CHAPTER 2

LOWER AND MIDDLE PALEOZOIC STRATIGRAPHIC SUCCESSIONS

Middle Arenigian quartzite beds (upper Armorican Quartzite) in the Estena river section, Cabañeros National Park

Gutiérrez-Marco, J.C.

Rábano, I.

Liñán, E.

Gozalo, R.

Fernández Martínez, E.

Arbizu, M.

Méndez-Bedia, I.

Pieren Pidal, A.

Sarmiento, G.N.

It has already been explained how the formation of the Iberian Massif, where the Iberian Peninsula basement crops out, is closely linked to the development of the Late Paleozoic Variscan orogeny. The result was the intense shortening and deformation of the marine sediments previously deposited along the vast Gondwana continental margins during the Early and Middle Paleozoic. The Iberian Massif contains the most extense and fossiliferous exposures in the European Variscan orogenic chain. Its different structural and paleogeographic zones include important stratigraphic successions from the Cambrian to the Devonian periods (García-Cortés *et al.*, 2000, 2001; Gutiérrez-Marco, 2006), making up one of the key geological frameworks to understand the latest Precambrian and Paleozoic evolution of the Iberian Peninsula and Western Europe, and with an abundant record of geological and biological global events.

The **Cambrian** record presents exceptional stratigraphic successions in the Cantabrian and Ossa-Morena Zones, as well as in the Iberian Range. In the southern Central Iberian Zone, the sections of the Huso river and El Membrillar (eastern Toledo Mountains - Villuercas) display the oldest fossils in the Iberian Peninsula, as well as a wide variety of ichnofossils around the Precambrian-Cambrian boundary (Brasier *et al.*, 1979; Vidal *et al.*, 1994). Carbonate and siliciclastic units in the Cantabrian Range, Iberian Range, Sierra de Córdoba and southern Extremadura, characterize a series of exceptionally fossiliferous and complete stratigraphic sections with an enormous correlation potential to North Africa, Newfoundland and southern Europe. The regional chronostratigraphic Mediterranean scale thus formed comprises the Cordubian, Ovetian, Marianian and Bilbilian (Lower Cambrian), as well as Leonian, Cesaraugustian and Languedocian (Middle Cambrian) stages, most of them Spanish stratotypes (Liñán *et al.*, 1993).

The **Ordovician** record of the Iberian Massif includes several sedimentary facies widely developed along the Gondwana paleocontinent margin ("Armorican Quartzite", "Tristani Layers", "Pelites with fragments", etc.) related to global transgressions and regressions, and to the end-Ordovician glaciation. The fossil record is strongly conditioned by the shallow shelf facies, and has been used to define the Oretanian stage of the Mediterranean regional scale (Gutiérrez-Marco *et al.*, 2002). The most important sections are located in the southern Central Iberian Zone (Almadén, Campo de Calatrava, Toledo Mountains and eastern Sierra Morena), eastern Iberian Range, Ossa-Morena Zone (north of Huelva and Sevilla provinces) and the northwest of Spain (Asturias coast, Mondoñedo Thrust) (Julivert and Truyols, 1983; Gutiérrez-Marco *et al.*, 2002).

The **Silurian** succession is especially continuous and fossiliferous north of Sevilla (Ossa-Morena Zone), linked to the most distal environments of the peri-Gondwana platforms, where black graptolitic slate facies with carbonate interbeds are developed. The

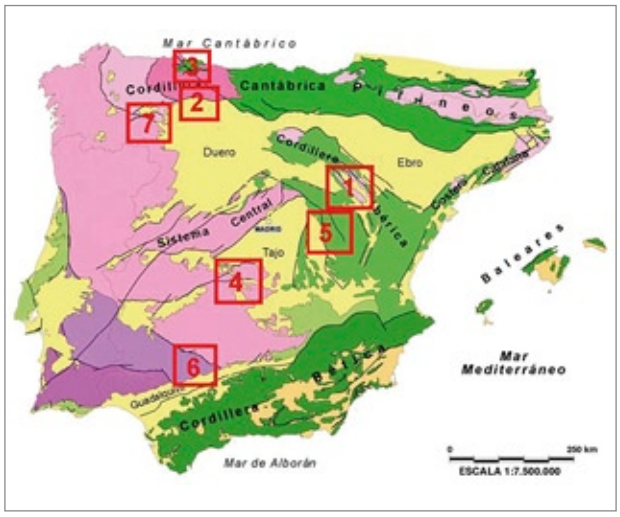


Figure 1. *Sites of Geological Interest (Geosites) described in the text: 1) Murero (Zaragoza), 2) Barrios de Luna (León), 3) Arnao (Asturias), 4) Cabañeros (Ciudad Real-Toledo), 5) Checa (Guadalajara), 6) Valle Syncline (Sevilla), and 7) Salas de la Ribera (León).*

sections of the Valle and Cerrón del Hornillo synclines have international relevance (Rábano *et al.*, 1999), and allow to study many Silurian physical and biological events (Gutiérrez-Marco *et al.*, 1996), as well as the Silurian-Devonian boundary (Jaeger and Robardet, 1979). In the rest of the Iberian Massif, shallower deposits prevail with the development of coarse-grained detrital units with few or no fossils at all (Robardet and Gutiérrez-Marco, 2002). However, the presence of graptolitic black slates at the base of many of these successions, provides relevant sections for the Llandovery and Lower Wenlock in the Central Iberian Zone (Almadén, Corral de Calatrava) and Iberian Range (northwest Guadalajara province), as well as in higher parts of the succession in the Galitian-Leonese boundary (La Cabrera-Valdeorras) (Robardet and Gutiérrez-Marco, 2002), which are beginning to be used as world reference sections for high resolution biochronostratigraphy.

The **Devonian** successions of the Iberian Massif are internationally famous, particularly the formations in the Asturian-Leonese Domain of the Cantabrian Zone and Celtiberia, which broadly speaking represent shallow peri-Gondwana environments with remarkable faunal endemisms (García-Alcalde, 1996). There are also complete successions in more pelagic facies (the so-called "Hercynian" magnafacies) as is the case in the Palentian Domain of the Cantabrian Zone or in the South Portuguese Zone. These latter units enable the correlation of most of the chronostratigraphic boundaries with physical or biological events taking place at global scale (García-Alcalde *et al.*, 1990).

Apart from the aforementioned successions, the Paleozoic exposures of the Iberian Massif are of **exceptional paleontological relevance**. This is due to its peculiar paleogeographic location at the margin of the Gondwana paleocontinent, evolving from a near-polar

position (Cambrian and Ordovician) to intermediate and paleotropical latitudes (Silurian and Devonian) characterizing environments almost unknown in other areas of the world. During a century and a half of research, the abundant endemisms have led to the description of tens of genera and hundreds of new species of all invertebrate groups.

Figure 1 shows the selected Sites of Geological Interest (Geosites) and the situation of the most representative stratigraphic successions, which will be developed below:

1 Cambrian of Murero (Zaragoza),
2 Paleozoic of the Luna river valley (León),
3 Devonian reef and platform of Arnao (Asturias),
4 Cambrian and Ordovician of the Cabañeros National Park (Ciudad Real-Toledo),
5 Glacial-marine deposits and paleontological site of Checa (Guadalajara),
6 Paleozoic of the Valle syncline (Sierra Norte of Sevilla) and,
7 Silurian of Salas de la Ribera (León).

Among the magnificent Paleozoic sections of the Cantabrian and Ossa-Morena Zones and Iberian Ranges, the **stratigraphic section of Murero** (Zaragoza) is the most representative for the Cambrian both within a European and international context, attending to the high resolution biochronological correlations it provides compared to other environments from North America, Africa and Asia. Murero displays especially relevant lithostratigraphic and chronostratigraphic stratotypes, such as the Cesaraugustian stage of the Mediterranean Cambrian, and the boundary between the Bilbilian and Leonian stages. It is also a key location to study the global faunal crisis at the end of the Lower Cambrian (Valdemiedes Extinction Event).

The Cambrian succession of Murero provides a continuous record from the Bilbilian to the lower Languedocian, and is made up by shales, marly shales and fine sandstones with frequent nodules and bioclastic and stromatolithic carbonate interbeds in certain units and intervals (figure 2).

The paleontological content is so exceptional that this locality records the faunal succession and radiation/extinction events occurred all along 10 million years, through the monitoring of more than 100 species of invertebrates: together with the abundant trilobites (30 genera and 70 species; figure 3) there are brachiopods, echinoderms, hyolithids, porifera, bradoriid crustaceans, onycophorans, paleoescolecid worms, celoscleritoforids, algae, filamentous cyanobacteria and ichnofossils. The biostratigraphic and biochronologic records have turned it into an international reference section for the Cambrian of the Mediterranean sub-province, which also includes Germany, Turkey and Jordan (Liñán and Gozalo, 1986; Sequeiros *et al.*, 1995; Liñán *et al.*, 1999; Gozalo *et al.*, 2000).

Figure 2, above. *Upper Cesaraugustian fossil-rich horizons in the upper Murero Formation.*

Figure 3, below. *Complete trilobite specimen* (Conocoryphe heberti) *of Caesaraugustian age in the Murero Formation, Valdemiedes ravine.*

The paleontological site of Murero was declared "Bien de Interés Cultural" (Cultural Interest Site) by the Government of Aragón in 1997, and in the future will be included in the Cultural Park of the Jiloca River. Because of its undeniable scientific interest, the town of Murero is a mandatory visit in national and international scientific meetings, and it is supported by the International Subcommission on Cambrian Stratigraphy (ICS-IUGS). Murero is one of the few towns in the world which has added a trilobite to its coat of arms, a reference to the international relevance of its paleontological heritage, known since the XIX century.

Figure 4. *Precambrian/Cambrian angular unconformity south of Irede de Luna, between the Lower Cambrian Herrería Sandstone Formation (upper right) and the turbiditic interbeds of the Narcea-Mora Slate Formation, here with Neoproterozoic Ediacaran microfossils.*

The stratigraphic section of the Luna river valley (León) is a privileged site for the observation of Paleozoic formations in the southern Cantabrian Zone, documented with a 5000m-thick section representing almost 250 million years of the Earth's history. Even if this section is complementary to others (Bernesga, Porma and Esla valleys), continuous research and the numerous Spanish and foreign doctoral dissertations since the middle twentieth century have given international recognition to the section around Barrios de Luna (Aramburu and García-Ramos, 1993; Keller, 1997; Aramburu, 2006).

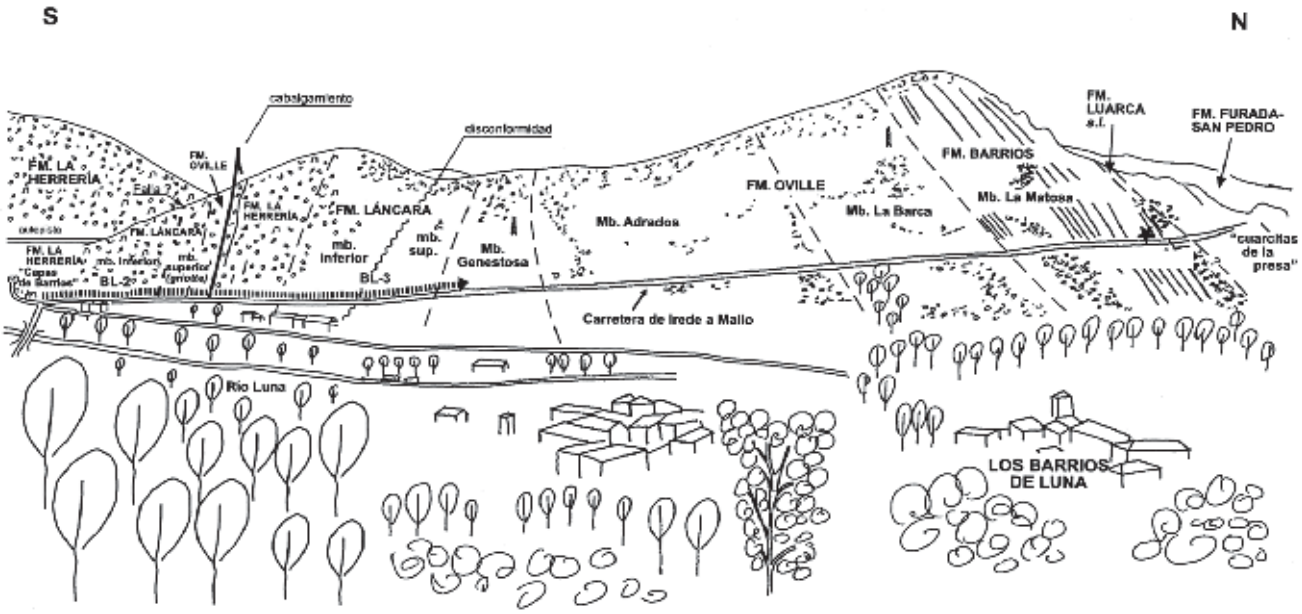


Figure 5. *Geological sketch of part of the Cambrian-Ordovician succession shown in the picture below (Aramburu., 2006). General view of the: Láncara (left), Oville (middle) and Barrios (quartzite crests to the right) Formations, in the right margin of the Luna river valley along the road from Irede de Luna to Mallo de Luna. In the foreground, the town of Barrios de Luna.*

Figure 6. *Iron-rich sandstone succession of the San Pedro Formation (foreground) and Devonian limestone crests of the Santa Lucia and Portillo formations (background), along the banks of the Luna reservoir in the southern flank of Alba syncline.*

The local Paleozoic succession starts with a discontinuity (figure 4) upon Precambrian turbidites (Narcea-Mora Formation) and comprises a very complete record of the Cambrian (figure 5), represented by the Herrería quartz-arenite, Láncara carbonates (including a paraconformity and "griotte-type" condensed facies) and Oville slate and sandstone formations. The features of the Cantabrian Cambrian are the ones used to name the regional Ovetian and Leonian stages in the north Gondwana regional chronostratigraphic scale. The Ordovician is represented by the Barrios quartzite Formation and some slates. The Silurian rests paraconformable upon these quartzites at the Luna reservoir and includes two units, the Formigoso Formation (slates) and the San Pedro Formation (sandstones with ironstones). It is in the second one where the Silurian-Devonian boundary is found.

The Devonian record (figure 6) is subdivided into ten formations with alternating siliciclastic and carbonate units, very fossiliferous and representative of the Lochkovian-Emsian (formations of the La Vid Group), Emsian-Eiffelian (Santa Lucía Formation, with important reef development), Eiffelian-Givetian (Huergas Formation), Givetian (Portilla Formation, with reef development), Givetian-Frasnian (Nocedo Formation), and Famennian (Ermita and Baleas formations, the first one unconformable with the Nocedo Fm, and the second one grading into the Carboniferous).

The marine Carboniferous succession starts with thick limestone units (Barcaliente and Valdeteja formations, commonly known as "Mountain Limestone") and the synorogenic Cuevas and San Emiliano formations, with slate, sandstone, limestone and coal. In the southern Luna river valley, the Paleozoic succession begins in the Late Carboniferous with the unconformable (post-Asturian phase) continental deposits of the Prado Formation (late Stephanian B), which comprise several coal cyclothems worked in La Magdalena basin.

Apart from this exceptional sedimentary record, the fame of this Paleozoic section of the Luna river valley is also due to the numerous pioneer paleontological discoveries. Among them are the Early Cambrian "*Dolerolenus* fauna", the Middle Cambrian trilobite deposit, the ichnofossils of the Oville and Barrios formations, the presence of Middle Ordovician trilobites within the Barrios Formation, the Silurian-Devonian continental palynomorphs, the bioherms and the rich brachiopod, echinoderm and coral associations of the Devonian units, etc.

Summarizing, the Luna river valley forms one of the classic reference areas for the Iberian Paleozoic. Within a few kilometers, it includes stratotypes and parastratotypes of different formations with exceptional outcrop conditions, easy access and scientific value of national and international relevance, combined with landscape and educational features added to the renowned natural and cultural heritage of the area where it is located.

The cliffs by the coast near **Arnao** (Castrillón, Asturias) provide a spectacular and very fossiliferous **Lower Devonian** stratigraphic section (figure 7), comprising the upper Rañeces Group (La Ladrona-Ferroñes and Aguión formations) and the Moniello Formation (Emsian). It is one of the best examples in Europe for the development of Paleozoic coral and stromatoporoid reef, as well as of the impact of global evolutionary extinction and radiation processes upon the marine platforms during this period (Méndez-Bedia, 1976; García-Alcalde, 1992; Méndez-Bedia *et al.*, 1994; Arbizu and Méndez-Bedia, 2006).

The **Arnao Reef** crops out between the beaches of El Cuerno and Arnao factory, near the road tunnel which also crosses the reef from side to side, and where the bioherm reaches a thickness close to 150 m. The reef, with development of massive limestones, is located on the bedded platform facies of the Moniello Formation

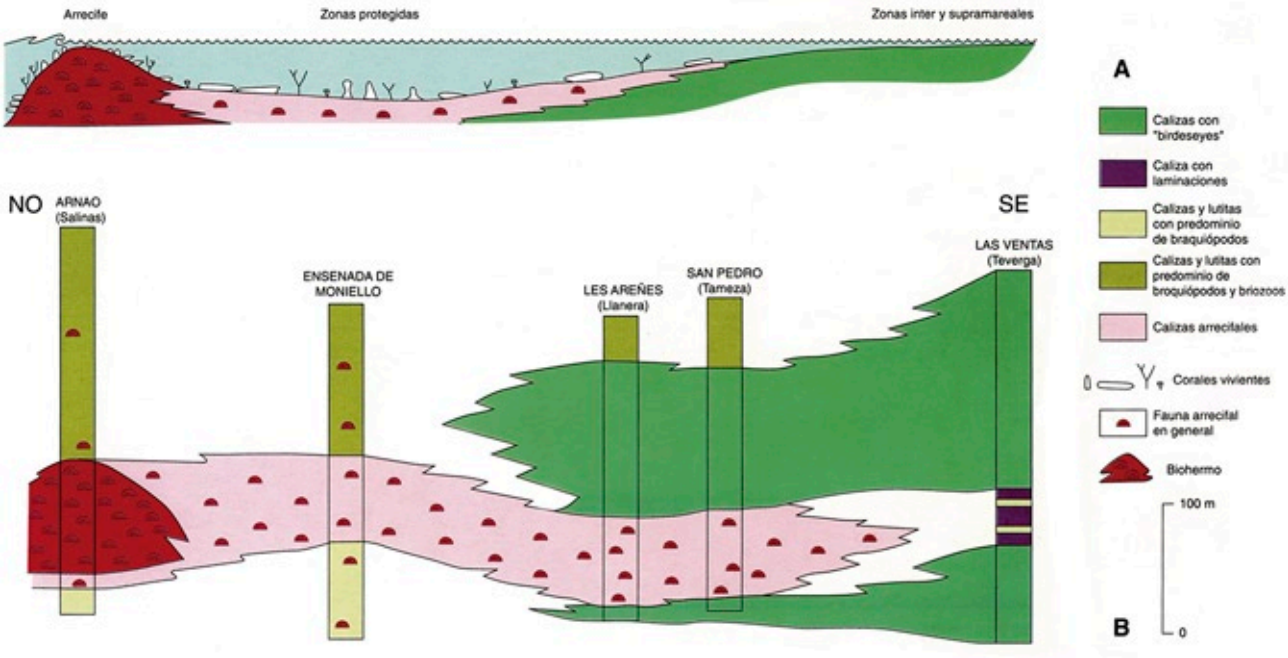


Figure 7. *Sedimentary environments and facies of the Moniella Formation (A), and NW-SE correlation between sections at several Asturian localities, with the Arnao reef to the left. Sketch after Méndez-Bedia (1976), reproduced in the book Geology of Asturias (Ediciones Trea, 1995).*

(figure 8). Clearly distinguishable are the four successive stages in its formation (stabilization, settlement, diversification and domination), followed by its extinction related to basin deepening and the return to bedded limestone deposition.

The main bioconstructing organisms (figure 9) are lamellar and massive tabulate corals (alveolitids, favositids, tamnoporids, etc.), colonial rugose corals and stromatoporoids (massive and lamellar), which often grow interconnected and are preserved in living position. Apart from these, there are also many algae and briozoans, together with frequent brachiopods, mollusks (bivalves, gastropods), echinoderms (mostly crinoids) and trilobites. An especial point of observation for the bioherm facies and the reef top is located in the old quarry near the tunnel, in front of Arnao factory, which is used as visitors parking.

In addition to the Arnao reef, the units underlying the Moniello Formation provide an exceptional succession of the Ferroñes /La Ladrona Formation at Santa María del Mar, and for the lower Aguión Formation at La Vela Cape, west of Arnao beach, where these units are inverted and the Devonian is thrusted over the productive Carboniferous of the Arnao mine. Outstanding among these Devonian formations is the classic paleontological site known as Arnao Platform, referring to the abundant neritic fossils ("*Trybliocrinus* layers", figure 10) in excellent preservation conditions found in the reef and as loose rocks shaped by the waves (Arbizu *et al.*, 1995). The fossiliferous interval belongs to the Aguión Formation, which begins with the development of a biostromal structure of "patch-reef" tabulate corals and briozoans upon bioclastic sandbars, followed by several benthic platform communities conditioned by the variations in the clastic input regime, and reaches the stabilization of the carbonate ramp with the lower Moniello Formation. The latter provides an interesting silicified "*Cyathaxonia* Fauna" (solitary corals) in the coastal exposure of Requeixu Point and in temporary excavations at Piedras Blancas (Castrillón), south of Arnao.

Figure 8. *General view of Arnao reef from the eastern end of Cuerno beach (high tide). The bedded part towards the base of the Moniello Formation, below the reef, can be seen in the foreground. The main bioherm stands out in the background with its massive aspect, and cut by the road tunnel.*

Figure 9. *Branching corals* (Favosites) *together with lamellar and massive stromatoporoids, the latter partially reworked, corresponding to the declining stage of the Arnao reef.*

Figure 10. *Encrinite with big stem plates and fragments of the camerated crinoidal calyx of* Triblyocrinus flatheanus *(ex* "Hadrocrinus hispaniae"*), which gives name to one of the most characteristic Emsian communities of the platform of Arnao.*

The **Cabañeros National Park** (Ciudad Real-Toledo) hosts an **Ordovician succession** with the most representative lithostratigraphic units of the southern Central Iberian Zone (Armorican Quartzite, Tristani Layers) laying unconformable over a Neoproterozoic-Lower Cambrian basement. The Boquerón del Estena route includes most of the formations with paleontological and stratigraphical interest, including the Toledanian Unconformity (figure 11) related to the Ordovician transgression with exposures of high international relevance (San José Lancha *et al.*, 1974, 1997; Gutiérrez-Marco *et al.*, 2007).

The term "Schist-Graywacke Complex" was used in the Central Iberian Zone to refer to the thick slate-sandstone succession underlying the "Armorican Quartzite". This pre-Ordovician complex was dated

Figure 11. *Toledanian unconformity in the Boquerón del Estena route (Cabañeros National Park), which creates an angular contact between the pre-Ordovician basement, represented by subvertical Lower Cambrian shales (Azorejo Sandstones, left), and Lower Ordovician quartzites dipping northwest ("Intermediate Beds", right).*

by microfossils, ichnofossils and U-Pb isotopes as late Ediacarian (="Vendian") – Early Cambrian (Neoproterozoic-Cambrian transition). It shows a lower mostly turbiditic Ediacarian group on top of which is a series of lithostratigraphic units (upper Alcudian and Pusa Group) with outstanding Early Cambrian fossils. The Ordovician sequence lays on an angular unconformity (figure 11) upon these rocks (Toledanian Unconformity).

The Lower Ordovician represents a transgressive episode with widespread middle Arenigian white ortoquartzite facies with *Cruziana* ("Armorican Quartzite"; figure 12), followed by middle and upper Arenigian interbedded quartzite and slate. The Middle Ordovician (Oretanian-Dobrotivian) is mostly slaty and highly fossiliferous, with quartzite interbeds towards the top. The Upper Ordovician is made up of slates, slate and sandstone interbeds, and a discontinuous carbonate unit towards the top, finishing up with a discontinuity (glacioeustatic erosive event). Upon these are end-Ordovician diamictites (Hirnantian graywackes and slates with glaciomarine clasts), followed by ortoquartzites which include the Ordovician-Silurian boundary at their top.

The **Ordovician-Silurian boundary at Checa** (Guadalajara, Castilla-La Mancha) is located in the so-called Nevera Mountain Massif, one of the areas with the oldest marine rocks in the Castillian Branch of the Iberian Range, and currently forming part of the large Alpine anticlinorium of Sierra de Albarracín as its geological basement (Herranz Araújo *et al.*, 2003). The geological heritage of the Nevera Massif is internationally relevant thanks to its exceptional Paleozoic exposures located east of Checa and along the road to Orea (Guadalajara).

The sequence includes spectacular outcrops of the Orea Formation (Hirnantian) with **glaciomarine diamictites** (Fortuin, 1984), mostly slates and graywackes with resedimented "dropstones" of limestone and sandstone (figure 13), as well as slumped and slided quartzite beds, contemporary of the end-Ordovician Gondwana glaciation, when the Southern Pole ice-cap was located on the current Sahara desert. Upper Ordovician microfossils (conodonts) have been found in the limestone *dropstones*, proving their deposition during a global warming period (Boda Event) prior to the glaciation, and so they were the first to be eroded during glacial eustatism and dragged by the ice.

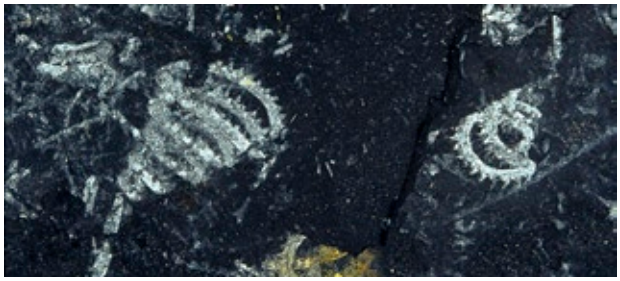
These glaciomarine rocks end in erosive contact with a quartzite presenting remarkable lateral thickness variations (Los Puertos Quartzite), deposited at the shallow environments generated by the isostatic rebound after glaciation, and including the Ordovician-Silurian boundary. This quartzite unit is overlain by a thick succession of extraordinarily fossiliferous black slates (Bárdenas Formation) where more the 60 different graptolite taxa have been found in its 60 m lower part (figure 14), among them several new taxa with high paleobiogeographical interest. The succession

Figure 12, above. *Lower side of a quartzite bed showing several specimens of lower Ordovician* Cruziana rugosa*. Boquerón del río Estena.*

Figure 13, below. *Sandstone cobble in the glaciomarine diamictites of the Orea Formation (Hirnantian), east of Checa, originally deposited as a dropstone in a sediment, and later affected by submarine mass movement (gravity flow).*

of graptolite species in the stratigraphic column (first appearance, extinction, relays) allowed to establish seven successive chronostratigraphic divisions within the deposit, and high resolution biochronological correlations to other reference sections for the Llandovery in Europe (Bohemia, Sardinia, Thuringia, Wales, Borholm), North America and Australia, for the interval 436-428 Ma (within the Telychian or late Early Silurian, figure 15).

Apart from the graptolites, the Checa section is interesting as it displays remains from other fossil groups such as conodonts, mollusks and arthropods (trilobites, euripterids), preserved in sediments representing typical marine anoxic to disaerobic benthic environments, where there must have formed hydrocarbons which disappeared millions of years later.



The graptolite site of Checa, albeit known since the XIX century, began to be internationally renowned with the work of Gutiérrez-Marco and Storch (1998) and after the visit of delegates from 14 countries of the International Subcommission on Silurian Stratigraphy (ICS-IUGS) and of the Graptolite Working Group of the International Paleontological Association (IPA). The studies in progress strengthen Checa as a necessary biostratigraphical reference for the Silurian period at a global scale.

The **Paleozoic succession of the Valle Sincline** (Cazalla de la Sierra, Sevilla) offers a very different paleogeographical and paleoenvironmental context compared to other areas of the Iberian Massif. Here, pelagic faunas and deposits of marginal environments of the peri-Gondwana platform dominate, and the local stratigraphic record is surprisingly complete and fossiliferous (Rábano *et al.*, 1999; Robardet and Gutiérrez-Marco, 2004). The sincline consists of a fault-bounded narrow syncline structure between

Figure 14, above. *Graptolite concentrations* (Oktavites spiralis) *in slates of the Bádenas Formation, Checa geosite (Guadalajara).*

Figure 15. *Graptolite colonies of* Spirograptus guerichi, *with a turriculate morphology, from the Telychian of Checa.*

Figure 16, below. *View towards the west of the Silurian-Devonian core of the Valle syncline, with El Pintado reservoir almost empty during the summer season.*

Figure 17. ***Pelmatozoan Limestone in an abandoned quarry to the South of El Pintado reservoir, displaying paleokarst features developed in the end-Ordovician.***

Cambrian limestones and volcanites, with its axis roughly coinciding with the southeastern branch of the El Pintado reservoir (figure 16). The main Silurian-Devonian exposures are found near the reservoir and along the streams flowing into it from the north, whereas the Ordovician succession crops out mainly in three nearby localities: Cortijo de Las Cañas, finca del Valle, and km 14 of the road SE-179.

The Ordovician sequence begins with Arenigian to Lower Oretanian green slates, followed by Dobrotivian sandstones and a succession of Upper Ordovician shales and limestones, among which stands out the Kralodvorian "Pelmatozoan Limestone" (figure 17). These are unconformably overlain by slates and shales with scattered clasts and slumped beds ("Valle slates"), which may be of Hirnantian age.

The Silurian and basal Devonian succession consists of black graptolitic slates with two carbonate interbeds in the upper half: the rather thin (0.5-0.8 m) "*Orthoceras* limestone" (upper Ludlow), and the "*Scyphocrinites* limestone" (figure 18). This second unit is mostly Pridoli and divides the succession into "Lower Graptolitic Slates" with remarkable lidite interbeds (Llandovery-Ludlow), and "Upper Graptolitic Slates" (Pridoli-Lochkovian), with the Silurian-Devonian boundary. The rest of the Devonian succession is represented by the El Pintado Group, with a lower unit of green to brown shales and slates (Praguian to lower Emsian). These are overlain by Famenian limestones, calcareous sandstones and slates, originating a paraconformity similar to the "middle Devonian hiatus".

From the paleogeographical and paleoenvironmental points of view, the Ordovician-Devonian sedimentary record of the Valle Syncline shows the tectonic overlap between the Ossa-Morena and Central Iberian zones, which originally where different sectors from the same passive margin in the peri-Gondwana platform. North of Sevilla, deeper and more distal environments predominate with Bohemian-Mediterranean biofacies, whereas the Central Iberian succession was shallower and had thick quartzite units (including the "Armorican Quartzite") and neritic faunas not found in the Ossa-Morena Zone.

The large number of pelagic fossils in the Valle Syncline has allowed the recognition of a complete succession from the Silurian to the Lower Devonian, with 25 successive graptolite biozones. These enable a high resolution correlation with other areas in the world, as well as a contribution to the detailed knowledge of global large-scale climatic and oceanographic events, including the global warming and glaciation at the end-Ordovician, and the Silurian radiation and extinction events. The Lundgreni Event (Wenlock) shows one of its international parastratotypes in this sector of the Iberian Massif (Gutiérrez-Marco *et al.*, 1996), whereas the base of the Hirnantian slates seals a remarkable paleokarst developed on the late Ordovician limestones (figure 17).

Even if the discovery and the study of this geosite was relatively late (mid XX century), its importance for pre-Variscan paleogeography and international correlations demand it to be incorporated into the inventory among the most interesting marine Paleozoic successions of the Iberian Massif. Furthermore, it has also already been officially visited by the International Subcommission on Silurian Stratigraphy (ICS-IUGS) and by the Graptolite Working Group of the International Paleontological Association (IPA).

The **Silurian paleontological site at Salas de la Ribera** (León) is located within the municipality of Puente de Domingo Flórez, and is one of the classic localities in the northwest of the Iberian Peninsula for Silurian graptolites. Apart from displaying a continuous succession of the Wenlock to Ludlow slates of

Figure 18, above. Scyphocrinites *stem plate in a planktonic crinoid typical of the Silurian-Devonian pelagic succession, typically well represented in the Valle syncline.*

Figure 19, right. *Field view of the fossiliferous slates at the Salas de la Ribera geosite, with several graptolites visible* (Colonograptus ludensis).

Figure 20, below. *Isolated synrhabdosome of* Colonograptus deubeli, *Homerian of Salas de la Ribera (León).*

the Llagarinos Formation (figure 19), with seven biozones, this geosite is unique and internationally renown as it gathers 90% of the world record of synrhabdosomes (Gutiérrez-Marco and Lenz, 1998), radial graptolite aggregates whose real paleobiological significance was identified thanks to the these Leonese fossils (figure 20).

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