



# ***NASA's ASTEP Program***

***Astrobiology Science and Technology for Exploring Planets***



***John D. Rummel, NASA HQ***



# Astrobiology

The study of life in the Universe, focusing on three fundamental questions:

- How does life begin and evolve?
- Does life exist elsewhere in the Universe?
- What is the future for life on Earth and beyond?

**How did we get here?**

**Where are we going?**

**Are we alone?**

**(or, Is there anybody else out there?)**

**Knowledge of Space  
Environments**

**Knowledge of Earth  
Organisms**





# Astrobiology Today: A Golden Age in Studies of Other Worlds –

- A revolution in our understanding of biology on Earth
  - New molecular tools
  - An appreciation of the extent of life in extreme environments ( $\text{pH} < 1$ ;  $T \geq 120\text{C}$ ;  $T_R \leq -20\text{C}$ ; ~All pressures)
- Increased mission opportunities and capabilities — a much higher rate of data being returned
  - We are landing-on, roving around, and delving into other worlds
  - We are planning to return to the best of them!

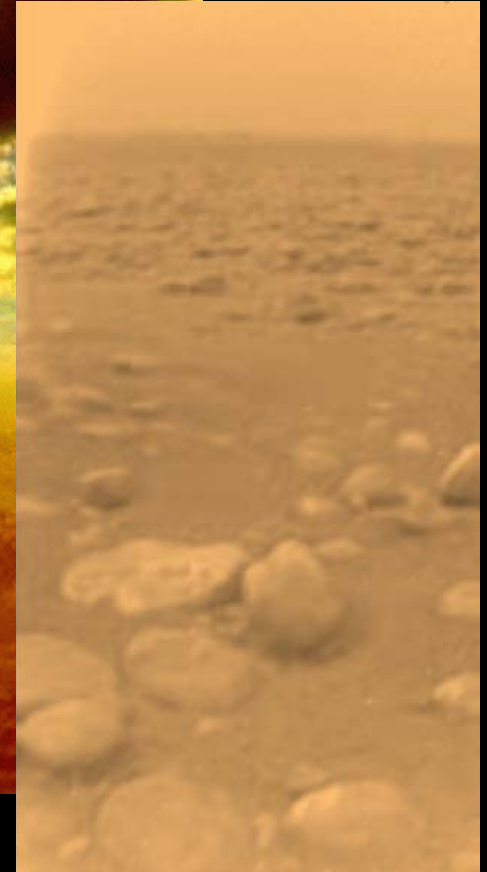
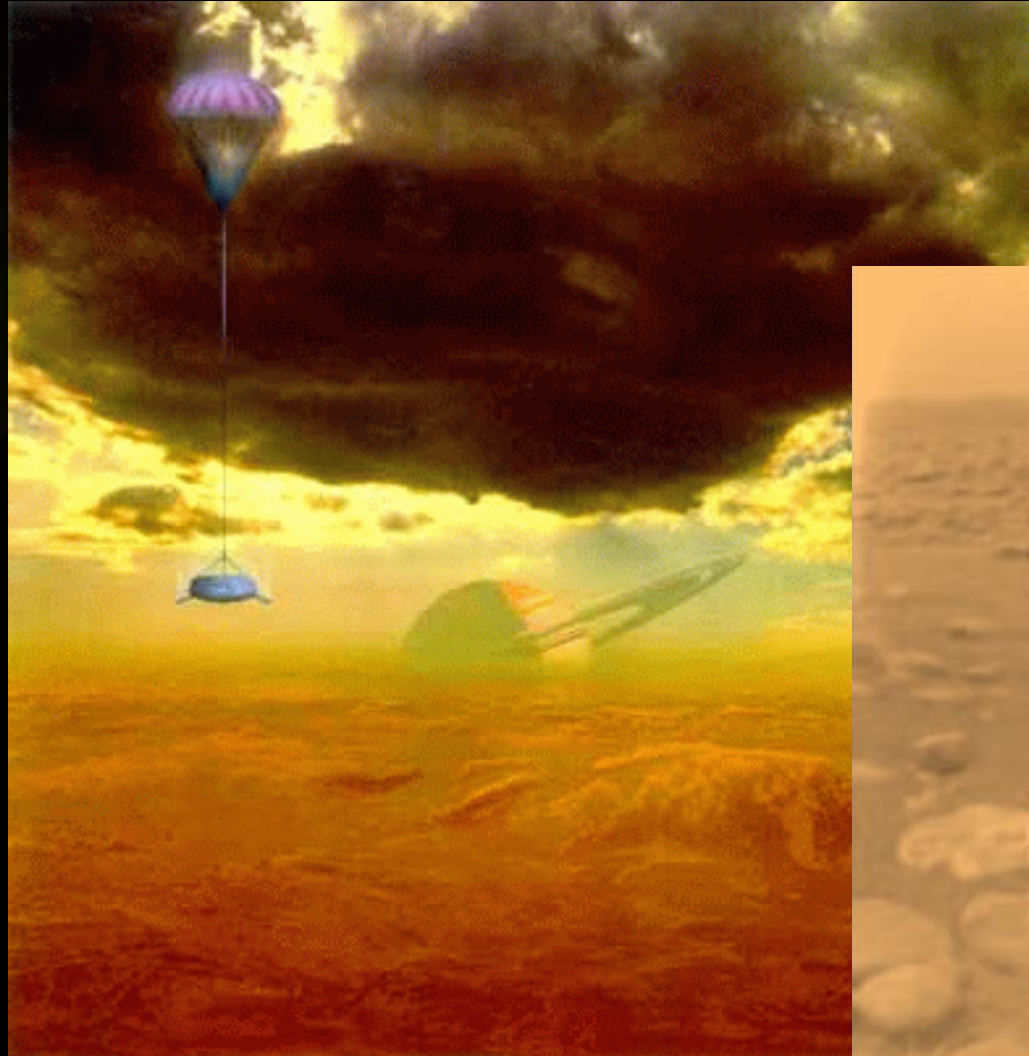
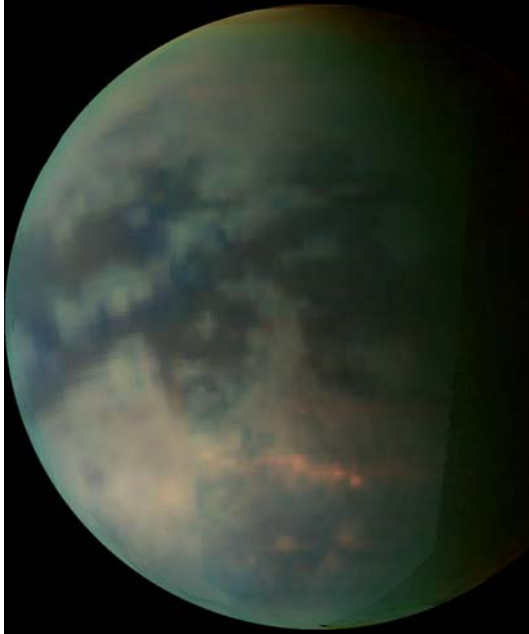
# *Outer Planets*

A close-up view of the planet Jupiter, showing its characteristic yellow and white bands and several small moons in the foreground.

“There are more things in heaven and earth, Horatio,  
than are dreamt of in your philosophy”

*Hamlet, Act 1, Scene V*

# Titan—Descent of the Huygens Probe, January, 2005





# Astrobiology Program Overview

## Exobiology & Evolutionary Biology (1965)

- ~150 research tasks at US universities, research institutions, Federal labs, and NASA Centers.

## NASA Astrobiology Institute (1998)

- Currently 16 Member-Institutions, plus NAI Central and international associates.

## ASTID (1988, 2001)

- ~49 instrument-development tasks at US universities, research institutions, Federal labs, and NASA Centers.

## ASTEP (2001)

- 8 science-driven field campaigns and/or advanced instrument projects based at US research institutions, universities, and NASA Centers.



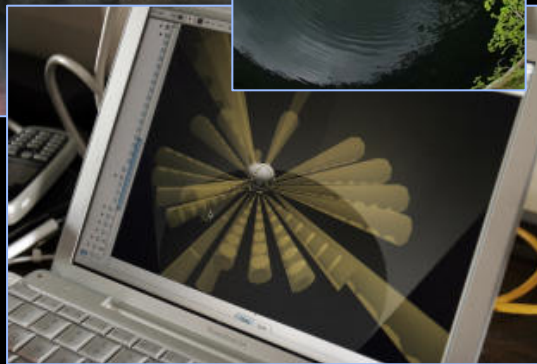
*Learn to Explore Such Worlds...*

## Cenote Zacaton

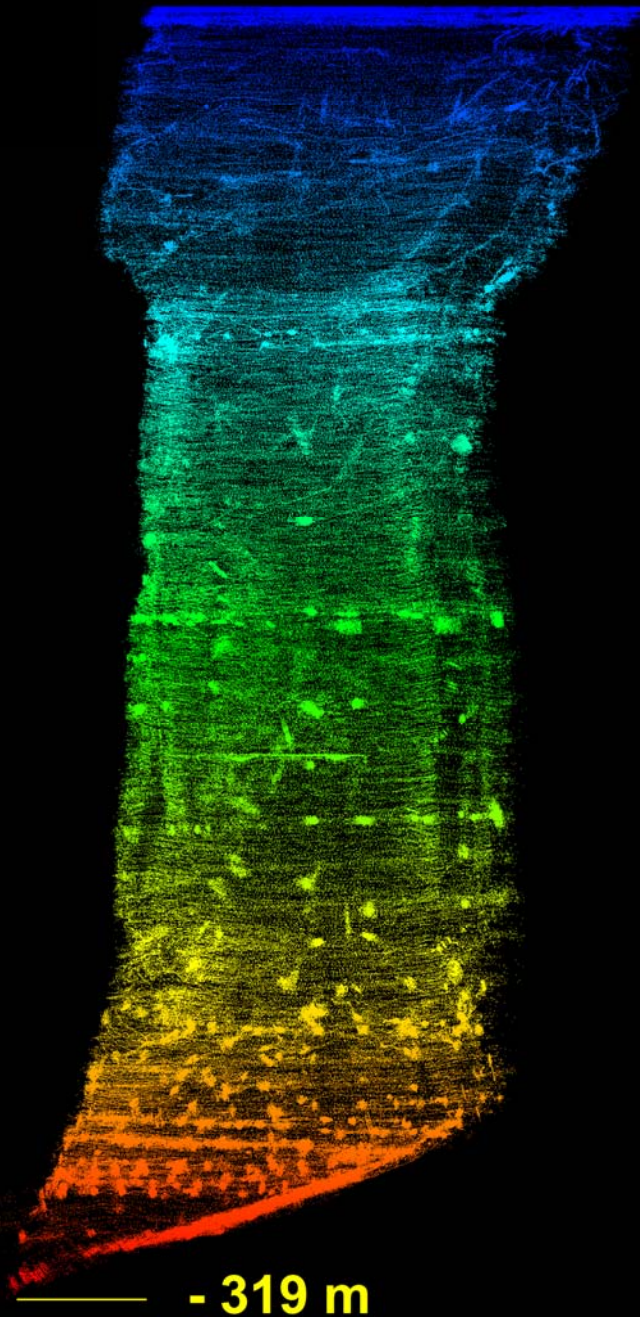
# DEPTHX –

Bill Stone, Stone Aerospace

- DEPTHX was been launched to do autonomous 3D mapping & sampling
- Maps are comprised of >300,000 individual sonar “hits”
- Vehicle does Simultaneous Localization and Mapping (SLAM), plus it can follow chemical, temperature, or depth profiles looking for life



— 320 Meters —



Stone Aerospace / Team DEPTHX

- 319 m

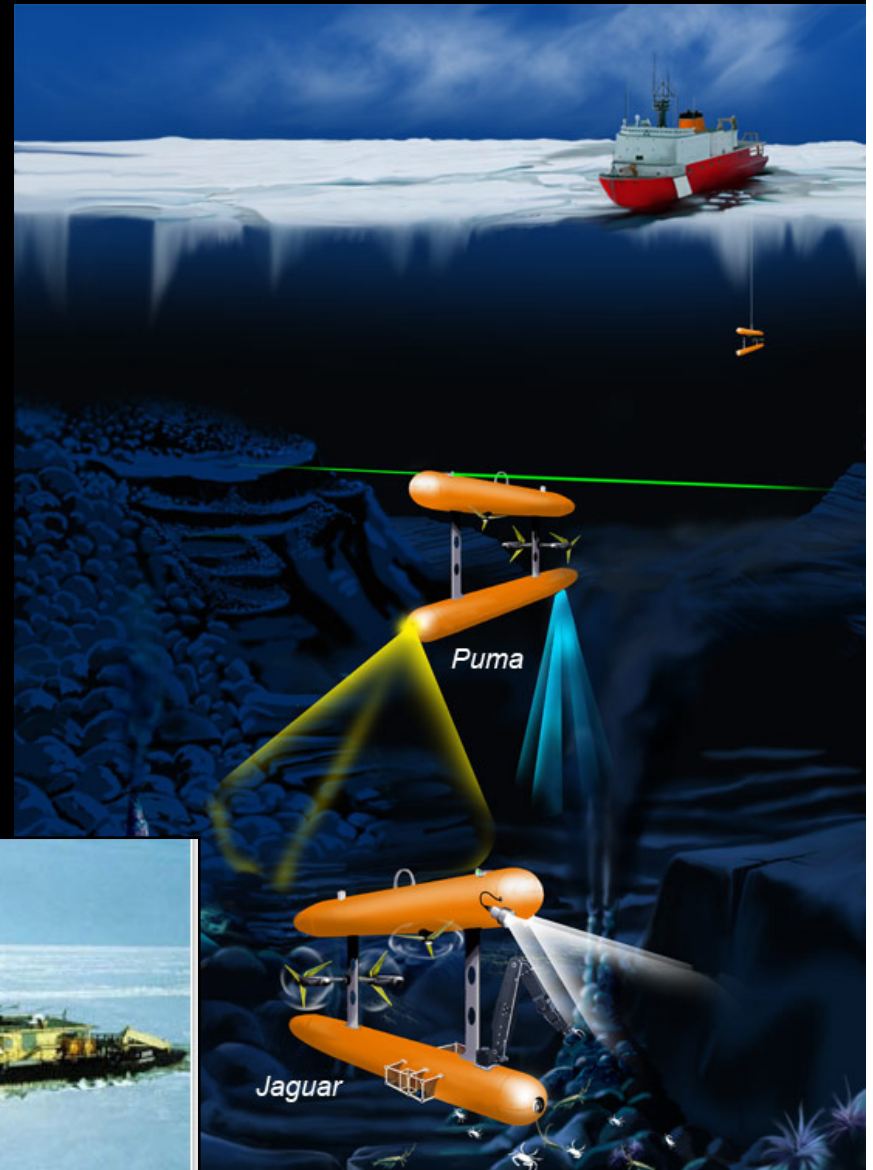
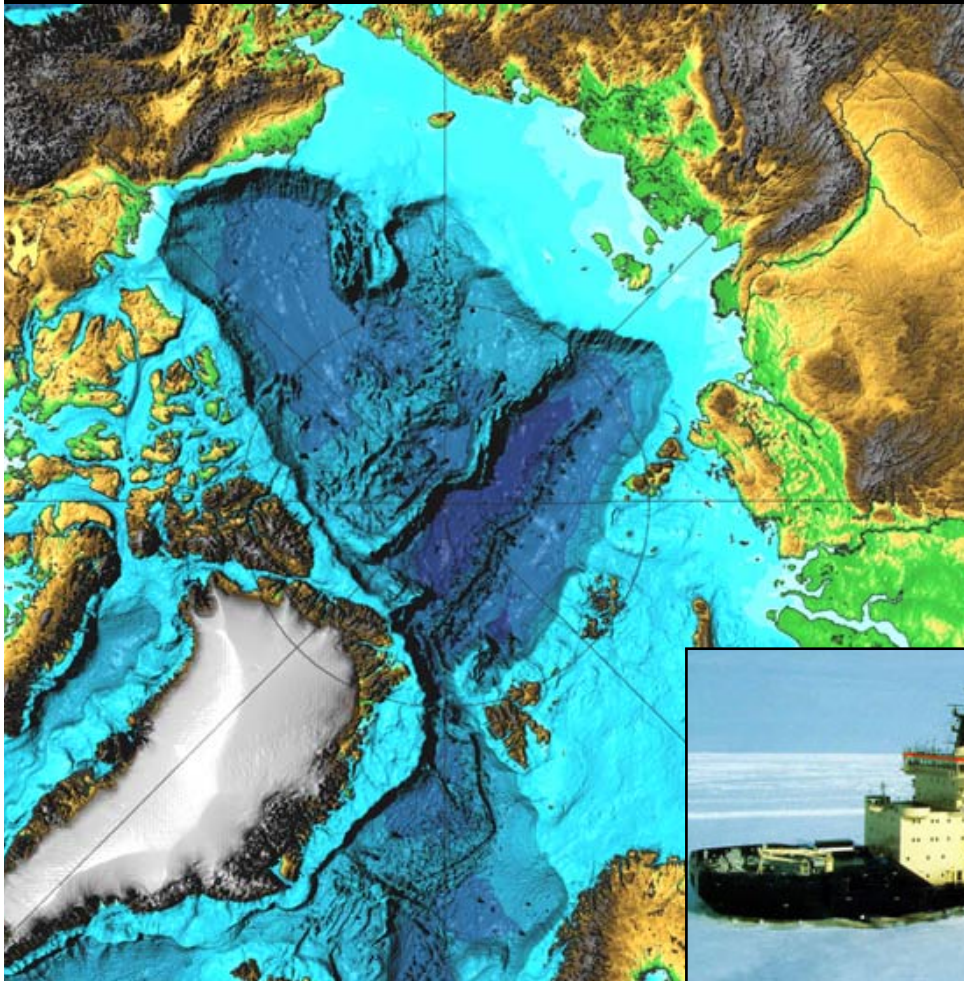




# ASTEP AGAVE

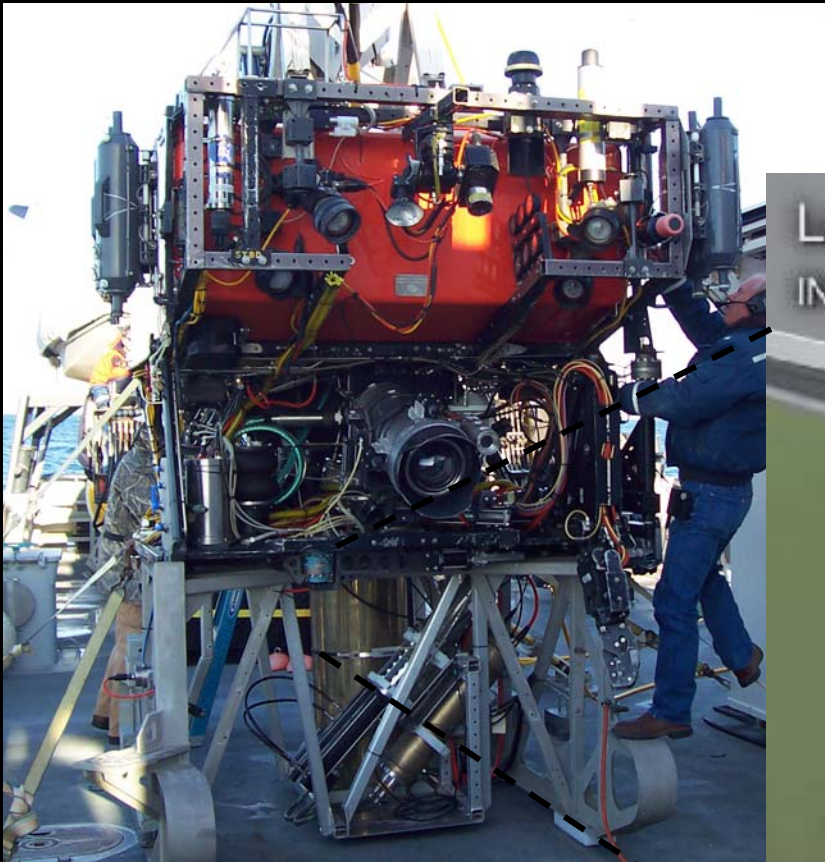
Reves-Sohn & Singh, Woods Hole Oceanographic Institution; Akin, U. of MD

Goal is to localize and characterize deep-sea hydrothermal vents at the Arctic Ocean's Gakkel Ridge (4,200 m depth).





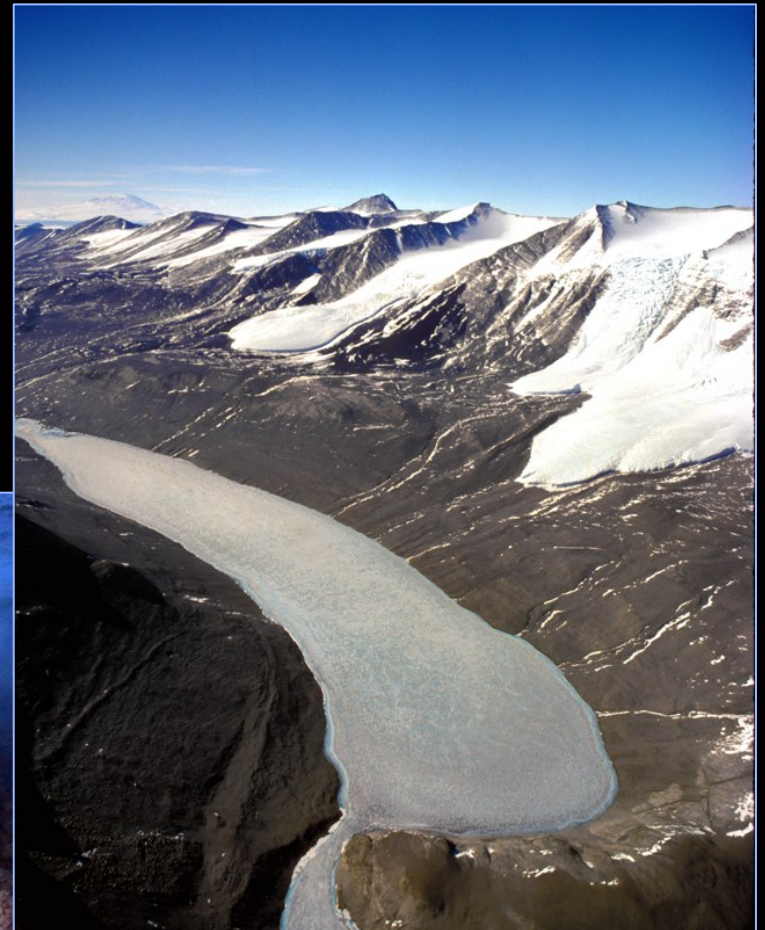
# ASTEP Environmental Sample Processor – Chris Scholin, MBARI

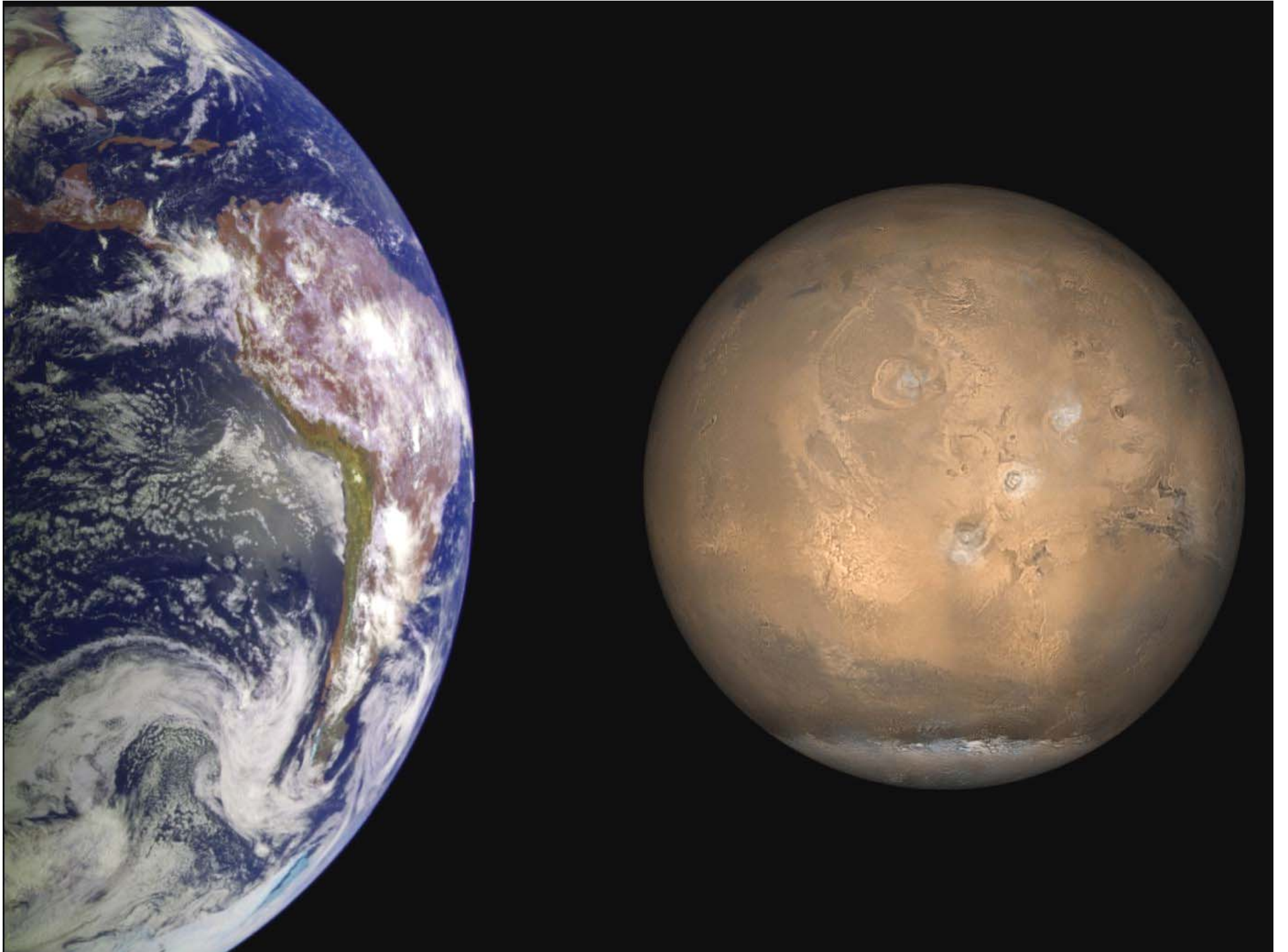




# **ASTEP ENDURANCE<sub>x</sub> –** **Peter Doran, University of Illinois, Chicago** **Bill Stone, Stone Aerospace**

Lake Bonney has two chemically stratified lobes  
The water below the chemoclines of both lobes  
is cold (below zero Celsius) and saline (more than  
3 times seawater). The lake is 40 meters deep.  
Ice thickness is 3.5 - 4.5 m.





# Questions





# Astrobiology Roadmap<sup>2nd</sup> (2003)

Goal 1: Understand the nature and distribution of habitable environments in the Universe

- Models of formation and evolution of habitable planets
- Indirect and direct astronomical observations of extrasolar habitable planets

Goal 2: Explore for past or present habitable environments, prebiotic chemistry, and signs of life elsewhere in our Solar System

- Mars Exploration
- Outer Solar System exploration

Goal 3: Understand how life emerges from cosmic and planetary processes

- Sources of prebiotic materials and catalysts
- Origins and evolution of functional biomolecules
- Origins of energy transduction
- Origins of cellularity and proto-biological systems

Goal 4: Understand how past life on Earth interacted with its changing planetary and Solar System environment.

- Earth's early biosphere
- Foundations of complex life
- Effects of extraterrestrial events upon the biosphere



# Astrobiology Roadmap<sup>2nd</sup> (2003)

Goal 5: Understand the evolutionary mechanisms and environmental limits of life

- Environment-dependent, molecular evolution in microorganisms
- Co-evolution of microbial communities
- Biochemical adaptation to extreme environments

Goal 6: Understand the principles that will shape the future of life, both on Earth and beyond

- Environmental changes and the cycling of elements by the biota, communities, and ecosystems
- Adaptation and evolution of life beyond Earth

Goal 7: Determine how to recognize signatures of life on other worlds and on early Earth

- Biosignatures to be sought in Solar System materials
- Biosignatures to be sought in nearby planetary systems