**CLYPEINA DRAGASTANI SP. NOV., SALPINGOPORELLA GRANIERI SP. NOV. AND OTHER DASYCLADALEAN ALGAE FROM THE BERRIASIAN OF EASTERN SARDINIA**

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**Abstract.** Dasycladalean algae of Early Berriasian age from Eastern Sardinia have been studied. In addition to species already quoted in the literature for Sardinia and other European regions, two forms which cannot be referred to any known taxa have been identified: *Clypeina dragastani* sp. nov. and *Salpingoporella granieri* sp. nov.

**Keywords:** Dasycladales, new taxa, Early Berriasian, Eastern Sardinia.

**INTRODUCTION**

Within the ambit of studies on the sedimentary cover of Eastern Sardinia, which have been continuing for many years at the Department of Geology, Palaeontology and Geophysics of the University of Padova, detailed litho- and biostratigraphic analyses have been carried out on the carbonate platform deposits of Late Jurassic-Early Cretaceous age outcropping in the Oliena-Orgosolo-Urzulei massif (“Supramonte”). These researches have also led to findings of abundant macro- and micro-palaeontological associations. In particular, as regards calcareous algae, as well as species already quoted in the literature for Sardinia and other European regions, forms which cannot be referred to any known taxa have been identified. Among these a new species of *Clypeina* and a new species of *Salpingoporella* are proposed here. They occur in beds of Early Berriasian age belonging to the Jurassic-Cretaceous succession of the Lanaittu valley (Oliena), a succession already described on occasion of the 19th European Micropalaeontological Colloquium, held in Sardinia in 1985 (DIENI & MASSARI, 1985b).

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The schema represents a tentative synthesis of the main lithofacies changes which can be observed from the interior of Sardinia (left) to the East (right) through a number of typical localities (top of the figure) where the Jurassic succession crops out (after DIENI & MASSARI, 1985a).

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THE JURASSIC AND LOWERMOST CRETACEOUS OF EASTERN SARDINIA

Resting on the Palaeozoic crystalline basement directly or through a discontinuous and thin package of continental deposits consisting of fluvial conglomerates, sandstones and mudstones rich in vegetal debris (Genna Selole Formation; Bajocian? Earliest Bathonian?; DIENI & MASSARI in DIENI et al., 1983), the Middle Jurassic to Berriasian marine succession of Eastern Sardinia is more than 1000 m thick. It is composed of three main lithostratigraphic units (Fig. 1): the Dorgali Dolostone (Bathonian in the coastal area but progressively younger towards the interior, locally extending up to the Upper Kimmeridgian), the ammonite-bearing s’Adde Limestone (Callovian to uppermost Kimmeridgian) and the Mt. Bardia Limestone (Tithonian to Berriasian in most areas but locally extending downwards into Kimmeridgian and Oxfordian). During the time span from Bathonian to Early Callovian a stack of minor shallowing-up cycles mostly consisting of oolitic calcarenites graded eastwards into outer-shelf limestones (Fig. 2), suggesting a scenario of a wide shallow shelf with a system of tidal oolitic bars periodically migrating seawards and separating an internal more or less open shelf-lagoon from an outer-shelf area with pelagic sedimentation.
Figure 4 - Sa Marghine Ruja section with list of principal dasycladales of bed 858 (from DIENI & MASSARI, 1985, integrated).
Following the Oxfordian transgression a reefal sedimentation developed until the Early Kimmeridgian, resulting in the growth of a series of patch reefs surrounded by considerable amounts of bioclastic deposits.

A major regressive episode led to repeated emergences in Late Kimmeridgian, documented by calcrite breccias and crusts, black-pebble breccias, wackestones with gypsum molds and oligotopic assemblages ( ostracods and charophytes).

The Tithonian-Berriasian interval is characterized by a rather uniform facies association, corresponding to a generalized peritidal environment with well-developed microbial mats and fine-grained fenestral limestones. The regressive acme is reached in the upper part of this complex, which is marked by many horizons of black-pebble breccias, mud-cracked laminites and oligotopic assemblages consisting of charophytes, ostracods and small molluscs suggesting a scenario of wide supratidal flats disseminated with lagoon to fresh-water ponds. The succession is commonly split into a number of high-frequency, metro-scale cycles.

One of the best exposures illustrating the peritidal deposits is that of Sa Marghine Ruja (Fig. 4), where the depositional pattern shows the characters of the well-known “Purbeckian facies”. This section is located within the Lanaittu valley, which is a structural depression to a thallus of Clavatoraceae (Charophyta), probably Clavator reidi (GROVES, 1924) MARTIN-CLOSAS, 1989, or Clavator grovesi (HARRIS, 1939) SCHUDACK, 1993. Bed 857 of Sa Marghine Ruja section. Lower Berriasian. Thin section 857(1); 60x.

As regards Dasycladales, starting from bed 857, in addition to species already quoted in the Upper Jurassic, such as Actinoporella podolica, Clypeina maslovi, Clypeina solkani, Otternstella lemmensis and Salpingoporella annulata (see GRANIER & DELOFFRE, 1993), there are taxa which, at least until now, have only been recorded beginning from the Berriasian, such as Actinoporella jaffrezoi, Clypeina estevezii (see GRANIER & DELOFFRE, op.cit.), Clypeina parasolkani and Salpingoporella granieri.

THE TITHONIAN-BERRIASIAN BOUNDARY IN THE SA MARGHINE RUJA SECTION

In the Sa Marghine Ruja section, the Tithonian-Berriasian boundary can be traced with good approximation only by means of the contents in plant remains, since foraminifers give no significant information from a bio- and chronostratigraphic viewpoint. The boundary was located by us between beds 856 and 857 on the basis of the following observations:

- As far as bed 856, Charophytes are represented, sometimes in particular abundance (e.g., bed 853), exclusively by gyrogonites belonging to the group of Porochara fusca (MÄDLER, 1952) MÄDLER, 1955, the stratigraphic distribution of which ranges from the Oxfordian to the Upper Berriasian (MOJON, 1989; SCHUDACK, 1993);
- In bed 857, still among Charophytes, the gyrogonites of the Porochara fusca group are associated with Clavatoraceae referable to Clavator reidi (GROVES, 1924) MARTIN-CLOSAS, 1989, or to Clavator grovesi (HARRIS, 1939) SCHUDACK, 1993 (Fig. 5), taxa both considered as significant markers of the Berriasian, in the lower part of which they make their first appearance (SCHUDACK, 1993, pp. 139 et seq., with references);
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Clypeina marteli EMBERGER, 1956 (Pl. V, figs. 6, 7)  
Clypeina maslovi (PRATURLON, 1964) CONRAD, PRATURLON & RADOIĆ, 1974 (Pl. V, figs. 1-5)  
Clypeina parasolkani FARINACCI & RADOIĆIĆ, 1991 (Pl. VIII, figs. 1-6)  
Clypeina radici SOKAČ, 1986 (Pl. VIII, fig. 10)  
Clypeina solkani CONRAD & RADOIĆ, 1972  
Clypeina sp. 'S 12' (sp. nov.? ex gr. Cl. jurassica FAVRE, 1927) (Pl. V, figs. 8, 9)  
Cylindroporella sp.  
Dissocladella sp. 'S 13' (Pl. VI, figs. 13, 14)  
Otternstella lemmensis (BERNARD, 1971) GRANIER, 1994 (Pl. VIII, figs. 11-13)  
Salpingoporella annulata CAROZZI, 1953 (Pl. VII, fgs. 6-8)  
Salpingoporella granieri sp. nov. (Fig. 8; Pl. VII, fgs. 1-3, 5)  
Salpingoporella sp. 'S 14' (Pl. VII, fig. 4)  
Salpingoporella sp. 'S 15' (Pl. VII, fgs. 9-11)  
Salpingoporella sp. 'S 16' (aff. S. steinhauseri CONRAD, PRATURLON & RADOIĆ, 1973) (Pl. VII, fgs. 12, 13)  
Holosporella? sp. 'S. 17' (Pl. VI, fgs. 8, 9)  

Salpingoporella annulata  
Salpingoporella granieri sp. nov. (Fig. 8; Pl. VII, fgs. 1-3, 5)  
Salpingoporella sp. 'S 14' (Pl. VII, fig. 4)  
Salpingoporella sp. 'S 15' (Pl. VII, fgs. 9-11)  
Salpingoporella sp. 'S 16' (aff. S. steinhauseri CONRAD, PRATURLON & RADOIĆ, 1973) (Pl. VII, fgs. 12, 13)  

Holosporella? sp. 'S. 17' (Pl. VI, fgs. 8, 9)  

and other forms which cannot be determined.

Among the associated foraminifers, the following species may be mentioned:

Nautiloculina oolithica MOHLER, 1938  
Feurtillia frequens MAYNC, 1958  
Pseudocyclammina lituus (YOKOYAMA, 1890)  
Trocholina sp. and  
Lenticulina sp., represented by few specimens.  

Other microfossils include  
Aeolisaccus inconstans RADOIĆ, 1967(1)  
Thaumatoporella parvovesiculifera (RAINERI, 1922)  
yoorongites of  
Porocharaceae  
Sporadic remains of  
Clavatoraceae and fecal pellets.

Since many of the identified dasycladales belong to already well-known taxa, we limit our observations here to lesser known species and to new ones. As regards the former, of which for the most part the photographic documentation is given, we refer to the specific literature.

All the studied material (samples and thin sections) is located in the Department of Geology, Palaeontology and Geophysics of the University of Padova (Sardinia collections). The thin sections containing the figured dasycladales are marked by round yellow labels on which sample and thin section numbers are indicated respectively in black and red.

PALAEONTOLOGICAL PART

Gen. Clypeina (MICHELIN, 1845) BASSOULLET et al., 1978  
Clypeina dragastani sp. nov.  
Fig. 7; Pl. I, fgs. 1-12; Pl. II, fgs. 1-14; Pl. VI, fgs. 10 and 11?

ORIGIN OF NAME: Species dedicated to Prof. Ovidiu Dragastan on occasion of his 60th birthday.  
HOLOTYPE: Transverse-oblique section shown in Pl. I, fgs. 1; thin section 858 (21).  
ISOTYPES: Specimens of sample 858, some of which are shown in Pl. I, fgs. 2-12 and Pl. II, fgs. 1-14.  
DEPOSITORY: Material (samples and thin sections) deposited at Department of Geology, Palaeontology and Geophysics, University of Padova (Sardinia collections).  
TYPE LOCALITY: Sa Marghine Ruja, Lanaittu valley, 8 km East of Oliena (prov. Nuoro, Eastern Sardinia) (Fig. 3).  

TYPE HORIZON: Bed 858 (white packstone) of Sa Marghine Ruja section (Fig. 4) illustrated (under name of 'Sa Oche section') on occasion of the 19th European Micropalaeontological Colloquium, Sardinia, 1985 (DIENI & MASSARI, 1985b).  
AGE: Early Berriasian.

(*) On this occasion, R. Radoiće designates as lectotype of this taxon the specimen illustrated by RADOIĆ (1967) in pl. 7, fig. 1 (thin section RR 1701, formerly 984-57).
CDIAGNOSIS: Cylindrical thallus with regularly spaced whorls of horizontal laterals symmetrical in transverse plane. Laterals, generally 14 per whorl (11 to 16), are in weak contact in their largest middle part; proximal part is bottle-necked in shape. Following this narrowest part, laterals develop in spherical-ovoidal form: circular in vertical section, oval in transverse section (Fig. 7). Calcification involves a relatively thick mucilage layer around main axis and proximal to middle parts of whorls; in addition, the latter generally are poorly preserved as internal moulds.

COMPARISONS: Cylpeina dragastani GRANIER, 1987
Pl. III, figs. 1, 2; Pl. IV, figs. 1-7; Pl. VI, fig. 12
+ 1987 Cylpeina estevezii n.sp. - GRANIER, p.46, pl.10, figs. f,j.
DIMENSIONS (in mm):
- Largest external diameter: 2.49 (small specimens: 0.91-1.00).
- Diameter of main axis: 0.47-0.59 (small specimens: 0.27).
- Length of laterals: max. 0.95.
- Diameter of laterals: max. 0.22.
- Number of laterals per whorl: 12-20.

COMPARISONS: Cylpeina estevezii, described by GRANIER (1987) from the Berriasian of the province of Alicante (Eastern Spain), was originally illustrated only by two oblique sections. This until now little-known species is frequent in Berriasian beds 858 and 860 of the Sa Marghine Ruja section (interval 1 m).

In the Sardinian material, specimens with large thallus predominate. They are quite well preserved and give more information than the types. Some are represented by internal moulds in which fusiform laterals (Pl. IV, fig. 1) and especially their distal end are clearly visible. Proximal part of laterals is well shown in Pl. IV, figs. 5-7.

The dasyclad association of bed 858 at Sa Marghine Ruja contains another little-known taxon, also described from the Berriasian of Alicante: Actinoporella jaffrezoi GRANIER, 1994 (Pl. VI, figs. 1-4). The same species also occurs in the Berriasian of Eastern Serbia, where it was recorded by RADOIĆIĆ (1978, Pl. 4, figs. 1-8) as Actinoporella cf. podolica.

Gen. Salpingoporella (PIA in TRAUTH, 1917), CONRAD, PRATURLON & RADOIĆIĆ, 1973

In addition to S. annulata CAROZZI, 1953 (Pl. VII, figs. 6-8), in the Sa Marghine Ruja section the genus Salpingoporella is also represented by rare specimens of several other species (Pl. VII, figs. 1-13), including a particularly interesting one. GRANIER (1987, p. 80, pl. 5, figs. d, e, here reproduced in Fig. 8) illustrated from the Berriasian of the province of Alicante (Eastern Spain) a tangential and an oblique sections of Salpingoporella sp.’ which very well match one of the Salpingoporellas of the Sardinian material (samples from beds 858 and 860). The same taxon was also presented as ‘Salpingoporella sp. 3’ by FARINACCI & RADOIĆIĆ (1991, pl. 5, fig. 7) from the Berriasian of the Western Pontides (Northern Turkey). This so far unnamed Salpingoporella, which evidently had extensive geographic distribution along the northern Tethyan margin during the Berriasian, is introduced here as:
Salpingoporella granieri sp. nov.

ORIGIN OF NAME: This Salpingoporella is dedicated to Dr. Bruno Granier, who was the first to illustrate some sections of the taxon as ‘Salpingoporella sp.’ in 1987.

HOLOTYPE: Specimen shown in Pl. VII, fig. 1: oblique-vertical, partly tangential section of whorls, in which characteristic shape of laterals (horizontally rectangular subcortical pattern) is visible; thin section 858 (19).

ISOTYPES: Specimens shown in Pl. VII, figs. 2, 3 and 5, and others not shown, all from bed 858 of Sa Marghine Ruja section.

DEPOSITORY: Material (samples and thin sections) deposited at Department of Geology, Palaeontology and Geophysics, University of Padova (Sardinia collections).

TYPE LOCALITY: Sa Marghine Ruja, Lanaittu valley, 8 km east of Oliena (prov. Nuoro, Eastern Sardinia) (Fig. 3).

TYPE HORIZON: Bed 858 (white packstone) of Sa Marghine Ruja section (Fig. 4), already described (under name of ‘Sa Oche section’) on occasion of the 19th European Micropalaeontological Colloquium, Sardinia, 1985 (Dieni & Massari, 1985b).

AGE: Early Berriasian.

DIAGNOSIS: Cylindrical thallus with relatively ample main axis (d = 0.24 mm). Whorls bear a small number (5) of flattened, horizontally elongated laterals (h = 0.2 mm), of which distal and subcortical parts have rectangular pattern. Calcification is typical for genus (filling space from main axis to cortex) and relatively massive.

COMPARISONS: Salpingoporella granieri sp. nov. belongs to the Salpingoporella group with flattened horizontal laterals (S. circassa Farinacci & Radoiĉić, 1991; S. hasi Conrad, Radoiĉić & Rey, 1977; S. urladanasi Conrad, Peybernès & Radoiĉić, 1977) which have rectangular (different in size, more or less elongated or high) cortical pattern.

As a marginal annotation, we report some short comments concerning a particular feature observed in the examined succession, on which we will investigate in the future.

Some packstone layers in the lower part of the Sa Marghine Ruja section (notably in beds 853, 855 and 857) are very rich in Girvanella-like filaments associated with dasycladales, charophytes and foraminifers. “Girvanella” appears as dense meshes of short slightly flexuous calcareous tubules up to 8-10µm in external diameter generally occurring in the outer rim of peloids, intraclasts and rarely Nautiloculina tests (Figs. 9 A-C; Pl. IX, figs. 1, 2). Tubules tend to be arranged perpendicular to the surface, an orientation clearly reflecting the original growth pattern, and usually show a slight inward increase in diameter. The boundary between the nuclei and the “Girvanella” rim is fairly gradual suggesting that the blue-green algae developed centripetally from the periphery and affected objects with an endolithic infesting activity, with a process very similar to that evidenced several times by one of us studying Upper Jurassic and Lower Cretaceous dasycladales from Herzegovina and Montenegro (Radoiĉić, 1970, p.103 and 106, fig. 3 of pl. 14; 1979, p. 89; 1986, p. 58 and 64).
The laminated and mud-cracked facies, almost totally devoid of fossils, associated with the packstone layers fail to show any evidence of these "Girvanella" meshes, indicating that the endolithic attack by cyanophycean algae only interested isolated objects in a setting of presumably higher energy.

Acknowledgements

Many sincere thanks to our friend F. Massari for helpful discussions and advices. We are grateful to S. Castelli for photographic work, C. Brogiato for plate layout, and N. Michelon for drawings. I. Dieni wishes to express gratitude to P. O. Mojon for his help in the study of charophytes.

Research supported by MURST (ex 40% 1997, grant to I. Dieni).

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PLATES

Plate I
Figs. 1-12: Clypeina dragastani sp. nov. Oblique-transverse, oblique and transverse sections.
Fig. 1: holotype.
All figures: 60x.
Thin sections: 858 (21, 11, 28, 10, 30, 22, 6, 7, 15, 14, 25, 2).

Plate II
Figs. 1-14: Clypeina dragastani sp. nov.
Fig. 1: partly dissolved internal mould of a thallus fragment with three whorls in which form of laterals and distance between whorls are clearly visible; longitudinal section.
Figs. 2, 3: fragments, longitudinal sections; bottle-necked pores visible in fig. 2.
Figs. 5, 7: fragments, longitudinal sections; dissolved (5) and deformed and dissolved internal moulds (7).
Figs. 4, 6, 8-14: oblique and oblique-transverse sections.
All figures: 60x.
Thin sections: 858 (11, 4, 10, 12, 19, 28, 4, 1, 16, 25, 11, 18, 22, 21).

Plate III
Figs. 1, 2: Clypeina estevezii GRANIER, 1987. Transverse sections.
Fig. 2: internal mould.
All figures: 60x.
Thin sections: 858 (17, 18).

Plate IV
Figs. 1-7: Clypeina estevezii GRANIER, 1987. Oblique (1, 3, 4), tangential (2) and transverse (5-7) sections.
Figs. 1-3: internal moulds.
All figures: 60x.
Thin sections: 860 (2), 858 (5, 26, 4, 24, 19, 26).

Plate V
Figs. 1-5: Clypeina mastovi (PRATURLON, 1964) CONRAD, PRATURLON & RADOIĆIĆ, 1974. Oblique (1, 2, 4, 5) and longitudinal (3) sections.
Figs. 6, 7: Clypeina marteli EMBERGER, 1956. Transverse sections; fig. 6: probably top thallus whorl.
Figs. 8, 9: Clypeina sp. 'S 12' (sp. nov. ? ex gr. Cl. jurassica FAVRE, 1927). Transverse and longitudinal sections (fig. 9 from bed 853).
Figs. 10-12: Actinoporella podolica (ALTH, 1878) CONRAD, PRATURLON & RADOIĆIĆ, 1974. Transverse-oblique and subaxial (12) sections.
All figures: 60x.
Thin sections: 859 (1), 858 (6, 20, 5, 31, 11, 7, 10), 853 (1), 858 (31, 1, 31).

Plate VI
Figs. 1-4: Actinoporella jaffrezoi GRANIER, 1994. Vertical, vertical-oblique, tangential and oblique sections. Fig. 2 clearly shows upper corona (arrow).
Fig. 5: Actinoporella aff. A. jaffrezoi GRANIER, 1994. Tangential-oblique section.
Figs. 6, 7: Actinoporella or Clypeina sp.? Oblique-vertical and oblique-transverse sections.
Figs. 8, 9: Holosporella? sp. 'S 17'. Transverse-oblique sections.
Figs. 10, 11: Clypeina dragastani sp. nov. or Actinoporella jaffrezoi GRANIER, 1994?. Transverse-oblique sections.
Fig. 12: Clypeina aff. Cl. estevezii GRANIER, 1987. Transverse section.
Figs. 13, 14: Dissocladella sp. 'S 13'. Oblique and transverse-oblique sections. Arrow: Dissocladella type laterals.
All figures: 60x.
Thin sections: 858 (4, 6, 4, 17, 4, 6, 21, 27, 26, 4, 8, 11, 7, 7)
Plate VII

Figs. 1-3, 5: Salpingoporella granieri sp. nov.
Fig. 1: holotype, vertical-oblique section.
Figs. 2, 3, 5: vertical-oblique (2, 5) and tangential (3, deformed skeleton) sections.
Fig. 4: Salpingoporella sp. 'S 14'. Vertical-oblique section.
Figs. 6-8: Salpingoporella annulata CAROZZI, 1953. Vertical-oblique and vertical (arrow) sections of fragments (6), transverse (7) and oblique (8) sections.
Figs. 9-11: Salpingoporella sp. 'S 15'. Tangential-oblique (9) and oblique (10, 11) sections.
Figs. 12, 13: Salpingoporella sp. 'S 16' (aff. S. steinhauseri CONRAD, PRATURLON & RADOIČIĆ, 1973). Vertical (12) and transverse (13) sections.
All figures: 60x.
Thin sections: 858 (19, 9, 4, 9, 9, 21, 4, 1), 860 (1), 858 (25, 10, 6, 9).

Plate VIII

Figs. 1-6: Clypeina parasolkani FARINACCI & RADOIČIĆ, 1991. Vertical (1), transverse-oblique (2-4, 6) and tangential (5) sections.
Fig. 7: Clypeina sp. ex gr. Cl. parasolkani-radici. Oblique-tangential section.
Figs. 8, 9: Transverse sections of Clypeina or Rajkaella like dasyclads.
Fig. 10: Clypeina radici SOKAČ, 1986. Axial section.
All figures: 60x.
Thin sections: 858 (26, 6, 13), 856 (1, 1), 858 (10, 28, 6, 5, 21, 6, 6, 23).

Plate IX

Figs. 1, 2: Dense meshes of calcareous tubules referable to Girvanella-like boring algae infesting the peripheral part of peloids and showing a slight inward increase in diameter (from right to left). Tithonian of the Sa Marghine Ruja section, bed 853. A = 100x; B = 260x.
Figs. 3, 4: Thaumatoporella parvesiculifera (RAINERI, 1922). Tangential and transverse sections. 60x.
Fig. 5: Deformed gyrogonite of Porocharaceae. 60x.
Figs. 6, 7: Pseudocyclammina litus (YOKOYAMA, 1890). Subaxial and tangential sections. Right side of fig. 6 also shows a specimen of Aeolisaccus inconstans RADOIČIĆ, 1967. 40x.
Figs. 8-11: Aeolisaccus inconstans RADOIČIĆ, 1967. Axial, subaxial and transverse sections. 60x