**DISSOCLADELLA? CHAHTORSHIANA RASHIDI & SCHLAGINTWEIT N. SP., A NEW DASYCLADELA (GREEN ALGAE) FROM THE PALEOCENE OF IRAN**

Felix Schlagintweit1*, Koorosh Rashidi2, Hamed Yarahmadzahi3, Sharam Habibimood4, Mahnaz Amirshahkarimi5, Hossain Ahmadi6 & Hossain Khokan7

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**Abstract** A new Dasycladea is described as *Dissocladella? chahtorshiana* Rashidi & Schlagintweit n. sp. from Iranian carbonates of Mount Chah Torsch, Central Iran (type locality). Other occurrence is from the Sistan Suture Zone of Eastern Iran (Seladian?, Thanetian?). The medium-sized taxon displays cylindrical to slightly claviform thalli with a relatively large main axis bearing alternating primaries of variable shape. The latter show either slowly widening towards the distal end or are club-shaped displaying very short secondaries. The morphological variability of the primaries, both typical and atypical for *Dissocladella*, account for some doubts on the generic assignment of the new species. *Dissocladella? chahtorshiana* occurs in bioclastic packstones with *Cymopolia mayuaense* Johnson & Kaska, *Acroporella cf. anceps* Segonzac, *Halimeda* sp., and benthic foraminifera (e.g., *soritids*) at its type locality.

**Keywords:** Green algae, Yazd Block, Paleogene, taxonomy, biostratigraphy

**INTRODUCTION**

Paleocene shallow-water carbonates are known from different parts (or tectonic zones) of Iran: the Kopet-Dagh Basin, NE Iran (e.g., Rahaghi, 1983; Rivandi and Moosavizadeh, 2015; Salahi et al., 2018), the Sistan Suture Zone, E Iran (e.g., Rahaghi, 1983; Tirrul et al., 1983), Central Iran (e.g., Deloffre et al., 1977; Khosrow-Tehrani, 1987), or Zagros Zone, SW Iran (e.g., James and Wynd, 1965; Kalantari, 1976; Lasemi et al., 2007). Micropaleontological, taxonomic, and biostratigraphic studies [referring to Paleogene Shallow Benthic Zones (SBZ) of Serra-Kiel et al., 1998] of these rocks are rare and date back mostly to the seventies and eighties. Being rich in dasyycladaleans and larger benthic foraminifera much more attention has been given to the latter group (Kalantari, 1976; Rahaghi, 1978, 1980, 1983). Data on Paleogene dasyycladaleans from Iran are scarce (e.g., Deloffre et al., 1977; Barani et al., 2017). In the present contribution a new Dasycladale is described from Paleogene carbonates of Central Iran in the wider area of Yazd (type locality), and the Sistan Suture Zone of Eastern Iran (Fig. 1).

**STUDIED SECTIONS**

The studied material comes from two localities, Kuh-e-Chah Torsch in Central Iran, representing the type-locality of *Dissocladella? chahtorshiana* n. sp., and Kuh-e-Patorgi in Eastern Iran. As Kuh means Mount in Persian, the localities are also named Mount Chah Torsch and Mount Patorgi sections.

**Kuh-e-Chah Torsch section**

The Mount Chah Torsch section is located about 55 km southeast of Mehriz, near Yazd city (Fig. 2/1). In previous works this locality is named Kuh-e-Tchahtor (Deloffre et al., 1977), Tchahtor-C (Khosrow-Tehrani, 1987), Kamar-e-Chahtor (Nabavi, 1972), and Kuh-e-Chah Torsch (Majidifard and Vaziri, 2000). Geotectonically, the study site is part of the Central Iranian Microcontinent, namely the Yazd Block (e.g., Takin, 1972) (Fig. 1). Palaeogeographically it is part of the former Northern Neotethyan margin. It is worth mentioning that in the Geological Map of Nabavi (1972) Mount Chah Torsch is shown build up only of Cretaceous strata. The Paleogene carbonates forming rather steep slopes (Figs. 2/2, 4) and reaching to the top of the mountain were instead correctly included in the map of Majidifard and Vaziri (2000). The highest point of Mount Chah Torsch reaches 2.304 m above sea-level, and the surrounding plain is about 1.870 m a.s.l. Mount Chah Torsch has an NW-SE directed extension of about 6.6 km, with a width of about 3.7 km. The exposed sedimentary sequence starts with Lower Cretaceous “Orbitolina” Limestone (= Taft Formation) containing *Dictyoconus? pachymarginalis* Schroeder (Fig. 2/2a) and *Mesorbitolina gr. parva* (Doughlass)-*texitana* (Roemer). The base of the Taft Formation is not exposed (hidden under alluvial deposits). The two mentioned taxa were observed within the whole part indicating that the Taft Formation at Mount Chah Torsch is Garaganian in age (Schlagintweit and Wilmsen 2014, with references therein). It is followed by erosional contact by clastic deposits, and Upper Cretaceous sandy limestones containing bryozoans, and the Larger Benthic Foraminifera *Orbitoides genusacidus* (Leymerie) (Fig. 2/2b), *Canalispsina iapygia* Robles-Salcedo, Vicedo, Parente & Caus, *Sirelima ordesianus* Mering & Inan, *Sirtina ornata* (Rahaghi), *Orbitoides gruenbachensis* Papp, and more rarely *Omphalocystus macroporus* (Lamarck). These deposits can be assigned to the late Maastrichtian (Robles-Salcedo et al., 2019). Above the last sample with orbitoidids assigned to the late Maastrichtian (AH 73), an

1Department of Geology, Faculty of Science, Payame Noor University, PO Box 19395-3697, Tehran, Iran
2Department of Geology, Yezd University, 89195-741 Yezd, Iran, koorosh.rashidi@yazd.ac.ir
3Department of Geology, Earth Sciences Research Center, Zahedan Branch, Islamic Azad, University Zahedan, Iran, hamed.yarahmadzahi@iau.zahedan.ac.ir
4Department of Geology, Faculty of Science, Payame Noor University, PO Box 19395-3697, Tehran, Iran
5Lerchenauerstr. 167, 80935 Munich, Germany, *Corresponding author: felix.schlagintweit@gmx.de*
interval of sandy marls (0.8 m to 1.0 m) follows lacking any sample data. Most likely it represents an emersion horizon at the K-Pg boundary interval (Figs. 3–4). The lowermost sample of the following mixed carbonatic-siliciclastic marine bed (Ah 74), documents a new transgression, and contains textulariids and rotaliids, among Rotorbinella detrecta Hottinger. This facies directly grades into grey carbonates displaying nodular habitus. These contain abundant rather thick-walled miliolids, (Ankarella, Haymanella), the agglutinating taxon Kolchidina paleocenica (Cushman), and bryozoans, assigned to the Danian (e.g., Sirel, 1999). Especially the presence of green algae (Ovalites morelleti Elliott, Terquemella sp., Cymopolia cf. barattoloi Parente), lacking in the late Maastrichtian samples is worth mentioning. The early Danian algal-miliolid limestones display infiltration of Microcodium aggregates at the top connected to an emersion horizon (see Košir, 2004; Kabanov et al., 2008, for origin and interpretation). Upwards it is followed by alluvial fan conglomerates, unfossiliferous reddish sandstones, mudstones exhibiting fine cracks and black pebble formation (mud-flat deposits), subtidal grain-packstones with miliolids and algae (subtidal lagoon), and intercalated lensoidal dolomite

Fig. 1 Tentative location of the Kuh-e-Chah Torsh (1) and Kuh-e-Patorgi (2) sections plotted on the tectonic map of Iran (modified from Zanchi et al., 2009). Abbreviations: AA = Anatolian–Armenian Block, AMC = Anarak Metamorphic Complex, KDF = Kopah Dagh Foredeep, MZT = Main Zagros Trust).
bodies. The repetitive appearance of (sandy) mudstones and lagoonal grain/packstones indicates cyclic sedimentation due to oscillating sea-level (Trangressive-Regressive cycles; TCR). In the lower part of the cycles a several metres (average 35-40 m) thick rhyolitic silt is intercalated (see Figs. 2, 4). This unit is followed by a package of limestones that correspond from a microfacies point of view with the subtidal beds of the T-R cycles. These are followed upwards by thick-bedded to massive limestones reaching up to the summit of Mount Chah Torsh. The diversification of benthonic foraminifera and calcareous algae starts in the middle to upper part increasing markedly in the last third of this unit. From this locality Deloffre et al. (1977) reported Cymopolia heruki Gušić (= Cymopolia mayaense Johnson & Kaska acc. to Deloffre and Génot 1982), Clypeina sp., and Acroporella cf. anceps Segonzac (see also Khosrow-Tehrani, 1987). From this upper unit, the new Dasyycladale Dissocladella? chahtorshiana is described (Fig. 4). The typical microfacies is a bioclastic packstone containing dasyycladaleans (Dissocladella? chahtorshiana n. sp., Cymopolia mayaense Johnson & Kaska, Acroporella? anceps Segonzac, Clypeina elliotti Beckmann & Beckmann, and others), halimedaceans, benthonic foraminifera (rotalids, and soritoids), and some gastropods (Fig. 5A–C). The coordinates of the Mount Chah Torsh section at its base are 31°14’37.28"N, and 54°33’43.27"E.

The larger benthic foraminifera Sistanites iranicus Rahghi is among the most common taxa in the upper part of the section (Figs. 2/2c, 3). Its first occurrence is (in accordance with literature data from other regions) tentatively used as the separation of SBZ 1 and SBZ 2 sensu Serra-Kiel et al. (1998) at Mount Chah Torsh. The SBZ 2 includes an interval from the latest Danian to the lower/middle part of the Selandian (e.g., Papazzoni et al., 2017, fig. 1). Near the top of the section we observed Ordovella sphaerica Sire (Fig. 2/2d) that is assigned the same stratigraphic interval as for S. iranicus (Sirel 2012, fig. 11). In conclusion, there is no evidence that the Paleogene carbonates exposed at Mount Chah Torsh reach into the Thanetian. Based on these statements, the interval containing Dissocladella? chahtorshiana n. sp. (Fig. 4) can be assigned to the Selandian.

Kuh-e-Patorgi section

It is located SE of Bandan village, about 215 km distance to Zahedan, the central province city (Zahedan), and close to the border to Afghanistan. Based on Bandan map 1:100000 (Efekhbar Nezhad et al., 1990), the oldest unit in the section is represented by the Sefidabeh Formation that consists of volcanoclastic deposits. It is conformably overlain by the Paleogene Palang Formation, subdivided into two limestone members separated by conglomerates. Geotectonically, the study area is located between the Lut Block in the west and Helmand (or Afghan) Block to the east (Fig. 1). It is known as East Iran Flysch Zone or Sistan Suture Zone and mainly includes ophiolitic mélanges and Upper Cretaceous to Paleogene sediments (Tirrul et al., 1983). Palaeogeographically it is part of the former Northern Neotheyan margin. At the Kuh-e-Patorgi section the new alga Dissocladella? chahtorshiana n. sp. is much less frequent than at its type-locality. It occurs in bioclastic packstones with dasyycladaleans, e.g., Rostroporella oviformis Segonzac, benthonic foraminifera (rotalids, soritoids) (Fig. 5D). In the northwestern vicinity of the Kuh-e-Patorgi section, Dissocladella? chahtorshiana n. sp. may be rather frequent in some layers (Fig. 5E). Based on the occurrence of Rotorbinella detrecta Hottinger in the layers below, and the appearance of the rhodophycean alga Distichopanax biserialis Dietrich in layers above, the samples with Dissocladella? chahtorshiana n. sp. can be assigned to the late Selandian-early Thanetian interval at Kuh-e-Patorgi (Hottinger, 2014). The Kuh-e-Patorgi section still needs detailed macrofossil and microfossil studies. The coordinates of the section base are 31°22'59.10"N, and 60°49'36.58"E.

MATERIAL AND DEPOSITORY

The analyses of the Paleocene limestones refer exclusively to thin-sections. The specimens illustrated in the present paper are from three thin-sections. Ah 185 from Kuh-e-Chah Torsh is deposited in the Geosciences Museum of Mashad (in the Geological Survey of North-Iran East territory) under the depository number Gmn13950F70. It is part of a series of 45 thin-sections that have been stored recently at the Museum in the framework of a micropalaeontological study focused on larger benthic foraminifera from Mount Chah Torsh. Thin-section CT 4 from Kuh-e-Chah Torsh and 2p29 from Kuh-e-Patorgi are stored at the Ardakan Payame Noor University, Iran, in the Rashidi collection.

SYSTEMATICS

By Rashidi, K. & Schlagintweit, F.

Phylum Chlorophyta
Class Dasycladophyceae Hoek et al., 1995
Order Dasyycladales Pascher, 1931
Family Dasyycladaceae Kützing, 1843

Remarks: The genus Dissocladella Pia has often been used as a waste-paper basket in the past to include dasyycladaleans with two orders of laterals among swollen primaries (club-shaped) (e.g., Sokàč and Nikler, 1973; Jaffrez, 1975). With the cylindrical to slightly claviform thallus, the club-shaped primaries, arranged perpendicular to the axis Dissocladella appears the nearest genus exhibiting two orders of laterals where the specimens from the Paleocene of Iran can be assigned (e.g., Jaffrez, 1975; Bucur et al., 2010). Some reservations are due to other morphologies of the primaries showing only slight and more or less continuous widening. These differences might refer to different parts of the thallus with fertile regions (swollen primaries) as has for example been demonstrated for Suppiliitudinaria Schroederi by Baratto-lo (1984). The type-species D. savitiae is unique among all species of the genus due to its outer thallus annulation leading to ring-shaped fragments (Rao and Pia, 1936). This feature however has never been considered as being of generic importance (e.g., Radioci et al., 2005), otherwise Dissocladella would represent a monospecific taxon.
Fig. 3 Simplified lithostratigraphic column of the Kuh-e-Chah Torsh section with position of samples and distribution of benthic foraminifera and calcareous algae. Inferred SBZ zones after Serra-Kiel et al. (1998), Sirel (2012), and Hottinger (2014) (modified from Schlagintweit & Rashidi, 2019, in press.).
**Dissocladella? chahtorshiana** n. sp.

**Figs. 5A–D pars. 6–8**

**Origin of the name:** The name refers to the type-locality Mount Chah Torsh, Central Iran (Figs. 1–3).

**Holotype:** Oblique section shown in Figure 8C, thin-section CT 4.

**Horizon and locality:** Selandian carbonates from Mount Chah Torsh, lithostratigraphically not defined (= no formation name assigned).

**Description:** A medium-sized, well calcified Dasycladale with a cylindrical to slightly clavate thallus (Fig. 7A–B, Fig. 8D). The large main axis of roughly two third of diameter is bordered by a rather smooth surface except common widenings of the proximal part of the laterals, assumed of secondary origin (Fig. 6A, F) (compare Pl. 1, Fig. 3 in Radoičić et al., 2005). The primary laterals are numerous and regularly alternating between consecutive verticils. In shallow tangential sections they are close-set and of round outline (Fig. 7A–B, lower part). In deep tangential sections they appear of triangular outline (with rounded edges) (Fig. 7B, middle part). The primaries are usually arranged perpendicular to the axis in cylindrical morphologies (Fig. 7B); in slightly claviform morphologies they are slightly inclined upwards (Fig. 8D). The shape of the primaries is variable: slightly widening outwards and without detectable secondaries (Fig. 6A–B) or with a distinct swelling (club-shaped morphology) and secondaries (Fig. 6E–F). Sometimes the swollen part of the primaries are almost touching (or do so) with neighbouring ones. The different morphologies might refer to different parts of the thallus (sterile? fertile?). In transverse or longitudinal sections, two secondaries distinctly shorter than the primaries and widening distally are detectable (Fig. 7C–D, E–G). The exact number of secondaries per primary however lateral is unknown. Often they appear as a united micritic diverging masse upon the distal surface of the primaries (Fig. 7C, E, G).

**Comparisons:** From the Paleogene, the following species of *Dissocladella* have been described (data from Barattolo, 2002): *D. deserta* Elliott (Selandian-Ypresian); *D. deserta* from the Paleocene of Iraq, and lower Eocene of Egypt (Elliott, 1968) is a very small species (*D* = 0.39–0.47 mm), and about twelve primaries. *D. gracilis* Radoičić (Thanetian of Slovenia, Radoičić, 1991): as name already implies, it represents a very small alga (*D*: 0.16–0.290 mm, max. 0.368 mm) with four primaries. *D. longiangensis* Mu & Wang (Lutetian of China, Mu and Wang, 1985): medium-sized species (*D* up to 0.65 mm, see Kuss and Herbig, 1993, Paleogene of Egypt), and a main axis occupying about half the diameter (*d/D* 0.50–0.55). *D. lunata* Segonzac (Thanetian of France, Segonzac, 1979): small sized species (*D*: 0.282–0.415 mm) with four to six primaries. *D. savitriae* Pia (Danian-Thanetian): large-sized and annulated representative of the genus (*D*: 1.5–2.0 mm) with more than 40 primaries per verticil (Rao and Pia, 1936). *D. turnsekae* Radoičić (Danian-Selandian of Slovenia, Radoičić, 1998): it represents a very small species (*D* = 0.24–0.35 mm) with about eight primaries aligned vertically between successive whorls.

We may also note some resemblances of the lateral morphology with the poorly known *Jodotella volpensis* described by Segonzac (1976) with two sections from the

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**Fig. 4** Close-up view of the south-western slope of Kuh-e-Chah Torsh showing the lithostratigraphic succession and the interval containing *Dissocladella? chahtorshiana* n.sp.
Fig. 5 Typical microfacies of samples with *Disso cladella? chahtorshiana* n. sp. (D), from the Paleocene of the Kuh-e-Chah Tors (a–c) and Kuh-e-Patorgi (d–e) sections. a–b Bioclastic packstone with dasycladalean (e.g., *Acroporella? anceps* Segonzac, A), halimedacean (ha) algae, gastropods, and porcelainous benthic foraminifera (e.g., soritoids). c Bioclastic packstone with dasycladalean algae (e.g., *Clypeina elliotti* Beckmann & Beckmann, C1). d Bioclastic packstone with dasycladaleans (e.g., *Rostroporella oviformis* Segonzac, R). e Weathered rock surface with thallus fragments of *Disso cladella? chahtorshiana* n. sp. The maximum observed length amounts for ~17.5 mm (arrow). Kuh-e-Patorgi area.
Thanetian of France. The transverse section shown in plate 3, fig. 1, shows primaries that are widened proximally, displaying distinct swelling in the middle part, and two secondaries. This alga is distinctly smaller, displays a much lower d/D ratio (about 0.38), a reduced number of laterals (w = 16). Jodotella is different by its fertile ampullae set in clusters laterally to the primaries (Deloffre and Génot, 1982).

**Dimensions (in mm):** The main biometric parameters are compiled in Table 1. The maximum observed length of a thallus fragment is about 17.5 mm (Fig. 5E).

**Palaeoenvironment:** Dissocladella? chahtarshiana occurs in bioclastic packstones with various dasycladalean algae (e.g., Clypeina, Cymopolia), among some rather large taxa such as Rostroporella oviformis Segonzac (Fig. 5D), halimedacean algae (Fig. 5A–B) gastropods, benthic foraminifera, and rare fragments of corals. The association generally points to an open marine, outer platform environment of moderate water energy. A similar association including Rostroporella, Clypeina, Cymopolia div. sp., has been reported by Deloffre and Radoičić.
Table 1 Dimensions of Dissocladella? chahtorshiana n. sp. from the Paleogene of Iran (in mm, except ratio d/D). D: outer diameter; d: inner diameter; pmax: maximum diameter of primary laterals; l: length of primary laterals; p’max: maximum diameter of secondary laterals; l’max: maximum length of secondary laterals; h: verticil spacing; w: number of primary laterals in a verticil.

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(1978, p. 63) from the Paleocene of Slovenia and designated as "reefal environment".

CONCLUSIVE REMARKS

A new medium-sized Dasycladale is described as Dissocladora? chahtorshiana from Selandian-early Thanetian micritic bioclastic packstones of Iran. Both localities, western margin of the Yazd Block, Central Iran, and the Sistan Suture Zone of Eastern Iran, belonged to the former Northern Neotethyan margin.

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Fig. 7 Dissocladella? chahtorshiana n. sp. from Selandian carbonates of Kuh-e-Chah Torsh, Central Iran. a–b, longitudinal (upper part) and tangential (lower part) sections. Primaries are arranged in alternating position between successive verticils. In shallow tangential sections they are close-set and display rounded transverse outline. In deep tangential section (b, middle part) the transverse sections are rounded triangular. c–h, detailed views of the primaries, showing short secondaries. Thin-sections: Ah 185 (a–b), CT 4 (c–h).


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