LECTURE

Soft-bodied sensations from the Silurian

Summary of the lecture presented to the Society on Saturday 18th January 2003 by Professor David Siveter, University of Leicester

Our detailed understanding of the history of life relies on the fossil record, and most especially on rare fossil deposits that preserve not simply the hard parts of animals but their entire bodies, soft parts and all. These conservation deposits (or Konservat-Lagerstätten) allow palaeontologists to reconstruct whole animals and communities with much more confidence. Three of the best known lagerstätten are those from Chengjiang, China, the Burgess Shale of British Columbia, and the Orsten deposits of Sweden. These have provided a wealth of information about the life forms that flourished during the Cambrian (490-540 million years ago). One such lagerstätte has recently been discovered in Herefordshire (Briggs, Siveter & Siveter 1996). It contains spectacular fossils of small marine invertebrates that lived about 425 million years ago (during the Silurian Period), and now preserved as crystals of calcite within rock nodules. Not only do the fossils preserve entire animals in fine detail, but almost uniquely they are fully three-dimensional rather than squashed flat.

The Herefordshire fossils represent an ancient community of small invertebrates that lived on the sea floor. They died and were preserved when they were engulfed in ash from a volcanic eruption. The animals themselves soon rotted away, but their shapes were faithfully recorded, initially by the ash itself, and then by crystals of calcite that grew within the resulting hollows. These crystalline shapes are now found within hard nodules in the ash layer. This is the first time that soft-bodied fossils have been found in a marine deposit of volcanic origin. Other volcanic rocks have yielded soft-bodied fossils, but not from marine settings and not from nodules.

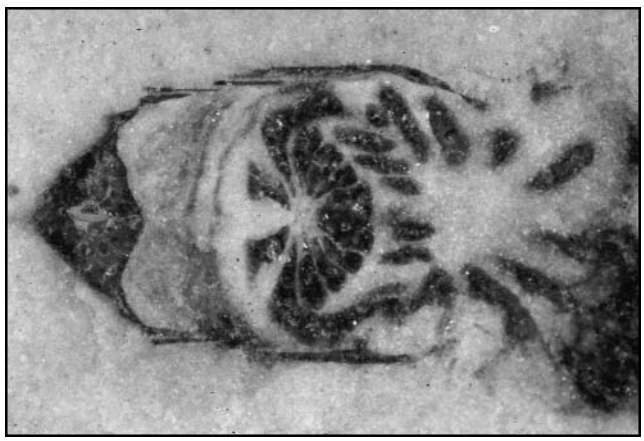

Figure 1. Photograph of a longitudinal section of the chelicerate 'king crab' *Offacolus kingi*. Note the battery of appendages surrounding the mouth area.

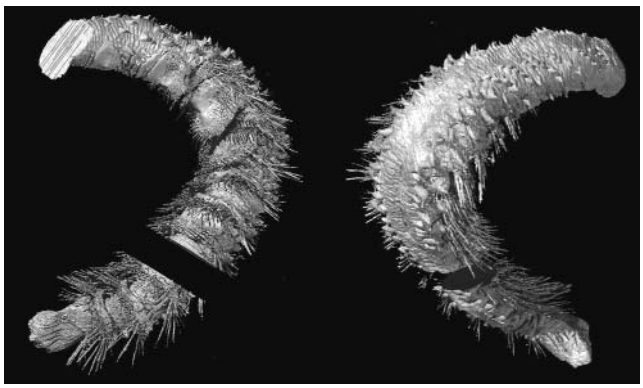

Figure 2. Virtual fossil: dorsal and ventral views of the worm-like mollusc *Acaenoplax hayae* (total length is about 30 mm).

It is a sobering thought that the rocks that yield the Herefordshire Lagerstätten were the stamping ground of no less a luminary than Sir Roderick Murchison, during his pioneer work that eventually saw the establishment of the Silurian System in the 1830's. Since then the area has been visited by generations of geologists.

The Herefordshire fossils cannot be studied effectively by normal means. They cannot be etched from the matrix because their chemical composition is the same as that of the nodules. Moreover, because of their small size and finely preserved structures, they do not easily lend themselves to any kind of mechanical preparation. So, they are reconstructed using a novel approach. This involves computer technology and, paradoxically, the destruction of the fossils themselves. First, in the laboratory the nodules are split to expose the tell-tail specs of calcite, indicating the possible presence of a fossil (about one in three nodules yield such palaeontological gold!). Fossil specimens are then ground away intervals of 20-30 microns at a time, and a digital photograph is taken of each freshly exposed surface (e.g. Fig. 1). Tens to hundreds of

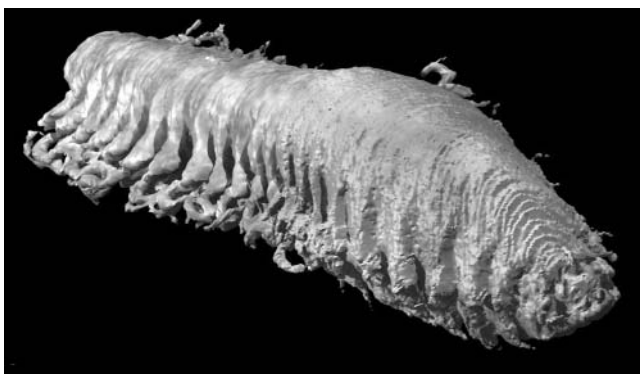

Figure 3. Virtual fossil: the polychaete ('bristle') worm Kenostrychus clements (total length is 15-20 mm).

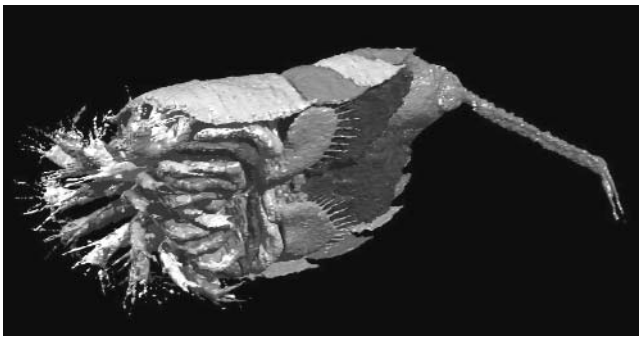

Figure 4. Virtual fossil: the chelicerate 'king crab' *Offacolus kingi* (total length is about 7 mm).

these photographs are then used to create a high-fidelity 'virtual fossil', which can be rotated or even dissected on a computer screen. The computer reconstruction can even be turned into a physical model through rapid -prototyping technologies.

The reconstruction of any one 'virtual fossil' is a time consuming process, but it has rich scientific rewards. The Herefordshire animals date from a period of time for which we have little knowledge of soft-bodied faunas, so they are helping us fill in a gap in the history of life. Those studied in detail so far (Sutton *et al*. 2002 and references therein) include the worm-like mollusc *Acaenoplax hayae* (Fig. 2), the bristle worm *Kenostrychus clementsi* (Fig. 3) and the tiny arthropod king crab *Offacolus kingi* (Fig. 4). These fossils are representatives of previously unknown evolutionary lineages, and are helping to resolve controversies about the relationships both of extinct animals and of those alive today. One of the aims of the research is to eventually reconstruct a snap-shot sea-scape of Silurian life as faithfully as possible. What is certain is that we have many more exciting finds now being studied; who knows what other amazing animals we may recover from the hundreds of 'unopened' nodules that we have collected.

Acknowledgement

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Literature

Briggs, D.E.G., Siveter, David J. & Siveter, Derek J. 1996. Soft-bodied fossils from a Silurian volcaniclastic deposit. *Nature*, **382**: 248-250.

Sutton, M. D., Briggs, D.E.G., Siveter, David J., Siveter, Derek J. & Orr, P. J., 2002. The arthropod *Offacolus kingi* (Chelicerata) from the Silurian of Herefordshire, England: computer morphological reconstructions and phylogenetic affinities. *Trans. Roy. Soc.*, B, **269**, 1195-1203.