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ANFIMOV A.L.
Algal microfacies of Moscovian (middle Carboniferous) carbonates of the Urals [1]

BIAN L., ZHANG S., ZHANG B., WANG F., LU B., YIN L., ZHEN J., and WANG L.
Benthic-macroalgae and their role in producing hydrocarbons [2-3]

AGUIRRE J. and BRAGA J.C.
Recovery of non-geniculate coralline algae following end-Cretaceous extinction [4-5]

BRAGA J.C. and AGUIRRE J.
Coralline algae in the Messinian (late Miocene) Cariatiz reef, Sorbas Basin, SE Spain [6-7]

BUCUR I.I. and ENOS P.
Middle Triassic Dasyclad algae from Guizhou, China [8-9]

CAO R.
Stromatolite-building microbial mats from Neoproterozoic Jindingshan Formation in N Jiangsu Province, China [10-13]

CHUVASHOV B.I., ANFIMOV L., and IVANOVA R.M.
Middle (Bashkirian-Moscovian) and late (Kasimovian-Gzhelian) Carboniferous algae flora: stratigraphic distribution and biogeography [14-16]

DAI Y., ZHU J., CHEN M., WANG Y. and SHENG J.
Iron microbialite in the Early-Middle Proterozoic Era, Xuanlong area of North China [17-18]

GHOSH A.K.
Late Oligocene (Chattian) coralline algae from southwestern Kutch (mainland India), and their palaeoenvironmental significance [19-20]

GHOSH A.K., MAITHY P.K., and KUMAR G.
Dasycladacean green algae from the Ordovician of Spiti Basin, Tethyan Himalaya, Himachal Pradesh, India and their connotation in palaeoenvironment [21-22]

GRGASOVIC T. and SOKAC B.
Teutloparella PIA and Euteutloparella DE CASTRO (Dasycladales, Green Algae) from the Triassic of Croatia [23-24]

GRGASOVIC T., SOKAC B., and HALAMIC J.
Salpingoporella scopuliformis n.sp. (Dasycladales, Green Algae) from the Middle Triassic of Croatia [25-26]
GRGASOVIC T. and SOKAC B.
Triassic Dasycladales from Croatia: a Review [27-28]

KERSHAW S., GUO L., and FAN J.
Origin of a carbonate crust at the Permian-Triassic boundary interval in Sichuan, China: organic or inorganic? [29-30]

KHODJANYAZOVA R.R.
Calcereous algae assemblages from the Upper Paleozoic of southern Fergana (Middle Asia) and their facies distribution [31-32]

KOLAR-JURKOVSEK T. and JURKOVSEK B.
Clypeina in the Belca section of the Karavanke Mts., Slovenia [33-34]

KUNDAL P. and WANJARWADKAR K.M.
Rivularia and Ethelia from Thanetian limestones of Middle Andaman Island, Andaman, India [35]

LI G.
Early Cambrian phosphate-replicated endolithic algae [36-37]

LI J., WANG Y., and BROCKE R.
Llanvirnian acritarchs from the Yangtze Platform of South China [38-40]

LI J., LI Y., and BROCKE R.
Planktonic algal microfossils from Early Silurian of northern Guizhou, South China [41-42]

LI Y., LI J., and XUE Y.-S.
Calcereous algae from Early Llandovery of Shiqian, Guizhou, South China [43-44]

LIU Z. and LIU X.
Artificial algal mats and biomineralization [45]

LUCHININA V.
Organogenic buildups and calcareous algae in the Siberian platform at the threshold between the Vendian and Cambrian [46-47]

MAKARIKHIN V.V.
Elements of the Mopanyu stromatolite assemblage in the Baltic Shield [48-49]

MAKARIKHIN V.V. and MEDVEDEV P.V.
System of stromatolites [50-51]

MATHUR S.C. and KUMAR S.
Geological nature and genesis of stromatolitic phosphorite of Birmania Basin, District Jaisalmer, western Rajasthan, India [52]

MOITRA A.K.
Exceptionally preserved facies-controlled algal remains of the Chhattisgarh Basin, M.P. India, and their significance [53-54]
PAUL J.
Stromatolites of the Upper Devonian Canning Basin (Western Australia) [55-56]

QIAN M., YUAN X., and YAN Y.
A megafossil assemblage from the Neoproterozoic Jiuliquiao Formation in northern Anhui Province, China [57-58]

RIDING R.
Stromatolite: what is it, what is it not? [60-63]

SHARMA M.
Mesoproterozoic microbial assemblage from Jaradag Fawn Limestone Formation, Rohtas, Bihar, India: an ancient analogue of sabkha ecosystem [64-66]

SHUYSKY V.P. and CHUVASHOV B.I.
The assemblages of reef-building algae of Uralian Late Precambrian to Palaeozoic, and main structural types of algal limestones [67-69]

SOARES L., DARDENNE M.A., FAIRCHILD T., and GUIMARÃES E.M.
Proterozoic stromatolites from central Brazil and their palaeoecological assessment [70]

TEWARI V.C.
Precambrian and lower Cambrian stromatolite diversity and decline in India, and its global comparison [71-73]

WU Q., YOSHIHIRO S., SHENG G., and FU J.
Hydrocarbons resulting from pyrolysis of the marine coccolithophores Emiliania huxleyi and Gephyrocapsa oceanica [59]

YANG R.-D. and ZHAO Y.-L.
Early-Middle Cambrian macroalgae fossils from Guizhou Province, China [74]

YIN L., XIAO S., and YUAN X.
Acicular objects of the Doushantuo Formation are not sponge spicules [86-87]

YIN L., XUE Y.-S. and YUAN X.
Spinose phosphatic microfossils from terminal Proterozoic Doushantuo Formation in southern China [75]

YUAN X. and MU X.-N.
A great morphologic diversification of seaweeds in Neoproterozoic (Sinian) Doushantuo epoch [76-81]

ZHOU C., XUE Y., and YUAN X.
Possible green algal fossils from the Neoproterozoic Doushantuo phosphorites in Weng’an, Guizhou Province, SW China [82-84]

ZHU S., SUN S., and HUANG X.
The carbonaceous megafossils, multicellular tissues and sexual reproductive organs from the Palaeoproterozoic Changzhougou Formation (1,800 Ma) in North China [85]
ANFIMOV A.L.

Algal microfacies of Moscovian (middle Carboniferous) carbonates of the Urals

Thin-sections of Moscovian carbonate were studied from three sites in the Urals: Mycha-Yol (Near-Polar Urals), Urtasym (Southern Urals) and Uly-Taldyk (Mugodzhary Mts.), to study the relationship between limestones facies and algal groups. The Mycha-Yol section comprises mainly packstone (including bioclastic packstone) and wackestone-packstone. The sediments contain a lot of micrite throughout. The Urtasym section is dominated by grainstone, wackestone-packstone and bioclastic packstone. The Mugodzharian section comprises mainly wackestone and packstone.

The group of green and red algal genera Beresella, Claracrusta, Ungdarella, and Komia occur as a background of Moscovian algal flora everywhere. Moreover, the majority of genera were found together as a result of allochtonous burial. However, more usually, green algae (Macroporella, Epimastoporella) were observed within grainstone and wackestone only; red algae (Ungdarella, Komia, Cuneiphycus) occur in packstone and wackestone-packstone together with green algae Dvinella and Beresella; but Ungdarella was more typical for packstones; Komia, Cuneiphycus, and Sinustacheoides occur in wackestones and wackestones-packstones. Red algae prevailed in quantity over green algae in the packstones-packstones of Mycha-Yol. Green algae are more typical in the grainstones and wackestones of Uly-Taldyk.

BIAN L., ZHANG S., ZHANG B., WANG F., LU B., YIN L., ZHEN J., and WANG L.

Benthic macroalgae and their role in producing hydrocarbons

Abundant remnants of benthic macroalgae have been found recently in palynological maceration from organic-rich source rocks of the Upper Ordovician in Tarim Basin, the Upper Triassic in Ordos Basin, the Lower Silurian in Sichuan Basin, and the Jurassic in Qiantang Basin.

Previous work paid much attention to the blue-green, green algae, dinoflagellates, coccolith and other phytoplankton because of their excellent potential as a source for petroleum. Commonly, most of the remnants of benthic macroalgae in palynological maceration have not been studied in detail. The segments of benthic macroalgae in palynological maceration contain remnants of blades, laminae with sori or conceptacles, branches with zystocarpes and some dispersed zystocarpes or sporangia of red, brown or green algae.

Recognition of these segments in palynological maceration is important for information on source rocks and helps to trace back the development and evolution of benthic-macroalgae in geological time:
1. Different biofacies of source rocks can be recognised based on the richness of different types of benthic macroalgae in kerogen. For example, at the north slope of central uplift of Tarim Basin, the Upper Ordovician can be divided into four sub-biofacies: benthic macroalgae type I, benthic macroalgae type A-H, benthic macroalgae type J and the fourth sub-biofacies containing carbonaceous bryophytes and ancestral *Cooksonia*.

2. Some kinds of benthic macroalgae are especially favourable to produce hydrocarbons. Excellent source rocks from the Upper Ordovician in Tarim Basin and Triassic in Ordos Basin contain the same kinds of benthic macroalgae.

3. Oil produced from benthic macroalgae is different from that related to phytoplankton in biomarker characteristics. Benthic macroalgae and acritarchs act as the main precursors of some kinds of oil in the central area of Tarim. This oil has different biomarkers from Kukeriste-type oil related to *Gloeocapsomorphy* in American and Australia.

**AGUIRRE J. and BRAGA J.C.**

Recovery of non-geniculate coralline algae following end-Cretaceous extinction

Two sedimentary units are present in coralline algae-bearing shallow Tethyan carbonate platform deposits of Palaeocene age in SE Spain. The lower Danian unit consists of whitish bioclastic dolostones. The upper Thanetian unit is formed by alternating limestones and marls. Calcareous algae (Dasycladaceans, Solenoporaceans, Peyssonneliaceans, Corallinaceans), benthic macroforaminifers, and fragments of corals, bryozoans, barnacles and equinoids, are the most common components in both units. In the upper unit, several patch reefs have been found.

Coralline species richness differs in these units. The Danian unit is characterised by very low diversity of coralline algal assemblages that only include *Sporolithon* sp., *Lithothamnion* sp. 1, *Lithoporella* (?) sp., and an unidentifiable species. Other calcareous red algae associated with these corallines are *Polystrata alba*, *Peyssonnelia* (?) sp., *Parachaetetes asvapatii* and *Distichoplax biserialis*.

The Thanetian unit contains coralline assemblages with higher species richness. In addition to the aforementioned coralline species, there are two further species of *Sporolithon* (*Sporolithon perplexum* and *Sporolithon* cf. *gosaviense*), *Lithothamnion villaegranis*, *Lithothamnion* sp. 2, and *Mesophyllum* (?) sp. Other coralline species are unidentifiable due either to absence of relevant taxonomic features (such as reproductive structures) or poor preservation. *D. biserialis*, *P. alba*, *A. asvapatii* and *Peyssonnelia* (?) also occur in this Thanetian unit.

This pattern indicates the Late Palaeocene evolutionary radiation of corallines. It shows that, following the major end-Cretaceous extinction that affected corallines (Aguirre et al., 1997), there was a time lag of about 4 Ma prior to recovery.

Braga, J.C. and Aguirre, J.

Coralline algae in the Messinian (late Miocene) Cariatiz reef, Sorbas Basin, SE Spain

The youngest pre-evaporitic Messinian sediments of the Sorbas Basin include a fringing reef unit. At the northern margin of the basin, near Cariatiz, this coral (Porites)-stromatolite reef (Riding et alii, 1991) advanced ~ 1km towards the basin centre. Reef facies distribution and geometries reveal cyclic relative sea-level changes during reef development (Braga & Martin, 1996). In a single episode of growth, horizontal lagoonal beds grade basinwards to subvertical coral-stromatolite reef framework. This in turn gives way downslope to poorly-bedded, steeply dipping talus-slope breccias, then to better-bedded lower angle proximal-slope calcirudites and calcarenites, and finally to distal-slope calcarenites and silty marls in. Basinwards, these slope deposits thin very rapidly.

Coralline algae occur in lagoon deposits as small rhodoliths and fragments of Spongites, Lithophyllum and minor Lithothamnion. Thin thalli of Lithophyllum (and probably Lithoporella) encrust Porites skeletons in the lower part of the reef framework (pinnacle and thicket zones). Small rhodoliths and fragments of Lithophyllum and Spongites occur in the matrix of the coral-stromatolite framework. Scarce Sporolithon is recorded in the pinnacles. Spongites increases in abundance towards the reef crest. Spongites and subordinate Lithophyllum and Neogoniolithon encrust the coral colonies and form rhodoliths at the top of the reef framework.

Coralline algae in talus and proximal slope deposits occur as fragments and rhodoliths dispersed among other bioclasts, and as components of framework clasts and downslope blocks. Spongites is the most common genus, with minor Lithophyllum. In some rhodoliths a Spongites nucleus is covered by Sporolithon or Phymatolithon. Mesophyllum rhodoliths occur in the proximal slope calcirudites. No corallines have been recorded in the fine-grained distal slope deposits.

Thus, the Cariatiz fringing reef contains low diversity coralline algal assemblages dominated by the mastophoroid Spongites. The low species richness of the flora is in accordance with the previously described low diversity of corals and bivalves in western Mediterranean Messinian reefs (Riding et alii, 1991, Jimenez & Braga, 1993). In contrast with coeval and younger reefs, coralline depth-zonation is poorly developed. Many coralline remains in the reef slope deposits are probably allochtonous, derived from shallower upslope sites.


Bucur, I.I. and Enos, P.

Middle Triassic Dasyclad algae from Guizhou, China

Branch morphology is an important criterion in Dasycladaean taxonomy. However, although initially considered by PIA (1912) to be important in separating the Middle
Triassic genera *Diplopora* and *Kantia*, this criterion was subsequently abandoned by PIA (1920) and the genus *Kantia* invalidated. Thus, PIA’s new interpretation combined forms with different types of branching (trichophore, phloiophore, vesiculiform) in a single species (*Diplopora annulata*). However, although PIA had abandoned this criterion for some forms of *Diplopora*, he continued to use it to separate some genera. For example, he used branch form to distinguish *Teutloporella* and *Gyroporella*, which are aspondyl genera differentiated by their branch form, trichophore and vesiculiform respectively.

In a reassessment of this criterion in the taxonomic hierarchy of metaspondyly dasyclads, GÜVENÇ (1979) reintroduced the genus *Kantia* (emended) and emended the diagnosis of the genus *Diplopora*. Unfortunately, this approach has not resolved all the problems. It is important to note that in *Kantia* PIA (1912) included metaspondyly forms bearing phloiophore branches with a tendency to be vesiculiform, and included in *Diplopora* only metaspondyly forms with trichophore branches. Yet in the emended diagnoses of GÜVENÇ (1979) *Kantia* comprises only forms with vesiculiform branches (corresponding to the diagnosis of the type species, *K. philosophi*), while *Diplopora* comprises only forms with trichophore branches (as in PIA’s 1912 diagnosis). Thus, forms with phloiophore branches are not included in either of the two emended diagnoses.

In addition, although the presence or absence of a vestibule (a short primary branch) is taken as an important criterion in delimiting some “metaverticillate” Paleozoic and Mesozoic algae (*Albertaporella*, *Columbiapora*, *Pekiskopora*, *Queenslandella*, *Falsolikanella*), this criterion has not been sufficiently considered in classifying Triassic “diplopores”.

A very rich and diversified association of Triassic dasyclads identified in Guizhou Province (China) requires renewed discussion of these criteria. It appears that two new genera will be required to circumscribe “diplopores” with phloiophore branches devoid of vestibules, on the one hand, and for “diplopores” with vestibules and phloiophore branches on the other.

Thus, the genus *Kantia* only includes genera with vesiculiform branches (*K. philosophi*, *K. dolomitica*) cf. GÜVENÇ’s definition (1979), and *Diplopora* only includes forms with trichophore branches, as suggested by PIA (1912) and reiterated by GÜVENÇ (1979).

The Middle Triassic assemblage of dasyclads from Guizhou Province includes the Anisian form “*Diplopora* proba” and the Anisian-? Lower Ladinian *Macroporella alpina*, *Macroporella dinarica*, *Diplopora annulatissima*, *Diplopora annulata*, “*Diplopora* subtilis”, and other “diplopores”.


PIA J. (1920) - Die Siphoneae verticillatae vom Karbon bis zur Kreide. Abhandl. zool.-botan. Gesellschaft in Wien, XI/2, 259 p., Wien

Stromatolite-building microbial mats from Neoproterozoic Jindingshan Formation in N Jiangsu Province, China

Microbial mats are accretionary cohesive microbial communities, which are often laminated and found growing at the sediment-water (occasionally sediment-air) interface. Many recent forms of microbial mats have a low preservation potential and hence little chance to accumulate and fossilise. Fossil stromatolites were widespread, but the mats have left few fossil records. The interpretation of fossil stromatolites as being produced by the trapping and binding of sediment by microorganisms, particularly blue-green algae, is essentially based on examination of recent living stromatolite surfaces.

Abundant stromatolites have been found from the Neoproterozoic Jindingshan Formation in Suining County, N. Jiangsu Province. Some of them have been mostly on partly silicified in favour of preservation of their constructions, microbial mats. The fossil mats form usually more or less cohesive fabrics of intertwined filaments or gelatinous matter produced by both filamentous and coccoid microorganisms. Cellular and filamentous structures within the mats are well preserved and fossilised. The stromatolites of well-preserved fossil microbial mats are mostly stratiform, namely conical and columnar, with more or less cleanly laminated structures. The following three points describe important features.

I. Two main morphological types of microbial mats have been recognised in Conophyton-like stromatolites. (1) Unlaminated pinnacle Siphonophycus sp. 1 microbial mat occurs in the base of stromatolites. It is constructed by a distinctive net-like complexity of growing monospecific filaments, Siphonophycus sp. 1, which possesses a few trapped detritus grains. The formation of this mat can be divided into two well-defined stages. Due to phototaxis, the tufts of erect filaments are initial accretions of this mat. Then a conical reticulated framework consisting of tangled unoriented filaments with entrapped sediments was formed on the tufts of erect filaments. (2) Laminated conical Siphonophycus sp. 1 microbial mat grew around the unlaminated pinnacle microbial mat. Each lamina of the mat consists alternatively of a light layer (sediment layer) and a dark layer (purely organic layer). The mechanically deposited sediments at the light layer of each lamina represent probably sediment influx higher current velocities. The dark layer represents probably a favourable condition of algal growth and a low, more or less constant rate of sedimentation. The central part of the dark layer is composed predominately of vertical filaments; but the filaments are usually arranged prostrate along both sides of the dark layer. As most dark layers are thickened more than 1-3 times at the central part, the crystal zone recognised in Precambrian Conophyton stromatolites is present in the column.

II. A short sub-cylindrical stromatolite is made up of laminated domed Siphonophycus inornatum microbial mat, which is constructed by a series of domed laminae. Each lamina consists alternatively of a light, thick, algae-poor layer, generally 0.4-1mm thick, and a dark, thinner, algal-rich layer, and generally 0.1-0.4mm thick. The light layers are composed of anastomosing bundles of filaments, assignable to Siphonophycus inornatum Y. Zhang, erect or inclined at various angles, which forms a three-dimensional reticulated framework. The dark layers consist of the same filamentous bundles, prostrate or inclined at various angles, which are closely crowded into a generally thin opaque partition, and form a planar reticulated
framework. Opening of irregular fenestra by internal solution is commonly developed
in the light microcrystalline layer. Gravel-sized grains have never been observed in
the laminae.

III. The following types of fossilised microbial mats occur in different laminae of
same or different stratiform stromatolites. (1) single flat Gloediniopsis suxianensis
microbial mat; (2) single flat Gloediniopsis suxianensis - Siphonophycus sp. 2
microbial mat; (3) single flat Siphonophycus sp. 2 - Myxococcolides sp. microbial
mat; (4) un laminated loosely lumped Siphonophycus sp. 2 microbial mat; (5)
laminated plane Siphonophycus sp. 2 microbial mat.

The present fossilised microbial mats also occasionally contain a few filaments of
Biocatenoids sp. and coccoids of Leiopsosphphaera sp. and Protosphoeridium sp.
They are probably mat-dwellers on allochtonous microorganisms.

Conclusions:

(1) Monospecific microfossils, assignable to the tubular Oscillatoriacean genus
Siphonophycus, account for an overwhelming majority of the total community
preserved in the present conical and short columnar stromatolites.

(2) Single flat microbial mats dominated by coccoid microorganisms occur only in
stratiform stromatolites.

(3) The development of laminated microbial mats relied on an oscillation balance
between algal growth and sedimentation rate. If the latter is too low, a purely
organic layer is formed, on the contrary, a sediment layer is formed.

(4) A corresponding relationship in orientation between filaments and laminae in
present stromatolites argues for the dependence on light of the ancient organisms
involved.

(5) The stromatolitic morphogenesis is probably closely connected with specificity of
stromatolite-building mats.

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CHUVASHOV B.I., ANFIMOV L., and IVANOVA R.M.

Middle (Bashkirian-Moscovian) and late (Kasimovian-Gzhelian) Carboniferous algae
flora: stratigraphic distribution and biogeography

The beginning of the Bashkirian was marked by a significant restriction of shallow-
water platform seas with essentially carbonate sedimentation, the main area of
occurrence of calcareous algae. The result of this event was very important for algal
history. The Moscovian age (especially Late Moscovian) is characterised by a very
wide transgression. The Late Moscovian was a time with a very big diversity of
calcareous algae. Most of the genera of green algae appeared during Late Moscovian
time; this is a key period of generation of Late Carboniferous and Permian algae
flora. Significant restriction of the shallow-water areas occurred during the Late
Carboniferous. These geological events defined the evolution and biogeography of
calcareous algae.
The roots of very scanty Bashkirian algae flora are possible to find in Early-Carboniferous-late Visean and Serpukhovian. Bashkirian algae flora could be named as "Donezella-algae flora". The Serpukhovian Predonezella can be treated like an ancestor of Donezella. It is possible that late relatives of Predonezella were Claracrusta and the first representatives of Beresellids-Dvinella. The assemblage of Early Carboniferous red algae (Ungdarella, Eflugelia, Masloviporidium and some genera of Stacheinaceae) almost do not change during the Bashkirian Age. The first appearance of Komia occurred at his time.

The Early Moscovian time was a period of expansion of Beresellids flora: Dvinella, Beresella and Samarella were distributed almost everywhere together with Donezella and Claracrusta. A very interesting assemblage of essentially red algae (Masloviporidium, Ungdarella, Cuneiphycus, Archaeolithophyllum, Fourstonella, Pseudostacheoides) together with Claracrusta and Donezella, but without any Beresellids, is in South America (Bolivia & Equador, Mamet, 1996).

A group of diverse green algal genera first appeared in the Late Moscovian on the background of diverse Beresellids. It includes: Ivanovia, Anchicodium, Eugonophyllum, Epimastopora, Macroporella, Gyroporella, Clavaporella, and Uraloporella. The appearance of mentioned algal genera occurred in regions of Tethys Basin (Fergana Valley, Precaspian Lowland and South Urals (as far south as 53 degrees north latitude) and the Cantabrian Mts., Spain (Racz, 1966).

In the other regions Beresellid algae-flora dominated until the beginning of Kasimovian time. A gradual extinction of Beresellids was followed by a replacement of them by phylloid algae: Ivanovia, Anchicodium, Eugonophyllum, Neoanchicodium. Also some new genera appeared: Epimastopora, Pseudoepimastopora, Globuliferoporella. Also, a Mizzia-like alga Cornutella Chuvashov, gen. nov. first appeared. The Late Carboniferous was the first appearance of a very important reef-building problematic organism - Tubiphytes.

Moscovian and Late Carboniferous algae have been well-studied in USA Midcontinent and in Arctic Canada. The taxonomic lists of the Moscovian algae of these regions are very similar and, on the whole, both of them are very close to assemblages of Moscovian algae of the Russian platform and Urals, but there are some differences. In Arctic Canada, and especially in USA, are very numerous Archaeolithophyllum, which formed small bioherms. These algae are very rare in Russia. Another speciality is more early (beginning of Moscovian): the first appearance of group of genera of phylloid algae. The conclusion about permanent connection between North America and Eastern Europe in Moscovian-Late Carboniferous should be made on the basis of the above data.

All the presented information makes it possible to draw a Moscovian - Late Carboniferous algal biogeographic sketch. A wide belt of rich taxonomic diversity of green algae could be traced from Central Asia, via South Urals, Precaspian Lowland to Cantabrian Mts. (Spain). This belt could be treated like tropical zone. To the south is situated a zone with relatively scanty algal assemblage: Vietnam, South China (Guizhou), Northern Africa (Tunisia). This zone could be followed in South America (Bolivia & Equador) where Beresellids are absent. The territory of Eastern Europe (to the north from 53 degrees latitude) can be divided in two sublatitudal belts. The zone between 53 and 60 degrees north is characterised by numerous Beresellids and some phylloid algae (Ivanovia is very useful here). To the north from 60 degrees, the Moscovian assemblage is represented by mostly red algae Ungdarella, Komia, Petchoria. The phylloid algae were useful in Late Carboniferous.
DAI Y., ZHU J., CHEN M., WANG Y. and SHENG J.

Iron microbialite in the Early-Middle Proterozoic Era, Xuanlong area of North China

Xuanlong oolitic iron ore deposit in North-western Hebei is a unique iron ore deposit in the world for extensively developed small columnar iron stromatolites. It formed at the Early-Middle Proterozoic Era, about 1.8 Ga age, and occurs in the lower part of the Chuanlinggou Formation of Changcheng system.

The types of the iron microbialite in the iron ore are mainly oolitic (fine oncolite) iron ore, secondarily stromatolitic and pisolithic (coarse oncolite) ones, and scarcely laminitic and microbialitic ones. The occurrence sequence of iron microbialite from nearshore to offshore is laminate --> columnar stromatolite. (Nucleela) --> lamino-columnar stromatolite (Gruneria, Parmites, Omatochenia) --> columnar stromatolite (Kussiella --> Parrinzeria and Pangjiapuella --> Eucapsiphora) --> coarse oncolite --> fine oncolite.

The iron microbialites consist of four kinds of microstructural laminae: pelletal, silky, fibrous and clast-bearing pelletal laminae, which are all made up of biominerlalized bacteria and hematite (or siderite and chamosite) foliates or fibers. The pellet is a hemated coenobium, a kind of colony with constant shape, composed of iron or blue bacteria.

The fossil bacteria discovered in the iron microbialite are as follows. Iron bacteria: Nummanniella neustonice (larger straight rod), Nummanniella (minor smaller curved rod), Ochrobium sp. (sheathed elliptical aggregate of sphere), Crenothrix sp. (sheathed and false branching long-chain rods), Lieskeela sp. (sheathed and double-twinned long chain rods), Siderocapsa eusphaera (sheathed and spherical aggregates). Cyanobacteria: Myxococcoides sp. (sheathed spherical aggregates), Eosynechocystis sp., Globophycus sp. (sheathed chain spheres), Biocatenoid sp. (chain spheres), Bigeminicoccus sp. (sheathed tetrad sphere), Micrococcus tetragons, (sheathed tetracoccus sphere), Anabaena sp. (sheathed, septulate and contract filament), Siphonophycus sp. (long and thick tube with developing sheath).

We propose a new genetic mechanism of the iron microbialite. At the Early-Middle Proterozoic Era, an oxygenated atmosphere had been established, the density-stratified ocean system started to break down, and intermediate-basic volcanic magma erupted a great deal along the fault rift and brought much more ferrous iron into bottom water of the ocean. Upwelling deeper anoxic water carried much more ferrous iron and carbon dioxide in the form of Fe (HCQ₃)₂ into surface oxygenated waters, especially in shallow shelf, such as Xuanlong gulf, where water was permeated with oxygen gas produced by cyanobacteria and other oxygenic photosynthetic bacteria. The iron bacteria used the oxygen gas to oxidise soluble ferrous iron into insoluble ferric iron, precipitating amorphous ferric oxide, then transforming into hematite. Benthic cyanobacteria and iron bacteria formed microbial mats on sea bottom or membranes on fragments, and concentrated hematite on the mat or membrane by agglutination, precipitation and biominerlalization. Hematite microbialite was formed under their co-operation.
GHOSH A.K.

Late Oligocene (Chattian) coralline algae from southwestern Kutch (mainland India), and their palaeoenvironmental significance

In the western margin of India, Kutch Basin is a peri-cratonic rift basin that has preserved almost a complete sequence from Triassic to Recent. The Kutch Basin extends far to the west over the present continental shelf. Recently, the Oil and Natural Gas Corporation Limited (ONGC Ltd., India) has proposed a revised classification for the sedimentary basins of India with special reference to hydrocarbon prospect. Kutch Basin has been included in the category of basins with hydrocarbon accumulation, but without commercial production. Most of the petroleum reservoirs of India are known from Tertiary sediments. The type sections or stratotypes of the Tertiary rocks are recognised in southwestern Kutch Mainland (Kutch District, Gujarat). Kutch Basin with its well-developed fossiliferous Tertiary sequence is considered as a Tertiary stratotype for shallow marine sediments of India. Significant contributions have so far been made on the biostratigraphic studies of Tertiary sequence of Kutch. However, the record of fossil algae from the Tertiary rocks of Kutch is very scanty and obviously fragmentary.

The present study on coralline algae has been carried out from the Late Oligocene (Chattian) limestone belonging to Bermoti Member of Maniyara Fort Formation, Kutch Basin. Samples for the present algal study were collected from the type section The type section is continuously exposed along the Bermoti stream flowing between Maniyara Fort and Bermoti Village (co-ordinates - north 23º25'00": east 68º35'00") from a locality about 1.6km NNE of Bermoti to a locality about 450m SE of the Bermoti Village. Lithologically, the Maniyara Fort Formation consists of bedded, yellow to ochre-coloured foraminiferal limestone with a basal greyish green, glauconitic siltstone. Based on the characteristic faunas, an Oligocene age has been assigned for the Maniyara Fort Formation. This formation overlies the Fulra Limestone Formation of Late Middle Eocene age. Maniyara Fort Formation is further divided into four members. Bermoti Member is the uppermost member of this formation and is about 11m thick. Rusty brown, friable, glauconitic argillaceous sandstones with pseudo-oolites characterise the lower part of Bermoti Member. The upper part is composed of thinly bedded, very hard, grey to yellowish foraminiferal limestone (biomicrites), which yielded a fairly rich algal assemblage. Bermoti Member has been dated as Late Oligocene (Chattian) on the basis of typical faunal assemblage. The algal forms recovered in thin sections from the Late Oligocene (Chattian) limestones of Bermoti Member is dominated by coralline red algal species belonging to the genera Lithothamnion, Mesophyllum and Lithophyllum. Bathymetric analysis of the algal forms as well as other supportive evidences indicate a shallow marine condition and in all probability a rather high energy open shelf environment existed during this time when the algal forms thrived.

GHOSH A.K., MAITHY P.K., and KUMAR G.

Dasycladacean green algae from the Ordovician of Spiti Basin, Tethyan Himalaya, Himachal Pradesh, India and their connotation in palaeoenvironment

The Spiti area of fascinating 'Tethys' Himalaya tenders a noteworthy sequence of formations ranging from Precambrian to Cretaceous times. The majority of the formations has excellent exposures though the accessibility to many of these
sections is limited. In the Spiti valley, Himachal Pradesh, India, the Ordovician-Silurian sequences constituting the Thango and Takche formations are well exposed at Muth in the Pin river and at Gechang in the Parahio river sections. Two contrasting lithological successions occur between the underlying fossiliferous Parahio Member of Kunzam La Formation and the overlying Muth Formation, the lower succession is unfossiliferous and is designated as Thango Formation. It consists of purple-coloured conglomerate along with quartzite, shale, siltstone, grit and is divisible into 4 units. Thango Formation rests over the Parahio Member with an angular unconformity. The upper fossiliferous sequence is referred to as Takche Formation, conformably overlying the Thango Formation. It includes 5 units of Ordovician and 3 of Silurian and is characterised by its rusty brown coloration on weathered surfaces. It comprises mainly a sequence of slate, greyish blue argillaceous limestone, dolomite and grey siliceous, flaggy limestone with marls. The Takche Formation attains a maximum thickness of about 245m and has been classified into three members viz, A, B and C. Based on chitinozoa, an Ordovician age has been ascribed for the members A and B. The Ordovician-Silurian boundary exists within the basal part of member C.

In the early part of 20th century, somewhat problematical and curious fossils were recorded from unit 3 of Member A belonging to Takche Formation (Late Ordovician). These problematical curious objects were described previously as Incertae sedis, referable to genera allied to *Pasceolus* or *Mastopora* and *Apidium*. The true biological affinity of these forms was not understood until these objects were definitely proved to be plant remains of marine dasycladacean green algae. Later on, these so-called ‘Incertae sedis’ were identified as *Coelosphaeridium shianense* and *Apidium indicum*. For the first time two species of *Cyclocrinites* i.e. *C. pyriformis* and *C. favus* belonging to Dasycladaceae have been recorded from unit 5 of Member A belonging to Takche Formation (Late Ordovician). Cyclocrinitids, an extinct tribe of Dasycladaceae have a narrow stratigraphic range extending from Middle Ordovician to near the Lower Silurian. It is well established that presence of Dasycladaceae in abundance indicates shallow water. Moreover, it is assumed that cyclocrinitids were commonly restricted to quiet water environments and probably they were vulnerable to strong water currents and were most common at relatively shallow depths, below wave-base. The overall dasyclad-rich algal flora from the Late Ordovician of Spiti Basin, Tethyan Himalaya also reveals the widely accepted view that the Ordovician period with its widespread shallow seas, mild climates and extensive areas of carbonate deposits should have supplied the proper environmental background for extensive development of algae.

**GRGASOVIC T. and SOKAC B.**

*Teutloporella* PIA and *Euteutloporella DE CASTRO* (Dasycladales, Green Algae) from the Triassic of Croatia

PIA (1912) established the genus *Teutloporella* and included species with thin trichophorous branches, essentially aspondyl, but sometimes euspondyl. As the type-species he chose *T. herculea* (STOPPANI). BASSOULLET et allii (1978) emended the genus to include only the aspondyl species, and the euspondyl ones were moved into the new genus *Neoteutloporella* with the type-species *N. socialis* (PRATURLON). After the discovery of two-order branches in *N. socialis* DE CASTRO (1993) changed the diagnosis of the genus *Neoteutloporella*, and established the new genus *Euteutloporella* included the euspondyl species with trichophorous branches. As the
type-species he chose *E. triasina* (SCHAUROTH). The establishment of this genus demands for a generic testing of the remaining species attributed to the genus *Teutloporella*.

In this work, species collected from the Middle Triassic carbonates of Croatia will be elaborated: *Teutloporella herculea* (STOPPANI) PIA has a relatively big cylindrical thallus (seldom slightly claviform) with wide central cavity. Thin trichophorous branches are inclined and slightly concave. They have aspondyl arrangement. Range: Ladinian, seldom Carnian-Norian (Langobardian of Croatia).

*Teutloporella tabulata* PIA has a cylindrical thallus with sporadically pronounced fissuration. The branches are somewhat thicker and taper towards the end (trichophorous type). The arrangement of the branches is aspondyl to mesospondyl (as in *Macroporella alpina* PIA). Range: Bithynian-Lower Illyrian (Pelsonian-Lower Illyrian of Croatia).

*Euteutloporella peniculiformis* (OTT) n. comb. has a cylindrical thallus with the fox-tail shape, and with a very narrow central cavity. It is often disintegrated into funnel-shaped fragments. Very thin trichophorous branches are inclined and mostly curved. They are arranged into compact and close whorls. Range: Pelsonian-Fassanian.

*Euteutloporella triasina* (SCHAUROTH) DE CASTRO has an annulated cylindrical thallus with inclined and concave furrows. The intensity of annulation is variable. Trichophorous branches are also inclined and concave. They are arranged into close whorls. Range: Illyrian-Ladinian.

Among the other species of the genus, as can be concluded on the basis of their protologues, *Teutloporella echinata* OTT and *Teutloporella maxima* OTT should retain their generic position, while others should be the scope of further investigations based on the type-material. *Teutloporella nodosa* (SCHAFHTL) PIA does not belong to this genus (= *Diplopora nodosa* SCHAFHTL, *emend.* DE CASTRO).

**GRGASOVIC T., SOKAC B., and HALAMIC J.**

*Salpingoporella scopuliformis* n.sp. (Dasycladales, Green Algae) from the Middle Triassic of Croatia

The new Dasycladalean species *Salpingoporella scopuliformis* n. sp. was identified in the Pelsonian (Anisian, Middle Triassic) limestones from the Belski dol quarry (Ivancica Mt., NW Croatia). The new alga is characterised by a cylindrical thallus with a very narrow central cavity. The thallus is often disintegrated into fragments. The branches swell above the thin basal part, and have slightly increasing (in some cases uniform) diameter along the most of their length. At the distal part they slightly expand (phloiophorous type), and probably touch each other forming an irregular cortex. Branches are arranged into close whorls and placed obliquely to the longitudinal axis. The euspondyl arrangement is well visible in the proximal part of the branches, but in the distal part the arrangement is more or less irregular and resembles a broom (lat. *scopulae* - small broom; *forma* form, shape). The euspondyl arrangement of the phloiophorous branches give rise to assigning the new alga to the genus *Salpingoporella*. The authors are aware that this genus includes a very wide range of forms.
Other *Salpingoporella* species are easily distinguishable from the new species in having a relatively wider central cavity. The majority of them have more pronounced distal swelling of the branches. Regarding Triassic species of this genus, Carnian *S. humilis* (BYSTRICKY) is smaller and has convex and thinner branches, while Ladinian-Norian *S. spectabilis* (BYSTRICKY), Carnian *S. sturi* (BYSTRICKY), and Carnian *S.? tibetica* FLUEGEL & MU have branches perpendicular to the longitudinal axis.

The new species resembles *Euteutloporella peniculiformis* (OTT), which also has a very narrow central cavity and often disintegrates into fragments, but has very thin and mostly curved trichophorous branches. *Macroporella alpina* PIA has somewhat similar external morphology and distally expanded branches, but with the wider central cavity, and the aspondyl to mesospondyl arrangement of the branches.

At the type-locality *Salpingoporella scopuliformis* n. sp. was found together with other dasycladaleans: *Oligoporella cornuta* (O. *pilosa* var. *varicans*), *Oligoporella pilosa*, *O. varicans* (Ph. *varicans*), *Physoporella pauciforata* var. *pauciforata*, *Ph. pauciforata* var. *sulcata*, *Euteutloporella peniculiformis*, and foraminifera *Meandrospira dinarica*. This assemblage clearly determines the Pelsonian age. The palaeoenvironment can be interpreted as a back-reef. Besides the type-locality, the new species has been found at several localities in the Croatian Outer Dinarides together with dasycladaleans typical for the Pelsonian-Lower Illyrian Range:

*Oligoporella*-Physoporella species, Diplopora *proba*, Teutloporella *tabulata*, Macroporella *alpina* and Euteutloporella *peniculiformis*.

**GRGASOVIC T. and SOKAC B.**

**Triassic Dasycladales from Croatia: a Review**

This review of dasycladalean fossil associations in the Middle and Upper Triassic of Croatia is given on the basis of re-examination of abundant material collected in the course of geological mapping during the sixties and the seventies (scale 1:100,000), and during the last few years (scale 1:50,000), as well as on the basis of the literature data (Herak, Sokac, Grgasovic). The emphasis is on the stratigraphical ranges of particular species and associations, inspired by the work of Bystricky (1986).

The first association that appeared in the lowermost Anisian (? Aegean) includes *Diplopora cellulata*, *Diplopora proba*, Poncetella *hexaster* and *Poncetella helvetica* (Aegean-Pelsonian), as well as *Diplopora subtilis* (Aegean-Lower Illyrian). Subsequently (? Bithynian) appeared the *Oligoporella*-Physoporella association including species: *Oligoporella cornuta* (= *Oli. pilosa* var. *varicans*), *Oli. dissita* (= *Ph. dissita*), *Oli. minutula* (= *Ph. minutula*), *Oli. pilosa* var. *intusannulata*, *Oli. pilosa* var. *pilosa*, *Oli. praepilosa* (= *Ph. praepilosa*), *Oli. varicans* (= *Ph. varicans*), *Physoporella pauciforata* var. *pauciforata*, *Ph. pauciforata* var. *sulcata* and *Ph. pauciforata* var. *undulata*. The *Oligoporella* - Physoporella association, together with Macroporella *alpina*, has its maximum in the Pelsonian and Lower Illyrian. Physoporella *croatica* (Pelsonian) and Teutloporella *tabulata* (Pelsonian-Lower Illyrian) also appeared in this interval, as well as *Euteutloporella peniculiformis* which is frequent during entire Pelsonian - Fassanian range.
The less numerous *Euteutloporella triasina*, *Diplopora nodosa* and *Diplopora annulatissima* (in the “classical” form, and in the form of *Favoporella annulata*) have been found in the Lower Illyrian layers, besides the already mentioned species. These three species, together with *Macroporella beneckei*, have their maximum in the Upper Illyrian and Fassanian. The Anisian-Ladinian border is marked by the appearance of the species *Diplopora annulata* and *Kantia dolomitica*, which are frequent through the entire Ladinian. In the Fassanian they are associated with the already mentioned Illyrian species, as well as the less frequent *Physoporella lotharingica* and *Clavapora clavaeformis*. In the Langobardian they are associated with *Teutloporella herculea*, as well as less frequent *Euteutloporella triasina* and *Diplopora nodosa*. The Carnian is characterised by the species *Clupeina besici*. In the Norian, *Dissocladella bystrickyi*, *Physoporella jomdaensis*, *Gryphoporella curvata*, and *Gyroporella vesiculifera* appeared, the last two of them being frequent in the Rhaetian together with foraminifera *Triasina hantkeni*.

**KERSHAW S., GUO L., and FAN J.**

**Origin of a carbonate crust at the Permian-Triassic boundary interval in Sichuan, China: organic or inorganic?**

Outcrops of Late Permian Changxing Formation reef complexes in east Sichuan are directly overlain by deposits of the Permian-Triassic Boundary Interval. The reefs are capped by a recrystallised carbonate crust, c. 1m thick, which has a predominantly digitate structure, in which most branches have lobate margins. The crust has not yet been dated or tied to a specific biostratigraphic horizon, but coincides with the termination of the reef complexes, and sediments amongst and above the branches of the crust have impoverished biotas. The crust is therefore associated with the end-Permian mass extinction event. The nature of the crust is unclear, but previous interpretations of it representing evaporites or calcretes are not consistent with its structure. Instead it exhibits a microbialite character, with a clotted internal fabric in most samples. However, a radial fabric in one sample superficially resembles a *Solenopora*-like alga. The crust is sharp-bounded top and bottom, and is internally layered. Its abrupt appearance and disappearance in the boundary interval appears to be a widespread feature of that level in northeast Sichuan Province over a distance of at least 240 km, and probably represents a major regional event. Evidence so far shows that the crust mostly formed on reef complexes, extending for only short distances beyond their edges, and wedges out down reef flanks; the crust has not been found in deeper facies, and it is therefore related to local topographic highs. The facies immediately overlying the crust are water-lain, and the sum of evidence so far indicates a sea-level rise in the interval.

Interpretations of the crust include:

1. inorganic cement growth on the seabed (but it is unlike cement botryoids found in Permian reef complexes and some Early Triassic deposits);
2. microbial (or microbially-mediated) cement, similar to Proterozoic precipitated stromatolites;
3. Part of the crust may be a skeletal frame of a *Solenopora*-like red alga.
The crust architecture is more like an organic than an inorganic structure. Unfortunately, all samples collected show diagenetic alteration, presently precluding unequivocal identification of its nature. If organic, the crust might represent either a “disaster biota”, following vacation of ecological niches after the mass extinction, or an episode of enhanced calcification involving microbial organisms. If inorganic, it could be the result of an inorganic calcification process. In either case, the crust may have been environmentally stimulated by rapid changes in seawater chemistry, leading to a relatively short-lived large concentration of seawater bicarbonate.

KHODJANYAZOVA R.R.

Calcareous algae assemblages from the Upper Paleozoic of southern Fergana (Middle Asia) and their facies distribution

Four algofloristic assemblages are distinguished here from a study of the calcareous algae of the stratotypic Karachatyr section. They have stratigraphic significance. The deposits of the Shunkmasar and Dzilginsay suites (C2m2-C3ks) are characterised by the development of the *Clavaporella-Beresella* association. In the Uchbulak suite (C3ks) members of the Gyroporelleae are abundant. A quasigyroporellid assemblage has been distinguished. The Dastar suite is characterized by the *Alpinogyroporella* association, which replaced the Uchbulak algoflora. Increasing abundance of pseudogyroporellids distinguishes the Kerkidon (P1as) suite. Comparative taxonomy of the Upper Paleozoic algofloristic assemblages from the Karachatyr section and their facies distribution allow three main types of algal association to be recognized, characterized by various combinations of dasycladacean, codiacean, and red algae, blue-green algae, and Problematica. These assemblages show changes in both space and time.

The associations are as follows: 1) the combined associations dominated by dasycladaceans, 2) associations consisting of phylloid algae, 3) associations dominated by a symbiotic relationship between the dasycladacean *Anthracoporella spectabilis* Pia and the blue-green alga *Tubiphytes obscurus* Maslov. All three types of the associations existed in shallow tropical marine seas of normal salinity. However, several bionomic zones can be noted. Association (i): Beresellids, clavaporellids, quasigyroporellids, alpinogyroporellids and pseudogyroporellids, characteristic of nearshore and offshore banks. The former three are typical of nearshore banks. The other two are typical of offshore banks. Association (u): *Paradella*, *Eugonophyllum*, *Neoanchicodium* and phylloid algae (generically indeterminate due to recystallization). The *Paradella* association in the Shunkmazar and Dzilginsay suites characterizes zones of littoral banks. The phylloid association of the Dzilginsay suite characterizes stagnant zones of littoral depressions. The *Eugonophyllum* association is present in the Uchbulak suite and is connected with littoral bank environments. In the Dastar and Kerkidon suites it is present both in the zones of offshore banks and in offshore interbank areas. This association is also abundant in the lagoon zone (the Dangibulak suite), where deviation of salinity from normal marine is noticed. The *Neoanchicodium* association is distinguished in the offshore bank zone in the Kerkidon suite. The third algofloristic association (*Anthracoporella*, *Tubiphytes*) shows little variation in taxonomic composition and was found in almost all the suites of the Upper Palaeozoic. In the Shunkmasar and Uchbulak suites it is linked with zones of the littoral depressions. In the Dastar and Kerkidon suites it is connected with the offshore and interbank zones, and in the Dangibulak suite with the lagoon zone.
KOLAR-JURKOVSEK T. and JURKOVSEK B.

Clypeina in the Belca section of the Karavanke Mts., Slovenia

Biostratigraphic studies of Triassic strata in the Southern Alps of Slovenia included a detailed sampling of the Julian-Tuvalian beds of the Kouta overthrust. In the Belca valley (Karavanke Mts.) these beds attain thickness of some hundreds of meters (Jurkovsek, 1987). The examined rock succession is formed of platy and bedded limestone; mainly in the lower part of the section, close to the Cordevolian dolomite, it contains chert lenses and nodules. In certain horizons there occur frequent beds and sheets of marly limestone and marl, as well as some (up to 0.5m thick) breccia layers.

The upper 85m of the Julian-Tuvalian succession, near Slovenian-Austrian boundary was sampled. Only three samples yield conodont apparatus Nicoraella ? budaeensis whereas other samples contain calcareous algae, sponge spicules, ostracods, holothurians and fish remains. Samples of the uppermost part of the section that includes also layers of breccia produced isolated whorls of alga Clypeina as well as a 7.3cm long thallus of exquisite preservation. The material from the Karavanke Mts. that contains also several parts of the thalli embedded in the slabs of marly limestone provides new information to the morphology of the dasyclad genus Clypeina. Foraminifers Agathammina austroalpina, Nodosaria ordinata, Pilaminella kuthani, Aulotortus sinusus and Permodiscus pragoides were determined in thin sections (Jurkovsek, 1987). Badly preserved ammonoids, echinoids and numerous posidonias occur frequently in the examined part of the section. In the marly limestone and marl well-preserved fishes of the genus Peltopleurus and plant remains Voltzia can be found. Ammonoids Trachyceras aonoides and Austrotrachyceras austriacum were collected in the lower part of the Julian-Tuvalian rock succession of Belca (Ramovs, 1993). The beds of Belca in the Karavanke Mts. and the contemporaneous beds of Beli potok in the Julian Alps were correlated by Ramovs (1993) and he stated that identical depositional conditions occurred in both areas during Middle and Upper Carnian.

References:


KUNDAL P. and WANJARWADKAR K.M.

Rivularia and Ethelia from Thanetian limestones of Middle Andaman Island, Andaman, India

Algal limestone olistoliths belonging to the Burma Dera Member of Baratang Formation are exposed at Burma Dera, Tugapur, Pahalgaon and Budha Nala localities of Middle Andaman Island, Andaman. The limestone is Thanetian in age. Eight species of Rivularia, a genus of family Cyanophyceae of division Cyanophyta, are present; these are R. carpathica Dragastan, Rivularia sp. cf. R. diana (Dragastan
and Bucur) Dragastan, *R. fruticulosa* (Johnson and Kaska) Dragastan, *R. kurdistanensis* (Elliott) Dragastan, *R. lissaviensis* (Bornemann) Dragastan, *R. piae* (Frollo) Dragastan, *R. tadeuszi* Dragastan and *R. theodori* Dragastan. Also there are five species of *Ethelia*, a genus of family Squamariaceae of division Rhodophyta, viz.: *E. alba* (Pfender) Massieux and Denizot, *E. andamanensis* sp. nov., *E. badvei* sp. nov., *E. squamosa* Kundal and *E. tugapurensis* sp. nov. are discovered. These species show Tethyan affinities. The species of *Rivularia* and *Ethelia* occur in association with Dasycladacean algae and this indicates that the limestone was deposited in shallow marine tropical water at a depth of 10-12m below low tide level.

**LI G.**

**Early Cambrian phosphate-replicated endolithic algae**

Although endolithic microorganisms, which penetrate shells, skeletal fragments and ooids through chemical or mechanical means, are ubiquitous in the modern marine environments ranging from supratidal and intertidal to depth over 4,000m, limited endoliths have been observed from the geological record of Pre-Pleistocene. The reason is mainly due to that the modern techniques applied to study endolithic microorganisms are no longer applicable after the cavities made by the endoliths have been destroyed by diagenesis (Runnegar, 1985). Nevertheless, endolithic microborings, which were preserved by the secondary fillings of phosphate, limonite, micrite, sparite, and pyrite during early diagenesis, have been described from geological records ranging from Precambrian to Mesozoic. And further, the study of fossil microborings has been taken as a new and discrete subfield of micropalaeontology and ichnology (Golubic et alii, 1984).

The explosive occurrence of diverse skeletal fauna during early Cambrian time provided a new kind of substrate for the endoliths, and boring microorganisms are mainly attached to skeletal fauna. The early Cambrian is an important period for phosphogenesis in the geological record. Widely occurring replacement and cementation of phosphate is the distinct feature of the early diagenetic environments during the phosphogenesis event. This diagenetic environment is of significance for the preservation of both the skeletal fossils and the microborings within the skeletons. The composition of most early Cambrian skeletal fossils might be originally calcitic or aragonitic during diagenesis, they were usually preserved as phosphatic moulds or steinkerns through the phosphate replacement or cementation. The microborings produced by the endoliths within the skeletons were also preserved as phosphatic casts through the filling of diagenetic phosphate, and consequently, by acetic acid etching, the phosphate-replicated microborings could be examined under inner sides of the partly phosphatized skeletal fossils or on the surfaces of the phosphatic steinkerns.

These phosphate-replicated endoliths have been examined from the Lower Cambrian strata of Australia, Siberia and south China, and they are usually attached to skeletal fossils, such as hyolithids, *Paracarinachites*, lathamellids, Zhijiniids, mollusks, etc. Morphologically, most of these endoliths are filamentous cyanophytes, including *Eohyella*, *Cunicularius* and *Endoconchia*, and other algae with uncertain affinity, including both solitary and colonial ellipsoidal vesicles.
Llanvirnian acritarchs from the Yangtze Platform of South China

A well-preserved acritarch assemblage has been found from the Shihtzupu Formation at Honghuayuan section, Tongzi County of Guizhou Province (Yangtze Platform, South China). The palyniferous sample of yellow-green shale is from the Didymograptus murchisoni Biozone hence it is dated as Late Llanvirn in age.


Among them the most common are Polygonium (13%), Multiplicisphaeridium (9%), Micryhystridium (9%) Coryphidium (7%) and leiosphaerids (12%). Veryhachium, Baltisphaeridium and Cymatiogalea are common as well. The abundance and high diversity of taxa within the acritarch assemblage suggests a marine site for the Shihtzupu Formation. The prevailing leiosphaerids in the assemblage may imply the shallow-water environment of the Shihtzupu Formation, even shallower than the Meitan Formation of the same section.

The occurrence of Arbusculidium, Coryphidium and Striatotheca in the Shihtzupu Formation confirmed the inclusion of the Yangtze Platform within the Perigondwanan Acritarch Paleoprovine in Llanvirnian times. Tongiogi et ali (1998) concluded that the possible inclusion of South China within the Perigondwanan (Mediterranean) Acritarch Paleoprovine can only be confirmed for early Arenigian times. According to them, near the end of Arenig, the Perigondwana markers Arbusculidium, Coryphidium and Striatotheca are missing and typical Baltic taxa Baltisphaeridium, Peteinosphaeridium and Goniosphaeridium can be found encroaching in the Yangtze Platform. We differ with them for the following reasons: 1. The Perigondwana markers Arbusculidium, Coryphidium and Striatotheca have been found in Late Arenigian-Llanvirnian rocks at several localities of Yangtze Platform such as Xiliangsi Formation of Shaanxi (Fu, 1986), Sichuan (Fang, 1990), Zitai/Shihtzupu Formation of Southeast Sichuan (Brocke 1997) and Shihtzupu Formation of Guizhou (this paper). 2. So-called Baltic taxa Baltisphaeridium, Peteinosphaeridium and Goniosphaeridium can be found not only in the Late Arenigian but also in Early Arenigian of Yangtze Platform. That is why we proposed that the affinity to the Mediterranean (Perigondwana) province should be determined by the occurrence of Arbusculidium, Coryphidium and Striatotheca instead of the prevalence of diacromorphs or of acanthomorphs (Li, 1989). An explanation for the occurrence of the cold-water acritarch assemblage in Early Ordovician Yangtze Platform was proposed by J. Li (1991) and supported by some colleagues (Yin, 1995; Tongiorgi et ali, 1995): the ocean current circulation made the Yangtze Platform be bathed by
cold water mass, hence many cold water taxa occurred in the Yangtze Platform of South China.

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LI J., LI Y., and BROCKE R.

Planktonic algal microfossils from Early Silurian of northern Guizhou, South China

Planktonic algal microfossils have been discovered from Lower Silurian of northern Guizhou, South China. The assemblage contains Prasinophyceae, Chlorophyceae, acritarchs with the association of scolecodonts and chitinozoans.

The Llandovery (Silurian) of the Baisha section at Shiqian County of northern Guizhou has been divided into Lungmachi Formation, Xiangshuyuan Formation, Leijiatun Formation, Majiaochong Formation, Rongxi Formation, Xiushan Formation and Huixingshao Formation in ascending order. The present microfossil assemblage is found from the Xiangshuyuan Formation, Leijiatun Formation and lower part of Majiaochong Formation.

Xiangshuyuan Formation, dated as late Rhuddanian to early-middle Aeronian and 57.9m in thickness, comprises limestones with shale intercalations and contains Prasinophycean algae *Leiosphaeridia*, and scolecodonts. Leijiatun Formation, dated as late Aeronian and 33m in thickness, comprises shales interbedded with limestones and yields Prasinophyceae *Leiosphaeridia*, Chlorophyceae *Dactylofusa* and scolecodonts. Majiaochong Formation, early Telychian in age and 30m in thickness, comprises yellow-gneen mudstones and yields richer microfossils: apart from *Leiosphaeridia, Dactylofusa*, scolecodonts, acanthomorphic acritarchs like *Tylotopalla, Diexallophasis, Micrhystridium* and chitinozoans occur in the lower part of the Majiaochong Formation.

The increase of microfossil diversity and abundance throughout the three formations suggests that in the Yangtze Platform some fossil groups like planktonic algae, acritarchs and perhaps chitinozoans as well, after the Late Ordovician mass extinction, recover in the Aeronian and start to radiate again in Telychian.

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LI Y., LI J., and XUE Y.-S.

Calcereous algae from Early Llandovery of Shiqian, Guizhou, South China

The start and the end of continental glaciation on Gondwana with the resultant eustatic changes, caused two main episodes of mass extinction in Rawtheyan and Hirnantian times by the end of Ordovician. It is especially well represented in South
China. During the second mass extinction period, most of Yangtze Platform deposits are graptolitic black shales, however, only some limited carbonate platforms from Kuangyinqiao Formation (Hirnantian) in age coincide with the start of a regression, occurred near the Qianzhong Oldland, Shiqian, Guizhou. These limestone beds were representative of survival interval during mass extinction period and they contain crytolites and very rare biodebris. Lungmachi Formation, lower part of Rhuddanian, comprises of black, green and yellow graptoloid shales and thin-bedded crytolitic limestone. The limestone platforms with shelly faunas began its recovery interval on the base of Xiangshuyuan Formation, upper Rhuddanian, and its radiation interval with reef buildups at the top of Xiangshuyuan Formation and Leijiatun Formation, Aeronian. Generally, calcareous algal taxa can extend much longer than that of metazoa and most of them can survive during the extinction periods. The recovery and radiation interval is not the same as that of the metazoa. To divide each interval depends on their diversity and richness in sediments. From material of Shiqian, the diversity of calcareous algae is extremely low in biostromes with only some thrombolites, *Girvanella* and *Solenopora*, etc. Most of them are on the surface of biodebris and bound limemud, but are not main components of the rocks. The diversity and thickness of calcareous algae in the reefs is higher than that in the biostromes. This indicates the recovery interval of calcareous algae. Generally, the diversity and richness of calcareous algae from this region are much lower than that in the large-scale buildups, especially in the lime-mudmounds reefs of pre-mass extinction, middle Ashgillian, border area of Zhejiang and Jiangxi. From Rhuddanian to Aeronian, the calcareous algae have not recovered to the level of pre-extinction. It may be that mudmound settings are the best conditions for calcareous algae preservation and we have not found these buildups in the Shiqian area. However, the conclusion can be made that the procession of calcareous algal recovery is slower than that of crytolites. Calcareous algae began their radiation interval and as a main builder of biostromes and reefs by the end of Telychian, in the northwest margin of Yangtze platform. It indicates that crytolites are more important indications of environmental recovery from aftermath in the margin area of Qianzhong Oldland than that of calcareous algae.

**LIU Z. and LIU X.**  
Artificial algal mats and biomineralization  
A plan of the development on large scale algal mats has been carried out in Guang Rao Salt-work, Shandong Province, China. The thickness of algal mats cultured by artificial inoculation for three years came up to 2.5 cm. The sediment microzones with relating redox-gradients which are developing in the algal mats on the test part floors have a strong influence on the mobilization and fixation of irons. Because the organic or inorganic sediments and binding between the organic matters of the mats and sand of clay, decrease 60%-84% of quantity of permeating water, the permeation-protecting and purifying effects created by mats are very important for the pro ducts of marine salt.  
* This work was supported by the National Natural Science Fund.

**LUCHININA V.**
Organogenic buildups and calcareous algae in the Siberian platform at the threshold between the Vendian and Cambrian

Stromatolithes occupied a vast areas within the littoral zone of the Siberian basin, beginning in Later Riphean throughout the Vendian period; their number reduced steadily related to a regressive cycle, which changed the regime of epicontinental sea during this time. New types of buildups, which were formed by calcareous algae, replaced stromatolithes. These buildups occupied a shallow shelf and their appearance is associated with a number of crisis events at the boundary between 535-550 Ma. Late Vendian-Cambrian organogenic buildups have been formed by the association of calcareous algae (Calcibionta or Calcinicrobes) and destructive bacteria. These were the main producers of calcareous mass and lithified bioherms. The area of expansion of buildups at the end of the Vendian and across the Vendian-Cambrian boundary (the very beginning of the Tommotian stage) was on the Siberian Platform. This was much wider than the Sakhayskaya organogenic belt, which existed in Cambrian. The thickness of Cambrian buildups was largely due to Archaeocyathus.

The buildups at the threshold between the Vendian and Cambrian were composed of calcareous algae Renalcis, Girvanella, Subtifloria, Korilophyton, and calcareous cover remained of them alone, that had microscopic sizes and granular microstructure characteristic of all calcareous organisms of the Early Cambrian. The deficiency of morphological features allows no confident systematic assignment of these algae; nevertheless the analyses of Riphean and Vendian non-calcareous (organic-walled and mineralized) algae flora suggests that calcification process took place not among new species, but among algae widespread in the Riphean. Against the background of the bulk of cyanobacteria there have already existed the representatives of Red and Green algae also.

MAKARIKHIN V.V.

Elements of the Mopanyu stromatolite assemblage in the Baltic Shield

1. Data available in the literature on Precambrian stromatolites in China show that their stromatolite communities are fairly bizarre. It seems, however, that a strong basis for the abundance of new taxa in these communities is not always provided. Formally, the stromatolite community characteristic of the upper part of the Gaoyuzhuang Formation and the lower portion of the Yangzhuang and Wumishan formations (assemblage III after Y. Liang et alii, 1985) does not contain any buildups that resemble stromatolites known in the Baltic Shield. It however, the pictures and characteristics of some genera and species of this community are compared with Upper Jatulian Karelian stromatolites, one is struck by some similarities first noticed by M.E. Raaben (1991). Some buildups that are thought to belong to the genus Schyphus may actually be analogues of the older stromatolites Butinella and Klimetia (Makarikhin & Kononova, 1983; Makarikhin, 1992). Therefore, these groups should be studied more closely.

2. The study of Chinese stromatolites from Early Precambrian units (Hutuo Group) has revealed quite a number of phytenic buildups typical of the eastern Baltic Shield such as Djulmekella, Nordia, Stratifera, Collumnacollenia rantamaa Kryl. et Pert., and Omachtenia kvartsimaa Kryl. et Pert. (S. Zhu & H. Chen, 1991). Although the isotopic ages of Precambrian Karelian and Chinese stromatolite-bearing suites
differ substantially in one case and are identical in another (D. Sun & S. Lu, 1985; Melezhik et alii, 1997), further studies are likely to make us substantially revise our concept of their real stratigraphic position.

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**MAKARIKHIN V.V. and MEDVEDEV P.V.**

System of stromatolites

It is proposed to combine phytogenic buildups to form the division Litophyta Div. nov. which falls into two subdivisions: Stromatolitophytina Subdiv. nov., buildups attached to the substrate, and Oncolitophytina (Pia, 1927), unattached buildups.

Stromatolites proper, Stromatophyceae (Kalkowsky, 1908), are considered a type class of attached buildups among others, e.g. Rodophyaceae (Boselli et Ginsburg, 1971), Thrombophyceae (Aitken, 1967), Ministromatophyceae (Raaben, 1980), and Stiriophyceae (Walter, 1976). Each of these classes is split up into four orders with regard for the dominant form of buildup called tentatively: a) columnar, b) barical, c) nodular, and d) stratiform. If the class Stromatophyceae is taken as an example, then they correspond to Collurnales (Koroljuk, 1960), Platellales, Ordo nov., Colleniales (Koroljuk, 1960), and Stratiferales (Koroljuk, 1960). In each order, columnar buildups are subdivided into two sub-orders in terms of the presence or absence of branching*, e.g. Gymnosolenaeae (Krylov, 1963), branching buildups, and Colonnellae (Komar, 1966), non-branching buildups. In other cases, an order falls into families with regard to the topographic ruggedness of stromatolite layers.
Let us discuss in more detail only the composition of the sub-order Gymnosoleneae (Krylov, 1963). It is subdivided on the basis of branching pattern into two families: 1) Gymnosolenaceae (Raaben, 1964), active branching stromatolites, and 2) Kussiellaceae (Raaben, 1964), passive branching ones. Distinguished in the former are several subfamilies: Gymnosolenoideae (Raaben, 1969) with the type genus Gymnosolena Steinman, 1911; Jacutoideae (Liang et alii, 1985) with the type genus Jacutophyton Shapovalova, 1965; Tungussoideae (Raaben, 1969) with the type genus Tungussia Semikhatov, 1962; and Kanpurideae Raaben, 1981. Passive branching buildups of Kussiellaceae incorporate wall-free columns, such as the subfamily Kussoideae (Konjuschkov, 1977), and columns restricted laterally by a more or less developed wall, e.g. the subfamily Coll umoideae Subfam. nov. with the type genus Collumnaefacta Koroljuk, 1960.

The classification scheme proposed covers all known formal genera of phytogenic buildups and shows stricter genetic relations between them.

* In the names of these taxa, the base of the word contains the roots of the name of a type family that are, in turn, derived from the name of a type genus.

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MATHUR S.C. and KUMAR S.

Geological nature and genesis of stromatolitic phosphorite of Birmania Basin, District Jaisalmer, western Rajasthan, India

The phosphorite of Birmania basin consisting of stromatolitic and bedded phosphorite represents a wide spectrum of phosphate types. The phosphorite of Birmania basin marks the Proterozoic-Cambrian phosphogenic event and boundary in northwestern India.

Stromatolitic phosphorite of Birmania comprises distinctly developed small domical to pseudocolumnar structures often laterally linked. They correspond to LLH-SH forms of Logan et alii (1964). The stromatolite columns are composed of alternate laminations of microcrystalline fluorapatite and carbonate minerals often studded with silt-sized quartz grains. The constituent laminations are moderately to steeply convex showing overlapping disposition and fairly good degree of inheritance. Their intercolumnar material is mainly clastogenic (coarse to medium quartz grains, phosphate clasts and some heavy minerals) and is cemented by phosphate or carbonate cement.

The detailed petrographic and geochemical analysis of stromatolitic phosphorite of the area suggests that they have been formed due to the in situ precipitation of phosphate influenced by the microbial communities in the intertidal areas of the Birmania Basin.

MOITRA A.K.

Exceptionally preserved facies-controlled algal remains of the Chhattisgarh Basin, M.P. India, and their significance
The Proterozoic Chhattisgarh basin comprising 200m-thick sedimentary rocks showing alternating clastic and non-clastic varieties is flanked by two major Proterozoic basins, namely Cuddapah to its South and Vindhyan to its north. The major portion of the basin falls in eastern Madhya Pradesh whereas a minor part extends to north-western part of Orissa, India.

The basin contains prolific growth and varieties of stromatolite restricted to only one unit, namely the Raipur Limestone. A rich variety of microfossils throughout the sequence, except in the basal sandstone unit, is noticed. The microfossils, which are dominantly cyanobacteria followed by acritarchs and green algae, are preserved mostly in grey and/or black pyritiferous calcareous shale and occasionally in black or grey pyritiferous chert. It is noteworthy that preservation in such calcareous shale is quite good, so much so that individual forms can be clearly seen and identified in thin section. Thus the prevalent idea that microbiota in case of Precambrian rocks can best be seen in cherts does not hold well. In case of Chhattisgarh basin, rocks showing evidence of reducing environments are potentially rich in microbiota.

The cyanobacteria assemblage is dominated by Oscillatoriaceae family in terms of abundance and varieties represented by the forms Oscillatoriopsis spp., Eomycetopsis spp., Siphonophycus spp., Cyanonema spp., Gunflintia spp., and Schizothrix sp. These are followed by family Chroococcaceae represented by Myxococcoid sp. and Gleocapsamorpha sp. and Rivulariaceae family represented by Caudiculophycus spp. Among acritarchs Protosphaeridium sp. and Trachysphaeridium sp. are predominant.

While computing the dimensions of these microbiota statistically it is observed that the dimensions show increase upwardly in the sequence.

From the study of microbiota following deductions are made:

1. The microbiota are facies-controlled, seen mostly in the rocks deposited under reducing conditions.

2. The entire population of microbiota is dominated by the Oscillatoriaceae family, possibly implying that these a played significant role in the stromatolite-building process. Their passive role in this context seems remote considering their overwhelming dominance.

3. An evolutionary trend of this biota within such a limited vertical span is discernible by gradual increase of their dimensions upward in the sequence.

PAUL J.

Stromatolites of the Upper Devonian Canning Basin (Western Australia)

In the Canning Basin of Western Australia, stromatolites are very abundant in marine sediments overlying extinct Frasnian stromatoporoid-coral reefs. There are stratiform, columnar, and domal types in extended beds of some m thickness as well as small bioherms of the same size. The bulk of microbial mats are agglutinating stromatolites, besides occur calcified cyanobacteria like Renalcis, Girvanella and Frutexites, which are cyanobacteria, most likely associated with iron-precipitating bacteria. The stromatolites are associated with normal marine or even stenohaline fossils like sponges, solitary rugose corals, calcareous algae, crinoids, brachiopods,
ammonoids, and conodonts. In some sections there is a more or less regular cyclic alternation of sponge, stromatactis-like structures and stromatolite-containing strata. Frequently, stromatolites are associated with reddish or brownish rock colours due to the presence of hematite, whereas sponge-bearing sediments are mostly greyish.

A strong depth zonation of stromatolitic growth forms can be observed at the flanks of the extinct stromatoporoid reefs: oncoids prevail in shallow areas, downslope follow columnar forms, deeper are domal, and finally scallop stromatolites. At the reef slope, stromatolites grew always asymmetrically: Steep flanks of domal and scallop forms are at the deeper side. The longer axes stromatolitic domes and micro-reefs are oriented parallel to the slope.

Crinoidal holdfasts and solitary corals are very common at the surface and within the laminated stromatolite. They prove a very early lithification as they need hardgrounds for settling. This is also shown by multiple phase filling and cementation of internal voids and the good preservation of the sponges.

Stromatolites have been formed during all the time of the latest Frasnian and the early Famennian, but a maximum frequency is found within the crepida Zone. A *Frutexites* bed of 12 cm thickness has been formed in a timespan more than a conodont zone that means more than 0.5 million years.

The red colour of the stromatolites point to oxidising conditions during deposition as a consequence of low productivity or a very low rate of sedimentation. Therefore, together with the relative scarcity of burrowing organisms, oligotrophic conditions of the sea can be assumed. An association of stromatolitic growth and highstands of the sealevel is unlikely.

All in all, the Upper Devonian stromatolites of the Canning Basin grew at shallow to moderately deep sites in stenohaline and oligotrophic conditions. The rate of sedimentation was very low.

**QIAN M., YUAN X., and YAN Y.**

A megafossil assemblage from the Neoproterozoic Jiuliqiao Formation in northern Anhui Province, China

A megafossil assemblage is well preserved in shales intercalated with stromatolite-bearing limestone of Neoproterozoic Jiuliqiao Formation at Baiguashan, Huaiyan County, northern Anhui Province, China. These megascopic fossils are preserved with holdfast, thallus or annulation, which reveals that they are probably multicellular organisms. Four morphological types are recognized: spheroidal to ellipsoidal-*Chuaria*; sausage-shaped-*Tawuia*; ribbon-like form with annulations-*Ruedemannella*, *Huaiyuanella* and *Protoarenicola*; and a three-dimensionally preserved tube-like form-*Anhuiella*, occurring on bedding planes of the shales. This fossil assemblage possibly presents a limited morphological diversification, and occurred at the Jiuliqiao epoch just before the Sinian with the isotopic age about 738 Ma.

Most fossils are preserved as carbonaceous remains, ranging from less than 0.1-20mm in length and 0.1-5mm in width. Of them, *Huaiyuanella*, "Ruedemannella" and *Protoarenicola* were previously interpreted as the candidates of Annelida. Here, we reinterpret them to be megascopic algae based on the morphological analysis of our
new specimens. The well-preserved specimens bear both holdfast and thallus, which are typical structures in modern seaweeds. Some transverse structures, e.g. annulation, possibly result from periodic growth of seaweed. The disc-like structures at ends of Protosaracenica may be holdfasts or broken surfaces of algae. Anhuiella, a three-dimensionally preserved tube-like type, is possibly a trace fossil rather than an earthworm-like body fossil.

**RIDING R.**

Stromatolite: what is it, what is it not?

Despite being an old and widely used term, there is currently no generally accepted definition of stromatolite. Kalkowsky (1908) evidently regarded stromatolites as laminated - as the name indicates - and microbial, but his long and intricate paper failed to specify a single clear definition. By the 1970’s, research had revealed that: (i) not all microbial deposits are laminated; and (ii) it can be difficult to demonstrate biogenicity in ancient examples. Attempts to deal with these two complications resulted in new definitions that were as different as the problems that they attempted to resolve. In order to encompass non-laminated deposits, one definition enlarged the term stromatolite into a broad “genetic” term that encompassed all microbial deposits irrespective of macrofabric (Awramik and Margulis 1974). In contrast, another definition avoided the problem of demonstrating biogenicity by being descriptive, and allowing stromatolite to apply to abiogenic as well as biogenic laminated deposits (Semikhatov et alii 1979).

Although it was endorsed in the seminal 1976 publication on stromatolites (Walter 1976), the genetic definition was unsatisfactory because it did not discriminate clearly between microbial deposits with markedly differing macrofabrics. The term thrombolite (Aitken 1967) for macroscopically clotted microbial carbonates was already gaining acceptance, and more precision was required than the Awramik and Margulis (1974) definition offered. The descriptive definition was even more problematic, for by emphasizing lamination over biogenicity it purposely disregarded the key feature of stromatolites: their microbial nature.

These limitations meant that neither new definition was satisfactory and neither gained general acceptance. As research moved on it became clear that a broad term, similar to that suggested by Awramik and Margulis (1974), was needed when referring to laminated stromatolites and clotted thrombolites as a whole, but that stromatolite would not do: it would be too confusing to try to simultaneously use stromatolite as both a specific term for laminated structures, and as an umbrella term for microbial deposits in general. The solution was simple: Burne and Moore (1987) took the Awramik and Margulis (1974) definition and applied it to a new, all-encompassing, term: microbialite. This not only permitted the terms stromatolite (laminated) and thrombolite (clotted) to coexist, but subsequently fostered further nomenclatorial innovation to accommodate other macrofabrics: dendrolite for dendritic (Riding 1991), and leiolite for aphanitic (Braga et alii 1995).

However, in the meantime, the term stromatolite remained untouched by these clarifications. Whereas thrombolite, dendrolite and leiolite, as well as microbialite, each had single uncontested definitions, stromatolite had three, which variously view it as essentially either:
(i) laminated and microbial (Kalkowsky, 1908),
(ii) just microbial (Awramik and Margulis, 1974),
(iii) just laminated (Semikhatov et alii, 1979).

Why has no agreed clarification emerged for such an important term during the past twenty years? The answer lies in the still unresolved problem of biogenicity and the choice between genetic and descriptive definitions. Setting aside Awramik and Margulis' (1974) definition in favour of microbialite does not resolve this issue, because Kalkowsky (1908) definition is also genetic. Kalkowsky (1908) was convinced that stromatolites are organic, even though he could not prove it and was unsure which organisms were responsible (although he suspected simply-organized plants). In fact, the terms dendrolite, leiolite and microbialite are also all genetic because they too are defined as microbial.

Semikhatov et alii's (1979) definition of stromatolite is inappropriate and too broad: (i) its descriptive rationale conflicts with the genetic one whose usage is now well-established for other microbial deposits; (ii) it negates the essential microbial nature of stromatolites; no present-day deposits are termed stromatolites if they are not microbial; (iii) it would include laminated domes as diverse as mineral deposits, diagenetic concretions, travertine crusts, and speleothem, as well as microbial deposits, within the term stromatolite. Use of dual definitions of stromatolite, descriptive for ancient and genetic for present-day examples (Ginsburg 1991, p. 27) would not reduce these deficiencies, and could increase confusion.

The Kalkowsky (1908) definition requires having to demonstrate biogenicity. This is not a problem in stromatolites that preserve the organisms responsible for their formation, such as skeletal stromatolites, but it can be a challenge in other types. However, interpretation of microbial carbonate fabrics, including microfabrics, is improving and can provide the ability to achieve the level of confidence required to apply the Kalkowsky (1908) definition. There will of course be examples where preservation will be inadequate, and in these cases uncertainty can be indicated by prefixes. This is no different from the difficulties involved in recognizing other fossils; the fact that we cannot always confidently recognize fossils in all geological situations does not prevent us usefully defining them. But it remains necessary to realize the difficulties and to rigorously apply biogenic criteria.

I propose that not only the oldest but also the best definition of stromatolite is that of Kalkowsky (1908) which can simply be restated: "stromatolite is a laminated benthic microbial deposit" (Riding 1991). This adds stromatolite to the suite of microbial deposits distinguished according to their differing macrofabrics: stromatolite, thrombolite, dendrolite, leiolite, with microbialite as the overarching term.

References


SHARMA M.

Mesoproterozoic microbial assemblage from Jaradag Fawn Limestone Formation, Rohtas, Bihar, India: an ancient analogue of sabkha ecosystem

The recent discoveries of trace and small shelly fossils from the Lower Vindhyan sediments exposed in central and eastern parts of India are being widely debated for their bearing on the evolution of multicellular life and age of the sediments. Palaeobiological evidence and geochronometric data suggest that the Vindhyan sediments belong to Mesoproterozoic to Neoproterozoic age. In this context the organo-sedimentary structures and microbial fossils recovered from the Jaradag Fawn Limestone Formation (JFLF) are evaluated both for their age implications and depositional environment.

The Great Vindhyan Basin occupies a large area of peninsular India extending from Sasaram (Bihar) in the east to Chittorgarh in the west. Successive lithostratigraphic order includes Semri, Kaimur Rewa and Bhandar groups. On the easternmost fringe only two groups (Semri & Kaimur) are exposed. The JFLF is part of the Semri Group. It has yielded varied types of microfossils and stromatolites. F/T and K/Ar dates of the Semri Group sediments indicate their deposition in the time span of 1,400-1,060 Ma.

Microfossils occur in all the three variety of cherts: in stratified stromatolites, bedded cherts, and stromatolitic cherts. Stratified stromatolites particularly *Stratifera irregularis, Irregularia* sp. are built by various species of *Eoentophysalis*. Coccolid unicells are common in the assemblage and probably represent fossilized chroococcacean cyanobacteria. Occurrence of various microbial elements indicates that different communities were involved in the formation of mats and some were
actively involved in accretion and others were simply mat dwellers. The stromatolitic chert also includes *Eosynecechococcus grandis*, *Palaeoanacystis vulgaris*, *Sphaerophycus* and *Tetraphycus*. *Eosynecechococcus* and *Palaeoanacystis* along with large amounts of mucilaginous sheath suggest their growth in arid and harsh conditions. Numerous solitary sporangia like spheroid of *Clonophycus elegans*, *C. ostiolum*, *Conhemisphaera pendula*, *Sahaniophycus precambricus* occur in the stromatolitic chert. Bedded chert of the JFLF is a storehouse of disorganised, randomly distributed coccoid algae. None of the members occurring in bedded chert have any tendency to form organic laminae or specific preference for association among the members of assemblage. It is likely therefore, that these members of assemblage of bedded chert were entrapped or might be living in the vicinity (or were washed into areas) of precipitating chert. Cellularly preserved filamentous organisms are rare in this assemblage. However preferential preservation of coccoid algae over the filamentous forms may be another possibility. Absence of cellular details in filamentous form and patchy organic mass dispersed in the chert support the view that these forms have washed into the realm of precipitating chert. Petrological studies of the chert encompassing the microbial fossils show voids, vugs and replacement sequence of carbonate to chert indicating the evaporites formation and replacement during the sedimentation of JFLF.

Analogy with the modern entophysalidacean mats that occur in arid, shallow-water environment often in intertidal to supratidal flats was also noticed. It is most likely that microbial assemblage of the JFLF grew in shallow and relatively saline waters. The other parameter is the evidence for the original pigment concentrations in the upper parts of the microbial mats constituted by *E. belcherensis*. Analogous conditions of colouring in modern *Entophysalis* is apparently a response to high light intensity and is characteristic of some algae that thrive in areas of high salt content. Depositional environment study amply demonstrates that arid, shallow marine bordering hypersaline embayments and sabkha like habitats were common during the deposition of JFLF. This environment was conducive for the preservation of chroococcacean and mat forming entophysalidacean algae because of formation of primary or early diagenetic cherts. Though no age marker fossil has been noted, a comparison of JFLF microbial assemblage with other known Proterozoic fossils indicates their Mesoproterozoic age affinity.

SHUYSKY V.P. and CHUVASHOV B.I.

**The assemblages of reef-building algae of Uralian Late Precambrian to Palaeozoic, and main structural types of algal limestones**

The Late Precambrian to Palaeozoic sequences of the Urals contain algal and microbial biotas throughout much of the sequence, and may be grouped into 4 types: “A-type” are true frame structures of bush-like (*Epiphyton*, *Renalcis*, *Shuguria*, *Tubiphytes*, *Fistulella* etc.), phylloid (*Calcifolium*, *Ivanovia*, *Anchicodium*, *Eugonophyllum*, *Neancheptocodium*) or kidney-like (*Solenopora*, *Parachaetetes*) biotas, which are preserved in situ after their death. Frames contain voids later filled by sediment, or micritic cement. “B-type” are cemented (non-skeletal) crust-like structures represented by two main subtypes: a) cementing layers of *Girvanella*, *Sphaerocodium* and others; b) stromatolite-like structures *Pycnostroma* and *Spongiosistema* without preserved thalli. This type is distributed very widely, either separate or in association with other buildups. “C-type” are subskeletal structures, widely-distributed, of in situ green or red algal thalli (e.g. *Voikarella*, *Lulipora*, *Ludia*, *Ameba*. **
Beresella, Dvinella, Anthracoporella, Ungdarella, Komia and others), often as oligotaxonomic structures. "D type" are pseudoskeletal (imitative) structures, represented by thrombolite and "waulsortian" type of organic buildups. The main sediments of these limestone types are micrite, pelmicrite, and biomicrite. Only types A and B are reef-building assemblages. The following is a brief survey of these types of buildups from Late Precambrian to Permian times in the Urals.

Precambrian, bedded, dome-like and conical stromatolites with features of type B occur in very thick (more 10km) sequences of carbonate, terrigenous and volcanic rocks. Early Cambrian type A small bioherms are composed of Epiphyton-Renalcis-Chabakovia within the Atdabanskian-Botomskian stratigraphic interval. In Early Ordovician, small (10′s cm) type C structures are composed of Nuia siberica, and type D buildups are thrombolites. Reefs up to 100′s m thick occur in Late Caradoc-Ashgill. made of oligotaxonomic assemblages of Renalcis granosum and the gigantic siphonales Kozhimella; lenses of Dimorphosiphon and Vermiporella thalli (type C) also occur. Silurian organic buildups and reefs are very widely distributed in the Urals, containing abundant Fistulella (? alga). Type A assemblage Renalcis-Epiphyton-Ludlovia, together with numerous spongy Aphrosalpingia, were important reef-builders, with accessory crusts of Sphaerocodium, Girvanella and Wetheredella. Stromatolite buildups occurred in back-reef lagoons. Lokhkovian (Early Devonian) buildups are usually similar to Silurian ones; with important reef-building assemblages of Renalcis-Shuguria-Izhella and Fistulella-Ikella, plus accessory Epiphyton-Ludlovia assemblage, and type B crusts of Sphaerocodium-Girvanella and Spongiostroma-Pycnostroma. Stromatoporoids and corals took over as key reef builders in Eifelian and Givetian structures. Widespread Frasnian reefs are composed of type A Epiphyton-Shuguria-Izhella-Renalcis-Wetheredella, with buildups up to 350m thick. Algal groups of type B and C also produced build-ups.

The Kellwasser event (Early Famennian) caused replacement of Frasnian reefs by mudmounds with rare calcareous algae, and during Late Famennian, type A buildups of Epiphyton-Shuguria-Renalcis formed, with local ~thrombolite bioherms, also in the Tournaisian. Late Visean-Serpukhovian are small and rare, with type A assemblage of Fasciella, Claracrusta and Predonezella, together with Renalcis and stromatolites. Thicker bioherms occur along the Russian platform rim. Green and red calcareous algae built reefs in Bashkirian and Early Moscovian times. Relatively rare and small (3-5m in thickness) bioherms were made by main bush-like Donezella together with crust-forming Claracrusta. A very specific biocoenosis then appeared, composed of sedentary forams, bacterial films and stromatolite crusts, up to end of the Permian. Late Moscovian-Late Carboniferous (Kasimovian-Gzhelian) organic buildups were constructed by phylloid algae (Ivanovia, Eugonophyllum, Anchicodium, Neoanchicodium), mostly along the tectonic boundary between Preduralian Foredeep and Russian platform; thickness of organic buildups is up to 30m. Similar-sized bioherms are composed of Tubiphytes only. There are very rarely small (up to 1m in thick) bioherms composed by the numerous kidney-like thalli of Solenopora. Major reef-building in the Urals occurred during Asselian-Sakmarian times, forming a thick (up to 500-600m) belt of reefs along the Russian platform-Preduralian foredeep. Reefs are mostly constructed by bryozoa and Tubiphytes, but also separate phylloid algae and Tubiphytes buildups are present. Also, the problematic organism Paleoaplysina was an important reef-builder. Diverse green algae were important components of the Artinskian-Sakmarian reefs. Patchreefs of assemblages of Tubiphytes, bryozoa and brachiopods, were distributed along the eastern rim of the Russian platform in Artinskian Age. Phylloid algae and stromatolites occur within
these organic buildups. Similar organic buildups existed also in Kungurian, together with very small (up to 5m) Solenopora and stromatolite bioherms.

SOARES L., DARDENNE M.A., FAIRCHILD T., and GUIMARÃES E.M.

Proterozoic stromatolites from central Brazil and their palaeoecological assessment

The studied area is located in the central part of Brazil, between São Gabriel and Mato Seco/Mimoso cities, State of Goiás. The Group Paranao, is part of the Brassilia fold belt and it is dated, considering its stromatolite associations, as Meso/Neoproterozoic. This group is a psammo-pelitic unit with an important carbonate content. The upper part presents stromatolite associations and is herein divided into three horizons: 1. Lower-quarzites, alternating limestones and dolostones lenses with a stromatolite association in a metargillite and metasiltite sequence; 2. Middle-metargillite and metasiltite intercalated with sporadic feldspathic metasiltite; 3. Upper-quarzites, alternating limestones and dolostones lenses with five stromatolite associations in a metargillite and metasiltite sequence. These associations were defined in terms of their morphology that vanes from non-structured to structured forms, as well as stratiform and cylindrical conical stromatolites. In addition, these associations can be used as a tool for a palaeoenvironmental interpretation of this unit. Hence, the conical forms indicate an offshore environment. However, the forms associated with intraformational breccias and desiccation cracks, Gymnosolena, indicate a very shallow to foreshore environment. The other forms, Baicalia, indicate an inshore environment with structures indicating depth variations.

TEWARI V.C.

Precambrian and lower Cambrian stromatolite diversity and decline in India, and its global comparison

The results presented here are the direct outcome of the several International Geological Correlation Program Projects (IGCP) in India in which the author has been associated over the last two decades (1978-1998). The studies related to Stromatolites (IGCP 261), Phosphorites (IGCP 325), Precambrian-Cambrian Event Stratigraphy (IGCP 303) and Biosedimentology of the Microbial Buildups (IGCP 380) have been integrated to give a comprehensive picture of the Proterozoic-Cambrian sedimentation, evolution, diversification and decline of life, isotopic and geochemical changes across the Precambrian-Cambrian boundary in the Indian subcontinent.

Archaean stromatolites are not found in the Himalayas but restricted in Sandur, Chitradurga and Shimoga Schist Belts of the Dharwar-Karntaka craton in the Peninsular shield of South India. Morphologically, they are stratified, laterally linked, domal and small columnar forms. They may be compared with Stratifera, Kussoidella and Externia but no microstructural details are available for comparison with known Achaean forms from other parts of the world. The Palaeoproterozoic stromatolite taxa Sundosia (Sundia), Pilbaria, Gruneria, Katernia, Patonia, Butinella and Kanpuria are more commonly found in the Aravallis of the Rajasthan area in Jhamarkotra and Kanpur phosphorite deposits. They are completely or partly phosphatic.
Mesoproterozoic (Riphean) taxa are recorded both from Central India (Vindhyans) and Peninsular basins (Cuddapahs, Pakhals etc.) and the Lesser Himalayan (northern) carbonate platforms (Jammu-Dharamkot, Larji - Shali - Simla - Deoban - Pipalkoti - Gangolihat - Thalkedar - Tejam belts) in western Lesser Himalaya. The characteristic taxa are Omachtenia, Colonella columnaris, Kussiella kussiensis, Conophyton, Cylindricus, C. garganicum, Rahaella elongate, Jacutophyton, Baicalia nova, Tungussia, Jurusania, Inzeria, Acaciella, Minjaria, Parmites, Linella, Malginella, Stratifera, Gongylina and Platella. Conophyton sp. and Platella sp. are also recorded from the Aravalli carbonates of the Udaipur and Kanur which are non phosphatic.

The Neoproterozoic-Terminal Proterozoic (Vendian) stromatolite assemblage Paniscollenia, Aldania, Tungussia, Linella, Colleniella, Linocollenia, linked Conophyton (Yugmaphyton), Minicolumellae (microstromatolites), Stratifera, Irregularia, Nucleella, digitate stromatolites are well developed in the Upper Krol peritidal carbonates of Nainital, Garhwal and Mussoorie synclines in the west and Buxa Dolomite and its equivalents (Menga Limestone/Dedza Limestone/Chilliepam Limestone) in the Arunachal, Sikkim and Bhutan, north-eastern Himalaya.

Lower Cambrian stromatolite assemblage Collumnaefacta vulgaris, Aldania mussoorica, Boxania gracilis,Compactocollenia, Colleniella, Ilicta talica, C. korgaensis, A. birpica are restricted to the Tal Formation of the Lesser Himalaya in the Central Sector. The stromatolite assemblage Stratifera, Irregularia, Conocollenia, Colleniella of Bilara Group and Birmania Basin (Lower Cambrian Marwar Super group) of Rajasthan are comparable with the Lower Tal Formation of the Lesser Himalaya. There is petrological, mineralogical, isotopic and biotic similarity between the Lower Cambrian phosphorite deposits (partly stromatolitic/biogenic) of the Lesser Himalayan Tal Phosphorite, Britannia Phosphorite of Marwar Basin, Rajasthan and its further extension in the Hahira and Abbot bad (Kabul) Phosphorites of Pakistan.

A global comparison of major events in the Precambrian and the Lower Cambrian stromatolite morphology, microstructures, environmental, isotopic and biogeochemical factors have been discussed.

WU Q., YOSHIHIO S., SHENG G., and FU J.

Hydrocarbons resulting from pyrolysis of the marine coccolithophores Emiliania huxleyi and Gephyrocapsa oceanica

Two marine coccolithophores, Emiliania huxleyi and Gephyrocapsa oceanica, were cultured at 23°C with a 16-h light/8-h darkness regime. These marine nanoplanktonic cells were then subjected to pyrolysis at 100-500°C without oxygen in order to produce hydrocarbons. The amount of saturated hydrocarbons from crude cells of E. huxleyi and G. oceanica and from their pyrolysates at 100 and 200°C was very low, only 0.05-0.15% in dry weight of the cells. The yields of the saturates in both cells reached as high as 2.8% and 2.1% at 300°C, and the values were about 20 times higher than those at 100 and 200°C. Their major components were a series of normal alkanes ranging from nC11 to nC35 with the predominant peak on nC15. At 400 and 500°C the level of saturates in both cells dropped to a very low value, since a lot of saturates had been transferred into gas compounds. The major hydrocarbons identified in all pyrolysates include normal C31 mono- and di-unsaturated alkanes, a series of normal alkanes, phytenes, C28 sterenes and steranes, etc. Hydrocarbon profiles in pyrolysates were different between E. huxleyi
and G. oceanica, and variations of them were obtained in relation to temperature. The results provide information for further studies on characterisations, sources and paleogeographic distributions of marine sediments, particularly that undergoing thermal evolution and relative to once living coccolithophores.

YANG R.-D. and ZHAO Y.-L.

Early-Middle Cambrian macroalgae fossils from Guizhou Province, China

Abundant and well-preserved macroscopic algal fossils have been discovered in black shale from the Lower-Middle Cambrian of Zunyi and Taijing country, Guizhou province, China. In 1998, abundant macroscopic algal fossils from the Lower Cambrian black shale of Niutitang Formation in Songlin section, Zunyi county, were discovered; these fossils were preserved altogether with Brachiopoda, Sponges, Hydrozoa, and Bradoriids fossils. They are older than the Chengjiang fauna in age. Middle Cambrian "Kaili fauna" was discovered by Y. Zhao et alii in 1984, abundant macroscopic algal fossils were collected in the past decade, and about 20 taxa are recognized. Morphologically, this macroscopic algal fossil assemblage is similar to the Burgess Shale algal remains, and also somewhat similar to the Sinian Miaohu biota and Lantian flora.

YIN L., XIAO S., and YUAN X.

Acicular objects of the Doushantuo Formation are not sponge spicules

Phylogenetic analyses based on morphology and molecules both suggest that sponges are the sister group of eumetazoaans (Wainright et alii, 1993; Nielsen, 1995). It is therefore not surprising to see fossil sponges among the earliest metazoan records. Sponge biomarkers have been detected from Vendian and late Riphean bitumens (McCaffrey et alii, 1994). Sponge spicules have been recovered from the Doushantuo and Dengying formations (terminal Proterozoic) in South China (Tang et alii, 1978; Ding et alii, 1985; Steiner et alii, 1993), terminal Proterozoic rocks in northern Iran (Brasier, 1992), as well as the Tindir Group (probably late Riphean in age) in Alaska (Allison, 1975). Probable sponge body fossils have also been reported from the Ediacaran deposits in Australia (Gehling and Rigby, 1996). It is, however, not straightforward in interpreting sponge spicule-like objects (Pickett, 1983). For example, the so-called sponge spicule clusters from the latest Neoproterozoic Tsagaan Oloom Formation in south-western Mongolia (Brasier et alii, 1997) are likely to be arsenic pyrite crystals (Zhou et alii, 1998).

Li et alii (1998) reported sponge spicules and larvae, including demospongian parenchymelllas and calcarean amphiblastulas, from terminal Proterozoic Doushantuo phosphorites in Weng’an, South China. Their interpretation of certain Doushantuo multicellular remains as sponge larvae has already been questioned (Zhang et alii, 1998). Here I present SEM-TEM observations and EDS-XRD analyses of these Doushantuo acicular objects, and suggest that these objects are unlikely to be sponge spicules.

Doushantuo phosphorites in Weng’an, Guizhou Province, South China, contain exceptionally preserved multicellular eukaryotes, including fossils interpreted as red algae, animal embryos (Zhang, 1989; Zhang and Yuan, 1992; Xiao et alii, 1998;
Yuan and Hofmann, 1998; Zhang et alii, 1998) and green algae (Xue et alii, 1996), as well as alleged sponge larvae and spicules (Li et alii, 1998). These spicules are found most abundantly along with algal thalli in a horizon of black, organic-rich phosphorites.

Often times, they occur exclusively in submillimeter-scale phosphatic intraclasts that Li et alii (1998) interpreted as sponge body fossils. These spicules are about 1-2µm in diameter and several tens µm in length. Although their small size in and of itself does not rule out the possibility of sponge spicules (sponge microscleres can be only a couple of µm thick), careful observations and analyses suggest that they are not sponge spicules.

The alleged sponge spicules are dominated by monaxons (Li et alii, 1998). For some populations, there are, however, a small percentage of spicules that branch and form feather-like structures. Such structures are incompatible with sponge spicules. Under SEM, some monaxons are revealed to be composed of a bunch of subcrystals. In a number of cases, these monaxons show dumbbell morphology that is very common in carbonate crystallites (Chafetz and Buczynski, 1992), indicating that they are inorganic precipitates rather than cellularly controlled mineralization as have been demonstrated in sponge spicule formation (Simpson, 1984). Furthermore, in SEM and TEM observations, none of these spicules are found to have axial canals, suggesting at the very least that they cannot be demosponge or hexactinellid spicules.

The exact chemical and mineralogical composition of these spicules are difficult to determine. Because they are so small and so closely associated with organic matter, their birefringence pattern is hardly recognizable. EDS analyses also suggest that these spicules are not composed of silica. Most spicules show high calcium and phosphorus concentrations, with only trace amount of silicon; apparently, these are phosphatic crystallites.

Dumbbell-like phosphatic crystals are discovered from HC1 macerated phosphatic intraclasts, which are described as sponge body fossils by Li et alii (1998). In morphology, dumbbell-like phosphatic crystals are very similar to micritic grains of calcium carbonate found in fossil and nature microbial mats (Chafetz and Buczynski, 1992). Although, at the moment, we can not conclude tat these phosphatic dumbbells are certainty to be products of bacterially induced precipitation, it could be suspected tat these phosphatic dumbbells were formed from original crystallites of calcium carbonate by replacement and pseudomorphology. The occurrence of phosphatic dumbbells after MCI maceration is considered to be at least depended on two main conditions. One is originally exist of dumbbell-like micritic grains of calcium carbonate precipitated by bacterial inducement; and another is that those dumbbells were more completely phosphorized.

**YIN L., XUE Y.-S. and YUAN X.**

Spinose phosphatic microfossils from terminal Proterozoic Doushantuo Formation in southern China

The spinose phosphatic microfossils we have examined are from phosphatic dolomites of the terminal Proterozoic Doushantuo Formation in Weng’an region of Guizhou Province, S. W. China. Such phosphatic microfossils were also known from
middle Ordovician, Silurian and lower Devonian elsewhere in the world (Sannemann, 1955; Le Herisse et alii, 1991; Dufka, 1991; Kozur, 1984, 1996; Norford and Orchard, 1985; Burett, 1985). However, their biological affinities have long been unclear and even are not determined to be microphytoplankton or microzooplankton.

On the basis of morphological comparison, analysis of their wall structure and composition, authors recognize those spinose phosphatic microfossils of the Doushantuo Formation in Weng’an region of Guizhou as originally organic-walled microphytoplankton, rather than microzooplankton. They are the fossil evidence to record the terminal Proterozoic phosphatization event that sit only happened after the Varanger glaciation and just before the Edicaran radiation.

YUAN X. and MU X.-N.

A great morphologic diversification of seaweeds in Neoproterozoic (Sinian) Doushantuo epoch

Much of Earth is covered by terrestrial plants and seaweeds that play a very important role in our life. They have a long history of evolution over millions of years. Terrestrial plants (vascular plants) originated from seaweeds about 450 Ma ago, and according to recent data, seaweeds (nonvascular plants) began relatively early in the Earth’s history, perhaps as early as 2 billion years ago. In other words, modern plants have an ancestry reaching back 2 billion years. But what are the differences between the old ones and modern ones? How did they evolve? To seek such problems, paleontologists have spent more than a century to collect their fossils from the old rocks over the world.

Many localities of Proterozoic sequences worldwide have yielded megascopic algal fossils in the form of black carbonaceous films on the surface of shales (Hofmann, 1994), and preserved microstructures of cellular tissue in cherts and phosphorites (Zhang, 1989, Zhang and Yuan, 1992). The carbonaceous remains were classified tentatively into 13 family-level morphological categories, they are of diverse form, varying from round bodies to filaments and intermediates, which preserved on micrometer size scale (see details in Hofmann, 1994). The affinities of most are uncertain because of lack of distinctive structures. Of interest here, we report a distinctive biota of metaphyte from Neoproterozoic Sinian Doushantuo Formation in Yangtze Platform of southwest China and about 600 Ma in age.

During the past 20 years efforts to collect megascopic algal fossils from Doushantuo Formation in Yangtze Platform and 3 typical sequences:

1. Weng’an phosphate Mine section at Guizhou Province, SW China;
2. Miaohe section at Zigui county, Huibei Province; and
3. Lantian section at Xiuning county, Anhui Province) yielded diversified megascopic algal fossils, which have been studied in detail by Chinese paleontologists. These fossil assemblages are usually three-dimensionally well preserved in shales and in phosphorites, black carbonaceous remains with various shape (mainly in sections 2-3) visible to the naked eyes, ranging from less than one to ten cm long and 0.1mm to 5mm wide. They are distinguished by the following features, which are different with those of other fossil assemblages reported from older rocks over the world:
**Organ differentiation.** Most specimens presented both fixative holdfast and vegetative thallus. This differentiation permitted thalli to grow erect and develop a benthic thallophyte group on the substrate of the Sinian Doushantuo submarine environment. Although a stipe-like structure appeared in the Longfengshania remains (with the age around 0.8 Ga) which is questionably assigned to eukaryotic algae, most megascopic carbonaceous films reported from pre-Doushantuo rocks didn’t preserve a distinguishable fixative part (Hofmann, 1994).

**Branching.** At least 4 branching types can be distinguished from the Doushantuo branched algal films. Branching specimens mainly collected by maceration from pre-Doushantuo strata, they preserved microscopic size (width of thalli less than 200mm), some of them are considered to be a contamination of modern fungi or insect parts. The affinity of these older branching types is still under investigation. There is no doubt that branching is an important character of advanced algae, a great variety of form is possible from this growth pattern.

**Tissue differentiation.** The algal fossils from Doushantuo phosphorites in section 1, are three-dimensionally well-preserved with fine microstructures and cellular tissues, especially reproductive structures which can be morphologically compared with those of modern seaweeds (Zhang and Yuan, 1995; Zhang et alii, 1998; Yuan and Hofmann, 1998; Xiao et alii 1998a-b). Most of the fossil thalli are constructed by differentiated tissues which can be recognized as cortex (outer part) and parenchyma (inner part) (Zhang, 1989; Zhang and Yuan, 1992). Although some *Chuaria* and *Tawuia* fossils from the 0.9-0.7 Ga sequence in the Huainan district of Anhui Province, China, are microstructurally studied and suggested to be aggregates of *Nostoc*-like cyanobacterial colonies (Sun, 1986), most carbonaceous films from pre-Doushantuo strata are strongly carbonated and only a simple outline is preserved.

**High diversification and abundance.** Each species from Sinian Doushantuo Formation presents a certain appearance, e.g., taenioidal type *Bacilliphyca taeniata*; taenioidal branched type- *Enteromophites siniansis* and *Konlingiphyton erecta*; filamentous branched type- *Doushantuophyton lineare*; and hair-like type- *Capilliphyca flexa*. Altogether, about 45 morphological genera have been recognized from the Doushantuo rocks (Zhang, 1989, Zhang and Yuan, 1992, Chen et alii, 1993, Xue et alii, 1992). The taxa may include synonyms and some may be invalid, but metaphytes with diversified shapes did exist at Doushantuo Stage.

According to recent data, more than 100 genus-level taxa have been reported from the rocks at the range of age from 2.1 to 0.7 Ga, but they include many synonyms, as well as names that are invalid (Hofmann, 1994). For example, about 30 genera preserved oval to elliptical shape, are assigned to be *Chuaria-Tawuia* and their synonyms. This shape variation can be ascribed to taphonomic factors and/or interpreted as the intermediate types of *Chuaria* and *Tawuia* (Hofmann, 1994). It should be mentioned here, a kind of megascopic compressed fossils, *Grypania spiralis*, with a stable shape of coil, sinuous ribbon, or cuspate ribbon, extends the stratigraphic range of 2.1-0.7 Ga, is regarded as the oldest body fossil of (interpreted) eukaryotic algae by many authors (e.g. Runnegar, 1994), but well-preserved Indian specimens reported by Kumar (1995) from Mesoproterozoic Rohtas Formation, Semri Group, showing a spiral disposition of the filament, the presence of septa and terminal cells, and he concluded that “there is no other characteristic except the megascopic size which supports a eukaryotic nature of these fossils for assigning them to Algae”.
Of all, most megascopic carbonaceous remains from pre-Doushantuo era are now known, due to a lack of distinctive characteristics other than megascopic size, the biological affinities of them to eukaryotes or prokaryotes are still uncertain. However, the Neoproterozoic Sinian Doushantuo fossils provide good evidence for the existence at 600 Ma of megascopic, benthic, erect growing, branching, and tissue differentiated metaphytes, which can be morphologically compared with the modern pattern of seaweeds.

The study of this distinctive megascopic algal assemblage concludes:

(1) Most morphological characteristics of modern seaweeds appeared in the fossil algae of the Neoproterozoic Doushantuo Formation with the absolute age around 600Ma, and a great evolutionary radiation of metaphytes took place in the shallow coastal basin of the Doushantuo depositional environment shortly after the Nantuo glacial epoch;

(2) The abundant megascopic algal specimens preserved in shales and phosphorites of Doushantuo Formation in the Yangtze Platform of southwest China, represent the entombment of a large fossil biomass. The distribution of carbonaceous remains is over 20% by area, as estimated from the bedding planes of shales in section 3 and fossil detritus is over 30% by volume, from thin sections of phosphorites in section 1. Additionally, available high rates of organic-carbon burial are represented in the Doushantuo rocks (Kauffman and Knoll, 1995). All of these data indicate the flourishing of seaweeds in the shallow coastal basin of the Doushantuo depositional environment and confirm that a great morphological radiation of seaweeds took place no later than the Doushantuo epoch (Yuan et alii, 1999).

References


**ZHOU C., XUE Y., and YUAN X.**

Possible green algal fossils from the Neoproterozoic Doushantuo phosphorites in Weng’an, Guizhou Province, SW China

Abundant three-dimensionally well preserved spheroidal green algal fossils have been found from the phosphorous dolostones and dolomitic phosphorites of the upper phosphorite sequences of the late Neoproterozoic Doushantuo Formation in Weng’an Phosphorite Deposit, Guizhou Province, SW China, by means of 10% acetic acid maceration. These fossils with originally organic walls were phosphatized during early diagenesis.

The fossils are uni- or multicellular spheroids, 50-1,200µm in diameter. They normally contain 1, 2, 4, 8, 16 units, well-preserved cell obviously presents a 1–3µm thick outer part. The cells within the 4-unit and 8-unit spheroids are closely arranged and radically concentrate to the spherical center. Most spheroids are encompassed by extra-cellular coverings, which bear tubercle ornaments. Some other spheroids contain hundreds of small regular spherical cells, which are in same size and same shape and densely arranged.

Xiao et alii (1998) reinterpreted these spheroidal fossils as animal embryos, the main criteria they gave are: 1) spheroids are the same size (roughly 500µm) no matter how many cells they contain; 2) the fossils undergo binary cell division. After our careful study of those fossils, we think there is insufficient evidence supporting their conclusion. On the contrary, some well preserved specimens bear important characters, which led us to make another interpretation: they are probably green algae. Our evidence for this conclusion is: (1) The statistical results of the spheroids show that the average size changes significantly from 2-unit- to 16-unit-containing individuals. As for the binary division, it is not the special cleaving pattern of animal embryos; most modern coenobial and colonial volvocaceans and Devonian volvocaceans experience coupled divisions (Kazmierczak, 1981). (2) SEM and thin section studies indicate that well preserved cells within spheroids bear a 1-3µm thick
covering, which probably represents a fossilized cell wall. (3) There are numerous small regular spheres (10-20µm in diameter) within the so called 4 or 8 blastomeres, these characters commonly occur in the reproductive stage of modern seaweed, such as the sexual reproductive tetraspores, but don’t in the cleavage of animal embryos. (4) Of the multicellular spheroidal fossils, 4-unit- and 8-unit-containing individuals predominate. The rate of division of animal embryos in the early cleavage stages is considerably fast, in the early development of the octopod embryo, for example, the 32-cell stage produces only 24 hours after spawning (Wells and Wells, 1977), and sea urchin embryos (even big direct-developers) reach 32-cell stage in about 5 hours. It is difficult to understand that embryos die in large numbers only after second or third division, whereas the fossils of gastrulas or later developmental stages have not yet been identified. (5) These spheres are widely distributed more than 200km² in area and also found in the late Neoproterozoic Doushantuo rocks in Yunnan, Hubei, Jiangxi provinces, which are hundreds of kilometers away from the Weng’an Deposits. Generally, the thickness of the sphere-containing rock is 1-20m and about 50 individuals can be observed in the plane less than the area of 100cm². This huge biomass possibly resulted from the phytoplanktonic microorganisms’ explosion, which just like the ‘red tide’ in modern sea or green algal radiation in some lakes where the rich phosphate is involved. After all, although the affinities of those spheroids are still under investigation, based on the above evidences, it is reasonable to interpret them as algae.

ZHOU S., SUN S., and HUANG X.

The carbonaceous megafossils, multicellular tissues and sexual reproductive organs from the Palaeoproterozoic Changzhougou Formation (1,800Ma) in North China

In 1997-1998, hundreds of specimens of carbonaceous megafossils have been found from the ~1800-million-year old Changzhougou Formation of the latest Palaeoproterozoic Changcheng Group (~1,600-1,800 Ma) in the middle Yanshan Range, North China. They are discoid, ellipsoid and sausage-like, and could be compared with Chunaria Walcott, Shouhstenia Xing (Ellipsophyta Zhen) and Tawuia Hofmann. Obviously, this is the most ancient geological record for the Chunaria-Tawuia assemblage of the carbonaceous megafossils.

To adopt HP acid-resistant maceration for carbonaceous fossil bodies, coupled with scanning electron microscope and petrologic section, the authors made a preliminary research on the histology for some circular and ellipsoid megafossils, namely Chunaria- and Shouhstenia-like forms. From the fragments of them, following three types of multicellular tissues have been found: colony-like, pseudoparenchyma-like and parenchyma-like. All of new data about multicellular tissues not only supply a very important basis in histology 4o determine the biological affinity of multicellular algal remains for the Changzhougou carbonaceous megafossils newly found, but also provide reliable fossil evidence to prove that metaphytes originated at least 1,800 million years ago.

In addition, some clear sexual reproductive organs have also been seen from the above-mentioned multicellular tissues. They can be represented by the spermatangial conceptacles and the conceptacles showing some cystocarp-like structures (including a lot of carposporangia) and surrounded by vegetative
parenchyma-like cells. The new data reported here, therefore, have also proved that the sexual reproduction originated at least 1,800 million years ago.