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Contents

Marine macroalgae from the 518-million-year-old Qingjiang biota of South China

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Abstract

Macroalgae are important component of the modern marine ecosystem. They are not only primary producer, but also provide essential food and oxygen for consumer. Particularly, in the costal environment, they also create new niches for animals and other organisms. In addition, marine macroalgae have an effect on sediment accumulated and organic carbon burial in the shallow water shelf, and even on the global carbon cycle and dynamic variation of the carbon stable isotope. Before the origin of the seaweed, macroalgae were the only macrophyte in the ancient ocean, and their net primary productivity was very high. Fossil macroalgae witnessed the co-evolution of biology and environment during the geological period. It can thus be seen that macroalgae played an even more important role in the ancient marine ecosystem.

For now, the origin of macroalgae can date back to the Paleoproterozoic. In the Neoproterozoic, macroalgae showed significant increases in taxonomic and morphological diversity and maximum size. The Cambrian explosion ultimately resulted in the critical transition from microbially-dominated ecosystems in the Precambrian to metazoan-dominated ecosystems in the Phanerozoic. Besides, a possible extinction event occurred in the last ~10Myr prior to the Ediacaran-Cambrian

boundary. According the fossil records, Cambrian macroalgae showed lower taxonomic diversity, morphospace range and morphological disparity than the Ediacaran macroalgae. In addition, no new morphogroup appeared in the Cambrian, and some Ediacaran morphogroup even disappeared.

Recently, abundant and well preserved macroalgae are found in the early Cambrian Qingjiang biota of South China. *Chuaria*, the ubiquitous form in the Precambrian, also occurs in this biota. Its presence fills the early Cambrian gap of *Chuaria* in the fossil record. Besides, a new form of branched macroalgae from the Qingjiang biota, *Qingjiangthallus cystocarpium*, is assigned to red algae. The branching patterns and branch width of *Qingjiangthallus* are consistent with the coarsely dichotomously branched morphogroup, which was previously present in the Ediacaran, Ordovician, and afterward, but absent in the Cambrian.

This shows that some taxa or morphogroups are not disappeared in the Cambrian, but just have not been found yet. Therefore, the taxonomic diversity, morphological disparity and evolution of the early Cambrian macroalgae need to be confirm further. The results can provide evidence for discussion of evolution of macroalgae and marine ecosystem during the Cambrian explosion.

Key words: *Chuaria*, *Qingjiangthallus*, macroalgae, Qingjiang biota, Cambrian, evolution

Barremian-Albian Palynological flora from Hailar Basin, Inner Mongolia, China

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Abstract

Hailar Basin is located in the southwest part of Hulunbeir League of Inner Mongolia Autonomous Region.The Basin is bounded to the east by Yimin River, to the west by west shore of Hulun Lake,to the north by the north of Hailaer River,to the south by the Mongolia. Sporopollen fossils in every member of Yimin Formation are very abundant (Barremian-early Albian), three sporopollen assemblages are divided from lower to upper,they are introduced as follows:

1) *Impardecispora-Aequitritadites-Clavatipollenites* assemblage (Menber1 of Yimin Formation): Fern spore content is not stable,but the most are more than 50% with the range of 21.64-85.3%, gymnosperm pollen content is 13.9-69.79%, angiosperm pollen content is fragmentary. To fern spores, *Cicatricosisporites australiensis* content is highest, next is *Cyathidites minor*, *Cicatricosisporites minutaetriatus*, *Impardecispora purveruleta*, *Pilosisporites verus*, the important elements are: *Impardecispora marlylandensis*, *Leptolepidites verrucatus*, *Klukisporites foreslatus*, *Appendicisporites auriflerus*, *A. erdtmanii*, *Crybelosporites striatus*, *Fixisporites tortus*, *Aequitritadites ornatus*, *Couperisporites complexus*, etc. To gymnosperm pollens, *dominated* by Pinaceae, the important elements are:*Jiaohepollis* cf. *verus*, *J. verus*. To angiosperm

pollens, *Clavatipollenites hughesii*, *C.* sp., *Asteropollis* sp. are just founded, though the types are monotonous, it has important meaning.

2) *Triporoletes-Pilosisporites-Asteropollis* assemblage (Menber 2 of Yimin Formation): Fern spore content is high (38.16-90.9%), gymnosperm pollen content is next (7.51-61.28%), angiosperm pollen content is fragmentary (0.56-2.13%). To fern spores, *Laevigatosporites ovatuo* content is highest, the next are *Deltoidospora hallii*, *Cicatricosisporites australiensis*, *C. minor*, *C. minutaestriatus*, the important fossils are: *Impardecispora apiverrucata*, *I. cavernosa*, *I. Purverulenta*, *I. Tribotrys*, *Pilosisporites brevipapillosus*, *P. concavus*, *P. scitulus*, *P. setiferus*, *P. trichopapillosus*, *Triporoletes involuratus*, *T. reticulates*, *Aequitriradites echinatus*, *A. spinulosus*, *A. verrucosus*. To gymnosperm pollens, *dominated by* Pinaceae. To angiosperm pollens, *Tricolpopollenites* sp. and *Asteropollis* sp. are just founded, which content is just little higher than Member 1.

3) *Appendicisporites-Asteropollis-Tricolpites* assemblage (Menber 3 of Yimin Formation): fern spore content is 36.53-65.05% , gymnosperm pollen content is next (33.01-58.71%), angiosperm pollen content is lowest (1.94-5.5%). To fern spores, *Cyathidites minor* content is highest (4.0-20.39%), *Cicatricosisporites* are abundant. The important elements are: *Lygodiumsporites subsimplex*, *Impardecispora minor*, *Pilosisporites trichopapillosus*, *P. verus*, *Appendicisporites crenensis*, *A. potomacensis*, *A. tricornitatus*, *Triporoletes reticulates*, *T. radiatus*, *Aequitritadites verrucosus*, *A.* sp., *Trilobosporites* sp., *Schizaeoisporites certus*, *S. evidensis*. To gymnosperm pollens, *dominated by Taxodiaceaepollenites* and *Inaperturopollenites genus*, other important type is *Exesipollenites tumulus*. To angiosperm pollens, which types are more than Member 2: *Clavatipollenites hughesii*, *C.* sp., *Asteropollis asteroides*, *Tricolpites* sp., *Tricolporoidites* sp., etc.

The spores of Lygodiaceae and sporopollens of other Middle-Late Age of Early Cretaceous of many Genera and Species: *Cicatricosisporites minor*, *C. minutaetriatus*, *C. mediostriatus*, *C. pacificus*, *C. australiensis*, *C. gracilis*, *C. augustus*, *C. exilioides* , *C. potomacensis*, *Klukisporites foveolatus*, *Foraminisporites asymmetricus*, *F. dailyi*, *F. wonthaggiensis*, *Appendicisporites crimensis*, *A. auriferous*, *A. erdtmanii*, *A. tricornitatus*, *Pilosisporites verus*, *P. trichopapillosus*, *Impardecispora cavernosa*, *I. tribotrys*, *Aequitriradites spinulosus*, *A. verrucosus*, *Fixisporites tortus*, *Triporoletes singularis*, *T. reticulates*, *T. involucratus*, *T. radiatus* , *Crybelosporites striatus*, *Kuylisporites lunaris*, *Schizaeoisporites certus*, *S. evidensis*, *S. kulandyensis*, *S.*

microsphaericus. Some early angiosperm pollens were found in Member 1 and 2 of Yimin Formation, Hailaer Basin: *Clavatipollenites hughesii*, *C.* sp., *Asteropollis* sp. and *Tricolpopollenites* sp., which show the evolution characteristics of monocolpates angiosperm pollens in Barremian-Aptian. Some original angiosperm pollens were founded in Member 3 of Yimin Formation: *Clavatipollenites hughesii*, *C.* sp., *Asteropollis asteroids*, *Tricolpites* sp. and *Tricolporoidites* sp., which already had the evolution characteristics of triptyches angiosperm pollens, perhaps belong to early Albian in age.

Key words: Barremian-Albian, Angiosperm pollens, Sporo-pollen assemblage, Hailar Basin

Phosphatized calcified cyanobacteria at the terminal Ediacaran and the earliest Cambrian transition: response to the paleoenvironment

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Abstract

Calcified cyanobacteria were only sporadically discovered in the Neoproterozoic and did not appear widely until the early Paleozoic. It is proved that the abundance of calcified cyanobacteria is related to the change of atmospheric CO_2 level and the calcium carbonate saturation of seawater. Description and systematic research of phosphatized calcified cyanobacteria in the Cambrian is rare, even though some phosphatized materials were reported. Anyhow, there is no report of phosphatized calcified cyanobacteria in the Precambrian except in Gaojiashan biota. Both the Gaojiashan biota of the end of the Ediacaran and the Kuanchuanpu biota of the early Cambrian yield a variety of phosphatized calcified cyanobacteria assemblages. Especially the former fills the vacancy of calcified cyanobacteria all over the world during this period. These two biotas contain same calcified cyanobacteria such as *Girvanella*, *Obruchevella* and *Cambricodium*, and they are all phosphatized preserved. Research on the phosphatized calcified cyanobacteria of the Kuanchuanpu biota and Gaojiashan biota, and comparison of the similarities and differences, morphological features and occurrence modes of calcified cyanobacteria around the boundary provide important biological evidence for the calcification mechanism, the continuity of evolution of cyanobacteria and the changes of marine chemical conditions reflected by

it during the critical transition period from the Precambrian to the Cambrian.

Key words: Phosphatized calcified cyanobacteria; the Gaojiashan biota; the Kuanchuanpu biota; the latest Ediacaran; the early Cambrian

Palynological assemblage and its paleoclimate of Jiufengshan Formation in Dayangshu Basin, Inner Mongolia, China

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Abstract

The Dayangshu Basin, as a Mesozoic faulted-basin in Northeast China, extends in NNE direction. Located in the southern depression of the basin, the Well Yang-3 outcropped the Cretaceous non-marine deposits, named as Longjiang, Jiufengshan and Ganhe Formations in ascending order. Eight black mudstone samples were collected from the coal-bearing deposit of the Jiufengshan Formation in the horizon (1804.46 - 1896.99 m in depth) of Well Y3. Abundant palynomorphs were recognized in the samples and named as the *Osmundacidites-Baculatisporites-Aequitriradite* Assemblage. This is significant in correlation of the Early Cretaceous strata, especially in the regional biostratigraphic correlation of the Jiufengshan Formation.

The assemblage is characterized by: 1) fern spores are diverse, accounting over 70.00% of the palynomorphs; while gymnosperm pollen account for 30.00% and angiosperm pollen are absent. 2) among the fern spores, *Osmundacidites* (11.18%), *Baculatisporites* (7.06%) and *Aequitriradites* (5.29%) are richest taxa. *Granulatiporites* (3.53%) and *Uvaesporites* (3.53%) are common. Other important genera including *Triporoletes*, *Cicatricosisporites*, *Foveotriletes*, *Lygodiumsporites*, *Yichangsporites*,

Hsuisporites, *Densoisporites*, *Foraminisporis*, *Pilosisporites*, *Leptolepidites* and *Fixisporites*, etc. are often seen. 3) gymnosperm pollen is damaged and difficult to be identified. *Inaperturopollenites*, *Paleoconiferus*, *Protoconiferus* are recognized. The assemblage is quite similar to the *Trilobosporite-Cicatricosisporite-Cycadopites* Assemblage established by Pu Ronggan and Wu Hongzhang (1985) from the coal seams of the Jiufengshan Formation in the Dayangshu Coal-Mine, however, *Cycadopites* and *Trilobosporites* were not found in the present samples of the Well Y3. Many species of fern spores such as *Triporoletes*, *Cicatricosisporites*, *Aequitriradites*, *Yichangsporites*, *Hsuisporites*, *Densoisporites* are important indicators of Cretaceous age, while others are wide distributed species during Jurassic and Cretaceous time, for examples, *Stereisporites*, *Lophotriletes*, *Cyathidites*, *Baculatisporites*, *Deltoidospora*, *Biretisporites*. Since no angiosperm pollen found, the geological age of the assemblage is assigned to the early and middle stage of the Early Cretaceous (Hauteriviann-early Barremian).

During the deposition period of 1804.46 m of the Jiufengshan Formation in the Well Y3, the coniferous forests (30%) and herbaceous (29.41%) were predominated, followed by broad-leaved forests (11.76%). The herb plants mainly contributed (10.59%), and the deciduous broad-leaved trees were entirely absent, showing a grass-coniferous forest landscape. The hygrophytic plants (27.65%) predominated, followed by the mesophytic (23.53%) and pelophytic (20.00%), xerophytic and aquatic were rare, these findings show that humid climate was dominant at that time. The palynological percentage of plants that could grow in both the temperate and the tropical-temperate zones (39.41%) were much higher than those of plants that could grow in both the tropical (15.88%) and the temperate zones (14.71%). Therefore, it can be inferred that the climatic had a tropical-warm temperate at that time. In sum, the Jiufengshan Formation in Well Y3 (depth: 1804.46 m) had the vegetation that was grass-coniferous forest landscape and a humid to tropical-warm temperate climate during its sedimentary period. This conclusion only comes from a core sample, so the paleovegetation and paleoclimate information only reflects the characteristics of the sporopollen occurrence horizon. Whether it can represent the paleovegetation and paleoclimate characteristics of the whole Jiufengshan Formation needs to be confirmed by the data of more layers of this Formation in other wells.

Key words: Dayangshu Basin, Early Cretaceous, Palynological assemblage, Jiufengshan

Formation, Paleoclimate, Paleovegetation

The permian-triassic boundary microfossils from gaohua section, cili county, hunan province

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Abstract

The End-Permian Mass Extinction Event (EPME) is the largest extinction event in the earth's history. The metazoans in the shallow marine dramatically suffered and were replaced by widely distributed microbialites in the early Triassic. Detailed researches regarding the distribution and the formation of microbialites are important. Especially, studies focusing on the temporal and spatial distribution of microbials in the microbialites is crucial to understanding the mechanisms of biological recovery after the EPME. To better understand the nature of microbialites, 47 thin sections from Gaohua section-a Permian-Triassic Boundary (P/TB) section from Cili County, Hunan Province, have been investigated in terms of the Metazoan and the microbial fossils. The P/TB strata from Gaohua are composed of the upper part of the Changxing Formation and the lower part of the Daye Formation. After carefully examining the thin

sections, abundant fossil fragments of ostracods, algae, foraminifera and fusulinids have been found in the uppermost Changxing Formation. Only a few foraminifera and ostracods remained at the bottom of the Daye Formation, and microfossils of conodont and microgastropod also appeared. Surprisingly, microbial fossils of *Stanieria* and *Gakhumella* were first found in the microbialites at the Gaohua section. The *Stanieria* are characterised by a better-preserved outline, but the *Gakhumella* group are remineralised and replaced by calcite crystals. Although the microbes in this study did not differ significantly from those reported from other parts of South China, the found of *Stanieria* and *Gakhumella* enhanced our understanding of the genesis of microbialites and the post-extinction marine ecosystem.

Keywords: microbialites, Stanieria, Gakhumella, Permian-Triassic boundary, Daye formation

Analysis on the microbial genesis of hydrogen sulfide in an offshore high-temperature W oilfield

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Abstract

This study aimed to analyse the biological genesis of hydrogen sulfide in an offshore high-temperature W oilfield. We quantitatively analyzed the sulfate-reducing bacteria (SRB) in production wells and pipelines on the offshore platform, and analyzed the SRB community composition via the high-throughput sequencing technology. Compared with production wells, SRB species in pipelines increased from 12 to 19, and the proportion of SRB rose from 26.32% to 54.57%, especially these thermophilic types including *Thermotoga*, *Thermodesulfobacterium*, *Thermovirga*, *Thermodesulforhabdus*, *Desulfothermus and Pseudothermotoga*. Moreover, the chao1 index, observed species value and PD whole tree value of the samples of pipelines were higher than those of production wells, while the shannon index value of the samples of pipelines was lower than that of production wells. It was suggested that the total number of species in the samples of pipelines was higher than that of production wells, while the microbial diversity of production wells was higher, indicating a greater potential for discovering new strains. We revealed the proliferation and microbial diversity of SRB in high temperature oilfields, providing a guidance for the treatment of secondary hydrogen sulfide in offshore oilfields.

Key words: hydrogen sulfide; sulfate-reducing bacteria; quantitative analysis; high-throughput

sequencing; community composition

Early Cambrian small shelly fossil assemblages and stratigraphic correlation: Fossil evidence from Hanzhong area, southern Shaanxi, China

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Abstract

Small shelly fossil (SSFs) is the main biomineralized marker of the transition between the Late Ediacaran and Early Cambrian on the earth. It is of great significance in the subdivision and correlation of early Cambrian strata in China and other continents. The fossil assemblage is first reported from the early Cambrian Yangjiagou Member of the Liangshan area and the Guojiaba Formation of the Fucheng area, southern Shaanxi, China. All specimens were found in bioclastic limestone and contain different kinds of fossils. Micro-morphological and elemental analyses of the small skeletal fossil assemblages were carried out using SEM, BSEM, and Micro X-ray fluorescence. The Yangjiagou Member of the Liangshan area is rich in hyolithelminths, chancelloriids,

and zhijinitids. By comparison of fossil assemblages of the Early Cambrian in eastern Yunnan and Zhenba areas, the Yangjiagou Member of the Dengying Formation in the Liangshan area could be correlated with the pre-trilobite Cambrian Stage 2 with abundant occurrences of hyolithelminths, chancelloriids. The fossils of the Guojiaba Formation of the Fucheng area consisted of brachiopods, sphenothallids, archaeocyaths, bradoriids, sponge spicules, echinoderm plates, and trilobite spines, etc. Among them, the archaeocyaths described herein are considerably older than those described from the Xiannvdong Formation, which was previously assumed to contain the lowest archaeocyath-bearing horizons in South China. The brachiopod *Lingulellotreta yuanshanensis* is recorded for the first time from the Fucheng area, with previous records confined mainly to the Chengjiang Fauna-bearing Yu'anshan Formation in the lower Cambrian, the eastern Yunnan Province. Based on the recovered assemblage, the biostratigraphic age of the Guojiaba Formation correlates with the Chiungchussuan Stage (Stage 3 of Cambrian Series 2). These provide new fossil evidences for the early Cambrian stratigraphic correlation in the Micang Mountain area of southern Shaanxi.

Keywords: small shelly fossils (SSFs); fossil assemblage; early Cambrian; biostratigraphic correlation; southern Shaanxi

The first look at the diverse fossil assemblage with soft parts preserved in the Upper Ordovician Pingliang Formation of North China

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Abstract

The exceptionally preserved soft-bodied fossils provide substantial information about the morphology of ancient organisms and palaeoecological complexities of the Palaeozoic evolutionary faunas. In North China, only graptolites, conodonts and brachiopods have been discovered during the Late Ordovician without any soft-bodied fossils reported until now. Here, we present a new late Ordovician fauna from the Pingliang Formation at the Xilinggou section, Jingyang County, Shaanxi Province, North China. The fauna includes brachiopods, trilobites, gastropods, crinoids, cnidarians, sponges, bryozoans, graptolites and other unidentified fossils. Of these, phosphate-preserved lingulid brachiopods predominate and preserve soft tissues, including vascular system of mantle canals, dorsal mensentery, gastroparietal bands and pedicle nerve markings. Graptolites with well-defined zooids show a high degree of diversity (six genera) and preserve nema and pneumatophore. This discovery represents the first exceptionally preserved fauna reported from the late Ordovician of North China

and has significant implications for the late Ordovician palaeogeography, faunal successions, and palaeoenvironments in North China.

Redescription of the Cambrian Stage 4 Guanshan Biota of South China

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Abstract

Amplectobeluidae, as a member of radiodonta, differs from the other three family by the existence of large proximal endite and gnathobase-like structure. Three genera of Amplectobeluidae are *Amplectobelua*, *Lyrarapax* and *Ramskoeldia*. *Amplectobeua* has an endite near proximal end stout and exceptionally long and paired of spine-like endites generally without auxiliary spines; frontal appendages of *Lyrarapax* are short and bear a stout, blade-shaped endite with pectinate, sclerotized spines that gradually become larger distally on the proximal podomere; *Ramskoeldia* has 16 podomeres bearing spinose endites and podomere 4 is the largest endite, but length not exceeding half the length of frontal appendage. Recently, *"Anomalocaris" kunmingensis* from Guanshan biota is classified into Amplectobeluidae, our study gets further morphology characters of this species and erects a new genus *Guanshancaris* on the basis of these traits. The presence of two large proximal endites, several anterior auxiliary spines as well as stout and thick dorsal spines and terminal spines distinctly differentiates *Guanshancaris* from other genera in Amplectobeluidae. These new characters prompt the diversity of morphology and eating strategy of Amplectobeluidae. Furthermore, the coexisting trilobites and brachiopods parts with frontal appendages adds to the possibility of amplectobeluids as a durophagous predation, as well as adds to understanding of its eating habits. In addition to the improved morphological information provided by the new specimen, the distribution date of Amplectobeluidae suggests that both variety and quantity of this group reach

its maximum in the early Cambrian and apparently decrease in the middle Cambrian, which may be caused by geochemical and eustatic change and volcanic activity. From spatio-temporal distribution of amplectobeluids, this group prefers shallow water in tropical/subtropical regions.

Keywords: Amplectobeluidae, Guanshan Biota, Guanshancaris gen. nov., Radiodonta, Durophagy