Geologia Croatica | 61/2–3 | 129–133 | 3 Figs. | | | Zagreb 2008

New findings of halimedacean algae from the Late Triassic Dachstein Limestone of the Northern Calcareous Alps (Hochschwab Area, Styria, Austria)

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Geologia Croatica

ABSTRACT

Two taxa of halimedacean algae are recorded from the Upper Triassic lagoonal Dachstein Limestone (Norian-Rhaetian) of the Hochschwab area in the south-eastern part of the Northern Calcareous Alps of Austria. They are described in open nomenclature as Halimeda*? sp. 1 and* Halimeda*? sp. 2. In contrast to the widespread occurrence of dasycladalean algae, representatives of Halimedaceans are very rare. These findings are the second record in the Northern Calcareous Alps since FLÜGEL (1975).*

Keywords: Calcareous algae, Halimedaceae, taxonomy, Triassic, Northern Calcareous Alps, Austria

1. INTRODUCTION

Dasycladales (calcareous green algae), such as diplopores, are widespread in the Middle and Upper Triassic limestones of the Northern Calcareous Alps (*e.g.* PIA, 1920; OTT, 1967). They appear in "*incredible abundance*" and "*were the Halimeda of their time, ecologically speaking*" (ELLIOTT, 1991, p. 127). Although there is a variety of genera assigned to halimedacean algae with their first records from the Middle Triassic as summarized recently by SENOWBARI-DARYAN & ZAMPARELLI (2005), records of the genus *Halimeda* Lamouroux (or *Boueina* TOULA) from the Triassic are comparably rare worldwide, but also include one occurrence from the Northern Calcareous Alps of Austria (see further below). In fact, even in the 1960's, the *Halimeda-Boueina* couplet wasn´t known to occur in the Triassic, being first known from the beginning of the Jurassic (e.g. JOHNSON, 1964). From the Triassic, their disarticulated segments were reported predominantly from lagoonal limestones, whereas almost all other Triassic halimedacean algae, often with bush-like growth forms, were described from reefal limestones (*e.g.* SENOWBARI-DARYAN & ZAMPARELLI, 2005). FLÜGEL (1975) reported on the occurrence of *Boueina hochstetteri liasica* LE MAITRE from the Norian-Rhaetian Dachstein limestone of the Gosaukamm. Later, the age of the *Boueina*-bearing limestones was refined to the Norian (FLÜGEL, 1988). From the Norian-Rhaetian of Western Thailand, FLÜGEL (1988) described the new species *Boueina marondei*, also recently discovered from the Upper Triassic of Iran (SENOWBARI-DARYAN & HAMADANI, 1999). Two further species have been established in recent times by DRAGASTAN et al. (2000) from the Rhaetian of Hydra (Greece) as *Halimeda helladica* and *Halimeda discreta*. In this work, *Boueina marondei* Flügel was treated as belonging to the genus *Halimeda*. In conclusion, there are now up to four geographic records (Austria, Thailand, Iran and Greece) of localities of Triassic representatives of the genera *Halimeda-Boueina*.

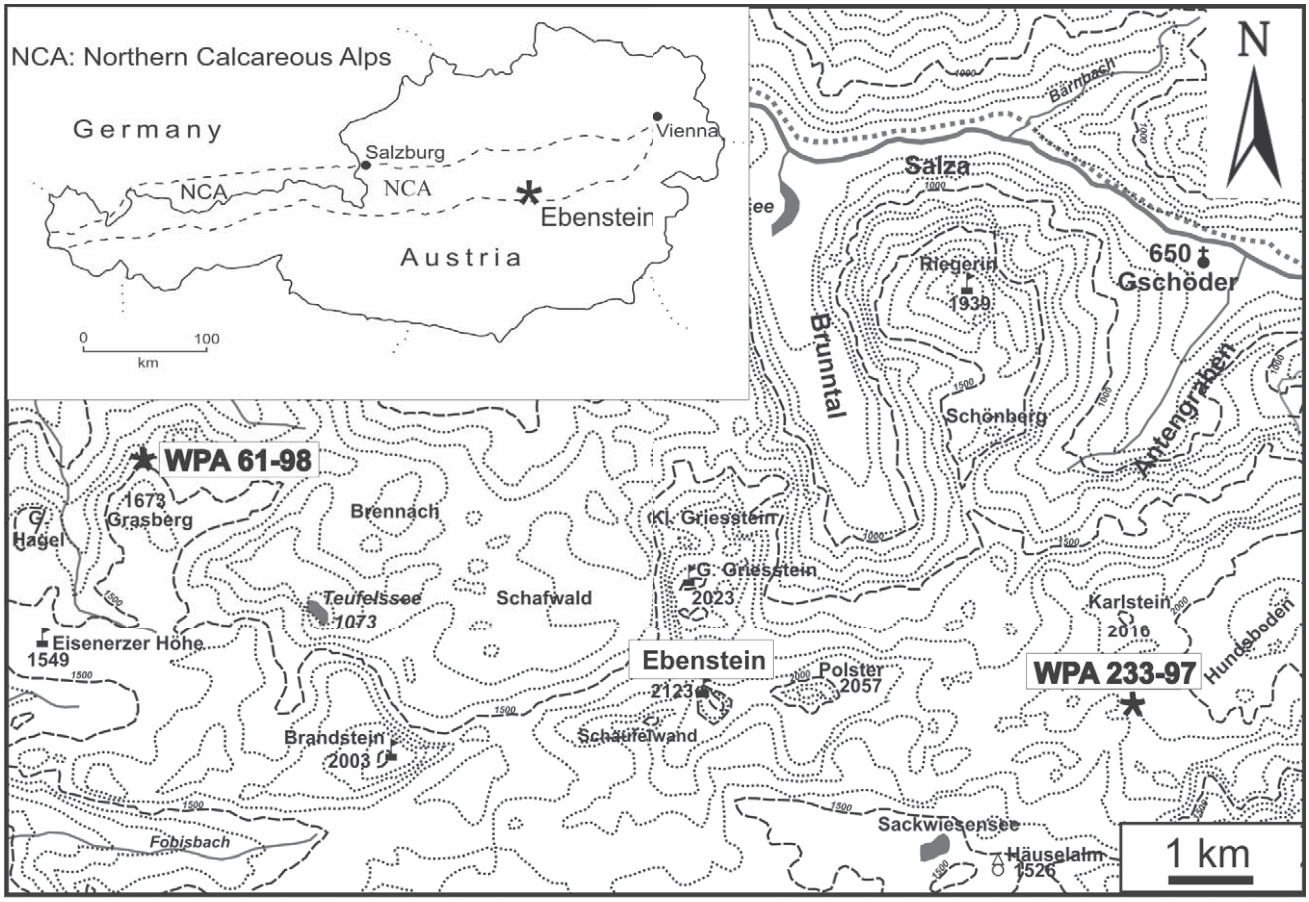

Figure 1: Topographic map of sample locations WPA 61–98 and WPA 233–97 in the Hochschwab area of the Mürztal Alps, Austria.

In the framework of a karst-hydrologic project, coordinated by the Geological Survey of Austria (MANDL[1] et al., 2002) representatives of halimedaceans tentatively ascribed here to the genus *Halimeda* LAMOUROUX, 1812 were discovered in two samples of Late Triassic limestones from the south-eastern part of the Northern Calcareous Alps of Austria (Fig. 1). Given the general rarity of Triassic halimedaceans, these findings are briefly described here, and represent the second record in the Northern Calcareous Alps since that of FLÜGEL (1975).

2. GEOLOGICAL OVERVIEW AND MATERIAL

The Muerztal Alps of Styria being part of the southeastern Northern Calcareous Alps are dominated by Middle and Upper Triassic limestones and dolomites (e.g. SPENGLER, 1920; LEIN, 2000; MANDL et al., 2002). In the Hochschwab area (or Hochschwab Unit) which forms part of the Muerztal Nappe, Wetterstein Limestone (Ladinian-Middle Carnian) and Dachstein Limestone (Norian-Rhaetian) are mostly prevalent. Both lithostratigraphic units may comprise both reefal and lagoonal facies. Representatives of Halimedaceae were observed in two samples:

Sample WPA 61/98. This sample comes from the northern side of the Grasberg (1673 m), (see the topographic map of Austria 1:25.000 ÖK no. 101, Eisenerz, coordinates 645935/277850). According to the geological map 1:25.000 in MANDL et al. (2002), the Grasberg is built up of lagoonal Dachstein Limestone (Norian-Rhaetian). The occurrence of the dasycladalean alga *Griphoporella curvata* (GÜMBEL) provides evidence for a Norian-Rhaetian age (e.g. BARATTOLO et al., 1993), thus confirming assignation to the Dachstein Limestone. The microfacies represent a biosparite (grain- to packstone). The sample contains *Halimeda*? sp. 1, dasycladalean algae, gastropods, foraminifera, peloids and aggregate grains and can be referred to an open-marine platform.

Sample WPA 233/97. Sample locality is situated south of the Karlstein (2013 m) and southwest of the Hundsboden, topographic map of Austria 1:25.000 ÖK no. 102, Aflenz Kurort, coordinates 656615/274660. In this area, the boundary between the Wetterstein and Dachstein Limestones occurs. The microfacies represent a biosparite (grainstone). Sample WPA 233/97 contains *Halimeda*? sp. 2, calcareous algae,

[1] MANDL, G.W. (project leader), BRYDA, G., KREUSS, O., MOSER, M., PAVLIK, W., DECKER, K., DRAXLER, I., KRYSTYN, L. & PIROS, O. (2002): Erstellung moderner geologischer Karten als Grundlage für karsthydrogeologische Spezialuntersuchungen im Hochschwabgebiet: Folgeprojekt Eisenerz – Schwabeltal – Meßnerin – Mitteralpe. Forschungsprojekt WA-4A F2000 & StA028n/F2000 der MA31 Wiener Wasserwerke, des Amtes der steiermärkischen Landesregierung und des Bundesministeriums f. Bildung, Wissenschaft & Kultur. – Unpubl. Final Report, Projektzeitraum 1. Juni 2000 – 31 Mai 2002, 211 p., Wien.

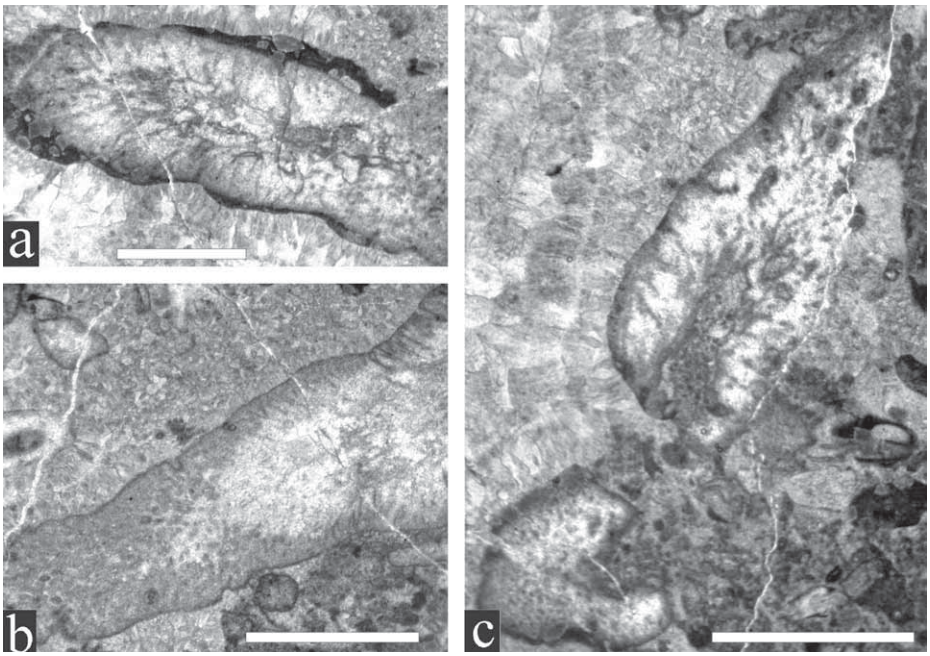

Figure 2: *Halimeda*? sp. 1. a) Longitudinal section. b) Longitudinal-oblique section. c) Two fragments. Sample WPA 233–97, scale bars = 2 mm.

gastropods, remains of sphinctozoan sponges, crinoids, *Tubiphytes* sp. and peloids. The sample can be refered to an open lagoon to back-reef facies. Direct stratigraphic dating of sample WPA 233/97 is not possible; because of the overall field relationships and samples taken from the immediate surroundings, it is also referred to the Dachstein Limestone.

3. TAXONOMIC DESCRIPTIONS

Before starting with the description of the Alpine material, some remarks on fossil halimedacean algae are vital. Algae today referred to the Halimedaceae (e.g. HILLIS, 1991) were formerly grouped within the Codiaceae, then afterwards in the Udoteaceae (e.g. BASSOULLET et al., 1983; MU, 1991, based on general morphology). Extant *Halimeda* species may show differences in the shape of the individual segments, and also segments from different parts of the plant may show variable numbers of utricle layers (e.g. DRAGASTAN et al., 2002). When referring these observations to fossil taxa, their correct determinations and descriptions become problematic. For instance, FLÜGEL (1975) remarked that differences in sizes of the thalli or siphons are not convenient for further splitting off the species *Boueina hochstetteri* TOULA. In fact, as has been pointed out by DRAGASTAN et al. (2002) the description of some fossil taxa are based on poorly, sometimes even insufficient material. As an exception to this, the thorough morphological study of the Turonian *Halimeda elliotti* by CONRAD & RIOULT (1977) differing between individual-sized segments within one taxon should be highlighted. As a consequence, DRAGASTAN et al. (2002) synonymized a large number of the fossil "taxa" with recent representatives of *Halimeda*. Also, the genera *Arabicodium* ELLIOTT, 1957 and *Boueina* TOULA, 1884 were included within this *Halimeda* concept and considered synonyms to *Halimeda*. As a consequence, all four representatives reported from the Triassic (*B. hochstetteri liassica, B. marondei, H. helladica*, *H. discreta*, see introduction) were put in synonymy with *Halimeda cylindracea* DECAISNE. This *Halimeda* concept of DRAGASTAN et al. (2002) only deals with a reduced number of methusalemi species exhibiting extremely long stratigraphic ranges, e.g. about 220 million years for *Halimeda cylindracea*. Despite the aforementioned problems with fossil taxa, such a rigid taxonomic reconsideration is at least problematic without restudying the original materials, especially the biometric variabilities of the topo-type material, and additional abundant and well-preserved material. As a consequence of these problems concerning fossil material, HILLIS (2000, p. 189) concludes that "it seems prudent to maintain the status quo of the taxa (remark: *Halimeda, Boueina, Arabicodium*)" for the moment being, as usually used by many workers (e.g. BUCUR, 1994). Another point to mention is that in some cases a radical synonymization obscures certain important biostratigraphic occurrences (e.g. BUCUR, 1999, tab. 17), for instance in the Upper Triassic-Liassic period. Therefore, and also due to the fact that our material is strongly recrystallized, not allowing observation of some morphological details, descriptions here use open nomenclature as *Halimeda*? sp. 1 and *Halimeda*? sp. 2. We agree with many other workers, that the structural differentiation of *Halimeda, Boueina* and *Arabicodium* is too artificial and non-specific for a clear-cut separation of the three. Thus, the open nomenclatural approach refers to the genus *Halimeda* having priority as described the earliest of the three. Referring to only two thin-sections for each species, with some segments in low abundance, statistical analysis of the morphometric parameters cannot be provided. Moreover, detailed dimensions with respect to the individual sizes of different siphon orders are not appropiate due to the comparably poor state of preservation, instead only the size ranges of the meduallar (dms) and cortical siphons (dcs) are indicated. Outer segment diameters are indicated as D.

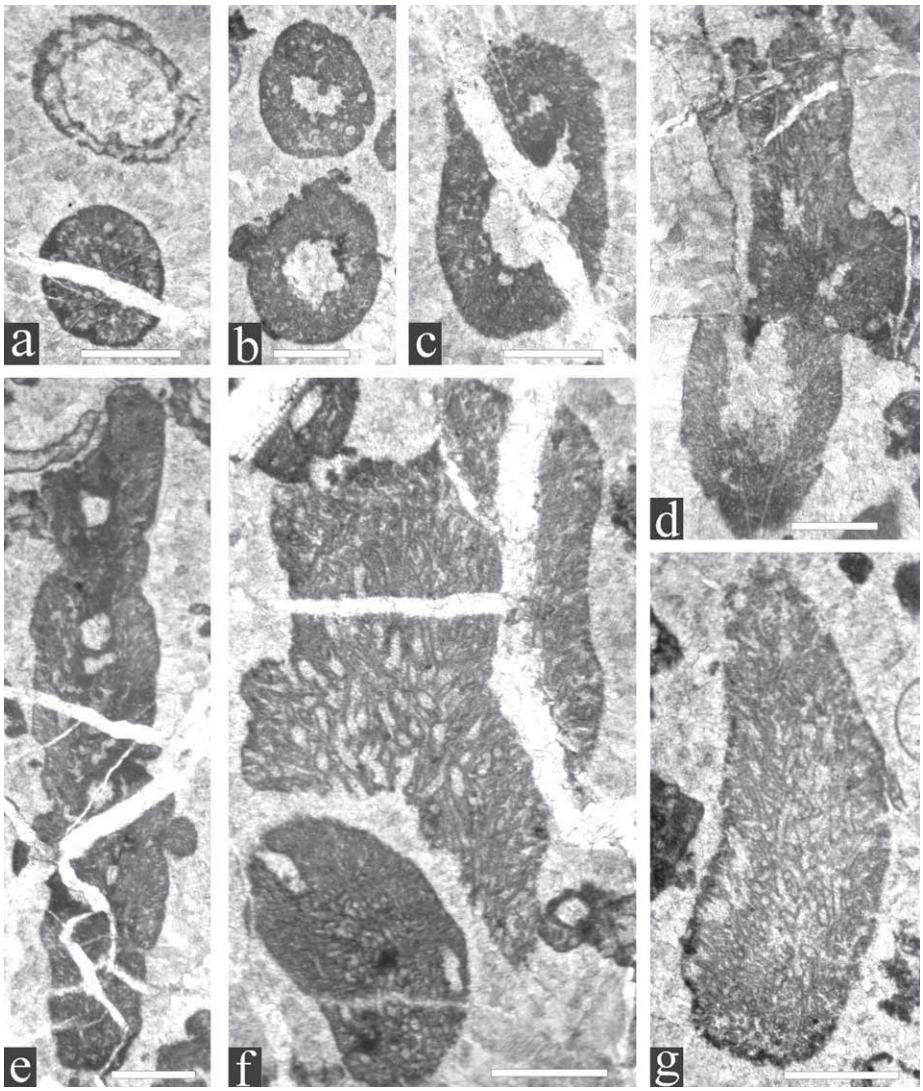

Figure 3: *Halimeda*? sp. 2. a) Transverse section (below) and oblique transverse section of *Griphoporella curvata* (GÜMBEL) (above). b) Two segments in oblique transverse sections. c) Oblique section. d) Longitudinal-oblique section. e) Longitudinal section showing segment constrictions. f) Fragmentary longitudinal section showing coarse and close-packed medullary siphons. g) Fragmentary oblique section.
Sample WPA 61–98, scale bars = 1 mm.

Family Halimedaceae LINK, 1832
Genus *Halimeda* LAMOUROUX, 1812
***Halimeda*? sp. 1**
(Fig. 2a–c)

Description: Thallus segments cylindrical, uncompressed, showing slightly undulating diameters. The poorly calcified medulla amounts about 1/3 of the segment diameter. There are no remarkable differences between the diameters of the medullary and first order cortical siphons. Higher order cortical siphons (up to 3–?4 series) become succesively reduced in their diameter. The cortical siphons continuously bend away from the axis.

Dimensions: D = 1.8–2.35 mm; dms = 0.038–0.067 mm; dcs = 0.02–0.05 mm.

Remarks: *Halimeda*? sp. 1 is distinguished from *Halimeda*? sp. 2 especially by the medullar zone composed of more loosely packed siphons not significantly different in diameter from the cortical siphons. Given that the fine medullary siphons are comparable to and not significantly different from the cortical siphons, this taxon indicates an *Arabicodium*-type halimedacean alga if separation of the three different genera is accepted (see remarks above).

***Halimeda*? sp. 2**
(Fig. 3a–g)

Description: Elongated-cylindrical segments (length up to 8 mm) showing constrictions at irregular distances (Fig. 3e). Cross-sections of segments are round. Medullar zone making up 28–45 % of the total segment diameter, broad with numerous close-set filaments, irregularly disposed. The medullar zone may be well calcified (Fig. 3a, f–g) but in other specimens appears as a sparitic central hollow (e.g. Fig. 3b, c). Spar-filled, interwoven medullar siphons are distinctly thicker than the cortical siphons, close-set leaving little intersiphonal space. Each medullar siphon is surrounded by a thin micritic wall (Fig. 3f–g).

Dimensions: D = 0.65–2.6 mm; dms = 0.06–0.15 mm; dcs = 0.03–0.05 mm

Remarks: *Halimeda*? sp. 2 resembles *Halimeda helladica* DRAGASTAN, KUBE & RICHTER, 2000, from the Rhaetian of Greece, later put in synonymy with *Halimeda cylindracea* by DRAGASTAN et al. (2002). *Halimeda*? sp. 2 is clearly separated from *Halimeda*? sp. 1 above all by the coarser and closer packed medularry siphons.

ACKNOWLEDGEMENT

We sincerely thank Olga (Budapest) for the determination of the dasycladales, the Vienna Waterworks and the Federal Ministry for Science and Research for their financial support of the karst-hydrologic project. Helpful comments provided by reviewers Ioan BUCUR (Cluj-Napoca) and Ovidiu DRAGASTAN (Bucharest) are kindly acknowledged.

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Manuscript received February 18, 2008
Revised manuscript accepted May 19, 2008