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Original article

First fossil record of early Sarmatian didemnid ascidian spicules (Tunicata) from Moldova☆

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ABSTRACT

Numerous ascidian spicules are reported for the first time from the lower Sarmatian Darabani-Mitoc Clays of Costeşti, north-western Moldova. The biological interpretation of the studied sclerites allows distinguishing at least three morphospecies (*Polysyncraton*-like, *Trididemnum*-like, and *Didemnum*-like) within the Didemnidae family. Eight other morphological types of spicules are classified as indeterminate didemnids. Most of the studied spicules are morphologically similar to those of Recent shallow-water taxa from the Mediterranean Sea. In contrast, some sclerites resemble those of taxa from the Indo-Pacific region. The greater size of the studied spicules, compared to that of present-day didemnids, suggests favorable physicochemical conditions within the Sarmatian Sea. The presence of these stenohaline tunicates that prefer normal salinity seems to confirm latest hypotheses regarding mixo-mesohaline conditions during the early Sarmatian.

1. Introduction

Ascidians, also called "sea squirts", are sessile marine tunicates. These filter-feeding colonial or solitary organisms inhabit both shallow-water and deep-sea environments all over the world. Amongst the approximately 3000 extant species described so far, 229 species are known from the Mediterranean (the closest marine area to the study site; Shenkar and Swalla, 2011), including 176 species inhabiting the eastern part of this basin (Coll et al., 2010). Ascidians are temperature and salinity-sensitive (Shenkar and Swalla, 2011), and despite being able to live in harbors, river mouths, or even marine lakes (Monniot and Monniot, 2008; Monniot, 2009), they prefer normal marine habitats (Monniot et al., 1991).

Some ascidian taxa are characterized by bearing mineral spicules. These include the Didemnidae, Pyuridae, Polyclinidae, and part of the Polycitoridae and Styelidae families. These sclerites are contained mainly within the tunic. The spicules of Ascidiacea are preserved quite frequently in the carbonate sediments of recent seas (e.g., the Great Barrier Reef and the Bahamas). However, despite being present since the early Cambrian (Shu et al., 2001; Chen et al., 2003), there is relatively scarce fossil record of ascidians. Moreover, the fossil spicules of Ascidiacea have rarely been described (Brookfield, 1988). The reasons for this are numerous. For example, ascidian spicules are often ignored or misassigned (Deflandre-Rigaud, 1956; Messenger et al., 2005). Alternatively, when fossil spicules are assessed, their biological assignment is less frequent than a pure parataxonomical approach. Unfortunately, the parataxonomical assignment does not associate spicules with the living species that bear them, thus making the findings of fossil ascidians worthless to modern biological sciences (Perch-Nielsen, 1988; Varol and Houghton, 1996; Varol, 2006; Cachão and Conceição Freitas, 2006; Jerković and Ćorić, 2006; Sagular, 2009).

The fossil record of disassociated ascidian spicules dates back to the Mesozoic. They were described from the Arabian Peninsula (Varol, 2006) and Mexico (Bonet and Benveniste-Velasquez, 1971; Buge and Monniot, 1972). There are also records of Cenozoic spicules of Ascidiacea from Australia (Wei, 1993; Łukowiak, 2012) and France (Durand, 1948, 1955; Deflandre and Deflandre-Riguard, 1956; Deflandre-Rigaud, 1968; Monniot and Buge, 1971). The fossil sclerites of these tunicates are also known from the middle Miocene deposits of Hungary (Bona and Gal, 1985), Turkey (Ćorić et al., 2012), Croatia (Galović, 2014), the Celtic Sea, the Mediterranean, the Coral Sea, Great Britain, the Atlantic, the NW Pacific, and Germany (Varol and Houghton, 1996).

The ascidian fossil record from the Moldova area have not been studied so far. Likewise, from the area of the Moldavian

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Platform (Romania), fossil ascidian spicules have already been mentioned only by Brânzilă and Chira (2005). The authors briefly described spicules of these tunicates, as well as thoracospheres (*Dinophyceae*) and calcareous nannofossils from the middle Miocene of Romania, but without any attempt to biologically assign the studied spicules. Also, Chira and Malacu (2008) noted the presence of ascidians in the Miocene sediments of Romania. Yet, in this case, the spicules were assigned to the parataxon *Micrascidites vulgaris*.

Spicules play an important role in ascidian taxonomy, but recent Ascidiacea are classified based mainly on soft body elements (Kott, 2001), whereas spicules are often the only hard elements of the ascidian body that are preserved in the fossil record. Despite the substantial intraspecific variation in the size and shape of spicules (Hirose et al., 2010), sometimes they can be diagnostic for a particular taxon. In that case, they can be used for taxonomic assignment (Monniot et al., 1991; Kott, 2001, 2004a, 2004b). However, it is then necessary to consider limitations of taxonomic information provided by spicules.

In this work, the studied spicules are compared to those of Recent species as well as the available record of fossil sclerites. First, the ascidians from the adjacent Mediterranean Sea are taken under consideration, being their geographically nearest recent relatives. However, a comparison with more geographically distant representatives of Ascidiacea is also provided when none of the Mediterranean species display comparable spicules, or when the morphological resemblance with geographically distant relatives is greater than with Mediterranean species (see Section 5).

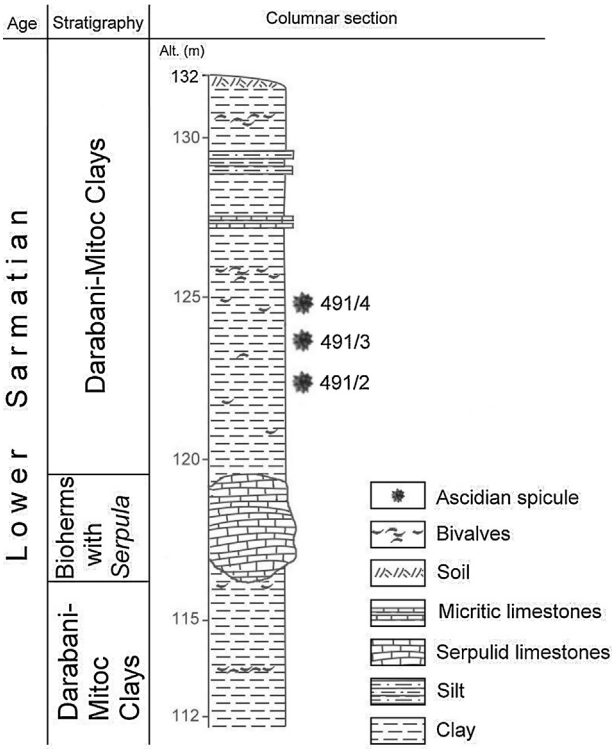

Fig. 2. Litostratigraphic column of the Costeşti area, with location of the samples in which the ascidians spicules were found.

2. Geological setting

During the Miocene, the studied area was part of the Eastern Paratethys, a large shallow sea that stretched from the region north of the Alps to Central Asia (Fig. 1). This part of the Eastern Paratethys was infilled with fine clastic sediments (Rögl and Steininger, 1984; Pisera, 1996). The samples containing the ascidian spicules were collected from the "Darabani-Mitoc Clays" at an altitude between 122 and 125 m a.s.l., approximately three to five meters above the "Bioherms with *Serpula*" (Fig. 2). The ash-grey clays are compacted or laminated. Moreover, some fine intercalation of sand can be observed. In these deposits, we found numerous fragments of bivalves, including *Inaequicostata inopinata* (Grischevich), associated with foraminifers, otoliths, statoliths of *Mysidae*, and dinoflagellate piritized cysts. The early Sarmatian age of these sediments was postulated by Simionescu (1902) and supported by more recent studies (Paghida-Trelea, 1969; Ionesi and Ionesi, 1981, 1982; Brânzilă, 1999).

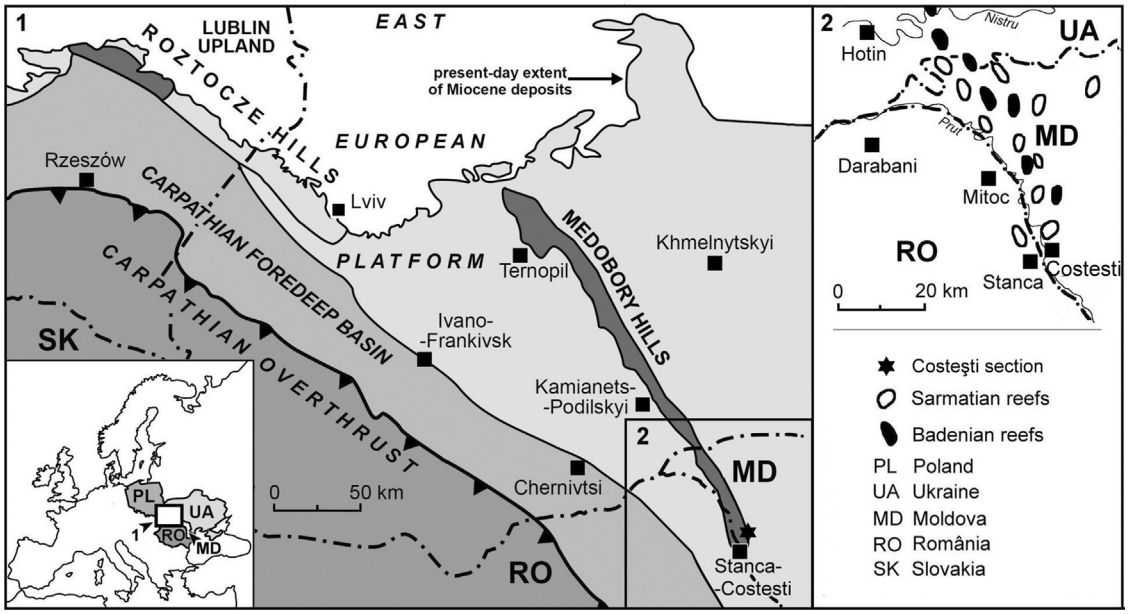

Fig. 1. 1. Map of the Middle Miocene deposits in the Carpathian Foredeep Basin showing the distribution of reef deposits (modified from Peryt and Jasionowski, 2012). **2**. Distribution of the Badenian and Sarmatian reefs from the left and right sides of the Prut River, respectively (after Bliuc and Malai, 2012).