

REVIEWS

Giant Meteorites; by E. L. KRINOV, translated from the Russian by J. S. Romankiewicz and M. M. Beynon. P. xxi, 397. Oxford, 1966 (Pergamon Press, Ltd., \$15.00).—The study of meteoritics and of meteorite craters in particular, has advanced by leaps and bounds in the past few decades. To this advance E. L. Krinov of the Committee on Meteorites of the U.S.S.R.. Academy of Sciences has contributed significantly. His recent book, *Giant Meteorites*, translated from an unpublished Russian version, is of interest both to the lay reader and the professional meteoritist. It is written in sufficiently general terms to be enjoyed by the former, while it gives a wealth of detailed original observations on Russian craters or impact sites not heretofore published in the English language.

An introduction of fourteen pages summarizes what sorts of bodies reach the Earth from outer space, giving the untrained reader sufficient background to appreciate the spectacular occurrences that constitute the main subject matter of the text. This is divided into four major parts and an appendix. Part I deals with meteorite craters in general and classifies them into "impact" and "explosive" categories. In the rare instances of massive meteorite showers, such as the famous Sikhote-Aline fall in 1947, both kinds of craters may be found close together. In agreement with theory (Krinov's) craters and debris are distributed over a roughly elliptical area, the larger or explosion craters near one end of the axis of the ellipse in the direction toward which the meteorites had been travelling, followed by smaller craters, mainly of the impact variety, with fragments too small to have produced craters trailing to the rear of the scatter ellipse.

The most famous of all meteorite craters is the Barringer Crater in Arizona, commonly known simply as "Meteor Crater". Assumed to be some 50,000 years old, it is 1.2 kilometers in diameter and 174 meters deep. Other large holes in the ground have also been suspected of being meteoritical in origin. When meteorites are actually found, there is no question as to the origin of the crater. In other cases, either the crater-producing explosion left no recognizable remains of meteorites or weathering has destroyed the evidence. Krinov lists and describes some 15 craters or groups of craters he considers authentic meteorite craters, ranging in size from 13.7 kilometers down to less than 10 meters. It is gratifying to note that all of these have likewise been declared authentic in recent American inventories. Krinov also describes about 35 "suspected" meteorite craters, 14 of which are now accepted as authentic by American authorities.

The remaining three parts of the book are devoted one each to three extremely impressive sites. The Barringer Crater is the first ever to have been recognized as a meteorite crater. The history of its exploration is familiar to meteoritists but is worthy of being retold. Of greatest value to English speaking meteoritists are part III on the Tunguska Meteorite and part IV on the Sikhote-Aline Iron Meteorite Shower. Here the author gives first-hand accounts of the hardships associated with the exploration, the excitement of discovery, and the problems for research.

The Tunguska Meteorite which fell in 1908 in well nigh inaccessible tundra was not explored by scientists until Kulik's first expedition in 1921, and the exact site was not actually found until a later expedition in 1927. Results and conclusions reported by the early investigators are carefully evaluated. In 1958, 50 years after the fall, a new expedition, armed with greater understanding as a result of intervening research, disproved a few previously accepted findings and clarified others. For example, while there is no denying that a meteoritic phenomenon was responsible for the devastation of a forest, felling trees to a radius of 30 kilometers, the "meteorite craters" found earlier are now understood to be the consequence of the natural terrain unrelated to the impact of meteorites. At this site no large meteorites have been found, but meteoritic dust is present in soil samples—iron fragments up to a few millimeters long, and magnetite and silicate globules less than a few hundred microns across. It is now supposed that the "meteorite" was the icy-conglomerate head of a comet. Much more research is contemplated before the final chapter on this remarkable phenomenon can be written.

Quite different is much of the story of Sikhote-Aline. As in 1908, a brilliant bolide was widely observed on February 12, 1947, and much destruction on the ground followed. There the analogy ends; for at Sikhote-Aline at least 70 tons of sizable meteorites were strewn over an ellipse 2.1 by 1.0 kilometers. The orbit of the meteoroid around the sun could be computed. Aphelion was in the asteroid belt between Mars and Jupiter, perihelion close to the orbit of Venus. This is not typical of a cometary orbit. Again the author stresses plans and needs for more research.

The appendix was obviously written considerably later than the body of the text. The bibliography for the text lists references up to 1960 whereas references for the appendix include some for 1964. In view of the fact that the book had not previously been published, it is a pity that the material in the appendix was not incorporated into the text proper. This could have been accomplished with very little editorial effort and would have averted the initial impression on reading part I that parts of the text are out of date. The bibliography is a valuable asset. There is an author index, but unfortunately no subject index such as every scientific treatise should have. With a few exceptions, the author index does not include the page numbers of papers listed in the bibliography. This is unfortunate since the arrangement in the bibliography is neither by author nor chronological. It is a mite confusing to find a page reference for an author and not find the author's name mentioned on the cited page. In such cases it develops that one of the references to the bibliography is meant. For example, Whipple is not mentioned on page xi as the index implies, but reference 8 on page xi cites on page 388 a paper by Whipple. It would have been more helpful to give page 388 rather than xi in the index.

A few redundancies and numerous small errors are detected, some typographical, others possibly arising from the translators' lack of familiarity with the English terminology of meteoritics. None of these detracts from the understanding of the intended meaning. One minor confusion in terminology is unfortunate. At the 1961 meetings of the International Astronomical Union, its Commission on Meteors and Meteorites agreed upon what the usage of certain key words should be. One of the words is "meteoroid", which is commonly used to describe an object of meteorite-dimensions while it is still orbiting the sun before it encounters the earth. (This is analogous to the term "asteroid.") Although this had long been the common usage of this word, the American meteoriticist H. H. Nininger is cited as having coined this very word to signify one variety of oxidized meteorites, and Krinov adopts this rare usage (p. 28).

Despite many trivial blemishes, primarily of an editorial nature, *Giant Meteorites* is highly recommended. Much of the book is more exciting than most human mystery stories. While stimulating the imagination it teaches a great deal about one of the relatively newest sciences, one bound to have bearing on how the features of the Moon will be interpreted in modern "space age". Meteoritics is a borderline science embracing parts of astronomy, geology, geophysics, mineralogy, chemistry, ballistics, and others. On reading this delightful account, especially of three of the greatest celestial bombardments of our Earth, a scientist in each of these fields can sense problems yet unsolved worthy of his own research effort.

DORRIT HOFFLEIT

The geochronology of equatorial Africa; by L. CAHEN and N. J. SNELLING. P. 195. Amsterdam, 1966 (North Holland Publishing Co., \$16.80).—Cahen and Snelling have provided a digest of geologic and geochronometric data that enables other geologists to learn the essentials of the geologic history of much of Africa. The presentation is a very satisfactory one, providing information of both a general and specific nature.

The first chapter contains a concise introduction to the various dating methods applied to African rocks. It is followed by a discussion of the interpretation of dating results. The analysis is clear and judicious. The real uncertainties, which completely overshadow analytical errors, are clearly stated, and rules of thumb are set forth for evaluating the results from orogenic belts. Greatest confidence is placed in U-Pb dates, whole rock Rb-Sr dates, and mineral dates from pegmatites; maximum dates are considered better limits on times of metamorphism than means or modes of date histograms; it is recognized that the lag in time between deformation accompanied by metamorphism and mineral dates may be as great as 100 to 200 million years. These two chapters together constitute one of the best introductions to practical geochronometry that can be found.

Chapter 3 discusses the terminology problem created by nature and man's provincialism—the brief chapter is more of a warning of the stra-