Brachiopod and fusulinid assemblages of Kasimovian (Pennsylvanian) age from the Ándara Massif (Picos de Europa, northern Spain)

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The analysis of early Kasimovian (Pennsylvanian) brachiopod assemblages from two fossiliferous localities of the Las Llacerias Formation (Ándara Massif, Picos de Europa, northern Spain) improve our knowledge of this fossil group in the Cantabrian Zone. At the Morra de Lechugales Peak (locality 1), marlstones and bioclastic limestones, accumulated in a low energy, subtidal, aphotic setting, characterize a soft muddy sea-floor affected by periodic intense bottom currents and provide a rich assemblage of brachiopods together with other macrofossils. Brachiopod specimens are characterized by their small size (<10 mm) and belong to 38 different taxa. The fossiliferous dark marly limestones at the Castillo del Grajal (locality 2) record a very shallow water, low energy, subtidal and photic environment, where bioclastic wackestone-packstone accumulated in a relatively clean and clear sea-water. Very diverse biotic associations including abundant photozoans and heterozoans characterize these strata. Brachiopod assemblages from this locality share 12 genera and five species with locality 1, but they also show striking differences such as the absence in the locality 2 of representatives of the family Spiriferellidae and the order Spiriferinida; moreover, the specimens from the last locality are of normal size. These differences are interpreted to be the result of very different environmental conditions between localities during the interval under consideration. Fusulinids studied from the Las Llacerias Formation allow correlation of the two fossiliferous localities with the lower Kasimovian.

The representatives of the family Spiriferellidae are described. They include the new species *Plicatospiriferella winklerprinsi*, a small sized form with slightly transverse shell, dorsal valve slightly convex, strongly incurved ventral umbo and simple plicae on flanks. The new genus *Winklerprinsia* (type species *Winklerprinsia europea* sp. nov.) is included in the family because of its plicate flanks, pustulose micro-ornament, ventral umbonal region thickened by a callus and short dental adminicula. The most distinctive feature of the new genus is a solid, elevated ventral platform, interpreted as a muscle platform. A new fusulinid species, *Protriticites winkleri,* is described from the Morra de Lechugales Peak section. Its overall characteristics somewhat resemble forms assigned in other areas of the world to *Obsoletes*, but its wall microstructure corresponds to that of *Protriticites* species.

Contents

Introduction

Late Pennsylvanian marine rocks crop out abundantly in the eastern part of the Cantabrian Zone (Picos de Europa and Ponga major structural units; Figs. 1, 2). The sedimentary successions include both siliciclastics and carbonates accumulated in a very wide range of depositional systems from deep water clastic and siliciclastic systems, shelves, deltas, fan deltas and carbonate platforms. Shallow water strata (mostly mixed siliciclastic-carbonate shelf deposits and carbonates) form a significant volume of the sedimentary record in the Picos de Europa Province and contain diverse biotas. Nevertheless, localities with abundant macrofossils that are easy to remove from the

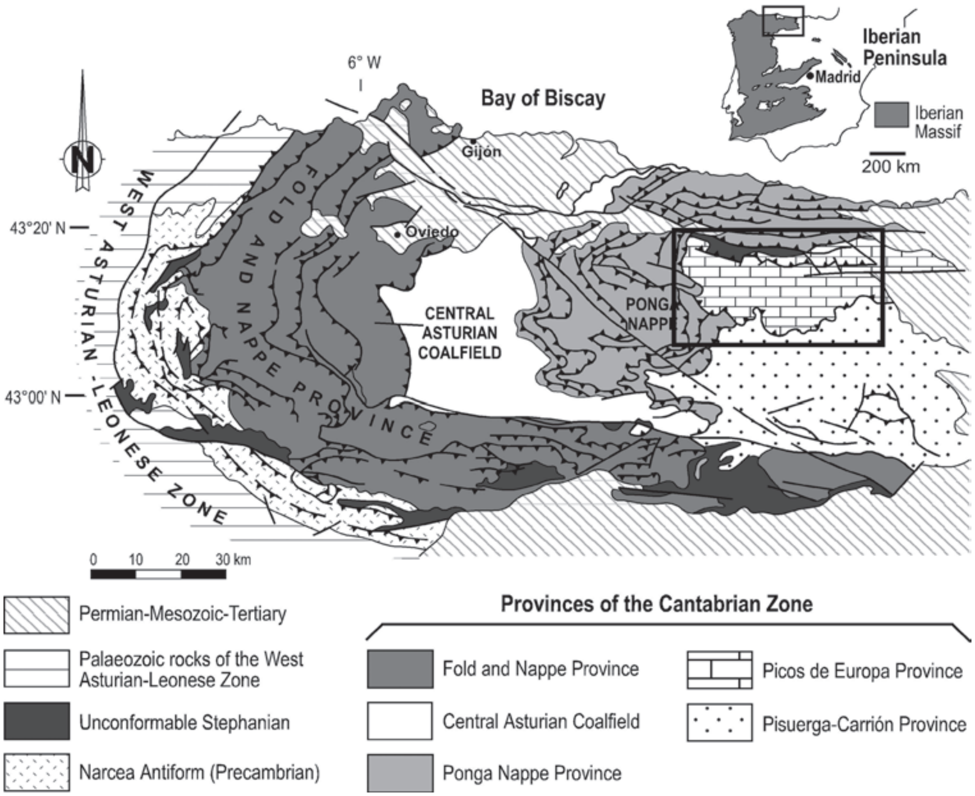


Fig. 1. Geological map of Cantabrian Zone showing the location of the Picos de Europa Province (based on Julivert, 1971 and Pérez-Estaún *et al.*, 1988). Boxed area indicates the location of geological map shown in Figure 2.

rock are rare. Therefore, only a limited number of studies of brachiopod fauna from the Picos de Europa Province had been published (Martínez Chacón, 1982; Martínez Chacón & Winkler Prins, 1985; Sánchez de Posada *et al*., 1999, 2002).

This study focuses on the analysis of brachiopod and fusulinid assemblages from two localities situated in the Ándara Massif (southeast part of the Picos de Europa Province, localities 1 and 2 in Fig. 2) within the Las Llacerias Formation (Early Kasimovian). These localities are rather exceptional since they had provided a great number of brachiopod specimens together with other macrofossils. Exceptional outcrop conditions have allowed, not only the recovery of abundant biota, but also the detailed analysis of sedimentary facies that support the reconstruction of the palaeoenvironmental conditions in which the fossil assemblages thrived. Significant differences in the environmental conditions and the nature of the substrate from locality 1 to 2 have also left a clear imprint on the fossil assemblages and might explain the observed differences in the composition of their respective brachiopods. The fusulinids described in this work, and previous data about the fusulinid content of the strata of the las Llacerias Formation in the vicinity of localities 1 and 2 (Maas, 1974; Maas & Ginkel, 1983; Ginkel & Villa, 1991), provide good biostratigraphic constraints.

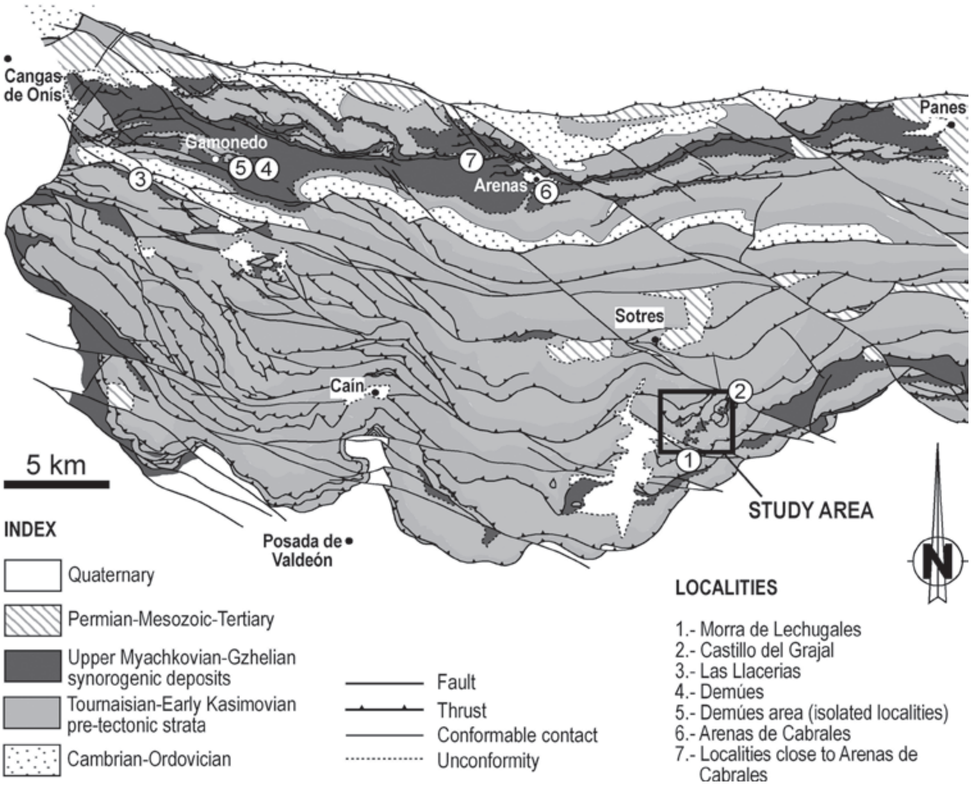
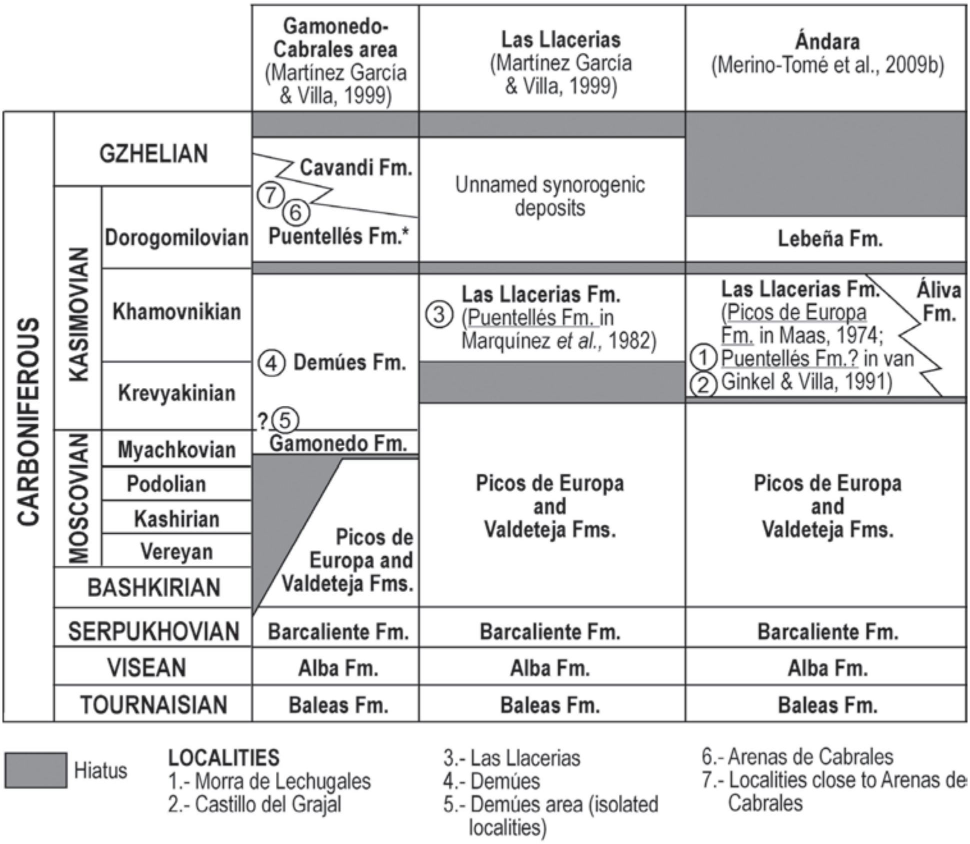


Fig. 2. Synthetic geological map of the Picos de Europa Province. Boxed area indicates the location of the detailed geological map shown in Fig. 4.

Geological setting

The Picos de Europa Unit (Figs. 1, 2) is one of the geological provinces in which Julivert (1971) subdivided the Cantabrian Zone (northwest part of the Iberian Massif; Lotze, 1945). This geological province is characterized by a very thick carbonate succession (over 1500 m) of Carboniferous age (Tournaisian-earliest Kasimovian) that composes most of its sedimentary record (Fig. 3). This carbonate succession was accumulated in the passive margin of the marine foreland basin located on the east coast of Pangea at palaeoequatorial latitude and facing the growing Variscan Orogen to the west. The youngest strata (Valdeteja and Picos de Europa formations, mostly Bashkirian-Moscovian in age) formed a giant, microbial-dominated carbonate shelf (see Bahamonde *et al.*, 2007) that was progressively deformed and thrusted during the last stages of the Variscan Orogeny (from the latest Moscovian to Gzhelian; Merino-Tomé *et al.*, 2009a).



* The name of Puentellés Formation was firstly used by Martínez García (1981) to define a 300 m-thick limestone succession of Kasimovian age. Recent studies have shown that this stratigraphic unit ranges in age from the late Kasimovian to the early Gzhelian (Villa *et al.*, 2003; Merino-Tomé *et al.*, 2006).

Fig. 3. Correlation of the Carboniferous successions in the Gamonedo-Cabrales area, Las Llacerias and Ándara showing the stratigraphic positions of the fossil localities 1-7 mentioned in the text.

Unconformable latest Moscovian-Ghzelian synorogenics, comprising both siliciclastics and calcareous deposits, outcrop in places (Fig. 2) and represent the remains of wedge-top basins developed during tectonic deformation (Merino-Tomé *et al.*, 2006, 2007, 2009a, b). During the Early Kasimovian (Krevyakinian and Khamovnikian) those basins had mostly a marine character being filled by both deep water siliciclastic and detrital calcareous deposits accumulated in deep troughs, and a suite of shallow water carbonates deposited in narrow thrust-top carbonate ramps developed on tectonically uplifted areas (Merino-Tomé *et al.*, 2009a, b). The Krevyakinian-Khamovnikian marls and limestones accumulated in those carbonate ramps are exposed in several localities along the Picos de Europa Province. These deposits correspond to the Las Llacerias Formation of Martínez García & Villa (1999) (Fig. 3). Nevertheless, in previous studies these rocks were not differentiated from the underlaying Picos de Europa Formation (Maas, 1974; Ginkel & Villa, 1991) or they were wrongly attributed to the younger Puentellés Formation (late Kasimovian-Gzhelian in age) (Marquínez *et al.*, 1982; Villa *et al.*, 1993). Although there arise some differences concerning the stratigraphy and age of the Las Llacerias Formation from one outcrop to the other, in general terms it is characterized by a basal unconformity developed above the Picos de Europa Formation; a pervasive dark colour; the presence of siliciclastic material; and more abundant and diverse marine biota than in the underlying Picos de Europa Formation.

The biostratigraphy, palaeontology and sedimentology of this stratigraphic unit have being studied in detail in the Las Llacerias section (northwest of Picos de Europa Province, the locality where this stratigaphic unit was initially described) (Marquínez *et al.*, 1982; Villa *et al.*, 1993; Coquel & Rodríguez, 1994; Villa & Ginkel, 1997, 2000; Ginkel & Villa, 1999; Bahamonde *et al.*, 2000; Mamet & Villa, 2004; Méndez, 2006; Cózar *et al.*, 2007). At present, this formation is the focus of a multidisciplinary research in the Ándara area, southeastern part of the Picos de Europa Province (see Merino-Tomé *et al.*, 2009b; Villa *et al.*, 2009), although the earliest biostratigraphic information to be gleaned from the Morra de Lechugales beds was by Maas & Ginkel (1983) and Ginkel & Villa (1991).

The Las Llacerias Formation at the Morra de Lechugales Peak

The Las Llacerias Formation is exceptionally well exposed in some of the summits of the Ándara Massif such as the Morra de Lechugales Peak (Figs. 2-4). Brachiopods studied in this paper have been collected in two localities from this area: a few metres below the summit of the Morra de Lechugales Peak (locality 1) and below the summit of the Castillo del Grajal Peak (locality 2). The stratigraphy of the Las Llacerias Formation is well exposed in the Morra de Lechugales Peak where it reaches 200 m in thickness and comprises two unconformity-bounded sequences (Merino-Tomé *et al.*, 2009b). Sequence 1 (Fig. 5) can be subdivided into two parts:

1) The lower part (up to 50 m thick) is composed of matrix-free, clast-supported breccias, with pebble- to cobble-sized calcareous lithoclasts, showing lateral variations in thickness.
2) The upper part (85 m thick) consists of dark authochtonous carbonates including black, nodular, skeletal marly wackestones and wacke- to packstones with a rich biota; chaetetid- and syringoporid-rich boundstones; phylloid and *Anthracoporella* bafflestones; dark and massive bioclastic wackestones; and rare bioclastic grain- to

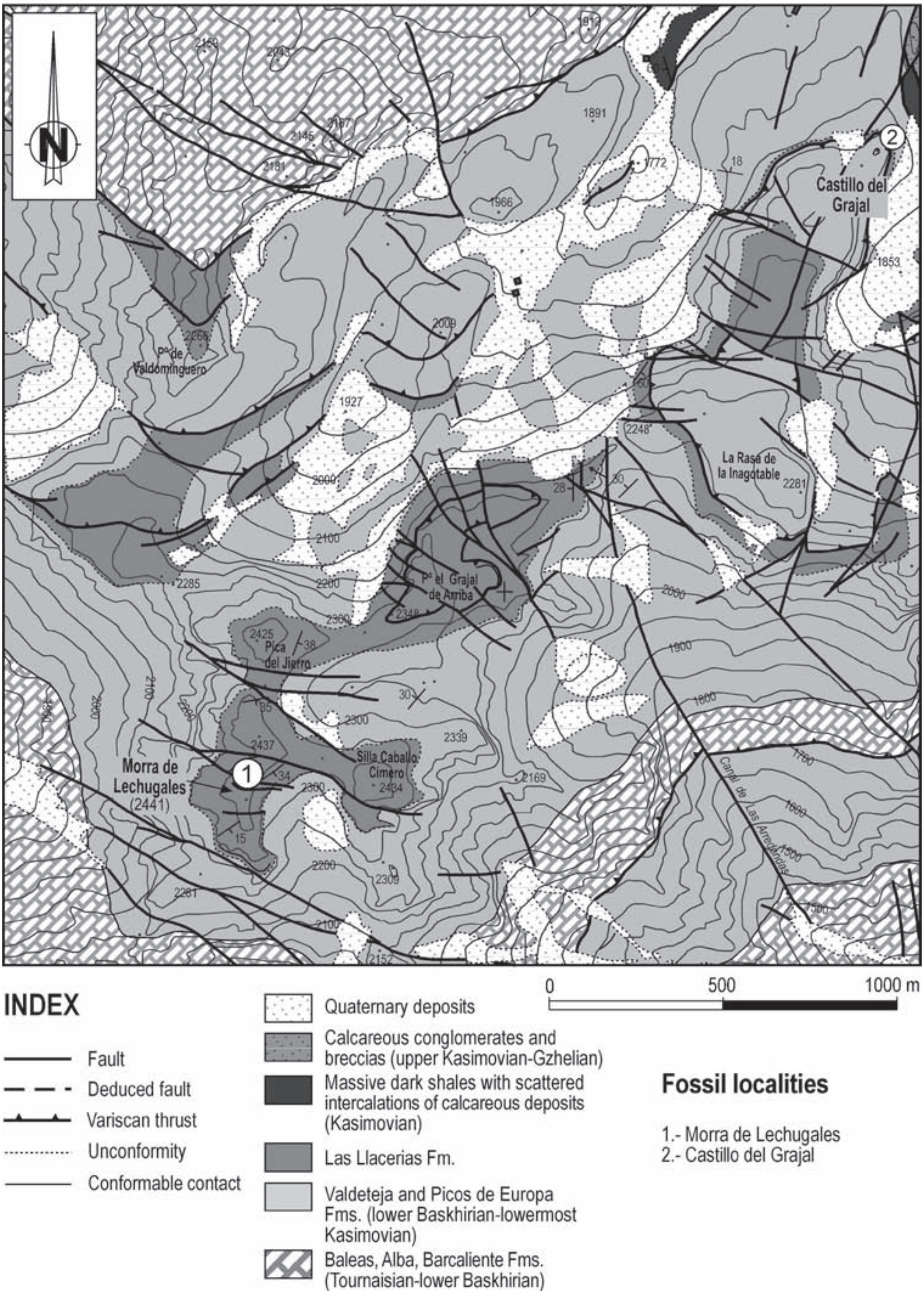


Fig. 4. Detailed geological map of Ándara area showing location of localities 1 and 2 (modified from Merino-Tomé *et al.*, 2009b). See Figure 2 for location.

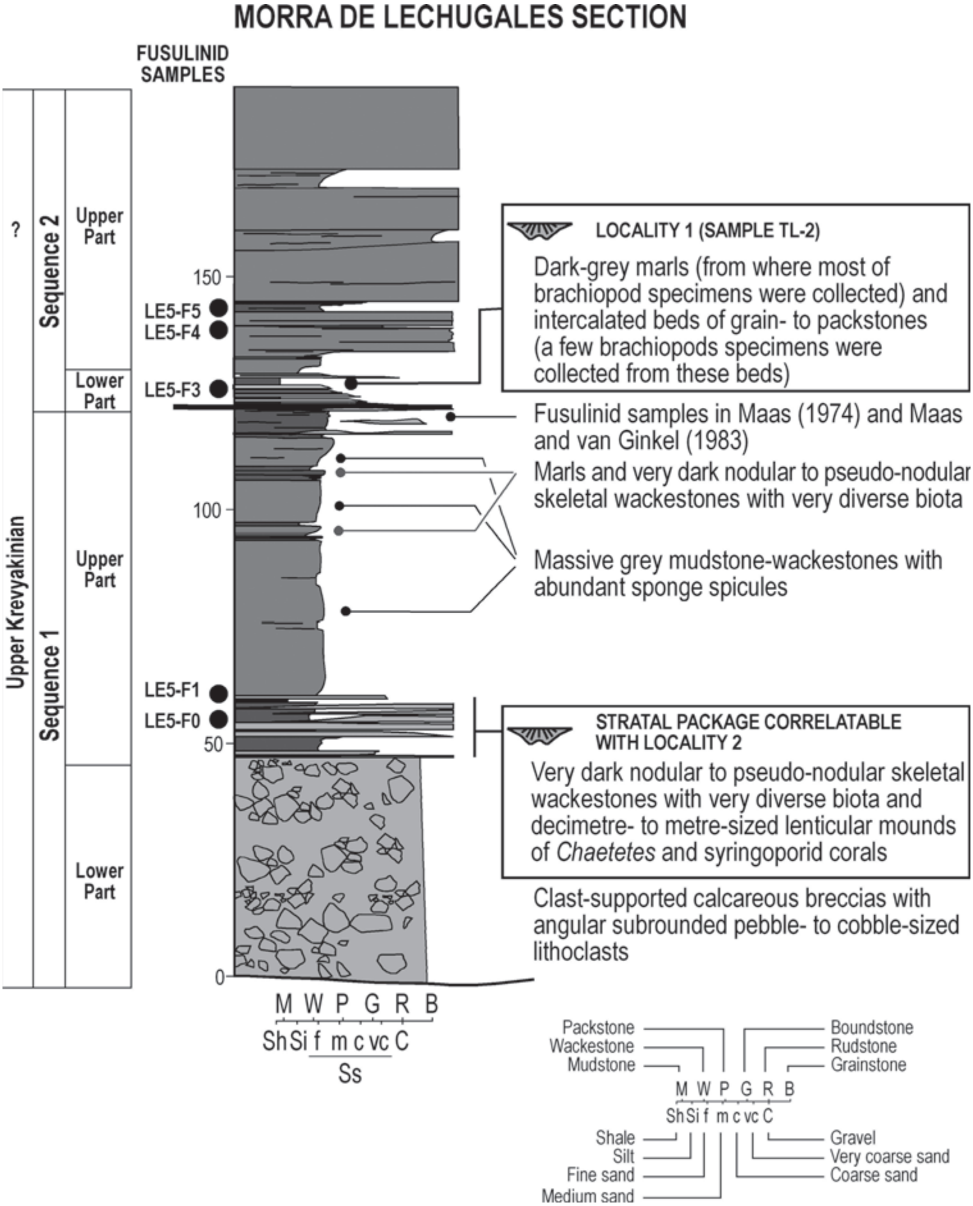


Fig. 5. Stratigraphic section of Las Llacerias Formation at Morra de Lechugales peak showing the location of the strata from which brachiopods were collected (locality 1) and the location of the stratigraphic package correlatable with locality 2. Fusulinid samples collected along the section had been also indicated.

packstones and dark marlstones. These deposits are arranged into three decametre-thick massive packages (also recognizable in nearby outcrops) separated by well-bedded metre-thick stratal packages characterized by the presence of dark marlstones and black nodular wackestones rich in biota.

The brachiopods from locality 2 (Castillo del Grajal) were collected from dark and biota-rich limestones and marls (with a rich association of calcareous algae, molluscs, crinoids, bryozoans, *etc*.) located at the base of the upper interval of Sequence 1. These strata correlate with the basal stratigraphical package of the upper part of Sequence 1 at the Morra de Lechugales section.

Sequence 2 (Fig. 5) comprises two parts. The lower part (*c*. 8 m thick) consists of graded decimetre- to centimetre-thick tabular beds of detrital intraclastic and skeletal rudstones, and grainstones to packstones alternating with dark marls. Locality 1 (Morra de Lechugales) is located within this stratigraphic package. Most of the brachiopods were collected from these marls, but a few come from the bioclastic limestones. Brachiopods are abundant, and occur in association with small solitary rugose corals (*Cyathaxonia* sp.), bryozoans and crinoids. The upper part (60 m thick) is composed of dark grey, nodular mudstones to wackestones, algal bafflestones and minor skeletal grainstones to packstones alternating with massive micritic boundstones.

Environmental conditions of the fossil-bearing strata

The Las Llacerias Formation carbonates represent the deposits accumulated in small thrust-top carbonate ramps developed during the thrusting of Picos de Europa Province (Merino-Tomé *et al*., 2009a, b). These early Kasimovian carbonate ramps developed synchronously with large deltaic systems, bordering the marine basin and originating from the adjacent and recently created mountainous areas of the Variscan Orogen. Terrigenous influx and, probably, periodic turbidity in the shallow waters affected the ramps developed in the Ándara area as recorded by the siliciclastic material present both in the clastic and autochthonous carbonates of the Las Llacerias Formation (Merino-Tomé *et al*., 2009b).

Brachiopod specimens from locality 2 (Castillo del Grajal) were collected from black to dark-grey nodular marly wackestones and packstones, punctuated by interbeds of marls. High-diversity biotic association characterizes these deposits containing abundant algae and very rich heterozoan fauna. Merino-Tomé *et al*. (2009a) considered that these deposits probably record a shallow (below fair-weather wave base) mid-ramp depositional setting under open-marine conditions and within the euphotic zone. In these settings, chaetetid sponges, tabulate (mainly syringoporid) and rugose corals, phylloid algae, and dasycladaceans thrived, and built small, metre-scale buildups. Abundant phylloid udoteaceans, minor ramose dasycladaceans and, maybe, poorly calcified algae colonized extensive areas of the sea floor.

The dark marlstones and marly mud- to wackestones (lower part of Sequence 2) from which most of the brachiopods of locality 1 (Morra de Lechugales) were collected are intensively burrowed, and contain, in addition to abundant small brachiopods, small solitary rugose corals of the '*Cyathaxonia* fauna', and remains of bryozoans, crinoids, gastropods and some trilobites. The intercalated centimetre- to decimetre-thick tabular beds, from which some brachiopod specimens were collected, can display a lower massive to normal graded layer of rudstones with gravel-sized grains, grading vertically into packstones with sand-sized grains to grainstones. They contain fusulinids and abundant skeletal grains, rip-up mudstone clasts, extraclasts, intraclasts and detrital quartz grains. The bed tops are usually formed by fine-grained sandstone to siltstone, spiculitic packstones with traction-current structures (parallel and ripple lamination).

These facies record the sedimentation of lime-mud in low energy, subtidal environments with a significant terrigenous input that caused frequently turbid waters and conditioned the composition of the biotic communities. The available data only permits the assessment that the depositional environment was located below the fair-weather wave base as indicated by the abundance of muddy lithofacies (marlstones and marly mud- to locally wackestones) and the lack of wave-traction sedimentary structures; and below the base of the photic zone as indicated by the lack of *in situ* accumulated photozoans such as calcareous algae. Although the euphotic zone in modern depositional environments is often limited to 20-30 m (Pomar, 2001; Wilson & Vecsei, 2005), the increase in turbidity linked to terrigenous and nutrient input may have reduced this limit to just a few metres. The graded beds of detrital carbonates are the result of sediment-load deposition by offshore-directed currents transporting the carbonate material eroded or reworked from shallower areas (Merino-Tomé *et al.*, 2009b). Although these beds show features (normal grading, laminated bed tops) commonly reported from tempestite and gravity flow deposits, sedimentary structures clearly recording storm wave action have not been observed and, as a consequence, the relative location of the depositional environment with respect the storm-wave base cannot be deduced. Nevertheless, their presence records the action of intense bottom currents that affected the sea floor. The '*Cyathaxonia* fauna' also points to a deep-water realm below normal wave-base (see review in Somerville & Rodríguez, 2007).

Some major differences arise in the environmental conditions envisaged at the time of deposition for Morra de Lechugales (locality 1) and Castillo del Grajal (locality 2). Lithofacies at the Castillo del Grajal locality are shallower and indicate an euphotic setting, while the deposits at the Morra de Lechugales locality point to an aphotic setting. Overall, seawater was probably clearer and less turbid at locality 2 than at locality 1 and contained less siliciclastic material in suspension. The seafloor (substrate) was formed by carbonate bioclastic-rich wackestone and locally packstone textures at locality 2, while in locality 1 the sea-floor was dominated by soft muddy sediments with scarce bioclastic material and was periodically affected by intense bottom currents.

Fossil assemblages

The fauna of locality 1 is abundant and diverse, even though the small size of most of the macrofossils is puzzling. Brachiopods are the most abundant group. Corals, especially solitary Rugosa, are the second group in abundance. They include different rugose species that are elements of the well-known '*Cyathaxonia* fauna', some of them represented by many specimens. Tabulates are also present. The fossil assemblage also includes siliceous sponge spicules, several kinds of bryozoans, and one small calyx and lots of plates of crinoids, as well as echinoid spines. Other fossil groups, far less abundant, are trilobites, a few molluscs (gastropods, rostroconchs and cephalopods, the last including one orthoconic nautiloid and two coiled ammonoids) and some fish scales.

In the locality 2, the biotic content is also abundant and even more diverse than in locality 1. Besides the brachiopods, this locality has yielded representatives of other fossil groups including abundant calcareous algae (*Eugonophyllum, Anthracoporella, Archaelithophyllum*, conspicuous swarms of *Penella*), polyaxon sponge spicules and very rich heterozoan fauna including abundant foraminifers (Bradyinidae, Palaeotextulariidae [mainly *Climacammina*], staffellids, other fusulinoideans, biseriamminids, tetrataxids, tubiforms, Calcivertellinae, Calcitornellinae, Apterrinellinae). Laminar chaetetids are characteristic, along with sphinctozoan, and less abundant inozoan and lithistid sponges, tabulate syringoporids (*Neomultithecopora*), solitary rugose geoyerophyllid corals and crinoids. Other fossils comprise bryozoans (described by Ernst & Winkler Prins, 2008: locality 6), echinoids, gastropods, bivalves, ostracodes, trilobites, rostroconchia and nautiloids. Skeletal grains usually show microborings, and micritization and constructive micritic encrustations with abundant *Girvanella*, encrusting foraminifers (tuberitinids, tubiforms and *Palaeonubecularia*?) and *Claracrusta*, commonly forming *Osagia*-type oncoids and recording the presence of microbial communities. The occurrence of such diverse assemblages was interpreted by Merino-Tomé *et al.* (2009b) as linked to increased levels of nutrients that resulted from siliciclastic input related to land-derived runoff.

Brachiopods

In the Ándara Massif, only brachiopods collected in two localities had been studied so far. The abundant and well preserved brachiopods from the Castillo del Grajal (locality 2 in Figs. 2-4; same as locality U-252 of Martínez Chacón & Winkler Prins, 1985) are listed in Table 1.

The rich and varied brachiopod fauna from the Morra de Lechugales (locality 1 in Figs. 2-4) is also reported in Table 1. The list includes 38 different taxa. Productida (13 species) and Spiriferida (12 species) are the most important orders. They are followed in abundance by Rhynchonellida (four species), Athyridida and Spiriferinida (three species each of them), and by Orthotetida, Orthida and Terebratulida (only one taxon each). Although the brachiopods are abundant, the specimens are usually broken, eroded and corroded. In many spiriferids (especially in the case of the Spiriferellidae) only the strong posterior part of ventral valves is preserved. The micro-ornamentation is difficult to see since it is usually preserved only in small parts of a few valves. Consequently, their study and certain identification are rather difficult. This is the main reason why some taxa are named in open nomenclature.

Table 1. Kasimovian brachiopods from localities in Picos de Europa Unit. Key: 1 – Morra de Lechugales; 2 – Castillo del Grajal; 3 – Las Llacerias; 4 – Demués section; 5 – Demués area (isolated localities); 6 – Arenas de Cabrales; 7 – Arenas de Cabrales area (isolated localities). See Figure 2 for locality map; see Figure 3 for correlation.

Brachiopods	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Isogramma aff. *paotechowensis* (Grabau & Chao)				×			
Isogramma sp.				×	×		
Subglobosochonetes sp.					×		
Rugosoghonetes? *latesinuatus* (Schellwien)	×			×		×	

Brachiopods	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Chonetinella? *jungchangensis* Chao	×						
Chonetinella sp.					×	×	×
Paramesolobus sinuosus (Schellwien)						×	×
Lissochonetes? *obtusus* (Schellwien)	×						
Sokolskya? sp. nov. ex gr. *rarispina* (Schellwien)	×					×	
Chonetoidea indet.				×			
Paramarginiferini indet.				×			
Comuquia curvirostris (Schellwien)	×				×		
Comuquia sp.				×			
Krotovia sp.	×	×					
Incisius aff. *incisus* (Schellwien)	×						
Incisiinae indet.				×	×	×	
Hexiproductus echidniformis (Chao)		×	×			×	
Hystriculina? sp.				×			
Kozlowskia splendens (Norwood & Pratten)	×						
Kozlowskia cabraliega Martínez Chacón	×	×		×		×	×
Kozlowskia sp.		×		×	×	×	
Kutorginella cf. *dastarensis* Volgin				×			
Kutorginella? sp.	×				×		
Alexenia cf. *gratiodentalis* (Grabau)					×	×	
Alexenia sp.					×		
Reticulatia cf. *transversalis* (Tschernyschew)				×			
Admoskovia? sp		×		×		×	
Yakovleviinae indet.	×						
Buxtoniini indet.				×			
Echinaria? sp.				×		×	
Karavankina cf. *fasciata* (Kutorga)				×			
Karavankina paraelegans (Sarytcheva)				×			
Karavankina cf. *rakusci* Winkler Prins					×		
Karavankina n. sp.	×						
Karavankina sp.	×			×	×	×	
Juresania sp.						×	
Linoproductus cf. *coralineatus* Ivanov						×	
"Linoproductus" sp.				×			
"Cancrinella" sp.				×	×		
Linoproductinae indet.				×			
Productoidea indet.				×			
Derbyia sp.	×						
Streptopomum? cf. *mjatschowense* (Sokolskaja)		×					
Schuchertella sp.					×		
Orthotetidina indet.				×			
Rhipidomella cf. *carbonaria* (Swallow)	×						
Rhipidomella cf. *cora* d'Orbigny				×			
Rhipidomella sp.		×			×	×	
Enteletes lamarcki (Fischer de Waldheim)		×			×		
Enteletes sp.					×		
Orthotichia aff. *pentamera* (Eichwald)		×					
Orthotichia sp.					×		
Pugnax cf. *tetraformis* Kalashnikov		×					
Stenoscisma cf. *alpinum* (Schellwien)	×	×			×	×	
Stenoscisma cf. *mutabile* (Tschernyschew)	×			×			
Stenoscisma sp.	×			×	×		

Brachiopods	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Camerisma sp.					×		
Rhynchopora cf. *illinoisensis* (Worthen)		×					
Pontisia sp.				×			
Rhynchonellida indet.	×			×			
Cleiothyridina cf. *pectinifera* (Sowerby)					×		
Cleiothyridina sp.	×	×		×	×		
Composita sp.				×			
Athyrididae indet.	×						
Hustedia miseri Mather	×						
Hustedia sp.		×			×	×	
Crurithyris? sp.	×			×			
Martinia cf. *changchiakouensis* Chao						×	×
Martinia? *karawanica* Volgin	×	×					
Tiramnia cf. *semiglobosa* (Tschernyschew)		×		×			
Tiramnia cf. *tschernyschewi* Grunt	×			×			
Tiramnia? sp.				×	×		
Jilinmartinia sp.	×						
Sergospirifer? sp.				×			
Brachythyrina cf. *carnica* (Schellwien)	×	×	×			×	×
Brachythyrina cf. *strangwaysi* (Verneuil)				×			
Brachythyrina sp.				×			×
Elinoria rectangula (Kutorga)				×			
Elinoria sp.				×			
Choristites myatschkovensis Fredericks		×					
Choristites? sp.	×			×			
Alphachoristites sp.		×		×	×	×	
Carthorium sp.		×					
“Neospirifer” cf. *dunbari* King		×					
“Neospirifer” sp.						×	×
Gypospirifer sp.	×						
Tegulispirifer cf. *tegulatus* (Trautschold)			×				
Plicatospiriferella winklerprinsi n. sp.	×			×			
Winklerprinsia europea n. gen., n. sp.	×						
Spiriferellidae indet.	×						
Spiriferoidea indet.				×			
Cantabriella sp.	×			×			
Phricodothyris cf. *asiatica* (Chao)		×					
Phricodothyris cf. *pyriformis* Pavlova	×						
Phricodothyris cf. *rostrata* (Kutorga)						×	
Phricodothyris sp.				×	×		×
Spiriferida indet.				×			
Punctospirifer? sp.						×	
Gjelispinifera sp.	×			×	×		
Altiplecus? cf. *antiquus* Martínez Chacón				×			
Reculariina? sp.							×
Paraspiriferina? sp.					×		
Zaissania sp.					×		
Spiriferellina? cf. *campestris* (White)					×		
Spiriferellina? sp.	×			×			
Spiriferellinidae indet.	×						
Cranaenidae indet.	×						
Terebratulida indet.				×			

In the order Productida, the suborder Chonetidina is represented by four species included in four genera. One of them, *Sokolskya*? ex gr. *rarispina* (Schellwien, 1892), is probably new. This species was also found in other localities of the northern part of the Picos de Europa Unit (Martínez Chacón & Winkler Prins, 1985, 2005), but has yet to be described. The other nine species correspond to the productids of the suborder Productidina; *Kozlowskia splendens* (Norwood & Pratten, 1855), *K. cabraliega* Martínez Chacón, 1982, and *Incisius* aff. *incisus* (Schellwien, 1900) are the most abundant. Perhaps owing to its multiple and short trails that strengthen the shell, *Kozlowskia cabraliega* is the best preserved species of this assemblage and is known from some particularly beautiful specimens. *Incisius* Grant, 1976, is a small genus represented by a species close to *I. incisus,* but with a more anterior origin of the sulcus. *Incisius incisus* was originally reported from the Lower Permian Trogkofel Limestone in Karavanken Mountains. Winkler Prins (*in* Wagner & Winkler Prins, 1970, p. 537) also described the species, as *"Horridonia" incisa*, from the Kasimovian Brañosera Formation (Palencia province, northern Spain). The occurrence of a small species of the genus *Karavankina* Ramovs, 1969, listed as *Karavankina* sp. nov., is also remarkable. This species looks like *K. schellwieni* Ramovs, 1969, but it is smaller in size and has thinner dorsal adductor scars; it also resembles *K. paraelegans* (Sarytcheva, 1968), especially the specimens described by Winkler Prins (*in* Wagner & Winkler Prins, 1970), differing by the slightly transverse shell (never elongate) of the specimens from Morra de Lechugales. Some of the 12 species of Spiriferida are represented by many individuals, especially the new species of the Family Spiriferellidae, *Plicatospiriferella winklerprinsi* and *Winklerprinsia europea*, although *Crurithyris* sp., *Martinia*? *karavanika* Volgin, 1959, and *Phricodothyris* cf. *pyriformis* Pavlova, 1969, are also relatively abundant.

Stenoscisma cf. *alpinum* (Schellwien, 1892) and *S.* cf. *mutabile* (Tschernyschew, 1902) among the Rynchonellida, and *Cleiothyridina* sp. and *Hustedia miseri* Mather, 1915, among the Athyridida, are relatively abundant. The rest of species are only represented by a few specimens.

Most of the brachiopod species from La Morra de Lechugales are known from the upper Moscovian and, especially, from the Kasimovian of different parts of the world. The closest palaeobiogeographical affinities are with the Carnic Alps and the Karavanken Mountains (brachiopods from these areas are described by Schellwien, 1892, 1900; Ramovs, 1969, among others). Similarities with the Moscow basin and other regions in the northern margin of the Palaeotethys, such as China, and with the Urals are also strong.

On the whole, the fauna coming from marls is small-sized. The length and width of many brachiopod species do not reach 10 mm (this is the case of *Comuquia curvirostris* (Schellwien, 1892), *Incisius* aff. *incisus* (Schellwien, 1900), *Karavankina* sp. nov., *Rhipidomella* cf. *carbonaria* (Swallow, 1858), *Cleiothyridina* sp., *Hustedia miseri* Mather, 1915, Athyrididae indet. and Cranaenidae indet.). However, their dimensions are similar to those in other localities of the Cantabrian Mountains, Carnic Alps and Karavanken Mountains. The specimens belonging to taxa not identified at species level are within the usual range of size of their genera or family. The absence of larger taxa is remarkable, although a few larger spiriferid specimens (belonging to *Gypospirifer* sp. and *Choristites*? sp.) were found in interbedded bioclastic limestones.

The assemblages of Castillo del Grajal and La Morra de Lechugales have 12 genera and five species in common, but they also show striking differences such as the absence in the former of representatives of the family Spiriferellidae and the order Spiriferinida as well as the presence of some relatively big-sized taxa (*Admoscovia*? sp., *Choristites myatschkovensis* Fredericks, 1926, *Alphachoristites* sp., *etc.*) (compare numbers 1 and 2 in Table 1). Moreover, on the whole, the brachiopods from Castillo del Grajal are of normal size, not as small as those from Morra de Lechugales. The different environmental conditions, and the nature of the substrate envisaged from the analysis of the lithofacies and biota, might provide a suitable explanation for the striking differences reported in both brachiopod assemblages.

In the northern part of the Picos de Europa there are some fossil localities with late Moscovian-Kasimovian brachiopod assemblages (Figs. 2, 3). These localities correspond to the Las Lacerias Formation (locality 3) or to strata correlatable with this stratigraphic unit (Demúes Formation, localities 4 and 5). Also, younger brachiopod assemblages had been described in other localities close to this corresponding to the Puentellés Formation (localities 6 and 7; Figs. 2, 3).

A number of fossil groups have been reported from the Las Llacerias Formation (locality 3; Figs. 2, 3) (Villa *et al.*, 1993), but identification of brachiopods has been only possible in one horizon, corresponding to the lower part of the formation (Table 1, number 3). These brachiopods were found associated with gastropods, sponges and crinoids.

The Demués section (locality 4), which exposes the Demués Formation, is described in detail by Sánchez de Posada *et al.* (1999, 2002) and constitutes one of the most fossiliferous successions of Kasimovian rocks known in the Cantabrian Zone (Figs. 2, 3). The fossil content of the section (detailed in the appendix of the aforementioned papers) include many different benthic groups, especially brachiopods, poriferans, molluscs, foraminifers and ostracodes, and palynomorphs. Brachiopods are the dominant group in these assemblages (Table 1, number 4).

Other brachiopod fauna from some isolated Kasimovian localities, outcropping in the area close to Demués (T-227, 228, 229, 231, WP-623B, 625, in Martínez Chacón & Winkler Prins, 1985) and corresponding to the Gamonedo? and Demués formations (Figs. 2 and 3) are included in Table 1, number 5.

The best site in the Puentellés Formation (locality B-126 of Martínez Chacón & Winkler Prins, 1985; locality 6 in Figs. 2, 3) is situated at the southeast of Arenas de Cabrales (Asturias). The abundant and reasonably well preserved brachiopods are listed in Table 1, number 6. Other localities close to Arenas (Inguanzo and Berodia; Martínez Chacón & Winkler Prins, 1985; locality 7, Figs. 2, 3 herein) have a much less abundant fossil content; the brachiopods of all of them are given on Table 1.

Fusulinids and age of the fossiliferous beds

The fossiliferous strata of the Morra de Lechugales Peak corresponding to the uppermost part of Sequence 1 and the lower part of the Sequence 2 of the Las Llacerias Formation (Fig. 5) were first mentioned by Maas & Ginkel (1983), who pointed out the existence of fusulinid-rich beds belonging to the *Protriticites* Zone. Ginkel & Villa (1991) further studied the locality, and identified an assemblage containing *Ozawainella* ex gr. *mosquensis*? Rauzer-Chernousova (*in* Rauzer-Chernousova *et al.*, 1951), *Pseudostaffella* cf. *sphaeroidea cuboides* Rauzer-Chernousova (*in* Rauzer-Chernousova *et al.*, 1951), *Fusiella* cf. *rawi* (Lee, 1927), *Protriticites* ex gr. *grosdilovae* (Miklukho-Maklay, 1949) and *Fusulina*

(*Quasifusulinoides*?) sp. 1. They correlated these beds with the top of the Picos de Europa Formation. However, they pointed out that the Morra de Lechugales beds exhibit significant differences in both lithology and fossil content to typical Picos de Europa Formation.

Recent sedimentological and biostratigraphical studies (Merino-Tomé *et al.*, 2009b; Villa *et al.*, 2009) have shown that Morra de Lechugales strata are younger than the Picos de Europa limestones and correlated them with the Las Llacerias Formation. A new sampling of this section yielded fusulinid species at the middle part of Sequence 1 and the lower part of Sequence 2 (Villa *et al.*, 2009) (Fig. 5). The fusulinid assemblages in these samples are composed of species belonging to *Fusiella, Protriticites*, *Pseudotriticites*? and *Quasifusulinoides,* with rare *Ozawainella.*

Some of the *Protriticites* representatives show subcylindrical shape resembling *Pr. mirabilis* (Kireeva, 1950), (Pl. 6, fig. 1) and *Pr. lamellosus* Kireeva, 1950 (Pl. 6, fig. 2); they exhibit a thin, four-layered wall, as is typical for *Protriticites*. One *Protriticites* form from sample LE-5 shows characteristics not yet documented in the literature and, therefore, it is described as *Protriticites winkleri* sp. nov. Forms questionably assigned to *Pseudotriticites* have a three-layered wall and are reminiscent of *Quasifusulinoides;* however, their rhombic shell and regular septal folding rather point to the genus *Pseudotriticites* (Pl. 6, figs. 7, 8). *Quasifusulinoides* is present in several samples. *Fusiella* specimens are close to *F. lancetiformis* Putrja.

These specimens are the focus of research in progress. Although their assignation is still tentative, their characteristics allow the establishment of some biostratigraphic conclusions. The most relevant observation concerns the wall microstructure of some *Protriticites* specimens, which show features transitional to *Montiparus,* so suggesting that they belong to the upper or uppermost part of the *Protriticites* Zone. The presence of forms resembling *Pr. mirabilis* Kireeva, 1950 (Pl. 6, fig. 1) also point to a high position within the *Protriticites* Zone. On the other hand, a sample collected from a nearby section exposing laterally equivalent strata provided a *Protriticites* species (sample AND-8; Pl. 6, fig. 3) resembling *Obsoletes* aff. *magnus* Kireeva, 1950, from the Voskresenks Formation of the Moscow Basin (Makhlina *et al.*, 2001; Goreva *et al.*, 2009) of late Krevyakinian age. We conclude that the fossiliferous beds of the Morra de Lechugales section belong to the higher part of the *Protriticites* Zone and are of late Krevyakinian age. It must be noticed, however, that the top of the section (higher 50 m) have not been sampled yet and, therefore, it cannot be excluded that these youngest beds could correlate with the basal Khamovnikian.

Systematic palaeontology
Phylum Brachiopoda

Remarks – This section deals with the representatives of the family Spiriferellidae found in the Morra de Lechugales locality. This is the first time that members of this family from the Cantabrian Mountains are described. The material includes a new genus and species (*Winklerprinsia europea* gen. et sp. nov.) and a new species of the genus *Plicatospiriferella*. The classification and terminology of Carter (2006) in the revised *Treatise on Invertebrate Paleontology* is followed herein. The specimens are deposited in the Department of Geology, University of Oviedo, Spain.

Order Spiriferida Waagen, 1883
Suborder Spiriferidina Waagen, 1883
Superfamily Spiriferoidea King, 1846
Family Spiriferellidae Waterhouse, 1968

Diagnosis – (After Carter, 2006, p. 1805.) "Lateral slopes plicate, coarsely costate to fasciculate; fold usually with median furrow; delthyrium commonly partially or completely occluded by convex stegidial plates; hinge line denticulate (poorly developed in narrow-hinged genera); micro-ornament pustulose, commonly capillate; ventral interior with strong, short dental adminicula; ventral umbonal region often greatly thickened by callus with deeply impressed ventral muscle field."

Remarks – The name was introduced by Waterhouse (1968) as a subfamily within the family Brachythyrididae and transferred to family level by Carter (*in* Carter *et al.*, 1994). Termier *et al.* (1974) proposed Spiriferellidae as a new family, apparently ignoring the earlier proposal of Waterhouse.

The family ranges from Pennsylvanian (Moscovian) to Permian (Lopingian). Only three of the 14 genera included in the family by Carter (2006) and Gourvennec & Carter (2007) started in the Pennsylvanian: *Spiriferella* Tschernyschew, 1902 (Pennsylvanian-Permian [Capitanian]), *Eridmatus* Branson, 1966 (Moscovian-Asselian) and *Plicatospiriferella* (Moscovian-?Gzhelian). The family was much more abundant and diverse in the Permian. Systematics, evolution, palaeoecology, palaeobiogeography and taphonomy of this family were discussed by Cooper & Grant (1976), Grant (1976), Legrand-Blain (1977), Waterhouse *et al.* (1978), Waterhouse & Waddington (1982), Archbold & Thomas (1985) and Angiolini (2001), among others.

A characteristic of this family is the thickened posterior part of the ventral valve. This feature, along with the covered delthyrium and long ventral interarea, suggest that these genera probably did not live attached by a pedicle, but rested on the sea bed on the ventral valve with the anterior slanting obliquely upward, stabilized by its own weight in the surrounding sediment (Cooper & Grant, 1976; Waterhouse *et al.*, 1978; Waterhouse & Waddington, 1982). The Cantabrian material mainly consists of ventral valves, with the anterior part broken and the thickened posterior preserved; complete shells, dorsal valves and even complete ventral valves are rare. This is in accordance with the observations of Cooper & Grant (1976), who attributed this fact to the mode of life inferred for this family. Moreover, our specimens are usually eroded and corroded, which is indicative that after death they rest for a long time on the sea bed and perhaps suffered some transport before becoming totally buried by sediment.

Genus *Plicatospiriferella* Waterhouse & Waddington, 1982

Type species – *Plicatospiriferella canadensis* Waterhouse & Waddington, 1982, by original designation.

Diagnosis – Small Spiriferellidae, with six or more simple plications on each lateral slope that extend to anterior margin; few costae except in sulcus and fold; fold and sulcus moderately developed; fold crest narrow and rounded or with shallow median groove; hinge alate; micro-ornament consisting of capillae and concentrically arranged, small, slightly transverse pustules.

Remarks – The genus is distinguished from *Spiriferella* by its lateral slopes provided with numerous plicae, being all or most of them simple, as well as by its alate hinge. *Eridmatus* is more elongate and has lateral slopes with numerous strong, nearly uniform costae arranged in fascicles.

Besides the type species, Waterhouse & Waddington (1982) included in their genus *Spiriferella gjeliensis* Stepanov, 1939, and *Spiriferella praesaranae* Stepanov, 1948, although they considered that these two species may be synonymous. The genus ranges from Moscovian (Podolian) to early Permian (Asselian) in Moscow Basin, Urals, Russian Arctic and Canadian Yukon Territory. The new species described below extends the geographical distribution of the genus.

Plicatospiriferella winklerprinsi Martínez Chacón sp. nov.

Pls. 1, 2; Pl. 3, figs. 1-5.

. 1999 *Plicatospiriferella* n. sp.; Sánchez de Posada *et al.*, pp. 351, 352.
. 2002 *Plicatospiriferella* n. sp.; Sánchez de Posada *et al.*, p. 594.

Derivatio nominis – Named after Dr Cor F. Winkler Prins of the Nationaal Natuurhistorisch Museum Naturalis, Leiden, who introduced M.L. Martínez Chacón to the study of Carboniferous brachiopods.

Holotype – DGO 3582, specimen with the dorsal valve crushed and eroded (Pl. 1, figs. 1-4).

Type locality and horizon – Just below the summit of the Morra de Lechugales Peak, Picos de Europa (Cantabria, northern Spain). Beds with siliciclastic content from the lower interval, Sequence 2 of Las Llacerias Formation, Kasimovian (late Krevyakinian), sample TL-2 (Figs. 2-5).

Material – Besides the holotype, about 100 specimens, DGO 3583-3598, from the type locality and horizon.

Diagnosis – Small *Plicatospiriferella* with slightly transverse shell, dorsal valve only slightly convex lending the shell a low thickness; ventral umbo prominent and strongly incurved; sulcus deep and broad; plicae simple except those bounding the sulcus and on the fold.

Description – Shell small (Table 2), ventribiconvex, slightly transverse, subhexagonal in outline, alate, maximum width at hinge, frontal commissure uniplicate.

Ventral valve strongly convex, with prominent umbo incurved on the interarea; interarea denticulate, relatively long, slightly concave or flat, forming a low angle with the commissural plane, from anacline to apsacline; delthyrium bounded by grooves in which some stegidial cover should fit, posteriorly filled by apical callus. Sulcus starting at umbo, widening and deepening towards the front where it reaches a width more or less half the maximum width of the shell; the sulcus is bounded by two strong plicae wider and higher than the rest, which bifurcate in the interior of sulcus giving some three rounded and low costae on each sulcal flank; no median costa.

Table 2. Measurements in mm of some specimens of *Plicatospiriferella winklerprinsi* Martínez Chacón sp. nov. Key: L – length of ventral valve; Ld – length of dorsal valve; W – width; Wsul – width of sulcus; Th – thickness; Hiv – height of ventral interarea. The asterisk indicates the holotype.

Specimen	L	Ld	W	Wsul	Th	Hiv
*DGO 3582	15.04	11.46	16.38	9.51		
DGO 3584	>13.88	>11.13	~16.60	~9.40	8.75	3.40
DGO 3585	>13.18	9.27	~19.70	>9		3.16
DGO 3586	13.67	10.76	~19.76	8		
DGO 3588	11.92	8.41	11.2	5.85	5.57	
DGO 3589	>8.80		>8.60	>5.88		
DGO 3590	13.17		~14.60	7.55		2.8
DGO 3591	14.37		~18.20	8.83		2.9
DGO 3592	6.55	5.99	~9	3.67	4.39	
DGO 3593	8.64		~10.10	~3.78		2.59
DGO 3596	13.89		~20	>8.38		2.48

Dorsal valve gently and regularly convex, rather shorter than ventral valve; interarea very short, anacline. Fold rounded and low, with some two costae on each flank branching from a central one; no median groove has been seen.

Lateral slopes of both valves carrying 4-6 (usually 5) plicae besides those bounding the sulcus; plicae are rounded and simple; their width and height decrease towards the postero-lateral ends, which are smooth. Micro-ornament capillate and pustulose, with some pustules slightly transverse.

Ventral interior with stout teeth, short diverging adminicula continuing anteriorly as ridges bordering the muscle field; umbonal region greatly thickened by callus, burying the adminicula; muscle field deeply impressed, anteriorly elevated, rhomboidal elongate in outline, divided by a low and thin median ridge; adductor scars long, narrow, clearly differentiated, bordered by the much bigger diductors; both sides of muscle field with big genital pits.

Dorsal interior with wide ctenophoridium and stout inner socket ridges. Other characters not observed.

Remarks – The shape, ornament and micro-ornament of the new species fit with the diagnosis of *Plicatospiriferella*, and is similar to that of the type species. However, *P. winklerprinsi* differs from that species in being smaller (more or less half sized), with all the plicae on flanks simple, strongly incurved ventral umbo, broader sulcus and less shell thickness owing to the low curvature of its dorsal valve. *Plicatospiriferella gjeliensis* (Stepanov, 1939) has a grooved fold, and a more elongate and less alate shell than the new species.

Occurrence – Besides the type locality, the new species was also found in the Demués Formation, Demués section (Figs. 2, 3, number 4; Table 1).

Genus *Winklerprinsia* Martínez Chacón gen. nov.

Type species – *Winklerprinsia europea* Martínez Chacón sp. nov.

Derivatio nominis – Named after the well-known brachiopodologist, Dr Cor F. Winkler Prins, Nationaal Natuurhistorisch Museum Naturalis, Leiden.

Diagnosis – Shell small, ventribiconvex, rounded in outline, roughly equidimensional, with rounded cardinal extremities; fold and sulcus well developed, smooth, fold lacking median groove; lateral slopes with 5-6 simple plicae, strong near the middle of the shell, and strongly decreasing in width and height towards the posterolateral ends; micro-ornament consisting of concentric fila and pustules. Long ventral interarea; delthyrium bounded by grooves and with some apical stegidial cover; short ventral adminicula almost indistinguishable; a solid platform, resting on the valve floor and very elevated anteriorly, lies between the adminicula burying them; the platform continues anteriorly as a tongue; its upper side bends dorsally and bears a low median ridge.

Remarks – The genus is included in the family Spireferellidae because of its plicate lateral slopes, pustulose micro-ornament, ventral umbonal region thickened by callus and short dental adminicula. Owing to poor preservation, the micro-ornament is only visible on small parts of a few specimens, but it is possible to see that radial capillae characteristic of most genera are lacking. Except for this, the genus fits in with the familial diagnosis. Moreover, into the family were included genera with different micro-ornament, which, in turn, allowed its subdivision. Angiolini (2001) divided the Spiriferellidae in two subfamilies, the Spiriferellinae, characterised by a wide hinge, strongly plicate lateral slopes and pustulose micro-ornament, and the Hunzininae, characterised by a narrow hinge, non-plicate lateral slopes ornamented by costae, and costellae and micro-ornament of predominantly concentric lamellae. Waterhouse (2004) added a third subfamily, Elivinae, characterised by a narrow hinge, plicae virtually absent, micro-ornament without pustules and little or not secondary ventral thickening. The new genus, with hinge relatively narrow, plicate lateral slopes, micro-ornament of concentric lirae and pustules, does not fit in with any of the aforementioned subfamilies. For this reason and following Carter (2006), we did not consider the position of this new genus in a subfamily.

Its outline, narrow hinge line with rounded cardinal extremities, and lateral slopes with coarse and simple plicae, link *Winklerprinsia* to the superfamily Brachythyridoidea. The new genus superficially resembles the external morphology of *Cathayspirina* Liang, 1990, or *Ella* Fredericks, 1918, although the latter has several faint costae on the fold and sulcus. But the ventral interior of *Winklerprinsia* is very different and characteristic for the Spiriferellidae.

Among the Spiriferellidae, the exterior of the new genus is very similar to *Arcullina* Waterhouse, 1986, especially to the type species, *A. polaris* (Wiman, 1914), by its fold without a median groove and simple plicae on its lateral slopes. By its outline and profile, the genus described here also resembles *Spiriferella*, but this genus has costate fold and sulcus, a fold with a median groove and lateral slopes with splitting, sometimes fasciculate costae. These two genera differ from *Winklerprinsia* in lacking the elevated ventral platform, which is here interpreted as a muscle platform (see below).

Species included – Type species only.

Winklerprinsia europea Martínez Chacón sp. nov.

Pl. 3, figs. 6-14; Pl. 4; Pl. 5, fig. 1.

Derivatio nominis – The species is named after the Picos de Europa mountains where the type locality is located.

Holotype – DGO 3599, an almost complete specimen (Pl. 3, figs. 6-11).

Type locality and horizon – The same as *Plicatospiriferella winklerprinsi*.

Material – Besides the holotype there are about 30 specimens, DGO 3600-3612.

Diagnosis – As for the genus.

Description – Shell small (Table 3), ventribiconvex, more or less equidimensional, rounded in outline, with rounded cardinal extremities and maximum width in front of the midlength; frontal commissure uniplicate.

Ventral valve longer than the dorsal one, with prominent umbo slightly incurved on the interarea, which is narrow, long, curved, apsacline to almost orthocline; the interarea bears growth lines parallel to the hinge, crossed by vertical striations, although denticles are not apparent; delthyrium bounded by grooves, partially filled by callus and covered apically by a stegidial cover; sulcus starting at umbo, distinct, but shallow, smooth, widening moderately towards the front; lateral slopes with six simple costae each in adults, the strongest bounding the sulcus and rapidly decreasing in width and height laterally, the sixth being almost imperceptible; costae rounded and interspaces of dimensions similar to costae. Micro-ornament of concentric fila and pustules.

Dorsal valve gently and regularly convex, clearly shorter than ventral; interarea very short, anacline; fold low, starting at umbo, lacking median groove and widening towards the front in accordance with sulcus; lateral slopes with five costae of similar characteristics than that on the ventral valve. Micro-ornament as the other valve.

Table 3. Measurements in mm of some specimens of *Winklerprinsia europea* Martínez Chacón sp. nov. Key as for Table 2 apart from the following: Wh – width of hinge; Lpm – length of muscle platform; Hpm – height of muscle platform. The asterisk indicates the holotype.

Specimen	L	Ld	W	Wh	Th	Hiv	Lpm	Hpm
* DGO 3599	10.23	9.05	~13.2	8.2	6.66	2.52		
DGO 3600	13.16		14.1	9.6		4.2		
DGO 3601	13.71	9.45	13.7	9.35	8.22	3.8		
DGO 3603							4.06	1.85
DGO 3604							5.19	3.03
DGO 3605							4.22	1.5
DGO 3606							5.07	2.31
DGO 3607	13.7	10.51	15.59	10.8		4.4		
DGO 3608	3.53	3.1	3.61	2.12	2.08			
DGO 3609	13.79	11.5	11.92	9.05	8.47	3.04		
DGO 3610	6.75	5.9	~7.6		4.1			

Ventral interior thickened apically, with very short diverging adminicula; between adminicula a platform, tongue-like in shape, is developed (Pl. 4, figs. 6, 8-11; Pl. 5, fig. 1), making the adminicula almost indistinguishable; the platform is thick, rests on the valve floor and is very elevated anteriorly, bending in dorsal direction; its upper side bears a low median ridge. On the valve floor, some genital pits are developed laterally; towards the front, a few grooves corresponding to mantle canals are observed; area just in front of the platform not clearly observed.

Dorsal interior unknown except for a wide ctenophoridium.

Remarks – The presence of an elevated platform in the postero-ventral region, coupled with the long ventral interarea and the situation of the ctenophoridium, indicates that the diductor muscles were attached on the platform, extending from there to the ctenophoridium. The adductors may have been attached on the valve floor in front of the platform, but the impossibility of observing this area in detail prevents the author from stating if these muscles are actually attached on the valve floor or on the muscle platform, together with the diductors. The ventral muscle field of the Spiriferellidae is deeply impressed; for *Spiriferella*, it "is often cupped or elevated anteriorly above the floor of the valve... to retain the base of the muscle insertions at an angle favourable for operating on the dorsal valve" (Waterhouse *et al.*, 1978, p. 418). Although a muscle platform like that of *Winklerprinsia* has never been described for a member of the family, it could be a structure with the utility mentioned by Waterhouse *et al.* (1978), that is approaching the ventral base of muscles to the ctenophoridium and to the floor of the dorsal valve. The muscles were probably arranged in the same way as that illustrated for *Tipispirifer oppilatus* Grant, 1976 (text-fig. 22, therein), but with a muscle platform instead of the false spondylium formed by the nearly convergent dental plates.

Comparisons – By its thickened umbo, short adminicula, well developed fold and sulcus, slightly convex dorsal valve, plicate lateral slopes and pustulose micro-ornament, *W. europea* is similar to *Plicatospiriferella winklerprinsi*, occurring in the same locality. Both species differ, however, by the narrow hinge, smooth fold and sulcus, as well as the ventral muscle platform of *W. europea*.

The exterior of *W. europea* is also similar to *Arcullina* and *Spiriferella*. The differences between the new species and these genera are pointed out in the remarks on the genus *Winklerprinsia*.

Occurrence – Type locality only.

Spiriferellidae gen. et sp. indet.

Pl. 5, figs. 2-5.

Material – Nine incomplete ventral valves, DGO 3613-3615, from the locality of Morra de Lechugales.

Description – Ventral valve moderately convex, small or medium sized, transverse. Complete valves have not been found; the largest preserved specimens are 19 mm in length and 25 mm in width; umbo strongly incurved on the interarea, which is longitudinally striated; delthyrium wide, covered apically by a stegidium; sulcus starting at umbo, moderately shallow, bounded by two strong plicae which bifurcate twice towards the interior of sulcus giving two costae on each sulcal flank; no median costa; lateral slopes with about five plicae, low and simple, except that bounding the sulcus which splits at least once; micro-ornament pustulose.

Ventral interior with umbonal region greatly thickened by callus, with stout teeth and short adminicula diverging anteriorly, buried by callus and continuing anteriorly as ridges bordering the muscle field; muscle field deeply impressed, lanceolate in shape, with a short and strong posterior median ridge, which is continuation of the callus; a low and thin median ridge longitudinally divides the muscle field; adductor scars long and narrow, bordered by the wider diductor scars; sides of muscle field with big genital pits.

Remarks – The ventral valves are fragmentary and eroded, so it is difficult to attribute them to any known genera of the family. The transverse outline links them to *Alispiriferella* Waterhouse & Waddington, 1982, and *Timaniella* Barkhatova, 1968. With *Alispiriferella*, these indeterminate specimens also share the type of ornamentation of sulcus and characteristics of ventral interior. However, judging from the fragmentary material on hand, the Spanish specimens seem to have a more transverse outline and simple lateral plicae. *Timaniella* differs from the Spanish specimens in its fasciculate ornament and sulcus with a median plica. The ventral interior of the indeterminate ventral valves is similar to that of the new species *Plicatospiriferella winklerprinsi* (which occurs in the same locality), but differs from it by its transverse shell, shallow sulcus and greater size.

Foraminifera
Superfamily Fusulinoidea Möller, 1878
Family Fusulinidae Möller, 1878
Genus *Protriticites* Putrya, 1948
Protriticites winkleri Villa sp. nov.
Pl. 6, figs. 4-6.

Derivatio nominis – Named after Dr. Cor F. Winkler Prins of the Nationaal Natuurhistorisch Museum Naturalis, Leiden.

Holotype – LE5-F5/9, axial section (Pl. 6, fig. 6).

Type locality and horizon – Morra de Lechugales Peak, Picos de Europa (Cantabria, northern Spain). Las Llacerias Formation (Sequence 2), Kasimovian (late Krevyakinian), sample LE5-F5 (Figs. 2-5).

Material – Three axial sections, one nearly axial section, two paraxial sections, two slightly oblique sections, and numerous parallel and oblique sections.

Measurements – Length: 3.45-4.75 mm; Diameter: 1.55-1.95 mm; L/D ratio: 2.23-2.55; number of whorls: 5.0-5.5; proloculous diameter: 100-125 μm; thickness of the penultimate whorl: 35-47 μm.

Repository – The specimens are deposited in the Department of Geology, University of Oviedo, Spain.

Diagnosis – Ellipsoidal shell with rounded poles and parallel or slightly convex median region. Chomata irregular and asymmetrical. Tunnel wide. Septa slightly folded in the polar ends. Wall consisting of four layers, tectum, diaphanoteca and thin tectoria, all of them pierced by fine pores.

Description – The form of the shell changes from oval or short fusiform in the inner whorls to ellipsoidal in one to two last volutions. Septal folding is confined to the polar areas, although in the last volution quite a wide undulation may extend occasionally over the tunnel. Chomata are asymmetrical and irregular, from wedge-shaped or rounded to flat-topped; they are wide, uncommonly reaching the poles and commonly low (less than half the chamber height, although they can be more prominent if isolated). The tunnel angle is about 70° in outer whorls. In the two first volutions the wall structure consists of three layers; subsequent volutions, except the last one, consist of four layers: tectum, a dark diaphanotheca and thin tectoria; in some specimens, the outer tectorium of the penultimate whorl is extremely thin or absent; thin pores pierce all layers.

Remarks – *Protriticites winkleri* sp. nov. somewhat resemble *Protriticites paraovoides* (Bensh, 1972) from Fergana and originally described as an *Obsoletes* species. *Protriticites winkleri* sp. nov. differs from the Fergana species by having more ellipsoidal shape, larger size, shorter L/D ratio, more rounded polar ends and larger proloculous. In addition, although Bensh mentioned a thin inner tectorium in some volutions, this type of secondary deposit, although poorly developed, seems to be more conspicuous in *P. winkleri.*

Age – Early Kasimovian, probably late or latest Krevyakinian.

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References

Angiolini, L. 2001. Permian brachiopods from Karakorum (Pakistan), pt. 3. *Rivista Italiana di Paleontologia e Stratigrafia*, **107**: 307-344.

Archbold, N.W. & Thomas, G.A. 1985. Permian Spiriferellinae (Brachiopoda) from Western Australia. *Alcheringa*, **9**: 35-48.

Bahamonde, J.R., Merino-Tomé, O.A. & Heredia, N. 2007. Pennsylvanian microbial boundstone-dominated carbonate shelf developed in a distal foreland margin (Picos de Europa Province, NW Spain). *Sedimentary Geology*, **198**: 167-193.

Bahamonde, J. R., Vera, C. & Colmenero, J.R. 2000. A steep-fronted Carboniferous carbonate platform: clinoformal geometry and lithofacies (Picos de Europa Region, NW Spain). *Sedimentology,* **47**: 645-664.

Barkhatova, V.P. 1968. Novye vidy pozdnepaleozoiskikh khorridonii severnogo Timana. *In*: Markowskii, B.P. (ed.), *Novye vidy drevnikh rastenii i bespozvonochnykh SSSR*, **2**: 98-100, 160-167. Nedra. Moscow. [In Russian.]

Bensh, F.R. 1972. *Stratigrafiya i Fuzulinidy Verkhnego Paleozoya Yuzkhnoy Fergany*. [*Stratigraphy and fusulinids from the Upper Palaeozoic in south Fergana*.] Tashkent, Izdatelstvo FAN, Akademiya Nauk Uzbekistan SSR: 146 pp. [In Russian.]

Branson, C.C. 1966. New genus of spiriferid brachiopod from Oklahoma and Texas. *Oklahoma Geology Notes*, **26**: 74-78.

Carter, J.L. 2006. Spiriferoidea. *In*: Kaesler, R.L. (ed.), *Treatise on Invertebrate Paleontology, Part H, Brachiopoda, Revised, vol. 5: Rhynchonelliformea (part)*: 1769-1811. Geological Society of America & University of Kansas, Boulder & Lawrence.

Carter, J.L., Johnson, J.G., Gourvennec, R. & Hou Hong-fei. 1994. A revised classification of the spiriferid brachiopods. *Annals of Carnegie Museum*, **63**: 327-374.

Cooper, G.A. & Grant, R.E. 1976. Permian brachiopods of West Texas, IV. *Smithsonian Contributions to Paleobiology*, **21**: 1923-2285.

Coquel, R. & Rodríguez, R. 1994. Palynology of the Picos de Europa and Puentellés Formations in the Picos de Europa area (Upper Carboniferous, northwest Spain). *Review of Palaeobotany & Palynology*, **80**: 65-74.

Cózar, P., Merino-Tomé, O. & Villa, E. 2007. New data (smaller foraminifers and correlation with depositional sequences) on the Las Llacerias section (Late Pennsylvanian, Cantabrian Mountains, NW Spain). *Facies,* **53**: 427-450.

Ernst, A. & Winkler Prins, C.F. 2008. Pennsylvanian bryozoans from the Cantabrian Mountains (northwestern Spain). *Scripta Geologica*, **137**: 1-123.

Fredericks, G.N. 1918. [On the adaptation of the apical-apparatus subdivision to the Brachiopoda's classification.] *Ezhegodnik Russkogo Paleontologicheskogo Obshchestva*, **2**: 85-91. [In Russian.]

Fredericks, G.N. 1926. Tablitsa dlya opredeleniia rodov semeistva Spiriferidae King. [Classification table of the genera of the family Spiriferidae King.] *Akademia Nauk SSSR, Izvestyia* (series 6), **20**: 393-423. [In Russian.]

Ginkel, A.C. van & Villa, E. 1991. Some fusulinids from the Moscovian-Kasimovian transition in the Carboniferous of the Cantabrian Mountains (NW Spain). *Proceedings, Koninklijke Nederlandse Akademie van Wetenschappen,* **94**: 299-359.

Ginkel, A.C. van & Villa, E. 1999. Late fusulinellid and early schwagerinid foraminifera: relationships and occurrences in the Las Llacerias section (Moscovian/Kasimovian), Cantabrian Mountains, Spain. *Journal of Foraminiferal Research*, **29**: 263-290.

Goreva, N.V., Alekseev, A.S., Isakova, T.N. & Kossovaya, O.L. 2009. "Sub-*Triticites* Beds" of the Donskaya Luka and Lower Boundary of the Kasimovian Stage. *Stratigraphy & Geological Correlation,* **17**: 43-61.

Gourvennec, R. & Carter, J.L. 2007. Spiriferida and Spiriferinida. *In*: Selden, P.A. (ed.), *Treatise on Invertebrate Paleontology, Part H, Brachiopoda, Revised, vol. 6: Supplement*: 2772-2796. Geological Society of America & University of Kansas, Boulder & Lawrence.

Grant, R.E. 1976. Permian brachiopods from southern Thailand. *Paleontological Society Memoir,* **9**: 269 pp.

Julivert, M. 1971. Décollement tectonics in the Hercynian cordillera of northwest Spain. *American Journal of Science*, **270**: 1-29.

King, W. 1846. Remarks on certain genera belonging to the class Palliobranchiata. *Annals & Magazine of Natural History,* **18**: 26-42, 83-94.

Kireeva, G.D. 1950. Novy vidy fuzulinid iz izvestnyakov svit C_3^1 i C_3^2 Donetskogo Basseyna. [New species of fusulinids from limestones of the series C_3^1 and C_3^2 of the Donets Basin.] *Materialy po stratigrafii i paleontologii Donetskogo Basseyna, Geologo- Issledovatel'skie Raboty, SSSR Glavnoe Upravlenie po Razved kam Uglya, Ministerstvo Ugol'noy Promyshlennosti*: 193-214. [In Russian.]

Lee, J.S. 1927. Fusulinidae of north China. *Palaeontologia Sinica* (series B), **4**: 1-172.

Legrand-Blain, M. 1977. Repartition du groupe de *Spiriferella rajah* (Salter, 1865), et description de *Spiriferella nepalensis*, sp. nov., appartenant a ce groupe. *In*: *Colloques Internationaux du C.N.R.S., nº 268 – Écologie et Géologie de l'Himalaya*: 237-250.

Liang Wenping. 1990. *Lengwu Formation of Permian and its brachiopod fauna in Zhejiang Province*. People's Republic of China, Ministry of Geology and Mineral Resources, Geological Memoirs (series 2), **10**: 522 pp. [In Chinese, with English summary.]

Lotze, F. 1945. Zur Gliederung der Varisziden der Iberischen Meseta. *Geotektonische Forschungen*, **6**: 78-92.

Maas, K. 1974. The geology of Liébana, Cantabrian Mountains, Spain. Deposition and deformation in a flysch area. *Leidse Geologische Mededelingen*, **49**: 379-465.

Maas, K. & Ginkel, A.C. van. 1983. Variscan olistostrome deposition and synsedimentary nappe emplacement, Valdeon area, Cantabrian Mountains, Spain. *Leidse Geologische Mededelingen*, **52**: 341-381.

Makhlina, M.Kh., Alekseev, A.S., Goreva, N.V. *et al.* 2001. *Middle Carboniferous of Moscow Syneclise (southern part). Volume 2. Paleontological Characteristics.* Nauchnyi Mir, Moscow: 328 pp.

Mamet, B. & Villa, E. 2004. Calcareous marine algae from the Carboniferous (Moscovian-Gzhelian) of the Cantabrian Zone (NW Spain). *Revista Española de Paleontología*, **19**: 151-190.

Marquínez, J., Méndez, C.A., Menéndez-Álvarez, J.R., Sánchez de Posada, L.C. & Villa, E. 1982. Datos bioestratigráficos de la sucesión carbonífera (Tournaisiense-Kasimoviense) de las Llacerías, Picos de Europa, Norte de España. *Trabajos de Geología, Universidad de Oviedo*, **12**: 187-193.

Martínez Chacón, M.L. 1982. El género *Kozlowskia* (Productidina, Brachiopoda) en el Carbonífero de la Cordillera Cantábrica (NO de España). *Trabajos de Geología*, *Universidad de Oviedo*, **12**: 73-82.

Martínez Chacón, M.L. & Winkler Prins, C.F. 1985. Upper Carboniferous (Kasimovian) brachiopods from Asturias (N Spain). *Comptes Rendu X Congrès International de Stratigraphie et de Géologie du Carbonifère, Madrid, 1983*, **2**: 435-448.

Martínez Chacón, M.L. & Winkler Prins, C.F. 2005. Rugosochonetidae (Brachiopoda, Chonetidina) from the Carboniferous of the Cantabrian Mountains (N Spain). *Geobios*, **38**: 637-651.

Martínez García, E. 1981. El Paleozoico de la Zona Cantábrica oriental (Noroeste de España). *Trabajos de Geología, Universidad de Oviedo*, **11**: 95-127.

Martínez García, E. & Villa, E. 1999. Edad de los primeros signos de actividad tectónica en el Carbonífero superior de los Picos de Europa (Asturias, NO de España). *Trabajos de Geología*, *Universidad de Oviedo*, **21**: 229-238.

Mather, K.F. 1915. The fauna of the Morrow Group of Arkansas and Oklahoma. *Bulletin of the Scientific Laboratories of Denison University*, **18**: 59-284.

Méndez, C.A. 2006. Upper Moscovian-middle Kasimovian conodonts (Pennsylvanian, Carboniferous) from the Las Llacerias Section (Cantabrian Zone, north Spain). *Geobios,* **39**: 245-254.

Merino-Tomé, O., Bahamonde, J.R., Colmenero, J.R., Heredia, N., Villa, E. & Farias, P. 2009a. Emplacement of the Cuera and Picos de Europa imbricate system at the core of the Iberian-Armorican arc (Cantabrian Zone, north Spain). New precisions concerning the timing of the arc closure. *Geological Society of America Bulletin*, **121**: 729-751.

Merino-Tomé, O.A., Bahamonde, J.R., Fernández, L.P. & Colmenero, J.R. 2007. Facies architecture and cyclicity of an Upper Carboniferous carbonate ramp developed in a Variscan piggy-back basin (Cantabrian Mountains, NW Spain). *In*: Nichols, G., Williams, E. & Paola, C. (eds.), *Sedimentary Processes, Environments and Basins: A Tribute to Peter Friend*. International Association of Sedimentologists, Special Publication **38**: 183-217.

Merino-Tomé, O., Bahamonde, J.R., Samankassou, E. & Villa, E. 2009b. The influence of terrestrial run off on marine biotic communities: An example from a thrust-top carbonate ramp (Upper Pennsylvanian foreland basin, Picos de Europa, NW Spain). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **278**: 1-23.

Merino-Tomé, O.A., Villa, E., Bahamonde, J.R., Colmenero, J.R. 2006. Fusulinoidean characterization of the uppermost Moscovian-Gzhelian (upper Pennsylvanian) synorogenic depositional sequences from northern Picos de Europa Unit (Spain). *Facies,* **52**: 521-540.

Miklukho-Maklay, A.D., 1949. *Verkhnepaleozoyskie fuzulinidy sredney Azii, Fergana, Darvaz i Pamir*. [*Upper Palaeozoic fusulinids of central Asia, Fergana, Darvaz and Pamir*.] Lenigradskiy Gosudartstvennyy Universitet: 111 pp. [In Russian.]

Möller, V. von. 1878. Die spiral-gewundenen Foraminiferen des russischen Kohlenkalks. *Mémoires de l'Academie Imperiale de Science* (série 7), **25**: 1-147.

Norwood, J.G. & Pratten, H. 1855. Notice of fossils from the Carboniferous Series of the western states, belonging to the genera *Spirifer, Bellerophon, Pleurotomaria, Macrocheilus, Natica* and *Loxonema*, with descriptions of eight new characteristic species. *Academy of Natural Sciences of Philadelphia Journal* (series 2), **3**: 71-77.

Pavlova, E.E. 1969. Razvitie brakhiopod semeistva Reticulariidae. *Akademiya Nauk SSSR, Trudy Paleontologicheskogo Instituta*, **120**: 130 pp. [In Russian.]

Pérez-Estaún, A., Bastida, F., Alonso, J.L., Marquínez, J., Aller, J., Álvarez Marrón, J., Marcos, A. & Pulgar, J.A. 1988. A thin-skinned tectonics model for an arcuate fold and thrust belt: the Cantabrian Zone. *Tectonics*, **7**: 517-537.

Pomar, L. 2001. Types of carbonate platforms: a genetic approach. *Basin Research*, **13**: 313-344.

Putrya, F.S. 1948. *Protriticites*, novy rod fuzulinid. [*Protriticites*, a new fusulinid genus.] *Trudy L'vovskogo Geologicheskogo Obshchestva pri Gosudarstvennom. Universitete im. Ivana Franko, Paleontologicheskaya Seriya*, **1**: 89-96. [In Russian.]

Ramovs, A. 1969. Karavankininae, nova podruzina produktid (Brachiopoda) iz alpskih zgornjekarbonskih in permijskih skladov. *Jeseniski Zbornik Jeklo in Ljudje*, **2**: 251-268.

Rauzer-Chernousova, D.M., Gryzlova, G.D., Kireeva, G.E., Leontovich, T.P., Safonova, T.P. & Chernova, E.I. 1951. *Srednekamennougolnye Fuzulinidy Russkoy Platformy i sopredelnykh oblastey*. [*Middle Carboniferous Fusulinids of the Russian Platform and adjacent regions*.] Akademiya Nauk SSSR, Institut Geologicheskiy Nauk, Moscow: 229 pp. [In Russian.]

Sánchez de Posada, L.C., Villa E., Martínez Chacón, M.L., Rodríguez, R.M., Rodríguez, S. & Coquel, R. 1999. Contenido paleontológico y edad de la sucesión de Demués (Carbonífero, Zona Cantábrica). *Trabajos de Geología, Universidad de Oviedo*, **21**: 339-352.

Sánchez de Posada, L.C., Villa E., Rodríguez, R.M., Martínez Chacón, M.L., Rodríguez, S. & Coquel, R. 2002. Paleontological content of the Demues section (Upper Carboniferous, Cantabrian Mountains, Spain) and its significance for correlation. *In*: Hills, L.V., Henderson, C.M. & Bamber, E.W. (eds.), *Carboniferous and Permian of the World*. Canadian Society of Petroleum Geologists, Memoir **19**: 832-850.

Sarytcheva, T.G. (ed.). 1968. Brakhiopody verkhnego paleozoya Vostochnogo Kazakhstana. *Akademiya Nauk SSSR, Trudy Paleontologicheskogo Instituta*, **121**: 212 pp. [In Russian.]

Schellwien, E. 1892. Die Fauna des karnischen Fusulinenkalks. 1 Theil. Geologische Einleitung und Brachiopoda. *Palaeontographica*, **39**: 1-56.

Schellwien, E. 1900. Die Fauna der Trogkofelschichten in den Karnischen Alpen und den Karawanken. 1 Theil: Die Brachiopoden. *Kaiserlich-Koenigliche Geologischen Reichsanstalt, Abhandlungen*, **16**(1): 122 pp.

Somerville, I.D. & Rodríguez, S. 2007. Rugose coral associations from the Late Viséan of western Tethys: examples from Ireland, Britain and Spain. *Schriftenreihe der Erdwissenschaftlichen Comisionen,* **17**: 329-351.

Stepanov, D.L. 1939. O stratigraphicheskom znachenii verkhnepaleozoiskikh brakhiopod. [On the stratigraphic significance of the late Palaeozoic brachiopods.] *Doklady Akademiya Nauk SSSR*, **25**: 755-758. [In Russian.]

Stepanov, D.L. 1948. Verkhnekamennougol'nye brakhiopody Bashkirii. *Trudy Vsesoyuznogo Neftyanogo Nauchno-Issledovatel'skogo Geologo-Razvedochnogo Instituta (VNIGRI)* (new series), **22**: 64 pp. [In Russian.]

Swallow, G.C. 1858. Descriptions of new fossils from the Coal Measures of Missouri and Kansas. *Transactions of Saint Louis Academy of Science*, **1**: 198-227.

Termier, G., Termier, H., Lapparent, A.F. de & Marin, P. 1974. Monographie du Permo-Carbonifère de Wardak (Afghanistan Central). *Documents des Laboratoires de Géologie de la Faculté des Sciences de Lyon* (hors serie), **2**: 167 pp.

Tschernyschew, T. 1902. Die obercarbonische Brachiopoden des Ural und des Timan. *Mémoires du Comité Géologique*, **16**(2): 749 pp.

Villa, E. & Ginkel, A.C. van. 1997. Early schwagerinids and accompanying fusulinid genera from the Kasimovian of the Cantabrian Mountains (Spain). *In*: Ross, C.A., Ross, J.R.P. & Brenckle, P.L. (eds.), *Late Paleozoic Foraminifera; Their Biostratigraphy, Evolution, and Paleoecology, and the Mid-Carboniferous Boundary*. Cushman Foundation for Foraminiferal Research, Special Publication **36**: 155-158.

Villa, E. & Ginkel, A. C. van. 2000. Some late Moscovian and Kasimovian fusulinaceans from the Las Llacerias section (Cantabrian Mountains, Spain). *Journal of Foraminiferal Research*, **30**: 219-243.

Villa, E., Ginkel, A.C. van, Leyva, F., Martínez Chacón, M.L., Méndez, C., Rodríguez González, R.M., Rodríguez, S. & Sánchez de Posada, L.C. 1993. Fossil content of the Moscovian-Kasimovian boundary in a section of the Picos de Europa area (Carboniferous, NW Spain). *Comptes Rendus XII ICC-P, Buenos Aires, 1991*, **2**: 384-406.

Villa, E., Merino-Tomé, O., Bahamonde, J. & Sanz-López, J. 2009. Note on recently discovered fossiliferous sections embracing the Moscovian/Kasimovian boundary (Andara Massif, Picos de Europa, NW Spain). *Newsletter on Carboniferous Stratigraphy*, **27**: 25-28.

Villa, E., Merino-Tomé, O., Bahamonde, J.R. & Ueno, K. 2003. Fusulinoideans from the Puentellés Formation (Upper Carboniferous, NW Spain): discussion on phylogeny, paleoecology and paleobiogeography. *Rivista Italiana di Paleontologia e Stratigrafia*, **109**: 241-253.

Volgin, V.I. 1959. New species of upper Paleozoic brachiopods (orders Rhynchonellida, Spiriferida and Terebratulida). *Paleontological Zhurnal*, **1959**: 115-125. [In Russian.]

Waagen, W.H. 1883. Salt Range fossils. I. Productus-Limestone fossils. *Geological Survey of India, Memoirs, Palaeontologia Indica* (series 13), **4**: 391-546.

Wagner, R.H. & Winkler Prins, C.F. 1970. The stratigraphic succession, flora and fauna of Cantabrian and Stephanian A rocks at Barruelo (prov. Palencia), NW Spain. *In*: *Colloque sur la Stratigraphie du Carbonifère*. Les Congrès et Colloques de l'Université de Liège, **55**: 487-551.

Waterhouse, J.B. 1968. The classification and description of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica*, **A129**: 1-94.

Waterhouse, J.B. 1986. New Late Palaeozoic invertebrate taxa. *Bulletin of the Indian Geologists' Association*, **19**: 1-8.

Waterhouse, J.B. 2004. *Permian and Triassic stratigraphy and fossils of the Himalaya in northern Nepal*. Earthwise, **6**: 285 pp.

Waterhouse, J.B. & Waddington, J. 1982. Systematic descriptions, paleoecology and correlations of the Late Paleozoic Subfamily Spiriferellinae (Brachiopoda) from the Yukon Territory and the Canadian Arctic Archipelago. *Geological Survey of Canada, Bulletin* **289**: 1-73.

Waterhouse, J.B., Waddington, J. & Archbold, N. 1978. The evolution of the Middle Carboniferous to Late Permian brachiopod Subfamily Spiriferellinae Waterhouse. *Geological Association of Canada, Special Paper* **18**: 415-443.

Wilson, M.E.J. & Vecsei, A. 2005. The apparent paradox of abundant foramol facies in low latitudes: their environmental significance and effect on platform development. *Earth Science Reviews*, **69**: 133-168.

Wiman, C. 1914. Über die Karbonbrachiopoden Spitzbergens und Beeren Eilands. *Nova Acta Regiae Societatis Scientiarum Upsalensis* (series 4), **3**: 1-92.

Plate 1

Plicatospiriferella winklerprinsi Martínez Chacón sp. nov., Kasimovian, Morra de Lechugales Peak.
Figs. 1-4. Holotype, DGO 3582. Ventral and dorsal views of a ventral valve with dorsal umbo preserved (x 4) and two details of the micro-ornament of ventral valve (× 9).
Figs. 5, 6. DGO 3583. Incomplete ventral valve in external and internal views, × 4.
Figs. 7-9. DGO 3584. Ventral, lateral and dorsal views of an incomplete specimen, × 4.
Figs. 10, 11. DGO 3589. Ventral valve in ventral view (× 5) and detail of the micro-ornament (× 16).

Figs. 3-11 taken with Stereoexplorer System Leica, financed by “Fondo Europeo de Desarrollo.”


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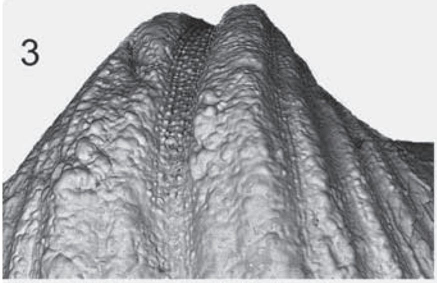
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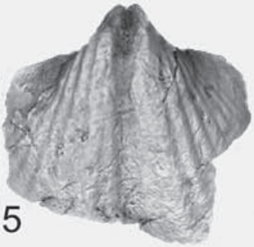
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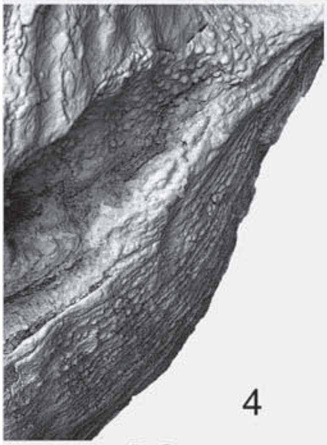
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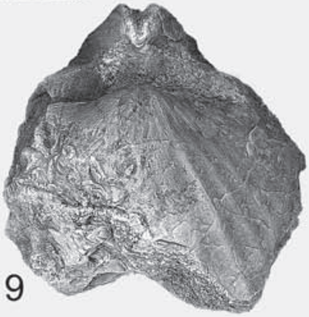
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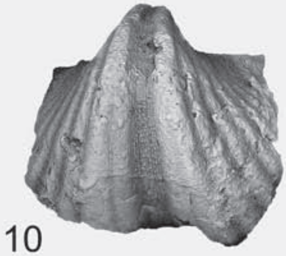
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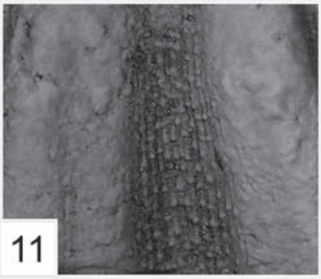
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Plate 2

Plicatospiriferella winklerprinsi Martínez Chacón sp. nov., Kasimovian, Morra de Lechugales Peak.
Figs. 1, 2. DGO 3585. Specimen with the valves slightly displaced each other, in ventral and dorsal views, × 4.
Fig. 3. DGO 3591. Ventral valve exterior, × 4.
Fig. 4. DGO 3587. Detail of a ventral valve showing the micro-ornament, × 10.
Fig. 5. DGO 3590. Ventral valve in external view, × 4.
Figs. 6-8. DGO 3586. Specimen with the dorsal valve broken, in ventral and dorsal views (× 4), and detail of ventral valve with micro-ornament (× 10).
Fig. 9. DGO 3594. Ventral valve internal view, × 4.
Fig. 10. DGO 3595. Ventral valve internal view, × 5.

Figs. 3-10 taken with Stereoexplorer System Leica, financed by “Fondo Europeo de Desarrollo.”


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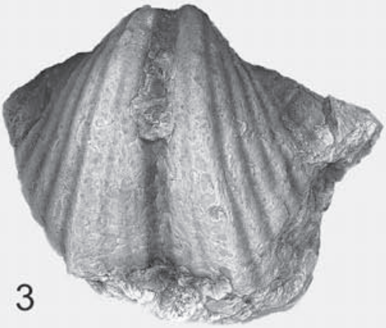
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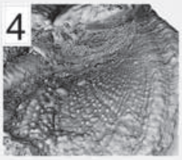
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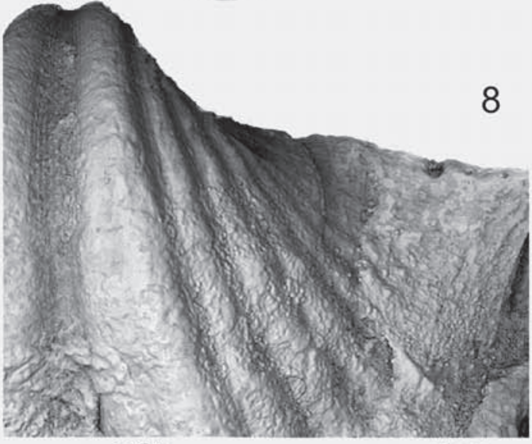
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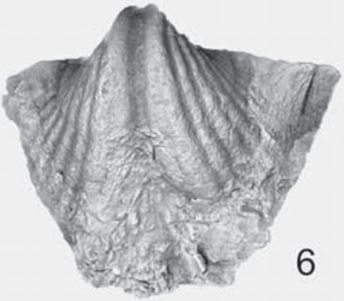
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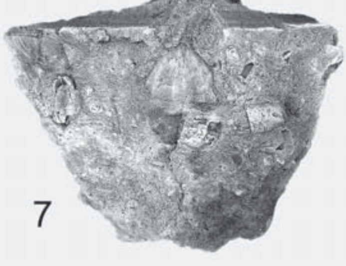
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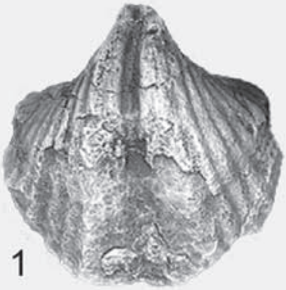
Plate 3

Figs. 1-5. *Plicatospiriferella winklerprinsi* Martínez Chacón sp. nov., Kasimovian, Morra de Lechugales Peak.
Fig. 1. DGO 3588. Ventral view of a ventral valve, × 4.
Figs. 2, 3. DGO 3593. Ventral valve in ventral view (× 5) and detail of micro-ornament (× 14).
Figs. 4, 5. DGO 3592. Small specimen in ventral and dorsal views, × 5.

Figs. 6-14. *Winklerprinsia europea* Martínez Chacón gen. et sp. nov., Kasimovian, Morra de Lechugales Peak.
Figs. 6-11. Holotype, DGO 3599. Ventral, dorsal, lateral, anterior and posterior views (× 4), and detail of dorsal valve with micro-ornament (× 14).
Figs. 12-14. DGO 3600. Ventral valve in ventral and posterior views (× 4) and detail of the exterior with micro-ornament (× 9).

Photos taken with Stereoexplorer System Leica, financed by “Fondo Europeo de Desarrollo.”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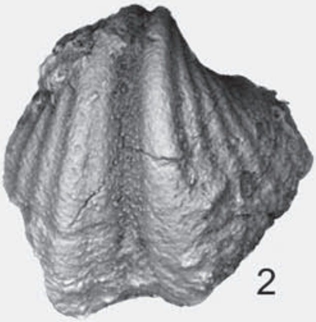
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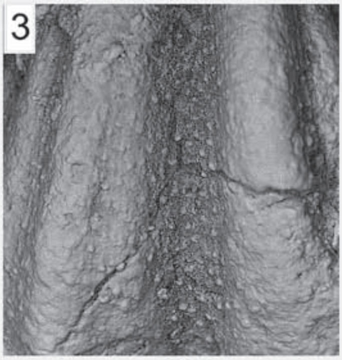
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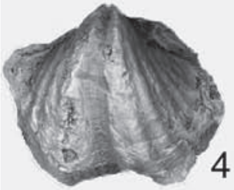
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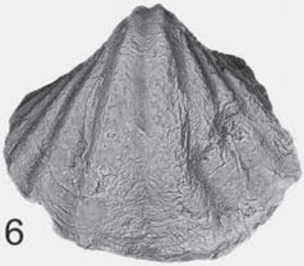
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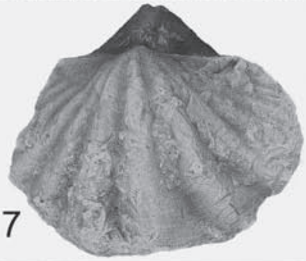
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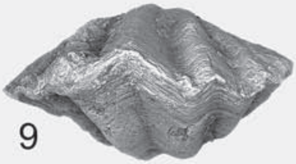
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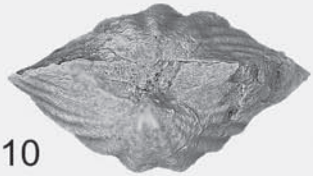
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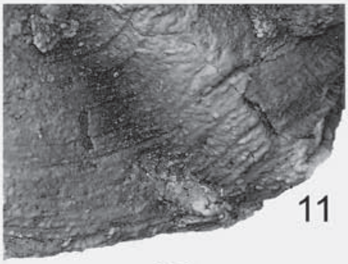
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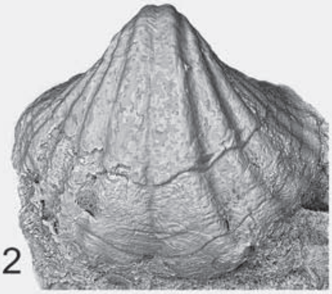
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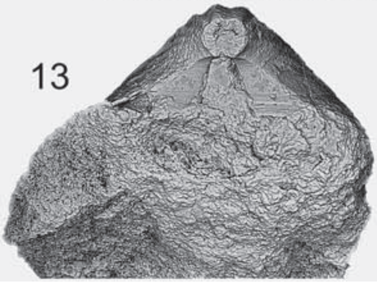
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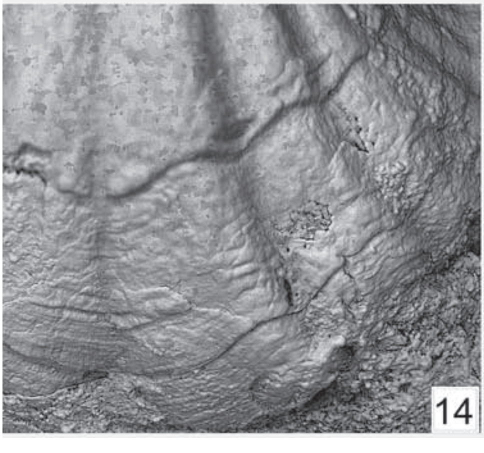
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Plate 4

Winklerprinsia europea Martínez Chacón gen. et sp. nov., Kasimovian, Morra de Lechugales Peak.
Figs. 1, 2. DGO 3601. Specimen in ventral and dorsal views showing the high ventral interarea and part of the stegidial cover, × 4.
Figs. 3, 4. DGO 3602. Posterior part of a broken specimen in postero-ventral and dorsal views, × 4.
Figs. 5, 6. DGO 3605. Posterior part of a ventral valve viewed externally (× 5), and internally showing the thick and elevated muscle platform (× 7).
Figs. 7, 8. DGO 3603. Posterior part of a ventral valve in external (× 5) and internal views (× 7), showing the elevated muscle platform, its median ridge and dental plates.
Figs. 9-11. DGO 3604. Three different views of the internal posterior part of a fragmentary ventral valve (× 7), showing the elevated muscle platform.
Figs. 12-15. DGO 3607. Ventral, dorsal, anterior and lateral views of a small specimen, × 7.

Photos taken with Stereoexplorer System Leica, financed by “Fondo Europeo de Desarrollo”.


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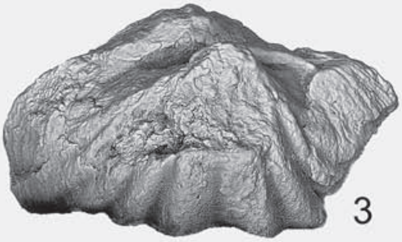
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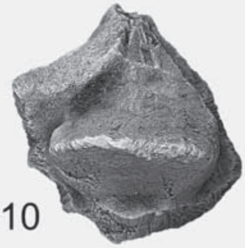
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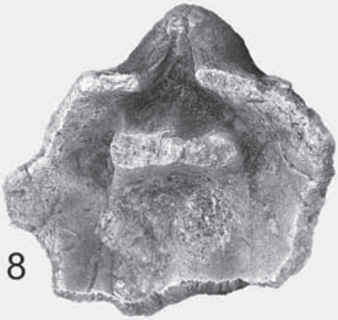
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Plate 5

Fig. 1. *Winklerprinsia europea* Martínez Chacón gen. et sp. nov., Kasimovian, Morra de Lechugales Peak. DGO 3606, ventral interior of a broken ventral valve, × 7.

Figs. 2-5. Spiriferellidae gen. et sp. indet., Kasimovian, Morra de Lechugales Peak.
Figs. 2, 3. DGO 3613. Incomplete and eroded ventral valve in external and internal views, showing muscle field and genital pits, × 3.5.
Figs. 4, 5. DGO 3614. Ventral valve in ventral and posterior views, × 3.5.

Photos 1 and 3 taken with Stereoexplorer System Leica, financed by “Fondo Europeo de Desarrollo”.

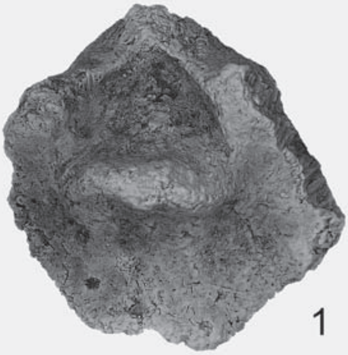

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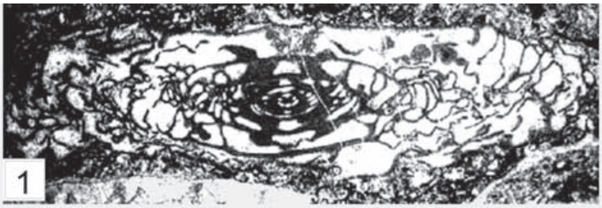
Plate 6

Fig. 1. *Protriticites* aff. *mirabilis* (Kireeva, 1950), Morra de Lechugales Peak section, sample LE5-F1, nearly axial section, Kasimovian (late Krevyakinian), × 14.
Fig. 2. *Protriticites* cf. *lamellosus* Kireeva, 1950, Morra de Lechugales Peak section, sample LE5-F1, axial section, Kasimovian (late Krevyakinian), × 14.
Fig. 3. *Protriticites* sp. 1, Traviesas del Grajal section, sample AND-8, axial section, Kasimovian (late Krevyakinian), × 14.
Figs. 4-6. *Protriticites winkleri* Villa sp. nov., Morra de Lechugales Peak section, sample LE5-F5, Kasimovian (late Krevyakinian), all × 14.
Fig. 4. Specimen LE5-F5/3, nearly axial section.
Fig. 5. Specimen LE5-F5/5, axial section.
Fig. 6. Holotype, specimen LE5-F5/9, axial section.
Fig. 7. *Pseudotriticites?* sp. 2, Morra de Lechugales Peak section, sample LE5-F0, axial section, Kasimovian (late Krevyakinian), × 17.
Fig. 8. *Pseudotriticites?* sp. 3, Morra de Lechugales Peak section, sample LE5-F3, axial section, Kasimovian (late Krevyakinian), × 17.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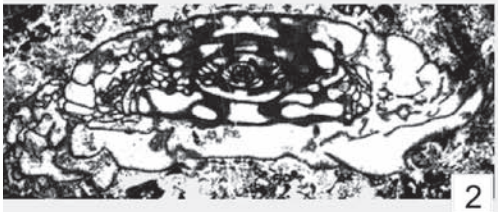
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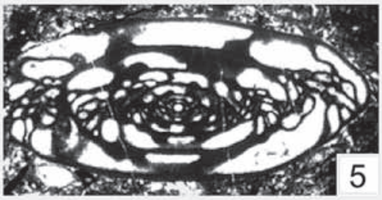
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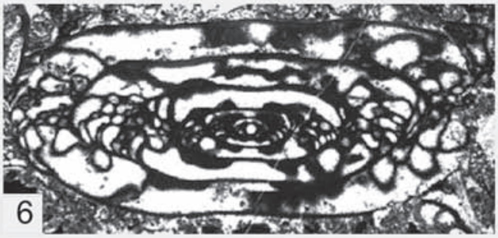
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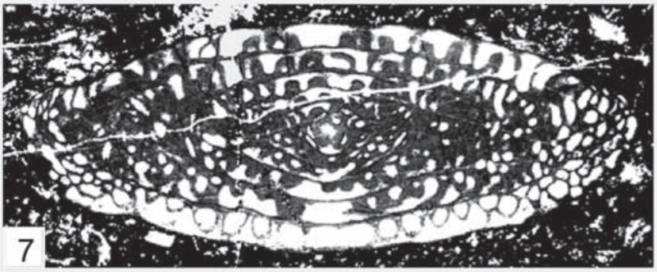
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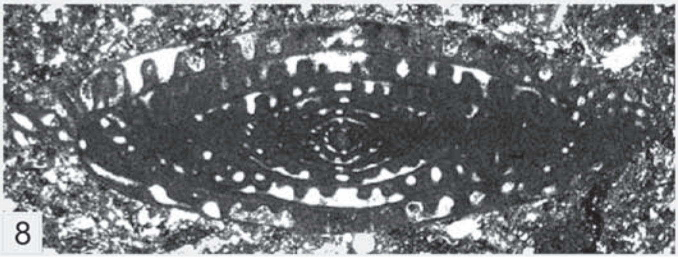
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