NOTES

A kind of coccoid dinoflagellates-like fossils gives a new explanation of source of dinosterane in the Early-Middle Cambrian

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Abstract **The coccoid fossils covered with thick gelatinous envelop containing several gametes are discovered in gyps and salt deposits of Cambrian, H_4 well and chert bed of the base of Yuertus Formation ($\in_1^1$) of Xiaoerbulake Section. The fossils are described and compared with coccoid dinoflagellates. These fossils may be a coccoid life-cycle stage (vegetative cyst) of coccoid dinoflagellates. If this identification is correct, the coccoid dinoflagellates-like fossils could give a reasonable explanation of the dinoflagellate-specific biomarkers from Cambrian, H_4 well, Tarim Basin.**

Keywords: **coccoid dinoflagellates-like fossils, dinoflagellate-specific biomarkers, Cambrian, Tarim Basin.**

Studying and discussing of the dinoflagellates which could be traced back to pre-Triassic or Paleozoic even to Proterozoic are stimulated by the presence of Precambrian to Devonian triaromatic dinosteroids which gives chemostratigraphic evidence of dinoflagellate occurrence. Many primitive features of the dinoflagellates suggest that they must have had a long geological history. The lack of fossil record in Pre-Paleozoic to Early Paleozoic could be explained as: they may be present but unrecognized or they did not develop the extremely resistant cysts that are preservable[1]. The Paleozoic parts of triaromatic dinosteroid abundance curves conform to that of acritarch species abundance curves. This implies that some acritarchs may be the ancestors of dinoflagellates[2]. But the morphological evidence has not been sufficient to establish links between acritarchs and dinoflagellates[2]. Furthermore, the data from the Lükati Formation and the Buen Formation indicate that although *Skiagia, Comasphaeridium, Globosphaeridium, Lophosphaeridium* could be responsible for the dinosterane and 4α-methy-24-ethylcholestane liberated from its kerogen, the whole-rock extract represents nonpreserved biota and contains higher relative abundance of dinosterane and 4α-methy-24-ethylcholestane than the fossils pyrolysates. This implies that an important component, which had not been preserved in the rocks, had a dinoflagellate affinity[3].

The fossils discovered from gyps-salt deposits of Cambrian of H_4 well and chert of the Yultus Formation ($\in_1^1$) of Xiaoerbulake Section of the Tarim Basin may be the ancestors of dinoflagellates. The reason will be given as follows.

1 Systematic description

Fossils embedded in salt crystals are found in perfection from debris-samples of 5778 m, H_4 well. These fossils are also found in 5780, 5700, 5359.40, 5325, 5348.13, 5300 m and 5079.9 m core-samples of H_4 well.

Kerogan concentration and fossil extracts are performed using advanced polynological techniques (HCl-HF and heavy liquid proceeding). The operating rules are strictly performed. Pollution, over-reaction and oxidizing agent are avoided as much as possible. In order to find pollutants in thin sections, all of kerogen thin sections are examined under a fluorescent microscope. Because autofluorescent of fossils is almost lost ($R_0 \geqslant 1.4\%$) and autofluorescent of pollutants (living organisms) is bright yellow or green, fossils and pollutants can be easily recognized. The fossils discovered from petrographic sections of chert demonstrate that these fossils are original and local.

Each of amber colored coccoid fossils covered with thick gelatinous envelopes contains one, two or several spindle gametes. These fossils are different from acritarchs in morphology.

Living coccoid dinoflagellates are a small group of dinoflagellates. The coccoid dinoflagellate is a popular name including only these genus such as *Desmocapsa, Desmomastix, Adinimonas, Pleuromonas, cystodininedria, Cystodinium, Dinamoeba, Dinastridium, Hemidinium, Hypnodinium, manchudinium, Rhizodinium, Spiniferodinium, stylodinium, Tetradinium* and so on. Some of them have a principal life-cycle phase constituted by coccoid vegetative cells, such as *Hemidinium* and *Desmocapsa*[4]. The *Hemidinium* has a coccoid vegetative life-cycle stage, which is called *Gloeodinium* klebs, 1912 (the taxonomic junior synonym of *Hemidinium*). Our fossils are very similar to *Gloeodinium* in morphology. *Gloeodinium* is a coccoid cyst with thick gelatinous envelope containing several gametes. The *Hemidinium* is placed within Subclass Uncertain, Order Phytodiniales, and Family Phytodiniaceae[4]. The fossils discovered from 5778 m, H_4 well might be the ancient representative of *Hemidinium.*

Paleogloeodinium gen.nov.
(genus type: *Paleogloeodinium tarim*)

Character: Spheroid cell, with amber colored thick gelatinous envelop, one, two or more spindle brown cells embedded in the spheroid cell. These spindle cells are explained as gametes.

Discussion: Although some kinds of microalgae such as Chroococcales, Chrysomonadineae, Chrysocapsales, Tetrasporales have gelatinous envelopes, they are different from *Paleogloeodinium* in many aspects. The *Paleogloeodinium* is considered to be a coccoid dinoflagellate-like fossil not only based on the similarity with *Gloeodinium*, but also on the characteristics of biomarks of Lower-Middle Cambrian of H_4 well.

Dinosterane and 4α-methyl-24-ethylcholestane are indicative for dinoflagellates[2, 3].

The high relative abundance of dinosterane and 4α-methyl-24-ethylcholestane and their corresponding aromatic compounds, especially triaromatic dinosterane have been identified in almost Cambrian and Upper Sinian analyzed samples of the Tarim Basin, including the samples from Cambrian of H_4 well (fig. 1). This implies that dinoflagellate and its relatives could exist during Cambrian and Sinian.

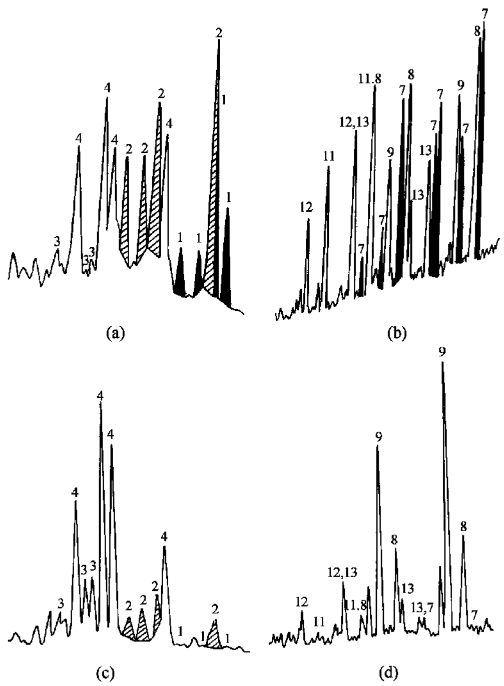

Fig. 1. MRMGCMS analysis of four series of methyl sterane (*m/z* 414—231; (a), (c) and GCMS analysis of triaromatic methy steroids (*m/z* 245, (b) and (d) in the extracts of Upper Ordovician of TZ6 well and Cambrian of H4 well in the Tarim Basin, showing that the Cambrian extract has predominant amounts of 4α,23,24-trimethyl cholestanes (C_{30} dinosteranes) and triaromatic dinosteroids. (a) and (b) were collected from 5079.9 m, $\in_2$, H4 well, Toc=0.48%, marlaceous dolomite. (c) and (d) were collected from 3886.1 m, O_3, TZ6 well, Toc=1.20%, argillite. 1, 4α,23,24-trimethylcholestane; 2, 4α-methyl-24-ethylcholestane; 3, 3α-methyl-24-ethylcholestane; 4, 2α-methyl-24-ethylcholestane; 7, 4,23,24-trimethyl triarometic cholesteroid; 8, 4-methyl-24-ethyl triaromatic cholesteroid; 9, 3-methyl-24-ethyl triaromatic cholesteroid; 10, 2-methyl-24-ethyl triaromatic cholesteroid; 11, 4-methyl triaromatic cholesteroid (C_{27}); 12, 3-methyl triaromatic choiesteroid (C_{27}); 13, 4, 24-dimethyl triaromatic cholesteroid (C_{28}).

Macerals of Lower-Middle Cambrian of H_4 well consist of abundant *Paleoglenodinium,* segments derived from benthic macroalgae, *Dunaliella, Porcatitubulus spiralis,* segments of animals and a few specimens of Sphaeromorphitae. Except *Paleogloeodinium*, other components cannot be the precursors of dinosterane and 4α-methyl-24-ethylcholestane.

If we want to demonstrate and confirm that the *Paleogloeodinium* is the precursor of the biomarks above mentioned, we will confront with a lot of work, such as culture and lipid extraction and analysis of living coccoid dinoflagellates and fossils pyrolysis.

In spite of some uncertain factors, some facts suppose that the *Paleogloeodinium* is similar to coccoid dinoflagellates. The kerogen thin section of 5778 m, H_4 well provides several specimens of *Paleogloeodinium* to show different development periods of cyst which can be compared with that of *Stylodinium globosum.* At the beginning of cyst development, there is not any gamete and then one gamete appeared. With gamete growing and dividing, then there are two gametes in the cyst. This process performed repetitiously and the cyst is filled by many gametes at last. During the cyst is getting mature, the thick getatinous envelop become a dense wall (fig. 2).

Paleogloeodinium tarim sp.nov,

(Plate Ⅰ-1—6)

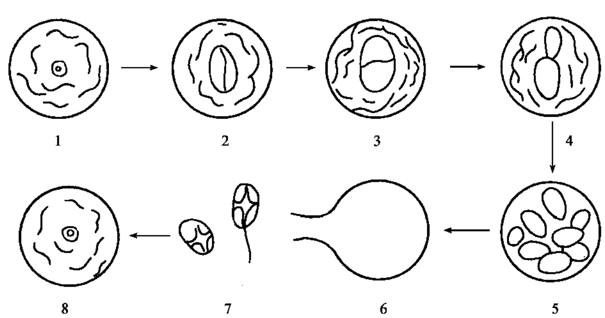

Fig. 2. Supposed life-cycle of *Paleogloeodinium tarim* from Kerogen section No. 2319. Stages 1—5 are respectively corresponding to fossils discovered from section No. 2319. Stages 6—8 are presumptive.

Diagnosis: Coccoid vegetative getatinous cyst, 50—120 μm in diameter. Spindle gamete 39.3 μm in length and 32 μm in width. A dense wall envelops mature cyst.

Holotype: Plate I -3.

Material: Kerogen thin section No. 2319 from 5778 m of H4 well, a debris sample, salt crystal.

Horizon and locality: Lower to Middle Cambrian, Tarim Basin.

2 Conclusion

In this note we describe the coccoid fossils discovered in the sample of 5778 m, H4 well and compare the life-cycle stages of these fossils with that of living Phytodiniales. Because the high relative abundances of dinosterane and 4α-methyl-24-ethylcholestane and their corresponding aromatic compounds, especially triaromatic dinosterane have been identified in Early-Middle Cambrian of H4 well, we consider that these coccoid fossils may be the ancient relative of phytodiniales, and the main source of particular biomarks.

If this identification is correct, the coccoid dinofiagellates-like fossils will provide another approach to explain why the high relative abundance of dinosterane occurs in Upper Sinian and Cambrian.

Living coccoid dinoflagellates are a small group of dinoflagellates and the knowledge of living coccoid dinoflagellates is limited. The fossil record of coccoid dinoflagellates has been lack before. The molecular organic-geochemical research (micro algal cultures and lipid extraction and analysis) of living coccoid dinoflagellates has not performed yet. So to place these coccoid fossils with dinoflagellates is not conclusive. Otherwise, these fossils are looked upon as a kind of coccoid dinoflagellates and that is a reasonable choice based on morphological feature and molecular biomarkers. We believe that paleontology combined with molecular organic-geochemistry will play an important role in completely reconstructing life history.

Salt deposits are widespread in Paleozoic-Cenozoic sedimental rocks. The algal community preserved in gyps and salt deposits including coccoid dinoflagelltes, *Dunaliella*, some kinds of benthic macro-algae, has been neglected for a long time. It is possible to get more abundant fossils and much more information about them from gyps-salt deposits in future. And our opinion will get examined as well.

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