Book Reviews

AN EARTH

The Earth

Its Origin, History and Physical Constitution. By Sir Harold Jeffreys. Fifth edition. Pp. xii + 525. (Cambridge University Press; London, April 1970.) 140*s*; $22.50.

In his preparation of the first edition of this famous book, Jeffreys must have been much influenced by the remarkable strides being made in the early part of this century by applied mathematicians in creating a theory of stellar interiors. Although the first edition of *The Earth* predates by two years Eddington's *Internal Constitution of Stars*, Jeffreys must have been emboldened by the astrophysicists' success and he sought to emulate it for the Earth. Applied mathematics—a very English discipline—uses sophsiticated mathematical tools to deduce from most simple physical laws (of wide ranging applicability) explanations of natural phenomena, The subject's intellectual excitement lies in the mathematical superstructure, whereas in theoretical physics it lies in the profundity of the physical ideas. The successful use of applied mathematics in understanding stellar interiors was possible because of the simple nature of the gas laws which ensured their truth in the interior of stars as in the laboratory. In the Earth and planetary interiors, as the geophysicist has now been forced to see, the equations of state are not simple: solid state physics must be used.

Nevertheless, in *The Earth* we have an example of the power of applied mathematics: the input of physics is remarkably small—Newtonian dynamics, classical elasticity and the conduction of heat. On this basis a model of the interior of the Earth is constructed which successfully explains a vast quantity of seismological and other mechanical data of classical geophysics. For nearly half a century this treatise has been the indispensable guide to the geophysicist and has stimulated the development of accurate determinations of variation with radius of the mechanical properties of the mantle and core, especially density. Discontinuities were discovered in the mantle and have recently been explained by phase changes in the silicate minerals—data on which are now obtained from laboratory experiments at high pressures. Jeffreys foresaw in the second edition the importance of such phase changes in the understanding of the physical constitution of the Earth.

The Earth closely approaches the state of hydrostatic equilibrium and evidence for departures from it has been hard to find. In fact, as described in this edition, the data determined from satellite orbits (though better maps might have been included) have revealed the presence of long wave undulations of the geoid, confirming Jeffreys's remarkable prediction of their existence from spherical harmonic analysis of early land and sea observations of gravity in an earlier edition. But essentially this classical model of the Earth has the physical properties depending on radius only, the mantle of the Earth having finite strength, the mechanics of the core unaffected by magnetic forces, the thermal history determined by the initial distribution of radioactive heat source and the equation of the diffusion of heat.

To most geologists *The Earth* in its successive editions on their shelves, often unread, was the portent of the "take over" of their subject by a more exact science with more powerful techniques: after all, the preface to the first edition put them and their data in their place ("If geophysics requires mathematics for its treatment, it is the Earth that is responsible, not the geophysicist"). Yet the geologist had one advantage—a decisive one—over the classical geophysicist: he was able to unravel the evolution of the Earth over millions of years—even though unquantitatively. Some geologists did not find *The Earth* so satisfactory a model for their data. The distribution of continents and oceans has some curious symmetries and the localization of tectonic features at any geological time does not sit happily on a uniform Earth: somehow the geological record required a more active interior than classical geophysics revealed. Jeffreys's explanation of mountain building in terms of thermal contraction causing crustal compression seemed to many geologists to give inadequate crustal shortening (although Lyttleton has recently proposed a possible route out of this difficulty).

The quantitative evidence for large horizontal displacements of the crust obtained from palaeomagnetism, and other branches of the new subject of palaeogeophysics, has reconciled the geophysicist's and geologist's view of the Earth. Convection currents in the "solid" mantle made possible by solid state creep, important at high temperatures, provide theory for the dynamic aspects of geology. And yet this replacement of the static model of the mantle is a second order phenomenon: it now seems likely that the density differences in the mantle revealed by the satellites are those associated with the rising and falling convection currents, but only a millionth of the range of density radially. Further, if convection was a little less vigorous it would not have broken the crust: mountain building, volcanism and earthquakes would not occur, let alone continental drift and sea floor spreading. Thus, Jeffreys's Earth model, so successful in its explanation of the physical constitution of the Earth, yet so notably failing to explain the remarkable recent discoveries, would probably be a complete theory of a large number of other planets in other systems of the universe.

On a number of matters, notably palaeomagnetism, palaeoclimatology, continental drift and convection, Sir Harold has refreshingly robust prejudices. He attacks these with relish, though indulging in selection quotation to a degree which would bring a blush to the cheek of a British politician on the hustings.

Nevertheless *The Earth* will rank among the few great classics of geology, rightfully taking its place beside Hutton's *Theory of the Earth*, Lyell's *Principles of Geology*, Holmes's *Principles of Physical Geology* and Wegener's *Origin of the Continents and Oceans*, as works which have transformed the study of our planet.

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"SKYIE-INFLUENCES"

Planets and Life

By P. H. A. Sneath. (The World of Science Library.) Pp. 216. (Thames and Hudson: London, June 1970.) 42*s* boards; 21*s* paper.

Popular science has two contrasted faults. When intended for students wishing to learn, it is apt to be orthodox and oversimplified. When, in the form of science fiction, it is intended primarily to amuse, it is apt to be unnecessarily extreme and to postulate hyper-drives, gravity-screens, thought-transference and so on. Sneath avoids the second fault, though he recognizes that science fiction writers have made some sensible suggestions. He is less successful in avoiding the first fault and he does not seem to have made up his mind who he is writing for. A reader who has to be