Sponges, Rather than Trilobites, Might Have Reigned Over Middle Ordovician Seas

By SONG Jianlan (Staff Reporter)

Obscure King of Ordovician: On the front center of the view of modern seabed is an individual of an extant sponge, a spherical soft-bodied creature with thin, delicate skeletons. It might be hard to imagine that an early sponge, in similar shape and structure like this, could have dominated the Ordovician sea, but this could have been true, according to Drs. Botting and Muir at the Nanjing Institute of Geology and Paleontology, CAS. (Photo: By ZHANG Fan)

For a long time paleontologists have thought that trilobites, a well-known group of arthropods, might have been the dominant animals on the Ordovician seabed. This belief, however, could be an illusion due to the loss of soft-bodied organisms from most fossilized marine faunas, according to recent results from a study of an exceptionally well-preserved fauna called the "Holothurian Bed" in Wales made by two British scholars working at the Nanjing Institute of Geology and Paleontology (NIGP), CAS.

According to Drs. J. Botting and L. Muir, both visiting scholars at NIGP supported by two CAS-sponsored talent programs, the conventional impression of Ordovician seabeds might be merely a distorted sketch picture resulting from incomplete information, as mostly only the skeletons of early animals were preserved as fossils. In other words, most of the ecological information has been lost during fossilization. Sponges, a representative group of these delicate species without easily preserved components, might have been the real rulers of Ordovician seas, interpreted via some newly developed techniques.

A specimen of a trilobite, *Protolloydolithus reticulatus*, found in the Holothurian Bed. Trilobites, described as rulers of the pre-historic seabed in paleontology textbooks, turned out to be secondary in Ordovician seas, according to the latest study. (Photo: By courtesy of Drs. Botting and Muir)

Missing Information in Preserved Faunas

Paleontologists come to conclusions about prehistoric ecosystems mainly by studying fossils from those periods. Such a methodology, however, could be misleading as fossils only tell part of the story: soft organisms perish easily and their bodies do not normally survive the fossilization process to be preserved under most conditions. Judging the original abundance of species in a fauna merely from fossils could lead to false conclusions, as only parts of skeletonized life, namely the hard bones and shells of organisms are visible and counted; species that had not a hardened component at all, like worms, would be overlooked. What is even worse is, the compositions of faunas vary remarkably, and sometimes communities with similar skeletonized species could have very different compositions of soft-bodied organisms, both in number of generic groups and of individuals. Therefore, faunas composed of very different species could share the same fossilized appearance. This could be very misleading.

A schematic reconstruction of the Ordovician seabed based on Drs. Botting and Muir's study of the Holothurian Bed. The soft-bodied animals rather than trilobites might have dominated the marine community. (Image: By courtesy of Drs. Botting and Muir)

As introduced by Drs. Botting and Muir in their paper published in the journal *Palaeontologia Electronica*, well-preserved communities have shown that soft-bodied and less easily preservable organisms could vary from one third to over 90 percent of the total number of species. For example, the majority of the species of the Burgess Shale, a locality famous for exceptionally well-preserved fossils from Cambrian period, would not have been preserved under normal burial conditions. In other words, if not for an unlikely chance, most of the fauna would have been erased from the fossil record. Similar cases also include the Chengjiang Lagerstätte, a Cambrian biota in China, on which the researchers' host institute NIGP has worked for decades. Therefore paleoecologists try to balance this bias by paying extra attention to exceptionally preserved biotas, hoping to get more information about the ancient ecology.

Converting Invisible to Visible

Rather than focusing on identification and description of new species as normally seen in palaeontological work, Drs. Botting and Muir placed more emphasis on the relative proportions of preserved species of the Holothurian Bed and managed to translate this information into estimated life abundances of the community, using some correction factors developed by themselves.

Such a holistic perspective demands extensive collection of specimens, ideally including every species with their numbers in proportion of their abundance in the community, to mirror the genuine landscapes of the palaeo-community. It took the researchers a number of years to excavate and collect specimens. They made a thorough investigation of the abundances of different species in the bed based on careful sampling of the rocks and counting of individuals of different species.

Data from such observations, however, do not directly represent the original abundance of the species present, according to the authors. The mode and the phases in which the organisms grew and the burial conditions could both have influenced the apparent fossil abundances. For example, as mentioned by the researchers, trilobites moulted and as a consequence an individual trilobite might have left behind multiple fossilized shells; and bodies of organisms subject to turbulent flows on death might have fallen apart. All these factors might cause errors in the estimates, if simply counting the complete specimens.

Aware of the potential biases, the researchers developed some correction factors to offset the counts, taking into account the special situation of the palaeo-environment of the fauna. Based on the ratio between the numbers of complete and disarticulated individuals of a baseline organism, an echinoderm species which did not moult and had easily preservable mineralized parts, the researchers established the basic proportion of individuals that a species might have lost. Considering the delicate structures of soft-bodied organisms, the researchers made some compensation to the basic proportion for different species, and hence got a series of correction factors. Using these correction factors they reconstructed the possible life abundances of different organisms in the community, presuming that they were all abruptly buried in the same environment, and they were subjected to the same deathly event, with varied proportions of individuals become invisible due to their different structures and compositions of soft tissues. In this way they managed to unveil the hidden organisms at the bottom of the pyramid, represented by the complete, exceptionally preserved individuals on the tip.

Even allowing for problems with using the correction factors to convert observed fossil abundance into an estimated life abundance of the Ordovician period, the researchers argued that this gives a much more reliable landscape of the life assemblages when compared with merely using the raw data.

Seen is a scenario from Dr. Botting's years-long fieldwork. Supported by two talent programs sponsored by CAS, he and Dr. Muir have got a chance to study biotas both in China and UK. (Photo: By courtesy of Drs. Botting and Muir)

Delicate Sponges Crowned King

The new methodology gives surprising results. Sponges, a soft, delicate group with multi-element skeletons, emerged as the most important group in the community after conversion. Ranking only second in fossil abundance (after a tiny but very abundant brachiopod shell), they turned out to have been the King of the Ordovician sea floor. While trilobites, the group previously believed to have dominated this age, held only a secondary position in the order of life abundance, with an abundance similar to that of carpoids and holothurians.

Seemingly the fauna might have actually been dominated by some soft-bodied taxa, like reticulosan and protomonaxonid sponges, and palaeoscolecidan worms.

Interestingly, the authors note that the biota did not closely resemble any of the previously described exceptional Ordovician faunas. This indicates that what people previously knew about the biodiversity of this age could be very insufficient: a large amount of diversity might have failed to leave any message in the strata and hence has been lost.

The unexpected nature of the fauna, the authors admit, might be specific to this locality, but they might also represent a typical type in Ordovician mudstones. For localities where the preservation conditions are not so good, the fossil fauna might yield a more trilobite-dominant mirage due to the loss of soft-bodied organisms, which might explain trilobites' mistaken position as Ordovician King.

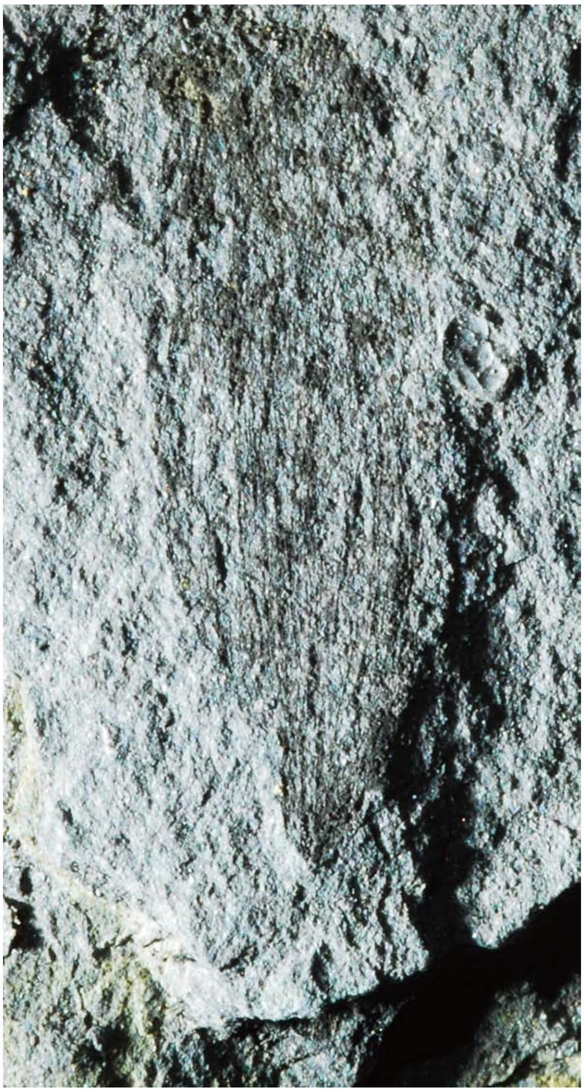
"We think that the fauna of the Holothurian Bed was probably not unusual for the Middle Ordovician. However, faunas during Middle Ordovician time were quite variable, even within a small region," explains Dr. Botting with caution, when asked if the Holothurian Bed represents a typical Ordovician marine ecology.

Some other findings in the same area support their interpretation. Besides the Holothurian Bed, they found a shallow-water fauna in the same area, dominated by large sponges and echinoderms, including starfish. They also found a deep-water mudstone fauna dominated by hydroids and sponge species different from those from the Holothurian Bed.

"In many of the communities that we study, sponges are the most abundant animals. We think that this was probably the case for many Ordovician communities, but often the sponges have not been preserved or are difficult to recognize," he continues, explaining that sponges that lived in these communities had very fragile skeletons: "They would fall apart very soon after they die." Therefore, sponges would basically not be preserved as fossils, unless they were buried alive; even if they were really buried alive, their fossilized skeletons would still be very hard to recognize. "Many of the sponge fossils are very hard to recognize, and sometimes cannot be confirmed without a microscope — in several of our faunas they have been overlooked by many previous palaeontologists, but we have simply learned what to look for," Dr. Botting emphasizes.

According to the authors, what they did was not a strict statistic analysis, but just a preliminary analysis to reveal the basic relative proportions of the groups involved in the community. They hope to conduct a more rigorous analysis using this method in the future, if a larger excavation is possible.

Their work might also shed some light on paleobiodiversity of Post-Cambrian biotas. "We hope that our work will encourage similar studies of both Cambrian and post-Cambrian biotas. Many of the Cambrian fossils (*e.g*. those from Chengjiang) are spectacular in appearance, but we think that there are many more exceptionally-preserved biotas yet to be found. In some of them, such as the Holothurian Bed, the exceptionally preserved fossils may not be obvious, and require detailed study in order to understand them. What we have tried to do is to show how much information can be obtained from even a relatively minor exceptionally-preserved fauna, and how this can result in a better overall understanding of the ecosystems. One of the most striking differences between Cambrian and Ordovician biotas is that the Ordovician ones are much more varied. Perhaps this is because they are rarer, and often harder to recognize, and if palaeontologists look for less obvious exceptionally preserved faunas in the Cambrian we will find that there was a surprising diversity of communities at that time as well," says Dr. Botting on behalf of the researchers.



A sponge identified by the researchers from the Holothurian Bed. With fine, fragile skeletons that would fall apart easily soon after death, the "King of Ordovician Seas" remained obscure for a long time in fossilized faunas. (Photo: By courtesy of Drs. Botting and Muir)

Oldest Articulated Sea Cucumber Revealed to Men

The researchers also identified among the exceptionally preserved taxa a nearly complete sea cucumber. They named the new species as *Oesolcucumaria eostre* after Eostre, the Celtic Goddess of the Spring, to mark the time of its discovery. With a spherical shape with a partially hardened ambulacrum, it is believed to be the earliest known articulated specimen of the group.

Living sea cucumbers represent one of the five classes of the Phylum Echinodermata, together with its sisters the sea lilies, starfish, sea urchins and brittle-stars. These classes played an important role in the Ordovician Radiation and left a lot of fossil evidence. Sea cucumbers, however, are the only exception. Complete specimens of this group are extremely scarce; their weak, microscopic skeletal spicules are tiny flakes buried beneath the skin that generally left no footprint in fossilization. The exceptional specimens of *Oesolcucumaria eostre* are hence believed to have important implications for studies of the origin and evolution of the Phylum Echinodermata.

The researchers, working for NIGP with support from the talent program called Fellowships for Foreign Young Scientists sponsored by CAS, have endeavored to unveil the hidden mystery in the fauna for years. They are also supported by another talent program of CAS, the Hundred Talents Program. Their host institute NIGP has a prestigious position in China for its excellent work in invertebrate paleontology.

"We came to work in Nanjing because it was a great opportunity to work with Chinese colleagues and on Chinese faunas. Support from the CAS fellowship and the Hundred Talents Program has enabled us to embark upon new projects in China, as well as continuing our ongoing work in the UK," the authors say.

In focus is a specimen of *Oesolcucumaria eostre*, an Ordovician sea cucumber from the Holothurian Bed. Named after Eostre, the Celtic Goddess of the Spring by the researchers to mark the time of its discovery, the Easter, it represents the oldest articulated holothurian known to human beings. This delicate, soft-bodied taxon was very hard to preserve as fossil due to its thin, tiny bony parts. (Photo: By courtesy of Drs. Botting and Muir)