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PREFACE

Preface: the early stage of the early Earth study in China

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This special issue is originated from two successive failures of our application of the major project of the National Natural Science Foundation of China (NSFC) under the discipline category of "Early Earth Evolution". In the end, this major project was awarded to a research proposal titled "Early shale oil evolution", and by that the NSFC closed the funding category "Early Earth Evolution". Undoubtedly, studying early shale oil evolution is very important which meets China's current national need of economic growth, but may be deviated from the original intent of NSFC's Early Earth Evolution program that was proposed by the grass-root Chinese research community several years ago. When I looked at the rejected application materials we had written and modified for many rounds, an idea occurred to me: maybe we could organize a special issue in *Acta Geochimica* on our progress in early Earth evolution research. It will make known not only to our Chinese colleagues but also international researchers on what we have been working on. Therefore, this special issue was born.

The name of this issue is "The Early Earth: Geochemistry's Perspectives". It could be alternatively called as "Early Earth Study in China" as most authors are from China. Even the name of "Early Earth Study in China" is not accurate, because many outstanding Chinese scientists have not contributed papers to this special issue. We did invite many of them, but the current evaluation system in China makes it difficult for them to contribute articles to *Acta Geochimica*. They chose to publish papers in prestigious journals as the Chinese evaluation system required. Therefore, this special issue is the best of what a lousy organizer could do to present to you.

Despite decades of research effort, a clear picture of the early Earth has not yet been painted, especially for the mechanisms of the geologic events in the Hadean Eon. The Hadean Earth was initially imagined as a hot, dark and simple period in the beginning history of our planet. New models developed in the last decade have proposed large-scale non-uniformitarian processes that do not resemble those of today's Earth. These early geologic processes were even more complex due to the repeated bombardments of the large impactors, and some of which could be so catastrophic that they may have profoundly reshaped the internal structure of the early Earth.

The early Earth is one of the cutting-edge research topics at the frontier of geoscience, involving more than a dozen first-order geological problems. Its key scientific questions include: the moon-forming giant impact and its influence on the chemical structure and composition of the Earth, the amount and varieties of late accretion (or late veneer) materials, dynamics and geochemical constraints on the core-mantle separation and differentiation processes, the sustainment of Geodynamo caused by chemical exsolution in Earth's core, composition of proto-atmosphere and prebiotic chemical reactions, the maintenance and escape of proto-atmosphere, thermal evolution of the Hadean Earth and related pre-plate tectonic regimes, the formation of the first continental crust, onset of the modern-style plate tectonics, heterogeneity of primitive mantle, and timing of early geologic events, etc.

The Early Earth study is the joint part of both geoscience and planetary science. Our planet is different than other

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rocky planets in the solar system such as Venus and Mars due to Earth's unique habitability. The Hadean geologic processes on Earth may have set the stage for the interior and surface conditions to be conducive to the emergence of life. Therefore, the underlying mechanisms are also essentially the major research topics of planetary science for the next 20 years.

Chinese scientists are under pressures in this early Earth research area. The first pressure is the contempt from the local geoscience community. I have met many respectful Chinese geoscientists who believe that, without real rock samples and actual geochemical and geophysical data, it is impossible to reach definitive conclusions on the early Earth. The real rock samples preserved to the present-day are actually what lack from the very early stage (i.e., the Hadean eon) of our planet. These scientists are often the same group of respectful geologists who have been complaining that few in China has put forward a novel theoretical model for important geoscience problems. They are disappointed that many Chinese researchers took the easy route by following the theoretical framework built by other people and simply to do the follow-up work. But it may not have occurred to them that the new theoretical framework for the next generation geosciences often emerge from those young and seemingly weak lines of research. Given the importance of geological processes involved in the early Earth, it may be worthwhile to invest tremendous effort in this challenging, painful and unascertained area. As the Indian poet Tagore said: "I must launch out my boat. The languid hours pass by on the shore". The early Earth is a field worth of taking the plunge.

The second pressure comes from their western peers. Because early Earth research has attracted wide attention in western countries for more than 20 years, their research level is far ahead of China's, which makes it difficult for Chinese scientists to publish in influential venues or make original theories in this field. Much effort should be focused on identifying new research problems and using novel research tools.

Early Earth's scientific problems need to be addressed jointly by high-temperature and high-pressure experiments, computational geochemistry, computational geodynamics, comparative planetology, planetary accretion dynamics, etc., which will eventually build a new interdisciplinary research philosophy for solid Earth research. If one just depends on a single research tool, even a well-developed one in a subdiscipline direction, he or she may still be frustrated by the many uncertainties when interpreting results. One of such examples is the isotopic compositions of the siderophile elements that has shown somewhat weakness when applied to the study of the early Earth. Early Earth processes are complex and even the bulk silicate Earth may not be within a closed system. Part of siderophile materials were believed to be sequestered in the Earth's metallic core during core-mantle differentiation, and the late veneer event continuously brought new materials into the bulk Earth. It makes the bulk mantle's isotopic signal difficult to interpret.

As a result, the early Earth provides a challenging target for all the disciplines of geosciences to demonstrate their martial arts, while allowing researchers who are interested in this field to merge and redesign the tools of different disciplines like never before, spawning a new paradigm of research. I was incredibly lucky to have a group of colleagues who are experts on various research tools. This special issue provides a place for them to address Early Earth's problem from different perspectives. We realized that proper and cutting-edge inter-discipline tools are needed for testing original ideas in early Earth research. Although the name of this special issue is "Geochemistry's perspectives", the used research tools are far more than just geochemical tools.

Early Earth research is still in its infancy stage. Five to ten years from now, when we look back on this special issue, many of our conclusions and ideas might be wrong. Nevertheless, this is how science evolves. I hope this special issue is just the beginning of a great journey. With my old-fashioned stubbornness, directions involving prebiotic chemistry and astrobiology are not included in this issue. Therefore, this issue is also incomplete in covering major topics of early Earth. I hope by publishing this issue we can attract more and more colleagues to devote themselves into different aspects of the early Earth study.