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PROTEROZOIC EVOLUTION AND ENVIRONMENTS

A special volume of the American Journal of Science (v. 290-A)

dedicated to

PRESTON E. CLOUD

ANDREW H. KNOLL AND JOHN H. OSTROM
EDITORS

1990
NEW HAVEN, CONNECTICUT
PROTEROZOIC EVOLUTION AND ENVIRONMENTS:
A SPECIAL ISSUE OF THE AMERICAN JOURNAL OF
SCIENCE IN HONOR OF PRESTON CLOUD

EDITORIAL INTRODUCTION

In one of history's more notable expressions of modesty, Isaac Newton insisted that if he had seen farther, it was because he had stood on the shoulders of giants. Newton may not be totally convincing on this point, but there can be no doubt that in general scientists build on the foundations established by others. This special volume of the American Journal of Science contains twelve contributions by geologists, paleontologists, and microbiologists who are striving to see more deeply into the Proterozoic history of our planet; to the extent that they succeed, it is because their feet are planted firmly on the slight but strong shoulders of Preston Cloud.

Pres Cloud's influence on twentieth century geology and paleontology is incalculable. He pioneered in studies of paleoecology, shaped the Paleontology and Stratigraphy branch of the U.S. Geological Survey, helped establish the field of marine geology, and made lasting contributions to our knowledge of modern carbonate sedimentation. By itself, this record would encompass the fruits of a distinguished career. However, it is yet another facet of Pres's work that we honor in this volume—his landmark contributions to our knowledge of the (as Pres would insist) pre-Phanerozoic Earth. The title of this volume intentionally echoes that of the 1968 book Evolution and Environment in which Pres presented one of his most influential papers. In focussing on Proterozoic evolution and environments, we explore new research directions in two areas Pres has properly viewed as the sides of a single coin.

Preston Cloud is one of an extraordinary group of four individuals who collectively established the field of Archean and Proterozoic paleontology. Elso Barghoorn, my own mentor, demonstrated the existence of life's remarkable pre-Cambrian record to a world of skeptics. The Soviet paleontologist Boris Timofeev established the now thriving study of Proterozoic microfossils preserved in shale, while Australian Martin Glaessner illuminated the earliest record of animals. Preston Cloud contributed to our knowledge in all three areas, but that is not the principal reason why we salute him today. Cloud's enduring contribution has been to establish the very way in which we think about early evolution. He has insisted that traditional paleontology be married to geology and geochemistry so that early biological history can be understood in the context of the developing planetary surface. This powerful vision established the essential research agenda of the field, and it lies at the heart of the papers contained in this volume.

Following John Rodgers' appreciation of Pres as a person and scholar, the volume begins with two contributions on one of Cloud's favorite subjects—the iron formations that are so characteristic of
Archean and Paleoproterozoic sedimentary successions and so conspicuously absent from most of the later record. Holland and Beukes use the weathering profile of a South African iron formation to place semi-quantitative limits on the timing and magnitude of the Paleoproterozoic oxygen revolution. Nealon and Myers approach the subject from a different perspective, reporting on the recent isolation of novel iron metabolizing bacteria and its implications for the interpretation of banded iron formations.

From iron formation, the volume moves to three papers on a more widely distributed class of Proterozoic sediments—the carbonates. Fairchild, Marshall, and Bertrand-Sarfati analyze the carbon isotopic record of stromatolitic carbonates from Mauritania. John Grotzinger continues what stands revealed as a family tradition: following on the contributions of his Uncle Pres, he takes a critical look at apparent secular variations in Proterozoic stromatolite record. Complementing work by Grotzinger, Knoll and Swett argue for possible secular patterns in Proterozoic carbonate sedimentation as a whole. In all three papers, the authors echo Pres Cloud's theme that there can be no meaningful understanding of the Proterozoic sedimentary and paleontological records unless the two are considered together.

Paleontology requires fossils, and new paleontological discoveries are reported in several papers. Walter, Du, and Horodyski discuss the emerging record of Mesoproterozoic metaphytes, while Horodyski and Mankiewicz report new, possibly calcareous metaphytes from the Neoproterozoic Beck Springs Dolomite—a formation whose paleontological riches were first discovered by Cloud. Vidal and Nystuen report on microfossils from the Neoproterozoic Hedmark Group, Norway. This paper provides a rare glimpse of Proterozoic microfossils in deep water sediments and contributes to another of Pres Cloud's goals, the accurate biostratigraphic correlation of Proterozoic strata. Summons and Walter report on the rapidly growing molecular record of Proterozoic life and compare it to the equally improving morphological record.

Cloud's contributions are commemorated in a number of taxonomic names, but no fossil so graced can claim greater importance than Cloudina, the earliest known skeletonized metazoan. Cloudina was first described by Gerard Germs while a post-doctoral fellow in Cloud's laboratory. Here Stephen Grant presents a new petrological and geochemical study that illuminates the biology and diagenesis of these remarkable calcareous remains. Conway Morris, Mattes, and Chen report new populations from Oman and China, with both papers demonstrating the widespread nature of Cloudina and, possibly, other architecturally similar animals in late Vendian rocks.

In the final contribution, Christie-Blick, von der Borch, and DiBona provide an illuminating application of sequence stratigraphy to Proterozoic sedimentary geology.

Every paper in this volume reflects the influence of Preston Cloud's thinking. All endeavor to combine the two features that set Pres Cloud's
papers apart from the ordinary: painstaking attention to empirical detail coupled with intellectual boldness in interpretation. Without the first, no claim about the early Earth can be taken seriously. In the absence of the second, we will not see farther, even when perched atop a mountain of data.

Fortunately for the rest of us, Pres Cloud hasn’t solved all the problems of early biological and environmental evolution. He has, however, framed the principal questions in a provocative and insightful fashion that will draw new talent and ideas into the field for years to come. That, really, is the way in which science honors her best. As guest editor, it is my special privilege to present this volume to my friend, colleague, and (more than he knows) teacher Preston Cloud in deeply felt appreciation for an exemplary lifetime in science.

Andrew H. Knoll
(For photo identification see page xvi)
APPRECIATION OF PRESTON CLOUD

The American Journal of Science is proud to offer this special volume as a tribute to Preston Cloud. Three of his first four papers appeared in our Journal, and he has been one of its Associate Editors for 21 years.

Preston Cloud’s many publications over 50 years reveal the extraordinary breadth of his intellectual interests and scientific competence. He began with classical descriptive paleontology, but that led him quickly into stratigraphy, then into the modern seas where stratigraphy and paleontology are being created before our eyes, if we would only look—he was one of the founders of the now immense field of marine geology—and on into organic reefs, marine ecology, and carbonate sedimentation. He then turned “back,” one might say, to the beginnings of life, to its ecology and evolution and the evolution of the atmosphere and the ocean that conditioned it. There have been other themes along the way, such as field mapping, especially in Paleozoic carbonate rocks, and study of economic mineral deposits. From these and from his deep ecological interests, he was led to the question of evaluating and conserving our fossil energy resources and indeed all mineral resources, and he has made major contributions in that direction as well. Clearly, choosing a central theme for this celebratory volume required a difficult choice, but we chose the conditions surrounding the beginnings of life on the primitive Earth as representing the core of his current interests. Of course, dealing with as versatile a mind as Preston’s, who is always moving on both geographically and intellectually, we may find that he has already left us behind. But we hope that this collection of articles, all on subjects that he has illuminated, will express the deep respect and gratitude of us all, authors and editors, for what he has accomplished over the years, and for just existing.

Preston Cloud grew up in southern Pennsylvania. After high school, he served a two-year stint in the U.S. Navy. Prevented by circumstances from going on to college in the regular way, he refused to be daunted by bad fortune; he went to work (in the pit of the depression) and at the same time put himself through night school, earning a bachelor’s degree. As it happened, the work was as a preparator in paleontology in the U.S. National Museum in Washington and the school was George Washington University, of which Pres is now recognized as a most illustrious alumnus. His mentor at the Museum was Dr. G. Arthur Cooper, and Cloud’s first paper was joint with Cooper. Cooper then called Professor Charles Schuchert’s attention to this gifted and indomitable young man, and Schuchert saw to it that Cloud could attend graduate school at Yale and earn his doctorate there. Yale, too, is proud to count him as an alumnus, and the Yale Graduate School awarded him its Lucian Wilbur Cross Medal in 1973.

By the time Pres was finishing his education, the depression world had changed into a war world, and soon he went to work for the U.S.
Geological Survey's Strategic Minerals Program. After the war, Harvard called him to its position in invertebrate paleontology, but after two years he returned to the U.S. Geological Survey, where he helped to create a vigorous program in mapping Pacific Islands and the surrounding seas, and then took on the task of building up the Survey's effort in paleontology and stratigraphy in both aspects—providing time controls for geological field projects and studying the past history of life on its own terms. In ten years, he quadrupled that effort. He was also a prime mover in persuading the Survey to step off the dry land into the oceans, initiating the Survey's marine geology program.

After more than a decade with the Survey Cloud was enticed back into university teaching and administration, successively at the University of Minnesota at Minneapolis, the University of California at Los Angeles, and the University of California at Santa Barbara. In theory, he retired from the last in 1976, but he has certainly not slowed down: he established a Biogeological Laboratory for the U.S. Geological Survey at Santa Barbara, and he has travelled widely as lecturer and researcher in the United States and on all the continents. He has served on a wide variety of committees, symposium panels, summer institutes, and consulting assignments for the U.S. Government, for professional societies, and for universities at home and abroad. Honors have come his way—to mention a few, election to the National Academy of Sciences in 1961, to the American Philosophical Society in 1973, the Paleontological Society Medal in 1971, the DuToit Memorial Lecturer in South Africa in 1975, the Walcott Medal of the National Academy in 1977, and the Penrose Medal of the Geological Society of America in 1976.

Preston, we salute you!

John Rodgers
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1990

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   bottom: Victoria Island, Northwest Territories, Canada 1939
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xi—upper left: Harry Whittington (arm in sling), Hugh Beach, and
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   front of Kirtland Hall at Yale University spring 1939
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   and Stass Serebryakov

xii—upper left: 1987
   upper right: 1981
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   sity—housemates from 67 Whitney Avenue with Pre-
   ston Cloud: Ralph Roberts, John Rodgers, Hugh
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   lower left: October 1979—office of Yang Zunyi at Institute of
   Geology, Chinese Academy of Geological Sciences—
   with Stanley Awramik and Yang Zunyi
   lower right: bank of Khandi River in East Siberia, 1975

   (photos, except for one on p. x, courtesy of Mrs. Preston (Jan)
   Cloud)