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Late Eocene siliceous sponge fauna of southern Australia: reconstruction based on loose spicules record

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Abstract

An abundant and diversified assemblage of siliceous loose sponge spicules has been identified in the Late Eocene deposits cropping out along the southern coasts of Australia. Based on the comparison of the obtained spicules with those of living sponges, representatives of at least 43 species within 33 genera, 26 families, and 9 orders of "soft" Demospongiae and Homoscleromorpha have been identified in the assemblage. Within the studied sediments, the spicules representing dem-

osponge orders Poecilosclerida, Hadromerida, and Astrophorida were the most diverse. The rest of the five demosponge orders (Halichondrida, Agelasida, Haplosclerida, Spirophorida, and Chondrosida) are represented by single families. Also, a single family Plakinidae within the class Homoscleromorpha that includes two genera was present. The diversity of spicules is similar in all studied samples and areas, even distant geographically, and there are only minor differences between the sections. That indicates a homogenous character of this rich siliceous sponge assemblage. Most of the studied sponge spicules have Recent equivalents among present-day siliceous spicules. However, the fossil ones are bigger which is most likely due to different environmental conditions. Among the recognized sponge species, at least eleven (*Agelas* cf. *axifera, Agelas* cf. *wiedenmayeri*, *Penares sclerobesa*, *Histodermella australis*, *Trikentrion flabelliforme*, *Cliona* cf. *mucronata*, *Tethya* cf. *omanensis*, *Terpios* sp., *Placinolopha* cf. *sarai*, *Dotona pulchella*, and *Sigmosceptrella quadrilobata*) are noted for the first time in the fossil record.

Key words: taxonomy, Porifera, Demospongiae, Homoscleromorpha, sponge spicules

Introduction

The fossil record of the phylum Porifera dates back to the early record of life on the Earth. There are early Vendian fossil sponges described from about 600 million years ago (Reitner & Mehl 1995; Hooper & van Soest 2002; Kaesler *et al*. 2004), but this was lately questioned by Antcliffe *et al.* (2014). According to this, the oldest fossil sponge material includes Iranian hexactinellid spicules from the Precambrian-Cambrian boundary (~ 535 Ma). There are numerous 19th century monographs describing rich fossil sponge assemblages (e.g., Goldfuss 1826–33; Quenstedt 1878; Roemer 1860; Hinde 1883, 1893; Zittel 1877; Rauff 1893-95; and Hall & Clarke 1899). More recent papers describe disassociated sponge skeletal elements—spicules from the Paleozoic (e.g., from all over the world: Bengtson 1986; Bengtson *et al*. 1990; and Zhang & Pratt 1994, including Australia: Bowerbank 1869; Hall 1888, 1889; Benson 1922; Chapman 1940; Howell 1952, 1956; Gatehouse 1967; Picket 1969; van Kempen 1978, 1990; Rigby 1986) and Mesosoic (e.g., Schrammen 1924, 1936, 1937; Reif 1967; Moczydłowska & Paruch-Kulczycka 1978; and Pisera 1997).

The majority of fossil sponge studies concerns bodily (entirely) preserved sponges while loose sponge spicules were a much less common object of investigations, and in most cases these studies do not proceed further than the description of spicule morphotypes (see Rigby *et al*. 2001 and the literature cited therein). However, diversified assemblages of disassociated sponge spicules are known already from the Cambrian (see Castellani *et al*. 2012 and reference therein) and were described several times from the Paleozoic (e.g., Mostler and Mosleh-Yazdi 1976; Mehl 1998; Debrenne and Reitner 2001; and Carrera & Maletz 2014) and Mesosoic (Rauff 1893-95; Mostler 1971, 1972, 1976, 1986; and Wiedenmayer 1994). The Tertiary record of loose sponge spicules is less studied (e.g., Etheridge 1888; Card & Dun 1897; De Laubenfels 1953; Picket 1983; Wiedenmayer 1994; Pisera & Hladilová 2003; Pisera *et al*. 2006; and Łukowiak *et al.* 2014).

From the Eocene of southern Australia the loose sponge spicules were already investigated by Hinde (1910) from the Princess Royal Spongiolite—the sediment which has been the subject of present investigation as well. The isolated spicules were assigned by Hinde to 20 genera (about 15 of them are demosponges and the majority of the spicule morphotypes were also found in present study). Seventeen new sponge species (both lithistids and non-lithistid demosponges) were described by Chapman & Crespin (1934) from the Plantagenet beds of Albany, Cape Riche, and Norseman, Australia (i.e. the same area and sediments from where the studied material comes). Also one sphinctozoan sponge was described by Picket (1982) from the Late Eocene of Western Australia. Finally, a sublithistid pachastrellid sponge *Brachiaster claudelevii* was recently described by Pisera & Bitner (2007) from the Eocene of Hamersley River section—the site, which is the subject of present investigations. On the other hand, the rich Late Eocene loose sponge spicule assemblage from New Zealand's Oamaru Diatomite was described by Hinde & Holmes (1892).

Even though some studies of the Eocene sponge fauna from SW Australia were already made, this paper, which deals with a rich loose siliceous sponge spicule assemblage, is a first attempt of biological interpretation of the studied spicules by attributing them to certain taxonomical groups. This can be done by comparing these loose sponge skeletal elements to spicules belonging to living sponges.

Conclusions

The biological interpretation of the studied Late Eocene spicules from the south Australian deposits revealed the presence of rich sponge assemblage that mainly consists of Demospongiae, represented by at least eight orders, and one order of Homoscleromorpha. Together, 9 orders, 26 families, 33 genera, and 43 species (including one fossil species) of "soft" sponges were recognized. Additionally, three families of lithistid demosponges and two orders from the class Hexactinellida were noted in the studied material. The most diverse spicules in the studied assemblage (in terms of the number of recognized families) are demosponge orders Poecilosclerida, Hadromerida, and Astrophorida. The remaining six sponge orders were represented by single families. This notable diversity makes the studied assemblage one of the most abundant fossil sponge associations known to date. Moreover, among the recognized species, at least ten are recorded in the fossil record for the first time. It proves that several Recent sponge taxa have a long evolutionary history. Likewise, it suggests that their evolutionary changes were rather slow. This is also supported by the fact that the majority of the studied spicule morphotypes may be found among living sponges. The studied Eocene sponge spicules were considerably bigger than their Recent morphological counterparts which might be due to the higher silica content in the sea water during that time.

Despite the fact that the studied spicules came from 3 different and distantly situated areas, there are no significant differences observable in the sponge composition. It proves that the structure of sponge communities was very similar over a large area during the Late Eocene suggesting small environmental differentiation.

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