

of the complexities of interplay among the various participants.

Dedicated readers of this collection of papers can, of course, prepare their own catalogs of cross-references, and they are given many productive sources to draw from. For such readers, these sources of information make the book quite worthwhile. In the remarks below, I touch on some of the highlights as a geological reader who is appreciative of the value of multiple approaches for understanding past environments. I do not dwell on the brief papers on local geology, climate, and archeology, not because they are without interest to some readers but because (in my view) they are not focused on the main point of this book.

The environmental history of the Central Great Plains that emerges from this book, as might be expected, is a sequence of cyclic changes prompted by the oscillations between glacial and interglacial climates. The beginnings of these cycles and their tangible effects, in the perspective of the preceding Tertiary environment, are outlined by P. V. Wells in a brief review of the paleobotanical record. The history continues in a paper by C. W. Hibbard, who argues from the evidence of vertebrate fossils that conditions of the early and middle Pleistocene were comparatively equable. From sparse records of fossil pollen described by R. O. Kapp, the vegetation of the Central Plains was then marked by spruce and pine, even though the vertebrates show that subtropical climates extended north into Nebraska during the interglacials. Kapp's results suggest that substantial areas of prairie did not exist until the late Illinoian. From then on, the oscillations of climate became more severe and culminated in the present sharp zonation of climate in late Wisconsin time. Because of Wisconsin-age forests at many sites, which are described in papers on fossil pollen by H. E. Wright, Jr., F. Wendorf, and P. J. Mehringer and his co-workers, the grasslands as seen today are very largely a post-Pleistocene development. Interestingly, a stratigraphic and geographic review by R. V. Ruhe on the buried, relict, and present soils also indicates the wider extent of former forests, even in areas that were receiving deposits of windblown silt from glacial streams laden with outwash. The culminating blow to the dogma that the treeless grasslands are a persistent product of climate is struck by P. V. Wells in two

papers, which show not only the recent existence of large stands of mature juniper and ponderosa pine in one of the driest areas (the Laramie Basin) but also the significance of existing "scarp woodlands" that are scattered throughout the Great Plains. To Wells, these protected stands of trees indicate that other factors (dominantly fires) have been more influential than climate in maintaining the prairie environment. In the matter of prairie fires, Ruhe explains that the organic carbon in surface soils can date back more than a thousand years, but this supportive fact was apparently not made known to Wells.

The sharply contrasted environments of the late Pleistocene, which led to greatly reduced areas of grassland during glacial times and to their probable expansion during interglacials, have stimulated zoogeographers to account for the observed distributions of several groups in terms of these changing habitats. Thus H. H. Ross, in reporting that only three of 108 grasshoppers and only a few of the lateline leafhoppers are prairie endemics, concludes that the areas of grassland during glacial stages were indeed small. R. M. Mengel, in a comprehensive study of 233 species of birds, only 37 being indigenous to the present Great Plains, sees the northern taiga as an intermittent connecting route for migration between the eastern deciduous forest and the western montane forest. The taiga was surely broad during interglacials when the grasslands were large, and it probably was frequently broken during glacial episodes when the grasslands were small. Mammalian distributions, however, as analyzed by R. S. Hoffman and J. K. Jones, Jr., seem to require at least some grassland throughout the late Pleistocene. In a longer view, F. B. Cross discusses the fishes as indicators of post-Pliocene environmental change in the Great Plains (details for Kansas are provided by G. R. Smith and D. R. Fisher). His review of the discontinuous ranges of fishes implies a history of reduced surface water and of lessened diversity in aquatic habitats.

These findings from botany, paleontology, pollen studies, and zoogeography are a long step forward, but the results are still indecisive for assessing the relative dominance of glacial and interglacial environments in directing evolutionary trends in the Great Plains. As these matters are worked out, the meaning of the fossil record for com-

prehending changes in the Pleistocene environment will become clearer.

Thus, a reader with the time and patience to search through some of the papers in this book will find that the traditional view about persistent grasslands in the Great Plains has crumbled under the combined attack of many techniques of study.

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A Weather Pattern

Monsoon Meteorology. C. S. RAMAGE. Academic Press, New York, 1971. xiv, 298 pp., illus. \$15.

The large fraction of the world's population living in monsoon countries, especially in tropical Africa and Asia, is critically dependent on weather for survival and progress. Yet it is not until now, when Ramage has drawn together the scattered bits of information available around the world, that a comprehensive survey of the weather factors that different monsoon areas do or do not have in common has been available.

Ramage's approach is that of traditional meteorology. He opens with a search for an adequate definition for the monsoon areas and concludes that the distinguishing characteristics are large seasonal reversal of prevailing wind and, within each season, a paucity of weather disturbances that mask the general pattern for any length of time. Appropriately, amount of rainfall is rejected as a criterion. Then follows a discussion of the general circulation in the monsoon belts, the day-to-day features leading to the observed large variations of precipitation within the rainy seasons, and a detailed discussion of weather through the year in all monsoon areas. The last topic takes up one-third of the book. There is some discussion of seasonal precipitation anomalies, their causes and forecasting. But this information is rather compressed; topics such as weather modification and air pollution are largely omitted; and the author does not take up the option his general title allows of considering the interdisciplinary and environmental aspects—notably water resource management—of meteorology for the monsoon areas.

In line with the contents of the book Ramage specifies in the introduction that his text is intended for graduate or

advanced undergraduate students of meteorology and for professional meteorologists. He adds that the book may also prove useful to meteorologists studying daily changes of global weather, a timely suggestion indeed. The book assumes knowledge of general meteorology and of many technical terms, but even readers with considerably less technical knowledge will find much handy information when using the book as a reference volume, especially the parts dealing with climate.

Technically, Ramage takes issue with various misconceptions that have plagued tropical meteorology for many years and are hard to eradicate. He makes a strong case against the concept, imposed from outside the tropics, that monsoon weather can be treated as being governed by an "intertropical front" or "intertropical convergence zone." Instead, he proposes a more realistic and complex overall classification scheme of monsoon weather which, it is hoped, will find general acceptance. He also places unusual emphasis on the role of coastal waters, which, under the influence of the broad wind systems, provide a feedback limiting or enhancing monsoon strength in various areas. His example of the situation off the African east coast north of the equator is particularly telling. Among the weather disturbances the treatment of the "subtropical cyclone," especially its role in the vertical mixing of the atmosphere, is novel and impressive. Throughout the book the point is made that heavy monsoon precipitation comes in the form of persistent rains, as contrasted with thunderstorm showers. Indeed, an inverse relation between total precipitation and thunderstorm frequency has been demonstrated by various researchers, for instance in northern Australia. To be sure, one can always find controversial matter in a volume treading so much new ground. For example, according to the author, the summer monsoon "heat" low pressure areas found persistently over West Pakistan and other areas occur under the influence of general subsidence in the upper air, keeping skies clear and permitting maximum radiation from the sun to reach the ground. Undoubtedly correct. But then he suggests that absorption by air of reradiation of this heat from the ground reduces the density of the lower atmosphere to create the heat low. At best, one could investigate the role of a heavy dust layer that may be present (as has been done by R. Bryson, University of Wisconsin).

But it is not demonstrated why heat convection from the ground should not be the principal mechanism here as everywhere else.

Ramage's writing technique consists largely of description backed by qualitative reasoning, a method he defends strongly in the "Concluding remarks." He feels, justly, that useful formulation of models for computers must be preceded by an understanding of the laws and special circumstances creating weather patterns. His book, drawing together the most important observations of the monsoon areas into a general scheme, should be useful in fur-

thering a realistic advance toward objective weather prediction. From the vast literature, he has selected a large and representative sample for references. Illustrative material is plentiful, including many satellite photos. However, the publisher has failed to provide adequate editing of the drawings; many have an excess of lines and are hard to interpret. Also, reduction has been carried too far; much lettering is reduced to 0.04 inch and may require a magnifying glass for reading.

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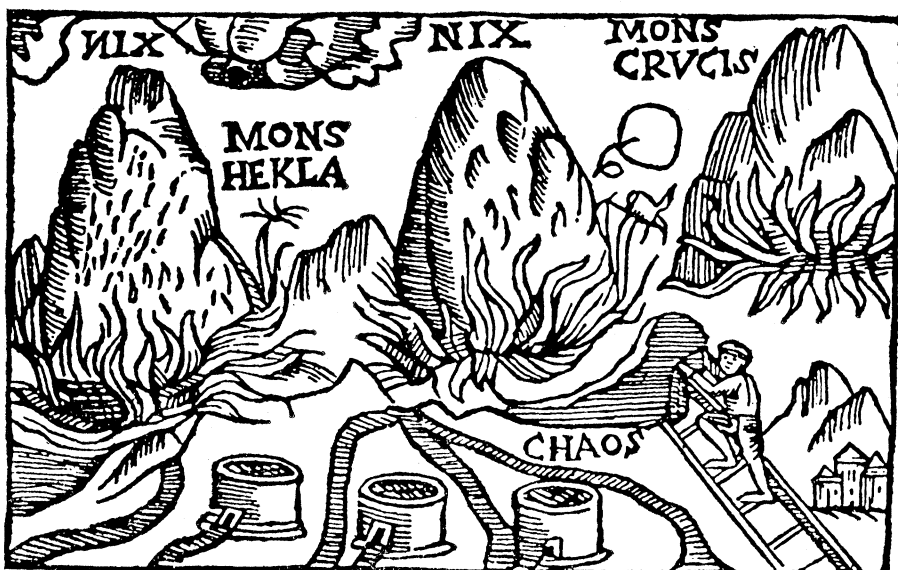
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A Feature of Iceland

Hekla. A Notorious Volcano. SIGURDUR THORARINSSON. Translated by Jóhann Hannesson and Pétur Karlsson. Almenna Bókafélagid, Reykjavik, Iceland, 1970. 62 pp. + plates. \$7.

From the land of fire and ice comes a most useful and interesting volume on Hekla, a notorious volcano. This is from the pen of Sigurdur Thorarinsson, who is an outstanding volcanologist and is

chairman of the Division of Geosciences of the Science Institute of the University of Iceland. The author's work in the study of tephra layers in Iceland has led to the development of the specialized scientific subject known as tephrochronology and has attained worldwide recognition. (Tephra" is a general term for all solid matter which comes from a volcano as airborne and thus is



The volcano Hekla as depicted in 1555. "After [the volcano] awoke from centuries of slumber in the year 1104 . . . horrific tales about it soon began to circulate throughout the Catholic world: there, said people, was to be found the gateway to Hell, if not Hell itself. . . . In the oldest reference to Hekla, the *Book of Wonders* dating from about 1180 and compiled by Chaplain Herbert of the Clairvaux monastery, the following passage is found: 'The renowned fiery cauldron of Sicily, which men call Hell's chimney . . . is affirmed to be like a small furnace compared to this enormous inferno . . . Who now is there so refractory and unbelieving that he will not credit the existence of an eternal fire?' . . . In a travel book by the Frenchman De la Martinière printed in 1675 readers are informed that the Devil now and again drags the souls of the damned out of Hekla's fires in order to cool them on the pack-ice in the seas off Iceland . . . Icelanders also stood in dread of the volcano, but this had its natural causes, for the damage it did to their property when in ugly mood was severe . . . the belief in Hell inside Hekla never made much headway in Iceland." [From *Hekla: A Notorious Volcano*]