Reviews

I


The International Auroral Atlas is a new production prepared by a Committee of the International Association of Geomagnetism and Aeronomy (IAGA) which was set up at the 1960 meeting of the IUGG in Helsinki with Dr. J. Paton (U.K.) as Chairman. The present Atlas will replace the “Photographic Atlas of Auroral Forms” published in 1930—32 before the Second Polar Year by an IUGG Committee under the Chairmanship of the late Professor Carl Störmer. The present Atlas will be a necessary guide to auroral observers during the IQSY and thereafter, but it is much more than an observer’s handbook. The aim of the atlas is “to provide a series of definitions and nomenclature adequate to describe the varied character and behaviour of auroras, leaving as few gaps as possible”. The classification of auroras is made according to—

1. Forms (bands or arcs, rays and diffused patches or veils) with qualifying symbols (multiple, fragmentary and coronal),
2. Structure (homogeneous, striated, rayed), and condition (quiet, pulsing) and,
3. Brightness, colour and colour distribution.

The Atlas has 52 plates in black and white, and 4 plates in colour. The photographs have been selected from collections made at auroral stations in Alaska, Canada, U.S.A., Greenland, Scotland, Sweden, Denmark, USSR, Australia, New Zealand and Antarctica. There are also two figures showing isolines of zenithal auroral frequency in the two hemispheres. They are closed curves round the two magnetic poles; the isolines in the southern hemisphere are nearly circular in shape, while those in the northern hemisphere are elongated towards Canada and Central Siberia.

The Atlas is superbly produced and will be invaluable not only to auroral observers but also to all students of the Earth’s Atmosphere and Solar-terrestrial relationships.

K. R. RAMANATHAN

II


“IT is with the core of the Earth where the earth’s magnetic field is believed to originate that this book is mainly concerned”. This sentence from the above, will give an idea of the extent and scope of the book which has seven chapters and five mathematical appendices. In the first and introductory chapter, some of the important limitations of studies in geophysics have been referred to. The first and the most important is that no direct observations of the Earth’s interior can be made below the depth of a few kilometres. It is almost impossible in any experimental work to make allowance for the enormous intervals of time involved in any geologic process. While the development of isotope geophysics, the radioactive dating of rocks and minerals, and the determination of remnant magnetism of rocks
have made it possible to read some of the pages of the history of the Earth, these more recent techniques, as stated by the author, are of little help in the study of the physics of the deep interior. This chapter gives valuable advice on the care and caution necessary while interpreting results of geophysical studies.

In the second chapter of the seismology and physics of the Earth's interior, the author has discussed elastic waves, travel-time and velocity-depth curves and variation of density and other physical properties within the earth and included tables giving distribution of density, gravity, and pressure in the mantle and the core.

While discussing the constitution and composition of the core in chapter 3, Ramsey's and Bullen's compressibility-pressure hypothesis is mentioned. An important section is the review of the experimental and theoretical work at high pressures. The composition of the outer core is as yet by no means settled though it probably consists of iron alloyed with lighter materials.

In the fourth chapter on the Thermal history of the core, the temperatures of the primitive earth and the physical state of the inner core are described. The concluding sentence of this chapter is worth quoting as illustrative of the need for careful critical examination before acceptance of results. 'Estimates of "actual" temperatures in the above case were based, among other things, on the hypothesis that the inner core is solid—it is all too easy to argue in a vicious circle and use such "actual" temperatures to prove that the inner core is solid!'

The Earth's magnetic field is described in chapter five. World maps showing contours of equal $H$ and $D$ and secular variation of $Z$ have been included. The various theories including the rotational theory of Blackett, of the origin of the Earth's magnetic field are mentioned. As remarked, there has been much speculation of this fundamental problem but there is as yet no satisfactory explanation. One is thus compelled if a little reluctantly, as the author says, to abandon rotational theories as a source of the Earth's main magnetic field.

The possibility that electric currents flow in the Earth's interior and set up a magnetic field by induction is discussed in some detail in chapter six with the title "The Dynamo Theory of the Earth's Magnetic Field". Two of the sections of this important chapter are devoted to the fluid motion in the Earth's core and the secular variation and westward drift of the Earth's magnetic field. As there are no means of estimating with any real certainty the total heat generated in the core, the estimates of thermal conductivity of the core may be out by a factor of five or more. The westward drift of the geomagnetic field has been interpreted to imply that the outer core is rotating more slowly than in the mantle. A table showing annual westerly drift in declination pattern for Epoch 1955 has been included.

The two major problems to be solved in a Dynamo Theory of the Earth's magnetic field are to show that some pattern of hydrodynamical flow exists which can produce an axial dipole field and also that it exists in the Earth's core. The notable contributions in this connection by Elsasser, Bullard, Backus, Herzenberg, Rikitake and other workers are briefly reviewed and discussed. The dynamo problem involves the solution of Navier-stokes equation of fluid motion in the core with Maxwell's equations and boundary conditions. The problem is highly complicated and awaits solution.

The concluding chapter of the book is on "Palaeomagnetism". The magnetisation of rocks, reversals of the Earth's magnetic field, and continental drift and convection in the Earth's mantle are discussed. An interesting diagram (due to Runcorn) shows the growth of the radius of the Earth's core with the age of the Earth,
In appendix A, expressions for the field of magnetic dipole and the magnetic potential of a uniformly magnetised sphere are derived. In appendix B, the spherical harmonic analysis of the Earth's magnetic field is briefly referred to. Values of Gauss' coefficients of the harmonic analysis of the Earth's main field from the time of Gauss (1835) to Finch-Leaton (1955 Epoch) are given. An important feature of this table is that it shows clearly the secular variation of the individual coefficients. A decrease of about six per cent in the dipole moment of the Earth's field is noted while the inclination of the dipole axis appears to have remained constant (about $11.6^\circ$).

The usual equations of the lines of force of a uniformly magnetised sphere are given in appendix C. The basic equations of magnetohydrodynamics in the Earth's core are stated in the next appendix D. In the final appendix E, the vector-wave equation and some of its solutions are indicated.

This is the first volume brought out in the Geophysics Division of the Commonwealth and International Library of Science, Technology, Engineering and Liberal studies. The general Editor of this division is Prof. J. T. Wilson. In about a hundred pages, Dr. Jacobs has presented an authoritative review and summary of the present knowledge of the Earth's core and Geomagnetism. The five mathematical appendices are useful but not very essential for going through the book. His stress on the need for caution and care in interpreting geophysical results in this field is timely and valuable. A pleasing feature of this book is the inclusion of references at the end of each chapter with suggestions for further reading. Dr. Jacobs is to be congratulated on this fine presentation of a difficult but important and interesting subject. The printing is of the usual high standard associated with Pergamon Press. The book is strongly recommended to all those who wish to know the latest developments in the subject without having to wade through equations and a vast published literature.

K. N. RAO

III


The Aurora has always been a source of wonder and fascination. The author has succeeded in catching the fancy of all who are interested in understanding the phenomena. While earlier accounts of the Aurora are not lacking, this book is specially recommended for study in view of the comprehensive treatment of all aspects of the subject. I have been particularly struck by the lucid and interesting manner in which the author has presented a physical picture of the latest developments and theories of the Aurora and allied phenomena to be intelligible even to a beginner for whom the book is primarily meant. The advanced research worker will no doubt appreciate the physical picture and latest general information included in the book.

The book contains nine chapters covered in 134 pages. Starting with an interesting historical background the author proceeds to give an account of the instrumentation for the study of the Aurora. In Chapters IV and V the forms and habitat of the Aurora have been described with the help of a number of fine photographs and diagrams, many of which are attractively coloured. The next two chapters deal with time and space variation, light and sound associated with the Aurora. In Chapter VIII, the author has given a vivid account of allied phenomena like ionospheric phenomena etc with instructive illustrations.
How a stream of charged particles—known as "Solar Wind" originating from active regions from the sun move towards the earth to cause the Aurora, has been described in the last chapter, in which the latest novelties like the Van Allen radiation belts and their influence on the solar wind have also been presented in detail.

The book has been attractively brought out to match the interesting text. At the end of each chapter there is a reference and bibliography for the serious student, with a useful Index at the end.

P. K. SEN GUPTA

IV


This is a revised edition of the book which was first published in 1958. It treats of the various processes acting on the solid earth and oceans and their effects. These are given a quantitative treatment where possible, making such basic assumptions as may appear reasonable, though several of them may be speculative and not susceptible of strict proof.

The book is divided into 8 major chapters, each sub-divided into sections. It begins with a description of the known physiography of the continents and oceans, of fault and fold patterns, volcanic features, meteorite craters, diapirs etc. The next chapter describes the structure of the earth and its interior as deduced from seismic data, diagnosing the nature of earthquake motion by the recently developed technique of 'fault plane solution'. It is, however, certain that 'faults' as we know them at the surface and in the upper crust cannot exist at depths of 500 or 700 km and the motion recorded by seismographs may merely be due to phenomena of volume changes of matter at those depths, the loci of motion being controlled by and connected with the regional crustal structure. Such deep 'faults', on the existence of which inferences have been drawn by seismologists, may thus be merely zones of phase change or material transfer, though they happen to be connected with surface faults along continental margins or orogenic belts. The rest of the chapter concerns itself with the thermal properties, heat flow and electromagnetic characteristics of the Earth. A rather surprising fact found in recent years is that the continental and oceanic crust give off the same amount of heat on an average per unit area (1.2 microcalories per cm² per sec) but there are some zones like the Mid-Ocean ridges and volcanic arcs where the heat emanation is much higher. The present explanation for the existence of Mid-Ocean ridges is that they mark the zones where the mantle convection currents are rising to the surface, though other opinions are also held. The surface heat measurements are used in conjunction with the specific heat and volume coefficient of expansion of crustal materials to work out a hypothesis of the thermal history of the earth, there being certain differences of opinion regarding the earth model and its characteristics to be used. There is, however, a consensus of opinion that the temperature of the earth's core is not far from 5000° or 6000° C, and that the earth follows a fairly uniform course of cooling.

In chapter 3 are considered some aspects of the deformation of the crust which is controlled by properties like the hydrodynamics of fluids, plasticity and rheological behaviour
of solids, the stresses being of short or long term. The next chapter deals with the effects of rotation of the earth on the figure of the earth, the stability of the earth on the figure of the earth, the stability of the axis of rotation, pole-wandering, tidal force etc. The author favors the formation of the earth from cold particles more or less on the lines of the planetesimal hypothesis. Theories of the origin of the moon are discussed which lead the author to support Jeffreys' idea that there are insuperable difficulties in the moon having ever been a part of the earth.

Some space is devoted to the growth and evolution of continents to which volcanism, meteorite impact and convection currents in the mantle may have contributed. Wegener's Drift and Gutenberg's Fliesstheorie are also examined in this connection. It is concluded, however, that the absence of definite knowledge on the early history of the earth seriously handicaps the postulation of a reasonably satisfactory hypothesis.

Chapter 6 considers orogenesis and its various suggested causes—contraction, expansion, convection currents, zonal rotation, Bemmelen's undulation theory, Polar wandering and continental drift. Grigg's experiments and Rittmann's adaptation of the convection theory are also gone into. Of the several hypotheses, only the contraction and convection hypotheses are considered as providing plausible explanations of the origin and development of geosynclines and of mountains therefrom. The contraction theory is, however, defective in that it cannot satisfactorily explain the absence of a depression of the Moho beneath the ocean trenches or the occurrence of deep focus earthquakes and their relationship to fault planes. The conclusion is that practically no theory is fully satisfactory and all of them require careful reconsideration.

The next chapter (7) deals with the dynamics of faulting and folding. The chief features connected with these, including rifts, horsts, plastic folds etc can be satisfactorily explained on the basis of the present knowledge of the behaviour of solids under stress under various conditions. The final chapter (8) considers certain miscellaneous features such as salt domes, volcanic phenomena, fold and shear patterns, post-glacial uplift of N. Europe and N. America etc. The author comes to the conclusion that though certain minor features like folds and faults of short duration can be explained from the present theory of behaviour of solids under stress, there are great difficulties in explaining several of the earth's major features like volcanism, orogenesis and crustal structure. This is largely due to lack of fundamental knowledge regarding the internal constitution of the earth, and the earth's early history and evolution. Several topics come up for discussion in more than one chapter according to the nature of the phenomena discussed.

The book provides stimulating reading to all interested in the earth and serves to highlight our lack of knowledge in many fields, particularly as all the topics are attempted to be discussed in a quantitative manner. The author's association with such well known geologists as Professor Niggli of Zurich and Professor Tuvo Wilson of Toronto has enabled him to relate his discussions to current geological facts and theories. The fact that an extensively revised second edition has come out within 6 years of the first is proof of the competent treatment of our planet the earth, about which we have still to learn a great deal before we can understand its structure, constitution and evolution. The book is well printed and got up and is worth serious study by all students of geology and physics of the solid earth.

M. S. KRISHNAN

This is a book on the physics of condensation, with applications of theory to the fundamental problems of cloud physics. The authors are two specialists from Europe, who have made original contributions in this subject. The present volume is an English translation from the original text in French.

The first half of the book, consisting of seven chapters, is concerned with the development of classical concepts of thermodynamics. There is a useful discussion of the phase rule in chapter V and of adsorption in chapter VII. This part of the book largely deals with surface phenomena.

The more interesting chapters, from a meteorologist's point of view, are in the second half of the book. We have here a fairly comprehensive treatment of important topics, such as, the equilibrium of a drop in contact with vapour, the formation of germs or aggregates, the stability of a population of embryos and, finally, the rate of transformation of embryos into droplets (nucleation rate). To some extent, comparison with Professor Mason's "The Physics of Clouds" appears inevitable. The reviewer found Mason's treatment of the kinetics of nucleation less involved and easier to follow. In particular, one missed a discussion on difficulties of the macroscopic concept for very small aggregates, in the early stages of embryo formation, in this volume.

A minor criticism of the book is the manner in which the material has been presented. Many readers may not like working through a large mass of equations and formulae before he can get at the physics of the problem. Much of the beauty of a physical concept is often marred by excessive use of algebraic manipulations. There is, also, little cohesion between the first and second half of the book. Perhaps these defects are largely because of the translation from the original text.

To summarize, this is a useful and rather interesting volume for cloud physicists. One will come across many new ideas not usually found in text books on physical meteorology, but one must be prepared to work through a surfeit of algebra and calculus, not all of which is rewarding.

P. K. DAS