VOL. 99 • NO. 8 • AUG 2018

EOS

Earth & Space Science News

Universities' Culture of Sexual Harassment

Radon Tracers at Mount Etna

Peer Review's Psychological Potholes

CROWDSOURCING STREAMFLOW DATA

AGU 100
ADVANCING EARTH AND SPACE SCIENCE

What Would Earth Be Like Without Life?

Workshop on a Cosmic Perspective of Earth: A Planet Permeated and Shaped by Life—Implications for Astrobiology
Tokyo, Japan, 13–15 September 2017

A drop of water clings to a chrysocolla speleothem (copper-rich stalactite) at the Kipuka Kanohina Cave Preserve in Hawaii. The speleothem is composed of microorganisms and their precipitated minerals, including white calcite. The width of the drop is approximately 0.5 centimeter. Credit: Kenneth Ingham

Microorganisms have inhabited nearly all of our planet's surface and near surface, Earth's critical zone, for the past 3.5 billion years. Given the vast time that Earth has been teeming with life, it is hard to imagine what the planet would be like without its biosphere.

But Earth without life is exactly what participants at a recent meeting sought to contemplate. More than 30 scientists from eight countries attended an international workshop hosted by the Earth-Life Science Institute Origins Network (EON) at the Tokyo Institute of Technology in September 2017. The participants contributed expertise in Earth science, planetary science, biology, chemistry, and mathematics.

To begin this thought experiment, participants sought to answer the question, What are the key characteristics of an abiotic Earth compared with the Earth that we know? Exploring this question may help uncover essential aspects of what makes our home planet habitable. What we learn may help us to assess the possibility of extraterrestrial life elsewhere in the universe.

Attendees contemplated the hypothesis that "everything on Earth that is or has been influenced by water is inseparably coupled with life." Scientists debated such questions as whether any surface process on Earth is truly abiotic, to what degree a process has been influenced by life, and whether everything in the critical zone (the Earth's surface and near-surface environment), deeper in the crust, and even in the mantle has been affected by life.

Participants engaged in spirited debates about how best to evaluate abiotic processes. They concluded that developing a set of standards for abiotic and biotic characteristics could help advance community understanding by providing quantitative metrics for comparison across what are often very different data types and observed time frames. Long discussions focused on whether enough is presently known about the boundaries of life on Earth to make such assessments, especially in light of continuing revelations about the many challenging conditions to which extremophiles have adapted.

Attendees agreed that evidence for life falls into three primary categories of biosignatures:

- objects: physical features such as mats, fossils, and concretions
- substances: elements, isotopes, molecules, allotropes, enantiomers, and minerals (including their identities and properties)
- patterns: physical three-dimensional or conceptual *n*-dimensional relationships of chemistry, physical structures, etc.

Small breakout groups addressed many different expressions and the preservation potential of biosignatures in these three broad categories.

Participants also identified five key issues that warrant further development:

- the criticality of examining phenomena at the right spatial scale and how biosignatures may elude us if not examined with the appropriate instrumentation or modeling approach at that specific scale
- the need to identify the precise context across multiple spatial and temporal scales to understand how tangible biosignatures may or may not be preserved
- the desire to increase the community's capability to mine big data sets to reveal major relationships, for example, how Earth's mineral diversity may have evolved in conjunction with life
- the need to leverage cyberinfrastructure for data management of biosignature types, classifications, and relationships
- the utility of 3-D to *n*-D representations of biotic and abiotic models overlain on multiple overlapping spatial and temporal relationships that can provide new insights

The lively and engaged mood of the participants resulted in emerging collaborations to pursue these challenges into the future.

By **Marjorie A. Chan** (email: marjorie.chan@utah.edu), Department of Geology and Geophysics, University of Utah, Salt Lake City; **H. James Cleaves II,** Earth-Life Science Institute, Tokyo Institute of Technology, Tokyo, Japan; and **Penelope J. Boston,** NASA Astrobiology Institute, Moffett Field, Calif.