TRABAJOS DE GEOLOGÍA, 4, Fac. Ci. Univ. Oviedo
«The Carboniferous of Northwest Spain»
pp. 603-663, text-figs. 1-10, pls 1-3

LITHOSTRATIGRAPHIC UNITS OF THE LOWER PART OF THE CARBONIFEROUS IN NORTHERN LEON, SPAIN

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(with a NOTE ON SOME GONIATITE FAUNAS by C. H. T. WAGNER-GENTIS ****)

ABSTRACT

A revision of Lower Carboniferous, Namurian and lowermost Westphalian lithostratigraphic units in northern León is presented for a better understanding of the areal extent and significance of the formations described. Type sections (stratotypes) and standard reference sections (hypostratotypes) are designated for these formations which are partly new and partly based on units named and more or less informally described in the past. The following formations are discussed and accepted here: -1/Ermita Fm., -2/Baleas Fm., -3/Vegamián Fm., -4/Genicera Fm. (subdivided into three members), -5/Barcaliente Fm., -6/Valdeteja Fm., -7/Olleros Fm. They range in age from Tournaisian to early Westphalian A. Formations 1 to 4 represent a condensed sequence of areally widespread deposits, whilst formations 5 to 7 are the product of more rapid sedimentation showing a marked lateral variation; e. g. the Olleros Fm. is the time equivalent of the lower part of the Barcaliente Fm. The lateral facies variation is linked to palaeogeographic units, viz. a Cantabrian Block to the north, a basin south of the block, and a hinterland area to the south.

A late Tournaisian goniatite, *Muensteroceras arkansanum* GORDON, and an assemblage of Lower Namurian goniatites with *Eumorphoceras bisulcatum* GIRTY, of the E_2 Zone, are described in a palaeontological note. A new goniatite, *Goniologoceras declive* sp. nov. is figured and described.

RESUMEN

Una revisión de las unidades litoestratigráficas correspondientes al Carbonífero Inferior, el Namuriense y el Westfaliense A inferior en el norte de León sienta las bases para un conocimiento mejor de la distribución geográfica de estos estratos y de su significado paleogeográfico. Se han designado cortes tipos y cortes de referencia para estas unidades, descritas en parte por primera vez. Por otra parte se describen unidades mencionadas de un modo más informal en otras publicaciones. Para cada unidad se presenta primeramente una reseña histórica, a la que siguen la descripción del estratotipo, una discusión de su edad, y de su distribución geográfica. Se han reconocido las formaciones siguientes: -1/Fm. Ermita, -2/Fm. Baleas, -3/Fm. Vegamián, -4/Fm. Genicera (dividida en tres miembros), -5/Fm. Barcaliente, -6/Fm. Valdeteja, -7/Fm. Olleros. La edad de estas formaciones se escalona de Tournaisiense a Westfaliense A inferior. Las formaciones 1 a 4 representan una sedimentación condensada, de larga duración (desde el Tournaisiense hasta el Namuriense A medio inclusive), mientras que las formaciones 5 a 7 atestiguan una sedimentación paulati-

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namente más rápida (del Namuriense A superior al Westfaliense A inferior). Las primeras formaciones presentan una extensión generalmente muy grande, mientras que las siguientes muestran variaciones laterales, a veces considerables. Por ejemplo, la Fm. Olleros es el equivalente cronoestratigráfico de la parte inferior de la Fm. Barcaliente. Esta variación lateral se debe a la distribución de áreas paleogeográficas mayores que son: el Bloque Cantábrico en el norte, una cuenca de sedimentación importante hacia el sur, y un postpaís aún más al sur. Además de las formaciones mencionadas se describe igualmente, aunque de modo informal, unos Estratos de Olaja, de facies terrígena, que reemplazan la parte superior de la Fm. Genicera hacia el sur del área considerada.

En una nota paleontológica, al final del trabajo, se describen goniatítidos del Tournaisiense superior (*Muensteroceras arkansanum* GORDON) y del Namuriense A medio (de la Zona E_2 de *Eumorphoceras bisulcatum* GIRTY). *Goniolobоceras declive* sp. nov. es descrito por primera vez.

INTRODUCTION

The Tournaisian, Viséan, Namurian and lower Westphalian chronostratigraphic units (the latter two being quite often identifiable rather as Bashkirian and lower Moscovian, in view of the fossil contents) are represented over much of the Cantabrian Cordillera in Northwest Spain by a suite of carbonate rocks and associated terrigenous sediments of variable thickness. The completeness of the record is dependent on the presence and relative importance of disconformities in this succession of almost entirely marine strata with rare intercalations of continental facies. Only in the coal mine of La Camocha, near Gijón (Asturias), a more predominant contribution of non-marine rocks to a paralic sequence has been recorded. The present paper is restricted to an area in the northern part of the province of León, on the southern flank of the mountain chain, where the marine facies is almost totally unrelieved by continental intercalations. The geology of this area has been represented diagrammatically in text-fig. 1. The succession discussed may be of the order of 1,000 to 1,200 metres, and forms the lower part of a sequence which is up to 2,500 m thick in this area and which reaches into Westphalian C (compare MOORE, NEVES, WAGNER & WAGNER-GENTIS 1971).

The Tournaisian to Westphalian deposits have been pressed together with older Palaeozoic strata, reaching down into the Cambrian, into a series of steeply dipping thrust units with an overall arcuate configuration reflecting the general distribution of palaeogeographic units. Three major units are recognised, viz. an enveloping hinterland, a geosynclinal basin within the confines of the hinterland margin, and a central Cantabrian Block (RADIG 1962) which splits the geosynclinal area into a southern and a northern basin. Most of the northern basin has been amputated by the Bay of Biscay (Mar Cantábrico), and the present paper is solely concerned with the southern area. This is limited southwards by the presence of an unconformable cover of Mesozoic and Tertiary + Quaternary strata forming the Meseta of Castile and León.

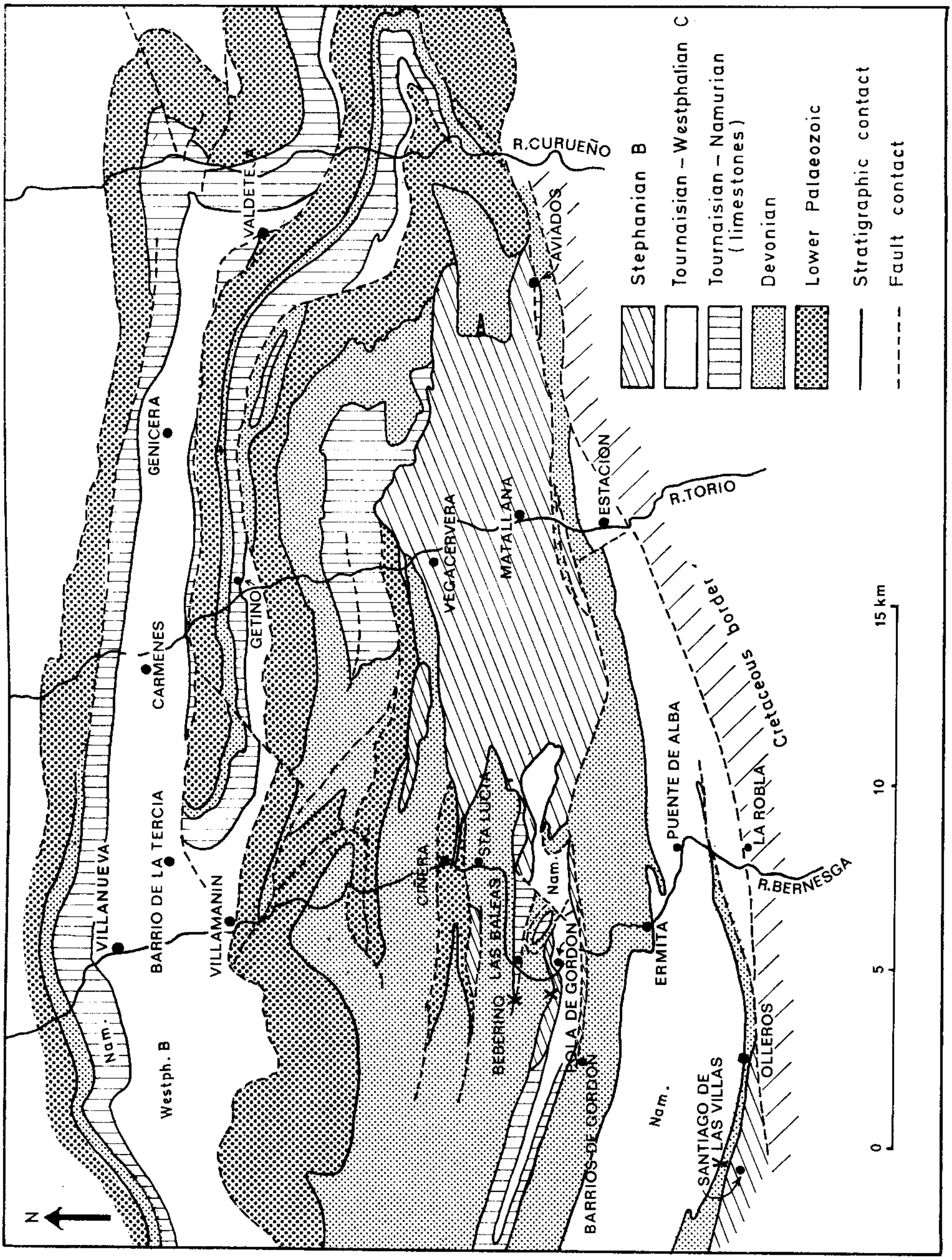
The Cantabrian Mountains (Cordillera Cantábrica) rise steeply above the Meseta of León, as the result of a reverse fault (EVERS 1967) lifting the Palaeozoic rocks well above the level of the Meseta.

Altogether, some 7,500 sq. km of Palaeozoic rocks, including Carboniferous, are represented in the Cantabrian Mountains of Asturias (province of Oviedo), northern León, northern Palencia and western Santander. A full succession of unconformable Mesozoic strata is present in the provinces of Santander and Burgos, covering the Palaeozoic and limiting the outcrop east- and south-eastwards, whilst Cretaceous and Tertiary deposits occur to the south. Westwards, Lower Palaeozoic and Precambrian rocks with intrusives occur in westernmost Asturias and in Galicia.

The Palaeozoic rocks in the Cantabrian Cordillera have been folded and thrust, generally in the direction of the Cantabrian Block which acted as a tectonic foreland. Folding took place in successive tectonic phases, from the middle Westphalian onwards into Permian times. The succession in northern León, discussed in the present paper, is that of the Carboniferous strata formed before the first folding phase. These rocks crop out in a series of east-west trending, fundamentally isoclinal units, separated by major thrust faults, providing frequent repetitions of the same succession. Even though severe shortening took place (probably at least 50 %), the relative order of the tectonic units does not seem to be disturbed, and a gradual change of facies is recorded from north to south, more or less perpendicular to the strike of the rocks. The tectonic shortening makes the facies changes appear to be more rapid than they really are. Text-fig. 1 (map) shows the main tectonic units recognized in the area discussed.

Several lithostratigraphic units (formations) were named in the past, but usage has tended to be informal and sometimes haphazard, without adequate regard to relationships between units and without a proper description of suitable type sections. The present paper aims at unifying the existing knowledge (both published and unpublished) of the lithostratigraphic units of up to lower Westphalian A age, and proposes a partly revised scheme based on suitably described type sections. Certain units are additional to those recognized previously. For the naming and description of lithostratigraphic units the recommendations given by the I. U. G. S. Commission on Stratigraphy, Subcommission on Stratigraphic Classification (HEDBERG 1970) have been followed.

The data and views presented in this paper are the result of stratigraphic mapping and palaeontological work carried out by R. H. WAGNER and by C. F. WINKLER PRINS, and the mapping with sedimentological research done by R. E. RIDING. Goniatite identifications made by C. H. T. WAGNER-GENTIS form an important line of evidence for stratigraphic dating, and some particularly interesting faunas, from the stratigraphic point of view, are documented in a palaeontological note. Published work of particular relevance includes COMTE (1959), WAGNER (1963), BROUWER & VAN GINKEL (1964), VAN GINKEL (1965), WINKLER PRINS (1968), MOORE, NEVES, WAGNER & WAGNER-GENTIS (1971), HIGGINS (1971). Additional palaeontological data for the present paper have been made available by Dr. M. J. M. BLESS (Geologisch Bureau, Heerlen), Dr. A. C. HIGGINS (Geology Department, University of Sheffield), Dr. W. H. C. RAMSBOTTOM (Institute of Geological Sciences, Leeds), Dr. J. BOUCKAERT (Service géologique de Belgique), Mrs C. H. T. WAGNER-GENTIS and Dr. K. GUEINN (Sheffield University), to whom the authors address their warmest thanks. The third author wishes to record his indebtedness to the Natural Environment Research



Stephanian B
Tournaisian – Westphalian C
Tournaisian – Namurian (limestones)
Devonian
Lower Palaeozoic
Stratigraphic contact
Fault contact
R. CURUEÑO
R. TORIO
R. BERNESGA
Cretaceous border
VALDETEJA
AVIADOS
GENICERA
ESTACION
MATALLANA
VEGACERVERA
GETINO
CARMENES
PUENTE DE ALBA
LA ROBLA
BARRIO DE LA TERCIA
VILLANUEVA
VILLAMANIN
CINERA
STA LUCIA
LAS BALEAS
BEBERINO
POLA DE GORDON
BARRIOS DE GORDON
ERMITA
OLLEROS
SANTIAGO DE LAS VILLAS
Nam.
Westph. B
N
0
5
10
15 km

Council of Great Britain for a research studentship, tenable at the University of Sheffield, which allowed him to study the Carboniferous in northern León.

HISTORICAL REVIEW

Aspects of the Carboniferous geology in the Cantabrian Mountains have been studied since the middle of the last century. Among the early workers are SCHULZ (1837, 1845, 1846, 1858), PAILLETTE (1845), DE VERNEUIL (1846), DE VERNEUIL & COLLOMB (1853) and DE PRADO & DE VERNEUIL (1850). SCHULZ (1858) and DE PRADO (1856, 1861) were the first to map parts of the Cantabrian Chain, and SCHULZ (*loc. cit.*) presented the first subdivision of Carboniferous rocks in N. W. Spain. He distinguished between -1/ Caliza carbonífera, -2/ Carbonífero pobre en hulla, -3/ Carbonífero rico. BARROIS (1881, 1882, p. 600) revised this scheme and presented a new one based on lithostratigraphic units which he fitted into stages:

(5) Assise de Tineo (Houiller supérieur).
(4) Assise de Sama (Houiller moyen).
(3) Assise de Lena (Carbonifère inférieur).
(2) Assise des Cañons (calcaire des cañons) (Carbonifère inférieur).
(1) Assise du Griotte (marbre griotte) (Carbonifère inférieur).

BARROIS dated the «marbre griotte» as Lower Carboniferous; thus revising a tentative attribution to the Upper Devonian as made by DE VERNEUIL (*in* DE PRADO & DE VERNEUIL 1850, p. 158—footnote).

ADARO (1914, 1926) introduced further subdivisions into the coal-bearing units 3 and 4, as found in the central Asturian coalfield (Cuenca Central de Asturias). These subdivisions were founded on the local succession in the region of Sama de Langreo, in the north-eastern part of the central Asturian coalfield. A recent study by BLESS (1968) proved the viability of these lithostratigraphic units in the Sama region, but attempts by ADARO to generalize these units throughout the coalfield resulted in correlations which were not invariably correct (compare JONGMANS & WAGNER 1957). ADARO (1914) also revived the term «caliza de montaña», which was used as early as the middle of the 19th century (EZQUERRA DEL BAYO 1844), for the division named «calcaire des cañons» by BARROIS. This term has since been used extensively in the literature, up to the present day, despite the fact that this invites comparison with the Mountain Limestone of Great Britain which is different in facies and in age.

←

Text-fig.1.—Generalized geological map of the Palaeozoic rocks traversed by the rivers Curueño, Torío and Bernesga in northern León, and representing the main area discussed in the present paper. The general structure and distribution of strata are shown with particular regard to the Carboniferous. Data are compiled from the maps published by DE SITTER (1962), EVERS (1967), and WAGNER *in* WAGNER & ARTIEDA (1970). Additional stratigraphic data have been derived from MOORE *et al.* (1971). *N. B.* The Carboniferous areas shown in white cover mainly Westphalian B and lower Westphalian C (with some Namurian C and basal Westphalian A) in the northern region (Cármenes Syncline), and Tournaisian, Viséan and Namurian A-B in the southern region (Alba Syncline). Apart from thin Lower Carboniferous and Lower Namurian limestones and incidental limestones higher in the succession, the white areas of Carboniferous strata represent terrigenous facies.

Barrois referred units 2 and 3 to the Lower Carboniferous, an age attribution which was corrected by Delépine (1928, 1943), who found that the «calcaire des cañons» belonged to the Upper Carboniferous, ranging from Lower Namurian to Middle Moscovian. This range later proved to be excessive. Delépine, as Barrois before him, referred to the «marbre griotte» as a transgressive unit and stressed its rôle as a basal transgressive deposit formed after a substantial uplift at the end of Devonian times. Delépine dated the «marbre griotte» as Upper Viséan, but its age proved to be more extensive, i. e. ranging from Lower Viséan to Lower Namurian (Wagner-Gentis *in* Wagner 1957, Schindewolf & Kullmann 1958, Kullmann 1961-63, Wagner-Gentis 1960-63). Delépine (1943) also studied the lithological succession within the «calcaire des cañons» and distinguished between a lower unit consisting of dark blue, well bedded limestones, up to 200 m thick, and an upper unit of light grey, massive limestones, 400 to 500 m thick. He dated the upper unit as Moscovian (on fusulinid foraminifera identified by Gübler), and referred the top part to the Podolskian (Delépine 1938). He apparently included a higher limestone («caliza masiva» of Julivert 1957, 1961, and Martínez Alvarez 1962) with the «calcaire des cañons» (= «caliza de montaña»), as appears from data presented by van Ginkel (1965) who examined some of the localities described by Delépine (van Ginkel 1965, loc. A 1). It seems likely that the «calcaire des cañons» proper does not, in fact, reach into the Moscovian. Delépine also distinguished between lower and upper parts of the «Assise de Lena», and referred to the upper part as the «couches de Lieres». These Lieres beds were dated on goniatites as lower Westphalian C (fauna of Petit Buisson). The «Assise de Lena» formed a kind of transition between the fully marine «calcaire des cañons» and the more paralic «Assise de Sama» and was, in fact, a unit comprising marine rocks, including limestones, with intercalated coal-measures. Such a facies may have been developed at more than one point in the succession, and the usefulness of the term is debatable.

Llopis Lladó (1954, 1960), after mapping areas on the margin of the central Asturian coalfield, described the «caliza de montaña» as consisting of three units, viz. -1/grey, bedded limestones (individual beds being 10-40 cm thick), up to 80 m in thickness; -2/white, dolomitic limestones, 80-500 m thick; and -3/black, fetid limestones (with abundant calcite veining), 2-150 m thick. He also presented isopachites for the «caliza de montaña», but the data used were insufficient and the resultant conclusions open to question.

Wagner (1957, p. 233 - footnote; 1959, pp. 396-397; 1963, pp. 240, 244) noticed that the «caliza de montaña» was replaced by shales and thinly bedded limestones in the most southerly exposures of northern León. He suggested a southerly derivation of the terrigenous material by postulating a landmass to the south, and assumed that this material would have been trapped behind a barrier reef corresponding to the greatest thickness of «caliza de montaña» to the north. This conception, admittedly presented as a working hypothesis, has had to be modified in several respects. Firstly, sedimentological work carried out by one of the present writers (R. E. R.) has shown that the reef limestones in the upper part of the «caliza de montaña» in northern León are too small to warrant interpretation as a barrier reef. Secondly, the terrigenous replacement of limestone in the southerly exposures has proved to be of an age corresponding to the lower part of the «caliza de montaña» where no evidence of reef limestone occurs anyway. Thirdly, the basinal facies of the terrigenous replacement is at odds with the suggested «lagoon» between a landmass and a barrier reef. It would seem more likely that the terrigenous succession represents a basin fill, of southerly derivation, which passes laterally, northwards, into carbonate deposits formed on a submerged platform, the Cantabrian Block of RADIG (1962) and corresponding to the Kantabrische Zone of LOTZE (1945, 1963).

JULIVERT (1957, 1961, 1967), working in an area east of the central Asturian coalfield and reaching the Picos de Europa, described a succession which he summarized as follows (1967, p.61): -1/black shales (10-15 m); -2/griotte limestone and radiolarites (15-30 m); -3/dark grey or black fetid limestone («caliza de montaña») (100-300 m); -4/red and variegated shales with thin layers and nodules of manganese as well as beds or lenses of limestone, the entire succession passing eastwards into green shales (20-30 m); -5/fine-grained shales and sandstones which are thinly bedded (300-400 m); -6/grey or white limestone («caliza masiva») with fusulinids (150-300 m); -7/shales, sandstones and limestone beds varying in thickness between 1 and 10 m (1000-1500 m); -8/ shales and sandstones with few or no limestone intercalations (no thickness mentioned).

COMTE (1959), in a chapter incidental to his detailed study of Cambrian to Devonian stratigraphic units in northern León, described a thin unit of black shales at the base of the Carboniferous succession. He referred to this unit as «couches de Vegamián» and described its passage to the overlying griotte limestone as rapid but gradual («continue bien que rapide»), whereas a disconformity marked the contact with underlying sandstones. COMTE mentioned the «marbre griotte» of BARROIS as «Griotte à *Goniatites crenistria*» and also referred to it as «Griotte de Puente de Alba». This informal usage was modified in 1965 by VAN GINKEL, who introduced the Alba Formation, attributing the name to COMTE. For the higher Carboniferous units COMTE (1959) accepted the names and characteristics as described by BARROIS (1882) and DELÉPINE (1943). However, on his map and sections he grouped them as the «calcaires et schistes de Villanueva». Below the «couches de Vegamián» COMTE (1938, 1959) found a transgressive sandstone which he recorded as the «Grès de l'Ermitage». This sandstone formation showed a marked overstep in north-eastern direction, cutting out progressively older parts of the Devonian and Lower Palaeozoic succession, until it came to rest eventually on Cambrian strata. The top part of the «Grès de l'Ermitage» was dated by COMTE as Strunian, and this formation apparently marked the beginning of a series of uplifts and associated transgressions which extended throughout the lower part of the Lower Carboniferous.

In a general review of the Carboniferous stratigraphy in Northwest Spain, WAGNER (1962) discussed briefly the facies distribution of various stratigraphic units in the western and south-eastern parts of the Cantabrian Chain. He adopted a number of formational names, including a «Caliza de Montaña Formation», and mentioned that the «Assise de Lena» of BARROIS apparently consisted of two parts which were probably separated by a major unconformity. The formations introduced in this paper were not formally described.

In 1962, DE SITTER published a general map of the southern slope of the Cantabrian Mountains, showing the Carboniferous divided into three groups (after KOOPMANS 1962), viz. -1/Ruesga Group, -2/Yuso Group, -3/Cea Group. Within the Ruesga Group he distinguished between (a) black shale facies (Tournaisian?), (b) Griotte, Limestone, Culm facies (Viséan-Namurian). The black shale facies referred to by DE SITTER is apparently the same as that of the «couches de Vegamián» of COMTE (1959). The Griotte, Limestone («Caliza de Montaña») and Culm facies of DE SITTER refer to «marbre griotte», «calcaire des cañons», and lower part of «Assise de Lena» respectively. The term «Culm», in this context, probably originated with QUIRING (1939), who described as Kulm a terrigenous facies of marine Carboniferous rocks in northern Palencia. The Groups used by DE SITTER are separated by major unconformities, some of which are more widespread than others. On the other hand, the Cea Group contains a major unconformity within the Group (see comments in WAGNER 1970, p. 451).

MARTÍNEZ (1962), working in the area immediately east of the central Asturian coalfield, introduced some informal lithostratigraphic terms which are as follows: -1/pizarroso improductivo (above the «caliza de montaña»), -2/caliza masiva (after JULIVERT 1957), -3/pizarroso productivo. These units correspond mainly to the «Assise de Lena» and partly to the «Assise de Sama» of BARROIS (1882).

WAGNER (1963) gave a general description of the area between the rivers Porma and Bernesga in northern León, and mentioned the following sequence of rocks formed after the late Devonian (uppermost Famennian) uplift: -1/La Ermita sandstone formation (as described by COMTE), -2/grey, coarsely crystalline limestone, -3/black shales based on a thin transgressive sandstone bed (Vegamián formation), -4/grey and red nodular limestones with a gradual transition into the preceding unit, -5/red shales and cherts, -6/grey and red nodular limestones, -7/dark grey, well bedded limestones, -8/grey, massive limestones interfingering with shales and sandstones, -9/shales with limestone and sandstone intercalations. A somewhat different development was recorded for the southernmost exposures which were predominantly terrigenous. No formational names were proposed for the units described. Unit 3 was tentatively dated as either Upper Tournaisian or Lower Viséan (WAGNER 1963, pp.224-225), unit 5 as Middle Viséan, unit 6 as Upper Viséan, and the basal part of unit 7 (which was found to contain goniatites in one locality, near Getino—see WAGNER-GENTIS 1963) as Lower Namurian. In the present paper the goniatite-bearing beds are assigned to unit 6 rather than unit 7, since they occur in nodular limestones intercalated with grey, bedded limestones at the base of the main development of the latter. Apparently, there is a gradual transition between these two units. The units 8 and 9 were assigned a Namurian age, whilst it was noted that a Lower Westphalian age could not be excluded.

In 1964, HIGGINS, WAGNER-GENTIS & WAGNER described the lithological succession, and the conodont and goniatite faunas of several sections of Lower Carboniferous rocks in northern León. This showed that the coarsely crystalline limestone (unit 2 of above) was of Strunian age (*costatus* Zone), and that the red nodular limestone (unit 4 of above, i.e. the basal part of the «Assise du Griotte» of BARROIS) commences with the *anchoralis* conodont zone or the III ß- γ goniatite zone of the Lower Viséan. They emphasized the presence of a number of small disconformities within the Lower Carboniferous.

BROUWER & VAN GINKEL (1964) erected a number of formally named formations, based partly on those of BARROIS, viz. -1/Sella Formation (= Assise du Griotte of BARROIS), -2/ Escapa Formation (= Assise des Cañons of BARROIS), -3/San Emiliano Formation. They further introduced the Lois-Ciguera Formation, the Pando Formation and the Prioro Formation for Moscovian rocks of mainly detrital facies in an area of north-eastern León which was stated to occur north of the Leonide Nappe region as described by DE SITTER (1962). It is doubtful that such a distinction can be maintained.

The Sella Formation of BROUWER & VAN GINKEL also included the black shales of the «couches de Vegamián» of COMTE. RÁCZ (1964) subsequently restricted the Sella Formation to the red and grey nodular limestones in the higher part of the «Assise du Griotte», and distinguished a new Getino Formation for the black shales together with the basal red and grey nodular limestone followed by red shales and cherts. This division of the «Assise du Griotte» into two parts is confusing, and RÁCZ's usage has not been followed by later authors.

In 1965, VAN GINKEL replaced the Sella Formation by -1/Vegamián Formation, -2/Alba Formation; these being based on COMTE's informal usage of «couches de Vegamián» and «Griotte de Puente de Alba». He also designated a type section for the Lena Formation (= Assise de Lena of BARROIS), and introduced the Beleño, Escalada and Fito formations for parts of the succession described by JULIVERT (1961).

SJERP (1967), working in the central part of the Cantabrian Chain, described a predominantly calcareous development of rocks below the Vegamián Formation. He assigned these to the Ermita Formation, but distinguished a lower, sandy Valverde Member and a higher, calcareous Mampodre Member, the latter being dated as *costatus* Zone. SJERP also described and named a Ricacabiello Formation of green and brown mudstones separating the «caliza de montaña» from the Lena Formation (*sensu* VAN GINKEL 1965), Lois-Ciguera Formation (BROUWER & VAN GINKEL 1964), and the Beleño Formation (VAN GINKEL 1965), depending on the subarea studied. The Ricacabiello Formation replaced the «serie abigarrada inferior» of JULIVERT 1961. In one locality studied by SJERP, the Ricacabiello Formation came immediately above a bed containing lower Namurian B goniatites of the *Reticuloceras* Zone, which is regarded as the top layer of the «caliza de montaña» (SJERP 1967, p.80). The Ricacabiello Formation marks a period of condensed sedimentation related to an important uplift of the central part of the Cantabric-Asturian area.

EVERS (1967) described a new type section for the Vegamián Formation near the original type locality (as mentioned by COMTE) which was flooded in 1966 when the Porma Dam was built. He reverted to the term «Caliza de Montaña Formation», and distinguished two members (corresponding to units 7 and 8 of WAGNER 1963), viz. -1/a lower micrite member, -2/an upper biosparite member, giving these members names as proposed by WINKLER PRINS in a paper published the following year.

WINKLER PRINS (1968) expanded the Ermita Formation to incorporate the succeeding, coarse, grey crystalline limestone bed mentioned by WAGNER (1963), and referred to «sandstone and limestone members»; thus conforming effectively in usage to that proposed by SJERP (1967). He also proposed type localities for three members of the Alba Formation, which he based on units described by WAGNER (1963). He referred to the «caliza de montaña» as the Escapa Formation (after BROUWER & VAN GINKEL 1964) and proposed type localities for the two constituent members which correspond to units recognized by DELÉPINE (1943), WAGNER (1963) and EVERS (1967). The names for these members were as follows: -1/ Gete Member, -2/ Valdehuesa Member, -3/ La Venta Member, -4/ Vegacervera Member, -5/ Valdeteja Member. In the present paper the Valdeteja Member is raised to formational rank, and the other members are redescribed and renamed after more suitable type localities.

VAN DEN BOSCH (1969) used the members as introduced by WINKLER PRINS but referred the Vegacervera and Valdeteja Members to the «Caliza de Montaña Formation».

BOSCHMA & VAN STAALDUINEN (1968) made a compilation of Carboniferous lithostratigraphic units used for mapping by members of the Department of Structural Geology in Leiden. Only a cursory description was provided, with little or no discussion of published opinion. A few new formational names were introduced, e.g. a Cuevas Formation for the predominantly terrigenous development of rocks considered to be the southern equivalent of the «caliza de montaña» in northern León. This formation lacks precision and is not accepted by the present authors (see under discussion on Olleros Formation—page 640).

In a paper by MOORE, NEVES, WAGNER & WAGNER-GENTIS (1971) the various formations from «Griotte» and «caliza de montaña» onwards are described for the Villamanín area of northern León, but no new formational names are introduced. They dated the top of the Barcaliente Formation (as mentioned in the present paper as a substitute for the lower part of the «caliza de montaña», i.e. for the Vegacervera Member of the Escapa Formation, as introduced by WINKLER PRINS 1968), and found that the Barcaliente Formation in the Villamanín area corresponded to upper Namurian A and Namurian B. The Valdeteja Formation reached into basal Westphalian A in the Villamanín area. MOORE *et al.* also drew attention to the presence of a disconformity below Westphalian B and compared with the disconformity described in relation to the Ricacabiello Formation of SJERP in the area south-east and east of the central Asturian coalfield.

The area near Valdeteja, with the type sections of Barcaliente and Valdeteja formations, is described in detail by WINKLER PRINS (1971[a]), particularly with regard to the faunal contents.

REVISED LITHOSTRATIGRAPHIC UNITS

The lithostratigraphic units recognized for the Carboniferous below the pre-Westphalian B disconformity are described here for that part of northern León which lies between the rivers Porma and Luna (text-fig. 1). Some of the names used have been introduced by COMTE (1959) and WINKLER PRINS (1968), but some are newly proposed in the present paper. Reasons are given for discontinuing the use of certain formational and member names introduced in the past. The following formations and members are recognized here:

7. Valdeteja Formation (type section along the road from Valdeteja to the Curueño River Valley).

6. Olleros Formation (type section in the exposures north of Olleros de Alba); this formation marks the lateral facies change southwards of the Barcaliente Formation (lower part).

5. Barcaliente Formation (type section in the Arroyo de Barcaliente, a lateral valley of the Curueño River Valley; section continues that of the Valdeteja Formation).

4. Genicera Formation (type section in the Arroyo de Gorgera, at 2 km SSW of Genicera; formation divisible into three members: -1/ Gorgera Mbr., -2/ Lavandera Mbr., -3/ Canalón Mbr.; top member may split into two separate units southwards where the top Genicera Fm. is progressively replaced by mudstones which are referred to informally in the present paper as the Olaja Beds).

3. Vegamián Formation (type section south of Vegamián in the Porma River Valley).

2. Baleas Formation (type section in the Baleas Quarry on the eastern bank of the Bernesga River, between Pola de Gordón and Vega de Gordón).

1. Ermita Formation (type section opposite the Ermita del Buen Suceso, near the León-Gijón road in the Bernesga Valley; hypostratotype in the Baleas Quarry).

The first four formations recognized represent a strongly condensed sedimentation with a number of disconformities separating different formations in different parts of the area. These formations may be grouped together as the Torío Group. Formations 5 to 7, though showing a transitional contact with the preceding unit, bear witness to a gradual increase in the rate of sedimentation which may be linked to the proper development of the basin. They are grouped together as the Curueño Group.

There is a lateral facies development of the Valdeteja Limestone Formation which is mainly terrigenous. The corresponding sequence has not yet been studied adequately, and no formational name is proposed until this has been done. The San Emiliano Formation of BROUWER & VAN GINKEL (1964) may be partly coincident with this unnamed unit which, in the area discussed here, is delimited upwards by the pre-Westphalian B disconformity recorded by MOORE, NEVES, WAGNER & WAGNER-GENTIS (1971). The type locality of the San Emiliano Formation (i.e. the San Emiliano Valley) lies outside the area discussed here.

Historical

Comte (1936, 1938, 1959) introduced the name «Grès de l'Ermitage» for a transgressive sandstone formation which, in late Upper Devonian times, initiated a sequence of successive transgressive deposits related to repeated uplift. This name was taken from the Ermita del Buen Suceso in the Bernesga Valley (text-fig. 1). The formation is therefore more properly called the Ermita Formation (Wagner 1963). Comte demonstrated in his 1938 and 1959 papers that the transgression of the Ermita Formation was linked to uplift of a landmass to the north which was extensively eroded, probably in Upper Devonian times, and which shows overstep onto progressively older strata towards the centre of this mass. This positive area, which was also tectonically active in Lower Palaeozoic times (Radig 1962), equates with the Cantabrian Block of Radig (1962, p. 354), the Central Asturian Dome of Sjerp (1967, p. 103), and the Asturian Geanticline of van Adrichem Boogaert (1967, pp. 168-173). Since this area acted as a tectonic foreland in later, Upper Carboniferous and Permian times, the latter name appears to be the least appropriate. Comte (1938, p. 1742) also noted that the transgression associated with the «Grès de l'Ermitage» progressed in a north-eastern direction in northern León, i.e. in a direction oblique to the prevalent E-W strike of Palaeozoic strata in this area.

Comte (1959, pp. 233-234) described the «Grès de l'Ermitage» as containing calcareous, non-calcareous (to quartzitic) and ferruginous sandstones, up to 1,000 m thick. However, Evers (1967, pp. 97-98) mentioned that Comte mistakenly incorporated some Lower Palaeozoic sandstones with the Ermita Formation, thus giving it an exaggerated thickness in some sections. Evers indicated that the true thickness of the Ermita Formation rarely exceeds 60 m, even though 140 m occur in the type locality. For the stratotype near the Ermita del Buen Suceso, Comte (1936) mentioned a thickness ranging from 80-120 m, an estimate which was changed to 140 m of «Grès quartziteux jaunâtres ou roses en bancs d'épaisseur variable» (Comte 1959, p.193).

As described by Evers (*loc. cit.*), the Ermita Formation consists of well sorted, coarse, calcareous and ferruginous sandstones, with current bedding throughout. At the base of the formation he records microconglomerates, and at the top a light grey, coarse crystalline limestone. It should be noted that Comte's original description of the Ermita Formation does not mention the presence of this limestone which seems to have been first described by Wagner (1963, p. 224). Where this limestone is present it shows a gradual passage downwards into sandstones which conform to the description given by Comte. Also the age of the type Ermita Sandstone Formation, equivalent to that of the Assise d'Etroeungt (Strunian) near the top (according to Comte 1959, p. 315), is the same or similar to that of the coarsely crystalline limestone which has been dated as *costatus* Zone by Higgins (*in* Higgins, Wagner-Gentis & Wagner 1964). Limestones of a different kind, but also belonging to the *costatus* conodont zone, were reported above

Upper Devonian sandstones (apparently belonging to the Ermita Formation) by VAN ADRICHEM BOOGAERT, BREIMER, KRANS & SJERP (1963). It appears that the incidence of limestone in the Ermita Formation increases northwards, and SJERP (1967) even mainly describes limestones from an area well on the Cantabrian Block. RUPKE (1965, pp. 25-27), SJERP (1967, pp. 69-75) and VAN ADRICHEM BOOGAERT (1967, pp. 159-161) all describe the Ermita Formation as a sandstone-limestone sequence. SJERP (1967, pp. 71-72) distinguished between a Valverde Ferruginous Sandstone Member and a Mampodre Limestone and Shale Member which he described from a section at Valverde, west of the Pico de Mampodre. In this section the sandstone unit represents only a fraction of the total sequence (0.45 m of sandstone as against 3.95 m of limestones and shales).

BROUWER (1968, p.42) introduced the name Aguasalio Formation for the Ermita Formation together with the earlier (Frasnian) Nocedo Formation, whenever the distinction between these two formations becomes difficult due to the absence of the intervening Fueyo Shale Formation. However, on the same page he stated that one should try to distinguish the Nocedo and Ermita formations, even where this may be difficult, since the Ermita Formation represents a disconformable unit deposited after considerable tilting took place. In view of the fact that a careful examination should not fail to separate the Nocedo Formation from the Ermita Formation, there is no apparent need for BROUWER's Aguasalio Formation.

Type locality

The section opposite the Ermita del Buen Suceso, in the Bernesga Valley, has obviously been considered as the stratotype (compare COMTE 1959, pp. 193-194). According to COMTE's description, the «Grès de l'Ermitage» consists here of 140 m of yellowish to pink quartzitic sandstones in beds of variable thickness. He also noted that the basal part of the unit is characterized by coarse sandstones and the presence of white quartzites. Decalcified beds occur, and the top part of the formation shows a recurrence of coarse-grained sandstones. The thickness of the formation is quoted as variable, ranging from 80 to 200 m in the overall vicinity of the Ermita del Buen Suceso (quoted as «El Ermitorio» or «l'Ermitage de Huergas» by COMTE 1959, p. 185).

Although the lithological description given by COMTE is correct in general outline, the exposures near the Ermita are patchy. Decalcified, fossiliferous sandstones occur, and these are mainly ferruginous. The latter characteristic has also been described by COMTE, though not for the type locality. One of the most serious drawbacks of this locality is the absence of exposed contacts with adjoining formations. In fact, it is impossible to determine its limits in the section near the Ermita del Buen Suceso. This makes it less suitable as a stratotype.

VAN ADRICHEM BOOGAERT (1967, p.159) also mentioned the type area as unsuitable, but vaguely remarked that this was due to its stratigraphic and sedimentological properties, without clearly stating the difficulty. However, he did suggest removing the type locality to an exposure south of Camplongo which, since COMTE described his sections from north to south, was mentioned before the one near the Ermita del Buen Suceso. Although VAN ADRICHEM BOOGAERT obviously intented to prove a point of priority in this sense, there can be no doubt that COMTE intented the Ermita type locality to be at the Ermita del Buen Suceso. The Ermita Sandstone Formation is only 2-3 m thick in the section south of Camplongo, which also clearly does not represent the complete development of this formation. COMTE explicitly stated it to be best developed in the southernmost tectonic units in the Bernesga Valley. This reason alone should be sufficient to reject VAN ADRICHEM BOOGAERT's suggestion about changing the type locality for one in a unit much further north. VAN ADRICHEM BOOGAERT's usage clearly involves a new concept and amounts to an emendation of the formation. It is necessary to stick as closely as possible to the concept of the Ermita Formation, as meant by COMTE, and this is especially important in the case of a transgressive unit which may well possess a diachronous base as the result of onlap. One should therefore take care to select a hypostratotype (auxiliary reference section), amounting to a new type locality for all practical purposes, from exposures as near as possible to the original type.

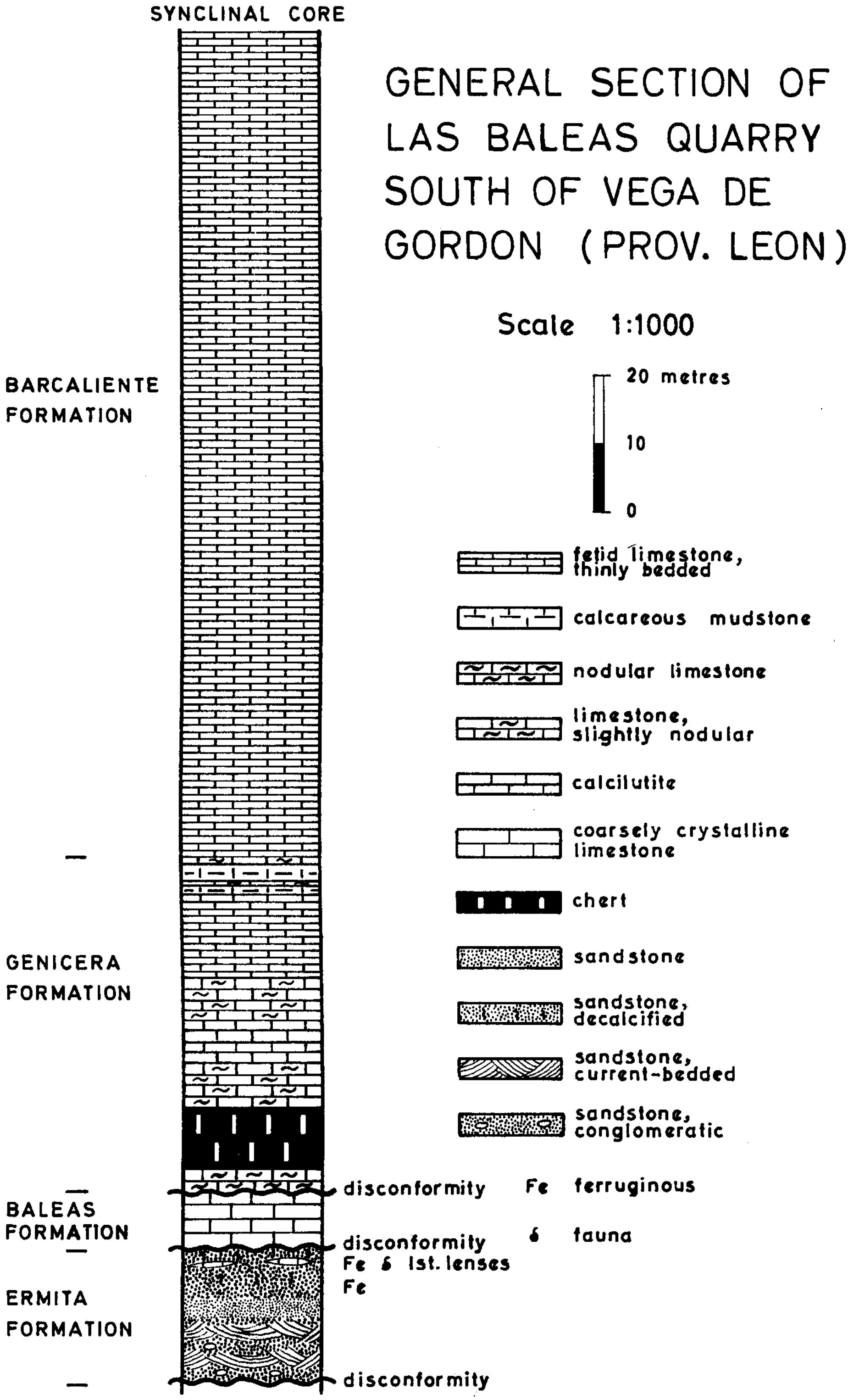
Such a locality has been found in the Las Baleas Quarry (text-fig. 2), 1 km north of Pola de Gordón, on the eastern bank of the Bernesga River, and 4 km NNW of the stratotype at the Ermita del Buen Suceso. This is the nearest locality of the Ermita Sandstone Formation north of the original type locality, and it conforms fairly closely to the lithological description of the latter. The hypostratotype is at the northern end of the quarry, where it is fully exposed. It is unlikely to be affected by the quarrying operations which are restricted to the limestones of the Barcaliente Formation, outcropping to the south in a nearly vertical sequence of strata (compare WAGNER 1963, Fig. 7). The reference section in the Baleas Quarry shows the following sequence, from top to bottom (text-fig. 2):

6/- 0.15 m ferruginous sandstone, decalcified with molds and casts of lamellibranchs, rhynchonellid brachiopods, crinoids, etc.
5/- 3.60 m slightly ferruginous, calcareous sandstone with limestone lenses, 8-12 cm thick (three lenses observed); mainly crinoid columnals, also brachiopods and lamellibranchs; limestone lenses light grey, coarse-grained and sandy.
4/- 1.25 m yellow, slightly calcareous sandstone with crinoid debris.
3/- 2.00 m slightly ferruginous, decalcified sandstone with crinoid debris.
2/- 3.00 m medium-grained sandstone.
1/- 9.50 m coarse-grained, slightly conglomeratic sandstone (quartz pebbles up to 3 mm diameter) with slightly ferruginous beds and current bedding occurring at intervals.
— disconformable contact with 1.40 m of limestone preceded by *ca.* 15 m of slightly calcareous sandstone (Nocedo Formation).

The Ermita Sandstone Formation in the Las Baleas Quarry is overlain disconformably by the Baleas Limestone Formation (see page 623).

⟶

Text-fig. 2.—General section of the Las Baleas Quarry which contains the hypostratotype of the Ermita Formation and the stratotype of the Baleas Formation. The presence of a calcareous mudstone near the top of the Genicera Formation announces the terrigenous Olaja Beds which replace the upper part of the Canalón Member of the Genicera Formation to the south (e. g. near Barrios de Gordón) and south-east.


GENERAL SECTION OF LAS BALEAS QUARRY SOUTH OF VEGA DE GORDON (PROV. LEON)
Scale 1:1000
20 metres
10
0
SYNCLINAL CORE
BARCALIENTE FORMATION
GENICERA FORMATION
BALEAS FORMATION
ERMITA FORMATION
disconformity
disconformity
Fe & lst. lenses
Fe
disconformity
fetid limestone, thinly bedded
calcareous mudstone
nodular limestone
limestone, slightly nodular
calcilutite
coarsely crystalline limestone
chert
sandstone
sandstone, decalcified
sandstone, current-bedded
sandstone, conglomeratic
Fe ferruginous
& fauna

A g e

COMTE (1959, p.315) recorded Strunian brachiopods from the top few metres of the Ermita Formation (zone of *Pugnax moresnetensis*) and mentioned that further down the formation only the more general Famennian fossils were found. The fossil contents of the hypostratotype in the Las Baleas Quarry have not yet been investigated. To the south, in the Alba Syncline, the exposures at Olleros de Alba and north of Santiago de las Villas (text-fig. 1) show the gradual passage of sandstone into a thin limestone, 0.60 m thick at Olleros and 0.25 m thick near Santiago, which contains conodonts of the *kockeli - dentilineata* Zone (HIGGINS *in* HIGGINS, WAGNER-GENTIS & WAGNER 1964, and HIGGINS 1971). This zone belongs to the Lower Tournaisian cu I division, and the record at Olleros and Santiago represents the highest beds thus far dated in the Ermita Formation. The top beds of the Ermita Formation in the more northerly units of northern León, e.g. near Genicera (text-fig. 1), show the presence of 2 m of grey, coarsely crystalline limestone which contains conodonts of the *costatus* Zone (HIGGINS *in* HIGGINS *et al.*1964), i.e. the zone preceding the *kockeli-dentilineata* Zone. The *costatus* Zone is variously attributed to the highest Famennian or the lowest Tournaisian, depending on the criteria employed. Limestones of the *costatus* Zone have also been recorded in exposures further north by VAN ADRICHEM BOOGAERT, BREIMER, KRANS & SJERP (1963) and by SJERP (1967) and VAN ADRICHEM BOOGAERT (1967).

VAN ADRICHEM BOOGAERT (1967) further reported faunas of the *kockeli-dentilineata* Zone from a limestone sequence in the Valverde, La Uña and Riosol sections of the area mapped by SJERP (1967), and attributed this sequence to the Ermita Formation. However, the faunas recovered are sparse and not particularly diagnostic of the *kockeli-dentilineata* Zone. It appears that they could equally well belong to the Baleas Formation, of Upper Tournaisian age. Until they have been re-investigated, no detailed stratigraphic conclusion can be attached to these faunas (A. C. HIGGINS, personal communication). A more convincing *kockeli-dentilineata* fauna was recorded by VAN ADRICHEM BOOGAERT (1967) from the top part of the Vidrieros Formation in the Cardaño-Triollo area of northern Palencia, where it occurs in nodular limestone representing a facies realm totally different from that of the Ermita Formation.

The Ermita Formation thins markedly northwards, where the limestone at the top of the formation becomes relatively more important due to the thinning of the sandy unit. COMTE already remarked that only the upper part of the Ermita Sandstone Formation seemed to be developed in the northern exposures, and observed that «la transgression esquissée au Famennien supérieur s'est soudainement intensifiée au Strunien» (COMTE 1959, p.316). He regarded this transgression as spreading north-northeastwards with progressive onlap. VAN ADRICHEM BOOGAERT (1967) used the presence of a limestone formation with Tournaisian faunas (which he attributed to the *kockeli-dentilineata* Zone - see above), in the exposures south-east of the central Asturian coalfield, as proof of a strongly diachronous base, varying in age from late Upper Famennian to Lower Tournaisian. Such a strong variation in the age of the basal Ermita rocks may not, in fact, exist and can certainly not be regarded as proven.

On the other hand, VAN ADRICHEM BOOGAERT *et al.* (1963), SJERP (1967) and VAN ADRICHEM BOOGAERT (1967) described several sections in the area south-east of the central Asturian coalfield which, generally, show the presence of thin sandstone deposits preceding slightly more considerable limestones. In some cases (e.g. the Mampodre limestones and shales of the Valverde section of SJERP 1967, fig. 15, and VAN ADRICHEM BOOGAERT 1967, fig.18), it is possible that these limestones belong to the independent Baleas Formation as described in the present paper. In other cases, however, it is clear that a rather coarsely detrital limestone with conodonts of the *costatus* Zone (Strunian) overlies the sandy basal deposits. One locality, at Felechosa (SJERP 1967, fig. 20), shows this limestone lying disconformably on Ordovician quartzite, without any intervening sandy deposits of the «standard» Ermita facies. This occurrence, which is well on the Cantabrian Block, does indicate a diachronous base to the Ermita Formation, the top part of which oversteps Lower Palaeozoic on the Cantabrian Block where the basal part (i.e. the type Ermita, which is sandy) has not been developed. Uplift of the Cantabrian Block was therefore likely to have lasted until late Upper Famennian times, and only the Strunian limestone at the top of the formation penetrated the main area of uplift; thus completing the transgression initiated on the flank of the uplifted Block.

Although the evidence for a diachronous base only holds conclusively for an age up to Strunian (*costatus* Zone), the age of the Ermita Formation as such ranges from late Upper Famennian (COMTE 1959) to Lower Tournaisian (*kockeli-dentilineata* Zone conodonts as described by HIGGINS 1971 from the Olleros and Santiago sections in the Alba Syncline).

E x t e n t

The Ermita Formation is widely distributed throughout northern León. Its most complete development seems to be in the Alba Syncline which contains the stratotype. This area, corresponding to the most southerly exposures of Palaeozoic rocks in this part of northern León (text-fig.1), possesses the full sequence of ferruginous and calcareous sandstones as described by COMTE, and also contains the *kockeli-dentilineata* limestone in the sections described by HIGGINS *et al.* (1964) and HIGGINS (1971). A most interesting section of the Ermita Formation occurs in the core of a small, accessory anticline immediately south-east of Puente de Alba, where the sandstone becomes increasingly calcareous in the upper part which also shows a rapidly alternating succession of sandstones and sandy limestones with erosive contacts between the different lithologies (see WAGNER & FERNÁNDEZ-GARCÍA 1971, text-fig.1). Unfortunately, none of the samples taken of the limestone horizons in this section yielded conodonts apart from occasional specimens insufficient for a stratigraphic dating. Some of the limestones contain brachiopods which have not been investigated. The many erosional contacts seem to point to a considerable instability at the end of the time of deposition of the Ermita Formation. In this section the Ermita sandstones and limestones are overlain disconformably by red nodular limestones of the Genicera Formation. This is the classical locality of «marbre griotte» described by BARROIS (1882) and from which DE VERNEUIL first mentioned the presence of griotte limestone in the Cantabrian Cordillera. It is the type locality of the Alba Formation of VAN GINKEL (1965).

In the more northerly exposures in that part of northern León covered by the map of text-fig. 1, the Ermita Sandstone Formation thins markedly and the common presence of a few metres of coarsely crystalline limestone is noted at the top of the formation (WAGNER 1963, EVERS 1967, WINKLER PRINS 1968). The contact between the sandstone and the limestone is gradual, and the following description is appropriate: «A gradual transition occurs from the decalcified sandstone, via a calcareous sandstone and a sandy limestone, to a pure coarse-grained limestone. The colour of the limestone is light grey, often with pink spots. Brachiopods, crinoidal fragments, bryozoans and conodonts have been found in this limestone» (WINKLER PRINS 1968, p.45). After the observations of one of us (R.E.R.), one can add that most of the limestone consists of crinoidal debris with subsequent recrystallization around these remains. One of the localities from which this limestone has been described is that SW of Genicera (text-fig. 4), where HIGGINS *(in* HIGGINS *et al.* 1964) found a conodont fauna of the *costatus* Zone dating the limestone as Strunian.

The sandstone member thins progressively north-northeastwards until, in the locality at Felechosa, described by SJERP (1967), only the limestone remains.

In a section near Entrago, in the general region of Teverga (Asturias), a dolomitic limestone, less than 1 metre thick, yielded conodonts of the *costatus* Zone and of the *kockeli-dentilineata* Zone (quoted as *Siphonodella-triangula-inaequalis* Zone) to BUDINGER & KULLMANN (1964). This limestone follows onto ferruginous sandstone, and one wonders if this represents the Ermita Formation.

South of the Teverga region, in the valley of San Emiliano and in the upper reaches of the rivers Luna and Sil, a variable thickness of Ermita Sandstone Formation was described by VAN DEN BOSCH (1969, pp.169-172). From a maximum thickness of *ca.* 200 m in the western part of the area a progressive thinning to less than 6 m thickness in the east-northeastern part of the area is reported (*op.cit.*, fig.44). The usual lithologies are recorded, viz. quartz sandstones, often ferruginous and showing cross bedding, with a gradual passage into a coarsely detrital limestone in the top part of the formation in that part of the area where a thinner development of sandstone indicates progressive onlap. Thicknesses of the Ermita Formation as plotted by VAN DEN BOSCH (1969, fig.44), apparently mark the western termination of the Cantabrian Block. The depositional environment and origin of the Ermita sandstones were also discussed by VAN DEN BOSCH, who concluded on a source to the NNE (i.e. the Cantabrian Block) which yielded river generated sand for deposition in a littoral environment.

North of Teverga, in the area west-northwest of the central Asturian coalfield, PELLO (1968) described a white limestone underlying «Griotte» limestone. This unit, only several metres thick, was compared with the late Upper Famennian (Strunian) and Lower Tournaisian limestones reported by HIGGINS *et al.* (1964) and by BUDINGER & KULLMANN (1964). PELLO also mentioned that, near Oviedo, at the northern boundary of the central Asturian coalfield, 2 to 3 metres of white quartzose sandstone appeared between the white limestone and underlying Ordovician sandstones. He referred this thin sandstone unit to the Ermita Formation.

Further east, near Cangas de Onís, MARCOS (1967) described 2.50 m of coarse-grained sandstone, white at the base and ferruginous in the top part, which he compared with the Ermita Formation. A Tournaisian conodont fauna was recovered from limestones higher in the succession and before the «Griotte» limestone was reached.

From this review of the published information it clearly follows that the Ermita Formation is widespread both in northern León and in the Asturias. Its progressive onlap onto the Cantabrian Block marks the contours of this area of uplift.

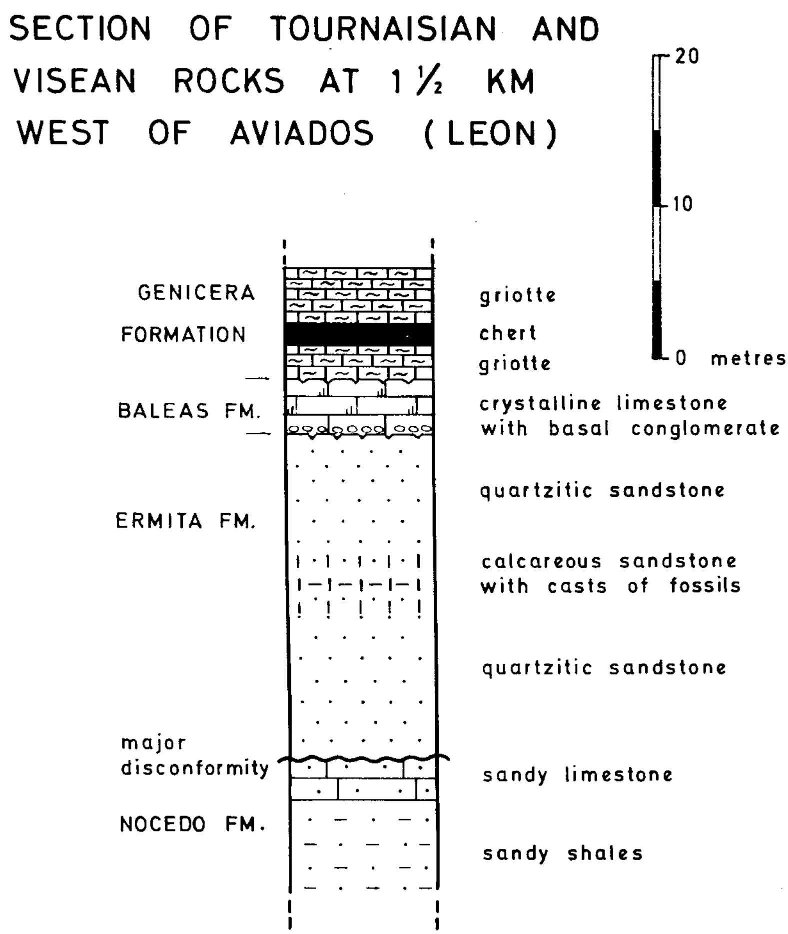
A completely different facies development of strata of the same age as the Ermita Formation has been recorded by BUDINGER & KULLMANN (1964) and by VAN ADRICHEM BOOGAERT (1967) from the north-eastern end of the province of León and the adjoining areas of northern Palencia and south-western Santander (VAN ADRICHEM BOOGAERT 1967, fig.64). Of particular importance is the Vidrieros Formation near Triollo and Cardaño de Arriba in the province of Palencia (VAN VEEN 1965), where nodular limestones show a passage from Upper Famennian (Strunian) into Lower Tournaisian of the *kockeli-dentilineata* Zone.

BALEAS FORMATION

Introduction

HIGGINS, WAGNER-GENTIS & WAGNER (1964) described a limestone succession from a section west of Aviados (see text-fig.1), which was disconformably overlain by Viséan «Griotte» limestone, and which appeared to grade downwards into sandstones attributable to the Ermita Formation. However, a re-investigation of this section by one of us (R.H.W.) showed the presence of an irregular contact between the limestone and the underlying sandstone formation. A basal conglomerate, 0.10-0.15 m thick, with small quartz pebbles (1-3 mm diameter) set in a limestone matrix, marks the base of the limestone formation which is 3.60 m thick in this locality. It is a coarse-grained, light grey limestone, superficially similar to the limestone which, further north, forms the top of the Ermita Formation. This limestone in the section west of Aviados (text-fig. 3) yielded an Upper Tournaisian conodont fauna to HIGGINS (*in* HIGGINS *et al.* 1964, and HIGGINS 1971); thus showing the age to be very different from that of the limestone of the Ermita Formation which only reaches the Lower Tournaisian. Similar Upper Tournaisian conodont faunas were found in a section immediately north of Pola de Gordón and at Beberino (HIGGINS 1971). The latter occurs in an exposure which is continued eastwards into the Baleas Quarry (text-fig.1), where the limestone of Upper Tournaisian age shows a disconformable contact with the Ermita Formation (in its hypostratotype), and is disconformably overlain by «Griotte» limestone of the Genicera Formation (text-fig.2).

The independent existence of the Upper Tournaisian limestone is clear, since it is not only quite different in age from the highest Ermita limestones (they correspond to lower *anchoralis* Zone and *kockeli-dentilineata* Zone, respectively), but also shows



Text-fig. 3.—Section of the Upper Devonian and Lower Carboniferous deposits at *ca.* 1,200 m west of Aviados. It shows a major disconformity between Frasnian rocks of the Nocedo Formation (as dated by HIGGINS 1971 on conodonts) and probable late Famennian to early Tournaisian strata of the Ermita Formation (undated in this locality), another disconformity at the base of the late Tournaisian Baleas Formation, and a further disconformity without a detectable time gap between the Baleas Formation and the Genicera Formation (Viséan). Scale of section 1 : 500.

a disconformable contact at the base. It is therefore to be regarded as a separate formation, which is here described as the Baleas Formation.

Type locality

The Las Baleas Quarry (text-figs. 1,2), 1 km north of Pola de Gordón, on the eastern bank of the Rio Bernesga, shows a well exposed section of the Baleas Formation in contact with equally well exposed Ermita Formation underneath and Genicera Formation («Griotte») above. The following units have been observed in the stratotype:

3/-0.68 m finely detrital crinoidal limestone, reddish tinted and becoming more intensely red towards the top.

2/-6.40 m crinoidal limestone, grey with reddish parts.

1/-1.10 m coarse-grained limestone, reddish with a little red shale.

A g e

A sample taken for conodonts at the extreme base of the formation proved to be barren, and this appears to be generally the case for the basal strata of the Baleas Formation. No further sampling was undertaken in the stratotype, but in the westward continuation of the same rocks, exposed in the western bank of a tributary to the Río Bernesga, at the village of Beberino, a sample taken at the top of the Baleas Formation yielded an abundant conodont fauna to HIGGINS (1971: sample 1364). Despite the absence of *Scaliognathus anchoralis* BRANSON & MEHL, it clearly belongs in the *anchoralis* Zone. The assemblage is not fundamentally different from that recovered from the overlying beds of the Genicera Formation which still belong to the *anchoralis* Zone, and there is no detectable time gap between the Baleas and Genicera formations in the Baleas type locality.

Further samples, taken from different levels of the Baleas Formation at Beberino, proved to be barren, but additional information has been obtained from the Baleas Limestone Formation exposed in a quarry, west of the railway, near the NW tip of Pola de Gordón (text-fig.1). Only 3.36 m of the limestone were sampled here, and five of these samples yielded conodonts. Two different assemblages were found, and these were delimited in the section by signs of a physical break occurring at 1.07 m below the top of the formation. The higher assemblage is characterized by *Scaliognathus anchoralis* BRANSON & MEHL and belongs to the upper part of the *anchoralis* Zone. The lower assemblage contains abundant *Gnathodus* and common *Siphonodella*. According to HIGGINS (1971), it compares closely with the *Gnathodus semiglaber -Pseudopolygnathus multistriatus* Zone of COLLINSON, SCOTT & REXROAD (1962) and should be assigned to the lower part of the *anchoralis* Zone, despite the fact that *Scaliognathus anchoralis* itself is missing in the assemblage. The erosional surface between the rocks containing these two assemblages does not apparently represent a measurable time interval, and there seems to be no reason to recognize more than one formation for the coarsely crystalline limestone described here as the Baleas Formation.

E x t e n t

The Baleas Formation has thus far been recognized only in three localities, viz. west of Aviados, at Pola de Gordón, and in the Baleas Quarry/Beberino. Together they occupy an E-W striking elongate area which shows a uniform succession of strata, consisting of Ermita Sandstone Formation followed by Baleas Limestone Formation which is overlain disconformably by «Griotte» limestone of the Genicera Formation.

There is an absence of intervening beds between the Baleas and Genicera formations, and this is remarkable because both north and south of the area occupied by the Baleas Formation in northern León the Genicera «Griotte» limestone is preceded by a development of black shales (Vegamián Formation) which is conspicuously absent in this area. Either the Baleas Formation is a time equivalent of the Vegamián Formation or the latter has been eroded from the area occupied by the Baleas Formation prior to the deposition of the Genicera «Griotte» limestone. Since the Baleas Formation and the basal part of the Genicera Formation both belong to the *anchoralis* Zone, of late Tournaisian and early Viséan age, the palaeontological dating is not yet fine enough to permit an evaluation of the time gap involved in the erosional break between these two formations. If the Vegamián Formation should be found to fit within this time gap, which is perhaps not an unreasonable assumption, the erosional break may be more important than the available dating suggests.

Although the residues of the limestone of the *costatus* Zone in the upper part of the Ermita Formation and those obtained from samples of the Baleas Formation are clearly distinct (A. C. Higgins, pers. comm.), the general lithological aspect of these limestones is rather similar and it must be considered possible that some of the field attributions of limestone to the Ermita Formation do in fact refer to the Baleas Formation. Future investigations will tell in how far this has been the case.

VEGAMIAN FORMATION

Historical

Comte (1959, pp. 330-331) described a unit, up to 15 m thick, of black shales with phosphatic nodules, occurring below the «Griotte» limestone (Genicera Formation of the present paper), and called it the «couches de Vegamián» after a locality south of the village of this name in the Porma River Valley (northern León). He recorded a gradual transition between the «couches de Vegamián» and the overlying «Griotte» and therefore assumed a Viséan age. Wagner (1963, p.209) referred to these rocks as the Vegamián formation and mentioned Comte's locality south of Vegamián as the type. Brouwer & van Ginkel (1964, pp.308-309) proposed the name Sella Formation for a sequence of rock units described by Schindewolf & Kullmann (1958, p. 17) from the Sella River Valley in eastern Asturias and northern León. This included a black shale unit (with *Pericyclus*) comparable to the «couches de Vegamián» of Comte. Subsequently, van Ginkel (1965, pp.182-184) reverted to Comte's divisions of «Vegamián» and «Alba» (for the «Griotte»), and accepted these as formations instead of the comprehensive Sella Formation.

Type locality

The section south of Vegamián referred to by Comte (*loc. cit.*) has since been flooded by the Porma Reservoir. Evers (1967, pp.104-105, fig. 18) described a new section in the same area, but higher up the mountain. The present writers accept the locality described by COMTE for the «couches de Vegamián» as the stratotype of the Vegamián Formation. The section along the road near the Mirador de Vegamián, described by EVERS, is accepted as the hypostratotype, but it is differently interpreted by the present authors. When the hypostratotype was recently visited by the second and third authors, it was found to be much weathered and some of the detail described by EVERS (*loc.cit.*) could no longer be observed. However, sufficient exposure remained to detect a lithological change at *ca.* 8 m above the base of the Vegamián Formation, and this can be regarded as marking the boundary with the overlying Genicera Formation. This boundary coincides with the base of the brachiopod-bearing red and black shales with limestone nodules mentioned in the description by EVERS. Shales are also known to replace the basal limestones of the Genicera Formation elsewhere in northern León (e.g. WINKLER PRINS 1968, p.46, text-fig.4). The hypostratotype of the Vegamián Formation is thus composed of fine-grained yellowish sandstones, black shales with chert and phosphatic nodules, and reddish brown mudstones forming a transitional layer with the overlying Genicera Formation.

Age

The Vegamián Formation is generally unfossiliferous, with the exception of some radiolarians in the chert nodules found throughout the black shales and the basal sandstones. COMTE (1959) recorded lamellibranchs from the Vegamián Formation but the first comprehensive fauna was obtained from a locality SW of Genicera (text-fig.4), originally studied by WAGNER (1963, p.224) and reinvestigated by WINKLER PRINS (1968, Table I). Conodonts from 0.05 m of basal sandstone, containing phosphatic nodules with generally broken specimens, include many polygnathids, siphonodellids and pseudopolygnathids (HIGGINS 1971). It appears likely that many specimens represent reworked material, and HIGGINS (1971) observes that the occasional presence of better preserved and fresher looking *Gnathodus punctatus* and *Gnathodus delicatus* may point to an age corresponding to the *anchoralis* Zone. From the top part of the black shales near Genicera HIGGINS (*in* HIGGINS *et al.* 1964, and HIGGINS 1971) recorded *Pseudopolygnathus triangula pinnata*, a characteristic species of the *anchoralis* Zone.

Most interesting is the find, also in the locality SW of Genicera, of a goniatite identified as *Muensteroceras arkansanum* GORDON (see «Note on some goniatite faunas» by C. H. T. WAGNER-GENTIS, in the present paper). This species found within the black shales by the second writer, is an index fossil of the late Kinderhookian in Arkansas (GORDON 1970, p.818), and represents a zone which has been equated with the early Tournaisian of Europe (GORDON 1970, p.823). Comments on this correlation are given by WAGNER-GENTIS on page 650 of the present paper. The conodont evidence from the Vegamián Formation near Genicera seems to preclude an early Tournaisian age for this locality, and it seems likely that the Vegamián Formation should be regarded as late Tournaisian.

Brachiopods from the upper part of the Vegamián Formation near Genicera were described by WINKLER PRINS (1968, Table I). They indicated either a late Tournaisian or an early Viséan age. Ostracodes from the same locality provided a similar indication (JORDAN & BLESS 1971), though favouring a late Tournaisian age.

Extent

The Vegamián Shale Formation is widespread in northern León and Asturias, but may be absent locally as the result of (submarine?) erosion along tectonic ridges (HIGGINS *et al.* 1964). VAN ADRICHEM BOOGAERT (1967, p. 174, text-fig.65) drew a map showing the general occurrence of the Vegamián Formation to be extending eastwards into northern Palencia. He also indicated (*loc.cit.*, pp. 163, 176) that the Vegamián Formation would have its most complete development in northern Palencia and southern Santander (Palentine facies area), where it would range into the Upper Viséan. The recognition and dating of the Vegamián Formation in the Palencia-Santander area may however pose problems which are not wholly resolved.

In northern León the Vegamián Shale Formation is always found to be separated by an erosional break from underlying formations.

GENICERA FORMATION

Historical

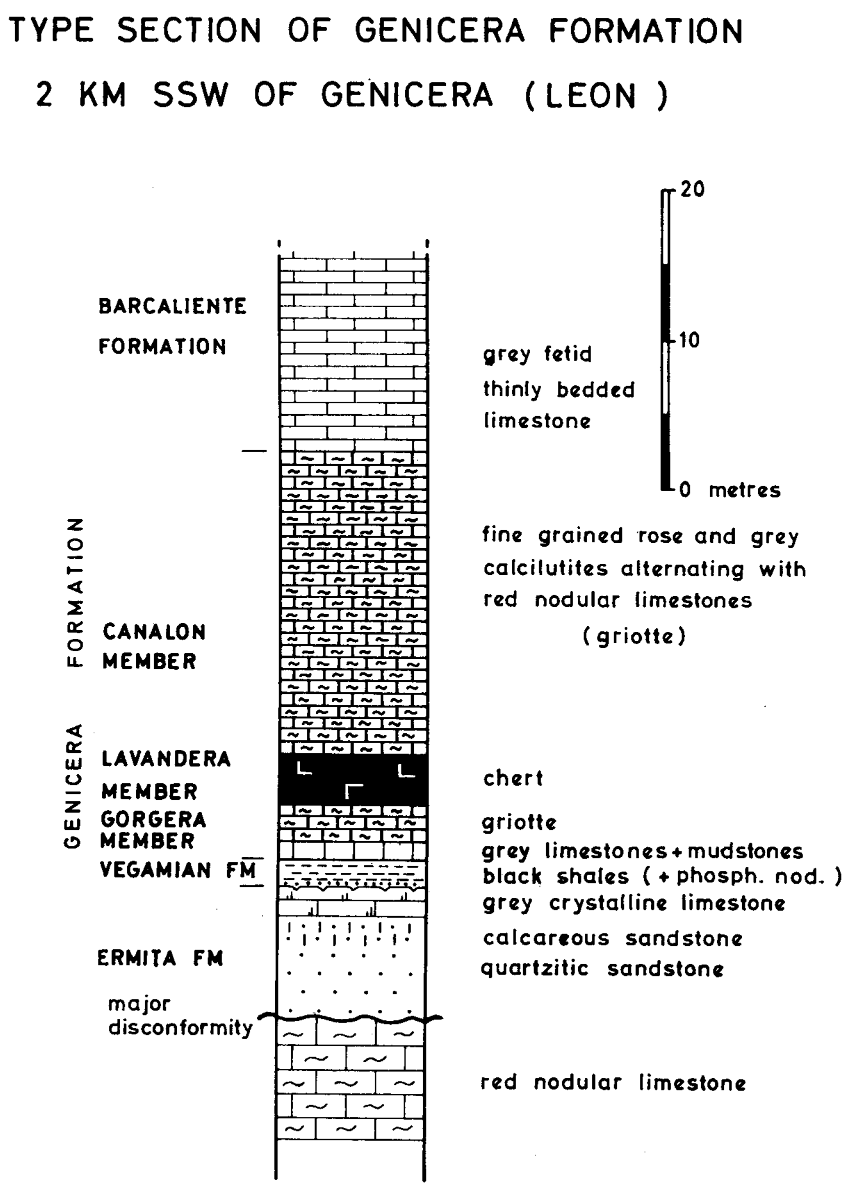
Perhaps the most widespread formation in the Carboniferous of NW Spain is the «marbre griotte» of BARROIS (1882), consisting of nodular limestones with subordinate cherts and shales. In northern León, COMTE (1959, p.330) referred to this unit informally as «Griotte à *Goniatites crenistria*» or «Griotte de Puente de Alba», and mentioned its age as Upper Viséan, after DELÉPINE (1928, 1943). BROUWER & VAN GINKEL (1964, pp.308-309) placed this unit in the upper part of their Sella Formation, subsequently modified by RÁCZ (1964, pp.10-12), who restricted the Sella Formation by making it the equivalent of the upper part of the «marbre griotte» only. RÁCZ combined the lower part of the «marbre griotte» with the Vegamián Shale Formation, calling the combined unit the Getino Formation. There is nothing to recommend this procedure, particularly because the «marbre griotte», representing a different lithology, also appears in a number of localities in isolation from the black shales of the Vegamián Formation, either by disconformity or by absence of the shales altogether. VAN GINKEL (1965, pp.184-185), without making any reference to RÁCZ's opinions, accepted the two units mentioned by COMTE (1959) and distinguished the Vegamián and Alba formations. He thus formalized the name «Griotte de Puente de Alba» used informally by COMTE and also abolished the Sella Formation of BROUWER & VAN GINKEL 1964 (see VAN GINKEL 1965, p.182). Although VAN GINKEL (1965, p.184) stated that he accepted «the Alba Formation as proposed by Comte», he did in fact introduce this formation, for COMTE only referred to the «Griotte de Puente de Alba» in a general sense and without mentioning a type locality. VAN GINKEL (1965) designated the type locality as being situated «near the village of Puente de Alba». This presumably refers to a section in the railway cutting at 500 m south-east of Puente de Alba, near an old aquaduct. There are several other exposures of «marbre griotte» near Puente de Alba, but most of these are rather disturbed tectonically, and the exposures in the railway cutting seem an obvious choice, sanctioned historically by DE VERNEUIL's (*in* DE PRADO & DE VERNEUIL 1850, p.158) comments (who compared it with the Devonian «Griotte» of the Pyrenees) and by BARROIS' (1882, pp. 576-577) pioneer studies. The red nodular limestones are exposed here in the flanks of a small, accessory anticline in the southern limb of the Alba Syncline north of La Robla; the most complete succession being found in the southern flank of the anticline (compare WAGNER & FERNÁNDEZ-GARCÍA 1971). However, the nodular limestones are affected here by strike faulting at the top which, though relatively unimportant, does cause a rather abrupt contact with a subsequent succession of mudstones (belonging mainly to the Olleros Formation of the present paper). Moreover, in this locality, as elsewhere along the southern border of the Cantabrian Cordillera, the nodular limestones are developed as a simple unit, whereas a division into limestone and mudstone/chert units is more common throughout the general area of northern León. The strike fault at the top and the somewhat unusual development of the «Griotte» limestone formation at Puente de Alba constitute reasons which are considered sufficiently important to reject VAN GINKEL's Alba Formation as based on this type locality near Puente de Alba.

In 1963 (p.212) WAGNER described the general sequence of Lower Carboniferous and Namurian rocks in the Porma-Bernesga region of northern León, subdividing the «Griotte» limestone into three units, viz. (1) red nodular limestone, (2) red cherts, (3) red and grey nodular limestones. WINKLER PRINS (1968, pp.45-46) formally named these units as (1) Gete Member, (2) Valdehuesa Member, and (3) La Venta Member, attributing these members to the Alba Formation. The various type localities proposed for these members occur in different parts of northern León and show inadequately exposed sections. The present writers here reject the Gete, Valdehuesa and La Venta members of WINKLER PRINS 1968, as well as the Alba Formation as introduced by VAN GINKEL 1965, and refer to the objections stated above. Instead, the Genicera Formation with constituent Gorgera, Lavandera and Canalón members are proposed, as based on a single type section in the mountains south-east of Genicera (text-figs 1, 4).

In the province of Palencia, a single unit of Viséan and Lower Namurian nodular limestones has been named the Villabellaco Formation (WAGNER & WAGNER-GENTIS 1963, p.152), referring to the «caliza con goniatítidos de Villabellaco» of WAGNER 1955 (p.156). This is distinguished from the Genicera Formation by the absence of a chert/shale member, and its grey colour (see further on page 631).

Type locality

The stratotype of the Genicera Formation is situated 2 km SSW of the village of Genicera (text-fig.1), at the head of the Arroyo de Gorgera. The stream which runs through the arroyo issues from near the base of a limestone cliff below a gully, dry



Text-fig. 4.—Section through the Upper Devonian, Lower Carboniferous, and Namurian A deposits 2 km SSW of Genicera in the Arroyo de la Gorgera. This section provides the stratotype of the Genicera Formation and its constituent members (i. e. Gorgera, Lavandera and Canalón members). Scale of section 1 : 500.

during the summer, called El Canalón. The type section is immediately east of the spring. The formation here is *ca.* 24 m thick, and is divisible into three members (text-fig.4), which are formally proposed here.

The Gorgera Member is proposed as the formal name for the lower limestone member. It conformably overlies and forms a transition with greenish mudstones at the top of the Vegamián Formation, immediately above loc. 1166 A (*in* WAGNER 1963, p.224), and consists of 0.80 m of light grey, fine-grained limestone alternating at the base with green mudstones containing crinoid ossicles (WAGNER 1963, loc. 1166 B), followed by 0.40 m of grey nodular limestone (WAGNER 1963, loc. 1166 C). The latter consists of medium grey limestone nodules, up to 15 cm across, in a matrix of medium grey shaly mudstone. The top of the Gorgera Member is made up of 0.75 m of red nodular limestone (WAGNER 1963, loc. 1167), followed by 1.20 m of red shales with bands of red nodular limestone. The red shales pass laterally into red nodular limestones which are frequently marly at this horizon. The Gorgera Member was measured in detail (WAGNER 1963, p.224), approximately 40 m east of the gully where the preceding Vegamián Shale Formation was exposed by digging.

The Lavandera Member is conformable with the preceding member, and consists of up to 5.30 m of red shales with beds and nodules of red chert, up to 5 cm thick. The cherts are heavily jointed and possess white and black spots, probably caused by leaching. In the absence of a more suitable local name, the member is named after the village of Lavandera, 1.5 km to the north-west.

The Canalón Member is named after the gully, El Canalón, which cuts through it. The small cascade at the base of the gully falls over the base of the Canalón Member at its contact with the Lavandera Member. The major part of the Canalón Member consists of 12.80 m of red and grey nodular limestones in beds varying between 5 and 50 cm in thickness, with undulose bedding surfaces. This grades rapidly into 3.25 m of grey nodular limestone, in beds 5-20 cm thick. These, in turn, grade upwards into the black, evenly bedded limestones of the next formation (i.e. the Barcaliente Formation of the present paper). The Canalón Member is thicker and less marly than the somewhat similar Gorgera Member.

Age

Dating of the Genicera Formation in its stratotype ranges from Lower Viséan to Upper Viséan, but it should be noted that the highest beds in this locality have not yet provided fossils. Loc. 1166 B in the Gorgera Member contains conodonts of the top of the *anchoralis* Zone (HIGGINS, *in* HIGGINS *et al.* 1964, p.219; HIGGINS 1971). At 1.10 m above the base of the grey limestone unit in the Gorgera Member a specimen of *Muensteroceras hispànicum* DELÉPINE (*non* FOORD & CRICK) was recorded (WAGNER-GENTIS, *in* HIGGINS *et al.* 1964, p.219), and both the grey and red limestone units of this member yielded specimens of *Merocanites subhenslowi* WAGNER-GENTIS. It therefore seems that the Gorgera Member ranges from Lower Viséan II β - γ (top *anchoralis* Zone) to Middle Viséan II γ - δ (lower B Zone). The Lavandera Member is undated, since it contains hardly any fossils except radiolarians. At 1-2 m above the base of the Canalón Member goniatites of the Upper Viséan III β Zone were found (mentioned as P Zone by WAGNER-GENTIS, *in* HIGGINS *et al.* 1964, p.223).

The westward continuation of the exposures in the Genicera stratotype has been investigated near the Venta de Getino (WAGNER 1963, pp.56-58), where the top of the Canalón Member yielded goniatite faunas of Lower Namurian age (corresponding to E_1 and E_2 Zones: WAGNER-GENTIS 1963). A peculiarity of this locality is that in the top part of the Canalón Member black limestones of the succeeding Barcaliente Formation interfinger with the goniatite-bearing nodular limestones. Some localities in the thrust unit north of that containing the Genicera stratotype also yielded Lower Namurian goniatites of the E_2 Zone (KULLMANN 1962, p.11).

In the E-W striking tectonic units south of the Genicera stratotype the transition between the Canalón Member and the succeeding black, fetid limestones of the Barcaliente Formation is interrupted by red, purple and green mudstones which in at least one locality (loc.1227: see the «Note on some goniatite faunas» by C. H. T. WAGNER-GENTIS) contain a similar E_2 goniatite fauna to that found at the top of the Canalón Member at Getino. This mudstone sequence is developed as a thin parting between the Genicera and Barcaliente limestones in a locality between the villages of Santa Olaja de la Varga and Ocejo de la Peña, in the Duerna Valley east of the Río Esla in northeastern León. Some 21.50 m of red nodular limestones are followed here by 0.50 m of red mudstone and 0.70 m of green and greenish grey mudstones, before some 250 m of fetid limestones are developed. The red nodular limestone in this locality ranges in age from Middle Viséan to Lower Namurian (B to E_2 goniatite zones - WAGNER-GENTIS, *in* HIGGINS 1962; WAGNER-GENTIS 1963, pp. 9-10). The E_2 fauna was recovered from the top layer of the limestone. At 1 m above the base of the succeeding mudstones some unidentifiable goniatites were found. The mudstones apparently represent a similar condensed facies to that of the nodular limestone of the Genicera Formation to which they are closely linked. Similar mudstones are developed above the red nodular limestones in localities of the Alba Syncline, the southernmost major tectonic unit in the area north of La Robla (text-fig.1). One of these, locality 1227, south of Barrios de Gordón, yielded an E_2 goniatite fauna with *Eumorphoceras bisulcatum* GIRTY (Pl. 1, fig.3, Pl. 2, fig.8) from green mudstones at *ca.* 10 m above the nodular limestone. It seems likely that the mudstones of condensed facies above the limestones of the Genicera Formation increase in thickness southwards, where they gradually replace the top part of the Canalón Member. They should be regarded either as representing a separate formation, replacing the Genicera Formation southwards, or be incorporated with the Genicera Formation in view of the existing close links and the similarly condensed facies. For the time being, they are referred to informally as the Olaja Beds.

Extent

The characteristic red and grey nodular and wavy bedded limestones of the Gorgera and Canalón members are widely represented throughout the Cantabrian Cordillera. It is this facies that has been generally recorded as «griotte limestone» (marbre griotte). The intervening Lavandera Member is less widely distributed and apparently wedges southwards (HIGGINS *et al.* 1964); thus leaving a single limestone unit in the most southerly exposures in the Cantabrian Chain. The Gorgera and Canalón members are still recognizable, however, on the basis of the marliness of the lower member. The red colour of the formation is characteristically present all over the Cantabrian

Chain, with the exception of an area in northern Palencia where this limestone formation is grey, though occasionally reddish tinted near the base. This is the Villabellaco Formation of WAGNER & WAGNER-GENTIS (1963) which shows a succession of marly nodular limestones followed by more compact nodular and wavy bedded limestones, without an intervening chert member. The Villabellaco Formation thus appears similar in development to the Gorgera and Canalón members of the Genicera Formation in the southernmost exposures of northern León (where the Lavandera Member is absent), but differs in not exhibiting the characteristic red colour. It also shows the same range in stratigraphic age, i.e. from Lower Viséan II ß- γ to Lower Namurian E_2 (WAGNER-GENTIS 1963, pp. 10-11). The distinction of a separate Villabellaco Formation is disputable, since only the grey colour of its rocks permits differentiation from the red, grey and green rocks of the Genicera Formation. If the two formations should be considered as one, the name and stratotype of the Genicera Formation are preferred, despite the priority enjoyed by the Villabellaco Formation (which has also been introduced prior to VAN GINKEL's Alba Formation whose stratotype shows the same development of a single limestone unit without an intervening chert and shale member). The Villabellaco Formation, though reasonably well developed near Villabellaco in north-eastern Palencia, is limited at the top by an unconformity, and is therefore less suitable as a type.

The base of the Genicera Formation in León and that of the Villabellaco Formation in Palencia both date equally, i.e. II ß-γ (*anchoralis*) Zone of Lower Viséan age, and it appears that the nodular limestone facies became established virtually at the same time all over the Cantabric-Asturian area. Only KULLMANN (1963, p.178 and table opposite page) and VAN ADRICHEM BOOGAERT (1967, p.165) indicated that the base of this limestone formation could be locally of a later, Upper Viséan age, corresponding to Go ß and Go γ in localities near Barruelo (Palencia) and Montó (north-eastern León). However, the sequence reported by KULLMANN from the Barruelo region was measured in that part of a nappe unit where the basal part of the formation was eliminated by the nappe thrust. Further along the same outcrop the complete formation (Villabellaco Formation) is present and shows II ß- γ faunas in the basal part (WAGNER-GENTIS 1963, p. 11, and personal communication). Outside the nappe unit, but in the same general area (i. e. near Villanueva de la Torre in NE Palencia), KULLMANN *(loc. cit.)* reported the presence of goniatites of the late Tournaisian II α Zone; thus providing an indication contrary to his statement as quoted above *(N. B.* in a personal communication to C. F. W. P. this record of Upper Tournaisian has subsequently been modified by KULLMANN to either late Tournaisian or early Viséan). In the Montó area the regional structure is characterized by thrusting which often affects the less competent Lower Carboniferous formations. In view of the experience gained in the Barruelo region, the present writers regard the evidence presented by KULLMANN as inconclusive, even though it should be noted that VAN ADRICHEM BOOGAERT (1967, p.144, Encl. 3) reports a sparse conodont fauna of the upper *bilineatus-commutatus nodosus* Zone (Upper Viséan) from the basal part of the nodular limestone formation in the Montó area.

It has already been noted that, whilst the base of the Genicera Formation appears to be uniformly of Lower Viséan age, the top of this limestone formation is diachronous in the southernmost exposures of this unit in the province of León where the upper part of the Canalón Member is progressively replaced southwards by mudstones of the Olaja Beds. Even though this replacement by a different lithology takes place, the condensed facies is maintained within the mudstones. One might regard the Genicera Formation as reaching always into the Lower Namurian E_2b subzone, if the Olaja Beds, of equally condensed facies, are incorporated within the formation. A similar replacement of limestone by a condensed mudstone facies is known as well for the —generally more marly— lower part of the Gorgera Member, at the base of the Genicera Formation.

BARCALIENTE FORMATION

Historical

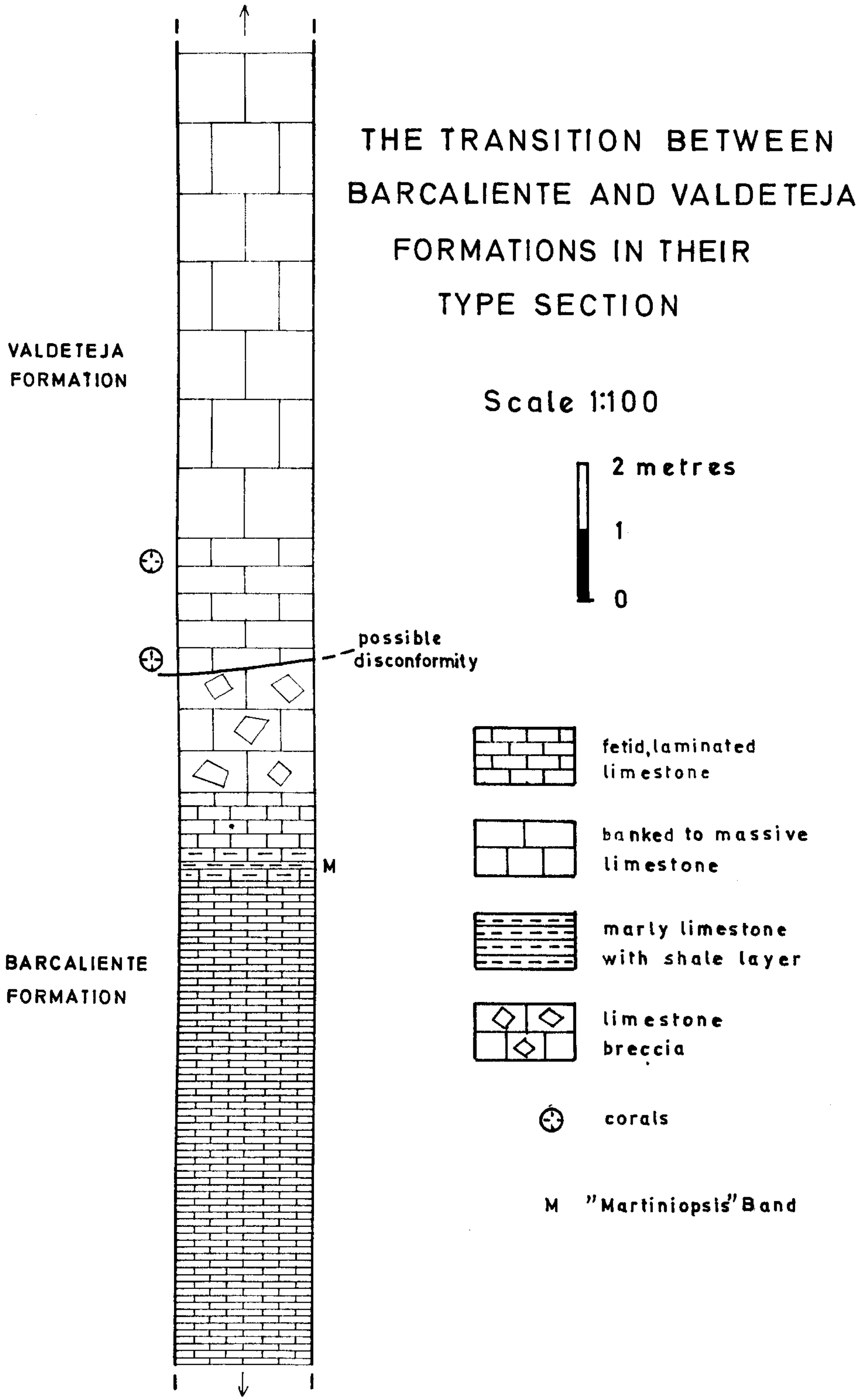
The nodular and wavy bedded limestones of the Genicera Formation are usually followed in a gradual transition by several hundred metres of limestone which are commonly referred to as «caliza de montaña» or «calcaire des cañons» (the latter name being due to BARROIS 1881, 1882). The informal names mentioned above were replaced by the Escapa Formation of BROUWER & VAN GINKEL (1964, pp.309-310), who mentioned the Sierra de Escapa in Asturias but failed to describe a stratotype. The Escapa Formation thus became just as informal as the «caliza de montaña» (sometimes, improperly, called Caliza de Montaña Formation: WAGNER 1962, and others). In northern León the «caliza de montaña» generally consists of two different units: a lower sequence of black, evenly bedded, fetid limestones showing a widespread lateral continuity, and a higher succession of more massive and less continuous limestones. This twofold division has been known for some time (e.g. DELÉPINE 1951, p.149; WAGNER 1963, p.62), and a formal description of the two units was recently given by WINKLER PRINS (1968, pp.46-49), who named the lower unit the Vegacervera Member of the Escapa Formation. The present writers consider this unit to be sufficiently distinctive and widespread to be recognized as a separate formation. They also consider that the name used previously as a member is unsuitable because the section in the Torío River Valley, near the northern end of the Vegacervera Gorge (Hoces de Vegacervera), used by WINKLER PRINS (*loc. cit.*) as the stratotype, is truncated in the upper part of the formation by a thrust fault. Also, the upper part of the unit is dolomitized in the Vegacervera type section. It is therefore proposed to describe a new stratotype, to be associated with a new formational name: the Barcaliente Formation.

Type locality

A suitable stratotype is found in the Arroyo de Barcaliente which continues the exposures along the Valdeteja road described by WINKLER PRINS (1968, 1971[a]) for the following unit, the Valdeteja Formation. The Arroyo de Barcaliente leads into the Curueño Valley, 9 km north of La Vecilla (see WINKLER PRINS 1971[a], text-fig. 1). The arroyo strikes eastwards from the Curueño Valley 200 m north of the junction between the road from Cármenes with that from La Vecilla to Lugueros. The section shows the contact with the Genicera Formation at *ca.* 250 m east of the Río Curueño. The stratotype starts here and continues down the arroyo and then southwards obliquely across the river to the road junction mentioned above. It shows a monotonous sequence of well bedded, black, micritic limestones which give off a fetid smell when broken. The bedding planes are even, and weather to between 7 and 30 cm apart, a thickness of 15 cm being typical. A fine parallel lamination is usually visible. Breccias occur at two levels, viz. at 160-200 m from the base and 1-3 m from the top. They consist of angular fragments of black limestone, identical to the rest of the formation. The first horizon shows blocks up to several metres across, which are set in a matrix of sparry calcite. The second horizon contains smaller fragments and does not show a sparry matrix. At its base the formation shows a rapid gradation from the grey and pink nodular limestones of the Canalón Member of the Genicera Formation, and there is a similar contact at the top with the Valdeteja Limestone Formation. The upper limit of the Barcaliente Formation in its stratotype is placed at *ca.* 2 m above a marly layer, 0.10-0.50 m thick, with brachiopods and crinoids (i.e. the *Martiniopsis* Band of WINKLER PRINS 1968, text-fig.8), at the horizon of an erosional breccia which may be of local importance only. The overlying basal beds of the Valdeteja Formation truncate this breccia (text-fig.5).

A g e

The Barcaliente Formation is mainly devoid of recognizable macrofossils, and the few brachiopods and crinoids found in the *Martiniopsis* Band near the top of the stratotype sequence provide no information with regard to stratigraphic age. Some poorly preserved, yet identifiable miospores were obtained from a limestone tongue of the Barcaliente Formation in exposures north of Olleros de Alba (see text-fig.1), and these demonstrate a Namurian B age (after identifications by Dr. K. GUEINN, pers. comm. to R. E. R.). A minimum age of the basal beds is provided by the goniatite faunas of Lower Namurian age, belonging to the E_2 Zone, which have been found in the top layers of the underlying Genicera Formation. Barcaliente type limestones are found intercalated with the goniatite-bearing horizon of E_2 age in some localities and the very gradational transition between the Genicera and Barcaliente formations suggests an immediately subsequent late Lower Namurian age for the basal beds of the latter. The top of the Barcaliente Formation has been dated in a goniatite and spore bearing locality near Viadangos de Arbas, west of Villanueva de la Tercia, and forming the lateral continuation of the Barcaliente stratotype (text-fig.1). This locality, as investigated by MOORE, NEVES, WAGNER & WAGNER-GENTIS (1971), shows the presence of *ca.* 12 m of thin, crinoidal limestones with calcareous mudstone intercalations at the top of the Barcaliente Formation and before a terrigenous facies is reached in a continuous succession. At the boundary between the carbonate and terrigenous facies a calcareous mudstone band occurs. This is the *Retites* Band of MOORE *et al.*


THE TRANSITION BETWEEN BARCALIENTE AND VALDETEJA FORMATIONS IN THEIR TYPE SECTION
Scale 1:100
2 metres
1
0
VALDETEJA FORMATION
possible disconformity
M
BARCALIENTE FORMATION
fetid, laminated limestone
banked to massive limestone
marly limestone with shale layer
limestone breccia
corals
M "Martiniopsis" Band

(1971), which contains basal Morrowan goniatites (*Retites semiretia* McCALEB) in association with Marsdenian spores; thus dating the top of the Barcaliente Formation as late Namurian B. A similar fauna with *Retites semiretia* was found by E. MARTÍNEZ-GARCÍA (1971) at *ca.* 50 m above the Barcaliente Formation in the eastern Asturian locality of Meré. In the region east of the central Asturian coalfield a lower Namurian B goniatite fauna of the *Reticuloceras* Zone was found by SJERP (1967, p.80), who recovered these goniatites from the top layer of the «caliza de montaña». Since the latter consists entirely of limestones of the Barcaliente Formation in the region studied by SJERP, this provides an additional dating of the top of the Barcaliente Formation which thus appears to be variable in age, ranging from lower to upper Namurian B. It is likely, however, that the earlier date indicated by the *Reticuloceras* fauna reported by SJERP (and identified by KULLMANN 1962) is due to the erosion of perhaps a rather substantial part of «caliza de montaña» in the central part of the Cantabric-Asturian area, corresponding to the Cantabrian Block of RADIG (1962). The upper part of the Barcaliente Formation may therefore be incomplete in the area studied by SJERP, who reported signs of erosion and a condensed facies above the «caliza de montaña». Apart from the apparently unimportant erosional breccia at the top of the Barcaliente Formation in its stratotype, it appears to be developed completely, as it is followed by the immediately subsequent Valdeteja Formation. An uninterrupted sequence from the Barcaliente Formation upwards is also recorded from the locality at Viadangos, yielding a late Namurian B spore flora, and it thus appears that the interval of time represented by a complete development of the Barcaliente Formation occupies upper Namurian A as well as practically all of Namurian B.

Extent

The evenly bedded, black or dark grey limestones of the Barcaliente Formation constitute a characteristic unit which can be traced over a large part of the Cantabrian Cordillera. In thin section these limestones are micrites which almost invariably underwent aggrading neomorphism (in FOLK's terminology). Pyrite microspheres are common (Dr. L. G. LOVE, pers. comm. to R. E. R.) and there is a high proportion of hydrocarbon material. Quartz crystals, partly replaced by calcite, and pyrite cubes occur locally.

The thickness of the formation varies from 50 to 350 m in different parts of Asturias, León and Palencia, but the lower values are probably associated with a disconformity which eliminated the higher part of the Barcaliente Formation. In a nappe structure in north-eastern Palencia the Barcaliente Formation is completely absent

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Text-fig. 5.—Section of Namurian limestone showing the boundary between the Barcaliente and Valdeteja formations of the «caliza de montaña» as exposed in the road junction in the Curueño River Valley, where the road to Valdeteja branches off from the main road from La Vecilla to Puerto de Vegarada. The boundary between the two formations lies at the base of a black limestone which truncates a limestone breccia at the top of the Barcaliente Formation.

due to a disconformity which put a massive and massively bedded limestone (Santa María Lst. Formation which probably equals the Valdeteja Formation of the present paper) in immediate contact with the Villabellaco Formation (= Genicera Formation) (compare WAGNER 1971).

The facies of the Barcaliente Limestone Formation is indicative of slow deposition and this is borne out by the stratigraphic dating which shows that 350 metres of limestones were formed in the interval of time covered by upper Namurian A and Namurian B. The widespread occurrence of the Barcaliente Limestone Formation shows that conditions were quite uniform for a rather considerable length of time in an area which probably corresponded to the Cantabrian Block, the central part of which was later uplifted and eroded. Towards the south, in northern León, the Barcaliente Formation has been found to split into various tongues interfingering with a terrigenous, more basinal sequence, the lower part of which is described in the present paper as the Olleros Formation.

VALDETEJA FORMATION

Historical

In most of the tectonic units in the Palaeozoic of northern León the rather thinly bedded limestones of the Barcaliente Formation are followed by more massive and massively bedded limestones of a different, more abruptly wedging formation which constitutes the upper part of the «caliza de montaña» or «calcaire des cañons». This formation was first described as a member by WINKLER PRINS (1968, p.49), but it is sufficiently distinct in facies and occurrence to be regarded as a separate formation. This Valdeteja Formation retains the type section as described in 1968 (see also WINKLER PRINS 1971[a]) for the Valdeteja Member which is merely raised in rank.

Type locality

The Valdeteja stratotype is the continuous section found along the road from the Curueño Valley to the village of Valdeteja. The base of the formation lies at a black limestone, 2 metres thick, which truncates the breccia at the top of the Barcaliente Formation in its type section along the same road, at the junction with the road following the Curueño River Valley. Its top lies at 500 m east of the village of Valdeteja, below a succession of mudstones with intercalated limestone bands*.

The Valdeteja Formation starts with a banked, black limestone (2 m) which truncates a breccia of Barcaliente limestone elements (text-fig.5). This basal limestone

* These mudstones were originally referred to the San Emiliano Formation of BROUWER & VAN GINKEL (RÁCZ 1964), but the application of this formational name to the sequence of mainly terrigenous rocks in the Cármenes Syncline has been put in doubt since MOORE *et al.* (1971) showed the presence of a disconformity in the Villamanín area at the horizon of the San Emiliano Formation.

of the Valdeteja Formation was originally attributed to the Barcaliente Formation (Winkler Prins 1971[a]) but should rather be considered as belonging to the Valdeteja Formation, since it is not laminated as is the case with the black limestones of the Barcaliente Formation and also contains corals. The truncation of the top breccia of the Barcaliente Formation, indicating a possible disconformity (albeit of little importance), supports the selection of the Barcaliente/Valdeteja boundary at this horizon.

After the initial 2 m of banked limestone a more characteristic facies for the Valdeteja Formation is reached with 45 m of brownish grey, massive limestone (compare the description given in Winkler Prins 1971[a]). This is followed by 10 m of bedded, light grey, greenish grey and purplish limestones and marls with abundant corals (especially *Cladochonus* sp., but also *Leonardophyllum leonense* de Groot — as figured *in* Winkler Prins 1971[a]), and a few brachiopods (e.g. *Plicatifera* aff. *plicatilis*) near the base. After some more banked limestones (containing crinoidal fragments) with shale partings, and several hundred metres of partly dolomitized, massive limestones with occasional corals and algae, 10 m of banked, light grey limestone is found. The latter contains a partly silicified fauna including primitive fusulinids. A few metres of unfossiliferous limestone are then succeeded by a brownish grey, banked limestone with a thin, reddish weathering, laminated limestone in the centre. The latter contains abundant brachiopods, especially productids (e.g. *Chaoiella gruenewaldti*). Another 130 m of massive, light grey, recrystallized limestone with a few dolomite lenses are followed by a crinoidal limestone grading into a light grey, hard limestone with abundant brachiopods (*Echinoconchus* Band), both lithologies being found in the stream bed, off the road. Across the bridge over the stream the section is continued along a path cutting off a bend in the main road. Here, black limestones consisting of laminated beds alternating with massive ones, are found to be containing a fauna with well preserved productid brachiopods, e.g. *Balakhonia continentalis* (Tornquist)*. The Valdeteja Formation ends with fossiliferous, dirty limestones separated by shale layers which herald the advent of the overlying terrigenous succession (*ex* San Emiliano Formation — see footnote on opposite page).

Age

The age of the Valdeteja Formation has been established only recently, and it should be noted that the strongly wedging character of this limestone formation tends to make dating of the upper part quite variable. Apart from early attributions to the Lower Carboniferous because of a similarity with the Mountain Limestone (Barrois 1882), the first real attempt at dating the upper part of the «calcaire des cañons» (caliza de montaña), and therefore of the Valdeteja Formation, was made by Delépine (1943, also *in* Delépine & Llopis Lladó 1956), who studied brachiopod faunas from Entrago

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* This is the *Linoproductus* Band of Winkler Prins (1968, 1971[a]) which should be referred to as the «*Balakhonia* Band» since it was named after *Linoproductus continentalis* (Tornquist 1895) which was transferred to *Balakhonia*.

(near Teverga) and Latores, in Asturias. DELÉPINE concluded on a Moscovian age, a conclusion which later proved to be incorrect. He based this conclusion partly on the presence of Moscovian fusulinids in limestones which locally appeared to form part of the «caliza de montaña» but which later proved to be separate and quite different in age (i.e. the «caliza masiva» of JULIVERT 1957, or Escalada Formation of VAN GINKEL 1965). He also misidentified some of the brachiopods which probably did come from the Valdeteja Formation, and perhaps attached too little importance to certain Viséan elements which he assumed to range into the Moscovian. VAN GINKEL (1965, p.186) mentioned the presence of poor fusulinid faunas of Bashkirian age in the upper part of the «caliza de montaña» (Escapa Formation of BROUWER & VAN GINKEL 1964) and also recorded a Lower Bashkirian fauna from the Mudá Limestone in northern Palencia, which is a probable equivalent of the Valdeteja Formation in northern León. Some fusulinid faunas have been found recently in the Valdeteja stratotype, and were made available to VAN GINKEL, but these faunas have not yet been studied. Although the evidence probably had to be regarded as incomplete, VAN GINKEL (1965, p.183, text-fig. 9) equated the upper part of the «caliza de montaña» (Escapa Formation) with the *Pseudostaffella antiqua* subzone of the *Millerella* Zone.

WINKLER PRINS (1968, pp. 61, 66; 1971[b]) considered a Lower Bashkirian age the most likely for brachiopod faunas recovered from the Valdeteja stratotype, and accepted such an age also for the faunas studied by DELÉPINE from his localities at Entrago and Latores. The occurrence of the coral *Leonardophyllum leonense* DE GROOT 1971 (*in* WINKLER PRINS 1971[a]), also in the Valdeteja stratotype, does not disagree with a Lower Bashkirian age, since the genus *Leonardophyllum* is known from the Morrowan in North America which is at least partly of Bashkirian age.

Most significant, however, is the recent discovery of the goniatite *Branneroceras branneri* (SMITH) in the lateral continuation of the Valdeteja stratotype north of Cármenes and in a terrigenous correlative of the top Valdeteja Formation north of Villamanín (see text-fig. 1), where fossil spores also indicated a lower Westphalian A age (MOORE, NEVES, WAGNER & WAGNER-GENTIS 1971). *Branneroceras branneri* is regarded as a characteristic element of Lower Bashkirian faunas and also occurs with a restricted range in the basal part of the Upper Morrowan. The base of the Valdeteja Formation in the Villamanín area is dated as probably early Namurian C by reference to the late Namurian B microflora which has been recovered from mudstones at the top of the Barcaliente Formation preceding a terrigenous correlative of the Valdeteja Formation (MOORE *et al.* 1971). The Valdeteja Formation therefore dates essentially as Namurian C, mainly equivalent to Lower Bashkirian, with a diachronous top reaching into (lower) Westphalian A.

Extent

Despite its considerable thickness (up to 700 m) the Valdeteja Formation is less widely distributed, both locally and regionally, than the underlying Barcaliente Limestone Formation. Its facies, which includes bioconstructed reef masses or banks (R. E. R. — unpublished information), allows for strong wedging to the extent that the whole formation has been seen to pass laterally in continuously exposed rocks from a maximum thickness of 700 m to nil within a distance of 2 km. Regionally, the Valdeteja Limestone Formation seems to be absent in an area east and south of the central Asturian coalfield, which corresponds to the Cantabrian Block, and which shows a condensed facies and probable disconformity above the Barcaliente Formation (compare the sequences described by JULIVERT 1967, SJERP 1967, and others). In northern Palencia, a low-angle unconformity is developed below a local equivalent of the Valdeteja Formation (i.e. the Santa María Limestone of WAGNER & WAGNER-GENTIS 1963) which eliminates the Barcaliente Formation in a nappe of southern derivation (WAGNER 1971). The Valdeteja Formation appears to be fringing the Cantabrian Block and occurs characteristically west of the central Asturian coalfield (e.g. at Entrago in the Teverga region of Asturias), some distance south of this coalfield in northern León, perhaps in eastern Asturias (Río Cares section), and in northern Palencia. It may however also have been deposited on the Cantabrian Block and removed by erosion during Westphalian A times (a major disconformity at a level just above the Valdeteja Limestone Formation has been recorded from the Villamanín area of northern León by MOORE *et al.* 1971, and this disconformity may well be developed more strongly further north in the area corresponding to the updoming central part of the Cantabrian Block). In the more southerly exposures of northern León, where the Barcaliente Formation interfingers with a terrigenous basin facies, the Valdeteja Formation has not been seen. It seems likely that the general tendency for carbonate deposits, from the top Canalón Member of the Genicera Formation upwards, to pass laterally into terrigenous rocks southwards, also extends to the Valdeteja Formation. However, the stratigraphic dating of these terrigenous deposits is too poor to be certain that the stratigraphic level of the Valdeteja Formation has been reached by the succession hitherto recorded (see under Olleros Formation).

The Valdeteja Limestone Formation was deposited fairly rapidly and at a much greater rate of sedimentation than the preceding Barcaliente Formation, since even at its maximum thickness of *ca.* 700 m it corresponds virtually to the Namurian C only (MOORE *et al.* 1971), i. e. the equivalent of the Lower Bashkirian.

OLLEROS FORMATION

Introduction

In tectonic units along the southern border of the Cordillera Cantábrica in the province of León the «caliza de montaña» is replaced by a terrigenous sequence of mudstones, sandstones, occasional conglomerates and tongues of Barcaliente limestone. WAGNER (1957, 1959, 1963, pp. 239-240) noted that this lateral facies change occurred «south of a line connecting the coalfields of Sabero and Ciñera-Matallana» and described the terrigenous sequence as consisting predominantly of shales and sandstones with thinly bedded bluish grey limestones. The terrigenous sequence of these southerly exposures was reported as a «Culm facies» by DE SITTER (1962) and RUPKE (1965, p.29).

BOSCHMA & VAN STAALDUINEN (1968, p.225) described the terrigenous sequence in the Alba Syncline north and north-west of La Robla as the Cuevas Formation and distinguished a lower shale/greywacke member and an upper limestone member. They noted that the thinly bedded limestone of the upper member appeared similar to the basal part of the «caliza de montaña» elsewhere in northern León, and mentioned an undescribed type section near the village of Cuevas. The area mentioned as a prospective stratotype of the Cuevas Formation was mapped by PASTOR (1963) and shows a patchily exposed succession of rocks in the folded southern flank of the Alba Syncline. It does not seem to be the ideal section for a stratotype, even though it may be difficult to judge in the absence of a properly described type section. It should also be noted that the thinly bedded limestone mentioned by BOSCHMA & VAN STAALDUINEN as the upper member of their Cuevas Formation undoubtedly represents a tongue of the Barcaliente Formation at the base of the «caliza de montaña». This limestone tongue can hardly be regarded as forming part of a different formation, and the introduction of BOSCHMA & VAN STAALDUINEN's Cuevas Formation is not justified by the evidence presented.

The present writers find that the succession of rocks in the terrigenous sequence of post-Viséan strata in the most southerly exposures of the Cordillera Cantábrica is variable, particularly with regard to tongues of Barcaliente limestone which occur at different levels and in different proportions, depending on the palaeogeographic position of the section examined. A characteristic succession occurs in the Alba Syncline, where the following general sequence is found:

3. Conglomerates, sandstones, mudstones and limestones (incomplete at the top as a result of its position in the core of the syncline).
2. Wedges of dark grey, thinly bedded limestone of Barcaliente type which occur at certain levels of the succession but forming together one horizon separated by sandstones and shales.
1. Shales, mudstones and sandstones of varied facies but mainly representing turbidites, which show occasional conglomerates and rare calcareous horizons. This unit follows conformably on mudstones referable to the Olaja Beds described earlier in this paper.

Unit 1 is described here as the Olleros Formation, and may eventually be subdivided into members, to be discussed below. Unit 2 represents mainly the wedging Barcaliente Formation disappearing southwards, but still present in the Alba Syncline. Unit 3 is insufficiently known to the present writers to be described as a formal lithostratigraphic unit. It contains the chert and quartz conglomerate described by PASTOR (1963) from the Alba Syncline north of Cuevas, where it appears as a prominent

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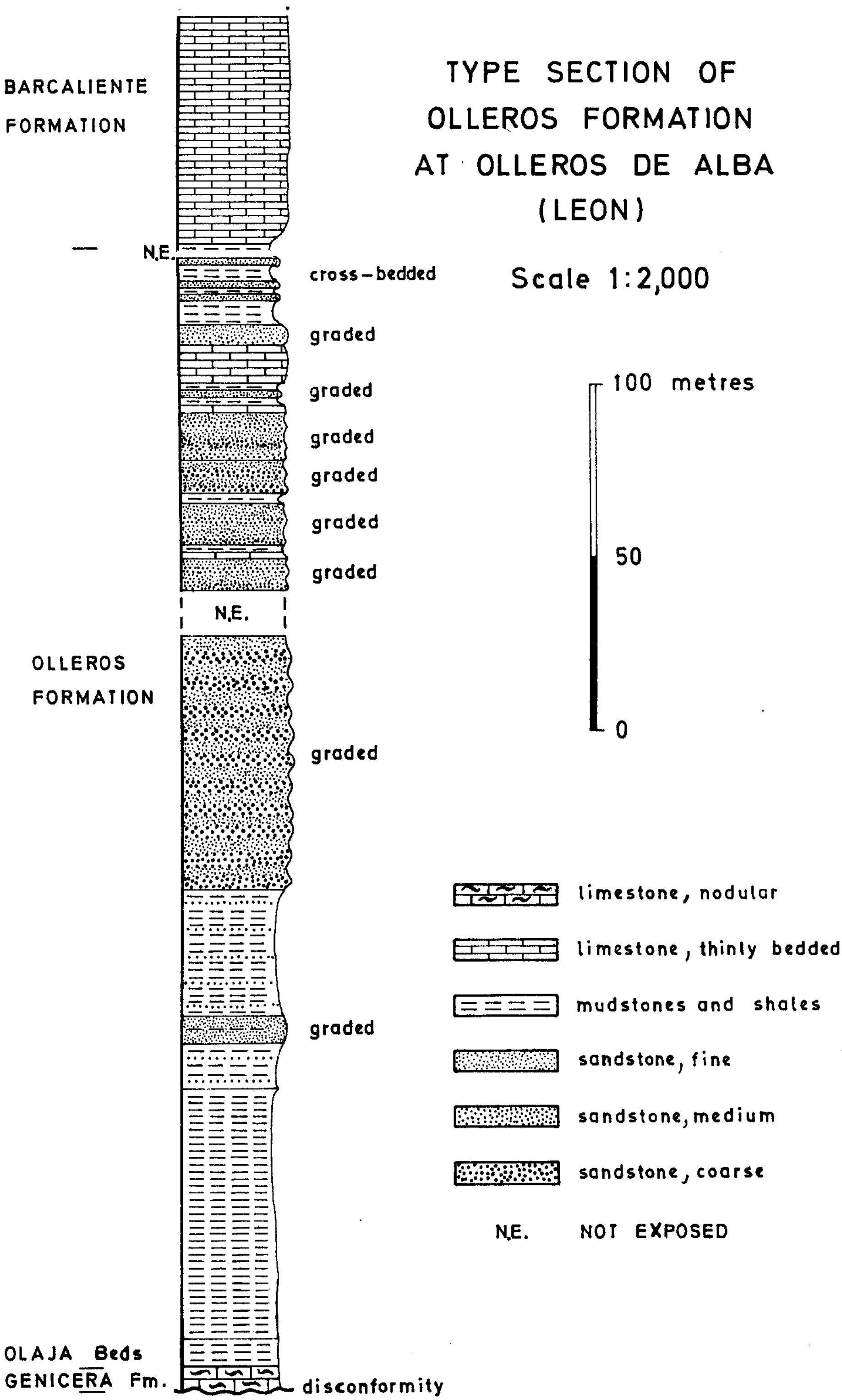
Text-fig. 6.—Section of Viséan and Namurian deposits at Olleros de Alba and north of this village. This section provides the stratotype of the Olleros Formation. Note the replacement of the upper part of the Canalón Member of the Genicera Limestone Formation by the terrigenous Olaja Beds.


TYPE SECTION OF
OLLEROS FORMATION
AT OLLEROS DE ALBA
(LEON)
Scale 1:2,000
100 metres
50
0
BARCALIENTE
FORMATION
N.E.
cross-bedded
graded
graded
graded
graded
graded
graded
N.E.
OLLEROS
FORMATION
graded
graded
OLAJA Beds
GENICERA Fm.
disconformity
limestone, nodular
limestone, thinly bedded
mudstones and shales
sandstone, fine
sandstone, medium
sandstone, coarse
N.E. NOT EXPOSED

band in a sequence with Barcaliente limestone wedges in the upper part of the sequence exposed in the syncline (but not at the top of this sequence and disconformable, as PASTOR described it).

Type locality

The stratotype of the Olleros Formation is along the Arroyo de San Martín north of Olleros de Alba (see text-fig.1). The section begins at the road on the eastern side of the arroyo. Green and grey mudstones of the Olaja Beds pass gradually into the basal beds of the Olleros Formation in this locality (text-fig. 6).

The type sequence (as measured by R. E. R.) is divisible into 28 sub-units. Between sub-units 1 and 3 the section is along the slope beside the road on the eastern side of the valley north of the church at Olleros. From unit 4 to 5 it continues northwards from the hairpin bend where the road crosses a stream, above and to the east of the stream before gradually descending to the bottom of the arroyo at the top of unit 5. From unit 6 to unit 28 the section is along the track on the west side of the stream.

Units (from base upwards):

1. Dark grey mudstones and occasional bands of well bedded, fine, dark grey sandstone, up to 20 cm thick, showing parallel lamination, with occasional groove and flute casts.	72.00 m
2. Dark grey mudstones with bands of medium to coarse sandstone, up to 30 cm thick, showing graded bedding.	13.00 m
3. Beds of grey-brown sandstone from 20 cm to 1 m thick, grading from medium-coarse to fine, alternating with dark grey silty mudstones.	8.00 m
4. Dark grey shales and mudstones with occasional bands, up to 1 m thick, of dark grey thinly bedded (5 cm) medium-fine carbonaceous sandstones.	37.00 m
5. Intermittently exposed graded sandstone units, up to 1.50 m thick, with coarse, very coarse, or conglomeratic bases (rounded quartz pebbles up to 13 mm diameter) and poor bottom structures.	73.50 m
6. Not exposed.	13.00 m
7. Grey brown sandstones, 15-80 cm thick, showing poor bottom structures and grading from coarse to fine, with parallel lamination in the upper parts; separated by shale and mudstone bands, up to 20 cm thick.	9.00 m
8. Thinly bedded, black marly limestone.	2.00 m
9. Poorly exposed mudstones with sandstone bands, up to 20 cm thick.	1.50 m
10. Bands of grey brown sandstone, *ca.* 30 cm thick, grading from coarse to fine, with occasional parallel lamination in the upper parts, separated by thin lutitic intercalations.	12.00 m
11. Poorly exposed mudstones, with sandstones up to 15 cm thick.	3.00 m
12. Bands of grey brown sandstone, from 0.20 to 1.75 m thick (average 0.75 m), grading from very coarse (with small pebbles 5 mm in diameter) to fine; basal surfaces plane or broadly undulose.	10.00 m
13. Grey brown, coarse to fine sandstone bands, 0.40-1.20 m thick, showing graded bedding and cross and parallel lamination, with plane or knobbed bases, separated by thin lutitic units.	13.00 m
14. Thinly bedded, black limestone.	3.00 m
15. Silty mudstone with thin bands of fine sandstone.	2.00 m
16. Graded, coarse to fine, grey brown bedded sandstones, up to 0.50 m thick, with large pebbles (up to 2 cm diameter) of dark grey mudstone near the base.	2.00 m
17. Silty mudstone.	2.00 m

18.	Thinly bedded, dark grey to black limestone (exposed in a side gully west of the main arroyo).	10.00 m
19.	Not exposed.	1.00 m
20.	Graded, coarse to fine, grey brown sandstones, up to 0.60 m thick, with swells and knobs at the bases; separated by thin (5 cm) shaly mudstones.	6.00 m
21.	Silty mudstones with occasional thin (up to 20 cm) medium to fine sandstones.	7.00 m
22.	Medium brown sandstone in beds 1-30 cm thick, separated by thin mudstones.	1.50 m
23.	Mudstones with grey brown, medium to fine, cross bedded lenticular sandstones, up to 12 cm thick.	2.00 m
24.	Medium, brown, bedded (1-30 cm) sandstones with undulose bases separated by thin mudstones.	2.50 m
25.	Mudstones with cross bedded, grey brown, medium to fine sandstones in lenticular bands between 2 and 6 cm thick.	4.00 m
26.	Cross bedded, grey brown, medium to fine sandstones in lenticular bands, 2-6 cm thick, separated by silty mudstones less than 1 cm thick.	2.00 m
27.	Not exposed.	3.00 m
28.	Grey mudstones with thinly bedded, dark grey limestones, up to 10 cm thick, passing upwards without marked change into the Barcaliente Formation.	2.00 m
	Total thickness	317.00 m

This sequence, following upon 21 m of condensed Olaja Beds, represents a gradual increase in the rate of sedimentation and basin slope, from the large mudstone unit at the base to the important development of turbiditic sandstones (graded) in that part which precedes the more prominent Barcaliente Limestone tongues and cross bedded sandstones (text-fig.6).

The thick development of mudstones at the base of the Olleros Formation forms a distinctive unit not only in the stratotype, but also in other localities. This unit may eventually be distinguished as a member. The graded sandstones which form the characteristic lithology of the succeeding unit are not so regularly developed as regards thickness and lateral continuity, but they do seem to characterize the upper part of the Olleros Formation and may therefore also be recognized eventually as a separate member.

Age

The lower age limit of the Olleros Formation is determined by its position above the Olaja Beds which yielded a goniatite fauna of late Arnsbergian age (E_2 Zone) in a locality south of Barrios de Gordón in the northern flank of the Alba Syncline (text-fig. 1; see also the «Note on some goniatite faunas» by C. H. T. WAGNER-GENTIS). Within the formation as represented in the stratotype and in other localities of the Alba Syncline no fossils have been recorded as yet, apart from a few drifted and highly fragmented plant remains near the top of the formation in the area north of La Robla (WAGNER & FERNÁNDEZ-GARCÍA 1971), which provide a general indication for Namurian B or C. Above the Olleros Formation in its stratotype a thick tongue of Barcaliente Limestone occurs, and this has yielded rather poorly preserved plant spores forming a Namurian B assemblage (after identifications by Dr. K. GUEINN, pers. comm. to R. E. R.). Near Pola de Gordón and further east in the core of an anticline in unconformable Stephanian B rocks of the Ciñera-Matallana coalfield (see text-fig.1) fragmentary faunas of *Reticuloceras* have been found in a few localities corresponding, apparently, to the lower mudstone member of the Olleros Formation. These taunas, which are too poorly preserved to be figured and described, represent the lower Namurian B. Locality 1485 (R. H. W. coll.), at 250 m north of the office of the La Competidora Mine, in the core of the Tabliza Anticline (see WAGNER & ARTIEDA 1970: Geol. Map), has yielded *Reticuloceras* cf. *paucicrenulatum* BISAT & HUDSON and *Reticuloceras* sp. ex gr. *nodosum* BISAT & HUDSON (both identified by Dr. W. H. C. RAMSBOTTOM — Institute of Geological Sciences, Leeds). These are species of the R_1a_3 and R_1b subzones. Locality 1722 (C. H. T. W.-G. coll.), immediately north of Pola de Gordón, along the main road and next to a small vertical fault separating a torrential conglomerate of Stephanian B age from the Namurian mudstones, has provided a fragment of *Reticuloceras* cf. *gulincki* BOUCKAERT (*det.* J. BOUCKAERT —Service géologique de Belgique). This is also an element of the R_1a_3 subzone. It is clear that these goniatite faunas occur in the lower part of the Olleros Formation which still shows a relatively slow sedimentation.

Extent

The Olleros Formation is represented throughout the Alba Syncline, i.e. the southernmost tectonic unit of the Palaeozoic north of La Robla (text-fig.1). It is also found in the next unit northwards, at Pola de Gordón, where the Olleros Formation follows upon a thin development of Barcaliente Limestone Formation. Both the lower mudstone member and the upper graded sandstone member seem to be present in the exposures along the main road from León to Oviedo. They occur in a succession of small folds which have not been mapped in detail, although it is apparent that the mudstones are found predominantly in the more northerly exposures along the road. An interesting section, probably representing the graded sandstone member, is present along the road in an exposure immediately north of the municipal swimming pool of Pola de Gordón. It shows an anticlinally folded turbidite sequence, with smaller folds at the southern end of the section. The sequence in the northern flank of the anticline is divisible into four units (as recorded by R. E. R.):

1. Dark grey shales, thinly bedded (2-4 cm interval), with chocolate to red ironstone bands and occasional ferruginous sandstones, 3-30 cm thick. The ironstones and sandstones have occasional groove casts and small flute casts at their bases. This unit is crumpled in the anticlinal core.	> 3.00 m
2. Alternations of siltstones, sandstones, shales and limestones. — *Sandstones* show 3-35 cm thick beds, medium to dark grey, weathering to a brown colour, medium to fine grained, with disseminated mica and macerated plant debris locally. Graded bedding frequent; bases show flute casts fairly commonly, and knobs up to 1 or 2 cm deep occur. A good slump structure is found at one horizon. — *Siltstones* in beds, 2-90 cm thick, dark grey in colour. This is the dominant lithology, and is often an extension of the graded sandstone units, when it usually shows convolute or current lamination. Darker laminae are due to inclusions of fine carbonaceous material. — *Shales* in beds 0.5-3 cm thick, somewhat blocky, dark grey, weathering buff or olive. Forms a minor constituent. — *Limestone* in beds up to 2 cm thick, marly, dark blue to grey. Minor constituent.	12.00 m

3. Mostly sandstones exceeding 0.40 m in thickness, with subsidiary siltstones and shales. 6.75 m
   - *Sandstones* in beds 6-105 cm thick, but nearly all thicker than 20 cm, medium grey, weathering to a brown colour, grading from coarse to fine, with granules of quartz and black chert up to 4 mm in diameter at the bases, which also show load casts, flute casts up to 6 cm deep, and groove casts, although some bottom surfaces are plane. Macerated plant debris is absent.
   - *Siltstones* in beds 4-8 cm thick, but sometimes up to 14 cm thick when mixed with fine sand and plant debris; grey to dark grey and cross laminated.
   - *Shales* grey to black, 1-4 cm thick beds, uncommon.
4. Alternations of thin sandstones, siltstones and shales, becoming contorted in the upper part of the section, which is also inaccessible. > 5.00 m
   - *Sandstones* blue-grey, medium to fine, brownish weathering, beds 4-10 cm thick, often graded. Occasional knobs, up to 1 cm deep on the basal surfaces.
   - *Siltstones* in beds 1-6 cm thick, grey, olive weathering, with thin (2 mm) hard layers of dark blue marly limestone.
   - *Shales* in beds 0-3 cm thick, dark grey.

Total thickness 26.75 m

No further localities of the Olleros Formation have been examined and the lateral passage northwards into the Barcaliente Formation (which is of the same age) cannot be studied in detail due to tectonic shortening. The next tectonic unit north of that containing the exposures near Pola de Gordón, already shows 120 metres of Barcaliente Limestone lying on Genicera Formation. Unfortunately, this is the highest formation preserved in this unit which has been studied in the Las Baleas Quarry (text-fig.2).

DEPOSITIONAL ENVIRONMENTS OF THE FORMATIONS DISCUSSED

Ermita Formation.—Quartz and carbonate sands in a high energy littoral or infralittoral environment; a transgressive deposit moving across a peneplained surface.

Baleas Formation.—Carbonate sands in a high energy littoral or infralittoral environment; quartz pebbles at the base of the Baleas Formation NW of Aviados represent a minor amount of reworking as the result of erosion.

Vegamián Formation.—Basal sandstone represents the residue of a littoral deposit; black shales deposited in a low energy, restricted environment with probably anaerobic bottom conditions (either depositional or immediately post-depositional); low rate of sedimentation.

Genicera Formation.—An oxidizing environment remote from sources of terrigenous mud; water depth probably in excess of infralittoral environment, since there is no evidence of the growth of benthonic calcareous algae and there is generally a low incidence of benthonic organisms; clear bottom conditions indicated by the presence of crinoids which are relatively common though overshadowed by pelagic fauna; chert of the Lavandera Member is of biogenic origin (radiolarians), probably with some physico-chemical addition; rate of sedimentation extremely low.

Olaja Beds.—A condensed mudstone replacement of the highest Genicera Limestone (Canalón Member); slowly deposited muds with pelagic fauna, and representing sedimentation nearer to the terrigenous source area but still beyond the infralittoral zone.

Barcaliente Formation.—Low energy environment, probably with stagnant bottom conditions; deposition far from source of terrigenous material (i.e. on the Cantabrian Block with tongues of limestone protruding into the basin); low rate of sedimentation.

Olleros Formation.—Rather slowly deposited muds followed by turbidites representing a marked increase in the rate of sedimentation under basinal conditions; lateral equivalent of the Barcaliente Formation which interfingers.

Valdeteja Formation.—Shallow, medium energy environment within the photic zone; random reef complex with terrigenous sediment surrounding reef and associated limestones.

PALAEOGEOGRAPHIC SIGNIFICANCE

In agreement with Comte (1938, 1959) the Ermita Formation represents a gradually advancing transgression with onlap in NNE direction. This transgression is linked to the Cantabrian Block which was first uplifted and then transgressed. A more complete late Upper Devonian and early Lower Carboniferous succession is found beyond the margins of the Block, and only the upper part of the formation is represented on the Block itself. The Lower Tournaisian limestone at the top of the Ermita Formation represents deposition on the Cantabrian Block, under shallow marine conditions, after submergence of the Block had eliminated the source of local terrigenous material.

Widespread abrasion, associated with a considerable time gap within the Tournaisian Stage, marks the Ermita Formation off from the succeeding Baleas and Vegamián formations. Probably the Cantabrian Block formed an exceedingly shallow submarine swell during the interval represented by the stratigraphic gap, and the possible deposition of limestones on the Block was offset by abrasion at this time.

The Upper Tournaisian Baleas Formation, represented along an E-W line from Pola de Gordón to NW of Aviados, was probably formed on a submarine ridge under very shallow conditions conducive to the formation of a calcarenite. On both sides of this ridge the black shales of the Vegamián Formation are found. Although it is possible that these shales were also deposited on the ridge, above the limestone of the Baleas Formation, and removed subsequently, it may be that the Vegamián Shale Formation is the lateral equivalent of the Baleas Formation and that it represents the more basinal facies alongside the ridge. Both the Baleas and Vegamián formations

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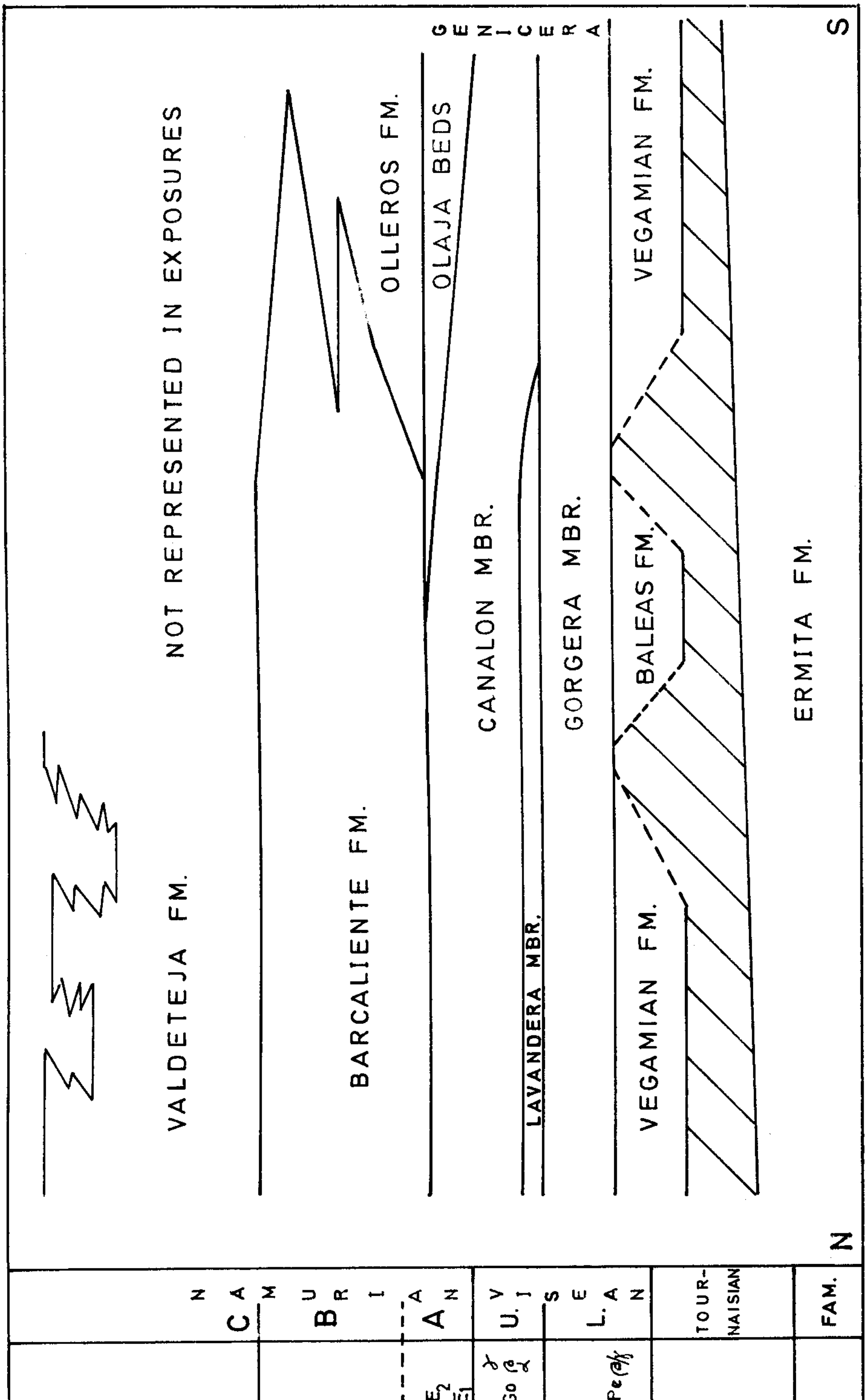
Text-fig. 7.—Diagram showing the mutual relationships of the formations and members recognized in the present paper. The representation is not to scale. The general dating and the goniatite zones recognized are to be found in the left hand columns. Ruled area represents stratigraphic gap. Section from north (N) to south (S).


S
N
NOT REPRESENTED IN EXPOSURES
VALDETEJA FM.
BARCALIENTE FM.
OLLEROS FM.
OLAJA BEDS
GENICERA
CANALON MBR.
LAVANDERA MBR.
GORGERA MBR.
VEGAMIAN FM.
BALEAS FM.
VEGAMIAN FM.
ERMITA FM.
NAMURIAN
C
B
A
VISEAN
TOUR-NAISIAN
FAM.
E_2
E_1

date as Upper Tournaisian, and both these formations are lying disconformably on the late Famennian - early Tournaisian Ermita Formation.

The disconformable contact between the Vegamián Shale Formation and Baleas Limestone Formation on the one hand and the Genicera Limestone Formation on the other, indicates the presence of movements in late Tournaisian - early Viséan times which, though rather slight, did affect a wide area. This area was probably linked to a southern hinterland, for the most northerly exposures in northern León show a gradual transition between the Vegamián and Genicera formations, without disconformity, and this apparently indicates stable conditions on the Cantabrian Block which was completely submerged at this time. The nodular limestones and cherts with minor shale additions of the Genicera Formation show the almost complete lack of terrigenous material coming into an area of sedimentation which was remarkably uniform during a long period of time (i.e. all of Viséan and most of Lower Namurian times). The Genicera Formation is characterized faunistically by a predominance of pelagic elements, though crinoids, lamellibranchs, gastropods, corals and brachiopods also occur sporadically. Sedimentation probably took place in an environment far from the coast.

The relative position of the coastline is indicated by the progressive replacement southwards of the limestone of the top member of the Genicera Formation by the terrigenous Olaja Beds which, though also representing a condensed facies, showed the availability of land-derived sediment. The same indication for a southern hinterland is provided by the Olleros Formation, consisting of mudstones followed by turbidites, which form the lateral replacement of the Barcaliente Limestone Formation. The latter was essentially linked to the Cantabrian Block, forming a submarine swell which was bordered by the basin receiving sediment from the southern hinterland (and from a north-western hinterland, after information published from northern Asturias — e.g. VIRGILI & CORRALES 1968).

The Cantabrian Block reasserted itself again in Westphalian A times, when movements of uplift took place, with the result that a widespread disconformity exists in the central area of the Cantabrian Cordillera (i. e. east of the central Asturian coalfield) between Westphalian B-C on the one hand and Namurian B on the other. This disconformity shows a lesser stratigraphic gap in the area marginal to the Block, and may be absent in the basinal region. The area marginal to the Cantabrian Block shows the presence of a thick limestone formation, the Valdeteja Formation, which is interpreted as a random reef complex with associated limestones and marls which are interfingering with mudstones and sandstones of the basinal area of deposition of Namurian C and early Westphalian A times.

Only the formations up to the Lower Westphalian disconformity are discussed in the present paper (see text-fig.7). Above this disconformity a mainly marine succession of Westphalian B and lower Westphalian C strata is found in the region discussed in the present paper (compare MOORE *et al.* 1971), and also further north in the central Asturian coalfield (see GARCÍA-LOYGORRI *et al.* 1971).

NOTE ON SOME GONIATITE FAUNAS

(C. H. T. WAGNER-GENTIS)

The find of a goniatite cast with preserved suture in black shales of the Vegamián Formation at 2 km SSW of Genicera (text-fig.1) and the discovery of an E_2 goniatite fauna with *Eumorphoceras bisulcatum* GIRTY from mudstones of the Olaja Beds at *ca.* 1,350 m south of Barrios de Gordón (text-fig.1) have provided additional biostratigraphic information which is recorded in this note. It also adds to the existing knowledge on the distribution of goniatite faunas in the Cantabrian Cordillera.

The writer wishes to express her appreciation to Dr. C. F. WINKLER PRINS and Dr. R. H. WAGNER for the provision of material from the localities near Genicera and Barrios de Gordón, respectively. She is deeply indebted to Dr. W. H. C. RAMSBOTTOM (Institute of Geological Sciences, Leeds, U. K.) for many helpful suggestions on the identification of certain specimens described in this note. Photographic facilities in the Geology Department, University of Sheffield (U. K.), are gratefully acknowledged.

Description of goniatite from Vegamián Formation

Family Muensteroceratidae LIBROVITCH 1957

Genus *Muensteroceras* HYATT 1884

Muensteroceras arkansanum GORDON 1964

Pl.1, figs 1a-b; text-fig.8

1964 *Muensteroceras arkansanum* GORDON, *U. S. Geol. Survey Prof. Paper,* 460, pp. 177-178, text fig. 37, Pl. 17, figs 10-16.

Material.—An internal cast with preserved suture found by C. F. WINKLER PRINS in black shales of the Vegamián Formation, 2 km SSW of Genicera (loc.1165 B of WAGNER 1963, p.54), Cordillera Cantábrica (prov. León). The locality is the same as that of the stratotype of the Genicera Formation which forms a gradual transition (text-fig.4).

Description.—Shell is an involute sphaerocone, with rounded ventral and lateral sides. The greatest width is at the middle of the sides. Umbilicus very small, and umbilical shoulders rounded. Dimensions: diameter 12 mm, width 8 mm, height of outer whorl 6 mm, height of opening 3.5 mm. No ornamentation preserved. Constrictions deep and narrow, crossing straight over the sides and venter. Seven constrictions are visible in one whorl. Suture line (text-fig.8) consists of a ventral lobe with diverging sides and a low median saddle; wide and rounded ventro-lateral saddles; V-shaped lateral lobes slightly inflated around the central part; and a wide, rounded lateral saddle ending at the umbilical shoulder. No suture visible on the umbilical wall.

Text-fig. 8.—Muensteroceras arkansanum Gordon. Suture (× 3) showing the low median saddle. RGM-St. 167508.

D i s c u s s i o n.—The shape of this specimen is similar to that of *Pericyclus minimus* Hind (1910, p.107, Pl. IV, figs 4-5a), the suture of which is unfortunately unknown. *Muensteroceras arkansanum* has been described by Gordon (1964, p. 177, text-fig.37, Pl.17, figs 10-16) from the late Kinderhookian of Arkansas (Gordon 1970, p.818). The goniatites found in association with *M. arkansanum* in North America include *Protocanites* cf. *P. lyoni* (Meek & Worthen). The species *P. lyoni* is regarded as early Tournaisian in age and occurs in the lower part of the *Gattendorfia* Zone in Germany (H. Schmidt 1925). Some doubt attaches, however, to the identification of the German Lower Tournaisian forms with *P. lyoni* (Schindewolf 1926— *fide* Miller & Collinson 1951, p. 481), and the correlation of late Kinderhookian with Lower Tournaisian is perhaps not quite as firmly established as might be desirable. In fact, Gordon (1964, p. 83) did at first suggest a correlation of late Kinderhookian with *late* Tournaisian, and apparently modified this opinion in 1970 (p. 824) by reference to the occurrence of *Merocanites* in rocks attributed to the Upper Tournaisian by Prentice & Thomas (1965). The latter authors recorded *Merocanites* from strata of the C_1 coral-brachiopod zone in Britain and adduced evidence for a late Tournaisian age by correlating with the II α goniatite zone. However, the goniatites recorded by George & Howell (1939) from the C_1 division in the Gower Peninsula of Wales belong to the II β-γ Zone, which is Lower Viséan. Since the *Merocanites* occurrences are clearly higher than that of *Protocanites lyoni* and *Muensteroceras arkansanum*, the latter were probably assigned too early an age on the basis of the dating published by Prentice & Thomas. Reasons have been given for regarding the locality of *Muensteroceras arkansanum* in NW Spain as late Tournaisian in age (compare page 625).

D i s t r i b u t i o n.—North America: Arkansas, Walls Ferry Limestone, where it occurs together with *Muensteroceras collinsoni* Gordon, *Gattendorfia* sp., *Imitoceras sinuatus* Gordon, *Ammonellipsites* sp. and *Protocanites* cf. *lyoni* (Meek & Worthen), a late Kinderhookian assemblage (Gordon 1970).—NW Spain: Cordillera Cantábrica, 2 km SSW of Genicera (prov. León), in black shales of the Vegamián Formation, of late Tournaisian age.

A n E_2 f a u n a f r o m t h e O l a j a B e d s s o u t h o f B a r r i o s d e G o r d ó n

In the summer of 1962 a fauna of squashed goniatites, some of them showing sutures and some the ornamentation, was discovered in a locality approximately 1,350 metres south of Barrios de Gordón, in the province of León (text-fig.1). This locality (No.1227, coll. Wagner) is in green mudstones forming part of a complex of green and red mudstones occurring at *ca.* 10 m above the Genicera Limestone Formation (an approximate estimate of stratigraphic distance which is not very reliable due to poor exposure of the intervening beds). The green and red mudstones represent a condensed facies of the Lower Namurian which is described as the Olaja Beds in the present paper (page 630). It replaces the upper part of the Canalón Limestone Member of the Genicera Formation (see the description provided by WAGNER, WINKLER PRINS & RIDING). Faunal elements at loc.1227 (and at loc.1128, 1.80 m higher in the same exposure) are mainly goniatites, but lamellibranchs, trilobites, crinoids and rare brachiopods also occur. Among the goniatites the following elements were recognized:

Eumorphoceras bisulcatum cf. *grassingtonense* DUNHAM & STUBBLEFIELD.
Eumorphoceras bisulcatum cf. *leitrimense* YATES.
Kardailites sp. (see footnote on page 653).
Glaphyrites? - *Eoasianites*? sp.1 and 2.
Proshumardites delepinei SCHINDEWOLF.
Delepinoceras thalassoide (DELÉPINE) SCHINDEWOLF.
Gonioloboceras declive sp.nov.
Stenopronorites cf. *arkansasensis* (SMITH) SCHINDEWOLF.

The presence of two varieties (subspecies?) of *Eumorphoceras bisulcatum* GIRTY indicates the E_2 Zone of the Lower Namurian Arnsbergian Stage. *Proshumardites delepinei, Delepinoceras thalassoide* and *Gonioloboceras* sp.nov. (the latter under the name of *Gonioloboceras goniolobum* (MEEK)) were already described from the Lower Namurian E_2 of Spain by KULLMANN (1962) and WAGNER-GENTIS (1963), who collected from nodular limestones at the top of the Genicera Formation. The find of *Eumorphoceras bisulcatum* in association with *P. delepinei, D. thalassoide* and *Gonioloboceras* now confirms the attribution to the E_2 Zone, made previously.

Lower Namurian goniatite faunas are also known from the western Pyrenees (SCHMIDT 1951, 1955, GÓMEZ DE LLARENA 1952), and one of these contains *Eumorphoceras* aff. *bisulcatum* GIRTY (as figured by SCHMIDT 1951, text-fig.3, Taf. 13, fig.1).

Family Girtyoceratidae WEDEKIND 1918

Genus *Eumorphoceras* GIRTY 1909

Eumorphoceras bisulcatum **cf.** ***grassingtonense*** DUNHAM & STUBBLEFIELD

Pl.1, fig.3

1945 *Eumorphoceras bisulcatum* GIRTY mut. *grassingtonensis* DUNHAM & STUBBLEFIELD. *Quart. Jl. geol. Soc. London,* 100 (for 1944), pp.258-260, Pl. XI, figs 4 a-c.
1962 *Eumorphoceras bisulcatum grassingtonense* YATES. *Palaeontology,* 5, pt.3, pp.381-382, Pl.52, figs 3-4.

M a t e r i a l.—One squashed specimen (part and counterpart) which is incomplete and slightly distorted (loc.1227).

D e s c r i p t i o n.—Diameter *ca.*10.5 mm, umbilicus *ca.* 3 mm. Specimen with strong, geniculate ribs, 8 per quarter whorl, and nodes at the umbilical margin where the ribs commence. Ribs cross straight over the lateral side and bend sharply forwards near the latero-ventral side. A bifurcating rib has been observed at one node, the orad one being the stronger of the two. Immediately after the bifurcating rib a fairly deep transverse groove is found, probably representing a constriction, and this is followed by a single rib. Subsequent ribs appear in pairs with the interspaces wider than the width of two ribs together. It is possible that the pairs of ribs are really constrictions with thickening at both sides of the constriction. Following ribs begin to fade and occupy only half the length of the whorl, whilst the tubercles at the base of the ribs become stronger. No ventro-lateral grooves are visible.

Discussion.—This specimen differs from *E. bisulcatum grassingtonense* in that it fails to show the fine ornamentation as mentioned by DUNHAM & STUBBLEFIELD (1945, pp.258-259). It also possesses a smaller umbilicus. On the other hand, it resembles *grassingtonense* closely in the bifurcation of the ribs, in the number of ribs per quarter whorl, the tubercles at the base of the ribs and, possibly, in the constrictions.

Distribution.—British Isles: E_2a subzone, together with *Cravenoceras cowlingense* (DUNHAM & STUBBLEFIELD 1945, p.212; YATES 1962, pp. 381-382).

Eumorphoceras bisulcatum cf. *leitrimense* YATES
Pl. 2, fig. 8

1962 *Eumorphoceras bisulcatum leitrimense* YATES. *Palaeontology*, 5, pt.3, pp.385-386, Pl.53, figs 4-5, Pl.54, figs 5-6, Pl.55, fig.5.

Material.—One poorly preserved impression (loc.1227).

Description.—Specimen of diameter 17 mm and umbilicus 1.75 mm, showing a flat flank, a rounded venter, and a deep latero-ventral groove continuing to the end of the whorl. Two constrictions are visible, the first one showing only the lateral part, and the second marking its course both laterally and ventrally. On the lateral side it curves strongly forwards into the longitudinal groove where it bends sharply backwards, forming a V-shaped point on the longitudinal groove and continuing as a sinus on the venter. At a shell diameter of *ca.* 10 mm the two constrictions, 40° apart, show two very short ribs in the interspace, one of which is virtually coincident with a constriction. Immediately after the constriction a further three ribs are seen before the whorl continues with a smooth surface, with the exception of the longitudinal groove.

Discussion.—Although the specimen in hand is much larger than the Irish ones (which have a diameter of 6-10 mm), and thus compares better in this respect with the German species *E. bisulcatum* var. *varicata* (SCHMIDT 1934, p. 455, p. 449, fig. 29), showing a diameter of *ca.* 15 mm, it resembles the Irish material more closely in possessing considerably fewer ribs between the constrictions. *Eumorphoceras bisulcatum varicatum* shows from 7 to 4 riblets between the constrictions at 12 mm diameter and over.

The specimen from Barrios has clearly a smaller umbilicus than either the German or the Irish variety (or subspecies). It possibly represents a new variety of *E. bisulcatum*, showing constrictions, but its poor preservation precludes a description as such.

D i s t r i b u t i o n.—Ireland: Slieve Anierin, Co. Leitrim (Eire), where it occurs with *Posidonia corrugata* (ETHERIDGE) and *Anthracoceras paucilobum* (PHILLIPS) in the E_2b subzone (YATES 1962).—Germany *(E. bisulcatum varicatum)*: Ruhrgebiet, at Arnsberg, high in the *E. bisulcatum* Zone (SCHMIDT 1934, p. 444).

Family Homoceratidae SPATH 1934

Genus *Glaphyrites* RUZHENCEV 1936

Glaphyrites? sp.

Pl. 2, fig. 11

M a t e r i a l.—One squashed specimen showing the suture but no ornamentation (loc. 1227).

D e s c r i p t i o n.—Incomplete specimens showing a very wide, rounded venter with a wide and shallow sulcus following the venter. The suture is characterized by a very wide, bifid ventral lobe with a wide and high median saddle. The ventro-lateral saddles are wide and rounded. Lateral lobes are V-shaped and slightly inflated. The remainder of the suture is not preserved.

D i s c u s s i o n.—Notable characteristics are the extremely wide ventral lobe with regard to its depth, and the wide median saddle taking up $^2/_5$ of the width of the ventral lobe. In *Neoglaphyrites* RUZHENCEV the ventral lobe is proportionately even wider than in the specimen at hand, which appears to be intermediate between *Neoglaphyrites* and *Glaphyrites* (compare RUZHENCEV 1960, p.212, text-figs 88 b-c). However, there is a good deal of variation in the width of ventral lobes as shown for different species of *Glaphyrites* (RUZHENCEV 1950, text-figs 59-66).

The specimen is not well enough preserved to attempt a specific identification.*

D i s t r i b u t i o n.—*Glaphyrites* is widely distributed, both geographically (Russia, North America, Spain) and stratigraphically (Namurian to Orenburgian, late Mississippian to late Pennsylvanian).

Glaphyrites? — *Eoasianites*? sp. 1.

Pl.1, fig.2

M a t e r i a l.—One poorly preserved imprint showing the ornamentation.

D e s c r i p t i o n.—Canted transverse ribs are seen crossing almost in a straight line over the lateral side and venter. There is no apparent ornament around

* *Note added when this paper was in press:* The recent description of the genus *Kardailites*, of the Cravenoceratidae, by RUZHENCEV & BOGOSLOVSKAYA (1971, pp. 271-272, fig. 65), is entirely applicable to the specimen in hand. This genus, with a single species, was found in the southern Urals where it occurred in a Lower Namurian assemblage containing similar forms to those of the E_2 faunas of N. W. Spain.

the umbilical edge which is smooth. Constrictions are present on the flank but not on the venter. The diameter is estimated at 35 mm, and the width is probably about half the diameter, with the umbilicus occupying one third of the diameter.

D i s c u s s i o n.—A similar ornament of canted transverse ribs has been figured for *Glaphyrites striatus* RUZHENCEV (see RUZHENCEV 1950, Tab. XI, figs 1, 3), but this species has coarser ribs showing a distinct forward bend over the venter. The specimen in hand also vaguely resembles *Cravenoceras hesperium* MILLER & FURNISH (compare GORDON 1964, Pl.3, figs 30-32). The same general kind of ornament may also occur in *Eoasianites* and, in the absence of a suture, no definite identification can be made.

Glaphyrites? — *Eoasianites*? sp. 2.
Pl.1, fig.4

M a t e r i a l.—One poorly preserved imprint of the ornamentation.

D e s c r i p t i o n.—Fragment showing the canted transverse striae, and a slightly undulose surface around the umbilicus.

D i s c u s s i o n.—In the absence of a suture and recognizable shell shape the identification is highly tentative. This ornament resembles slightly that of *Cravenoceras miseri* GORDON (compare GORDON 1964, Pl.21, figs 1-7) from Arkansas, which also shows undulations around the umbilicus. The presence of ribs or folds around the umbilicus has been described for *Eoasianites* (RUZHENCEV 1960). Both *Glaphyrites* and *Eoasianites* have an ornament of transverse striae.

Family Agathiceratidae ARTHABER 1911
Genus *Proshumardites* RAUSER 1928
Proshumardites delepinei SCHINDEWOLF
Pl. 1, fig. 5; Pl. 2, fig. 10

This species, described previously from NW Spain by KULLMANN (1962, pp.328-331) and WAGNER-GENTIS (1963, pp.14-15), is represented here by two squashed specimens showing the characteristic suture. *P. delepinei* also occurs in the Lower Namurian of the western Pyrenees (recorded under the name of *P. karpinskyi* by H. SCHMIDT 1951 — compare KULLMANN 1962 and WAGNER-GENTIS 1963) and in the S^{4}c Zone of PAREYN (1961, pp. 159-163) in Algeria, North Africa.

Family Thalassoceratidae HYATT 1900
Genus *Delepinoceras* MILLER & FURNISH 1954
Delepinoceras thalassoide (DELÉPINE) MILLER & FURNISH
Pl.2, fig.9

This species was also recorded previously from NW Spain by KULLMANN (1962, pp.79-83, under the name of *Delepinoceras bressoni cantabricus* KULLMANN) and by WAGNER-GENTIS (1963, pp.16-18). It is found here (loc. 1227) in a squashed condition but showing the suture on the venter and on the ventro-lateral sides. *D. thalassoide* was first described from North Africa (DELÉPINE, *in* DELÉPINE & MENCHIKOFF 1937, p.83, Pl.V, figs 6-7), where it occurs in the S^4c Zone of PAREYN (1961, p. 134).

Family Gonioloboceratidae SPATH 1934
Genus *Gonioloboceras* HYATT 1900
Gonioloboceras declive sp.nov.
Pl.1, fig.6; Pl.3, figs 12a-c; text-figs 9-10

1962 *Gonioloboceras goniolobum* KULLMANN, *non* MEEK. *Abh. Math.-Naturwiss. Kl., Akad. Wiss. Lit., Jg.* 1962, 6, pp.277-279, Abb.2g, 3a, Taf.1, fig.1.

M a t e r i a l.—One squashed specimen is available from loc. 1227, near Barrios de Gordón. An internal mould in limestone (holotype: Pl.3, figs 12 a-c; text-fig.9) was recently collected from loc. 1069, opposite the Venta de Getino (additional to the fauna described by WAGNER-GENTIS 1963, p.8), and a fragment of a whorl preserved as an internal mould in limestone was found in loc.352, NW of Villanueva de la Tercia, in the Bernesga Valley (compare MOORE, NEVES, WAGNER & WAGNER-GENTIS 1971, p. 312). All three specimens show sutures and lack the living chamber.

Text-fig. 9.—Gonioloboceras declive sp. nov., holotype. Sutures (× 1) at heights of 32 mm and 48 mm, respectively. RGM-St. 167519.

R e p o s i t o r y o f h o l o t y p e.—Rijksmuseum van Geologie en Mineralogie, Leiden, Cat. No. RGM-St. 167519.

D e r i v a t i o n o m i n i s.—The term steep (*Lat. adj.* declivis, declive) is being used to indicate the relative steepness of the slope of the median saddle which only possesses a faint indication of the shoulders which are so clearly developed in the younger species of *Gonioloboceras*.

D i a g n o s i s.—Discoidal, extremely involute shell with a high opening, and the greatest width of whorl near the umbilicus; venter rounded, umbilicus very small;

typical *Gonioloboceras* suture with a high median saddle showing incipient shoulders, and the apices of first lateral saddles hardly deflected towards the umbilicus.

D e s c r i p t i o n.—The holotype has a diameter of 80 mm, a width of *ca.* 24 mm, a whorl height of 48 mm, an opening of 24 mm, an umbilicus of 1 mm, and 6 to 7 sutures per quarter whorl. The specimen from loc. 352, which is only a fragment, has a whorl height of 33 mm, and 7 sutures per quarter whorl. The flattened specimen of loc.1227 has a diameter of *ca.* 45 mm, a whorl height of *ca.* 22 mm, and 8 sutures per quarter whorl. The holotype has a flat discoidal shape and is extremely involute. It has a narrow, rounded venter and wide, only slightly curved sides. The greatest width is near the umbilicus.

The holotype shows a suture with a ventral lobe possessing sharp tips and containing a median saddle with fairly steep slopes and only a faint indication of a shoulder near its tip. The siphonal notch is small (for measurements of the ventral lobe see the

Text-fig. 10.—Gonioloboceras declive sp. nov., unfigured specimen from loc. 352. Suture (× 1) at a whorl height of 31 mm. RGM-St. 167520.

Table on the opposite page). The first lateral saddle is bluntly pointed and pinched at its top. The ventral slope of this saddle is only a little longer than the umbilical slope and the saddle is therefore pointing only slightly towards the umbilicus. The lateral lobe has a sharp point which is apparently lengthened by a spiral line cutting through its tip and linking successive lobes. The lower part of the lateral lobe is a little pinched. The second lateral saddle is wide and rounded and ends in the umbilicus at a level above that of the tip of the lateral lobe (see text-fig.9). The fragment from loc. 352 shows the same suture (text-fig.10). The flattened specimen from loc.1227 gives a slightly distorted picture of the width of the lobes and saddles, especially near the venter. However, it does show clearly the median saddle with a slight bend in the upper portion. The ventral lobe and the first lateral saddle appear narrower in this specimen because its venter was squashed in one plane with the lateral side.

An interesting feature is the presence of a fine longitudinal tube which is seen to cut through the tips of the lateral lobes, and which is clearly visible in the last part of the whorl of the flattened specimen as figured on Pl.1, fig.6, where it appears to be open. Lower down the whorl this tube appears as a fine spiral ridge. Only a spiral line occurs in the holotype and in the specimen from loc.352.

No ornamentation has been preserved.

D i s c u s s i o n.—The spiral tube, as described above, is also visible as a spiral line on the photograph published by KULLMANN (1962, Taf.1, fig.1) for a specimen which is here placed in the synonymy of *Gonioloboceras declive*. A similar spiral line is visible in a *Gonioloboceras* cf. *goniolobum* from northern Kazakhstan (LIBROVITCH 1940, Tab. XXII, fig.4a), and it also appears in specimens of *Gonioloboceras welleri*

Table 1.—Measurements of the ventral lobe in some species of *Gonioloboceras* and *Eogonioloboceras*

	I_1	I_2	II	III	IV	V	VI	VII	VIII
H	32	48	31	34	41	34	17	—	—
d. VL	14	23	17	18	19	19	14	16	17
m. w. VL	22	38	27	28	36	27	21	30	34
w. VL	10	15	11	11	14	14	10	14	15
h. MS	9	14	9	10	12	8	5	9	9
h. MS in % of w. VL	80 %	90 %	80 %	80 %	85 %	57 %	50 %	63 %	60 %
d. VL in % of m. w. VL	63 %	60 %	64 %	64 %	50 %	70 %	70 %	60 %	50 %

Explanation of table: H=whorl height of specimen; d.VL=depth of ventral lobe; m.w.VL = maximum width of ventral lobe, taken between the tips of first lateral saddles; w.VL = width of ventral lobe, taken between lower tips of the ventral lobe; h.MS = height of median saddle. $I_{1,2}$ = holotype from Getino (León), loc.1069; II = specimen from Bernesga River Valley (León), loc.352; III = «*Gonioloboceras goniolobum*» from Tolibia (León) (KULLMANN 1962, Abb. 3a, Taf. 1, fig. 1); IV = *Gonioloboceras goniolobum* from the Upper Pennsylvanian of New Mexico (ELIAS 1962, Pl.4,fig.2); V=*Eogonioloboceras asiaticum* from northern Kazakhstan (LIBROVITCH 1940, p.180, fig.70); VI = *Gonioloboceras* cf. *goniolobum* (*Ibid.*, p.175, fig.68); VII = *Gonioloboceras* sp.nov. from the Lower Namurian (RUZHENCEV 1960, p.207, fig.84c); VIII = *Gonioloboceras goniolobum* from the Orenburgian (*Ibid.*, fig.84d). All measurements in mm.

(PLUMMER & SCOTT 1937, Pl.34, fig.3), and *Neodimorphoceras* cf. *armstrongi* (CURRIE 1954, Pl.III, fig.13). Two spiral lines are visible in *Neodimorphoceras texanum* (PLUMMER & SCOTT 1937, Pl.35, fig.5). In *Girtyoceras weetsense* (PAREYN 1961, Pl.X, fig.9) and *Eumorphoceras bisulcatum* (MOORE 1946, Pl.III, fig.7) a single spiral line is seen to cut through the ventral leg of the lateral lobe. This is a most intriguing feature which does not show up in all the specimens figured of the genera mentioned above.

A tabular review of the measurements of the ventral lobe in various published specimens (and including those described here) shows the same proportions for the material found in NW Spain (Table 1 — specimens I, II and III), and different proportions for superficially similar Russian and American specimens. This supports the attribution of the Spanish material to a single species, different from the comparable ones in the table. This species is referred to *Gonioloboceras* in preference to *Eogonioloboceras* LIBROVITCH 1957, because it shows a higher median saddle at the same whorl height than *Eogonioloboceras*. The Spanish species shows a similar height of median saddle to *Gonioloboceras goniolobum* (MEEK) from the American Upper Pennsylvanian, but differs in possessing a narrower ventral lobe. *Eogonioloboceras* has an even narrower ventral lobe, and thus differs in more than one respect from the Spanish material which is closer to *Gonioloboceras*. The new species *Gonioloboceras declive* can be distinguished from *G. goniolobum* and other late Carboniferous species of *Gonioloboceras* by noting the following characteristics: (1) the tips of the first lateral saddles of the Upper Pennsylvanian and Orenburgian species are more deflected towards the umbilicus; (2) the median saddle of these species has more pronounced shoulders in the top part. The Lower Namurian *Gonioloboceras* sp.nov. of RUZHENCEV 1960 (p. 207, fig. 84c) shows different proportions of the ventral lobe, although the general shape of its suture is similar to that of *Gonioloboceras declive*. No later information on RUZHENCEV's species is known to the present author.

Occurrence.—NW Spain:-limestone quarry opposite the Venta de Getino, Torío River Valley, prov. León (loc. 1069); -mudstones at *ca.* 1,350 m south of Barrios de Gordón (León) (loc.1227); - limestone quarry in a side valley just off the Bernesga River Valley at *ca.* 2 km NW of Villanueva de la Tercia (León) (loc.352); - Curueño River Valley, south of Tolibia de Abajo (León) (KULLMANN 1962, pp.269-270); - limestone quarry immediately west of Perlora, SE of Candás on the North Asturian coast (KULLMANN 1962, p.267). All specimens from E_2 Zone.

Family Pronoritidae FRECH 1901
Genus *Stenopronorites* SCHINDEWOLF 1934
Stenopronorites cf. *arkansasensis* (SMITH) SCHINDEWOLF
Pl.2, fig.7

A well preserved fragment, showing part of the suture, is available from loc.1227, south of Barrios de Gordón. *Stenopronorites* cf. *arkansasensis* is a common constituent of the E_2 goniatite faunas in NW Spain which has been mentioned but not described from this area (WAGNER-GENTIS 1963, p.8). The specimen in hand is insufficient for a detailed description, which will have to wait till additional material can be considered.

The Spanish Lower Namurian (E_2) specimens compare with *St. arkansasensis* in possessing a symmetrically divided ventro-lateral lobe of which the secondary saddle has a semicircular top. However, the American material (e.g. McCALEB 1968, pp.76-79) is characterized by a deeper indentation of the bifid ventro-lateral lobe, and therefore appears to be more highly evolved than the Spanish specimens. *St. arkansasensis* is mentioned as a common element throughout the Morrowan and ranges into the Missourian (McCALEB 1968, p.79). It thus occurs in strata higher than the Lower Namurian.

REFERENCES

ADARO, L. DE (1914).—Emplazamiento de sondeos para investigar la probable prolongación de los senos hulleros por bajo de los terrenos mesozoicos. *Bol. Inst. Geol. España*, XXXIV (1913), pp.9-79, láms I-III.

ADARO, L. DE (1926).—Atlas del Estudio estratigráfico de la Cuenca Hullera Asturiana. *Inst. Geol. España*, láms 1-10.

ADRICHEM BOOGAERT, H. A. VAN (1967).—Devonian and Lower Carboniferous conodonts of the Cantabrian Mountains (Spain) and their stratigraphic application. *Leidse Geol. Meded.*, 39, pp.129-192, text-figs 1-68, pls 1-3, Encl. 1-6.

ADRICHEM BOOGAERT, H. A. VAN, BREIMER, A., KRANS, Th. F. & SJERP, N. (1963).—A new stratigraphic interpretation of Palaeozoic sections in the region between San Isidro Pass and Tarna Pass (province of León, Spain). *Notas y Comuns. Inst. Geol. Min. España*, 70, pp.131-135, 1 fig.

BARROIS, Ch. (1881).—Sur le calcaire carbonifere du Nord de l'Espagne. *Ass. français avanc. Sci., C. R. X session (Alger)*, pp.516-524.

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

BLESS, M. J. M. (1968).—On two hollinid ostracode genera from the Upper Carboniferous of northwestern Spain. *Leidse Geol. Meded.*, 43, pp. 157-190, text-figs 1-49, pls 1-10, strat. sections.

BOSCH, W. J. VAN DEN (1969).—Geology of the Luna-Sil region, Cantabrian Mountains (NW Spain), *Leidse Geol. Meded.*, 44, pp.137-225, text-figs 1-116, geol. map and sections.

BOSCHMA, D. & STAALDUINEN, C. J. VAN (1968).—Mappable units of the Carboniferous in the southern Cantabrian Mountains. *Leidse Geol. Meded.*, 43, pp.221-232, text-figs 1-6, Encl. (fig.7).

BROUWER, A. (1968).—Devonian of the Cantabrian Mountains, northwestern Spain. *Int. Symp. Devonian System, Calgary 1967*, II, pp. 37-45, text-figs. 1-2.

BROUWER, A. & GINKEL, A. C. VAN (1964).—La succession carbonifère dans la partie méridionale des Montagnes Cantabriques (Espagne du Nord-Ouest). *C. R. 5e Congrès Carbonifère, Paris 1963*, I, pp.307-319, text-figs 1-2.

BUDINGER, P. & KULLMANN, J. (1964).—Zur Frage von Sedimentationsunterbrechungen im Goniatiten- und Conodonten-führenden Oberdevon und Karbon des Kantabrischen Gebirges (Nordspanien). *Neues Jb. Geol. Paläont. Mh.*, 1964-7, pp.414-429, Abb.1-2.

COLLINSON, C. (1955).—Mississippian Prolecanitid Goniatites from Illinois and adjacent states. *Jl. Paleont.*, 29, pp.433-438, pl.45.

COLLINSON, C., SCOTT, A. J. & REXROAD, C. B. (1962).—Six charts showing Biostratigraphic Zones, and Correlations based on Conodonts from the Devonian and Mississippian Rocks of the Upper Mississippi Valley. *Illinois Geol. Survey Circular*, 328, pp.1-32, charts 1-6.

COMTE, P. (1936).—La série dévonienne du Léon (Espagne). *C. R. Acad. Sci., Paris*, 202, pp.337-339.

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

COMTE, P. (1959).—Recherches sur les terrains anciens de la Cordillère Cantabrique. *Mem. Inst. Geol. Min. España*, LX, pp.1-440, carte géol. et coupes.

CURRIE, E. D. (1954).—Scottish Carboniferous Goniatites. *Trans. Roy. Soc. Edinburgh*, LXII (1951-53), II, no.14, pp.527-602, text-figs 1-9, pls I-IV.

DELÉPINE, G. (1928).—Sur les faunes marines du Carbonifère des Asturies (Espagne). *C. R. Acad. Sci., Paris*, 187, pp.507-509.

DELÉPINE, G. (1938).—Corrélations entre le Carbonifère moyen de la Russie et celui de l'Europe Occidentale. *Bull. Soc. géol. France*, (5), VIII, pp.593-598, 1 fig.

DELÉPINE, G. (1941).—Les goniatites du Carbonifère du Maroc et des confins algéro-marocains du Sud (Dinantien-Westphalien). *Notes Mém. Serv. géol. Maroc*, 56, pp.1-110, pls I-VIII.

DELÉPINE, G. (1943).—Les faunes marines du Carbonifère des Asturies (Espagne). *Mém. Acad. Sci. Inst. France*, 66, pp.1-122, pls I-VI (trad. extr. P. HERNÁNDEZ-SAMPELAYO 1946 - Faunas marinas del Carbonífero de Asturias. *Bol. Inst. Geol. Min. España*, LIX, pp.21-127, láms I-VI).

DELÉPINE, G. (1951).—Studies of the Devonian and Carboniferous of Western Europe and North Africa. *Proc. Geol. Ass.*, 62, 2, pp.140-166, text-figs 1-8.

DELÉPINE, G. & LLOPIS LLADÓ, N. (1956).—Nouvelle faune carbonifère à Latores (Asturies, Espagne). *C. R. somm. Soc. géol. France*, 1956-8, pp.106-108.

DELÉPINE, G. & MENCHIKOFF, N. (1937).—La faune des schistes carbonifères à *Proshumardites* de Haci-Diab (Confins algéro-marocains du Sud). *Bull. Soc. géol. France*, (5), VII, pp.77-90, pl.V.

DUNHAM, K. C. & STUBBLEFIELD, C. J. (1945).—The stratigraphy, structure and mineralization of the Greenhow Mining Area, Yorkshire. *Quart. Jl. geol. Soc. London*, C (for 1944), pts 3 & 4, pp. 209-268, pl. XI.

ELIAS, M. K. (1938).—Revision of *Gonioloboceras* from late Paleozoic rocks of the Midcontinent Region (pt. II of «Studies of late Paleozoic Ammonoids»). *Jl. Paleont.*, 12, pp.86-105, text-figs 1-2, pls 19-20.

ELIAS, M. K. (1962).—Differentiation of species in *Gonioloboceras* (Studies of late Paleozoic ammonoids No.4): *Paläont. Z.* (H. SCHMIDT-Festband), pp. 29-37, pls 3-4.

EVERS, H. J. (1967).—Geology of the Leonides between the Bernesga and Porma Rivers, Cantabrian Mountains, NW Spain. *Leidse Geol. Meded.*, 41, pp.83-151, text-figs 1-77, geol.map and sections.

EZQUERRA DEL BAYO, J. (1844).—Descripción geognóstica y minera de la provincia de Palencia. *Bol. Oficial Minas*, XIV, pp.160-163.

GARCÍA-LOYGORRI, A., ORTUÑO, G., CARIDE DE LIÑÁN, C., GERVILLA, M., GREBER, Ch. & FEYS, R. (1971).—El Carbonífero de la Cuenca Central Asturiana. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 3, pp. 101-150, Figs. 1-24, láms. 1-5.

GEORGE, T. N. & HOWELL, E. J. (1939).—Goniatites from the Caninia Oolite of Gower. *Ann. Mag. Nat. Hist.*, (11), IV, pp.545-561. text-figs 1-10.

GINKEL, A. C. VAN (1965).—Carboniferous fusulinids from the Cantabrian Mountains. *Leidse Geol. Meded.*, 34, pp.1-225, text-figs 1-13, pls I-LIII, maps and sections.

GÓMEZ DE LLARENA, J. (1952).—La magnesita sedimentaria de los Pirineos navarros. *Actas Primer Congr. Int. Pirineo*, 1950, pp.1-19, figs 1-20.

GORDON, M. (1964[a]).—Carboniferous Cephalopods of Arkansas. *U. S. Geol. Survey, Prof. Paper*, 460, pp. 1-305, text-figs 1-96, pls 1-30.

GORDON, M. (1964[b]).—California Carboniferous Cephalopods. *U. S. Geol. Survey, Prof. Paper*, 483-A, pp.4-25, text-figs 1-12, pls 1-4.

GORDON, M. (1970).—Carboniferous Ammonoid Zones of the South-Central and Western United States. *C. R. 6[e] Congrès Carbonifère, Sheffield 1967*, II, pp.817-826.

HEDBERG, H. (1970).—Preliminary report on stratotypes. *Int. Subcomm. Strat. Classification, Int. Comm. Strat., Circular* 27, pp.4-32.

HIGGINS, A. C. (1962).—Conodonts from the «Griotte» Limestone of Northwest Spain. *Notas y Comuns. Inst. Geol. Min. España*, 65, pp.5-21, text-figs 1-2, pls 1-3.

HIGGINS, A. C. (1971).—Conodont biostratigraphy of the late Devonian - early Carboniferous rocks of the south central Cantabrian Cordillera. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 3, pp.179-192, text-figs 1-4, pls 1-5.

HIGGINS, A. C., WAGNER-GENTIS, C. H. T. & WAGNER, R. H. (1964).—Basal Carboniferous Strata in Part of Northern León, NW. Spain: Stratigraphy, Conodont and Goniatite Faunas. *Bull. Soc. belge Géol. Paléont. Hydrol.*, LXXII (for 1963), 2, pp.205-248, text-figs 1-5, pls I-V.

HIND, W. (1910).—On four new Carboniferous Nautiloids and a Goniatite new to Great Britain. *Proc. Yorks. Geol. Soc.*, XVII, II, pp.97-109, pls III-VII.

HUDSON, R. G. S. (1946).—The Namurian goniatites *Cravenoceratoides bisati* HUDSON and *Cravenoceratoides lirifer* n.sp.—*Proc. Yorks. Geol. Soc.*, XXV, 6, pp.375-386, pls XXI-XXIa.

JONGMANS, W. J. & WAGNER, R. H. (1957).—Apuntes para el estudio geológico de la Zona Hullera de Riosa (Cuenca Central de Asturias). *Estudios Geol.*, XIII, 33, pp.7-26, lám. II.

JORDAN, H. & BLESS, M. J. M. (1971).—Nota preliminar sobre los ostrácodos de la Formación Vegamián. *Breviora Geol. Astúrica*, XIV (1970), pp. 37-44, figs, 1-21.

JULIVERT, M. (1957).—Síntesis del estudio geológico de la cuenca de Beleño (Altos valles del Sella, Ponga, Nalón y Esla). *Breviora Geol. Astúrica*, I, 1-2, pp.9-12.

JULIVERT, M. (1961).—Estudio geológico de la cuenca de Beleño. Valles altos del Sella, Ponga, Nalón y Esla, de la Cordillera Cantábrica. *Bol. Inst. Geol. Min. España*, LXXI (1960), pp.1-346, figs 1-72, fotos 1-17, mapa geol.

JULIVERT, M. (1967).—La ventana del río Monasterio y la terminación meridional del manto del Ponga. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 1, pp.59-76, figs 1-5, mapa geol.

KANIS, J. (1956).—Geology of the eastern zone of the Sierra del Brezo (Palencia - Spain). *Leidse Geol. Meded.*, XXI, pp.377-445, text-figs 1-27, pls 1-3, map and sections (edición esp. KANIS, J. 1960 - Investigaciones geológicas en la zona oriental de la Sierra del Brezo. *Estudios Geol.*, XVI, pp.109-156, figs 1-31, láms I-III, mapa geol. y cortes).

KOOPMANS, B. N. (1962).—The sedimentary and structural history of the Valsurvio Dome, Cantabrian Mountains, Spain. *Leidse Geol. Meded.*, 26, pp.121-232, text-figs 1-38, geol. map and sections.

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

KULLMANN, J. (1962).—Die Goniatiten der Namur-Stufe (Oberkarbon) im Kantabrischen Gebirge, Nordspanien. *Abh. Math.-Naturwiss. Kl., Akad. Wiss. Lit., Jg.* 1962, 6, pp.258-377, Abb.1-17, Tafn 1-7.

KULLMANN, J. (1963[a]).—Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien). II. Paläontologie der U. O. Prolecanitina MILLER & FURNISH. Die Altersstellung der Faunen. *Neues Jb. Geol. Paläont., Abh.*, 116, 3, pp.269-324, Abb.1-11, Tafn 17-20.

KULLMANN, J. (1963b).—Las series devónicas y del Carbonífero inferior con ammonoideos de la Cordillera Cantábrica (trad. J. GÓMEZ DE LLARENA). *Estudios Geol.*, XIX, pp.161-179, figs 1-5, láms I-VI.

KULLMANN, J. (1966).—Goniatiten-Korallen-Vergesellschaftungen im Karbon des Kantabrischen Gebirges (Nordspanien). *Neues Jb. Geol. Paläont., Abh.*, 125, pp.443-466, Abb.1-6, Tafn 40-41.

LIBROVITCH, L. S. (1940).—Carboniferous Ammonoids of North Kazakhstan. *Akad. Nauk SSSR, Paleont. Inst., Paleontologiya SSSR*, IV, pt. 9, 1, pp. 1-391, text-figs. 1-78, Tab. I-XXV (in Russian, English Summary pp. 219-329).

LIBROVITCH, L. S. (1957).—About certain new groups of goniatites from Carboniferous deposits. *Ezhegd. vsesojuzn. paleont. obshtch.*, XVI, pp. 246-272, figs. 1-10, Tab. I-IV (in Russian).

LLOPIS LLADÓ, N. (1954).—Estudio geológico del reborde meridional de la Cuenca Carbonífera de Asturias. *Rev. Pirineos*, 31-32, pp.33-177, figs 1-29, láms I-XI, mapa geol. (*Mon. Geol. Inst. Geol. Apl. Oviedo*, III, 1955).

LLOPIS LLADÓ, N. (1960).—Estudio geológico de las Sierras de Coruxera, Mostayal y Monsacro. *Mon. Geol. Inst. Geol. Apl. Oviedo*, XIV, pp.1-132, figs 1-19, láms I-IV, mapa geol. (publ.1950).

LOTZE, F. (1945).—Zur Gliederung der Varisziden der Iberischen Meseta. *Geotektonische Forschungen*, 6, pp.78-92, Abb. 1.

LOTZE, F. (1963).—Die variszischen Gebirgszusammenhänge im westlichen Europa. *Giornale Geol., Ann. Mus. geol. Bologna*, (2), 31, pp.394-411, Abb.1-9.

McCALEB, J. A. (1968).—Lower Pennsylvanian Ammonoids from the Bloyd Formation of Arkansas and Oklahoma. *Spec. Paper Geol. Soc. America*, 96, pp.1-91, text-figs 1-27, pls 1-12.

MARCOS, A. (1967).—Estudio geológico del reborde NW de los Picos de Europa (región de Onís-Cabrales, Cordillera Cantábrica). *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 1, pp.39-46, fig.1, mapa geol.

MARTÍNEZ ALVAREZ, J. A. (1962).—Estudio geológico del reborde oriental de la cuenca carbonífera central de Asturias. *Inst. Est. Asturianos*, pp.1-229, figs 1-31, fotos 1-49, mapas geol. y cortes.

MARTÍNEZ-GARCÍA, E. (1971).—The age of the Caliza de Montaña in the eastern Cantabrian Mountains. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 3, pp. 267-276, text-figs 1-2.

MILLER, A. K. & COLLINSON, C. (1951).—Lower Mississippian Ammonoids of Missouri. *Jl. Paleont.*, 25, no.4, pp.454-487, text-figs 1-14, pls 68-71.

MOORE, E. W. J. (1946).—The Carboniferous goniatite genera *Girtyoceras* and *Eumorphoceras*. *Proc. Yorks. Geol. Soc.*, 25, 6, pp.387-454, text-figs 1-29, pls XXII-XXVII.

MOORE, L. R., NEVES, R., WAGNER, R. H. & WAGNER-GENTIS, C. H. T. (1971).—The stratigraphy of Namurian and Westphalian rocks in the Villamanín area of northern León, NW Spain. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 3, pp. 307-363, text-figs 1-7, pls 1-8.

PAILLETTE, A. (1845).—Recherches sur quelques-unes des roches qui constituent la province des Asturies (Espagne). *Bull. Soc. géol. France*, (2), II, pp.439-458, pl. XII.

PAREYN, C. (1961).—Les massifs carbonifères du Sahara sud-oranais. *Publ. Centre Recherches sahariennes*, (série géol.), I, tome II: Paléontologie, pp.1-244, figs 1-27, pls I-XXVIII.

PASTOR, V. (1963).—Explicación de la Hoja núm. 129, La Robla (León). *Mapa Geol. España, escala 1 : 50.000, Inst. Geol. Min. España*, pp.1-68, figs 1-6, fotos 1-32, mapa geol. y cortes.

PELLO, J. J. (1968).—Sobre la existencia de Devónico superior en la región central de Asturias y los problemas que plantea el contacto Devónico-Carbonífero al W de Oviedo. *Breviora Geol. Astúrica*, XII, 3, pp.11-16, figs 1-2.

PLUMMER, F. B. & SCOTT, G. S. (1937).—Upper Paleozoic Ammonites in Texas. *In* «The Geology of Texas» III, pt. 1, *Univ. Texas Bull.*, 3701, pp.1-516, text-figs 1-87, pls 1-41.

PRADO, C. DE (1856).—Mapa geológico de la provincia de Palencia (Escala 1 : 400.000). Grabado por G. PFEIFFER, C. del Prado 12, bajo, Madrid. (2.ª edición 1861).

PRADO, C. DE & VERNEUIL, E DE (1850).—Note géologique sur les terrains de Sabero et de ses environs dans les montagnes de León (Espagne). *Bull. Soc. géol. France*, (2), VII, pp. 137-186, pls. II-IV.

PRENTICE, J. E. & THOMAS, J. M. (1965).—Prolecanitina from the Carboniferous Rocks of North Devon. *Proc. Yorks. Geol. Soc.*, 35, pt. I, pp. 33-46, text-figs 1-2, pls 1-2.

QUIRING, H. (1939).—Die ostasturischen Steinkohlenbecken. *Archiv f. Lagerstättenforschung*, 69, pp.1-66, Abb.1-14, Tafn 1-3.

RÁCZ, L. (1964).—Carboniferous calcareous algae and their associations in the San Emiliano and Lois-Ciguera Formations (prov. León, NW. Spain). *Leidse Geol. Meded.*, 31, pp.1-112, text-figs 1-26, pls I-XIII, geol. map.

RADIG, F. (1962).—Ordovizium/Silurium und die Frage prävariscischer Faltungen in Nordspanien. *Geol. Rundschau*, 52, pp.346-357, Abb. 1.

RAMSBOTTOM, W. H. C. (1957).—Namurian Goniatites in the U. S. S. R. *Geol. Mag.*, XCIV, 4, pp.305-311.

RUPKE, J. (1965).—The Esla Nappe, Cantabrian Mountains (Spain). *Leidse Geol. Meded.*, 32, pp.1-74, text-figs 1-34, geol. map and sections.

RUZHENCEV, V. E. (1950).—Upper Coal Measure Ammonites of the Urals. *Trudy Paleont. Inst. Akad. Nauk SSSR*, XXIX, pp.1-222, text-figs 1-84, Tab. I-XV (in Russian).

RUZHENCEV, V. E. (1960).—Principles of systematics, systems and phylogeny of the Palaeozoic Ammonoidea. *Trudy Paleont. Inst. Akad. Nauk SSSR*, 83, pp.1-350, text-figs 1-128 (in Russian).

RUZHENCEV, V. E. & BOGOSLOVSKAYA, M. F. (1971).—Namurian time in ammonoid evolution. *Trans. Palaeont. Inst., Acad. Sci. USSR*, 133, pp. 1-382, Figs 1-89, Tab. I-XI. (in Russian).

SCHINDEWOLF, O. H. (1926).—Zur Kenntnis der Devon-Karbon-Grenze in Deutschland. *Zeitschr. Deutsche Geol. Gesell.*, 78, pp.88-133, Taf.33.

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

SCHMIDT, H. (1925).—Die carbonischen Goniatiten Deutschlands. *Jb. Preuss. geol. Landesanstalt*, XLV (1924), pp. 489-609, Tafn 19-26.

SCHMIDT, H. (1931).—Das Paläozoikum der Spanischen Pyrenäen. *Abh. Gesell. Wiss. Göttingen, Math.-Phys. Kl.*, III, 5, pp. 980-1065, Abb. 1-21, Tafn I-II (trad. esp. 1943.-El Paleozoico del Pirineo español. *Publ. alemanas Geol. España, C.S.I.C.*, II (1944), pp. 99-195, figs 1-21, láms I-II).

SCHMIDT, H. (1934).—Cephalopodenfaunen des älteren Namur aus der Umgegend von Arnsberg in Westfalen. *Jb. Preuss. geol. Landesanstalt*, 54 (1933), pp.440-461, Abb. 1-86.

SCHMIDT, H. (1951).—Neue Faunen aus dem Namur des nordöstlichen Spanien. *Paläont. Zeitschr.*, 24, pp.184-193, Abb.1-3, Taf.13 (trad. esp. J. GÓMEZ DE LLARENA 1951 - Nuevas faunas namurienses de los Pirineos occidentales de España (Navarra y Guipúzcoa). *Publ. extranjeras Geología España*, VI, pp.7-23, figs 1-4, lám. I).

SCHMIDT, H. (1955).—Einige Goniatiten aus spanischem Oberkarbon. *Publ. Ass. Etud. Paléont.*, 21 (hors série), pp.47-59, Taf.A.

SCHULZ, G. (1837).—Note sur la géologie des Asturies. *Bull. Soc. géol. France*, (1), VIII, pp.325-328.

SCHULZ, G. (1845).—Vistazo geológico sobre Cantabria. *Bol. Oficial Minas*, 34, pp. 452-453; 35, pp. 461-462.

SCHULZ, G. (1858).—Descripción geológica de la provincia de Oviedo. *Madrid, José González*, pp. 1-138, láms I-III, mapa geol. 1 : 400.000 (4.ª edición *Madrid, Gráficas Reunidas, S. A.*, pp. 1-132, mapa geol., 11 cortes geol., 1930).

SITTER, L. U. DE (1962).—The structure of the southern slope of the Cantabrian Mountains. Explanation of a geological map with sections (scale 1 : 100,000). *Leidse Geol. Meded., 26*, pp.255-264, geol. map and sections.

SJERP, N. (1967).—The geology of the San Isidro - Porma area (Cantabrian Mountains, Spain). *Leidse Geol. Meded.*, 39, pp.55-128, text-figs 1-62, pls I-II, geol. map and sections.

SMITH, J. P. (1903).—The Carboniferous Ammonoids of America. *Mon. U. S. Geol. Survey*, XLII, pp.1-211, pls III-XXIX.

VEEN, J. VAN (1965).—The tectonic and stratigraphic history of the Cardaño area, Cantabrian Mountains, Northwest Spain. *Leidse Geol. Meded.*, 35, pp.45-103, text-figs 1-39, geol. map and sections.

VERNEUIL, E. DE (1846).—Note sur les fossiles des localités charbonnières importantes des Asturies. *Bull. Soc. géol. France*, (2), III, pp.454-457.

VERNEUIL, E. DE & COLLOMB, E. (1853).—Coup d'oeil sur la constitution géologique de quelques provinces de l'Espagne. *Bull. Soc. géol. France*, (2), X, pp.61-147.

VIRGILI, C. & CORRALES, I. (1968).—Observaciones sobre el flysch carbonífero de la Playa de San Pedro (Asturias).—*Breviora Geol. Astúrica*, XII, 1, pp.5-8, 1 fig.

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

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

WAGNER, R. H. (1959).—Flora fósil y estratigrafía del Carbonífero en España NW y Portugal N. *Estudios Geol.*, XV, pp.393-420, figs 1-6.

WAGNER, R. H. (1962).—A brief review of the stratigraphy and floral succession of the Carboniferous in NW. Spain. *C. R. 4ᵉ Congrès Carbonifère, Heerlen 1958*, III, pp. 753-762, text-figs 1-2, pls 29-33.

WAGNER, R. H. (1963).—A general account of the Palaeozoic Rocks between the Rivers Porma and Bernesga (León, NW. Spain). *Bol. Inst. Geol. Min. España*, LXXIV, pp.171-331 (1-161), figs 1-35, geol. map.

WAGNER, R. H. (1966).—Palaeobotanical Dating of Upper Carboniferous Folding Phases in N. W. Spain. *Mem. Inst. Geol. Min. España*, 66 (1965), pp.1-169, text-fig. 1, pls 1-77.

WAGNER, R. H. (1970).—An Outline of the Carboniferous Stratigraphy of Northwest Spain. *In* «Colloque sur la stratigraphie du Carbonifère», *Congrès et Colloques Univ. Liège*, 55, pp.429-462, text-figs 1-3, pl.I.

WAGNER, R. H. (1971).—Carboniferous nappe structures in north-eastern Palencia (Spain). *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 4, pp. 431-459, text-figs 1-5, pls 1-7.

WAGNER, R. H. & ARTIEDA, J. I. (1970).—La Cuenca Minera Ciñera-Matallana. *S. A. Hullera Vasco-Leonesa*, pp.1-238, figs 1-40, figs II-1-99, láms. I-XIX.

WAGNER, R. H. & FERNÁNDEZ-GARCÍA, L. (1971).—The Lower Carboniferous and Namurian rocks north of La Robla (León). *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 4, pp. 507-531, text-figs 1-6, pl. 1.

WAGNER, R. H. & WAGNER-GENTIS, C. H. T. (1963).—Summary of the Stratigraphy of Upper Palaeozoic Rocks in NE. Palencia, Spain. *Proc. Kon. Ned. Akad. Wetenschappen, Amsterdam*, (B), LXVI, 3, pp.149-163, 1 fig.

WAGNER-GENTIS, C. H. T. (1960).—On *Nautellipsites hispanicus* (FOORD & CRICK). *Estudios Geol.*, XVI, I, pp.43-51, figs 1-4.

WAGNER-GENTIS, C. H. T. (1963).—Lower Namurian goniatites from the Griotte Limestone of the Cantabric Mountain Chain. *Notas y Comuns. Inst. Geol. Min. España*, 69, pp. 5-23, pls I-VIII.

WINKLER PRINS, C. F. (1968).—Carboniferous Productidina and Chonetidina of the Cantabrian Mountains (NW Spain): Systematics, Stratigraphy and Palaeoecology. *Leidse Geol. Meded.*, 43, pp.41-126, text-figs 1-18A, pls I-IX.

WINKLER PRINS, C. F. (1971[a]).—The road section east of Valdeteja with its continuation along the Arroyo de Barcaliente (Curueño Valley, León); with a «Note on *Leonardophyllum leonense* sp. nov.» by G. E. DE GROOT. *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 4, pp. 677-686, text-figs 1-2, pls 1-2.

WINKLER PRINS, C. F. (1971[b]).—Connections of the Carboniferous brachiopod faunas of the Cantabrian Mountains (Spain). *Trabajos de Geología, Fac. Ci. Univ. Oviedo*, 4, pp. 687-694.

YATES, P. (1962).—The Palaeontology of the Namurian Rocks of Slieve Anierin, Co. Leitrim, Eire. *Palaeontology*, 5, pt. 3, pp. 355-443, text-figs 1-4, pls 51-62.

PLATE 1

Fig. 1.—*Muensteroceras arkansanum* GORDON, × 3.—(1a). Lateral view showing the suture and constrictions.—(1b). Ventral view showing the opening and part of the suture.
Loc. 1165 B (WINKLER PRINS coll.), black shales of Vegamián Formation, at 2 km SSW of Genicera (León); Upper Tournaisian. RGM-St. 167508.

Fig. 2.—*Glaphyrites*? - *Eoasianites*? sp. 1, × 2. Ventro-lateral view showing the strongly canted transverse striae.
Loc. 1227 (WAGNER coll.), Olaja Beds at *ca.* 1,350 m south of Barrios de Gordón (León); Lower Namurian E_2 Zone. RGM-St. 167509.

Fig. 3.—*Eumorphoceras bisulcatum* cf. *grassingtonense* DUNHAM & STUBBLEFIELD, × 3. Lateral view showing transverse ribs.
Loc. 1227, Olaja Beds south of Barrios de Gordón: E_2 Zone. RGM-St. 167510.

Fig. 4.—*Glaphyrites*? - *Eoasianites*? sp. 2, × 3. Ventral view showing canted transverse striae, faintly undulose near the umbilicus, and a constriction.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167511.

Fig. 5.—*Proshumardites delepinei* SCHINDEWOLF, × 3. Ventro-lateral view showing the ventral saddle and trifid lateral lobes of the suture.
Loc. 1227, Olaja Beds south of Barrios; E_2 Zone. RGM-St. 167512.

Fig. 6.—*Gonioloboceras declive* sp. nov., × 2. Lateral view showing the sutures and a spiral ridge (tube) linking the tips of lateral lobes.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167513.

N.B. All specimens shown are in the Rijksmuseum van Geologie en Mineralogie, Hooglandse Kerkgracht 17, Leiden, the Netherlands (Catalogue numbers prefixed RGM-St.).

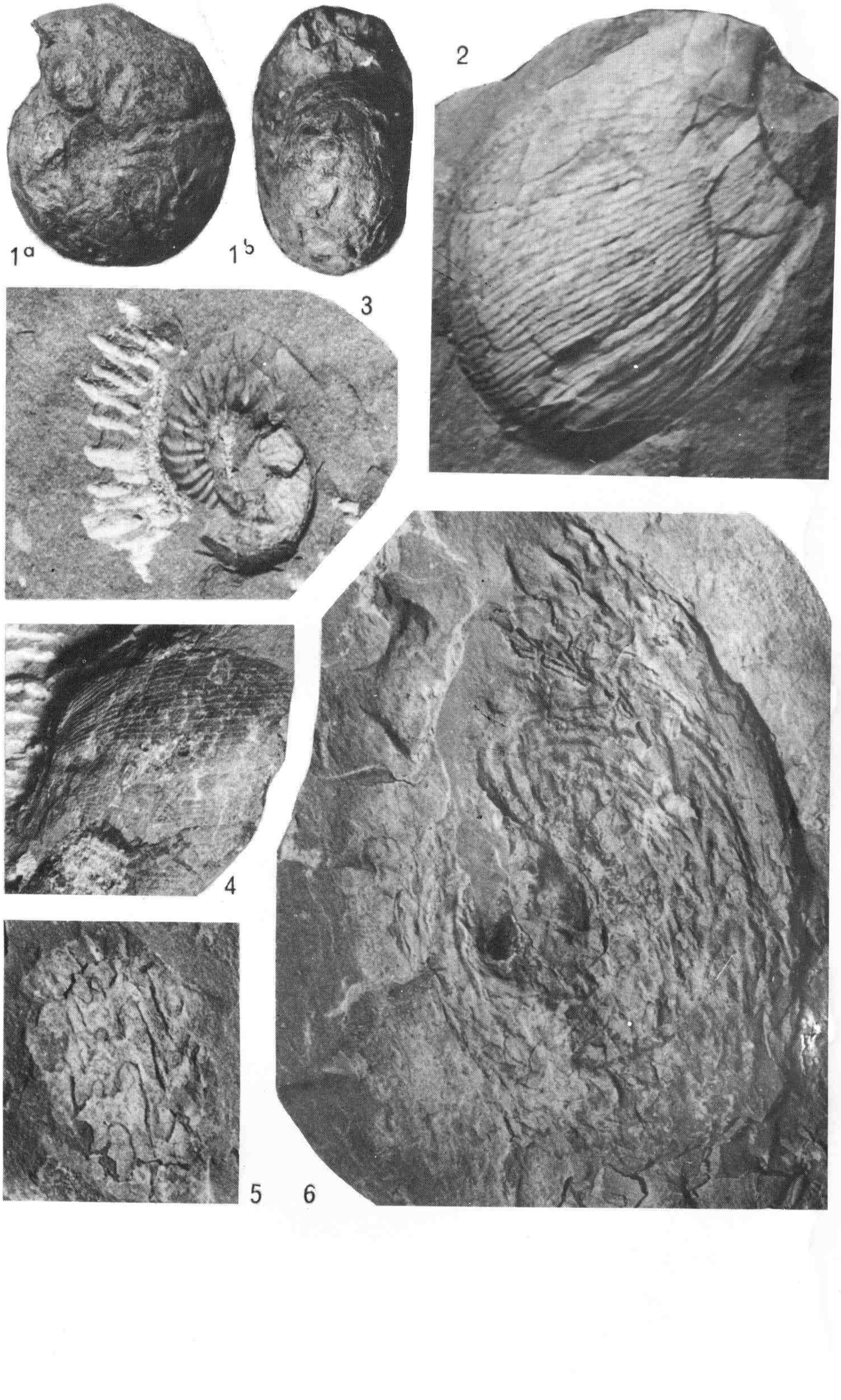


PLATE 2

Fig. 7.—*Stenopronorites* cf. *arkansasensis* (SMITH) SCHINDEWOLF, × 2. Lateral view showing part of suture.
Loc. 1227 (WAGNER coll.), Olaja Beds at *ca.* 1,350 m south of Barrios de Gordón (León); Lower Namurian E_2 Zone. RGM-St. 167514.

Fig. 8.—*Eumorphoceras bisulcatum* cf. *leitrimense* YATES, × 3. Lateral view showing the ventrolateral groove, two constrictions, and short transverse ribs near the umbilicus.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167515.

Fig. 9.—*Delepinoceras thalassoide* (DELÉPINE) MILLER & FURNISH, × 2. Ventral view showing the ventral saddle and the first trifid lateral lobe of the suture.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167516.

Fig.10.—*Proshumardites delepinei* SCHINDEWOLF, × 3. Ventral view showing the ventral saddle and the trifid ventral lobe of suture.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167517.

Fig.11.—*Kardailites* sp., × 2. Ventral view showing the longitudinal sulcus over the venter. Its suture is characterized by the very wide bifid ventral lobe with a high median saddle, rounded first lateral saddle and pointed, very slightly inflated lateral lobe which is not constricted. Specimen described as *Glaphyrites* ? sp. on page 653.
Loc. 1227, Olaja Beds south of Barrios de Gordón; E_2 Zone. RGM-St. 167518.

N.B. All specimens shown are in the Rijksmuseum van Geologie en Mineralogie, Hooglandse Kerkgracht 17, Leiden, the Netherlands (Catalogue numbers prefixed RGM-St.).

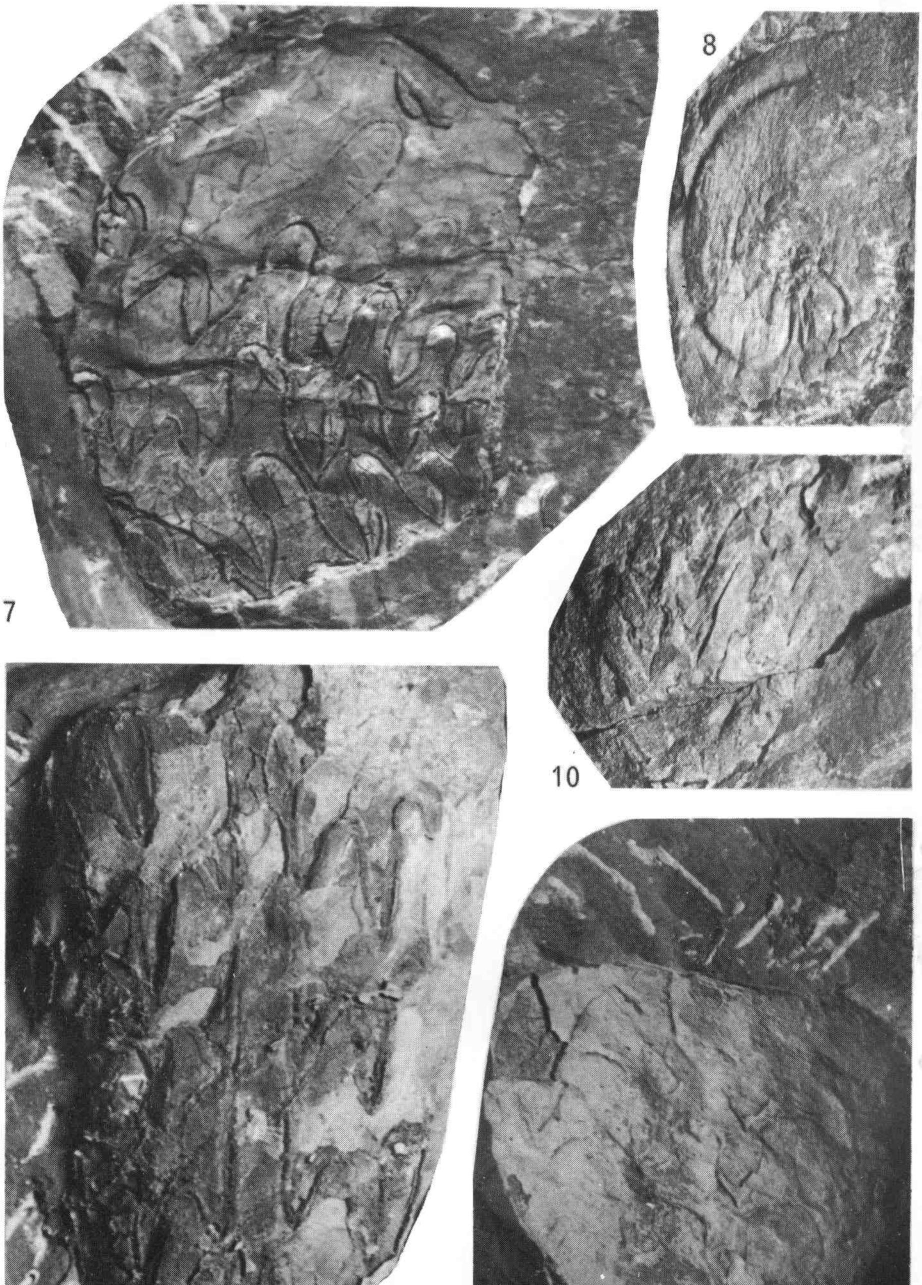

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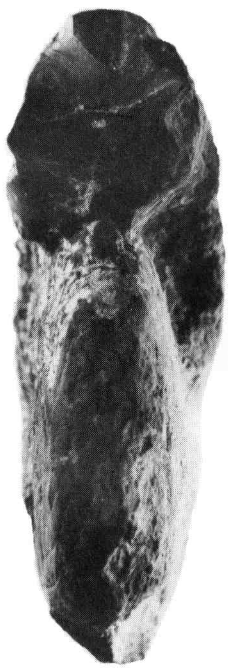
PLATE 3

Fig. 12.—*Goniloboceras declive* sp. nov., × 1. Holotype.—(12a). Lateral view showing the extremely small umbilicus and the sutures.—(12b). Ventral view showing the platycone shape.—(12c). Ventral view showing median saddles. On the right hand side the sutures are rather worn.

Loc. 1069 (WAGNER coll.), top Genicera Formation (Canalón Member) in nodular limestone quarried opposite the Venta de Getino in the Torío River Valley (León); Lower Namurian E_2 Zone. RGM-St. 167519.

12 a

12 b



12 c