

Cambrian arthropod soft-parts revealed

Classic sequences are still revealing palaeontological gems

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The fossils of animals complete with soft anatomy preserved in three-dimensions have been discovered in Cambrian rocks from Shropshire (*below*). The specimens are, in almost all respects, akin to Crustacea, the group that includes such familiar forms as the crabs, shrimps, lobsters, and barnacles. The discovery of these exceptionally well-preserved fossils — an example of what palaeontologists

refer to as a ‘Konservat-Lagerstätte’ — from the Welsh Borderland, provides a remarkable insight into the palaeobiology of a relatively advanced group of marine arthropods that are more than 500 million years old.

In the early Cambrian, the area that is now Shropshire was covered by a shallow sea at the margins of a marine basin centred on Wales. This sea

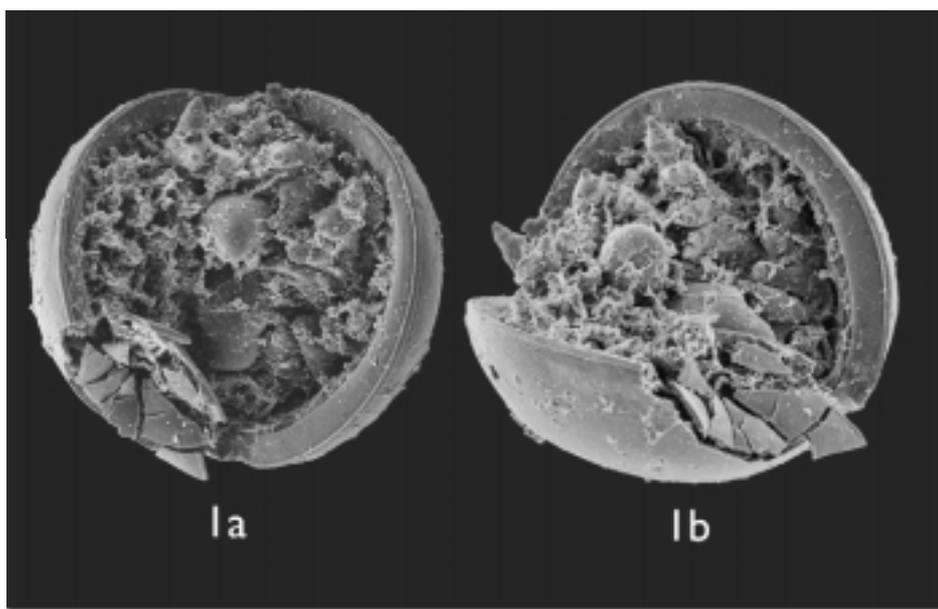
harboured a great diversity of animals, including many that are familiar fossils, such as brachiopods, trilobites, and the relatives of snails and other molluscs. In most Cambrian rocks such animals are known only from their hard (biomineralised) shells, while their soft parts, and the associated, entirely soft-bodied, animals that must have accompanied them, have perished.

The hunt

In the early part of the twentieth century, Edgar Sterling Cobbold, an amateur geologist who lived for many years in the Welsh Borderland town of Church Stretton, made extensive fossil collections from the rocks of his home county of Shropshire. He amassed a huge collection of trilobites and small shelly fossils that he used to help establish the standard rock succession for the British Cambrian. Amongst his fossils were the tiny bivalved carapaces (‘head shields’), only one to two millimetres long, of a group of arthropods that traditionally have been considered to be the ancestors of ostracod crustaceans. Diminutive in size, ostracods are by far the most abundant group of arthropods in the fossil record. They are richly represented at the present time, in a range of freshwater, brackish water, and fully marine environments by more than 10 000, mostly benthonic, species.

As part of an NERC-funded project to document the biodiversity and relationships of the supposed ostracods from the Cambrian — especially those from North America, China and Europe — one of Cobbold’s now overgrown localities, sited near the small hamlet of Comley in Shropshire, was targeted for re-excavation. Our trench exposed a richly fossiliferous, near-complete rock sequence through the upper part of the lower Cambrian. We were looking for the Lower Comley Limestones, the oldest carbonate deposits in England. These rocks are rich in the mineral phosphate, which is known to preserve the soft parts of animals in similar, but somewhat younger, Cambrian rocks in Siberia, Australia, and especially in the famous Upper Cambrian ‘Orsten’ deposits of Sweden, the spectacular meiofauna which is known through the studies of the German palaeontologists Klaus Müller and Dieter Waloszek.

From the several kilograms of limestone that we recovered from our trench, we



Ventral (left) and oblique posteroventral (right) views of a phosphatocopid with soft parts, from the lower Cambrian of Shropshire. The specimen is 0.3 millimetres long.

selected many of the larger fossils for identification at the BGS. Such macro-fossils proved important in providing an accurate date for the rocks. Similar faunal assemblages in rock sequences in Newfoundland, Canada, are bracketed by radiometric dates, and by this correlation the Comley Limestones are judged to be between 511 to 517 million years old.

In the micropalaeontological laboratory at the University of Leicester, acid dissolution of the limestones yielded a residue of phosphatic material containing fossils. There were fragments of the shells of relatively large animals such as brachiopods, the skeletal hard parts of smaller animals of enigmatic affinity, such as the elongate cone-shaped *Lapworthella*, and also the small carapaces of ‘ostracods’. The search was on for ‘ostracods’ with soft parts, or indeed similarly preserved specimens of any other group. However, even by

narrowing the odds by looking in the right kind of rocks, the chances of finding such examples of exceptional preservation is the palaeontological equivalent of winning the lottery.

The discovery and its significance

After weeks of painstakingly picking through the fine residue using a binocular microscope, two tiny crustacean specimens with preserved soft parts were recovered. Each specimen is only slightly more than 0.3 millimetres long and represents a juvenile stage of development, but the preservation is so detailed that the animals look almost as though they had died yesterday. Hairs less than 10 microns in length are present on the limbs.

The discovery provides much additional morphological information to help trace the origins of the Crustacea. The fossils, which belong to a group called the phosphatocopids, have virtually all of the head appendage and feeding apparatus morphology that characterises living crustaceans (see diagram, left). The Comley specimens have two sets of antennae, mandibles, an upper lip and mouth, and maxillae. In fact the phosphatocopids have so much morphology in common with the group that embraces present-day Crustacea that they are considered to be very closely related (‘sister-’) groups.

The Shropshire find is also significant because it is from lower Cambrian rocks. It is in the early Cambrian that shelly fossils first appear in great numbers, as a part of what is often referred to as the ‘Cambrian explosion’ of multicellular life. If relatively advanced arthropods such as phosphatocopids are present in the early Cambrian, when did the less derived forms that must have preceded them start to evolve?

The Shropshire fossils represent the oldest post-embryonic animals preserved in three-dimensions with their full complement of articulated appendages. In most other instances of soft part preservation of animals in rocks older than the Swedish ‘Orsten’, the material is flattened. This is the case, for example, with the middle Cambrian fossils of the celebrated Burgess Shale



courtesy of D Siveter

Trenching the lower Cambrian rocks of Shropshire: the search for carbonate deposits with the potential to yield soft-bodied fossils.

of British Columbia, the lower Cambrian Chengjiang biota of southwest China, and the Sirius Passet fauna of northern Greenland.

Meticulous, long-term examination of many residues of the ‘Orsten’ limestones has produced a wonderful range of different types of animals with soft parts, including crustaceans and ancient relatives of the velvet worms. In comparison, we have so far processed only a relatively small amount of rock from Comley — just four samples in fact. So, with the recovery of two key specimens, comes the tantalizing prospect that soft-bodied specimens of other animal groups may also occur in the same deposits. The hunt is on!

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Reconstruction, in ventral view, of a phosphatocopid with soft parts, from the lower Cambrian of Shropshire. The anterior-most pair of appendages, the first antennae (coloured in green), are single-branched. The second (second antennae), third (mandibles) and fourth (first maxillae) pairs of appendages each have inner (endopod — tan) and outer (exopod — purple) branches that project from the limb stem (basis — red; plus either a coxa — yellow or a proximal endite — pink). The upper lip (blue) lies behind the supposed eyes (dark blue) and in front of the sternum (turquoise). Some parts of the reconstruction, for example the outer branches of the third and fourth appendages, are based on what is known from juveniles of upper Cambrian phosphatocopids.