Introduction

Graptolites are one of the more studied fossil groups of the Palaeozoic Era; they are very common in the black shales, and very useful for biostratigraphic studies on this sedimentary rocks, from Ordovician to Lower Devonian.

During 19th and the first part of 20th centuries, according to previous studies in Czech Republic and England, graptolites started to be studied also in the Carnic Alps, where they were used to differentiate the shales of this area on the basis of their paleontological content.

The first studies on graptolites in this area was made by Staché (1872), who found the following species: Diplograptus folium Hisinger, D. pristis Hisinger, Graptolithus (Monograptus) proteus Barrande, G. triangulatus Harkness, G. nilsoni Barrande, Rastrites cf. peregrinus Barrande, Retiolites sp. in the Uqua (Uggwa) valley, north of Ugovizza (Udine, Italy), but at that time the area was part of Austrian territory. The same author (Staché 1881) reported, later, the presence of two graptolites species, which left in open nomenclature but similar to the Monograptus pridon and the Retiolites geinitzianus, in the area near Mt. Cocco-Malborghetto.

In the same year, Taramelli documented shales with Monograptus colonus in the southern slope of the Mt. Lodin (Taramelli 1881). At the end of the 19th century, Geyer (1895) discovered two new outcrops of graptolitic shales (with Monograptus sp.) in the northern part of the Carnic Alps, along the Rio Nöbling Valley and in the northern side of the Mt. Lodin group.

The first studies on the Italian part of Carnic Alps started at the beginning of the 20th century, when Vinassa de Regny and Gortani reported many species of well preserved graptolites from an outcrop close to Casera Meledis (Vinassa de Regny & Gortani 1905). Twenty-three species of graptolites were figured by Vinassa de Regny (1906) from the same outcrop. Subsequently, Gortani (1920) described and figured 29 species of graptolites from “Casera Meledis”.

The aim of this paper is updating data from the historical locality of “Casera Meledis” (Carnic Alps, NE Italy) are here described; 96 specimens were collected and analyzed, reporting 7 genus and 6 species, all refer to the triangulatus Biozone of the Aeronian age.

Key words: Graptolites, triangulatus Biozone, Silurian, Carnic Alps.
(Harkness), *Monograptus revolutus* Kurck, *Monograptus gemmatus* (Barrande), *Parapetalolithus palmeus* (Barrande), *Climacograptus rectangularis* (M’Coy) and *Torquigraptus* sp.

All samples from “Casera Meledis” refer to the *triangulatus* Biozone of the lower Llandovery.

### The “Casera Meledis” outcrop

The Meledis section crops out along the path CAI 449a between Casera Meledis bassa and Casera Meledis alta at coordinates N 46° 34’ 56.4” E 013° 07’ 41.1”. It is a very small outcrop, almost hidden in the wood, where abundant shale debris occur on the path and a few beds are exposed after digging a short trench. In general, the stratigraphic sequence of the area is overturned, since Ordovician siltstones and sandstones (Uqua Fm.) occur just above the graptolitic shales, and a large block of middle/upper Silurian *Orthoceras* limestones is exposed several meters below.

### Systematic section

The graptolites were colonial organisms and the exterior form (macro-character) or the measurement
(micro-character) of the colony are used to determine them. Among the macro-characters there are: form of the rhabdosome (straight, curve, sigmoidal, etc.), presence of ramifications (secondary branches), thecal morphology etc.

Among the micro-characters there are: measurements of the rhabdosome, measurements of the sicula, measurements of the thecae, overlapping between thecae, angle between thecae and rhabdosome axis, etc.

One of the most important micro-character is the 2TRD (two thecae repeat distance), that measures the increase factor of the rhabdosome.

Class Graptolithina BRONN 1846
Order Graptoloidea LAPWORTH 1875
Genus Rhaphidograptus BULMAN 1936

Rhaphidograptus thoernquisti (ELLES & WOOD), 1906 (fig. 2.b; fig. 4.1, 4.2)

1906 Climacograptus thoernquisti ELLES & WOOD, p. 190, tav. 26, fig. 6a-6f, textfig. 123a-123b.

1920 Climacograptus thoernquisti (ELLES & WOOD) - GORTANI, p. 15, tav. I (I), fig. 16-19.
1976 Rhaphidograptus thoernquisti (ELLES & WOOD) - BJERRESKOV, p. 43, fig. 1, pag. 44, fig. 2.
1978 Rhaphidograptus thoernquisti (ELLES & WOOD) - BJERRESKOV, tav. 18, fig. 1; tav. 21, fig. 1, 3-5.
1989 Rhaphidograptus thoernquisti (ELLES & WOOD) - BARCA & JAEGGER, pag. 577, fig. 11 (15).
1993 Rhaphidograptus thoernquisti (ELLES & WOOD) - STORCH & SERFAGLI, tav. 5, fig. 2, 4; pag. 29, fig. 8E.
1994 Rhaphidograptus thoernquisti (ELLES & WOOD) - ZALASIEWICZ & TUNNICLIFF, pag. 710, textfig. 8E-8J.
2003 Rhaphidograptus thoernquisti (ELLES & WOOD) - MASI, PODHALANSKA & STEMPEL-SALEK, pag. 318, textfig. 50.
2003 Rhaphidograptus thoernquisti (ELLES & WOOD) - LOYDELL, MANNIK & NESTOR, p. 209, fig. 4a.

Material: 13 rhabdosomes in bad preservation condition (MFSNgp 39719-39731) from "Casera Meledis" (Ud).
Locality: trail between Casera Meledis bassa and Casera Meledis alta.

Description: biserial graptolite, straight and slender, with a long virgella. The longest rhabdosome measured is of 38 mm, but, on average, the sample studied are 30 mm long, with a virgella that can exceed 10 mm. The rhabdosome is about 0.5 mm wide at the theca 1, 0.6 mm wide at the theca 3, and 1.5-1.7 mm in the distal part. The sicula is straight, about 1.5 mm long with a small aperture (about 0.2 mm), the apex achieve to the level of the 21 theca. The thecae are strongly geniculated, with a tiny aperture; on average there are 5-6 thecae in the distally 5 mm.

Observations: the specimens of Rhaphidograptus thoernquisti of “Casera Meledis”, despite their bad preservation, show the same characteristics as the samples of the same species globally known. Distribution: Llandovery, triangulatus biozone. Diffusion: global.

Family Monograptidae Lapworth 1873

Genus Demirastrites Eisel 1911

Demirastrites triangulatus (Harkness) 1851 (fig. 2.a; fig. 3.1, 3.2, 3.3; fig. 5.2)

1851 Rastries triangulatus - Harkness, p. 38, tav. I, fig. 3 a - d.
1907 Monograptus triangulatus (Harkness) - Vinassa de Regny, p. 29, tav. I, fig. 14.
1920 Monograptus triangulatus (Harkness) - Gortani, tav. III, fig. 17-18.
1920 Monograptus triangulatus var. cirratus (Harkness) - Gortani, tav. III, fig. 22-24.
1985 Demirastrites triangulatus (Harkness) - Xiaofeng, p. 237, pl. 2, fig. 2 - 3.
1899 Monograptus triangulatus (Harkness) - Barca & Jaeger, p. 577, fig. 18.
1993 Demirastrites triangulatus triangulatus (Harkness) - Storch & Serpagli, p. 51, textfig. 16 A-B.
2003 Demirastrites triangulatus (Harkness) - Loydell, Mannik & Nestor, p. 209, fig. 4h.
2009 Demirastrites triangulatus (Harkness) - Picarra, Robardet, Oliveira, Paris & Lombardeaux, p. 47, fig. 5A.
2009 Demirastrites triangulatus (Harkness) - Storch & Kraft, p. 63, fig. 8B.

Material: 30 rhabdosomes in bad preservation condition (MFSNgp 39719, 39722b, 39724, 39732-39758) from “Casera Meledis” (Ud).

Località: tratto tra Casera Meledis bassa e Casera Meledis alta.

Descrizione: graptolita biserial, diritto e snello, con lunga virgella. Il rhabdosome più lungo misura 38 mm, ma, in media, il campione studiato è 30 mm lungo, con una virgella che può superare 10 mm. Il rhabdosome è circa 0.5 mm largo al primo theca, 0.6 mm al terzo theca e 1.5-1.7 mm nel distale. La sicula è diritta, circa 1.5 mm lunga con una piccola apertura (circa 0.2 mm), l'apice raggiunge il livello del 21 theca. Le thecae sono fortemente geniculato, con una piccola apertura; in media ci sono 5-6 thecae nel distale 5 mm.


Famiglia Monograptidae Lapworth 1873

Genere Demirastrites Eisel 1911

Demirastrites triangulatus (Harkness) 1851 (fig. 2.a; fig. 3.1, 3.2, 3.3; fig. 5.2)

1851 Rastrites triangulatus - Harkness, p. 38, tav. I, fig. 3 a - d.
1907 Monograptus triangulatus (Harkness) - Vinassa de Regny, p. 29, tav. I, fig. 14.
1920 Monograptus triangulatus (Harkness) - Gortani, tav. III, fig. 17-18.
1920 Monograptus triangulatus var. cirratus (Harkness) - Gortani, tav. III, fig. 22-24.
1985 Demirastrites triangulatus (Harkness) - Xiaofeng, p. 237, pl. 2, fig. 2 - 3.
1899 Monograptus triangulatus (Harkness) - Barca & Jaeger, p. 577, fig. 18.
1993 Demirastrites triangulatus triangulatus (Harkness) - Storch & Serpagli, p. 51, textfig. 16 A-B.
2003 Demirastrites triangulatus (Harkness) - Loydell, Mannik & Nestor, p. 209, fig. 4h.
2009 Demirastrites triangulatus (Harkness) - Picarra, Robardet, Oliveira, Paris & Lombardeaux, p. 47, fig. 5A.
2009 Demirastrites triangulatus (Harkness) - Storch & Kraft, p. 63, fig. 8B.

Material: 30 rhabdosomi in conservazione povera (MFSNgp 39719, 39722b, 39724, 39732-39758) da “Casera Meledis” (Ud).
1978 Monograptus revolutus Kurck - Bjerrøsøv, pl. 18, fig. 4; pl. 20, fig. 1-4.
2009 Monograptus revolutus Kurck - Zalasiewicz, p. 810, fig. 12 s67.

Materiale: 22 rhabdosome (MFSNgp 39725, 39732, 39734, 39747, 39751, 39755, 39756, 39759-39773) in bad preservation condition from “Casera Meledis” (Ud).

Località: trail between Casera Meledis bassa and Casera Meledis alta.

Descrizione: rhabdosome slender, strongly curved in the proximal part that becomes straight distally. The maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 23 mm, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long, the width of the rhabdosome at the first teca is 0,2 mm; the maximum rhabdosome length is about 30 mm long.

Osservazioni: the samples of Monograptus revolutus Kurck from “Casera Meledis”, despite their bad preservation, are comparable with the graptolites cited by Gortani (1920) in other sites in the Carnic Alps (Casera Meledis, Uqua, Ramàz, Rio Nöbling and Cristo of Timau) and preserved in the museum collections of Pisa, Perugia, Pavia and Vienna. The thecal count is 10-12 theca in 10 mm.

Diffusion: global.

Materials: 5 incomplete rhabdosome (MFSNgp 39725a, 39737, 39738, 39774, 39775) from “Casera Meledis” (Ud).

Località: trail between Casera Meledis bassa and Casera Meledis alta.

Descrizione: very slender rhabdosome, straight or slightly curved. The graptolites are in large part fragments, without the proximal part. The maximum length observed is about 23 mm, the width of the rhabdosome is between 0,16-0,24 mm. The sicula is not present. The thecae have a “hooked” shape, not well visible, with the aperture direct downward. The thecal overlapping between thecae is about 1/6 of their length, and the thecae form an angle of 8°-10° with the axis of the rhabdosome. The 2TRD is about 2 mm in the distal part of the rhabdosome. Thecal count is 10-12 in the distal 10 mm of the rhabdosome.

Osservazioni: the samples of Monograptus revolutus Kurck from “Casera Meledis”, despite their bad preservation, are comparable with the graptolites cited by Gortani (1920) in other sites in the Carnic Alps (Casera Meledis, Uqua, Ramàz, Rio Nöbling and Cristo of Timau) and preserved in the museum collections of Pisa, Perugia, Pavia and Vienna. The thecal overlapping between thecae is about 1/6 of their length, and the thecae form an angle of 8°-10° with the axis of the rhabdosome. The 2TRD is about 2 mm in the distal part of the rhabdosome. Thecal count is 10-12 in the distal 10 mm of the rhabdosome.

Diffusion: global.
**Parapetalolithus palmeus** (Barrande) 1850
(fig. 2.c; fig. 4.3, 4.4; fig. 5.3)

- 1850 *Graptolithus palmeus var. lata* Barrande, p. 61, pl. 3, figs. 3, 4.
- 1908 *Petalograptus palmeus s. str.* (Barrande) - Elles & Wood, p. 274, pl. 32, fig. 1d, text-fig. 188a.
- 1920 *Diplograptus (Petalograptus) palmeus* (Barrande) - Gortani, tav. I (1), fig. 35.
- 1996 *Petalograptus palmeus palmeus* (Barrande) - Churkin & Carter, p. 58, fig. 39 A, B, H.
- 1998 *Parapetalolithus palmeus* (Barrande) - Gutierrez-Marco & Storch, p. 77, fig. 4; p. 84, fig. 8g.

**Material:** 4 rhabdosomes (MFSNgp 39734, 39749, 39776a-b, 39779) from “Casera Meledis” (Ud).

**Locality:** trail between Casera Meledis bassa and Casera Meledis alta.

**Description:** biserial graptolite with a characteristic “leaf” shape; thecae are simple tubular tubes. In our graptolites collection there are only two complete specimens: the longest is 22 mm long; on average, our samples are about 2.8-3 mm wide, with a maximum of 3.6 mm in one specimen. The thecae are simple tubes, with an angle of $40^\circ$-$45^\circ$ to the rhabdosome axis, the thecae overlap each other for 3/4 of their length. The 2TRD is about 2-2.6 mm and the thecal count in the distal part of the rhabdosome is of 12-14 thecae in 10 mm.

**Observations:** the samples of *Parapetalolithus palmeus* founded on the trail between Casera Meledis bassa and Casera Meledis alta are similar to the specimens founded by Gortani (1920) in the same locality and housed in the museum collections of Perugia e Pisa. The *Parapetalolithus palmeus* of “Casera Meledis” are well comparable with the figured specimen of *Graptolithus palmeus var. lata* by Barrande (1850) from Czech Republic, and with the specimens described by Elles & Wood (1908) from Scotland. The graptolites described by Churkin & Carter (1996) from Alaska are similar to our *Parapetalolithus palmeus* from the Carnic Alps and are similar to the samples figured by Gutierrez-Marco & Storch (1998) from Spain.

**Distribution:** Llandovery triangulatus biozone.

**Diffusion:** U.K., Spain, China, U.S.A., Czech Republic, Carnic Alps.

**Climacograptus rectangularis** (M’Coy) 1850
(fig. 4.7, 4.8)

- 1850 *Diplograpsus rectangularis* M’Coy, pl. IV, p. 271.
- 1920 *Climacograptus rectangularis* (M’Coy) - Gortani, tav. I (I), fig. 11, 12.
- 1920 *Climacograptus rectangularis var. alpinus* (M’Coy) - Gortani, tav. I (I), fig. 13, 15.
Material: 4 rhabdoses in badly condition of preservation (MFSNgp 39757, 39766, 39771, 39777) from “Casera Meledis” (Ud).

Locality: trail between Casera Meledis bassa and Casera Meledis alta.

Description: small biserial Graptolite with a slender shape, thecae with a small “geniculate” aperture. In our specimens there is one small complete Climacograptus rectangularis and the longest incomplete specimen is about 20 mm long. The average width is 1.8 mm, with a maximum of 2 mm measured in one specimen. The sicula is not visible or measurable. The 2TRD is about a maximum of 2 mm measured in one specimen. The about 20 mm long. The average width is 1.8 mm, with specimens there is one small complete shape, thecae with a small “geniculate” aperture. In our specimens described by (Gortani 1920) from the same locality of Carnic Alps.


Torquigraptus sp. (fig. 5.1)

Material: 1 rhabdosome in bad condition of preservation (MFSNgp 39750) from “Casera Meledis” (Ud).

Locality: trail between Casera Meledis bassa and Casera Meledis alta.

Description: slender and flexed rhabdosome, hooked in the proximal part, slightly curved distally. The rhabdosome is 12 mm long, the width is about 0.8 mm. The thecae are triangular, and the aperture is ornamented by slender lappets. The thecal inclination to the rhabdosome axis is 20°, and the overlapping between thecae is 1/10 of their length. The 2TRD distally measured is about of 1.84 mm, the thecae are 7 in 10 mm (measured in the distal part of the rhabdosome).

Observations: the sample MFSNgp 39750 of “Casera Meledis”, shows similar form to Torquigraptus denticulatus reported by Gortani (1920) in the locality of Rio Uqua, but the bad preservation of the sample does not permit a precise attribution at the level of species.

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