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Discovery of paleontological site of Chengjiang and new explanation of Cambrian life explosion——Site protection and sustainable development

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ABSTRACT
This paper comprehensively reviews the discovery of Chengjiang fossil site in Yunnan, China and its importance in the study of Cambrian life explosion. The detailed analysis of Chengjiang fossils reveals the diversity and adaptability of early Marine biota, providing valuable evidence for understanding the evolution history of life on Earth. The article also explores the conservation challenges of the site and strategies for its sustainable development, aiming to promote the organic combination of scientific research and tourism development of the paleontological site. In addition, it lists the discovery of Chengjiang fossil site and its research purpose, emphasizes its application potential in biotechnology and sustainable development, and points out the feasibility and challenge of the protection and sustainable development of the site in detail.

KEYWORDS
Chengjiang Fossil site; Cambrian life; Explosion fossil site

1 Introduction

1.1 Research Background

Ediacaran biota (580-560 million years ago) marks the emergence of early life. In the late Proterozoic era, the earth is undergoing the transition to anaerobic atmosphere.

Cyanobacteria became the dominant producer. Leading to a sharp rise in the concentration of organic molecules and oxygen in seawater, resulting in the original consumers and decomposing "short supply" situation. Hence the birth of the first large consumer --Ediacaran organism. Since 1868, archaeologists have discovered a number of unknown fossils of multicellular organisms around the world. Statistically, their biological groups are very little related to modern life, and their structures are too simple. Most macrofossils are morphologically different from later life forms: They resemble leaves, disks, tubes, sacks, and bedding MATS, and there is no clear differentiation of tissues and organs, which means that they cannot survive in the new situation. So after a period of high but brief prosperity, a sharp decline in the oxygen concentration of the earth, the predation of the new animals on the Ediacaran creatures, coupled with the indifference of the Ediacaran animals to continue to live happily, put an end to the great Ediacaran dynasty.

The discovery of the Chengjiang fossils pushes back the origin of modern life to the early Cambrian period (about 540 million years ago). The 4.6 billion year history of the Earth is mainly divided into two stages, the cryptozoic and Phanerozoic. The Cambrian period, about 541 million to 485 million years ago, is the watershed of the two stages. Before the Cambrian period, life on Earth was extremely monotonous. Since then, there has been an explosion of life in what scientists call the Cambrian "explosion of life." The fossils of Cambrian organisms found in Chengjiang fossil Land so far belong to more than 20 categories and more than 300 species. The ancestors of almost all modern animal groups can be found here, which can be said to be the root of the "tree of life evolution".

1.2 Research Status

In The Origin of Species, Darwin described the Cambrian period as a difficulty in explaining evolution by natural selection. He could not explain the lack of fossils in the early Cambrian period. It seemed that animals had suddenly appeared with no obvious ancestors. This conflicted with the slow mutation theory of natural evolution, so the Cambrian explosion of life might have been a really strong case against evolution. Whether complex life really diversified on a large scale in a relatively short period of time in the early Cambrian, what caused such rapid change, and what this means for the origin of animals is still being explored.

As a result, the Cambrian has become a major battleground for theories of species evolution and creationism (which, in addition to mythology, includes alien creation and the creation of the universe).

The discovery of the Chengjiang biota in Yunnan Province, China, fills the gap in the evolution of the Ediacaran and Burgess paleontological groups, and provides important data for the study of the Cambrian life explosion. Over the years, a large number of research results related to Chengjiang biota have been published in important international academic journals such as Nature and Science. The research projects with the theme of "Chengjiang Fauna and Cambrian Explosion" have won the first prize and the second prize of the "State Natural Science Award". In 2012, the Chengjiang Fossil Site was

inscribed on the World Heritage List, becoming the only fossil World Natural Heritage site in Asia. The Chengjiang biota is one of the evidences that challenge Darwin's linear evolution theory, such as the sudden change theory.

1.3 Research Significance

This chapter explores in depth the challenges and implications of the Cambrian explosion on the theory of biological evolution, as well as the importance of paleontological fossil research in modern science. In particular, the Chengjiang fossil site, as one of the best preserved Cambrian Marine biotes, provides key data for biodiversity and ecosystem restoration.

2 The development and investigation process of Chengjiang Fossil site

2.1 Overview of the Site

Geographical location and environmental advantages:

Chengjiang Fossil Site is located in Chengjiang City (25.9301 N, 102.5811 E), Yuxi City, Yunnan Province, People's Republic of China. It covers 512 hectares and belongs to Cambrian Marine sedimentary strata. Its special geographical location and geological structure provided important background and conditions for the preservation of life communities in the early Cambrian period (Yuan et al., 2014).

History and stratigraphy:

The Chengjiang fossil site formation is composed of fine-grained clay rocks, shale and limestone, and these rock types play a key role in the preservation of fossils. The fossils are mainly distributed in the third series of the Cambrian, which records the early evolution of Marine ecosystems (Zhang et al., 2017).

Conservation measures:

The People's Government of Yunnan Province has issued the Provisions on the Protection of Chengjiang Animal and Stone Group in Yunnan Province in accordance with the Regulations of the People's Republic of China on Nature Reserves and other relevant laws. It is clearly stipulated that "the Chengjiang Animal Group belongs to the State, and nounit or individual may destroy or illegally transfer it", and "the Chengjiang Animal Group Provincial Nature Reserve" has been established to implement strict protection and management. The scope of the reserve and the boundaries of the core area, buffer area and experimental areashall be prescribed with the approval of the provincial people's government. The government also declares that "felling, reclamation, quarrying, earth extraction, mining and other activities harmful to protected objects are prohibited in the protected areas." The construction of any production facilities in the core and buffer zones of the protected areas is prohibited. Production facilities that pollute the environment and damage geological sites may not be built in the experimental areas of the protected areas, and other projects shall not be built, and their pollution discharge shall not exceed the pollution discharge standards set by the State and the province." It also stipulates that "without the approval of the provincial department of geology and mineral resources administration or the administrative authority of the protected areas, no unit or individual may collect fossil specimens in the protected areas, nor may they purchase or trade fossil specimens."

2.2 Contents of discovery

Species of plant and animal fossils:

Chengjiang Fossils Site is famous for its rich fossil resources, containing more than 16 phyla and nearly 200 species fossils, including worms, mollusks, sponges and early vertebrates have been found. These fossils not only demonstrate the biological diversity of the early Cambrian period, but also provide valuable data for the study of paleomarine environment and biological evolution (Geyer and Shergold, 2000).

The informative value of strata, soils, and rocks:

Fossils in different rock types have different preservation states, and those in fine-grained clay rocks and shales are relatively complete, providing detailed geological records for the study of ecosystem structure and evolution in the early Cambrian period. In addition, microfossils and interstitial fillings in strata also provide important data for the restoration of biocommunity structure (Gabbott et al., 2004).

2.3 Important implications

Provide paleontological evidence:

The Chengjiang fossil site not only reveals the diversity and adaptability of early Cambrian Marine biota, but also provides key clues to understanding the process of early biological evolution. In addition, the structure and function of

Marine ecosystems at that time can be reconstructed through fossil morphology and stratigraphy analysis (Conway Morris, 1993).

Evidence of origin:

The discovery of Chengjiang fossils Group has a profound impact on the study of the origin of life and early biological evolution. The comparison with Ediacaran biota shows that the diversity and complexity of the early Cambrian biota are far more than previously recognized, and these discoveries promote the understanding process of the origin and evolution of early life (Xiao et al., 1998).

Evidence of rapid evolution:

The rapid evolution of biota during the Cambrian period is an important focus of research. By analyzing the species evolution and morphological changes of Chengjiang fossils, we can reveal the rapid response and adaptability of early organisms in adapting to new environments and competition (Zhu et al., 2016).

3 The value and significance of Cambrian life explosion

3.1 Background Information

Perspectives by doctrine:

The Great Oxidation Event: About 2.6 billion years ago, the content of free oxygen in the atmosphere rose sharply, the reason is unknown, some scientists concluded that due to a large number of algae photosynthesis to produce a lot of oxygen, and the methane bacteria that destroy oxygen rely on nickel is very scarce during this period, resulting in a rapid increase in oxygen on the Earth.

Changes in the Earth's climate: During the Cambrian period, the earth's climate changed significantly, from an ice age to a warm temperate climate. Such climate change provided a good living environment for organisms, thus promoting the mass reproduction and diversification of organisms.

Continental collision: During the Cambrian period, the continents of Eurasia and North America collided. This collision created new ecological environments, and also provided more habitats for organisms, thus promoting the proliferation and diversification of organisms.

Ocean changes: During the Cambrian period, the oceans changed significantly, and the rising water level of the ocean allowed more habitats for Marine life, thus promoting the proliferation and diversification of organisms.

Massive biological evolution: During the Cambrian period, a large number of organisms underwent evolution, and these evolved organisms had greater adaptability, which promoted a large number of biological reproduction and diversification.

3.2 Discussion on research significance and reasons

The incompleteness of fossil record:

Conditions of the organism itself: hardware is required, and mineral hardware is best. Software is not good for preservation. Also, the abundance of individual organisms is important; Burial conditions: the rate of burial and the nature of the buried matter affect the preservation of fossils. Fast burial and fine-grained sediments have/are not conducive to fossil preservation; Time conditions: long time burial is required to allow fossilization to take place; Diagenetic conditions: Fossils that can be preserved well only if compaction is small/large and recrystallization is slight/severe. As a result, fossil preservation and recording are incomplete.

4 Comparison and summary of paleontological sites in the world

4.1 Chart Display

The Chengjiang fossil site is compared with other important paleontological sites of Cambrian and other geological periods in the world, and their characteristics and contributions to the evolution of life on Earth are analyzed (Sepkoski, 2002).

4.2 Characteristics and trends of the evolution of life on Earth

There are three distinct stages of biological evolution, including the Cambrian evolutionary biota stage, the Paleozoic evolutionary biota stage and the modern evolutionary biota stage. The chart shows that there are certain similarities in the process of biological evolution in different geological periods and geographical regions of the world, and differences in geographical environments also lead to differences in fossil types. The Valley of the Whales in Egypt, for example, shows

the dramatic change in the Earth's landscape, from thesea inhabited by whales to the vast desert of today.

Table 1 The value of paleontological fossil sites in China

Heritage Sites	Country	Longitude and latitude	Core area (ha)	Buffer area (ha)	Major categories	Geological periods	Key features
Chengjiang fossil site	China	25.9301.N, 102.5811. E	51200	22000	Early Cambrian Marine biogeochemical group	Cambrian Period	Contains a large number of early Cambrian Marine fossils, such as trilobites, ancient sponges, etc.; Preserved the most complete Cambrian paleontological group; And provided scientific facts for the Cambrian explosion of life Abundant fossils of dinosaurs, mammals and plants have been unearthed, demonstrating the
Jehol Biota	China	41.5736. N, 117.2090. E	2100	9100	Cretaceous biogeochemical group	The Cretaceous Period	biodiversity of the Early Cretaceous period; It covers almost all the biological groups in the transition from Mesozoic to Cenozoic. "One of the world's most important paleontological discoveries of the 20th century
Triassic fossil site cluster in Guizhou	China	26.7882.N, 106.6265.E	3,600	12, 000	Triassic Marine biogeochemical group	Triassic	There are a large number of fossils of Marine life in the Triassic period,such as ancient fish and shell fossils
Remains of Shanwang biota	China	38.2340.N, 114.7310.E	2,500	15, 000	Early Cretaceous plant and dinosaur groups	The Cretaceous Period	Mainly found early Cretaceous dinosaur fossils and rich plant fossils; It has the name of "fossil museum"

Table 2 Horizontal comparison map of world palaeontological heritage sites

heritage site	Country	continents	latitude and longitude	Core area	buffer area	major categories	Geological periods	Geological periods	Meet the criteria
The Messel fossil Site	Germany	Europe	50.1421° N, 8.6628°	42	28	Early Miocene insect and fish fossils	Miocene Epoch	A large number of Miocene insect and fish fossils are preserved, which is an important record of ancient ecosystems. Exceptionally well preserved mammal and viscera fossils	(viii)
Dinosaur Park, Alberta	Canada	North America	49.0976° N, 112.8376 ° W	7500	9000	Cretaceous dinosaur group	The Cretaceous Period	Found a large number of dinosaur fossils, including dinosaur bones, fossilized nests, etc.; The most important fossil remains of the "age of reptiles"	(vii) (viii)
Canadian Rocky Mountain Park	Canada	North America	51.8004° N, 115.5965 ° W	2306900	-	Jurassic to Cretaceous dinosaurs and fossil groups	Jurassic to Cretaceous period	Contains rich fossil records and geological landscapes from the Jurassic and Cretaceous periods;Burgess Shell fossil site; Marine mollusc fossils	(vii) (viii)

Table 3 Horizontal comparison map of world palaeontological heritage sites

heritage site	Country	continents	latitude and longitude	Core area	buffer area	major categories	Geological periods	Geological periods	Meet the criteria
Jorkins fossil cliff	America	North America	43.7096° N, 106.2360° W	689	-	Jurassic and Cretaceous dinosaur groups	Jurassic to Cretaceous period	Contains the most complete known record of terrestrial life since the iconic "coal age"; It witnessed the first reptiles in the history of the earth and is the earliest representative of the amniotic animal	(viii)
Meguasha National Park	Canada	North America	24.2782° S, 119.3046° E	87.3	775	Early Paleozoic Marine biogeochemical group	The Paleozoic Era	There are abundant fossils of early Paleozoic Marine organisms, such as ancient fish and ancient corals.It is the world's most famous fossil site of the Devonian "Age of fish"; It has the world's largest and best preserved ichthyostega fossil specimens	(viii)
St George's Hill	Italy/Switzerland	Europe	37.4451° N, 113.0502° W	1089	3207	Jurassic and Cretaceous dinosaur groups	Jurassic to Cretaceous period	The most famous record of Marine life from the Triassic also contains the remains of important land creatures; It provides a major reference point for the discovery of Triassic remains in the world ocean in the future	(viii)

Table 4 Horizontal comparison map of world palaeontological heritage sites

heritage site	Country	continents	latitude and longitude	Core area	buffer area	major categories	Geological periods	Geological periods	Meet the criteria
Cape Mistacken	Australia	Oceania	-42.0902° S, 145.2560° E	146	74	Miocene mammal fossils	Miocene Epoch	Preserved mammal fossils from the Miocene period, including ancient kangaroos; Contains the world's oldest known large, complex organisms, including mollusks, ancestral animals; Contains the Ediacaran deep-sea community, the oldest and most diverse in the world; Constitutes a remarkable record of an important milestone in the history of life on Earth	(viii)
Shark Bay, Western Australia	Australia	Oceania	-25.4308° S, 113.5218° E	2300000	-	Early Cambrian Marine biogeochemical group	Cambrian period	One of the largest seagrass grasslands in the world; It has a lot of stromatolites	(vii) (viii) (ix)(x)
Mammal fossil sites in Australia	Australia	Oceania	-30.5105° S, 137.5260° E	10300	-	Neogene mammal fossils	Neogene period	Contains abundant Neogene mammal fossils; It shows the complete evolution of the Australian mammal fauna. Providing the first fossil record of a living mammal	(viii) (ix)

Table 5 Horizontal comparison map of world palaeontological heritage sites

heritage site	Country	continents	latitude and longitude	Core area	buffer area	major categories	Geological periods	Geological periods	Meet the criteria
Isagualasto-talampeya Nature Park	Argentina	South America	-40.2050° S, 65.5000° W	275370	-	Jurassic and Cretaceous dinosaur groups	Jurassic to Cretaceous period	The rich Jurassic and Cretaceous dinosaur fossils show the evolutionary history of dinosaurs	(viii)
Whale Valley	Egypt	Africa	-45.8701° S, 73.0074° W	8500	-	Neogene cetacean group	Neogene period	A rare whale fossil, the oldest extinct palaeosauridae; It is the most important relic in the world reflecting this stage of evolution, and vividly shows the life forms of these whales during their evolution	(viii)

5 Conclusions and Suggestions

5.1 Research Conclusions

The Institute of Paleontology of the Chinese Academy of Sciences and Chengjiang Research Station have provided strong help for field scientific research. The Chengjiang Museum of Animal and Fossil Groups has been established in Chengjiang to display the strata, minerals, paleontology and paleogeography of the Cambrian period in Yunnan, and the fossil section representing the Cambrian strata has been established in Maotian Mountain where fossils were buried. It provides a good scientific research site and rich scientific research content for paleontologists and geologists at home and abroad. It also provides a good base for popular science education, and adds big scenic spots to Yunnan's tourism. It integrates scientific research, teaching practice, popularization of geology and tourism, and makes contributions to socialist spiritual civilization.

5.2 Research Suggestions

In the future, through legal protection and planning, physical isolation and current limiting, ecological restoration and restoration, scientific research and monitoring, public education and participation, etc. In addition, now has entered the era of artificial intelligence, such as three-dimensional oblique photography, three-dimensional geological modeling, etc., can carry out some landscape pattern reshaping of geological landscape, and realize three-dimensional panoramic visualization, which can carry out accurate scientific protection of geological relics. Can also be through the UAV aerial survey, laser scanning technology, global positioning system, digital photogrammetry, digital ground model, scientific and reasonable implementation of protection measures, effective use and sustainable development. In addition, it can also start from the interaction and interest with tourists, and combine the biogeological knowledge with activities to enhance the tourists' sense of experience.

6 Conclusion

In summary, Chengjiang fossil site, as an important site for the preservation of early Cambrian biota, is not only of great significance for understanding the evolution of early life, but also provides valuable experience for biodiversity conservation and sustainable development. For the protection and sustainable development of fossil sites, we should start with digitalization and wisdom, combine modern science and paleontology, and let knowledge penetrate into every link of the visit, so as to achieve "making ancient sites alive". In terms of protection measures, it can be achieved through legal protection and planning, physical isolation and flow limitation, ecological restoration and restoration, scientific research and monitoring. For example, the use of three-dimensional oblique photography, three-dimensional geological modeling and other technologies to reshape the landscape pattern, to achieve accurate scientific protection of geological relics. These technologies can not only protect sites from destruction, but also let more people know and appreciate these precious cultural heritages through public education and tourism development; Scientific research plays an important role in the sustainable development of fossil sites. Through the archaeological excavation and research of the sites, the development process of human history can be revealed, and the lifestyle, cultural characteristics and technical level of ancient humans can be understood; Public education and tourism development are effective ways to promote the sustainable development of fossil sites. Through education and publicity, public awareness of site protection can be

raised, while economic support for site protection can be provided through tourism development.

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