Juraella bifurcata BERNIER, 1984 (Calcareous alga, Gymnocodiaceae?) from the Lower Cretaceous (Barremian) Tirgan Formation of the Kopet Dagh basin, north-east Iran

By

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With 4 figures

Key words:
Calcareous Algae
Systematics
Gymnocodiaceae
Reproductory structures
Stratigraphy
Lower Cretaceous
Tirgan Formation

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Journal of Alpine Geology	51	S. 79-86	Wien 2009

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Abstract

Juraella bifurcata BERNIER, 1984 (calcareous alga, Gymnocodiaceae?) is described from the Lower Cretaceous (Barremian) Tirgan Formation of the Kopet Dagh sedimentary basin, northeast Iran. *Juraella bifurcata* represents a rather poorly known alga reported so far only from the Upper Jurassic of SE France (type-locality) and Austria, and the Lower Cretaceous of Romania and south-Italy. The new findings reveal possible preserved cysts inside the enlarged swollen filaments indicating their role as reproductive organs. The genus *Juraella* can be well placed in the siphonous bryopsidalean green algae; family uncertain. The belonging to the Gymnocodiaceae is shortly discussed and considered doubtful.

1. Introduction

There are only a handful of studies dealing with Lower

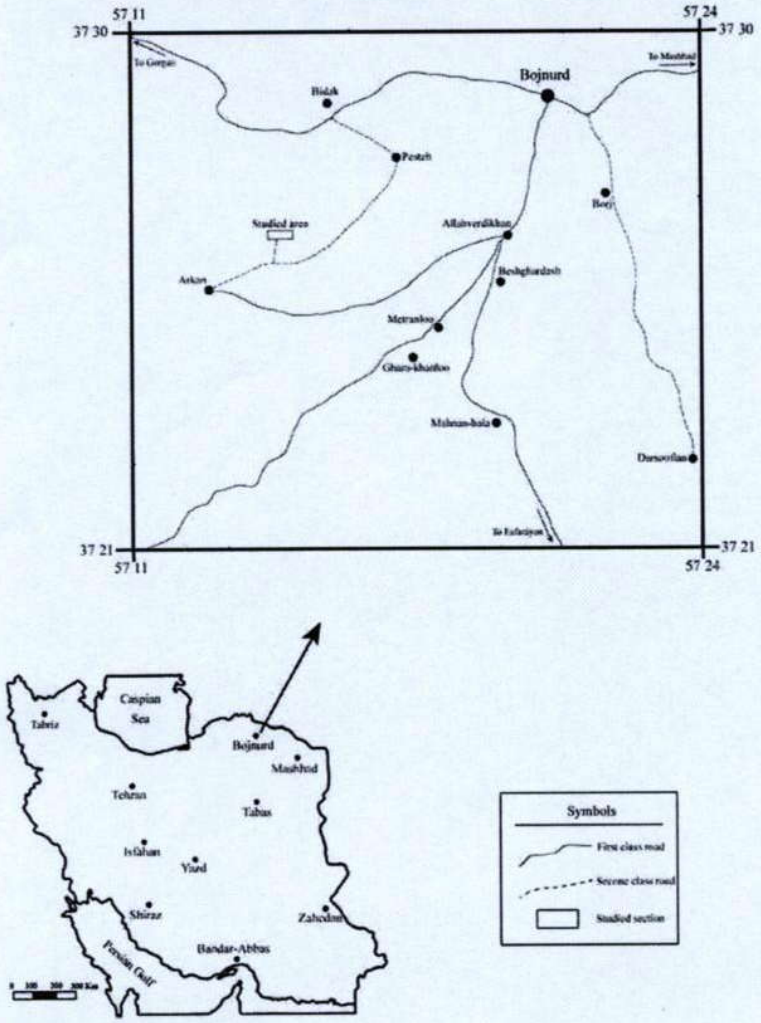

Fig. 1: The location of the studied area in the northeastern part of Iran.

Cretaceous calcareous algae of Iran (GOLLESTANEH 1979, BUCUR et al. 2003, SHIRAZI 2008, 2009, HOSSEINI & CONRAD 2008). These studies mainly focus on occurrences in the Zagros Mountains in the southern and southwestern and central parts of Iran. In the present paper the poorly known alga *Juraella bifurcata* BERNIER, 1984 with only rare findings in the Western Tethyan domain is described for the first time from the Barremian of the Kopet Dagh mountains in the north-eastern part of Iran.

2. Geological setting

The Kopet Dagh mountain range represents a NE-trending about 650 km long and about 200 km wide active fold belt at the frontier between Turkmenistan and Iran, east of the Caspian Sea. It was formed on Hercynian metamorphosed basement at the SW margin of the Turan Platform (unpubl. report Geological Survey of Iran) and is composed of about 10 km of Mesozoic and Tertiary sediments (mostly carbonates). Like the Zagros Mountains, the Kopet Dagh was folded into long linear NW-SE trending folds during the last phase of the Alpine orogeny in Plio-Pleistocene times. No magmatic rocks are exposed in Kopet Dagh except those at the basement occuring in the Aghdarband window and some Triassic basic dikes (unpubl. report Geological Survey of Iran). The studied samples are from the Barremian-Aptian Tirgan Formation refering to the Tirgan Valley in the eastern central Kopet Dagh sedimentary basin in the northeast of Iran (Fig. 1). The name, introduced by geologists of the National Iranian oil company (AFSHAR-HARB 1969, 1970), applies to a feature-forming unit of massively bedded, oolitic and organodetrital limestones occurring throughout the Kopet Dagh mountain range. For the eastern part of Kopet Dagh, AFSHAR-HARB (1969) indicated a thickness of 50 m and less but in the type area of the Tirgan Valley the thickness is about 700 m. The Tirgan Formation overlies the Shurijeh Formation and underlies the Sarcheshmeh Formation (Fig. 2); the contacts with both are conformable and a transitional interfingering between the Tirgan and Shurijeh Formations have been observed in the southeastern Kopet Dagh. The lithology of the Tirgan Formation includes oolithic, partly fossiliferous (e.g. orbitolinid limestones), partly marly limestones, and marls allowing further differentiation of the formation (Fig. 2). The age of Tirgan Formation is essentially Neocomian, in places extending as high as Aptian (STOCKLIN & SETUDEHNIA 1991). According to KALANTARI (1969) the studied Barremian deposits of the Tirgan Formation may reach up to 300 m thickness and consist of alternating calcareous sand and oolitic sandy limestone containing bryozoans, calcareous algae and both benthonic and planktonic foraminifera. The Aptian part of the Tirgan Formation may reach up to 1100 m in thickness and is mainly represented by massive limestones; its foraminiferan fauna includes beside others orbitolinids such as *Palorbitolina lenticularis* (BLUMENBACH).

3. Study area

Bojnourd area is a part of Kopet Dagh sedimentary basin located in Northern Khorasan (Fig. 3). In this area, some outcrops of the Shurijeh Formation, Tirgan Formation, Sarcheshmeh Formation, Sanganeh Formation, and Abderaz Formation exist all belonging to the Cretaceous. Tirgan's type-section is located about 39 km southeast of Dargaz and mainly includes mid to thick grey fossiliferous limestones (AFSHAR-HARB 1994). Arkan section is located 10 km southwest of Bojnourd, heading for Esfarayen (Figs. 1, 3). In this section, the thickness of the Tirgan Formation is about 195 m underlain by sandstones and limestones of the Shurijeh Formation. The Tirgan Formation persistently underlies the Sarcheshmeh Formation (Fig. 2). In the study area, the general striking of the beds is approximately E-W with a dipping of 15-35°. For micropaleontological studies, 85 samples were taken from which 108 thin-sections were prepared. The following calcareous algae, mainly dasycladales, have been identified (in alphabetical order): *Actinoporella* cf. *podolica* (ALTH), *Boueina* cf. *hochstetteri* TOULA (Fig. 4g, h pars, i), *Clypeina* cf. *gigantea* SOKAC, *Clypeina* cf. *solkani* CONRAD & RADOICIC, *Cylindroporella elliptica* BAKALOVA, *Juraella bifurcata* BERNIER (Fig. 4a-f), *Neomeris* cf. *cretacea* STEINMANN, *Polystrata* cf. *alba* (DENIZOT), *Praturlonella nerae* (DRAGASTAN, BUCUR & DEMETER), *Praturlonella dalmatica* (SOKAC & VELIC), *Pseudoactinoporella* cf. *fragilis* (CONRAD), *Salpingoporella* cf. *cemi* RADOICIC, *Salpingoporella* aff. *hasi* CONRAD, RADOICIC & REY, *Salpingoporella* cf. *hispanica* CONRAD & GRABNER, *Salpingoporella* aff. *istriana* (GUŠIC), *Salpingoporella* aff. *katzeri* CONRAD & RADOICIC, *Salpingoporella* aff. *milovanovici* RADOICIC, *Salpingoporella muehlbergii* (LORENZ) (Fig. 4h, pars) *Salpingoporella* cf. *parapiriniae* CONRAD et al. According to the mentioned microflora, the Barremian-Aptian age for this studied section is suggested (e.g. BASSOULLET et al. 1978, GRANIER & DELOFFRE 1993, BUCUR 1999).

4. Systematic paleontology

Phylum Chlorophyta
Class Ulvophyceae
Order Bryopsidales
Family Uncertain
Genus *Juraella* BERNIER, 1984
Juraella bifurcata BERNIER, 1984
Figs. 4a-f

***1984 *Juraella bifurcata* n. sp. - BERNIER: p. 488, Pl. 13, Figs. 1-7.**

1984 Organisme indéterminé - MASSE & LUPERTO SINNI: Pl. 39, Fig. 3.

1988 *Juraella bifurcata* BERNIER - BUCUR: p. 84, Pl. 1, Figs. 1-5, Pl. 2, Figs. 1-10.

1994a *Juraella bifurcata* - BUCUR: p. 17, Pl. 4, Figs. 5-8, Pl. 6, Fig. 7.

1994b *Juraella*? sp. cf. *J. bifurcata* BERNIER - BUCUR: Pl. 8, Fig. 11.

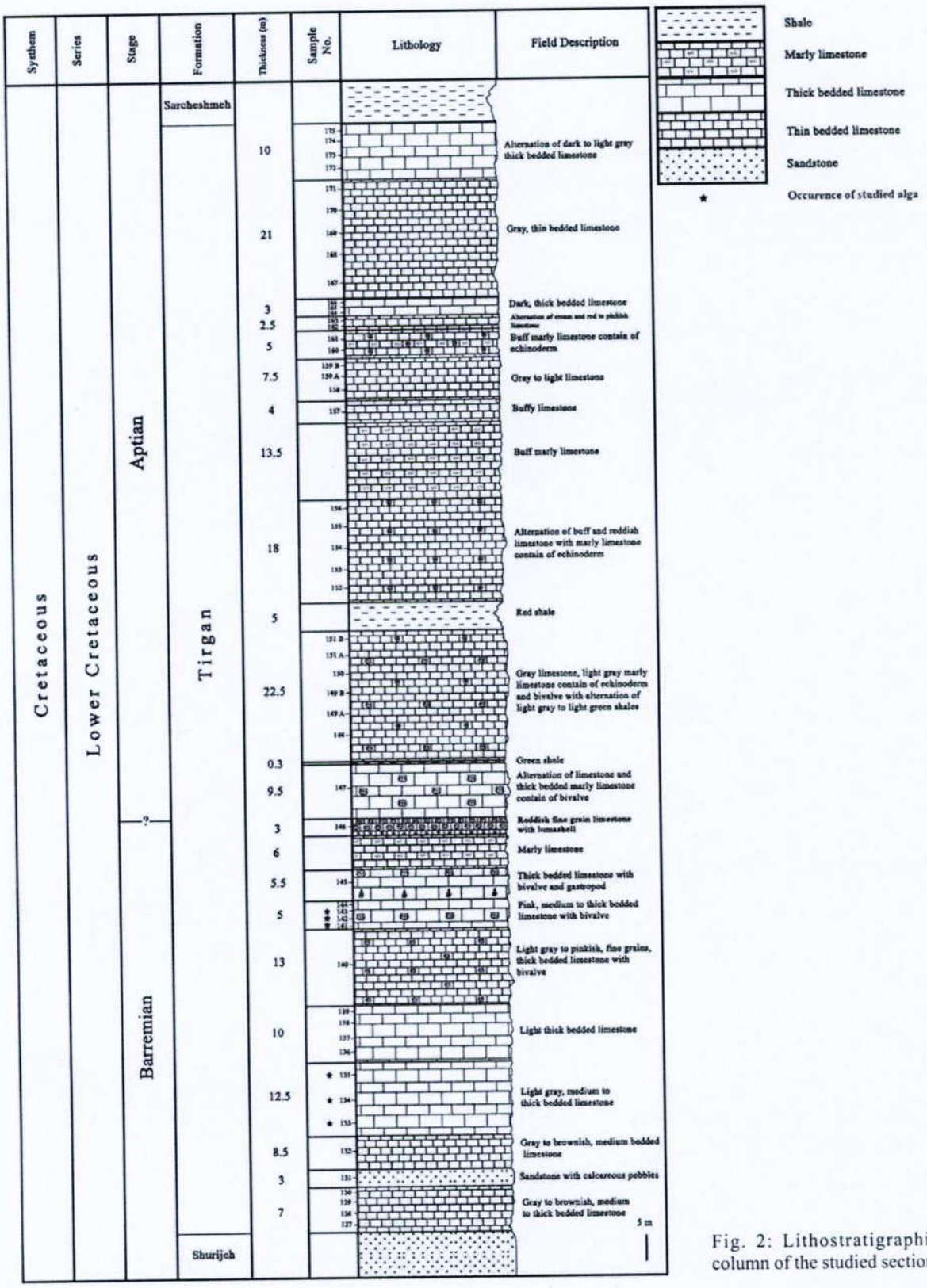

Fig. 2: Lithostratigraphic column of the studied section.

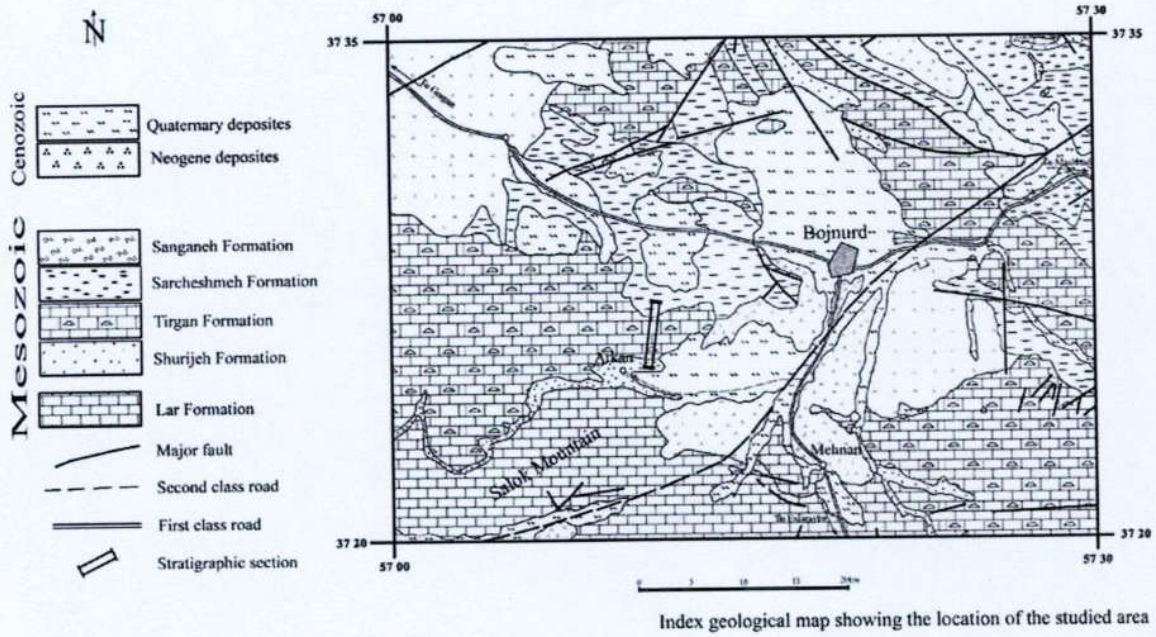

Fig. 3: Geological map showing the location of the studied area and section.

2008 *Juraella bifurcata* BERNIER - BUCUR: Fig. 8c.
?2008 *Juraella bifurcata* BERNIER- SCHLAGINTWEIT et al.: Fig. 3.

Original diagnosis (translated): *Thallus ramified. Medullary zone with fine, subparallel fascicles (= filaments) that curve to the exterior in the lateral and cortical zones. Some filaments are much enlarged in the medullar or cortical zone* (BERNIER 1984, p. 488)

Description: Cylindrical branching thalli (diameter: 0.77-1.46 mm) differentiated into a medullar and cortical zone. Medullar zone comparable broad making up about 50 to 60 % and composed of close-set more or less or longitudinally arranged fine siphons. More details are not discernible as the medullar zone appears mostly as a dark to light grey mass (Figs. 4a-b, e). Cortical siphons (diameter: 0.015-0.037 mm) are arising from the medullary siphons bending outwards and showing branching (Fig. 4d). The cortical siphons do not display such a close setting as the medullary ones, leaving sparitized intersiphonal spaces (Figs. 4d-e). Thallus branching was detectable in a single fragment (Fig. 4d). The low-angle branching occurs without a notible constriction/segmentation. The most conspicuous characteristic are modified swollen cortical siphons starting approximately at the medulla/cortex boundary then bending outwards like all the other unmodified siphons (Figs. 4d, f). When cutted proximally their transverse sections are almost round, more distally ovoid to elliptical. Their diameter (0.1-0.2 mm) is not constant throughout their length but shows greatest width in the first third then becoming thinner. Occasionally, a distal widening can be observed (Fig. 4b). One transverse section shows tiny dark micritic corpuscles (diameter: 0.03-0.075 mm) inside the swollen filaments that most likely represent reproductory structures (e.g. cysts) (Fig. 4e)

Remarks: Deduced also from the selected species name and description/diagnosis, the branching thallus was considered as one of the main striking characteristics by BERNIER (1984). Branching thalli (or segments), however, are not unusual among more or less cylindrical algae with internal filamentous structure reported for example from *Boueina* TOULA (e.g. LE MAITRE 1937), *Halimeda* LAMOUROUX (e.g. PIA 1932; CONARD & RIOULT 1977) or *Permocalculus* ELLIOTT (e.g., SCHLAGINTWEIT & SANDERS 2007). This type of branching without constrictions between individual segments, however, is totally different from modern *Halimeda* with superimposed segments connected by flexible and uncalcified strongly constricted parts, the so-called nodes (e.g. HILLIS-COLINVAUX 1980; VERBRUGGEN 2007). This structure accounts for the fragmentation after the lifetime of the alga producing a multitude of individual segments for each single specimen. The equally calcified and non-constricted branching in *Juraella* accounts for the often preserved branched fragments.

The genus *Juraella* was originally ascribed to the green algal family Udoteaceae by BERNIER (1984). BUCUR (1994a) was discussing the taxonomy of halimedacean/udoteacean algae *versus* gymnocodiacean algae and favoured an integration of *Juraella* into the latter group. Moreover, he stressed the siphonal green algal character of the Gymnocodiaceae obviously lacking a multi-cellular structure that should be expected if they would belong to the rhodophyta. The artificial separation of Gymnocodiaceae on the one side and the Udoteaceae/Halimedaceae on the other side is mainly focusing on the presence of internal reproductory organs within the Gymnocodiaceae, usually lacking in the Udoteaceae (see MU 1991, HUBMANN & FENNINGER 1997, for further discussion). Mention that in this discussion, the

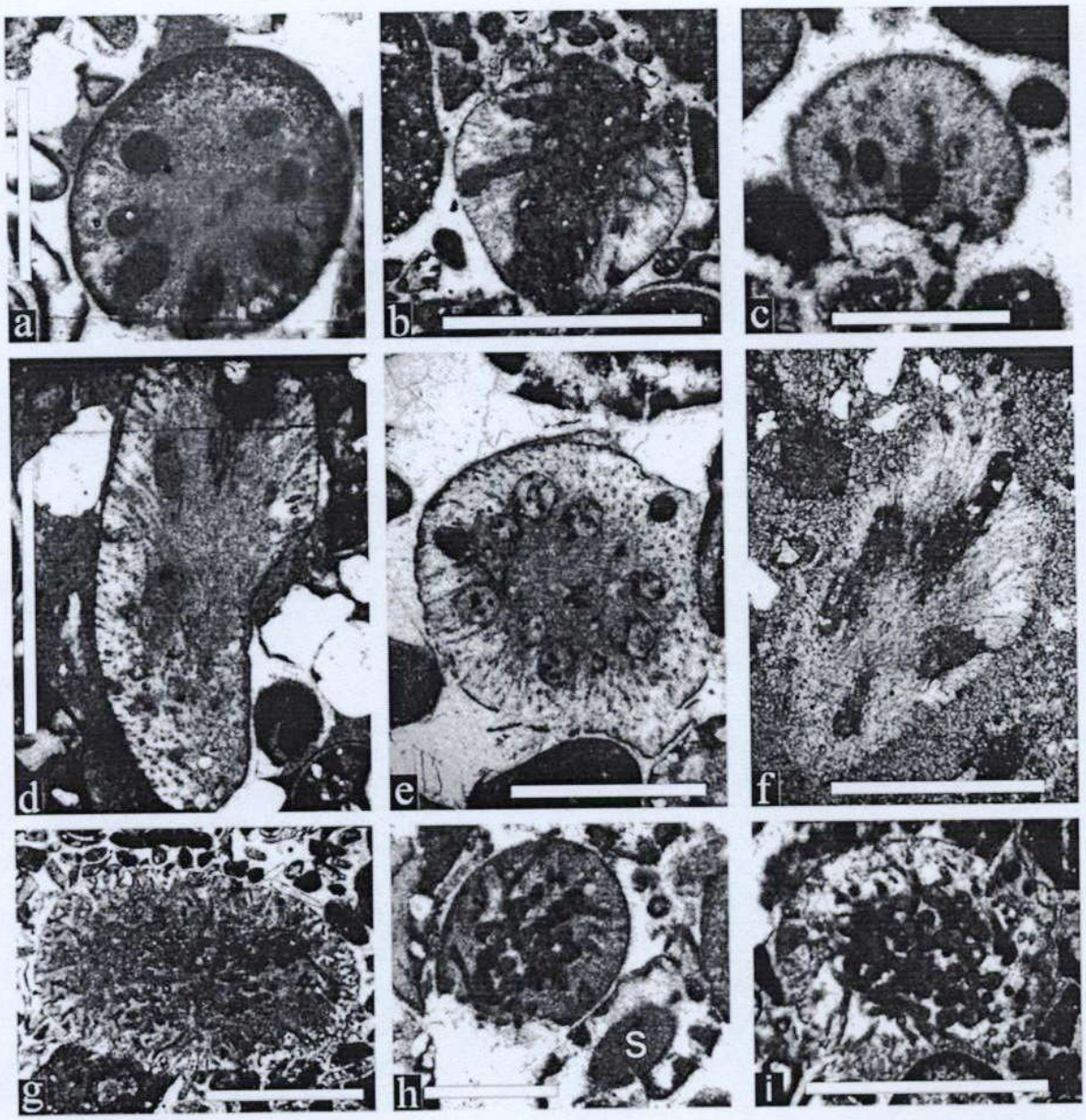

Fig. 4: *Juarella bifurcata* BERNIER (a-f) and *Boueina* cf. *hochstetteri* TOULA (g-i) from the Barremian Tirgan Formation of Iran.

a) *Juraella bifurcata*, slightly oblique transverse section showing rather regular arranged 7 modified enlarged filaments; note diffus recrystallized medullar zone difficult to separate from the cortical zone, sample 133.
b) *Juraella bifurcata*, oblique section; the shape could indicate a barrel-shaped segment, sample 143.
c) Fragment of *Juraella bifurcata*, oblique section, sample 143.
d) Oblique longitudinal section; possible branching may be indicated by the widening in the upper part, sample 133.
e) Transverse section, slightly oblique, showing several swollen filaments with dark micritic bodies inside (possible cysts), sample 133.
f) Oblique section of *Juraella bifurcata*, sample 134.
g) Oblique section of Boueina cf. *hochstetteri* TOULA, sample 141.
h) Oblique transverse section *Boueina* cf. *hochstetteri* TOULA showing comparable thick medullary siphons, together with *Salpingoporella muehlbergii* (LORENZ) (S), sample 135.
i) Oblique transverse section of *Boueina* cf. *hochstetteri* TOULA, sample 142.
Scale bars 1 mm, except c) and h) = 0.5 mm.

genus *Halimeda* was previously regarded a representative of the Udoteaceae, today is the only genus of the family Halimedaceae (e.g. VERBRUGGEN 2005). The solely focus on the position of the reproductory organs, however, maybe also misleading as green algae of this/these group(s) may develop gametangia at different parts of the thallus, for example in stalked bunches at the margin of segments as in *Halimeda* LAMOUROUX (e.g. DREW & ABEL 1988), as terminal siphons like in *Rhipidosiphon* MONTAGNE (e.g., LITTLER & LITTLER 1990) or inside the thallus, e.g. as in the codiacean *Codium* STACKHOUSE arising laterally from cortical utricles (e.g., CHANG et al. 2003, VERBRUGGEN et al. 2007); both *Halimeda* and *Codium* with siphonous organization belong to the order Bryopsidales. Like *Halimeda*, reproductive organs of many other bryopsidalean green alga (e.g., *Caulerpa*, *Penicillus*, *Udotea*, *Rhipocephalus*) are formed episodically (seasonality!) with only short time between fertility and a synchronous release of gametes (e.g., CLIFTON & CLIFTON 1999). In *Juraella*, however, these modified filaments are integral part of the thallus architecture, meaning that they can be observed in every thin-section of every specimen (or parts of specimens). However, it is unknown whether *Juraella* also evidenced a seasonal reproductive cycle.

Accepting the proposed siphonous green algal nature of *Juraella*, it should consequently be placed within the order Bryopsidales, but the belonging to the Gymnocodiaceae is doubtful as in within this family sporangia should be „*ovoid, in terminal segments*" (ELLIOTT 1955, p. 85). Neither can these modified swollen filaments be regarded as ovoid in shape nor are they developed only in the terminal part of the cortex accounting for the doubted belonging to the Gymnocodiaceae.

Occurrences and stratigraphy (see synonymy): Upper Oxfordian-Kimmeridgian of France, Kimmeridgian of Austria, Barremian of Romania and Italy, Barremian of Iran. A possible single finding, figured as *Juraella*? sp. comes from the Upper Cenomanian-Lower Turonian of Serbia (RADOICIC 2006) indicating that the stratigraphic range might be larger than previously indicated.

5. Conclusions

The identification of the calcareous alga *Juraella bifurcata* BERNIER in the Barremian Tigran Formation of the Kopet Dagh sedimentary basin represents its first record in Iran. It enlarges its paleogeographic distribution as this alga was so far only known from the Western Tethyan realm with records in Switzerland, Austria, Romania Italy. The stratigraphic range known so far is Upper Oxfordian-Barremian. *Juraella bifurcata* occurs in agitated external environments in back-reefal shoals.

Acknowledgements

The authors wish to thank Marc A. Conrad (Perly) and Ioan Bucur (Cluj-Napoca) for determinations of calcareous algae and helpful remarks on the manuscript.

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