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Application Research on Meso-Neoproterozoic Stromatolites

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Abstract

The study of the relationship between stromatolites and paleo-environmental evolution is of great significance for the in-depth understanding of paleo-environment and global major events. The Meso-Neoproterozoic was a period of relatively stable global environment and stromatolite development.Meso-Neoproterozoic stromatolites are abundant and diverse in type. These stromatolites record changes in the Earth's environment during the early Meso-Neoproterozoic., it provides an important carrier for us to reveal the paleontological evolution and global major events in the Meso-Neoproterozoic. Through analyzing the Meso-Neoproterozoic stromatolites, the characteristics of stromatolites are described in detail and the sedimentary environment is analyzed. Morphologically, stromatolites are flourishing, mainly columnar stromatolites, cone-shaped stromatolites, stratiform stromatolites and dome-shaped stromatolites. It can also be divided into the following types according to origin: skeleton stromatolites, agglutinated stromatolites, fine grained stromatolites, and terrestrial stromatolites. The formation of stromatolites is affected by hydrodynamic, water salinity and light conditions. According to the combination, shape and size of stromatolites fossils, the characteristics of the early paleo-environment can be reflected. The formation of stromatolites is affected by hydrodynamic, water salinity and light conditions. According to the combination, shape and size of stromatolite fossils, the characteristics of the early paleo-environment can be reflected.

Keywords

Classification of Stromatolites; Origin of Stromatolites; Stromatolites.

1. Introduction

After the formation of the Earth, with the melting, aggregation, upward migration of material deep underground, under its own gravity, the Earth captured the volatile components produced by volcanic eruptions, which filled the crater on the Earth's surface, and then gradually formed the first primitive oceans. Around 4.0 Ga, the continent gradually stabilized, and the crust growth rate significantly slowed down, mainly in the form of shallow sea distribution, the shallow sea environment is suitable for algae, which allows cyanobacteria microbial communities to flourish[1]. Cyanobacteria are the earliest forms of life on Earth, which absorb sunlight and photosynthesize, creating an atmosphere containing oxygen and creating conditions for life to develop on Earth[2].

Many key events occurred in the Meso-Neoproterozoic period, which is an important period in the evolution history of the earth. Among them, stromatolites are widely developed and closely related to global events. Stromatolites have important scientific value, they can record the earth's past climate, environment and early life evolution and other important information. Through the study of stromatolites, we can understand the paleontological evolution process of this period and the occurrence mechanism of global major events. Therefore, the in-depth study of stromatolites and their

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relationship with paleo-environmental evolution is of great significance to our understanding of Neoproterozoic geological history, the paleontological evolution and the occurrence mechanism of global geological events. This research can not only promote progress in the field of earth science, but also provide a valuable scientific basis for human understanding and protection of the earth.

In this paper, the Meso-Neoproterozoic stromatolites are mainly studied. By analyzing and summarizing the form types, origin, and application of stromatolites, the formation process, sedimentary environment and control factors are studied in detail, so as to divide the form types of stromatolites.

2. The Origin of the Definition of "Stromatolite"

Stromatolites are considered to be the oldest fossils on the earth. In the two hundred years since the discovery of stromatolites, predecessors have conducted continuous exploration and defined stromatolites for many times, but no unified opinion has been formed in the end. In 1974, Awramik et al.[3,4] held that "stromatolites are biosedimentary structures formed by microorganisms dominated by cyanobacteria, which adhere to and precipitate minerals or capture mineral particles during the process of growth and metabolic activities". This has been acknowledged by many geologists, but the focus of this definition is only biased towards the explanation of its origin.

The earliest stromatolites appeared 3.5 billion years ago and are considered to be the oldest fossils on Earth[5-7]and an important basis for exploring the origin and evolution of life on Earth.In the 1980s, Burne and Moore came up with a new term, microbial stone[8]. It was later replaced by Riding's term "microvitrite", which was used to study stromatolites, litholiths, dendroplites, and thrombus[9]. Kalkowsky first defined the term "stromatolites" in 1908, and emphasized that those with a certain geometric shape and a cross-section showing typical lamellar structure should be of microbial origin. Over the following decades, the definition of stromatolites has been supplemented and revised, for example, Aitken introduced the concept of "lumps" to describe biological sedimentary formations that are not internally stratified, have distinct clots, or are internally porous[9]. In his discussion of its origin, Ginsburg proposed that stromatolites are a stratified biological sedimentary structures. In 2004, Reiji Cao summarized that stromatolites are biological sedimentary structures composed of cyanobacteria microorganisms interacting with inorganic sediments in a specific environment [8].

3. Genetic Types of Stromatolites

Because the purpose of studying stromatolites is different, the basis for the division of stromatolites is also different.Generally, stromatolites in the form of columns, cones and mounds can be seen, and this classification is mainly divided according to the morphology of the layers, which is also the most common classification.

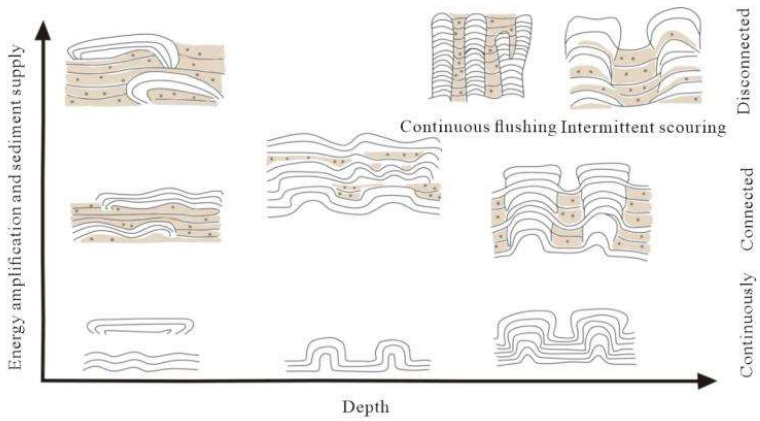

Figure 1. Different forms of stromatolites[10]

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(1) Conical stromatolites

Figure 2-a is an isolated single cylinder or a cone stromatolite with extended base, which can also be called a cone stromatolite because of its pointed laminae.Figure 2-b shows the smaller cone-columnar stromatolites, some of which exhibit interstratification and are usually free of clastic material, which can be interpreted as weak hydrodynamics and a quiet water environment. Figure 2-c shows clearly layered cone-shaped stromatolites, indicating that the hydrodynamics was weak at that time. Figure 2-d shows that the cross section is oval.

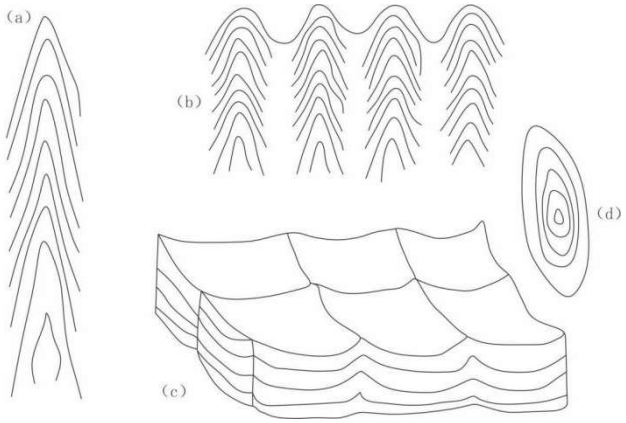

Figure 2. Conical stromatolites

(2) Columnar stromatolites

Figure 3-a shows columnar stromatolites with parallel branches and multiple branches. Figure 3-b divergent bifurcated columnar stromatolites. The density of the columns is related to the grain size of the sediments. The denser the columns, the finer the grain size of the intersubject sediments. Figure 3-c shows isolated single-columnar stromatolites with parallel laminae and upward columns becoming younger or wider. Figure 1-3-d shows columnar stromatolites that are occasionally connected laterally, but are mostly wall shaped.

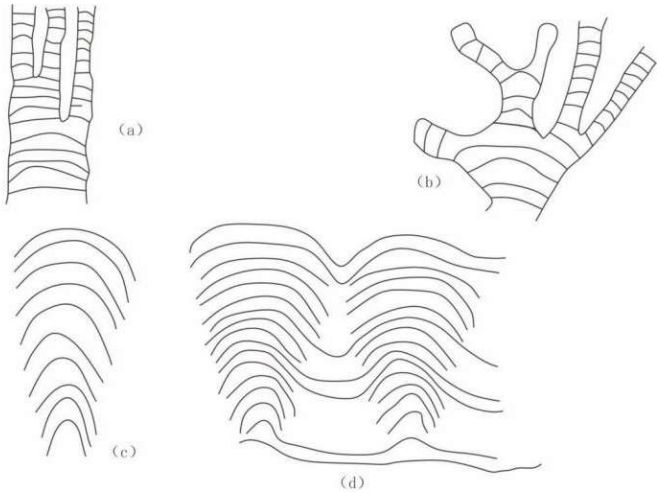

Figure 3. Columnar stromatolites

(3) Layered stromatolites

Figure 4-a shows a flat lamellar microbial mat, and the increase in the roughness of the lamellar surface is related to the increase in the grain size range of the sediments in the lamellar surface.This suggests that an increase in surface roughness means an increase in energy. From Figure 4-a to Figure

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4-c, it can be seen that laminar curvature is gradually dense, indicating that the hydrodynamic force is gradually enhanced from Figure 4-a to Figure 4-c.

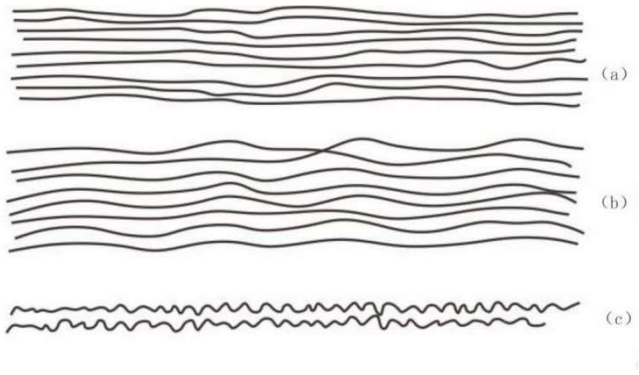

Figure 4. Layered stromatolites

(4) Dome stromatolites

For laterally connected pseudocolumnar stromatolites, the increase of surface roughness is related to the increase of sediment particle range and the increase of water flow and wave energy. From Figure 5-a to Figure 5-c, the hydrodynamic energy increases gradually, and its extension direction is consistent with the direction of water flow.

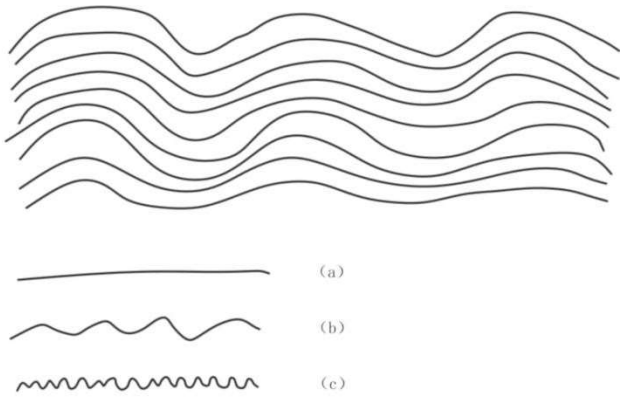

Figure 5. Dome stromatolites

It can also be divided according to the causes as follows:

(1) Skeleton stromatolite

Skeleton stromatolites are formed by the mineralization of microorganisms or biological tissues. According to previous studies, skeleton stromatolites play an important role in the formation process of some low bacteria and algae organisms through their own calcification, and these calcified fossil characteristics can be preserved in the stromatolites. Therefore, it is named "skeleton stromatolite", and this naming can clarify the origin of this stromatolite. In Paleozoic and Mesozoic Marine environments, stromatolites once existed widely, while in modern river environment, stromatolites are the main existing environment, but the number has been reduced.

(2) Agglutinated stromatolites

Agglutinated stromatolites, by their name, are formed mainly by trapping and binding detrital material, and are considered to be one of the most intensively studied types. During the formation of agglutinated stromatolites, due to the variety of sediment particles captured and bonded by agglutinated stromatolites, clastic particles ranging from micrite grade to gravel grade can appear in

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the stromatolites. For example, the stratification of agglutinated stromatolites formed by coarse-grained sediments is coarse and irregular, but such coarse gravel stromatolites are rare in the Paleozoic and Precambrian periods.

(3) Fine-grained stromatolites

Fine-grained stromatolites are controversial because it is unclear whether they are agglutinative or precipitative [11].The presence of microorganisms and their role in the formation of fine-grained stromatolites are currently the focus of research.The study of modern stromatolites shows that some stratified stromatolites in the intertidal zone belong to fine grained stromatolites.

(4) Terrestrial stromatolites

The microbial calcareous layer developed on the land surface was once called lichen, terrestrial stromatolites, etc. It was believed that microorganisms played an important role in the development of these calcareous sediments. Therefore, some calcareous sediments on land are often considered to be carbonate rocks influenced by microorganisms, and the lamellar characteristics of these carbonate rocks are terrestrial stromatolites[12].

4. Application of Stromatolites

According to the combination, shape and size of stromatolite fossils, it can reflect the characteristics of the early paleomarine environment. Through the investigation of the structural characteristics of stromatolite species and the sedimentary characteristics of related strata, and the application of relevant theoretical knowledge, it is of great significance for the study of paleogeography and paleoclimate[13-15].

(1) hydrodynamic condition

Because the growth of stromatolites has high requirements on water depth and water environment, and the morphological characteristics of stromatolites have a great relationship with the water flow environment in the formation process. After studying and consulting the data, it is found that stromatolites can bifurcate, and the strength of the hydrodynamic force can be the cause. When the kinetic energy of the water increases, more detrital material will be deposited, and the nature of the microbial community that forms stromatolites will also change, and the bifurcation phenomenon of stromatolites can be caused by this change. The bifurcation characteristics of the columnar stromatolites in the Hejiazhai Formation can be observed. Therefore, stromatolites that bifurcated mostly grew in high-energy environments, such as waves and turbulence [12], while stromatolites formed in stable water bodies generally did not bifurcate.

(2) Water salinity

The influence of water salinity on stromatolites is mainly manifested in certain morphological variations. For example, in a coastal environment with normal salinity, there is sufficient sunlight and many biological species, especially algae flourishing[16,17]. Therefore, the form of stromatolites changes greatly, the evolution rate is fast, and the individual stromatolites formed are large. In the water environment with abnormal salinity, such as semi-deep sea, deep sea and desalinated seawater, the types of microorganisms are mainly wide-lithologic algae. The evolution rate of stromatolites decreases, so the form of stromatolites is smaller and fewer in number.

(3) Lighting conditions

During the growth of stromatolites, the physical and chemical conditions and biological effects of the growth environment have a certain influence on it, so the light condition is a very important factor. Because a part of the stromatolite is composed of algae, and the other part is mainly composed of captured and bonded detrite material, the phototaxis of the stromatolite will make it capture detrite material to grow upward during the day, and the algae tend to grow horizontally at night, thus forming light and dark layers superimposed on each other[18]. Under such periodic lighting conditions, the stromatolite can show obvious laminar structure. In the sedimentary environment, the general tidal flat environment is full of sunlight, so stromatolites mostly grow in the tidal flat environment.

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5. Conclusion

Meso-Neoproterozoic stromatolites were flourishing. Macroscopically, it can be divided into conical stromatolites, columnar stromatolites, layered stromatolites and Dome stromatolites according to its lamellar morphology. Because the growth environment of stromatolites is affected by many factors, the same type of stromatolites will also have differences in morphology, such as columnar stromatolites can appear bifurcated, and columnar stromatolites can be seen in the stratification. It can also be divided into the following types according to origin: skeleton stromatolites, agglutinated stromatolites, fine grained stromatolites, and terrestrial stromatolites. The formation of stromatolites is affected by hydrodynamic, water salinity and light conditions. According to the combination, shape and size of stromatolite fossils, the characteristics of early paleomarine environment can be reflected.

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