"Saline Giants", Cold Cradles and the Global Playgrounds of Earth.
The Origins of Animalia.
Report on talk given by Prof. Patricia Vickers-Rich on Wednesday 22 March 2006

Prof. Patricia Vickers-Rich of the School of Geosciences, Monash University is better known for her work on vertebrates of the Mesozoic, Tertiary and Recent periods. Her more recent work, however, involves the earliest identifiable animal fossils of the Proterozoic. About 30 years ago it was considered that the earliest animals could be identified as belonging to groups recognisable today: jellyfish, soft corals, segmented worms etc. Nowadays these identifications are regarded as too simplistic or even incorrect, and there is much controversy over what evolutionary pathways these early animals followed.

At this early period, the Precambrian of about 1 billion to 542 million years ago, the first consideration must be whether the fossils can be identified as belonging to the Animal Kingdom. What is an animal?

The Animalia, or Metazoa, can be defined as:

- multicellular life forms (therefore excludes Protozoa)
- which are mobile in at least some phase of their life cycle
- which are heterotrophic - consumers in the food chain, incapable of generating their food directly from inorganic materials (although some appear to do so, but in reality by forming symbiotic relationships with autotrophs, e.g. coral polyps need dinoflagellates).

In addition, most animals are diploid organisms, and most are also triploblastic (structures are formed from 3 embryonic layers: the endoderm, mesoderm and ectoderm).

The difficulty of identifying early life forms as animals is well illustrated by even older fossils from about 1.5 billion years ago. From West Australia there are round colonies connected by threads, much like a pearl necklace, with up to 30 nodes. From the Northwest Territory of Canada are carbonaceous films. It is not settled if either of these fossils types represent metazoans.

Precambrian fossils of about 600 million to 542 million years ago are referred to as the Ediacaran fauna, after the geological type area in the Flinders Ranges of South Australia. However, better preserved and better dated Ediacaran fossils have now been found in a number of overseas countries. These have enabled correlations with two major Precambrian glaciations (and perhaps as many as five), which occurred 635 and 560 million years ago. These covered most of the planet with ice, they were much more severe than any glaciations since.

At Doushantuo, in the Yangtze Gorges of China, are found phosphatised embryonic forms fossilized at various multicellular stages of development. These date from just after the more recent of the glaciations.

In Newfoundland is found the oldest truly macro-Ediacaran fauna. The main locality is at Mistaken Point (named from the number of ships that came to grief there). The localities are well dated because of layers of volcanic ash. The fosils are well-preserved Rangeomorphs, which are characterised by fractal branching unlike any modern metazoans.

Prof. Vickers-Rich's recent work has been in the White Sea region of Russia, near the Arctic Circle. The nearest city is the port of Archangel'sk, from which a palaeontological team was flown to the area by ex-Soviet Army MI8 helicopters. The site is on high cliffs backed by taiga and tundra. Hazards are the short cold summer, mosquitos, midges and bears. Although conditions can be severe, a number of companies are searching for oil and diamonds in this area, including Rio Tinto.

The fossils from this locality are dated to 550-560 million years ago by U-Pb dating of zircons from volcanic ash layers. They occur in storm-generated turbidites and tempestites, meaning many animals were buried suddenly in life positions. At this stage of life on earth, there was nothing burrowing in the sediment. Microbial mats could form on the surface of the sediment without being disturbed, and many animals seemed to live off these, or were planktonic. Later, in the Cambrian and after, microbial mats are not found and sediments are commonly burrowed. The fossils range from 2-3 mm to 1 metre in length.

Kimberella is a fossil which could represent an early mollusc, as it seems to possess a single small, flat shell on an elongated body. At the Palaeontological Institute in Moscow is the largest collection in the world of these fossils, some 800 specimens. Prof. Vickers-Rich raised $70,000 to fund the curation and storage of this collection, which provides the best evidence of the lifestyle of this animal. As it sat on the microbial mat, *Kimberella* would extend a proboscis out, then draw it back in, scraping up the mat with two hard prongs in a manner similar to the use of a radula by gastropods. After sweeping around in this manner until a fan-shaped area had been harvested, the animal moved on to a new patch.

Dickinsonia is another typical Ediacaran fossil. Specimens from the White Sea show that it was flexible, and that it seemed to sit in one spot and absorb the microbial mat, then move on.

Prof. Vickers-Rich next hopes to visit another Russian locality, on the Olenek River in Siberia. This is much less accessible, in fact the weather only allows visting in August, and even then only for a couple of days sometimes. Fossils here are again well-dated by volcanic ash, and cross the Cambrian-Precambrian boundary.

The Ediacaran type locality in the Flinders Ranges was discovered in late March 1946 by Reg Sprigg, who was then working for the Geological Survey. The Flinders section is now designated as the type section for a new geologic period, the Ediacaran. It needs more study, such as that currently underway by Jim Gehling of the South Australian Museum and his colleagues Mary Drosser and Soren Jensen, for the section still lacks absolute dates and large segments of the section are lacking in fossils.

The youngest Ediacaran fauna comes from Namibia. There are numerous datable ash beds, and exquisite preservation of fossils dominated by pteridinids. These are more common than in South Australia or Russia. At the top of the sequence, animals with carbonate shells begin to appear, and one, *Claudinia*, even forms the first known reefs.

Some years ago, Knauth observed that there were massive deposits of halites (sea salt) at about 610, 540 and 500 million years ago. These “saline giants” were not matched again until the late Palaeozoic-Early Mesozoic. Knauth hypothesized that the deposition of this salt lowered the salinity of the oceans, which would have allowed a higher oxygen content in sea-water. Glaciations would also increase the oxygen content, which is higher the colder the water. Prof. Vickers-Rich is now following this up to see if they correlate with increasing biodiversity and the global spread of the Ediacarans in late Neoproterozoic. Animals prefer less saline environments, and it could be that life evolved in estuarine or even fresh water environments, which would have had more limited preservation potential, and spread out into the oceans when the salinity dropped and oxygen levels increased.

Our thanks to Prof. Vickers-Rich for a fascinating talk with profusely illustrated with many pictures of the strange fauna of this little-known period of Earth’s history.

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