Concepts of change

A. Hallam

Catastrophes and Earth History: The New Uniformitarianism.
Edited by W.A. Berggren and John A. Van Couvering.
Princeton University Press: 1984. Pp.464. Hbk $65, £60.10; pbk $19.50, £13.90.

WHILE generations of geologists have been reared on Charles Lyell's doctrine of uniformitarianism, few have had an adequate appreciation of just what was meant by the term, or of why the issue was so contentious during much of his lifetime. His opponents, collectively dubbed "catastrophists" by one of them, William Whewell, have not had a fair press partly because Lyell's own version of the history of geological thought has been so widely and uncritically accepted. Certainly the uniformitarian doctrine is not satisfactorily rendered by the trite phrase taught to every geological student, "the present is the key to the past", because this actualistic principle was accepted by catastrophists and uniformitarians alike. What was more significantly at issue was whether, as Lyell believed, the Earth was essentially in a condition of steady state, or whether there had been progressive changes through time, with infrequent cataclysmic interruptions to a normally rather quiescent planet.

In recent years there has been considerable re-evaluation of the work of the leading early-nineteenth-century geologists, and a reaction against Lyell has set in. Lyell of course lost the argument about progressionism in the biosphere well before the end of the century, ironically because of the success of the theory of evolution propounded by his most ardent uniformitarian supporter, Charles Darwin, but the situation with regard to the inanimate world has been less clear-cut. It now appears that Lyell's steady-state Earth model is not at all a bad approximation for the past 2,500 Myr, provided that the cyclic changes inferred are considered as gross entities — the world of the Archaean was, after all, a closed book to nineteenth-century geologists. On the other hand there has been a resurgence of interest in "catastrophes" viewed as short-lived, comparatively violent interruptions to longer-lived episodes of relative quiescence, in fields as diverse as geomorphology, sedimentology, volcanology, tectonics and evolutionary palaeontology.

This volume contains 18 contributions to two symposia held in 1977, one at Woods Hole on the current state of uniformitarianism, and the other at the University of Kansas on the subject of the Cretaceous–Tertiary boundary. The deplorable lapse of time between the holding of the symposia and publication of the book has meant that a number of the articles seem badly dated, such that a few authors might feel embarrassed to see their work in print at this late stage. Fortunately some chapters, especially those with substantial palaeontological documentation, are still well worth reading.

The longest and most interesting articles stemming from the Woods Hole meeting are the historical and philosophical essays by Gould and Benson. Both authors recognize that catastrophists such as Cuvier were the true empiricists of the day, interpreting the stratigraphic record as it appeared, for instance in the abruptly changing succession of fossil faunas, and that Lyell introduced confusion into the argument. Gould maintains that Lyell's gradualism, which so deeply influenced Darwin, was ideological in origin, imposing on the natural world a view derived from contemporary liberal politics, as opposed to the alternative Marxist view of history, propounded a few decades later, which claimed periodic revolutionary interruptions to a stable order.

It is always difficult to find firm supporting evidence for arguments postulating an influence by the contemporary *Zeitgeist*, because by its very nature the influence might be unconscious, but one can propose a more likely alternative. A link can be traced between Lyell's *Principles of Geology* and the earlier writings of James Hutton, though this is not acknowledged by Lyell himself:

> In examining things present, we have data from which to reason with regard to what has been . . . *Therefore, upon the supposition that the operations of nature are equable and steady*, we find . . . a means of concluding a certain portion of time to have necessarily lapsed, in the production of those events of which we see the effects [J. Hutton in *Theory of the Earth;* my italics].

Thus the assumption of "equable and steady operations of nature" could be used as a heuristic principle to evaluate the passage of time, and it seems to me that here we have the key to Lyell's doctrine. If any politics were involved they were the politics of a scheming and ambitious scientist who failed to give acknowledgement where it was due and unfairly denigrated the work of his opponents.

The proceedings of the Kansas symposium include two general articles by Newell and Fischer. Newell reviews mass extinctions in their historical context, referring to the pioneer work of Cuvier and Brongniart in the Paris Basin, and looks to their cause in the chance coincidence of multiple factors such as changing habitat area, climate, and air and water chemistry. Fischer puts forward a stimulating model involving two Phanerozoic super-cycles in which the Earth oscillates between an *Icehouse* and a *Greenhouse* state. The former is characterized by low sea-level, cold ice-capped poles and strong ocean currents, the latter by high sea-level, equability and widespread oceanic anoxia. A prime link is seen with plate tectonics. As continents split up, ocean ridges increase in volume and displace water over the continents. As a result of greater volcanicity producing more carbon dioxide and reduced land area limiting the amount of carbon dioxide lost by rock weathering, the atmospheric greenhouse effect causes a global rise in temperature.

In the light of the enormous interest generated over the "catastrophe" at the Cretaceous–Tertiary boundary, the articles of greatest value may well be the reviews of changes in various animal and plant groups across the boundary. These have been updated to 1980 and hence contain mention of the Alvarez hypothesis. Kauffman points out that extinctions in the marine realm were graded over a 1–5 Myr period and are primarily the result of general environmental deterioration produced by a fall in sea-level and water temperature. The extinction pattern is thought, however, to have probably been enhanced by some extraterrestrial event near the terminal phase, which served as "the last straw". Neither Hickey nor Tschudy find any evidence in the plant record of a terminal Cretaceous catastrophe consistent with the Alvarez dust-cloud scenario, as opposed to a more gradual increase in extinction rate caused by climatic deterioration. Similarly, Archibald and Clemens state that the turnover in terrestrial mammals was not catastrophic, indeed was no more marked than usually seen between any given succession of North American land-mammal ages. Russell, however, finds no evidence of a decline in dinosaur diversity before the end of the Cretaceous, and therefore feels that it is not possible to eliminate extraterrestrial hypotheses from consideration for this group at least.

Although the Alvarez team and others have recently found iridium anomalies at many more Cretaceous–Tertiary boundary localities, serious doubts and difficulties persist about extraterrestrially-induced catastrophes, especially as a *general* explanation for mass extinctions. The issue is likely to remain unresolved for a considerable time yet, and much cooperative analysis is called for between teams of specialists working on the Phanerozoic as a whole. Lyell accused his catastrophist opponents of trying to cut, rather than patiently unravel, the Gordian Knot. He would no doubt shake his head sadly at those modern catastrophists who favour a quick fix for a long-standing problem. □

A. Hallam is Lapworth Professor of Geology at the University of Birmingham, UK.