PALAEONTOLOGY

Glimpsing the hidden majority

Per Erik Ahlberg

WHAT are we to make of *Anomalocaris*, a metre-long fossil with two rows of fins at the back, a pair of arthropod-like claws at the front and mouthparts shaped like a pineapple ring? Or *Wiwaxia*, a rounded, headless organism covered in scales and spikes? These are just two members of a host of bizarre soft-bodied creatures known only from the Middle Cambrian Burgess Shale of British Columbia, a deep-water marine deposit in which numerous organisms were preserved because of anoxic conditions and near-instantaneous burial by mudflows. The presence of many otherwise unknown groups in the Burgess fauna underlines the biased and incomplete nature of the fossil record: fossils of the hard parts of animals can never by themselves yield a complete picture of early metazoan ecology or evolution. For this reason, the presentation at a recent meeting* of further fossils of soft-bodied animals from newly discovered Cambrian localities was the subject of considerable discussion.

The first hard-shelled animals appeared at the beginning of the Cambrian (about 560 million years ago). They evolved with explosive speed and by the end of the period, some 60 million years later, almost all the modern groups with mineralized skeletons had arrived. The emergence of these organisms was almost certainly accompanied by an even greater radiation of soft-bodied animals; it is sobering to realize that 85 per cent of the Burgess genera lack mineralized tissues[1] and would not normally have been fossilized. As the few shelly fossils — brachiopods, trilobites and hyoliths — are all common Middle Cambrian types, the fauna is probably a normal marine community, unusual only in being completely preserved.

Although most of the soft Burgess animals are strikingly different from the contemporary hard-shelled forms, the majority belong to familiar modern groups such as annelids, arthropods and priapulids. But some are so different from anything alive today that they defy classification. This problem is exacerbated by their isolated position in the fossil record. With no obvious close relatives to compare them with, it is hard to say which features of an animal such as *Anomalocaris* are restricted to that genus, and which are fundamental characteristics of the group to which it belongs.

The presence of relatives of both *Wiwaxia* and *Anomalocaris* in the new faunas, from the Buen formation of North Greenland and a new horizon in the Burgess Shale itself, will help to answer such questions. The Buen assemblage is particularly important as it comes from the Lower Cambrian, close to the beginning of the metazoan radiation (S. Conway-Morris, University of Cambridge; J. Peel, Greenland Geological Survey). In general aspect it resembles the younger Burgess fauna: it is dominated by soft-bodied arthropods, some of which resemble the Burgess crustacean *Canadaspis*, but annelid and priapulid worms are also present. Trilobites and hyoliths are the only hard-shelled taxa. The preservation is good enough to show appendages and gut traces in many of the arthropods. Small shelly fossils of uncertain origin are common in Lower Cambrian rocks: one of these, the scale-like *Halkieria*, had been tentatively interpreted[2] as part of the armour of an animal like *Wiwaxia*. This hypothesis has been dramatically confirmed by the discovery in the Buen formation of a slug-shaped creature covered in a dense mail of *Halkieria* scales. In most respects it closely resembles *Wiwaxia*, although the armour is mineralized and slightly different in pattern, and the two can now be grouped together as 'halkieriids'. Their wider affinities are still in doubt, but they may lie with the molluscs[3].

The original Burgess Shale locality lies on a steep mountainside and is part of a thick sedimentary sequence. Most of it represents deposition in deep water, but about 55 metres above the original quarry shallow-water features start to occur; from this horizon comes a new and surprisingly different soft-bodied fauna (D. Collins, Royal Ontario Museum). Although it contains several now-familiar Burgess animals such as *Canadaspis* and the worm *Banffia*, it is dominated by a previously unknown arthropod with pincers and a spiky tail. There are also new representatives of more exotic groups, one of which is unmistakably related to *Anomalocaris*. The fossil shows the same pineapple ring array of sliding mouthparts and two rows of fins on the posterior part of the body, but the form of the dorsal surface and claws is different in the new form. As the new Burgess fauna is only slightly younger than the classic assemblage, the differences between them probably reflect ecological factors rather than evolutionary change. The new fossils seem to represent a shallow-water community, one that perhaps lived inshore of the typical Burgess animals.

The recent discoveries show the Burgess fauna to be just one of a widespread and fairly long-lived group of marine invertebrate communities. Our understanding of these soft-bodied faunas and their evolutionary significance[4] is still incomplete, but more and more of the hidden majority of Cambrian animal life is now emerging into view. □

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1. Conway-Morris, S. *Science* **246**, 339–346 (1989).
2. Bengtson, S. & Conway-Morris, S. *Lethaia* **17**, 307–329 (1984).
3. Conway-Morris, S. *Phil. Trans. R. Soc.* B**307**, 507–582 (1985).
4. Gould, S.J. *Wonderful Life* (Norton, New York, 1989).

* *The Palaeontological Association Annual Conference*, Liverpool, 19–21 December, 1989.

GALACTIC STRUCTURE

Seeing the wood, not the trees

James Binney

WHAT shape is our Galaxy? We probably know much more about the form of neighbouring galaxies than we do about our own. Our view from half way out in the Galactic disk is highly skewed and horribly obscured by stars, gas and dust. Nevertheless, Leo Blitz (University of Maryland) and David Spergel (Princeton University) were able to reveal to a recent meeting* that the inner region of our Galaxy is highly elliptical, not symmetrical about its rotation axis as many had supposed. The problem now is to understand the Galactic dynamics that give rise to this form.

Blitz and Spergel draw their conclusion from a study of asymmetries in published surveys of emission in the 21-cm line of atomic hydrogen. When a radio telescope looks out from the Earth along a line that lies in the Galactic plane, it detects radiation from hydrogen atoms that are moving at up to 150 km s^{-1} with respect to the Sun. The density of atoms in each velocity range depends on the angle l between the telescope's line of sight and the Galactic Centre (see figure, over).

The convex boundaries at upper right and lower left of the high-density region of the figure arise from gas at the outer boundary of the Galactic disk, about 18 kiloparsecs (kpc) from the Galactic centre (the Sun's galactocentric distance is $R_0 \approx$ 8 kpc). If the Galaxy were axisymmetric, the velocity of the convex boundary at angle $l = 360 - x$ would be the same as that at $l = x$. Actually the two velocities differ by an amount $\Delta v(l)$ that falls from 20 km s^{-1} at $l = 0°$ to -20 km s^{-1} at $l = 180°$.

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