Zoogeography

AAAS 1848

Zoogeography

A SYMPOSIUM PRESENTED ON AUGUST 26-27, 1957, AT THE STANFORD UNIVERSITY JOINT MEETING OF THE AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES AND THE PACIFIC DIVISION OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AND

A SYMPOSIUM PRESENTED ON DECEMBER 28, 1957, AT THE INDIANAPOLIS MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Edited by

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This volume is dedicated

to the memory of

two great zoogeographers,

CHARLES DARWIN AND

ALFRED RUSSEL WALLACE

Whose observations and reflections on the distribution of animals provided much of the evidence that led them, just one hundred years ago, to propose to the world the epochal concept of Organic Evolution, which unshackled the minds of men and helped inaugurate the Age of Science.

Preface

As science expands and fragments, reviews and syntheses of broad areas become increasingly useful and necessary. Among the more effective means of review and synthesis are the symposia that are being held in increasing numbers at scientific meetings. Two such symposia, in 1957, encompassed the field of zoogeography, with due attention to the underlying data of geomorphology, paleoclimatology, paleontology, and physiology. The fifteen papers that have become available from these two symposia comprise a notable and rather comprehensive, though somewhat diverse contribution to zoogeography and to its background sciences. The extent of the contribution is greatly enhanced by the publication of these assembled papers as one of the symposium volumes of The American Association for the Advancement of Science.

The first of these two symposia (Part I) was held under the prime auspices of the Pacific Section of The Society of Systematic Zoology, as a feature of the joint meeting of the American Institute of Biological Sciences and the Pacific Division of the American Association for the Advancement of Sciences, at Stanford University, in August, 1957. The symposium, bearing the ample title "The Origins and Affinities of the Land and Freshwater Fauna of Western North America," was abundantly cosponsored by the American Society of Ichthyologists and Herpetologists (Western Division), American Society of Zoologists, California Academy of Sciences, Pacific Coast Entomological Society, Society for the Study of Evolution, and Western Society of Naturalists. The fourteen papers ran through well-attended morning and afternoon sessions on August 26 and 27, plus a final panel discussion that nearly filled a spacious hall on the evening of the second day. The large and attentive audiences demonstrated the liveliness of the subject. Audience contribution was so spirited at the panel discussion that I had difficulty in closing the session at a reasonable hour.

It was my pleasure and privilege to act as general chairman of this symposium. In conducting the sessions I was ably joined by the late Karl P. Schmidt, as one of the last of his many generous acts, and by George F. Edmunds, Jr. Panel members William H. Burt, Alden H. Miller, Robert W. Pennak, Herbert H. Ross, and Dr. Schmidt helped enliven the informal discussion.

Gratitude is expressed to the fifteen participants, all of whom made notable contributions. Most of the contributors made an extensive and thorough analysis of their chosen subjects, and some treated their topics in exhaustive and carefully documented style.

Credit for the success of this symposium goes to the symposium committee, all of the University of California, Los Angeles: John N. Belkin, chairman, Donald Heyneman, and Marietta Voge. These zoologists were the prime actors in the conception of the idea, in lining up the able speakers, in arranging and managing the sessions, and, as not the least difficult task, in extracting manuscripts from thirteen of the participants. They also helped in processing the manuscripts. I am sure that the officers of the meetings, the speakers, the audiences, and, now, the scientific public, join me in expressing hearty thanks to these tireless and self-effacing workers.

The second symposium (Part II), which is herein represented by three of the six papers, was a feature of the American Association for the Advancement of Science meeting at Indianapolis, and was held on December 28, 1957. It was entitled "Geographic Distribution of Contemporary Organisms," and constituted Part I of the general symposium, "Some Unsolved Problems in Biology, 1957." This was a joint program of AAAS sections F (Zoological Sciences) and G (Botanical Sciences), and was extensively cosponsored, by the Society of Systematic Zoology, Ecological Society of America, Genetics Society of America, American Society of Naturalists, and Botanical Society of America. The program was arranged by Harold H. Plough, of Amherst College, as Secretary of Section F, ably assisted by Ernst Mayr of Harvard University and E. Raymond Hall of the University of Kansas. Dr. Hall presided at the symposium and contributes the introductory remarks.

We of the Pacific Section of the Society of Systematic Zoology welcome the privilege of combining the papers resulting from our symposium with the three submitted from the Indianapolis symposium. As editor of the combined symposia, I want to express the feeling that they very nicely complement the contributions from the first symposium.

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October 1958

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Contents

PART I

The Origins and Affinities of the Land and Freshwater Fauna of Western North America

1

Evolution of Modern Surface Features of Western North America[1]

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In preparing a summary of the geological background of the origins and affinities of the land and fresh-water faunas of western North America, I am faced with several difficulties.

First is the well-known lack of communication between the sciences—a difference in language, in thinking, and in emphasis. Thus, items that may be decisive to a zoologist may receive little attention from a geologist. I welcome this opportunity to bridge a gap between the zoological and geological sciences, to make a contribution to a problem shared by both of us, and to enhance my own education. At the same time, I must admit my present ignorance of facets of the problem which are not geological, so that my analysis in this paper must be mainly geological.

Then, too, even in making a purely geological analysis of the problem one discovers wide gaps in the record, much evidence that is equivocal rather than decisive, and much divergence among geologists as to what the evidence means. Broadly, the subject here treated is the evolution through time of the geological features of western North America, but the aspect of most zoological interest is evolution of the surface forms only. For the record up to the middle Tertiary, the surface forms must be deduced from rocks and structures of various ages, since none of the landscape of that time is now preserved. Some fragments of surface forms as old as middle Tertiary are preserved, and younger ones are preserved in in-

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[1] Publication authorized by the Director, United States Geological Survey.

creasingly larger entities, but even these surface forms are diversely interpreted.

Finally, in so large a subject as western North America, I cannot hope to do justice to all items and problems in a single paper. The best one can do is to make a sampling and to hope that the samples will be sufficiently representative of the whole. In this paper, the samples will be chosen mainly from the segment in the United States, partly because this is the region I know best, partly because it is the region best known to geologists in general.

PRESENT GEOGRAPHY

Western North America is the region of the Cordilleran system of mountain ranges, which extend unbroken along the Pacific Coast from Alaska to Central America, and beyond, and inland 400 to 1,000 miles (Fig. 1). In Canada and the western United States they front eastward on the Great Plains of the continental interior, but in Alaska they front northward on a coastal plain at the edge of the Arctic Ocean, and in Mexico they front northeastward on a coastal plain at the edge of the Gulf of Mexico.

Geographically, the Cordillera north of Mexico is commonly divided into two chains of ranges, one along the coast on the west, another fronting the Great Plains on the east, with lower, more broken ranges and plateaus intervening. Highest summits in North America and in the United States are in the chain nearest the coast, Mount McKinley in Alaska at 20,300 feet and Mount Whitney in California at 14,495 feet. The summit of the interior chain, Mount Elbert in Colorado at 14,431 feet, is somewhat lower. Many other peaks in both chains project to heights nearly as great as the absolute summits, and some of these have greater relief relative to their immediate surroundings.

The western mountain chain includes the Alaska Range of Alaska, and the Coast Mountains of British Columbia. In the United States the chain is double, with low Coast Ranges on the west separated by the Puget Trough, Willamette Valley, and Great Valley of California from the higher Cascade Range and Sierra Nevada on the east. A comparable pattern is expressed to the north, in Canada and southeastern Alaska, by the offshore islands and Inland Passage, and to the south, in Mexico, by the peninsula of Baja California and the Gulf of California.

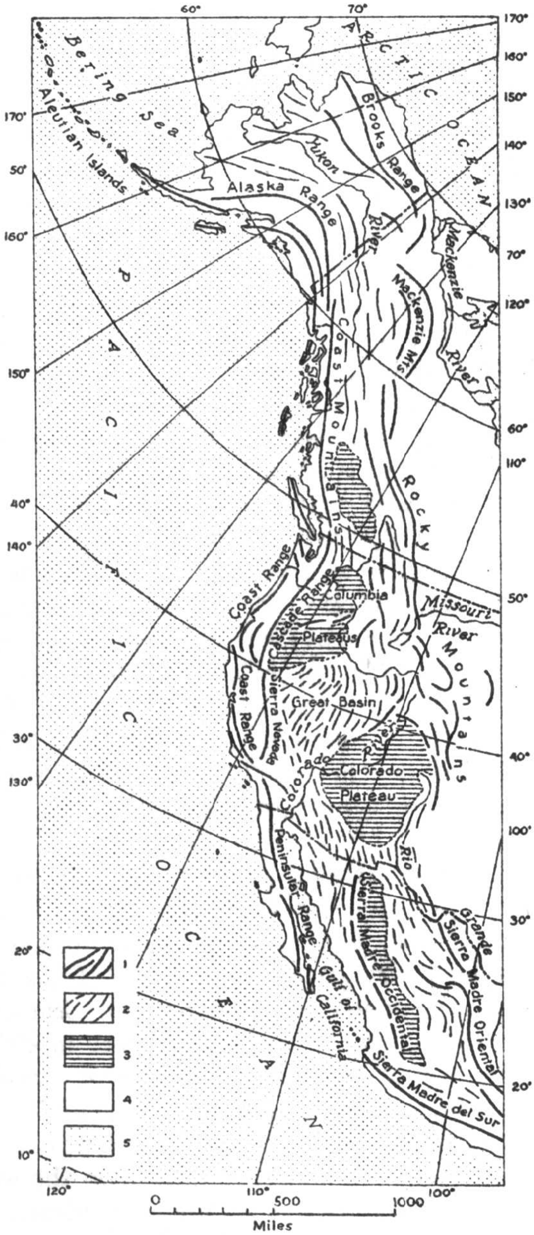

Fig. 1. Generalized map of North American Cordillera, showing present topographic configuration. 1, Principal ranges. 2, Minor ranges. 3, Plateaus. 4, Lowlands, including plains of continental interior. 5, Submerged areas, mainly ocean basins, but including continental shelves.

The lower intermontane belt begins on the north with the wide depression along the Yukon River in Alaska, continues southward through various plateaus and ranges in Yukon Territory and British Columbia, and includes the Columbia Plateau, Colorado Plateau, and Basin and Range province in the western United States.

The eastern mountain chain is represented in Alaska by the Brooks Range, and farther south, in Canada and the western United States, by ranges that go under the general title of Rocky Mountains. The Rocky Mountains end as a continuous barrier in northern New Mexico, and for considerable distances southward the eastern ranges are discontinuous and are of Basin and Range type.

In Mexico, the tripartite division of the Cordillera farther north is lost. Here the Cordillera is essentially a high plateau, breaking off in ranges on the east, west, and south, which form the three Sierra Madres of that country—Oriental, Occidental, and del Sur.

These are the gross geographic forms of the Cordillera today, yet to some extent they are accidental, and at most reflect only latest warping of the crust. They have slight utility in an analysis of the evolution of the surface features of the Cordillera, as each consists of diverse geological features that have developed at different times and in different ways. For example, the Sierra Nevada is an uplifted block of crystalline rocks, whereas the Cascade Range, its orographic continuation on the north, was built primarily by volcanic eruptions.

Present surface forms, rocks, and structures of the Cordillera have developed through a long span of geologic time. Mountains arose first in the western part of the region, in the middle of Mesozoic time; others farther east developed in later Mesozoic and early Tertiary times. Subsequently, in Tertiary and Quaternary times, the initial mountains of the whole region were modified into the forms we now see—by a continuation of crustal mobility, supplemented by volcanism, erosion, and sedimentation. The eastern part of the Cordillera appears to be attaining stability now, so that the modifying processes are becoming less active. On the west they are still at work, as may be seen by the seismic and volcanic unrest near the Pacific Coast, and one may anticipate continuing rearrangements of the geography there. It is my purpose in the pages that follow to elaborate on the sequence of events thus briefly outlined.

CONTROLLING PRINCIPLES

Nature of Mountain-Building Processes

Ultimate cause of mountain building is to be sought, not in such merely superficial processes as erosion, sedimentation, glaciation, or volcanism (however much these may shape the landscape in detail), but in forces within or beneath the crust of the earth, which have deformed the rocks and raised or lowered large areas of the surface. Little is known about these forces themselves, but much has been learned about their effects.

Some of the orogenic phases have been referred to as "revolutions," because they are supposed to have brought about drastic rearrangements of the geography and climate, and so modified the environments as to cause far-reaching changes in distribution and kinds of life. Detailed study shows, however, that the different phases merge into each other, and that the changes they brought about were evolutionary rather than revolutionary. Operation of crustal forces was persistent through time, and although there were certain crescendos, development was orderly and progressive, rather than catastrophic.

Nature of Continental and Oceanic Crusts

In North America, at least, mountain building was a feature of the edge of the continent—the border zone between the *continental platform* and the adjacent *ocean basins*.

Sequentially, the processes may be divided into an initial or geosynclinal phase, followed by an orogenic phase and a post-orogenic phase, the nature of which will be examined later. The phases were prolonged. In the Cordilleran region the geosynclinal phase endured for at least 350 million years, from Cambrian to Triassic; the orogenic phase, for about 100 million years, from Jurassic to Paleocene; and the post-orogenic phase, for about 50 million years, from Eocene to present (Table I).

Continental platforms and ocean basins are fundamentally different elements of the crust of the earth (the crust is the relatively thin skin of rocks that overlies the dense material of the interior of the earth). Their surfaces stand today at different levels: the continental averages about half a mile above sea level; the oceanic, 3 miles or more below sea level. The two levels reflect contrasting