

## Devonian graptolites from southwestern Europe: a review with new data

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Lower Devonian graptolite faunas have been recognized in the Normandy and southeastern regions of the Armorican Massif, France; the Pyrenees and Catalonian Coastal Ranges regions and northern Minorca, Balearic Islands, Spain; the southern Hesperian Massif (Ossa Morena Zone) of the Iberian Peninsula; and from southeastern Sardinia, Italy. All but one of the graptolite faunas collected throughout this large region are from Lochkovian age strata, representing the *Monograptus uniformis*, *Monograptus praehercynicus*, and *Monograptus hercynicus* biozones corresponding to the lower, middle and upper Lochkovian, respectively, and mostly represented by monospecific or low diversity assemblages. Although many individual sections contain representatives of two of the biozones, relatively few reveal all three. A single, poorly preserved faunule, collected in the Ossa Morena region of Spain from strata dated by brachiopods as Pragian–early Emsian may represent the only known graptoloid fauna of post-Lochkovian age.

Almost all graptolites have been recovered from condensed successions of black shales and limestone nodules, similar to those of other proto-Tethyan (i.e. outer shelf, with dominantly pelagic faunas) regions such as Thuringia, Bohemia, the Carnic Alps and northwestern Africa. The two exceptions are an occurrence in a shallow-water, coarser clastic sequences at the Carteret locality in Normandy and in deep water turbidites on the island of Minorca. Graptolites are not known from any other thick, shallow water clastic sequences, although whether this is because of paleo environmental exclusion or simply lack of recovery to date is unknown. Other fossil evidence (e.g. chitinozoans), however, indicates continuous marine sedimentation from the Silurian to Devonian. © 1996 by John Wiley & Sons, Ltd.

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### 1. INTRODUCTION

Devonian graptolites are known from diverse localities of the French Armorican Massif, the southern Hesperian Massif of Spain, the Palaeozoic basement of the Spanish Alpine belt and from southern Sardinia. The first records of what have subsequently been recognized as Devonian graptolites in southwestern Europe were collected from France (Péneau 1944; Philippot 1950) and Spain (Bourrouilh 1963), all of whom identified them as common silurian species (e.g. *Monograptus riccartonensis*, *M. flemingii primus*, *M. vomerinus crenulatus*). Distinctive Devonian forms (*M. hercynicus*, *M. uniformis*, *M. praehercynicus*) were later reported from Silurian–Devonian sequences in the Catalonian Coastal Ranges (Greiling and Puschmann 1965) and central Pyrenees (Llopis and Rosell 1968), although at the time these faunas were still considered to be of late Silurian, post-Ludlow age. The first actual recognition of Devonian graptolites in southwestern Europe stems mainly from the taxonomic studies of H. Jaeger, whose identifications were incorporated into several papers on regional geology and stratigraphy. The only descriptions and/or illustrations of Devonian graptolites in this region are by Bourrouilh (1963, 1983), Jaeger and Robardet

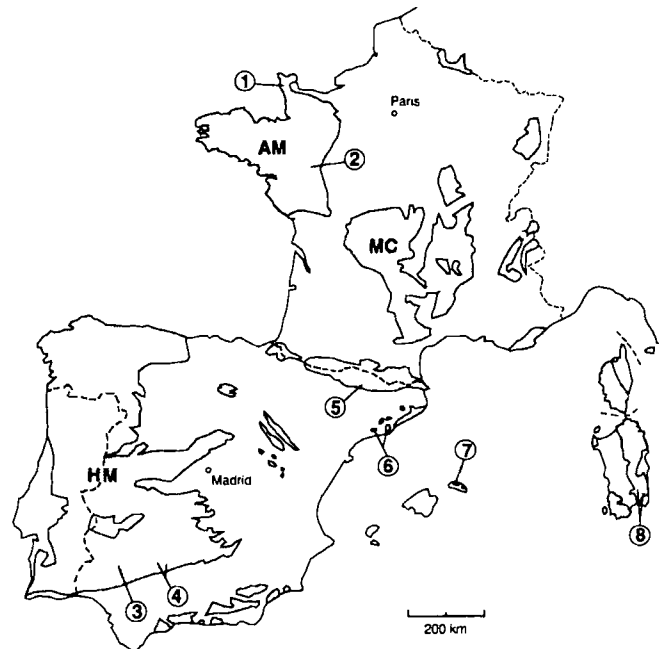


Figure 1. Devonian graptolite localities in southwestern Europe. AM, Armorican Massif; MC, Massif Central; HM, Hesperian Massif. 1, Carteret, Normandy; 2, La Meignanne, SE Armorican Massif; 3, Venta del Ciero, Ossa Morrena Zone; 4, Valle and Cerrón del Hornillo synclines, Ossa Morena Zone; 5, Gerri de la Sal, central Pyrenees; 6, Miramar and Barcelona area, Catalan Coastal Ranges; 7, northern Minorca, Balearic Islands; and 8, Goni and Baccu Scottis, SE Sardinia

(1973, 1979), Jaeger (1976), Rickards and Chapman *in* Julivert *et al.* (1985), Oczlon (1989, unpublished data), and Rickards *et al.* (1995).

The aim of this paper is to provide a synthesis, updated assessment and an overview of the present state of knowledge of Devonian graptolites of Spain and France, where most of the localities occur, along with a short discussion of the island of Sardinia, Italy (Figure 1).

## 2. ARMORICAN MASSIF

### 2a Normandy

*Monograptus uniformis* Přibyl (Fig. 6) and, questionably, *M. uniformis angustidens* Přibyl were reported from 1 km NNE of the village of Carteret in northwestern Normandy (Cotentin Peninsula; Figure 1, locality 1) (Jaeger and Robardet 1973). The graptolites were found in black shales in the uppermost part of the Saint-Germain-sur-Ay Formation, a succession of alternating sandstones and shales. They are separated by a small, but unknown, interval from the overlying, sandstone-dominated, La Haye-du-Puits Formation, dated by chitinozoans as of early Lochkovian age (Paris 1981). The same fossiliferous interval also yielded scyphocrinoid and ceratiocarid remains and bivalves (Babin and Robardet 1974). The state of preservation of the very thin shells, with details of ornamentation, indicates a quiet environment and very limited transport. These alternating shales and sandstones do not show any of the characteristics of turbidites; they correspond to inner shelf shallow water deposits in which the upwards increase in sandy terrigenous influx culminates in the sandstones of the overlying La Haye-du-Puits Formation.

### 2b. Southeastern Armorican Massif: La Meignanne locality

*Monograptus uniformis* was identified by Jaeger (*in* Paris 1981) from a collection of black, calcareous claystones from the La Meignanne quarry near Angers (Figure 1, locality 2). The sequence comprises an

unknown thickness of Ludlow to Lochkovian age, probable offshore facies, black, argillaceous limestones that are highly tectonized and are envisaged to be of allochthonous origin (Kříž and Paris 1982). They contain bivalves, cephalopods and chitinozoans, as well as graptolites.

### 3. HESPERIAN MASSIF

Devonian graptolites are known only in the southern segment (Ossa Morena Zone) of the large west Iberian Massif, where a distinctive and continuous Silurian–Devonian succession in the graptolitic facies shows a striking similarity to coeval sequences of ‘Mediterranean type’ facies (Thuringia, Carnic Alps, Algeria, Sardinia). Most of the graptolites were collected from the upper half of the ‘Upper Graptolitic Shales’ that overlie Pridoli limestones in two small synclines north of the Seville Province.

#### 3a. *Cerrón del Hornillo syncline*

Devonian graptolites have been identified from several levels in two separate sections (sections 2 and 3, Figure 5, in Jaeger and Robardet 1979; Figures 1 and 2). The Lochkovian sections appear to be entirely of shales, unlike those of the Valle syncline where limestone lenses and nodules occur within the shale. Graptolites from at least two levels comprise *Monograptus praehercynicus* Jaeger, *M. hercynicus* Perner, and *Linograptus posthumus* (Richter) or ?*Abiesgraptus* sp.

#### 3b. *Valle syncline*

On the northern margin of the El Pintado reservoir (locality 4, Figures 1 and 2) *M. hercynicus* was recovered by Oczlon (1989) from black limestone lenses or mega-nodules somewhere within the upper part of the ‘Upper Graptolitic Shales’ of Jaeger and Robardet (1979, section 3, Figure 4). This section corresponds to section 1 of Racheboeuf and Robardet (1986), who recovered the tentaculitoid *Homoctenowakia bohémica bohémica* from the same beds (see Gessa *et al.* 1994). The presence of *M. hercynicus* (Fig. 7) has been further confirmed by us, with the addition of a new section south of El Pintado reservoir where two assemblages, a lower one with *M. praehercynicus* (Fig. 7), *L. posthumus* and *Abiesgraptus* sp., and an upper of *M. hercynicus*, have been recovered.

#### 3c. *Barrancos–Hinojales domain*

A remarkable record of a post-Lochkovian Devonian graptolite in the Ossa Morena Zone consists of a badly preserved rhabdosome of *Monograptus* sp. (with hooked thecae: see Figure 5.6 and 5.7) from the middle Verdugo Formation in the Venta del Ciervo section southeast of Cañaveral de León (Huelva Province), Spain (Figure 1, locality 3). Tectonic complications in this locality (see Figure 2C), however, do not allow the reliable reconstruction of a stratigraphic column. Although the graptolite is not identifiable at the species level, associated late Pragian–early Emsian brachiopods (Racheboeuf and Robardet 1986) and trilobites and ostracodes (Robardet *et al.* 1991) indicates that the fossiliferous level of the Venta del Ciervo is the equivalent of the lower part of the El Pintado Group of the Cerrón del Hornillo and Valle synclines (see Figure 3, column 4) and suggest a possible correlation with the time equivalent of the *Monograptus yukonensis* Biozone. This represents the youngest graptoloid now known in southwestern Europe.

This is worthy of note, as post-Lochkovian graptolites have until now, been mainly recognized in North America and Asia, the only exceptions in the North Gondwanan region being the Barrandian area in central Europe and in the Algerian Sahara (Jaeger 1978, 1988).

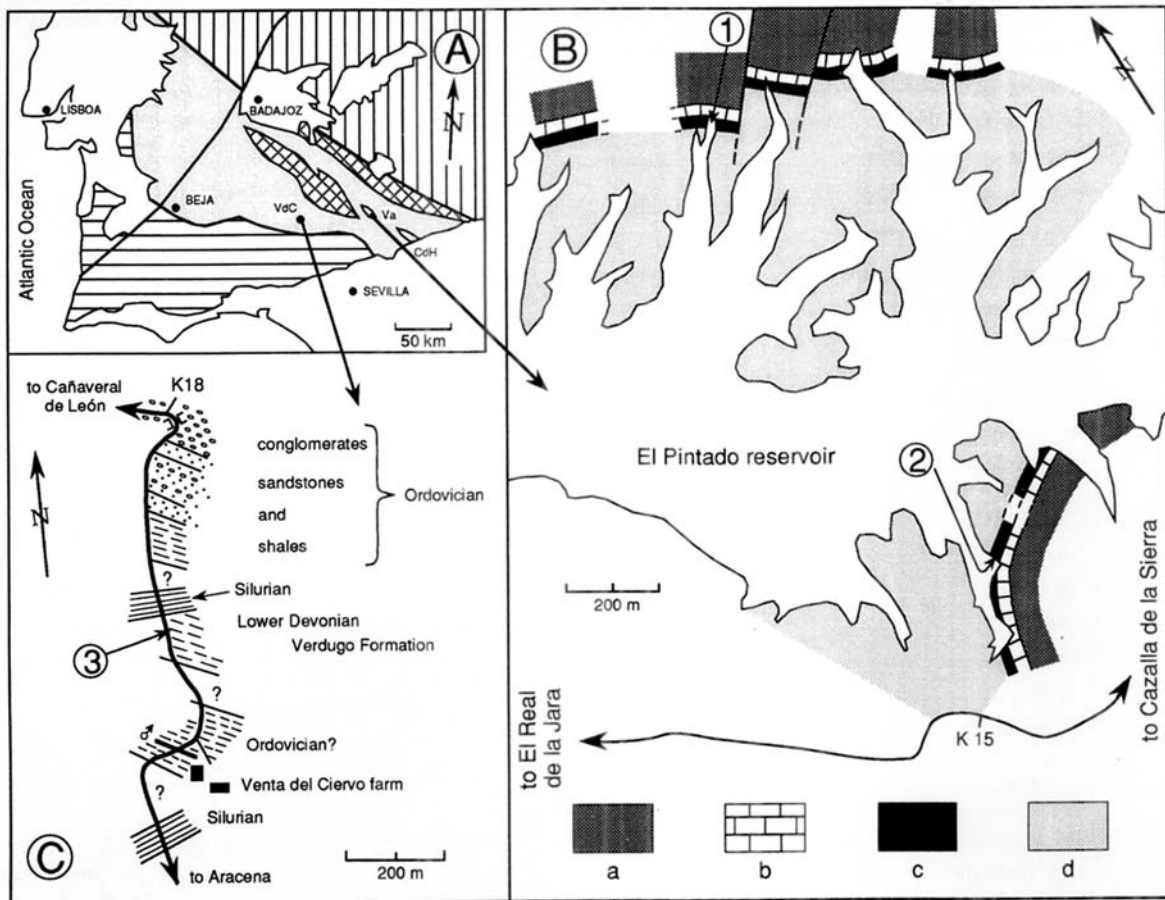


Figure 2. Devonian graptolite localities from the Ossa Morena Zone. (A) Southwestern Iberian Peninsula. Vertical hatching, Central Iberian Zone; dotted, Ossa Morena Zone (crossed areas are Precambrian antiforms); horizontal hatching, south Portuguese Zone; white, post-Palaeozoic; CdH, Va and VdC correspond, respectively, to Cerrón del Hornillo and Valle synclines, and the Venta del Ciervo fossiliferous locality. (B) Devonian graptolite localities in the Valle syncline. 1, Levels with *M. praehercynicus* (after Oczlon 1989; Gessa *et al.* 1994); 2, new section with *M. praehercynicus* and *M. hercynicus*. Lithostratigraphic units: a, Lower Graptolitic Shales; b, Scyphocrinites limestone; c, Upper Graptolitic Shales; and d, El Pintado Group. (C) Post-Lochkovian graptolite (*Monogratus* sp.) (locality 3, figure 1) at Venta del Ciervo

#### 4. PYRENEES

In the central part of the Spanish Pyrenees, *M. uniformis*, *M. praehercynicus* and *M. hercynicus* were identified by Llopis and Rosell (1968) in black shales and calcareous claystones underlying Devonian limestones near Gerri de la Sal (Lérida Province, Figures 1 and 3). The mention of *M. praehercynicus* from below Upper Silurian limestones in the report of Llopis and Rosell (1968), as well as recent findings of Lochkovian conodonts from the *woschmidti* to *delta* biozones above the graptolite occurrences (Valenzuela-Rios 1990), however, introduces a considerable degree of uncertainty on the validity of the graptolite identification, or of the stratigraphic/tectonic relationships. A thorough review is needed.

#### 5. CATALONIAN COASTAL RANGES

Graptolite-bearing shales are known in the basal member of the Olorda Formation, a unit that separates two important carbonate-forming episodes of Pridoli and Lochkovian ages, respectively (Figure: 1, locality

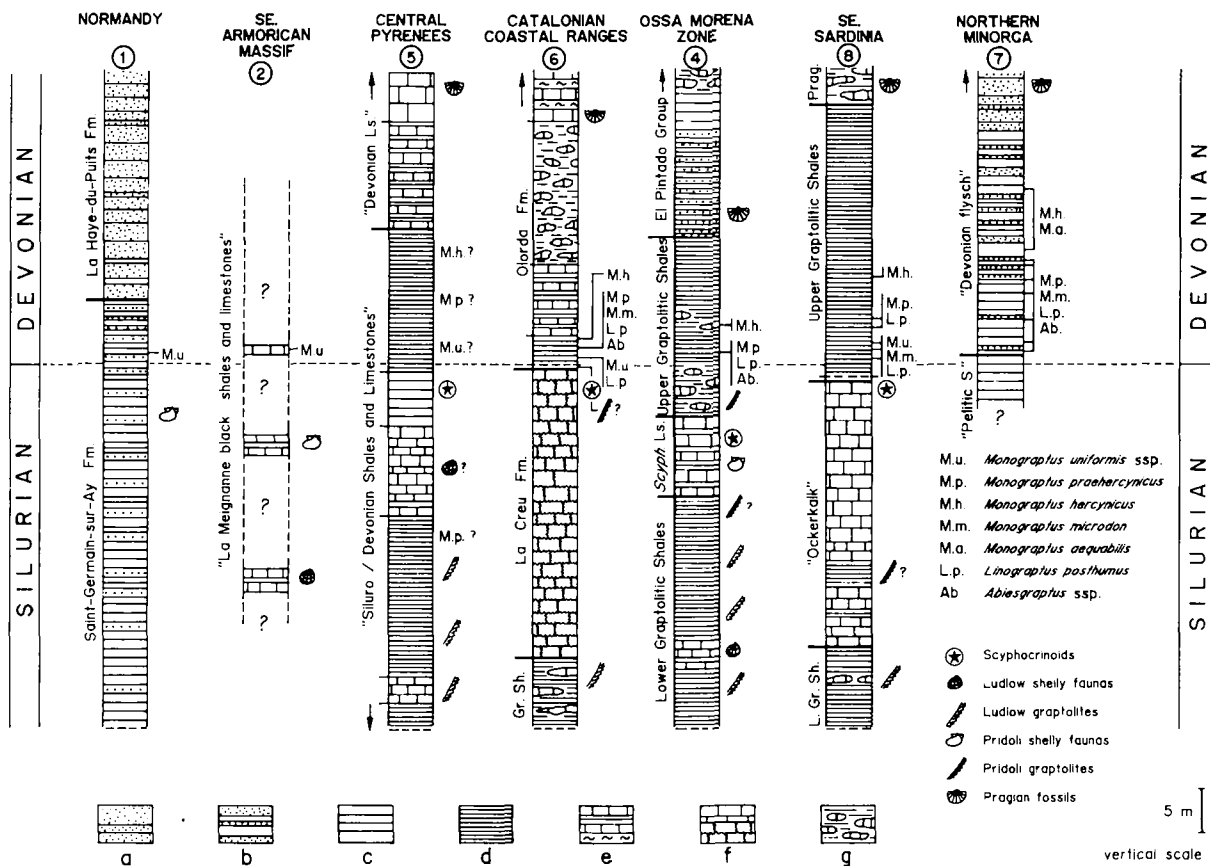


Figure 3. Upper Silurian and Lower Devonian sections from southwestern Europe showing lithostratigraphy and fossil distributions; the section numbers correspond to those in Figure 1. The datum corresponds to the base of the Devonian. Lithological characteristics are as follows: a, sandstones; b, alternating sandstones and shales; c, dark pelites; d, black shales; e, limestones, marls and shales alternating; f, limestones and massive nodular limestones; and g, shales with limestones lenses and nodules

6 and Figure 3). Following the initial discovery of *M. hercynicus* and *Abiesgraptus* sp. in these shales (Greiling and Puschmann 1965), further new localities have been reported. Rickards and Chapman (in Julivert *et al.* 1985) recognized two assemblages, an older one with *M. uniformis uniformis* or *M. uniformis angustidens* (Fig. 6), and a younger assemblage with *M. cf. hercynicus* and *L. posthumus*. Recent work by Ferrer *et al.* (1992) near Barcelona reveals three successive assemblages (graptolite identifications by Jaeger): the *uniformis* Biozone with *M. uniformis* and *L. posthumus*; the *praehercynicus* Biozone, recognized for the first time in that area and containing *M. praehercynicus*, *M. microdon* Richter, *L. posthumus*, and *Abiesgraptus* sp.; and a single assemblage of *M. hercynicus* corresponding to the *hercynicus* Biozone (Figure 4).

In addition to this, the green shales of the uppermost member (Member E) of the Olorda Formation have yielded the first known, but poorly preserved and indeterminable, benthic (dendroid) graptolite from the Devonian of the Iberian Peninsula.

## 6. BALEARIC ISLANDS

These constitute the northeastern extension of the Betic Cordillera of southeastern Spain. The oldest Palaeozoic basement is exposed along the northern coast of the island of Minorca (Figure 1, locality 7). The sequence begins with Lochkovian age turbidites that have yielded graptolites at differing stratigraphic levels

	GERMANY Jaeger 1988	RUSSIA Koren 1975	YUKON Lenz 1988	CZECH REP. Chlupac 1988	SPAIN
PRAGIAN		yukonensis craigensis fanicus falcarius	yukonensis  fanicus	yukonensis/ atopus	<i>Monograptus</i> sp.
LOCHKOVIAN	hercynicus praehercynicus uniformis	hercynicus  ?	hercynicus  ?	hercynicus praehercynicus uniformis	hercynicus praehercynicus uniformis

Figure 4. Lower Devonian graptolite biostratigraphy and biozonal correlations. The suggested biostratigraphic position of the post-Lochkovian graptolite *Monograptus* sp. is indicated

(Figure 3). Jaeger (*in* Bourrouilh 1983) identified a lower assemblage with *M. praehercynicus*, *M. microdon* and *L. posthumus*; and an upper assemblage with *M. cf. hercynicus* and *M. aequabilis* Příbyl, the latter fauna being accompanied by a late Lochkovian conodont fauna.

## 7. SARDINIA

Lower Devonian graptolites are well known in southeastern Sardinia (Figure 1, locality 8, and Figure 3) where the entire Silurian to Lochkovian sequences is developed in the classic 'Thuringian triad' i.e. graptolitic black shale and lydite units, separated by 'Ockerkalk' or *Scyphocrinites* limestones. The 'Upper Graptolitic Shales' overlying the limestones (the so-called calcareous 'intermezzo') have yielded a lower *uniformis* Biozone assemblage (*M. uniformis*, *M. microdon*, *L. posthumus*); a *praehercynicus* Biozone (*M. praehercynicus*, *L. posthumus*); and, lastly, an upper assemblage with *M. hercynicus* (Helmcke 1973, Jaeger 1976, 1977). Rickards *et al.* (1995) described *M. praehercynicus*, *L. posthumus* and *Abiesgraptus (sic) multiramosus* Hundt from an assemblage referable to either the late *uniformis* Biozone or the early *hercynicus* Biozone. These workers also briefly discuss the concept of a *praehercynicus* Biozone. Lower Devonian graptolites are thus far unknown in the Upper Silurian-Lower Devonian sequences of southwestern Sardinia. The biomicritic to biodetrital limestones of the uppermost part of the Fluminimaggiore Formation have yielded cephalopods, scyphocrinoids, bivalves and conodonts, but no graptolites; the Lochkovian age of these strata is based on conodonts of the *woschmidti* Biozone and on bivalve communities almost identical to those of the Lochkovian of the Prague area, Bohemia (Gnoli *et al.*, 1988, 1990; Olivieri and Serpagli 1990; Kříž and Serpagli 1993).

## 8. GENERAL REMARKS

From the biostratigraphic point of view, the *uniformis* Biozone has been recognized in Normandy, the southeastern Armorican Massif, the ?Pyrenees and Sardinia. The *praehercynicus* and *hercynicus* biozones are documented from the ?Pyrenees, Ossa Morena, Minorca and Sardinia. Only in Sardinia and the Catalonian Coastal Ranges, however, have all three biozones been recognized. Post-Lochkovian graptoloids, albeit poorly preserved, have been recovered from only a single locality in the Ossa Morena zone.

Species diversity is typically very low, generally being represented by monospecific assemblages of the zonal species. Along with *Linograptus posthumus* and ?*Abiesgraptus* sp., which are present in several of the

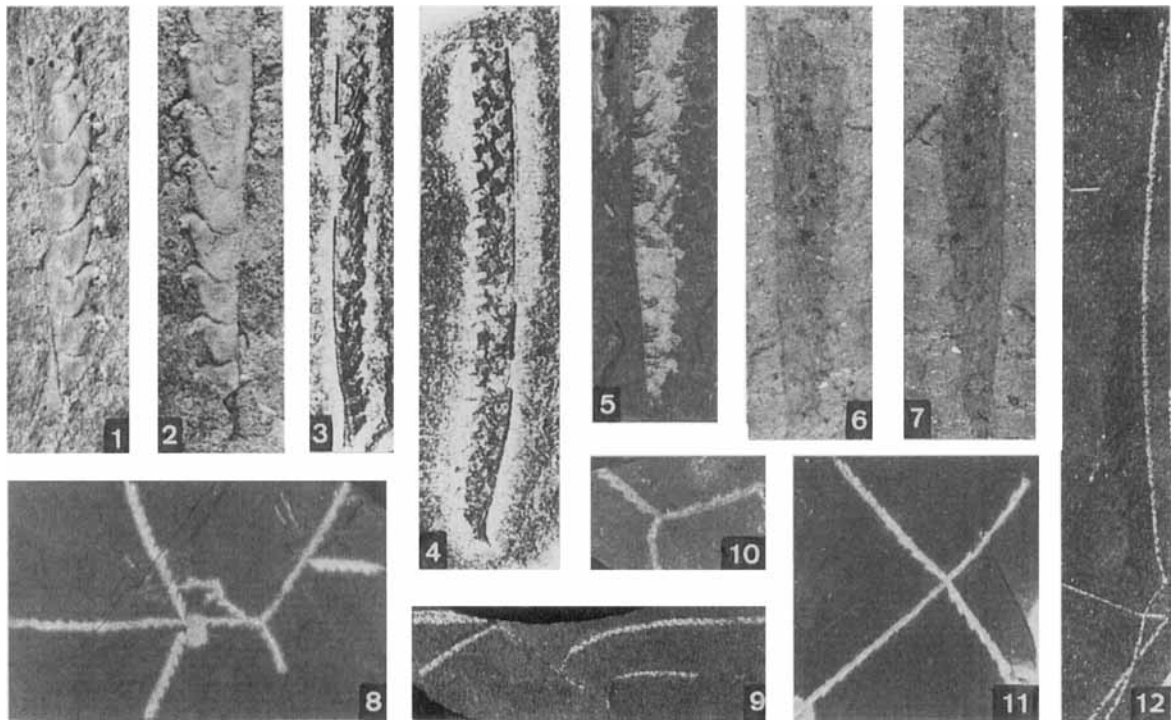


Figure 5. Devonian graptolites from Spain. 1, 2, *Monograptus hercynicus* Perner, from the northern margin of El Pintado Reservoir (Valle syncline), showing two proximal parts in relief, DPM 3701 and 3702,  $\times 7$ ; 3, *Monograptus aequabilis aequabilis* Přibyl, from Minorca, *praehercynicus* Biozone (from Bourrouilh 1983: pl. 7, figure 3),  $\times 3.2$ ; 4, *Monograptus cf. hercynicus* Perner, from Minorca, *hercynicus* Biozone (after Bourrouilh 1983: pl. 7, fig. 1),  $\times 3$ ; 5, *Monograptus praehercynicus* Jaeger, from the new locality south of El Pintado Reservoir (Valle syncline), DPM 3703,  $\times 4.1$ ; 6, 7, *Monograptus* sp., from late Pragian – early Emsian locality at Cañaver de León (Huelva), part and counterpart, DPM 3704,  $\times 6$ ; 8, 9, *Abiesgraptus* sp., *praehercynicus* Biozone  $\times 1.25$ ; 8, from El Pintado Reservoir-south (new locality), DPM 3705,  $\times 1.25$ ; 9, from Minorca (after Bourrouilh 1983: pl. 2, figure 8),  $\times 0.9$ ; 10–12, *Linograptus posthumus* (Richter), *praehercynicus* Biozone, proximal parts of three- (10, DPM 3706,  $\times 1.9$ ) and four-stiped (11, DPM 3707,  $\times 2$ ) rhabdosomes, from El Pintado Reservoir-south (new locality); 12, a more complete rhabdosome from Minorca (figured in Bourrouilh 1983: pl. 2, figs. 3, 4),  $\times 0.9$

localities, *Monograptus microdon* is present only on Minorca, the Catalanian Coastal Ranges and Sardinia, and *Monograptus aequabilis aequabilis* (Figure 5.3) has been found only on Minorca. By comparison, Jaeger (1988) indicates as many as seven species in the *uniformis* Biozone, five in the *praedeubeli* Biozone and four in the *hercynicus* Biozone of central Europe, all three zones including the very long-ranging taxa *M. aequabilis*, *Linograptus* and *Abiesgraptus*.

Lower Devonian graptolites of southwestern Europe have been found mainly in rocks typical of outer shelf, 'proto-Tethyan' regions similar to those in Thuringia, Bohemia, the Carnic Alps and northwestern Africa. These sequences contain abundant pelagic faunas and are commonly condensed sections, characterized by an overwhelming dominance of argillaceous or argillaceous and carbonate sediments with only minor components of coarser, terrigenous sands.

Although thick, sparsely fossiliferous, shallow water (inner shelf) sequences dominated by coarser clastic sediments are common in the central Iberian and mid-Armorican regions (e.g. Furada-San Pedro, Carazo, Alcolea and Luesma formations, and Cerro Escudero Group, Spain; and the Saint Germain-sur-Ay Formation of the Normandy region, and the Gahard and Plougastel formations, Brittany, France), they have not, with the exception of the Carteret section, yielded graptolites. Certainly, however, other fossils (e.g. chitinozoans; Paris 1981) indicate continuous marine sedimentation from the late Silurian through to the early Devonian. Whether the absence of graptolites signifies environmental exclusion, lack of preservation or a failure to collect rare material is not known. However, it must be again pointed out that in all of the regions in southwestern Europe where Devonian graptolites occur, there is only one exception to

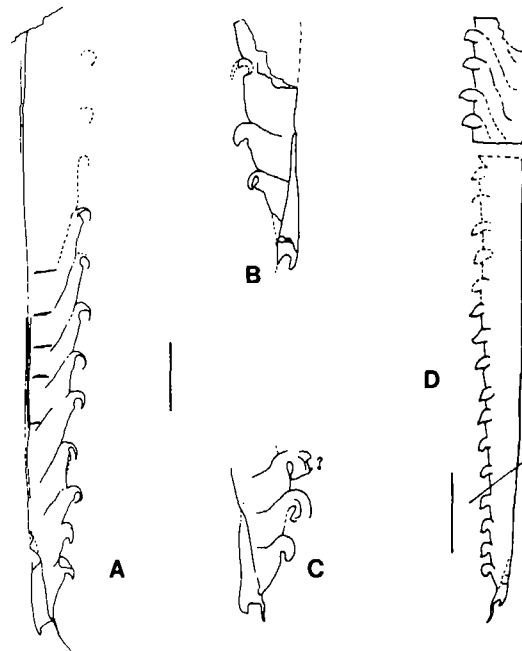


Figure 6. *Monograptus uniformis* Přibyl from the Catalonian Coastal Ranges, Spain (A–C), and Normandy, France (D). (A) *M. uniformis uniformis*, flattened specimen from Serra de Miramar; (B, C) *M. uniformis angustidens* Přibyl, specimens in relief, from Cervelló; and (D) *M. uniformis* s.l., from Carteret, proximal and distal parts of two different rhabdosomes on the same slab. (A–C redrawn from Rickards and Chapman, in Julivert *et al.* 1985, text-figure 4 a, 4c, 4f; and D, after Jaeger and Robardet 1973, text-figure 1a and 1b). Graphic scale, 3 mm

the fact that the early Silurian to Lochkovian successions consist of almost identical, monotonous euxinic sequences of black shales and lydites with a minor 'intermezzo' of argillaceous limestones within the Pridoli. The presence of a complete graptolitic zonal succession throughout the condensed sequences indicates a low but continuous deposition with a very limited influx of terrigenous particles (Robardet 1982). These characteristics strongly suggest that during Silurian and early Devonian times these regions belonged to the distal-most parts of the North Gondwanan shelf.

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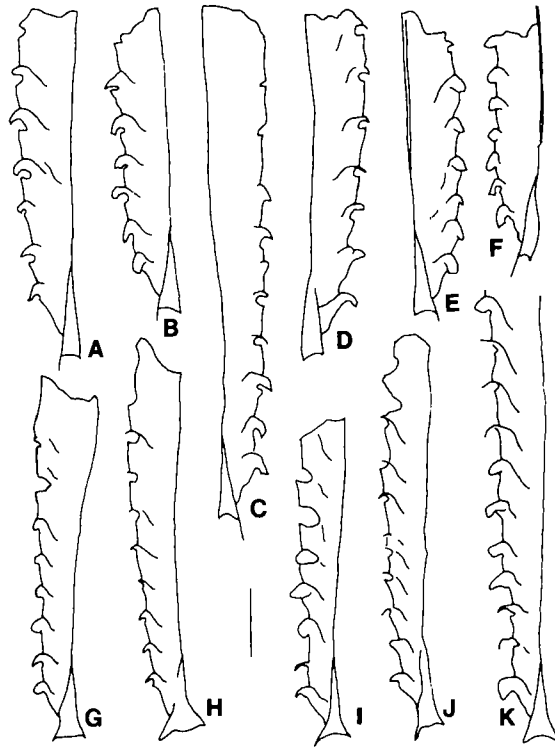


Figure 7. Devonian graptolites from El Pintado Reservoir-south (new locality). (A–F) *Monograptus praehercynicus* Jaeger, DPM 3708, 3709, 3710, 3711, 3712, 3713; (G–K) *Monograptus hercynicus* Perner, DPM 3714, 3715, 3716, 3717, 3718. Graphic scale 2 mm

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