THE FOSSIL WEEK

ABSTRACT BOOK

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Determining phylogenetic position of Ediacaran macrofossils *Dickinsonia* and *Andiva* using biomarkers

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The Ediacara biota appears in the palaeontological record just before the Cambrian explosion, and represents the oldest macroscopic complex organisms. The organisms themselves and the ecosystems they formed were ”strange as life on another planet”, so debate about the nature of these fossils is still ongoing, with interpretations ranging from marine animals or giant protists to lichen growing on land. Extremely low thermal maturity and lack of weathering of Ediacaran deposits in the White Sea Region (Russia) allowed organic matter and biomarkers (extractable organic molecules) of Ediacaran fossils to be preserved. Biomarkers contain information about biological molecules produced by organisms living in the past, and many of these molecules are specific to certain phylogenetic groups. We used biomarkers extracted from organically preserved Ediacaran fossils in the genera *Dickinsonia* and *Andiva* to determine their phylogenetic positions. These organisms largely or exclusively produced cholesteroids, a group of C27 sterols characteristic of animals (Metazoa). This striking molecular signal, in combination with palaeontological observations, establishes these two iconic members of the Ediacara biota as the oldest confirmed macroscopic animals preserved in the palaeontological record.

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The first evidence of disability in the ”Garden of Ediacara”

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The romantic theory of the ”Garden of Ediacara” proposed by M. McMenamin is based on the assumption that the proliferation of ”peaceful” immobile organisms feeding by photo- symbiosis, chemosymbiosis, and osmotrophy made up the macrobiota of the Late Precambrian (Ediacaran). However, studies over the last two decades have shown the presence of mobile Metazoa, which cause damage to their prey in the benthic communities of marine shallow waters of the Late Precambrian of Russia and Australia. The bilateral animal *Kimberella* had sharp teeth by which it left scratches on the microbial mat and tore out large pieces of it. And it seems that the microbial substrate was not alone in experiencing aggression from this animal. There are imprints of attachment discs of macroorganisms belonging to the genus *Cyclomedusa* that show traces of having been disturbed by *Kimberella*. However, it is impossible to claim with certainty that the damage was caused to a living organism rather than to its carcass or even to a postmortal imprint. Evidence of damage to the bodies of living examples of the Metazoan *Dickinsonia* was found in one of the White Sea localities. The low but wide body of *Dickinsonia* consisted of numerous identical right- and left-handed transverse elements (isomers) that extended from the body axis in an alternating order. The growth of *Dickinsonia* was expressed in the appearance of new isomers at the posterior end, with each new element longer than the previous one. Several dozen specimens of *Dickinsonia* of various sizes and ages were found in the White Sea locality. The number of isomers varies from 20 to more than 170 pairs. Clear damage to the growth zone was found only in 11 large specimens. The area of damage usually is limited in extent and is located between the anterior and posterior regions of unaffected isomers. The healthy body elements surrounding the damaged areas bent to compensate for the missing tissue, indicating that the damage was sustained when the *Dickinsonia* was alive. The arrangement of variously deformed isomers suggests the accumulation of negative impact over time, and then its abrupt cessation, which led to a rapid recovery of the body’s normal morphology. Young individuals that appeared in the basin later did not experience it at all. The nature of this effect is not defined, so it is not completely unambiguous that it was caused by another organism. Thus, despite the discovery of damaged individuals in the ”Garden of Ediacara”, the presence of predatory animals in the Late Precambrian has not been established yet.

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Paleoecological analysis of Late Vendian benthic communities of the southeastern White Sea region

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Several localities of the White Sea Region (northern part of Russia) dated from the Late Vendian (Ediacaran) yield exceptionally well-preserved fossils of soft-bodied metazoans. Ten fossil assemblages of Flinders-style preservation (i.e. imprints on the bottom surfaces of sandstone beds) were chosen for study because of their high diversity and numerical abundance. The localities have the great advantage to have organisms and assemblages preserved in situ. A study of the population structure of these local assemblages was carried out on the basis of the distribution of specimens by size using a one-dimensional BIC analysis. About 1,800 specimens of fossils belonging to 25 genera and 29 species were used in calculations. We found that, within most assemblages, two distinct size classes occur in *Parvancorina*, *Kimberella*, *Dickinsonia,* and *Aspidella.* Less frequent forms are represented by a single cluster, probably due to the low number of specimens. The fact that specimens of different sizes co-occur spatially indicate separate age groups within populations. These age groups reflect the successive stages of a settlement of mobile and sedentary zoobenthos on the substrate surface. Combined results obtained from the quantitative and species composition of communities, calculated paleoecological parameters, the nature of microbial surfaces, and also the population structure analysis, allow to characterize settlement episodes, and the subdivision of communities into three groups. Each group reflects a particular stage (initial, middle, and late) in the existence of the biocenosis of Vendian macroorganisms within a given territory. The communities at the initial stage of development are characterized by a low diversity, a single age group in all fossils and the presence of an immature microbial mat. The communities at the middle and late stages of development are characterized by a high diversity, the presence of two age groups or more in case of the late stage, and a more mature mat. However, our results do not allow, unlike, for example, the Avalon complex, to characterize the succession of communities through time. This is due to the fact, that there are no major differences in the taxonomic composition of the studied communities. There are several endemic forms in some communities, but the dominating species remain the same in all of them. This indicates that all studied communities represent different stages in the development of similar biocenoses dominated by benthic organisms living in the sublittoral area.

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The Ediacaran organism *Rangea* as a possible source of three different forms of macrofossils

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The iconic Ediacaran fossil *Rangea schneiderhoehni* was found in Namibia at the beginning of the 20th century. However, its body plan was properly described only in 2013 by Prof. P. Vickers-Rich and colleagues. The main body or crown of *Rangea* was egg-shaped and resembled a revolving door: it consisted of six radially located vanes attached to a longitudinal axial stalk. Six marginal stalks were laterally extended from the axial stalk, each bounding the vanes along the outer edge. The complex of these stalks represented a specific part of the *Rangea* body, which was filled with sand particles even during the lifetime of the organism. Judging by the characteristics of morphology and basal position of these parts within the body, they served a supporting function and contributed to the attachment of the sedentary organism to the substrate. The detailed study of *Rangea* is complicated by the taphonomic conditions. The known fossils were buried in a redeposited state with light-weight top parts bulging out and heavy, sand-filled bases having a very little chance of a joint burial. Only remains preserved *in situ* can give information on the habitat of this organism. In the Late Precambrian of the Russian White Sea area, typical fossil remains of *Rangea* in the form of imprints of joint vanes were found in burials within sandstone lenses. Six-fold star-shaped structures of *Basisacculus stellatus* composed of sandstone were also discovered here. They are close in morphology to basal parts of the Namibian *Rangea* but are isolated from the crowns. Along with the remains of typical Ediacaran organisms, several discoid imprints of *Jampolium tripartitum* resembling a positive form of *Aspidella terranovica* were found on the bottom of the sandstone layer in one burial. *Jampolium* is distinguished from other representatives of a large group of holdfasts by the presence of 3 or 6 deep radial furrows. The type of symmetry and close stratigraphic distribution allow us to connect the imprints of the crowns, the casts of the basal structures, and the imprints of the attachment discs together and assume that they belong to *Rangea*. The consequence of this conclusion is an implication that *Rangea* from the White Sea was a part of a typical community of benthic Ediacaran organisms that lived attached to the surface of a microbial mat.

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Age variability of the Late Vendian microbial mats of the southeastern White Sea region

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Folded and wrinkled structures on the bedding surfaces of Precambrian sedimentary rocks have traditionally been interpreted as the remains of microbial mats. In the Vendian time, mats played an important role in the ecology of organisms, being both a substrate for settlement, a source of food, and a source of oxygen in photosynthetic shallow-water marine environments. Noticeable differences occur in the surface structure of microbial mats found in various fossils localities of the southeastern White Sea region. They cannot be explained only by topographical variations of the substrate, but are likely to be determined by the individual age of the microbial mats that developed along with their associated macro-organisms. The various textures of the microbial mat can be put into a sequence that is interpreted as evidence of the development and growth of the microbial mat. We recognized four types of mats: 1) an incipient mat is characterized by a shagreen surface with uneven distribution of tubercules. The plucking grooves and drag marks are seen on the hard ground underlying the mat, which appeared due to some abiogenic effects before the mat started to grow. Large areas with a smooth surface correspond to a lack of microbial mat that developed irregularly. 2) a thin, underdeveloped mat is characterized by a shagreen surface with an even distribution of tubercules covering an extensive area. The markings on the underlying hard substrate are indistinct 3) a mildly developed mat is characterized by a surface with evenly distributed fine tubercules. Because the mat was denser and thicker, no structure is visible on the underlying substrate. 4) a developed mature mat is represented by a coarsely tuberculate surface with an uneven distribution of tubercules. Unlike younger mats, mature ones grew slowly and could not recover quickly the physical damage caused by the activity of *Kimberella* and Proarticulata. The large corrugated structures of the mat that resemble the ”old-elephant-skin texture” and the healed cracks are also observed in this particular type of mat. These structures were commonly interpreted as typical of a thick, mature, well-developed microbial mat in different publications. Spots of decomposed organics and filamentous algal thalli only occur on the surface of mature mats, indicating that the structure of the mat was changing with its age.

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Precambrian shell beds consisting of body fragments of Ediacaran macroorganisms

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In the stratotype section of the Ust-Yudoma formation (southeast of the Siberian platform, Russia), a type of organogenic-detrital rock closely resembling a typical Phanerozoic shell bed is found in layers, attributed to the Ediacaran both paleontologically and according to isotope dating. The rock is a finely cavernous dolomite of light gray color. In places, thin angular plates and curved shells of centimeter dimension make up more than half of its volume by visual observation. The layer of this rock is 1.5 – 2 m in thickness and can be traced along the outcrop for at least 0.5 km. Very rarely there are more or less complete objects that have become a source of debris in the layer. They have the appearance of discs or very low and wide goblets, covered with sharp concentric folds. The fossil was described long ago as *Suvorovella aldanica* Vologdin et Maslov, 1960. In its general morphology, *Suvorovella* is very similar to the attachment structure of the frondomorph, *Aspidella terranovica* Billings, 1872, which is the usual component of most localities of Ediacaran macrofossils. However, in contrast to initially entirely soft-bodied *Aspidella* consisting of organic matter, the remains of *Suvorovella* were solid and mineralized from the very beginning. A microscopic examination showed that fossils are secondary structures and represent incrustations composed of crystalline high-magnesia calcite. Fossil plates consist of two layers, given that the surfaces of the layers facing each other bear the impressions of the organism's body, and the inverted ones are covered with druses of calcite crystals. Apparently, during the fossilization process, the initial substance of *Suvorovella* was completely dissolved and gave material for incrustations. The acute-angled features of the fragments and no evidence of roundness of the crystals' apexes indicate that the original structures of *Suvorovella* were also solid. The process of precipitation of the secondary mineral on the fragments and bodies proceeded after the formation of the sediment. An enrichment of the incrustations with calcium in comparison with the dolomite of the host rock indicates the predominance of this element in the composition of the primary substance of the buried organism. Most likely, the outer parts of the *Suvorovella* dis consisted of calcium carbonate (aragonite?). Thus, the Yudomian finding shows that the Ediacaran organisms were not always completely soft-bodied, but could also form clastic rocks of the Phanerozoic appearance under carbonate sedimentation conditions.

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