

esting comments on Galileo's perception of the problems arising from any attempt at measurement in the study of physics.

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STELLAR EVOLUTION

Stellar Evolution

By R. F. Stein and A. G. W. Cameron. (Proceedings of an International Conference, Nov. 13-15, 1963, sponsored by the Institute for Space Studies of the Goddard Space Flight Centre, NASA.) Pp. xiv + 464. (New York: Plenum Press, 1966.) \$19.50.

THE number of books written on stellar evolution has never been very large. The present volume is therefore a welcome addition, not least because it ranges over the whole of the field. As Geoffrey Burbidge points out in his concluding remarks, this was the first conference for several years at which all aspects of the subject were discussed. His claim can easily be confirmed by a glance at the titles of the individual sections—"Physics of Stellar Interiors"; "Stellar Evolution"; "Stellar Variability"; "Stellar Mass Loss"; "Observations concerning Stellar Evolution". Not all the sections, however, receive equal treatment. Thus the final, observational, section accounts for only 60 pages out of a total of more than 450. The papers in this section are also marked by their brevity; D. L. Crawford's report on "Photometry of B Stars", for example, consists of one page of written material and three pages of diagrams.

It is natural in reading these proceedings to try to deduce from them the current state of research in the field. It should be remarked in this connexion that the lapse of time between the holding of the conference (1963) and the publication of the proceedings (1966) is rather less important than would appear at first sight. Most of the papers have been revised to 1964 and a few to 1965. Nevertheless, some papers might be slightly modified if rewritten today—Dicke's article on "Stellar Evolution with Varying G ", for example—while others are now easily available in journals.

Such drawbacks are normal in the publication of conference proceedings. They may be offset when the papers spark off vigorous discussions which are reported in full. Unfortunately, the present volume is disappointing in this respect. Apparently less than a third of the papers evoked any discussions, and many of these consist of one, or two, comments only. Despite this, it is clear from the papers presented that further developments in the study of stellar evolution now wait mainly on advances in adjacent fields. There is a need, in the first place, for a more detailed knowledge of the physical processes occurring within stars (for example, an accurate formulation of convection and a greater knowledge of neutrino processes). Second, more observational data are required, particularly on helium abundances in different types of stars.

An active worker in the field of stellar evolution will probably find relatively little which is new to him in this book, though it certainly provides a generally readable summary of recent progress. It may well prove to be of considerable use, however, in teaching. Its value for this derives especially from the long introduction by Robert Stein. One of the great problems in teaching the theory of stellar structure and evolution is that so much depends on machine computation. As a result, a student often has difficulty in seeing the physical significance of what he is calculating. Stein shows that an approximate, analytical approach is extremely helpful in overcoming this difficulty. That this semi-quantitative approach can also sometimes be useful in original research is shown in a subsequent article by K. von Sengbusch and S. Temesváry on "Schematic Pre-Main-Sequence Evolution".

A. J. MEADOWS

DROPS IN ROCKS

Research on the Nature of Mineral-forming Solutions

With special reference to Data from Fluid Inclusions. By N. P. Yermakov *et al.* Translated by V. P. Sokoloff. Edited by Edwin Roedder. (International Series of Monographs in Earth Sciences, Vol. 22.) Pp. 743. (London and New York: Pergamon Press, Ltd., 1965.) 160s. net. MANY natural crystals, especially those that have developed freely in cavities in rocks, enclose drops of the fluid from which they crystallized. If the temperature of crystallization is appreciably higher than present normal temperature, the drop of fluid fails completely to fill the cavity. The liquid inclusions thus provide a means of determining the original temperature of formation by heating them under controlled conditions until the liquid fills the cavity. An approximate measure of the salinity of the fluid can be obtained by freezing until the formation of ice sets in. Furthermore, delicate analysis of the small amounts of fluid obtained from careful crushing of the crystal provides one of the few methods available for obtaining information about the composition of mineral and ore-forming solutions.

More than 100 years have passed since H. C. Sorby first explored these possibilities and deduced the temperature of formation of some crystals from Cornish pegmatites and lodes. Since his time the subject has been neglected in Britain until very recently. In the United States, W. Newhouse reopened the subject in 1932 and others have followed him, but the substantial contributions from workers in Russian laboratories were little known outside the Soviet Union until this able translation by V. P. Sokoloff of Professor Yermakov's book appeared. In an editorial preface, Dr. Edwin Roedder, of the United States Geological Survey, himself the leader in this field in the United States, hails Yermakov as the foremost exponent in the Soviet Union.

The work is in two sections. The first (348 pages), entitled "Studies of Mineral-forming Solutions", is a systematic account of the subject dealing with the classification of cavities and of inclusions generally, noting that they include single-phase and multi-phase types, and may enclose gas, liquid and solid. Homogenization for the purpose of estimating temperature of formation is considered at some length, and details are given of microthermo-chamber methods, and of acoustic methods, where the bursting of the cavities during controlled heating is observed. An excellent critical account of sources of error is included. The growth of daughter crystals and the state of aggregation of mineral forming solutions as deduced from the course of homogenization forms an interesting new aspect of the work. Examples are given of studies of calcite, fluorite and quartz, favourite minerals for this purpose, and many results obtained by the author and his students at Lvov State University are set out and discussed. The familiar stages of crystallization starting from silicate melts with water in solution are followed from endomagmatic, through aplite-pegmatite to pneumatolytic (early and late supercritical) and hydrothermal with temperatures assigned from the fluid inclusion measurements. Yermakov maintains that his studies provide one of the most important keys to the understanding of the genesis of ores, and makes a strong case for the introduction of these techniques as part of the standard equipment of the ore geologist. Part I is well illustrated and includes a comprehensive international bibliography.

The second part, entitled "Transactions of the All-union Institute of Piezo-optical Mineral Raw Materials", is a symposium by Yermakov and fifteen others. Apart from quartz from Barsukechi, Pamir and Kazakhstan, gold ores from the Urals, skarns from the Northern Caucasus, and pegmatites from Volynia are described. One of the most valuable papers in the series is that by G. M. Safronov and V. Ye. Khadzhi dealing with thermometric investigations of liquid inclusions in synthetic quartz, for here