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MAPPABLE UNITS OF THE CARBONIFEROUS IN THE SOUTHERN CANTABRIAN MOUNTAINS (NW-SPAIN)

BY

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ABSTRACT

Distinct general lithological features, separated by unconformities, serve to distinguish three groups of mappable formations in the Carboniferous of the area, the Ruesga Group, the Yuso Group and the Cea Group.
The formations which compose the Ruesga Group can be found in the greater part of the area. In general they start with a limestone series developing upwards and laterally into greywackes. The conglomerates and molasse greywackes formations of the Yuso Group follow and are limited by two major structural zones; in the west the zone that runs over the Pardomino Ridge and the Pontón fault line and in the south the León line. West of the "Pardomino-Pontón" zone other formations have been mapped, but the information is still insufficient for a good correlation of the depositions on both sides of that zone. The mainly continental formations of the upper Cea Group occur mostly in unconformable intramontane basins. In the easternmost part of the area the unconformity is only locally present.

INTRODUCTION

The Carboniferous sequence in the southern Cantabrian Mountains contains limestones and shales with greywackes, but also quartzites and sandstones. At various levels exploitable coal-seams occur. At the base marine sedimentation took place more or less uniform over a large area, later sedimentation was restricted to separated basins, of which the pattern changed. In these basins several formations have been mapped.
The lithostratigraphic units in the Carboniferous of the Cantabrian Mountains are not easy to define. Rock units like sandstone, limestone etc. here have a restricted lateral extension and moreover they have a variable character. On the other hand we find similar rock units on various non-correlable levels.
The strong inhomogeneity of the succession is the result of rapid lateral facies changes. Different facies are found side by side, and one and the same facies occurs repeatedly in the vertical column. Thus, the practical mappable unit here contains a variety of rocks. Gradual transitions of rock units in lateral and vertical sense render the mapping even more subjective.
Fortunately, however, we have a few horizons in the Cantabrian Mountains which are reasonable constant over large distances. A limestone formation such as the Caliza de Montaña has a large spread over the areas with equal habits in various exposures. The same is true of the conglomerates of the Curavacas Formation. Many limestones have been found, however, which look very much like those of the Caliza de Montaña, but do not belong to that formation. Also several conglomerates do not belong to the Curavacas Formation.
Koopmans (1962) reasoned that the Carboniferous in the Cantabrian Mountains can be split up into three divisions, separated by two tectonic phases. Thus he started with the major units, which he called the Groups, rightfully expecting them to include a number of formations.
Koopmans defined the Ruesga Group as composed of the Carboniferous units which have been deposited before the Sudetic folding phase (Curavacas folding phase, Kanis, 1955). The units deposited after the Sudetic folding phase, but before the Asturian folding phase, compose the Yuso Group. The Cea Group contains the units deposited after the Asturian folding phase.
Koopmans' groups were composed of lithologic and facies units. Later authors described formations, some of which are about equal to Koopmans' units (Brouwer & van Ginkel, 1964; van Veen, 1965; Rupke, 1965; Helmig, 1965; Frets, 1965; de Sitter & Boschma, 1966; Sjerp, 1967 and Savage, 1967).
The distinction of the groups as proposed by Koopmans is still based on the occurrence of unconformities, but moreover his groups prove to be lithostratigraphically distinct. His first group starts with black cherty shales changing into limestone and an association of limestones and greywackes, the second has mainly greywackes, some limestones and generally a huge conglomerate at its base, and the third one has mainly continental deposits. It is, however, impossible to distinguish all unambiguously on lithostratigraphic features only. In many cases the knowledge of the biostratigraphic correlation is necessary to identify the units, i.c. van Ginkel (1965).
Several of the Carboniferous formations which have been mapped are restricted to areas bounded by structural lines, with the result that similar groups of formations can not be distinguished everywhere in the area. The major structural lines in the southern Cantabrian Mountains are shown on the structural map, fig. 1, modified after de Sitter (1962).

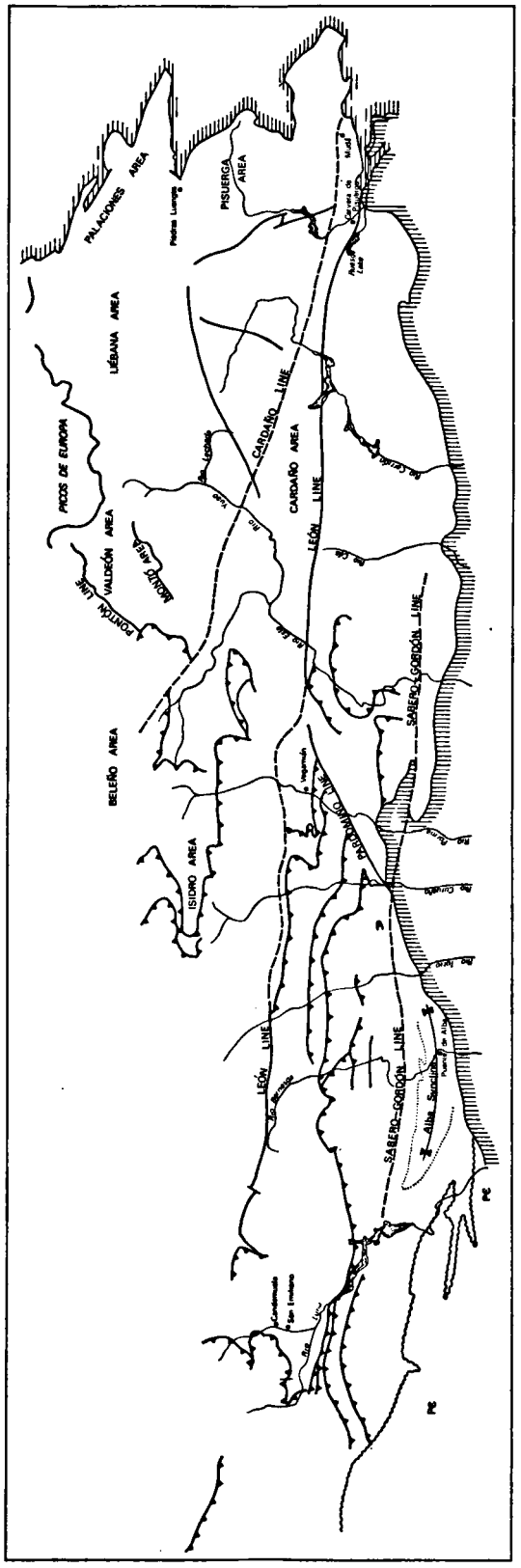

Fig. 1. Major structural lines in the southern Cantabrian Mountains (1 : 800.000).

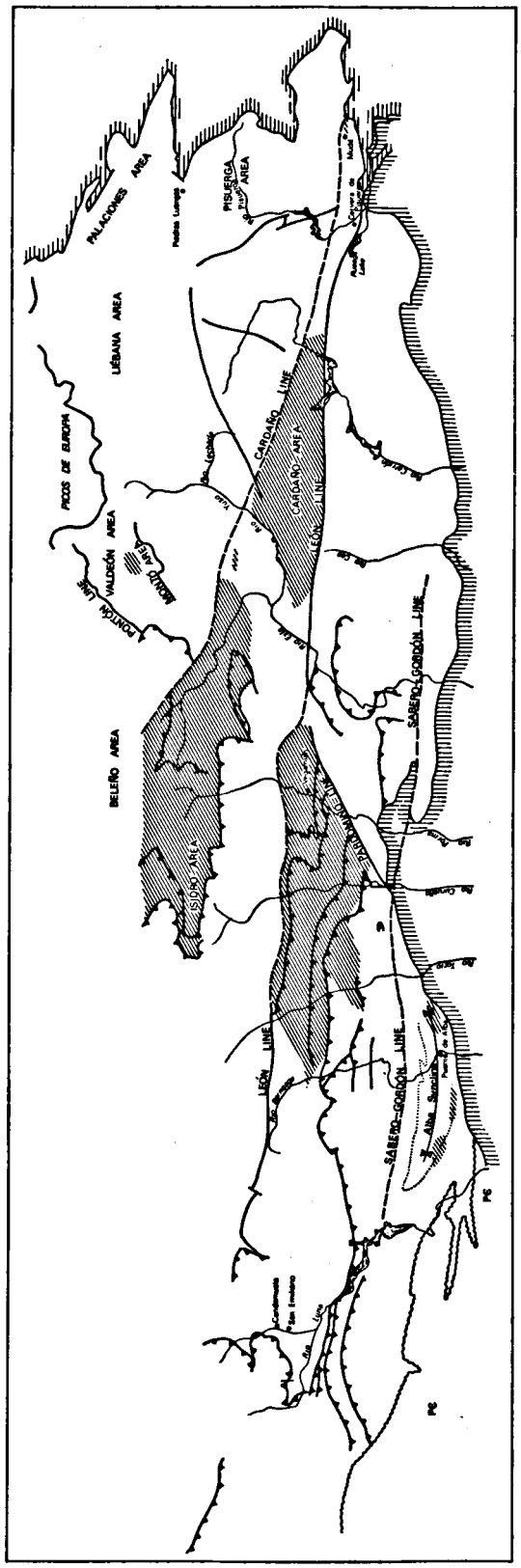

Fig. 2. Distribution of the Vegamián Formation.

FACIES DISTRIBUTION

Limits of areas in which one distinctive sediment facies can be identified are often found to be clearly defined and important structural lines. It seems clear that the distribution must have been controlled by primary structural movements during sedimentation. Some evidence of early movements can even be found in the Devonian sequence, but the effects upon the Carboniferous were much more marked.

Near Cervera de Pisuerga, the León line (fig. 1) separates the limestones of the Caliza de Montaña Formation in the south and southwest from the flysch of the Cervera Formation north of that line.

The presence of limestone conglomerates just south and north of the Cardaño line (the Triollo Limestone Conglomerate Member, van Veen, 1965) marks the local border of the Caliza de Montaña, as these conglomerates are typical for the zone of interfingering between limestone and flysch sedimentation.

The western continuation of the León line in the province of León is less important as a facies boundary. Here the facies distribution is controlled by another structural line, the Sabero-Gordón line (fig. 1). South of that line the Caliza de Montaña Formation is absent and flysch facies is found instead (de Sitter, 1967; Rupke, 1965; Evers, 1967).

Between the Montó outcrops and the Cuenca de Beleño a structural zone is present, the Valdeón zone between two faults, the Pontón fault and the Montó fault; the Pontón fault operated possibly before as well as during the Bretonnic phase (late Devonian), separating an area void of Devonian from one with more or less well developed Middle and Upper Devonian. This fault separates the Cuenca de Beleño from the Montó area in the same sense as the León line separates a Leonide facies (Koopmans, 1962) from a Palentian facies (van Veen, 1965). The Pontón fault apparently did not affect the distribution of facies during the Lower Carboniferous, as Vegamián Formation, Alba Formation and Caliza de Montaña Formation show the same development in both the Montó and Beleño areas.

The Montó area itself, with its different facies on both sides, acted as a facies boundary during the deposition of the Lower Carboniferous Ruesga sediments. On the northern part of the Montó, the Alba Griotte and the Caliza de Montaña are abundantly represented, whilst on the southern border of the area the Lower Carboniferous contains shales, greywackes and breccias.

Another apparent feature shows the continuation of the Montó line to along the Picos de Europa. In the Picos de Europa we find an extensive development of the Alba Griotte and the Caliza de Montaña, whilst south of the Picos de Europa in the Liébana and Polaciones areas a flysch facies of the Ruesga Group (the Cervera Formation) occurs. The difference between the Picos de Europa and the Liébana-Polaciones area is comparable to the situation near Cervera de Pisuerga, where the León line separates the Caliza de Montaña abruptly from the greywacke development of the Cervera Formation (de Sitter & Boschma, 1965; van Ginkel, 1965; Kanis, 1956). The wedge-shaped area between the Pontón-Picos de Europa line in the north and the León line in the south we call the Palentian area. The Caliza de Montaña Formation developed outside the Palentian area, with one exception: the area between the Cardaño line and the León line where the limestones interfinger with the contemporaneous flysch facies of the Cervera Formation. This Cervera Formation is completely restricted to the Palentian area.

The activity of the structural lines along the borders of the Palentian area is again demonstrated by the deposits of the Curavacas conglomerates (Yuso Group), which do not cross over the Pontón line (de Sitter, 1967) in the northwest, nor the León line in the south, with only two exceptions, near Prioro and in the Valle de Burón.

THE RUESGA GROUP

This group contains limestone and shale formations ranging in age from Lower Carboniferous up to lowermost Westphalian. Limestones and shales succeed each other, partly contemporaneous and interfingering.

The Ruesga Group includes the following formations; the Vegamián Formation, the Alba Formation, the Caliza de Montaña Formation, the San Emiliano Formation, the Cuevas Formation, the Ricacabiello Formation, and the Cervera Formation. Of these formations the Vegamián Formation, the Alba Formation and the Caliza de Montaña Formation are represented almost over the whole southern Cantabrian Mountains, while the other formations have only local significance.

The Vegamián Formation

The Vegamián Formation has been reported first by Comte (1959). Black shales, black cherts and black sandy limestone beds are the main constituents. In the Cardaño area as well as in the Alba syncline phosphatic nodules are common in the black shales. The type locality has been chosen by Comte at about 1 km south of Vegamián along the Porma River (fig. 7, section 1).

The Vegamián Formation is present in the Leonides and in the Isidro area. Black chert has also been found in the Pisuerga area. Between the rivers Carrión and Pisuerga, Kanis (1955) found exposures of the Vegamián Formation only north of the León line. In the western Leonides the distribution of the black shales and cherts seems to be restricted to the area east of the Bernesga River, apart from some outcrops of the Vegamián Formation in the southern border of the Alba syncline. Along the Cardaño line the Vegamián Formation reaches its greatest thickness (van Veen, 1965).

A general distribution map, modified after van Adrichem Boogaert (1967), shows the distribution of the

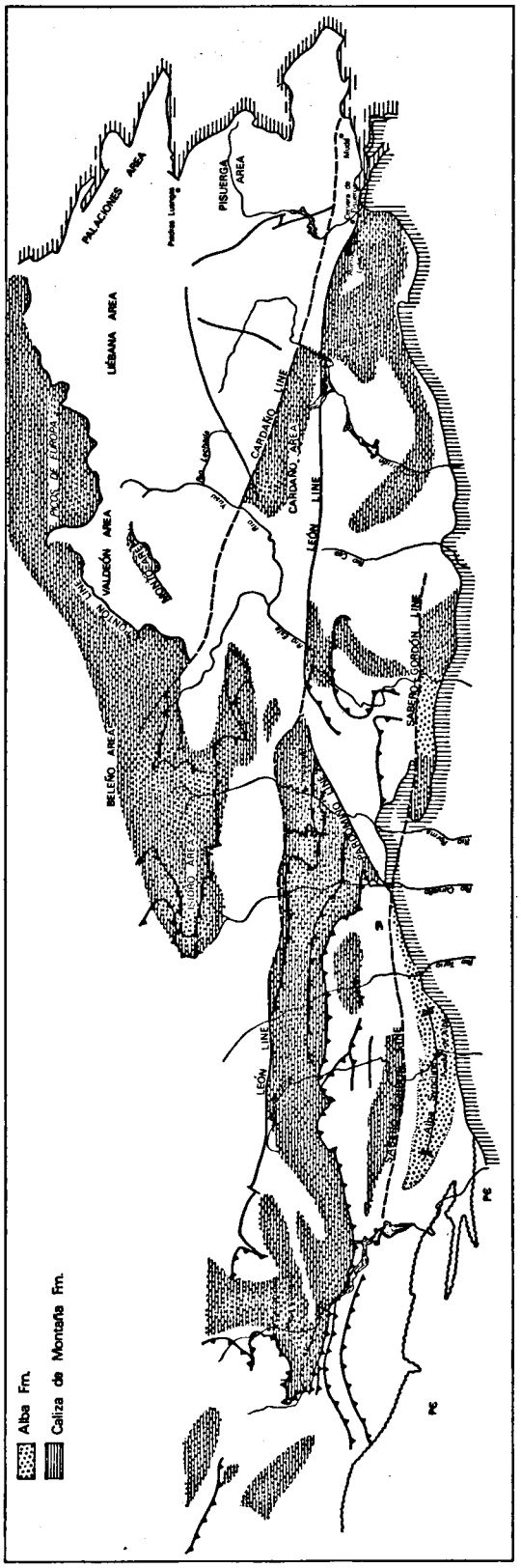

Fig. 3. Distribution of the Alba Formation and the Caliza de Montaña Formation.

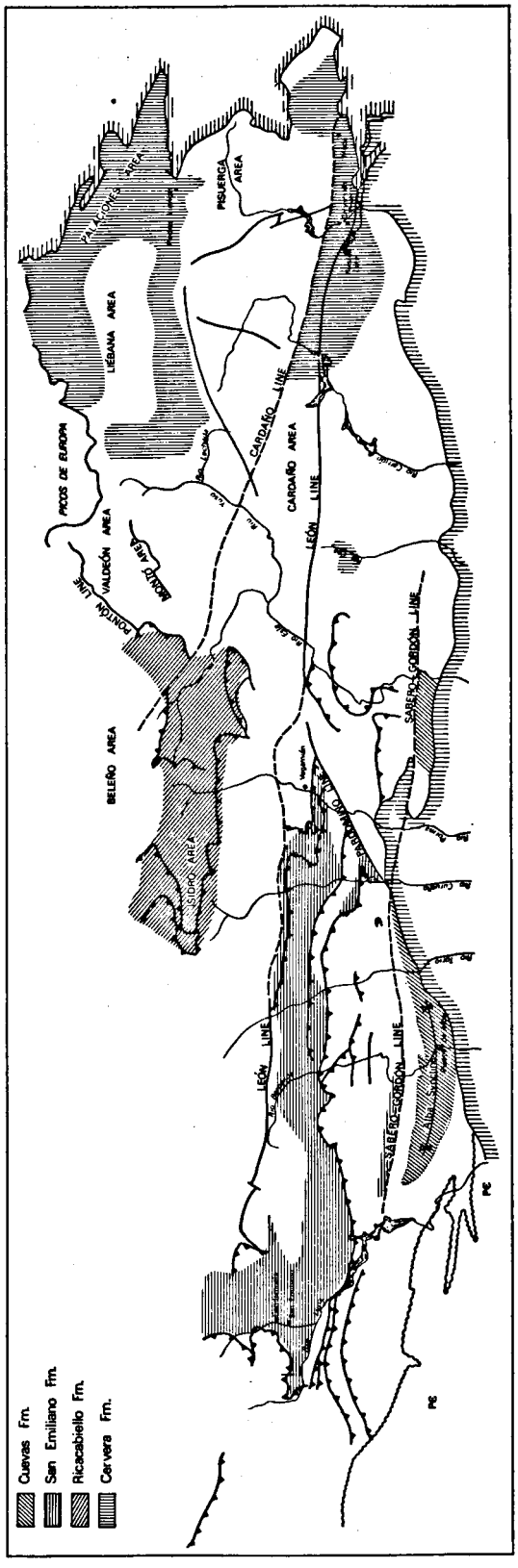

Fig. 4. Distribution of the Cuevas Formation, the San Emiliano Formation, the Ricacabiello Formation and the Cervera Formation.

Vegamián Formation in the southern Cantabrian Mountains (fig. 2).

The Alba Formation

The Alba Formation is built up of red and green nodular limestones with red shales between the nodules. The type locality is at Puente de Alba along the Bernesga River in the Leonides (Comte, 1959) (see columnar section 2, fig. 7).

The Alba Griotte occurs in the Leonides, the Isidro area and north of the Montó-Picos de Europa line. The formation is absent in the Pisuerga area and the Liébana area. In the Valdeón area the formation is only present in the Montó structure (see fig. 3).

Determination of the rich fossil fauna (Kullmann, 1961 and Wagner-Gentis, 1963) shows that its deposition started earlier in the Leonides than in the Palentian area. This diachronism, also reported by van Adrichem Boogaert (1967), only holds for the basal part of the formation as the top has the same Upper Viséan age in all areas. The large time-interval in which this relatively thin formation has been deposited shows that it is a condensed sequence.

The Alba Formation is normally overlain by the Caliza de Montaña Formation except for the Alba syncline where it is followed by shales and greywackes of the Cuevas Formation.

The Caliza de Montaña Formation

The limestones of the Caliza de Montaña Formation have been reported by many authors under different names, but no good type section has yet been described. The following names are used in literature: Calcaire de Cañons (most French authors), Calcaire de Villanueva (Comte, 1959), Escapa Formation (Brouwer & van Ginkel, 1964). In this paper we use the name Caliza de Montaña Formation, generally accepted by Spanish authors and those of the Leiden University.

The Caliza de Montaña Formation can be subdivided into two parts: a lower part, mainly composed of thin-bedded fetid limestone in which calcite veins are very common, and an upper part consisting of more competent, often reefoid limestone which in several places has been dolomitized.

The Caliza de Montaña Formation has been found in the Leonides as well as north of the León line, in the Isidro area and in the Montó structure (fig. 3). The formation is absent north of the Cardaño line in the Palentian area, whereas between the Cardaño line and the León line isolated outcrops of the formation occur. Here, and especially between San Martin and Triollo (Koopmans, 1962), the interfingering can be seen of the Caliza de Montaña Formation with the Cervera Formation. In the "Cuenca Central", west of the Isidro area, where only younger sediments are exposed, the Caliza de Montaña Formation is not found. The distribution of the formation is not very different from that of the Alba Formation (fig. 3).

The Cuevas Formation

In the Alba syncline the Cuevas Formation conformably lies upon the Alba Formation. The formation can be subdivided into two members; a lower shale/greywacke member and an upper limestone member. The lower shale/greywacke member starts with shales and a few thinbedded sandstones, which higher up grade into thicker greywackes. At the top thinbedded limestone beds are intercalated between greywacke beds. The limestone content of the rocks increases upwards. This marks the gradual transition into the upper limestone member. The thinbedded aspect of the upper limestone member is very similar to the basal part of the Caliza de Montaña elsewhere.

The type-section, near the village of Cuevas, will be described by van Staalduinen in the near future (columnar section 4, fig. 7).

The formation is not really restricted to the Alba syncline, which lies south of the Sabero-Gordon line, because in the area west of the Esla River and also south of the Sabero-Gordon line, rocks very similar to those of the Cuevas Formation are exposed (Rupke, 1965) (fig. 4).

The San Emiliano Formation

The San Emiliano Formation has been designated by Brouwer & van Ginkel (1964).

Greywackes and shales as well as limestones are common constituents of the formation. In the upper part of the formation minor coal-bearing horizons appear.

The type section lies approximately one kilometre north of the Luna River between San Emiliano and Candemuela (fig. 7, section 3). From here the rocks can be found to continue towards the east and south-east. They are not correlated with rocks east of the Pardomino line and south of the Sabero-Gordon line (fig. 4).

The formation partly succeeds the Caliza de Montaña Formation conformably, partly the limestone beds of the latter formation interfinger in lateral sense with shales of the San Emiliano Formation.

In the Leonides, the San Emiliano Formation represents the youngest deposits before the Sudetic folding: Westphalian A (Wagner, 1966); Profusinella B zone (van Ginkel, 1965); Lower Moscovian (Rácz, 1964).

The Ricacabiello Formation

The Ricacabiello Formation has been introduced by Sjerp (1967). The formation is composed of brown/red mudstones in which manganese-bearing nodules are important markers.

The type section (section 5, fig. 7) is located just south of the Pico Ricacabiello in the Isidro area. The formation is of local interest and probably restricted to the Isidro area (fig. 4). The Ricacabiello Formation lies conformably upon the Caliza de Montaña Formation. It is not certain whether these beds have the standard of a formation.

The Cervera Formation

The Cervera Formation was first mentioned by Brouwer and van Ginkel (1964). The rocks are composed of a monotonous clastic sequence of greywackes and shales as well as sandstones and quartzite conglomerates. Several limestone members (de Sitter and Boschma, 1966), which were regarded as formations by Brouwer and van Ginkel (1964), complete the irregular sedimentation. A satisfactory type section has not been described. Brouwer and van Ginkel indicate as a typical area the rock-sequence between Mudá and Cervera de Pisuerga, which, however, is intricately folded.

The Cervera Formation occurs north of the León line in the Palentian and Liébana area. South of the Cardaño line the formation interfingers with the Caliza de Montaña Formation (figs. 3 and 4). In general the Cervera Formation rests unconformably upon the underlying sediments. At the upper boundary we find the unconformable conglomerates of the Yuso Group or even of the Cea Group (Peña Cildá Formation).

Concluding remarks on the Ruesga Group

In general it can be stated that the Ruesga in the southern Cantabrian Mountains starts with a sedimentation in a relatively flat area without an important supply of sediment. Yet small depressions in the topography gave the distribution of the Vegamián Formation still a basin-like pattern over the whole area. The younger Alba Formation and the Caliza de Montaña Formation were not deposited in the Palentian area. The upper Ruesga sediments are even more limited by structural lines and show a distribution in separated basins.

The Vegamián Formation, the Alba Formation and the Caliza de Montaña Formation represent sediments which have been deposited under rather stable transgressive conditions with slow subsidence of the area. The San Emiliano Formation and the Cervera Formation show typical flysch facies features. The distribution of these sediments indicates the complex pattern of ridges and basins with rapid subsidence and sedimentation. The Cuevas Formation seems to have been deposited in a basin in which sedimentation exceeded subsidence.

THE YUSO GROUP

The Yuso Group consists of the formations, which have been deposited after the Sudetic folding phase and before the Asturian folding phase. The major mappable unit in the group is the Curavacas Conglomerate (Kanis, 1955). This formation represents the basal conglomerates after the Sudetic folding phase. Upwards this formation interfingers with the flysch facies of the Lechada Formation (van Veen, 1965). In the Pisuerga area three formations were mapped: the Corisa Formation, the Vañes Formation and the Molino Formation (van Ginkel, 1965; Frets, 1965; de Sitter and Boschma, 1966).

In the Valdeón and Liébana area the Curavacas Conglomerate is also present. Here it is conformably followed by the Buyon Beds of the Lechada Formation, the Pandetrave Formation and the Valdeón Formation.

The formations of the Yuso Group have been deposited roughly during the Westphalian.

Sjerp (1967) has placed five more formations in the Yuso Group; the Lois-Ciguera Formation, the Lena Formation, the Caliza Masiva Formation, the Fitó Formation and the Beleño Formation. None of these formations, however, can be correlated with one of those known in the Palentian area, which renders correlation with the Palentian Yuso Group rather premature (see below).

The Curavacas Formation

The Curavacas Formation, first reported by Kanis (1955), is composed of an oligomict quartzite series of about 500 m thick. The name Curavacas Formation has been derived from the Monte Curavacas in NW Palencia. A type section of the Curavacas Formation in the Cardaño area has been given by van Veen (1965) (fig. 7, section 6). The Curavacas Formation is unconformable upon Devonian or Lower Carboniferous rocks. Upwards the formation grades into and interfingers with shale greywacke sequences of the Lechada Formation.

The conglomerates, which occur in the Liébana area and in the northern Pisuerga basin (Piedrasluengas) are to be correlated with the Curavacas Formation. These conglomerate beds are very similar to the Curavacas Conglomerates. Furthermore, in the Liébana as near Piedrasluengas they represent the first deposits after the Sudetic folding. As these conglomerates do not have that regular and extensive development of the Curavacas Formation, the name Curavacas Conglomerate Beds (de Sitter and Boschma, 1966) will be used here.

The conglomerates which lie at the base of the Molino Formation (see below) in the Perapertú area, are also regarded to be Curavacas Conglomerate Beds. Outcrops of the Curavacas Conglomerates are restricted to the area north of the León line except for a small area near Prioro (fig. 5). The Curavacas Conglomerates are furthermore restricted to the area east of the Pontón line (de Sitter, 1967). They are still abundant in the Valle de Burón, but west of the Puerto de Tarna they fail altogether.

The Lechada Formation

Van Veen (1965) called the shale-sandstone sequence which interfingers with the Curavacas Formation and lies upon it the Lechada Formation.

The name Lechada comes from the Lechada River, a tributary of the Yuso River. In the section, however, chosen by van Veen (1965) in the Carrión area (fig. 7, section 6), mostly lenticular sandstone beds alternate rapidly in lateral as well as vertical sense with shales and limestone beds.

The Lechada Formation is represented only north of

the León line (fig. 5), with probably two exceptions:
a. the outcrops in the area around Prioro (Pando Formation) (van Ginkel, 1965) along the Cea River;
b. the deposits near Vegamián along the Porma River also might be regarded to belong to the Lechada Formation.

Both sequences represent sediments in subbasins caused by depressions along the León line. North of the León line the westernmost outcrops of the Lechada Formation have been found in the Valle de Burón (Sjerp, 1967). Similar rocks in the Isidro area have not yet been correlated with those of the Lechada Formation.

The Molino Formation

The name Molino Formation has been used by Frets (1965) for outcrops which occur west of Perapertú in the Pisuerga area (fig. 5). Subgreywackes, sandy shales, greywackes and conglomerates are the main constituents. The type section (fig. 7, section 7) is along the road from San Cebrían to Perapertú. The conglomerates at the base of the formation which lie unconformably upon the Cervera Formation, are considered as Curavacas Conglomerate Beds.
The Molino Formation is conformably followed by the Vañes Formation.

The Vañes Formation

The Vañes Formation has been described first by Brouwer and van Ginkel (1964). The formation is composed of a shale and sandstone sequence which may be compared with the rocks of the Lechada Formation. The presence of several thick crossbedded sandstones in the Vañes Formation is, however, unlike the lithology of the Lechada Formation.
The type section of the Vañes Formation is the sequence which lies just north of Rabanal de los Caballeros, northwards to the San Cristóban hill (fig. 7, section 7) (van Ginkel, 1965).
In the area of Perapertú the formation lies conformably on the Molino Formation, whereas in the south of the Pisuerga area a faultline between the Vañes Formation and the Cervera Formation marks the boundary between the Yuso Group and the Ruesga Group. The Vañes Formation is limited to the Pisuerga basin (fig. 5).

The Corisa Formation

This formation contains thick limestone beds intercalated with shales and sandstones. The Corisa Formation lies conformably upon the Vañes Formation. Different opinions exist about the boundary between both formations. Brouwer and van Ginkel included the Socavon limestone in the Corisa Formation. Nederlof (1959), who first reported the Corisa Formation, put the lowermost limestones in the Sierra Corisa, north of Vergaño, at the base of this type section (fig. 7, section 8).
The Corisa Formation is the uppermost formation of the Yuso Group in the Pisuerga area. On the San Cristóbal hill the Corisa Formation has been eroded away and Stephanian deposits overlie the Vañes Formation unconformably (de Sitter and Boschma, 1966). In the Redondo area a slight unconformity appears from the map, but in the Casavegas basin the Cea follows conformably.

The Buyon Beds of the Lechada Formation, and the Pandetrave Formation

In the Liébana (Potes) area (fig. 5) the Buyon Beds of the Lechada Formation above the Curavacas Conglomerate Beds have been mapped by Lanting (internal report). Description of this formation will be published in the near future.
In the eastern Liébana we find the Coriscao Beds above the Curavacas Conglomerates and also the Panda Limestone. Both units are part of the Lechada Formation. Upon these beds follow the turbidites of the Pandetrave Formation (fig. 5). Further publications about these sequences are in preparation.

Valdeón Formation

In the Valdeón area (fig. 5), which was mapped by Kutterink (internal report) a sequence of greywackes, shales and conglomerates composes the Valdeón Formation. At the base these deposits rest unconformably upon the Devonian Montó structure. The top probably reaches up in the Stephanian.

Concluding remarks on the Yuso Group

The Yuso Group shows distinct boundaries, the basal unconformity is an especially good marker. The formations which appear on the distribution map (fig. 5) can be joined together into a stratigraphic unit, which is limited by major tectonic lines. In the Isidro area the unconformity at the base of the Yuso Group is absent (Sjerp, 1967).
By lack of sufficient information about the sequences in the Cuenca Central we regard joining of formations, mapped by Sjerp (1967) into a group, premature. Whether that unit should be identified with the Yuso Group also is subject to further investigation.
Undoubtedly some of the rocks mapped by Evers (1967) and by Sjerp (1967) are correlable with the Yuso Group, and for this reason the maps published and edited by de Sitter and Boschma, show the same colour for the formations of the Yuso Group as for the Fitó Formation, the Beleño Formation, the Lois-Ciguera Formation, the Caliza Masiva Formation and the Lena Formation (Sjerp, 1967; Evers, 1967). Unfortunately, in the absence of a clear basal unconformity the precise equivalent cannot be distinguished and further work is needed, especially in the Cuenca Central.

THE CEA GROUP

The usually limnic coal-bearing formations which have been deposited after the Asturian folding phase, together constitute the Cea Group. After this phase followed a period of sedimentation in separated basins

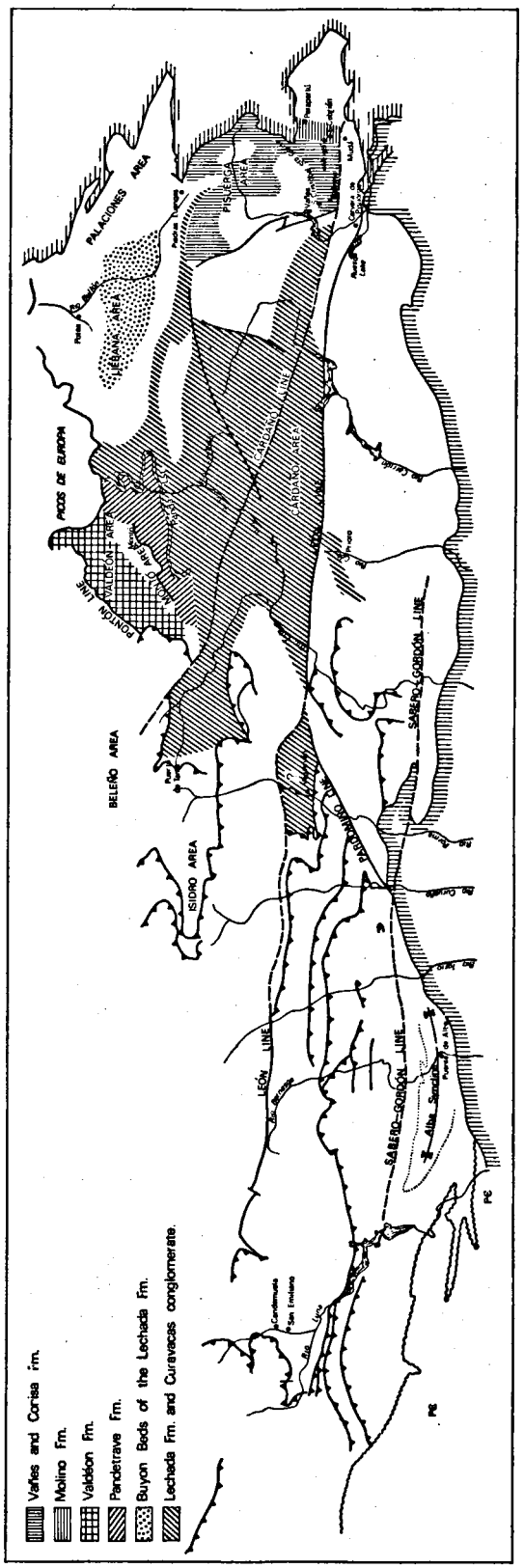

Fig. 5. Distribution of formations of the Yuso Group.

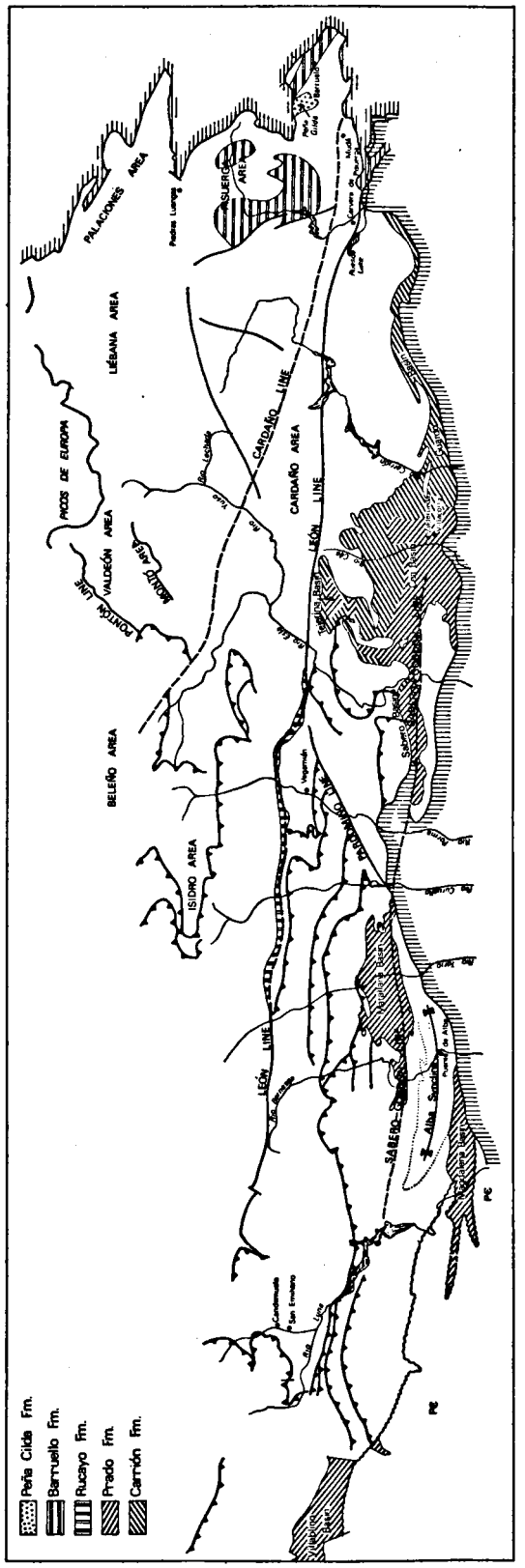

Fig. 6. Distribution of formations of the Cea Group.

in the southern Cantabrian Mountains. These intramontane basins can be found in the Leonides (Villablino, Magdalena, Sabero, Tejerina, Cea and Guardo), along the León line (Rucayo), and in the Pisuerga area. Helmig (1965) regarded the post-Asturian sediments in the Cea area together one Cea Formation. The major argument for this point of view was the monotonous development of the series. Considering, however, the diversity of Stephanian deposits in other areas in the southern Cantabrian Mountains, Helmig's Carrión and Prado members are to be regarded as formations. In the Cea Group we have the following formations; the Carrión Formation, the Prado Formation, the Rucaya Formation, the Peña Cilda Formation and the Barruelo Formation.

The Carrión Formation

The type area of the Carrión Formation is the Cea basin, which lies roughly between the Carrión and Esla Rivers. The most complete stratigraphic section of the formation has been found east of Valderrueda. The type section is exposed along the Carrión River between Guardo and Velilla (fig. 7, section 9). This section shows a cyclic sedimentation with coal-seams at the top and quartzite conglomerates at the base of many cycles.

Limestone conglomerates occur in this sequence only in the Tejerina area. According to Helmig (1965), the environment is paralic, although the marine intercalations never reach an important amount of the total sediment.

The Carrión Formation is restricted to the Tejerina basin, the Cea basin, the Guardo basin and the Sabero basin (fig. 6).

The Prado Formation

Unlike in the Carrión Formation, limestone conglomerates are important constituents in the Prado Formation, especially in the Cea basin. More to the west, like in the Magdalena basin, quartzite conglomerates become more abundant.

The type section is composed of a section which lies in the concessions of the Hulleras de Prado S.A. in the Cea basin and a section in the Sabero basin. The latter represents the younger part of the formation (fig. 7, section 10).

The formation starts in the type area with a thick series of limestone conglomerates, the Villacorta beds (Helmig, 1965). Upon these limestone conglomerates follows a sequence of clastic sediments of limnic origin. In the younger part of the formation no indications of marine intercalations have been found. The coal-seams are of major importance in this part of the sequence.

The Prado Formation occurs in the Cea basin, the Tejerina basin, the Sabero basin, the Matallana basin, the Magdalena basin and probably in the Villablino basin (fig. 6).

In the latter four basins the Prado Formation is the only representative of the Cea Group in these basins. Fossil-plant determinations show a Stephanian A age in the Cea basin; towards the west younger plants have been found (Wagner, 1965 and other publications; Stockmans, 1965). In the Villablino basin, Wagner (1965) found a Stephanian C flora.

The Rucayo Formation

The Rucayo Formation contains the unconformable Stephanian sediments along the León line. The formation is predominantly conglomeratic with a few coal-seams at the base.

Evers (1967) described a type section east of Rucayo between the rivers Torio and Porma (fig. 7, section 11). The location of the Rucayo Formation is strongly influenced by faulting along the León line (fig. 6).

Wagner (1963) and van Amerom (1965) determined the Stephanian B age of the floras collected from coal mine tips near the village of Rucayo.

The Peña Cilda Formation

The unconformable Pena Cilda deposits in the Barruelo area (fig. 6) have been described by Wagner (1955) who collected a Stephanian B flora.

The Barruelo Formation

The type section is in the Barruelo area and has been described by Wagner and Wagner-Gentis (1963) and van Ginkel (1965) (fig. 7, section 12). There are different opinions about names in the Pisuerga area. To avoid further ambiguity, de Sitter and Boschma (1966) incorporated all Stephanian deposits in the Pisuerga area into one Barruelo Formation (fig. 6), in which several limestone and coal members can be distinguished.

The base of the Barruelo Formation in the Pisuerga area is mainly determined by palaeontological data collected by van Ginkel (1965), based upon fusulinids from the limestones, and Wagner (1955 etc.), based upon fossil plants.

A clear unconformity at the base of the formation can be found only locally.

Concluding remarks on the Cea Group

The formations of the Cea Group have in general a continental character. Deposited in intramontane basins, they are distributed over three main areas.

1. The Leonides. Here the Carrión Formation and the Prado Formation are found in the Upper Stephanian coal basins.
   The development of the mostly east-west striking separated basins has been controlled by structural lines in the underlying Palaeozoic.
2. Along the León line, the Rucayo Formation has been developed in small basins in front of the Leonides.
3. The Pisuerga area. The Barruelo Formation and the Peña Cilda Formation represent the Cea Group in the Pisuerga area.
   Here fault zones also mark the distribution of a great part of the Barruelo Formation.
   In the Valdeón and Liébana areas no unconformable Stephanian deposits have been mapped.

FORMATIONS, NOT INCLUDED IN THE YUSO GROUP

North of the Leonides and west of the Palentian area five formations have been recognized (van Ginkel, 1965; Sjerp, 1967 and others). Before establishing lithostratigraphic groups in these areas, these formations need further investigation. These formations are:

The Lena Formation
Barrois (1882) named the mainly clastic series in the "Cuenca Central" de Asturias near the village Pola de Lena as the "Grupo de Lena". Van Ginkel (1965) called the rock-sequence which represents the southeastern continuation of the "Cuenca Central" the Lena Formation. The series has been built up by shales, which are often carbonaceous, sandstones, greywackes, thin limestone beds, thin conglomerate beds and some poor coal-seams. Total thickness reaches up to approximately 1700 m. The formation generally lies conformably upon the Caliza de Montaña Formation. Age determinations on fusulinids of the limestone beds indicate a Lower Moscovian age (van Ginkel, 1965). The Lena Formation is exposed in the area between the Isidro thrusts and the León line.

The Lois-Ciguera Formation
The Lois-Ciguera Formation has been designated by Brouwer and van Ginkel (1964). The formation represents the limestones, greywackes and shales in the area north of the upper Esla-valley near the villages Lois and Ciguera. Total thickness is about 1250 m. The high limestone content, more than 50 % of the whole series in the Lois syncline, distinguishes this sequence from that of the Lena Formation. The formation lies conformably upon the Caliza de Montaña Formation. Age determinations of fusulinids show a Lower to Upper Moscovian age range (van Ginkel, 1965).

The Beleño Formation
Van Ginkel (1965) called the clastic deposits immediately west of the Picos de Europa the Beleño Formation. Spanish authors, e.g. Julivert (1960) generally called these series the "Conjunto pizaroso". Shales, sandstones and thin limestone beds are the main constituents of this sequence. Total thickness is about 250—350 m. The Beleño Formation lies conformably upon the Caliza de Montaña Formation and is conformably overlain by the Escalada Formation. Age determinations of fusulinids indicate a Lower Moscovian age.

The Escalada Formation
Van Ginkel (1965) called the massive limestone sequence, which conformably lies upon the Beleño Formation, the Escalada Formation. Julivert (1960) used the name "Caliza Masiva Superior" and Sjerp (1967) called this limestone unit the Caliza Masiva Formation. The thickness of the formation varies from 80—250 m. The sequence is conformably overlain by the Fitó Formation. Age determinations of fusulinids in the limestone indicate the presence of Lower-Upper Moscovian assemblages.

The Fitó Formation
The clastic series which conformably lies upon the Escalada Formation represents the Fitó Formation (van Ginkel, 1965 and Sjerp, 1967). Julivert (1960) described this sequence of shales, sandstones and thin limestone beds as the "Serie superior con intercalaciones Calizas". The total thickness is approximately 700 m. Fusulinids of the limestone beds are of Upper Moscovian age.

REFERENCES

Adrichem Boogaert, H. A. van, 1967. Devonian and Lower Carboniferous conodonts of the Cantabrian Mountains (Spain) and their stratigraphic applications. Leidse Geol. Med., vol. 39, 130—189.

Amerom, H. W. J. van, 1965. Note préliminaire sur quelques flores stéphaniennes de la bordure nord des Léonides dans les Montagnes Cantabriques (Espagne du Nord-Ouest). Leidse Geol. Med., vol. 32, 151—156.

Barrois, Ch., 1882. Recherches sur les terrains anciens des Asturies et de la Galicie. Mém. Soc. Géol. du Nord, vol. 2, no. 1, 630 pp.

Brouwer, A. & Ginkel, A. C. van, 1964. La succession carbonifère dans la partie méridionale des Montagnes Cantabriques (Espagne du Nord-Ouest). C. R. 5e Congr. Internat. Strat. Géol. Carbonifère, Paris 1963, 307—319.

Comte, P., 1959. Recherches sur les terrains anciens de la Cordillère cantabrique. Mem. Inst. Geol. Min. Esp., vol. 60, 1—440.

Evers, H. J., 1967. Geology of the Leonides between the Bernesga and Porma rivers, Cantabrian Mountains, NW Spain. Leidse Geol. Med., vol. 41, 83—151.

Frets, D. C., 1965. The geology of the southern part of the Pisuerga basin and adjacent area of Santibañez de Resoba, Palencia, Spain. Leidse Geol. Med., vol. 31, 113—162.

Ginkel, A. C. van, 1965. Spanish Carboniferous fusulinids and their significance for correlation purposes. Leidse Geol. Med., Vol. 34, 175—225.

Helmig, H. M., 1965. The geology of the Valderrueda, Tejerina, Oceja and Sabero Basins (Cantabrian Mts, Spain). Leidse Geol. Med., vol. 32, 77—149.

Julivert, M., 1960. Estudio geológico de la cuenca de Beleño. Valles altos del Sella, Ponga, Nalón y Esla de la Cordillera Cantábrica. Bol. Inst. Geol. y Min. Esp., vol. 71, 1—346.

Kanis, J., 1956. Geology of the eastern zone of the Sierra del Brezo (Palencia, Spain). Leidse Geol. Med., vol. 21, 375—445 and Est. Geol., vol. 16, 109—156.

Koopmans, B. N., 1962. The sedimentary and structural history of the Valsurvio Dome, Cantabrian Mountains, Spain. Leidse Geol. Med., vol. 26, 121—232.

Kullmann, J., 1961. Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien). I. Stratigraphie, Paläontologie der U.O. Goniatitina Hyatt. Neues Jahrb. Geol. Paläont., Abh. 113, 219—326.

Nederlof, M. H., 1959. Structure and sedimentology of the Upper Carboniferous of the Upper Pisuerga valleys, Cantabrian Mts, Spain. Leidse Geol. Med., vol. 24/2, 603—703.

Rácz, L., 1964. Carboniferous calcareous algae and their associations in the San Emiliano and Lois-Ciguera Formations (León, NW Spain). Leidse Geol. Med., vol. 31, 1—112.

Rupke, J., 1965. The Esla Nappe, Cantabrian Mountains (Spain). Leidse Geol. Med., vol. 32, 1—74.

Savage, J. F., 1967. Tectonic analysis of Lechada and Curavacas synclines, Yuso Basin, León, NW Spain. Leidse Geol. Med., vol. 39, 193—247.

Sitter, L. U. de, 1962. The structure of the southern slope of the Cantabrian Mountains. Leidse Geol. Med., vol. 26, 255—264 and Bol. Inst. Geol. Min. Esp., vol. 74, 393—412 (with 1 : 100.000 geological map).

—, 1966. De relatie tussen orogenese en epeirogenese in het Cantabrisch Gebergte. Kon. Ned. Ak. Wet. Afd. Natuurk., 75, no. 7, 114—120.

Sitter, L. U. de & Boschma, D., 1966. Explanation geological map of the Palaeozoic of the southern Cantabrian Mountains 1 : 50.000, sheet Pisuerga. Leidse Geol. Med., vol. 31, 191—238.

Sjerp, N., 1967. The Geology of the San Isidro-Porma area (Cantabrian Mountains, Spain). Leidse Geol. Med., vol. 39, 55—128.

Stockmans, F. & Willière, Y., 1965. Documents paléobotaniques pour l'étude du Houiller dans le Nord-Ouest de l'Espagne. Inst. Royal Sci. Nat. Belgique, mém. 2e série, fasc. 79, 1—92.

Veen, J. van, 1965. The tectonic and stratigraphic history of the Cardaño area, Cantabrian Mountains, NW Spain. Leidse Geol. Med., vol. 35, 43—103.

Wagner, R. H., 1955. Rasgos estratigráfico-tectónicos del Paleozoico Superior de Barruelo. Est. Geol., vol. 11/26, 145—202.

—, 1960. Middle Westphalian floras from northern Palencia (Spain). Est. Geol., vol. 16, 55—92.

—, 1963. A general account of the Paleozoic rocks between the rivers Porma and Bernesga (León, NW Spain). Bol. Inst. Geol. Min. Esp., vol. 74, 173—329.

—, 1965. Palaeobotanic dating of Upper Carboniferous folding phases in NW Spain. Mem. Inst. Geol. Min. Esp., t. 66.

Wagner, R. H. & Wagner-Gentis, C. H. T., 1952. Aportación al conocimiento de la geología de la zona de Barruelo (Palencia). Est. Geol., vol. 8/16, 310—344.

—, 1963. Summary of the stratigraphy of Upper Paleozoic rocks in NE Palencia, Spain. Proc. Kon. Ned. Ak. Wet. B, vol. 66/3, 149—163.

Wagner-Gentis, C. H. T., 1963. Lower Namurian goniatites from the Griotte Limestone of the Cantabrian Mountain Chain. Not. y Comuns. Inst. Geol. Min. Esp., vol. 69, 5—42.

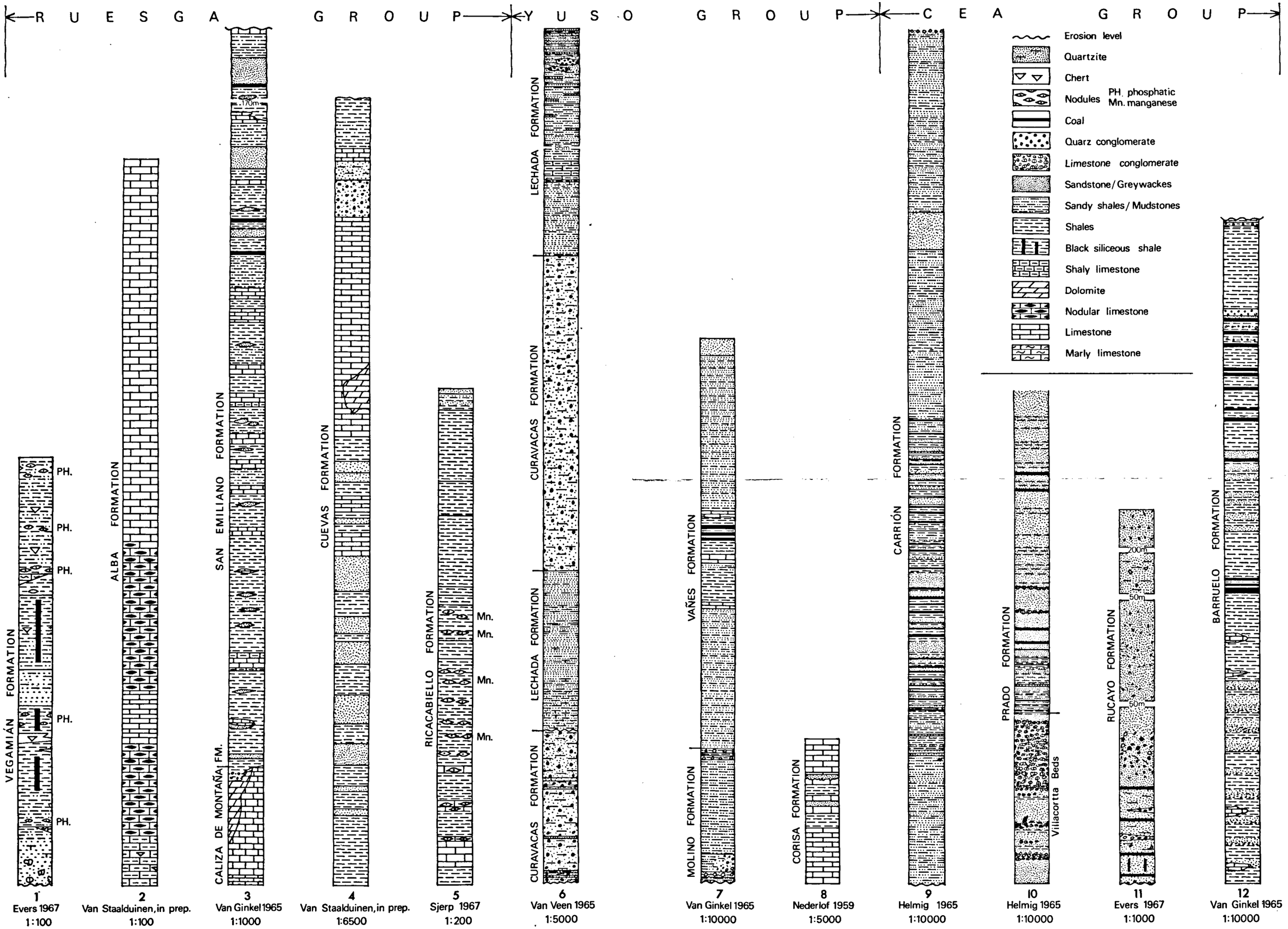

Fig. 7. Stratigraphic Columns.