

Silurian graptolites of the *spiralis* and *lapworthi* biozones (upper Telychian, Llandovery) in the Sulcis area, SW Sardinia

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ABSTRACT – Numerous graptoloid specimens have been discovered and identified in a large olistolith of Silurian black shales and lydites situated within the Culm-type Hercynian Sulcis flysch complex of SW Sardinia. The graptolite fauna discovered at Punta S'Omù de Is Abis (Sulcis area) is attributable to the middle *spiralis* – lower *lapworthi* biozones of the upper Llandovery. Of nine species recorded, *Stomatograptus grandis*, *Monoclimacis geinitzi*, *Diversograptus ramosus*, ?*Cyrtograptus lapworthi*, *Oktavites excentricus* and "*Monograptus*" aff. *nodifer* have been recognized for the first time in Italy. Using the specimens from Punta S'Omù de Is Abis and topotypic material from Bohemia, *Stomatograptus grandis* (Suess, 1851) is revised and its stratigraphical range re-evaluated.

RIASSUNTO – [Graptoliti siluriani delle biozone *spiralis* and *lapworthi* (parte alta del Telychian-Llandovery) nel Sulcis, Sardegna sud-occidentale] – All'interno di grandi olistoliti siluriani formati da scisti neri e liditi, "imballati" nel complesso flyschioide ercinico tipo Culm affiorante nella Sardegna sud-occidentale, sono stati trovati e identificati numerosi esemplari di graptoliti. La fauna scoperta a Punta S'Omù de Is Abis (Sulcis) viene collocata nell'intervallo tra la parte intermedia della biozona a *spiralis* e la parte inferiore della biozona a *lapworthi*. Sei specie (*Stomatograptus grandis*, *Monoclimacis geinitzi*, *Diversograptus ramosus*, ?*Cyrtograptus lapworthi*, *Oktavites excentricus* e "*Monograptus*" aff. *nodifer*), delle nove riconosciute, vengono segnalate per la prima volta nel Paleozoico italiano. Dallo studio di esemplari sardi di Punta S'Omù de Is Abis e di materiale topotipico della Boemia, è stato possibile effettuare la revisione di *Stomatograptus grandis* (Suess, 1851) rivalutandone anche il significato stratigrafico.

GEOLOGICAL AND STRATIGRAPHICAL SETTING OF THE PALAEOZOIC IN SULCIS AREA

The graptolite-bearing rocks studied in this report belong to the Palaeozoic sequence of eastern Sulcis, which is part of the autochthonous basement of south-western Sardinia. It is equivalent to the "External Zone" (or Vorland) of the Hercynian Chain (Carmignani *et al.*, 1992) and progressively grades to the "Nappe Zone" of eastern Sardinia.

The Palaeozoic rocks cropping out in this area belong to two main sequences, in many places separated by a tectonic contact (Barca *et al.*, 1998).

The lower part comprises a 150-200 m thick low-grade metamorphic succession. This consists of an irregular alternation of metasandstones and meta-siltites with levels of light-grey limestones, partly siliclastic, often fully silicified. Elements of typical southern Sardinian Caradoc-Ashgill benthic faunas, consisting mainly of brachiopods, bryozoans, echinoderms, trilobites, etc., can be found in the succession (Leone *et al.*, 1991, 1998). The sequence continues locally with Silurian metasediments typically represented by black graptolitic silica-argillaceous and siltitic shales interbedded with lydites (Barca *et al.*, 1998). The Ordovician and Silurian metasediments to the west are intruded, and altered by thermal metamorphism, by Hercynian granitoids.

The Sulcis Palaeozoic sequence continues with a carbonate and argillite unit hundreds of metres thick, of Silurian-Devonian age, formed by nodular and massive metalimestones alternating with compact dark siltstones and shales. This complex includes also the *stromatactis*-bearing carbonate mound of Mt Padenteddu which forms a lenticular body of massive limestone (Gnoli *et al.*, 1981) dated to the early Devonian *pireneae* and *dehishens* conodont biozones (spanning across the Pragian/Emsian boundary). In the mud-mound facies tabulate and colonial corals are also present, as well as abundant *stromatactis* structures (Gnoli *et al.*, 1981). Fossils, including tentaculites, crinoids, conodonts and trilobites, have been occasionally recorded in Sulcis whereas in nearby Iglesiente the fauna is dominated by dacroconarids, cephalopods, conodonts and ostracods, with rare crinoids, brachiopods, bivalves, gastropods, trilobites, phyllocarids, corals, forams, and sponge spicules (Gnoli *et al.*, 1990).

This succession is tectonically overthrust by a flysch sequence, several hundred metres thick, of terrigenous sediments. Metasandstones with planar and cross lamination, metasiltites, dark-grey metargillites, arenaceous-pelitic intercalations with typical turbiditic structures (plane-parallel, convolute and cross laminations, ripple marks, flute casts, etc.) and thin bedded light quartzites with fine intercalations of

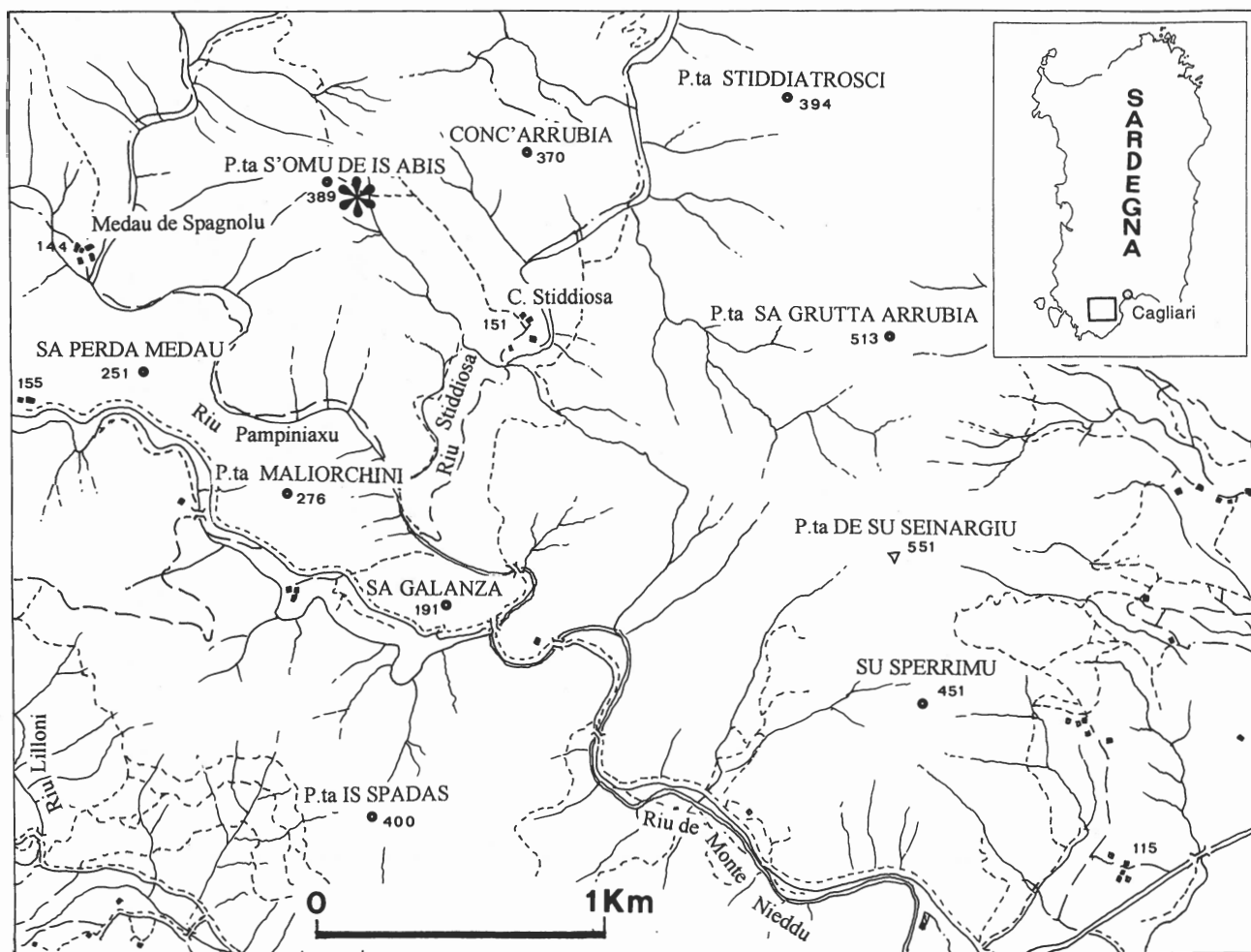
metapelites, sometime bearing slump-features, are the main lithologies of the sequence.

Within this complex lenticular intercalations, varying in size from decimetres up to tens of metres, of megabreccias (olistostromes), with black lydite clasts, polymictic metaconglomerates (containing cobbles of black lydites, quartz, quartzites, metavolcanites) and also volcanic products and volcanoclastites (both acid and basic) are present. Resedimented blocks (olistoliths) of shales and black lydites, extremely variable in size (up to tens of metres thick and to hundreds of metres long), also occur, mainly along preferential belts. Fossiliferous levels, such as the graptolite-bearing outcrop of Punta S'Omù de Is Abis, are sometimes present in such large olistoliths.

The flysch complex cropping out in eastern Sulcis shows lithostratigraphical and structural analogies with the Hercynian synorogenic deposits occurring in the allochthonous tectonic units of south-eastern Sardinia. Such analogy is particularly close with the succession of the Pala Manna Formation belonging to the Sarrabus

Tectonic Unit, indirectly dated as post-Devonian (Dinantian or Visean-Namurian ?) on the basis of late Devonian conodonts recovered in the calcareous olistoliths (Barca, 1991; Barca & Olivieri, 1991).

The Sulcis flysch complex which can be correlated, on the basis of lithostratigraphic features, with the Culm-type Hercynian flysches of Southern Europe (Spalletta, 1982; Ebner, 1991) accumulated in a fore-deep basin. This basin was located at the outermost nappes front of the Sardinian segment of the Hercynian orogen during the early Carboniferous. Such nappes, during their SSW movement, could have involved, more or less intensely, the eocarboniferous basin the siliciclastic and volcanogenic deposits of which have been transported in the same direction, thrust over the "autochthonous" Palaeozoic sequence of Sulcis. It is possible that the "Outer Allochthonous Units" supplied the resedimented material to the fore-deep basin.



Text-fig. 1 - Map showing location of the graptolite-bearing outcrop at Punta S'Omù de Is Abis, SW-Sardinia.

GRAPTOLITE-BEARING ROCKS IN EASTERN SULCIS

Several of the olistoliths of the Sulcis region, such as that cropping out at Punta de Su Seinargiu, Punta S'Omù de Is Abis, Riu Lilloni, contain black shales and lydites bearing graptolites in different state of preservation.

The fossiliferous outcrop with the graptolite assemblage here described was discovered by one of us (S.B.) at a locality about 800 m SW of Ovile Stiddiosa (Text-fig. 1) and a good collection was assembled by two of us (P.Š. & E.S.) during field work in 1995. Graptolites have been collected from laminated metasiltstones and black metargillites (here-after referred to as black shales and lydites) belonging to a large and thick olistolith of the eocarboniferous synorogenic Culm-type sequence (Text-fig. 2).

PREVIOUS GRAPTOLITE RECORDS IN SARDINIA

Graptolites are well known from the lowermost Ordovician, upper Ordovician, Silurian and Lower Devonian of Sardinia and numerous papers describing several assemblage zones and new taxa have been published (Meneghini, 1857,1880; Novarese, 1920; Gortani, 1922; Taricco, 1922; Jaeger, 1976; Barca *et al.*, 1977; Pillola & Gutiérrez-Marco, 1988; Barca &

Jaeger, 1990; Gnoli *et al.*, 1990; Leone *et al.*, 1993; 1998; Štorch & Serpagli, 1993; Rickards *et al.*, 1995; Štorch, 1996b). Barca & Jaeger (1990) recorded late Llandovery strata in several outcrops in the Rio Ollastu area (district of Sarrabus) in SE-Sardinia. Their samples have generally been assigned to the lower part of the *Oktavites spiralis* Biozone due to the joint occurrence of *O. spiralis* (Geinitz), *Torquigraptus flagellaris* (Törnquist) and a species referred to by Barca & Jaeger as *Streptograptus anguinus* Přibyl. Barca *et al.* (1998) published the first, preliminary note about the *spiralis* Biozone graptolites from Punta S'Omù de Is Abis and about probable *linnaei* Biozone graptolites from the adjacent outcrop of black lydites and shales at Ovile Stiddiosa.

GRAPTOLITE BIOSTRATIGRAPHY AND CORRELATION

Late Telychian strata preserved in the large olistolith at Punta S'Omù de Is Abis have yielded common, flattened, moderately well preserved graptolites, slightly deformed by lineation. Of the nine species recorded in a more than 1m thick, tectonized succession (Text-fig.3), *Oktavites spiralis* (Geinitz), *Stomatograptus grandis* (Suess) and *Cyrtograptus lapworthi* Tullberg have been widely employed as index taxa indicating graptolite biozones (or subzones) in upper Telychian biozonal schemes world-wide.

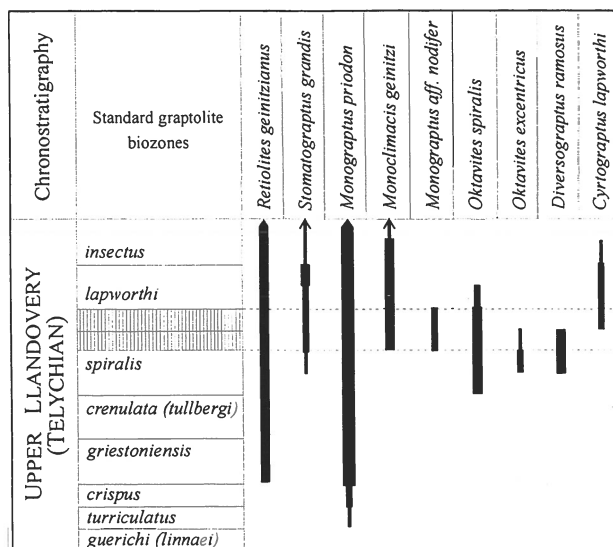


Text-fig. 2 - Sampled exposure of black, thin-bedded, Silurian laminated metasiltstones and black metargillites at Punta S'Omù de Is Abis.

Abundant *Oktavites spiralis*, accompanied by *Oktavites excentricus* (Bjerreskov), abundant *Diversograptus ramosus* Manck, *Monoclimacis geinitzi* (Bouček) and *Monograptus* aff. *nodifer* Törnquist suggest that the upper part of the *Oktavites spiralis* Biozone is exposed at Punta S'Omù de Is Abis (Text-fig.3). It needs to be mentioned, however, that the stratigraphical extent of the internationally applied *spiralis* Zone (e.g. Koren'et al., 1996) differs from that used by Bouček (1953), Jaeger (1976), Barca & Jaeger (1990), Storch (1994), and many other authors. Bouček subdivided his *spiralis* Zone in three subzones: in ascending order *M. parapriodon* Subzone, *Str. anguinus* Subzone and *Mcl. geinitzi* Subzone. The above listed graptolite taxa occur together in about the boundary interval between his latter two subzones. They also occur, together or individually, in the middle-upper *spiralis* Biozone of Loydell & Cave (1996) in Wales, Loydell et al. (1998) in Latvia, and also in Spain (Gutiérrez-Marco & Storch, 1998, unpublished data of J.C. Gutiérrez-Marco, D.K. Loydell and P. Storch). The joint occurrence of rare *St. grandis*, rare *Cyrt. lapworthi* and common *O. spiralis* and *Div. ramosus* has been recently recorded (personal observation, P.Š.) in a road cutting between Ochserbach Alm and Dr Steinwender Hütte in the Austrian Carnic Alps. *O. excentricus* has been found some 0.2 m below this assemblage in the section referred to above.

O. excentricus is a species recorded from the middle part of Bjerreskov's (1975) *spiralis* Biozone in Denmark (isle of Bornholm), from Scotland (Bull & Loydell, 1995) and from Spain (Corral de Calatrava; Gutiérrez-Marco, Loydell & Storch, unpublished data).

In Bohemia an assemblage containing *O. spiralis*, *Mcl. geinitzi* and *M. aff. nodifer* immediately precedes the earliest occurrences of *Cyrt. lapworthi* which is followed by common *St. grandis* higher up in the sequence (at Vyskočilka section in Prague). Both ?*Cyrt. lapworthi* and abundant *St. grandis* appear in Punta S'Omù de Is Abis Section too, thus indicating the presence of still higher stratigraphical level which can be referred to the *Cyrtograptus lapworthi* Biozone (Text-fig.3). The *Cyrt. lapworthi* Biozone was introduced by Bjerreskov (1975) and has been widely applied to characterize late Telychian strata overlying the *spiralis* Biozone (Koren'et al., 1996; Loydell & Cave, 1996; Storch, 1998, a.o.). In the Vyskočilka



Text-fig. 3 - European biostratigraphical ranges of the graptolite taxa recorded in Punta S'Omù de Is Abis (SW-Sardinia) and the probable biostratigraphical assignment of its faunal assemblage (shaded with vertical lines). Relative species abundance is illustrated by the width of the range-bar.

section in Bohemia *O. spiralis*, *Mcl. geinitzi* and *M. aff. nodifer* range well into the *lapworthi* Biozone (Storch, 1994; 1996a). The same overlap was also recorded by Bouček (1953) in the *geinitzi* Subzone of his *spiralis* Zone (= lower part of present *lapworthi* Biozone). The remaining two species of the Punta S'Omù de Is Abis assemblage – *Monograptus priodon* (Bronn) and *Retiolites geinitzianus* Barrande – are long ranging species through most of the Telychian and lower Sheinwoodian and are thus of very limited biostratigraphical value.

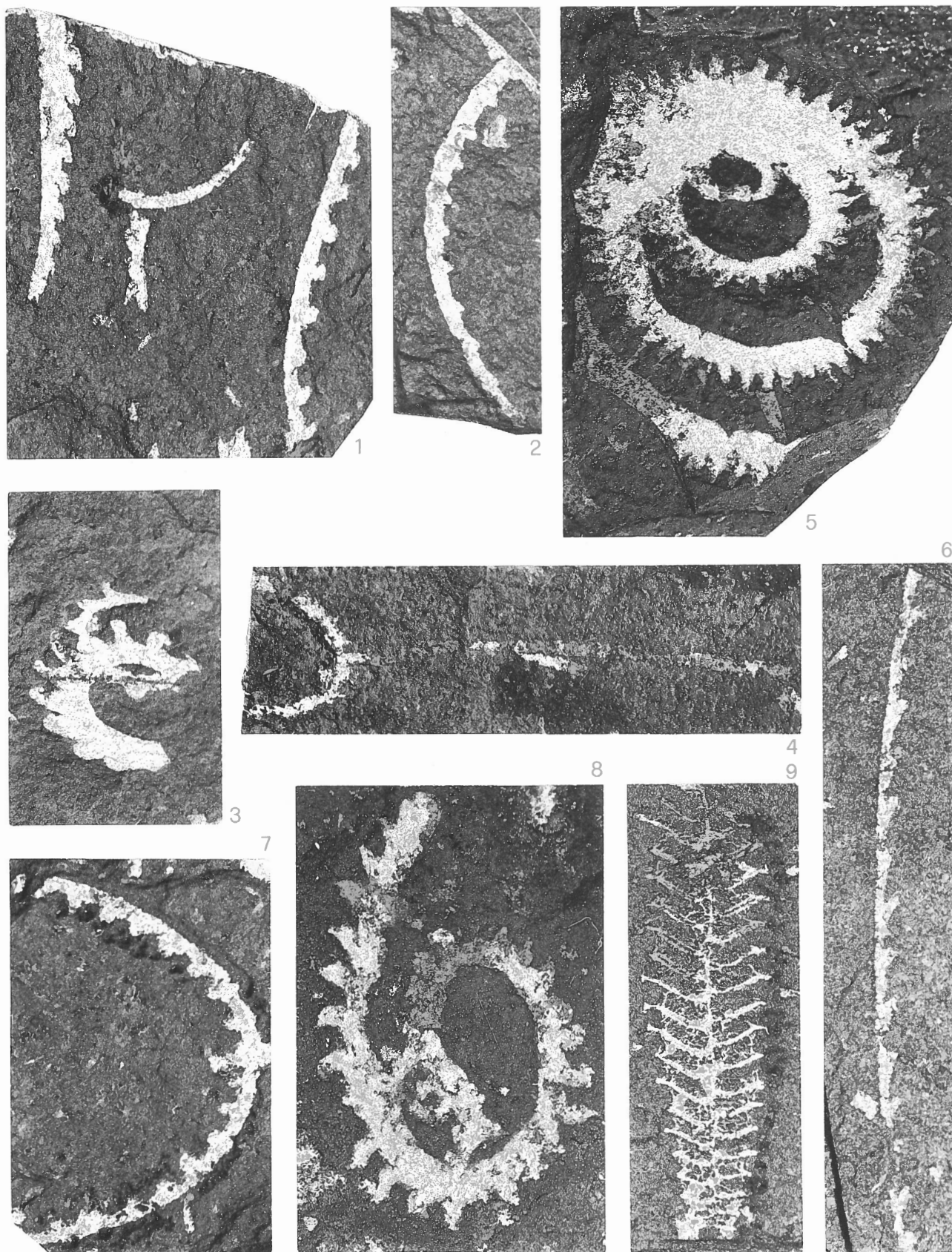
We use the two graptolite biozones under discussion as assemblage zones characterized by their entire graptolite associations. Biozonal boundaries have not been identified due to metamorphic and tectonic affects on the exposed strata.

PALAEONTOLOGICAL REMARKS

Several ventrally curved rhabdosomes, resembling "*Monograptus*" *nodifer* Törnquist, 1881 by their cur-

EXPLANATION OF PLATE 1

- Fig. 1 (left side) - *Monograptus priodon* (Bronn), IPUM n. 24142, x 5.
 Figs 1-2,7 - "*Monograptus*" aff. *nodifer* (Törnquist); 1) (right side) IPUM n. 24142, x 5; 2) IPUM n. 24137, x 5; 7) IPUM n. 24136, x 5.
 Figs 3,5,8 - *Oktavites spiralis* (Geinitz); 3) IPUM n. 24143, x 5; 5) IPUM n. 24134, x 3; 8) IPUM n. 24144, x 5.
 Fig. 4 - ?*Cyrtograptus lapworthi* Tullberg, IPUM n. 24140a, x 2.
 Fig. 6 - *Diversograptus ramosus* Manck, IPUM n. 24141, x 5.
 Fig. 9 - *Retiolites geinitzianus* Barrande, IPUM n. 24132, x 5.



vature and principal parameters, are referred to as "*Monograptus*" aff. *nodifer* Törnquist. These fragmentary rhabdosomes widen from c. 0.3 mm most proximally to 1.0–1.2 mm distally. Distal 2TRD is 2.2–2.55 mm. The longest fragment measures 20 mm. No details can be discerned on the badly preserved thecae of semi-rounded streptograptid outline. The present taxon differs from *Streptograptus anguinus* Přibyl, 1941 in having robust, more ventrally coiled rhabdosome.

Two specimens (on single slab) assigned to *Oktavites excentricus* (Bjerreskov, 1975) were distinguished from the otherwise similar, obliquely flattened spiraliform rhabdosomes of *O. spiralis* (Geinitz) by their loosely conical shape and lesser dorso-ventral width (1.8 mm) which is maintained distally from the first whorl. The rhabdosome of *O. excentricus* is coiled in a conspicuously excentric, formerly conical spiral having two and one-quarter whorls. The badly preserved thecae of our specimens do not exhibit the long apertural horns (see Lenz & Melchin, 1989) typical of *O. spiralis*.

Worthy of note is the abundance in some beds of *Diversograptus ramosus* Manck which is one of the most characteristic elements of middle *spiralis* Biozone graptolite assemblages in peri-Gondwanan Europe (Central Iberian Zone, Ossa Morena Zone and Central Iberian Cordillera in Spain; Thuringia; Barrandian in Bohemia; Austrian Carnic Alps) and occurs also in Wales at this level (Loydell & Cave, 1993, 1996). Ventrally curved to almost straight rhabdosome fragments possess gently inclined thecae without any apparent overlap. The thecal apertures appear tightly hooked. The dorso-ventral width of the rhabdosome ranges from 0.6 to 0.8 (exceptionally 0.9) mm, 2TRD from 2.6 to 3.8 mm.

Two badly preserved fragmentary specimens, one a dorsally curved proximal portion and the other a mesial part with a metacladium are assigned in *Cyrtograptus*. They are tentatively assigned to *Cyrtograptus lapworthi* Tullberg since their dorso-ventral width and general shape agree with those of the latter species. The present assignment is supported by the fact that no other *Cyrtograptus* species appears together with *O. spiralis* in upper Llandovery strata in Europe.

The graptolites encountered in Punta S' Omu de Is Abis are very widely distributed taxa without any known palaeobiogeographical significance. The graptolite assemblage is very similar to coeval graptolite

associations known from other sections in peri-Gondwanan Europe.

SYSTEMATIC PART

STOMATOGRAPTUS GRANDIS (Suess, 1851)

Pl. 2, fig. 2

- 1850 *Retiolites geinitzianus* BARRANDE, (*partim*), pl. 4, figs 20–23.
 1851 *Retiolites grandis* SUESS, p. 15, pl. 7, fig. 2
 1883 *Stomatograptus Törnquisti* Tullb. - TULLBERG, p. 42, pl. 1, figs 1–8.
 1892 *Stomatograptus grandis* Suess - TÖRNQUIST, pp. 8,9; pl. 2, figs 22–23.
 1899 *Stomatograptus grandis* Suess sp. - PERNER, pp. 38,39; text-figs 33, 34a,b; 35
 1931 *Stomatograptus grandis* var. *maior* BOUČEK, pp. 13,14.
 1944 *Retiolites (Stomatograptus) grandis grandis* Suess 1851 - BOUČEK & MÜNCH, pp. 45,46; text-figs 15e, 16a–c, 17a–c; pl. 3, figs 7,8.
 1944 *Retiolites (Stomatograptus) grandis maior* Bouček 1931 - BOUČEK & MÜNCH, pp. 48, 49; pl. 3, figs. 9,10; text-fig. 16 d,e.
 1955 *Retiolites (Stomatograptus) grandis grandis* Suess - MALINOWSKA, p. 35, pl. 2, fig. 2.
 1955 *Retiolites (Stomatograptus) grandis maior* Bouček - MALINOWSKA, p. 35, pl. 2, fig. 3.
 1975 *Stomatograptus grandis grandis* (Suess, 1851) - BJERRESKOV, pp. 39,40; pl. 5, fig. 1, tab. 3. (see for further references)
 ? 1978 *Stomatograptus grandis* (Suess) - WANG, p. 309, pl. 3, figs 3–4.
 1979 *Stomatograptus elegans* Paškevičius sp. nov. - PASKEVIČIUS, pp. 146–148, pl. 7, figs 4,5; pl. 23, figs 2,3.
 ? 1981 *Stomatograptus grandis grandis* (Suess, 1851) - BJERRESKOV, p. 21, pl. 5, fig. 7.
 1982 *Stomatograptus grandis grandis* (Suess, 1851) - LENZ, pp. 36,37; Fig. 16 A–C.
 ? 1989 *Stomatograptus grandis grandis* (Suess) - MELCHIN, fig. 13B (not described).
 1990 *Stomatograptus grandis grandis* (Suess, 1851) - TOMCZYK, URBANEK & TELLER, p. 388, pl. 183, figs 5,6.
 1990 *Stomatograptus grandis maior* Bouček, 1931 - TOMCZYK, URBANEK & TELLER, p. 389, pl. 183, fig. 4.
 non 1987 *Stomatograptus grandis grandis* (Suess) - LENZ & MELCHIN, p. 166, pl. 2, fig. 2.
 non 1990 *Stomatograptus grandis* (Suess) - GE MEIYU, ZHENG ZHAOZHANG & LI YUZHEN, p. 116, pl. 61, figs 1,16.
 1996a *Stomatograptus grandis grandis* Suess, 1851 - ŠTORCH, pl. 2, fig. 3 (not described).

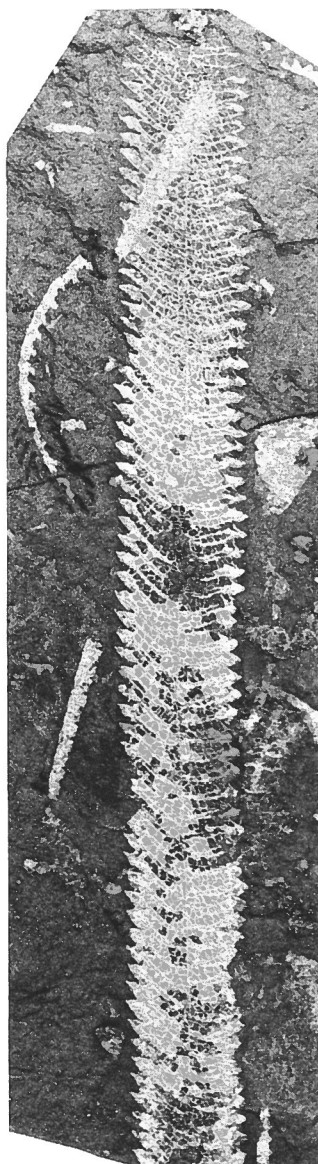
Type specimen – The only specimen figured by Suess (1851, pl. 7, fig. 2), which Přibyl (1948) stated as being holotype by monotypy, has not been traced. Thus a neotype specimen, no. L31630, is selected herein from the topotypic material which originates

EXPLANATION OF PLATE 2

- Fig. 1 - *Oktavites excentricus* (Bjerreskov), IPUM n. 24138a, x 3.
 Fig. 2 - *Stomatograptus grandis* (Suess), IPUM n. 24129, x 2.
 Fig. 3 - *Monoclimacis geinitzi* (Bouček), IPUM n. 24133, x 5 (right side).
 Figs 3–5 - *Diversograptus ramosus* Manck; 3) (left side) IPUM n. 24133, x 5; 4) IPUM n. 24135, x 3; 5) IPUM n. 24139, x 3.



1



2



3



4



5

from the upper part of the *lapworthi* Biozone (*grandis* Subzone) of the Motol Formation at Vyskočilka near Malá Chuchle (Prague, Bohemia). The proposed neotype was figured by Bouček & Münch (1944, text-figs. 16b, 17c).

Material (in Sardinia) – Three complete, flattened rhabdosomes, two distal portions, and several fragments. All specimens are slightly tectonically broadened.

Diagnosis – Large *Stomatograptus* with ventrally thickened thecal apertural lips. Proximal end of the rhabdosome broad and rounded. Flattened specimens widen from 2.4–3.2 mm (at the level of 5th thecal pair) to 6.0–7.5 mm at th40, and then more gradually to the distal maximum of c. 7–8 mm. 2TRD increases from 1.4–1.6 mm (th5 level) to 2.2–2.4 mm distally.

Description – The rhabdosome exceeds 100 mm long (the longest complete specimen measured 101.5 mm). It widens from 1.9 mm (at the level of the lips of the apertures of the first thecal pair) to 5.0 mm at the level of the 5th thecal pair, 6.3 mm at the 20th pair, and then slowly widens to a maximum of 7.8–8.3 mm, which is attained at th40 or later. The broad proximal end of mature rhabdosomes appears to have a dense meshwork of the ancora sleeve. Neither prosicula nor details of the ancora sleeve proximally, have been preserved. Details of the initial thecae are often obscured too.

Apertural lists of the distal thecae (terminology *sensu* Bates & Kirk, 1997) are 0.9–1.1 mm apart, 4.25–5.0 mm long and are inclined at c. 50° to the nema. Distal parts of the thecae are fully sclerotized and the ventral apertural lips are thickened.

Specimen no.	DVW	Th 1	Th 5	Th 10	Th 20	Th 40	Dist.
IPUM 24129	1.9	3.7	5.0	6.3	7	.8	8.3
IPUM 24131	-	-	-	-	-	-	7.8
L31633, L31617	1.5	2.4	3.8	4.8	7.1	7.4	-
L31630	1.45	2.6	3.45	4.7	6.0	-	-
PS 1047	1.65	2.7	3.9	-	6.9	7.3	-
PS 1046	-	-	-	-	7.2	7.65	-
PS 1044	1.3	3.0	3.8	5.0	6.5	-	-

Specimen no.	2TRD	Th 2	Th 5	Th 10	Th 20	Th 40	Dist.
IPUM 24129	1.3	1.65	1.9	2.1	2.2–2.4	2.2–2.3	-
IPUM 24131	-	-	-	-	-	-	2.7
L31633, L31617	1.2	1.4	1.45	2.05	2.2	2.3	-
L31630	-	1.4	1.75	2.2	2.4	-	-
PS 1047	1.1	1.45	1.9	-	2.3	2.4	-
PS 1046	-	-	-	-	2.2	2.3–2.4	-
S 1044	1.0	1.35	1.7	2.0	2.15	-	-

Tab. 1 – Measurements of rhabdosome width (DVW) and two theca repeat distance (2TRD) in Sardinian specimens of *St. grandis* compared to the neotype and selected specimens from the *grandis* Subzone of the Velká Ohrada section, Bohemia (in mm).

The thecae number 6.8 in the initial 5 mm of the rhabdosome, and 8.5–9 in 10 mm in its distal part. The two theca repeat distance (2TRD) is 1.3 mm at the level of th2, 2TRD 5 is 1.65 mm and the maximum 2TRD of 2.2–2.7 mm is attained some 40 mm from the proximal end. The meshwork of the ancora sleeve is dense proximally but becomes increasingly coarse distally, being composed of irregularly quadrate to subhexagonal meshes, 0.3–0.45 mm in diameter. Small median pores are badly recognizable in the present limited material.

Remarks – *St. grandis* is readily distinguishable from other *Stomatograptus* species – *Stomatograptus imperfectus* Bouček & Münch, *Stomatograptus asiaticus* Golikov, *Stomatograptus sinensis* Wang, *Stomatograptus grandis sensu* Ge *et al.* (1990), and *Stomatograptus grandis sensu* Lenz & Melchin (1987), Melchin (1989) and Bjerreskov (1981) – by its large, robust rhabdosome with broad and rounded proximal end, solid apertural lists and thickened apertural lips. The outer thecal walls are convex in profile. The maximum width of simply flattened rhabdosomes (not affected by tectonic deformation) ranges from 6 to 8 mm, varying in a manner similar to *Retiolites geinitzianus* (see Loydell *et al.*, 1997). Similarly prominent is the ancora sleeve meshwork density variation of the two respective taxa which reflects the maturity of the specimen studied. The broad and rounded proximal end of *St. grandis* possesses a broad and short ancora (badly seen in many flattened specimens). Observation on dozens of large, mature rhabdosomes from Bohemia suggests that the median row of pores (stomata) is rarely seen in flattened specimens. Bouček & Münch (1944) made the same observation.

The isolated rhabdosomes, illustrated by Lenz & Melchin (1987), attain a maximum uncompressed width of 4 mm. Such a rhabdosome could hardly be flattened without any tectonic enhancement to a width of more than 7 mm which is common in undeformed European specimens. It is very likely indeed that Cape Phillips populations (arctic Canada) are the same species as the 5 mm wide specimens assigned to *St. grandis* by Bjerreskov (1981) from Groenland. These probably represent a new species of *Stomatograptus*.

A single, 7.4 mm wide rhabdosome from the *murchisoni* Biozone of Bohemia was assigned to the subspecies *Stomatograptus grandis maior* by Bouček (1931). This is considered to be simply a mature specimen of *Stomatograptus grandis grandis* (Suess). *St. grandis maior* was distinguished from the type subspecies by its broader rhabdosome, slightly coarser ancora sleeve (“reticulum”) noticeably thickened apertural lips and stratigraphic occurrence. The rhabdosome, however, does not attain the maximum width of 8.5 mm, reported by Bouček (1931) and Bouček & Münch (1944), but only 7.4 mm. It must be stat-

ed that Bouček & Münch (1944) had considered the validity of *St. grandis maior* doubtful. *Stomatograptus elegans* Paškevičius was distinguished from *St. grandis maior* principally by its narrower proximal end and thicker apertural lips. The rhabdosome width (max DVW = 7.5 mm) and ancora sleeve and thecal parameters reported by Paškevičius (1979), however, correspond well with those of the topotypical specimens of *St. grandis*. Thus *St. elegans* is regarded as another junior synonym of the latter species.

Distribution – *St. grandis* is widely distributed in both peri-Gondwanan and Baltoscandinavian Europe. It is well documented from Sweden (Törnquist, 1892; Tullberg, 1883), Denmark (Bjerreskov, 1975), Lithuania (Paškevičius, 1979), Poland (Malinowska, 1955; Tomczyk *et al.*, 1990), the Czech Republic – Barrandian (Bouček & Münch, 1944; Bouček, 1953; Štorch, 1994; 1996a), Germany – Thuringia (Bouček & Münch, 1944), Austria – Carnic Alps (personal observation), Bulgaria – Iskar Valley (Spassov, 1958; and Bouček's collection, personal observation), E-Serbia (Mihajlovic', 1974) and now SW-Sardinia. It is confined to the upper *spiralis*, *lapworthi*, and *insectus* Biozones, its acme being in the upper *lapworthi* Biozone (*grandis* Subzone in Bohemia). Single specimen was reported from the *murchisoni* Biozone of Bohemia by Bouček (1931). The specimen probably came from debree and its stratigraphical assignment needs to be further confirmed.

The same stratigraphic range was reported for *St. grandis* also from Russia – Northern Caucasus Mts (Obut & Morozova, 1988), Northern Ural Mts (Koren', 1972), Taimyr Peninsula (Obut *et al.*, 1965), Kolyma District (Obut *et al.*, 1967) and Chukotka Peninsula (Obut & Sennikov, 1977). Lenz (1982) recorded *St. grandis* from the *spiralis* and *sakmaricus-laqueus* biozones in the Northern Canadian Cordillera. It should be pointed out, however, that his *spiralis* Biozone ranges from at least the *griestoniensis* Biozone to the *spiralis* Biozone of the European biozonal scheme. Melchin (1989) reported the same range (*griestoniensis* to *sakmaricus* biozones) from the Canadian Arctic Archipelago. The apparent early appearances of many graptolite taxa in the Canadian Arctic (Melchin, 1989) – *Div. ramosus* being reported from the lower Telychian *crispus* Biozone and *O. spiralis* and *Torquigraptus flagellaris* Törnquist even from the *turriculatus* Biozone – require further examination. Wang (1978) reported *St. grandis* from southern China (Lientan) and Fu (1986) from central China (Ziyang).

Sardinian specimens (abbreviated IPUM in Tab. 1) are housed in the University of Modena (collections of the "Museo di Paleobiologia") under the Catalogue numbers 24128-24144. Bohemian topotypic specimens of *St. grandis* are housed in the

National Museum, Prague (those abbreviated L in Tab. 1) and the Czech Geological Survey, Prague (those abbreviated PS in Tab. 1) respectively.

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