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A Givetian tintinnid-like palynomorph from Libya

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ABSTRACT

Bulk maceration of Givetian palynological samples from the A1-69 borehole drilled in the Ghadamis Basin, western Libya, yielded intriguing, very large, acid-resistant palynomorphs that are described here. The palynomorphs come from a horizon containing also abundant large megaspores and the enigmatic 'mega-acritarchs' *Vanguestainidium cucurbitulum* Steemans et al. 2009. The former are vase shaped; they include an open mesh structure; their size is about 1,500 μm in length. Their shape and general appearance are tentatively compared with those of tintinnids, extant ciliate protozoans characterised by an organic lorica. There is a paucity of literature describing and detailing fossilised tintinnids. They will nonetheless be, the oldest organic lorica which may be related to tintinnids that have been extracted from several Jurassic and Cretaceous pelagic limestone.

1. Introduction

Tintinnids are ciliate protozoans, an important component of the extant zooplankton (Dolan et al., 2013). They are characterised by a vase-shaped organic covering (lorica) and are acid-resistant like other palynomorphs (e.g. acritarchs, chitinozoans or miospores). The lorica may be covered by attached mineral remains of other microorganisms such as foraminifera, diatoms, coccoliths, etc. Tintinnids constitute an important link in the oceanic food chain: they are primary consumers feeding on phytoplankton and in turn are used as food by larger zooplankton, mainly copepods, and fishes. They may be neritic or pelagic plankton living in the upper part of the ocean. Additionally, several neritic species live in brackish environments and rare extant species are present in fresh water lakes. Tintinnids are known from all latitudes.

Modern lorica may have various shapes: cup, vase, bottle, tube, horn, etc. They are generally longitudinally symmetrical. The base of the lorica is closed and its top open, allowing the protozoan to excyst. The oral diameter is related to the food items ingested. The size of the prey ranges from 25% to 50% of the oral diameter (Tappan, 1993). Extant tintinnids range in length from 10 μm to about 1000 μm. Most of them range from 100 to 300 μm. Pre-Mesozoic tintinnid-like fossils are smaller than 300 μm in length, and with a lorica on which fragments of mineralised microfossils are agglutinated (Tappan, 1993). The lorica surface may be smooth or ornamented by perforations, honeycomb-like shapes, ribs, fluting, shelves, etc. For sexual reproduction, two (or rarely more) specimens fuse together. Fossilised paired loricae have also been observed in Upper Jurassic sediments of Greece (Bosak et al., 2011a). Spherical cysts have been observed within the lorica of few extant species (e.g. Tappan 193, p. 297). The cyst is closed by an operculum. The cysts are thin-walled or hyaline and acid-resistant. They may be smooth-walled or ornamented or within an outer very thin membrane. Their role in the tintinnid life cycle is not well understood. Cysts may be developed in response to stress conditions (reduced salinity and high temperatures). To our knowledge, there is only one occurrence of a vase-shaped microfossil containing a spheroidal structure inside the test, which has been reported from the Neoproterozoic Visingsö Group, Sweden (Mus and Moczydlowska, 2000).

Here we report very well preserved palynomorphs suggestive of organic lorica of putative tintinnids observed in the organic residues of Givetian sediments from Libya. While selecting megaspores under a dissecting microscope, two kinds of enigmatic large palynomorphs have been observed. The first one has been identified as a very large acritarch: *Vanguestainidium cucurbitulum* (Steemans et al., 2009). The second kind, a vase-shaped palynomorph, is described here. The sample is very rich in trilete spores; acritarchs are common and chitinozoans are rare.

2. Material and methods

Samples have been collected from cores of the A1-69 borehole drilled in 1959 through the Ghadamis Basin and provided during the

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eighties to the palynological laboratory of the Liège University thanks to the courtesy of D. Massa. The geological background has been summarised recently in Breuer (2007); Breuer and Steemans (2013 and herein). The Ghadamis Basin is a large intra-cratonic basin covering portions of Algeria, Tunisia and Libya, and extending over 350,000 km^2. The basin contains up to 6000 m of Palaeozoic and Mesozoic sediments. It is bounded to the north by the Dahar-Nafussah High, to the south by the Qarqaf Uplift (Libya) and the Hoggar Shield; and its western limit is represented by the Amguid-El Biod Arch. The eastern margin is not well-defined, being overlapped by the western flank of the younger Sirt Basin. The Illizi Basin in Algeria is often considered as the southwestern part of the Ghadamis Basin (Echikh, 1998). The Caledonian tectonic activity caused the uplifting and erosion of the southwestern and southern flank of the Ghadamis Basin, where the Lower Devonian (Tadrart Formation) overlies unconformably the Upper Silurian. Two additional unconformities are observed higher in the Devonian from the Ghadamis Basin, particularly over the southern flank representing late Caledonian tectonic phases. These unconformities are observed at the top of the Emsian (Abdesselam-Rouighi, 1991; Echikh, 1992) and at the base of the Frasnian radioactive carbonate shale layer. In addition, biostratigraphic hiatuses occur in the Givetian and Frasnian (Echikh, 1992, 1998).

The borehole is drilled across, from base to top, the Ouan-Kasa, Awaynat Wanin I, Awaynat Wanin II and Awaynat Wanin III formations. In the Ghadamis Basin, these lithological units have been recently redescribed by Rahuma et al. (2007) from outcrops of the Awaynat Wanin area (southern flank). Northwestward, along a dip section, correlation shows an overall thinning of the sandstone units and thickening and deepening of the shaly units. Nevertheless, these formations have been described by Massa (1988) from subsurface data. Previous palynological results on this borehole have been published (Breuer, 2007; Breuer & Loboziak et al., 1992; Loboziak and Streel, 1989; Steemans et al., 2009; Streel et al., 1990). The level containing miospores, megaspores (Steemans et al., 2011), enigmatic palynomorphs, *V. cucurbitulum* (Steemans et al., 2009) and the tintinnid-like form reported here is situated at 1293 ft of depth, from the Awaynat Wanin II Formation. This Formation is described in Breuer (2007): "On the southern flank of the Ghadamis Basin, this unit is mixed with clay and well isolated sand strata which progressively decrease in thickness and gradually disappear laterally. On the northern flank, the clayey facies predominates with rare and thin marl-limestone strata. Black shale facies occurs sporadically. For the first time during the Devonian in North Africa, a large eustatic transgression developed with the deposit of the Awaynat Wanin II Formation. Sediments were deposited in deltaic to nearshore facies on the south whereas they were more distal on the north with open marine facies. According to pelagic organisms, bathymetry should vary, from north to south, from 10 to 20 m to 100 to 200 m". The sample coming from the 1293 ft. level is Givetian in age as demonstrated by miospore analysis (Loboziak and Streel, 1989; Streel et al., 1990; Loboziak et al., 1992; Breuer, 2007; Breuer and Steemans, 2013) and macrofauna (Massa, 1988).

In order to prevent the destruction of the large palynomorphs, samples have been prepared following a specific laboratory treatment, "less aggressive" than the usual technique used for miospores. The technical process of the sample has been described by Steemans et al. (2009). The specimens described here are exceptionally well preserved.

3. Tintinnid-like palynomorph description

Because of the lack of information, one should consider that the palynomorphs described here belong to the polyphyletic acritarch group. Acritarchs are exclusively composed of *incertae sedis* palynomorphs. However, it is not really the case here. The studied palynomorphs are supposed to have affinities with tintinnids; therefore they are not *incertae sedis* and not acritarchs.

Ciliate Protozoan Class *Spirotrichea* Subclass Bütschli, 1989 *Tintinnidia*? Kofoid and Campbell, 1929 *Nassacysta* gen. nov. Type: *Nassacysta reticulata* gen. and sp. nov.

Derivation name: compounded name from the Latin word "*nassa*" meaning bow-net, referring to the general aspect of the palynomorphs, and from the English word "cyst", meaning "small capsule-like sac enclosing an organism in a dormant stage".

Diagnosis: organic-walled palynomorph ranging from 564 μm to 1617 μm in length, composed by two main structures: an outer sheath looking like a fish trap open at its narrowest tip; and an inner rounded body enclosed in a thin membrane.

Nassacysta reticulata sp. nov. Plate 1, 1–11 Derivation name: from the Latin "*reticulata*", meaning reticulated, referring to the general structure of the palynomorph.

Holotype and type locality: Plate 1, 1 from 1,293 ft. in the A1-69 borehole, Ghadamis Basin. Slide Number 63065 in the collections of the PPP Laboratory, Liège, Belgium. Specimen A. Paratype: Plate 1, 6 from 1293 ft. in the A1-69 borehole, Ghadamis Basin. Slide Number 63072 in the collections of the PPP Laboratory, Liège, Belgium. Specimen D.Diagnosis: Outer sheath is more than 1000 μm long and 500 μm wide at its largest extremity. Opposite extremity open and 270 μm in width. Mesh of the outer sheath polygonal, with a diameter size ranging from 50 to 90 μm; "threads" of the mesh about 10 μm wide. Short "sticks" visible on the "threads". Central body 343 μm in diameter, enclosed in a thin indistinct membrane.

Description: 14 specimens have been discovered. The palynomorphs are composed of three distinct parts:

(1) A spherical inner body (Plate 1, 1A).
(2) This central body is covered by a membrane looking like a network of interweaved fibres (Plate 1, 1C, 7A). Under light microscope, the aspect is like a spiderweb, or like a silk ball. (Plate 1,1B). The central body and the membrane are brown to dark brown in colour, spherical or ovoid, with a diameter size ranging from 260 to 450 μm.
(3) The central body and its outer fibrous membrane are both enclosed in a reticulate sheath (lorica) with a vase/bottle shape and looks looking like a net closed at its largest part (Plate 1, 2A) and open at its narrowest extremity (Plate 1, 1B, 6B).

The general aspect is that of a "fish trap" enclosing a spherical central body (1 and 2 here above described. The meshes of the "traps" are polygonal to subcircular at the largest extremity and strongly elongated close to the opening. The mesh diameter size ranges from around 40 μm to 60 μm at the base and from around 16 × 90 μm to 20 × 160 μm at the top. The "threads" of the mesh are around 10 μm in width. Some specimens have projections (Plate 1, 4A) on the "threads" of the mesh, 20 to 50 μm long and 10 μm large at their base. The "sticks" are enlarged at their extremity and flat. A very thin membrane, 5 to 20 μm thick, runs all along the "threads" on the centre part of their surface (Plate 1, 8A, 9A) and, more rarely visible, along their internal edge (Plate 1, 10A). At some places, the meshes are completely closed by the thin membrane (Plate 1, 10B). This suggests that the mesh structure (lorica) was closed by a membrane which has been destroyed during taphonomic processes. When spines are present, they subtend the membrane. In one case, two palynomorphs are attached to one another, one above the other (Plate 1, 3).

Dimensions: Length: 564-(940)-1617 μm (the lowest dimensions are underestimated as several specimens are broken). Base width: 401-(500)-603 μm. Top width: 186-(260)-341 μm.

4. Discussion

4.1. Fourier transformed infrared (FTIR) micro-spectroscopy

In order to try to chemically establish the biological affinity of the enigmatic specimens studied here, we undertook FTIR microspectroscopic