Mass extinctions

Confusion at the boundary

Stephen K. Donovan

IT IS fashionable to examine geological boundary sections in search of geochemical anomalies, such as the iridium peak of possible extraterrestrial origin that was discovered at the Cretaceous/Tertiary boundary[1]. Most of the boundaries that have been investigated are associated with mass-extinction events (see my recent News and Views article[2]), but there is one horizon that has excited particular interest. This is the Precambrian/Cambrian (PЄ/Є) boundary, at about 570 million years ago, that immediately preceded the great radiation of the first shelly faunas following the genesis of metazoan organisms in the late Precambrian. It has been suggested variously that this boundary does[3] or does not[4,5] represent a mass extinction. There are two problems in such discussions: the actual level of the boundary has not been defined internationally; and, more seriously, a mass extinction can be recognized only if a significant faunal turnover is detected, which is difficult in strata where fossils are already so sparse. A new compilation of data[6] by Crimes, concerning faunal activity around the PЄ/Є boundary, suggests that metazoan behaviour was little affected by any faunal turnover.

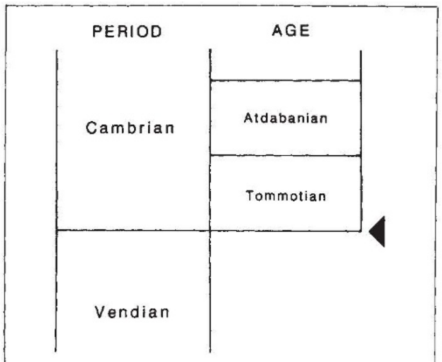
There are essentially two forms of fossil, body and trace fossils. As the name implies, a body fossil comprises the remains of the body of an organism, such as the shell of a mollusc or the skeleton of a dinosaur, and almost invariably comprises only the hard, skeletal parts of an organism, although soft tissues and soft-bodied organisms have been preserved in exceptional circumstances. In contrast, trace fossils represent the activities of organisms: tracks, trails, burrows, borings, fecal material are all examples, but the identities of trace-producing organisms are usually impossible to ascertain. Many traces were formed by soft-bodied organisms that are not otherwise preserved. Additionally, one organism may produce different traces, and a single trace morphology may be common to several forming organisms. Many marine traces, however, have a form influenced by the environment, so although the fauna has changed drastically since the PЄ/Є, many trace fossils are essentially unaltered.

Geochemical evidence suggests that various significant events related to organic productivity occurred close to the PЄ/Є boundary. But different rock sequences give different patterns of geochemical fluctuation. Tucker[7] found a $\delta^{13}C$ carbon-isotope peak just below the level of the first trilobites in Morocco. This peak could indicate an increase in organic productivity corresponding to the early Cambrian radiation of metazoans, associated with increased plankton diversity, which could approximately correspond to the Tommotian/Atdabanian boundary (see figure).

Magaritz *et al.*[8], however, found a $\delta^{13}C$ peak immediately below the Vendian/Tommotian (= PЄ/Є ?) boundary in Siberia, followed by a sharp decrease at the boundary and a second, smaller peak early in the Tommotian. The decline between peaks could indicate a decrease in organic productivity, if not an actual extinction event. Hsü *et al.*[3] suggested that an iridium anomaly associated with a sharp decrease in $\delta^{13}C$ found in the Tommotian or Atdabanian of China could be related to a bolide impact and mass extinction.

Others[4,5] have pointed out that the iridium peak occurs during a period in which the organisms that produced small shelly fossils were radiating, before the appearance of the trilobites. By this time, the late Precambrian soft-bodied fauna had gone into decline[9]. The new work of Crimes shows that other soft-bodied organisms left a good fossil record across the PЄ/Єboundary in the form of plentiful trace fossils at several localities[6]. Some groups of trace fossils are limited to the late Precambrian but many originated in the late Vendian and in the Tommotian, and continued through most or all of the Phanerozoic[6]. The general pattern is undoubtedly one of increasingly diverse metazoan behaviour (presumably indicating a related radiation of the metazoans) from the late Precambrian and into the early Cambrian, before the appearance of the trilobites. Indeed, the first trilobite trace fossils pre-date the earliest trilobite body fossils, suggesting that soft-bodied trilobites arose very early in the Cambrian or even in the late Precambrian.

Thus, the earliest trace fossils, which record the diversification of the primitive metazoans as a function of their increasingly varied behaviour, show a similar pattern of increase across the PЄ/Є boundary to the small shelly fossils. Whatever we read into the geochemical anomalies, our interpretation of mass extinction must depend upon changes seen in the fossil record. Both body and trace fossils, as well as carbon isotopes, show a pattern of distribution across the PЄ/Є boundary that suggests the early metazoan radiation was not punctuated by the hiccup of an extinction event. □



Stratigraphic units around the Precambrian/Cambrian (PЄ/Є) boundary, marked by the arrow. Some authorities would place it in the Tommotian. The age of the boundary is between 590 and 550 million years.

1. Alvarez, L.W., Alvarez, W., Asaro, F. & Michel, H.V. *Science* **208**, 1095–1108 (1980).
2. Donovan, S.K. *Nature* **326**, 331–332 (1987).
3. Hsü, K.J. *et al. Nature* **316**, 809–811 (1985).
4. Awramik, S.M. *Nature* **319**, 696 (1986).
5. Conway Morris, S. & Bengtson, S. *Nature* **319**, 696–697 (1986).
6. Crimes, T.P. *Geol. Mag.* **124**, 97–119 (1987).
7. Tucker, M.E. *Nature* **319**, 48–50 (1986).
8. Magaritz, M., Holser, W.T. & Kirschvink, J.L. *Nature* **320**, 258–259 (1986).
9. McMenamin, M.A.S. *Palaios* **1**, 178–182 (1986).

Stephen K. Donovan is in the Department of Geology, University of the West Indies, Mona, Kingston 7, Jamaica, West Indies.

FIRST OBSERVATIONS ON A LIVING COELACANTH

READERS of the paper by H. Fricke *et al.* on locomotion of the coelacanth *Latimeria chalumnae* (page 331 of this issue) may be interested in this dramatic account by J. Millot of his attempts to obtain a living coelacanth for investigation.

Throughout the night — which the delighted population of Mutsamudu passed in singing and dancing to celebrate the capture — the Coelacanth was watched over with admirable care. It seemed, although quite bewildered at the sequel to its ascent to the surface, to be taking the situation very well, swimming slowly by curious rotating movements of its pectoral fins, while the second dorsal and anal, likewise very mobile, served together with the tail as a rudder.

After daybreak it became apparent that the light, and above all the sun itself, was upsetting the animal very much, so several tent canvases were put over the boat to serve as some kind of protection. But despite this precaution and the more or less constant renewal of the water, the fish began to show more and more obvious signs of distress, seeking to conceal itself in the darkest corners of the whaler.

At 14.45 hr. it was still swimming feebly; but at 15.30 hr. it had its belly in the air and only the fins and gill-covers were making agonized movements. It was then covered with a sheet and taken immediately to the hospital. There was not a scratch on it, apart from a tiny incision in the centre of the anterior part of the floor of the mouth made by the fisherman when recovering his hook.

It measured 1.42 m. in length and weighed 41 kgm. Chemical and histological investigations could be made under the best possible conditions on perfectly fresh tissues.

From *Nature* **175**, 362; 26 February 1955.