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On the occurrence of *Likanella spinosa* (Milanović, 1965) (Dacycladales algae) in the fusulinid limestones from the Late Permian of the Zindandere formation (Belemedik sequence)

Zindandere formasyonu Geç Permiyen yaşlı (Belemedik istifi) fusulinli kireçtaşlarında Likanella spinosa (Milanović, 1965) (Dasiklad alg)'ın varlığı

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ABSTRACT

The micropaleontologic propreties of the fusulinid and dacycladacean algae-rich limestone at the Zindandere formation from the Belemedik sequence was investigated in the eastern Taurides. The limestones are mainly composed of benthic foraminifera and dasycladales algae. The present work deals with the systematic description, paleogeography, and stratigraphic value of dascycladales algae species Likanella spinosa (Milanović, 1965) from the Upper Permian limestones of southern Turkey.

Keywords: Belemedik sequence, Dacycladales, Likanella spinosa, Southern Turkey, Upper Permian.

ÖZ

Bu çalışmada, Doğu Toroslarda fusulin ve dasiklad algce zengin Belemedik istifi Zindandere formasyonunun mikropaleontolojik özellikleri araştırılmıştır. Türkiye'nin güneyinde Geç Permiyen yaşlı kireçtaşlarında bulunan Likanella spinosa (Milanovic, 1965) alg türünün sistematik tanımı, paleocoğrafyası ve stratigrafik konumu üzerinde tartışılmıştır.

***Anahtar Kelimeler*:** *Belemedik istifi, Dacycladales, Likanella spinosa, Güney Türkiye, Üst Permiyen.*

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INTRODUCTION

During construction of Pangaea in the Carboniferous and Permian, corals, bivalves, fusulinaceans and algae became progressively segregated into increasingly isolated geographical populations (Kobayashi, 1999; Leven, 2003; Okan and Hoşgör, 2005 and 2007). Dasyclad algae contributed significantly to the formation of extended algal carbonates (grain-and wackestones) and the formation of reef mounds and mud mounds in Carboniferous and Permian shelf environments (Flügel, 2004). Calcareous algae and dasycladales algae are stratigraphically and palaeoenvironmentally important components of Taurus carbonates. Dating the Permian formations in central Anatolia, central and eastern Taurus are commonly studied by using foraminifera (Okan, 1978; Altıner, 1981 and 1984; Köylüoğlu and Altıner, 1989; Leven 1995; Altıner et al., 2000; Okuyucu, 1999 and 2008). However, in some cases dasyclad algae are used for dating the Permian shallow marine sequences (Bilgütay, 1960; Güvenç, 1969, 1970 and 1972).

The studied material, which is very rich in calcareous algae, was collected and given in 2002 to the corresponding author by İsmet Alan (2008) from the Late Permian successions of Belemedik sequence from the southern Turkey. The algal remains belong to the species Likanella spinosa (Milanović, 1965). The present paper supplies further data on the knowledge of this species.

GEOLOGICAL SETTING

Belemedik sequence, which crops out between Pozantı and Karaisalı (Adana) towns east of Ecemiş Fault Zone, consists of Upper Devonian to Upper Cretaceous formations in the Eastern Taurides (Alan et al., 2004) (Figure 1). The Lower Permian Sarıoluk formation is mainly composed of limestones and clayey limestone including *Girvanella* and *Pseudofusilinoides* and forms overlying Belemedik sequences. This unit is followed by Zindandere formation which is mainly characterized by fusulinid and *Mizzia* bearing limestones (Alan et al., 2004). The presence of fossil algae in the Zindandere formation has been known for several years in Adana region (Ayhan and Lengeranlı, 1986). However, they have not been previously described nor identified in the published record. Fusulinid-bearing successions have been known from the eastern Taurus since Blumenthal (1947). Quartzites and limestones bearing this succession were attributed to the Zindandere formation by Ayhan and Lengeranlı (1986), and Alan et al. (2004). The stromatolitic limestones, sandy limestones, marls and claystones of the Lower Triassic Katararası formation conformably overlie the Upper Permian sediments (Zindandere formation) (Alan et al., 2004). The studied section are characterized by carbonate-rich, badly sorted fusulinid-bearing limestones which have been interpreted as shelf tempestites (Figure 2). Late Paleozoic calcareous foraminifera are the another components of this sections with their complicated shells.

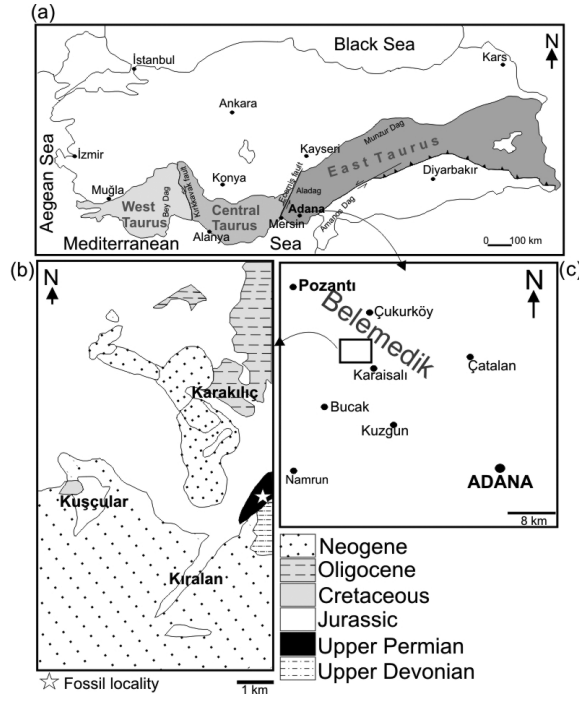

Figure 1. (a) The broad geographical subdivision of the Taurus Belt, (b) regional geological map of the study area, and (c) location (after Özgül, 1976; Alan et al., 2004; Alan, 2008).
Şekil 1. (a) Toros kuşağının esaslı coğrafik bölümleri, (b) çalışma alanının bölgesel jeoloji haritası ve (c) yerbulduru haritası (Özgül, 1976; Alan vd., 2004; Alan, 2008).

Late Permian shallow marine carbonates of the Zindandere formation yield, *Mizzia velebitina* (Rezak), *Gymnocodium* sp. and *Permocalculus* sp., as calcareous algae. Biostratigraphic

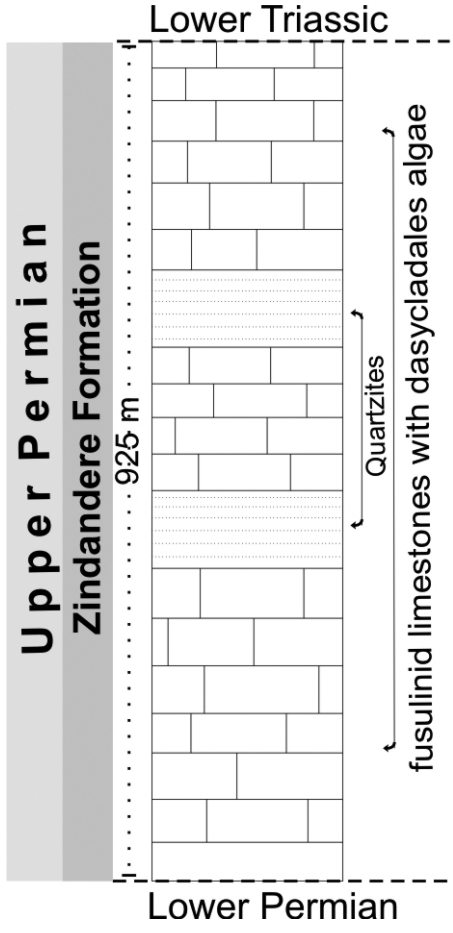

Figure 2. Generalized column of the studied Upper Permian stratigraphic section and its paleontological characteristics.
Şekil 2. Çalışılan Üst Permiyen stratigrafi kesitinin genelleştirilmiş kolon kesiti ve paleontolojik özellikleri.

control of the Zindandere formation for Late Permian was provided by foraminifera, as *Dunbarula mathieui* Ciry*, Nodosinelloides mirabilis* (Lipina)*, Nodosinella* sp., *Stafella* sp., *Pachyphloia* sp., *Tetratxis* sp. and *Glomospira* sp. Calcareous algae and foraminiferal assemblage of the succession reveals the warm and shallow marine environment during the Late Permian time and they were strongly controlled by local ecological conditions.

There is no previously published data related with the dasycladacean algae fauna of Belemedik sequence. The present study describes the dasyclades in the Belemedik sequence of Adana and establishes its age and paleobiogeographic affinities.

SYSTEMATIC PALEONTOLOGY

Order **Dacycladale**s Pascher 1931

Family **Dascyladaceae** Kützing 1843

Genus ***Likanella*** (Milanović, 1965)

The original diagnosis of that genus (Milanovic 1965) was revised by Granier and Deloffre (1995).

Likanella spinosa Milanović in Granier and Deloffre 1995, non 1966

Plate 1, Figures 1-6

1965 *Likanella spinosa* Milanović, fig. 2.

1966 *Likanella spinosa* Milanović, p. 10-11, pl. 1, figs. 1-6; pl. 2, figs. 1-7; pl. 3, figs. 1-7; pl. 4, figs. 1-8.

1973 *Likanella spinosa* Milanović, Kochansky-Devidé et al., pl. 2, figs. 9-10.

1974 *Likanella spinosa* Milanović, Mirković, pl. 10, fig. 1.

1995 *Likanella spinosa* Milanović, Granier and Deloffre, p. 57.

2000 *Likanella spinosa* (Milanović), Granier and Grgasovic, p. 91-92

Description and Discussion: The thallus is composed of loosely connected cylindrical segments, which at their lower end possess three whorls of branches. Cylindrical thallus eigth phloiophorous branches, massive calcification near the stem and around the branches. The main characteristics of the species are peculiar thallus structure (lower cylindrical portion and well differentiated branches), the presence of sterile and fertile laterals. The main stem is big, cylindrical, and elongated. Branches are in the form of hollow elongated defective cones, and resemble large thorns. The size of segment varies. The length of articles is between 0.99 and 1.96 mm, the diameter of the widest parts of the thallus varies between 0.84 and 1.7 mm. The length and the diameter of branches are also very different. The length of the branches measured is between 0.35 and 0.42 mm.

Milanovic (1965) established *Likanella* as a genus of dasyclad algae for specimens occurring mainly in Middle-Upper Permian carbonate deposits in Velebit Mountain (ancient Yugoslavia).

Later, Milanovic (1966) provided a brief account about the newly described species, *Likanella spinosa*, taken from the Lika area as the holotype and, provided seven photographic illustrations of this material, and assigned the genus to the family of Dasycladaceae. Based on its morphologic characteristics, the *Likanella spinosa* species resembles somehow the Late Jurassic species *Actinoporella podolica* (Alth), which also has a segmented thallus (Milanovic, 1965).

STRATIGRAPHIC AND PALEOGEOGRAPHIC IMPORTANCE

At the base of the Permian, an extensive development of Dasycladales suddenly started. This first flourishing period of Dasycladales reached its peak during the Middle Permian. After rapid appearing of the general, the diversity of the species started to reduce toward the Late Permian time. The Late Permian is, therefore, characterized by a low diversity of the algae (Berger and Kaever, 1992; Flügel, 2004). At least 47 genera have been described for the Permian as a whole. The most common genera are *Diplopora, Anatolipora, Vermiporella, Pseudovermiporella, Anthracoporella, Kochanskyella, Clavaporella, Gyroporella, Pseudogyroporella, Mizzia, Macroporella,* and *Velebitella* (Riding and Guo, 1987; Berger and Kaever, 1992) (Figure 3). Details of Permian dasycladalean associations are best known from Iraq (Elliott, 1958), Japan (Endo, 1959), the Carnic Alps (Flügel, 1966), Adriatic-Dinaridic Platform (Herak and Kochansky, 1960; Kochansky and Herak, 1960; Milanovic 1966; Kochansky-Devide, 1967; Kochansky-Devide and Gušić, 1971; Kochansky-Devide et al., 1973; Sremac, 1991; Sremac and Aljinovic, 1997), Tunisia (Vachard, 1985), Afghanistan (Vachard, 1980), central and northwestern China (Mu and Riding, 1983; Wendt, 1997; Mamet and Zhu, 2005), Turkey (Bilgütay, 1960; Güvenç, 1969, 1970 and 1972), Saudi Arabia (Rezak, 1959; Okla, 1992; Hughes, 2005; Vachard et al., 2005), East Oman (Vachard et al., 2001) and Texas (Johnson, 1951). In addition, the vertical distribution of most of these species was too large to make them suitable for very fine stratigraphic investigations.

Species of the genus *Likanella* are well known for their stratigraphic distribution in the Early Permian-Late Cretaceous interval (Schlagintweit, 1991; Granier and Grgasovic, 2000). *Likanella spinosa* (Milanović, 1965) is a well-known species that occurs frequently and abundantly throughout the Mediterranean, marking the Middle-Late Permian. Although it is one of the most common of the Late Permian calcareous algae of the entire Adriatic-Dinaridic Platform and is found at

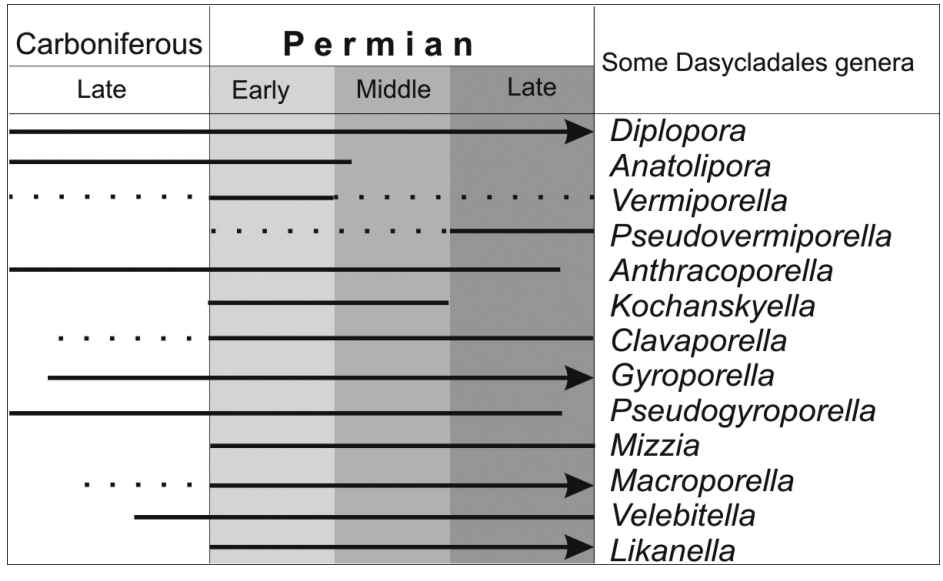

Figure 3. Stratigraphic distribution of some Dasycladales genera in the Late Carboniferous and the Permian (after Berger and Kaever, 1992).
Şekil 3. Bazı Geç Karbonifer ve Permiyen Dasiklad alglerinin stratigrafik dağılımı (Berger ve Kaever, 1992'den).

almost every Upper Permian locality. Especially, during detailed mapping of Velebit Mt. and the Lika region performed by many Croatian palaeontologists (Herak and Kochansky, 1960; Kochansky and Herak, 1960; Milanovic, 1966; Kochansky-Devide, 1967; Kochansky-Devide et al., 1973; Sremac, 1991; Sremac and Aljinovic, 1997), a rich collection of Permian fossils was found. The dominant carbonate producers during the Middle-Late Permian were calcareous algae, Dasycladales (*Mizzia*, *Vermiporella*, *Velebitella*, *Salopekiella*, *Connexia*, *Likanella*) or gymnocodiaceans (*Gymnocodium*, *Permocalculus*) (Sremac, 2005).

A number of quantitative studies are available on worldwide distribution of various marine invertebrates in the Permian, and these all show patterns relevant to the tropical water masses mentioned above (Ziegler et al., 2003). Belasky (1994) grouped the lists of the coral genera from the Early Permian into the Late Permian. Fusulinid distribution parallel the corals, and, coral like organisms, were mainly restricted to the tropical carbonate platforms and probably accompaning calcareous algae (Kobayashi, 1999; Ziegler et al., 2003). The fusulinids are common faunal elements in the Middle-Late Permian in the Central and Eastern Mediterranean together with calcareous algae and charachterized the biozones of this time interval. Their presence has stimulated research for the possible relationships between the Laurussian and Gondwanian domains well before the Triassic. These major microfaunal and algal elements are distributed only between Adriatic-Dinaridic Platform and eastern Turkey (Figure 4).

The Paleotethys Ocean was situated between the Laurussian (North America, Baltica and Siberia) and Gondwanian (Africa, Arabia, Lut and other Iranian terranes) branches of Pangea (Şengör and Natalin, 1996). At the end of the Early Permian a new ocean – Tethys (Neotethys) was born within marginal Gondwana, south of Palaeotethys, extending from Timor to Sicily (Stampfli et al., 2002; Sremac, 2005; Cocks and Torsvik, 2006; Thery et al., 2007). Several palaeogeographical reconstructions have been proposed for the Middle–Late Permian (Schönlaub, 1992, Demirel and Tekin, 1993; Altıner et al., 2000; Dercourt et al., 2000; Stampfli et al., 2002; Cocks and Torsvik, 2006; Thery et al., 2007; Moix et al., 2008). Palaeogeographical reconstructions

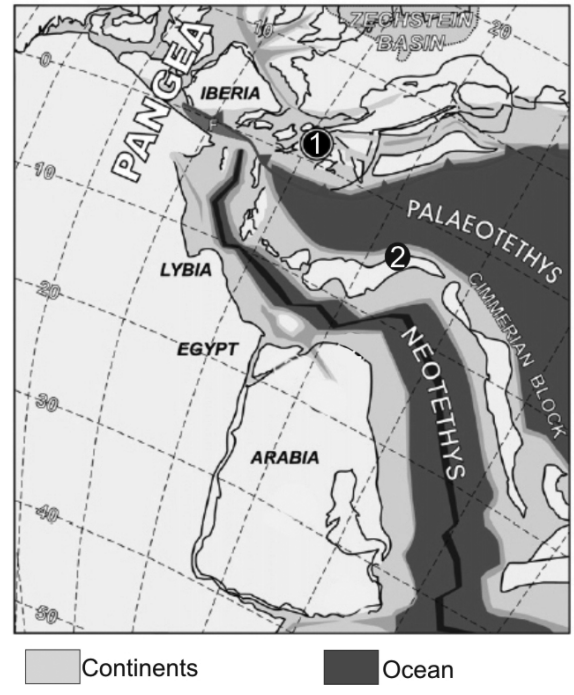

Figure 4. Late Permian localities in the Tethyan region. 1. Adriatic-Dinaridic Platform, 2. Eastern Taurus (Stampfli et al., 2002).
Şekil 4. Geç Permiyen Tetis bölgesindeki lokaliteler: 1. Adriatik-Dinaridik Platform, 2. Doğu Toroslar (Stampfli vd., 2002).

show that the eastern Taurus was detached from Gondwana together with Cimmerian blocks in Permian times during the opening of Neotethys and the East Mediterranean oceans (Thery et al., 2007; Moix et al., 2008). The palaeogeographic position of the eastern Taurus locality with *Likanella spinosa* indicates a Cimmerian blocks (see Figure 4). Actually, Paleotethys species *Likanella spinosa* migrated northward during the Middle Permian, which seems to have originated in the paleotropics, later migrated southward. Besides, in the study section, *Permocalculus* and *Mizzia* are discovered. The gymnocodiacean *Permocalculus* and dasycladales green algae *Mizzia* accumulations are common everywhere from NW Caucasus to Hungary, and quite puzzling during a Late Permian period of limestones deposits elsewhere (Thery et al., 2007).

CONCLUSIONS

The Late Permian fusulinid limestones of the Zindandere formation are characterized by a

comparably weakly diversified microfauna and –flora. The micropaleontologic assemblages are rather homogeneous when compared to the localities from the Karaisalı area, the eastern part of the Taurus. Generally, widely distributed in the Permian of Paleotethys (Adriatic-Dinaridic Platform); in Turkey the species occurs in the Late Permian of the Zindandere formation (Belemedik sequence) in the Cimmerian blocks. This study deals with the first occurence of the eastern European species *Likanella spinosa* in Turkey. It is associated with *Dunbarula mathieui, Nodosinelloides mirabilis, Nodosinella* sp., *Stafella* sp., *Pachyphloia* sp., *Tetratxis* sp. and *Glomospira* sp. foraminifera.

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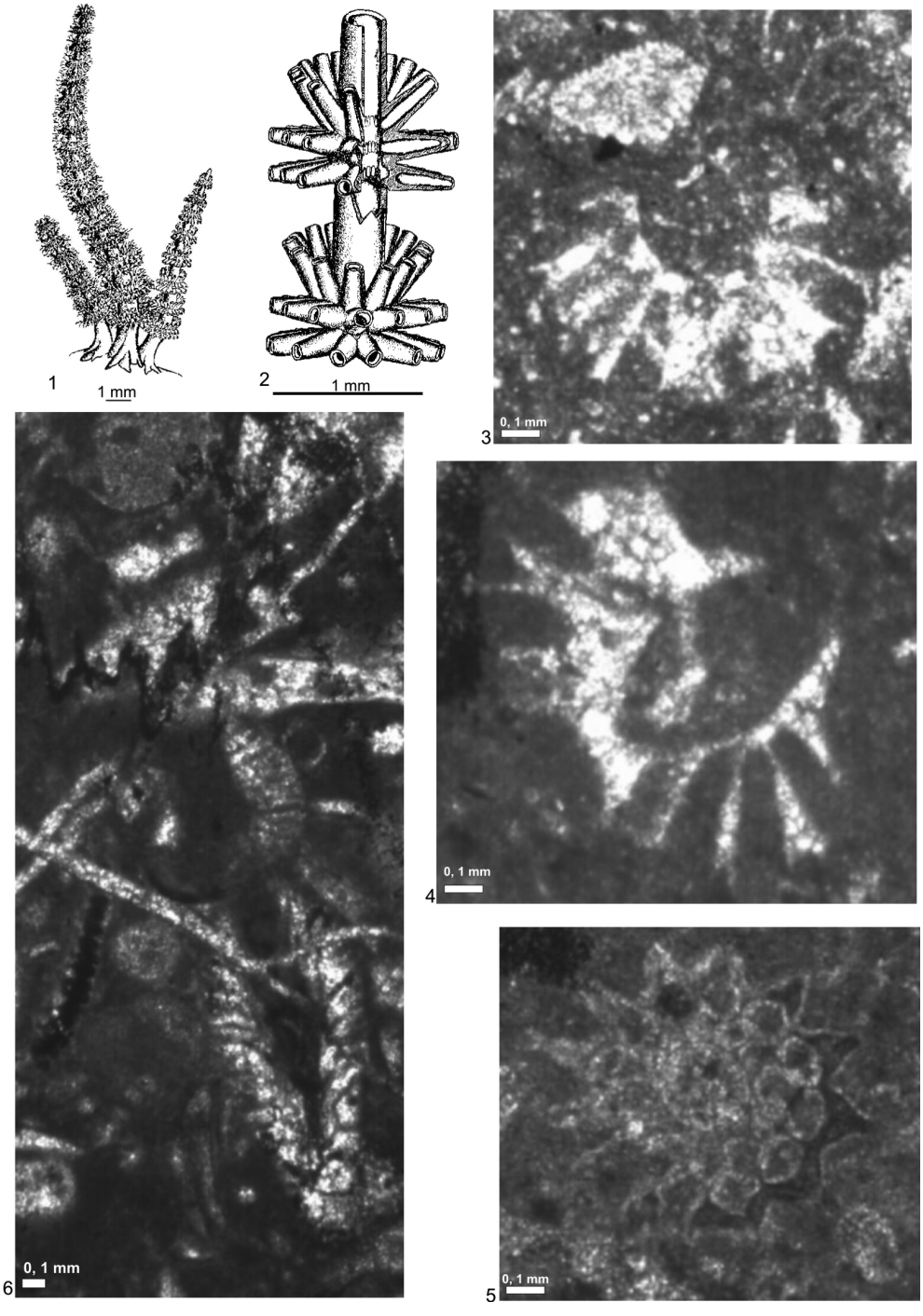

PLATE 1 / LEVHA 1

Likanella spinosa (Milanović, 1965)

1-2. Reconstruction of two segments and living algae (Milanović, 1965).
1-2. Yaşayan alg ve iki segmentinin canlandırılması (Milanović, 1965) .
3-5. Transversal section.
3-5. Transversal kesit.
6. Oblique section
6. Oblik kesit.