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CARBONIFEROUS PRODUCTIDINA AND CHONETIDINA OF THE CANTABRIAN MOUNTAINS (NW SPAIN): SYSTEMATICS, STRATIGRAPHY AND PALAEOECOLOGY

BY

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ABSTRACT

The Carboniferous sediments of the thrust structures between the Porma and Bernesga rivers (map 2) and the headwaters of a tribuary of the Luna River (map 3) are described. In the lithostratigraphic chapter, the Vegamián, Alba, Escapa and San Emiliano formations are described, ranging in age from the Tournaisian to the lowermost Westfalian. The Alba and Escapa formations are subdivided into three and two members, respectively.

An attempt has been made to reconstruct the palaeoecological conditions during sedimentation. The palaeoecological interpretation is based mainly on the productoids and chonetoids, but other palaeontological and lithological evidence has also been used. Many faunal assemblages have been found, which are comparable to those described by Moore (1964) from Pennsylvanian and Permian deposits in Kansas (U.S.A.). A short sedimentary history is given in chapter IV.

A systematic study has been made of the Carboniferous representatives of two suborders of the phylum Brachiopoda: the Productidina and the Chonetidina. 22 Genera of the Productacea are described. They are represented by 51 species and subspecies, three of which are new. The new species are *Levipustula breimeri, Karavankina rakuszi* and *K. wagneri.* Twelve species and subspecies of seven different genera are described from the family Chonetidae.

The investigation of these brachiopods resulted in a reappraisal of the Spanish Carboniferous productoids and chonetoids, combined with the description of a number of elements previously unknown in Spain. The genus *Karavankina* is described in some detail since only a short introductory note (Ramovs, 1966) has been published previously. A pedicle sheath is described for the first time for the genus *Chonetipustula.* The groove in the internal moulds of small pedicle valves of that genus are shown to be due to a groove anterior to the pedicle sheath, and not to a median septum as supposed by previous authors.

A comparison of the faunas with those of other areas leads to some interesting conclusions. The fauna of the Vegamián Formation is closely comparable with German faunas of a slightly younger, distinctly Viséan age. The fauna appears to be dependent on the type of sediment deposited, viz. black shales, and not so much on the stratigraphic age. Van Ginkel (1965b) has dated the top of the Escapa Formation on the basis of fusulinids as Lower Bashkirian. The productoid assemblage of these deposits is unique and consists mainly of forms found in the Viséan of north-western Europe, together with a few genera and species known from Moscovian and even younger strata elsewhere. The upper Bashkirian and the lowermost Moscovian faunas in Spain become more cosmopolitan, the Viséan and Namurian elements being replaced by new ones. In Moscovian strata, it is found that the fauna shows close relationships with the faunas described from Russia and China as well as with those found in the Westfalian marine bands of north-western Europe. The Carboniferous faunas in nord-west Spain apparently belong to the Europe Tian-Shan faunal province, because the productoid fauna as well as the fusulinid fauna agree with those described for this province (Einor et al., 1965). It seems that *Karavankina* should be added as another characteristic genus for this faunal province. It occurs from the Cantabrian Mountains to China. The Kasimovian productoids belong to the Moscovian genera, but differ at a specific level.

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CHAPTER I

LITHOSTRATIGRAPHIC SUBDIVISION

The Carboniferous formations of the Cantabrian Mountain chain can be arranged in three groups (Koopmans, 1962):
1. The *Ruesga Group* of Lower and early Upper Carboniferous age. This group occurs together with older Palaeozoic rocks in generally E-W striking thrust structures; in the area between the Porma and Bernesga rivers, from S to N, they are called the Rozo, Correcilla, Gayo, Bodón and Forcada units. The formations are characterized by limestones and fine-grained, clastic deposits.
2. The *Yuso Group* of Upper Carboniferous (Moscovian) age. The rocks of this group are found predominantly in basins outside the Leonide thrust fold area. The lithology of the sediments often changes within short distances and many coarse sediments occur. They were deposited in a time of active orogenic movement. The San Emiliano Formation can be best placed in this group because it contains an abundance of coarse sediments.
3. The *Cea Group* of Upper Carboniferous age. This group consists of paralic and continental sediments.
The Ruesga Group is often clearly exposed because it dips very steeply and consists mainly of resistant limestones with a sparse vegetation. The Yuso Group is also steeply folded. In the area investigated, it contains the Lena Formation, which is principally a shale-sandstone sequence covered by dense vegetation. The Cea Group, lying unconformably on older rocks, will not be considered.
Attention will be focussed on the Ruesga Group and the San Emiliano Formation because these contain the most promising faunas in the area between the Porma and Bernesga rivers (map 2). The Ruesga Group consists of the following formations in descending order:

Escapa Formation
Alba Formation
Vegamián Formation.

The stratigraphy of the Yuso Group will not be discussed but its Productidina and Chonetidina will be described. For the stratigraphy of this group the reader is referred to van Ginkel (1965b); for the stratigraphic subdivision of the Carboniferous deposits of Palencia, see van Ginkel (1965b) and de Sitter and Boschma (1966).
Lists of fossils are given in Tables I to V at the end of the thesis.

VEGAMIÁN FORMATION

The Vegamián Formation consists of the beds originally described by Comte (1959, p. 330) as the "couches de Vegamián" (fig. 1). The type section is 1 km SSW of the village Vegamián in the Porma Valley. The term Vegamián Formation is applied here with the same connotation used by van Ginkel (1965b).
This unit is a thin but remarkably widespread sequence of black, often brilliant, sometimes grey or greenish-grey, shales. The shales contain nodules of silico-phosphate and markasite. Occasionally thin beds of black chert and limestone occur; near the base and near the top, thin sandstone layers are often found. The thickness of the formation is ca. 5 m.
The Gete and the Valdehuesa members are similar in lithology to the La Venta Member and are therefore included in the Alba Formation instead of the Getino Formation of Rácz (fig. 1). The lithologically quite

SPANISH AUTHORS		FRENCH AUTHORS		DUTCH AUTHORS					
Patac (1920) a.o.	Martínez Alvarez (1962)	Barrois (1884) a.o.	Comte (1959)	Brouwer & van Ginkel (1964)	Rácz (1964)	van Ginkel (1965)	Rupke (1964) a.o.	Evers (1967)	Winkler Prins (1968)
	IMPRODUCTIVO PIZARROSO	ASSISE DE LEÑA	CALCAIRES ET SCHISTES DE LENA	SAN EMILIANO FORMATION				MUDSTONE AND LIMESTONE MEMBER MUDSTONE AND GREYWACKE MEMBER BASAL MUDSTONE MEMBER	SAN EMILIANO FORMATION
CALIZA DE MONTAÑA	IMPRODUCTIVO CALIZO	ASSISE DE CAÑONS	CALIZA DE MONTAÑA	ESCAPA FORMATION			CALIZA DE MONTAÑA FORMATION	UPPER BIOSPARITE MEMBER LOWER MICRITE MEMBER	ESCAPA FORMATION: VALDETEJA MEMBER VEGACERVERA MEMBER
MARMOL GRIOTO (CALIZA GRIOTTE)	SERIE GRIOTTE	ASSISE DE GRIOTTE	GRIOTTE DE PUENTE DE ALBA (GRIOTTE A *GONIATITES CRENISTRIA*)	SELLA FORMATION	SELLA FORMATION GETINO FORMATION	ALBA (GRIOTTE) FORMATION			ALBA FORMATION: LA VENTA MEMBER VALDEHUESA MEMBER GETE MEMBER
	PIZARRAS NEGRAS		COUCHES DE VEGAMIAN			VEGAMIAN FORMATION			VEGAMIAN FORMATION
			GRES DE L'ERMITAGE	ERMITA(GE) FORMATION					ERMITA FORMATION: LIMESTONE MEMBER SANDSTONE MEMBER

Fig. 1. Review of the different stratigraphic interpretations of the lower part of the Carboniferous in León and adjacent areas.

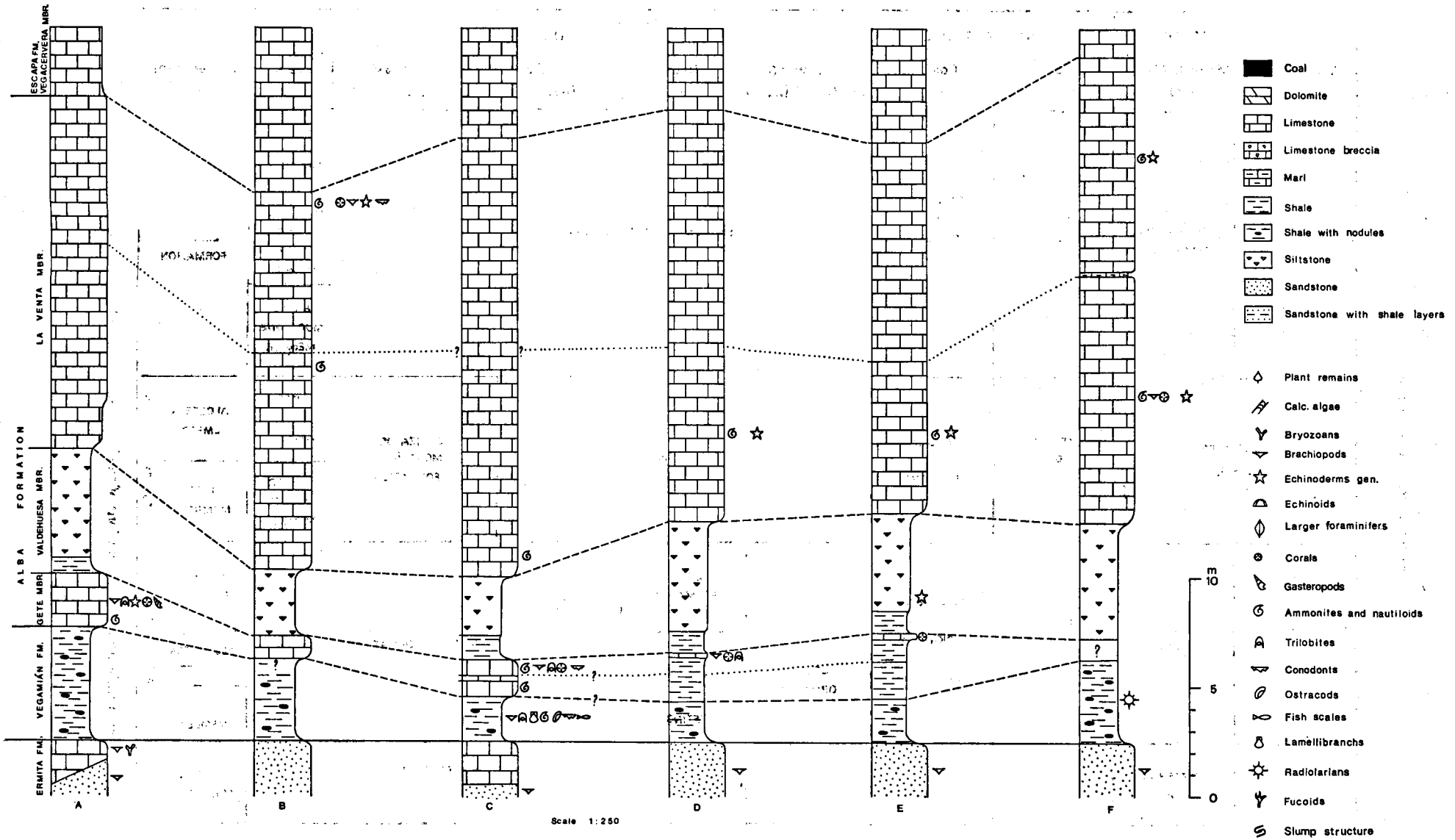


Fig. 2. Stratigraphic sections of the Vegamián and Alba formations.
A. Section NW of Gete (loc. 8), type loc. of the Gete Members.
B. Section at Getino (loc. W 1069; Wagner, 1963, p. 56ff).
C. Section SW of Genicera (loc. W 1162; op. cit., p. 53ff).
D. Section S of Valverde (loc. 5). E. Section S of Valdeteja (loc. 4). F. Section at the quarry of La Venta (Vega de San Pedro), type loc. of the La Venta Mbr. (loc. 2).

Fig. 2a. Legend for the stratigraphic sections.

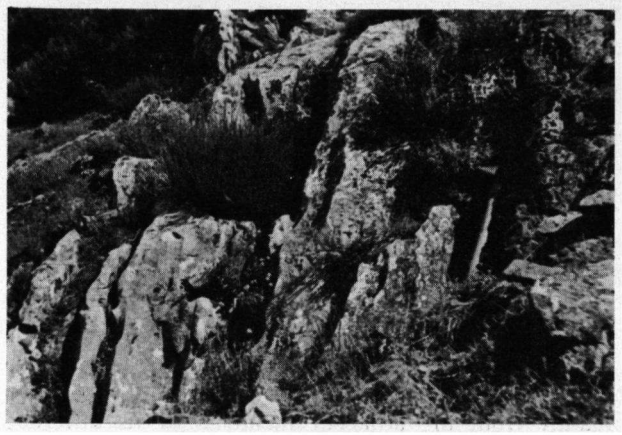


Fig. 3. View of the upper part of the Ermita Formation NW of Gete (loc. 8). The limestone member is to the left of the hammer, the sandstone member to the right.

different black shales of the Getino Formation are now called the Vegamián Formation.

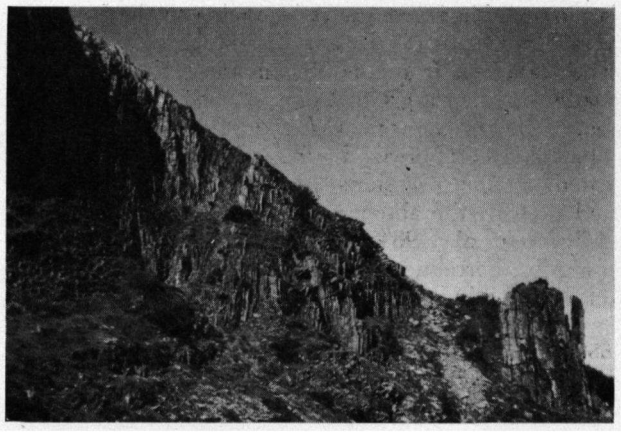
In the investigated area, the Vegamián Formation usually rests with a slight disconformity upon the Ermita Formation which in turn lies unconformably on rocks of different ages.

The Ermita Formation consists of decalcified sandstones, which are variably developed depending on the nature of their source area. The moulds of brachiopods are helpful in recognizing this formation. Often a limestone is found near the top of the formation and in such a case, a gradual transition occurs from the decalcified sandstone, via a calcareous sandstone and a sandy limestone, to a pure coarsegrained limestone (fig. 3). The colour of the limestone is light grey, often with pink spots. Brachiopods, crinoidal fragments, bryozoans and conodonts have been found in this limestone.

The gradual transition from the sandstone to the limestone, the local development of the latter, and the sharp boundary with the Vegamián Formation are the reasons that this limestone is considered a member of the Ermita Formation rather than a separate formation and definitely not a part of the overlying Vegamián Formation. Rácz (1964, p. 10) probably also meant this when he stated: "Because the transformation is gradual, in each locality there is a good continuity between the limestones and the underlying sandstone, there can be no doubt that this limestone bank represents the highest Devonian deposits and are [sic!] of Famennian age." It is not as certain as this statement suggests that the limestone belongs completely to the Upper Devonian.

The lenticular shape of the limestone member of the Ermita Formation and the irregular surface of the sandstone member sometimes found when the limestone is absent are strong indications of an erosional hiatus. The sandy and gritty layers in the basal part of the Vegamián Formation (Higgins et al., 1964) support this idea.

Fig. 4a. View of the lower part of the Ruesga Group SW of Genicera, photographed from loc. W1162 to the west.

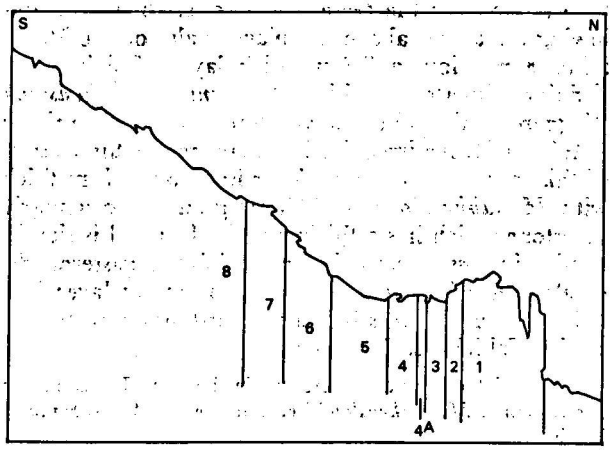


ALBA FORMATION

Comte (1959, p. 330) described as the Griotte de Puente de Alba (Griotte à *Goniatites crenistria)* a sequence with nodular limestones near the village of Puente de Alba in the Bernesga Valley. This sequence is called the Alba Formation here in accordance with van Ginkel (1965b). This formation is a widespread unit known throughout the Cantabrian Mountains.

When the Alba Formation is completely developed, about one metre of cream-coloured, fine-grained limestone is found at the base. This layer is followed by ca. 0.50 m of grey nodular limestone, changing in its turn into 1 m of red-coloured nodular limestone which is somewhat marly at its top. The variability in the development of these limestones can be seen in figure 2. The transition from limestones to shales is especially remarkable and can be seen clearly in the exposures of the Gayo thrust structure between Genicera in the west (fig. 4) and Valdeteja in the east. At the latter, the black shales of the Vegamián Formation are over-

4b. Schematic representation of fig. 4a. 1 = Ermita Fm., sandstone mbr.; 2 = idem, limestone mbr.; 3 = Vegamián Fm.; 4 = Alba Fm., Gete Mbr.; 5 = idem, Valdehuesa Mbr.; 6 = idem, La Venta Mbr., bed A; 7 = idem, bed B; 8 = Escapa Fm., Vegacervera Mbr.



lain by nearly 2 m of greenish-grey shale, followed by another 2 m of red, somewhat marly, shale with a red nodular limestone band 30 cm thick. The greenish shales can be considered a part of the Vegamián Formation and the absence of the greyish limestones can be explained by a break in the sedimentation. It seems, however, more likely that the greenish shales replacing these limestones indicate only a lateral facies change due to a larger supply of detrital material, since the red limestone is also largely replaced by a marly shale. Red shales with thin layers of bright green shale occur above these limestones. The total thickness is a little more than a metre. They are followed by red siltstones with irregular patches of white, purple or black. The siltstones have a few thin shale partings and are 3 to 6 m thick. Only radiolarians and moulds of small crinoid ossicles have been found in these siltstones.

These clastic deposits are followed by a nodular limestone which is a pure, fine-grained micrite with only a few marly layers. The lower part varies in colour from pink to red; the upper part is grey. The distinction between the two parts is not always as easy as would be expected because the limestones of the lower part sometimes weather grey; on a fresh surface, they are usually pink but some grey layers do occur. The upper part has a lighter grey colour, often somewhat greenish or cream-coloured. The thickness is variable, the reddish part being 7 tot 15 m thick, while the grey part varies from 4 to 10 m. These limestones, known as the Griotte, attracted attention quite early because of their constant position at the base of the impressive limestone sequence of the Escapa Formation, the typical pink to red colour and their rich cephalopod content.

The siltstones and shales separate the lower nodular limestone from the upper. Since both limestones are readily distinguished it seemed justified to divide the Alba Formation into three members, in descending order:

La Venta Member
Valdehuesa Member
Gete Member.

Gete Limestone Member. — An exposure in the Gayo nappe NW of Gete (loc. 8, fig. 1) has been chosen as type section for the Gete Member. It shows the following sequence: above the black shales of the Vegamián Formation, a 0.8 m thick layer of light grey, nodular limestone with *Merocanites subhenslowi* Wagner-Gentis and *Muensteroceras sphaeroidale* (McCoy) [1]). An irregular boundary marks the change of this layer into a red, nodular limestone 1.5 m thick with *M. subhenslowi*. This layer grades into a marly limestone which has a thickness of 0.4 m and is rich in benthonic fossils: brachiopods, trilobites, gasteropods, corals and echinoderms. Above this marly layer is a red shale which turns into a red siltstone; both belong to the Valdehuesa Member.

[1]) The determinations were made by Dr. J. Kullmann (pers. com.), *M. subhenslowi* being quoted as *M. applanatus* Frech.

Other good exposures occur SW of Genicera (fig. 4) and near Olleros de Alba (Higgins et al., 1964, p. 214). The Gete Member can be distinguished from the La Venta Member by its less pure, more nodular limestones which are less resistant to erosion and much thinner.

Valdehuesa Siltstone Member. — The Valdehuesa Member consists of fine-grained detrital sediments. A section N of Valdehuesa in the Forcada nappe, where this member is well-developed, has been chosen as type section (loc. 18′, just E of the area of map 2). At the type section, this member consists of a 6 m thick shale-siltstone sequence (Evers, 1967, fig. 19). The Valdehuesa Member can usually be distinguished readily from the adjacent members by its different lithology and faunal content. The Gete Member may cause some difficulties whenever it has developed predominantly as a shale. The base of the Valdehuesa Member has been placed immediately above the limestone. The transition from the Gete to the Valdehuesa Member is a gradual one, as the shale is somewhat marly at its base. The boundary has been drawn where the shale looses its marly character. The upper boundary is lithologically very distinct, although the siliceous nodules in the lower part of the La Venta Member indicate that this transition is also a gradual one.

La Venta Limestone Member. — In the area discussed, the La Venta Member can be divided into two parts: a lower, red-coloured, nodular limestone often called the Marbre Griotte (bed A) and an upper, light grey, nodular limestone and marl, the so-called Marbre Campan (bed B). As type section for this member, a quarry at La Venta, also called Vega de San Pedro, in the Bodón thrust unit situated in the Curueño Valley, has been chosen. In this section, the siltstones of the Valdehuesa Member, which are badly exposed, are followed by 5 m of pink-red limestone with cephalopods, approximately 1 m of dark grey limestone, 3 m of purple-red limestone with crinoid remains and an occasional brachiopod, and 2 m of purplish-pink limestone with cephalopods, corals and crinoids. Above these reddish limestones (bed A) are 4 m of light yellowish-grey limestone with marly layers and calcite lenticles (bed B). These limestones contain cephalopods and crinoid remains. Above them follow laminated, black limestones belonging to the Vegacervera Member of the Escapa Formation.

The transition from the Vegamián to the Alba Formation is often a gradual one; a good example is the section SW of Genicera (Wagner, 1963, p. 54). Sometimes, however, breaks in the sedimentation are indicated by thin, occasionally conglomeratic, sandstones and even by the absence of the Vegamián Formation (Higgins et al., 1964; Budinger & Kullmann, 1964), the Alba Formation lying in that case upon the Ermita Formation.

ESCAPA FORMATION

The Escapa Formation is quite extensive geographically and forms a conspicuous feature in the scenery.

The thick sequence of massive limestones and dolomites results in high mountain ridges often with steep slopes. For this reason, it drew the attention of early geologists, and Spanish authors have always called it the "Caliza de Montaña". The literal translation of this name brings to mind the "Mountain Limestone" of Great Britain, which is, however, slightly older. French authors refer to this formation as the "Calcaire des Cañons", the name given by Barrois (1882) because of the many impressive gorges cut into the limestones by the rivers. Instead of these descriptive terms, however, it is preferable to use a name derived from a geographical feature. The Escapa Formation, proposed by Brouwer and van Ginkel (1964, p. 309), has the Sierra de Escapa (Asturias) as the type area. It is, however, unfortunate that no measured type section of that area is available.

The Escapa Formation starts with a thick sequence of black to dark grey, fetid, micritic limestones with streaks of white calcite. The laminated limestones are well-banked. The rocks may, however, have a massive appearance when the bedding is concealed by weathering (fig. 5). Fossils are almost absent, although a

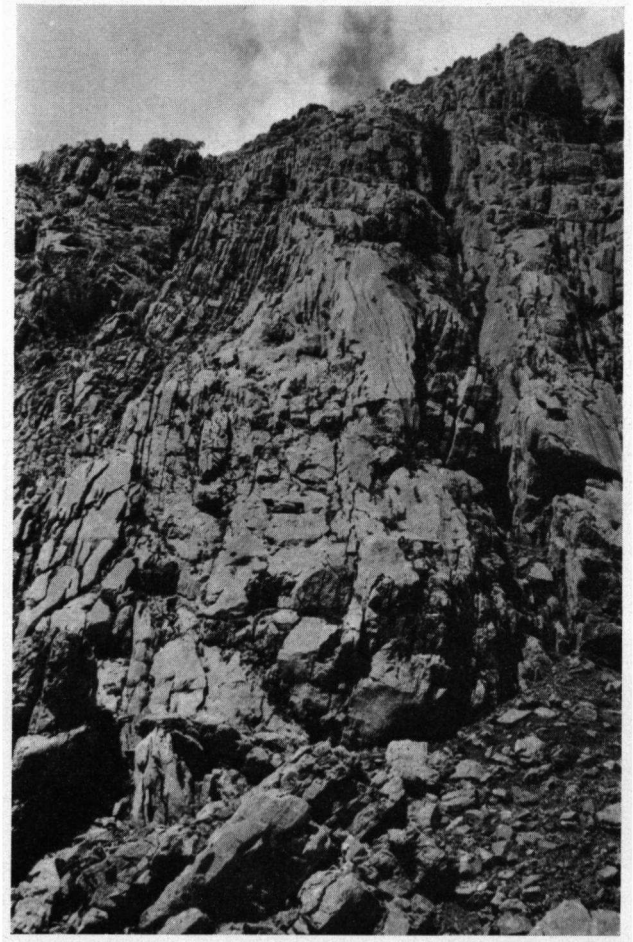


Fig. 5. View of a section of the Vegacervera Member on the eastern bank of the Curueño River (loc. 3) showing the laminated limestone appearing partly massive because of weathering.

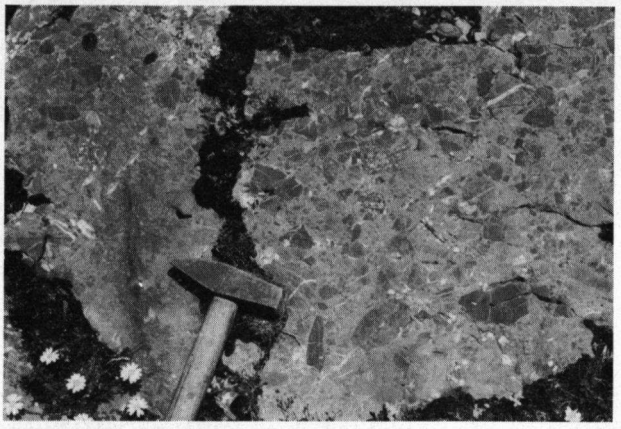


Fig. 6. The intraformational breccia in the upper part of the Vegacervera Member on the eastern bank of the Curueño River (loc. 3).

scanty fauna of small brachiopods and crinoids has sometimes been found near the top of this sequence of black limestones. In the upper part of this sequence, an intraformational breccia has been found. This breccia is composed of randomly oriented, angular fragments of the normal black limestones of this member, embedded in a matrix of similar but somewhat lighter limestone and white calcite (fig. 6). This breccia has been found in many places and is therefore of importance for the environmental interpretation of the Vegacervera Member.

Light grey, thick-bedded or massive limestones with occasional shale and marl layers are found above the dark-coloured micrite limestones. The limestones are often biosparitic but the thick, massive parts are, for the most part, recrystallized and contain dolomite lenses; they may even be completely dolomitized. Together with the dolomite are poor mineral deposits of malachite, clear quartz crystals and calcite.

Recrystallization and dolomitization destroyed most of the fossils in the massive parts, though they may be faintly visible on a weathered surface. For this reason, the Escapa Formation was not extensively investigated for fossils, although some have been described from Asturia. A careful search may show this formation to be more fossiliferous than was supposed, as is indicated by the rich fossiliferous finds near Valdeteja and Cármenes (loc. 3, 10). In this connection, it is interesting to note that all important fossil localities for the upper half of the formation are situated in gorges along road sections, since the best fossiliferous layers are thin-bedded limestones and marly shales, which are not exposed elsewhere. In the massive parts, the fossils are difficult to discover. Because of recrystallization, they weather in the same way as the matrix and it is therefore difficult to extract them from the rock. In many places, the top of the Escapa Formation is fossiliferous, containing specifically auloporid corals. Several groups of fossils have been encountered in this member (compare Table III), the Productidina being the most abundant animals.

The black, micritic limestones forming the lower part

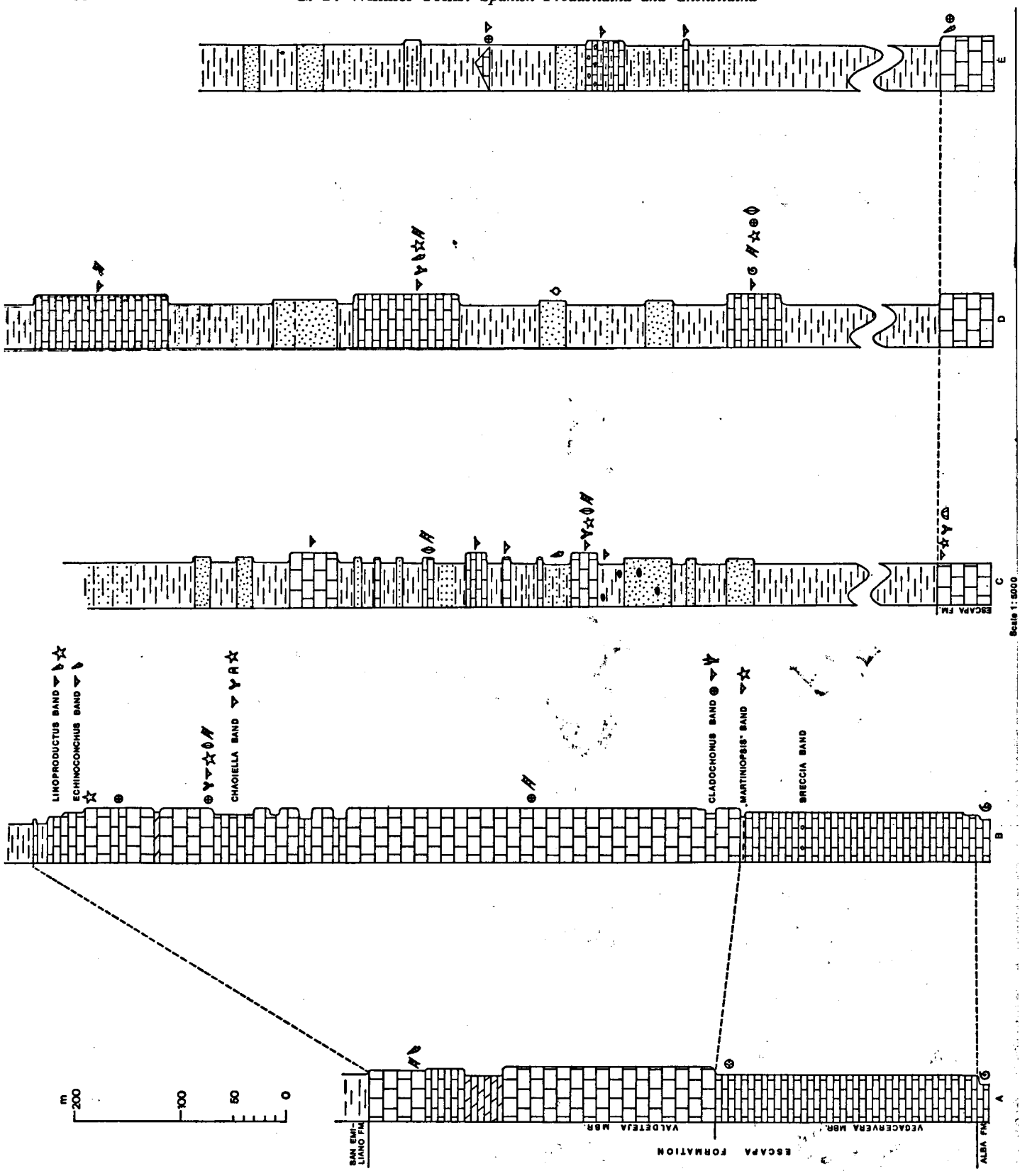


Fig. 7. Stratigraphic sections of the Escapa and San Emiliano formations. A. Section E of Caldas de Nocedo (loc. 1). B. Section E of Valdeteja along the road to the Curueño River, type of the Valdeteja Mbr. (loc. 3). C. Section of the San Emiliano Fm. N of Barrio de la Tércia (loc. 13). D. Section of the San Emiliano Fm. E of Genicera (loc. 14). E Section of the San Emiliano Fm. N of Valverde (loc. 15). A barren shale sequence of 250 m thickness has been omitted from the lower part of the San Emilliano Fm. in columns C-E.

of the Escapa Formation are quite distinct from the light-coloured, partly biosparitic limestones of the upper part. This twofold division has already been indicated by previous authors (e.g. Delépine, 1951, p. 149), but no formal names have yet been given to these parts. The names Vegacervera Member and Valdeteja Member are introduced here for the lower and upper parts, respectively.

The Vegacervera Member is lithologically very uniform and is found over a large area. The Valdeteja Member, on the other hand, is more variable in its lithology and faunal content and could therefore be divided into countless minor units, which would only be of local significance. Another alternative has been used instead: only the characteristic beds in the sections are named, usually after a diagnostic fossil. In the type section E of Valdeteja (fig. 7, col. B), for example, there is a *Cladochonus* band, a *Linoproductus* band, etc. This procedure was chosen in order to avoid long and confusing descriptions of fossil locations in the chapters on ecological and systematic palaeontology.

Vegacervera Micrite Member. — The Vegacervera Member is remarkably wide-spread and uniform in its development. This unit is named after the Hoces de Vegacervera, a gorge in the Torío Valley, S of Felmín. The road section lying in the Correcilla nappe has been chosen as type section. This member varies in thickness from 100 to 400 m and a value of 250 m, measured at the type section, is a good average.

At the type section in the northern flank of the Correcilla syncline, the intraformational breccia cannot be found; it has been found in the southern flank somewhat below a fossiliferous shale bed separating the Vegacervera and the Valdeteja Members. The greater part of the Vegacervera Member in the southern flank is covered by the Lower Palaeozoic deposits of the Rozo nappe (Lekahena, 1964).

The Vegacervera Member can be easily distinguished by its dark-coloured micritic limestones and the almost complete absence of fossils.

Valdeteja Biosparite Member. — The Valdeteja Member is highly variable in its development, which is in sharp contrast to the abovementioned member. The section E of Valdeteja (fig. 7) along the road to the Curueño River has been chosen as type section, because the limestones are well exposed, only slightly dolomitized and exceptionally rich in fossils. At the type section of the Valdeteja Member in the Bodón nappe, the Vegacervera Member ends with one metre of black, laminated, calcareous shale (*"Martiniopsis"* band) followed by 2 m of banked, dark grey limestone. The Valdeteja Member begins with 45 m of light brownish-grey, massive, recrystallized limestone with greyish-black parts. At the top of this limestone, a light grey limestone is found which turns into a greenish-grey marl followed by grey to purplish limestones with shale partings. This sequence is 10 m thick. At the base are some brachiopods followed by abundant corals, especially *Cladochonus,* whence this sequence is called the *Cladochonus* band. Above this band are 15 m of thick-bedded, dark grey limestones with shale partings containing large crinoid stems. It is followed by 440 m of thick-bedded to massive, grey to brownish-grey, recrystallized limestones. These limestones are usually unfossiliferous but occasionally ghost-structures of corals and algae have been found. In the recrystallized limestones, dolomite lenses occur with calcite masses. A 10 m thick, grey, banked limestone with a varied, partly silicified fauna follows these massive limestones. After another 5 m of unfossiliferous, grey limestone, a reddish weathering, laminated limestone with an adjacent, dark grey to grey-brown, banked limestone, 2 m thick, is found containing a rich brachiopod fauna with a high productoid content and a few other fossils (*Chaoiella* band). This layer is followed by 130 m of massive light grey limestone with a few dolomite lenses up to 5 m thick containing calcite, malachite and quartz. This limestone grades into a 6 m thick, light grey, irregularly bedded, crinoidal limestone, in its turn overlain by 1 m of tough, light grey limestone with abundant productoids and a few other fossils (*Echinoconchus* band). This band is followed by ca. 25 m of massive grey limestone and then a black limestone which is partly laminated and partly banked. This black limestone (*Linoproductus* band) contains many well-preserved productoids, some with their spines adhearing, and other fossils. The productoids are conspicuous as they are of white calcite. This black limestone is followed by 20 m of grey, banked limestones with a poor fauna, separated by shale intercalations. This is considered the top of the Valdeteja Member. The limestones are followed by a barren shale sequence which forms the basal part of the San Emiliano Formation.

The section S of Valdeteja in the Gayo thrust unit reveals fewer marly layers and no productoids have been found, but in the massive, often recrystallized, limestones are a few layers rich in fusulinids and algae. The Valdeteja Member is easily distinguished by its thick, massive limestone layers which dominate the sequence, and by the predominance of light grey colours, although red, beige and black are occasionally encountered. The black *Linoproductus* band near the top of this member at the type section could be mistaken for the Vegacervera Limestone, if not for its stratigraphic position and its fauna.

The thickness of the Valdeteja Member is highly variable and often difficult to establish when this member is interbedded with the overlying San Emiliano Formation. At the type section this member has a thickness of 675 m.

The boundary between the La Venta Member of the Alba Formation and the Vegacervera Member of the Escapa Formation is usually very distinct. Interbedding of the two types of limestone, however, can make it difficult to draw an exact boundary. For this thesis the boundary is drawn above the highest, light grey, fossiliferous limestone of the Marbre Campan type.

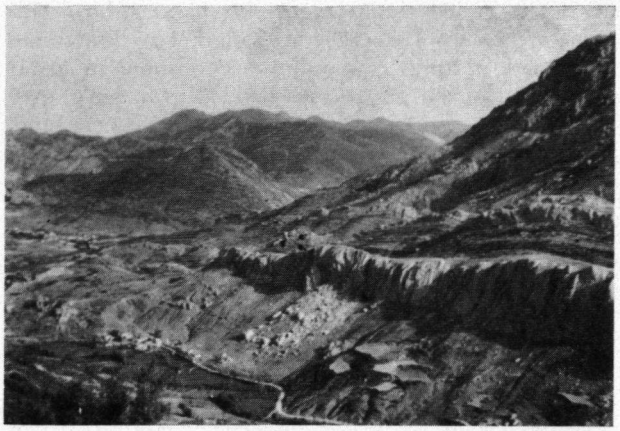


Fig. 9. View of the San Emiliano Fm. E of Cármenes with the Escapa Fm. in the background to the right. A typical development of the San Emiliano Fm. is shown with the occasional wedging out of the limestones. The village in the left foreground is Valverdín.

SAN EMILIANO FORMATION

The San Emiliano Formation is a heterogenous unit, both in lithology and fossil content. It lies conformably on the Escapa Formation and forms the highest unit in the Leonide thrust structures. The San Emiliano Formation was designated by Brouwer and van Ginkel (1964). The type section lies between the villages of Villargusan and Pinos in the Luna area (map 3). The San Emiliano Formation is assumed a part of the Yuso Group and not of the Ruesga Group, because this formation consists largely of clastic sediments and is comparable to the Lena Formation.

The San Emiliano Formation consists of a thick clastic sequence of shales with sandstone and limestone layers and lenses (fig. 9). The shales vary in colour from yellowish-grey to red-brown and are usually poorly exposed. A more resistant, dark grey to black type, which may be coal-bearing, is found in the upper part of the formation. A remarkable feature of the shales is the occurrence of red-brown clay-ironstones, sometimes with well-preserved brachiopods (loc. 11). The shales are normally devoid of fossils, but in the San Emiliano area highly fossiliferous marly shales do occur.

The limestones in the type area are marly; pure limestones are rare. In the Cármenes area (map 2), on the other hand, the limestones described in detail by Rácz (1964) are normally pure.

The sandstones are grey to brown quartzwackes, often showing slump structures. Fossils are generally scarce in the sandstones, except for fragmentary plant remains. A remarkable rock type is found in the Gayo thrust sheet near Valdorria. It is a para-conglomerate consisting of well-rounded quartzite boulders up to 25 cm in diameter embedded in a shale layer (loc. 6). Similar boulders, together with angular limestone fragments, have been found in a limestone matrix (loc. 7).

At a section E of Genicera (loc. 14, fig. 7, col. D), the San Emiliano Formation starts with a 350 m thick sequence of dark grey, brownish-grey weathering, shale with a 10 m thick greenish-grey, brownish weathering, quartzwacke in the upper part. After the shales are 3 m of a brown weathering, dark grey, marly limestone containing brachiopods and a large coiled nautiloid. This layer is followed, after a few metres of less marly, dark grey limestone with brachiopods and a few corals, by 30 m of grey, banked limestone with crinoids and a few brachiopods and finally by a 2 m layer of a greyish black, platy limestone with algae. After these limestones are 50 m of dark grey, brownish-grey weathering, partly sandy shale with some black layers followed by a 16 m thick, grey-brown quartzwacke layer with indeterminable plant fragments. After another 85 m of shale with some sandy intercalations, there is a 20 m thick quartzwacke layer in which *Calamites suckowi* Brongniart (determination by Mr. H. W. J. van Amerom, pers. com.) was found. This sandstone layer is followed by 60 m of shale, 1 m of dark greenish-grey, quartzitic sandstone containing burrows and some plant fragments, and another 50 m of shale. Above the shales is a limestone: from the base, it consists of a black layer, 4 m thick, with crinoids, brachiopods, corals and algae, a marly layer containing an occasional gasteropod and trilobite, 10 m of marly shale and finally 5 m of brownish weathering, grey, detrital limestone containing bachiopods and crinoids. This limestone is followed by a shale which rapidly grades into a thick sequence of alternating thin layers of greenish-grey quartzwacke and grey shale which then turn into 100 m of sandy and normal shales. After these shales, a 60 m thick grey limestone occurs which forms the core of the syncline.

The limestones cannot be correlated from one thrust structure to another. Even within the same nappe many problems arise because the limestones change in lithology and in fossil content over short distances. Thus the limestones can only be correlated between sections with an equal number of limestones, which are comparable in stratigraphic position and thickness. No subdivision of the San Emiliano Formation into members has therefore been made.

The transition from the Escapa Formation to the San Emiliano Formation is gradual. The upper part of the Valdeteja Member often contains shale layers wedging out into the limestones, indicating the predominantly clastic sequence of the San Emiliano Formation.

CHAPTER II

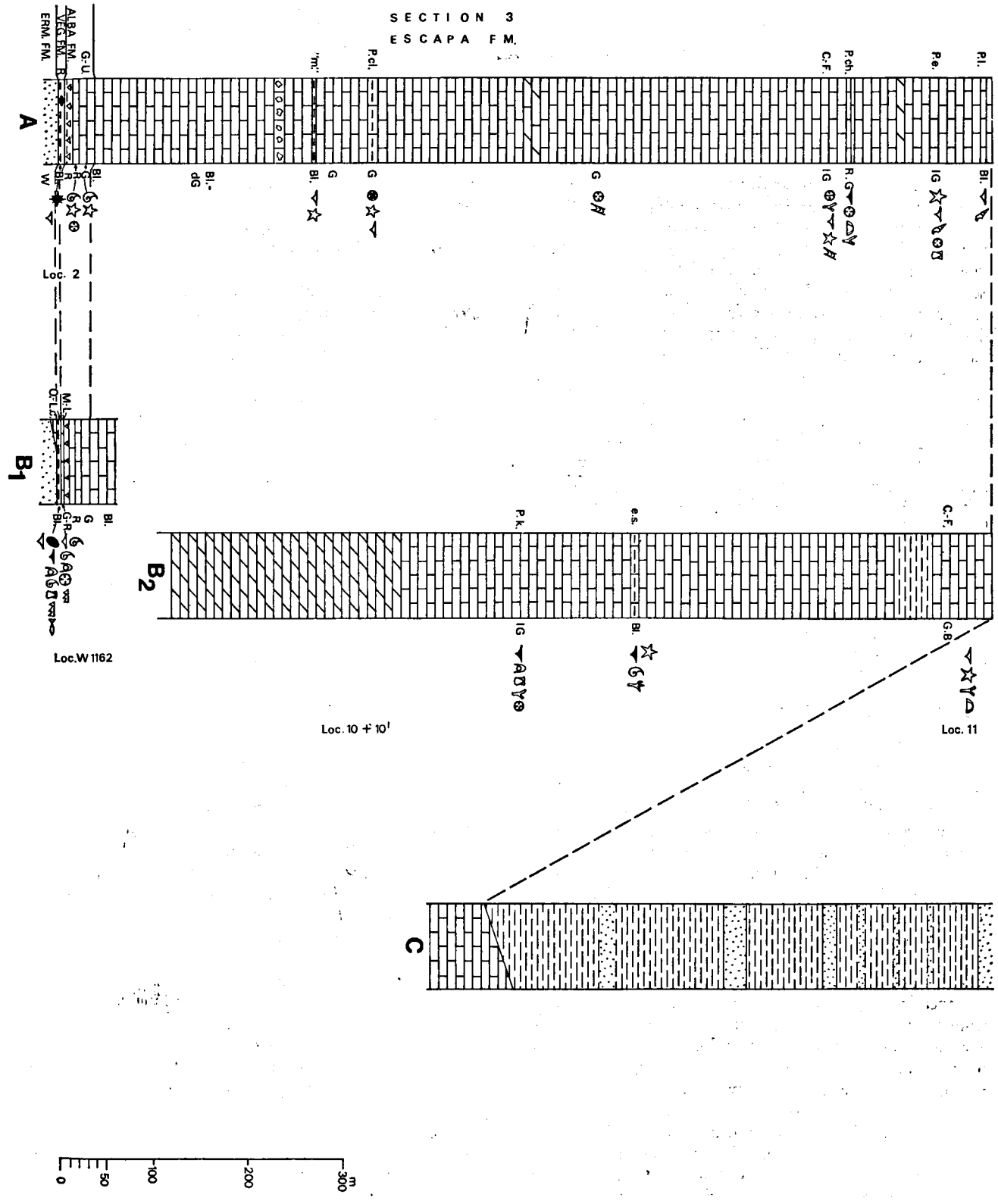
PALAEOECOLOGICAL CONSIDERATIONS

INTRODUCTION

In order to give a palaeoecological interpretation of the fauna and flora, their distribution — both vertical and horizontal — has been investigated and will be described in the first part of this chapter. Some attention has also been given to the kind of rock in which the fossils were found. The special assemblages described in the second part of this chapter have been compared with descriptions from the literature. The descriptions of fossil assemblages from the Pennsylvanian and Permian of Kansas (U.S.A.) by Moore (1964) have been especially helpful since their position in a cyclothem formed a good check on the palaeoecological interpretation, which unfortunately is missing in the present investigation. The palaeoecological interpretation presented here is only a tentative one since considerable work, especially in the fields of petrography and geochemistry, ought to be done before well-founded conclusions can be reached.
A few diagrammatic sections compiled from different localities are given in figure 8 to show the faunal content and to indicate the faunal assemblages. Lists recording the fossil content of the formations considered palaeoecologically are given in Tables I to IV at the end of this thesis.

FAUNAL DISTRIBUTION

The Vegamián Formation consists of black shales which in many places contain silico-phosphatic nodules with numerous radiolarians, already described by Delépine (1937). Other fossils are usually absent from this formation, but there is one locality (W 1162) with a rich and varied fauna located just above the middle of the formation. This fauna (Table I) is dominated by ostracodes and small brachiopods, both articulate and inarticulate. Other faunal elements are conodonts, lamellibranchs, trilobites and fish scales.
The Alba Formation starts with the Gete Member, which in its grey, lower part (beds A and B) contains an occasional cephalopod and conodonts. In its red, upper part (bed C) the fauna is more varied consisting, in addition to the cephalopods and conodonts, of small articulate brachiopods, gasteropods, trilobites, crinoids and corals. They may occur all together, but often only one or two of these faunal elements are encountered. The red shales and siltstones of the Valdehuesa Member have yielded only radiolarians and a few moulds of crinoid stems. Both the red and grey parts of the La Venta Member yielded a rich fauna in which cephalopods again predominate and orthoceratids, crinoids, corals, brachiopods and conodonts are also found.
The Escapa Formation begins with a thick practically unfossiliferous succession of black to dark grey, micritic limestones: the Vegacervera Member. Only some problematic microfossils have been found in this member, and in the uppermost layer a poor fauna of brachiopods, crinoids and bryozoans has occasionally been encountered. The upper part of the Escapa Formation, the Valdeteja Member, is highly variable in its lithology and fossil content. The greater part of this member consists of massive, recrystallized limestones and dolomites which show hardly any trace of fossils; only ghost structures of corals and algae are occasionally found. Some thin fossiliferous bands have been found where the limestones are well-exposed.
Especially at the type section of the Valdeteja Member, along the road from Valdeteja to the Curueño River, several interesting, fossiliferous layers have been found. The lowest one, the *Cladochonus* band, starts with a light grey limestone layer containing brachiopods of one kind only. It is followed by a slightly marly layer with abundant specimens of the tabulate coral *Cladochonus*. Finally a marl layer occurs with rugose corals (a.o. *Leonardophyllum*) and small colonies of the tabulate coral *Pseudofavosites*. Much higher in the section, a light grey, banked limestone is of fusulinids, small brachiopods, solitary corals, bryozoans and crinods. An algal flora is also present. Slightly above this layer, a reddish weathering limestone is found, the *Chaoiella* band. The fauna consists, found with a varied, partly silicified fauna. It consists mainly of productoids with their spines partly preserved, but other brachiopods and corals are also present. The productoids are largely dominated by *Chaoiella gruenewaldti* (Krotow), hence the name of the band. After approximately one hundred metres of grey, recrystallized limestone with some dolomite lenses, a layer is found composed largely of crinoid stems. Slightly above this crinoidal limestone, another light grey, tough limestone is found with abundant brachiopods, especially productoids, the *Echinoconchus* band. Rare faunal elements, such as gasteropods, corals and lamellibranchs are also present. The fauna is dominated by dictyoclostids. Somewhat higher in the section, near the top of this member, a black, micritic limestone, partly laminated and partly banked, has been found: the *Linoproductus* band. In this limestone are many productoids and an occasional gasteropod but hardly any other brachiopod. The productoids are rather well-preserved; often they are found with their spines intact although sometimes they were broken off in situ by compaction (fig. 10). The large specimens of *Echinoconchus punctatus* (Sow.) and *Linoproductus continentalis* (Tornquist) as well as the numerous brachial valves of *Productus carbonarius* de Koninck showing the diaphragm and other internal features are remarkable.


SECTION 3
ESCAPA FM.
ERM. FM.
ALBA FM.
VEG. FM.
G-U
P.cl.
C-F
P.ch.
P.e.
P.l.
A
Loc. 2
B1
B2
Loc.W 1162
P.k.
e.s.
Loc. 10 + 10'
Loc. 11
C
0
50
100
200
300
m

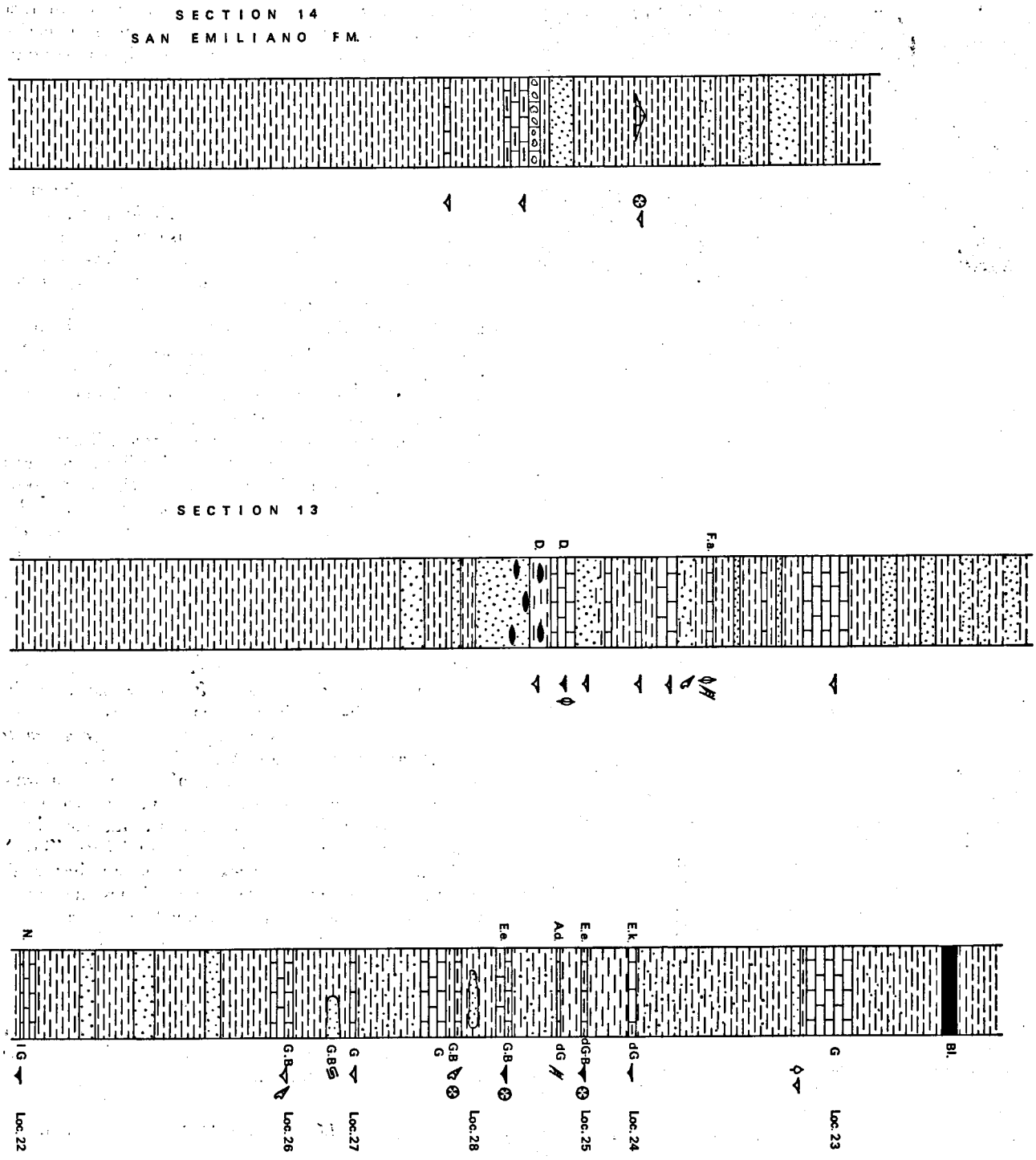


Fig. 8. Schematic sections composed from different localities to show the faunal distribution. A. Composite section of sections E of Valdeteja and a section N of Valverde showing the eastern-most section of the San Emiliano Fm. of the Cármenes area. B1. Section SW of Genicera. B2. Composite section of the Escapa Fm. between Cármenes and Pontedo and near the Mina Profunda (loc. 10, 11) together with a section through the San Emiliano Fm. in the western part of the Cármenes area N of Barrio de la Tércia. C. Composite section of the San Emiliano Fm. in the San Emiliano area.

The abbreviations used to the left of the columns indicate the fossil assemblages, sub-assemblages and bands: e.s. = *Eomarginifera setosa* band, "m" = "*Martiniopsis*" band, etc. To the right of the columns, the colour of the sediments is indicated: B = brown, Bl = black, G = grey, R = red, d = dark and l = light.

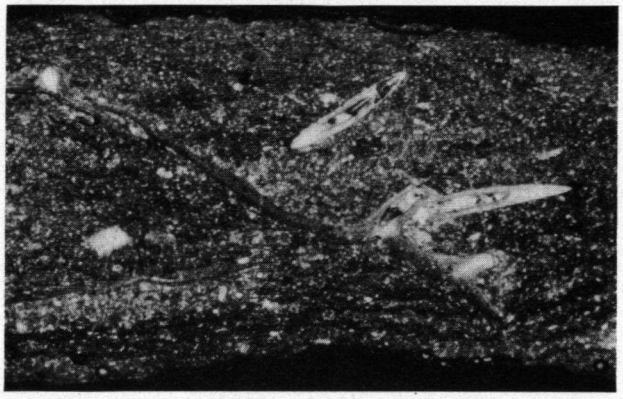


Fig. 10. Transverse section of *Avonia* (*Quasiavonia*) *aculeata* (Sow.) with the spines preserved, partly broken off but remaining in situ (lower right). WP. 16406, × 10, *Linoproductus* band of the Valdeteja Member (acetate peeling).

In the section of the Valdeteja Member along the road from Pontedo to Cármenes (loc. 10, 10′), quite different fossiliferous bands occur. In the middle of a massive grey limestone, fossiliferous beds are found containing brachiopods, bryozoans, corals, lamellibranchs and trilobites. The brachiopods are diversified; many small brachiopods occur, but also several productoid genera. Of the latter, *Krotovia spinulosa* (Sow.) has not been found elsewhere in the Escapa Formation and these fossils are therefore called the *Krotovia* band (P.k.) [2]). The massive limestone is followed by a succession of marly limestones with a black, slightly calcareous shale layer. This layer contains many specimens, but only two species of brachiopods, one being *Eomarginifera setosa* (Phill.), and one specimen of a cephalopod.

Still farther to the west, a light brown, siliceous limestone is found at the top of the Valdeteja Member near an abandoned copper mine, the Mina Profunda (loc. 11). This limestone contains brachiopods (a.o. *E. setosa*), crinoids, corals and echinoids. A similar limestone has been found in the lower part of the San Emiliano Formation (loc. W905) with the same faunal components and bryozoans. In many other places, auloporid corals, gasteropods or brachiopods are found at the top of the Escapa Formation.

The San Emiliano Formation in the Cármenes (map 2) and San Emiliano (map 3) areas are best considered separately for palaeoecological interpretation. This formation starts in both areas with a thick sequence of unfossiliferous greyish-brown shales with minor amounts of quartzwacke.

Above this shale sequence, a limestone with a poor fauna has been found in the easternmost part of the Cármenes area grading into an unfossiliferous sedimentary breccia. Higher in the section, a few thin marly limestones are found with a similar poor fauna of small brachiopods, corals and crinoids and an algal flora. In the upper part, a limestone lens occurs formed largely by a coral colony which also contains some brachiopods. Further west, the limestones are much thicker and more abundant (fig. 7) and contain a more varied fauna and flora. These limestones and their faunal and floral content have been described in some detail by Rácz (1964). In the western part near Barrio de la Tercia (section 13), the first limestone contains abundant specimens of *Derbyia* sp., almost forming a coquina, and some fusulinids. The shales directly below this limestone contain clay-ironstones with specimens of *Derbyia* sp. and *Reticulatia moelleri* (Stuck.). The sandstone somewhat above the limestone also contains specimens of *Derbyia* sp. The other limestones contain a few brachiopods and crinoids, but one layer consists largely of fusulinids and some algae. In the middle of this section is a sandstone with a few gasteropods (*Bellerophon* sp.).

In the San Emiliano area, the lowermost limestone is unfossiliferous, but directly below this limestone lies a thin, light-grey shale layer (1 dm thick) with abundant chonetoids represented by *Neochonetes acanthophorus* (Girty) and one specimen of *Chonetinella flemingi crassiradiata* (Dunbar & Condra). The following limestone layers contain a poor brachiopod and gasteropod fauna. Near Pinos, after a shale sequence, a thick, massive unfossiliferous limestone occurs and somewhat above it a thin marly limestone, which together with the shale below contains a varied gasteropod fauna and some corals. After a few metres of the usual brownish-grey shale, a marl layer is found containing brachiopods, especially *Eomarginifera lobata* (Sow.), and a few corals. After 40 m of shale, a pure limestone is found consisting of algae. Somewhat higher, the section now taken near the road from San Emiliano to Candemuela, a marl is found containing abundant specimens of *Eomarginifera lobata* (Sow.), and *Alitaria nasuta* (Paeck.). After another shale succession, a somewhat less marly limestone occurs which contains a varied brachiopod fauna, especially productoids. Interesting species are: *Karavankina wagneri* sp. nov. and *Krotovia granulosa* (Phill.). This limestone is followed by a shale succession, a quartzwacke layer with some plant remains, again some shale and finally a thick, massive limestone which contained only a *Derbyia* sp. at its base. Not far above it, a coal layer is found in shales.

FAUNAL AND FLORAL ASSEMBLAGES

After the brief account of the faunal distribution, this chapter continues with a description of the floral and faunal assemblages. Many of these assemblages correspond with those known from the Pennsylvanian and Permian of the U.S.A. (Moore, 1964), although they are often slightly different and are considered belonging to separate sub-assemblages.

The description of an assemblage starts with a short

[2]) The faunal and floral assemblages are indicated in figure 8 by letters: a capital for the name of the assemblage, usually followed by a small letter indicating the sub-assemblage or fossiliferous band. In this case, the *Krotovia* band of the *Pulchratia* assemblage becomes: P.k. The abbreviations are placed behind the name of an assemblage the first time the name is used.

enumeration of the general features. This is followed by a description of the Spanish instances; the degree of agreement with the general concept of the assemblage is discussed. Finally a palaeoecological interpretation is given of the assemblage.

Archaeolithophyllum assemblage. — The *Archaeolithophyllum* assemblage is an algal flora predominated by the genus *Archaeolithophyllum.* The algae formed a self-supporting skeletal framework which bound the sediment. The limestones consisting predominantly of this flora contain no faunal elements.

Algae are common in the Upper Carboniferous limestones of the Cantabrian Mountains (Rácz, 1964). They are encountered in the Valdeteja Member, the San Emiliano Formation and younger limestones. Good examples of algal limestones are found in the lower San Emiliano Formation of the eastern part of the Cármenes area (R 42). These are pure limestones, free of mud, with abundant algae, indicating well-lighted water with moderate-to-strong wave action (Rácz, 1964, p. 27). Although *Archaeolithophyllum* is among the algae, these limestones are not considered typical examples of the *Archaeolithophyllum* assemblage, because other fossils occur together with the algae.

Typical algal limestones are found in the San Emiliano Formation of the type area. It is preferable to compare them with the *Archaeolithophyllum* assemblage, because they contain only algae, which form wavy flakes. They differ in that these algae belong to the genus *Donezella* and therefore these finds are best called the *Donezella* sub-assemblage (A.d.).

The algal limestones of the Cármenes area containing *Archaeolithophyllum* have been deposited in well-lighted water with moderate-to-strong wave action (Rácz, 1964, p. 27). A shallow depth, above wave base, probably did occur. The salinity is not assumed to be abnormal, since many other fossils are found with the algae. The *Donezella* sub-assemblage indicates shallow, well-lighted water with a medium wave action. The occurrence of *Donezella* indicates less strong wave action than *Archaeolithophyllum* (Rácz, 1964, p. 75), but it was sufficient to keep the area free of mud. The cause of the absence of other fossils is not clear; a possible explanation is abnormal salinity, as suggested by Moore (1964) for the *Archaeolithophyllum* assemblage.

Radiolaria assemblage. — The occurrence of pelagic radiolarians in the chert nodules of the Vegamián Formation is described here as the Radiolaria assemblage (R.). The radiolarians have been found in many locations in phosphatic nodules of the black shales, which are otherwise unfossiliferous. Similar radiolaria-bearing black shales have often been described from the Lower Carboniferous of Europe and the U.S.A. and also from similar deposits of other ages.

The Radiolaria are porous forms with long spines: typical pelagic forms. Their good state of preservation indicates that they occurred in a quiet environment with little coarse detritus. The position of the Vegamián Formation in a sequence of sub-littoral deposits often bounded by breaks in the sedimentation from the adjacent formations makes a deep sea origin, as formerly assumed for such radiolarian deposits, highly improbable. The modern idea of a shallow sea transgressing over a flat area and covered by large amounts of seaweed preventing wave action provides a better explanation of these deposits. Dixon and Vaughan already proposed this explanation in 1911 for the radiolarian cherts in the Culm Measures of southern England. The stagnant water and the oxygen deficiency during the decomposition of the seaweed explains the scarcity of benthonic animals. Cayeux (1939) explained the occurrence of phosphatic acid in the chert nodules and carbon in the black shales from similar radiolarian-bearing black shales in the Pyrenees and the Montagne Noire as a consequence of a covering of abundant algae on the water. The same explanation is also applicable to the Vegamián Formation.

Keulegan and Krumbein (1949) calculated that waves can loose their power without disturbing the sediment when reaching a coast over a bottom with a slope of only a few degrees. The flat bottom could thus have been the cause of the quiet environment and the algal cover at least partly the result.

Fusulinid assemblage. — Moore (1964) described the *Triticites* assemblage, which is characterized by a fauna consisting almost exclusively of fusulinids, especially *Triticites.* A more general fusulinid assemblage, which has been used by many authors, is preferred. Even typical *Triticites* assemblages from Kansas (U.S.A.) may be characterized by other genera than *Triticites* and in the Cantabrian Mountains this genus is altogether absent. The differences in the genera represented are considered by the present author to have been caused mainly by the different stratigraphic and geographic positions and not by important ecological changes. In the San Emiliano Formation this assemblage is represented by several genera. A typical example is a limestone with the genera *Aljutovella* and *Staffella,* which is therefore called the *Aljutovella* sub-assemblage (F.a.). Many such sub-assemblages with little more than stratigraphic value can be differentiated in the Cantabrian Mountains. The *Triticites* assemblage is also considered a sub-assemblage.

The fusulinids are now generally considered to be benthonic organisms because of their comparatively heavy shells. They are now no longer assumed indicative of deep water. Since the *Aljutovella* sub-assemblage is often found in an intraclastic limestone together with algae, deposition probably took place at a moderate depth (about 30 m) in well-aerated water of normal salinity. They probably lived in open water far from the coast. The occurrence of this sub-assemblage in the western part of the Cármenes area near the *Derbyia* assemblage and in the type area of the San Emiliano Formation lend strong support to this idea.

Orbiculoidea-Lingula assemblage. — The *Orbiculoidea-Lingula* assemblage is characterized by abundant inarticulate brachiopods which occur in black-to-grey shales. Other faunal elements are the articulate brachiopod *Crurithyris,* conodonts, ostracodes and fish remains.

In the Vegamián Formation, there is one rich fossil locality SW of Genicera (loc. W1165B, Wagner, 1963, p. 54). The fauna is very rich compared with the normal *Orbiculoidea-Lingula* assemblage. It consists of phosphatic and calcareous brachiopods, lamellibranchs, trilobites, small goniatites, fish remains, abundant ostracodes and conodonts (Table I). This fauna clearly belongs to the *Orbiculoidea-Lingula* assemblage, as both these genera and *Crurithyris* are present in the black and grey shales. The abundance of other faunal elements causes the author to consider it a separate sub-assemblage. It is named the *Chonetipustula* sub-assemblage (O.L.c.) after the characteristic productoid.

The modern idea, considering many black shales as deposits in a shallow sea with restricted circulation and with large floating masses of kelp-like algae (Krumbein & Sloss, 1963, p. 228), provides a good explanation. Weller (1960, p. 170) suggested that small animals could have lived among, or attached to, the upper parts of the seaweed and this was probably the case with this fauna. Many of the benthonic animals, such as the brachiopods, trilobites, lamellibranchs, some ostracodes and perhaps the goniatites, will thus have lived pseudo-planktonically, entangled in the seaweed. Schmidt (1935, p. 138) had already explained the occurrence of small chonetids in the German Kulm Measures by this way of life. *Chonetipustula* in particular was especially adapted to this mode of life with its flat, thin and therefore light shells, semi-circular outline, concentric ribs and large spines. The representatives of this genus thus lived in the seaweed, but could probably make jumps (Rudwick, 1965, p, H202) by forcefully snapping their valves, like pectens. The greater part of the fauna from this sub-assemblage will have been able to "swim" short distances.

The *Chonetipustula* sub-assemblage is composed of three groups of animals, viz. pelagic forms (like fishes, conodont-bearing animals and some ostracodes (e.g. *Richterina),* pseudo-planktonic animals and a poor benthonic fauna of ostracodes (e.g. *Amphissites*) and brachiopods (especially *Lingula* and *Crurithyris).* In the normal *Orbiculoidea-Lingula* assemblage only two groups are represented; the pseudo-planktonic forms are absent. The assumption that *Lingula* might have lived pseudo-planktonically during the Carboniferous (e.g. Weller, 1957) has been shown to be improbable by Ferguson (1963), who described specimens of *Lingula squamiformis* Phill. from the Viséan of Scotland which were found in growth-position in their hole indicating that they evidently lived in the same way as today.

The *Orbiculoidea-Lingula* assemblage as well as the *Chonetipustula* sub-assemblage is typical of an initial phase in marine transgressions, often giving rise to a paraconformity or a disconformity. Depth estimates vary widely: 30 to 60 feet (Elias, 1937), 0 to 10 feet (McCrone, 1963) and 0 to 170 feet (Ferguson, 1963). Weller (1957) considered depth an unimportant factor. A maximum depth of 20 m seems to be a reasonable approximation since modern *Lingula* is most abundant at this depth. *Lingula* favours a mud bottom, rich in organic material, and a warm sea with a minimum temperature of 15°C. These were probably the conditions found during the Carboniferous. The sediment and the state of preservation of the fossils indicate deposition in a quiet sea with an undisturbed seabottom ("stiller Boden" of Schmidt, 1935). The occurrence of the Radiolaria assemblage in the same formation with the *Chonetipustula* sub-assemblage is in agreement with their supposed environmental conditions.

Neochonetes assemblage. — The *Neochonetes* assemblage is characterized by the abundance of chonetoids especially *Neochonetes granulifer* (Owen, 1852) and the virtual absence of other faunal elements. The assemblage is typically found in a grey laminated shale. A thin layer of light grey shale occurs below the lowermost limestone of the San Emiliano Formation just outside the village of San Emiliano (loc. 21). This layer contains abundant chonetoids, especially *Neochonetes acanthophorus* (Girty, 1934), but is without other fossils. It is a typical example of the *Neochonetes* assemblage. This is the only locality where the chonetoids are abundant in the San Emiliano Formation, although they are sometimes found together with the productoids.

The fine sediments and the well-preserved shells, often with both valves together, indicate a quiet environment with a soft mud bottom. The existence of this assemblage below the lowest limestone of the San Emiliano Formation and above a sequence of barren shales indicates a shallow transgressive sea, probably away from the shore. This agrees closely with the environmental conditions suggested by Moore (1964) for the Kansas examples which are found near the base of a cyclothem. He gave as a possible explanation for the absence of other fossils a decreased salinity of the water. Stevens (1966), however, demonstrated that his "Chonetoid Community" had lived in sea water of normal salinity and he explained the virtual absence of productoids and bryozoans by too soft a substratum and too great a turbidity. Although he considered only non-ribbed chonetoids, this explanation is also preferred here since an abnormal salinity is improbable for brachiopods.

Enteletes assemblage. — The *Enteletes* assemblage is characterized by well-preserved specimens of *Enteletes* and *Hystriculina hystricula* (Dunbar & Condra, 1932). They are found in a brittle limestone from which they can be easily extracted.

At several localities in the type area of the San Emiliano Formation, marls occur with abundant specimens

of *Eomarginifera* and *Alitaria* together with occasional dictyoclostids, spiriferids and rhynchonellids. Typical localities are SW of La Majua (loc. 22), Pinos (loc. 27) and between San Emiliano and Candemuela (loc. 24). The specimens of *Eomarginifera* are well-preserved and can easily be prepared since the marl can be peeled off. This fauna is called the *Eomarginifera* sub-assemblage (E.e.). The fauna resembles the *Enteletes* assemblage, although it is different at a generic level. In both cases, small marginiferids are abundant and the difference in genus can be easily explained by their widely separated stratigraphic and geographic position.

The good state of preservation of the shells, though often crushed by compaction, indicates a quiet environment for the *Eomarginifera* sub-assemblage. The bottom was muddy but there was less detrital material than in the normal shales. The environment was fully marine at moderate depths off-shore, for example 10 to 30 m deep, which explains the tranquil environment.

The *Eomarginifera* sub-assemblage is transitional between the *Neochonetes* assemblage and a real brachiopod facies, which occurs in the same area in grey, less marly limestones. A site rich in productoids other than marginiferids, especially *Krotovia granulosa* (Phill.), has been found S of Candemuela (loc. 25) and another with many spiriferids and only a few productoids E of Pinos (loc. 28). These faunas obviously mark a culmination of the marine environment. The turbidity of the water and the firmness of the bottom were probably important factors. The marginiferids were adapted to living on a rather soft bottom, too soft for other productoids (Wilson, 1966, p. 118) though not as soft as that of the *Neochonetes* assemblage.

Pulchratia assemblage. — The *Pulchratia* assemblage is characterized by a very rich, well-preserved fauna dominated by brachiopods, especially productoids. Other faunal elements are fusulinids, bryozoans, corals, crinoids, gasteropods, pelecypods and trilobites.

In the Valdeteja Member of the Escapa Formation, several fossiliferous beds are found, which together give a rich fauna best designated as the *Pulchratia* assemblage, since they have many genera in common and the general features of the fauna, dominated by the productoids, are the same. This fauna has the following genera in common with the list of fossils of the *Pulchratia* assemblage given by Moore (1964). Corals: *Cladochonus; Lophophyllidium* has been replaced by the closely related *Leonardophyllum, Aulophyllum* by the aulophyllids and *Syringopora* by the auloporids; brachiopods: *Antiquatonia, Linoproductus, Reticulatia* and *Rhipidomella; Echinaria, Desmoinesia* and *Kozlowskia* have been replaced by *Echinoconchus, Eomarginifera* and *Alitaria,* respectively. This agreement is quite good when the great difference in geographic and stratigraphic position is taken into consideration. Fish teeth, a rare faunal element of the *Pulchratia* assemblage, have not yet been found in the Escapa Formation. The corals are found mainly in a marly limestone near the base of the Valdeteja Member (*Cladochonus* band). The productoids are abundant in the upper part of this member. They are found in fine-grained limestones with their spines partly intact (*Chaoiella* and *Linoproductus* bands) and in coarse limestones where they are less well-preserved (*Echinoconchus* band).

The *Pulchratia* assemblage indicates that optimal conditions for benthonic invertebrate life prevailed. The fossilliferous bands described below differ in some details in that one kind of animal or another predominates; they can be considered sub-assemblages.

The most typical example of the *Pulchratia* assemblage is in the *Chaoiella* band (P. ch.). This is a reddish weathering, thin-bedded limestone with abundant productoids, especially *Chaoiella gruenewaldti* (Krotow). In the adjacent thick limestone beds, the productoids rapidly decrease in number away from this layer. The water was probably well-lighted and well-aerated; the bottom consisted of lime mud and it was far from the coast, as is indicated by the small amount of detrital sediments. The depth is difficult to establish and the maximal depth of 20 m given by Moore (1964) for the *Pulchratia* assemblage must not be taken as absolute.

A similar environment is assumed for the *Linoproductus* band (P. l.). This is a black, micritic limestone with thick-bedded sections alternating with laminated layers. Many well-preserved productoids occur in this limestone partly with their spines intact. The black colour and the fetid odour of the limestone indicates that the organic remains were only partly decomposed. The alternation of laminated and massive beds can be explained by quiet periods following more turbulent ones. A bank could have broken the waves causing calm water. A slight rise in the sealevel would permit the waves to pass unhindered and thus disturb the bottom.

A bank deposit, the *Echinoconchus* band (P.e.), has been found somewhat below the *Linoproductus* band. The limestone is coarse-grained, light grey — almost white. The fossils are not well-preserved; they are usually recrystallized. At the base of this band, a crinoidal limestone is present. Bank deposits form in approximately the same environment as reefs, i.e. in a shallow, warm, well-aerated sea with a depth of less than 30 m and probably with violent wave action. The banks were situated at the basin margin close to nutrient-rich waters (Newell et al., 1953). Although the sediments of the *Echinoconchus* band are quite different from those of the typical *Pulchratia* assemblage, the environment was not so very different, as demonstrated by the many genera common to both. The most important differences are a more steady substrate and stronger wave action for the bank deposits.

The corals of the *Cladochonus* band (P. cl.) belong to the Tabulata and the *Cyathaxonia* group of corals, which are similar to those of the *Goniatites-Ufimia* assemblage only more diversified. The fauna indicates

that conditions were not ideal for coral growth. One reason is obvious from the sediment: the turbidity of the water. The depth is difficult to establish.

Fenestrellina-Composita assemblage. — The *Fenestrellina-Composita* assemblage is characterized by a varied fauna dominated by bryozoans and brachiopods (especially *Composita).* The existence of echinoid remains is also characteristic. The fauna is found in a cherty or chalky limestone.

In addition to the faunas, which can be considered the *Pulchratia* assemblage, a partly silicified fauna has been found in a grey limestone layer of the Valdeteja Member. This fauna can best be regarded as belonging to the *Fenestrellina-Composita* assemblage (F.C.). The composition of the fauna, considered in orders and phyla, and the type of sediment agree well with this assemblage. The fossils are in part silicified, but not the crinoids. They have a massive skeleton which is much more resistent to silicification than the more porous or aragonitic skeletons (Reynolds & Vaughan, 1911). Other examples of this assemblage are a greyish-brown siliceous limestone at the top of the Escapa Formation (loc. 11) and a similar limestone in the lower part of the San Emiliano Formation near Barrio de la Tercia (loc. W905). These limestones contain brachiopods, bryozoans, crinoids and echinoid remains. The only productoid determined is *Eomarginifera setosa* (Sow.).

The *Fenestrellina-Composita* assemblage is indicative of a culmination of the marine environment. The rich fauna suggests that conditions were optimal for marine invertebrates: thus the water was probably warm, well-aerated and contained sufficient food. A depth of about 60 m seems a reasonable assumption, since the small brachiopods, solitary corals and sponges indicate a water depth of 40 to 100 m and the occurrence of algae suggests shallower water (Rácz, 1964). The occurrence of this assemblage in the same sequence with the *Pulchratia* assemblage is not surprising since they lived in closely comparable environments (Moore, 1964). A slightly greater depth is the only distinguishing feature of this assemblage.

Derbyia assemblage. — The *Derbyia* assemblage is characterized by an abundance of *Derbyia,* a few other brachiopods and molluscs. Other faunal elements are fusulinids, corals, bryozoans, ostracodes, crinoids (cups), echinoids and conodonts. *Derbyia* may be so abundant that the shells are packed together almost as a coquina.

The first limestone of the San Emiliano Formation in the Cármenes area (loc. 13) is a typical example of the *Derbyia* assemblage. The medium grey, marly limestone contains numerous specimens of *Derbyia* sp. and some fusulinids. The same limestone recurs further south in the section where considerably fewer orthotetids and *Reticulatia moelleri* (Stuck.) are found. These brachiopods together with some fragmentary plant remains occur also in a quartzwacke layer above the *Derbyia* limestone. Below this limestone, clay-ironstones are found containing well-preserved specimens of the same brachiopods. These deposits are considered part of the *Derbyia* assemblage.

The *Derbyia* assemblage is the first fauna after a thick unfossiliferous shale sequence. Unfortunately little is known about the conditions under which clay-ironstones were formed. The fauna above the unfossiliferous shales point to a transgressive sea in an off-shore zone. The large brachiopods suggest a rather shallow sea of normal salinity. This is in good agreement with the American examples of this assemblage. There, it is an initial marine phase of a cyclothem. It is usually found above non-marine deposits and it is followed by beds containing a variety of typical marine invertebrates. Hattin (1957, p. 113) considered this assemblage indicative of an off-shore zone of nearly normal salinity with moderate wave action.

Goniatites-Ufimia assemblage. — The La Venta Member contains a fauna of abundant cephalopods and orthoceratids and a few corals (*Ufimia*), crinoids and brachiopods, described here as the *Goniatites-Ufimia* assemblage (G.U.). The limestone is a nodular, rather pure micrite with marly beds, red in the lower section and light grey in the upper.

A fauna closely related to this assemblage is found in the Gete Member. This fauna is distinguished by its more abundant benthonic elements. It is called the *Merocanites-Liobole* sub-assemblage (m.l.) after a common cephalopod representing the pelagic fauna and a trilobite (*Liobole*) representing the benthos.

The fauna of the *Goniatites-Ufimia* assemblage is typical for comparatively deep water (about 50 m), far from the coast, as indicated by the pelagic fauna and the corals of the *Cyathaxonia* group (Kullmann, 1966, p. 447). The oxidizing conditions of the bottom mud, inferred from the red colour of the limestone, indicate well-aerated water, an open sea and little organic material. Lack of nutrients will have caused the scarcity of the benthonic fauna. Hallam (1967) indicated the same environmental conditions for the similar Ammonitico Rosso of the Mediterranean region.

A more varied fauna, the *Merocanites-Liobole* sub-assemblage, is found in a marly limestone. The larger supply of mud may be associated with a larger supply of nutrients, which thus made the environment suitable for a varied bottom fauna. The small shape of the benthonic animals and the corals without dissepiment indicate an environment below wave base, probably at a depth of about 40 m, and far from the coast, though perhaps not as far as the *Goniatites-Ufimia* assemblage.

DEPOSITIONAL CONDITIONS

The sandstones of the Ermita Formation are sandstones deposited in a transgressive, turbulent sea. The limestones of that formation were deposited in a similar environment; the lithological difference is caused by the difference in the material supplied. The

gradual change from sandstone to limestone — first limestone pebbles are found in the sandstone, then the lime content gradually increases while the sand content proportionally decreases — indicates an active supply of lime at the expense of the sand supply. At least part of the lime originated locally from Devonian limestones, such as the Santa Lucia and Portilla limestones, just as the Barrios Quarzite, San Pedro Formation or other sandy formations are the source of the sand. In this connection, it is interesting that whenever the erosion level fell below the Barrios Quarzite, so that little or no sand was available in the immediate neighbourhood, the Ermita Formation developed as a limestone-shale alternation (Sjerp, 1967, p. 104, 105).

The decalcification of the sandstones is definitely post-diagenetic, since well-preserved moulds of brachiopods and crinoids were found showing fine details, especially when the coarseness of the sediment is taken into consideration.

The black shales of the Vegamián Formation are typical deposits of a quiet, shallow sea covered with seaweed, which transgressed over a peneplained area. The climate was probably warm, tropic or subtropic, and semi-arid with periods of heavier rainfall indicated by the grey shale layers (Connant & Swanson, 1961; Zangerl & Richardson, 1963). The phosphatic shells of the inarticulate brachiopods and the conodonts are well-preserved but the calcareous shells are represented by internal and external moulds, often coated with iron-oxyde. Only in a grey marly layer were some remnants of the calcareous shells observed. The moulds are extremely well-preserved showing considerable detail, for example an internal mould of a pedicle sheath with a diameter of 0.05 mm (pl. 1, fig 4) belonging to a juvenile specimen of *Chonetipustula plicata* (Sarres, em. Kayser). This indicates that the dissolution of the shells took place during a late stage of the diagenesis or afterwards.

The Gete Limestone was deposited far from the coast, in a comparatively deep, quiet sea with a small supply of detrital material. A typical feature is the change in colour from grey to red, which recurs in the La Venta Limestone in the reverse order. This colour change depends on the carbon content and the Fe^{3+}/Fe^{2+} ratio, a low value for the former and a high value for the latter producing a red colour; the reverse yields black. Intermediate values give grey or green colours (Janov, 1956). Red indicates an oxidizing and grey a reducing environment. The red colour of the unconsolidated sediment is, however, easily changed into grey or green during diagenesis since reduction by water is greater in lime mud than it is in the mud at the bottom. The irregular boundary between beds B and C of the Gete Member can be explained by this change of the lime-mud from red to grey during diagenesis. The regular grey bed A can best be explained by an environment transitional between those of the highly reductive black muds and the oxidizing red lime-muds. Bed B of the La Venta Member is also explained by a transitional environment. The grey parts in bed A of that member were probably formed during diagenesis.

Red shales, like those of the Valdehuesa Member, are often considered to have been deposited above the high-water line (Elias, 1932, p. 426; Hattin, 1957, p. 83). The green layers could have been caused by exceptional high water levels (spring tides). A shallow marine environment, possibly intertidal, is favoured by McCrone (1963, p. 65) and, according to him, the red shales indicate a hypersaline environment and the green shales brackish conditions. A very shallow marine environment, with a slightly abnormal salinity, seems to be the best explanation in the case of the Valdehuesa Member, since proof of the sub-aerial nature of these shales is lacking. The red siltstones of the Valdehuesa Member are truely marine, since they contain a scanty marine fauna, and probably also indicate shallow water. Oele (1964, p. 22) explains a high silica content by a supply of river water supersaturated in silica from strong chemical weathering. For this a humid tropical climate is necessary, as well as alternating wet and dry seasons (monsoons) (Weller, 1960, p. 134). The red colour indicates that oxidizing conditions prevailed during deposition. The small, irregular, white, purple and black areas in the siltstones can be explained by leaching and concentration of the metallic oxides during diagenesis.

The fetid, black limestone of the Vegacervera Member indicates anoxic conditions. The lower part of the limestone is comparable to the Fetid Dolomite and the upper part to the Grey Aphanitic Dolomite described by Teichert (1965) from the Devonian of Arizona (U.S.A.). He presumes a depth of maximal 100 m, but more probably 50 m for the Fetid Dolomite. The Grey Aphanitic Dolomite he assumes was deposited in a very shallow sea covering a flat mud surface, probably in the intertidal zone since autobrecciation and mud-cracks occur. A similar environment is supposed for the Vegacervera Limestone since it lies on the La Venta Limestone indicating a depth of about 50 m; in the upper part of the Vegacervera Member a synsedimentary breccia also occurs indicating a shallow depth.

During deposition of the Valdeteja Limestone, the sea was warm, generally well-aerated and well-lighted, of a medium depth (less than 50 m) and far from the coast. The food supply was sufficient as is indicated by the varied fauna, for instance the *Pulchratia* assemblage. The massive limestones and the biohermal structures (fig. 11) led some authors (e.g. Wagner, 1962) to call them coral reefs but, although corals are found in these massive limestones, much work has still to be done before the reef-like nature of these limestones is proven.

Wedging shale layers at the top of the Escapa Formation, in one case even with a paraconglomerate, suggest less stable conditions. These are fully developed in the San Emiliano Formation with its rapidly wedging strata and slump structures in the sandstones. The basal limestones of the San Emiliano Formation, both

Fig. 11. View of the San Emiliano Fm. (foreground) and the upper part of the Valdeteja Mbr. showing biohermal structures in the latter. Photograph taken near loc. R43 to the north.

in the Cármenes and the San Emiliano areas, indicate shallow water (*Neochonetes, Derbyia* assemblages). The other limestones vary in depth from about sea level to 60 m; in the Cármenes area, these depths are often found within one limestone layer (Rácz, 1964). In the San Emiliano area, the depth changed more regularly with time and the deposits were probably never deeper than 40 m. Ultimately, the sea rapidly became shallow again, as is indicated by coal seams in the upper part of the sequence. The unstable conditions, expressed by the numerous depth changes and the differences in the firmness of the bottom, gave rise to a great variety of faunal assemblages.

CHAPTER III

CORRELATION AND FAUNAL AFFINITIES

INTRODUCTION

In the last decade much research has been done on the different groups of animals and plants. Of special interest for the chronostratigraphy of the Lower Carboniferous are the cephalopods (Kullmann, 1961, 1962, 1963a, b; Wagner-Gentis, 1963; Higgins et al., 1964) and the conodonts (Boogaert et al., 1963; Boogaert, 1967; Budinger & Kullmann, 1964; Higgins et al., 1964). For the Upper Carboniferous, the fusulinids (van Ginkel, 1959, 1965a, b) and the land plants (Jongmans & Wagner, 1957; Wagner, 1955, 1962, 1963, 1966) are important. The algae (Rácz, 1964) although of little value in establishing long-distance correlations can be used within the Cantabrian area. A correlation diagram for the Carboniferous deposits of the Cantabrian Mountains is shown in figure 12. The age determinations provided by the different groups of animals and plants are indicated.

To date, investigation of the brachiopods of the Cantabrian Carboniferous has been scant. This is the more surprising in view of the value of this phylum in Devonian stratigraphy.

The Carboniferous deposits of the Cantabrian Mountains are of special interest because they represent an almost continuous marine succession from the Tournaisian to the Stephanian. Marine deposits of Westfalian age are scarce in western Europe. The West-European standard is therefore largely based on continental deposits with land plants. The marine succession of the Russian Carboniferous provides a better means of comparison. Van Ginkel (1965b) has already made a comparison between the Spanish succession and the Russian subdivision based on fusulinids.

This chapter begins with a discussion of the age indications based on brachiopods by means of brachiopod zones. The zones have been named after two genera since combinations are especially characteristic. The genera can occur in other brachiopod zones, a combination of the two cannot. Next, the relationships between the ages provided by the brachiopods and those provided by other groups of animals and plants are discussed. The last part of this chapter deals with the relationships found between the Carboniferous faunas of the Cantabrian Mountains and other parts of the world.

BRACHIOPOD ZONES

The Carboniferous succession (fig. 13) usually starts with a black shale; at one locality (W1162), this shale contains a rich fauna with abundant small brachiopods, especially chonetoids (*Chonetipustula-Plicochonetes* Zone). The following Alba Formation contains mainly cephalopods and only a few brachiopods which, when located in the lower part, are related to the brachiopods from the black shales.

In the lower member of the Escapa Formation no productoids or chonetoids have been found. Only in the upper part of the Valdeteja Member of the Escapa Formation do rich productoid faunas occur (*Echinoconchus-Chaoiella* Zone). The Mudá Formation of Palencia contains a poor brachiopod fauna which is questionably referred to the *Echinoconchus-Chaoiella* Zone.

In the upper part of the San Emiliano, Cervera and

Perapertú formations, another rich productoid fauna is found (*Alitaria-Karavankina* Zone), which can be easily distinguished from the *Echinoconchus-Chaoiella* Zone. In the lower part of the Perapertú Formation is an entirely different fauna. In the lower part of the San Emiliano Formation of the type area, a chonetoid fauna has been located which is questionably assigned to the *Alitaria-Karavankina* Zone.

Above the San Emiliano, Cervera and Perapertú formations, a disconformity occurs so that the stratigraphic position of the next brachiopod zone cannot be directly compared with that of the *Alitaria-Karavankina* Zone. The fauna of the La Camocha Formation from an isolated coal basin in northern Asturias is considered to be the next younger zone (*Cancrinella-Tornquistia* Zone). In the other, better known, successions no faunas have been found which could be assigned to this zone, though some isolated fossil finds might be roughly of the same age.

Much higher in the succession is again a widespread, rich, marine fauna, which contains many productoids and chonetoids (*Kozlowskia-Karavankina* Zone) and which is easily distinguished from the others. This is the highest brachiopod zone distinguished at the moment, since younger deposits have provided so far only poor brachiopod faunas. These younger deposits therefore have largely been omitted from figure 13.

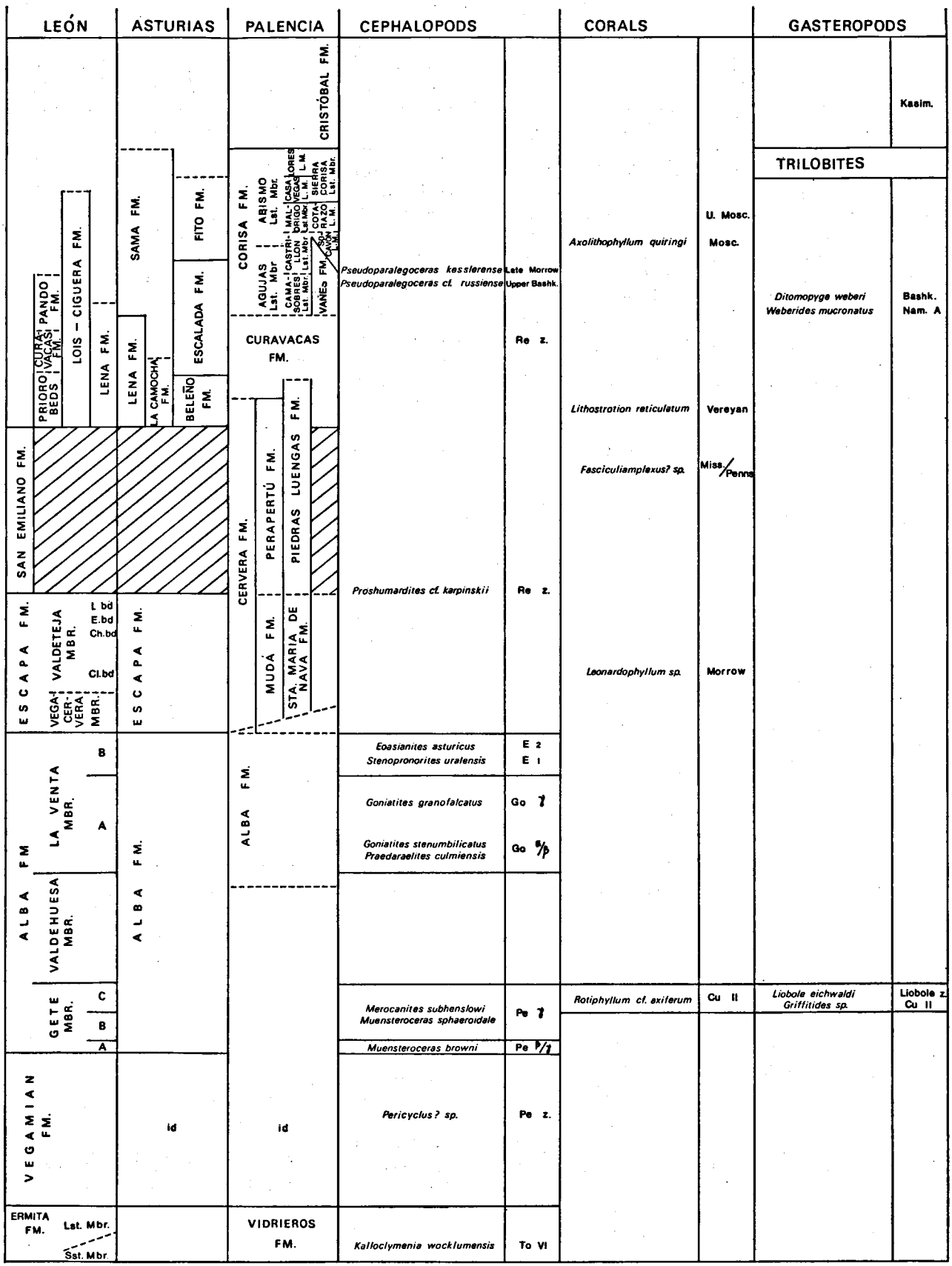
Chonetipustula-Plicochonetes Zone. — The *Chonetipustula-Plicochonetes* Zone is characterized by the occurrence of several species of *Chonetipustula* and the chonetoid species *Plicochonetes kayserianus, P. tricornis?* and *Rugosochonetes laguessianus angustus* (fig. 14). *Chonetipustula* and the chonetoids are typical for the Viséan and two of the three chonetoid species are also known from the Tournaisian. This zone thus comprises at least the Viséan. The fauna is, however, a better indicator of the environment than of the age, since these species are typically found in black shales. A comparable fauna has been found in black shales of Namurian A age in the Pyrenees (Schmidt, 1951). The Namurian A age is based on the goniatites, but the (pseudo)benthonic forms point to a Viséan rather than a Namurian age (Schmidt, 1951, p. 191) and even contain species of *Chonetipustula.*

Echinoconchus-Chaoiella Zone. — The *Echinoconchus-Chaoiella* Zone is characterized by the occurrence of *Ovatia ovata, Chaoiella gruenewaldti,* and several species of *Echinoconchus, E. punctatus* and *E. elegans* being especially common. Other typical, though less common species are: *Productina pectinoides, Plicatifera* cf. *plicatilis, Krotovia spinulosa* and some species of *Antiquatonia. Avonia (Quasiavonia) aculeata, Linoproductus continentalis* and *Reticulatia moelleri* are sometimes found abundantly in this zone, but they occur also, though rarely, in the next higher zone (fig. 14).

This fauna has no species in common with the *Chonetipustula-Plicochonetes* Zone which is not surprising since a thick sequence separates the two zones. At first sight this zone also seems to indicate a Viséan age, since it contains some species exclusively known from the Viséan together with many species known from the Viséan and the Lower Namurian. The occurrence of *Chaoiella gruenewaldti* and *Reticulatia moelleri* suggests, however, that the fauna is younger since neither species have been recorded below the Moscovian. It is thus the first time that these species have been found together with species known from the Viséan and Namurian. This mixture has not been caused by reworking since the specimens are usually well-preserved, often with the spines attached to them. It seems logical therefore that the older species occurred somewhat later in the Cantabrian area and the younger species somewhat earlier, placing the fauna in the Bashkirian. The great number of "older" species makes a Lower Bashkirian age for this zone the most probable.

Bashkirian brachiopod faunas are not well known and the Moscovian forms may, therefore, have lived earlier and the Lower Namurian forms later. The species known only from the Viséan were probably restricted to the environment in which the massive limestones were deposited and could not live in the muddy environment of the Namurian shales. In the Escapa Limestone, which is comparable to the massive Viséan limestones, the same species are found again.

Delépine came to quite different results when studying the brachiopod faunas from the upper part of the Escapa Formation at Entrago (Delépine, 1943) and Latores (Delépine & Llopis Llado, 1956). He placed special emphasis upon the stratigraphically young forms and concluded a Moscovian age. In the discussion on the faunal evidence he states that *Chonetes* e.g. *flemingi* N. & P., *Juresania* cf. *ovalis* D. & C. and *Neospirifer triplicatus* Hall indicate a Lower Pennsylvanian age. Of these species, the first identification is doubtful and the species was not found in the present material. Only the stratigraphically older subspecies *Chonetinella flemingi crassiradiata* (D. & C.) has been found in the San Emiliano Formation. The second species has been shown to be *Productina pectinoides* (Phill.), a typical Viséan species. The species of *Neospirifer,* like other spiriferids Delépine identified, occurs in Pennsylvanian and Moscovian deposits. They need, however, a careful reexamination before one relies too heavily upon them. The two marginiferids indicate a Moscovian age according to Delépine. The first species, *Marginifera pseudoplicatilis* (M.-W.) has, however, not been described in beds above the Viséan as far as this authors knows. In any case, the specimens referred to this species by Delépine belong to *Alitaria frechi* (Paeck.), which has not been recorded from beds above the lowermost Namurian. The other species, *Marginifera pusilla* Schellwien, is indeed typical for the Moscovian. It has not been found in the Escapa Formation during the present investigation, only in much younger deposits. The specimens from Entrago described and illustrated by Delépine (1943, p. 72, pl. 3, figs. 8—11) are indeterminable fragments, probably marginiferids. Another


LEÓN
ASTURIAS
PALENCIA
CEPHALOPODS
CORALS
GASTEROPODS
TRILOBITES
CRISTÓBAL FM.
Kasim.
CORISA FM.
ABISMO Lst. Mbr.
AGUJAS Lst. Mbr
CURAVACAS FM.
CERVERA FM.
PERAPERTÚ FM.
PIEDRAS LUENGAS FM.
MUDÁ FM.
STA. MARIA DE NAVA FM.
ALBA FM.
PRIORO BEDS
CURAVACAS FM.
PANDO FM.
VASCAS FM.
LOIS – CIGUERA FM.
LENA FM.
SAMA FM.
LENA FM.
LA CAMOCHA FM.
BELEÑO FM.
FITO FM.
ESCALADA FM.
SAN EMILIANO FM.
ESCAPA FM.
VALDETEJA MBR.
VEGA-CERVERA MBR.
ESCAPA FM.
ALBA FM
LA VENTA MBR.
VALDEHUESA MBR.
GETE MBR.
ALBA FM.
VEGAMIAN FM.
id
ERMITA FM.
Lst. Mbr.
Sst. Mbr.
VIDRIEROS FM.
Pseudoparalegoceras kessterense
Late Morrow
Pseudoparalegoceras cf. russiense
Upper Bashk.
Re z.
Proshumardites cf. karpinskii
Re z.
Eoasianites asturicus
E 2
Stenopronorites uralensis
E 1
Goniatites granofalcatus
Go
Goniatites stenumbilicatus
Praedaraelites culmiensis
Go
Merocanites subhenslowi
Muensteroceras sphaeroidale
Pe
Muensteroceras browni
Pe
Pericyclus? sp.
Pe z.
Kalloclymenia wocklumensis
To VI
Axolithophyllum quiringi
U. Mosc.
Mosc.
Lithostrotion reticulatum
Vereyan
Fasciculiamplexus? sp.
Miss./Penns
Leonardophyllum sp.
Morrow
Rotiphyllum cf. axiferum
Cu II
Ditomopyge weberi
Weberides mucronatus
Bashk.
Nam. A
Liobole eichwaldi
Griffitides sp.
Liobole z.
Cu II

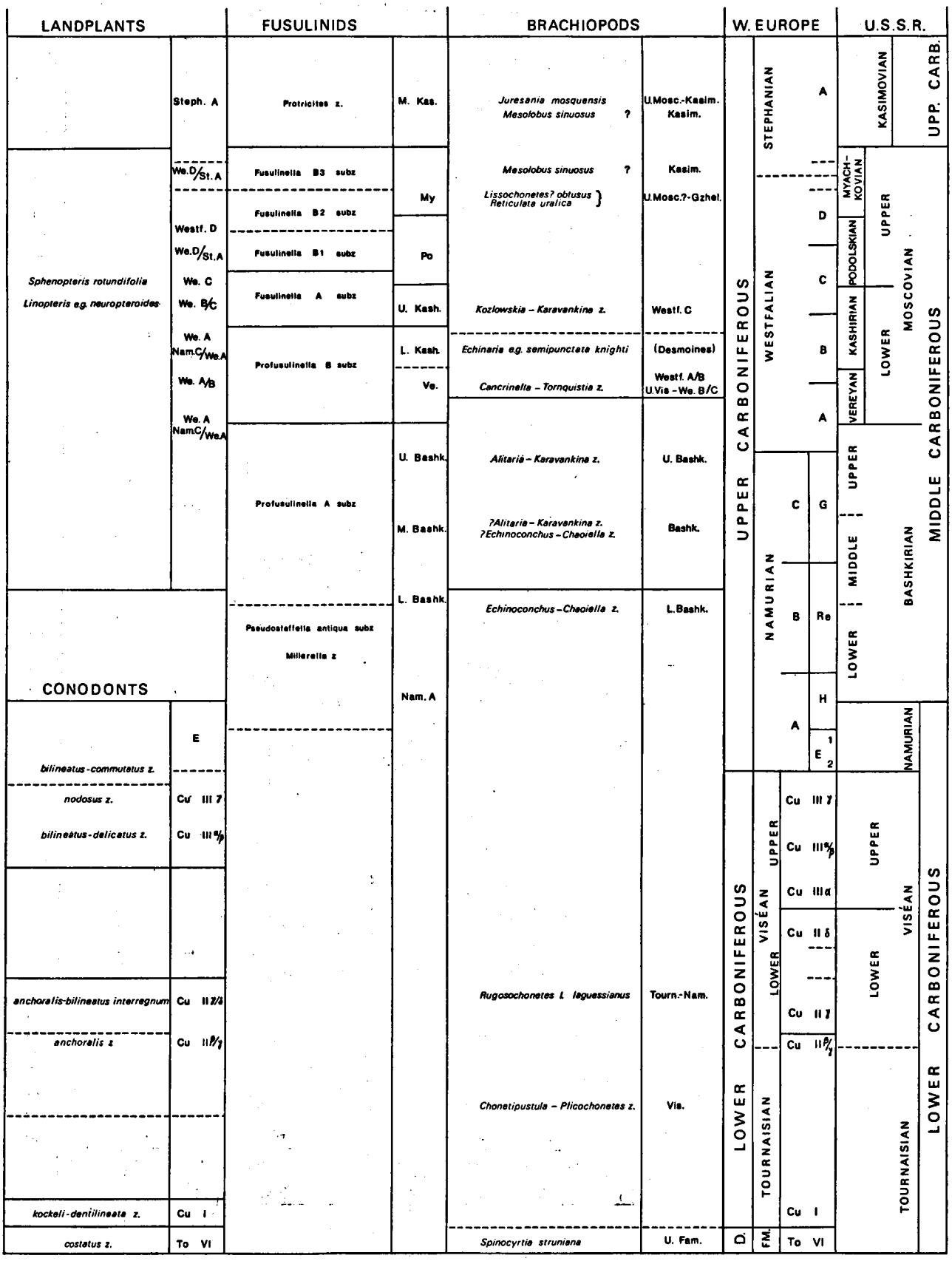


Fig. 12. Correlation chart of the Carboniferous formations of the Cantabrian Mountains showing the correlations with the western European and Russian standards. The different faunal and floral evidences are given as well as the ages they indicate. The following litereature was used: Boogaert (1967) conodonts; van Ginkel (1965b), fusulinids and comparisons with other groups de Groot, (1963), corals Hahn (1965 pers. com.), trilobites; Kullmann (1961, 1962, 1963a, b) and Wagner-Gentis (1963), cephalopods; Wagner (a.o. 1962), land plants. Detailed lists of the brachiopods are given in Tables I to VII.

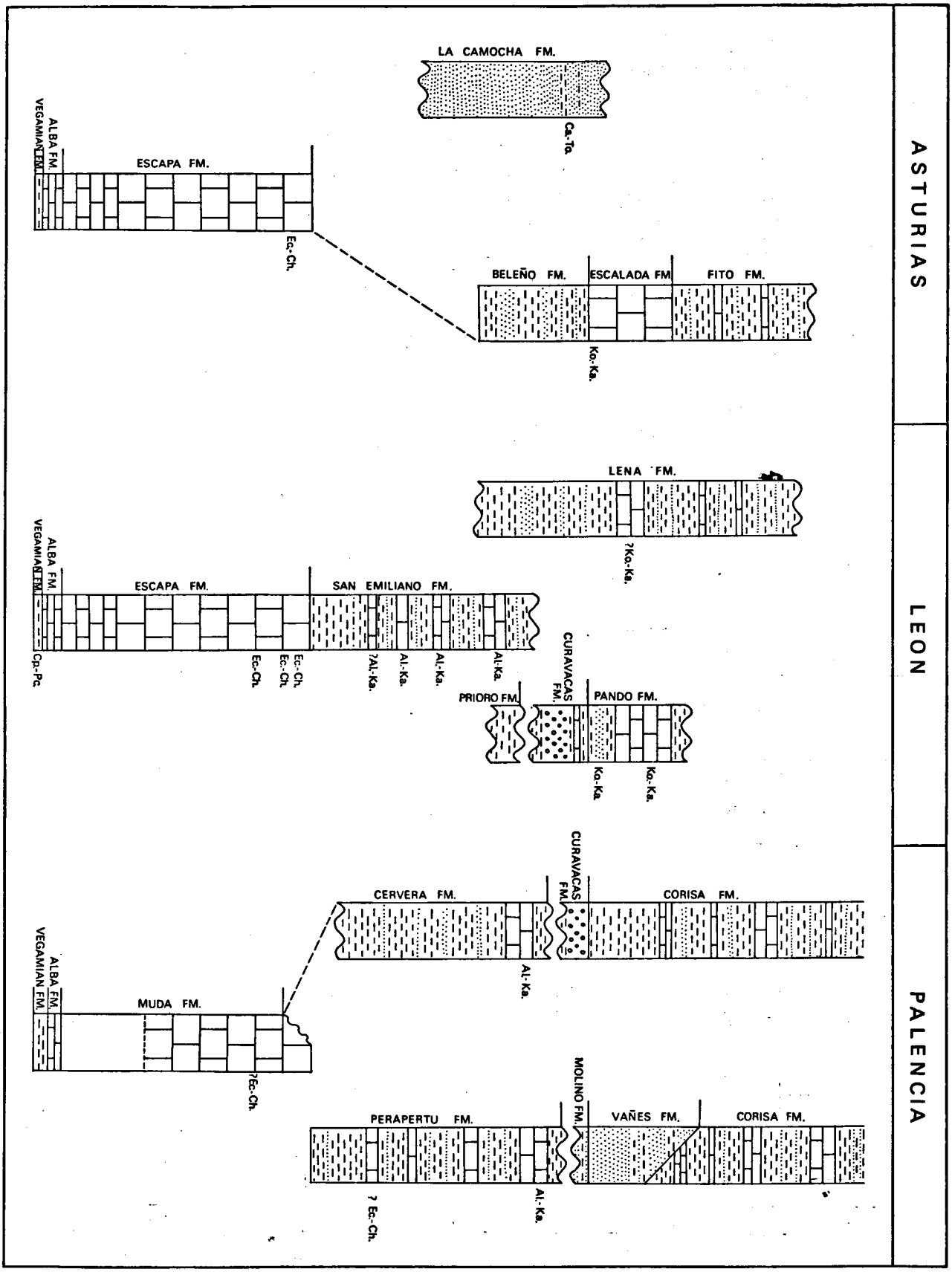


Fig. 13. Generalized sections showing the distribution of the brachiopod zones. Cp.-Pc. = *Chonetipustula-Plicochonetes* zone; Ec.-Ch. = *Echinoconchus-Chaoiella* zone; Al.-Ka. = *Alitaria-Karavankina* zone; Ca.-To. = *Cancrinella-Tornquistia* zone; Ko.-Ka. = *Kozlowskia-Karavankina* zone.

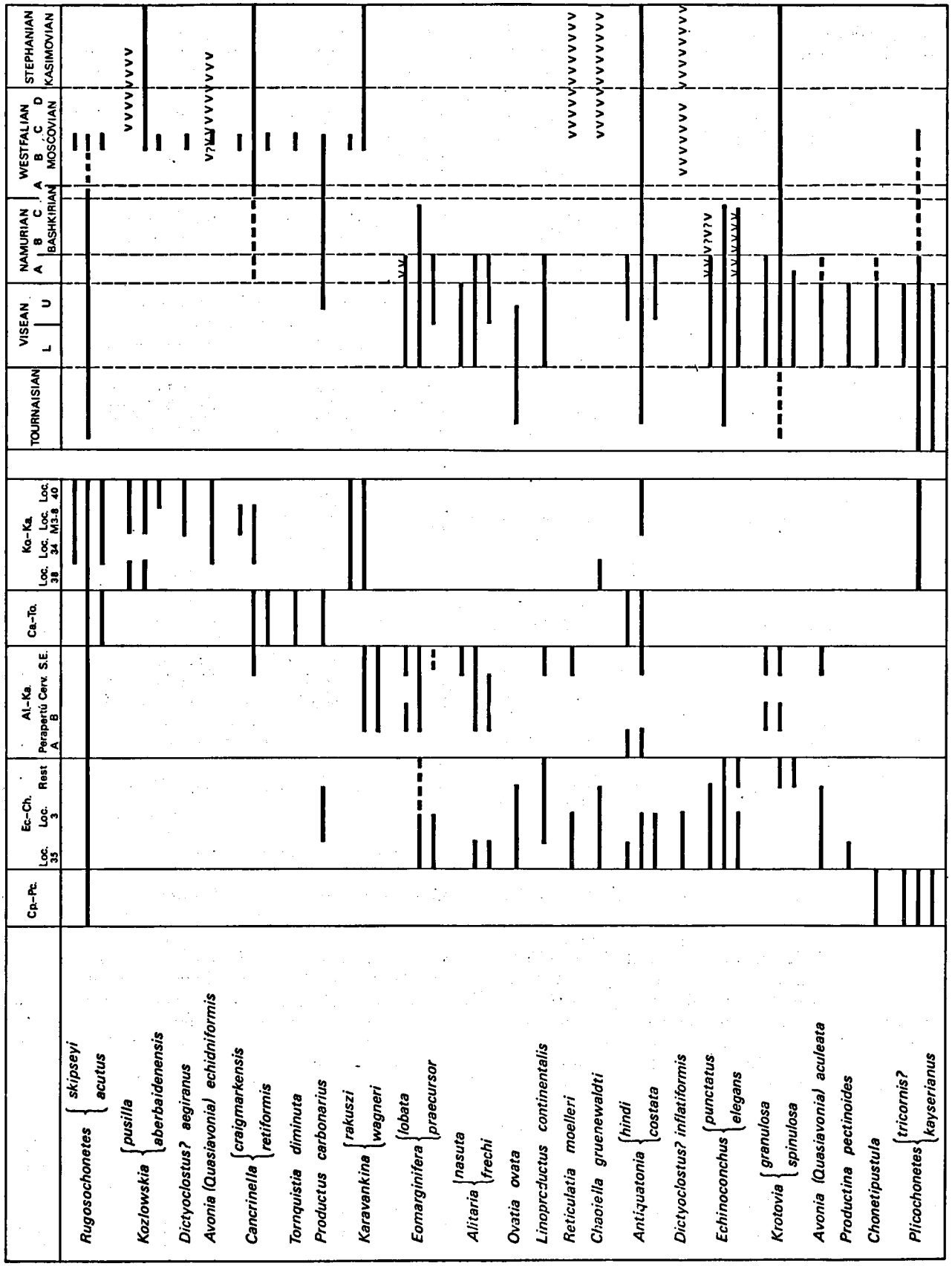


Fig. 14. Range chart showing the most important species of the brachiopod zones and their stratigraphic range. The drawn line indicates the occurrence in western Europe and the areas directly correlated with the European standard. The line consisting of VVV indicates the occurrence in the U.S.S.R. and the areas correlated with it.

species indicating a Moscovian age, *Avonia echidniformis,* is shown to be *Avonia (Quasiavonia) aculeata* (Sow.), a species known from the Viséan and the Namurian. The genuine *A. (Q.) echidniformis* (Chao) has been found in the Cantabrian Mountains in much younger, definitely Moscovian, strata.

Delépine considered the Viséan and Namurian elements to be less important since they were considered to range into the Moscovian to a large extent. The Moscovian specimens of such species as *Echinoconchus punctatus, E. elegans,* etc. are now considered to belong to different species and genera. The Viséan and Namurian elements are much better represented in the fauna than Delépine thought and the Moscovian elements much less, which made the author assume these faunas to be Lower Bashkirian instead of Lower Moscovian.

An Upper Namurian fauna comparable in age to the *Echinoconchus-Chaoiella* Zone from northern France (Waterlot, 1932) has several species in common with the Viséan of western Europe, e.g. *Institina marginalis* (de Kon.), *Pustula interrupta* Thomas and *Buxtonia scabricula* (Sow.). It further contains *Echinoconchus elegans* (McCoy) and *Productus carbonarius* de Kon. which are also found in the *Echinoconchus-Chaoiella* Zone. In North Africa, several species known from the Viséan of western Europe have been described for the first time from the Namurian (Pareyn, 1961). In Namurian deposits of the Donetz Basin, a brachiopod fauna of a Viséan type has also been found (Stepanov et al., 1937, p. 14).

The brachiopod faunas of the Mudá and Santa Maria formations are scanty and seem to indicate a Viséan or Lower Namurian age. The species are known from the *Echinoconchus-Chaoiella* and *Alitaria-Karavankina* zones and are questionably referred to the former zone on the basis of their stratigraphic position.

A remarkable fauna has been found in the lower part of the Perapertú Formation. The most important species are *Proboscidella proboscidea* (de Verneuil), a typical Viséan species, and *Antiquatonia hindi* (M.-W.) known from the Upper Viséan and the Namurian. This fauna has no typical elements from the *Echinoconchus-Chaoiella* Zone, or the *Alitaria-Karavankina* Zone. Although the first species strongly suggests a Viséan age, even the genus has only been recorded from the Viséan, a much younger age is supposed for this fauna; this was also the case for faunas of the *Echinoconchus-Chaoiella* Zone which locally point to a Viséan age when the Moscovian forms are absent. The stratigraphic position just below a fauna belonging to the *Alitaria-Karavankina* Zone makes a Viséan or Lower Namurian age highly improbable. The occurrence of a Viséan species and the absence of Moscovian forms suggest a relation to the *Echinoconchus-Chaoiella* Zone rather than to the *Alitaria-Karavankina* Zone. Therefore this fauna has provisionally been indicated as *Echinoconchus-Chaoiella* Zone.

Alitaria-Karavankina Zone. — The *Alitaria-Karavankina* Zone is characterized by the occurrence of *Alitaria nasuta, Eomarginifera lobata* and *Karavankina wagneri.* Other elements are *Krotovia granulosa* and some species known from the *Echinoconchus-Chaoiella* Zone (compare Table VI).

This zone is comparable to the *Echinoconchus-Chaoiella* Zone because the same mixture of Viséan/Namurian and Moscovian forms occurs. In this zone, however, hardly any species restricted to the Viséan are found and most species occur in western Europe in the Upper Viséan and the Namurian. The same number of Moscovian species has been found, but since the total number of species is much smaller this means a relative increase of the Moscovian element. An important feature is the absence of the genus *Echinoconchus* and the presence of the externally similar genus *Karavankina,* which is typical for Moscovian and younger deposits. The *Alitaria-Karavankina* Zone is thus related to, but distinctly younger than, the *Echinoconchus-Chaoiella* Zone and thus indicates a Middle or Upper Bashkirian age. This result is in good agreement with the stratigraphic evidence, since the *Alitaria-Karavankina* Zone is found just above the *Echinoconchus-Chaoiella* Zone.

A chonetoid fauna has been found at the base of the first limestone of the San Emiliano Formation in the type area. This fauna cannot be definitely assigned to one of the two adjacent zones. It consists of numerous specimens of *Neochonetes acanthophorus* and one specimen of *Chonetinella flemingi crassiradiata.* The latter subspecies is also found in other faunas of the San Emiliano Formation belonging to the *Alitaria-Karavankina* Zone and both species are known from the Desmoinesian of the U.S.A., which can be correlated with the Lower Moscovian. This fauna is therefore questionably assigned to the *Alitaria-Karavankina* Zone.

Cancrinella-Tornquistia Zone. — The *Cancrinella-Tornquistia* Zone is characterized by the occurrence of *Cancrinella retiformis* and *Tornquistia diminuta. Productus carbonarius, Antiquatonia hindi* and *Rugosochonetes acutus* are also found but they have a wide range (fig. 14). *A. hindi* is known from the Viséan and Namurian, *P. carbonarius* from the Upper Viséan to the Westfalian C and the other species are only known from the marine bands found in western Europe at the boundary of Westfalian B and C. It is remarkable that this fauna is so distinct from the *Kozlowskia-Karavankina* Zone which also has many species in common with the marine bands of a Westfalian B/C age and is considered to indicate a lower Westfalian C age. The latter zone consists mainly of typical Moscovian species which are usually not found below the Westfalian B/C. The genera of the *Cancrinella-Tornquistia* Zone have a long range and are all known from the Lower Carboniferous and become partly extinct in the Westfalian C. The *Cancrinella-Tornquistia* Zone is therefore considered to be much older than the *Kozlowskia-Karavankina* Zone. It is

not known if the species from the marine bands have lived earlier in some instances since no rich brachiopod faunas have been recorded from the Westfalian A and B. The intermediate position between the *Alitaria-Karavankina* and *Kozlowskia-Karavankina* zones points to a Lower Moscovian, probably upper Vereyan, age or the lower part of the Westfalian B, although a slightly older or younger age is also possible.

The stratigraphic position unfortunately gives no indication since the La Camocha Formation occurs in an isolated basin and no contacts with older or younger Carboniferous formations have been observed. In other deposits in the Cantabrian Mountains which might be of a similar age, only isolated brachiopods have been found.

Kozlowskia-Karavankina Zone. — The *Kozlowskia-Karavankina* Zone is characterized by the occurrence of *Kozlowskia aberbaidenensis, K. pusilla, Karavankina rakuszi, Avonia (Quasiavonia) echidniformis Dictyoclostus? aegiranus* and *Rugosochonetes skipseyi.* Other, less common forms are: *Linoproductus latiplanus* and *Cancrinella craigmarkensis.* To a large extent these species are known from the marine bands of a Westfalian B/C age and Hungarian lower Westfalian C deposits, the z horizont of Rakusz (1932; Boucek & Pribyl, 1960, p. 41). The same lower Westfalian C age is assigned to the *Kozlowskia-Karavankina* Zone since no species are found indicating an older age.

The *Kozlowskia-Karavankina* Zone has been found in several localities in the Escalada, Pando and Lena formations. After the disconformity, which is found above the deposits containing the *Alitaria- Karavankina* Zone, a thick sequence occurs before faunas of the *Kozlowskia-Karavankina* Zone are found (fig. 13). The great difference in faunal content between both zones is therefore not surprising. The stratigraphic relationship with the *Cancrinella-Tornquistia* Zone is not clear, but the fauna of the latter zone is distinctly older.

The fauna of the Riosa area ("Calizas" Member) (Jongmans & Wagner, 1957) belongs to the *Kozlowskia-Karavankina* Zone, since both genera are present. The fauna is, however, rather poor and not very typical. The occurrence of *Chaoiella gruenewaldti,* which in the Cantabrian Mountains is found in the Bashkirian, may point to an age slightly older than the examples of this zone described above, possibly an upper Westfalian B age.

The Upper Moscovian brachiopods are too scarce to allow a zonal subdivision. The only fauna with some characteristic elements is the one from the Verdiana Limestone which contains among others *Karavankina praepermica* and *Lissochonetes? obtusus* indicating an uppermost Moscovian or Kasimovian age (Table VIII). It has not been distinguished as a special zone since this fauna cannot be compared with other rich faunas from Upper Moscovian deposits of the Cantabrian Mountains.

CHRONOSTRATIGRAPHY

Lower Carboniferous

Tournaisian. — The lowermost deposit of the Tournaisian is in the limestone member of the Ermita Formation, which predominantly belongs to the uppermost Famennian (Strunian) according to the brachiopod and conodont faunas (Boogaert et al., 1963). The uppermost part of this limestone locally contains conodonts indicating a Lower Tournaisian age (Higgins et al., 1964). Sporadic Upper Tournaisian conodonts have been found in the uppermost part of these limestones, but they probably leaked in (Boogaert, 1967, p. 158).

In the Palentine Basin (Province Palencia) of Boogaert (1967), the Ermita Formation did not develop. A nodular limestone, called the Vidrieros Formation, or "Capas del Monto", was deposited instead. The cephalopods and the conodonts give a Famennian age (Kullmann, 1963b), although the latter are of a lowermost Tournaisian age in the uppermost beds (Boogaert, 1967, p. 162).

Both the Ermita and Vidrieros Formations are followed by the Vegamián Formation, usually after a short break in the sedimentation. The base of the Vegamián Formation has been dated by conodonts as Middle or Upper Tournaisian (Higgins et al., 1964, p. 213, 219). The Lower and Middle Tournaisian are thus at least partly lacking and when the Vegamián Formation is absent almost the entire Tournaisian has not been recorded.

A conodont fauna from the upper part of the Vegamián Formation (loc. W1162) indicates an uppermost Tournaisian or lowermost Viséan age (Higgins et al., 1964, p. 219). The ostracodes found together with the conodonts are related both to the Upper Tournaisian and the Lower Viséan. The brachiopods of the *Chonetipustula-Plicochonetes* Zone, which come from the same locality, seem to point to a Lower Viséan age, although the Upper Tournaisian cannot be excluded. The boundary between the Tournaisian and the Viséan can provisionally be drawn at the top of the Vegamián Formation awaiting more definite evidence.

Viséan. — The Viséan is represented by the greater part of the Alba Formation. In the Palentine Basin, the Lower Viséan is still represented by the Vegamián Formation; the Alba Formation there comprises only the Upper Viséan. The different parts of the Alba Formation are well dated by cephalopods and conodonts.

Bed A of the Gete Member belongs to the *Pericyclus* zone β/γ (Higgins et al., 1964) and is best considered as the lowermost Viséan. Beds B and C have a distinct fauna from bed A and belong to the *Pericyclus* zone γ. The occurrence of *Rotiphyllum* cf. *axiferum* Hudson points to a Lower Carboniferous Cu II age (*Pericyclus* zone) which confirms the cephalopod and conodont evidence. The occurrence of *Rugosochonetes laguessianus laguessianus* (de Koninck) gives no precise age indication. The Valdehuesa Member contains no diag-

nostic fossils, but since there is a gradual transition to the adjacent members it represents at least a part of the *Pericyclus* zone δ, and probably also the *Goniatites* zone α. Bed A of the La Venta Member belongs to the *Goniatites* zone α/β and γ (Kullmann, 1963) and thus represents the Upper Viséan. Bed B has been dated as Namurian and therefore already belongs to the Upper Carboniferous.

Upper Carboniferous

Namurian. — The presence of the lowermost Namurian is well established through cephalopods, although the upper part is not; the boundary with the Bashkirian is still very uncertain. The uppermost part of the Alba Formation, bed B of the La Venta Member, belongs to the *Eumorphoceras* zone 1 and 2 (Kullmann, 1962; Wagner-Gentis, 1963). The lower half of the Escapa Formation, the Vegacervera Member, contains hardly any fossils and cannot be dated exactly. The Vegacervera Member probably comprises the upper part of the Namurian A (*Homoceras* zone) and perhaps also a part of the Namurian B, since there is no disconformity between the Alba and the Escapa formations. The boundary between the Namurian of Russian authors and the Bashkirian probably approximates the boundary between the Vegacervera and the Valdeteja members, since the Namurian B is here considered to be the lowermost part of the Bashkirian, in accordance with van Ginkel (1965b).

Bashkirian. — The Valdeteja Member belongs predominantly to the Lower Bashkirian, although the fusulinid evidence is still scanty. The *Cladochonus* band has yielded some corals of which *Leonardophyllum* sp. is especially interesting because this genus has not been found below the Morrowan stage (Dr. G. E. de Groot, pers. com.), which can be correlated with the Bashkirian or a part of it. For the time being, therefore, the lower boundary of the Bashkirian can best be drawn somewhere belong this band, for example at the base of the Valdeteja Member. The fusulinid faunas of the middle and upper part of that member indicate a Lower Bashkirian age. The cephalopods found near the top of the Valdeteja Member and near the base of the San Emiliano Formation belong to the *Reticuloceras* zone indicating a Namurian B or lowermost Bashkirian age (Kullmann, 1962). This result is in conflict with the fusulinid evidence because the fusulinids of the lower part of the San Emiliano Formation indicate a Middle Bashkirian age. The age of the fusulinids has been used, because the cephalopod faunas are rather poor.

The Productidina of the upper part of the Escapa Formation belong to the *Echinoconchus-Chaoiella* Zone. This zone indicates a Lower Bashkirian age, as shown above. This agrees well with the fusulinid evidence and the Lower Bashkirian age for the upper part of the Escapa Formation is thus fairly well established.

The brachiopods of the Mudá Formation correspond to the Viséan species of the Escapa Formation. Therefore, a Lower Bashkirian age has been concluded. The fusulinids give the same age. The Santa Maria Formation is probably of the same age, but the fossil evidence is too scanty to state this with certainty.

In the lower part of the Perapertú Formation, a special fauna occurs which can best be compared with the *Echinoconchus-Chaoiella* Zone, since it shows clear Viséan affinities. The great difference in species makes a Middle Bashkirian more probable. The stratigraphic position supports the probability as well as the fact that the fusulinids from the lower part of the San Emiliano Formation are also of a Middle Bashkirian age. The upper part of the Perapertú Formation contains a fauna belonging to the *Alitaria-Karavankina* Zone which is of an Upper Bashkirian age. The fusulinids from the uppermost part of the Perapertú Formation indicate a lowermost Moscovian (Vereyan) age and one of the corals is also known from the Lower Moscovian of the U.S.S.R. The brachiopods may indeed also have lived in the lowermost Moscovian, since the change in the brachiopod faunas need not have taken place exactly at the boundary between the Bashkirian and the Moscovian.

The Cervera Formation is locally unconformable on the Mudá Formation and is therefore at least of Bashkirian age. Fusulinids from a limestone near Rabanal de los Caballeros give an uppermost Bashkirian or lowermost Vereyan age (uppermost part of Profusulinella A subzone). This limestone was considered by van Ginkel (1965b, loc. P23 on map 4) to belong questionably to the Mudá Formation. Here, it is referred to the Cervera Formation since its strike is comparable to the strike of the Cervera Formation and quite different from that of the limestones near Mudá; in addition, its age is much younger than that accepted for the Mudá Formation. A similar limestone is also found at the top of the Cervera Formation. De Sitter and Boschma (1966) considered the Mudá and Perapertú formations equivalent to the Cervera Formation, which thus extends from Santa Maria de Nava in the east to Triollo in the west. They correlated the Rabanal limestone with the upper part of the Perapertú Formation and included it in the Cervera Formation. From the western part of the Cervera Formation at loc. 71 near Resoba a small fusulinid fauna is known giving an Upper Namurian or more probably Westfalian A age (Kanis, 1956, p. 405). A brachiopod fauna from the same locality belongs to the *Alitaria-Karavankina* Zone and is considered to be of an Upper, or perhaps Middle, Bashkirian age. The fusulinid and brachiopod evidence thus agrees completely. In contrast to these results, a small flora and a goniatite give a Namurian A-B (= Lower Bashkirian) and Upper Viséan age respectively (Wagner, 1966, p. 16). These occurrences are, however, from the lower part of the formation while the fusulinid and brachiopod faunas come from the uppermost part of the formation. A provisional determination of the conodonts from the Perapertú Formation by Higgins (in: Wagner & Wagner-Gentis,

1963) gives an Upper Namurian or Westfalian A age, which agrees well with the results above.

The San Emiliano Formation lies concordant upon the Escapa Formation. At its base, a cephalopod fauna has been found belonging to the *Reticuloceras* zone, thus indicating the Namurian B, the same age found at the base of the Cervera Formation. The fusulinids from the lower part of the San Emiliano Formation give, however, a Middle Bashkirian age, which agrees better with the results from the Escapa Formation. The upper part of the San Emiliano Formation contains fusulinids and brachiopods (*Alitaria-Karavankina* Zone) of an Upper Bashkirian age. The plants from the top of this formation indicate a corresponding age, i.e. Namurian C or Westfalian A. The occurrence of the coral *Fasciculiamplexus?* sp. in the upper part of the formation does not contradict this age since that genus is typical for deposits near the Mississippian-Pennsylvanian boundary (Dr. G. E. de Groot, pers. com.).

Concluding, it can be noted that the upper parts of the Escapa and the Mudá formations are of the same, Lower Bashkirian, age. The San Emiliano, Cervera and Perapertú formations are also essentially of the same, Middle and Upper Bashkirian, age. The top of these formations may, however, become gradually younger towards the east, because the top of the San Emiliano Formation in the San Emiliano area (extreme west) is of an Upper Bashkirian age, the top of the Perapertú Formation in the east near Verbios gives a lowermost Moscovian age based on fusulinids and the fusulinids from the top of the Cervera Formation at Rabanal de los Caballeros, which lies in between, gives an indeterminate Upper Bashkirian or lowermost Moscovian age.

Moscovian. — A fauna of the *Alitaria-Karavankina* Zone in the lowermost Moscovian deposits has been considered in the foregoing paragraph on the Bashkirian. The brachiopods of the *Cancrinella-Tornquistia* Zone are of an upper Vereyan or lowermost Kashirian (Westfalian A/B) age and are found in the La Camocha Formation. Some cephalopods from the same formation were only tentatively referred to the Upper Namurian and are not considered reliable. The flora was originally placed in the Upper Namurian and the lower Westfalian A. New data on the flora and the spores gave a Westfalian A, and for the upper part a lower Westfalian B, age. The older age determinations based on the flora indicated the same age as that of the San Emiliano Formation and in that case, it would be expected that the older brachiopods of the *Alitaria-Karavankina* Zone would be found. The latest data on the flora and the spores give an age which agrees well with the supposed age of the brachiopods.

At several localities widely apart and from different formations (Escalada, Lena and Pando formations), rich brachiopod faunas are found belonging to the *Kozlowskia-Karavankina* Zone indicating a lower Westfalian C age. The fusulinid faunas from those formations have been dated by van Ginkel (1965b) as upper Kashirian and partly perhaps lowermost Podolskian (Fusulinella A subzone). This is in complete agreement with the age of the brachiopods since the upper part of the Kashirian is correlated by van Ginkel with the lower Westfalian C. The plants of the Pando Formation indicate a Westfalian B or C age.

It is therefore the more surprising that the trilobites of the Pando Formation (*Weberides mucronatus, W* aff. *eichwaldi* and *Ditomopyge* species of the *weberi-granulatus* group) point to a Namurian or Bashkirian age according to Dr. G. Hahn (in: van Ginkel, 1965b). A brief investigation of the modern literature on the Upper Carboniferous trilobites has therefore been made to see if the stratigraphic range of the species and genera has been altered. The genus *Weberides* is characteristic for the Namurian, but it is a synonym of *Paladin,* which ranges from the Viséan to at least the Westfalian C (Boucek & Pribyl, 1960, p. 34). The other genus, *Ditomopyge,* occurs throughout the Pennsylvanian. At a specific level it is especially *Paladin mucronatus* (McCoy) which gives a contradictory age, since it is characteristic for the Namurian A. *P. eichwaldi* (Fischer) ranges from the Viséan to the Westfalian B and since the specimens were only provisionally assigned to that species it results in no important contradiction. Concluding it can be noted that at a generic level there is no contradiction in age between the trilobites on the one hand and the fusulinids on the other. At a specific level the difference in age remains, but is based mainly on one species and a revision of the trilobite fauna seems to be highly desirable and should be awaited before the possible causes of the age discrepancy are considered in detail. According to Dr. J. Kullmann, one goniatite from the Pando Formation is of a Bashkirian type, but one specimen not even specifically identified does not seem to be important evidence.

A poor brachiopod fauna from the "Calizas" Member of the Riosa area has been questionably assigned to the *Kozlowskia-Karavankina* Zone. It has been argued that it might be of a slightly older age. The age supposed for this fauna by Almela and Rios (1953), Westfalian C/D, is thus certainly too young, as has been supposed by Jongmans and Wagner (1957) who referred these deposits questionably to the Westfalian B/C, which is in close accordance with the present results.

Other isolated brachiopod finds from the Lower Moscovian, like those of *Echinaria semipunctata knighti* (D. & C.), give hardly any positive age indications, but they do not contradict the ages based on the fusulinids.

In the Upper Moscovian, the productoids have not been divided into zones since the productid faunas are too scarce and too poor. All the productoids are known from the Upper Moscovian or higher and the species of the Westfalian B/C of western Europe are practically lacking, so that the faunas are definitely of a younger type than those of the *Kozlowskia-Karavankina* Zone.

Kasimovian. — The productoids from the Kasimovian differ at a specific level but are closely related to the Moscovian forms. The occurrence of *Mesolobus sinuosus* (Schellwien) at a locality in Palencia which cannot exactly be located seems to point to a Kasimovian age for that locality, although an uppermost Moscovian age is also possible.

FAUNAL AFFINITIES

The fauna of the Vegamián Formation shows a close resemblance to the Viséan faunas of Germany, e.g. those described by Nicolaus (1963) of the *Pericyclus* δ and *Goniatites* α zones and the fauna from Aprath (Kayser, 1882; Paeckelmann, 1930, 1931). The faunas not only resemble each other in general, but they also have many species in common. These related faunas, described here as the *Chonetipustula* assemblage, are found in the same type of sediment and indicate a comparable environment. They do not indicate the same age for these deposits, since the Spanish deposits are older than the German. Similar black shales with comparable, though not so closely related, faunas have been found in many parts of the world at the base of the Carboniferous, e.g. in the Pyrenees, the Montagne Noire and the U.S.A.

The Lower Viséan fauna of the Gete Member bears a close resemblance to that of western Europe, as shown by the cephalopods. In the Upper Viséan, the affinities to western Europe are less marked and a Mediterranean influence becomes perceptible in the cephalopod fauna (Kullmann, 1963, p. 316, 317).

The trend towards a stronger Mediterranean influence is continued in the Namurian. The cephalopod fauna shows close affinities with the Mediterranean province, especially northern Africa, and no connections at all with western Europe.

The occurrence of many productoids, known from the Viséan and Lower Namurian of western Europe, in the Valdeteja Member of Lower Bashkirian age seems to indicate a renewed European influence. The great difference in age makes a direct connection improbable and many of these "Viséan" species have been found in the U.S.S.R. (Sarycheva & Sokolskaja, 1952) and northern Africa (Pareyn, 1961), partly in strata of a younger age than in western Europe. It is thus possible that the brachiopods have reached the Cantabrian area along a detour via a part of the Mediterranean area. These productoids were probably confined to a special environment, as described for the *Pulchratia* assemblage, and will have migrated with this environment. It is represented in Belgium and Great Britain by the Viséan limestone deposits, such as the Mountain Limestone, and in the Cantabrian Mountains by the much younger Escapa Formation. The younger age of the Escapa Formation is reflected in the brachiopod fauna by some Moscovian predecessors. Good examples are: *Chaoiella gruenewaldti* (Krotow), *Reticulatia moelleri* (Tschernyschew) and *Rhynchopora nikitini* Tschernyschew (an Upper Carboniferous and Lower Permian species occurring in the U.S.S.R., Nova Zembla and South America). These new forms indicate that the evolution did not stop during the migration of the "Viséan" fauna and that new forms evolved which were also restricted to the special environment.

The deposits of an Upper Bashkirian and lowermost Moscovian age also contain some productoids known from the Upper Viséan and Namurian of western Europe, generally younger forms than in the Escapa Formation. Modern forms are *Neochonetes acanthophorus* (Girty) and *Chonetinella flemingi crassiradiata* (Dunbar & Condra) found in the Desmoinesian of the U.S.A. The Spanish examples are much older, Namurian C to Westfalian A instead of Westfalian C, but when the correlation between the U.S.A. and Spain is made through the U.S.S.R. instead of through western Europe, the age difference becomes very small, almost negligible.

The occurrence of *Echinaria* cf. *semipunctata knighti* (Dunbar & Condra) in deposits of Kashirian age may also point to some connections with the U.S.A. The upper Kashirian deposits show a great similarity in their faunal content with the marine bands at the boundary between the Westfalian B and C from western Europe, such as the Cefn Coed Marine Band. Species in common are *Cancrinalla craigmarkensis* (Muir-Wood), *C. retiformis* (Muir-Wood), *Kozlowskia aberbaidenensis* (Ramsbottom), *Rugosochonetes skipseyi* (Currie) and possibly *Karavankina rakuszi* sp. nov. Ramsbottom (1952) considered a southern origin for *Kozlowskia aberbaidenensis* possible since he compared it with *Marginifera pusilla* Schellwien described by Delépine (1943) and found in older deposits in the Cantabrian Mountains. The connections now appear to be even closer because the British species has also been found in Spain, in strata of roughly the same age.

The productoids of the Moscovian differ considerably from the Bashkirian forms, though this change commenced in Upper Bashkirian times and was not finished until the Kashirian. The Moscovian fauna has a distinctly Mediterranean character as shown by the similarity of the faunas from the Alps, Hungary (Rakusz, 1932) and the U.S.S.R. The resemblance to the marine bands of western Europe has been described above. It is better, however, not to regard western Europe as a separate unit during the Moscovian. The similarities are not restricted to the Mediterranean area. The faunas of the Moscovian of China and, to a lesser extent, of the Pennsylvanian of the U.S.A. also indicate a relationship. This cosmopolitan character of the Moscovian fauna in the northern hemisphere led the Russian geologists (Einor et al., 1965) to propose one faunal domain for Eurasia and North America together. The Cantabrian Mountains belonged, during the Moscovian, to the Europe — Thian-Chan province. The disgnostic productoids are *Linoproductus, Marginifera* [= *Kozlowskia*], *Buxtonia* [= *Juresania*] *mosquensis* and *Avonia echidniformis* and all of these have been encountered in Spain. *Karavankina* also is diagnostic for this province, since

it occurs from the Cantabrian Mountains to China. Almost all fusulinids considered to be characteristic for this province have been described for the Cantabrian area by van Ginkel (1965). It is not surprising that Spain belonged to this province because the Russian authors state that western Europe and north Africa belonged to it, especially during the Viséan. In Spain, the connection persisted much longer.

CHAPTER IV

SEDIMENTARY HISTORY

In the Famennian, after a period of tilting and erosion, the sea rapidly transgressed again leaving a stratigraphic gap, the largest on the Asturian Geanticline of Boogaert (1967) and absent in the southern part of the region studied. The tilting must have occurred before the deposition of the sandstones since the area was already peneplained when the sea, which deposited the Ermita Formation, spread rapidly over the whole territory. The sediments are locally derived since the sandstones greatly resemble the formations immediately or closely below. It is a striking fact that when the erosion level was below the Barrios Quartzite so that little or no sand was available in the immediate neighbourhood, the Ermita Formation developed as a limestone-shale alternation (Sjerp, 1967, p. 104, 105). Above the sandstones, coarse-grained limestones often developed, deposited under conditions similar to those for the sandstones. They will, at least partially, have been derived from outcropping Devonian limestones, such as the Santa Lucia and Portilla Formations. Only in the Palentine Basin did sedimentation continue during the Devonian; in the Famennian, the nodular limestones of the Vidrieros Formation were deposited in a quiet environment.

The sea level dropped at the beginning of the Tournaisian so that the sedimentation was generally interrupted. However, in one area in the Palentine Basin, there is a conformable relationship between the Vidrieros and Vegamián Formations; the boundary between them lies in the lower part of the Tournaisian. In the other areas, deposition usually started up again during the middle part of the Tournaisian producing the Vegamián Formation. The black shales of this formation were deposited in a shallow sea which rapidly transgressed over the flat post-Ermita surface. The rate of sedimentation was extremely slow and temporary interruptions in the sedimentation are indicated by the occurrence of chert nodules and layers. A part of the Cantabrian Mountains, such as the Esla region (Rupke, 1965), remained above sea level at least during the greater part of the Tournaisian, since the Vegamián Formation is absent there. These areas may have partly provided the detrital material for the Vegamián Formation.

After a slight regression, which locally put an end to the sedimentation, a renewed, rapid transgression covered the whole area, also the parts where the Vegamián Formation is absent, in the earliest Viséan or perhaps latest Tournaisian times. Only in the Palentine Basin was the deposition of black shales continued until the Upper Viséan. The anomalous behaviour of this area may be explained by local epirogenetic movements. At the end of the Lower Viseán and the beginning of the Upper Viseán, a slight regression occurred as is indicated by the large amount of detrital material in the Valdehuesa Member of the Alba Formation. A renewed transgression gave rise to the La Venta Member of Upper Viséan and Lower Namurian age. The sedimentation continued to be slow during the Viséan and lowermost Namurian, since this space of time is represented by ca. 30 m of sediment. Hereafter, the basin rapidly subsided as is shown by the thick accumulation of sediments during the greater part of the Namurian A and the Bashkirian, represented by the Escapa and San Emiliano formations. The sedimentation began in a quiet basin which was probably sheltered from the open sea to a great extent, as is indicated by the euxinic conditions that prevailed. In the southernmost part of the region studied, e.g. in the southern flank of the Alba syncline near Olleros de Alba, a thick shale sequence is found instead of the black limestones of the Vegacervera Member, indicating proximity to land. The shales are followed by thick, recrystallized, unfossiliferous limestones and the whole sequence can therefore be dated only as post-Viséan. The upper part of the Escapa Formation consists of light grey, usually massive, limestones with an occasional rich fauna indicating that access to the open sea had improved. In the Palentine Basin, coral reefs have been found embedded in a shale sequence of the same age as the Escapa Formation.

At the end of the Escapa Formation and during deposition of the San Emiliano Formation, the sedimentation was no longer quiet: the rapid wedging of the strata and the slump structures indicate a time of strong motion. The source area was rising and the sea level probably lowered. The existence of paraconglomerates in the Gayo thrust sheet near the base of the San Emiliano Formation and the absence of fossiliferous limestones indicate that the rise of the source area was greater and occurred earlier. This agrees closely with the wedging out of the limestones in the southern flank of the Cármenes syncline. It can be explained by deposition of the San Emiliano Formation during the formation of the thrust structures which proceeded gradually towards the north (Evers, 1967).

During the Moscovian many local basins were formed;

some received enormous masses of coarse clastic material (Curavacas Conglomerate) and in others, thick limestone sequences developed (Escalada Formation). Usually, however, both kinds of sediment were deposited, alternating with some coal layers formed during continental periods.
In the Stephanian, the continental deposits dominate and paralic sediments were deposited only locally.

CHAPTER V

SYSTEMATIC DESCRIPTIONS

INTRODUCTION

The classification, as well as the specialized terminology, adopted by Muir-Wood (Muir-Wood & Williams, 1965) has been used with some minor variations. When the Spanish data provided no new details for a genus, only a short diagnosis is given (or none at all) since exhaustive descriptions are available in the monographs by Muir-Wood and Cooper (1960) on the productoids and by Muir-Wood (1962) on the chonetoids.
In addition to his own collection, the author has investigated the collections of several other students of Leiden University. The specimens stored in the "Rijksmuseum van Geologie en Mineralogie" in Leiden (Holland) are indicated by „R.G.M.", while the samples stored with the Department of Stratigraphy and Palaeontology of Leiden University are indicated by "St.P.". The specimens collected by Jongmans and Wagner (1957) in the Riosa area were mostly sent to the "Instituto Lucas Mallada" of the "Consejo Superior de Investigaciones Científicas" in Madrid (Spain) and are indicated by "I.L.M."; only a few were kept in the "Rijksmuseum van Geologie en Mineralogie". The collectors are indicated by two letters of their name set before the catalogue number. They are Drs. A. Breimer (Br.), A. C. van Ginkel (vG.), G. E. de Groot (dG.), J. Kanis (Ka.), L. Rácz (Ra.) and R. H. Wagner (Wa.), Mrs. C. H. T. Wagner-Gentis (W-G.) and Messrs. M. J. M. Bless (Bl.), J. A. van Hoeflaken (vH.), J. J. de Meijer (dM.), H. J. W. G. Schalke (Sc.), T. A. Sieswerda (Si.) and the author (WP.). Of great interest was a collection of specimens identified by the late Prof. Dr. G. Delépine (D.) from Latores (loc.35), because he listed only the fossils without including a description of the material (Delépine & Llopis Llado, 1956).
Preservation. — The fossils are found in various kinds of rock and are also preserved differently. In many shales and sandstones, they occur as interior and exterior moulds and are often coated with iron-oxide which makes them readily visible. The moulds frequently show the parts of the internal structures of the shells and the surface ornamentation perfectly, but unfortunately the shell texture cannot be examined. In the quartzwackes of the San Emiliano Formation, moulds of brachiopods occur seldom and are not well-preserved. The moulds in the Pando Formation are often distorted, but these deformations do not cause serious trouble in the determinations.
In some shales, and especially in the marls of the San Emiliano Formation, well-preserved shells occur, but they have suffered greatly from compaction which crushed the brachial valve into the pedicle valve and changed the angle of geniculation. This is very inconvenient when studying the interiors by serial sectioning, because the valves have moved relative to each other. In siltstones from the Asturian coal mines (Calizas Inferiores Member of the Lena Formation), the shells are beautifully preserved with their spines intact, but they are greatly flattened; an extreme example is a shell of *Juresania juresanensis* (Tschernyschew) with the pedicle valve completely flattened so that no visceral cavity is left (pl. 5, figs. 3a, b).
The shells in the limestones vary widely in their state of preservation. Many shells have suffered from recrystallization, which obscures the shell texture, or from solution. The limestone does, however, split along the shell surface so that external or internal features can be observed, although the specimens are of little use for study by serial sectioning. This mode of preservation prevails in the material from Latores and many other samples from the Valdeteja Member of the Escapa Formation. In some other limestones from the same member, well-conserved specimens are found with their spines preserved, though partly recrystallized. The shells have often suffered from compaction which caused the spines to break off but remain in place (fig. 10).
Several specimens show irregularities in growth and ornamentation due to damage of the mantle, most probably caused by predation.
When it is not otherwise stated, the shells have been whitened with an ammonium-chloride vapour to improve the details on the photographs.

PRODUCTIDINA

Phylum BRACHIOPODA Dumeril, 1806
Classis ARTICULATA Huxley, 1869
Ordo STROPHOMENIDA Öpik, 1934
Subordo PRODUCTIDINA Waagen, 1883
Superfamilia PRODUCTACEA Gray, 1840
Familia PRODUCTELLIDAE Schuchert & Le Vene 1929
Subfamilia CHONOPECTINAE Muir-Wood & Cooper, 1960

Genus CHONETIPUSTULA Paeckelmann, 1931

1931 *Chonetipustula* Paeckelmann, p. 31.
1960 *Chonetipustula* Paeckelmann, — Muir-Wood & Cooper, p. 159.

Type. — Type species by original designation *Productus plicatus* Sarres, 1857, emend. Kayser, 1882.

Diagnosis. — Small, thin-shelled, slightly concavo-convex productellids with a narrow body cavity and a semi-circular outline. Pedicle valve ornamented by rugae and spines, regularly scattered over the valve and in a row along the hinge. In juvenile specimens, a groove is developed on the umbo bounded by clasping spines. A pedicle sheath, as described by Brunton (1965) for some other productoid genera, is also present at the posterior end of the groove (pl. 1, fig. 4), but usually not preserved. Brachial valve with less pronounced rugae and without spines; narrow interarea is present. Interior of the pedicle valve shows the reverse ornamentation of the exterior as well as the spine apertures; muscle scars are obscure. Interior of the brachial valve with a cardinal process of the productellid type nearly perpendicular to the valve, a deep alveolus separating the cardinal process from a breviseptum which is usually half the valve length; with short lateral ridges. Interior surface with radiating rows of papillae. The adductor scars are marked by pronounced development of the papillae, sometimes situated on an elevated base.

Discussion. — The cardinal process is bilobed, typically productellid (Muir-Wood & Cooper, 1960, p. 27, text-fig. 5). No five-lobed cardinal process as described by Paeckelmann (1931, p. 35) has been found in the present material. The same author (op. cit., p. 42) mentions, however, a bilobed cardinal process in the description of *Chonetipustula carringtoniana*. It seems therefore best to regard the bilobed cardinal process as normal of *Chonetipustula* and to await a reinvestigation of the German material to see if a five-lobed cardinal process actually does occur in unquestionable specimens of *Chonetipustula*. No median septum has been found in the pedicle valve interior. The groove in the interior moulds of the pedicle valve is due to a groove on the umbo anterior to the pedicle sheath and is also visible on exterior moulds as a ridge (pl 1, fig. 5).

The interior and exterior characteristics leave no doubt about the productellid character of this brachiopod and the original assignment to the chonetoids has proven to be entirely unfounded.

Chonetipustula plicata
(Sarres, 1857, emend. Kayser, 1882)
Pl. 1, figs. 1—5

1857 *Productus plicatus* sp. nov. — Sarres, p. 20 (fide Kayser, 1882).
1882 *Productus plicatus* Sarres. — Kayser, p. 81, pl. 3, figs. 1, 2.
1931 *Chonetipustula plicata* (Sarres, em. Kayser). — Paeckelmann, p. 34, pl. 1, figs. 3—7.
1960 *Chonetipustula plicata* (Sarres, em. Kayser). — Muir-Wood & Cooper, p. 159, pl. 37, figs. 6—9.
1963 *Chonetipustula plicata* (Sarres, em. Kayser). — Nicolaus, p. 170, figs. pl. 11, fig. 6.

For a more extensive synonymy see Paeckelmann (1931, p. 34).

Diagnosis. — A species of *Chonetipustula* with a slightly convex pedicle valve and an almost flat brachial valve. The valves are semi-circular with rounded cardinal extremities, the greatest width occurring below the hinge. The pedicle valve has flat ears and a small umbo. It is ornamented with spines and sharp irregular rugae, numbering about 16 on a mature specimen. The brachial valve is similar, but without spines.

The interior of the pedicle valve has obscure muscle scars. An interarea with a delthyrium and teeth is developed. The interior of the brachial valve has numerous papillae and a long median septum, a shallow alveolus and muscle scars which are not elevated.

Description. — The Spanish material consists of a few comparatively large specimens, comparable with the lectotype of Kayser (1882, pl. 3, fig. 1), but most specimens are rather small with special features indicating juvenile stages. The large specimens agree with the diagnosis.

Some well-preserved interior and exterior moulds of pedicle valves from juvenile specimens have a well-defined groove on the umbonal part anterior to the pedicle sheath which is sometimes preserved (pl. 1, fig. 4). The umbonal part is markedly convex; the shell becomes flattened anteriorly. The surface is ornamented with a few regular rugae and clasping spines. The spines occur along the hinge, in symmetrical pairs on either side of the umbonal groove and are more scattered anteriorly.

A normal-sized adult pedicle valve measures: L = 8 mm, W = 12 mm; the juvenile specimens vary in length from 1.8 to 4.3 mm and width from 3.— to 6.5 mm.

Discussion. — This species is distinguished from *C. concentrica* by its rounded cardinal extremities which form an angle of less than 90° and the more closely spaced and strongly developed rugae. It differs from *C. carringtoniana* in its flatter valves, its broader shape and less numerous, but more prominent costae.

Material. — All specimens come from one locality (W1162) SW of Genicera, which was discovered by Wagner (1963, p. 54). The material was collected in part by Wagner (R.G.M. Wa.116507) and in part by the author (St.P. WP.014001—17). Alle specimens are preserved as moulds.

Occurrence. — In the upper half of the Vegamián Fm., which is of Upper Tournaisian or lowermost Viséan age. It has been found in the Posidonia shales (Viséan) of Germany, especially near Aprath, and probably also in the Viséan of England.

Chonetipustula concentrica
(Sarres, 1857, emend. Kayser, 1882)
Pl. 1, figs. 6—8

1857 *Productus concentricus* sp. nov. — Sarres, p. 21 (fide Kayser, 1882).
1882 *Productus concentricus* Sarres. — Kayser, p. 83, pl. 3, figs. 3, 4.
1931 *Chonetipustula concentrica* (Sarres, em. Kayser). — Paeckelmann, p. 37, pl. 1, figs. 10, 11.
1963 *Chonetipustula concentrica* (Sarres, em. Kayser). — Nicolaus, p. 169, pl. 11, figs. 3, 4.

Diagnosis. — A species of *Chonetipustula* broader than it is long with rectangular cardinal extremities. The pedicle valve is slightly convex and the brachial valve is almost flat with a strong umbonal knob caused by a deep alveolus in the interior. The surface is ornamented by a few, widely spaced, weakly developed rugae with growth lines in between and scattered spines.

Description. — The pedicle valve is semi-circular with rectangular cardinal extremities. The ornamentation consists of a few rugae, growth lines, and spines in a row along the hinge and a few scattered on the valve.
In the anterior part of the interior of the pedicle valve is a smooth rim, sharply separated from the remainder of the valve; fewer rugae are found than on the exterior. The interior of the brachial valve has a deep alveolus, a thin breviseptum of about half the length and elevated adductor scars with large papillae. The surface is covered with a few papillae arranged in radial rows. In small specimens the median septum could not be observed and the adductor scars were not elevated.
The length varies from 11 to 20 mm and the width from 18 to 25 mm in mature specimens.

Discussion. — This species is distinguished from the other species of *Chonetipustula* by its broad shape, rectangular cardinal extremities, the deep alveolus in the interior of the brachial valve and a few rounded rugae. Some specimens have indistinct rugae and numerous growth lines (pl. 1, fig. 8).

Material. — Several moulds from a locality SW of Genicera (loc. W1162, R.G.M. Wa. 116501—06; St.P. WP. 014031—37, 41, 42).

Occurrence. — The same as *C. plicata. C. concentrica* has been found in Germany, but not in England. It occurs also in the Viséan of Poland.

Chonetipustula carringtoniana (Davidson, 1863)

1863 *Productus carringtonianus* sp. nov. — Davidson, p. 274, pl. 55, fig. 5.
1914 *Pustula carringtoniana* (Davidson). — Thomas, p. 324, pl. 19, figs. 12—14, text-fig. 12.
1931 *Chonetipustula carringtoniana* (Davidson). — Paeckelmann, p. 41, pl. 1, figs. 14—16.
1960 *Chonetipustula carringtoniana* (Davidson). — Muir-Wood & Cooper, p. 159, pl. 37, figs. 10, 11.
1963 *Chonetipustula carringtoniana* (Davidson). — Nicolaus, p. 171, pl. 11, fig. 5.

Diagnosis. — A comparatively large species of *Chonetipustula* with a distinctly convex pedicle and concave brachial valve, without interareas, teeth or sockets. The ornamentation consists of numerous, not prominent, rather regular rugae and spines scattered over the shell and in a row along the hinge.

Description. — Only a few fragmentary, external moulds of the brachial valve are present. The moulds are distinctly convex with an elongated outline. The ornamentation consists of inconspicuous rugae with many intercalating growth lines. The row of spines along the hinge of the pedicle valve is represented by a row of shallow pits. The material is too poorly preserved for reliable measurements.

Discussion. — This species is easily recognized by its distinctly concavo-convex shells, lack of interareas and teeth, and the elongated outline: the length often being almost equal to the width.

Material. — A few moulds from a locality (W1162) SW of Genicera (St.P. WP.014022—24).

Occurrence. — The same as *C. plicata. C. carringtoniana* is especially prolific in the British Culm Measures.

Familia LEIOPRODUCTIDAE Muir-Wood & Cooper, 1960
Subfamilia LEIOPRODUCTINAE Muir-Wood & Cooper, 1960
Genus PLICATIFERA Chao, 1927

E.P. 1927 *Plicatifera* Chao, p. 25.
E.P. 1928 *Plicatifera* Chao. — Chao, p. 61.
E.P. 1931 *Plicatifera* Chao. — Paeckelmann, p. 112.
1960 *Plicatifera* Chao. — Muir-Wood & Cooper, p. 201.
1966 *Plicatifera* Chao. — Brunton, p. 203.

Type. — Type species by original designation *Productus plicatilis* J. de C. Sowerby, 1824.

Discussion. — *Plicatifera* has been placed in a new subfamily, the Plicatiferinae, of the family Overtoniidae by Muir-Wood and Cooper (1960). Brunton (1966) placed this genus without comment in the subfamily Leioproductinae of the Leioproductidae. Judging from the external characteristics, it seems indeed more logical to group this genus with the Leioproductinae. The redescription of *Acanthoplecta* and *Plicatifera* shows that their interiors are more similar than was previously supposed. Thus, classification with the Leioproductinae is completely justi-

fied and a special subfamily for this genus is no longer necessary.

Plicatifera cf. plicatilis (J. de C. Sowerby, 1824)
Pl. 1, figs. 9—12

1956 *Productus plicatilis* Sowerby. — Delépine (in: Delépine & Llopis Llado), p. 107.
vide 1960 *Plicatifera plicatilis* Sowerby. — Muir-Wood & Cooper, p. 201, pl. 56, figs. 16—23.

Diagnosis. — Shell: rounded quadrate to sub-rectangular; the hinge forms the widest part of the shell. Pedicle valve: slightly sulcate with a gently convex posterior section bounded by a rounded geniculation into a curved trail; the umbo is small and curves inward only slightly. Ornamentation of rounded rugae on posterior part, spines scattered over the visceral disc in an irregular quincunx and a row of clasping spines along the hinge curving towards the umbo. The brachial valve is like the pedicle valve, but with a slightly concave visceral disc without spines.

Description. — Specimens of all sizes occur, but never with costae developed. A trail was not observed. The pedicle valves are greatly decorticated, often almost interior moulds, while the brachial valves are preserved as exterior moulds. The pedicle valve shows small triangular adductor scars in the decorticated shells. The preservation in the recrystallized limestones was too poor to permit the study of the shells by serial sections; the brachial interior could not be observed for the same reason. The shape of the shells varies from rounded quadrate to broadly rectangular. The rugae follow the shape of the shell and also form almost right angles at the corners. A row of clasping spines is occasionally preserved along the hinge. The spines nearest to the umbo form a closed ring which probably served for attachment immediately after the larval stage; the other spines all curve towards the umbo. They closely resemble the spines observed on juvenile pedicle valves by Brunton (1966, fig. 4d—f), but in this case they are found on mature specimens.
The dimensions are highly variable: the length varies from 5 to 23 mm and the width from 8 to 36 m..

Discussion. — As Brunton (1966) has shown, the type species *Plicatifera plicatilis* (Sow.) is ornamented with costae and the shells without costae belong to another species. The present material shows no costae, but the shell surface is rather poorly preserved; it is therefore possible that they were present. Because the interiors of the shells could not be observed, the material was considered inadequate to use as the basis for a new species of non-costate specimens, which have hitherto been assigned to *P. plicatilis.*

Material. — This species is very prolific at Latores (loc. 35): specimens St.P. Br.L1401—1443; D.18, 19 and many other samples. One fragmentary pedicle valve with the spines partly preserved on the surface has been found near Valdeteja (loc. 3, St.P. WP. 14901).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. *P. plicatilis* is found in the Viséan of western Europe.

Subfamilia PRODUCTININAE
Muir-Wood & Cooper, 1960
Genus PRODUCTINA Sutton, 1938

1928 *Thomasia* Fredericks, p. 783, 790 (non Poche, 1908).
1931 *Thomasina* Paeckelmann, p. 181 (non Poche, 1908).
1938 *Productina* Sutton, p. 551.
1942 *Thomasella* Paul, p. 191 (non Fredericks, 1928).
1951 *Argentiproductus* Cooper & Muir-Wood, p. 195.
1960 *Productina* Sutton. — Muir-Wood & Cooper, p. 181.
1960 *Argentiproductus* Cooper & Muir-Wood. — Muir-Wood & Cooper, p. 182.
1966 *Productina* Sutton. — Brunton, p. 208.

Type. — Type species by original designation *Productus sampsoni* Weller, 1909.

Discussion. — Brunton (1966) has shown in his study on well-preserved silicified material that the brachial interior of *Productus margaritaceus* Phillips, 1836 agrees with that of *Productina sampsoni* (Weller). The brachial interior from Visé (Belgium), described and photographed by Muir-Wood and Cooper (1960, p. 182, pl. 123, figs. 17, 17A) as *Argentiproductus margaritaceus,* does not belong to that species and the other differences between *Productina* and *Argentiproductus* do not warrant a separation higher than specific rank.

Productina pectinoides (Phillips, 1836)
Pl. 1, figs. 13, 14; text-fig. 15

1836 *Producta pectinoides* sp. nov. — Phillips, p. 215, pl. 7, fig. 11.
1844 *Producta pectinoides* Phillips. — McCoy, p. 113.
1931 *Productus (Thomasina) pectinoides* Phillips. — Paeckelmann, p. 188, pl. 17, figs. 13—16.
1956 *Juresania* cf. *ovalis* Dunbar & Condra. — Delépine (in: Delépine & Llopis Llado), p. 107.

Diagnosis. — Medium-sized species of *Productina,* strongly concavo-convex, about as long as it is wide. Pedicle valve with large umbo and ornamented with flattened costae and few spines.

Description. — The pedicle valves are severely decorticated, due to the lamellose structure of the shell, and usually only small portions of the exterior ornamentation of broad costae are preserved. The decorticated surfaces show no sign of papillae, because recrystallization of the shell destroys the taleolae; the interior moulds do show them. The pedicle valve is highly convex with spreading flanks turning into short, convex ears. The costae are

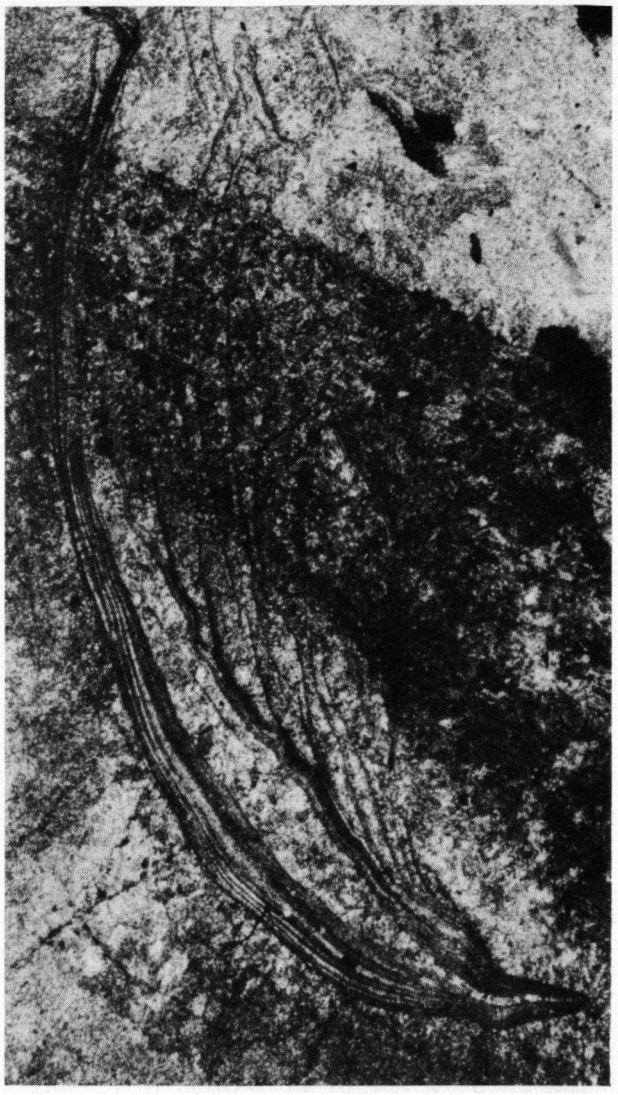


Fig. 15. *Productina pectinoides* (Phill.). Longitudinal section showing the lamellose structure of the shell, especially of the brachial valve. Br. L1083, × 20, loc. 35, Valdeteja Mbr. (acetate peeling).

broad, flattened and rarely branching; there are 8 costae in 5 mm at the anterior margin. Only a few spine bases have been observed. No brachial valve has been observed as they remain completely embedded in the rock and it is almost impossible to separate them. Acetate peels from serial sections, however, show that the brachial valve is concave and has dense lamellae (fig. 15).

The interior of the pedicle valve is distinctly papillose. The adductor muscle scars are elevated and lanceolate in shape; the diductor scars are faint. The interior of the brachial valve has not been observed.

The length of the shell varies from 10.2 to 15.5 mm, the width from 11.0 to 16.2 mm; a medium-sized specimen measures: L = 12.5; W = 13.4 and Th = 4.5 mm.

Discussion. — This species is distinguished from the type species *P. sampsoni,* which it resembles in shape, by its larger size and coarser costae. It differs from *P. margaritacea* because it is more inflated and has a narrower pedicle valve with coarser costae. In the collection of Delépine there are some specimens labelled *Juresania* cf. *ovalis* D. & C., which belong to this species. Because there is no *Pulchratia,* to which genus this species is now assigned, in the collection from Latores, the reference (Delépine & Llopis Llado, 1956) has been quoted in the synonymy.

Material. — This species has only been found at Latores (loc. 35, St.P. Br.L1075—84, 1136; D.5—8).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. It is known from the Viséan of western Europe.

Familia OVERTONIIDAE Muir-Wood & Cooper, 1960

Subfamilia OVERTONIINAE Muir-Wood & Cooper, 1960

Genus AVONIA Thomas, 1914

1914 *Avonia* Thomas, p. 259.
1928 *Avonia* Thomas. — Muir-Wood, p. 36.
1960 *Avonia* Thomas. — Muir-Wood & Cooper, p. 185.
1966 *Avonia* Thomas. — Brunton, p. 218.

Type. — Type species by original designation *Productus youngianus* Davidson, 1860.

Diagnosis. — Small, sub-orbicular to elongated oval, concavo-convex shells. Pedicle valve not sulcate, umbo curved sharply inward beyond the hinge. Ornamentation of bands with a concentric row of round spine bases in the early growth stages; the spine bases become elongated and form longitudinal ribs towards the anterior margin. Interior of the brachial valve: small, sessile, bilobate cardinal process supported by lateral ridges diverging from the hinge line; adductor scars smooth and triangular; brachial ridges spoon-shaped diverging at an angle of 45° from the median septum; brachial area smooth, otherwise surface papillose; median septum weak between the adductors extending about two-thirds of the valve length.

Discussion. — *Avonia* is easily distinguished from other genera of the Overtoniidae by its typical ornamentation and internal characteristics.

Subgenus QUASIAVONIA Brunton, 1966

1966 *Avonia (Quasiavonia)* Brunton, p. 219.

Type. — Type species by original designation *Productus aculeatus* Sowerby, 1814.

Diagnosis. — Rounded quadrate to sub-circular outline, maximum width (predominantly at hinge line) slightly greater than length; half as thick as it is

wide; concentric lamellae more prominent on the pedicle valve; spines suberect to recumbent.

Discussion. — *Avonia (Avonia) youngiana* (Davidson) is smaller, longer than it is wide, has a more concave brachial valve, finer spines and a more lamellose than rugose surface. The strength of the growth lines and lamellae are however unimportant, because they are dependent on the state of preservation.
Productus echidniformis is also assigned here to this subgenus, because it has a rounded rectangular outline — the width being much greater than the length, a prominent rounded umbo, a moderate body cavity and ornamentation of lamellae and radially aligned elongated spine bases at the anterior.
This species differs from the type species of the subgenus, because its width is much greater than its length (the greatest width always occurring anterior to the hinge), it has rounded cardinal extremities instead of perpendicular like *A.* (*Q.*) *aculeata,* and more prominent costae occur starting at an earlier growth stage.

Avonia (*Quasiavonia*) *aculeata* (J. Sowerby, 1814)
Pl. 1, figs. 15—20

1809 *Conchyliolithus Anomites (aculeatus)* sp. nov. — Martin, p. 8, pl. 37, figs. 9, 10.
1814 *Productus aculeatus* Martin. — Sowerby, p. 156, pl. 68, fig. 4.
1861 *Productus aculeatus* Martin. — Davidson, p. 166, 233, pl. 33, figs. 16—20; pl. 53, fig. 10.
1882 *Productus aculeatus* Martin. — Barrois, p. 324, pl. 16, fig. 7.
1914 *Pustula aculeata* (Martin). — Thomas, p. 320, pl. 19, figs. 9, 10, 11?
1943 *Productus (Pustula) aculeatus* var. *radialis* var. nov. — Delépine, p. 66, pl. 3, fig. 12.
1951 *?Krotovia aculeata* (Sowerby). — Muir-Wood, p. 101, pl. 3, fig. 3.
1956 *Productus aculeatus* Martin. — Delépine (in: Delépine & Llopis Llado), p. 107.
1956 *Avonia echidniformis* Grabau. — Delépine (in: Delépine & Llopis Llado), p. 107.
1966 *Avonia (Quasiavonia) aculeata* (Sowerby). — Brunton, p. 220, pl. 10, figs. 8—17; pl. 11, figs. 1—21; text-fig. 10.
For other references see Thomas (1914).

Diagnosis. — A *Quasiavonia* with the width slightly greater than the length; a rounded umbo extending beyond the hinge; greatest width at or slightly below the hinge; cardinal extremities perpendicular and flattened. The interior of the pedicle valve has trigonal to lanceolate adductor scars separated by a narrow depression and indistinct, flabellate diductor scars. Interior of the brachial valve typical of the genus *Avonia.*

Description. — The shells are highly variable in shape and ornamentation. The pedicle valve may be globose or less convex showing a rounded geniculation. The ornamentation consists of more or less pronounced rugae, growth lines and concentric rows of spines. Costae are developed anteriorly, but may start at a rather early stage in the ontogeny. They are usually weakly developed. About 4 costae are found within 5 mm on the median part of the pedicle valve. The width of the shells is somewhat greater than the length, L/W varying from 0.8 to 0.95. The thickness is about half the width. The ears are rather large and flattened, triangular, but usually broken off along the ridge developed in the brachial interior, thus giving the shell an almost circular appearance. When the ears are preserved the cardinal extremities form a right angle, which may be rounded. The umbo is sharp, curved in over the straight hinge line. The brachial valve is regularly concave with flat ears. Ornamentation as on the pedicle valve, but with fewer spines and more pronounced rugae.
Some very small, probably immature, specimens appear similar to *Avonia* (*A.*) *youngiana* because of their narrow, highly inflated visceral disc which seems longer than it is wide. When, however, the comparatively large ears are preserved these specimens prove to be of about equal length and width, and they obviously belong to *A.* (*Q.*) *aculeata.* Some pedicle valves from the *Linoproductus* band near Valdeteja (loc. 3) are also placed in this species; they are peculiar in that a flattened rim has developed around the visceral portion. It may be that the lamellae are the remains of rims which broke off. The material is unfortunately insufficient to determine whether there are more differences from the normal *A.* (*Q.*) *aculeata;* therefore, no new subspecies has been made for this variety.
The interior of the pedicle valve has lanceolate, slightly elevated adductor scars and indistinct rounded diductor scars. The interior of the brachial valve has a sessile, bilobed cardinal process, supported by lateral ridges diverging at an angle of about 25° from the hinge line. The median septum is approximately two-thirds of the valve length, weakly developed between the muscle scars, becoming broader and shallower at the anterior end. The brachial ridges are faint and several concentric ridges are visible, extending from the muscle scars at an angle of 45° to the median septum. The brachial area is smooth, in contrast to the remainder of the shell surface which is papillose. The muscle scars are raised and triangular in outline.
The average size in mm of this species (minimal and maximal size) is: L: 10.8 (5.0, 20.8) and W: 11.7 (6.4, 22.0).

Discussion. — This species is highly variable depending on age, state of preservation and individual characteristics. The costae usually developed in a later stage although occasionally they started quite early. It is especially this latter feature that has caused much confusion and led to new varieties or the assignment to *A.* (*Q.*) *echidniformis,* which is

however clearly distinguished by its broader, more oval shape and more prominent umbo. These varieties are found together in one layer and many transitional forms occur, so that they can barely be separated and are best placed in one species. Brunton (1966) in his redescription of this species also included greatly divergent specimens, some with well-developed costae (pl. 10, figs. 8—11). The degree of development of lamellae and rugae is not an important feature, since this depends highly on the state of preservation. This is also considered to be the cause of the absence of lamellae in the material from Latores. The brachial interiors described here differ slightly from those described and photographed by Brunton (1966) because they have a longer median septum and better developed brachial ridges. The specimen described here (Br. L.1038) is larger than the interiors described by Brunton, which belonged to young, probably immature animals, which provides a ready explanation for the differences.
In the collection determined by Prof. Dr. G. Delépine are three specimens labelled *Avonia echidniformis* Grabau. These specimens, however, definitely belong to *A.* (*Q.*) *aculeata*. Because in other material from Latores (collected by Dr. A. Breimer), many specimens of *A.* (*Q.*) *aculeata* have been found and none of *A.* (*Q.*) *echidniformis* (the latter is only found higher in the Carboniferous), his reference to the latter in his list of fossils from Latores (Delépine & Llopis Llado, 1956) has been included in the synonymy. The specimens described by Delépine (1943) from Entrago as *Productus* (*Pustula*) *aculeatus* var. *radialis* are also specimens of *A.* (*Q.*) *aculeata* with well-developed costae, as far as can be judged from the description and the poor figure; therefore this variety is also listed in the synonymy.

Material. — This species is abundant at Latores (loc. 35, St.P. Br.L1001—56; D.1—3; and in many other samples). E of Valdeteja they also occur (loc. 3, St.P. WP.14411—15, 15401, 16401—05). A few specimens have been found E of Pinos (loc. 30, St.P. WP.36531—33), in a reef just E of Mudá (loc. 51, R.G.M. W-G.01) and near Resoba (loc. 42, R.G.M. Ka.7101).

Occurrence. — In the Mudá Fm. and in the Valdeteja Mbr., both of Lower Bashkirian age, in the San Emiliano Fm. of Middle to Upper Bashkirian age and in the Cervera Fm. of Bashkirian age. This species is known from the Viséan of Great Britain, Belgium and Germany.

Avonia (*Quasiavonia*) *echidniformis* (Chao, 1925)
Pl. 1, figs. 21, 22

1892 *Productus aculeatus* Martin, var. — Schellwien, p. 25, pl. 3, figs. 10, 11.
1899 *Productus aculeatus* Martin. — Loczy, p. 64, pl. 2, fig. 9.
1911 *Productus scabriculus* Martin. — Frech, p. 75, pl. 11, fig. 4.
1922 *Productus echidniforme* sp. nov. — Grabau (in: Norin, 1922), p. 44.
1925 *Productus echidniformis* Grabau. — Chao, p. 239, pl. 2, figs. 7—9.
1927 *Avonia echidniformis* Grabau, em. Chao. — Chao, p. 120, pl. 14, figs. 17—27.
1931 *Avonia echidniformis* (Grabau, em. Chao). — Ozaki, p. 108, pl. 10, figs. 6—9.
1932 *Productus echidniformis* Grabau, em. Chao. — Rakusz, p. 49, pl. 1, figs. 19—23.
1937 *Avonia echidniformis* (Grabau, em. Chao). — Reichhardt, p. 986, pl. 101, fig. 9.
1948 *Avonia echidniformis* (Grabau, em. Chao). —Sokolskaja, p. 119, pl. 8, figs. 16—18.
1952 *Avonia echidniformis* (Grabau). — Sarycheva & Sokolskaja, p. 89, pl. 15, fig. 104.
1956 *Avonia echidniformis* (Grabau, em. Chao). — Nakamura, p. 201, pl. 1, figs. 2—8.
For other references see Chao (1925) and Rakusz (1932).

Diagnosis. — Small to medium-sized species with a moderate body cavity and the greatest width occurring in the middle. Pedicle valve with small, rounded ears; flanks steep at the umbo, spreading anteriorly; a median flattening occurs, but no median sulcus. Ornamentation of lamellae separating bands of concentric rows of spines, growth lines and prominent costae, which start below the umbo. Brachial valve highly concave, ornamented similarly to the pedicle valve.

Description. — The shells have a regular, transverse oval shape, with a pronounced, greatly rounded umbo, sharply curving in over the straight hinge line. The ears are small, ill-defined and the cardinal extremities rounded, so that the greatest width occurs at midvalve. The ornamentation consists of lamellae, which separate bands of radiating rows of spines forming concentric rows anteriorly. On the posterior part there are elongated spine bases, which rapidly form pronounced costae. About 5 costae are developed within 5 mm on the median portion of the pedicle valve. At the point where the costae begin, a median flattening is formed but no true sulcus is developed. The brachial valve is highly concave, leaving a rather thin body cavity. The ornamentation is the same as on the pedicle valve, but no spines have been observed.
The interior of the pedicle valve shows the reverse ornamentation of the exterior. The adductor scars are slightly elevated, smooth, elongated and trigonal in shape, and separated by a thin ridge; the diductor scars are indistinct. The interior surface posterior to the development of the costae is papillose, spine apertures were also observed anteriorly. An interior of the brachial valve was not available.
The measurements in mm of two of the best examples of the pedicle valves (Br.1601, Br.M801) are: L = 16.7, 11.8; W = 24.2, 17.7; the L/W ratio varies from 0.65 to 0.70.

Discussion. — This species was originally mentioned in a list of fossils by Grabau (in: Norin, 1922), who described it only in manuscript. Chao (1925) was the first to publish a description of the species and later he gave a more detailed description (Chao, 1927).
A. (Q.) echidniformis is distinguished by its broad oval shape, prominent and distinctly rounded umbo and the strong development of its costae. In the discussion of *A. (Q.) aculeata,* it has already been stated that the costate specimens of that species do not belong to *A. (Q.) echidniformis,* to which they were sometimes attributed. In addition, the Chrome Hill specimen (Davidson, 1863, pl. 33, fig. 19), which was often compared with *A. (Q.) echidniformis,* does not belong to this species but is a costate specimen of *A. (Q.) aculeata.*

Material. — Only moulds of the interior and exterior have been found but they are well-preserved. In Asturia, this species has been found at loc. 37 (St.P. Bl.49212) near the Mina Ana Mari, San Julian de Bimenes and at loc. M7, 8 (Martínez Alvarez, 1962, p. 79) along the road near Campo de Caso, directly below the Caliza Masiva (St.P. Br. M702, 821, 822). In Palencia, this species has been found 2.5 km NE of Vergano (loc. 50, R.G.M. Br.1602) and near Puente de Camasobres (loc. 48, R.G.M. vG.111) and in León NE of Tejerina (loc. 40, St.P. Si.M 1602).

Occurrence. — In the Cantabrian Mountains, this species has been found in the Calizas Inferiores Mbr. of the Lena Fm. of a Lower Moscovian age, in the Escalada Fm. in strata of Lower Moscovian, Kashirian, age (Fusulinella A subzone), in the Casavegas Lst. Mbr. and Sierra Corisa Lst. Mbr. of the Corisa Fm. of an Upper Moscovian, Myachkovian or uppermost Podolskian, age (upper part Fusulinella B_2 or base of B_3 subzone). *A. (Q.) echidniformis* is typical for the Moscovian and Upper Carboniferous of Eurasia and the Spanish fossils are in accordance with this picture. It has been found in the Moscovian of Hungary and the Moscow Basin, the Taiyuan Series of China which is considered of Moscovian and Uralian age, and the Upper Carboniferous of the Alps.

Genus KROTOVIA Fredericks, 1928

1928 *Krotovia* Fredericks, p. 779, 790.
1952 *Krotovia* Fredericks. — Sarycheva & Sokolskaja, p. 92.
1960 *Krotovia* Fredericks. — Muir-Wood & Cooper, p. 188.
1966 *Krotovia* Fredericks. — Brunton, p. 223.

Type. — Type species by original designation: *Productus spinulosus* J. Sowerby, 1814.

Diagnosis. — Thin-shelled, sub-circular, concavo-convex productoids. Ornamentation of more or less quincuncially arranged, rounded or elongated spine bases on the pedicle valve, which are indicated on the brachial valve by pits.

Discussion. — *Krotovia spinulosa* (J. Sowerby, 1814) is marked by its inflated shell, rather smooth surface with the tubercles in a regular quincunx composed of two alternating rows of spine bases on the anterior part. Many growth lines occur forming rugae on the ears. *Krotovia granulosa* (Phillips, 1836) is distinguished by its stronger growth lines, often becoming rugae, and its ornamentation of irregular, concentric rows of spine bases, which clearly become elongated on the anterior half of the pedicle valve. *Krotovia pustulata* (Keyserling, 1853) is distinguished from the two species named above by its larger size, broader and less inflated pedicle valve with a median flattening or sinus and its more numerous spine bases (compare Tschernyschew, 1902, p. 272, 617). These are easily distinguished from the other species of *Krotovia.*

Krotovia spinulosa (J. Sowerby, 1814)
Pl. 1, figs. 23, 24

1814 *Productus spinulosus* sp. nov. — J. Sowerby, p. 155, pl. 68, fig. 3.
E.P. 1861 *Productus spinulosus* Sowerby. — Davidson, p. 175, pl. 34, figs. 18, 19.
1914 *Pustula spinulosa* (Sowerby). — Thomas, p. 314, pl. 18, figs. 7—9, pl. 19, figs. 7, 8.
1931 *Productus (Krotovia) spinulosus* Sowerby. — Paeckelmann, p. 79, pl. 4, figs. 1—5.
1938 *Productus (Krotovia) spinulosus* Sowerby. — Demanet, p. 78, pl. 7, figs. 35, 36; text-figs. 24, 25.
1952 *Krotovia spinulosa* (Sowerby). — Sarycheva & Sokolskaja, p. 92, pl. 4, fig. 98.
1960 *Krotovia spinulosa* (Sowerby). — Muir-Wood & Cooper, p. 188, pl. 50, figs. 1—5.
1961 *Productus — Krotovia — spinulosus* Sowerby. — Pareyn, p. 207, pl. 26, fig. 1.
1966 *Krotovia spinulosa* (Sowerby). — Brunton, p. 224, pl. 12, figs. 1—8; pl. 13, figs. 1—7.

Diagnosis. — This species of the genus *Krotovia* has the spine bases arranged in a regular quincunx, formed by alternating, concentric rows of tubercles, which are slightly elongated on the anterior section. On the brachial valve the spine bases are represented by pits and the growth lines, which on the pedicle valve are only distinct on the ears, are stronger and can be traced across the venter. The pedicle valve is quite inflated with large, slightly convex ears, which can be easily differentiated from the venter. The brachial valve conforms to the pedicle valve rather closely leaving a thin body cavity.
The relation of this species to other species of *Krotovia* has already been described in the genus discussion.

Description. — The Spanish specimens are remarkable because of their large size, but are otherwise typical for the species. This difference may well have

been caused by old age or optimal conditions.
The best specimen (WP.13101) measures: L = 30.5 W = 24.0 and Th. = 2.5 mm.

Material. — This species has only been found in the *Krotovia* band, about halfway between the villages of Cármenes and Pontedo (loc. 10, St.P. WP.13101—4).

Occurrence. — In the Valdeteja Member of Bashkirian age. In the Viséan of western Europe and also in the Namurian and Bashkirian of the U.S.S.R. and in north Africa.

Krotovia granulosa (Phillips, 1836)
Pl. 1, figs. 25—30

1836 *Producta granulosa* sp. nov. — Phillips, p. 216, pl. 7, fig. 15.
E.P. 1861 *Productus spinulosus* J. Sowerby. — Davidson, p. 175, pl. 34, figs. 20, 21.
1931 *Productus (Krotovia) spinulosus* var. *granulosa* Phillips. — Paeckelmann, p. 82, pl. 4, fig. 6.
1961 *Productus — Krotovia — spinulosus* var. *granulosus* Phillips. — Pareyn, p. 207, pl. 26, fig. 2.

Diagnosis. — A small species of *Krotovia* with a narrow body cavity. It has a broad, regularly inflated pedicle valve with spreading flanks and a pointed umbo. The ornamentation consists of conspicuous growth lines and tubercles arranged in irregular concentric rows. The brachial valve has less numerous and more regularly arranged pits in concentric rows separated by more or less distinct rugae. The tubercles of the pedicle valve are small, rounded on the posterior half and clearly elongated on the anterior half.

Description. — The pedicle valve is regularly, but not highly, convex with spreading flanks turning into large triangular ears and a pointed umbo curving in over the straight hinge line. The outline is rounded quadrate to transversely oval. The ornamentation consists of prominent growth lines, often developing into true rugae. Spine bases are developed in irregular concentric rows, three such rows forming a quincuncial arrangement. In one specimen (Wa. 32301), a median sulcus is developed, but otherwise no more than a flattening occurs.
The brachial valve is slightly concave with spreading flanks and large flattened ears. The ornamentation is similar to that of the pedicle valve with more strongly developed rugae and more regularly arranged spines. The interior of the pedicle valve was not observed. The interior of the brachial valve has a dense papillose surface: the papillae become thinner and elongated anteriorly. A short median septum, about one-third of the valve length, is weakly developed between the smooth, triangular muscle scars, but has a clavate anterior end. Lateral ridges, bounding the cardinal process which was unfortunately not observed, diverge at an angle of 20° from the hinge and curve around the interior of the ears. The brachial ridges are obscure. The mean (minimal and maximal) measurements in mm are: L = 10.2 (7.0—16.5) and W = 14.3 (8.9—± 24).

Discussion. — The relation of *K. granulosa* to other species of *Krotovia* has been considered in the genus discussion. *K. granulosa* has often been considered a synonym of *K. spinulosa,* but has certain distinguishing features described above. The specimen with a slight median sulcus in the pedicle valve agrees exactly in all other aspects with this species and is therefore assigned to it; this is strengthened by Paeckelmann's (1931, p. 81, pl. 4, fig. 4) description of a specimen of *K. spinulosa* with a median sulcus.

Material. — This species has been found S of Candemuela(loc. 25′, 25, St.P. WP.33901—2; 34901—7) near Pinos (loc. 28, 30, St.P. WP.33501—7; 36501) and about 1 km NW of Verbíos (loc. 54, R.G.M. Wa.32301—5).

Occurrence. — *K. granulosa* has been found in the San Emiliano Fm. in strata probably of Upper Bashkirian age and in the Perapertú Fm. (loc. 54) probably of lowermost Moscovian, Vereyan, age (Profusulinella B subzone) (van Ginkel, 1965, p. 198). In western Europe this species occurs in the Viséan and in north Africa in the Lower Namurian.

Familia MARGINIFERIDAE Stehli, 1954
Subfamilia MARGINIFERINAE Stehli, 1954
Genus ALITARIA Cooper & Muir-Wood, 1967

1960 *Alifera* Muir-Wood & Cooper, p. 207 (non Piette, 1891).
1967 *Alitaria* Cooper & Muir-Wood, p. 808.

Type. — Type species by original designation *Alifera koninckí* Muir-Wood & Cooper, 1960 (nom. nov. for *Productus expansus* de Koninck, 1842, non Pander, 1830).

Diagnosis. — Small to medium-sized shells. Pedicle valve highly convex with a rounded geniculation; large ears giving the shell a subtriangular outline; a median flattening or shallow sulcus; a cincture around the visceral disc corresponding to an interior ridge. Ornamentation semireticulate with four or six halteroid spines. Brachial valve with a slightly concave visceral disc, geniculated. Interior of the brachial valve: widely bilobed cardinal process, small, smooth adductor scars and brachial ridges lying on a narrow angle with the horizontal.

Discussion. — This genus is distinguished by its large ears giving the shell a more or less triangular outline, four or six symmetrically placed halteroid spines, and especially by a cincture corresponding to an interior ridge in the pedicle valve around the visceral disc. The interior of the brachial valve is distinguished by

its papillose surface, strongly bilobed cardinal process, small smooth adductor scars and brachial ridges lying on a narrow angle with the horizontal. The Permian genus *Paramarginifera* is similar, but differs in the presence of a strong median sulcus and the absence of rugae. Some species of *Alitaria,* however, have a faint sulcus and the rugae may also be faintly developed so that these differences seem to be more a matter of degree and hardly sufficient to separate the two genera. The interior characteristics of *Paramarginifera* are largely unknown and therefore a re-examination of *Paramarginifera juresanensis* (Tschernyschew, 1902) is necessary to decide if *Alitaria* is a synonym or clearly different.

Alitaria frechi (Paeckelmann, 1931)
Pl. 2, figs. 9—13

1931 *Productus (Eomarginifera) frechi* sp. nov. — Paeckelmann, p. 339, pl. 41, figs. 7—10.
1931 *Productus (Eomarginifera) simplex* sp. nov. — Paeckelmann, p. 337, pl. 41, fig. 6.
1938 *Productus (Eomarginifera) frechi* Paeckelmann. — Demanet & van Straelen, p. 122, pl. 108, figs. 23—25.
1938 *Productus (Eomarginifera) frechi* Paeckelmann. — Demanet, p. 76, pl. 7, figs. 29—31.
1938 *Productus (Eomarginifera) frechi* var. *peracutus* var. nov. — Demanet, p. 77, pl. 7, figs. 32—34.
1956 *Marginifera pseudoplicatilis* Muir-Wood. — Delépine (in: Delépine & Llopis Llado), p. 107.
1961 *Productus — Eomarginifera — frechi* Paeckelmann. — Pareyn, p. 206, pl. 25, figs. 18, 19.
1961 *Productus — Eomarginifera — frechi* var. *peracutus* Demanet. — Pareyn p. 207, pl. 25, figs. 20—22.

Diagnosis. — Small to medium-sized species of *Alitaria.* Ornamentation semireticulate with about 16 rugae on the visceral disc, only a few spines in addition to the 6 halteroid spines. The interior of the pedicle valve has a weak marginal ridge, appearing on decorticated specimens and interior casts as a cincture.

Description. — The slightly convex posterior half of the visceral disc of the pedicle valve turns with a rounded geniculation into a slightly curved anterior part and short spreading trail. The outline of the visceral disc is rounded quadrate, but the outline of the shell with full-grown ears is sub-triangular with the greatest width at the hinge. The umbo is small, pointed, slightly curved in over the hinge. A median flattening is present which only in rare instances develops into a weak median sulcus. The ears are large in full-grown specimens, but they are often broken off or concealed in the matrix. They are triangular in outline, make almost a right angle with the visceral disc and are sharply marked off by a cincture, which fades away towards the venter. Only in decorticated specimens and interior casts can the "cincture" be traced around the front of the valve, but on well-preserved surfaces it is absent from the venter. About 8 costae occur within 5 mm on the posterior part of the trail. On the visceral disc are 16 pronounced rugae, which can be traced across the venter. Just before the anterior margin of the visceral disc are six halteroid spines, one on each side of the middle, one on each antero-lateral margin and one near each cardinal extremity. There are also a few small spines scattered over the visceral disc. The brachial valve has a concave visceral disc geniculated to form a short trail. Sometimes a shallow median fold is developed. The ornamentation is similar to that of the pedicle valve, with prominent rugae and without spines.

The interior of the pedicle valve has a barely developed marginal rim; elevated, oval adductor scars surrounded by flabellate diductor scars. The sulci are indicated in the interior by papillose radial ridges, which are usually most prominent on the median part and probably caused by a pinnate mantle canal system. They become indistinct on the trail in a gerontic stage. The interior of the brachial valve has a strongly bilobed cardinal process supported by prominent crenulated lateral ridges diverging from the hinge at an angle of about 30°, curving around the interior side of the ears and terminating anterior to the ears. The median septum is fine, extending for half the length of the visceral disc. The adductor scars are oval and elevated. Brachial ridges were not observed. The interior surface is rugose with radially, as well as concentrically, aligned papillae, except in the brachial area.

The measurements (in mm) vary from 13 to 16 in length and 16 to 20 in width. A normal-sized specimen with the ears preserved measures: L = 15 mm, W = 19 mm.

Discussion. — The species *Eomarginifera frechi* and *E. simplex* of Paeckelmann (1931) and the variety *E. frechi peracutus* Demanet, 1938 are considered by the present author to fall within the variability range of one species. The development of a trail and a marginal rim in the interior of the pedicle valve started only when the maximal curvature was reached, which probably occured at maturity or slightly afterwards. At that point, the rotation of the shell also ceased and the large halteroid spines developed, while the smaller spines on the visceral disc were sealed off from the interior and usually broke off during the rotation since they no longer served as stabilizers.

The growth of the ears served also for stabilisation, since they grew at right angles to the trail, which lies vertically to keep the aperture above the surface and to improve water circulation. Because the growth of the ears continued when the visceral disc stopped growing, the shell became more triangular in outline with old age. It is these specimens which were referred to the variety *E. frechi peracutus* by Demanet (1938).

A. frechi seems to be closely related to *A. triquetra* (Muir-Wood, 1928), which is distinguished by its more prominent median sulcus and marginal ridge,

less well-developed rugae and the presence of a median fold near the anterior margin of the pedicle valve. This species differs from *A. panderi* (Muir-Wood & Cooper, 1960) in its larger size and more prominent rugae and from *A. koninckí* (Muir-Wood & Cooper, 1960) in its less transverse shape, less distinct median sulcus and better developed rugae. It is distinguished from *Eomarginifera derbiensis* (Muir-Wood, 1928) by its more strongly developed rugae, its large ears and different internal characteristics. Brunton (1966, p. 205) showed *Productus pseudoplicatilis* Muir-Wood, 1928 to be a synonym of *Plicatifera plicatilis* (Sowerby, 1924), which is clearly distinct in its shape, ornamentation and internal characteristics.

Material. — Many specimens were found at Latores (loc. 35, St.P. Br.L.1201—1256, D.10—12), a few specimens at a locality near Resoba (loc. 42, R.G.M. Ka.7111—4) and 1300 m NW of Verbíos (loc. 54, R.G.M. Wa.32320—22).

Occurrence. — In the upper part of the Escapa Fm. of Lower Bashkirian age and in the Perapertú Fm., probably in the upper part, of a Lower Moscovian or uppermost Bashkirian (Profusulinella A or B subzone) and in the Cervera Fm. of about the same age. This species occurs in Germany and Belgium in strata of Viséan age and in north Africa in the Upper Viséan and Lower Namurian.

Alitaria nasuta (Paeckelmann, 1931)
Pl. 2, figs. 14—19

1931 *Productus (Eomarginifera) nasutus* sp. nov. — Paeckelmann, p. 344, pl. 41, figs. 14—17.

Diagnosis. — A small species of *Alitaria.* Pedicle valve moderately inflated with a median fold at the anterior margin. Flat ears separated from the visceral disc by a faint cincture, which can just be traced across the venter. Ornamentation of comparatively coarse costae, intersected on the visceral disc by about twelve rugae. Only a few small spines occur at the umbo in addition to the six halteroid spines.

Description. — The posterior part of the visceral disc of the pedicle valve is moderately convex, separated by a rounded geniculation from the anterior part of the visceral disc and the trail. The ears form a large angle with the visceral disc and are separated from it by a cincture, which can just be faintly traced across the front of the shell, separating the trail from the visceral disc. A median flattening occurs, but no median sulcus was observed. The outline is rounded triangular and the flanks are spreading. Usually an antero-median fold is developed. The costae are fine on the posterior part of the visceral disc. On the anterior part of the visceral disc and trail they become rather coarse: 7 to 9 costae occurring within 5 mm at 10 mm from the umbo, while approximately eleven are found at a distance of 5 mm from the umbo. On the visceral disc are 11 to 14 rugae, which are well-developed and can be traced around the venter. On the ears only growth lines are visible and no costae. Six halteroid spines are developed and a few small spines are visible on the posterior part of the visceral disc. The brachial valve has a slightly concave visceral disc geniculated to form a short trail. The ornamentation is comparable to that of the pedicle valve but without spines.

The interior of the pedicle valve has a marginal ridge separating the visceral disc from the trail and corresponding to the cincture on the exterior. Other internal features were not observed, except that the surface is papillose.

The interior of the brachial valve has not been observed.

The width of the shells varies from 7 to 12 mm and the length from 8 to 13.5 mm; a normal-sized specimen is 10.5 mm in width and 12 mm long.

Discussion. — *A. nasuta* is distinguished from *Eomarginifera tissingtonensis* (Sibly, 1908), which is comparable in size and also has a median fold anteriorly, by the much finer costae, its flat ears and the presence of a cincture. This species differs from *A. panderi* (Muir-Wood & Cooper, 1960) in the occurrence of a median fold and the more distinct rugae, which can be traced across the venter, and the less inflated visceral disc. It is distinguished from *A. frechi* by its small size, the occurrence of a median fold, and relatively coarser and less numerous rugae.

Material. — This species was found S of La Majua (loc. 21, St.P. WP.32850—66), S of Candemuela (loc. 25; 24, St.P. WP.34945, 34951; 349101—10) and E of Pinos (loc. 30, St.P. WP. 36510—25).

Occurrence. — *A. nasuta* has only been found in the upper part of the San Emiliano Fm. of the type area, in strata of Upper Bashkirian age (Profusulinella A subzone). In Germany this species occurs in the Viséan.

Genus EOMARGINIFERA Muir-Wood, 1930

E.P. 1930 *Eomarginifera* Muir-Wood, p. 103.
E.P. 1931 *Eomarginifera* Muir-Wood. — Paeckelmann, p. 336.
1960 *Eomarginifera* Muir-Wood. — Muir-Wood & Cooper, p. 209.
1966 *Eomarginifera* Muir-Wood. — Brunton, p. 229.

Type. — Type species by original designation *Productus longispinus* J. Sowerby, 1814.

Diagnosis. — Small shells; subquadrate or subtriangular in outline. The pedicle valve has a convex visceral disc and curved trail. The ornamentation is semireticulate with three to ten halteroid spines and some small spines on the posterior part of the shell. Brachial valve slightly concave, geniculated to form a short trail with a lamellose rim around the anterior margin.

Discussion. — The genus *Eomarginifera* is distinguished from the genus *Alitaria* by the absence of a cincture around the visceral disc of the pedicle valve and a corresponding marginal ridge in the interior, the presence of a broad lamellose rim around the brachial valve and differences in the interior of the brachial valve, for example, the divided adductor scars, the dorsally trilobate cardinal process and the one or more rows of large endospines around the anterior margin of the visceral disc.

Eomarginifera lobata (J. Sowerby, 1823)
Pl. 2, figs. 3—6

E.P. 1823 *Productus lobatus* sp. nov. — J. Sowerby, p. 16, pl. 318, figs. 2, 4, 6.
1928 *Productus lobatus* Sowerby. — Muir-Wood, p. 173, pl. 11, figs. 6, 12, 13.
1952 *Marginifera lobata* (Sowerby). — Sarycheva & Sokolskaja, p. 166, pl. 45, fog. 232.
For other reference see Muir-Wood (1928).

Diagnosis. — A deeply sulcate species of *Eomarginifera.* Pedicle valve with a flattened posterior portion turning with a geniculation into a curved anterior part; a median sulcus starts at the middle of the visceral disc and becomes deep on the anterior part; the outline is broad and rectangular with large ears; the umbo is pointed and slightly curved inwards over the hinge line. Ornamentation of pronounced rugae on the posterior portion and prominent costae (about 8 costae in 5 mm). Eight prominent halteroid spines and many fine spines.

Description. — The pedicle valve has a slightly convex posterior section turning with a rounded geniculation into a curved anterior part. The ears are large, slightly enroled along the hinge and sharply differentiated from the visceral disc. The large ears give the shell a trapezoid outline in posterior view. The umbo is pointed and curves over the hinge line. A median sulcus starts at the middle of the posterior part and is usually deep, but is differently developed and often the depth is exaggerated through distortion by compaction. The ornamentation consists of prominent costae, 8 to 10 costae within 5 mm on the anterior part of the visceral disc although some costae unite to form broad costae on the trail. On the posterior section, the costae are crossed by about 12 rugae giving rise to nodular swellings at the intersections. Usually eight halteroid spines are developed, two on each side of the median sulcus, one at each antero-lateral margin and one on each ear. In addition to these large spines, quite a few small spines are found on the posterior part. Most of these small spines occur on the umbo, but one or two occur on each ear and a rather large one in each sulcus separating the ears from the visceral disc. The brachial valve has a slightly concave visceral disc with a shallow median fold geniculated to form a short trail. The ornamentation is the same as on the pedicle valve but without spines.

The interior of the pedicle valve shows the same ornamentation as the exterior with fine papillae. The muscle scars were not observed. The interior of the brachial valve was not observed except for a thickened lamellose rim around the front of the visceral disc and some large endospines, arranged in at least two rows.
The measurements (in mm) vary from 7.2 to 10 in length and from 10.5 to 17.5 in width; a normal-sized specimen with the ears preserved is 8.5 mm long and 14.5 mm wide.

Discussion. — This species is distinguished by its well-developed median sulcus, comparatively large clearly separated ears, prominent costae and rugae, and transverse shape. This species is most closely related to *Eomarginifera laqueata* (Muir-Wood, 1928), which is distinguished by its elongated outline and the longitudinal folds below the spine bases on the anterior part. The present shells resemble this species in their numerous spine bases but this is probably due for a large part to the good state of preservation of the shell surface in the marly shales, since *E. laqueata* was described by Muir-Wood (1928, p. 179) from similar sediments.

Material. — From a locality (loc. 21) just S of La Majua (St.P. Sc.121—125; WP.32801—15), S of Candemuela (loc. 25; 24, St.P. Wp.34910—40; 349111—115), near the village of Pinos (loc. 26, St.P. WP.31501—05) and 1300 m NW of Verbíos (loc. 54, R.G.M. Wa.32325—35).

Occurrence. — In the upper part of the San Emiliano Fm. of the type area indicating an Upper Bashkirian age (upper part of the Profusulinella A subzone) and in the Perapertú Fm. indicating a lowermost Moscovian, Lower Vereyan (Profusulinella B subzone), or perhaps uppermost Bashkirian age. In Great Britain this species occurs in the Viséan and Lower Namurian and in Russia in strata corresponding to the lower Namurian.

Eomarginifera praecursor (Muir-Wood, 1928)
Pl. 2, figs. 1, 2.

1928 *Productus praecursor* sp. nov. — Muir-Wood, p. 191, pl. 12, figs. 1, 2.
1952 *Marginifera praecursor* (Muir-Wood). — Sarycheva & Sokolskaja, p. 167, pl. 45, fig. 234.
1956 *Productus minutus* Muir-Wood. — Delépine (in: Delépine & Llopis Llado), p. 107.
For earlier references see Muir-Wood (1928).

Diagnosis. — A species of *Eomarginifera,* sub-circular in outline. The pedicle valve has a slightly convex posterior part geniculated into a regularly curved anterior section with a V-shaped extension in the middle; the ears are small. Ornamentation of weakly developed costae intersected on the anterior part by a few rugae. The brachial valve is moderately concave with a broad lamellose rim around the valve.

Description. — The pedicle valve has a slightly convex to almost flat posterior part turning with a more or less rounded geniculation into a regularly curved anterior section. The ears are small, slightly convex and sharply marked off from the visceral disc by a sulcus along which the ears often broke off. The greatest width occurs at the hinge. The umbo is small, pointed and barely curved in over the hinge. The anterior part shows a V-shaped extension in the middle of the anterior margin in many specimens indicating a gerontic stage, but no antero-median fold is developed. The ornamentation consists of inconspicuous costae, 7 to 9 costae occurring within 5 mm at the point of geniculation. They are regular on the posterior part, but become irregular and often bifurcating on the anterior part. About 7 rugae are traceable across the venter on the posterior section. Apart from the 6 halteroid spines, a few small spines occur behind the geniculation. Often longitudinal plicae are developed anterior to the halteroid spines. The brachial valve has a moderately concave visceral disc surrounded at the lateral and anterior margins by a lamellose rim, usually with a thickness of about 1.5 mm, sometimes thickened in the middle of the anterior margin to close the V-shaped extension of the pedicle valve. The ornamentation is similar to that of the pedicle valve: without spines but with more numerous rugae, averaging about 10.

The interior of the pedicle valve has narrow oval adductor scars and indistinct diductor scars. Radial ridges are developed anterior to the muscle scars. They correspond to the sulci on the pedicle exterior, but become irregular anterior to the geniculation. The interior of the brachial valve has a dorsally bilobed, ventrally trilobed cardinal process supported by lateral ridges curving around the side of the ears forming a broad rim around the lateral and anterior margins.

The width varies from 9.5 to 12.3 mm, and the length from 8 to 10.5 mm. The median values in mm are: L = 9.2, W = 10.1 and Th = 4.1.

Discussion. — This species is distinguished by its subcircular outline, prominent costae and rugae, the absence of a median sulcus and the V-shaped extensions in the middle of the anterior margin. It differs from *Alitaria panderi* (Muir—Wood & Cooper, 1960), a new name for *Productus minutus* Muir-Wood, 1928, to which Delépine (Delépine & Llopis Llado, 1956) erroneously assigned the shells from Latores, in its less globose visceral disc, more prominent rugae which can be traced around the venter, the absence of a cincture on the pedicle valve and the presence of a lamellose rim around the brachial valve.

Material. — Many specimens from Latores (loc. 35, St.P. Br. L1258—1299; D.13—15) and some from a locality near La Majua (loc. 22, St.P. WP.31801—10), which are dubious because of their poor state of preservation.

Occurrence. — In the Valdeteja Mbr. of a Lower Bashkirian age and probably in the upper part of the San Emiliano Fm. of an Upper Bashkirian age. In Great Britain it occurs in the Upper Viséan and in the U.S.S.R. in the Namurian.

Eomarginifera setosa (Phillips, 1836)
Pl. 2, figs. 7, 8.

1836 *Producta setosa* sp. nov. — Phillips, p. 214, pl. 8, figs. 9, 17.
1928 *Productus setosus* Phillips. — Muir-Wood, p. 182, pl. 11, figs. 14, 15; text-figs. 31—33.
1938 *Productus setosus* Phillips. — Demanet, p. 74, pl. 7, figs. 22—25.
1952 *Marginifera setosa* (Phillips). — Sarycheva & Sokolskaja, p. 166, pl. 45, fig. 233.
1960 *Eomarginifera setosa* (Phillips). — Muir-Wood & Cooper, p. 210, pl. 61, figs. 1—6, 8—17.
For earlier references see Muir-Wood (1928).

Diagnosis. — Small to medium-sized species of *Eomarginifera* with a rounded quadrate outline. Pedicle valve with a flattened posterior part turned with a rounded geniculation into a trail; small ears; prominent umbo; a median sulcus weakly developed or absent. The ornamentation consists of fine costae intersected on the posterior part by rugae.

Description. — The pedicle valve has a slightly convex posterior part turning with a rounded geniculation into a regularly curved anterior section. The posterior part has a sub-rectangular outline with the greatest width at the hinge line. A median flattening or weak median sulcus starts posterior to the geniculation but ends before reaching the anterior margin, which shows a V-shaped extension in elongated specimens, which probably represent a gerontic stage. The ears are small, slightly enroled at the hinge and not sharply demarcated. The pointed umbo is slightly turned in over the hinge. The costae are rather fine, 8 to 10 occurring within 5 mm just anterior to the geniculation, becoming more prominent on the anterior part. The rugae are well-developed posterior to geniculation, 10 to 12 rugae being traceable across the venter where the rugae appear as nodular swellings of the costae. In addition to the six halteroid spines, several smaller spines are developed.

The interior of the pedicle valve has small, elevated, elongated oval, slightly dendritic adductor scars separated by a groove, with laterally placed, prominent, flabellate diductor scars. Only fragments of the brachial valve were observed. The interior of the brachial valve shows a dorsally bilobed and ventrally trilobate cardinal process supported by lateral ridges, which probably curve around the lateral and frontal margins of the valve. The adductor scars are separated into elongated oval, strongly elevated scars in the middle and triangular shaped, less elevated, lateral scars. Between the two pairs of scars is a narrow groove with a threadlike median septum, which becomes much broader and more elevated anterior to the scars, extending about two-thirds the length of the visceral disc. Two elevated curved ridges occur laterally at the end of the median septum, representing the antero-

lateral margins of the interrupted brachial ridges. Several rows of endospines are developed anterior to the brachial ridges and the median septum. The surface is papillose.

The specimens differ widely in size and the development of a trail in different kinds of sediment. Those found in the marls of the San Emiliano Formation from the type area are rather small specimens with a well-developed trail. The measurements (in mm) of a full-grown specimen are L = 14.5, W= 13; the length of the visceral disc is 8.5 mm. The specimens from a marly, highly organic limestone in the San Emiliano Formation of the Cármenes area are comparable but larger forms: the largest specimen, a poorly preserved visceral disc, measures 14.5 mm in length and 20 mm in width. The largest specimens, found in a black, slightly calcareous shale from the Escapa Fm., are remarkable for their very short trails. The average length of the visceral disc of these specimens is 13.5 mm and the average width 19.5 mm.

Discussion. — This species is distinguished by its comparatively large size, quadrate outline, small ears, weakly developed costae and rugae, shallow median sulcus terminating before the anterior margin and V-shaped antero-median extension. It is distinguished from *E. praecursor* which is the most closely related species by its larger size, more numerous and less distinct rugae, absence of plicae anterior to the halteroid spines and its more quadrate instead of rounded outline.

Material. — About halfway between Cármenes and Pontedo (loc. 10, St.P. WP.14101—19), near Villanueva de la Tercia (loc. 12, St.P. WP.1961), S of Barrio de la Tercia (loc. 13, R.G.M. Wa.9051—55, St.P. WP.2171), near Pinos (loc. 29; 30, St.P. WP.34501—5; 36502—05) and S of La Majua (loc. 21, St.P. WP.32821—3).

Occurrence. — In the Upper part of the Escapa Fm. of Lower Bashkirian age and in the San Emiliano Fm. of Middle and Upper Bashkirian age. In Great Britain and Belgium this species is found in the Upper Viséan and Namurian and in the U.S.S.R. it is reported from the Namurian and Moscovian. The latter is very high in the Carboniferous for a species of *Eomarginifera.*

Genus KOZLOWSKIA Fredericks, 1933.

1960 *Kozlowskia* Fredericks. — Muir-Wood & Cooper, p. 212.

Type. — Type species by original designation *Productus capacii* d'Orbigny, 1842.

Diagnosis. — Shells small with the greatest width at the hinge. Pedicle valve highly inflated with a rounded geniculation. The ornamentation consists of costae, which become indistinct on the trail and rugae posterior to the geniculation, poorly developed on the venter; six to nine halteroid spines arranged in the usual way; a row of spines along the hinge and a few on the posterior part. Brachial valve with lamellose rim around the valve. Interior of the pedicle valve with a marginal ridge around the visceral disc and strongly developed muscle scars. Interior of the brachial valve with lateral ridges parallel to the hinge, curving around the valve; thin median septum with broad base and clavate anterior end; divided muscle scars; discontinuous brachial ridges; one or two rows of large endospines, anterior to brachial ridges and median septum.

Discussion. — This genus resembles the genera *Alitaria* and *Eomarginifera* in its shape and symmetrically placed halteroid spines. This genus is distinguished from *Alitaria* by its lamellose rim of broken trails around the brachial valve, a row of spines along the hinge and the one or two rows of large endospines in the interior of the brachial valve. It differs from *Eomarginifera* in its marginal ridge around the visceral disc in the interior of the pedicle valve, the larger and less numerous endospines and non-dendritic muscle scars.

Kozlowskia aberbaidenensis (Ramsbottom, 1952)

Pl. 2, figs. 20, 21; pl. 3, figs. 1, 2.

1952 *Productus (Marginifera) aberbaidenensis* sp. nov. — Ramsbottom, p. 17, pl. 2, figs. 1—4.

Diagnosis. — Pedicle valve with at least 4 halteroid spines and a row of spines on the ears. Interior of the brachial valve: well-defined brachial ridges given off at a low angle to the horizontal; a row of large endospines anterior to the brachial ridges, and well behind the anterior margin of the visceral disc; a second short row further behind at the anterior end of the median septum.

Description. — The pedicle valve has a flattened posterior part of the visceral disc geniculated to form a regularly curved anterior part and trail. The outline is sub-quadrate to transversely rectangular. The ears are small, well demarcated from the visceral disc, and usually broken off. The umbo is broad and slightly curved over the hinge. A median sulcus is weakly developed. The ornamentation consists of 7 or 8 costae in 5 mm anterior to the geniculation and 10 rugae on the visceral disc. Four symmetrically placed halteroid spines; a row of small spines on the ears, at least two on each ear; and a few small spines on the visceral disc. It could not be ascertained if a halteroid spine occurred near the cardinal extremities. The brachial valve has a slightly concave visceral disc geniculated to form a short trail. The ornamentation is the same as on the pedicle valve but without spines. A rim is developed around the lateral and anterior margins of the visceral disc, probably formed by broken off trails.

The interior of the pedicle valve has highly elevated triangular adductor scars separated by a groove and laterally placed, slightly flabellate diductor scars. A marginal rim is developed separating the visceral disc from a short trail which is usually broken off. The interior of the brachial valve has a sessile trilobate

cardinal process. The median septum is broad and indistinct below the cardinal process, becomes very thin between the adductor scars, and clavate at the anterior end, halfway along the visceral disc. The muscle scars are smooth and divided into two laterally placed scars: the outer scars are indistinct; the inner are elevated, triangular in shape. The brachial ridges are well-defined, not connected with the lateral margins of the adductor scars, and given off at a low angle to the horizontal. A row of 10 to 18 large endospines occurs at the anterior margin of the brachial ridges, clearly posterior to the anterior margin of the visceral disc. A short second row occurs at the anterior end of the median septum consisting of two or four endospines. When there are only two anterior endospines, the row of endospines appears to curve sharply towards the median septum, but when four are present it is clear that there is a separate row. Lateral ridges start at the base of the cardinal process going along the hinge and curving around the interior of the ears along the lateral margins and the front of the visceral disc. The ridge is crenulated along the hinge and the lateral margins. The interior surface is faintly papillose, rugose and costate, the costae being only visible on the anterior part of the visceral disc.

The length of the visceral disc varies from 6.2 to 10 mm and the width from 11 to 20 mm. The present material can be divided into two groups: one of forms with a rounded quadrate outline and 10 endospines and another consisting of shells with a transversely rectangular outline and up to 18 endospines. The first group agrees in every respect with the species description by Ramsbottom (1952). A normal-sized specimen of the first group has a visceral disc length of 9.4 mm and a width of 12 mm and a typical specimen of the second group (Si.P.825) measures 16.9 mm in width, 6.2 mm in visceral disc length and 6.1 mm in trail length. The least transverse specimen of the second group holds an intermediate position between the specimens of the first group and the most extreme transverse specimen. Therefore, since the only primary difference is the degree of transversity, this second group is not considered a new species. Neither is it a new subspecies, because specimens of both groups occur together. The numerous endospines and the transverse outline of the brachial ridges are clearly secondary features, caused by the transverse growth of the shell. The agreement between the shape and the internal features are proof that the transverse outline was not caused by distortion of the moulds.

Discussion. — This species is placed in the genus *Kozlowskia* because it shows the typical features of the genus. Ramsbottom (1952, p. 19) compared this species with *„Marginifera" splendens* (Norwood & Pratten, 1855) and *„M". haydenensis* Girty, 1908, which are now considered to belong to *Kozlowskia*. *K. haydenensis* is distinguished by a stronger geniculated pedicle valve and by the less numerous and larger endospines and more prominent adductor scars in the interior of the brachial valve. *K. splendens* is distinguished by an interior of the brachial valve comparable to that of *K. haydenensis* and by its larger size and more prominent median sulcus. *K. kingi* Stehli, 1954, differs in its larger ears, fainter costation, more numerous spines and oval adductor scars in the interior of the brachial valve. *K. schellwieni* (Tschernyschew, 1902) has a similar outline, but is much smaller and has a row of endospines close to the anterior margin, as seen in a specimen shown by Schellwien (1892, pl. 4, fig. 21) as *Marginifera pusilla,* but later assigned to *M. schellwieni* by Tchernyschew (1902).

Material. — Several well-preserved interior and exterior moulds found NE of Prioro (loc. 40, St.P. Si.M421; M721,2, M1621), a locality N of Prioro, near the Puerto de Pando (loc. 40, St.P. Si.P.521, 825) and an unknown locality near loc. 40 (St.P. 1101, 1121—25).

Occurrence. — In the lower part of the Pando Fm., probably of a Lower Moscovian, Kashirian, age since a limestone (loc. L. 11, van Ginkel 1965b) occurring higher in the Pando Fm. was dated by its fusulinid content as probably belonging to the Fusulinella A subzone indicating the Kashirian or lower part of the Podolskian (probably the upper part of the Kashirian). This species has been found in Great Britain in the Cefn Coed Marine Band, which indicates the boundary between the Westfalian B and C.

Kozlowskia pusilla (Schellwien, 1892)
Pl. 3, figs. 3—6.

1892 *Marginifera pusilla* sp. nov. — Schellwien, p. 20, pl. 4, figs. 18—20.
1926 *Marginifera pusilla* Schellwien. — Chao, p. 244, pl. 1, figs. 5—9.
1927 *Marginifera pusilla* Schellwien. — Chao, p. 168, pl. 9, figs. 10—12; pl. 10, fig. 9; pl. 12, figs. 7—9.
1953 *Marginifera pusilla* Schellwein [!]. — Almela & Rios, p. 20.

Diagnosis. — Globose species of *Kozlowskia.* Pedicle valve with a highly convex visceral disc and short trail; ears large, flattened; a median sulcus is usually well-developed.

Description. — The pedicle valve is highly globose with a rounded geniculation in the middle. The umbo is small, pointed, slightly curved in over the hinge. The ears are large, triangular, flattened with pointed cardinal extremities and clearly separated from the visceral disc. A median sulcus originates just posterior to the point of geniculation and continues to the anterior margin. The median sulcus is often bordered by two ridges which are, in their turn, bordered by broad sulci bearing a halteroid spine. The median sulcus is weakly developed in some specimens, but is deep in others. The ornamentation consists of regular costae, 7 to 10 occurring in 5 mm just anterior to the geniculation, intersected on the posterior section by about 10 rugae which are prominent on the flanks

and indistinct on the venter. Five or six halteroid spines are developed: one in the middle of the median sulcus or two bordering it, two antero-laterally placed and one near each cardinal extremity. Small spines occur on the visceral disc. The brachial valve has a slightly concave visceral disc geniculated to form a short trail. A median fold may be developed. The ornamentation consists of prominent rugae and costae which are not very pronounced on the visceral disc.
The interior of the pedicle valve has a marginal ridge just below the halteroid spines, separating the ears and the trail from the visceral disc. The adductor scars are narrow, elongated, dendritic, distinctly elevated and separated by a thin ridge. They are separated from two indistinct large diductor scars by a broad groove. The surface is papillose and shows the reverse ornamentation of the exterior, with less well-developed rugae. The interior of the brachial valve has a bilobed cardinal process supported by a fine median septum and lateral ridges along the hinge, curving around the interior of the ears and along the lateral and anterior margins of the visceral disc. The adductor scars are strongly elevated medianly, but the lateral scars are indistinct. The brachial ridges are weakly developed, projecting along a small angle with the horizontal. A row of endospines occurs near the anterior margin of the brachial ridges. Only a few endospines were observed, but this may be due to the poor state of preservation.
The normal, minimal and maximal measurements (in mm) are: L = 8.7, 6.4 and 10.5; W = 12.5, 9.8 and 17.8.

Discussion. — This species is distinguished by its small size, highly convex visceral disc and large ears. Almela and Ríos (1953) have been quoted in the synonymy although they gave no description, because material from this locality collected by Jongmans and Wagner (1957) has been determined as *"M." pusilla.*

Material. — From the Riosa region (loc. 38, I.L.M. Wa.R571; 10001—09), from a locality near the Puerto de Pando, N of Prioro (loc. 40, St.P. Si.P821—23), NE of Prioro (loc. 40, St.P. Si. M101, 821—3, 1421, 22) and somewhere near loc. 40 (St.P. 1126).

Occurrence. — In the "Calizas" Mbr., dated by Jongmans & Wagner (1957) as Westfalian B—C? and in the lower part of the Pando Fm. of Moscovian, probably Kashirian, age (Fusulinella A subzone). *K. pusilla* has been described from the Upper Carboniferous of the Alps and from the Taiyuan Series of China.

Familia PRODUCTIDAE Gray, 1840
Genus PRODUCTUS Sowerby, 1814

E.P. 1814 *Productus* Sowerby, p. 153.
E.P. 1928 *Productus* Sowerby. — Muir-Wood, p. 35.
1930 *Productus* Sowerby. — Muir-Wood, p. 102.
1931 *Productus* Sowerby, em. Muir-Wood. — Paeckelmann, p. 326.
1960- *Productus* Sowerby. — Muir-Wood & Cooper, p. 239.

Type. — Type species by original designation *Productus productus* (W. Martin, 1809), replaced by the name *Productus martini* Sowerby, 1814, which was later rejected.

Diagnosis. — Pedicle valve with a convex visceral disc almost at right angles to the trail which often bears an antero-median fold; flanks steep; small, flat ears. The ornamentation is slightly semireticulate. Brachial valve with flattened visceral disc, geniculated to form a trail in contact with that of the pedicle valve. Interior of the brachial valve with one or more diaphragms around the visceral disc.

Discussion. — The most typical feature of this genus is the diaphragm developed around the visceral disc of the brachial valve at the point of geniculation sealing off the visceral cavity from the trail. The most closely related genus is *Diaphragmus* which also has one or more diaphragms, but differs in having a short trail, narrower and more concave visceral disc of the brachial valve tapering towards the umbo, a cincture around the pedicle valve and less pronounced rugae.

Productus carbonarius de Koninck, 1842
Pl. 3, figs. 7—11.

1842 *Productus carbonarius* sp. nov. — de Koninck, p. 181, pl. 12 bis, fig. 1 (fide Muir-Wood, 1928).
1861 *Productus carbonarius* de Koninck. — Davidson, p. 160, pl. 34, fig. 6.
1928 *Productus carbonarius* de Koninck. — Muir-Wood, p. 56, pl. 2, figs. 3—7, text-fig. 13.
1932 *Productus (Dictyoclostus) carbonarius* de Koninck. — Waterlot, p. 154; 167, pl. 2, figs. 1—3; pl. 4, fig. 10.
1932 *Productus (Eomarginifera) derbiensis* Muir-Wood. — Waterlot, p. 157, pl. 2, figs. 12—14.
1938 *Productus carbonarius* de Koninck. — Demanet & van Straelen, p. 122, pl. 108, figs. 26—30.
1960 *Productus carbonarius* de Koninck. — Muir-Wood & Cooper, p. 240, pl. 72, figs. 13, 14.
1963 *Productus carbonarius* de Koninck. — Böger & Fiebig, p. 124, pl. 14, figs. 1—14; text-figs. 8—10.
For other references see Muir-Wood (1928).

Diagnosis. — Medium-sized species of *Productus,* wider than it is long. The pedicle valve has a short convex visceral disc turning with a sharp curvature to a moderately large trail; venter flattened, but no median sulcus is developed; the ears are pointed towards the cardinal extremities, but usually broken off. The ornamentation consists of fine costae and a few rugae. The spines are scattered over the venter at a low angle with the shell surface and occur in rows on the ears.

Description. — The shells are small to medium-sized. The pedicle valve has a short visceral disc which probably turns with a rounded geniculation into a moderately large trail. The exact curvature could not be observed because the valves are distorted. It appears that a shallow median sulcus is present, but this may also be due to distortion. The umbo is pointed, slightly curved over the hinge. The ears are distinctly demar-

cated from the visceral disc and in one specimen, a long pointed ear was observed with the spines preserved. The costae are fine, 10—13 occurring within 5 mm on the posterior part of the trail. On the visceral disc there are about 10 rugae which are prominent on the flanks, but can hardly be traced across the venter. The spines are numerous, scattered over the valve, in two rows on the ears and a row along the flanks. The brachial valve has a more or less flat visceral disc, probably geniculated to form a trail, which has however not been observed. The ornamentation is the same as on the pedicle valve, but with more evenly developed rugae.

The interior of the pedicle valve has not been observed. The interior of the brachial valve has a well-developed diaphragm around the visceral disc. The ornamentation of the visceral disc is the reverse of the exterior, but the diaphragm usually shows only growth lines, although sometimes the strongest costae of the visceral disc are continued. The cardinal process is ventrally bilobate and dorsally trilobate. It is supported by two short buttress plates bounding a deep alveolus. The lateral ridges occur along the hinge, curve around the inside of the ears and terminate soon afterwards. The breviseptum is very thin and extends for about two-thirds the length of the visceral disc. The adductor scars are narrow elongated ovals, close to the median septum. Brachial ridges were not observed.

The length of the visceral disc of the brachial valve, including the diaphragm, is about 10 mm and the width 15 mm. A pedicle valve with the ears partly preserved has a width of 19 mm, the length of the part posterior to the geniculation is 8.5 mm and the trail has a length of 12 mm.

Discussion. — This species is easily distinguished by its transversely oval outline and fine ornamentation. *P. redesdalensis* resembles it the most, but is distinguished by its more elongated outline, coarser costae, a group of spines on the ears instead of two or three rows and the occurrence of erect spines on the trail.

The internal features of *Diaphragmus fasciculatus bipilus* Elias, as shown by him (Elias, 1957, pl. 53, figs. 1—6; pl. 54, figs. 6—9; text-figs. 18—20), resemble closely the interiors of the brachial valves of *Productus carbonarius* as described above. Unfortunately, the shape of the diaphragm and the pedicle valve are unknown for this subspecies, so it cannot be definitely assigned to *Diaphragmus* or *Productus* and it is therefore not listed in the synonymy. In this connection, it is of interest to note that Elias (op. cit., p. 508) cited *Productus carbonarius* (Muir-Wood, 1928, pl. 2, fig. 6) questionably in the synonymy of *Diaphragmus fasciculatus* (McChesney), thus indicating the close resemblance between both species, especially in their brachial valves.

Material. — Many specimens were found E of Valdeteja (loc. 3) in the *Linoproductus* band (St.P. WP.16430—45), one specimen (St.P. WP.14405) in the *Chaoiella* band and several specimens from La Camocha (loc. 39, St.P. Bl.T1001—08).

Occurrence. — In the Valdeteja Mbr. of a Lower Bashkirian age and from the T.10 coal layer of the La Camocha Fm. of Lower Moscovian age. In western Europe *P. carbonarius* ranges from the uppermost Viséan to the Westfalian C.

Productus concinnus J. Sowerby, 1821

1821 *Productus concinnus* sp. nov. — J. Sowerby, p. 16, pl. 318, fig. 1.
1861 *Productus semireticulatus* var. *concinna* Sowerby. — Davidson, p. 149, pl. 43, figs. 9, 10.
1928 *Productus concinnus* Sowerby. — Delépine, p. 20, pl. 1, figs. 6, 8; pl. 2, figs. 12, 18.
1928 *Productus concinnus* Sowerby. — Muir-Wood, p. 49, pl. 1, figs. 7—10; text-fig. 12.
1943 *Proboscidella fasciculata* sp. nov. — Delépine, p. 71, pl. 3, figs. 1, 2.
1952 *Productus concinnus* Sowerby. — Sarycheva & Sokolskaja, p. 137, pl. 37, fig. 184.
1956 *Productus concinnus* Sowerby. — Delépine (in: Delépine & Llopis Llado) p. 107.
For other references see Muir-Wood (1928).

Diagnosis. — Small to medium-sized species of *Productus.* Pedicle valve with slightly convex visceral disc geniculated into a short trail; median fold at anterior margin.

Description. — The pedicle valve has a slightly convex visceral disc making a large angle with an almost straight trail. The venter is flattened, but no median sulcus was observed. The flanks are steep and spread anteriorly. An antero-median fold is usually present, well-developed. The ornamentation consists of costae, 6—8 occurring in 5 mm on the posterior part of the trail. Many costae bifurcate on the anterior half of the trail and there are 11 costae within 5 mm near the anterior margin. The visceral disc of the brachial valve is nearly flat, ornamented as on the pedicle valve.

The largest and best preserved specimen (Ka. 7131) has a length of 48 mm and a width of ca. 38 mm. This specimen resembles in full detail a specimen photographed by Muir-Wood (1928, pl. 1, fig. 8).

Discussion. — *P. concinnus* is distinguished from *P. productus* by its less convex visceral disc and shorter trail, often with a prominent median fold. It differs from *P. carbonarius* in its more spreading flanks and coarser costae. The tube-like antero-median fold is quite distinct from the tube-like shells of *Proboscidella* and the shells described by Delépine (1943) as *Proboscidella fasciculata* sp. nov. certainly do not belong to that genus. This species cannot be distinguished, as far as the description and figures are concerned, from *P. concinnus* and it is therefore listed in the synonymy.

Material. — Some fragmentary specimens from Latores (loc. 35, St.P. Br.L1301—04), one specimen from a locality (Wagner & Wagner-Gentis, 1963, loc. 21) 1 km E of Santa Maria de Nava (loc. 55,

St.P. Wa. 211) and one from a limestone near Resoba (loc. 42, R.G.M. Ka. 7131).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age, in the Santa María Fm. (Wagner & Wagner-Gentis, 1963) of about the same age and in the Cervera Fm. in a limestone of Bashkirian age. In western Europe this species has been found in the uppermost Viséan and Namurian.

Familia ECHINOCONCHIDAE Stehli, 1954
Subfamilia ECHINOCOCHINAE Stehli, 1954
Genus ECHINOCONCHUS Weller, 1914

1914 *Echinoconchus* Weller, p. 138 (fide Chao, 1927).
1927 *Echinoconchus* Weller. — Chao, p. 24, 63.
1931 *Echinoconchus* Weller. — Paeckelmann, p. 152.
1960 *Echinoconchus* Weller. — Muir-Wood & Cooper, p. 243.

Type. — Type species *Productus punctatus* Sowerby, 1822. This species was described as a typical representative of the genus by Weller (1914; fide Muir-Wood & Cooper, 1960).

Diagnosis. — Concavo-convex shells with a large body cavity. Ornamentation of concentric bands with several rows of spines of two diameters, the larger ones occurring posteriorly. Interior of the brachial valve has a prominent dorsally recurved, trilobed cardinal process; lateral ridges along hinge only; weakly developed median septum, prominent anteriorly; adductor scars smooth, elongated; brachial ridges usually not observable; surface papillose.

Discussion. — The Upper Carboniferous and Permian species formerly assigned to this genus are now placed in other genera such as *Echinaria* and *Karavankina,* because of differences in internal structures and distinct ornamentation (see discussion of *E. punctatus* and *E. elegans).*

Echinoconchus punctatus (Sowerby, 1822)
Pl. 3, figs. 12—14.

E.P. 1809 *Conchyliolithus Anomites (punctatus)* sp. nov. — Martin, pl. 37, fig. 6.
E.P. 1822 *Productus punctatus* Martin. — J. Sowerby, p. 22, pl. 323.
E.P. 1863 *Productus punctatus* Martin. — Davidson, p. 172, pl. 44, figs. 9—11, 16, 17.
1914 *Pustula punctata* (Martin). — Thomas, p. 303, pl. 17, figs. 16—19.
1927 *Echinoconchus punctatus* (Martin). — Chao, p. 67, pl. 6, figs. 7, 8, 15, 16.
1931 *Productus (Echinoconchus) punctatus* Martin. — Paeckelmann, p. 152, pl. 15, figs. 7—10.
1943 *Productus (Echinoconchus) punctatus* Martin. — Delépine, p. 65, pl. 3, figs. 5—7.
1951 *Echinoconchus punctatus* (J. Sowerby). — Muir-Wood, p. 102, pl. 4, fig. 2.
E.P. 1952 *Echinoconchus punctatus* (Martin). — Sarycheva & Sokolskaja, p. 99, pl. 18, fig. 120.
1956 *Productus punctatus* Martin. — Delépine (in: Delépine & Llopis Llado), p. 107.
1960 *Echinoconchus punctatus* (Sowerby). Muir-Wood & Cooper, p. 243, pl. 66, figs. 1, 2; pl. 82, figs. 8—10; pl. 83, figs. 1—4; pl. 88, fig. 11; pl. 125, fig. 5.
1961 *Productus — Echinoconchus — punctatus* Martin. — Pareyn, p. 197, pl. 23, figs. 1—4.
For other references see Davidson (1863) and Thomas (1914).

Diagnosis. — A large species of *Echinoconchus* with a transversely elongated, oval shell. Pedicle valve moderately convex with spreading flanks; usually distinct median sulcus; small ears; umbo only slightly curved inward. Ornamentation of well-defined bands with one row of large spine bases and three or four rows of small ones anteriorly, crowded together in irregular quincunxes; bands not developed on the umbo. Brachial valve slightly concave with a flat visceral disc having a median fold anteriorly.

Description. — The shape varies from rounded quadrate to transversely oval. A median sulcus is always present, but may be weakly or strongly developed. The bands vary in width, are absent on the umbonal parts and crowded with spines. The brachial valve is nearly flat with a more or less distinct median fold developed anteriorly. The interior of the brachial and pedicle valves has not been observed.
Most specimens are fragmentary and thus cannot be measured exactly. A large brachial valve (WP.16411) measures about 43 mm in length and 62 mm in width.

Discussion. — This species is closely related to *E. defensus,* from which it is distinguished by its broader shape, moderately convex pedicle valve, flattish brachial valve and numerous crowded spines. It is easily distinguished from most other species of *Echinoconchus* by its large size and the median sulcus in the pedicle valve.
This species was originally described by Martin (1809) but declared invalid. Muir-Wood (1951) referred it to the first subsequent author, J. Sowerby, 1822.
The specimens from the Upper Carboniferous and Permian formerly referred to *E. punctatus* show many differences in the interior and exterior and belong to the genus *Echinaria.*

Material. — Medium-sized specimens occur at Latores (loc. 35, St.P. Br.L.1101—1110; D.16, 17). In the *Linoproductus* and *Chaoiella* bands E of Valdeteja (loc. 3) large brachial valves have been found (St.P. WP.16411—16; 14403,04) and in the *Echinoconchus* band NE of Valdeteja, a medium-sized shell has been found (loc. 17, St.P. WP.1202).

Occurrence. — This species was found in the Valdeteja Mbr. of Lower Bashkirian age. *E. punctatus* is a cosmopolitan species during the Viséan, but in the U.S.S.R. may also occur in the Namurian and Bashkirian. In north Africa it is found in the Upper Viséan and Lower Namurian.

Echinoconchus defensus (Thomas, 1914)
Pl. 3, figs. 15, 16.

1914 *Pustula defensa* sp. nov. — Thomas, p. 310, pl. 17, figs. 20—23.
1931 *Productus (Echinoconchus) defensus* Thomas. — Paeckelmann, p. 157, pl. 16, figs. 1—3.
1961 *Productus — Echinoconchus — defensus* Thomas. — Pareyn, p. 198, pl. 23, figs. 5—9.
For a detailed synonymy see Paeckelmann (1931).

Diagnosis. — A medium to large-sized species of *Echinoconchus* with an elongated oval to almost rounded quadrate shape. Pedicle valve highly convex with steep flanks, a pointed umbo sharply curved in over the hinge and a median sulcus starting below the umbo, usually weakly developed. Ornamentation of bands with a posterior row of large spines with two or three irregular rows of smaller spines in front. Brachial valve concave with a median fold.

Description. — The pedicle valve is highly convex with steep flanks, turning into small slightly convex ears. A median sulcus is always present, sometimes faint, sometimes clearly marked. The ornamentation consists of narrow or broad bands, which are well marked and contain a row of large spines and two or three rather widely spaced rows of smaller spines forming a regular quincunx. The brachial valve is distinctly concave with anteriorly a median fold and small flattened ears, not clearly separated from the visceral disc. The ornamentation is the reverse of the pedicle valve, but with narrower bands and more closely spaced spines.
The interior of the pedicle valves has elongated smooth adductor scars separated by a narrow ridge and large flabellate diductor scars developed laterally. The ornamentation of bands is also visible on the interior. The interior of the brachial valve has not been observed.
Most specimens are of medium size but some larger ones have been found. A normal-sized specimen has a length of 34 mm and a width of 42 mm; a large pedicle valve (WP.1201) has a length of at least 55 mm and a width of 62 mm.

Discussion. — The differences between this species and *E. punctatus* have been considered in the discussion of that species. Some species of *Echinaria* may be comparable in shape but they differ in the development of spines of three diameters.

Material. — Several specimens from Latores (loc. 35, St.P. Br.L1120—24) and a large pedicle valve from the *Echinoconchus* band NE of Valdeteja (loc. 17, St. P. WP.1201).

Occurrence. — In the Valdeteja Mbr. of a Lower Bashkirian age. In western Europe this species occurs in the Viséan. In north Africa it has been found in the Lower Namurian.

Echinoconchus elegans (McCoy, 1844)
Pl. 4, figs. 1—3.

1844 *Producta elegans* sp. nov. — McCoy, p. 108, pl. 18, fig. 13.
1863 *Productus punctatus* Martin var. *elegans* M'Coy. — Davidson, p. 173, pl. 44, fig. 15.
1914 *Pustula elegans* (McCoy). — Thomas, p. 292, pl. 17, figs. 1—4.
E.P. 1927 *Echinoconchus elegans* (M'Coy). — Chao, p. 64, pl. 6, figs. 1—6.
1931 *Productus (Echinoconchus) elegans* M'Coy, em. Thomas. — Paeckelmann, p. 161, pl. 16, figs. 6—8.
1932 *Productus (Echinoconchus) elegans* M'Coy. — Waterlot, p. 149, pl. 2, fig. 5.
1952 *Echinoconchus elegans* (M'Coy). — Sarycheva & Sokolskaja, p. 99, pl. 18, fig. 123.
1956 *Productus elegans* McCoy. — Delépine (in: Delépine & Llopis Llado), p. 107.

Diagnosis. — Small, semi-globose species of *Echinoconchus* with a comparatively large body cavity. Pedicle valve highly convex without a median flattening or sulcus; ears small, convex; umbo pointed, slightly curved inwards over the hinge. Brachial valve moderately concave with small flat ears.

Description. — The pedicle valve has an outline of about two-thirds of a circle with a prominent pointed umbo, slightly curved in over the hinge. The convexity is usually strong but varies in different specimens (compare pl. 4, figs. 1b and 2a). The greatest width occurs at or anterior to the middle. The pedicle valve is ornamented with convex bands, separated by a groove. The bands increase regularly in width from the umbo, but usually become narrower again near the anterior margin. The posterior third of a band is smooth; the anterior two-thirds contain three or four rows of small spines in front of a row of larger ones. The spines are quincuncially arranged. The brachial valve is moderately concave, the concavity being about equal in different specimens. The ears are small, flattened, distinctly marked off from the visceral disc. The ornamentation is the reverse of the pedicle valve. The bands are narrower than on the pedicle valve and have the same kind of spinal arrangement, although somewhat more crowded. The interiors of the pedicle and brachial valves have not been observed except for a ventrally bilobed cardinal process.
The specimens vary little in size; a normal-sized specimen measures 10.8 mm in length, 10.1 mm in width and 3.6 mm in thickness. The ears are often broken off, probably along the lateral ridges in the brachial interior, giving the shell an almost circular outline.

Discussion. — *E. elegans* is easily distinguished from *E. punctatus* and *E. defensus* by its small size and the lack of a sinus. It differs from other small species of *Echinoconchus* in its sharply marked bands starting at the umbo and its spinal arrangement. Its concave, instead of flat, brachial valve distinguishes it from

E. gradatus Campbell, 1956 from the Tournaisian of Australia.
The specimens of Moscovian, Upper Carboniferous and Permian age, formerly assigned to *E. elegans* and referred to as *E. elegans* auctorum, not McCoy, by Branson (1948, p. 352), probably all belong to the genus *Karavankina.* This genus has only slight differences in exterior characteristics, but a completely different interior (see discussion of *Karavankina).* The specimens from the Chinese Taiyuan Formation of Moscovian age described by Chao as *E. elegans,* but unfortunately not photographed, are considered to belong to the genus *Karavankina,* because the specimens described by Loczy (1899) from the same formation clearly belong to that genus. The Viséan specimens from China described and photographed by Chao as *E. elegans,* however, do belong to this species.

Material. — Many complete shells and loose valves have been found at Latores (loc. 35, St.P. Br.L1131—71, D.21) and some poorly preserved specimens were found at loc. 10, halfway between Cármenes and Pontedo in the *Krotovia* band (St.P. WP.13110—13) and in the *Chaoiella* band E of Valdeteja (loc. 3, St.P. WP.14401).

Occurrence. — This species is found in the Valdeteja Mbr. of Lower Bashkirian age. *E. elegans* is known from the Viséan and the Namurian of Eurasia.

Echinoconchus venustus (Thomas, 1914)

1914 *Pustula venusta* sp. nov. — Thomas, p. 297, pl. 17, figs. 5, 6.
1931 *Productus (Echinoconchus) venustus* (Thomas). — Paeckelmann, p. 168, pl. 17, figs. 1, 2.

Diagnosis. — A small, hemiglobose, concavo-convex species of *Echinoconchus.* Pedicle valve strongly convex with a broad umbo. Ornamentation of broad sharply marked bands with one row of large spines posteriorly and five rows of small ones anteriorly. Brachial valve strongly concave with an ornamentation similar to the pedicle valve, but with narrower bands.

Description. — Only some fragments of pedicle and brachial valves are available. These show the typical ornamentation of rather broad bands with numerous spines, forming five concentric rows of small spines anterior to a row of large spines.

Discussion. — This species is easily distinguished from other small species of *Echinoconchus* by its highly concave brachial valve and the typical ornamentation of well-defined bands with numerous spines.

Material. — Some fragmentary specimens from Latores (loc. 35, St.P. Br.L1180,81).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. In western Europe, this species is found in the Viséan.

Genus ECHINARIA Muir-Wood & Cooper, 1960

1960 *Echinaria* Muir-Wood & Cooper, p. 248.
1965 *Echinaria* Muir-Wood & Cooper, — Gauri, p. 78.

Type. — Type species by original designation *Productus semipunctatus* Shepard, 1838.

Discussion. — This genus differs from *Echinoconchus* in its tapering visceral disc, sharply curved umbo, bands developed at the umbo and the development of spines of three diameters. The cardinal process is broader, more massive and less recurved, and the adductor scars of the brachial valve are also distinct. To this genus belong the Upper Carboniferous (Pennsylvanian) forms, which were thought to be closely related to *Echinoconchus punctatus* but have been proven to be quite distinct in interior and exterior characteristics.

Echinaria sp. ex. gr. *E. semipunctata knighti* (Dunbar & Condra, 1932)

vide 1932 *Echinoconchus semipunctatus* var. *knighti* var. nov. — Dunbar & Condra, p. 208, pl. 26, figs. 1—3.

Description. — The shells are large, concavo-convex, with a rounded trapezoid shape. The pedicle valve is highly convex with spreading flanks which are steep on the umbonal part. The umbo is large, rounded, steeply curved inwards over the hinge. A median sulcus is moderately developed. The ornamentation consists of concentric bands, which show three series of spines on the small surface fragments that are preserved. The brachial valve is slightly concave and has a stout cardinal process, which is trilobate on its dorsal surface.
The measurements in mm of the best preserved shell (28402920) are: L = 62, W = 58, Th = 25.

Discussion. — The specimens distinctly belong to the genus *Echinaria,* because of their shape, spinal arrangement and the broad cardinal process, which is quite similar to the one photographed by Muir-Wood and Cooper (1960, pl. 86, fig. 8). The poor state of preservation prevents definite specific determination. The general shape and size agree closely with *E. semipunctata knighti* and these specimens are therefore tentatively referred to this subspecies.

Material. — One specimen (St.P. 28402920) was found by Mr. W. J. E. van de Graaff at a locality NE of Camasobres (loc. 48) and another was found near Pola de Lena (loc. 31, St.P. dM.16301). The first locality is comparable to loc. P3 and the second to loc. A3 of van Ginkel (1965b).

Occurrence. — The first specimen comes from the Albas Lst. Mbr. of the Curavacas Fm., which points to a Lower Moscovian, lower or middle Kashirian, age (Profusulinella B subzone); the second specimen is from the Lena Fm. also indicating a Lower Moscovian, Kashirian, age (Profusulinella B or Fusulinella A subzone). Both specimens were found widely apart

but in strata of roughly the same age, which is comparable to the age of the strata in which *E. semipunctata knighti* occurs, viz. the Desmoinesian, although the American example is slightly younger.

Echinaria sp.
Pl. 4, fig. 4.

Description. — A medium-sized species of *Echinaria.* The pedicle valve is moderately convex with spreading flanks, medianly sulcate, with the greatest width behind the middle of the valve, and a rounded quadrate outline. The ornamentation consists of lamellose bands with several rows of spines in three sizes, the largest occurring on the two posterior rows. The bands become much narrower at the anterior margin and the hinge line.
The brachial valve is slightly concave with an indistinct median fold. The outline of the brachial valve is about three-quarters of a circle. The ornamentation consists of very narrow bands, otherwise the same as the pedicle valve. The measurements in mm are: L = 21, W = 25.

Discussion. — Only one fragmentary exterior mould of both valves is in the collection so it cannot be ascertained whether it was a fully grown animal. The specimen is too poorly preserved to allow a reconstruction of the exact shape of the pedicle valve; thus it seems best to await more and better preserved material before a definite designation is made.
This species is distinguished by its slightly lamellose bands, like those of *E. longa* Gauri, 1965. It differs, however, from this and other species of *Echinaria* by its rounded quadrate outline and the greatest width occurring posterior to the middle. It seems to be closely related to some specimens described as *Pustula (Echinoconchus) punctata* Martin by Rakusz (1932, p. 52, pl. 3, figs. 3—5), which probably also belong to *Echinaria,* although their spinal arrangement cannot be ascertained from the figures and description.

Material. — This species was found 2.5 km NE of Vergano (loc. 50, R.G.M. Br.1601A,B).

Occurrence. — In the Sierra Corisa Lst. Mbr. of an Upper Moscovian, Myachkovian, age (Fusulinella subzone B, base of B3 or top of B2).

Familia BUXTONIIDAE Muir-Wood & Cooper, 1960
Subfamilia BUXTONIINAE Muir-Wood & Cooper, 1960

Genus LEVIPUSTULA Maxwell, 1951

1951 *Levipustula* Maxwell, p. 10.
1960 *Levipustula* Maxwell. — Muir-Wood & Cooper, p. 190.
1961 *Levipustula* Maxwell. — Campbell, p. 432.
1963 *Levipustula* Maxwell. — Böger & Fiebig, p. 139.

Type. — Type species by original designation *Levipustula levis* Maxwell, 1951.

Diagnosis. — Medium-sized, sub-circular to oval shells. Pedicle valve convex with a flattened venter and spreading flanks. Ornamentation of irregularly developed growth lines and quincuncially arranged spine ridges bearing fine spines. Brachial valve concave or with a flat visceral disc and short geniculated trail. Ornamentation the reverse of the pedicle valve, also with fine spines. Interior of the pedicle valve with elongated trigonal or lanceolate adductor scars, surrounded by large flabellate diductor scars. Interior of the brachial valve with a trilobate cardinal process supported by two buttress plates enclosing an alveolus during the young stages; later the alveolus is closed by secondary shell deposits; lateral ridges diverging slightly from the hinge, not extending across the ears; trigonal adductor scars; brachial ridges usually obscure, leading off horizontally.

Discussion. — *Levipustula* was assigned by Muir-Wood & Cooper (1960) to the Overtoniinae, but it is quite distinct from other members of this subfamily in its internal characteristics, especially of the brachial valve. The brachial ridges are usually obscure, but when they can be observed they lead off horizontally from the adductor scars and not at a large angle with the horizontal as in the Overtoniidae.
The internal characteristics of the brachial valve differ from those of the family Echinoconchidae in the shorter shaft of the cardinal process and the development of an alveolus and buttress plates in the young stages. The assignment to the subfamily Waagenoconchinae of that family (Böger & Fiebig, 1963) is therefore unwarrented; the more so as the spines do not diminish anteriorly and Campbell seems to be quite right in denying a relationship with *Waagenoconcha* (Böger & Fiebig, 1963, p. 140).
The interior characteristics agree well with those of the Buxtoniidae. The exterior ornamentation also agrees rather well with those of the Buxtoniinae and therefore they are assigned here to this subfamily. The ornamentation may become quite similar to that of the Juresaniinae, but the latter are distinguished by two or more series of spines instead of one as in *Levipustula.*

Levipustula breimeri Winkler Prins, sp. nov.
pl. 5, figs. 1, 2.

Holotype. — A pedicle valve St.P. Br.M704.

Locus typicus. — Near Fores de Campo de Caso (Asturias), just before km-stone 52 (coming from 53), somewhat above the road to the right. This locality corresponds to locality M7 of Martínez Alvarez (1962, p. 79).

Stratum typicum. — Thin marly shale just below the Caliza Masiva, Escalada Formation.

Derivatio nominis. — This species was named for Dr. A. Breimer, whose large collection of Carboniferous brachiopods from the Cantabrian Mountains has been tremendously important for this study.

Diagnosis. — A small species of *Levipustula.* Pedicle valve strongly convex, medianly flattened with a sub-

circular outline. Ornamentation of strong growth lines and large elongated spine bases, which contain a fine suberect spine at their highest point, usually in the middle or at the posterior end. The interior of the pedicle valve shows the reverse ornamentation of the exterior. Brachial valve unkown.

Description. — The pedicle valve is highly convex with spreading flanks and a medianly flattened venter. The surface is ornamented with growth lines and large elongated spine bases, few in number, quincuncially arranged. The spines are placed at the highest point of the spine ridge, which lies in the middle or more posteriorly. They are suberect, at least on the flanks.
The interior of the pedicle valve shows the reverse ornamentation of the exterior. The adductor scars are strongly elevated and lanceolate in shape. The diductor scars are flabellate and pronounced. In a small, probably young, animal (Si.M1102) the diductor scars show fine radial ridges with rows of very fine papillae in between.
No brachial valve was observed.
The holotype measures about 11.5 mm in length, 15 mm in width and 6.5 in height. This is the largest specimen; another specimen has a length of 8.5 mm and a width of 10 mm.

Discussion. — This species is assigned to *Levipustula* because of its typical ornamentation of widely spaced, quincuncially arranged, large, elongated spine ridges, and the internal characteristics of the pedicle valve. *L. breimeri* is distinguished from *L. levis* by its hemiglobose shape and more strongly developed spine ridges with suberect spines which start on the median or posterior portion of the spine ridge instead of the anterior.

Material. — The holotype (St.P. Br.M704) and a paratype (St.P. Br.M701) from the type locality comparable to loc. A5 of van Ginkel (1965b) and two small specimens (St.P. Si.M1102.6,7) from a locality NE of Tejerina (loc. 40).

Occurrence. — In the Escalada Fm., of Lower Moscovian age, probably upper part of the Kashirian (Fusulinella A subzone), further in the Pando Fm., which is Kashirian or lower Podolskian in age, probably also the upper part of the Kashirian.

Subfamilia JURESANIINAE Muir-Wood & Cooper, 1960

Genus JURESANIA Fredericks, 1928

1928 *Iurezania* Fredericks, p. 786, 792.
1960 *Juresania* Fredericks. — Muir-Wood & Cooper, p. 266.
1965 *Juresania* Fredericks. — Gauri, p. 81.

Type. — Type species by original designation *Productus juresanensis* Tschernyschew, 1902.

Discussion. — Since the type species is barely known, the description of the genus by Muir-Wood and Cooper (1960) was based largely on *Juresania nebrascensis* (Owen, 1852) which is comparable externally to *J. juresanensis* (Tschernyschew). Gauri (1965) stated that the cardinal process of *J. juresanensis* was bilobed and therefore he thought that *Productus nebrascensis* might belong to a new genus. The imperfect mould of the brachial valve interior, which he assumed to be *J. juresanensis* but which more closely resembles *J. mosquensis* (Ivanov), is however hardly representative. A study of the Spanish material from Asturias showed that the cardinal process falls completely within the variability range of *J. nebrascensis,* so that this latter species is rightly assigned to this genus and the genus was correctly described by Muir-Wood and Cooper (1960).
J. juresanensis is distinguished by its rounded triangular shape from *J. nebrascensis,* which is rounded quadrate although the shape is variable and may perhaps grade into *J. juresanensis.* Tschernyschew (1902, p. 621) stated that the latter had steeper flanks and a greater difference between the large and small spines; however, the steepness of the flanks seems to be comparable in both species (Muir-Wood & Cooper, 1960, pl. 79, figs. 6, 11) though the umbo might be somewhat steeper. A possible difference may also be that the anterior adductor scars are more knob-shaped in the Spanish specimens of *J. juresanensis,* while they are more ridgelike in *J. nebrascensis;* the interior characteristics are highly variable in *J. nebrascensis,* as shown by Fagerstrom and Boelstorff (1964, p. 24). A restudy of topotype material of *J. juresanensis* is urgently needed to establish the differences between *J. nebrascensis* and *J. juresanensis.* Both of these species are distinguished by their ill-defined bands and their rounded quadrate to subtriangular shape. *J. subpunctata* is characterized by its transverse rectangular outline, the well-marked narrow bands on the pedicle valve, and the brachial valve with large flat ears, strong median fold and the prominent rugae. *J. mosquensis* can be easily recognized by its large size, elongated rectangular shape and the ornamentation of quincuncially arranged spine bases posteriorly and strongly marked bands with alternating rows of spine bases anteriorly. *J. buekkiana* resembles *J. juresanensis* in shape, but is distinguished by its sharply separated bands with long spine ridges.

Juresania juresanensis (Tschernyschew, 1902)
Pl. 5, figs. 3—8.

1902 *Productus juresanensis* sp. nov. — Tschernyschew, p. 276, 620, pl. 29, figs. 1, 2; pl. 47, figs. 1, 2; pl. 53, fig. 4.
1935 *Productus juresanensis* Tschernyschew subsp. *typicus* subsp. nov. — Miloradovich, p. 79, 140, text-fig. 29, pl. 5, figs. 25, 26.
1952 *Buxtonia juresanensis* Tschernyschew. — Sarycheva & Sokolskaja, p. 97, pl. 17, fig. 117.
1963 *Juresania juresanensis* (Tschernyschew). — Gobbet, p. 82, pl. 4, figs. 34—37.

Diagnosis. — Medium-sized species of *Juresania.* Pedicle valve highly convex with a rounded triangular visceral disc; maximal width near the anterior border;

ears distinctly separated from the steep flanks; a shallow median sulcus is developed, disappearing towards the anterior margin; umbo pointed, strongly curved in over the hinge line. The ornamentation consists of indistinct concentric bands with a row of large elongated spine bases and a row of small spines inserted at the front of the band on the anterior part. Brachial valve with nearly flat visceral disc turning with a rounded geniculation into a short trail. Ornamentation of rugae with short spine bases and a second row of small spine bases is inserted on the trail.

Description. — The pedicle valve has a highly convex posterior portion grading into a slightly curved anterior part. The umbo is rounded, curved in over the visceral disc. The ears are comparatively large, slightly convex. A shallow median sulcus disappears towards the anterior margin. The flanks were probably steep but they cannot be determined exactly because of distortion by compaction. The ornamentation consists of ill-defined bands with long spine ridges, especially on the posterior half; on the anterior half a second row of small spines is developed between the large ones at the anterior end of a band. The spines are prostrate, except along the hinge and on the ears where large suberect spines occur, usually somewhat curved. The growth lines are not prominent but clearly visible. The brachial valve has a nearly flat visceral disc with a faint median fold curving with a rounded geniculation into a short trail, but in small specimens no trail is developed. The ornamentation consists of rugae and short spine ridges in alternating concentric rows with a second row of small spines between the larger ones on the trail.
The interior of the pedicle valve is not well-known. It shows the reverse ornamentation of the exterior, but no muscle scars could be observed. The interior of the brachial valve is quite distinct in different growth stages. In a young specimen, the cardinal process is quadrilobed on the dorsal surface, appearing bilobed on the ventral surface. The cardinal process is supported by two buttress plates, which may be slightly divergent at their anterior end and surround a shallow alveolus. The faint lateral ridges diverge first from the hinge and then follow the hinge for a short distance. The adductor scars are indistinct, dendritic. The breviseptum is about two-thirds the length of the valve. The ornamentation is the reverse of the exterior with endospines in concentric rows. In old age, the cardinal process becomes distinctly trilobate on the dorsal side, while the ventral side becomes quadrilobed by a recurving of the primary lobes. The buttress plates become fused with the median septum and the alveolus has almost vanished. The muscle scars have become strongly elevated and clearly divisible into a posterior dendritic scar and an anterior smooth knob-like one. The median septum has become comparatively shorter and is hardly more than half the length of the visceral disc. Lateral and brachial ridges were not observed. The length varies from 8.4 to 32.6 mm and the width from 9.5 to ± 35 mm; the average values are: L = 19.5 mm and W = 20.5 mm. The largest spines observed were 15 mm long.

Discussion. — The close affinity of this species to *J. nebrascensis* has been pointed out in the genus discussion as well as the differences with other species of *Juresania. Levipustula rimberti* (Waterlot, 1932) is also closely comparable in shape and ornament. This species is distinguished by the absence of a second row of small spines, but it is practically indistinguishable from young specimens of *J. juresanensis* which have not yet developed the smaller spines, or from poorly preserved specimens.
Much confusion has risen around *J. jurasanensis* because Tschernyschew labeled a specimen as *Productus juresanensis,* which is not comparable with the other specimens. Tschernyschew had not designated a holotype, but Gobbet (1963, p. 82) chose a specimen from the Juresan River (Tschernyschew, 1902, pl. 47, fig. 2) as lectotype and the specimen named above (Tschernyschew, 1902, pl. 29, fig. 1) must be excluded from this species. This is what Miloradovich (1935) did and he designated the remaining specimens as a new subspecies, *Productus juresanensis typicus,* but since it was really a redefinition of the species no new subspecific name was necessary.

Material. — Many well-preserved specimens with adhering spines, but more or less flattened, from the Pozo La Vina and Pozo Carolina coal mines at Villona (loc. 32, St.P. Bl.Fr.1—15).

Occurrence. — In the capa cuarta of the Calizas Inferiores Mbr. belonging to the Lena Fm. and of a Lower Moscovian, Kashirian, age (Fusulinella A subzone).

Juresania mosquensis (Ivanov, 1935)
Pl. 5, figs. 11A,B.

1952 *Buxtonia mosquensis* Ivanov. — Sarycheva & Sokolskaja, p. 96, pl. 16, fig. 115.
1965 *Juresania juresanensis* (Tschernyschew). — Gauri, p. 82, pl. 15, figs. 1—4.

Diagnosis. — Large species of *Juresania* with a longitudinally elongated rectangular outline; hinge line about equal to the greatest width. Pedicle valve highly convex with a shallow median sulcus posteriorly ornamented by quincuncially arranged elongated spine bases and strong growth lines, anteriorly replaced by strongly developed bands with alternating rows of elongated spine bases with a second row of small spine bases inserted in front on the anterior part of a band.

Description. — The outline is elongated rectangular. The pedicle valve is highly convex on the posterior part, which shows an ornamentation of quincuncially arranged elongated spine bases. Anteriorly, a slightly curved trail is developed ornamented by well marked bands with alternating rows of spine ridges on successive bands. Below the middle of the valve, there is a

second row of small spines between the anterior ends of the large ones.
The minimal measurements in mm are L: 40, W: 42 and H: 15.
The interior of the pedicle valve and the brachial valve were not observed.

Discussion. — This species is easily distinguished from other species of *Juresania* by its shape and ornamentation, as described in the genus discussion.
The species from the Upper Carboniferous of the Alps described by Gauri as *J. juresanensis* belong to *J. mosquensis,* judging from their typical shape and ornamentation.

Material. — Only one fragmentary pedicle valve (R.G.M. Br.101) from a locality about 1 km S of Felices (loc. 45).

Occurrence. — The limestone in which this species was found lies above strata of Upper Moscovian, Myachkovian, age (Fusulinella B3 subzone) and can probably be correlated with a limestone from the Cristóbal Fm. (loc. P99 of van Ginkel, 1965b), which belongs to the lower or middle part of the Kasimovian (Protriticites zone).
In the U.S.S.R. this species has been found in the Moscow Basin from the Namurian up to and including the Kasimovian. In the Alps it was found in strata which, according to Gauri (1965), are of an Ouralian (Kasimovian?) age.

Juresania subpunctata (Nikitin, 1890)
Pl. 5, figs. 9, A, B

1890 *Productus subpunctatus* sp. nov. — Nikitin, p. 58, 159, pl. 1, figs. 5, 6.
1931 *Pustula (Juresania) juresanensis* (Tschernyschew). — Ozaki, p. 109, pl. 10, figs. 4, 5.
1932 *Pustula (Juresania) subpunctata* (Nikitin). — Rakusz, p. 56, pl. 2, fig. 25; pl. 3, fig. 9.
1952 *Buxtonia subpunctata* (Nikitin). — Sarycheva & Sokolskaja, p. 96, pl. 16, fig. 115.
1965 *Juresania subpunctata* (Nikitin). — Gauri, p. 83, pl. 15, figs. 5—7.

Diagnosis. — Medium-sized species of *Juresania,* transversely rectangular in outline with large body cavity. Pedicle valve highly convex with steep flanks; small convex ears; shallow median sulcus. Ornamentation of narrow well marked bands with long spine bases and a second row of small spine bases inserted anteriorly. Brachial valve slightly concave with large flat ears and strong median fold.

Description. — The pedicle valve is highly convex, transversely sub-rectangular in outline with rounded corners. A distinct median sulcus is developed, widening towards the anterior margin. The flanks spread steeply, turning into small, indistinct, convex ears. The umbo is curved in over the hinge line, possibly with a cicatrix of attachment, which could not be observed; the brachial valve however has a knob in the middle of the hinge, which is often found when a cicatrix is present. A peculiarity of one specimen (dG.901) is its highly asymmetrical shape, the right half being much lower than the left. The best explanation seems to be an injury or illness, but this cannot be verified since that half of the shell is poorly preserved. The ornamentation of the pedicle valve consists of well-defined bands, with spine ridges as long as the bands are wide, and a second row of small spines between the ends of the ridges at the anterior part of the valve. The brachial valve is slightly concave with large flat ears and a strong median fold, widening towards the front. This valve is ornamented by stout rugae with short spine ridges in between. Just below the middle of the hinge a smooth knob is developed, indicating the presence of an alveolus in the interior of the brachial valve. It is possible that the brachial valve had a geniculation and a short trail, but that this has broken off leaving small parts of an upturned anterior margin. The interior of the pedicle valve has the reverse ornamentation of the exterior. Muscle scars were not observed. The interior of the brachial valve has a dorsally recurved trilobate cardinal process, probably separated from a long breviseptum by a deep alveolus. The measurement of the two specimens (dG.901, Si.M.1102) in mm are L: ± 19, ± 8; W: ± 30, 14.5; Th: 11.8, —.

Discussion. — This species is easily recognized by its broad shape and well-developed median sulcus. It is closely comparable to *J. rectangularis* R. H. King, 1938, which is distinguished by its concave ears and flat visceral disc of the brachial valve, prominent cicatrix of attachment and more prominent spine bases.

Material. — A damaged shell NW of the Mina de San Cebrian (loc. 52, R.G.M. dG.901) and one from a locality NE of Prioro (loc. 40, St.P. Si.M502).

Occurrence. — In the Socavón Lst. Mbr. of the Corisa Fm. which is of Upper Moscovian, Podolskian, age (Fusulinella B1 subzone) and in the Pando Fm. of a Moscovian, probably Kashirian, age. In the Moscow Basin this species has been found in the Upper Carboniferous (Kasimovian and Gzhelian).

Subfamilia KARAVANKININAE Ramovs, 1966
Genus KARAVANKINA Ramovs, 1966

1966 *Karavankina* Ramovs, p. 120.

Type. — Type species by original designation *Karavankina typica* Ramovs, 1966, since the denomination *typica* makes it automatically the type species.

Diagnosis. — Small to medium-sized concavo-convex shell with a large body cavity and a rounded subquadrate to rectangular outline. Pedicle valve strongly convex with rather large, well marked, convex ears and a pointed umbo, curved inwards over the hinge line; the valve is medianly flattened and sometimes a shallow median sulcus is developed. The ornamentation consists of regularly spaced bands with a poste-

rior row of large elongated spine bases and usually up to three quincuncially arranged rows of small spines. The bands are sharply separated from each other by a furrow and often lamellosely developed; the spines are prostrate. The brachial valve is moderately concave to almost flat with large well-defined flat ears. The ornamentation is similar to that of the pedicle valve but with narrower bands; along the hinge there are usually no small spines, only large erect ones in rows diverging from the hinge.

The interior of the pedicle valve has elevated, long, smooth, elongated trigonal adductor scars and obscure, faintly flabellate diductor scars. The interior shows the reverse ornamentation of the exterior with irregular concentric rows of closely spaced endospines on the posterior part of a band between the large spines of the exterior or just behind them. The interior of the brachial valve also has the reverse ornamentation of the exterior and concentric rows of endospines, which even occur between the buttress plates and the median septum; a trilobed or quadrilobed cardinal process, supported by two large diverging buttress plates and two lateral ridges parallel to the hinge or slightly diverging from it; a short breviseptum, about one-third of the valve length, separated from the cardinal process by a shallow alveolus, which is often closed by secondary shell deposits; the anterior part of the breviseptum is clavate in some species, but remains thin in others. Adductor scars and brachial ridges were not observed (in one species (*K. wagneri* sp. nov.) the lateral margins of the buttress plates continued into thin diverging ridges, which may have had a function similar to that of the brachial ridges); the adductor muscles were probably attached to the buttress plates.

Discussion. — Externally the genus closely resembles *Echinoconchus elegans* (McCoy) from the Lower Carboniferous, but is distinguished by its different internal characteristics and externally by its somewhat more regularly placed and slightly smaller spines, median flattening or sulcus on the pedicle valve, larger ears and more prominent umbo. A typical feature of the genus *Karavankina* is that all species have practically the same spinal arrangement. The Permian and Upper Carboniferous specimens assigned to *Echinoconchus elegans* probably all belong to this genus. Branson (1948, p. 353) already classified many of these specimens as *Echinoconchus elegans* auctorum (not McCoy, 1844), but did not state the distinguishing features. Rakusz (1932, p. 56) noted the concentric rows of strong endospines in the pedicle valve as a distinctive feature and called those specimens *Echinoconchus* sp. nov. ind.; however, he paid no special attention to the buttress plates which are clearly visible in his figures. The taxonomic position of the genus *Karavankina* is still not exactly known. It was assigned, together with the genus *Ramavectus,* to the new subfamily Karavankininae, which in turn was questionably assigned to the family Buxtoniidae (Ramovs, 1966, p. 123). The short buttress plates of *Ramavectus* seem, however, to have had a function different from those of *Karavankina,* as they end at the postero-lateral margins of the adductor scars; in *Karavankina* no muscle scars are observed and it may very well be that the adductor muscles were attached to the buttress plates. It seems therefore best to leave *Ramavectus* in the subfamily Juresaniinae.

Karavankina cf. *dobsinensis* (Rakusz, 1926)
Pl. 4, figs. 17, 19

vide 1932 *Pustula (Echinoconchus) dobsinensis* sp. nov. — Rakusz, p. 55, pl. 2, figs. 21, 22; pl. 3, fig. 2.
vide 1932 *Pustula (Echinoconchus) elegans* M'Coy var. — Rakusz, p. 55, pl. 3, fig. 10.

Description. — Pedicle valve transversely oval in outline, moderately convex. The umbo is clearly separated from the remainder of the valve and curved in over the hinge line. The ears are large, almost flat. The anterior part of the valve is only slightly curved. Ornamentation of narrow lamellose bands with a posterior row of large spines and two or three rows of small ones. The brachial valve is distinctly concave with a shallow median fold, widening markedly towards the anterior margin. The ears are large and flat. The hinge line is shorter than the greatest width, which occurs near the straight anterior margin. The ornamentation consists of narrow bands becoming lamellose anteriorly. On each band there is a posterior row of large, elongated spine bases and anteriorly two rows of small spines. At the ears there are also some small spines together with the large ones.

The interior of the pedicle valve of a young animal has elongated adductor scars surrounded by large flabellate diductor scars. The ornamentation is the same as on the exterior with concentric rows of endospines, which occur not on the posterior margin of the bands, but more anteriorly at about one-third of the width of the band. The interior of the brachial valve was not observed.

The best preserved brachial valve measures 8.7 mm in length and 15 mm in width and has 9 bands within 5 mm. The pedicle valve varies from 5.0 to 9.2 mm in length and 8.0 to 13.4 mm in width and only 4 bands occur within 5 mm.

Discussion. — *K. dobsinensis* is easily distinguished by its transversely oval shape, large ears, sharply demarthe same thinning and thickening as the Spanish specimens which are concave with a broad median fold are smaller and have somewhat narrower bands than the specimens shown by Rakusz (1932). He also described the brachial valve as being flat, but in his figure (Rakusz, 1932, pl. 2, fig. 22) the bands show the same thinning and thickening as the Spanish specimens which are concave with a broad median fold and flat ears. The Hungarian specimens are probably flattened, as stated for the pedicle valve. The specimens described by Rakusz as *Pustula (Echinoconchus) elegans* M'Coy var. have also, though questionably, been referred to this species. They are slightly less

transverse in outline and have smaller ears. Since they are smaller, they may represent younger growth stages, because the band arrangement of a typical *K. dobsinensis* also shows that the shells become more transverse with increasing age.
This species has been ascribed to the genus *Karavankina,* although the interior of the brachial valve could not be observed so that the presence of the large buttress plates, the most typical feature of the genus, could not be ascertained. The ornamentation, the median flattening of the pedicle valve and the concentric rows of endospines leave, however, no doubt about the generic determination.

Material. — Several moulds from a locality N of Prioro (loc. 40, St.P. Si.P201-04, P601).

Occurrence. — In the lower part of the Pando Fm. indicating a Moscovian, probably Kashirian, age. In Hungary this species was found in the Carboniferous deposits of Dobsina most probably of a Moscovian age.

Karavankina praepermica Ramovs, 1966
Pl. 4, figs. 8, 10

1966 *Karavankina praepermica* sp. nov. — Ramovs, p. 129, pl. 11, figs. 4, 5.

Diagnosis. — Medium-sized species of *Karavankina,* sub-triangular in outline, the greatest width occurring near the anterior margin. Pedicle valve strongly convex with a shallow median sulcus and steep flanks. Ornamentation of numerous prominent bands with a posterior row of large elongated spine bases and up to three rows of small spines. Brachial valve highly concave posteriorly, anteriorly only moderately concave. Ornamentation the same as on the pedicle valve, but with narrower bands, converging sharply towards the umbo at the hinge and becoming much narrower near the anterior margin of large specimens.

Description. — The shells are small to medium-sized, rounded sub-triangular in outline. The pedicle valve is highly convex with steep flanks, especially on the umbonal part which is U-shaped in cross-section. The umbo is pointed, curved over the hinge line, with an umbonal angle of about 60°. The ears are small, slightly convex, not sharply separated from the flanks. The hinge line is much shorter than the greatest width, which occurs near the anterior margin. The venter is greatly flattened and often a shallow median sulcus is developed. The ornamentation consists of concentric bands, which are sharply separated from each other, 4 bands occurring within 5 mm. Each band bears a posterior row of widely spaced large spines and anterior to them, two or three rows of small spines which have an irregular quincuncial arrangement. The brachial valve is moderately concave, the concavity being prominent on the posterior part, with a shallow median fold. The ears are rather large, flat and distinctly marked off from the remainder of the valve. The cardinal extremities are rounded. The ornamentation is similar to that of the pedicle valve with narrower bands, becoming extremely narrow and less differentiated near the anterior margin. The bands also narrow markedly towards the hinge, where they converge towards the umbo.
The interior of the pedicle valve shows the reverse ornamentation of the exterior with a row of endospines between the large spine bases. Muscle scars have not been observed. The interior of the brachial valve has a quadrilobed cardinal process. Ornamentation as normal for the genus. No other internal features have been observed.
A normal-sized specimen measures (in mm); L = 21.2, W = 22.3 and Th = 10.

Discussion. — The Spanish specimens resemble those of the Karavanke Mountains in their sub-trigonal outline, short hinge line and same ornamentation. Unfortunately there is little known about the variability of this species because the complete description of *K. preapermica* has not yet been published. Only a brachial valve interior and exterior were shown by Ramovs (1966, pl. 11, figs. 4, 5); another brachial valve interior and a flattened pedicle valve were kindly placed at the author's disposal by Prof. Dr. A. Ramovs for comparison. Because of the difference in preservation, it could not be ascertained if the specimens from the type locality also had steep flanks and a shallow median sulcus. The more rounded outline of many brachial valves from Spain is considered due to a variability within the species, since the flattened pedicle valve also has a rounded outline.
K. praepermica is distinguished from other species of *Karavankina* by its rounded trigonal outline, small umbonal angle and the large angle between the buttress plates in the brachial valve interior. Other possible distinguishing features, observed on the present material, are the steep flanks and the development of a median sulcus on the pedicle valve.

Material. — Several specimens from a locality NE of Celada de Roblecedo (loc. 46, R.G.M. Wa.7501—10).

Occurrence. — In the Verdiana Lst. Mbr. which was tentatively correlated with the Maldrigo Lst. Mbr. of the Corisa Fm. (van Ginkel, 1959, p. 718, fig. 4), which is of an Upper Moscovian, either uppermost Podolskian or basal Myachkovian, age (Fusulinella B2 subzone). *K. praepermica* has been originally described from the Upper Carboniferous of the Karavanke Mountains.

Karavankina rakuszi Winkler Prins, sp. nov.
Pl. 4, figs. 11—16, 18, 20; text-fig. 16

Holotype. — A mould of a brachial valve interior (St.P. Br.M801.1).

Locus typicus. — A locality halfway between Campo de Caso and Coballes (Asturias). This is locality M8 of Martínez Alvarez (1962, p. 79).

Stratum typicum. — A fossiliferous sandy shale just below the Caliza Masiva, Escalada Formation.

Derivatio nominis. — This species has been named for Dr. Gyula Rakusz who, in his excellent work on the Upper Carboniferous fossils of Hungary, described and photographed several specimens which belong to *Karavankina,* possibly to this species.

Diagnosis. — Pedicle valve highly convex with a more or less oval outline and the greatest width at the middle of the valve, the hinge being slightly narrower; the ears are moderately large, slightly convex. Ornamentation of narrow lamellose bands with the usual spinal arrangement. Brachial valve slightly concave with a rounded quadrate outline, ornamented as the pedicle valve.
Interior of the pedicle valve with elongated trigonal adductor scars and indistinct flabellate diductor scars laterally placed. Ornamentation as on the exterior with a row of endospines posterior to the large spines. Interior of the brachial valve has broad buttress plates diverging at an angle of about 70° and a thin breviseptum.

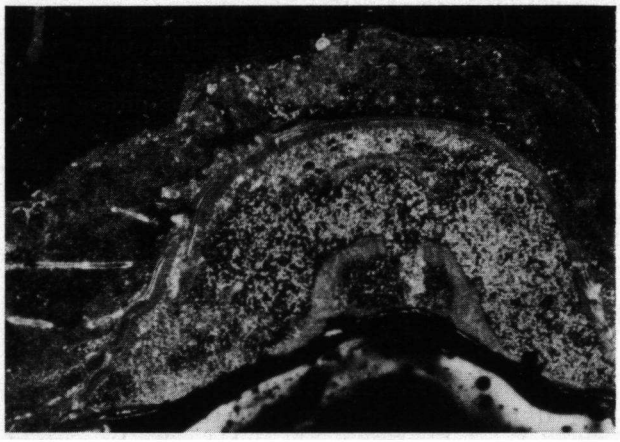


Fig. 16. *Karavankina rakuszi* sp. nov. Transverse section showing the pedicle valve ornamented with numerous spines and the buttress plates within the brachial valve, inclined towards the middle. The brachial valve was not preserved. Br. 7503A, × 13, loc. 46, Verdiana Limestone Member (acetate peeling).

Description. — The pedicle valve is highly convex with a median flattening. The umbo is prominent, curved in over the hinge, and has an umbonal angle of about 90°. The ears are moderately large, flattened, turning gradually into steep, spreading flanks. The hinge line is straight, only slightly less than the greatest width. The ornamentation consists of lamellose bands, six occurring within 5 mm, with posteriorly a narrow smooth part and then a row of large, elongated spine bases and anteriorly up to three rows of small spines. The large spines are at least 5 mm long measured at the anterior margin of a specimen with a length of 9.2 mm. The brachial valve is only slightly concave, particularly in the posterior part. The ears are large and flat. The ornamentation consists of lamellose bands, slightly narrower than on the pedicle valve, seven occurring within 5 mm. The spines are arranged as on the pedicle valve with diverging rows of large erect spines without small spines on the ears.
The interior of the pedicle valve has elongated trigonal adductor scars and usually faint, flabellate diductor scars. The surface is ornamented like the exterior, except for a row of endospines at the posterior end of the large spine bases. The interior of the brachial valve has a dorsally trilobed, ventrally bilobed cardinal process supported by two short lateral ridges, which are almost parallel to the hinge, or diverging from it at an angle of maximally 20°, and do not reach the cardinal extremities, and by two buttress plates diverging at an angle of about 75°. A short breviseptum extends for about one-third of the valve length. It is separated from the cardinal process by a pronounced alveolus and remains very thin over its total length, about one-fifth the width of a buttress plate. The buttress plates are very prominent, more or less rectangular in outline, slightly curved at the posterior end to join the lateral ridges, forming a broad base for the cardinal process. In juvenile specimens the buttress plates are relatively much thinner and longer, diverging at an angle of only 60°. The buttress plates are not vertical, but they converge slightly towards the middle, making an angle of about 70° to the surface of the valve and become rapidly thinner above the broad base. The ornamentation of the interior is comparable to that of the pedicle valve.

Discussion. — This species differs from *K. praepermica* in the more spreading flanks, larger umbonal angle, sub-oval rather than sub-triangular outline of its pedicle valve and the relatively broader hinge resulting in less convergent bands at the hinge of the brachial valve. This species is easily distinguished from *K. dobsinensis* by its less transverse outline and broader, less lamellose bands.
The specimens described by Rakusz (1932, p. 54, 56, pl. 2, figs. 17, 19, 20, pl. 3, figs. 8, 14) as *Pustula (Echinoconchus) elegans* (M'Coy) and *P. (E.)* sp. nov. ind. may belong to this species or else to a new, closely related species. The long median septum is peculiar, as it is exceptional for the genus, but this great length may be apparent, as the groove in the mould may have become longer through damage. The specimen described and photographed as *Productus (Echinoconchus)* cf. *elegans* (McCoy) by Ramsbottom (1952, p. 20, pl. 2, fig. 5) probably also belongs to this species, but this cannot be determined definitely from the fragmentary specimen. This species was identified by Breimer (Martínez Alvarez, 1962, p. 88) as *Echinoconchus fasciatus* (Kutorga).

Material. — The holotype and several paratypes from the type locality (St.P. Br.M801—811), two specimens from the Mount El Figar near San Julian de Bimenes (loc. 37, St.P. Bl.49211,12), some specimens from a locality (loc. 40) NE of Prioro (St.P. Si.M601,2, 1101—4; P202), from a locality near loc. 46 (St.P. 75101—110), from Puente de Camasobres (loc. 48, St.P. Br.G101—12)) and a specimen (R.G.M. Br.M 1601.2) from a locality NE of Vergano (loc. 50).

Occurrence. — Just below and above the Caliza Masiva in the Escalada Fm. in strata of Lower Moscovian, Kashirian, age (Fusulinella A subzone), in the Calizas Inferiores Mbr. of the Lena Fm. of a Lower Moscovian age, in the lower part of the Pando Fm. of about the same age and in the Sierra Corisa Lst. Mbr. and Casavegas Lst. Mbr. of the Corisa Fm. indicating an Upper Moscovian, Myachkovian, age (Fusulinella B2 or B3 subzone).

Karavankina wagneri Winkler Prins, sp. nov.
Pl. 4, figs. 5—7, 9

Holotype. — Specimen R.G.M. Wa.32314.

Locus typicus. — locality (loc. 54) 1300 m NW of Verbíos (Palencia).

Stratum typicum. — A limestone in the upper part of the Perapertú Formation.

Derivatio nominis. — This species was named for Dr. R.H. Wagner, who collected the material from the type locality and supported the present investigation considerably, putting his large collection of Carboniferous brachiopods at the disposal of the author by sending it to the „Rijksmuseum voor Geologie en Mineralogie".

Diagnosis. — A medium-sized species of *Karavankina.* Pedicle valve with spreading flanks and a median flattening; umbo pointed, curved in over the hinge. Interior of the brachial valve with a trilobate cardinal process, supported by triangular buttress plates and short lateral ridges; breviseptum short, slightly clavate anteriorly; the lateral margins of the buttress plates continue into diverging ridges.

Description. — The shells are small to medium-sized, concavo-convex with a large cavity. The small specimens are definitely young animals and cannot be distinguished from the posterior parts of the older shells. The outline is rounded trigonal, the greatest width occurs well before the anterior margin. The pedicle valve is strongly convex posteriorly, but soon becomes gently curved with spreading flanks and medianly flattened. A real median sulcus is not developed. The umbo is pointed, curved inwards over the hinge line, with an umbonal angle of about 80°. The ears are convex, well marked and of moderate size. The ornamentation is of the usual type for the genus, as shown by Ramovs (1966, pl. 11, fig. 6e) for *Karavankina schellwieni,* and consists of regularly spaced bands, 5 within 1 cm on the median portion of the shell. The bands are ornamented anteriorly by a row of large elongated spine bases which are widely spaced followed by up to three rows of crowded small spines. The bands increase in width towards the middle of the shell, but decrease again on the anterior section. The brachial valve is highly concave posteriorly and flattens towards the anterior border. The ears are large and flat. The ornamentation is comparable to that of the pedicle valve with narrower bands, 8 to 9 in 1 cm. The spinal arrangement is comparable, the large spine bases are, however, not elongated and along the hinge diverging rows of large spines without small spines occur.

The interior of the pedicle valve has elevated, narrow, elongated trigonal adductor scars of about one-third the valve length, the width being one-seventh of the length of the scars. The diductor scars were not observed. The interior surface shows the reverse ornamentation of the exterior with concentric rows of endospines posterior to or between the posterior ends of the large spines. The interior of the brachial valve has a short trilobed cardinal process, supported by short lateral ridges and two triangular buttress plates diverging at an angle of 60° in a medium-sized specimen (the holotype), but at an angle of only 30° in a small specimen (WA.32315). A shallow alveolus is developed between the cardinal process and a short breviseptum, which extends about one-third of the valve length. The breviseptum starts as a very thin ridge, becoming broader anteriorly but terminating in a sharp point. The greatest width of the breviseptum is about one-third of the greatest width of a buttress plate, the length being about one and a half times the length of a buttress plate. The lateral margins of the buttress plates continue into thin ridges, which diverge at the same angle as the lateral margins and terminate on the anterior part of the valve. The most logical explanation seems to be that they served the same purpose as the brachial ridges, although their origin is different and they are not closed anteriorly. These ridges, which are best called buttress ridges to distinguish them from ordinary brachial ridges, do not occur in the small, probably immature, specimen (Wa.32315), but are clearly visible on the holotype. The ornamentation of the internal surface is comparable to that of the interior of the pedicle valve.

The measurements of the holotype in mm are: L = 18.3, W = ± 20; Th. = 6.8. The holotype is an imperfectly preserved specimen of which it is impossible to measure the width exactly. It was however chosen as holotype, because it has approximately the average size for the species and it is the only mature specimen with both valves intact and showing the internal features, which have been made visible by etching with hydrochloric acid. The minimal and maximal measurements for the species, also in mm, are: L = 12 to 28.5, W = 14 to 30 and H = ± 6 to 16.

Discussion. — *K. wagneri* is easily distinguished by its large size for a species of this genus. The brachial interior is also quite distinct because of its buttress ridges. This species most closely resembles the Permian species *K. schellwieni* Ramovs, 1966, which has a similar shape, though the brachial valve is somewhat more transversely oval instead of rounded quadrate, the same umbonal angle and an indistinguishable ornament. A normal-sized specimen is, however, only half as large as a normal specimen of *K. wagneri.* It

is best recognized on the basis of the internal characteristics of the brachial valve. *K. schellwieni* has buttress plates which are more quadrate in outline, instead of triangular, and diverge at an angle of 90° instead of the 30° found in a specimen of *K. wagneri* with a comparable size or the 60° in a normal-sized specimen, and no buttress ridges are developed in *K. schellwieni*. It is easily distinguished from the other species of *Karavankina* by its pedicle valve with a rounded trigonal outline, spreading flanks and an ornamentation of broad non-lamellose bands. The large pedicle valves could be mistaken for specimens of *Echinoconchus punctatus,* but they are distinguished by the pointed umbo curved inwards over the hinge, the development of bands starting at the umbo and the finer spines. The brachial valves are, of course, easily recognized by their interior characteristics.

Material. — The most typical specimens come from the type locality: the holotype and several paratypes (loc. 54, R.G.M. Wa.32311—17). Other specimens were found near Resoba (loc. 42, R.G.M. Ka.7110), near Candemuela (loc. 25, St.P. WP.34991—2,33904), just S of La Majua (loc. 21, St.P. Sc.101—2) and W of Pinos (loc. 27, St.P. WP.32501). A few specimens found near El Vez W of Curavacas conglomerate (loc. 41, R.G.M. vH.01,02) are questionably referred to this species.

Occurrence. — Type horizon, Perapertú Fm. of uppermost Bashkirian or lowermost Moscovian, Vereyan, age (Profusulinella B subzone), in the upper part of the San Emiliano Fm. of Upper Bashkirian age, in the Cervera Fm. of Upper Bashkirian or lowermost Moscovian, Vereyan or Kashirian, age (Profusulinella B subzone).

Familia DICTYOCLOSTIDAE Stehli, 1954
Genus DICTYOCLOSTUS Muir-Wood, 1930

E.P. 1930 *Dictyoclostus* Muir-Wood, p. 103.
1949 *Dictyoclostus* Muir-Wood. — Sarycheva, p. 113.
1952 *Dictyoclostus* Muir-Wood. — Sarycheva & Sokolskaja, p. 136.

Type. — Type species by original designation *Productus semireticulatus* (Martin, 1809).

Discussion. — The genus is distinguished by its large size, prominent reticulation and groups of spines on the ears and flanks. The interior of the brachial valve is distinguished by a large trilobate cardinal process; lateral ridges along hinge; dendritic adductor scars; brachial ridges given off at a small horizontal angle.

Dictyoclostus? aegiranus Böger & Fiebig, 1963
Pl. 5, figs. 10, 13, 14.

1963 *Dictyoclostus aegiranus* sp. nov. — Böger & Fiebig, p. 131, pl. 16, figs. 5—10.

Diagnosis. — Medium-sized shells with a moderately convex pedicle valve, sub-quadrate in outline. Ornamentation of prominent costae, which extend fan-wise from the umbo, and weakly developed rugae being prominent only on ears and flanks. Dorsal valve practically flat and with a similar ornamentation.

Description. — The pedicle valve is medianly flattened, moderately convex, without a geniculation. The outline is rounded quadrate, the hinge being slightly less than the greatest width. The umbo is prominent, curved slightly inwards over the hinge. The ears are flattened, well separated from the visceral disc and have rounded cardinal extremities. The ornamentation is semireticulate with a median fan-shaped sector, distinguished by a prominent costation and the absence of rugae. The intercalating costae are prominent on the middle of the valve and faint on the ears. There are 7 or 8 in 5 mm on the anterior portion of the valve. The rugae are distinct on the flanks and ears only. The spines have been observed only in a row along the hinge. The interior of the pedicle valve has not been observed. The brachial valve is more or less flat with an ornamentation similar to that of the pedicle valve. The interior of the brachial valve shows short lateral ridges, an externally bilobate cardinal process and a shallow alveolus; other internal features could not be observed.
The length varies from 12 to 20 mm and the width from 17 to 26 mm.

Discussion. — The Spanish specimens belong undoubtedly to this species. The assignation to the genus *Dictyoclostus* appears to be doubtful as this species lacks the group of spines on the ears and flanks and it has an alveolus developed in the brachial interior.

Material. — Several specimens (St.P. Br.M.321—28; M.720) from localities near Campo de Caso (M.3 and M.7 of Martínez Alvarez, 1962), from a locality W of the Puerto de Pando (loc. 40, St.P. Si.M322—4) and from a locality (41) near El Vez (R.G.M. vH.02—04).

Occurrence. — In the Escalada Fm. and Pando Fm. of Lower Moscovian age and in the Curavacas Fm. of Lower Moscovian, Vereyan or Kashirian, age. This species occurs in Germany in the Aegir Marine Band of Westfalian B/C age.

Dictyoclostus? inflatiformis Ivanov, 1935
Pl. 5, figs. 12A, B.

1952 *Dictyoclostus inflatiformis* Ivanov. — Sarycheva & Sokolskaja, p. 144, pl. 39, fig. 196.
pl. 8, figs. 7—9.
1963 *Dictyoclostus* aff. *inflatiformis* Ivanov. — Gobbet, p. 84, pl. 8, fig. 6.
1963 *Chaoiella* cf. *grünewaldti* (Krotow). — Gobbet, p. 89, pl. 8, figs. 7-9.

Description. — The pedicle valve is medium to large-sized with a rounded quadrate outline, the greatest width occurring at the hinge line when the ears are preserved. The valve is strongly convex, regularly curved without a geniculation. The umbo is prominent, curved in over the hinge line and has an umbonal angle of about 90°. The ears are small, slightly convex, not distinctly marked off from the visceral

disc. A median sulcus is weakly to moderately developed. The ornamentation is semireticulate with fine costae, 6 to 7 occurring within 5 mm at the middle of the valve. About 20 rugae are clearly visible on the flanks, but indistinct on the venter. Only a few spines have been observed scattered on the visceral disc and in a row along the hinge. The brachial valve has a slightly convex visceral disc turning with a rounded geniculation into a curved trail. A weak median fold is developed corresponding to the median sulcus of the pedicle valve.

The internal characteristics have not been completely observed, only the pedicle valve appears to have small, elevated adductor scars.

A medium-sized specimen has a visceral disc length of 22 mm, a visceral disc width of 37 mm, a trail length of 29 mm and a height of 18.5 mm. A specimen with the ears preserved has a width of 41 mm, the width of the visceral disc being 36 mm.

Discussion. — This species was originally referred to *Dictyoclostus,* but it lacks the patch of spines on the flanks and is less strongly semireticulate than *Dictyoclostus* s.s. Since Muir-Wood & Cooper (1960) have not classified this species and the present material provided no new information on this species, it has been referred to the genus *Dictyoclostus* with reservation. This species somewhat resembles *Reticulatia moelleri* (Stuck.) but has a more globose visceral disc, less prominent and fewer rugae. Especially this latter feature makes a designation to the genus *Reticulatia* improbable.

The specimens described by Gobbet (1963) as *Dictyoclostus* aff. *inflatiformis* Ivanov are smaller and somewhat less rugose, but this may be due to a younger age. The specimens described by Gobbet as *Chaoiella* cf. *grünewaldti* are distinctive, as he stated, in their prominent costae and smaller ears. The costae do not become obsolete on the trail, the spine bases are small, no longitudinal plications are developed below them and the valve is not geniculated; therefore, it is improbable that these specimens belong to the genus *Chaoiella.* These specimens are indistinguishable, as far as the description and figures permit, from the Spanish specimens and are therefore listed in the synonymy.

Material. — Several specimens from Latores (loc 35, St.P. Br.L1535—37; D.29) and from the *Echinoconchus* band E of Valdeteja (loc. 3, St.P. WP.15436,37).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. This species occurs in the Moscovian of the Moscow Basin and the Upper Carboniferous or Lower Permian of Svalbard (Spitsbergen).

Genus ANTIQUATONIA Miloradovich, 1945

1949 *Antiquatonia* Miloradovich. — Sarycheva, p. 213.
1952 *Antiquatonia* Miloradovich. — Sarycheva & Sokolskaja, p. 145.
1960 *Antiquatonia* Miloradovich. — Muir-Wood & Cooper, p. 720.
1963 *Antiquatonia* Miloradovich. — Gobbet, p. 84.

Type. — Type species by original designation *Productus antiquatus* J. Sowerby, 1821.

Diagnosis. — Semireticulate shells with spines in a curved row on flanks, often set on a ridge and in one or two rows on the ears; no costae and rugae on the ears. Brachial valve geniculated.

Discussion. — This genus is distinguished by the occurrence of a spine-bearing ridge (preaural ridge), separating the visceral disc from the ears. The ridge was first described by Girty (1935) for the group of *Productus hermosanus* Girty, but he gave no name to this group. The ridge is not always present, but the row of spines is. The ornamentation is semireticulate with less pronounced rugae than *Dictyoclostus,* the rugae being absent from the ears. The development of one or two rows of spines on the ears, instead of a cluster is another distinguishing factor.

Antiquatonia costata (J. de C. Sowerby, 1827)
Pl. 6, fig. 1.

1827 *Productus costata* sp. nov. — J. de C. Sowerby, p. 115, pl. 560, fig. 1.
1928 *Productus costatus* Sowerby. — Muir-Wood, p. 143, pl. 10, figs. 1—3.
1949 *Antiquatonia costata* Sowerby. — Sarycheva, p. 240, pl. 23, figs. 1—6; pl. 24, figs. 1—4; text-figs. 82, 83.
1952 *Antiquatonia costata* Sowerby. — Sarycheva & Sokolskaja, p. 156, pl. 42, fig. 214.
1956 *Productus* aff. *costatus* Sowerby. — Delépine (in: Delépine & Llopis Llado), p. 107.
1960 *Antiquatania costata* Sowerby. — Muir-Wood & Cooper, p. 271, pl. 94, fig. 11.
For other references see Muir-Wood (1928) and Sarycheva (1949).

Diagnosis. — A medium-sized species of *Antiquatonia.* Pedicle valve with large ears and a deep median sulcus. The outline is almost triangular, the greatest width occurring at the hinge. Ornamentation of costae which rapidly increase and become very prominent, rugae on visceral disc only.

Description. — The pedicle valve has a convex visceral disc turning with a rounded geniculation into a curved trail. The ears have not been observed, since they are broken off along the sulci separating them from the visceral disc. A spine-bearing ridge is developed along the flanks. The median sulcus is deep. The umbo is prominent, pointed, slightly curved over the hinge and with an umbonal angle of 90°. The costae become rapidly coarse and prominent, 4 costae occurring in 5 mm at the point of geniculation. The sulci are much narrower than the costae. About 20 rugae are developed posterior to the geniculation. They are prominent on the flanks and weak on the venter. The spines are few in number and are placed in a row along the hinge and on the preaural ridges. The brachial valve has a slightly concave visceral disc geniculated to form a regularly curved trail. A prominent median fold is developed corresponding to the median sulcus of the pedicle valve. The ornamentation is similar to that of

the pedicle valve, the costae being, however, somewhat narrower and the sulci wider. Internal features have not been observed.
The best preserved specimen measures 31.5 mm in width, although the ears are broken off; the visceral disc has a length of 17 mm and the trail 27 mm.

Discussion. — This species is distinguished by its transverse outline, deep median sulcus and coarse costation, the costae starting fine and becoming progressively coarser towards the anterior margin. *Productus* aff. *costatus* Sow. of Delépine (Delépine & Llopis Llado, 1956) has been listed in the synonymy, although no actual specimens determined by him as such were available for comparison; it is probable however that they do occur as they have been found near Valdeteja in strata of the same age. Perhaps he so identified specimens without a median sulcus, which are questionably referred to this species since Sarycheva (1949, pl. 24, fig. 4) also labelled a specimen without a median sulcus as *A. costata.* These Spanish specimens are, however, too poorly preserved to be identified with certainty.

Material. — Two specimens from the *Echinoconchus* band E of Valdeteja (loc. 3, St.P. WP.15445,46). Two specimens without a median sulcus from Latores (loc. 35, St.P. Br.L.1505,6) are tentatively referred to this species.

Occurrence. — In the upper part of the Valdeteja Mbr. of Lower Bashkirian age. This species occurs also in the Viséan and Namurian of Great Britain and the U.S.S.R.

Antiquatonia gallatinensis (Girty, 1899)

1899 *Productus gallatinensis* sp. nov. — Girty, p. 533, pl. 68, figs. 7, 11.
1903 *Productus gallatinensis* Girty. — Girty, p. 361, pl. 3, figs. 4—8.
1938 *Productus (Dictyoclosus) gallatinensis* Girty. — Demanet & van Strealen, p. 123, pl. 109, figs. 4, 5.
1943 *Productus (Dictyoclostus) gallatinensis* Girty. — Demanet, p. 78, pl. 2, figs. 8—11.
1961 *Antiquatonia? gallatinensis* (Girty). — Hoare, p. 54, pl. 7, figs. 1—5.
For other references see Hoare (1961).

Description. — The shells are small with the greatest width at the hinge line. The pedicle valve has a moderately convex posterior part turning with a rounded geniculation into a long regularly curved anterior part. The umbo is pointed, curved in over the hinge line. The median sulcus is shallow. The ears are large, separated from the visceral disc by a sulcus. Ornamentation of rugae posterior to the geniculation and thick costae (2 to 4 within 5 mm on the anterior part). Many comparatively large spines are scattered symmetrically over the valve and occur in a row in the sulcus separating the ears.
The brachial valve has not been observed. The interior of the pedicle valve has large diductor scars, surrounding narrow elongated adductor scars. The surface shows the costation of the exterior very poorly.
A normal-sized specimen measures 13 mm in length and 14 mm in width.

Discussion. — This species is distinguished by its small size, highly curved visceral disc, regular costation and regularly scattered spines. It is distinguished from the genus *Kozlowskia* by its differently arranged, more numerous spines, absence of marginal ridges and other differences in the internal features.

Material. — A few specimens from the Pozo Pumerabule at Carbayin (loc. 36, St.P. Bl.La.4131-3), from the Pozo Mosquitera at Mosquitera (loc. 36, St.P. Bl. 3591) and from a locality (loc. 40) near the Pando Pass N of Prioro (St.P. Si.M1120,21).

Occurrence. — In the Madama and Cantera coal layers of the Modesta Mbr. of the Sama Fm. of a Moscovian age. This species occurs in the U.S.A. in the Desmoinesian and younger strata. In Europe it has been described from the Petit Buison Marine Band indicating the boundary between the Westfalian B and C.

Antiquatonia hindi (Muir-Wood, 1928)
Pl. 6, figs. 2, 3.

1928 *Productus hindi* sp. nov. — Muir-Wood, p. 108, pl. 6, figs. 3—6, text-figs. 1—5, 21.
1949 *Antiquatonia hindi* (Muir-Wood). — Sarycheva, p. 219, pl. 16, figs. 1—4; pl. 17, figs. 1—5; pl. 18, figs. 1—8; pl. 19, figs. 1—3; pl. 20, figs. 1—5; text-figs. 66—79.
1952 *Antiquatonia hindi* (Muir-Wood). — Sarycheva & Sokolskaja, p. 155, pl. 43, fig. 211.

Diagnosis. — Large species of *Antiquatonia* with a quadrate outline, the greatest width at the hinge. Pedicle valve with a rounded geniculation and long trail; median sulcus usually shallow; flanks steep with a prominent spine-bearing ridge; finely costate.

Description. — The pedicle valve has a convex visceral disc geniculated to form a long curved trail. The ears are large, separated from the visceral disc by a sulcus and a spine-bearing ridge along the flanks. The umbo is rounded, prominent, greatly curved in over the hinge. The median sulcus is differently developed, varying from shallow to moderately deep. The costae are fine, 5 to 7 occurring within 5 mm anterior to the geniculation. The rugae are distinct on the flanks but faintly traceable across the venter; they are only on the visceral disc. Spines occur in one or two rows along the hinge, in a row on the preaural ridges and scattered over the remainder of the shell. The size of the spines is inversely related to their number. Sometimes the shell is slightly folded for a short distance below the spine bases and often bifurcations of the costae occur anterior to a spine base and the costae may coalesce again posterior to the spine base. The brachial valve has an almost flat visceral disc geniculated to form a curved trail. A median fold is developed corresponding to the median sulcus of the pedicle valve. The ornamentation is similar to that of the pedicle

valve, but without spines and with better developed rugae.
The interior of the pedicle valve has not been observed. The interior of the brachial valve has a long median septum extending two-thirds the length of the visceral disc, the septum being thin between the adductor scars and prominent at the anterior end. The adductor scars are elevated, triangular in outline and dendritic, but the anterior end is smooth and knob-shaped. The brachial ridges are given off horizontally, the lateral ends forming a prominent loop.
The length varies between 32 mm and 45 mm and the width between 40 mm and about 60 mm.

Discussion. — This species is highly variable as has been demonstrated by Sarycheva (1949, p. 229). The development of the preaural ridges, the median sulcus, spinosity and the width of the costae vary considerably. The Spanish specimens also differ greatly. *A. hindi* is distinguished by its larger size, quadrate outline with a rectangular visceral disc, the less prominent rugae, finer costae and distinct preaural ridges.

Material. — Two fragmentary specimens from Latores (loc. 35, St.P. Br.L1550), one good specimen from a reef WNW of Verbíos (loc. 54, R.G.M. dG. 521) and a few specimens from La Camocha (loc. 39, St.P. Bl.T1010—13).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age, in the lower part of the Perapertú Fm. of a Middle to Upper Bashkirian age, and from the T.10 layer of the La Camocha Fm. of Lower Moscovian age. This species occurs in Great Britain and the U.S.S.R. in strata of Upper Viséan and Namurian age.

Antiquatonia insculpta (Muir-Wood, 1928)
Pl. 6, figs. 8, 10

1928 *Productus insculptus* sp. nov. — Muir-Wood, p. 89, pl. 3, figs. 10—12.
1949 *Antiquatonia insculpta* (Muir-Wood). — Sarycheva, p. 257, pl. 26, figs. 3—6; pl. 27, figs. 1—8; text-figs. 88—92.
1952 *Antiquatonia insculpta* (Muir-Wood). — Sarycheva & Sokolskaja, p. 157, pl. 42, fig. 216.
1956 *Productus inflatus* Mc Chesney. — Delépine (in: Delépine & Llopis Llado), p. 107.

Diagnosis. — Medium-sized species of *Antiquatonia*, elongate in outline with the hinge forming the widest part of the shell. Pedicle valve with a short, slightly convex visceral disc turning with a rounded geniculation into a long trail; median sulcus well-developed; flanks steep with a low preaural ridge; ears large, usually broken off. Ornamentation of fine costae which rarely bifurcate and rugae on the visceral disc. Brachial valve with a flat visceral disc geniculated to form the trail.

Description. — The pedicle valve has a moderately convex posterior part turning with a rounded geniculation into a long curved trail. The outline is subquadrate with the greatest width at the hinge. A distinct median sulcus is developed. The umbo is prominent, slightly curved in over the hinge. The ears are large, rolled along the hinge, separated from the visceral disc by a sulcus and a weakly developed preaural ridge. The ornamentation is semireticulate with indistinct rugae, only faintly traceable across the venter. The costae are fine, regular, 6 to 8 occurring within 5 mm anterior to the geniculation. A few spine bases are scattered over the valve and placed in a row on the preaural ridges and along the hinge. The brachial valve has an almost flat visceral disc geniculated to form a regularly curved trail. A median fold is developed corresponding to the median sulcus of the pedicle valve. The ornamentation is similar to that of the pedicle valve, but without spines. Internal characteristics have not been observed.
The measurements (in mm) of a medium-sized specimen are: W = 24, L = 25 and the length of the visceral disc is 13.5.

Discussion. — This species is distinguished by its medium size, highly globose pedicle valve and geniculated brachial valve, large, sharply demarcated ears and fine, regular costae. It is distinguished from *Inflatia inflata* (McChesney) by the spine-bearing ridge along the flanks and the costae not becoming obsolete anteriorly.

Material. — Several specimens from Latores (loc. 35, St.P. Br.L1551—53; D.34, 35).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. In Great Britain and the U.S.S.R., this species has been found in strata of Upper Viséan age.

Antiquatonia khimenkovi Sarycheva, 1949
Pl. 6, figs. 4—7, 9

1935 *Productus crassicostatus* sp. nov. — Yanischevsky, p. 182, pl. 2, figs. 1—4, 18, 19; pl. 4, fig. 18 (fide Sarycheva, 1949).
1949 *Antiquatonia khimenkovi* (Yanischevsky) nom. nov. — Sarycheva, p. 290, pl. 30, figs. 1—13; pl. 31, figs. 1—11; text-figs. 102—104.
1952 *Antiquatonia khimenkovi* (Yanischevsky). — Sarycheva & Sokolskaja, p. 158, pl. 43, fig. 219.
1956 *Productus* aff. *sulcatus* Sowerby. — Delépine (in: Delépine & Llopis Llado), p. 107.
For other references see Sarycheva (1949).

Diagnosis. — Medium-sized species of *Antiquatonia*, about as long as it is wide. Pedicle valve highly convex, usually with a distinct median sulcus. Ornamentation of a few, weakly developed rugae and costae which are fine on the posterior third but become coarse and of unequal width on the anterior part, often terminating by convergence.

Description. — The pedicle valve is medium-sized, highly convex. The umbo is prominent, slightly turned over the hinge, with an umbonal angle of 90°. The median sulcus is usually shallow. The ears are rounded triangular, sharply separated from the visceral disc by a sulcus and an indistinct preaural ridge on the flanks. The ornamentation is semireticulate with twelve weakly developed rugae on the visceral disc. The costae are fine on the visceral disc, but become coarse and irregular in width on the trail, the fine costae often coalescing to form broad costae; 6 costae occur within 5 mm on the anterior end of the visceral disc and 4 in the same width on the middle of the trail. The spines are few in number: one row on the preaural ridges, one row along the hinge and several scattered over the valve. The brachial valve has a nearly flat visceral disc geniculated to form a curved trail. Ornamentation as on the pedicle valve, with more distinct rugae and without spines.

The interior of the pedicle valve has lanceolate, dendritic, slightly elevated adductor scars and indistinct, oval diductor scars. The interior of the brachial valve has an internally bilobed cardinal process supported by a broad base formed by the coalescence of the short lateral ridges. The median septum is indistinct between the adductor scars, becoming prominent anterior to them and terminating at two-thirds of the length of the visceral disc. The adductor scars are elevated, elongated oval and almost smooth. The brachial ridges are distinct, given off almost horizontally.

The length varies from 11 to 18 mm and the width from 16 to 24 mm, the measurements being largely determined by the presence or absence of the ears and the trail.

Discussion. — *A. khimenkovi* is distinguished by its medium size, coarse, irregular costation on the anterior part of the shell, the sharply demarcated ears with a well-developed row of spines on the flanks and the geniculated brachial valve. A preaural ridge was not described by Sarycheva (1949), but a weakly developed ridge comparable to those of our specimens is visible (op. cit., pl. 30, fig. 10). The specimens determined by Delépine as *Productus* cf. *sulcatus.* Sowerby belong to this species and since no true *A. sulcata* has been found, this reference has been listed in the synonymy.

This species has originally been described by Yanischevsky as *Productus crassicostatus* sp. nov., but this name had already been used for a variety of *P. portlockianus* Norwood & Pratten, by Dunbar & Condra (1932). Yanischevsky suggested in a letter to Sarycheva the name *P. khimenkovi,* which she adopted and referred to him (Sarycheva, 1949).

Material. — Several specimens from Latores (loc. 35, St.P. Br.L1501, 02; D.25—27) and from a locality M8 (Martínez Alvarez, 1962) halfway between Campo de Caso and Coballes (St.P. Br. M830—35).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age and in the Escalada Fm. of Lower Moscovian, Kashirian, age. In the U.S.S.R. this species has been found in strata of Namurian age.

Genus CHAOIELLA Fredericks, 1933

1960 *Chaoiella* Fredericks. — Muir-Wood & Cooper, p. 275.

Type. — Type species by original designation *Productus grünewaldti* Krotow, 1888.

Chaoiella gruenewaldti (Krotow, 1888)
Pl. 6, figs. 11—15; pl. 7, figs. 1, 2

1888 *Productus semireticulatus* var. *Grünewaldti* var. nov. — Krotow, p. 404, 546, pl. 1, figs. 8—11.
1898 *Productus semireticulatus* var. *bathykolpos* var. nov. — Schellwien, p. 22, pl. 2, figs. 4—10; pl. 3, fig. 2; pl. 8, fig. 22.
1902 *Productus Gruenewaldti* Krotov. — Tschernyschew, p. 252, 608, pl. 32, fig. 3, pl. 61, figs. 3, 5—7; pl. 62, figs. 4—5.
1902 *Productus Gruenewaldti* Krotov, var. — Tschernyschew, p. 255, 610, pl. 61, figs. 1, 2, 4; pl. 62, fig. 3.
1927 *Productus gruenewaldti* Krotow. — Chao, p. 57, pl. 3, figs. 6—12; pl. 8, figs. 13—15.
1936 *Productus gruenewaldti* Krotow. — Metz, p. 169, pl. 6, 1—3.
1952 *Dictyoclostus gruenewaldti* (Krotov). — Sarycheva & Sokolskaja, p. 144, pl. 39, fig. 197.
1956 *Productus hermosanus* Girty. — Delépine (in: Delépine & Llopis Llado), p. 107.
1956 *Productus semireticulatus* Martin. — Delépine (in: Delépine & Llopis Llado), p. 107.
1960 *Chaoiella Gruenewaldti* (Krotov). — Muir-Wood & Cooper, p. 275, pl. 54, figs. 1—11.

Description. — The shells are thin, large, concavo-convex with a subquadrate outline. The pedicle valve has a moderately convex visceral disc turning with a rounded geniculation into a regularly curved trail. A median sulcus starts below the umbo and is usually well-developed on the trail, varying from shallow to deep. The umbo is prominent, slightly curved in over the hinge and has an umbonal angle of about 90°. The ears are large, triangular, slightly rolled along the hinge line and separated from the visceral disc by a shallow sulcus. The ornamentation is semireticulate with about 20 rugae which are distinct on the ears and can be traced across the visceral disc. On the trail numerous growth lines are visible. The costae are medium-sized, 5 to 6 occurring within 5 mm just anterior to the geniculation. They bifurcate often and become obsolete anteriorly. Sometimes short longitudinal folds are developed below the spine bases on the trail. The spines are developed in a row diverging slightly from the hinge and scattered over the visceral disc and trail, becoming larger anteriorly. The brachial valve has a slightly concave visceral disc, geniculated to form a short trail. A median fold is developed corresponding to the median sulcus of the pedicle valve.

The ornamentation of the brachial valve is similar to that of the pedicle valve but without spines, those of the pedicle valve being represented by pits.
The internal surface of the pedicle valve shows the reverse ornamentation of the exterior and is papillose. The adductor scars are elongated, slightly elevated, radially ridged; the diductor scars are flabellate, diverging, finely ridged. The interior of the brachial valve has a sessile, dorsally recurved cardinal process, ventrally bilobate and dorsally trilobate, supported by lateral ridges diverging slightly from the hinge and extending almost to the ears. The median septum is very thin, only becoming prominent anterior to the adductor scars and extends about two-thirds of the length of the visceral disc. The adductor scars are oval in outline. The brachial ridges are usually indistinct. The internal surface shows the reverse ornamentation of the exterior and is papillose, the papillae developing into endospines at the anterior end of the visceral disc.
A normal-sized pedicle valve has a visceral disc with a width of 30 mm, a length of 20 mm, the trail has at least the same length, and the width is at least 40 mm when the ears are preserved.

Discussion. — The shells agree completely with the descriptions of *C. gruenewaldti,* but are rather small for the species; the medium size is about equal to the measurements of the smallest specimens shown in the literature. The development of the median sulcus is quite variable and therefore *Productus semireticulatus* var. *bathykolpos* Schellwien (1892) and *P. gruenewaldti* var. Tschernyschew, 1902, the two extremes (the former with a deep sulcus and the latter with almost no sulcus), have been listed in the synonymy.
C. gruenewaldti is distinguished by the rounded geniculation, its pedicle valve ornamentation of comparatively well developed rugae and the development of longitudinal plications below the large spine bases on the trail.

Material. — Many specimens from the *Chaoiella* band E of Valdeteja (loc. 3, St.P. WP.14420—35), from the *Echinoconchus* band of the same locality (St.P. WP.15410—30), from Latores (loc. 35, St.P. Br.L. 1520—22; D.30, 31), from La Vega (loc. 38, I.L.M.R. 10010—25, see Jongmans & Wagner, 1957) and near Pola de Lena (loc. 31, St.P. dM.16301—03).

Occurrence. — In the Valdeteja Mbr., of Lower Bashkirian age, in the Lena Fm. of Lower Moscovian, Kashirian, age and in the "Calizas" Mbr., which was dated by Jongmans & Wagner (1957) as Westfalian B—C? This species is known from the Upper Carboniferous and Lower Permian of Europe, Asia and America; in the Moscow Basin it occurs in the Upper Moscovian.

Genus RETICULATIA Muir-Wood & Cooper, 1960

1960 *Reticulatia* Muir-Wood & Cooper, p. 284.

Type. — Type species by original designation *Productus huecoensis* R. E. King, 1931.

Discussion. — *Reticulatia* is distinguished by the development of a ginglymus, the marked reticulation on the visceral disc with many closely placed rugae and its narrow body cavity.

Reticulatia huecoensis (R. E. King, 1931)
Pl. 7, figs. 3—6

1931 *Productus huecoensis* sp. nov. — R.E. King, p. 68, pl. 11, figs. 7, 8.
1932 *Dictyoclostus americanus* sp. nov. — Dunbar & Condra, p. 218, pl. 34, figs. 3—6.
1960 *Reticulatia huecoensis* (King). — Muir-Wood & Cooper, p. 284, pl. 104, figs. 1—5; pl. 105, figs. 1—8.
1961 *Reticulatia huecoensis* (King). — Hoare, p. 50, pl. 5, figs. 8—10.
For other references see Hoare (1961).

Description. — This is a large species of *Reticulatia.* The pedicle valve is strongly convex and has a subquadrate outline. The umbo is broad, curved only slightly over the hinge. The ears are moderately large, slightly convex, separated from the visceral disc by a sulcus. A median sulcus is weakly developed. A ginglymus occurs, but could not be observed on most specimens due to the poor state of preservation. The ornamentation is markedly semireticulate. 8 to 10 costae occur within 5 mm on the middle of the valve; they often bifurcate and intercalate. The rugae are numerous, closely spaced. The spines occur in two rows on the ears, diverging slightly from the hinge, in a row on the flanks aligning the sulci separating the ears, and include many small spines scattered over the valve. The brachial valve has a slightly concave to almost flat visceral disc, geniculated to form a short trail. A median fold is weakly developed or may be absent. The ornamentation is similar to that of the pedicle valve, but with the rugae more closely spaced and without spines.
The interior of the pedicle valve has not been observed. The interior of the brachial valve has a trilobed cardinal process: the two median lobes have coalesced, but are medianly grooved; the two outer lobes are quite divergent. The cardinal process is supported by a thin median septum with a broad base, extending about two-thirds the length of the visceral disc, and by heavy lateral ridges along the hinge curving around the inside of the ears and terminating near the anterior end of the lateral margins. The lateral ridges form a broad triangular base projecting above the ginglymus on the dorsal side but remaining on the inside of the pedicle valve. The adductor scars are large, dendritic and posteriorly placed. Brachial ridges have not been observed. The internal surface is papillose; the papillae develop into strong endospines near the point of geniculation.
A typical specimen measures 65 mm in width, 40 mm in length and the visceral disc is 35 mm long.

Discussion. — This species is distinguished by its large size, moderately large body cavity, two rows of large spines on the ears and prominent lateral ridges in the brachial interior.

Material. — Some specimens from a locality NE of Valdeteja (loc. 16, St.P. WP.1491—93), a locality 1300 m NW of Verbíos (loc. 54, R.G.M. Wa.32340—46; dG.11), a locality NE of Tejerina (loc. 40, St.P. Si.S201—05), and NE of Prioro (loc. 40, St.P. Si.P801;1121).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age, the top of the Perapertú Fm. of lowermost Moscovian, Vereyan, age and in the Pando Fm. of Moscovian, probably Kashirian, age.

Reticulatia moelleri (Stuckenberg, 1898)
Pl. 7, figs. 7, 8

1898 *Productus Mölleri* sp. nov. — Stuckenberg, p. 220, 340, pl. 2, figs. 15a—c.
1902 *Productus Moelleri* Stuckenberg. — Tschernyschew, p. 613, pl. 34, fig. 1.
1915 *Productus Moelleri* Stuckenberg. — Fredericks, p. 40, pl. 1, figs. 1—9.
1952 *Dictyoclostus moelleri* (Stuckenberg). — Sarycheva & Sokolskaja, p. 143, pl. 39, fig. 194.
1956 *Productus transversalis* Tschernyschew. — Delépine (in: Delépine & Llopis Llado), p. 107.
1961 *Reticulatia* cf. *moelleri* (Stuckenberg) — Gobbet, p. 89, pl. 8, figs. 10, 11; pl. 9, fig. 8.

Description. — The pedicle valve has a moderately convex visceral disc turning with a sharp curvature into a regularly curved trail. The body cavity is thin to moderate. The median sulcus is weakly to moderately developed, eye-shaped. The ears are large, but usually broken off. The umbo is prominent, slightly curved in over the hinge, the umbonal angle is 90—100°. A narrow ginglymus is present. The ornamentation is strongly semireticulate with fine bifurcating costae, 5—6 occurring within 5 mm at the posterior end of the trail, and about 30 closely spaced rugae on the visceral disc, which can be traced across the venter giving nodular swellings at the intersection with the costae. On the visceral disc and trail are many small, erect spines causing only slight swelling of the costae, also a row diverging from the hinge and along the base of the ears. The brachial valve has a slightly concave visceral disc turning with a rounded geniculation into a short trail. A median fold is moderately developed or may be practically absent. The ornamentation is similar to that of the pedicle valve, the spines being represented by pits.
The interior of the pedicle valve has lanceolate, dendritic adductor scars slightly elevated, the two scars being separated by a groove. Broad longitudinally ridged diductor scars lie laterally to the adductor scars. The interior surface is anteriorly costate and papillose. The interior of the brachial valve has a long median septum, almost equal to the length of the visceral disc with a broad base. The lateral ridges curve away from the hinge and die out before reaching the ears. The diductor scars are elevated, triangular, dendritic with a smooth knob-like anterior scar. The surface shows the reverse ornamentation of the exterior and is papillose. Brachial ridges were not observed.
The length of the visceral disc varies from 19.5 to 25 mm, the width varies from 36 to 42 mm and the thickness from 5 to 12.5 mm.

Material. — At Latores (loc. 35, St.P. Br.L.1411, 1525—31, D.28), in the *Echinoconchus* band E of Valdeteja (loc. 3, St.P. WP.15431—35), in the *Krotovia* band between Cármenes and Pontedo (loc. 10, St. P. WP.13131—33), N of Bario de la Tercia (loc. 11, St.P. WP.2651—53), S of Majua (loc. 21, St.P. Sc.110), E of Pinos (los. 30, St.P. WP.36530) and at Pola de Laviana (loc. 32, St.P. Br.1201).

Occurrence. — In the upper part of the Valdeteja Mbr. of Lower Bashkirian age, in the San Emiliano Fm. of Upper Bashkirian age and in the Lena Fm. of Lower Moscovian age. *R. moelleri* occurs in the Upper Moscovian and Gzhelian of the U.S.S.R.

Reticulatia cf. *uralica* (Tschernyschew, 1902)
Pl. 7, figs. 9A, B

vide 1902 *Productus uralicus* sp. nov. — Tschernyschew, p. 259, 612, pl. 32, fig. 1; pl. 33, fig. 1; pl. 62, fig. 1.
vide 1915 *Productus Moelleri* var. *uralicus* (Stuckenberg) Tschernyschew. — Fredericks, p. 40, pl. 1, figs. 10—12, text-fig. 15.

Description. — The shells are large-sized with a narrow body cavity and a transversely rectangular outline. The pedicle valve is highly convex with a well-developed median sulcus. The flanks are spreading. The greatest width occurs at the anterior margin, but when the ears are preserved the greatest width will probably occur at the hinge. A narrow ginglymus is developed. The ornamentation is strongly semireticulate. The costae are moderately coarse, 5 costae within 5 mm at the anterior end of the visceral disc. The rugae are numerous, prominent, crossing the visceral disc. Fine spines are scattered over the valve. The brachial valve has a slightly concave visceral disc geniculated to form a curved trail. A median fold is developed corresponding to the median sulcus of the pedicle valve. The ornamentation is similar to that of the pedicle valve, but without spines.
The interior of the pedicle valve has not been observed. The interior of the brachial valve has a quadrilobed? cardinal process supported by prominent lateral ridges and the broad base of the median septum. At the anterior end of the visceral disc are prominent endospines. Other internal structures have not been observed.
The best preserved specimen, without the ears, however, has a width of 53 mm, a visceral disc length of 31.5 mm and a trail length of 19 mm.

Discussion. — The Spanish specimens agree best

with the species *R. uralica,* especially with the forma *minor* of Fredericks, 1915, but they are not well enough preserved to be definitely assigned to this species. The specimens are distinguished by their moderately large size, narrow body cavity and spreading flanks.

Material. — A few specimens from a locality NE of Celada de Roblecedo (loc. 46, R.G.M. Wa.7515—17; St.P. Br. 7551) and from an unknown locality in Asturia (St.P. dM.1351,2).

Occurrence. — In the Verdiana Lst. Mbr. of an Upper Moscovian age (see occurrence of *Karavankina praepermica*) and probably in the Lena Fm. of Lower Moscovian age. This species occurs in Russia in the Lower Permian.

Familia LINOPRODUCTIDAE Stehli, 1954
Subfamilia LINOPRODUCTINAE Stehli, 1954
Genus LINOPRODUCTUS Chao, 1927

1927 *Linoproductus* Chao, p. 25, 128.
1928 *Linoproductus* Chao. — Chao, p. 63.
1928 *Cora* Fredericks, p. 781, 790.
1928 *Euproductus* Whitehouse, p. 281 (fide Muir-Wood & Cooper, 1960).
1954 *Linoproductus* Chao. — Stehli, p. 319, text-fig. 27.
1960 *Linoproductus* Chao. — Muir-Wood & Cooper, p. 296.

Type. — Type species by original designation *Productus cora* d'Orbigny, 1842.

Diagnosis. — Concavo-convex shells. Pedicle valve ornamented by fine costae, a few rugae as broad wrinkles on flanks and ears but not traceable across the venter, a few large spines, costae uniting above spine bases and bifurcating again below them. Brachial valve with a nearly flat visceral disc, geniculated with a short trail. Ornamentation of fine costae and few rugae crossing the visceral disc, no spines.

Discussion. — This genus is distinguished by its medium to large size, fine irregular costation, few large spines, geniculated brachial valve and specific characteristics of the brachial valve interior, for example, the long breviseptum.

Linoproductus cora (D'Orbigny, 1842)
Pl. 7, figs. 10—12; pl. 8, figs. 1—3

1914 *Productus cora* d'Orbigny. — Kozlowski, p. 48, pl. 4, fig. 19; pl. 5, fig. 5; pl. 6, figs. 1—10; text-fig. 8.
1927 *Linoproductus cora* (d'Orbigny). — Chao, p. 132, pl. 13, figs. 17, 18, pl. 14, figs. 1—4.
1931 *Linoproductus cora* (d'Orbigny). — Ozaki, p. 140, pl. 13, figs. 1—5.
1932 *Productus (Linoproductus) cora* d'Orbigny. — Waterlot, p. 167, pl. 4, fig. 13.
1936 *Productus (Linoproductus) cora* d'Orbigny. — Metz, pl. 5, fig. 10.
1938 *Productus (Linoproductus) cora* d'Orbigny. — Demanet & van Straelen, p. 124, pl. 109, figs. 10—13.
1943 *Productus (Linoproductus) cora* d'Orbigny. — Demanet, p. 80, pl. 2, figs. 16—19.
1943 *Productus cora* d'Orbigny. — Delépine, p. 73, pl. 6, fig. 15.
1945 *Productus (Linoproductus) cora* d'Orbigny. — Dorsman, p. 28, pl. 3, figs. 1, 2.
1952 *Linoproductus cora* (d'Orbigny). — Sarycheva & Sokolskaja, p. 114, pl. 20, fig. 147.
1960 *Linoproductus cora* (d'Orbigny). — Muir-Wood & Cooper, p. 296, pl. 111, figs. 3—6.
1963 *Linoproductus* cf. *cora* (d'Orbigny). — Böger & Fiebig, p. 137, pl. 17, figs. 7—9, pl. 18, figs. 1—31.
1965 *Linoproductus cora* (d'Orbigny). — Gauri, p. 75, pl. 14, figs. 1—5.

Description. — The shells are of medium size, although some large specimens occur; the greatest width is at the hinge. The pedicle valve is highly convex with a small umbo, slightly curved inwards over the hinge. A median sulcus is weakly developed or only a median flattening is present. The ears are large, clearly separated from the visceral disc. The ornamentation consists of fine flexuous costae, 9 to 13 within 5 mm at the middle of the valve. They bifurcate often and may be highly irregular. On the ears are a few prominent folds which die out on the flanks. Several large spines occur on the ears and scattered over the valve. Three to five costae coalesce above a spine base and split again anterior to the spine base, but usually there is one costae less anteriorly. The brachial valve has a slightly concave visceral disc geniculated to form the trail. A median flattening occurs, but usually no median fold is developed. The ornamentation is similar to that of the pedicle valve; the folds cross, however, the visceral disc and form irregular rugae. No spines are developed.
The interior of the pedicle valve has indistinct muscle scars. The surface shows the reverse ornamentation of the exterior and is papillose. The interior of the brachial valve has a quadrilobate cardinal process with the two median lobes coalesced but medianly grooved. The cardinal process is supported by two short lateral ridges along the hinge terminating at the ears. A long, thin breviseptum, extending almost to the end of the visceral disc, is separated from the cardinal process by a shallow alveolus. The adductor scars are dendritic, rounded triangular, posteriorly placed, not very distinct. The brachial ridges are indistinct, lie on a large horizontal angle, only the antero-lateral ends are visible. The internal surface is papillose and shows the reverse ornamentation of the exterior. At the end of the visceral disc are fine endospines.
This species is highly variable in size; a medium-sized specimen measures 23 mm in length and 32 mm in width.

Discussion. — *L. cora* is distinguished by its medium size, rounded quadrate outline, marked convexity, the greatest width occurring at the hinge, the concave and geniculated brachial valve, fine costation,

a few rugae on flanks and ears and few, large spines.

Material. — Many specimens from a locality 1.5 km NW of Vergaño (loc. 50, R.G.M. Br.901—23), other specimens from a locality N of Piedrafita de Torio (loc.19, St.P. Ra.101—3), from Sama de Langreo (loc. 34, St.P. dM.62181,2) and from the Pozo Mosquitera at Mosquitera (loc. 36, St.P. Bl.Fe.342).

Occurrence. — From the Sierra Corisa Lst. Mbr. of an Upper Moscovian, Myachkovian, age, from strata of uppermost Lower or lowermost Upper Moscovian (Kashirian to Podolskian) age belonging to the Lena Fm., from the 3d Valle coal layer of the Soton Mbr. of the Sama Fm. of Upper Moscovian age. This species is found world-wide in the Upper Carboniferous and Lower Permian. In the U.S.S.R. it has been described from the Upper Moscovian to the Lower Permian and in western Europe, it has been found in marine bands of the Westfalian B/C, e.g. the Petit Buisson Marine Band.

Linoproductus continentalis (Tornquist, 1895)
Pl. 8, figs. 4—6

1895 *Productus continentalis* sp. nov. — Tornquist, p. 437, pl. 14, figs. 5, 7, 8.
E.P. 1928 *Productus cora* d'Orbigny. — Delépine, p. 24, pl. 4, figs. 41, 42, 44.
1931 *Productus (Linoproductus) continentalis* Tornquist. — Paeckelmann, p. 215, pl. 19, figs. 5—7.
1932 *Productus (Linoproductus) cora* d'Orbigny. — Waterlot, p. 158, pl. 2, fig. 15.

Description. — The shells are large with the greatest width occurring at the middle, the outline being about three-quarters of a circle. The pedicle valve is moderately convex with a small umbo slightly curved over the hinge. The ornamentation consists of fine costae, 12 to 15 occurring within 5 mm on the middle of the valve, and rugae which are strong on the ears and die out on the flanks. Two rows of alternating spines occur along the hinge and a few spines are scattered over the valve. Above the base of a spine the costae converge, 3 to 5 costae coalescing at the spine base; they diverge again below the spine. The costae often bifurcate and intercalate and become indistinct on the ears. The brachial valve is slightly concave leaving a moderately large body cavity. The ornamentation is similar to that of the pedicle valve but without spines. The rugae are somewhat better developed and partly traceable across the venter. Internal features have not been observed.
The length varies from 33 to 54 mm and the width from 45 to ± 60 mm.

Discussion. — *L. continentalis* is distinguished by its hinge which is distinctly shorter than the greatest width, large size, moderate body cavity and faintly concave, not geniculated brachial valve.

Material. — Several specimens from the *Linoproductus* band E of Valdeteja (loc. 3. St.P. WP.16451—59), from the *Echinoconchus* band (loc. 3, St.P. WP. 15447, 53) and from a locality near Pinos (loc. 29, St.P. WP.34301).

Occurrence. — In the upper part of the Valdeteja Mbr. of Lower Bashkirian age and the San Emiliano Fm. of Middle or Upper Bashkirian age. In western Europe this species occurs in the Viséan and Namurian.

Linoproductus latiplanus Ivanov, 1935
Pl. 8, figs. 7, 8

1952 *Linoproductus latiplanus* Ivanov. — Sarycheva & Sokolskaja, p. 112, pl. 20, fig. 142.

Description. — The shells are large with the greatest width at the hinge line and rounded quadrate in outline. The pedicle valve is moderately convex with a median flattening. The umbo is small, curved slightly over the hinge. The ears are large, convex, clearly separated from the visceral disc. The ornamentation consists of moderately fine costae, 5 to 7 in 5 mm on the anterior part of the valve, and a few rugae on ears and flanks. There is one row of spines along the hinge and a few spines are scattered over the valve. The brachial valve is moderately concave with large, flattened ears. The ornamentation is similar to that of the pedicle valve, but without spines and some of the rugae are traceable across the venter.
The internal characteristics of the pedicle valve have not been observed. The interior of the brachial valve has a dorsally trilobate cardinal process supported by short lateral ridges along the hinge. A long, thin breviseptum is separated from the cardinal process by a small alveolus.
A medium-sized shell has a length of 34 mm and a width of 42 mm.

Discussion. — This species is distinguished by its large size, sub-quadrate outline, moderate convexity, moderately fine costation and the occurrence of one row of spines along the hinge.

Material. — Several specimens from a locality NE of Prioro (loc. 40, St.P. Si.M001,02) and near the Puerto de Pando (loc. 40, St.P. Si.P401—03).

Occurrence. — In the Pando Fm. of Lower Moscovian, probably Kashirian, age. In the U.S.S.R this species occurs in the Vereyan substage of the Lower Moscovian.

Genus CANCRINELLA Fredericks, 1928, em. Sarycheva, 1937

1928 *Cancrinella* Fredericks, p. 784, 791.
1932 *Cancrinella* Fredericks. — Dunbar & Condra, p. 257.
E.P. 1937 *Cancrinella* Fredericks. — Sarycheva, p. 78, 110.
E.P. 1952 *Cancrinella* Fredericks. — Sarycheva & Sokolskaja, p. 103.
1956 *Cancrinella* Fredericks. — Stehli, p. 321, text-fig. 28.
1960 *Cancrinella* Fredericks, em. Sarycheva. — Muir-Wood & Cooper, p. 301.
1963 *Cancrinella* Fredericks. — Gobbet, p. 101.

Type. — Type species by original designation *Productus cancrini* de Koninck, 1842. This species was referred by Fredericks to de Verneuil, 1845, probably because de Koninck also referred this species to de Verneuil from whom he had received a specimen labelled with that name. De Koninck (1842) was, however, the first to publish this name.

Discussion. — *Cancrinella* is a small-sized genus of the Linoproductinae. It is characterized by its thin shell, fine costae, prominent rugae and abundant spines. The interior of the brachial valve is distinguished by a bilobate (dorsally often trilobate) cardinal process, short breviseptum and slightly curved, short lateral ridges.

Cancrinella craigmarkensis (Muir-Wood, 1937)
Pl. 8. figs. 10, 11

1937 *Dictyoclostus craigmarkensis* sp. nov. — Muir-Wood, p. 442, pl. 3, fig. 15—19; text-fig. 9.
1943 *Productus (Dictyoclostus) craigmarkensis* Muir-Wood. — Demanet, p. 77, pl. 2, fig. 1.
1945 *Productus (Dictyoclostus)* cf. *craigmarkensis* Muir-Wood. — Dorsman, p. 29, pl. 3, fig. 3.

Diagnosis. — Pedicle valve with slightly convex visceral disc, geniculated to form a short trail. Ornamentation of very fine costae and a few rugae, faintly traceable across the visceral disc. Spines in a row along the hinge, and scattered over the shell.

Description. — The pedicle valve is small, slightly convex with a rounded geniculation and a short trail. The ears are moderately large, clearly demarcated from the visceral disc. Outline rounded quadrate with the greatest width near the middle of the valve. The umbo is prominent, slightly turned over the hinge. No median sulcus is present. The costae are very fine, about 15 occurring in 5 mm on the anterior part of the valve. Six to ten rugae occur, which are prominent on the flanks and the ears and only faintly traceable across the venter. Several specimens show spines in a row along the hinge, one in the sulcus separating the ears from the visceral disc and scattered on the visceral disc. The costae usually bifurcate anterior to the spine bases, which are thicker than the costae. The brachial valve is moderately concave. The ornamentation is similar to that of the pedicle valve, but without spines and with prominent rugae which are easily traced across the visceral disc.
The interior of the brachial valve shows the reverse ornamentation of the exterior. The cardinal process is bilobed, supported by short lateral ridges. It is separated from a short breviseptum, which is less than half the length of he visceral disc, by a shallow alveolus.
The specimens measure (in mm): L = 7 to 11.5 and W = 9 to 16.5, the average values being L = 9.5, W = 12.

Discussion. — This species was originally assigned to the genus *Dictyoclostus* (s.l.). It does not belong to that genus as it is defined now nor does it fit in any other genus of the Dictyoclostidae and Muir-Wood & Cooper (1960) accordingly left it unclassified. Muir-Wood (1937) stated that this species could not belong to *Linoproductus* (s.l.) because the rugae do not form folds on the flanks and ears, the bifurcation of the costae and the erect spines causing only a slight enlargement of the costae. These objections do, however, not prevent an assignment to the genus *Cancrinella* of the Linoproductinae and, indeed, all external features agree closely with this genus as do the internal features as far as they could be studied in the present material.
From other species of *Cancrinella, C. craigmarkensis* is distinguished by its small size, slightly convex pedicle valve, fine costation and few rugae, which are only prominent on flanks and ears.

Material. — Several specimens (St.P. Br.M701, 711—15; M601; M331—37) from localities M.3,6 and 7 of Martínez Alvarez (1962) near Campo de Caso, from the Pozo Fondón at Sama de Langreo (loc. 34, St.P. Bl.Fe.45352;4481), from the Pozo San Enrique at La Felguera (loc. 34, St.P. Bl.La39101,2) and the Pozo San Luis at La Nueva (loc. 33, St.P. Bl.4581—3).

Occurrence. — In the Escalada Fm., indicating a Lower Moscovian, Vereyan, age, in the 2nd. Carbonero Techo Dos Venas of the Soton Bajo Mbr., in the Carbonera Muro Angelita and the Capa 33 of the San Antonio Mbr. and from the Venon Coal layer of the Sorriego Mbr., all from the Sama Fm. indicating a Moscovian age. This species has been found in western Europe in marine bands at the boundary of the Westfalian B and C, e.g. in the Skipsey's and the Cefn Coed Marine Bands.

Cancrinella retiformis (Muir-Wood, 1937)

1937 *Dictyoclostus retiformis* spec. nov. — Muir-Wood, p. 446, pl. 3, figs. 12—14.
1943 *Productus (Dictyoclostus) retiformis* Muir-Wood. — Demanet, p. 76, pl. 2, figs. 2, 3.
1945 *Productus (Dictyoclostus) retiformis* Muir-Wood. — Dorsman, p. 30, pl. 3, fig. 4.

Diagnosis. — Pedicle valve slightly convex with the hinge a little shorter than the greatest width. Ornamentation of very fine costae and numerous sharp rugae; two rows of spines are developed on the ears and fine spines are scattered on the visceral disc. Brachial valve almost flat with a similar ornamentation, but without spines.

Description. — The brachial valve is almost flat and shows the typical ornamentation of numerous rugae and fine costae, 16 costae within 5 mm. The valve is large for the species, the length being 10 mm and the width 13 mm. Internal characteristics have not been observed.

Discussion. — *C. retiformis* is closely related to *C. craigmarkensis* and is also assigned to the genus

Cancrinella, although no internal features could be observed. This species is distinguished from *C. craigmarkensis* by its numerous, sharp, prominent rugae and almost flat brachial valve.

Material. — Two fragmentary brachial valves from La Camocha (loc. 39, St.P. Bl.T1001, 1009).

Occurrence. — In the Capa T. 10 of the La Camocha Fm. of Lower Moscovian age. In western Europe, this species has been found in marine bands of a Westfalian B/C age.

Genus FLUCTUARIA Muir-Wood & Cooper, 1960
1960 *Fluctuaria* Muir-Wood & Cooper, p. 303.

Type. — Type species by original designation *Productus undatus* Defrance, 1826.

Discussion. — This genus is distinguished by its medium size, high convexity and the ornamentation of fine intercalating costae, prominent, angular rugae often irregularly developed, crossing the venter, and a few spines, especially along the hinge and the ears.

Fluctuaria undata (Defrance, 1826)
Pl. 8, figs. 12A, B

1863 *Productus undatus* Defrance. — Davidson, p. 161, pl. 34, figs. 7—13.
1895 *Productus undatus* Defrance. — Tornquist, p. 448, pl. 14, figs. 9, 12.
1931 *Productus (Linoproductus)? burbachianus* Tornquist. — Paeckelmann, p. 214, pl. 19, fig. 4.
1931 *Productus (Linoproductus) undatus* Defrance. — Paeckelmann, p. 217, pl. 19, fig. 9.
1937 *Cancrinella undata* (Defrance). — Sarycheva, p. 82, pl. 7, figs. 1—6.
1952 *Cancrinella undata* (Defrance). — Sarycheva & Sokolskaja, p. 108, pl. 20, fig. 136.
1960 *Fluctuaria undata* (Defrance). — Muir-Wood & Cooper, p. 303, pl. 115, figs. 11—20.
1961 *Productus — Linoproductus — undatus* Defrance. — Pareyn, p. 205, pl. 25, fig. 10.
1963 *Fluctuaria undata* (Defrance). — Sarycheva (in: Sarycheva et al.), p. 229, pl. 371, figs. 6—11, text-figs. 101, 102.

Description. — The pedicle valve is medium-sized, highly convex. The umbo is large, prominent, curved inwards over the hinge. No median sulcus is present. The ears are small, only partly preserved. The ornamentation consists of fine, intercalating costae, 15 in 5 mm on the anterior part. The rugae are numerous, prominent, angular and irregularly developed. The brachial valve and the internal features have not been observed.
The largest pedicle valve has a length of 35 mm, a width of 40 mm and a height of 20 mm, approximately.

Discussion. — This is the only species assigned to the genus *Fluctuaria* and distinguished by the same features, which have been described in the discussion of the genus. The ornamentation is especially typical.

Material. — One specimen (St.P. Ra.17) from an unknown locality probably near locality 10 between Cármenes and Pontedo and one from a locality between Vagacervera and Felmín (loc. W925, R.G.M. Wa.925). Another from a locality near Celada de Roblecedo is tentatively referred to this species (loc. 46, R.G.M. Wa.7525).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age and probably from the Verdiana Lst. Mbr. which can be correlated to the Maldrigo Lst. Mbr. of Upper Moscovian, uppermost Podolskian or lowermost Myachkovian, age. This species occurs in the Viséan of western Europe and in the U.S.S.R. it has been found from the Viséan to the Moscovian (Podolskian).

Genus OVATIA Muir-Wood & Cooper, 1960
1960 *Ovatia* Muir-Wood & Cooper, p. 311.

Type. — Type species by original designation *Ovatia elongata* Muir-Wood & Cooper, 1960.

Discussion. — This genus is distinguished by its elongated shell, highly convex pedicle valve, fine costation and numerous, fine spines.

Ovatia ovata (Hall, 1858)
Pl. 8, fig. 9

1858 *Productus ovatus* sp. nov. — Hall, p. 674, pl. 24, fig. 1.
1935 *Linoproductus ovatus* (Hall). — Hernon, p. 682.
1938 *Linoproductus ovatus* (Hall). — Sutton, p. 558, pl. 65, figs. 8—13.
1952 *Cancrinella* (?) *ovata* (Hall). — Sarycheva & Sokolskaja, p. 106, pl. 19, fig. 132.
?1956 *Productus cora* d'Orbigny. — Delépine (in: Delépine & Llopis Llado), p. 107.
1957 *Linoproductus ovatus* (Hall). — Elias, p. 514, pl. 55, figs. 20—23.
?1961 *Productus — Linoproductus* — nov. sp. (?). — Pareyn, p. 204. pl. 25, figs. 6—9.

Description. — Small to medium-sized, thin shelled species of *Ovatia.* The pedicle valve is highly convex with an elongated oval outline. The ears are rather large, flattened. The ornamentation consists of fine, intercalating and bifurcating, costae, 12 to 15 within 5 mm on the anterior part of the shell, and a few rugae on the ears and flanks but not crossing the visceral disc. The costae are regular, but in some places they change their direction. This is probably caused by damage to the shell during life-time. A few spines are arranged in a row along the hinge and scattered over the valve. The brachial valve has a moderately convex visceral disc and an ornamentation similar to the pedicle valve, but without spines. Internal features have not been observed in the present material.
A large rather well preserved specimen has a length of about 25 mm and a width of about 20 mm.

Discussion. — The Cantabrian specimens are referred to *Ovatia ovata* because of their shape and ornamentation. This species is interpreted here in a rather broad sense, because it is not well-defined (vide Muir-Wood & Cooper, 1960, p. 313) and the present material is not very well preserved.
Productus — Linoproductus — sp. nov. of Pareyn (1961) has been questionably listed in the synonymy since that species appears to be closely related as far as can be judged from the short description and figures. The specimens questionably determined by Delépine as *P. cora* belong to this species, although he may also have regarded some specimens of *L. continentalis* as *L. cora.*

Material. — Several specimens from the *Chaoiella* band (St.P. WP. 1206, 07), the *Echinoconchus* band (St.P. WP.15451—54) and the *Linoproductus* band (St.P. WP.16461—67) of Valdeteja (loc. 3) and from Latores (loc. 35, St.P. Br.L1601—04, D.51.52).

Occurrence. — In the Valdeteja Mbr. of Lower Bashkirian age. This species is widespread in the upper part of the Mississippian of the U.S.A. and has also been reported in the Viséan of the U.S.S.R.

Subfamilia PROBOSCIDELLINAE
Muir-Wood & Cooper, 1960
Genus PROBOSCIDELLA Oehlert, 1887

1928 *Proboscidella* Oehlert. — Muir-Wood, p. 37.
1960 *Proboscidella* Oehlert. — Muir-Wood & Cooper, p. 325.

Type. — Type species by original designation *Productus proboscideus* de Verneuil, 1840.

Diagnosis. — Pedicle valve with a slightly convex visceral disc and tubular trail. Ornamentation of fine costae, regular rugae on visceral disc and as annulations on the trail, and few spines. Brachial valve with a slightly concave visceral disc, sometimes also with a tubular trail.

Discussion — *Proboscidella* is distinguished by its tubular shape and fine costae and rugae.

Proboscidella proboscidea (de Verneuil, 1840)
Pl. 8, figs. 13 A, B.

1840 *Productus proboscideus* sp. nov. — de Verneuil, p. 259, pl. 3, figs. 3a—d.
1863 *Productus proboscideus* de Verneuil. — Davidson, p. 163, pl. 33, figs. 1—4.
1928 *Proboscidella proboscidea* (de Verneuil). — Muir-Wood, p. 37, pl. 12, figs. 16, 17.
1960 *Proboscidella proboscidea* (de Verneuil). — Muir-Wood & Cooper, p. 325, pl. 39, figs. 14, 15; pl. 124, figs. 1—16.

Description. — The pedicle valve is small, with the flanks grown together to form a tube. The visceral disc is slightly convex, rounded quadrate. The flanks are steep and form a semi-cylindrical trail anteriorly. The present specimen was too poorly preserved to decide whether a complete cylindrical tube was formed. The ornamentation is markedly semireticulate. The costae are fine with numerous intercalations, 12 within 5 mm on the posterior part of the trail. The rugae are numerous, prominent and closely spaced on the visceral disc, but less prominent and more widely apart on the trail. Spines have not been observed. The brachial valve has only partially been observed. The trail forms a (semi)cylinder similar to that of the pedicle valve. The ornamentation is also similar. Internal features have not been observed.
The measurements of the only, fragmentary, specimen are: L = 21 mm, W = 16 mm.

Discussion. — The Spanish specimen shows the typical shape and ornamentation of the species and is therefore assigned to it, although no internal features could be observed and the specimen is not very well preserved.

Material. — One specimen (dG.511) from a reef limestone WNW of Verbíos (loc. 54).

Occurrence. — In the Perapertú Fm. in strata of a Bashkirian age. In western Europe, this species has been found in the Viséan.

Proboscidella? sp.
Pl. 8, fig. 14

Description. — The pedicle valve is medium-sized, highly convex, semi-cylindrical in shape, with a slightly convex visceral disc. Ears were not observed and no median sulcus is present. The ornamentation consists of fine costae and rugae. The costae have a peculiar arrangement posteriorly of two to four fine costae between two prominent ones. Anteriorly the coarse costae die out; thus 10 fine costae can occur between two larger ones until all costae become equally fine, 20 to 25 in number within 5 mm. The rugae are regular, prominent and cross the venter. Spines have not been observed. The brachial valve and internal features have not been observed.
The material is very fragmentary, so that the specimens could not be measured exactly. The length of the best preserved specimens is at least 30 mm and the width at least 40 mm.

Discussion. — This species is easily distinguished by its specific ornamentation, which resembles a *corrugatus*-like ornamentation, but more pronounced. This costation and the strong, regular rugae made me decide to refer it to *Proboscidella.* In its costation, this species is quite unlike any species known to the author.

Material. — Several fragmentary specimens from a locality near Resoba (loc. 42, R.G.M. Ka.7141—47).

Occurrence. — In the Cervera Fm. in a limestone of Bashkirian age.

CHONETIDINA

Subordo CHONETIDINA Muir-Wood, 1955
Superfamilia CHONETACEA Brown, 1862
Familia CHONETIDAE Brown, 1862
Subfamilia ANOPLIINAE Muir-Wood 1962
Genus TORNQUISTIA Paeckelmann, 1930

1930 *Chonetes (Tornquistia)* Paeckelmann, p. 227.
1932 *Tornquistia* Paeckelmann. — Dunbar & Condra, p. 168.
E.P. 1952 *Paeckelmannia* Licharew. — Sarycheva & Sokolskaja, p. 61.
1952 *Tornquistia* Paeckelmann. — Ramsbottom, p. 15.
1962 *Tornquistia* Paeckelmann. — Muir-Wood, p. 58.
1963 *Chonetes (Tornquistia)* Paeckelmann. — Böger & Fiebig, p. 145.

Type. — Type species by original designation *Leptaena (Chonetes) polita McCoy, 1855.*

Diagnosis. — Small concavo-convex shells with a smooth surface, rare growth lines and a row of spines at a large angle to the hinge of the pedicle valve. Interior of brachial valve with two long diverging septa and radial rows of papillae, narrow sockets and socket ridges almost parallel to the hinge.

Discussion. — This genus is distinguished by its small size, smooth surface, a median septum and obscure muscle scars in the pedicle valve interior, and in the interior of the brachial valve, two diverging septa usually without a median septum, narrow sockets and a few papillae in radial rows.
Tornquistia was considered by Licharew (1934, fide Ramsbottom, 1952) to be a synonym of *Törnquistia* Reed, 1896, a genus of the trilobites, and he therefore renamed the genus *Paeckelmannia.* The trilobite genus should be spelled *Toernquistia* and is not a synonym of *Tornquistia,* as was stated by Ramsbottom (1952). This name can thus be retained as ruled by the International Commission on Zoological Nomenclature (Bull. Zol. Noomencl., 6, p. 92).

Tornquistia polita (McCoy, 1855)

1863 *Chonetes polita* M'Coy. — Davidson, p. 190, pl. 47, figs. 8—11.
1882 *Chonetes polita* M'Coy. — Kayser, p. 80, pl. 3, fig. 15.
1930 *Chonetes (Tornquistia) politus* M'Coy. — Paeckelmann, p. 227, pl. 15, figs. 11, 12.
1952 *Paeckelmannia polita* (M'Coy). — Sarycheva & Sokolskaja, p. 62, pl. 12, fig. 74.
1962 *Tornquistia polita* (McCoy). — Muir-Wood, p. 61, pl. 5, figs. 17—23, text-figs. 12A—C.
1963 *Chonetes (Tornquistia) politus* M'Coy. — Nicolaus, p. 153.
1963 *Chonetes (Tornquistia) politus celatus* subsp. nov. — Nicolaus, p. 154, pl. 10, fig. 1.

Diagnosis. — Semi-circular to sub-triangular species of *Tornquistia.* Pedicle valve highly convex with large ears and a row of 6 or 8 erect spines along the hinge.

Description. — The pedicle valve is highly convex with a semi-circular outline without a median sulcus. The ornamentation consists only of fine growth lines. On one specimen a spine was observed standing vertically to the hinge. The brachial valve is slightly concave.
The interior of the pedicle valve has a median septum of one-third the length of the pedicle valve and small transversely elongated teeth. The muscle scars are obscure. The interior of the brachial valve has not been observed.
The specimens vary little in size: a normal specimen has a length of 1.9 mm and a width of 2.5 mm.

Discussion. — The specimens are relatively small; they may be juvenile specimens or they were not suited to the environment. The specimens from the comparable black shales of Aprath are also small.
The subspecies *T. polita celata* Nicolaus, 1963 is considered here as *T. polita* (McCoy) since the spine angle is rather variable in this species and no other differences exist than the vertical spines. Muir-Wood (1962) also mentions a specimen of *T. polita* with a long, almost vertical spine. It also cannot be a true subspecies since it occurs together with *T. polita* .

Material. — Several specimens from a locality SW of Genicera (loc. W.1162, St.P. WP.014140, 152—155, 240).

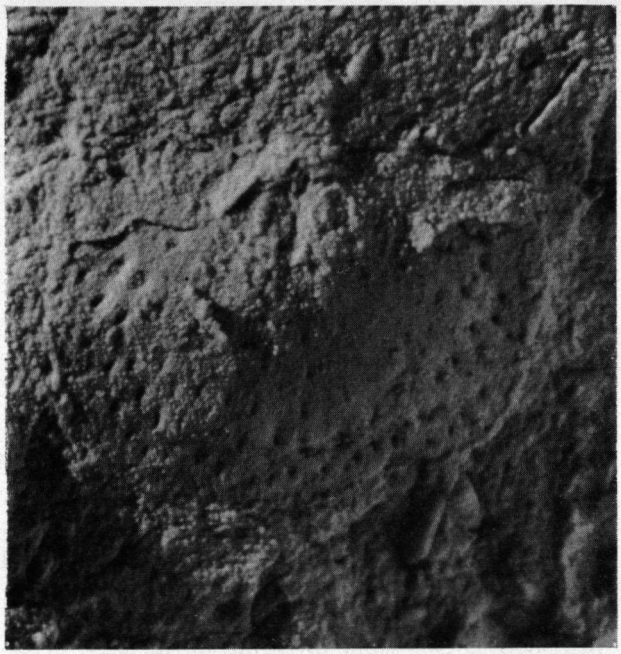
Occurrence. — In the Vegamián Fm. of Upper Tournaisian or lowermost Viséan age. This species occurs in the Viséan of western Europe and the U.S.S.R. It probably has also been found in the Tournaisian, perhaps even in the uppermost Devonian, and in the Namurian.

Tornquistia diminuta (Demanet, 1949)
Text-figs. 17A, B

1943 *Chonetes (Lissochonetes) minutus* sp. nov. — Demanet, p. 72, pl. 1, figs. 20—22.
1949 *Chonetes (Lissochonetes) diminutus* nom. nov. — Demanet, p. 5.
1952 *Tornquistia diminuta* (Demanet). — Ramsbottom, p. 16, pl. 2, figs. 11, 12.
1963 *Chonetes (Tornquistia) diminutus* Demanet. — Böger & Fiebig, p. 148, pl. 20, figs. 1—6; text-fig. 20.

Diagnosis. — A small species of *Tornquistia* with a transversely rectangular outline.

Description. The pedicle valve is convex, rounded rectangular in outline, with a shallow median sulcus. The surface is smooth and the spines form a large angle with the hinge. The brachial valve is almost flat with an indistinct median fold and slightly demarcated ears.
The interior of the pedicle valve has a short, prominent median septum. The surface is covered with a few, comparatively large papillae in radiating rows. The interior of the brachial valve shows two septa diverging at an angle of about 30° and radiating rows of papillae giving the impression of costae.



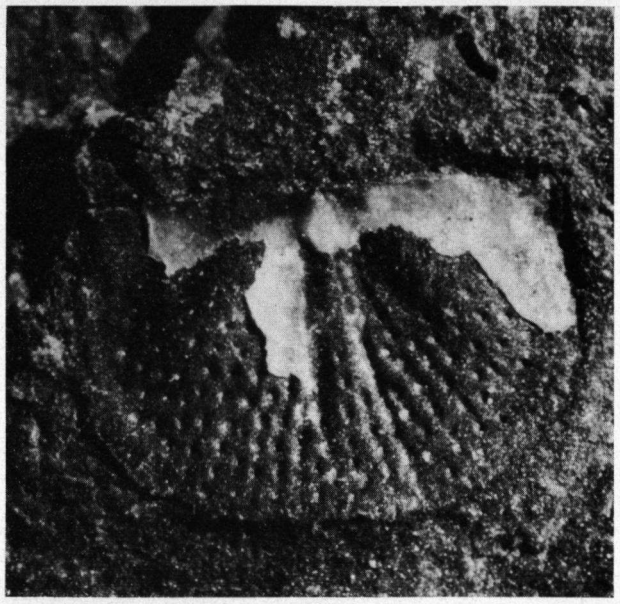


Fig. 17A. *Tornquistia diminuta* (Demanet). Pedicle valve interior with part of the exterior preserved, showing the median septum and smooth exterior. Bl. T1003, × 20, loc. 39, La Camocha Formation. 17B. Brachial valve interior, probably the same animal showing the radial rows of papillae and the two large septa. Same specimen and enlargement as fig. 17A. Uncoated with ammonium chloride.

The length of this specimen is 2 mm and the width, 3 mm.

Discussion. — The internal characteristics of both valves leave no doubt that this species belongs to the genus *Tornquistia.* Ramsbottom (1952) correctly indicated that one of Demanet's figures (1943, pl. 1, fig. 20) shows the diverging septa of the brachial interior, though the figure was described as a pedicle valve.

This species has been mentioned twice by Muir-Wood (1962) in her monograph of the chonetoids under two different names and in different genera. She used the old name, *Lissochonetes minutus* Demanet which had already been replaced by the author, and left it in the genus *Lissochonetes* (op. cit., p. 77). In the description of the genus *Tornquistia* (op. cit., p. 59), she lists the species *Chonetes diminituva* Demanet, 1938, This name cannot be found in the works of Demanet of 1938, but from her remarks (op. cit., p. 60) it becomes clear that this name is an erroneous citation of *Chonetes* (*Lissochonetes*) *diminutus* Demanet, 1949 which is a new name for *Chonetes* (*Lissochonetes*) *minutus* Demanet, 1943 cited under *Lissochonetes!* The name *"minutus"* had already been used by Goldfuss for another species of *Chonetes,* belonging to another subgenus. To avoid confusion Demanet (1949) has renamed this species *C.* (*L.*) *diminutus* and so the old name can no longer be used.

Material. — A brachial and a pedicle valve probably belonging to the same animal (St.P. Bl.T1003A, B) from a locality (loc. 39) near La Camocha.

Occurrence. — In the La Camocha Fm. of a Lower Moscovian age. In western Europe this species has been found in marine bands of a Westfalian B/C age.

Tornquistia schmiereri Paeckelmann, 1930

1930 *Chonetes (Tornquistia) schmiereri* sp. nov. — Paeckelmann, p. 232, pl. 15, fig. 18.

Diagnosis. — Small species of *Tornquistia* with a rounded triangular outline. Pedicle valve convex with a distinct median sulcus. Brachial valve concave with a corresponding median fold.

Description. — The pedicle valve is moderately convex with a well-developed median sulcus and a triangular outline caused by the large ears. The surface is smooth, except for some growth lines. A row of spines occurs along the hinge making an angle of ca. 45° with it. The brachial valve is concave with a prominent median fold leaving a thin body cavity. The moulds of the brachial valve exterior are often difficult to distinguish from poorly preserved interior moulds of the pedicle valve, which is slightly more convex.

The interior of the pedicle valve has two small adductor scars and a short median septum. The interior of the brachial valve has two large diverging septa and radial rows of papillae.

The specimens vary from 1.— to 2.4 mm in length and 1.8 to 3.8 mm in width.

Discussion. — This species is distinguished by its moderate convexity, broad triangular outline, and the median sulcus and fold.

Material. — Many moulds were found SW of Genicera (loc. W1162, St.P. WP.014101—15).

Occurrence. — In the Vegamián Fm. of Upper Tournaisian or lowermost Viséan age. *T. schmiereri* occurs in Germany in the Viséan.

Subfamilia RUGOSOCHONETINAE Muir-Wood, 1962
Genus RUGOSOCHONETES Sokolskaja, 1950

1952 *Chonetes (Rugosochonetes)* Sokolskaja. — Sarycheva & Sokolskaja, p. 52.
1962 *Rugosochonetes* Sokolskaja. — Muir-Wood, p. 64.

Type. — Type species by original designation *Orthis hardrensis* Phillips, 1841.

Diagnosis. — Small, plano-convex or slightly concavo-convex shells. Ornamentation of fine, bifurcating costae with rare intercalations and many growth lines. Interior of the pedicle valve with a short median septum. Interior of the brachial valve with lateral septa diverging at an angle of about 60° and a short median septum, about half the valve length.

Discussion. — This genus is distinguished from *Chonetes* by its short median septum in the pedicle valve, the less numerous septa in the brachial valve and its more transverse outline. *Plicochonetes* is distinguished by its well-developed ears, the costae which rarely bifurcate and are clearly visible in the interior of the pedicle valve, smooth ears, the well-defined brachial ridges and the occasional absence of the median septum in the brachial valve. The factors distinguishing it from *Neochonetes* are described in the discussion of that genus.

Rugosochonetes acutus (Demanet, 1938)
Pl. 9, figs. 8 A, B.

E.P. 1938 *Chonetes (Chonetes) laguessianus* De Koninck. — Demanet (in: Demanet & van Straelen), p. 120, pl. 108, figs. 6, 7.
1938 *Chonetes (Chonetes) laguessianus* var. *transversalis* var. nov. — Demanet (in: Demanet & van Straelen), p. 120, pl. 108, figs. 8—10.
1938 *Chonetes (Chonetes) laguessianus* var. *acutus* var. nov. — Demanet (in: Demanet & van Straelen), p. 120, pl. 108, figs. 11—13.
1943 *Chonetes (Chonetes) granulifer* Owen. — Demanet, p. 68, pl. 1, figs. 5—11.
1943 *Chonetes (Chonetes) granulifer transversalis* Dunbar & Condra. — Demanet, p. 71, pl. 1, figs. 12—17.
1945 *Chonetes granulifer* Owen. — Dorsman, p. 22, pl. 2, figs. 1—4.

Diagnosis. — Transversely rectangular species of *Rugosochonetes* with the length approximately half the width. Angle of the cardinal extremities about 80°, but they may be pointed; median sulcus weakly developed or absent. Spines set at a large angle to the hinge.

Description. — The pedicle valve is moderately convex with a sub-rectangular outline, the lateral borders being straight, slightly converging anteriorly. The ears are large, flattened, usually with pointed cardinal extremities. A median sulcus is faint or absent. The ornamentation consists of fine, branching costae, 4 to 5 occurring in 1 mm near the anterior margin; the costae are weakly developed on the ears. A row of 6 or 7 spines, at a large angle to the hinge, occurs on each side of the umbo. Numerous spinule apertures occur. The brachial valve is moderately concave, closely following the pedicle valve. The interarea is narrow, reflexed and the cardinal process is externally tetralobate. The valves are very thin and show short ribs in the internal shell layers, like those described for *Plicochonetes poljenowi* (Tolmatchov) (Sarycheva et al., 1963, p. 121, text-figs. 34, 35).
The interior of the pedicle valve has a short, high median septum continued as a low ridge for about two-thirds the valve length. The vascular trunks are weakly developed on both sides of the ridge. The teeth are narrow, broad. The surface is costate and papillose. The interior of the brachial valve has a median septum of about half the valve length and two short lateral septa diverging at an angle of ca. 60°. The inner socket ridges are prominent, the outer are obscure and the brachial ridges are well-developed.
The length varies from 7.5 to 15.— mm, the width from 15.— to 30.— mm and the spine length is ca. 3 mm.

Discussion. — *R. acutus* is distinguished by its transverse outline, the length being about half the width, and its pointed cardinal extremities. Assignment by Muir-Wood (1962, p. 65) to the genus *Rugosochonetes* and not, for example, to *Neochonetes* as indicated by Demanet's (1943) references to *Chonetes granulifer* is strongly supported by its interior characteristics and the large angle between the spines and the hinge. The two varieties of Demanet are combined and raised to species level, for several reasons. First of all, both varieties occur at the same locations in the same layers and thus cannot be considered subspecies. An important distinguishing feature, the pointed cardinal extremities of *C. laguessianus acutus,* was later considered by Demanet himself (1943, p. 71) to be due to the state of preservation. The only difference remaining is the more transverse outline of *transversalis.* There is, however, no marked difference in transversity between both varieties as can be judged from the figures: a complete gradation exists; the average L/W ratio being 0.6.
The name *tranversalis* had already been used by Dunbar & Condra (1932) for a variety of *Chonetes granulifer* Owen, which species is now assigned to the genus *Neochonetes.* Since the variety *acutus* was published simultaneously with *transversalis* on the same page, the name *acutus* is preferred to avoid confusion, although the name is based on a characteristic which is not typical and it was later abandoned by Demanet (1943).

Material. — Several specimens from La Camocha (loc. 39, St.P. Bl.T1051—60), from the Pozo Carbonero at La Nueva (loc. 36, St.P. Bl.Nu4815), from a locality (M8) near Campo de Caso (St.P. Br.M 851, 52), and near the Pando Pass (loc. 40, St.P. Si.M751, 1151, 52, 1521, P501, P18).

Occurrence. — In the La Camocha Fm. of a Lower Moscovian age, in the Sotón Alto Mbr. of the Sama Fm. of a Moscovian age, in the Escalada Fm. of a Lower Moscovian, Kashirian, age and in the Pando Fm. in strata of the same age. *R. acutus* has been found in western Europe near the boundary of the Westfalian B and C.

Rugosochonetes laguessianus laguessianus (de Koninck, 1843)

1861 *Chonetes Hardrensis* var. *laguessiana* De Koninck. — Davidson, p. 188, pl. 47, fig. 19.
E.P. 1882 *Chonetes laguessiana* de Koninck. — Kayser, p. 77, pl. 3, fig. 18.
1930 *Chonetes (Chonetes) laguessianus* de Koninck. — Paeckelmann, p. 239, pl. 16, figs. 1, 2.
E.P. 1938 *Chonetes (Chonetes) laguessianus* de Koninck. — Demanet (in: Demanet & van Straelen), p. 120, pl. 108, figs. 1—5.
1938 *Chonetes (Chonetes) laguessianus* de Koninck. — Demanet, p. 59, pl. 5, figs. 9—12.
1952 *Rugosochonetes laguessianus* (de Koninck). — Sarycheva & Sokolskaja, p. 54, pl. 10, fig. 57.
1963 *Chonetes (Chonetes) laguessianus* de Koninck. — Nicolaus, p. 161.
For other references see Paeckelmann (1930) and Nicolaus (1963).

Diagnosis. — Pedicle valve highly convex, rounded rectangular; costae fine, regularly bifurcating; spines diverging, 3 to 5 on each side of the umbo. In the pedicle valve interior costae only visible along the anterior margin.

Description. — The pedicle valve is highly convex with a rounded, transversely rectangular outline. The ears are large, clearly marked off from the visceral disc. The ornamentation consists of fine, regularly bifurcating costae, 9 to 10 within 2 mm near the anterior border, and fine growth lines. Four or five spines occur on each side of the umbo. The brachial valve is highly concave, closely following the shape of the pedicle valve. The costae are intercalating, no spines occur. The interareas are narrow.
The interior of the pedicle valve has a short median septum, strong teeth and a costation only around the anterior margin.
The length varies from 4.6 to 7.— mm and the width from 7.8 to 13.6 mm.

Discussion. — This species is distinguished by its rounded rectangular outline, high convexity and fine regular costation.

Material. — A few well preserved specimens from a locality SW of Valdeteja (loc. 8, St.P. WP.02602,03) and some poorly preserved specimens from localities SW of Genicera (loc. W1162, St.P. WP.02401—03) and NW of Gete (loc. 9, St.P. WP.02206,10).

Occurrence. — In the Gete Mbr, (bed C) of the Alba Fm. indicating a Lower Viséan (Cu IIγ) age. In western Europe this species has been found in the Viséan and Namurian.

Rugosochonetes laguessianus angustus (Paeckelmann, 1930) Pl. 9, fig. 5.

1930 *Chonetes (Chonetes) laguessianus* de Koninck *angusta* var. nov. — Paeckelmann, p. 241, pl. 16, figs. 3, 4.
1932 *Chonetes (Chonetes) laguessianus* de Koninck var. *angusta* Paeckelmann. — Gallwitz, p. 117, pl. 8, fig. 14.
1963 *Chonetes (Chonetes) laguessianus angustus* Paeckelmann. — Nicolaus, p. 162, pl. 10, fig. 5.
For earlier references see Paeckelmann (1930).

Description. — The pedicle valve is highly convex, medianly flattened and has a semi-circular outline. The ears are small, flattened, with rectangular cardinal extremities. The ornamentation consists of fine costae which often bifurcate, 5 to 6 within 1 mm near the anterior margin. The costae become obsolete on the ears. In comparison, the concavity of the brachial valve is less than the convexity of the pedicle valve. The ornamentation is similar, but the costae are mainly intercalated.
The interior of the pedicle valve has a prominent median septum, about one-third the valve length. The costae are only developed near the anterior margin; posteriorly, they are replaced by rows of papillae which soon become obsolete leaving the posterior part smooth. The ears show large papillae, irregularly placed.
A medium-sized specimen has a length of 4 mm and a width of 4.7 mm.

Discussion. — This subspecies is distinguished from *R. l. laguessianus* by its smaller size and less transverse, semi-circular outline, the width being almost equal to the length. The interior characteristics leave no doubt about the generic assignment.

Material. — Several moulds from a locality SW of Genicera (loc. W1162, R.G.M. Wa.116536, St.P. WP.014301—10).

Occurrence. — In the Vegamián Fm. of Upper Tournaisian or lowermost Viséan age. This subspecies has been found in western Europe in the Tournaisian and Viséan.

Rugosochonetes skipseyi (Currie, 1937) Pl. 9, figs. 6, 7

1937 *Chonetes hardrensis* (Phillips) var. *skipseyi* var. nov. — Currie (in: Currie et al.), p. 420, pl. 2, figs. 4—7.
1943 *Chonetes (Chonetes) hardrensis skipseyi* Muir-Wood [sic!]. — Demanet, p. 71, pl. 1, figs. 18, 19.
1945 *Chonetes (Chonetes) hardrensis* var. *skipseyi* Currie. — Dorsman, p. 25, pl. 1, figs. 18, 19.
1952 *Chonetes skipseyi* Currie. — Ramsbottom, p. 12.

Diagnosis. — Small species of *Rugosochonetes*. Pedicle valve highly convex with a pointed umbo, slightly curved inwards over the hinge; median sulcus weakly developed or absent; lateral margins straight; fine costation with numerous bifurcations; a row of curved spines at a moderate angle to the hinge.

Description. — The pedicle valve is highly convex with large, almost flat ears, the cardinal extremities forming an angle of a little less than 90°. A median sulcus is usually weakly developed, but may be absent. The lateral margins are straight. The ornamentation consists of bifurcating costae, 5 to 6 within 1 mm near the anterior margin. Six diverging, curved spines have been observed along the hinge. The brachial valve is concave: further similar to the pedicle valve. The ornamentation consists of fine intercalating costae.
The interior of the pedicle valve has a short, but prominent median septum, somewhat less than half the length of the valve. The surface is covered with comparatively large papillae, especially on its ears. The interior of the brachial valve has two long diverging septa and a median septum of about half the length of the valve. The cardinal process is externally quadrifid.
The length varies from 3.5 to 6.5 mm and the width from 6.— to 11.5 mm.

Discussion. — *R. skipseyi* is distinguished by its small size, large ears, marked convexity, prominent umbo and straight lateral margins.
Muir-Wood (1962, p. 68) referred this species tentatively to the genus *Rugosochonetes* and this assignment is completely confirmed by the internal characteristics.

Material. — A few specimens from the Monte El Figar near San Julian de Bimenes (loc. 37, St. P. Bl.49250, 51), from a locality (M8) near Campo de Caso (St.P. Br.M853—57) and near the Pando Pass (loc. 40, St.P. Si.P701).

Occurrence. — In the Capa X of the Calizas Inferiores Mbr. of the Lena Fm. of a Lower Moscovian age, in the Escalada Fm. of Lower Moscovian, Kashirian, age and in the Pando Fm. from strata of the same age. In western Europe *R. skipseyi* has been found in marine bands at the boundary of the Westfalian B and C, e.g. the Skipseyi's Marine Band.

Genus LISSOCHONETES Dunbar & Condra, 1932

Lissochonetes? obtusus (Schellwien, 1892)
Pl. 9, fig. 17

1892 *Chonetes obtusus* sp. nov. — Schellwien, p. 31, pl. 1, figs. 14, 15.

Diagnosis. — Small species probably belonging to *Lissochonetes* with a rectangular outline, sometimes highly transverse, hinge about equal to the greatest width. Shell surface smooth with growth lines. Median sulcus faintly marked or absent.

Description. — The shells are smooth, rounded rectangular to highly transverse in outline. The pedicle valve has a median flattening sometimes developing into a weak sulcus. About five spine bases are developed on each side of the umbo. The interarea is broad, separated into two halves by a transverse groove. The brachial valve is concave closely following the contours of the pedicle valve.
The interior of the pedicle valve has a median septum and strong teeth. The interior of the brachial valve shows curved socket ridges uniting in a bilobed cardinal process. The decorticated surface shows fine radial ridging.
The measurements (in mm) are: L = 8.— to 12.5, W = 14.5 to 20.—. Specimens comparable in shape to both the specimens shown by Schellwien (1892, pl. 1, fig. 14, 15) have been found although the latter figure is an extreme.

Discussion. — The present material is too poorly preserved to permit definite assignation to *Eolissochonetes* or *Lissochonetes*. This species has been questionably referred to *Lissochonetes* by Muir-Wood (1962, p. 77).

Material. — Several specimens (R.G.M. W.7520—35) from a locality NE of Celada de Roblecedo (loc. 46).

Occurrence. — About 75 m above the base of the Verdiana Lst. Mbr. of the Corisa Fm. of an Upper Moscovian, top Podolskian or base Myachkovian, age (Fusulinella B2 subzone). In the Alps, this species has been found in the Upper Carboniferous Auernig Series.

Genus MESOLOBUS Dunbar & Condra, 1932

1932 *Mesolobus* Dunbar & Condra, p. 159.
1962 *Mesolobus* Muir-Wood, p. 79.

Type. — Type species by original designation *Chonetes mesolobus* Norwood & Pratten, 1855.

Discussion. — This genus is distinguished by its moderately concavo-convex shells and the fold which is usually developed in the median sulcus of the pedicle valve and the sulcus on the median fold of the brachial valve. The shell surface may be finely costate or smooth.

Mesolobus sinuosus (Schellwien, 1898)
Pl. 9, fig. 19

1892 *Chonetes lobata* sp. nov. — Schellwien, p. 29, pl. 1, figs. 1—3.
1898a *Chonetes sinuosa* nom. nov. — Schellwien, p. 697, footnote.
1931 *Chonetes sinuosa* Schellwien. — Heritsch, p. 11.
1958 *Chonetes (Mesolobus) mesolobus* Norwood & Pratten. — Ivanova, p. 104, pl. 19, fig. 4.

Diagnosis. — A comparatively large species of *Mesolobus* with a sub-rectangular outline and prominent costation. The pedicle valve has a rapidly widening median sulcus with a low, rounded median fold.

Description. — The pedicle valve is sub-rectangular with the lateral margins converging slightly towards the anterior margin. The valve is moderately convex with a pointed umbo, curved slightly inwards over the hinge. A median sulcus is developed somewhat below the umbo and rapidly widens towards the front, the lateral borders of the sulcus forming an angle of about 60°. In the middle of the median sulcus is a low, rounded median fold; in the only available specimen there is a nodular swelling at the posterior end, which is probably due to deformation. A row of 8 spines has been observed along the hinge, but probably 10 spines were developed, since the cardinal extremities are poorly preserved and show no spines. Several spinule bases are scattered over the valve. The ornamentation consists of prominent, bifurcating costae, 15 occuring in 5 mm at the anterior margin. The costae become less prominent on the ears. The brachial valve and the interior characteristics have not been observed.
The dimensions (in mm) of the only specimen are L = 9.2 and W = 15.6.

Discussion. — *M. sinuosa* is easily distinguished from other species of *Mesolobus* by its prominent costation, weakly convex, transverse pedicle valve with a broad median sulcus and a shallow fold in it. The specimens from the Upper Carboniferous of the U.S.S.R. described and photographed by Ivanov & Ivanova in 1936 as *Chonetes mesolobus* Norwood & Pratten and also photographed but not described by Ivanova in 1958 (pl. 19, fig. 4) are considered members of this species, since the figure shows a specimen which is almost identical in shape, size and ornamentation. The description of Ivanov & Ivanova (1936) was unfortunately not available, but the quotation by Muir-Wood (1962, p. 81) leaves no doubt that it deals with this species.
The original name of this species, *Chonetes lobata* Schellwien, 1892, was already used for *Chonetes lobatus* Grünewaldt, 1860; it was therefore renamed *Chonetes sinuosa* Schellwien, 1898. Unfortunately this name was first used in lists of fossils (Schellwien, 1898a, p. 697; 1898b, p. 360) for a Permian form, though it was stated in the footnotes that *C. sinuosa* was a new name for his *C. lobata*. The Permian specimens, later described in full (Schellwien, 1900, p. 38, pl. 9, figs. 17, 18) are, however, quite distinct from the Carboniferous specimens. Because it was explicitly stated that *C. sinuosa* was a new name and because the Permian specimens were not described until later, it seems best to retain the name for the Carboniferous specimens as Heritsch (1931) has done and to consider the Permian forms as a new, unnamed species (Heritsch, 1938, p. 103, pl. 7, figs. 6, 7). Muir-Wood (1962) seems to have retained *C. sinuosa* for the Permian form, since she cites (op. cit., p. 80) *C. lobatus* Schellwien, 1892 (non Grünewaldt, 1860) in the list of species of the genus *Mesolobus* and it is improbable that she did not know of the renaming by Schellwien.

Material. — One specimen (R.G.M. Br.2101) from an unknown locality in Palencia.

Occurrence. — Probably from the Cristóbal Fm. of a Kasimovian age or else from the Corisa Fm. of Upper Moscovian age. *C. sinuosa* is known in the Alps in the Upper Carboniferous Auernig Series, in the Upper Carboniferous of the Karavanke Mountains and in the U.S.S.R., it has been found in the Kasimovian.

Genus PLICOCHONETES Paeckelmann, 1930

1930 *Chonetes (Plicochonetes)* Paeckelmann, p. 222.
1952 *Plicochonetes* Paeckelmann. — Sarycheva & Sokolskaja, p. 59.
1962 *Plicochonetes* Paeckelmann. — Muir-Wood, p. 82.
1963 *Plicochonetes* Paeckelmann. — Böger & Fiebig, p. 146.

Type. — Type species by original designation *Chonetes buchianus* de Koninck, 1843.

Discussion. — This genus is distinguished by its thin shell, fine, prominent costae which rarely bifurcate and intercalate and are clearly visible on the internal surface, numerous growth lines and specific internal characteristics.

Plicochonetes kayserianus (Gallwitz, 1932)
Pl. 9, figs. 3, 4.

E.P. 1882 *Chonetes laguessiana* de Koninck. — Kayser, p. 77, pl. 3, fig. 17.
1930 *Chonetes (Chonetes) kayseri* sp. nov. — Paeckelmann, p. 252, pl. 16, figs. 13, 14.
1932 *Chonetes (Chonetes) kayserianus* nom. nov. — Gallwitz, p. 119, pl. 8, fig. 15.

Description. — The pedicle valve is highly convex with a rounded transverse outline. The ears are flattened. The ornamentation consists of rounded costae, which are prominent with a few intercalations and bifurcations, about 4 costae within 1 mm at the anterior margin, and prominent growth lines. The spines make a large angle with the hinge. The brachial valve is markedly concave, similar to the pedicle valve.
The interior of the pedicle valve has a short median septum, small teeth and a costate surface covered with papillae in radial rows. The interior of the brachial valve has two diverging septa, an alveolus and prominent socket ridges.
The length varies from 2.4 to 4.8 mm and the width from 4.6 to 9.— mm.

Discussion. — *P. kayserianus* is distinguished by its prominent costae and transverse shape. This species was assigned by Muir-Wood (1962, p. 36) to the genus *Chonetes* (s.s.) but both the exterior and interior features differ from that genus. They agree rather well with the genus *Plicochonetes* to which it is referred.
C. kayseri Paeckelmann, 1930 was renamed *C. kayserianus* by Gallwitz (1932), since it was preoccupied by *C. kayseri* Dahmer, 1929.

Material. — Several moulds from a locality SW of Genicera (loc. W1162, R.G.M. Wa.116501,03,21—25; St.P. WP.014263—72).

Occurrence. — In the Vegamián Fm. of Upper Tournaisian or lowermost Viséan age. This species has been found in western Europe in the Tournaisian and Viséan.

Plicochonetes tricornis? (von Semenov, 1854)

vide 1930 *Chonetes (Plicochonetes?) tricornis* v. Semenov. — Paeckelmann, p. 306, pl. 24, figs. 3—5.
vide 1952 *Plicochonetes tricornis* (v. Semenov). — Sarycheva & Sokolskaja, p. 60, pl. 11, fig. 71.
vide 1963 *Chonetes (Plicochonetes) tricornis* v. Semenov?. — Nicolaus, p. 167, pl. 10, fig. 6.

Description. — This is a small species of *Plicochonetes.* The pedicle valve is highly convex with a rounded triangular outline. The ears are flat and a median sulcus is developed. The ornamentation consists of prominent costae, becoming obsolete on the ears, their total number being about 16. The brachial valve is similar to the pedicle valve, markedly concave, but the curvature is distinctly less than that of the pedicle valve. Internal features have not been observed.
All specimens are small, measuring 0.8 to 1.2 mm in length and 1.1 to 1.4 mm in width.

Discussion. — This species is distinguished by its small size, triangular outline and relatively coarse costae which become weak on the ears. This species undoubtedly belongs to the genus *Plicochonetes.*
It is not certain, as pointed out by Nicolaus (1963), that these specimens are the same as von Semenov's species, which has more numerous costae and a smooth pedicle valve interior. A reassessment of the topotype material of this species is needed to settle the matter.

Material. — Many specimens (St.P. WP.014201—25) from a locality (W1162) SW of Genicera.

Occurrence. — See "Occurrence" for *P. kayserianus. P. tricornis?* has been found in the Viséan of Germany, Poland and the U.S.S.R.

Plicochonetes waldschmidti Paeckelmann, 1930
Pl. 9, figs. 1, 2.

1930 *Chonetes (Plicochonetes) waldschmidti* sp. nov. — Paeckelmann, p. 319, pl. 24, figs. 21, 22.
1938 *Chonetes (Plicochonetes) crassistrius minimus* Paeckelmann. — Demanet, p. 66, pl. 6, figs. 5—10.
1938 *Chonetes (Plicochonetes) crassistrius minimus* Paeckelmann. — Demanet & van Straelen, p. 121, pl. 108, figs. 20—22.
1949 *Plicochonetes waldschmidti* Paeckelmann. — Schwarzbach, p. 26, text-fig. 7.
1949 *Plicochonetes waldschmidti auriculatus* subsp. nov. — Schwarzbach, p. 27, pl. 1, figs. 9, 10, text-figs. 8, 9.
1952 *Plicochonetes waldschmidti* Paeckelmann. — Sarycheva & Sokolskaja, p. 61, pl. 11, fig. 72.
1963 *Chonetes (Plicochonetes) waldschmidti* Paeckelmann. — Nicolaus, p. 166, pl. 11, fig. 20.
1963 *Chonetes (Plicochonetes) waldschmidti* Paeckelmann. — Böger & Fiebig, p. 147, pl. 20, figs. 9, 10.

Description. — The pedicle valve is moderately convex with a rounded rectangular outline, the width being slightly larger than the length. The ears are distinct, less convex than the visceral disc. The ornamentation consists of branching costae, 22 to 40 found at the anterior margin. The costae become obsolete on the ears. They show short grooves similar to the ribs described in the internal layers of *Plicochonetes poljenowi* (Tolmatchow) (Sarycheva et al., 1963). The costae are crossed by prominent growth lines, especially near the anterior margin. The brachial valve is similar to the pedicle valve.
The interior of the pedicle valve shows no median septum. The internal surface is covered by radiating rows of papillae. The interior of the brachial valve has two diverging septa and teeth sockets anteriorly bounded by a curved ridge.
The length measures 1.4 to 3.5 mm and the width 2.— to 6.— mm.

Discussion. — *P. waldschmidti* is distinguished by its semi-circular outline and prominent, fine costae. *P. crassistrius minimus* Paeckelmann is closely related and is considered to be a synonym, because the slightly less transverse outline seems to be due to individual variability and to be insufficient for specific separation.

Material. — Several moulds (R.G.M. W.116526—30; St.P. WP.014155,230—35, 250—52) from a locality (W1162) SW of Genicera.

Occurrence. — See "Occurrence" for *P. kayserianus.* In western Europe, *P. waldschmidti* has been found in the Viséan and the Westfalian C.

Subfamilia CHONETINELLINAE Muir-Wood, 1962
Genus CHONETINELLA Ramsbottom, 1952

E.P. 1932 *Chonetina* Krotow. — Dunbar & Condra, p. 147.
1952 *Chonetinella* Ramsbottom, p. 13.
1962 *Chonetinella* Ramsbottom. — Muir-Wood, p. 85.

Type. — Type species by original designation *Chonetes flemingi* Norwood & Pratten, 1855.

Diagnosis. — Small, concavo-convex shells. Pedicle valve with a deep median sulcus bilobating the shell. Ornamentation of fine costae with few spinule bases; spines set at a small angle to the hinge. Brachial valve concave with a median fold, similar in shape to the pedicle valve leaving a thin body cavity. Interior of the pedicle valve with a short, prominent median septum. Interior of the brachial valve has a short median septum and lateral septa. Ornamentation of the interior surface the reverse of the exterior, papillose.

Discussion. — *Chonetinella* is distinguished by its small size, its prominent median sulcus in the pedicle valve and the comparatively coarse costae.

Chonetinella flemingi, crassiradiata
(Dunbar & Condra, 1932)
Pl. 9, figs. 9, 10.

1932 *Chonetina flemingi* var. *crassiradiata* var. nov. — Dunbar & Condra, p. 157, pl. 19, figs. 37—40.
1961 *Chonetina flemingi* var. *crassiradiata* Dunbar & Condra. — Hoare, p. 35, pl. 2, figs. 1—4.

Diagnosis. — A species of *Chonetinella* with a trapezoid outline. The pedicle valve is highly convex with a deep median sulcus; the umbo is slightly curved over the hinge which forms the widest part of the shell. The ornamentation consists of rather coarse costae and a row of 7 spines on each side of the umbo.

Description. — The Spanish specimens are rather small for the subspecies, but otherwise they agree in all details. The pedicle valve is strongly convex with a deep median sulcus. The ears are large with pointed cardinal extremities. A row of spines occurs, the spines set at a small angle to the hinge. No more than three spines have been observed on each ear, probably due to the small size of the valves and their poor state of preservation. The costae are comparatively coarse for the size of the shell. 9 within 2 mm at the anterior margin.
The length of a typical specimen is 3 mm and the width 5 mm.

Discussion. — This subspecies is distinguished by its moderately deep median sulcus and comparatively coarse costation.

Material. — Only a few specimens from Pinos (loc. 26; 28, St.P. WP.37501; 33301) and near San Emiliano (loc. 20, St.P. WP.33850).

Occurrence. — In the middle of the San Emiliano Fm. of Middle to Upper Bashkirian age. In the U.S.A. this subspecies has been found in Desmoinesian strata.

Genus NEOCHONETES Muir-Wood, 1962

1962 *Neochonetes* Muir-Wood, p. 87.
1963 *Quadranetes* Sadlick, p. 721.

Type. — Type species by original designation *Chonetes dominus* R. H. King, 1938.

Discussion. — *Neochonetes* is distinguished by its slightly lamellose surface with numerous spinules on the bifurcating and intercalating costae, the weakly developed median sulcus and fold on the pedicle and brachial valves respectively, and by the numerous spines set at a low angle to the hinge. The interior of the pedicle valve is characterized by a raised rim around the diductor scars and two prominent, parallel vascular trunks anterior to them.
The genus *Quadranetes* was designated by Sadlick (1963) using the same type species as *Neochonetes, Chonetes dominus* King, and is thus a junior objective synonym. He based *Quadranetes,* however, on quite distinct characteristics. Much stress was laid on the sub-quadrate outline (hence the name) and he considered the lamellose surface and the degree of development of the vascular trunks and brachial ridges of minor importance since they vary considerably with the age of the animals. The angle of the spines with the hinge, an important feature of *Neochonetes,* was not considered by Sadlick in his description of *Quadranetes.* In view of these differences, it is not surprising that the generotype is the only species common to both genera according to the original descriptions. Several of the species assigned by Sadlick to *Quadranetes* probably do not belong to *Neochonetes. Chonetes tumescens* Easton, 1943, for example, has spines which make a large angle with the hinge (Easton, 1943, pl. 24, fig. 2), weakly developed brachial ridges and obscure vascular trunks; it is a *Rugosochonetes.* The range of *Quadranetes* is considered mainly Namurian and that of *Neochonetes* from the Lower Pennsylvanian to Permian. At the moment there is not sufficient reason to separate the Lower Pennsylvanian sub-quadrate specimens from the other species of *Neochonetes* and this genus has been retained in its original sense.

Neochonetes acanthophorus (Girty, 1934)
Pl. 9, figs. 11—16, 18; text-figs. 18a, b.

1911 *Chonetes granulifer* var. *armatus* var. nov. — Girty, p. 127.
1915 *Chonetes granulifer* var. *armatus* Girty. — Girty, p. 62, pl. 7, figs. 2—7.
1932 *Chonetes granulifer* var. *armatus* Girty. — Dunbar & Condra, p. 146, pl. 20, figs. 1—4.
1934 *Chonetes acanthophorus* nom. nov. — Girty, p. 541.

Diagnosis. — Medium-sized species of *Neochonetes* with a rounded quadrate outline. Pedicle valve markedly convex, usually with a median sulcus. Ornamentation of fine costae; 7 or 8 spines occur on each side of the umbo. Brachial valve concave, ornamented as the pedicle valve.

Description. — The pedicle valve is convex with a rounded quadrate outline, the greatest width occurring at or near the hinge. Whenever the shell is completely preserved, the greatest width will be at the hinge. The cardinal extremities are almost rectangular with small points. A median sulcus is usually well developed, but sometimes it is faint or even absent with only a median flattening. The ornamentation consists of fine, branching and intercalating costae, 26 to 30 occurring within 5 mm at the anterior margin. Scattered spinules occur on the costae. They are clearly visible on slightly weathered shells where the spinule apertures appear as white spots. The surface is lamellose, the lamellae being marked by white bands. On both sides of the umbo are up to 8 spines, placed at a low angle to the hinge. There is a wide, triangular interarea with a delthyrium. The brachial valve is concave, but the degree of the concavity could not be ascertained as the brachial valves are crushed into the pedicle valves. A median fold is usually developed corresponding to the median sulcus of the pedicle

valve. The ornamentation of the brachial valve is similar to that of the pedicle valve but without spines along the hinge. The interarea is reflexed.

The interior of the pedicle valve has a short median septum with two parallel vascular trunks at the end. The round diductor scars are bounded by a raised rim; the adductor scars have not been observed. The inner surface is papillose, the papillae becoming much more pronounced anteriorly and developing finally into real endospines. At the anterior margin the shell becomes costate and finely papillose. The teeth are well developed. The interior of the brachial valve is also papillose and costate at the anterior margin. The cardinal process is quadrifid.

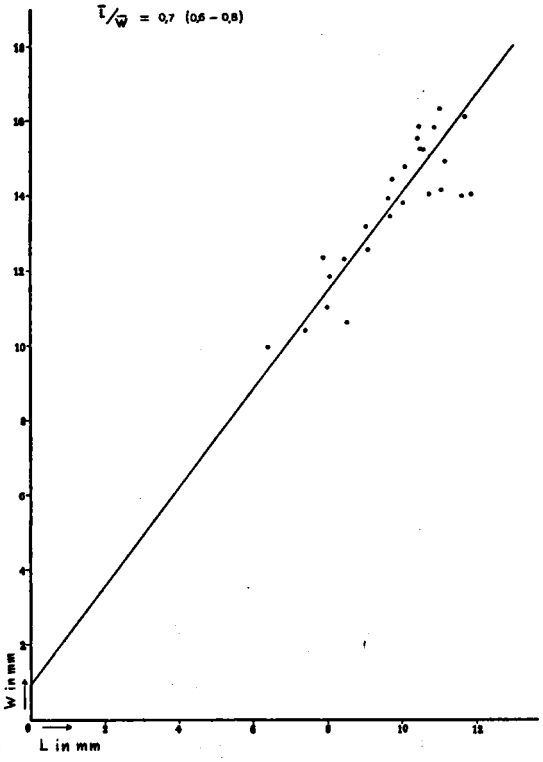
The measurements of many shells from one location (20) at San Emiliano are presented in figures 18a, b. The median values in mm are: L = 9.6, W = 13.5 and H = 3.4. H is the height of the pedicle valve, because the thickness of the shells could not be measured due to crushing of the brachial valve.

Discussion. — This species is distinguished by its rounded quadrate outline, numerous spinule apertures on the surface, the height of the pedicle valve being a third of the length and the moderate development of the median sulcus. *N. acanthophorus* closely resembles the type species *N. dominus,* but it has a more prominent umbo and is slightly smaller. *N. acanthophorus* has abundant spinule apertures which were not described for *N. dominus,* although this feature depends largely on the state of preservation.

C. granulifer var. *armata* was renamed *C. acanthophorus* by Girty (1934), since the name *armatus* was preoccupied by *C. armata* Bouchard-Chantereaux in de Verneuil. 1845.

Material. — Many specimens from one locality just outside San Emiliano (loc. 20, St.P. WP.33801—40).

Occurrence. — This species has been found at the base of the lowermost limestone of the San Emiliano Fm. of Middle or Upper Bashkirian age. In the U.S.A., *N. acanthophorus* has been found in the Desmoinesian.



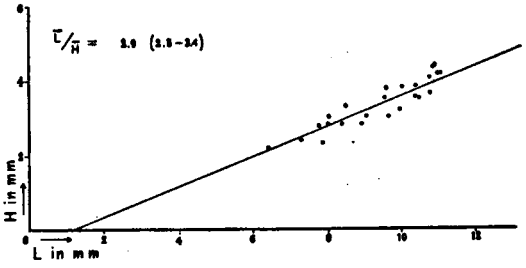


Fig. 18A. Diagram showing the relation between the length and the width of 25 specimens of *Neochonetes acanthophorus* (Girty) from a locality at San Emiliano (loc. 20). The mean value, as well as the maximum and minimum values, is given for the length/width ratio. 18B. The same as fig. 18A, giving the realtion between the length and height. The Thickness could not be measured because the brachial valves were crushed into the pedicle valves.

SUMARIO

Los depositos carboníferos de los frentes cabalgantes ("nappes") entre los rios Porma y Bernesga (mapa 2) y del curso superior de un afluente del rio Luna (mapa 3) estan descritos. En la descripción litoestratigrafica las formaciones de Alba y de Escapa se han subdivido en tres y dos miembres respectivamente. Una reconstrucción de las condiciones paleoecologicas durante la sedimentación es presentada. La interpretación paleoecologica está basada en la mayor parte en productoideos y chonetoideos. Tambien otros datos paleontologicos y litologicos se han tomado en cuenta. Muchas asociaciones faunisticas se han encontrado, que son comparables con aquellas descritas por Moore (1964) del Pennsylvaniense y Permico de Kansas (E.U.). Una reseña corta de la historia sedimentaria se encuentra en el capitulo IV.

La parte sistematica trata de los representantes carboníferos de dos subordenes de los Brachiopoda, o sea los Productidina y Chonetidina. 23 generos estan descritos de la superfamilia Productacea, integrando 52 especies, de las cuales 3 son nuevas. Las especies nuevas son: *Levipustula breimeri, Karavankina rakuszi* y *K. wagneri.* En total 12 especies y subespecies de 7 generos de la familia Chonetidae estan descritas.

Una reclassificación de los productoideos y chonetoideos del Carbonífero español ha sido el resultado de la investigación sobre estos braquiopodos. Muchos generos y especies aqui descritos fueron reconocidos por primera vez en España. El genero *Karavankina* está descrito mas detallado puesto que solo una pequeña nota (Ramovs, 1966) se ha publicado hasta ahora. Una funda peduncular (pedicle sheath) es descrito por primera vez en el genero *Chonetipustula*. Queda demonstrado que la ranura en los moldes de pequeñas valvas pedunculares en este genero está originada por una ranura adelante de la funda peduncular y no por un septo mediano como se supusó ántes.

Una comparación de las faunas con las de otras regiones conduce a unos resultados interesantes. La fauna de la Formación de Vegamián está estrechamente ligada a las faunas algo mas jovenes de Alemania. Estas ultimas tienen una edad claramente Viseense. La fauna aparece ser pendiente del tipo de sedimiento (pizarras negras) mas que por la edad de los sedimientos. Van Ginkel (1065 b) ha datado el techo de la formación de Escapa por medio de fusulinas como Bashkiriense inferior. La asociación de productoideos de estos depositos es muy especial, porque consiste principalmente de formas conocidas del Viseense de Europa occidental, junto con unos generos y especies, que solo se conocen del Moscoviense o de estratos aun mas jovenes en otras partes. Esta fauna demuestra que se tiene que obrar con mucha prudencia en correlaciones sobre grandes distancias. En cuanto haya formas, que no caben en el cuadro general que se ha establecido, se tiene que verificar la correlacion con otros medios. En la parte superior del Bashkiriense y en la parte mas baja del Moscoviense la fauna se hace mas cosmopolita. Los generos y especies del Namuriense y Viseense se sustituyen por otros nuevos. En el Moscoviense la fauna esta muy ligada a aquella descrita de la región mediteranea, de Rusia y de China, y tambien a las faunas de los niveles marinos del Westfaliense de Europa occidental. La Cordillera Cantabrica pertenece sin duda alguna a la provincia faunistica de Europa—Thian-Chan porque la fauna de productoideos y fusulinas corresponde completamente con aquella considerada tipica para esta provincia (Einor et al., 1965). Un nuevo genero caracteristico, *Karavankina,* se ha añadido, puesto que este se extende durante el Carbonifero superior desde la Cordillera Cantabrica hasta China. Los productoideos del Kasimoviense son estrechamente relacionado con las formas del Moscoviense, pero pertenecen a especies differentes.

SAMENVATTING

De carbonische afzettingen uit de dekbladen tussen de rivieren Porma en Bernesga (kaart 2) en van de bovenloop van een zijrivier van de Luna (kaart 3) zijn beschreven. In de lithostratigrafische beschrijving zijn de Alba- en de Escapa-formaties respectievelijk in drie en twee laagpakketten verdeeld. Een poging is gedaan om de palaeoecologische omstandigheden gedurende de sedimentatie te reconstrueren. De palaeoecologische interpretatie is voor een groot deel gebaseerd op de productoïden en chonetoïden, maar andere palaeontologische en lithologische gegevens zijn ook in overweging genomen. Vele fauna-associaties zijn gevonden, die vergelijkbaar zijn met de door Moore (1964) uit het Pennsylvanien en Perm van Kansas (V.S.) beschreven associaties. Een kort overzicht van de sedimentaire geschiedenis is gegeven in hoofdstuk IV.

De systematiek van de carbonische vertegenwoordigers van twee subordes der Brachiopoda, de Productidina en Chonetidina, is bestudeerd. Drieëntwintig genera zijn beschreven van de superfamilie Productacea, vertegenwoordigd door 52 soorten, waarvan er drie nieuw zijn. De nieuwe soorten zijn: *Levipustula breimeri, Karavankina rakuszi* en *K. wagneri.* Twaalf soorten en ondersoorten van zeven verschillende genera van de familie Chonetidae zijn beschreven.
Het onderzoek van deze brachiopoden resulteerde in een reclassificatie van de Spaanse productoïden en chonetoïden uit het Carboon en vele genera en species werden voor het eerst uit Spanje beschreven. Het geslacht *Karavankina* is vrij uitvoerig beschreven aangezien er slechts een kort, inleidend artikel (Ramovs, 1966) over gepubliceerd is. Een steelschede (pedicle sheath) is voor het eerst beschreven voor het genus *Chonetipustula*. Voorts is aangetoond, dat de groeve op de steenkernen van kleine steelkleppen van dit genus veroorzaakt is door een groeve vóór de steelschede en niet door een mediaan septum, zoals vroeger verondersteld werd.

Een vergelijking van de faunas met die van andere gebieden levert interessante resultaten op. De fauna uit de Veagmián-Formatie is nauw verwant met de iets jongere, faunas uit Duitsland van een duidelijke Viséen ouderdom. De fauna blijkt meer bepaald te zijn door de aard van het sediment, zwarte schalies, dan door de ouderdom van de afzettingen. Van Ginkel (1965b) dateerde de top van de Escapa-Formatie met behulp van fusulinen als Onder-Bashkirien. De productoïden-associatie van deze afzettingen is merkwaardig, daar deze hoofdzakelijk uit vormen bestaat, die bekend zijn uit het Viséen van West-Europa, samen met enige geslachten en soorten, die alleen uit het Moscovien of zelfs jongere lagen bekend zijn. Deze fauna toont aan, dat men zeer voorzichtig moet zijn met correlaties over grote afstanden. Zodra er een paar vormen voorkomen, die niet in het bekende beeld passen, moet de correlatie geverifieerd worden met behulp van onafhankelijke middelen. Boven in het Bashkirien en in het onderste deel van het Moscovien wordt de fauna meer kosmopolitisch, de Viséen en Namurien genera en species worden vervangen door

nieuwe. In het Moscovien is de fauna nauw verwant aan de uit het mediterrane gebied, Rusland en China beschreven fauna's, maar ook aan de fauna's uit de mariene banden van het westeuropese Westfalien. Het Cantabrisch Gebergte behoorde ongetwijfeld tot de Europa—Thian-Chan-faunaprovincie, omdat de productoïden- en de fusulinen-fauna volledig overeenstemt met de als typisch voor deze provincie beschreven fauna (Einor et al., 1965). Een nieuw karakteristiek genus, *Karavankina,* is er aan toegevoegd, daar het in het Boven-Carboon van het Cantabrisch Gebergte tot in China voorkomt. De productoïden uit het Kasimovien zijn nauw verwant aan de vormen uit het Moscovien, maar zij behoren tot andere soorten.

REFERENCES

Almela, A. & Ríos, J. H., 1953. Datos para el conocimiento de la geologiá asturiana (valles de Riosa y Proaza). Bol. Inst. Geol. Minero España, 65, p. 1—34.

Barrois, C., 1882. Recherches sur les terrains anciens des Asturies et de la Galice. Mém. Soc. Géol. Nord, 2/1, p. 1—630.

Böger, H. & Fiebig, H., 1963. Die Faunen des westdeutschen Oberkarbons. II. Die articulaten Brachiopoden des westdeutschen Oberkarbons. Palaeontographica (A), 122, p. 111—165.

Boogaert, H. A. van Adrichem, 1967. Devonian and Lower Carboniferous conodonts of the Cantabrian Mountains (Spain) and their stratigraphic application. Leidse Geol. Med., 39, p. 129—192.

Boogaert, H. A. van Adrichem, 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 Léon, Spain). Notas Comuns. Inst. Geol. Minero España, 70, p. 131—135.

Boucek, B. & Pribyl, A., 1960. Revision der Trilobiten aus dem slowakischen Oberkarbon (Revise trilobitu slovenského svrchního karbonu). Geologické práce (Bratislava), 20, p. 5—49.

Branson, C., 1948. Bibliographic index of Permian invertebrates. Mem. Geol. Soc. America, 26, p. 1—1094.

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

Brunton, C. H. C., 1965. The pedicle sheath of young productacean brachiopods. Palaeontology, 7, p. 703—704.

—, 1966. Silicified productoids from the Viséan of County Fermanagh. Bull. British Mus. (Nat. Hist.) Geol., 12, p. 175—243.

Budinger, P. & Kullmann, J., 1964. Zur Frage von Sedimentationsunterbrechungen im Goniatiten- und Conodontenführenden Oberdevon und Karbon des Kantabrischen Gebirges (Nordspanien). N. Jahrb. Geol. Paläont., Mon.h., p. 414—429.

Campbell, K. S. W., 1956. Some Carboniferous productid brachiopods from New South Wales. Jour. Paleont., 30, p. 463—480.

—, 1961. Carboniferous fossils from the Kuttung rocks of New South Wales. Palaeontology, 4, p. 428—474.

Cayeux, L., 1939. Etudes des gîtes mineraux de la France. Les phosphates de chaux sédimentaires de France. T.I. Services de la carte géologique de la France et des topograhies souterraines, Paris, p. 1—349.

Chao, Y. T., 1926. On the age of the Taiyuan Series of North China. Bull. Geol. Soc. China, 4, p. 221—249.

—, 1927. Productidae of China. Pt. I Producti. Palaeont. Sinica (B), 5/2, p. 1—244.

—, 1928. Productidae of China. Pt. II Chonetinae, Productinae and Richthofeninae. Palaeont. Sinica (B), 5/3, p. 1—103.

Comte, P., 1959. Recherches sur les terrains anciens de la Cordillère Cantabrique. Mem. Inst. Geol Minero España, 60, p. 1—440.

Conant, L. C. & Swanson, V. E., 1961. Chattanooga Shale and related rocks of Central Tennessee and nearby areas. U.S. Geol. Surv., Prof. Paper, 357, p. 1—91.

Cooper, G. A., 1957. Permian brachiopods from central Oregon. Smithsonian Misc. Collections, 134/12 (4302), p. 1—79.

Cooper, G. A. & Muir-Wood, H. M., 1951. Brachiopod homonyms. Jour. Washington Acad. Sci., 41, p. 195—196.

Cooper, G. A. & Muir-Wood, H. M., 1967. New names for brachiopod homonyms. Jour. Paleont., 41, p. 808.

Currie, E. D., Duncan, C. & Muir-Wood, H. M., 1937. The fauna of Skipsey's Marine Band. Trans. Geol. Soc. Glasgow, 19/3, p. 413—453.

Davidson, Th., 1858—1863. A monograph of the British fossil Brachiopoda. Vol. 2, pt. 5. The Carboniferous Brachiopoda. London, Palaeontographical Soc. Mon., p. 1—280.

Delépine, G., 1928. Les brachiopodes du Marbre Noir de Dinant (Viséen inferieur). Mém. Mus. roy. Hist. nat. Belgique, 37, p. 1—38.

—, 1935. Contribution à l'étude de la faune du Dinantien des Pyrénées. 2e pt. La faune de Mondette. Bull. Soc. géol. France (5), 5, p. 171—189

—, 1937. Le Carbonifère du sud de la France (Pyrénées et Montagne Noire) et du nord-ouest de l'Espagne (Asturies). C.R. 2e Cong. Internat. Strat. Carbonifère, Heerlen 1935, 1, p. 139—158.

—, 1943. Les faunes marines du Carbonifère des Asturies (Espagne). Acad. Sci. Inst. France, Mém., 66/3, p. 1—122.

—, 1951. Studies of the Devonian and Carboniferous of Western Europe and North Africa. Proc. Geologists' Assoc., 62, p. 140—166.

Delépine, G. & Llopis Llado, N., 1956. Nouvelle faune Carbonifère à Latores (Asturies, Espagne). C.R. somm. Séances Soc. Géol. France, p. 106—108.

Demanet, F., 1938. La faune des couches de passage du Dinantien au Namurien dans le synclinorium de Dinant. Mém. Mus. roy. Hist. nat. Belgique, 84, p. 1—201.

—, 1943. Les horizons marins du Westphalien de la Belgique et leurs faunes. Mém. Mus. roy. Hist. nat. Belgique, 101, p. 1—166.

—, 1949. Contribution à l'étude de la microfaune marine du Westphalien de la Campine. Bull. Inst. roy. Sci. nat. Belge, 25/37, p. 1—16.

Demanet, F. & Straelen, V. van, 1938. Faune houillière de la Belgique. In: Renier, A., Stockmans, F., Demanet, F. & Straelen, V. van, Flore et faune houillières de la Bel-

gique, 3e partie. Bruxelles, Patrimoine Mus. roy. Hist. nat. Belg., p. 99—246.

Dixon, E. E. L. & Vaughan, A., 1911. The Carboniferous succession in Gower (Glamorganshire), with notes on its fauna and conditions of deposition. Quart. Jour. Geol. Soc. London, 67, p. 477—571.

Dorsman, L., 1945. The marine fauna of the Carboniferous in the Netherlands. Med. Geol. Stichting (C), 4/3, no. 3, p. 1—101.

Dunbar, C. O. & Condra, G. E., 1932. Brachiopoda of the Pennsylvanian System in Nebraska. Nebraska Geol. Surv., Bull. (2), 5, p. 1—377.

Easton, W. H., 1943. The fauna of the Pitkin Formation of Arkansas. Journ. Paleont., 17, p. 125—154.

Einor, O. L., Voynovsky-Krieger, K. G., Vassiluk, N. P., Vdovenko, M. V., Gorak, S. V., & Dunayeva, N. N., 1965. Caractères généraux de la biogéographie de l'U.R.S.S. pendant la periode carbonifère. Bull. Soc. géol. France, (7), 7, p. 110—123.

Elias, M. K., 1937. Depth of deposition of the Big Blue (late Paleozoic) sediments in Kansas. Bull. Geol. Soc. America, 48, p. 403—432.

—, 1957. Late Mississippian fauna from the Redoak Hollow formation of southern Oklahoma. II. Brachiopoda. Jour. Paleont., 31, p. 487—527.

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

Fagerstrom, J. A. & Boelstorff, J. D., 1964. Taxonomic criteria in the classification of the Pennsylvanian productoid *Juresania nebrascensis*. Palaeontology, 7, p. 23—28.

Ferguson, L., 1963. The paleoecology of *Lingula squamiformis* Philips during a Scottish Mississippian marine transgression. Jour. Paleont., 37, p. 669—681.

Frech, F., 1911. Abschliessende palaeontologische Bearbeitung der Sammlungen F. von Richthofens, die Untersuchung weiterer fossiler Reste aus den von ihm bereisten Provinzen sowie den Entwurf einer erdgeschichtlicher Uebersicht China's. In: Richthofen, F. von, China. Ergebnisse eigener Reisen und darauf gegründeter Studien. Vol. 5. Berlin, Verlag D. Reimer, p. 1—289.

Fredericks, G., 1915. Notes paléontologiques. 1. Sur les *Productus* du Carbonifère supérieur et de l'Artinskien (in Russian, with a French summary). Mém. Com. Géol. N.S., 103, p. 1—63.

—, 1928. Communication for the classification of the genus Productus Sow. (In Russian, with an English summary). Bull. Com. Géol., Leningrad, (1927), 46, p. 773—792.

Gallwitz, H., 1932. Die Fauna des deutschen Unterkarbons. 3. Teil 2. Die Brachiopoden, 3. Teil. Die Orthiden, Strophomeniden und Choneten des unteren Unterkarbons (Etroeungt). Abh. Preuss. Geol. Landesanst. N.F., 141, p. 75—131.

Gauri, K. L., 1965. Uralian stratigraphy, trilobites and brachiopods of the western Carnic Alps (Austria). Jahrb. Geol. Bundesanst., Sonderb., 11, p. 1—94.

Gehrig, J. L., 1958. Middle Pennsylvanian brachiopods from the Mud Springs Mountains and Derry Hills, New Mexico. State Bureau Mines Mineral Resources, etc., Mem., 3, p. 1—24.

Ginkel, A. C. van, 1959. The Casavegas section and its fusulinid fauna. Leidse Geol. Med., 24, p. 705—720.

—, 1965a. Carboniferous fusulinids from the Cantabrian Mountains (Spain). Pt. 1. Systematic palaeontology of Spanish fusulinid faunas. Leidse Geol. Med., 34, p. 1—170.

—, 1965b. Spanish Carboniferous fusulinids and their significance for correlation purposes. Leidse Geol. Med., 34, p. 173—225.

Girty, G. H., 1899. Geology of the Yellowstone National Park. Part II. Descriptive geology, petrography, and paleontology. U.S. Geol. Surv., Mem., 32, p. 1—893.

—, 1903. The Carboniferous formations and faunas of Colorado. U.S. Geol. Surv., Prof. Paper, 16, p. 1—546.

—, 1911. On some new genera and species of Pennsylvanian fossils from the Wewoka formation of Oklahoma. Ann. New York Acad. Sci., 21, p. 119—156.

—, 1915. Fauna of the Wewoka Formation of Oklahoma. U.S. Geol. Surv., Bull., 544, p. 1—353.

—, 1934. *Pleurotomaria pseudostrigillata* nom. nov. and *Chonetes acanthophorus* nom. nov. Jour. Washington Acad. Sci., 24, p. 541.

—, 1935. An unrecorded structure in certain semireticulate Producti. Jour. Paleont., 9, p. 7—9.

Gobbet, D. J., 1963. Carboniferous and Permian brachiopods of Svalbard. Norsk Polarinst. Skr., 127, p. 1—201.

Groot, G. E. de, 1963. Rugose corals from the Carboniferous of northern Palencia (Spain). Leidse Geol. Med., 29, p. 1—123.

Hahn, G., 1965. Unterkarbon-Trilobiten als Leitfossilien. In: Max Richter-Festschrift (Schmidt-Thomé, P. & Schönenberg, R., ed.), Clausthal-Zellerfeld, E. Piepersche Buchdr. Verlaganst., p. 331—340.

Hall., J., 1858. Pt. 2. Palaeontology. In: Hall, J. & Whitney, J. D., Report on the geological survey of the State of Iowa: embracing the results of investigations made during portions of the years 1855, 56 & 57. Vol. 1, p. 473—724.

Hallam, A., 1967. Sedimentology and palaeogeographic significance of certain red limestones and associated beds in the Lias of the Alpine region. Scott. Jour. Geol., 3/2, p. 195—220.

Hattin, D. E., 1957. Depositional environment of the Wreford Megacyclothem (Lower Permian) of Kansas. Bull. State Geol. Surv. Kansas, 124, p. 1—150.

Heritsch, F., 1931. Versteinerungen aus dem Karbon der Karawanken und Karnischen Alpen. Abh. Geol. Bundesanst., 23/3, p. 1—56.

—, 1938. Die stratigraphische Stellung des Trogkofelkalkes. N. Jahrb. Min. Geol. Palaeont., Beil. Bd. (B), 79, p. 63—168.

Hernon, R. M., 1935. The Paradise Formation and its fauna. Jour. Paleont., 9, p. 653—696.

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., 72, p. 205—248.

Hoare, R. D., 1961. Desmoinesian Brachiopoda and Mollusca from Southwest Missouri. Univ. Missouri Studies, 36, p. 1—263.

Ivanova, E. A., 1968. Development of the fauna of the Middle and Upper Carboniferous in the western part of the Moscow Basin. 3. Oecological development of the fauna (in Russian). Trudy Paleont. Inst., Akad. Nauk S.S.S.R., 69, p. 1—303.

Janov, E. N., 1956. Contributions à l'étude de l'origine des colorations rouges et grises des roches sédimentaires (in Russian; trad. B.R.G.M. 1650). Dokl. Akad. Nauk S.S.S.R., 111, p. 1330—1331.

Jongmans, W. J. & Wagner, R. H., 1957. Apuntes para el estudio de la Zona Hullera de Riosa (Cuenca Central de Austurias). Est. Geol., 33—36, p. 7—26.

Johnson, J. G., 1967. Systematic position of the genus *Irbosskites* (Brachiopoda). Jour. Paleont., 41, p. 1003—1004.

Kanis, J., 1956. Geology of the eastern zone of the Sierra del Brezo (Palencia, Spain). Leidse Geol. Med., 21, p. 375—445.

Kayser, E., 1882. Beiträge zur Kenntniss von Oberdevon und Culm am Nordrande des rheinischen Schiefergebirges. Jahrb. Kön. Preuss. geol. Landesanst. Bergakad. Berlin 1881, p. 51—91.

Keulegan, G. H. & Krumbein, W. C., 1949. Stable configuration of bottom slope in a shallow sea and its bearing on geological processes. Trans. Am. Geophys. Union, 30, p. 855—861.

King, R. E., 1931. The geology of the Glass Mountains, Texas. Pt. 2. Faunal summary and correlation of the Permian formations with descriptions of the Brachiopoda. Univ. Texas, Bull., 3042, p. 1—245.

King, R. H., 1938. New Chonetidae and Productidae from Pennsylvanian and Permian strata of North-central Texas. Jour. Paleont., 12, p. 257—279.

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

Kozlowski, R., 1914. Les brachiopodes du Carbonifère Supérieur de Bolivie. Ann. Paléont., 9, p. 1—100.

Krotow, H., 1888. Geologische Forschungen am westlichen Ural-Abhange in den Gebieten von Tscherdyn und Ssolikamsk (in Russian, with an extensive German summary). Mém. Com. Géol., 6, p. 1—563.

Krumbein, W. C. & Sloss, L. L., 1963. Stratigraphy and sedimentation. San Francisco & London, Freeman & Co., p. 1—660.

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

—, 1962. Die Goniatiten der Namur-Stufe (Oberkarbon) im Kantabrischen Gebirge, Nordspanien. Akad. Wiss. Lit. Mainz, Abh. Math. Naturw. Kl., 6, p. 1—119.

—, 1963a. Die Goniatiten des Unterkarbons im Kantabrischen Gebirge (Nordspanien). II. Paläontologie der U.O. Prolecanitina Miller & Furnish. Die Altersstellung der Faunen. N. Jahrb. Geol. Paläont., Abh., 116, p. 269—324.

—, 1963b. Las series devonicas y del Carbonifero inferior con ammonoides de la Cordillera Cantabrica (translation by J. Gómez de Llarena). Est. Geol., 19, p. 161—191.

—, 1966. Goniatiten-Korallen-Vergesellschaftungen im Karbon des Kantabrischen Gebirges (Nordspanien). In: Festband Schindewolf, N. Jahrb. Geol. Paläont., Abh., 125, p. 443—466.

Lekahena, E. G., 1964. Scriptie over de doctoraal kartering in het oostelijk Correcilla-dekblad, gedurende de zomers 1961 t/m 1963. Unpublished internal report, Leiden University.

Lóczy, L. von, 1899. Beschreibung der fossilen Reste von Wirbeltieren und von Mollusken und die palaeontologisch-stratigraphischen Ergebnisse. In: Széchenyi, B. Wissenschaftliche Ergebnisse der Reise des Grafen Béla Széchenyi in Ostasien. Abt. 6. Th. 1. E. Hölzel, p. 9—228. (Hungarian ed. in 1897).

McCoy, F., 1844. A synopsis of the characters of the Carboniferous Limestone fossils of Ireland. Dublin, Univ. Press, p. 1—207.

McCrone, A. W., 1963. Paleoecology and biostratigraphy of the Red Eagle cyclothem (Lower Permian) in Kansas. State Geol. Surv. Kansas, Bull., 164, p. 1—114.

Martin, W., 1809. Petrificata Derbiensia, or, figures and descriptions of petrifications collected in Derbyshire. D. Lyon, p. 1—28, 52 pls.

Martínez Alvarez, J. M., 1962. Estudio geológico del reborde oriental de la cuenca carbonífera central de Asturias. Inst. Est. Asturianos, Oviedo, p. 1—229.

Maxwell, W. G. H., 1951. Upper Devonian and Middle Carboniferous brachiopods of Queensland. Univ. Queensland Paper, 3/14, p. 1—27.

Metz, K., 1936. Eine Fauna aus den untersten Schichten des Oberkarboons der Karnischen Alpen (Waideggerfauna). N. Jahrb. Min. Geol. Paläont., Abh. (B), Beil. Bd., 75, p. 163—189.

Miloradovich, B. V., 1935. Materials to the study of the upper paleozoic Brachiopoda from the northern island of Novaya Zemlya (in Russian, with an extensive English summary). Trans. Arctic Inst. 19, p. 1—166.

Moore, R. C., 1964. Paleoecological aspects of Kansas Pennsylvanian and Permian cyclothems. State Geol. Surv. Kansas, Bull., 169, p. 287—372.

Muir-Wood, H. M., 1928. The British Carboniferous Producti. II. *Productus (sensu stricto); semireticulatus* and *longispinus* groups. Mem. Geol. Surv. Great Britain, Palaeont., 3/1, p. 1—217.

—, 1930. The classification of the British Carboniferous brachiopod subfamily Productinae. Ann. Mag. Nat. Hist., (10), 5, p. 100—108.

—, 1937. Productidae. In: Currie, E. D. et al., The fauna of Skipsey's Marine Band. Pt. 3. Description of species, h., Trans. Geol. Soc. Glasgow, 19, p. 442—448.

—, 1951. The Brachiopoda of Martin's „Petrificata Derbiensia". Ann. Mag. Nat. Hist. (12), 4, p. 97—118.

—, 1962. On the morphology and classification of the brachiopod suborder Chonetoidea. London, British Mus. (Nat. Hist.), p. 1—132.

Muir-Wood, H. M. & Cooper, G. A., 1960. Morphology, classification and life habits of the Productoidea (Brachiopoda). Geol. Soc. Am., Mem., 81, p. 1—447.

Muir-Wood, H. M. & Williams, A., 1965. Strophomenida. In: Treatise on invertebrate paleontology. Pt.H. Brachiopoda (Moore, R. C., ed.), p. H361—H521.

Nakamura, K., 1959. Some Lower Permian Sakamotozawa brachiopods Jour. Fac. Sci. Hokkaido Univ. (4), 10, p. 199—207.

Newell, N. D., Rigby, J. K., Fischer, A. G., Whiteman, A. J., Hickox, J. E. & Bradley, J. S., 1953. The Permian reef complex of the Guadalupe Mountains region, Texas and New Mexico. A study in paleoecology. San Francisco, Freeman & Co., p. 1—236.

Nicolaus, H. J., 1963. Zur Stratigraphie und Fauna der *crenistria*-Zone im Kulm des Rheinischen Schiefergebirges. Beih. Geol. Jahrb., 53, p. 1—246.

Nikitin, S., 1890. Dépôts carbonifères et puits artésiens dans la region de Moscou (in Russian, with an extensive French summary). Mém. Com. Géol., 5/5, p. 1—182.

Norin, E., 1922. The late Palaeozoic and early Mesozoic sediments of Central Shansi. Bull. Geol. Surv. China, 4, p. 3—80.

Oele, E., 1964. Sedimentological aspects of four lower-paleozoic formations in the Northern part of the Province Léon (Spain). Leidse Geol. Med., 30, p. 1—99.

Ozaki, K., 1931. Upper Carboniferous brachiopods from North China. Bull. Shanghai Sci. Inst., 1/6, p. 1—205.

Paeckelmann, W., 1930. Die Fauna des deutschen Unterkarbons. 1. T. 3. Die Brachiopoden des deutschen Unterkarbons. 1. T.: Die Orthiden, Strophomeniden und Choneten des Mittleren und Oberen Unterkarbons. Abh. Preuss. Geol. Landesanst. N.F., 122, p. 143—326.

—, 1931. Die Fauna des deutschen Unterkarbon. 2. T. Die Brachiopoden des deutschen Unterkarbons. 2. T. Die Productinae und Productus-ähnlichen Chonetinae. Abh. Preuss. Geol. Landesanst. N.F., 136, p. 1—440.

Pareyn, C., 1961. Les massifs carbonifères du Sahara sud-orannais. T. 2, Paléontologie stratigraphique. Paris, Publ. Centre Nat. Recherches Sahariennes, Sér. Géol., 1/2, p. 1—244.

Patac, I., 1920. La formación uraliense asturiana. Estudio de cuencas carboniferas. Gijón, p. 1—50.

Paul, H., 1942. *Thomasella* n. nom. = *Thomasina* Paeckelmann 1931 (Brachiop., Productidae). Zentralbl. Min. Geol. Paläont. (B), p. 191.

Phillips, J., 1836. Illustrations of the geology of Yorkshire. II. The Mountain Limestone district. London, J. Murray, p. 1—253.

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

Rakusz, G., 1926. Zur Kenntniss der Brachiopodenfauna des Dobschauer Carbons. Centralbl. Min. Geol. Paläont. (B), p. 515—520.

—, 1932. Die oberkarbonische Fossilien von Dobsina (Dobšina) und Nagyvisnyó. Geologica Hungarica (Palaeont.), 8, p. 1—223.

Ramovs, A., 1966. Revision des *„Productus elegans"* (Brachiopoda) im ostalpinene Jungpaläozoikum. Festb. Schindewolf, N. Jahrb. Geol. Paläont., Abh., 125, p. 118—124.

Ramsbottom, W. H. C., 1952. The fauna of the Cefn Coed Marine Band in the Coal Measures at Aberbaiden, near Tondu, Glamorgan. Bull. Geol. Surv. Great Britain, 4, p. 8—32.

Reichardt, W., 1937. Die Ostalpinen Nassfeldschichten — eine Brücke zwischen Mitteleuropa und Russland. 2e Cong. Strat. Carbonifère, Heerlen 1935, C.R., 2, p. 919—1055.

Reynolds, S. H. & Vaughan, A., 1911. Faunal and lithological sequence in the Carboniferous Limestone Series (Avonian) of Burrington Combe (Somerset). Quart. Jour. Geol. Soc. London, 67, p. 342—392.

Rudwick, M. J. S., 1965. Ecology and paleoecology. In: Treatise on invertebrate paleontology. Pt. H. Brachiopoda (Moore, R. C., ed.), p. H199—H214.

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

Sadlick, W., 1963. *Quadranetes*, a new Carboniferous chonetid. Jour. Paleont., 37, p. 721—723.

Sarycheva, T. G., 1937. Lower Carboniferous Producti of the Moscow Basin (genera *Striatifera, Linoproductus* and *Cancrinella*) (in Russian, with an English summary). Inst. Paleozool., Trudy, 6/1, p. 1—123.

—, 1949. Morphologie, écologie et évolution des Productidés (genres *Dictyoclostus, Pugilis* et *Antiquatonia*) du Carbonifère du Bassin de Moscou. (in Russian; trad. B.R.G.M. 1874). Trudy Paleontol. Inst., Akad. Nauk S.S.S.R., 18, p. 1—386 (Pagination of the French translation.)

Sarycheva, T. G. & Sokolskaja, A. N., 1952. Guide de détermination des brachiopodes paléozoiques de la dépression de Moscou (in Russian; trad. B.R.G.M. 1814). Trudy Paleontol. Inst., Akad. Nauk S.S.S.R., 38, p. 1—322. (Pagination of the French translation).

Sarycheva, T. G. & Sokolskaja, A. N., 1960. The classification of the pseudopunctate brachiopods. Doklady Acad. Sci. U.S.S.R., Washington, earth sci. sec., 125, p. 348—350. (Russian ed. of 1959.)

Sarycheva, T. G., Sokolskaja, A. N., Beznosova, G. A. & Maksimova, S. V., 1963. Brachiopodes et paléogéographie du Carbonifère de la cuvette de Kuznetzk (in Russian). Trudy Paleontol. Inst., Akad. Nauk S.S.S.R., 95, p. 1—547.

Schellwien, E., 1892. Die Fauna des karnischen Fusulinenkalks. T. 1. Geologische Einleitung und Brachiopoda. Palaeontographica, 39, p. 1—56.

—, 1898a. Bericht über die Ergebnisse einer Reise in die Karnischen Alpen und die Karawanken. Sitz. ber. kön. Preuss. Akad. Wiss. Berlin, 44, p. 693—700.

—, 1898b. Die Auffindung einer permocarbonischen Fauna in den Ostalpen. Verh. k.k. geol. Reichsanst. Wien, 1898, p. 358—363.

—, 1900. Die Fauna der Trogkofelschichten in den Karnischen Alpen und den Karawanken. I. Die Brachiopoden. Abh. k.k. geol. Reichsanst. Wien, 16/1, p. 1—122.

Schmidt, H., 1935. Die bionomische Einteilung der fossilen Meeresböden. Fortschritte Geol. Palaeont., 12/38, p. 1—154.

—, 1951. Neue Faunen aus dem Namur des nordöstlichen Spaniens. Paläont. Z., 24, p. 184—193.

Schwarzbach, M., 1949. Die Fauna des Bug-Karbons, ihre stratigraphische und paläogeographische Bedeutung. Palaeontographica (A), 97, p. 1—74.

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. Med., 26, p. 255—264.

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

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

Sokolskaja, A. N., 1948. L'évolution du genre Productella et des vormes voisines dans le Paléozoïque da la dépression de Moscou (in Russian, with a French summary). Trudy Paleont. Inst., Akad. Nauk S.S.S.R., 14/3, p. 1—168.

Sowerby, J., 1812—1815. Mineral conchology. Vol. 1. London, p. 1—234.

—, 1821—1822. Mineral conchology. Vol. 4. London, p. 1—113.

Sowerby, J. de C., 1823—1825. The Mineral conchology of Great Britain, Vol. 5, London, p. 1—168.

—, 1826—1829. The Mineral conchology of Great Britain. Vol. 5. London, p. 1—230.

Stehli, F. G., 1954. Lower Leonardian brachiopods of the Sierra Diablo. Bull. Am. Mus. Nat. Hist., 105, p. 257—358.

Stepanov, P., Rotai, A., Licharev, B. & Maliavkin, A., 1937. Geological description of the Donetz Coal Basin (Donbass). In: The southern excursion. Donetz Coal Basin (Donbass) (P. Stepanov, ed.). Intern. Geol. Cong., 17th session U.S.S.R. 1937, p. 5—43.

Stevens, C. H., 1966. Paleoecologic implications of Early Permian fossil communities in Eastern Nevada and Western Utah. Geol. Soc. Am., Bull., 77, p. 1121—1130.

Stuckenberg, A., 1898. Allgemeine geologische Karte von Russland. Blatt 127 (in Russian, with an extensive German summary). Mém. Com. Géol., 16/1, p. 1—362.

Sutton, A. H., 1938. Taxonomy of Mississippian Productidae. Jour. Paleont., 12, p. 537—569.

Teichert, C., 1965. Devonian rocks and paleogeography of Central Arizona. U.S. Geol. Surv., Prof. Paper, 464, p. 1—181.

Thomas, I., 1914. The British Carboniferous Producti. I. Genera Pustula and Overtonia. Mem. Geol. Surv. Great Britain, Paleont., 1/4, p. 197—366.

Tornquist, A., 1895. Das fossilführende Untercarbon am östlichen Rossbergmassiv in den Sudvogesen. I. Einleitung, Beschreibung der Brachiopoden-Fauna. Abh. geol. Sp. Karte Elsass-Lothringen, 5/4, p. 379—528.

Tschernyschew, Th., 1902. Die obercarbonische Brachiopoden des Ural und des Timan (in Russian, with an almost complete German translation). Mém. Com. Géol., 16/2, p. 1—749.

Verneuil, P. E. P. de, 1840. Sur quelques espèces intéressantes des brachiopodes des terrains anciens. Bull. Soc. géol. France, 11, p. 257—264.

Wagner, R. H., 1955. Rasgos estratigráfico-tectónicos del Paleozoico superior de Barruelo (Palencia). Est. Geol., 11/26, p. 145—202.

—, 1962. A brief review of the stratigraphy and floral succession of the Carboniferous in NW. Spain. C.R. 4e Cong. Strat. Géol. Carbonifère, Heerlen 1958, 3, p. 753—762.

—, 1963. A general account of the Paleozoic rocks between the Rivers Porma and Bernesga (León, NW Spain). Boll. Inst. Geol. Minero España, 74, p. 171—334.

—, 1966. Palaeobotanical dating of Upper Carboniferous folding phases in NW. Spain. Mem. Inst. Geol. Minero España, 66 (1965), p. 1—169.

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. Wet. (B), p. 149—163.

Wagner-Gentis, C. H. T., 1963. Lower Namurian goniatites from the Griotte limestone of the Cantabric Mountain Chain. Notas Comuns. Inst. Geol. Minero España, 69, p. 5—42.

Waterlot, G., 1932. Les Productus du Terrain houiller du Nord de la France. Ann. Soc. Géol. Nord, 57, p. 145—176.

Weller, J. M., 1957. Paleoecology of the Pennsylvanian Period in Illinois and adjacent states. In: Treatise on marine ecology and paleoecology. V. 2. Paleoecology. (Ladd, H. S., ed.), Geol. Soc. America, Mem., 67/2, p. 325—364.

—, 1960. Stratigraphic principles and practice. New York, Evanston & London, Harper & Row publ., p. 1—725.

Wilson, R. B., 1966. A study of the Neilson Shell Bed, a Scottish Lower Carboniferous marine shale. Bull. Geol. Surv. Great Britain, 24, p. 105—130.

Zangerl, R. & Richardson, E. S. Jr., 1963. The paleoecological history of two Pennsylvanian black shales. Fieildiana, Geol. Mem., 4, p. 1—352.