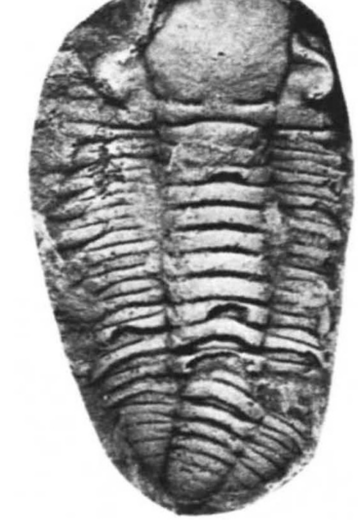
Devonian trilobites

from R. A. Fortey

IN a recent publication*, Eldredge and Branisa describe a whole series of beautifully preserved trilobites from Devonian rocks in Bolivia, including a number of genera and species new to science.

The trilobites are an extinct group of arthropods that flourished from the Cambrian to Permian periods (about 600—250 Myr BP). Unlike many invertebrate fossils, they have a complex and varied morphology, and rapid changes have occurred in virtually all parts of the exo-skeleton. They are therefore an ideal group to use as tests of the different theories for reconstructing phylogeny. The visual system in particular is very sophisticated and there are complex shufflings in the arrangement and numbers of lenses. The specimens described by Eldredge and Branisa are remarkable for their well-preserved muscle impressions and they have been able to record speciation within a geographically and taxonomically limited group. Of particular interest is their demonstration of the number of specific variations that can be played on a relatively few morphological themes — a product of one of the rapid 'radiations' that happened from time to time during the long history of the trilobites. □

Bainella (Bainella) 'acacia'. Pebble Island, Falkland Islands. Dorsal view of cephalon × 1.



Andinacaste legrandi. Sora Sora, Bolivia. Dorsal view of cast of a complete individual × 3.

Phacopina. Belén region, Bolivia. Dorsal view of portion of thorax × 3.

R.A. Fortey is in the Department of Palaeontology, British Museum of Natural History, London.

*Niles Eldredge & Leonardo Branisa *Calmoniid Trilobites of the Lower Devonian Scaphiocoelia zone of Bolivia, with remarks on related species* Bulletin of the America Museum of Natural History **165**, 2; 1980.

variations could be used as a means of determining luminosity changes has encountered several problems. First of all, similar calculations conducted by different groups have found widely discrepant values for W. (Dearborn and Blake found $W = 5 \times 10^{-3}$. Sofia *et al.* found $W = 7.5 \times 10^{-2}$. In my own studies I have found $W = 8.5 \times 10^{-4}$. This is a total spread of × 100!) The numerical discrepancies are related to a much more fundamental problem. The mixing length theory does not model the turbulent convective flow in a time-dependent deterministic sense (feedback with variations of individual cells or the magnetic field can not be included). The mixing length is a free parameter which is normally adjusted in order for the calculation to match time-averaged global observed conditions (for example, radius and luminosity). While the mixing length theories may adequately describe time-independent global structure, results of perturbations within the mixing length theory framework do not necessarily have any relation to actual physical processes. The mixing length theory does not adequately describe the detailed structure of the outer 3,000 km of the solar convection zone (where the changes in question arise). Indeed different versions of mixing length theory exist which give observationally indistinguishable solar models, but quite different structures in the outer 3,000 km which are so important for this problem. Using mixing length theory to determine more than rough qualitative estimates for the relative radius and luminosity variations is highly questionable.

In order to predict reliable quantitative results for solar radius and luminosity variations it will be necessary to directly incorporate the causal mechanisms. For the stochastic variation mechanism a deterministic hydrodynamic model of convection in multiple dimensions is required. To follow the effects of a variable magnetic field one must couple the full 3-dimensional hydrodynamic treatment of convection with an equation to determine the magnetic field. One must thus solve the non-linear astrophysical dynamo problem (see Moffat, H.K. *Nature* **285**, 16; 1980). This is a very difficult problem — reliable quantitative results are unlikely to be found in the near future.

While past measurements of solar luminosity and radius variations have not been highly significant, our ability to make precise measurements may be expected to improve in the near future. The Solar Maximum Mission launched February 14, 1980 should provide measurements of the solar luminosity with an absolute accuracy of 0.1% and a relative precision 0.02% over a planned period of 1-2 years. Preliminary results indicate that the quoted precision will be achieved and that statistically significant variations are occurring. Willson *et al.* (*Science* **207**, 179; 1980) have claimed direct detection of a 0.4% luminosity increase over a 2.4 year period with two rocket flights. A change of this magnitude occurring periodically over a few years or as part of a longer trend would have probable climatological significance. SMM and future satellite missions should allow us to know whether or not solar luminosity variations are taking place. The High Altitude Observatory is sponsoring a solar diameter measuring project based on transit timings which should be capable of detecting monotonic radius changes to < 0.01% over a baseline of a few years. Simultaneous radius and luminosity determinations are of importance in developing and checking theoretical models of solar variations. Thus, while current theoretical models of solar variations can be viewed as little more than suggestive, the day is near when direct observational determinations of such changes can be made, which in turn should help the development of realistic models. □

0028-0836/80/350839-02$01.00