Qing TANG Report rcvd 10.25.16

Lewis and Clark Fund for Exploration and Field Research in Astrobiology;

Paleobiology of the Tonian Chuar Group in North America and its implications for the evolution of complex eukaryotes

Project Report

Our research program "Paleobiology of the Tonian Chuar Group in North America and its implications for the evolution of complex eukaryotes" has been funded with pleasure by the Lewis and Clark Fund for Exploration and Field Research in Astrobiology in June of 2016. With this important financial assistance, we were able to carry out the associated field work in eastern Grand Canyon, Arizona (Fig. 1; GPS: 36.114293°N, 111.857336°W) from August 30 to September 24, 2016.

In order to have enough time to finish the planned field work and to avoid the cold season in Arizona, we set off for the field work a couple of days earlier than we had planned in the application form. There were two major tasks for this field work, one was to measure the outcrop of the Chuar Group to set up a detailed stratigraphic column; the another one was to collect many carbonaceous compression megafossils and mudstone/shale samples for acritarch analysis in order to understand the paleobiology of the Chuar Group.

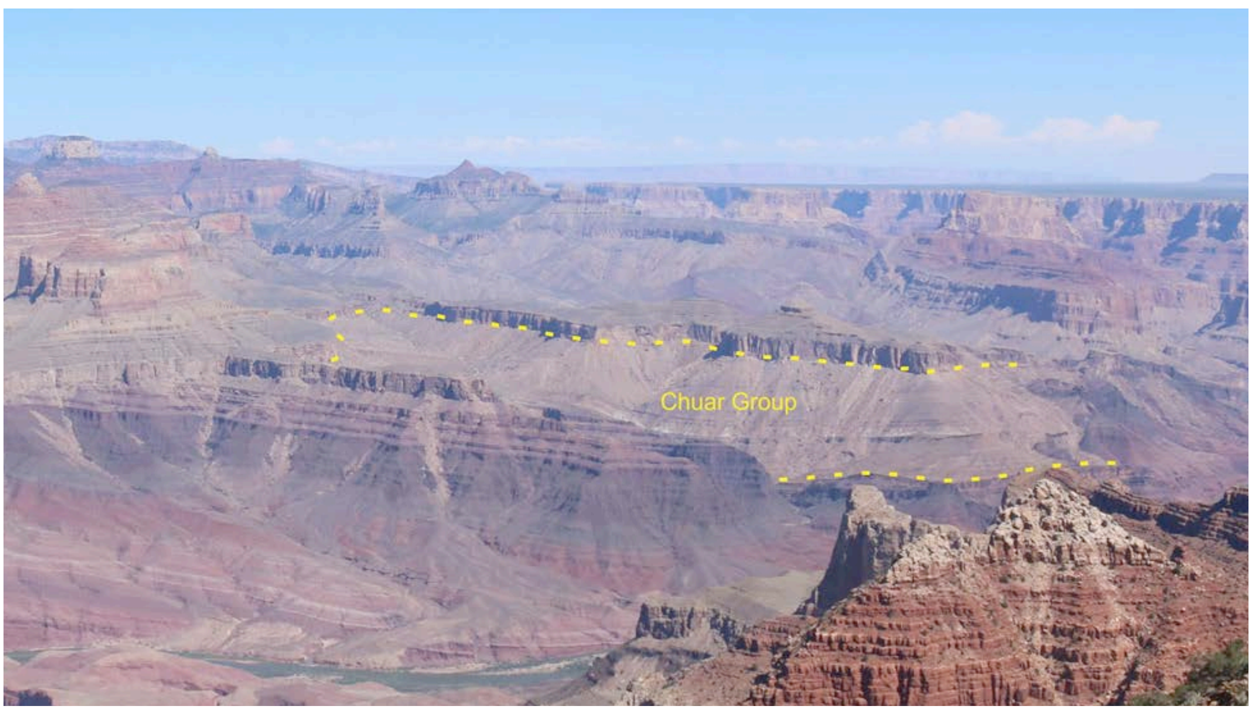

Fig. 1. A panorama of the measured outcrop of the Chuar Group bracketed in yellow dash lines in eastern Grand Canyon, Arizona.

This project is very important for us to understand the rise of complex multicellular organisms on our planet. Although significant achievement have been reached in the past decades concerning the origin of life and how it evolved on the basis of fossil record on Earth, significant questions remain with regard to the rise of complex life. Paleontological data show that various complex multicellular organisms and putative animals evolved in the Ediacaran Period (635 to 541 million years ago) following the end of terminal Cryogenian (720 to 635 million years ago) glaciation. However, the evolutionary patterns and mechanisms behind the transition from simple eukaryotes to complex multicellular organisms remain ambiguous, mostly because of the poor documentation of fossil record in pre-Cryogenian strata. This significantly hampers our perspective on the key steps in the pathway toward biological complexity during the evolutionary history of life. Therefore, to understand the paleobiology of Tonian Period that predates Cryogenian has the potential to shape our view on the biodiversity on early Earth, to enable a deeper understanding of the pathways leading to complex life, and to guide our search for extraterrestrial life.

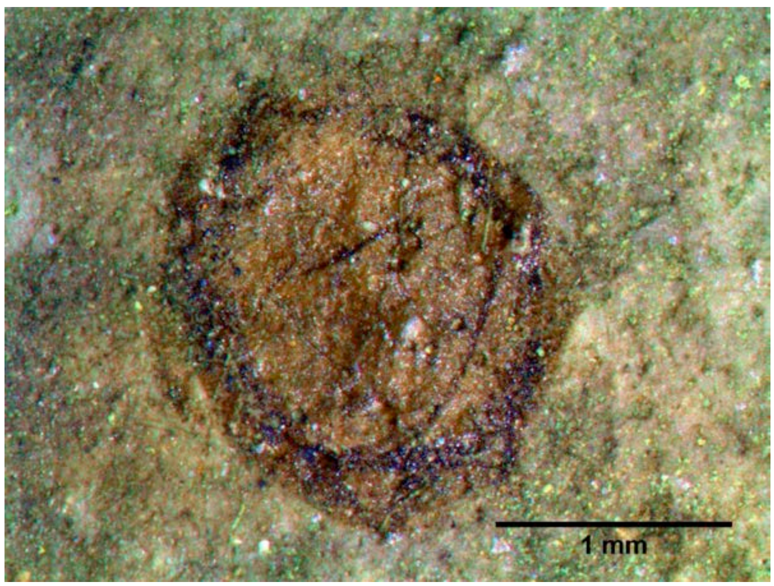

Fig. 2. Reflected light microphotograph of a carbonaceous compression macrofossil *Chuaria* excavated from the Chuar Group during the field work in Arizona.

Recently, emerging paleobiological data, partly based on my own work on Tonian paleobiology in North China Block, suggest that the diversity of eukaryotes in Tonian is surprisingly greater than previously appreciated, and eukaryotic multicellularity may have been extensive during the Tonian Period. Therefore, our project on the paleobiology of the anther Tonian succession, the Chuar Group, in Arizona of North America has the potential to test the hypothesis that the paleobiology of Tonian has globally established a solid foundation for the radiation of complex life in the Ediacaran in terms of eukaryotic diversity and cellular complexity. And the associated field work that we conducted on the outcrop of Chuar Group in Arizona has set up a solid foundation for accomplishing the goals of this project. During the 25-day field work, we have thoroughly measured the more than one-thousand-meter thick outcrop of

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Chuar Group and have collected important samples, including approximately five hundred carbonaceous compression macrofossils (Fig. 2) and around eighty mudstone/shale samples.

The next step of our project will focus on analyzing those samples that we have collected during the field work. The shale and mudstone samples will systematically processed in the Virginia Tech paleontological lab using an improved palynological maceration technique for extracting organic-walled microfossils. The excavated carbonaceous compression macrofossils and extracted microfossils will be analyzed using a series of optical and electron microscopy, including secondary electron microscopy (SEM) and backscattered electron microscopy (BSEM), in Virginia Tech Nanoscale Characterization and Fabrication Laboratory to characterize their morphologies and ultrastructures, which are critical for taxonomic identification and cytological reconstruction. The sequence of fossil occurrence and fossil abundance will be established by tabulating the paleontological data against stratigraphic measurements, resulting in high-resolution biostratigraphic data which will then be integrated with available geochronological and paleoenvironmental data to establish a comprehensive stratigraphic outline of Tonian in North America. Critical assessment of biological affinities and biodiversity of both micro- and macrofossils will be based on the integrated morphological and ultrastructural data obtained from light and electron microscopy. The paleobiological data will have the potential to shed significant light on the transition from simple to complex eukaryotes before the Cryogenian.

We appreciate the generous financial assistance from the American Philosophical Society and the NASA Astrobiology Institute. If any related data of this project turn out to be publishable, we would like to address our acknowledgement in the publications.