilutite.
—0.80 m reddish calcilutite with stylolitic structures; also some reddish marl.
—0.75 m red nodular limestone with some red marl.
—0.60 m reddish calcilutite.
—0.50 m reddish nodular limestone with red marls.
—3.40 m reddish grey nodular limestone.
—0.26 m reddish calcilutite.
—0.20 m green calcilutite.
—0.35 m red nodular calcilutite.
—0.24 m reddish calcilutite.

Genicera Formation (Lavandera Member).

—0.12 m red chert.
—1.10 m alternating greenish calcilutites and red shales.
—6.50 m red cherts with some shale intercalations.
—0.15 m red chert.

Genicera Formation (Gorgera Member).

— 0.17 m red shales with some limestone nodules.
— 0.46 m green calcilutite.
— 0.11 m red calcilutite.
— 2.38 m red, slightly marly, nodular limestone (calcilutite) with crinoid debris.

Disconformable (erosional) contact with:

Baleas Formation.

— 0.68 m rather fine-grained crinoidal limestone, reddish and becoming more intensely red towards the top.
— 6.40 m grey crinoidal limestone, reddish in part.
— 1.10 m coarse-grained crinoidal limestone, with some red clay at the base.

Disconformable (erosional) contact with:

Ermita Formation.

— 0.15 m ferruginous, decalcified sandstone with lamellibranchs, brachiopods (rhynchonellids), crinoids, etc.
— 3.60 m slightly ferruginous sandstone with small lenses of limestone containing crinoid columnals, brachiopods and lamellibranchs; 3 limestone lenses have been seen (thickness 8 to 12 cm).
— 1.25 m yellowish, slightly calcareous sandstone with crinoid debris.
— 2.00 m slightly ferruginous, decalcified sandstone with crinoid columnals.
— 3.00 m medium-grained sandstone.
— 9.50 m coarse-grained, slightly conglomeratic sandstone (quartz pebbles up to 3 mm across), with slightly ferruginous bands and cross bedding at certain intervals.

Disconformable (erosional) contact with:

— 1.40 m somewhat sandy limestone.
— 15.00 m slightly calcareous sandstone (probably Nocedo Formation of the Upper Devonian).

Road Section at Pola de Gordón.

Almost immediately south of the Las Baleas Quarry, along the main road above Pola de Gordón, a terrigenous lateral replacement of the Barcaliente Limestone For-

mation, i. e. the Olleros Formation (compare WAGNER, WINKLER PRINS & RIDING 1971) was briefly examined in two exposures. The first exposure consisted of shales in the lower part of the Olleros Formation at a locality which had yielded *Reticuloceras* of R_1 age (lower Namurian B) and which showed a strongly angular unconformity with overlying Stephanian B torrential conglomerates. A small normal fault produced a locally abnormal contact between the conglomerate and the underlying marine shale of R_1 age. The second exposure visited represented a slightly higher horizon of the Olleros Formation and showed turbiditic sandstones in a steeply folded, small anticline, accessory to a major syncline which is limited southwards by a large strike fault bringing the terrigenous Namurian strata into contact with Stephanian B coal-measures.

Crossing over to the Stephanian B rocks non-marine lamellibranchs and ostracodes were collected from roof-shales of a thin seam of coal, probably belonging to the San José Formation (see WAGNER 1971, geol. map).

Olleros de Alba.

Via La Robla, the road was taken to Olleros de Alba where an almost completely exposed succession of Tournaisian, Visean and Namurian strata was examined in the steeply dipping southern flank of the Alba Syncline. Following upon the Devonian six lithostratigraphic units of the Carboniferous are represented, viz. the Ermita (late Famennian? -Lower Tournaisian), Vegamián (Upper Tournaisian) and Genicera (Viséan) formations, the Olaja Beds (Lower Namurian), and the Olleros (Namurian A-B) and Barcaliente (Namurian B) formations. The Olleros Formation finds its stratotype in this locality (WAGNER, WINKLER PRINS & RIDING 1971, text-fig. 6). The Olaja Beds are the terrigenous equivalent of the top part of the Canalón Member of the Genicera Formation.

Barcaliente Formation.

— *ca.* 250 m dark grey, thinly bedded, fetid limestones folded into the core of a small, accessory isoclinal syncline.

Olleros Formation.

— 24 m mudstones and silty mudstones with cross bedded sandstones.
— 7 m graded sandstone.
— 10 m thinly bedded black limestone.
— 6 m silty mudstone with a graded sandstone interval.
— 3 m thinly bedded black limestone.
— 39.50 m mainly graded sandstone with some intervals of shale.
— 2 m thinly bedded limestone.
— 9 m graded sandstone.
— 13 m not exposed.
— 73. 50 m intermittently exposed graded sandstone units.
— 37 m dark grey shales and mudstones with thin sandstone bands.

— 8 m sandstone grading from medium-coarse to fine.
— 13 m dark grey mudstones with some graded sandstone.
— *ca.* 72 m dark grey mudstone with some graded sandstone.

Olaja Beds.

— *ca* 20 m green and reddish mudstones, with some squashed goniatites and lamellibranchs.

Genicera Formation.

—3 m red and green nodular limestone.
—1 m chert and limestone.
—8 m pink and grey limestones with red shale.
—6.40 m red and grey nodular limestones; *Merocanites subhenslowi* WAGNER-GENTIS near the base.
—1.30 m cream coloured nodular limestone with *Pericyclus hauchecornei* DELÉPINE *(non* HOLZAPFEL), *Munsteroceras browni* (MCCOY) DELÉPINE, etc. (figured *in* HIGGINS, WAGNER-GENTIS & WAGNER 1964).
—0.12 m quartzitic sandstone.

Disconformable (erosional) contact with:

Vegamián Formation.

—2.20 m black shales with phosphatic nodules.

Disconformable (erosional) contact with:

Ermita Formation.

—0.10 m mudstone.
—0.60 m limestone with conodonts of the Lower Tournaisian *kockeli-dentilineata* Zone (HIGGINS 1971).
—21.30 m sandstone with dark, sandy shale partings.

North of La Robla: private road to the cement quarries.

After lunch in La Robla the party travelled through the Cement Works in this industrial town onto the private road of «Cementos La Robla» with the kind permission of this company, representatives of which accompanied the excursion. The section commenced in anticlinally folded Viséan limestones of the Genicera Formation and continued in the steeply dipping southern flank of the Alba Syncline (compare text-figs 1, 2 and 4 of WAGNER & FERNÁNDEZ-GARCÍA 1971). A few dykes were seen in the lower part of this succession. After a long mudstone sequence, mainly belonging to the lower part of the Olleros Formation (and which is poorly exposed along the road), the first sandstone units were encountered. These show bottom structures and occasional channelling, but little grading.

A poorly exposed interval with sandstones is followed by a mudstone sequence with graded siltstones and sandstones showing well developed sole markings. The subsequent, long succession of turbiditic sandstones is broken by a single horizon of mudstones and marly limestone. These turbidites consist of numerous graded sandstone units, usually coarse-grained or conglomeratic at the base, with load casts and sole markings, and grading upwards into medium and fine-grained sandstone with ripplemarks at the top. Usually, there is a gradual contact with a thin development of silty shales containing abundant drifted plant remains which are sometimes sufficiently common to produce dirty coal smuts.

Within the thick sandstone succession the incidence of sole markings decreases upwards where the facies becomes less turbiditic. A mudstone interval in this part of the succession has yielded some poorly preserved plant remains including *Pecopteris aspera* BRONGNIART. Further upwards, the sandstone facies passes into tongues of Barcaliente Limestone (representing quiet basin conditions) alternating with sandstone/shale units. These limestone horizons are worked in the principal cement quarries.

By analogy with the succession at Olleros de Alba, the turbidites and other terrigenous rocks exposed along the road to the cement quarries should be regarded as being mainly of Namurian B age. They represent the basinal facies of the Namurian which is represented entirely by limestones of the Barcaliente Formation further north, and there is no doubt about the southerly derivation (i. e. from the Hinterland) of the turbidites.

La Magdalena coalfield.

Time permitted a brief visit to a Stephanian B plant locality on the northern rim of the La Magdalena coalfield, west of La Robla (text-fig. 1). The well preserved flora from this locality has been reported in the literature by WAGNER (1966, p. 52, Pls 49-52) and STOCKMANS & WILLIÈRE (1966, Pls XXXII-XXXVIII).

MONDAY 21st SEPT: EXPOSURES IN THE CURUEÑO, TORIO AND BERNESGA VALLEYS

(Excursion leaders: C. F. WINKLER PRINS & R. H. WAGNER)

The party travelled through Villamanín along the central part of the Cármenes Syncline to Valdeteja and into the Curueño Valley for a completely exposed succession of the Barcaliente and Valdeteja Limestone Formations (ex «caliza de montaña» or «calcaire des cañons») in their stratotypes.

The road section east of Valdeteja with its continuation along the Arroyo de Barcaliente.

In the Arroyo de Barcaliente, type locality of the Barcaliente Formation (WINKLER PRINS 1971), the dark grey, fetid, laminated limestones of this formation (225m thick) follow conformably on limestones of the Genicera Formation. A prominent breccia of Barcaliente Limestone blocks in a sparry matrix occurs at *ca.* 160 m from the base, and another breccia forms the top of the formation (WAGNER, WINKLER PRINS & RIDING 1971, text-fig. 5). Just below the top breccia a band with brachiopods and crinoids is recorded (*«Martiniopsis»* Band).

The top part of the Barcaliente Formation crops out in the Curueño River Valley where, at the junction between the road following the main valley and that leading to Valdeteja, the contact with the basal Valdeteja Formation is found. The basal bed is a dark grey, fetid, banked (but not laminated) limestone which truncates the top breccia of the Barcaliente Formation. The line of junction probably represents a break in sedimentation which reflects more important movements of uplift in a nearby area. The Valdeteja Formation in its stratotype is generally characterized by relatively light coloured, banked to massive, often recrystallized limestones which are locally rich in fossils, especially corals and brachiopods. A coral locality occurs at *ca.* 50 m above the base, and this contains *Cladochonus* sp. and *Leonardophyllum leonense* DE GROOT. Several hundred metres of massive limestone are then followed by other fossil horizons, viz. the *«Fenestella-Composita»* Band and the *«Chaoiella»* Band, containing Lower Bashkirian brachiopod faunas. Some 130 m higher in the formation another brachiopod horizon (*«Echinoconchus»* Band) is found in a stream bed off the road. This band, like the *«Linoproductus»* Band, a little higher in the succession, consists of dirty limestones with shale partings which form an apparent transition with an overlying formation of mudstones with limestone bands.

Venta de Getino.

After a pleasant lunch at the Balneario of Caldas de Nocedo, the party crossed to the Torío River Valley, and travelled through the spectacular Gorge of Vegacervera where a brief stop allowed members of the field meeting to view the steepened overthrust which makes for an abrupt contact between Middle Cambrian Limestone (Láncara Formation) and Namurian Barcaliente Limestone at the entrance to the gorge. The party then stopped at the Venta de Getino, a roadside inn, which is situated at the junction between limestones of the Genicera and Barcaliente formations. Opposite the inn a small quarry worked a band of yellowish nodular limestone with abundant goniatites, orthoconic nautiloids, solitary corals, lamellibranchs and crinoids. The goniatites were figured and described by WAGNER-GENTIS (1963). Finds made at a later date and also during the field meeting added to the list: *Delepinoceras thalassoide* (DELÉPINE), *Proshumardites delepinei* SCHINDEWOLF, *Gonioloboceras declive* WAGNER-GENTIS, *Kazakhoceras* sp., *Tympanoceras getinoi* WAGNER-GENTIS, *Somoholites cadiconiformis* (WAGNER-GENTIS), *Eoasianites* sp., *Stenopronorites* cf. *arkansasensis* (SMITH). A similar

assemblage was found associated with *Eumorphoceras bisulcatum* GIRTY, of Lower Namurian age (E_2 Zone), in a locality of the same general area in northern León (WAGNER-GENTIS *in* WAGNER, WINKLER PRINS & RIDING 1971).

Railway section south of Villanueva de la Tercia, Bernesga Valley.

Returning through Cármenes and Villamanín a section in lower Westphalian C (also Kashirian) rocks was examined in a railway cutting at a little over 2 km north of Villamanín and 500 m south of Villanueva de la Tercia. The Villamanín area was studied recently by MOORE, NEVES, WAGNER & WAGNER-GENTIS (1971), and the stratigraphic section in this railway cutting is discussed in their paper.

The middle Westphalian rocks crop out in the northern flank and the core of the Cármenes Syncline, and are slightly overturned in the section examined. The general succession consists of limestones of the Valdeteja Formation wedging into a mudstone sequence with the Lower Bashkirian goniatite *Branneroceras branneri* (SMITH); a mudstone/sandstone/limestone succession with Kashirian fusulinids and Westphalian B spores; a poorly exposed mudstone succession; and, finally, the lower Westphalian C strata exposed in the railway cutting. The sample containing the Lower Bashkirian goniatite yielded an assemblage of basal Westphalian A spores, and there is evidence of an important disconformity eliminating most of Westphalian A.

Dating of the rocks in the railway section is based on plant spores giving assemblages of lower Westphalian C age (R. NEVES *det.*), on fusulinid foraminifera indicating Kashirian (G. SCHMERBER *det.*), and on brachiopods of upper Kashirian to Podolskian age (C. F. WINKLER PRINS *det.*). The upper Kashirian thus equates to lower Westphalian C.

Most of the rocks in the railway section (MOORE *et al.* 1971, text-fig. 3) are marine, but two thin coals with the accompanying seat-earths are also present. They participate in regressive rhythmic sequences which commence with fusulinid limestone and end with coal. This kind of rhythmic sequence is quite common in Westphalian C rocks of the central Asturian coalfield north of the Villamanín area (compare GARCÍA-LOYGORRI *et al.* 1971, and BLESS *et al.* 1971), and it is more than likely that the Villamanín area forms the southern extension of the central Asturian coalfield, representing one and the same basin of sedimentation.

Lecture on the stratigraphy of the Central Asturian Coalfield.

During the evening an introductory lecture on the stratigraphic succession present in the central Asturian coalfield was given by Dr. A. GARCÍA-LOYGORRI. The discussion centred on the presence of Moscovian fusulinids in a sequence which also yielded the remains of land plants providing the opportunity to compare the Russian

and West European chronostratigraphic units. It also focussed on the suggested presence of lower Stephanian (*sensu lato*) deposits in the highest part of the succession in the central Asturian coalfield. The lecturer emphasized the preliminary nature of the palaeontological data suggesting lower Stephanian, and it was mentioned in the discussion that a more detailed palaeontological comparison might be made with the more fully documented strata of lower Stephanian (and including Cantabrian) ages in adjacent areas of Northwest Spain, viz. in eastern Asturias, north-eastern León and northern Palencia (compare MARTÍNEZ-GARCÍA & WAGNER 1971, and WAGNER & VARKER 1971).

INTRODUCCION A LA ESTRATIGRAFIA DE LA CUENCA CENTRAL ASTURIANA

(Resumen de la conferencia pronunciada por A. GARCIA-LOYGORRI)

Como introducción general a las excursiones que estaban programadas para el día sucesivo, el Dr. Ingeniero A. GARCÍA-LOYGORRI, Jefe de la «Investigación geológica y minera de la Cuenca Central Asturiana», que la Empresa Nacional ADARO de Investigaciones Mineras, S. A. viene desarrollando desde 1968, expuso el estado actual del conocimiento que se tiene sobre la estratigrafía de esta cuenca, la más importante en cuanto a la producción hullera de entre todas las cuencas mineras españolas.

Señaló en primer lugar el Sr. GARCÍA-LOYGORRI, que el conocimiento de la serie estratigráfica carbonífera asturiana, no se puede tomar aún como definitivo, toda vez que, constituyendo la investigación en curso, el primer intento serio desde hace más de 50 años, de estudio del todo el conjunto de la cuenca, los trabajos en curso aún no se hallan finalizados, estando prevista su terminación para después de 1971. Ello trae, como principal consecuencia, que sean los paquetes productivos inferiores y medios los que estos momentos mejor se conocen, mientras que los superiores, que se presentan con más frecuencia en el extremo norte de la cuenca, donde faltan aún trabajos por realizar, todavía no estén estadísticamente perfectamente definidos.

Con todo, sí es posible definir las unidades estratigráficas que componen la columna de la cuenca y establecer una primera correlación geocronológica de las mismas.

En la conferencia, tras describir rápidamente los diferentes tipos litológicos del Carbonífero asturiano, se señaló la gran importancia de la sedimentación marina en la historia de la cuenca, que llega a constituir más del 80 % del espesor total de la serie. Esta, que presenta una potencia total de unos 5.800 m, se inicia con la formación del «grioto», sobre la que descansan sucesivamente la «caliza de montaña» y los paquetes Fresnedo, Levinco, Llanón y Tendeyón, considerados tradicionalmente como improductivos, pese a que en ocasiones se ha explotado localmente algunas de sus capas de carbón, y los paquetes productivos Caleras, Generalas, San Antonio, María Luisa, Sotón, Entrerregueras, Sorriego, Modesta, y Oscura, que son asiento de las actuales explotaciones.

La correlación entre estas unidades y la escala mundial del Carbonífero es

aún cuestión no resuelta definitivamente, puesto que, a falta de terminar los estudios emprendidos, las diferentes disciplinas paleontológicas empleadas en las determinaciones de edad,—Macro y Microflora, Macrofauna y Foraminíferos—, no están siempre en perfecta concordancia. De todas maneras, se ha podido reconocer un Viséense-Namuriense inferior y medio, representado por el «grioto» y la «caliza de montaña», de la cual las muestras recogidas más modernas, son en todo caso anteriores al Bashkiriense y, por tanto, a su equivalente europeo, Namuriense C, dado su contenido micropaleontológico (*Archaesphaera*). Encima y, al parecer, en tránsito gradual observado en el extremo SE de la cuenca, descansa el paquete Fresnedo, estéril en carbón y en fósiles, y sobre él, el paquete Levinco, en el que se ha reconocido una parte inferior (Bashkiriense medio), una parte media (Bashkiriense superior), y una parte alta (Bashkiriense superior-Muscoviense inferior o Vereyense). Siguiendo la correlación propuesta por los autores rusos en el 4.º Congreso Internacional sobre Estratigrafía del Carbonífero (Heerlen 1958), atribuimos provisionalmente edades desde el Westfaliense A hasta el Westfaliense C a este paquete, estando consciente, sin embargo, de las críticas que se han formulado últimamente acerca de esta correlación. Todo el paquete Llanón y la parte baja del Tendeyón, presentan una microfauna del Muscoviense (Vereyense, Kashiriense, y Podolskiense), lo cual, según la correlación rusa, corresponde al Westfaliense C-D. Sin embargo, la macroflora da una edad Westfaliense C para el paquete Tendeyón, al igual que para el paquete Caleras, primero de los productivos.

Los paquetes Generalas y San Antonio encierran una flora en la que no se encuentra ninguna especie característica del Westfaliense D, y sí, únicamente, especies banales que se pueden dar indistintamente en todo el Westfaliense superior.

A partir del paquete María Luisa, hace su aparición *Neuropteris ovata* HOFFMANN, que encuentra su apogeo, junto con *Neuropteris scheuchzeri* HOFFMANN, en el paquete Sotón, donde coexiste con *Pecopteris micromiltoni* P. BERTRAND, hasta el final del paquete Entrerregueras.

Los paquetes Sorriego y Modesta muestran ya una flora más moderna, con *Pecopteris unita* BRONGNIART, *Pecopteris* del grupo *arborescens-cyathea*, *Pseudomariopteris ribeyroni* (ZEILLER), *Dicksonites sterzeli* (ZEILLER), etc.

La microflora estudiada en los paquetes productivos fija las edades de manera más definida, haciendo desaparecer las ambigüedades que, para los paquetes Generalas —San Antonio, y Sorriego— Modesta, establece la macroflora. Así, el paquete Caleras, sería de edad Westfaliense C; los paquetes Generalas, San Antonio, María Luisa, Sotón, Entrerregueras y parte del Sorriego, tendrían una edad Westfaliense D; y la parte superior de éste último y el paquete Modesta serían ya del Estefaniense inferior, dada la presencia de especies que aparecen en la cuenca de Sarre-Lorena por encima del conglomerado de Holz.

Tras la conferencia tuvo lugar un animado coloquio en el que participaron los señores BOUROZ, CHATEAUNEUF, GARCÍA-LOYGORRI, GEORGE, GREBER, KNIGHT, MARTÍNEZ DÍAZ y VAN GINKEL, acerca de las correlaciones por Foraminíferos entre las escalas estratigráficas rusa y de Europa Occidental, de gran interés en el caso asturiano,

donde coexisten formaciones westfalienses marinas y continentales, que permiten vislumbrar la posibilidad de que sea precisamente el Carbonífero asturiano un buen punto de unión para la equiparación de dichas escalas, sobre todo para la serie del Namuriense-Westfaliense que, en el Noroeste de España, se halla mejor representado que en ningún otro lugar de la Península. También se trató por los Sres. WAGNER, KNIGHT, TRUYOLS, GREBER, CHATEAUNEUF y GARCÍA-LOYGORRI, acerca de la falta de coincidencia que, en cuanto a la datación de los estratos superiores, parecen presentar los estudios de macro y microflora realizados en la Cuenca Central hasta el momento; fenómeno que puede tener su explicación, a juicio del señor GARCÍA-LOYGORRI, en el hecho de que la serie que integra la cuenca sea en su gran mayoría de origen marino, lo que condiciona la escasez relativa de especies florísticas, muchas de las cuales son banales, haciendo muy difícil la comparación con las escalas macroflorísticas de Europa Occidental, y por otra parte, en que a falta de terminar la investigación en curso, no sea aún totalmente representativa la macroflora recogida en los pocos puntos en que hasta ahora se han reconocido los paquetes superiores; menos estudiados, como ya se indicó al principio de la conferencia, que el resto de los paquetes productivos.

Los Sres. WAGNER y KNIGHT pusieron de relieve la conveniencia de integrar la columna estratigráfica de la Cuenca Central asturiana en el conjunto de la estratigrafía del Carbonífero del NW de España, recomendando sobre todo una comparación detallada con las floras y faunas descritas últimamente del Westfaliense D superior y Estefaniense inferior *sensu lato* (Cantabriense y Estefaniense A) en Asturias oriental, el NE de León y el norte de Palencia. Sobre todo, Palencia, con unos 8.000 m. de estratos del Westfaliense C superior, Westfaliense D, Cantabriense y Estefaniense A, en facies predominantemente marinas, con intercalaciones continentales, ofrece la posibilidad de efectuar correlaciones inmediatas.

Por último, el Sr. BOUROZ hizo algunas consideraciones acerca del piso Cantabriense, propuesto por el Sr. WAGNER, recomendando, como Presidente de la Subcomisión del Léxico Estratigráfico del Carbonífero, la constitución de un grupo de trabajo que estudie y compare las floras recogidas y clasificadas por WAGNER en la región palentino-leonesa, con las procedentes de otras cuencas europeas.

TUESDAY 22nd SEPT: CENTRAL ASTURIAN COALFIELD

(Excursion leaders: A. GARCIA-LOYGORRI, G. ORTUÑO, M. GERVILLA, CH. GREBER & R. FEYS)

This excursion aimed at showing the most salient features of the stratigraphy of the Central Asturian Coalfield by examining two long sections of several hundred metres of strata exposed along two major roads.

Driving northwards from the mountain pass of Pajares into the central Asturian coalfield, participants in the field meeting noticed first of all the complete change in landscape and climate with regard to the Leonese side of the mountain chain visited during the preceding two days. The steep northern slope of the Cordillera Cantábrica

forced a descent of 800 metres in 5 kilometres horizontal distance. This side of the mountain chain is not only more precipitous but collects a good deal more rain, with the resultant increase in vegetation.

Aller River Valley.

Passing through Pola de Lena (text-fig. 1), the road follows the Río Caudal until a bifurcation is reached just south of Ujo, where the bridge is crossed for the road to Moreda and Cabañaquinta, following the Río Aller. The valley of the Aller river bears the marks of intensive coal mining, with numerous pitheads and coal tips bearing witness to the fact that this is one of the three main areas of workings in the central Asturian coalfield. Rocks of upper Westphalian C and Westphalian D ages are exposed along the road. They belong to the «paquetes» Tendeyón, Caleras, Generalas, San Antonio, María Luisa and Sotón (compare GARCÍA-LOYGORRI *et al.* 1971).

At the first stop, near Trullones, the quartzitic sandstones, limestones and marine mudstones with occasional non-productive coal smuts of the paquete Tendeyón (Westphalian C) were examined. This is the sequence inmediately below the paquete Caleras, which is the first to contain workable coal seams. Along the road a number of the characteristic rhythmic sedimentary sequences of the paquete Tendeyón were seen. These rhythmic units are characteristically initiated by a limestone, sometimes preceded by marine calcareous mudstone, and develop upwards into calcareous mudstones with marine fauna and into sandy mudstones and shales. Within the latter a calcareous and shaley sandstone horizon of up to 30 metres thickness may be intercalated. These mudstones, which also contain marine fossils, are usually followed by quartzitic sandstone and, sometimes, by a seat-earth which may be accompanied by a thin coal.

The second stop, in the general vicinity of Piñeres, was made to show the basal beds of the paquete Caleras, at the horizon of the «Cuarcita de la Cruz». The participants in the field meeting remarked upon the evidence of channel fills at this horizon, which has been traced widely within this part of the central Asturian coalfield. The marine facies of the majority of strata in the paquetes Tendeyón and Caleras was noted.

Following the road to La Venta, a large part of the paquete Caleras and the lower two thirds of the paquete Generalas were examined. The higher part of the paquete Generales does not crop out along the road, since it occurs in the core of the San Fernando Syncline. Although the predominant facies in the Caleras and Generalas beds is marine, the thickness of continental intervals increases, with local concentrations of coal seams, seat-earths and plant-bearing roof deposits. Limestone bands are still present (there are three outcropping in this section). The sandstones in this part of the succession become less quartzitic and a little more calcareous.

A third stop, in the vicinity of Bustiello, the top of the paquete Generalas was observed with a quartzite conglomerate (1ª Pudinga) showing well rounded boulders in a quartz matrix. This horizon forms the core of the Revallinas Anticline. Following the road to Santa Cruz, which cuts through the western limb of the anticlinal structure, a full section of the paquete San Antonio was examined. At its base several rhythmic units are found, with marine beds forming the roofs of coal seams. One of these marine

roofs is almost 100 m thick. The closing phase of marine deposition, which is clearly of a regressive nature, is formed by a second conglomerate horizon (2ª Pudinga), similar in characteristics to the first, and also representing a littoral facies. It is followed by another development of coals, both workable and non-workable, which show marine roof measures and «*in situ*» vegetation in the shape of root beds forming seat-earths. They are furthermore associated with mudstones and shales, micro-conglomerates with calcareous clasts, and with non-marine sandstones in characteristic rhythmic units. The highest part of the paquete San Antonio is very sandy and is known as the «Arenisca de La Voz», which consists of several bands of micro-conglomerate composed of shale and limestone elements, and thin intervals of shale with occasional coal smuts.

Finally, at a locality near the San Jorge Colliery, the «Arenisca de la Voz» was seen again in conjunction with the basal part of the paquete María Luisa, showing beds of Westphalian D age with 2 to 3 workable coal seams and several smaller veins. A lacustrine fauna has been observed at the roof of some of these coals. The coal-bearing interval is followed by a marine horizon of some 40 m thickness, viz. the Bocadillo Horizon.

The party then returned to Moreda for lunch, and continued afterwards to Ujo where an exhibition of sections, maps and samples had been prepared by the investigators of the Empresa Nacional ADARO in the offices of the Empresa Nacional «Hulleras del Norte», S. A. (HUNOSA). Some 50 maps and sections, representing subsurface and surface information, were exhibited together with selected samples of Carboniferous flora and fauna. Pride of place was taken by a series of 36 stratigraphic columns, at scale 1:2,000, showing the local correlation between coal seams and certain characteristic horizons.

The President of the field meeting, Prof. T. N. GEORGE, thanked Dr. GARCÍA-LOYGORRI and his collaborators for the effort which had gone into preparing this very instructive exhibit and recorded everybody's appreciation for the explanation provided by Dr. GARCÍA-LOYGORRI.

Road from San Emiliano to El Cabo.

After the visit to the offices at Ujo the party completed their impressions of the productive coal-measures of the Central Asturian Coalfield by examining several sections and exposures in the higher part of the succession, viz. the paquetes San Antonio, María Luisa, Sotón, Entrerregueras and Sorriego, belonging to the Westphalian D and possibly reaching into lower Stephanian (*sensu lato*). These rocks were seen along the main road from Mieres to Sama and, particularly, along the road which branches off at the height of San Emiliano, at 6.4 kilometres, and which leads to the hamlet of El Cabo, in the north-eastern part of the coalfield.

The first stop was made almost at the end of the road, in the core of the Samuño Anticline. Continuing on foot in northward direction, a continuous succession of 720 metres thickness was examined in rocks of the paquete Sotón (upper part), paquete

Entrerregueras and paquete Sorriego (lower part). The upper part of the paquete Sorriego was absent because of its position in the core of the Sama Syncline.

The highest measures of the paquete Sotón are markedly continental in facies, with 3 workable seams and 4 thinner veins of coal, all of which show the presence of seat-earths. Plant-bearing roof shales are common in this part of the succession, which also shows a predominance of coarse sandstones and micro-conglomerates, with a thickness of individual horizons of up to 34 m. Subsequently, the paquete Entrerregueras commences with a large interval of marine mudstones and sandstones, containing in its central part a thin, non-workable coal seam with a lacustrine fauna in its seat-earth and a marine fauna in its roof shales. This predominantly marine interval is followed by a group of seams and coal smuts, generally with marine roof measures and showing autochthonous seat-earths. There follows another large marine interval, predominantly sandy, and two continental horizons separated by a thin marine band which is near to a limestone conglomerate horizon (1ª Gonfolita) of a lenticular nature and not developed in the section examined. The two continental horizons show the presence of numerous thin coals (around 30) which are mainly characterized by seat-earths and plant-bearing roof measures.

The visible part of the paquete Sorriego commences (like the paquete Entrerregueras) with a large marine interval containing a thin coal with seat-earth in its central part. This marine interval is also followed by a group of coal seams and smuts, which occur as two horizons separated by a predominantly sandy development of strata, probably of marine facies. The coals of these horizons, as sampled in the workings of the Nalón valley, have yielded a microflora indicative of the lower Stephanian. However, the macroflora is not inequivocally lower Stephanian, even though younger than the florules of Westphalian D age recovered from the paquetes María Luisa, Sotón and Entrerregueras.

Finally, in the vicinity of La Cantera, the first limestone conglomerate (1ª Gonfolita) was seen in the northern flank of the Sama Syncline.

This day in Asturias ended with a reception given by the Empresa Nacional ADARO in Oviedo. It was attended by members of the Press, who interviewed various personalities among the participants in the field meeting. On behalf of the Empresa Nacional ADARO, Dr. A. GARCÍA-LOYGORRI acknowledged the interest and enthusiasm shown by the participants in this day of excursions in the Central Asturian Coalfield, thanking the members of the field meeting for their good humour and companionship, and expressed his good wishes and support for the aims and fruitful continuation of the meeting during the rest of the week. Professor T. N. GEORGE replied on behalf of the participants by expressing their feelings of sincere gratitute and appreciation for all that the group of investigators of the Empresa Nacional ADARO had done to make a success of the excursions held in Asturias, and congratulated Dr. GARCÍA-LOYGORRI with the extremely interesting results that he and his collaborators had obtained in the course of their detailed investigation of the geology of the Central Asturian Coalfield.

WEDNESDAY 23rd SEPT: CIÑERA-MATALLANA COALFIELD (LEON)

(Excursion leaders: R. H. WAGNER & F. J. VILLEGAS).

Unconformable Stephanian B coal-measures, alternating with lacustrine and fluviatile deposits, were examined in the Ciñera-Matallana coalfield, east of Santa Lucía de Gordón (text-fig. 1), between La Robla and the Pass of Pajares. This coalfield was studied most recently by WAGNER & ARTIEDA (1970) and WAGNER (1971), who recognized 7 formations representing different episodes in the development of the exclusively non-marine succession of strata, up to 1,500 metres thick. These are the San Francisco, Pastora, Cascajo, Roguera, San José, Bienvenidas and Matallana formations (WAGNER 1971, text-fig. 2).

Coladilla.

Travelling along the northern rim of the coalfield, in splendid scenery dominated by Devonian limestones and Ordovician quartzite forming E-W striking ridges, the party reached the village of Coladilla where a fossil valley fill was seen in the San Francisco Formation. Only the top part of this formation has been developed near Coladilla, and further westwards a basin margin prevented deposition of the San Francisco Formation as well as the lower part of the Pastora Formation. South of Coladilla, a full succession was seen of the Pastora, Cascajo and Roguera formations on a well exposed hillside (Pl. 2) where additional trenching permitted a complete log to be taken (VILLEGAS *in* WAGNER 1971, text-fig. 17). A description of this log is provided in the cited paper.

Matallana.

Just north of Matallana, after crossing the bridge over the Torío River at Serrilla, an exposure was visited of fluviatile sandstone followed by the Miñón (= Picalín) Seam of the Matallana Formation. This seam is covered by lacustrine roof-shales with *Anthraconauta* and *Carbonita*, which were sufficiently abundant to be collected in quantity. This section was studied from a sedimentological point of view by READING (1970, text-fig. 3, section 3), who noted coarsening upward (regressive) sequences showing basin filling and fining upward (fluviatile) sequences. These sequences are all non-marine.

Tabliza Valley near Llombera.

After crossing the coalfield at its widest near Matallana, in the valley of the Torío River (see the section in WAGNER 1971, text-fig. 20), it was entered again from the south in the Tabliza Valley, east of Llombera. At Tabliza an enlarged exposure was seen of a basic sill intruding coal of the Pastora Formation and forming natural coke. Prepared samples of ostracode-bearing shales of the sequence below the Compe-

tidora (= Pastora) coal seam and the *Leaia*-bearing roof shales were collected, and Professor D. LAURENTIAUX remarked upon the relatively abundant remains of insects in the former horizon. Insect wings from this horizon had been made available to Prof. LAURENTIAUX and were under study.

A full succession of strata of the Roguera and San José formations was exposed by trenching in the hillside east of the Tabliza Valley (see the log and description in WAGNER 1971, text-fig. 18), in the steeply dipping northern flank of the Llombera Syncline. At *ca.* 190 m above the top seam of the San José Formation a very fossiliferous exposure was visited in old diggings along the Bisvita Seam of the Bienvenidas Formation. The fossil flora from this locality is listed in WAGNER 1971 and a number of specimens were figured in WAGNER & ARTIEDA (1970).

Ciñera

Through Llombera the party crossed to the Bernesga Valley where the main road was joined to Santa Lucía and the mining village of Ciñera. Here, a reception was given by the S. A. Hullera Vasco-Leonesa in the restaurant «Hornaguera», using an old Castilian name for coal. At «La Hornaguera» a modest exhibition had been prepared of maps, sections, rock samples and the principal fossils encountered in the Ciñera-Matallana coalfield. Considerable interest was evinced for a model of the kind of coal working developed for the thick seam of Pastora (5-20 m coal with dips varying between 25° and 45° on the average), and the Director of the Company, Dr. J. I. ARTIEDA, kindly explained the highly effective system employed (see also the second part of WAGNER & ARTIEDA 1970). The President, Professor T. N. GEORGE, thanked Dr. ARTIEDA and the S. A Hullera Vasco-Leonesa for their hospitality and the careful preparation for an enjoyable day spent in this coalfield of Ciñera-Matallana.

Discussion on a probable correlation between the Ciñera-Matallana and Sabero coalfields in the province of León.

In the evening Mr. J. A. KNIGHT presented the general information available on a probable correlation between the Stephanian B strata in the Ciñera-Matallana coalfield, visited during the day, and the Sabero coalfield, to be visited the following day. The discussion centred on methods of correlation and the kind of basin to be envisaged. It was noted that cineritic horizons would be extremely useful for correlation if a reasonably complete sequence of these horizons could be found. Lacustrine episodes did not need to be absolutely synchronous in the two coalfields considered, and would have to be used in the context of the general stratigraphic succession, a point emphasized by the lecturer. A query about the possible intramontane character of the coalfields considered, was answered in the negative. Although the presence of torrential conglomerates indicated a nearby relief, the basin itself was situated on a coastal plain, and would thus qualify as paralo-limnic.

A PROBABLE CORRELATION BETWEEN THE CIÑERA-MATALLANA AND SABERO COALFIELDS

(Lecture by J. A. KNIGHT)

The proposed correlation between the two coalfields is based primarily upon floral evidence and notably upon a comparison between the flora of the Pastora Formation of the Ciñera-Matallana coalfield and that of «Paquete Norte», Unit 12 of the Sabero coalfield. Using the published sections of both coalfields (WAGNER 1971, KNIGHT 1971), a correlation of the lithological successions is suggested.

The lower part of the Sabero succession is subdivided into 13 informal units, the floral contents of which have been stated. There is a marked similarity in flora as well as lithology between Unit 12 of Sabero and the Pastora Formation. With regard to flora, it is noted that a number of reputed Middle and Upper Stephanian elements make an uncharacteristic early appearance in Sabero. These are the elements regarded as «hill-slope» flora, and it is thought that the early occurrence of these species is due to the proximity of a mountainous hinterland. The subtraction of these «hill-slope» elements from the floral list leaves an assemblage similar to that of the Pastora Formation, and indicative of lower Stephanian B. Using this as a basis for further conjecture about lithological similarity, the general successions at Sabero and in the Ciñera-Matallana coalfield can be compared.

The presence of a marine horizon near the base of the Sabero sequence indicates that, opposed to previous belief, the coalfield is not intramontane. WAGNER (1971), for the Ciñera-Matallana coalfield, argues that the flora of this post-Asturian coalfield shows a composition indicative of a paralo-limnic facies of the coastal plain (compare JONGMANS 1952, p. 302). The distance between the two coalfields being less than 10 km, it is to be assumed that they both belonged to the same paralo-limnic basin. The two concurrent coalfield sequences, broadly correlated with regard to age on the basis of floras, should therefore illustrate the same broad pattern of sedimentary history.

Within both coalfields two characteristic, thick lacustrine sequences have been used as marker lithologies. It is proposed that the Tabliza Horizon, at the base of the Pastora Formation, with a *Leaia* Band at its base, represents the same lacustrine interval as the blue shales of Units 10 and 11 at Sabero. The latter also have a *Leaia* Band, albeit poor, at their base. These shales at Sabero make a very sudden appearance, sharply interrupting the coal-bearing sequence, and their thickness (100 m) indicates a prolonged period of deposition. Since there is no sedimentary evidence for transgression, their sudden appearance may have been controlled by tectonism. If this is regarded as true, the same control should have operated at Ciñera-Matallana, believed to be part of the same subsiding basin. Hence, the appearance of a similar, characteristic lacustrine shale succession might be expected near or at the same horizon in both coalfields. There is a difference in the relative importance of the lacustrine horizon in Sabero and in Ciñera-Matallana, a much greater thickness being recorded in the former. However, there is no reason to assume that the lacustrine interval should have lasted just as long in one area as in the other.

The coal-bearing Unit 12 at Sabero and the Pastora Formation of Ciñera-Matallana (upper part) are both characterized by the presence of channel sandstones in a coal-bearing sequence which also contains thin lacustrine shale bands. Both are also characterized by the frequent occurrence of *Alethopteris zeilleri* RAGOT which, although by no means restricted to these beds, does occur very commonly in Unit 12 and the Pastora Formation.

Above both these coal-bearing units there occurs a further thick lacustrine formation, viz. the Cascajo Formation of Ciñera-Matallana and Unit 13 (lower part only) of Sabero. Some differences exist in that at Sabero the lacustrine shales are somewhat finer and the characteristic *Leaia* Bands at the base of the Cascajo Formation are absent at Sabero. On the other hand, in both cases there is a gradual increase in siltiness upwards with low angle cross bedding in sandstones at the top, and both show the presence of occasional *Anthraconauta* Bands. It should be noted that the Cascajo Formation reaches a thickness of *ca.* 100 m and Unit 13 shows a development of up to 300 m of lacustrine deposits. They cannot be regarded in the same light as casually occurring thin lacustrine horizons, common throughout the coal-bearing sequences in both coalfields, but represent important episodes of relatively long duration.

The tentative correlation is further supported by floral evidence from the beds overlying the succession discussed above. Although the full succession in the Sabero coalfield is still subject to further investigation, it may be mentioned that the uppermost beds contain certain elements (e. g. *Sphenophyllum* cf. *thoni* VON MAHR) which are comparable to species encountered in the higher beds of the succession at Ciñera-Matallana.

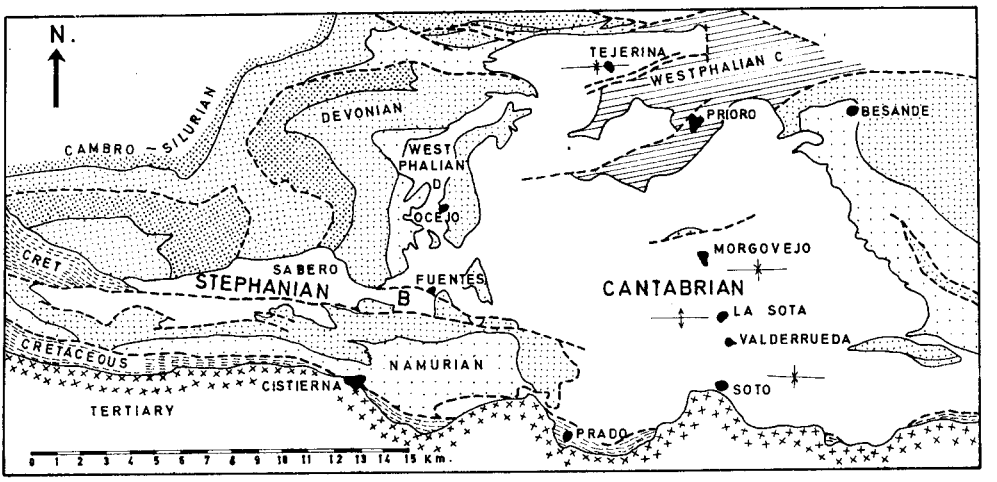
It is noted that the total succession at Sabero is over 2,500 m thick, as against 1,500 m for Ciñera-Matallana. A gradual onlap westwards has been recorded within the Ciñera-Matallana coalfield (WAGNER 1971), and this may account for the much more complete succession at the base of the Sabero sequence. However, the correlation proposed above also requires a thicker succession of strata to have been deposited in Sabero with regard to Ciñera-Matallana, and this may be related to the fact that Sabero contains the oldest rocks formed above the Asturian unconformity and thus appears to have been at the centre of subsidence of the paralo-limnic basin considered.

THURSDAY 24th SEPT: SABERO COALFIELD (LEON) AND THE AREA NEAR OCEJO DE LA PEÑA

(Excursion leaders: J. A. KNIGHT & R. H. WAGNER)

Via La Robla the participants in the field meeting travelled to Sabero, in NE León, where late Stephanian A and Stephanian B strata, almost entirely non-marine, are exposed in a steeply dipping E-W trending syncline with a westward plunge. North of Saelices, immediately west of the village of Sabero, a continuous section of strata,

1,200 m thick, has been studied recently by KNIGHT (1971). They represent the first half of the succession found in the Sabero coalfield, and they lie unconformably on older Palaeozoic rocks (Cambrian to Namurian) which were folded and thrust previously.



Text-fig. 2.—General map of the area containing the Sabero coalfield (mainly Stephanian B but with late Stephanian A deposits at the base), the Valderrueda coalfield (upper Westphalian D and Cantabrian), the Ocejo de la Peña region (upper Westphalian D), and the Tejerina Syncline (upper Westphalian D and lower Cantabrian). The upper Westphalian D to Stephanian B coal-measures occur in two independent, strongly unconformable, post-orogenic successions (formed after the Leonian and the Asturian phases, respectively). Below the upper Westphalian D and lower Cantabrian of Tejerina lie the Westphalian C marine deposits of the Prioro and Pando formations (pre-Leonian folding phase). The dating of the various Upper Carboniferous (post-Namurian) deposits mentioned above is discussed in papers by VAN LOON *et al* (1971), KNIGHT (1971) and WAGNER (1959, 1966).

Sabero coalfield

The well exposed section north of Saelices has shown the presence of 13 informal lithological units:

(1) The base of unit 1 is marked by thick torrential conglomerates with large boulders of varied local derivation. This fluviatile deposition in valleys of high relief was followed by marginally marine incursions, represented by at least three bands of decalcified *Myalina* and *Curvirimula*. Considerable interest was taken in these marine bands which may well have formed in local rias, and which provide the first and only direct evidence of the proximity of the sea in the post-Asturian succession of strata near Sabero.

(2-9) These units, distinguished for the convenience of description, form a continuous succession which is generally fining upwards. Fluviatile sandstones occur

throughout the rather sandy sequence, and upward gradations are found from channelling and irregularly cross bedded «in river» sediments to ripplemarked, thinly bedded overbank deposits. Intermediate coal-measure swamp deposits alternate with occasional lacustrine bands with *Anthraconauta* (characteristic of unit 8). The sequence as a whole fines from thick deposits of sandstone in unit 3 to lutitic seat-earths and coals in unit 9. The coals become concentrated near the top of unit 9 and represent the lowest seams worked in the Sabero coalfield.

(10-11) A sudden change to blue lacustrine shales marks the base of unit 10 with a thin *Leaia* Band providing a useful horizon for local correlation. Unit 10 also contains some *Anthraconauta/Carbonita* Bands. Some 80 m above the base of unit 10 a gradual coarsening upwards is noted, and this culminates in the low angle cross bedded sandstones of unit 11.

(12) The re-establishment of continental conditions marks the base of unit 12 which is placed at the seat-earth of Capa Sucesiva, the first seam of «Paquete Norte» of the mine at Sotillos. Above this seam generally lacustrine conditions prevail, but these are interrupted by channelling sandstones and rootlet beds, culminating in three non-workable coal seams. The second of these seams has a thin (3-7 cm) cinerite band at its roof. The petrographic characteristics of this cinerite are comparable to those of a cineritic horizon in a coal seam of the Cévennes in southern France which occurs at a similar stratigraphic horizon (A. BOUROZ, pers. comm.). The top of unit 12 is placed at a sandstone showing a stand of *Calamites* in position of growth.

(13) The *Calamites* Forest Bed (KNIGHT 1971, text-fig. 4) is overlain by channelling sandstones at the base of a thick sandstone unit *(ca.* 30 m), which shows a gradual passage from «in river» to river overbank deposits, the latter being followed fairly abruptly by over a hundred metres of lacustrine shales coarsening upwards into mixed sandstones.

Non-marine shells were collected at different points. Remains of fossil flora indicated the transition from late Stephanian A to early B. A probable olivine basalt dyke was found above the torrential conglomerates of unit 1 and andesitic dykes were encountered in units 7,9 and 10, above all.

After visiting the section described above (compare KNIGHT 1971, text-fig. 2), the participants in the field meeting were received by the S. A. Hulleras de Sabero y Anexas, in the Casino of Sabero. The President, Professor T. N. GEORGE, thanked the Directors of the mining company, Drs E. VALMASEDA and J. SERRANO for their hospitality and for the preparations made to allow fossil collecting from the interesting section visited.

Section from Santa Olaja de la Varga to Ocejo de la Peña.

East of Sabero a succession of Viséan and Namurian rocks, overlain by unconformable upper Westphalian D, were examined in the valley of the Duerna River,

a tributary of the more important Río Esla. The corresponding section was explored along the road leading from Santa Olaja de la Varga to Ocejo de la Peña (text-fig. 1). This road was originally built as a mining railway intended for the coal workings near Ocejo de la Peña. However, the mines in this area were never important enough to justify the railway which was converted into an access road to the village. The small mines near Ocejo, working from adits, were finally abandoned a few years ago.

Just north of Santa Olaja, after a tunnel in Givetian limestone, a succession of Upper Devonian rocks was passed along the road which cuts the strike at approximate right angles. Upper Westphalian D conglomerates fill in hollows corresponding to fossil stream beds in the steeply dipping Devonian rocks, and both a highly angular unconformity and valley fill are noticed. Further along the road the Upper Devonian is followed in the same steeply dipping succession by disconformable Viséan strata of the Genicera Formation. No Tournaisian has been recorded in this section. The red nodular limestones of the Genicera Formation span an interval from Lower Viséan to mid-Namurian A, with a total thickness of some 22 metres. E_2 goniatites were recorded from the top of the Genicera Formation in this locality by WAGNER-GENTIS *(in* WAGNER 1957, *in* HIGGINS 1962; WAGNER-GENTIS 1963) and KULLMANN (1962). The E_2 limestone is followed by 1.20 m of red and green mudstones (Olaja Beds) with squashed goniatites, crinoid ossicles, lamellibranchs and brachiopods. They are succeeded by some 250 m of thinly bedded, dark grey, fetid limestones (Barcaliente Formation).

These Namurian limestones are cut by a tunnel on the other side of which a large valley fill is entered in upper Westphalian D strata. A fossil scree of angular limestone elements is found in contact with the underlying Namurian limestone in a gully on the eastern side of the road, and this scree is overlain by extremely coarse and ill sorted limestone, sandstone and quartzite boulders of local derivation in a quartz sandstone matrix (WAGNER 1957, láms XXXIII-XXXIV) . Torrential conglomerates with predominant limestone boulders occur at several intervals in this valley fill, several hundred metres thick, which at its extreme base, along the road, shows an important development of red beds. A sedimentary analysis given by OELE & MABESOONE (1963), investigating these deposits, concluded that they were laid down by torrents at the foot of a rising mountain chain which possessed a thick cover of red soil on top of limestones. The corresponding tectonic movements are those of the Leonian Phase, of late Westphalian D age.

Continuing to Ocejo de la Peña, the participants in the field meeting climbed to the locality at *ca.* 1 km NW of the village which yielded the upper Westphalian D flora recorded by WAGNER (1959; 1966, p. 28) at some 50 m above the Leonian unconformity. The floral remains occur in roof shales of a thin coal (Pl. 4, fig. 2). Both the roof shales and the coal are channelled into by a fluviatile, torrential conglomerate with limestone boulders. From the various fossil localities explored in the vicinity of Ocejo de la Peña a total of some 37 plant species has been recorded (WAGNER 1969, pp. 145, 148). They constitute a flora of late Westphalian D age which is only a little older than the basal lower Stephanian (or lower Cantabrian)

floras found at horizons several hundred metres higher in the local succession at Tejerina (compare page 31).

After returning to Santa Olaja de la Varga, the party drove directly to the capital city of León where the night was passed.

FRIDAY 25th SEPT: UPPER WESTPHALIAN D AND CANTABRIAN ROCKS IN NORTHERN PALENCIA

(Excursion leaders: R. H. WAGNER & W. J. VARKER)

Driving out from León in the direction of Puente Almuhey (text-fig. 1), the party crossed into northern Palencia. From Prado de la Guzpeña, west of Puente Almuhey, the party travelled variously on coal-measures of Cantabrian age and on Cretaceous rocks which generally show a faulted contact, though they lie fundamentally with a strongly angular unconformity on the Carboniferous. The road followed the foot of the mountain chain for 40 km from Puente Almuhey (León) to Cervera de Pisuerga (Palencia), where the Cordillera Cantábrica was entered again in a northerly direction. In this area of northern Palencia a predominantly marine succession of upper Westphalian D and Cantabrian strata, followed by Stephanian A rocks, was formed after the Leonian movements which gave rise to a widespread disconformity due to uplift accompanied by normal faulting (WAGNER & VARKER 1971). The total succession in the post-Leonian basin of northern Palencia reached a maximum thickness of over 5,000 metres.

Casavegas Syncline.

The post-Leonian basin was first established in the north-western part of the area considered, and the lower part of the succession, of upper Westphalian D and lower Cantabrian ages, is most completely represented in the Casavegas Syncline (WAGNER & VARKER 1971, text-fig. 1). Predominantly marine deposits alternate with paralic coal-measures which provide the elements of correlation with the non-marine Westphalian D and lower Stephanian of NW Europe.

The first stop was made at the village of Lores where the Casavegas coal-measures, of upper Westphalian D age, yield a well preserved flora as listed in WAGNER & VARKER (1971). The horizon sampled by the participants in the field meeting lies at a maximum of 900 metres above the Leonian disconformity in the Casavegas Syncline. Since the base of the post-Leonian succession in northern Palencia is diachronous, as the result of progressive onlap, only the maximum thickness from the base upwards is significant in terms of the history of the basin.

The marine beds overlying the Casavegas coals were examined subsequently in a road section at some 600 m SE of the village of Casavegas. These beds are highly fossiliferous, with numerous remains of brachiopods, bryozoa, lamellibranchs, crinoids,

gastropods, trilobites, etc. In view of the fact that the Lores Limestone, at a somewhat higher horizon in the succession, has yielded Myachkovian fusulinids to VAN GINKEL (1965), these faunas are to be regarded as Myachkovian in age. The investigation of brachiopod faunas by C. F. WINKLER PRINS (*in* WAGNER & VARKER 1971) only broadly agrees with this opinion and suggests that basal Kasimovian may also be present.

A higher horizon, some 1,700 metres above the base of the post-Leonian succession, was sampled at *ca.* 1 km south of Areños, opposite the abandoned Mina Aurora. Plant fossils found on the tip of the abandoned workings of the Areños coals tentatively suggest a basal lower Stephanian age, i. e. lower Cantabrian (WAGNER & VARKER 1971). An examination of the sedimentary sequence exposed in the Areños river section opposite the Mina Aurora shows a gradual marine transgression above the coal-measures, and a progressive deepening of the basin (READING 1970, WAGNER & VARKER 1971).

A visit to the SANFESA tip along the main road, some 600 m SE of San Salvador de Cantamuda, yielded plant fossils of a middle Cantabrian age with some elements (e. g. *Sphenophyllum nageli* GRAND'EURY) which are directly comparable to the lower Stephanian flora of the Cévennes in southern France. The coals worked formerly by the SANFESA Mine lie at some 2,500 m above the base of the post-Leonian succession. Local correlations, which have not yet been verified entirely, suggest that this coal horizon is only a little older than the Vañes Limestone which yielded a Kasimovian fusulinid fauna to VAN GINKEL (1965).

Castillería Syncline.

The basal part of the post-Leonian succession in the Castillería Syncline, which corresponds to an horizon approximately 2,300 m above the base of the post-Leonian succession at Casavegas (a detailed local correlation is being worked out), has been examined along the road leading to Celada de Roblecedo. It consists of marine transgressive deposits filling up the hollows of an erosional surface, and passing upwards into sandstone with floated tree trunks and a seat-earth. Renewed transgression flooded the latter and initiated a long marine succession culminating eventually in a protracted regressive sequence leading to tectonically disturbed coal seams and deltaic sandstones.

Lack of time prevented visiting the later Cantabrian and Stephanian A *(sensu stricto)* deposits which complete the *ca* 5,000 m thick post-Leonian succession in northern Palencia, and which underlie the strongly unconformable torrential conglomerates of Stephanian B age in the Barruelo region (compare WAGNER & WINKLER PRINS 1970). The latter represent the first deposits formed after the Asturian folding phase which was strongly diastrophic in northern Palencia (as against the preceding Leonian phase which only produced uplift and normal faulting in this part of the Cantabrian Chain).

General discussion on the Carboniferous in NW. Spain.

A general discussion was held during the evening after a brief summary was presented by Dr. R. H. WAGNER (reproduced at the end of the «Account»). The discussion briefly alluded to the possibility of using the interlocking marine and continental facies of the Carboniferous of NW. Spain as a bridge for correlation between NW. Europe and Russia. Most of the discussion was devoted however to the lower Stephanian (*sensu lato*), with particular regard to the Cantabrian Stage proposed as the basal chronostratigraphic unit of a Stephanian Series (WAGNER 1969). The presence of a previously unrecorded sequence older than stratotypic Stephanian A and younger than stratotypic Westphalian D was generally admitted, but the limits of the stages (or substages) to be recognized within the lower Stephanian *(sensu lato)* were regarded as being open to discussion. A recent paper by BOUROZ, GRAS & WAGNER (1970), available at the meeting, suggested certain correlations between the «Cantabrian» rocks in Spain and the lower part of the Stephanian sequence in the Cévennes area of southern France. The lower Stephanian succession in both areas should be examined and judged on their respective merits as possible stratotypes, before a binding conclusion can be drawn with regard to the limits of the chronostratigraphic units to be recognized. This question is to be discussed more fully during the next general meeting of the IUGS Subcommission on Carboniferous Stratigraphy (in Krefeld, 1971), and during specialist gatherings taking place beforehand.

SATURDAY 26th SEPT: WESTPHALIAN C AND LOWER CANTABRIAN IN NE. LEON

(Excursion leaders: A. J. VAN LOON & R. H. WAGNER)

The party left León in the morning for Prioro in NE. León (text-fig. 1), where most members continued for the marine Westphalian C succession at the Pando mountain pass. Some participants went immediately to Tejerina in order to have more time for the lower Cantabrian type section described here by WAGNER, VILLEGAS & FONOLLÁ (1969). Later, the full party gathered on the section at Tejerina.

Puerto Pando.

Travelling up the road from Prioro a road section in the Mesao Limestone Member of the Pando Formation was examined at the Pando mountain pass. Abundant marine faunas (e. g. fusulinid foraminifera, brachiopods) from this member indicated an upper Kashirian or Podolskian age, whilst drifted plant remains associated with the marine fauna showed a Westphalian C age. Since the immediately overlying Upper Sandstone Member yielded upper Podolskian to lower Myachkovian brachiopods, a Podolskian age seems to be generally indicated. Calcareous mudstone, limestone

and mudstone of various facies alternate in the section which has been described in detail by VAN LOON (1971) in an Appendix.

Tejerina.

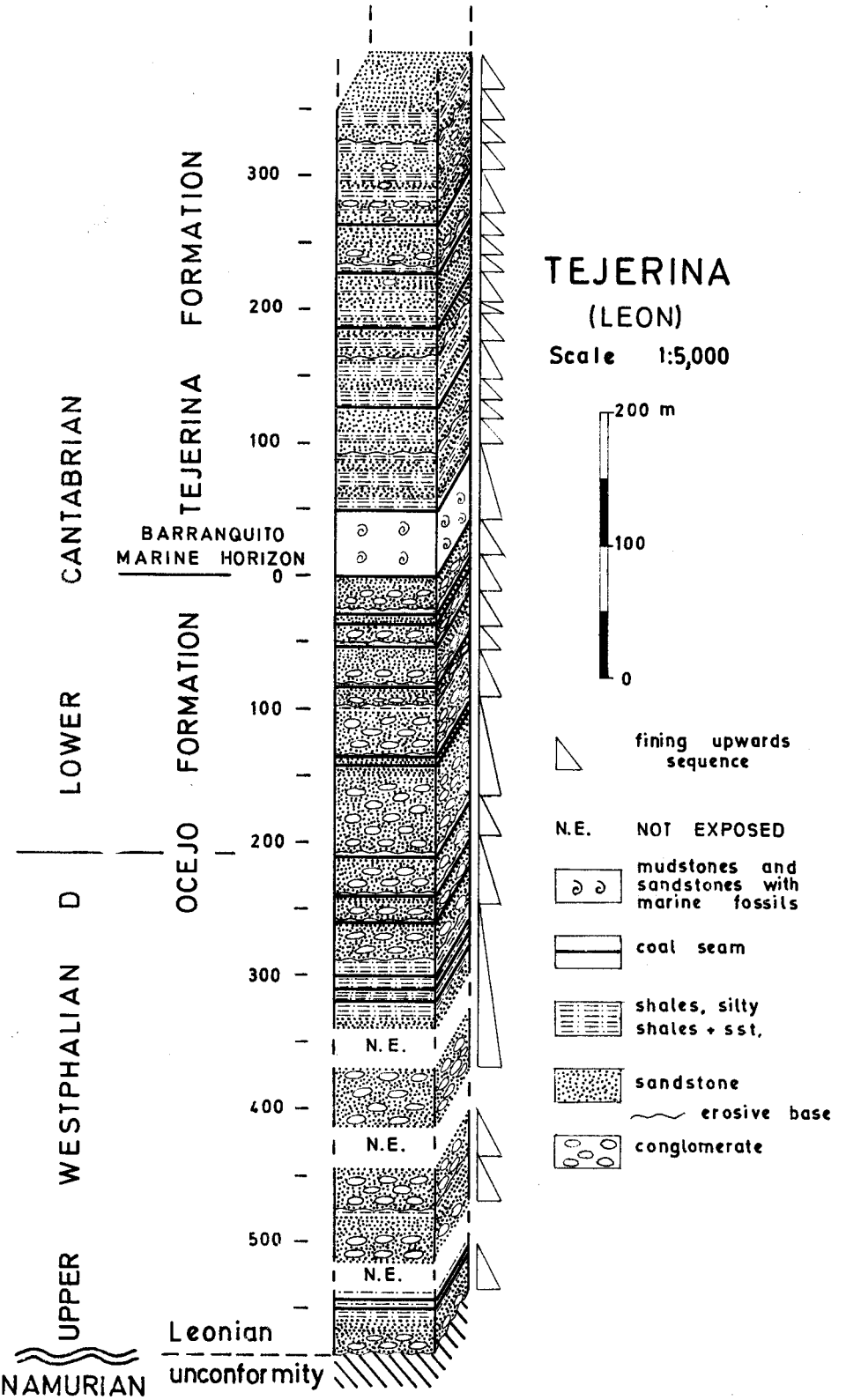
The Westphalian C/Podolskian rocks of the Pando Formation are overlain with a marked angular unconformity by limestone and quartzite conglomerates alternating with coal-measures containing floras of upper Westphalian D and lower Cantabrian (i. e. basal lower Stephanian *sensu lato*) ages. The unconformity is related to the Leonian Phase which acted here as a folding phase and not merely as a phase of uplift as in northern Palencia, only 35 km to the east.

The post-orogenic succession, some 1,200 m thick, is well exposed along a path and in a mountain gorge north of the village of Tejerina, where a detailed stratigraphic section has been measured. A simplified section was figured and described by WAGNER, VILLEGAS & FONOLLÁ (1969), and a more detailed section, to the scale of 1:200, was made available to the participants in the field meeting. Although the latter will be published in due time, only a general column (scale 1 : 5,000) is included in this Account (text-fig. 3). It shows the large development of torrential conglomerates in the lower part of the succession which is a striking feature of the Tejerina exposure (Pl. 5), and which link it with the conglomeratic sequence near Ocejo de la Peña seen on a previous day. They form part of the Ocejo Formation. A marine transgressive horizon, the Barranquito Marine Horizon, is here considered to represent the basal beds of the succeeding Tejerina Formation (text-fig. 3). The Barranquito Horizon was previously described as the Barranquito Formation (WAGNER *et al.* 1969), but should probably not be recognized as a separate formation. However, it does show an important change from the torrential conglomerates which characterize the preceding beds of the Ocejo Formation, and thus seems likely to provide a stable reference for local correlation. Although the succeeding Tejerina Formation is not fundamentally different in facies from the Ocejo Formation, it contains only sparse torrential conglomerates, and is thus quite different for the purpose of mapping.

The Ocejo Formation consists of a succession of fining upwards rhythmic units with limestone and quartzite conglomerates at the base of each complete unit. The characteristic development of a unit consists of: —a/ limestone conglomerate with an admixture of better rounded, probably reworked quartzite boulders and a quartzose matrix; —b/ coarse, rather massive sandstone, sometimes current-bedded; —c) seatearths and thin coals in a shale-sandstone sequence of coal-measure facies.

The Tejerina Formation also consists of fining upwards sequences, essentially of a rhythmic nature, but the units are smaller, probably because the rapidly deposited torrential conglomerates are generally lacking. Commonly, coarse-grained, rather massive channel sandstones form the basal bed of the rhythmic units in the Tejerina Formation.

The Barranquito Marine Horizon occupies the same relative postion as a limestone conglomerate in a fining upwards sequence, and this seems to indicate that


TEJERINA
(LEON)
Scale 1:5,000
200 m
100
0
fining upwards sequence
N.E. NOT EXPOSED
mudstones and sandstones with marine fossils
coal seam
shales, silty shales + sst.
sandstone
erosive base
conglomerate
CANTABRIAN
LOWER
WESTPHALIAN D
UPPER
NAMURIAN
TEJERINA FORMATION
OCEJO FORMATION
BARRANQUITO MARINE HORIZON
300
200
100
0
100
200
300
400
500
N.E.
N.E.
N.E.
Leonian unconformity

the rhythmic units are controlled by pulses of downwarp. A sudden steepening of the gradient would increase the amount of torrential sedimentation, and subsidence to below sea level would cause a rapid transgression such as seems to be indicated by the basal bed of the Barranquito Horizon which shows ostracode- and lamellibranch-bearing mudstone immediately overlying a thin coal.

Throughout the 940 metres of strata measured in detail north of Tejerina, a large number of plant localities have been found. A total of 46 plant beds were sampled (and the floras listed in WAGNER *et al.* 1969). Up to *ca.* 330 m from the local base of the unconformable Ocejo Formation (which is probably several hundred metres thicker at Ocejo de la Peña where a more complete sequence appears to have been deposited) the floras collected can still be assigned to upper Westphalian D. Approximately 440 m above the local base, however, a flora younger than Westphalian D was encountered, and this has been used to determine the base of the lower Cantabrian. During the field meeting the opportunity existed to collect from this basal Cantabrian plant locality (loc. 1184: WAGNER *et al.* 1969, p. 119) which is in the upper part of the Ocejo Formation. Just above the Barranquito Marine Horizon another good plant locality was sampled (loc. 1795: *op. cit.*, p. 120), and a third one (loc. 1821: *op. cit.*, p. 121) was visited at *ca.* 150 m above the base of the Tejerina Formation.

GENERAL SUMMARY OF THE CARBONIFEROUS STRATIGRAPHY OF NW. SPAIN

(corresponding to the Introduction to the general discussion in the evening of 25th Sept).

The general geological map of NW. Spain (text-fig. 4), which was published in 1967 under the general editorship of I. PARGA PONDAL, shows the Carboniferous to be mainly concentrated in an area limited west and south-westwards by Lower Palaeozoic and Precambrian rocks, whilst east and south-eastwards it is covered by unconformable Mesozoic and Tertiary. To the north lies the Bay of Biscay (Mar Cantábrico).

The area of exposed Carboniferous is almost wholly within the Cantabrian Cordillera, a mountainous complex which reaches its highest altitude at 2,800 m in the Picos de Europa. Structurally, it conforms to the arcuate shape of Late Palaeozoic folds and thrusts which are centred upon south-central Asturias and which show a progressively greater amount of Carboniferous rocks towards the central part of the orogen.

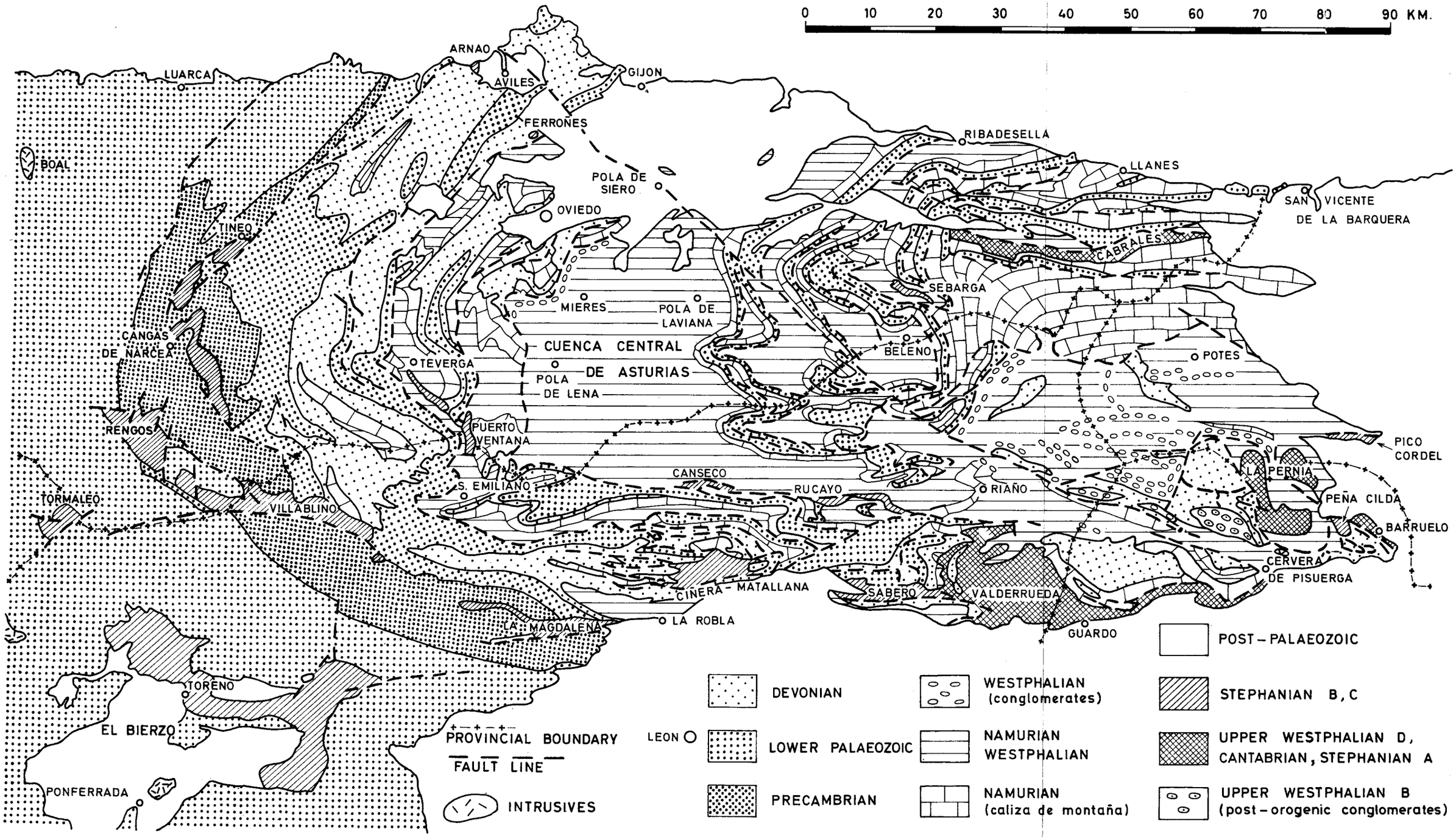
←

Text-fig. 3.—General stratigraphic column of the Ocejo and Tejerina formations as found in the Lower Cantabrian stratotype described by WAGNER, VILLEGAS & FONOLLÁ (1969) from the northern flank of the Tejerina Syncline (compare Pl. 5). Note that the Barranquito Marine Horizon, here incorporated with the Tejerina Formation, was described originally as a separate formational unit. The thickness of strata in the two formations mentioned has been measured from the base of the Barranquito Marine Horizon downwards and upwards. This horizon is likely to serve as a marker band and is thus regarded as a stable reference for local correlation.

The stratigraphic history of the Carboniferous in N. W. Spain is dominated by two major palaeogeographic elements which operated as such since the Lower Cambrian, viz. an enveloping hinterland to the south, south-west, west and north-west, and a foreland massif (Cantabrian Block) in the centre of the orogen. Between the foreland massif and the enveloping hinterland a basin was situated, and a considerable amount of sedimentation took place in this area which was gradually encroached upon from the hinterland.

An important uplift of the Cantabrian Block in late Upper Devonian times produced a disconformity or low-angle unconformity between late Famennian/Strunian strata and earlier Palaeozoic rocks which are sometimes eroded down to the level of the Ordovician (in the central part of the uplift). Subsequent vertical movements during the Lower Carboniferous produced a number of small disconformities within a sequence of rather condensed facies. The first really widespread deposit was formed after the latest of these uplifts, in this case a movement of the hinterland or of a geosynclinal ridge, which occurred in lowermost Viséan times. A subsequent deposit of *ca* 20 m of nodular limestone and chert, dated on goniatite and conodont faunas as ranging from Lower Viséan to mid-Namurian A, represents an extremely condensed formation which is found everywhere in the Cordillera Cantábrica. This is the «marbre griotte» of BARROIS (1882) or Genicera Formation of WAGNER, WINKLER PRINS & RIDING (1971). It is followed in the area corresponding to the Cantabrian Block by thinly bedded, dark grey, rather fetid limestones, several hundred metres thick, which form a gradual transition with the nodular and wavy bedded limestones of the Genicera Formation. These fetid limestones have been described as the Barcaliente Formation *(op. cit.)*. In the areas marginal to the Cantabrian Block the Barcaliente Limestone is followed in a conformable sequence by the more massively bedded, generally thicker limestones of the Valdeteja Formation *(op. cit.)*. These two limestone formations, of Namurian A-B and Namurian C age, respectively, may form up to 1,100 m thick masses through which spectacular gorges have been cut by rivers. This is the «caliza de montaña» (mountain limestone) of Spanish authors, and «calcaire des cañons» (canyon limestone) of French authors (since BARROIS 1882). The Valdeteja Formation was apparently removed from the central part of the Cantabrian Block by an important uplift taking place before Westphalian B. It seems to be represented only in areas marginal to the Block (compare text-fig. 5, where the columns for the San Emiliano Valley, the Cármenes Syncline, and the Ponga thrust unit east of the central Asturian coalfield, show the progressive increase of a stratigraphic gap below Westphalian B in the direction of the central Cantabrian Block). Uplift of either the Hinterland or, more likely, a geosynclinal ridge, resulted in the elimination of the Barcaliente Formation and the presence of a low-angle unconformity between the Genicera and Valdeteja formations in a nappe structure in northern Palencia.

The Barcaliente Formation in northern León, in an area immediately south of the Block, wedges southwards into a terrigenous sequence with turbidites which forms the basinal equivalent of the late Namurian A/Namurian B limestone. Tongues



Text-fig. 4.— General map of the Palaeozoic strata in the Cordillera Cantábrica (based on the «Carte geólogique du Nord-Ouest de la Peninsule Ibérique» by I. PARGA *et al.* and modified and simplified to show the distribution of Carboniferous strata above all). This figure was also published in WAGNER & ARTIEDA 1970.

of the Barcaliente Limestone are found as intercalations within the terrigenous succession which is particularly well developed north of La Robla.

The succession above the Valdeteja Formation is interrupted by the pre-Westphalian B disconformity in the Cármenes Syncline (text-fig. 5), but it is continuous in areas which are assumed to lie further away from the Cantabrian Block (e. g. the incompletely studied succession in the San Emiliano Valley, the westernmost part of the central Asturian coalfield —compare CARIDE DE LIÑÁN & GARCÍA-LOYGORRI 1969 and MARTÍNEZ DÍAZ 1969—, and the La Camocha coalfield near Gijón— compare NEVES 1964).

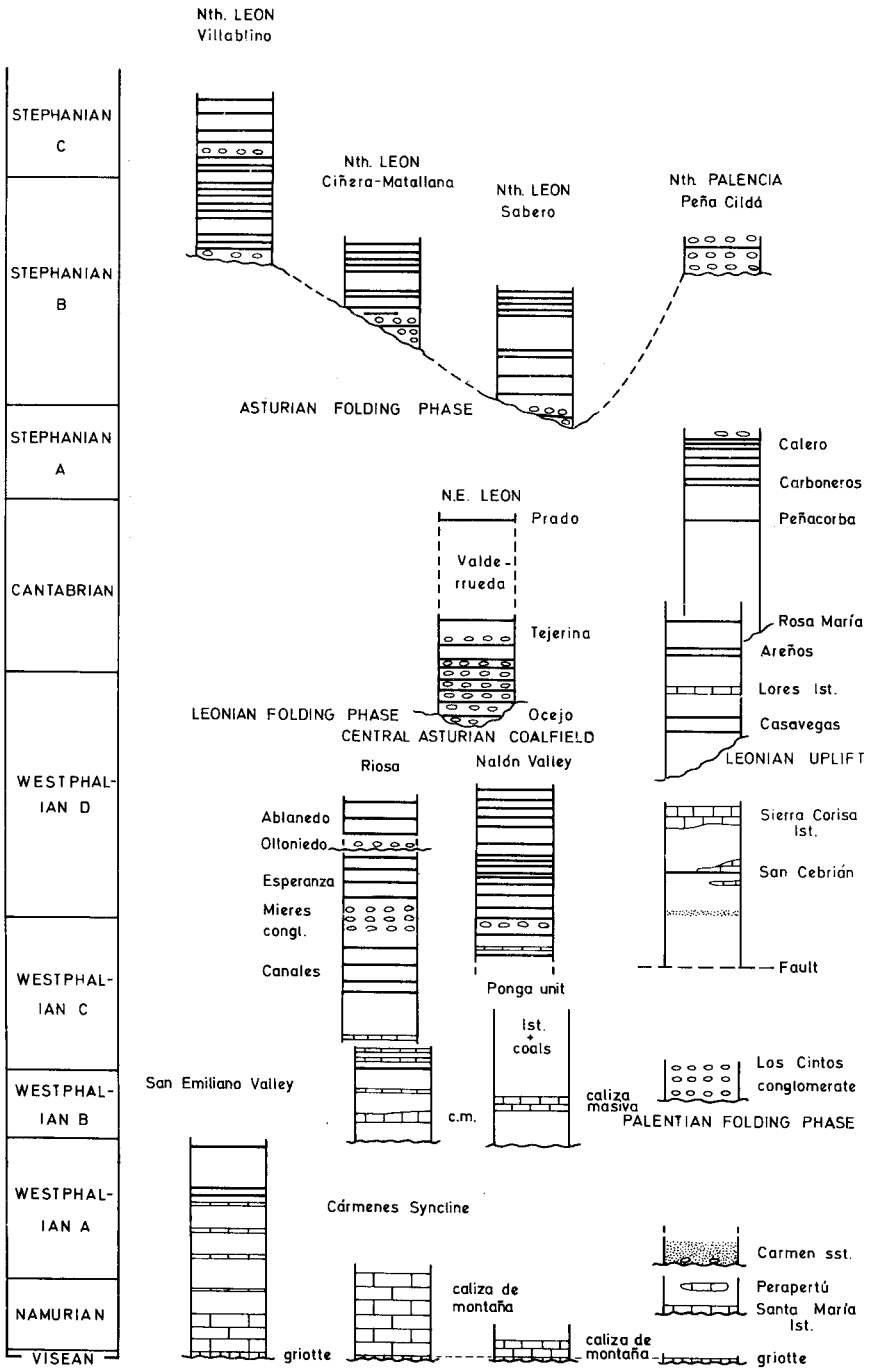
Westphalian B, C and D strata are generally found to be conformable and continuous (with the exception of a relatively minor disconformity of lower to middle Westphalian D age as reported by PELLO 1968) in the central Asturian coalfield, which is mainly situated on the Cantabrian Block. VAN AMEROM, BLESS & WINKLER PRINS (1970) and, particularly, GARCÍA-LOYGORRI *et al.* (1971) suggest that this succession reaches even into lower Stephanian, but the evidence for the latter is probably open to discussion. In the basinal area south of the block, the Westphalian sequence is violently interrupted by the strongly diastrophic Palentian folding phase, of Westphalian B age. Northward directed thrusts affected E-W striking isoclinal folds, and nappe structures have been found as allochthonous units on autochthonous isoclines in NE. Palencia (WAGNER 1971). Evidently, strong folding movements emanating from the Hinterland produced isoclinal folds, thrust slices and nappes moving towards the Foreland (Cantabrian Block) during the Palentian Phase. The diastrophism of the basin did not, however, reach the Cantabrian Block.

Strata of late Westphalian B, Westphalian C and most of Westphalian D ages, in a succession several thousand metres thick, constitute a post-Palentian basin fill in northern Palencia. The facies of these rocks is generally more basinal than that of the Upper Westphalian strata in the central Asturian coalfield, and they are more continuously marine (compare VAN DE GRAAFF 1971).

Widespread tectonic movements occurred again during late Westphalian D times. These movements of the Leonian Phase produced a strongly angular unconformity in NE. León (e. g. at Ocejo de la Peña and at Tejerina), perhaps a somewhat less clearly marked unconformity in eastern Asturias, east of Cangas de Onís (MARCOS 1967), and uplift combined with normal faulting in northern Palencia. The subsequent basin with upper Westphalian D and lower Stephanian (*sensu lato*) deposits, gradually extended its area eastwards during the lower Stephanian and, eventually, produced a basin fill of *ca.* 5,000 metres in NE. León and N. Palencia. A similar onlap in an eastern direction has been recorded from eastern Asturias, where a much thinner succession of post-Leonian strata was laid down (compare MARTÍNEZ-GARCÍA & WAGNER 1971). It is by no means clear that the Leonian movements reached the Cantabrian Block, but it is quite likely that the post-Leonian basin incorporated the area originally occupied by the Block in south-central Asturias. The Leonian movements probably continued the foreland-directed diastrophism of the Palentian Phase, and further restricted the Basin as well as the Foreland; thus marking a further advance of the Hinterland area.

CARBONIFEROUS SUCCESSIONS IN NW SPAIN

Scale 1:100,000



The subsequent Asturian Phase, of late Stephanian A and early Stephanian B age, apparently folded the entire area of the Cantabrian Cordillera. This is the first folding phase that clearly reached the former area of the Cantabrian Block (viz. most of the central Asturian coalfield and the region east of this coalfield). The post-Asturian basin does no longer conform in shape to the earlier basins existing in the Cantabric-Asturian area, and appears to be more or less independent from the major palaeogeographic units as discussed for the earlier Carboniferous. Recently obtained evidence (KNIGHT 1971) indicates that the post-Asturian basin spread from a low point in the Sabero coalfield both northwest and northeast-wards. A sum total of *ca.* 4,500 metres of Stephanian B and C rocks (with some late Stephanian A at Sabero) was formed in this basin which was probably situated on a coastal plain between the sea and a mountainous area occupying the main part of the present Cantabric-Asturian area. Although subsequent folding during the Permian followed the same structural lines as the earlier (Palentian, Leonian and Asturian) tectonic phases, it is not immediately obvious that the tardi-geosynclinal post-Asturian basin would have conformed to the shape of the earlier geosynclinal basin. In contradistinction to the earlier basins, which were to a large extent marine, there was only a very limited marine influence on the sedimentation in the post-Asturian basin. In fact, the latter is almost entirely continental in facies, and qualifies as a paralo-limnic basin in the sense of JONGMANS (1952).

Autunian deposits are only known from a single locality near Pola de Siero in Asturias (PATAC 1920). This isolated exposure shows no connection with Stephanian strata and the relationship with the Carboniferous is therefore unknown. The Autunian rocks are however steeply folded and since they are covered with angular unconformity by Mesozoic strata, they obviously participated in the late Palaeozoic movements.

The latter movements, of Permian age, closed the effective tectogenesis of the Cantabric-Asturian area, which was cratonized from there-on. A Mesozoic basin of sedimentation was established both east and north of the Cordillera Cantábrica which acted as a massif. The present mountain chain was uplifted during late Tertiary and perhaps even more recent times. Its southern boundary is often a reverse fault which brings the Palaeozoic into contact with steepened Cretaceous strata (EVERS 1967).

One of the most interesting features of the Carboniferous in NW. Spain is the gradual increase in the rate of sedimentation, from the highly condensed Tournaisian, Viséan and Lower Namurian (perhaps some 50 m thick), to a less condensed late

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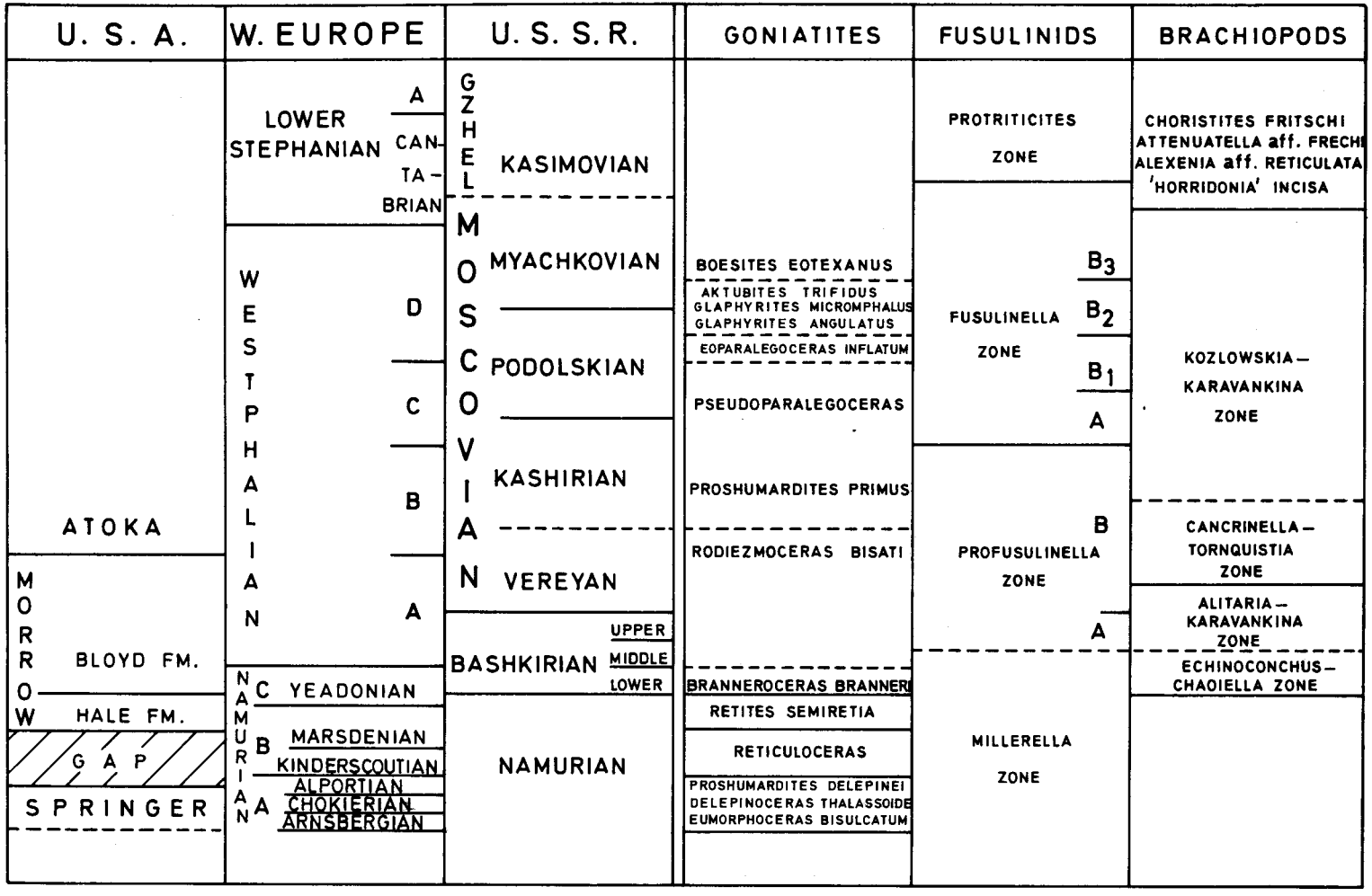
Text-fig. 5.—Generalized stratigraphic columns for the Carboniferous successions in N. W. Spain (data as mentioned in WAGNER 1970, text-fig. 3, with the addition of VAN DEN BOSCH 1969, KNIGHT 1971, and MOORE *et al.* 1971, for the successions at San Emiliano, Sabero and Cármenes Syncline, respectively). Heavy black lines for coals; block symbol for limestones; ovals for conglomerates and dots for sandstones. It will be noted that the thickness of the successions increases upwards, and this is a reflection on the palaeogeographic position of the deposits which commenced in a very condensed facies on the Cantabrian Block and which became increasingly more basinal as the Block yielded territory to the basin.
Erratum: for Olloniedo *read* Olloniego.


U. S. A.
W. EUROPE
U. S. S. R.
GONIATITES
FUSULINIDS
BRACHIOPODS
LOWER STEPHANIAN
A
CAN-TA-BRIAN
WESTPHALIAN
D
C
B
A
ATOKA
MORROW
BLOYD FM.
HALE FM.
G A P
SPRINGER
NAMURIAN
C YEADONIAN
B MARSDENIAN
KINDERSCOUTIAN
ALPORTIAN
A CHOKIERIAN
ARNSBERGIAN
GZHELIAN
KASIMOVIAN
MOSCOVIAN
MYACHKOVIAN
PODOLSKIAN
KASHIRIAN
VEREYAN
BASHKIRIAN
UPPER
MIDDLE
LOWER
NAMURIAN
BOESITES EOTEXANUS
AKTUBITES TRIFIDUS
GLAPHYRITES MICROMPHALUS
GLAPHYRITES ANGULATUS
EOPARALEGOCERAS INFLATUM
PSEUDOPARALEGOCERAS
PROSHUMARDITES PRIMUS
RODIEZMOCERAS BISATI
BRANNEROCERAS BRANNERI
RETITES SEMIRETIA
RETICULOCERAS
PROSHUMARDITES DELEPINEI
DELEPINOCERAS THALASSOIDE
EUMORPHOCERAS BISULCATUM
PROTRITICITES ZONE
FUSULINELLA ZONE
B3
B2
B1
A
PROFUSULINELLA ZONE
B
A
MILLERELLA ZONE
CHORISTITES FRITSCHI
ATTENUATELLA aff. FRECHI
ALEXENIA aff. RETICULATA
'HORRIDONIA' INCISA
KOZLOWSKIA–KARAVANKINA ZONE
CANCRINELLA–TORNQUISTIA ZONE
ALITARIA–KARAVANKINA ZONE
ECHINOCONCHUS–CHAOIELLA ZONE

Namurian A and Namurian B carbonate sequence *(ca* 350 m), and more quickly developed Namurian C (some 600 m), and Westphalian A-D (some 6,000 m). More than likely, this progressive increase in the rate of sedimentation is related to a gradual shift of the basin on towards the Cantabrian Block in south-central Asturias. Important post-orogenic basin fills, of the order of 4000 to 5000 metres for each fill, were formed during late Westphalian D/Cantabrian/Stephanian A, Stephanian B and Stephanian C times (text-fig. 5).

A very large proportion of the Carboniferous in NW. Spain is marine, and only from late Stephanian A onwards an almost exclusively non-marine facies is developed. The alternating marine and non-marine facies throughout most of the succession recorded, permit of a correlation between the fusulinid, brachiopod and goniatite zonations established in European Russia and North America, and the plant impression and spore zonations founded in Northwest Europe. A summary of the correlations obtained thus far is presented in text-fig. 6. Although it represents an advance on the earlier correlations proposed by DELÉPINE (1938) and VAN GINKEL (1965), and provides a useful check on the correlations put forward by GORSKY, STEPANOV *et al.* (1960), there is still an element of tentativeness which can only be removed by further investigations. Too much reliance has to be placed on spot samples, in the absence of a sufficiently large number of adequately sampled long sections. However, it is evident that the Carboniferous of NW. Spain, with its varied marine faunas alternating in the same successions with continental floras, is in a good position to provide a bridge between NW. Europe on the one hand and the U. S. S. R. and North America on the other.

Within western Europe it provides one of the very few places where a complete succession of lower Stephanian *(sensu lato)* is developed, and perhaps the only one which also shows the transition from late Westphalian D to lower Stephanian. It is unique in showing varied marine strata alternating with non-marine deposits in rocks of lower Stephanian age; thus providing almost ideal conditions for a stratotype.

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Text-fig. 6.—Suggested correlation between American, Russian and West European chronostratigraphic units, as dated in Northwest Spain, and represented from Arnsbergian (E_2) onwards. Incidental goniatite finds, fusulinid and brachiopod zones are represented in the right hand columns. Floral (macro —and micro—) evidence has dated the West European units from Marsdenian upwards.

-Data after VAN GINKEL 1965 (fusulinids); MOORE, NEVES, WAGNER & WAGNER-GENTIS 1971 (goniatites, plants, spores, fusulinids); WAGNER-GENTIS 1963, 1971; KULLMANN *in* VAN LOON 1971 (goniatites); WINKLER PRINS 1968, 1971, *in* WAGNER & WINKLER PRINS 1970 (brachiopods); WAGNER 1962, 1966, *in* WAGNER & WINKLER PRINS 1970, *in* WAGNER & VARKER 1971 (plants). Figure constructed in collaboration with Dr. C. F. WINKLER PRINS.

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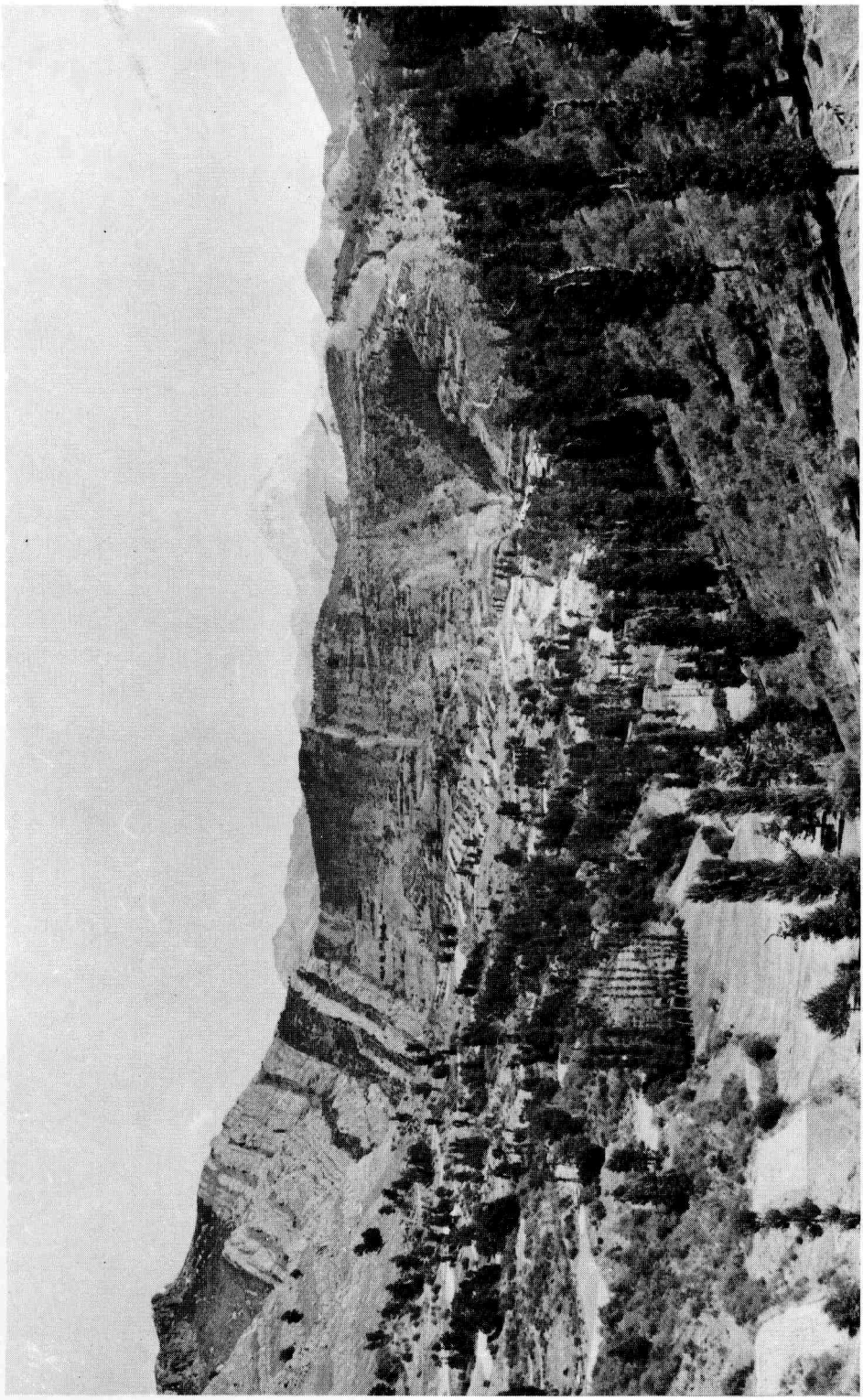
PLATES 1-5



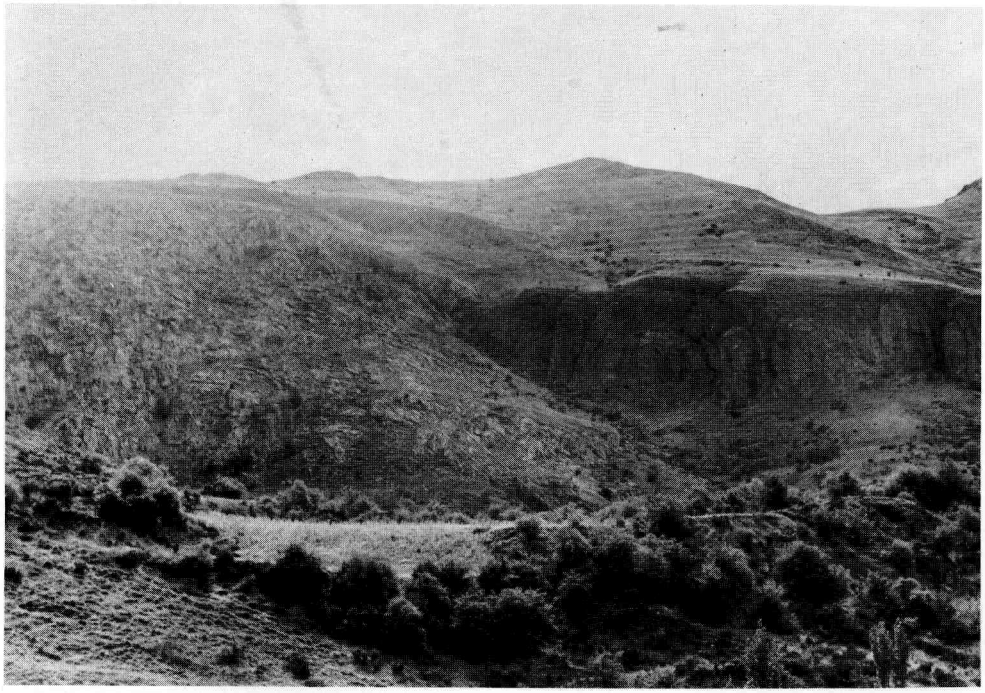


Fig. 1.—Valley fill deposits of upper Westphalian D age, showing prominent bands of limestone conglomerate banked up against Namurian limestone in the valley of the Río Duerna, east of Sabero and Santa Olaja de la Varga.

Fig. 2.—Sr. Tomás Fernández, discoverer of the upper Westphalian D flora at Ocejo de la Peña, which occurs in the roof shales of a thin coal seam overlain by torrential limestone conglomerate. The erosive base of this conglomerate is seen above the roof shales which yielded the fossil flora.

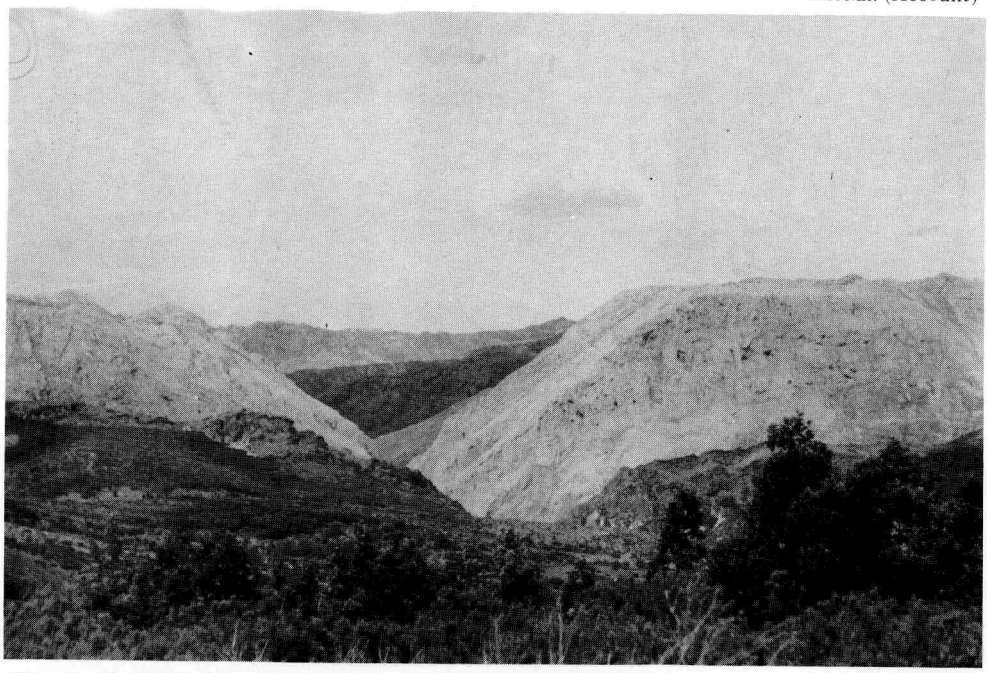
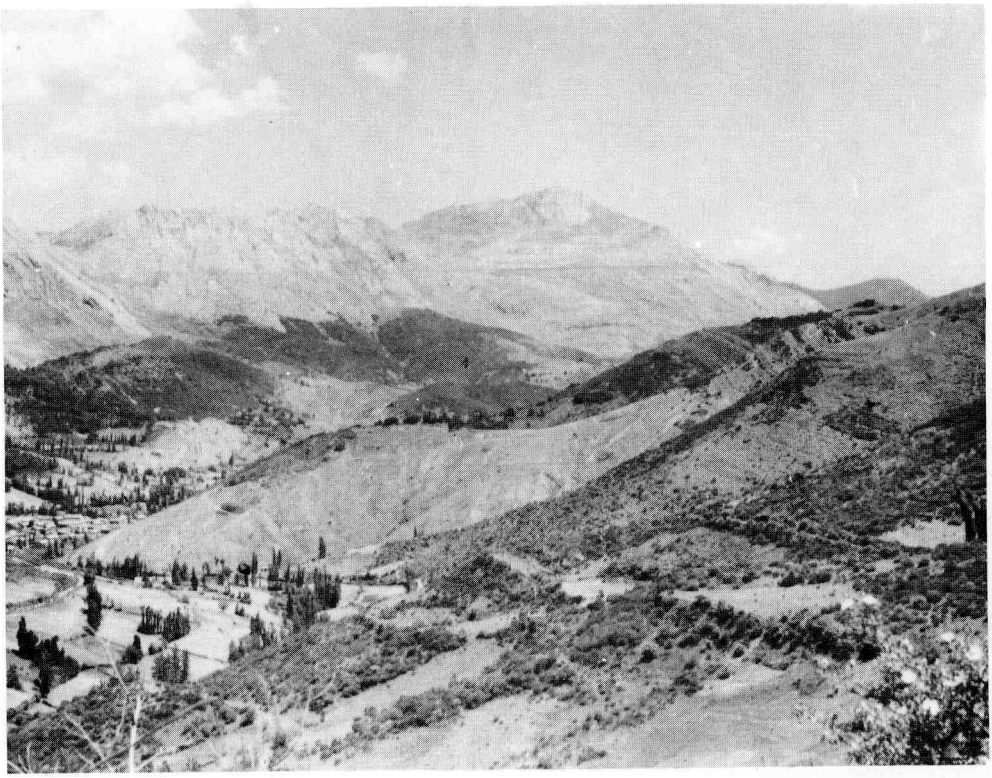
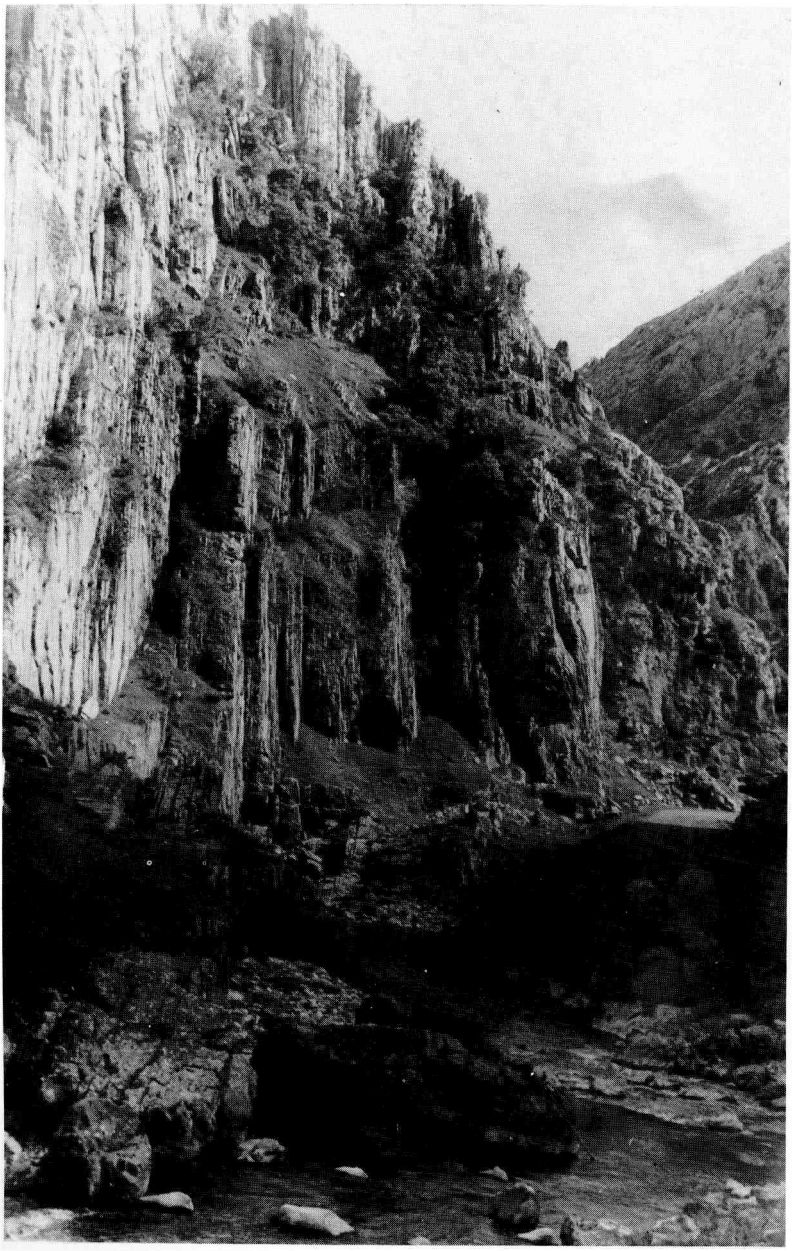


Fig. 1—Namurian limestone of the Barcaliente and Valdeteja formations in the Vegacervera Gorge, as seen from high ground to the south. Ordovician quartzite of the Barrios Formation forms the ridge with more darkly coloured rock in the middle ground. Successive ridges of dark Ordovician quartzite and lighter coloured Namurian limestone are visible in the background. Northern rim of the Ciñera-Matallana coalfield (León).

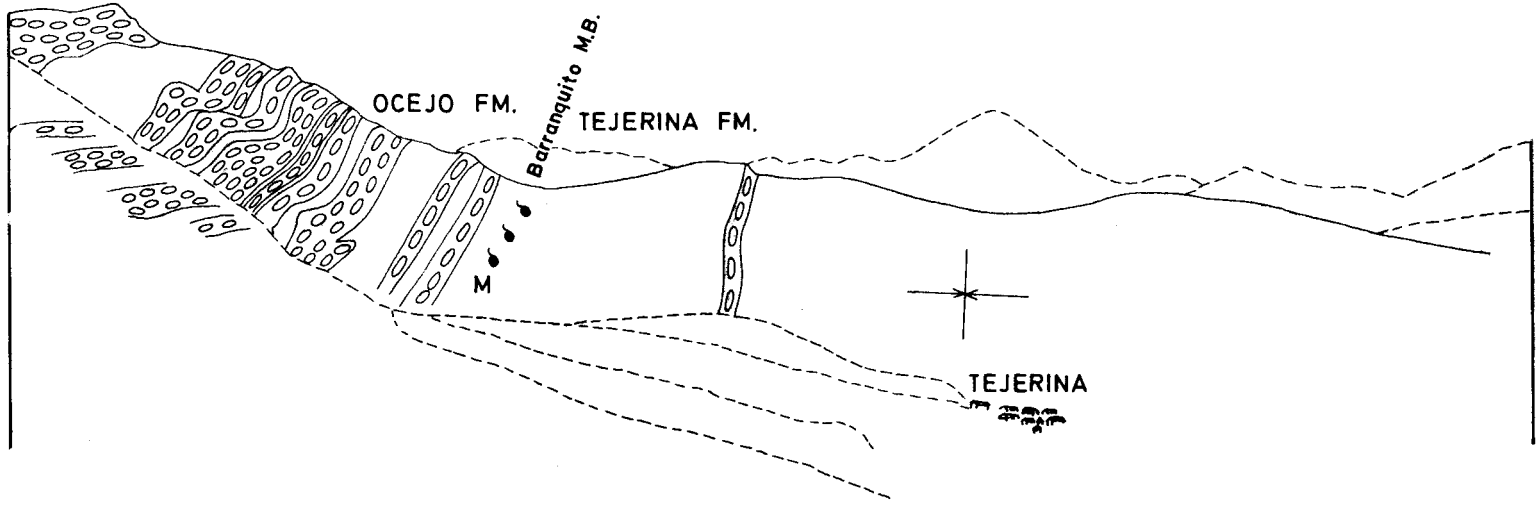
Fig. 2.—The pithead of Pozo Herrera No. 2 at Sotillos in the western part of the valley of Sabero. The mountains in the background represent mainly Devonian, Lower Carboniferous and Namurian deposits with unconformable upper Westphalian D.



A view of the northern part of the Ciñera-Matallana coalfield at Coladilla. East-west striking Ordovician, Silurian, Devonian, Lower Carboniferous and Namurian rocks include the thick limestone deposits of the Barcaliente and Valdeteja formations (Namurian) of the higher mountain ridges. The bare slopes of the hill south of Coladilla, constitu ting the middle ground, show the rocks of the Pastora, Cascajo and Roguera formations (Stephanian B) which have been examined during the field meeting.



Thinly bedded limestone of the Barcaliente Formation (Namurian) in the Río Curueño (León).



The top of the Ocejo Formation and the Tejerina Formation (Lower Cantabrian) in the northern flank of the Tejerina Syncline, as seen from the west. Note the rhythmic disposition of the limestone conglomerates in the upper part of the Ocejo Formation, which contains the Westphalian D - Cantabrian boundary.