

The Secret Life of Lake Vostok

Robin E. Bell

Lamont-Doherty Earth Observatory of
Columbia University
New York, USA



Overview

- Life on Earth - Life on Ice -Life Elsewhere
- Science as a Collaborative International Effort
- A Story of Discovery
- Next Steps Into The Unknown Subglacial Environment

Why Are We Motivated to Explore Life in Extreme Locations

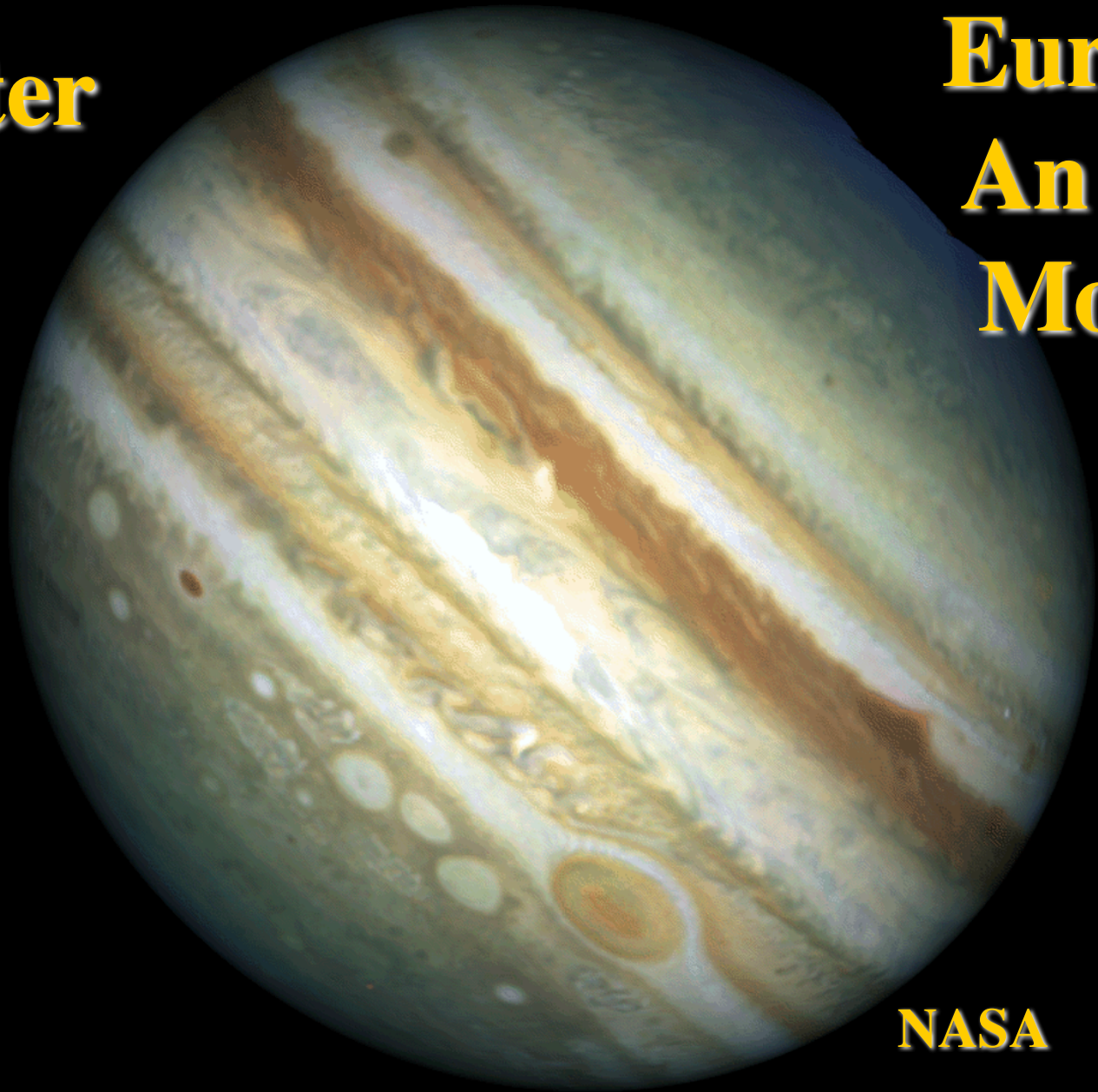
- How Life Began
- Where Else May We Find Life in the Universe
- What Causes Major Changes in Life

Where Else May We Find Life

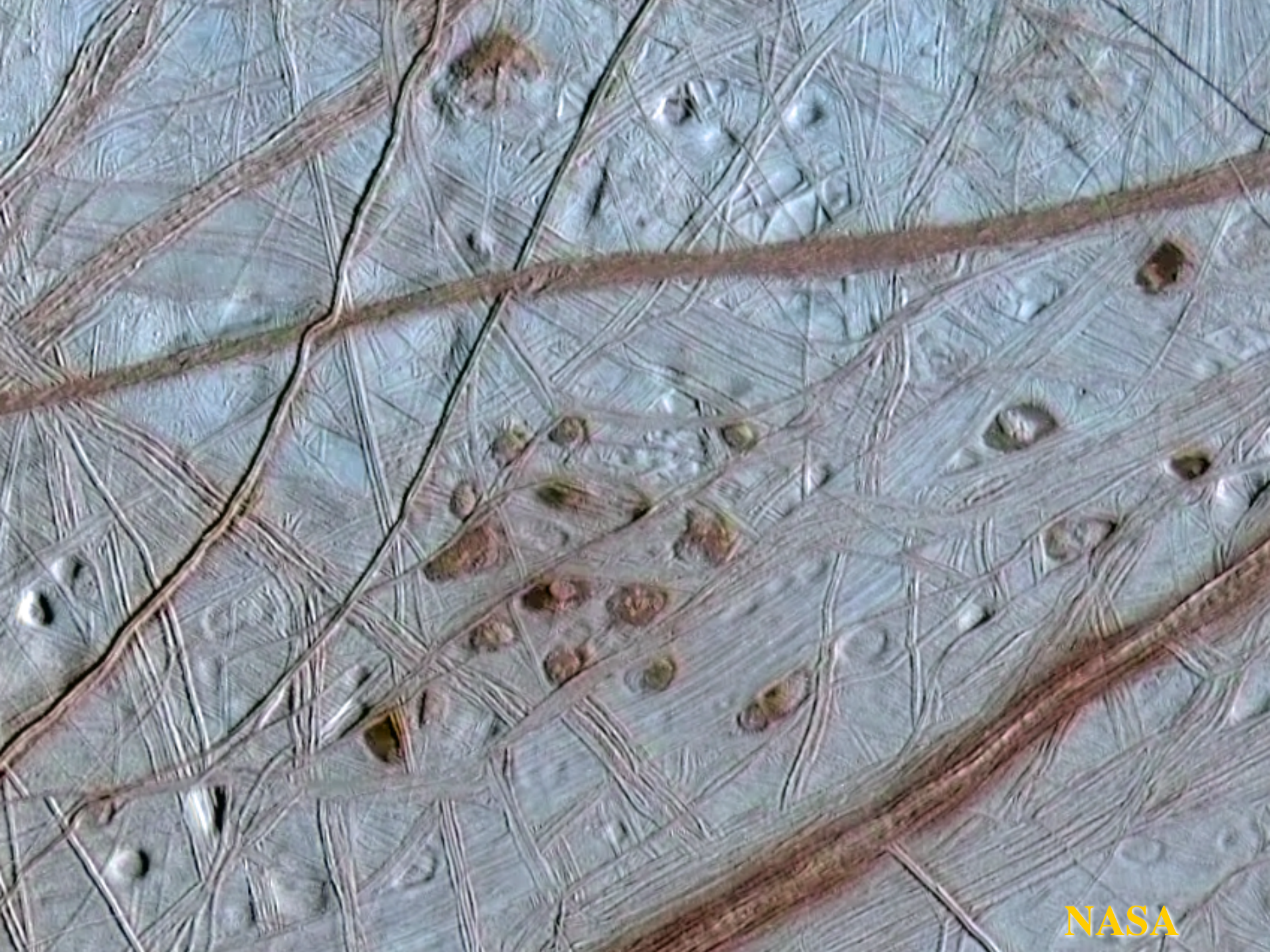
- Life Needs Water and Energy
- Europa - Moon of Jupiter
- Mars
 - Icy Soils
 - Polar Ice Caps

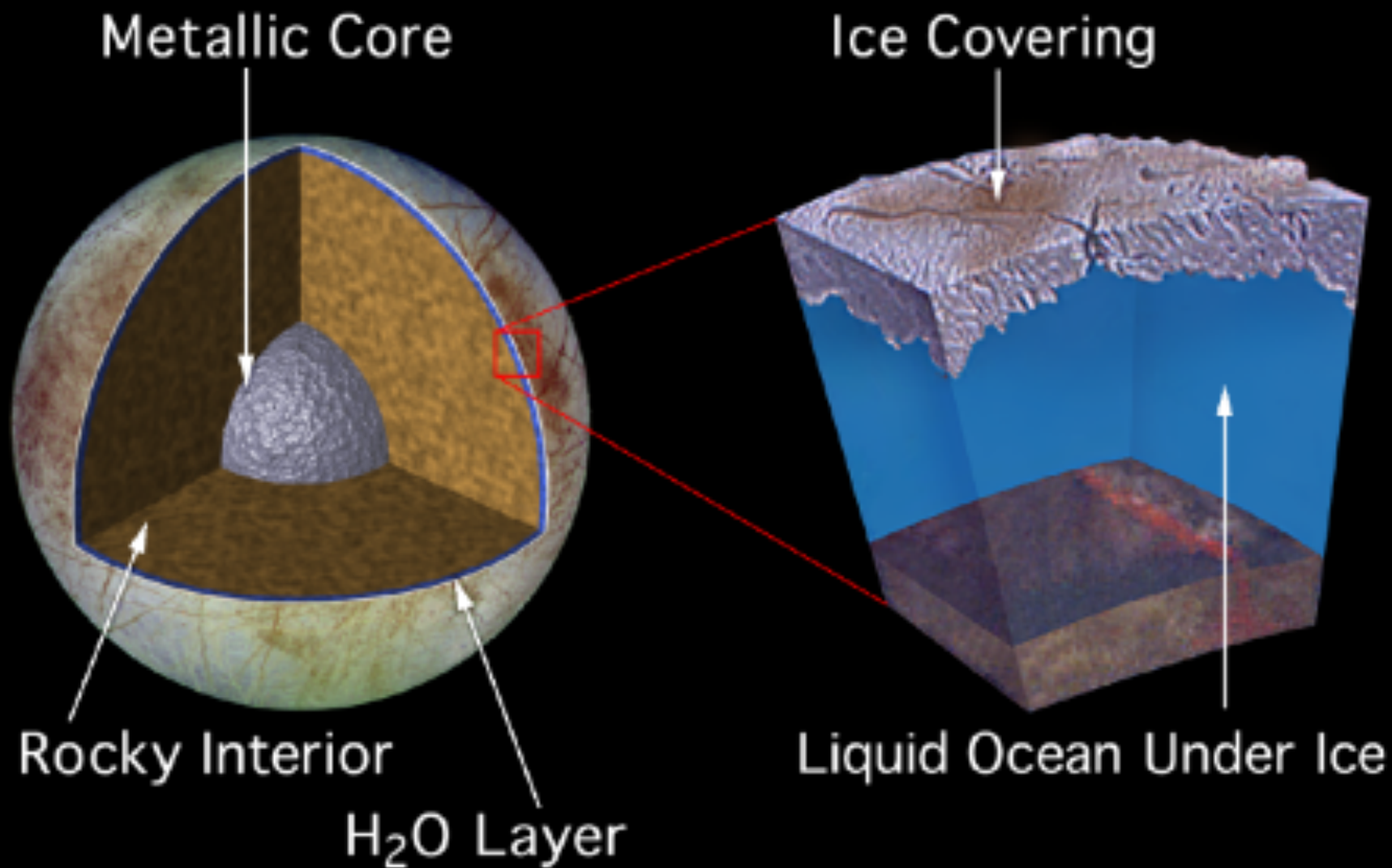
Jupiter

**Europa
An Icy
Moon**



NASA

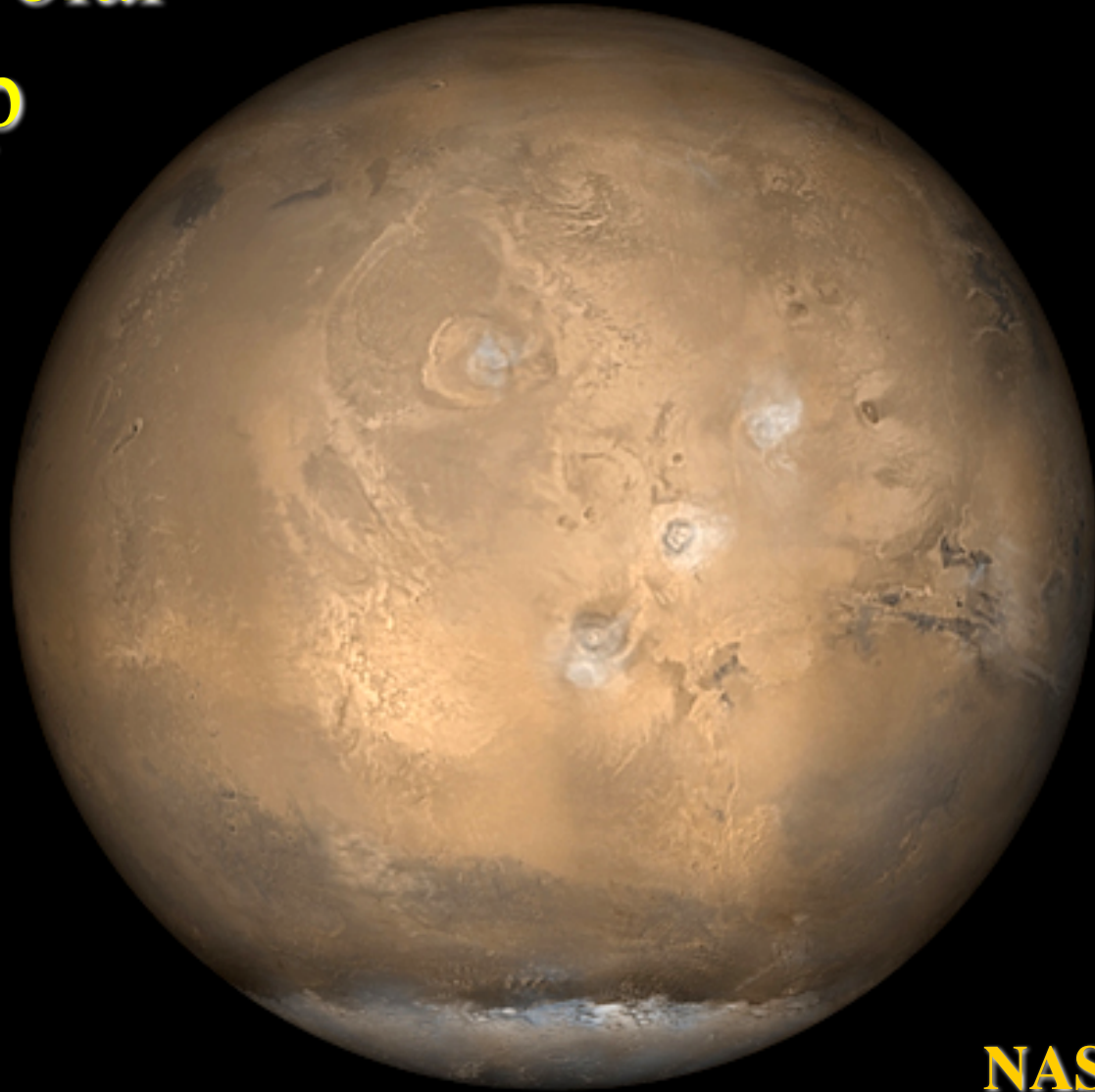




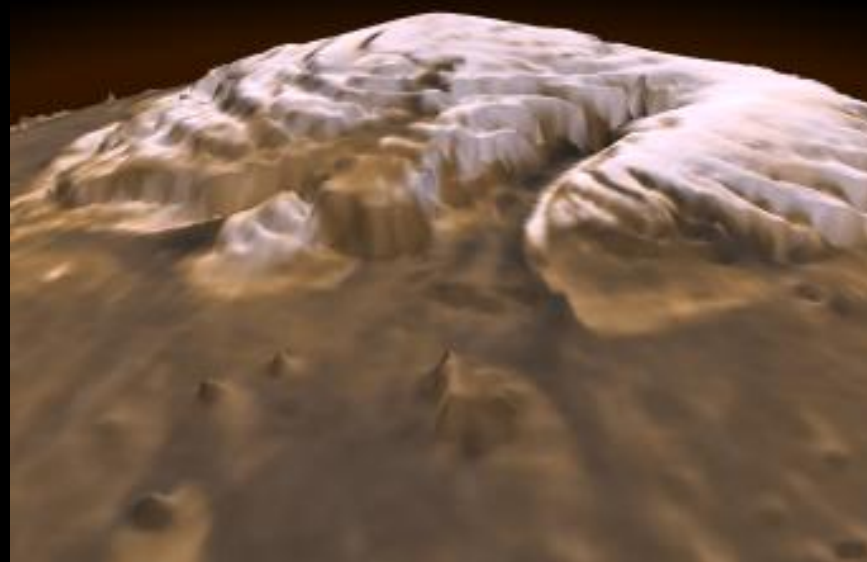
NASA



Mars Polar Cap



NASA



NASA

What Triggers Changes in Life

- Crises --- of Many Forms
- Meteorite Impacts
- Volcanic Eruptions
- Change in Living Conditions - Climate

Icy Origin of Life

Snowball Earth



Hoffman & Schrag *Terra Nova* 2002,
dropstone

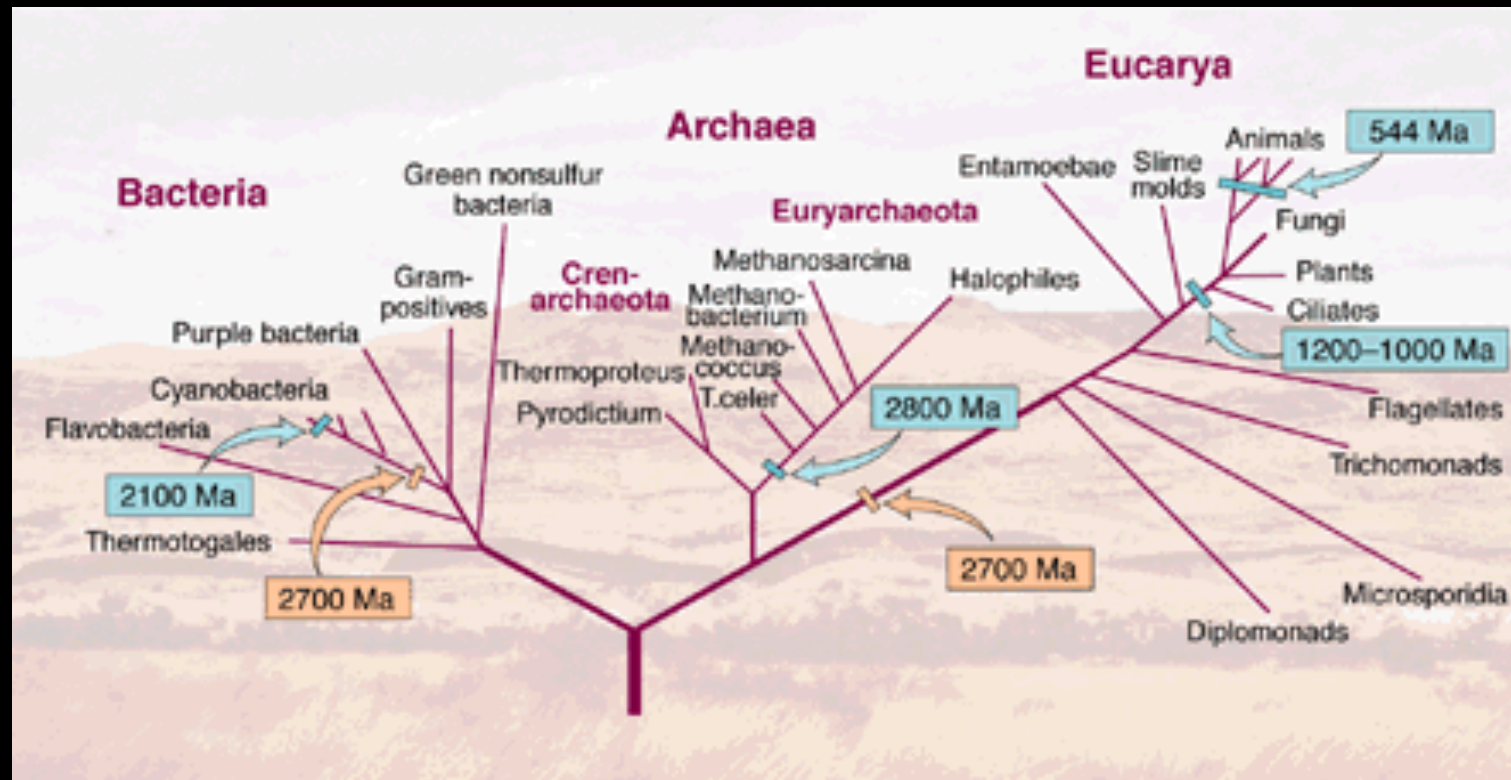
- Major Glaciations Recorded in the Rock Record
- Proposed Links to Increased Biodiversity

Snowball Earth - Triggers Exploding Biodiversity

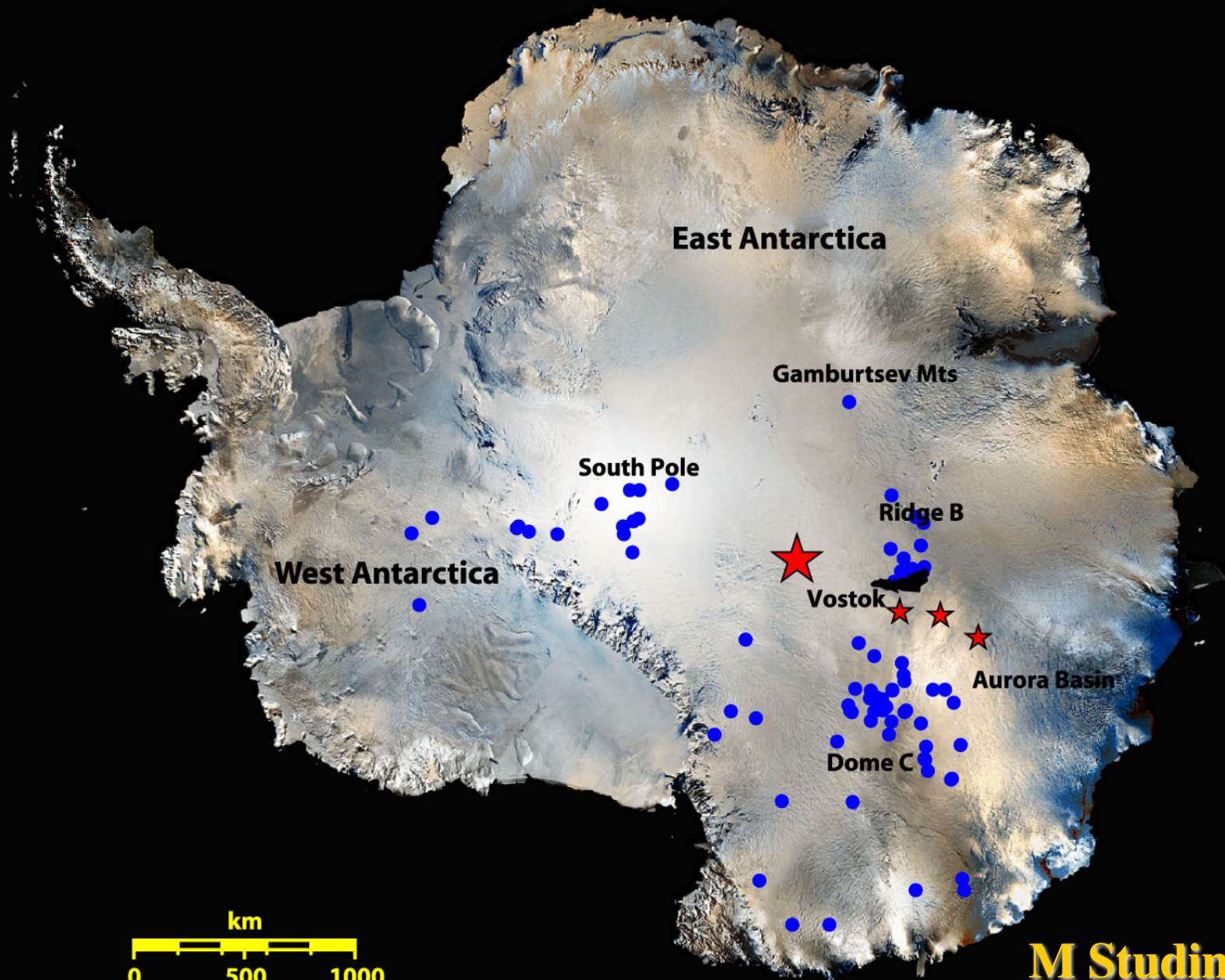


Joseph L. Kirschvink
California Institute of
Technology

Tree of Life



H. Knoll, Science 1999



East Antarctica

Gamburtsev Mts

South Pole

West Antarctica

Ridge B

Vostok

Aurora Basin

Dome C

km
0 500 1000

M Studinger,
LDEO

How Was Vostok Discovered?

- The Result of International Collaboration
- Merging of Diverse International Data Sets



Karl Weyprecht 1879

**The Earth should be
studied as a planet.**

First Polar Year 1882-1883

- **Karl Weyprecht**
 - Argued in Imperative to Shift From Nationally Motivated Geographic Exploration to Understanding the Planet as a System Through Coordinated Observation
- **International Meteorological Organisation**
- **11 Nations - 12 Arctic stations, 2 southern**

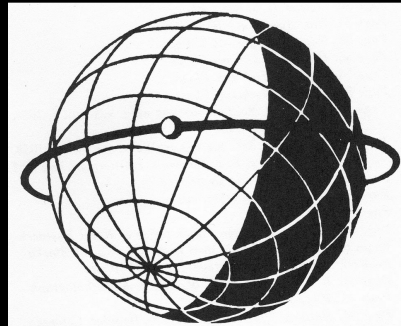
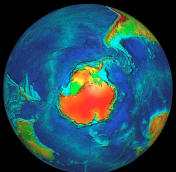


First International Polar Year - Jan Mayen

Emil Edler von Wehlsmuth

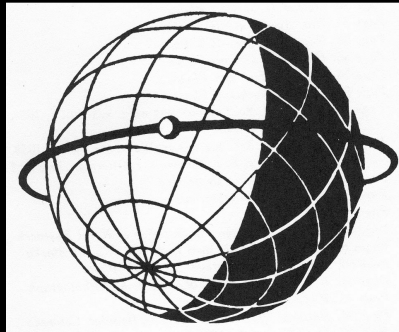
International Geophysical Year 1957-1958

- **Multiple Sponsors**
 - **International Council of Scientific Unions (ICSU)**
 - **UNESCO**
 - **World Meteorological Organization (WMO)**
- **67 nations, 8000 stations (Antarctica - 12 nations / 40 stations), ~80,000 scientists and volunteers**
- **In Shadow of the Cold War fostered High Level International Co-operation**



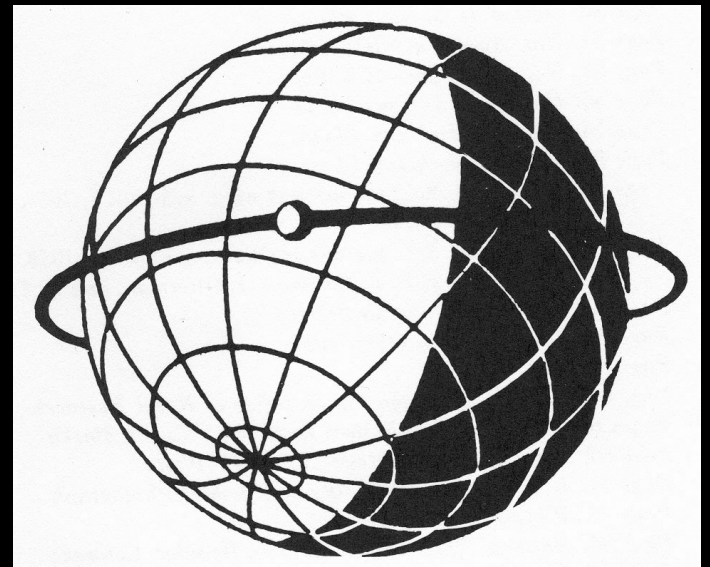
IGY Outcomes

- **Major advances in Polar Regions and Global Processes**
 - **discovery of Van Allen Belts**
 - **measurement of thickness of Antarctic Ice Sheet**
- **Establishment of Arctic and Antarctic permanent bases and *in-situ* programs (South Pole, Vostok)**
- **Establishment of SCAR , World Data Centers, International Research Unions**
- **Antarctic Treaty System**
- **Major public impact**



**International
Geophysical
Year
1957/8**

**Exploration
Interior of
Antarctica**

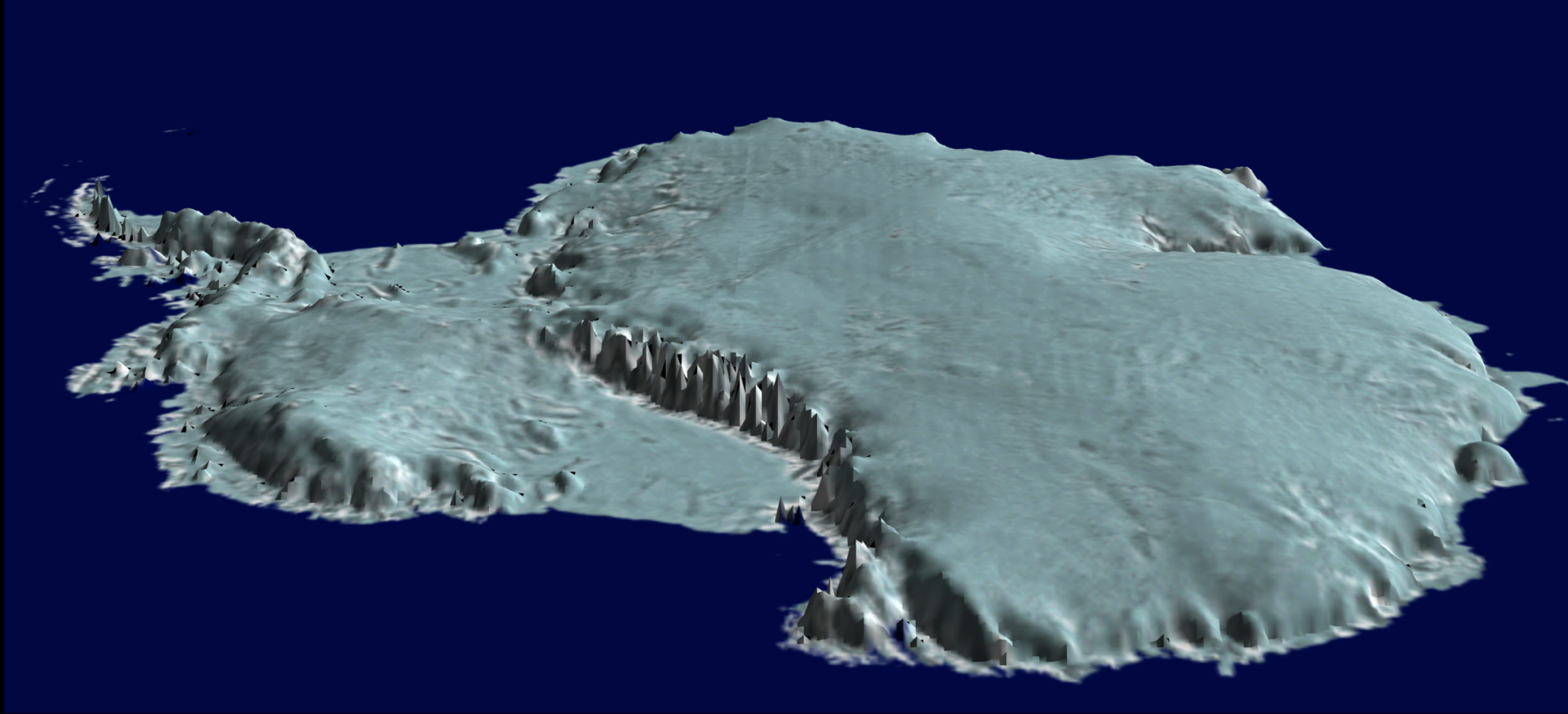




• Evseev



Establish Vostok Station



- **Science Around the Edges for Decades**

International Program of Airborne Exploration in 1970's Danish - British - American

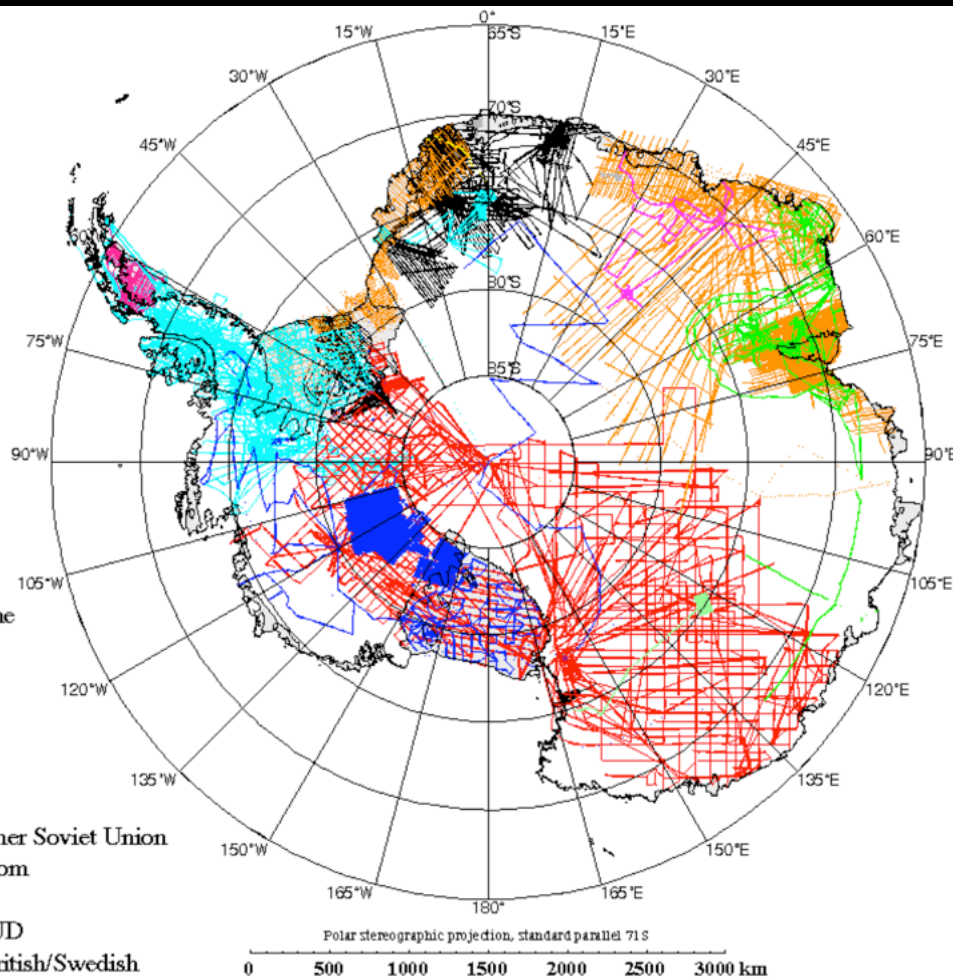


Total Missions: 127
 Airborne RES: 62
 Oversnow RES: 20
 Seismic: 32
 Gravimetric: 9
 Ice coring: 4

Note: squares denote seismic stations

Data Source

- BAS/Argentine
- Australia
- Belgium
- Chile
- Germany
- Italy
- Japan
- Russia & former Soviet Union
- United Kingdom
- United States
- SPRI/NSF/TUD
- Norwegian/British/Swedish



Imaging 4 Km of Ice With Radar

Ice Surface



Internal Layers

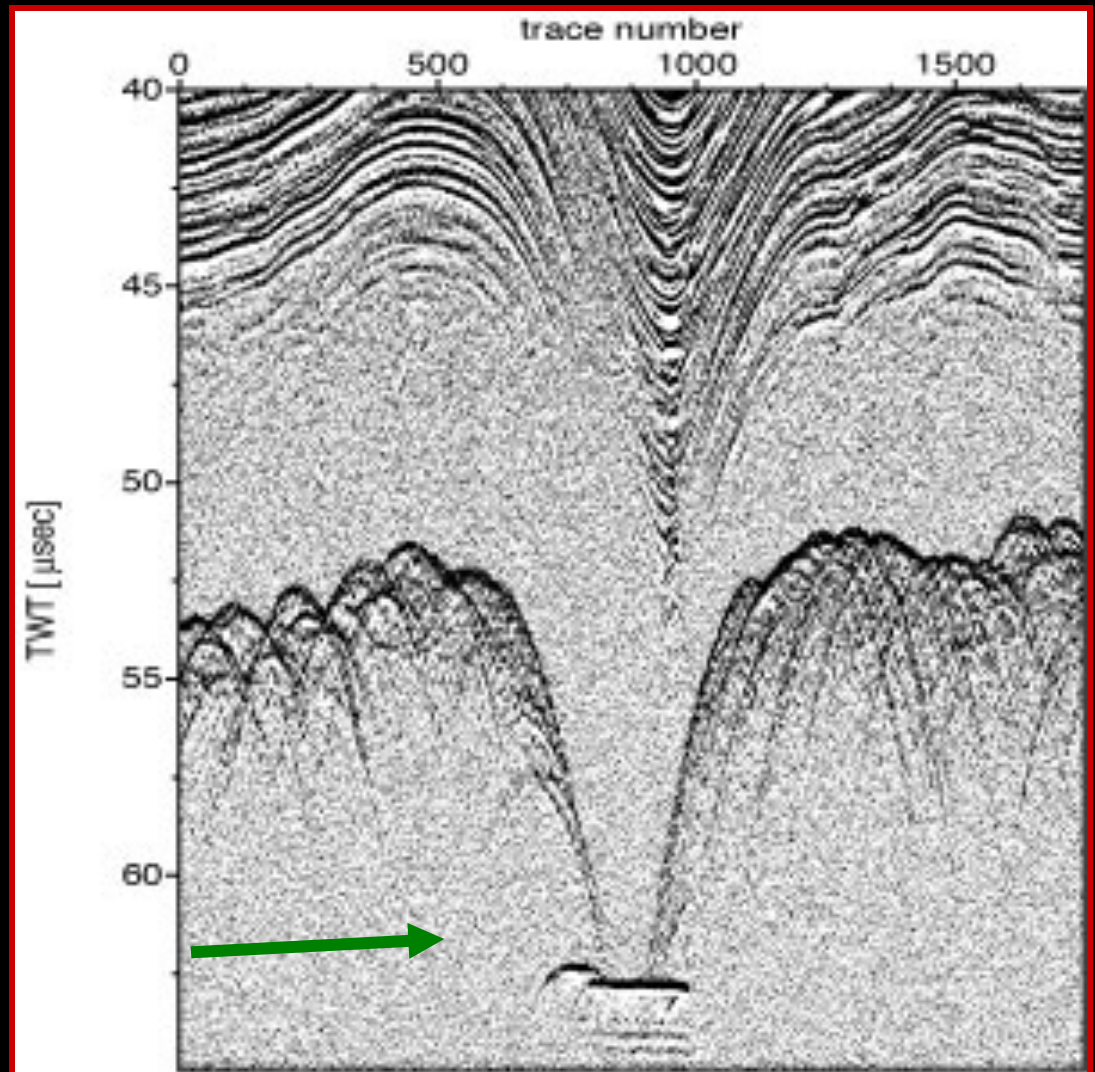


Rugged Topography

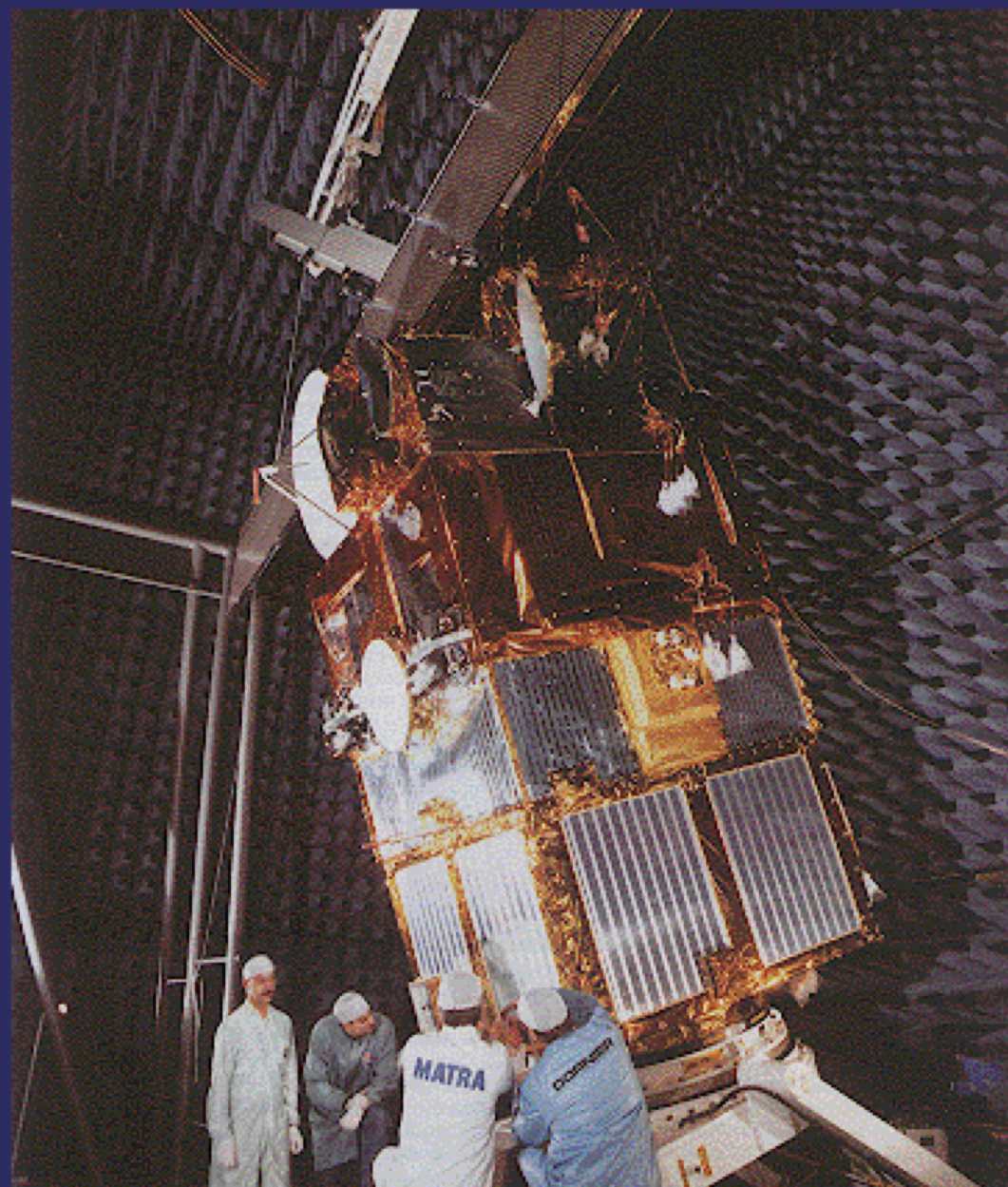


Radar Evidence

- Some Small Pools of Water
- 1970's



ERS-1 inside the Interspace Test Facility

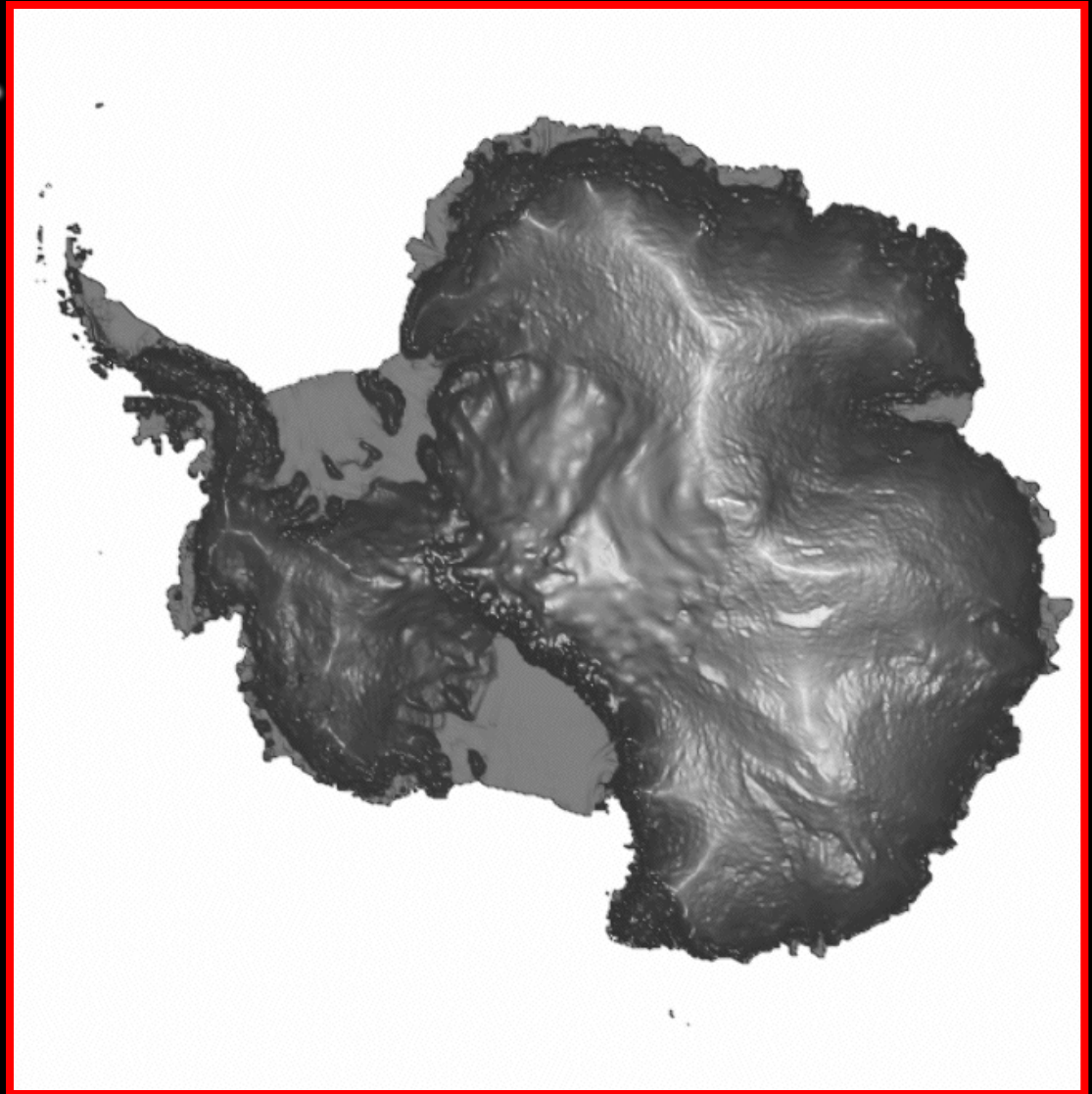


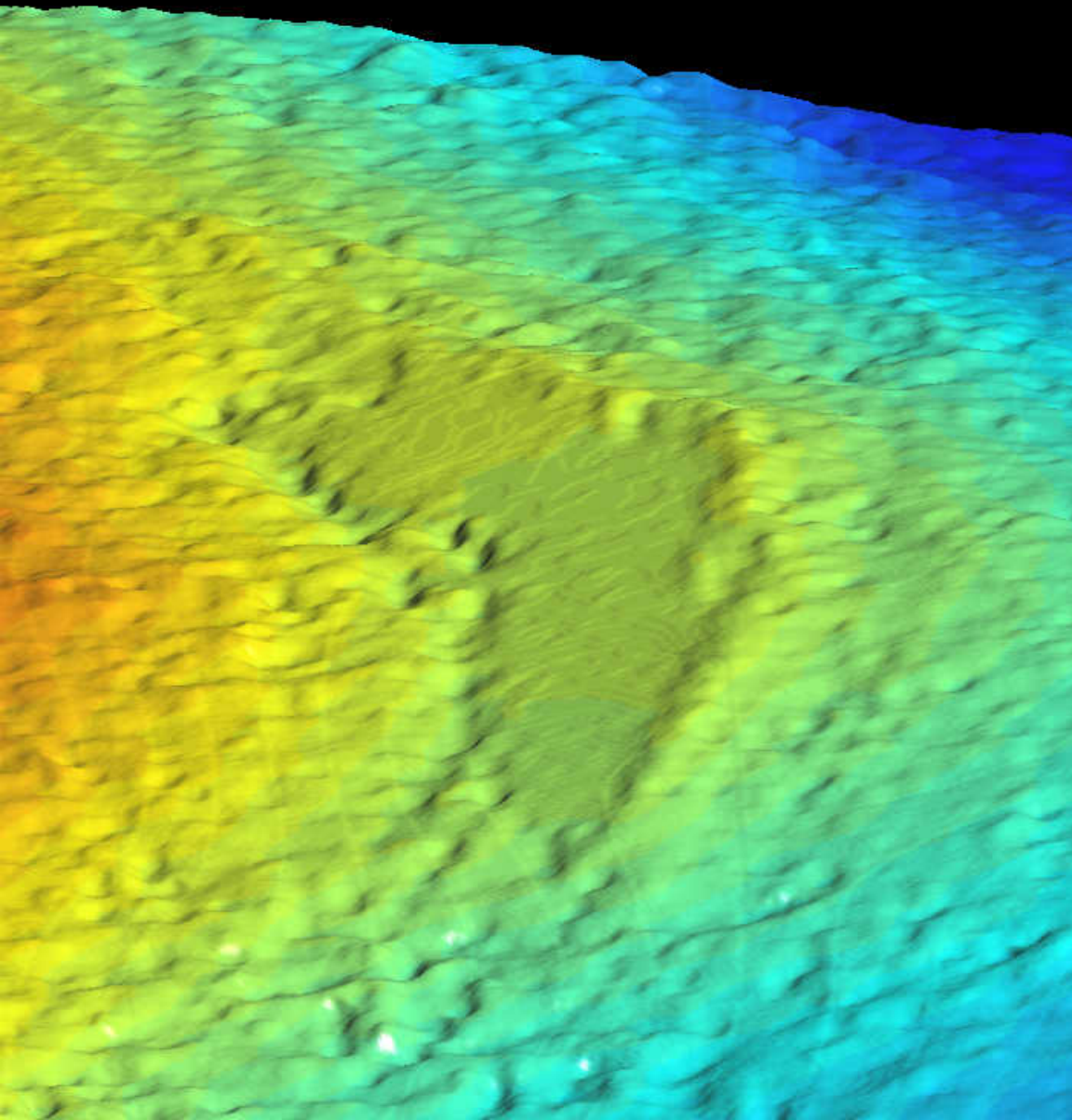
ERS-1 fully deployed inside the Interspace Test facility, Toulouse, France.

Satellite Mapping of Continent

- 1990's

Ice Surface
Elevation
ERS-1





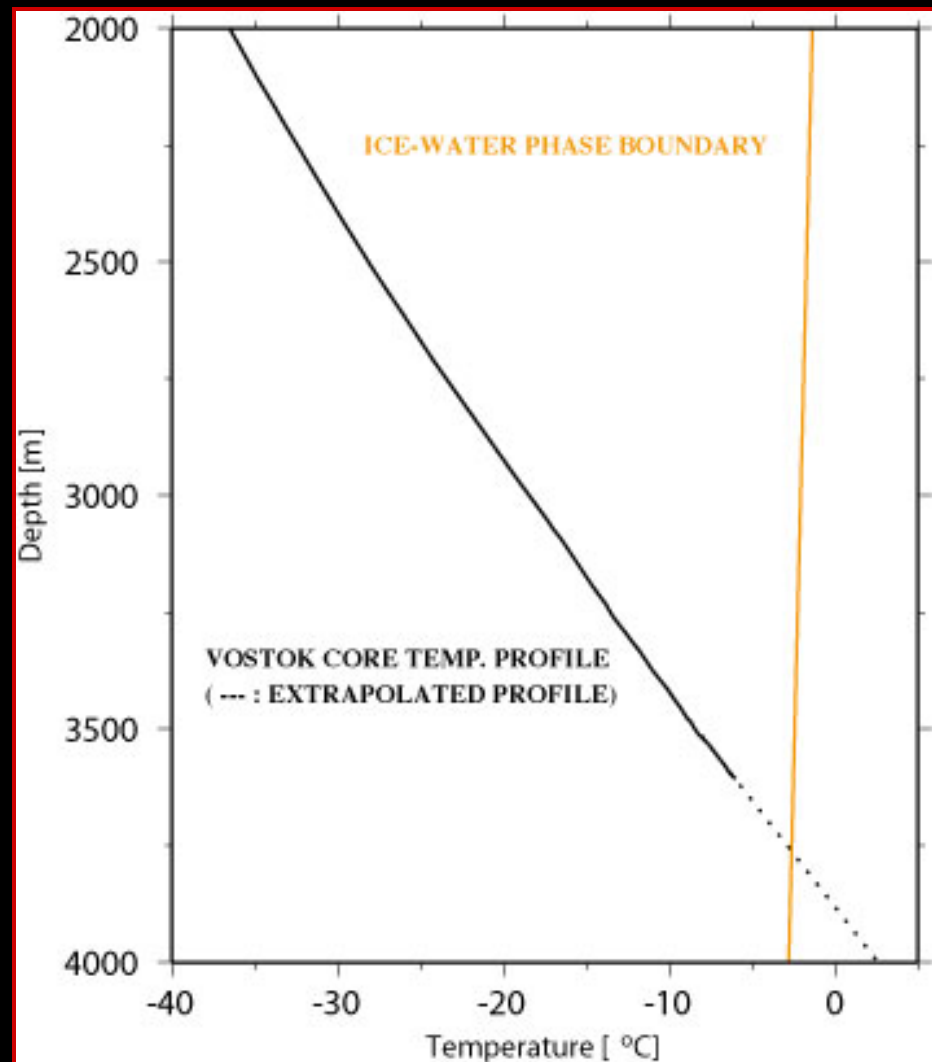
View of Vostok from Space

Ice
Surface
Elevation

M Studinger,
LDEO

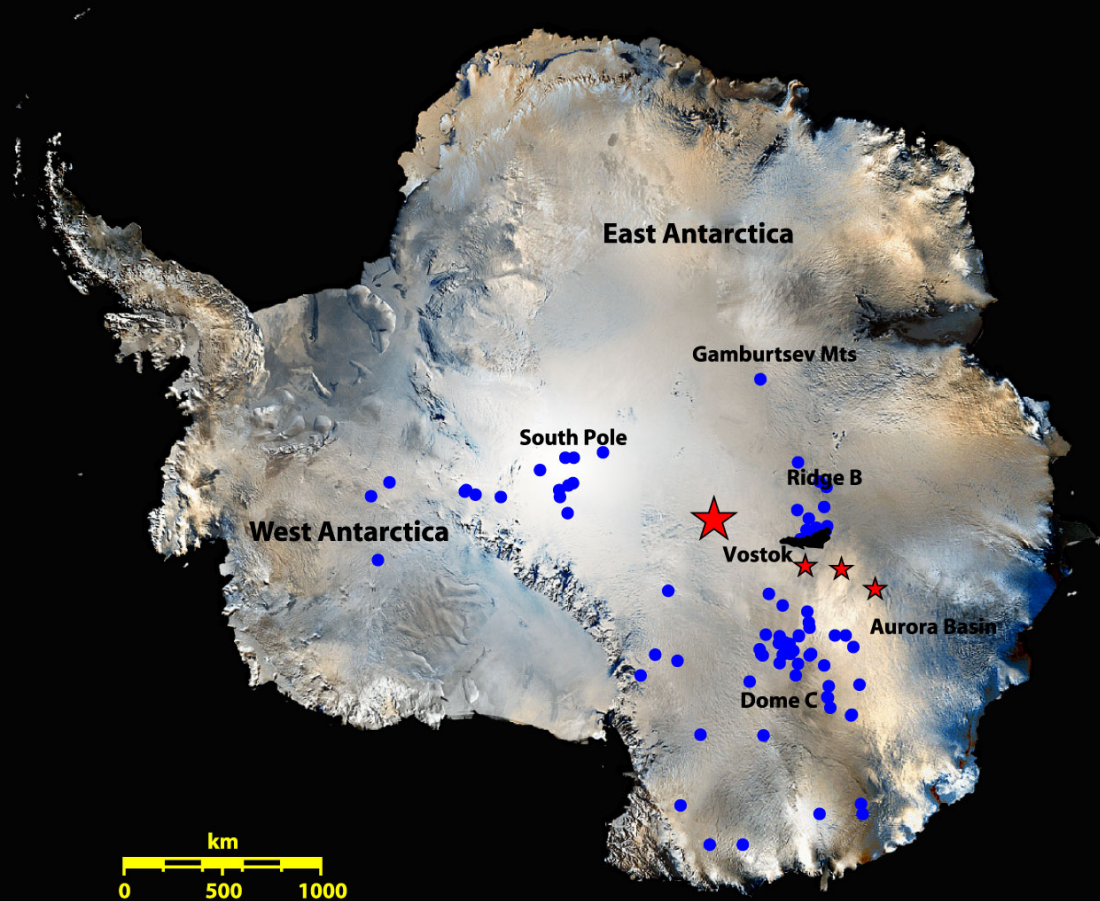
Why Is There a Lake at ALL?

**Temperature
Cold at
Surface
“Warm” at
Base**



Is Vostok the Only Lake?

- NO



Dome Concordia - The Lake District

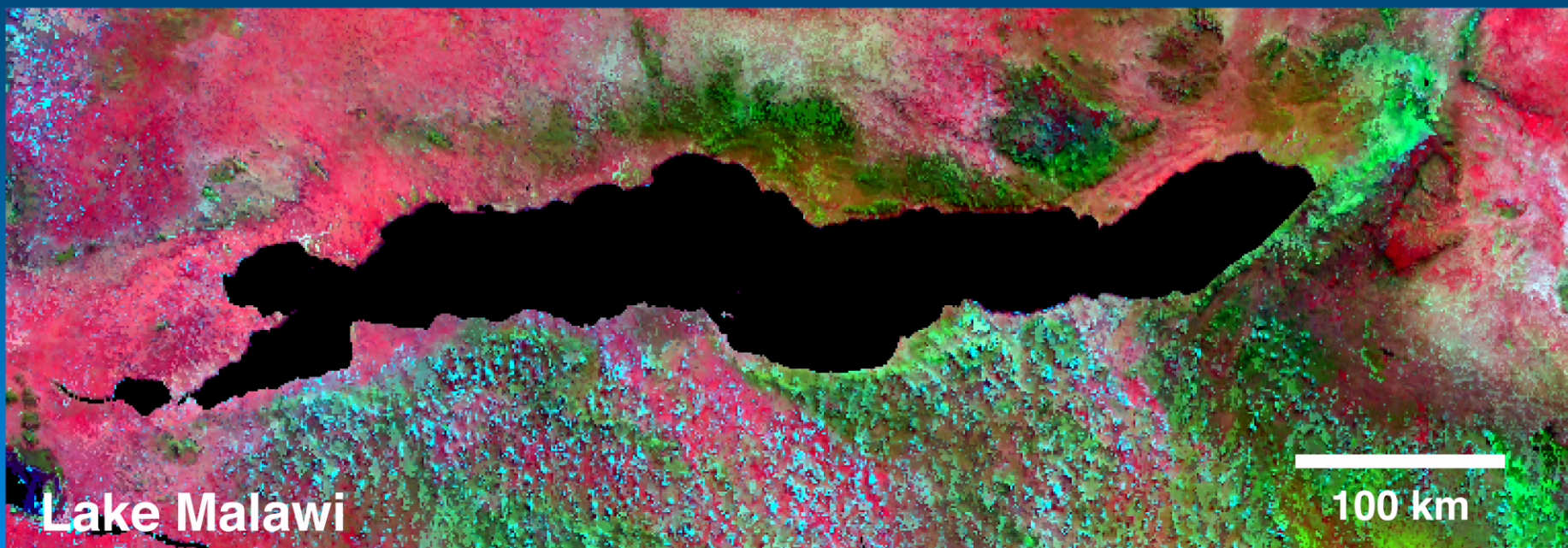
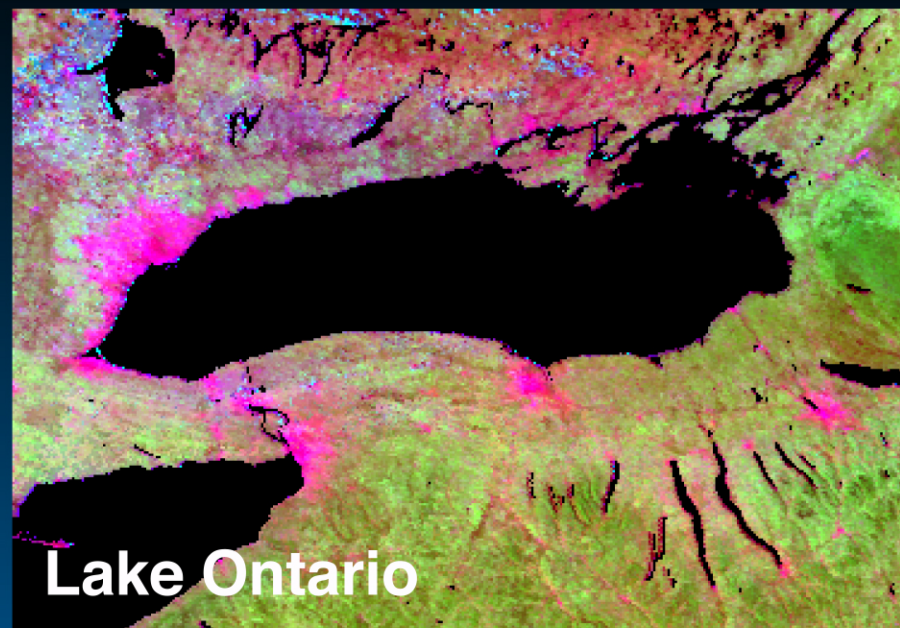
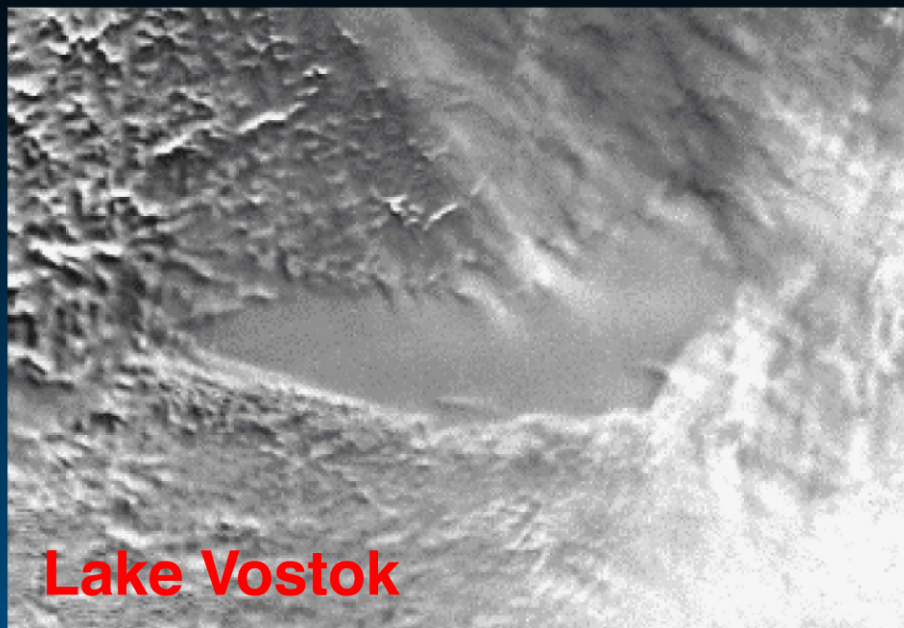


**Italian Antarctic
Programme**



How Does Lake Vostok Compare to Familiar Lakes

Similar in Size But ISOLATED



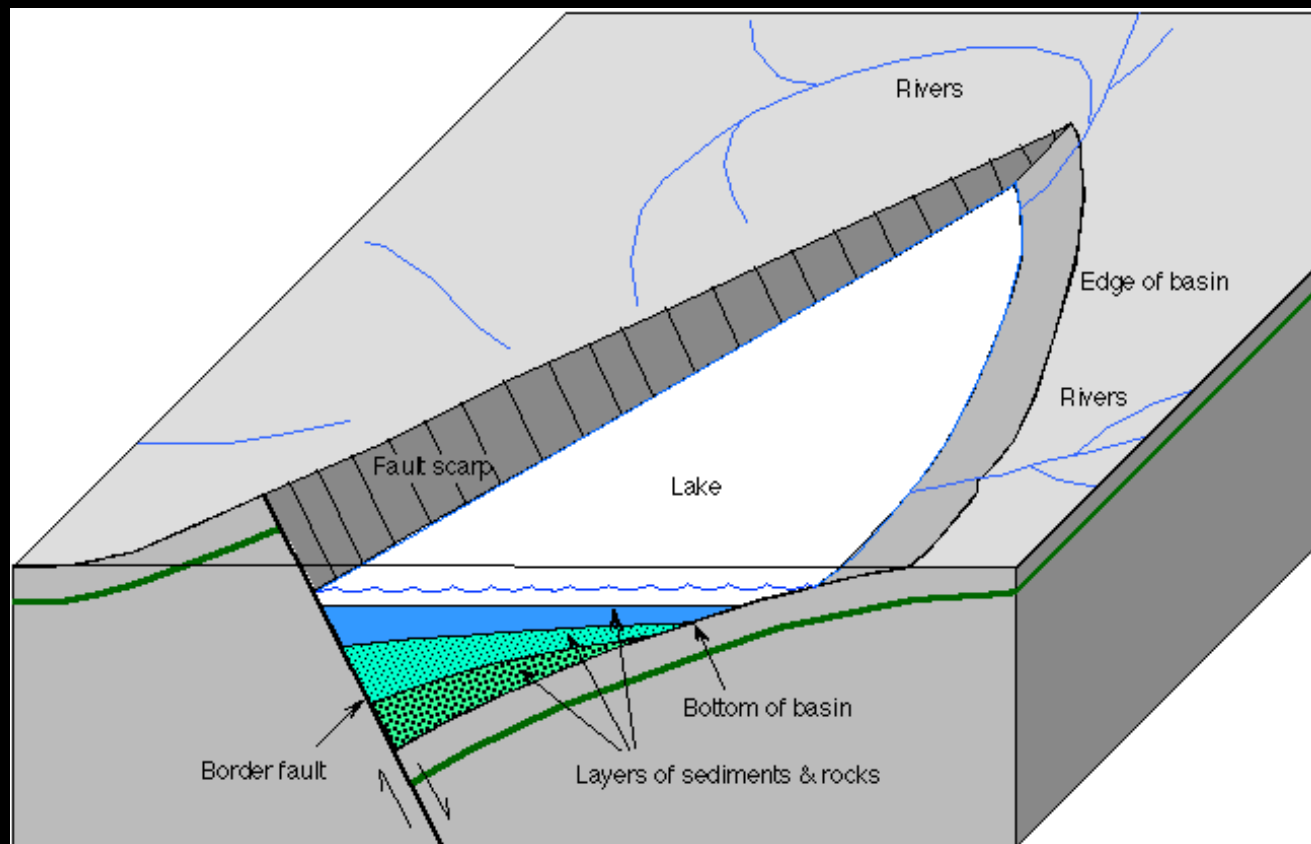


Figure 4: Cutaway block diagram of a rift basin. Note the half-graben geometry (triangular) in the cross section view (front panel).

- Schlische et al

Ice Cores

Insights Into Climate



EPICA



**Russian
Antarctic
Program**

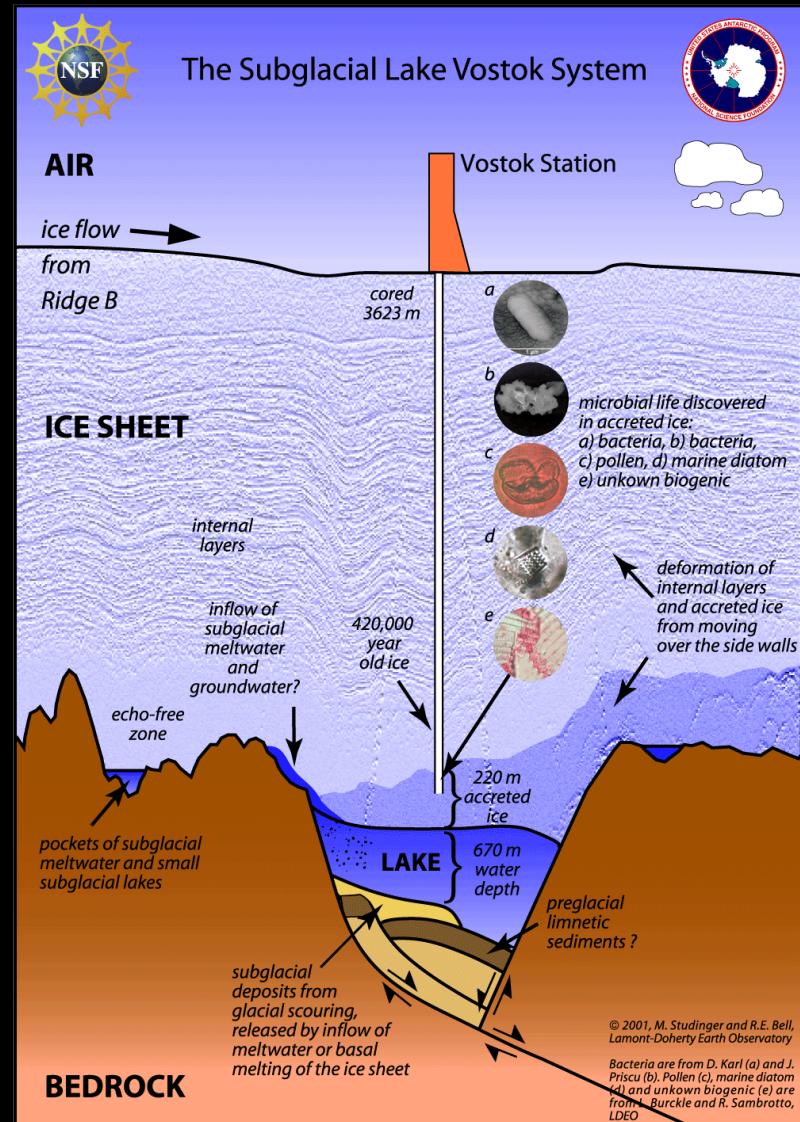
Vostok Ice Core

- Insights Into Climate
- Insights into Subglacial Life

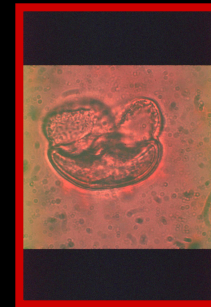
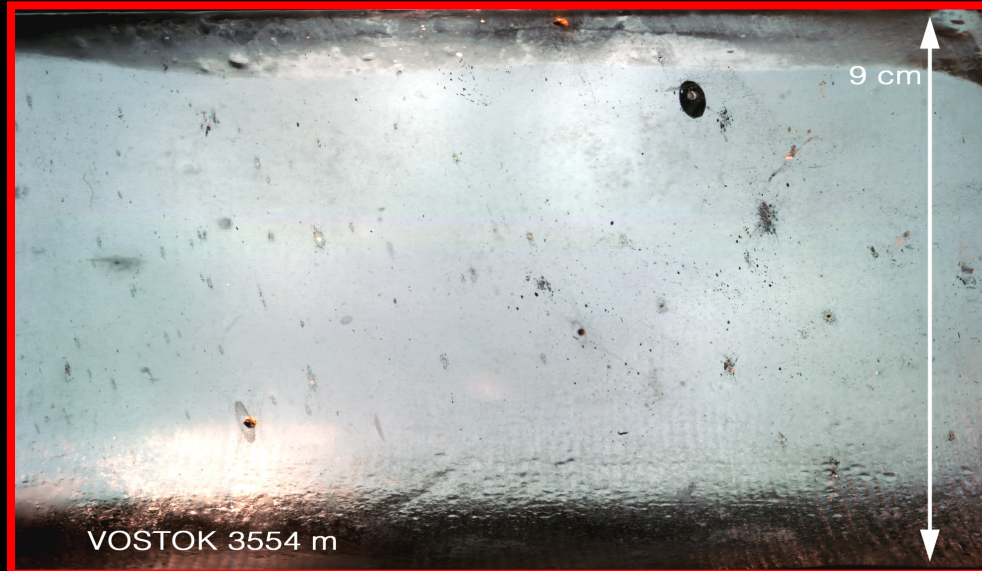
**Russian
Antarctic
Program**



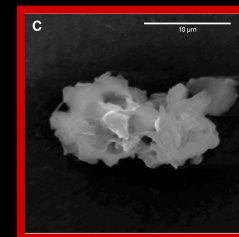
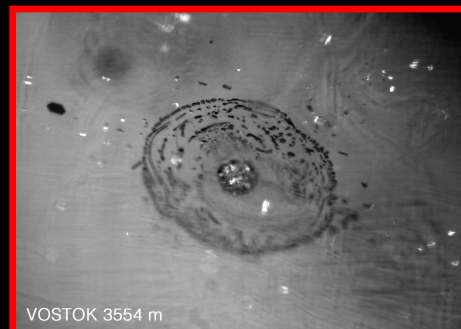
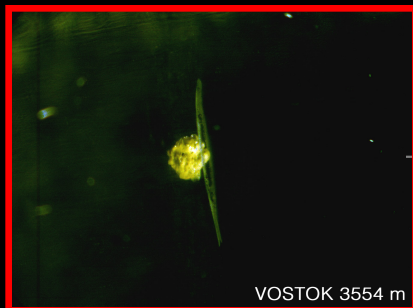
Lake Vostok



Ice From Lake Shoreline

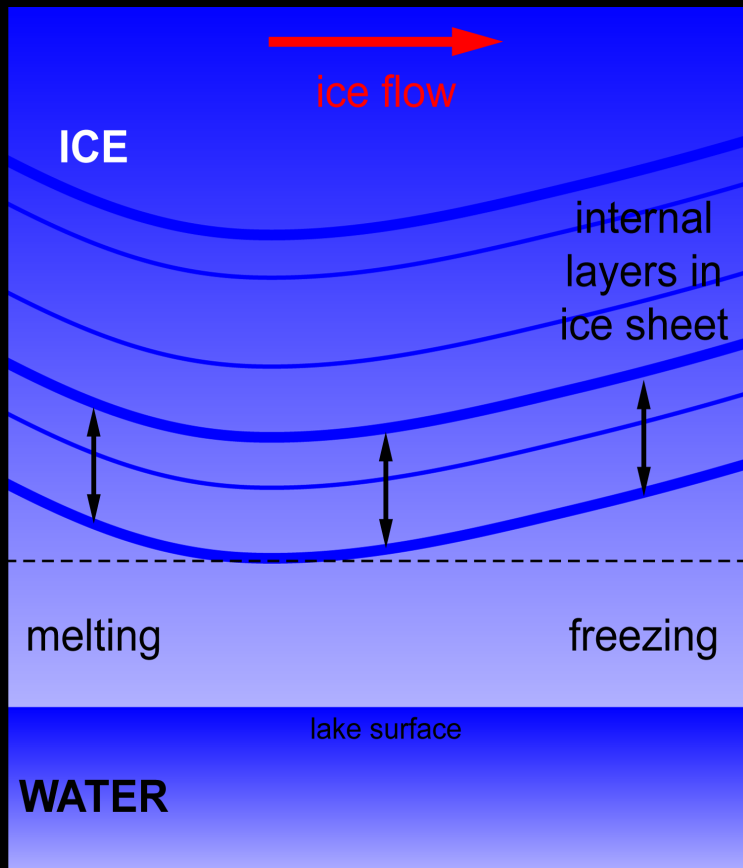


Pollen (Burckle)

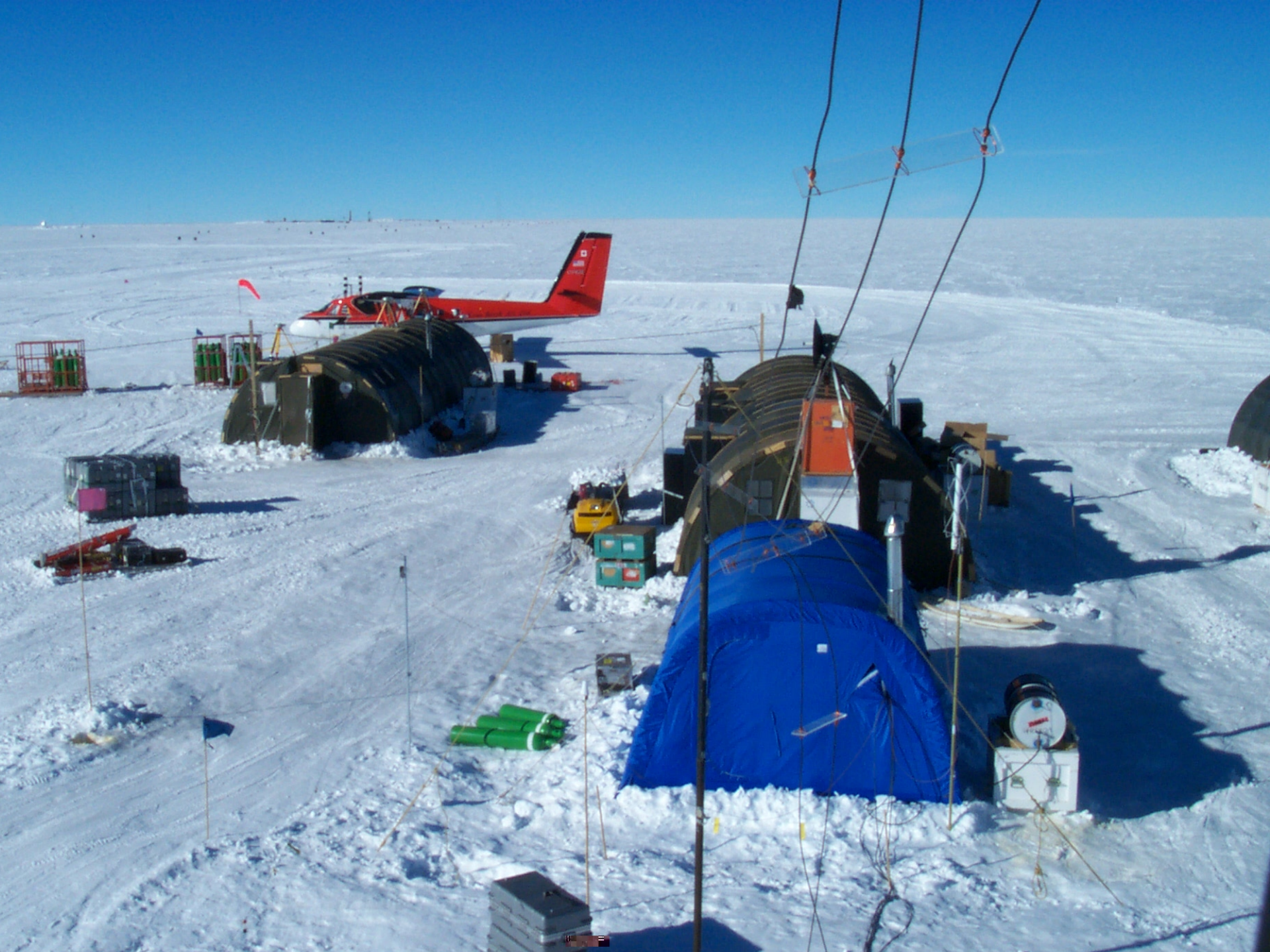


Bacteria (Karl et al)

Thickness Change Along Flow Lines

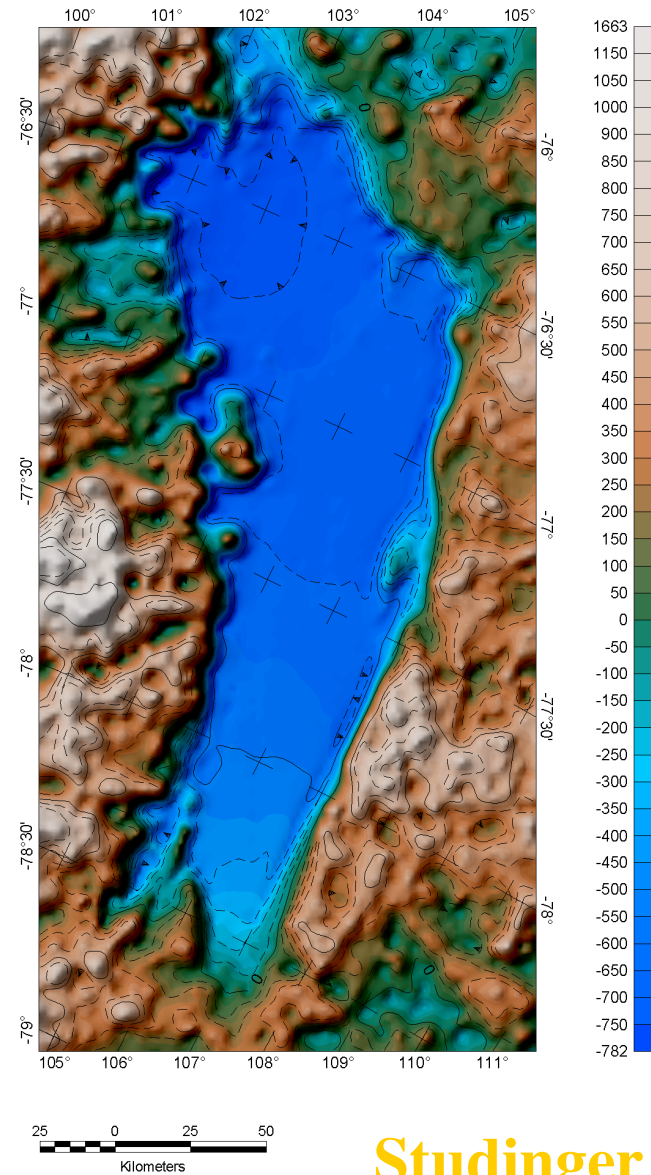






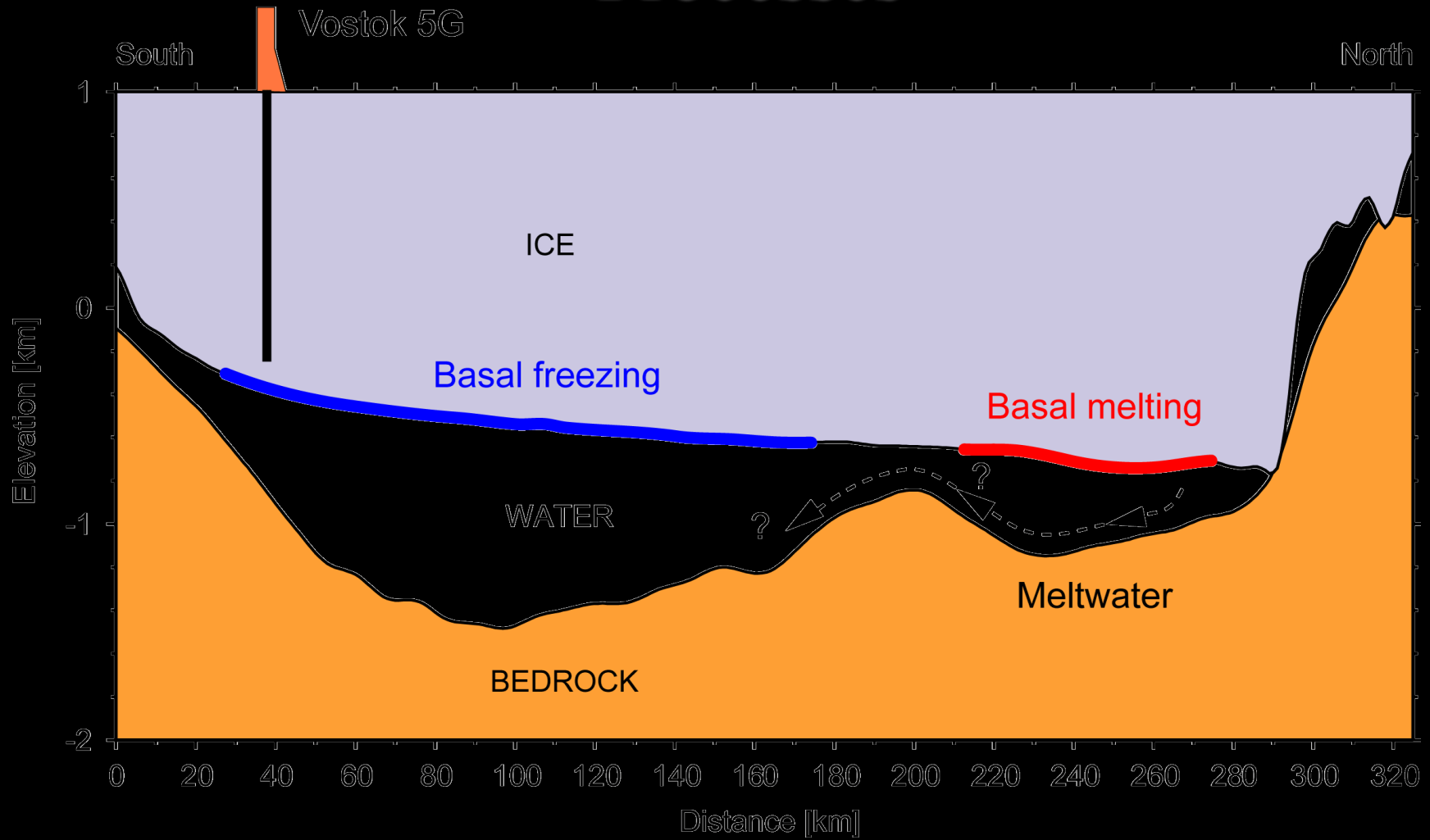


Subglacial Topography Lake Elevation



Studinger et al

The Shape of the Lake - Dynamic Processes



Ice sheet from ice
penetrating radar



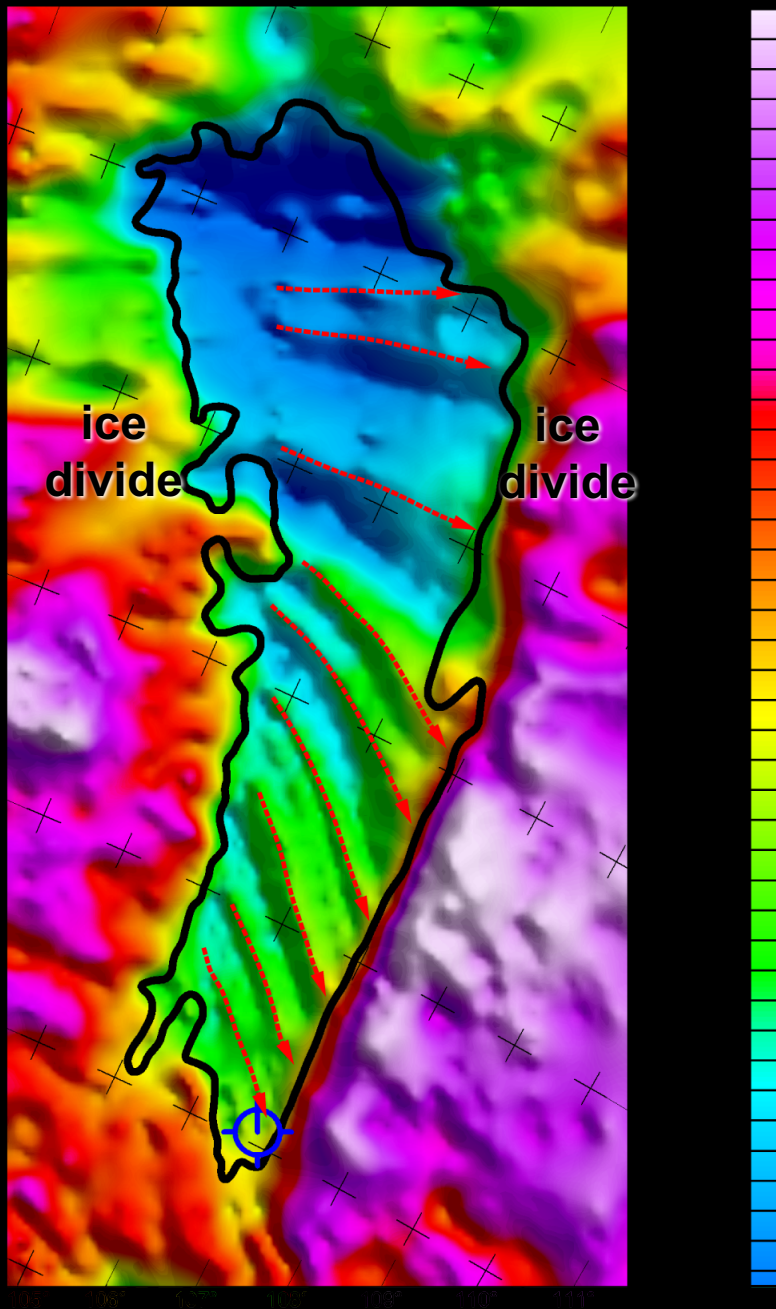
Bedrock from inversion
of aerogravity data

Studinger et al

- Interesting Water Characteristics:
- Maximum Melt Rate: 20 ± 2 Cm/yr
Maximum Freezing Rate: 7 ± 2 Cm/yr
- Water Residence Time 37,000 Years
- Age of Water Entering Lake ~400,000 Years

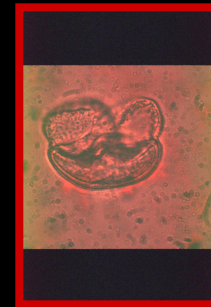
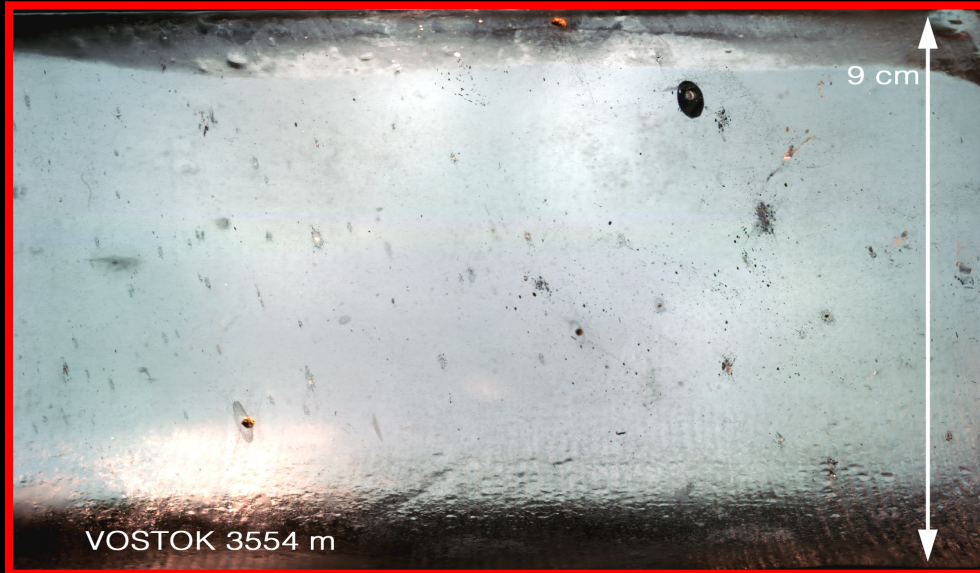
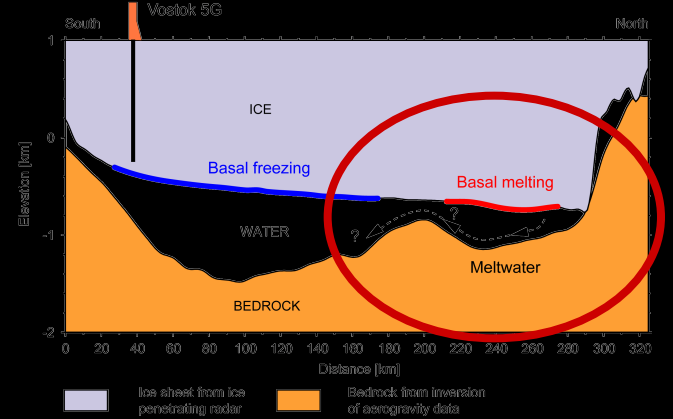
Ice Flow Important to Understanding Water Sources and Fluxes

Calculate Budgets for Lake

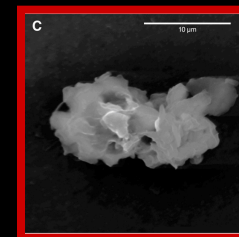
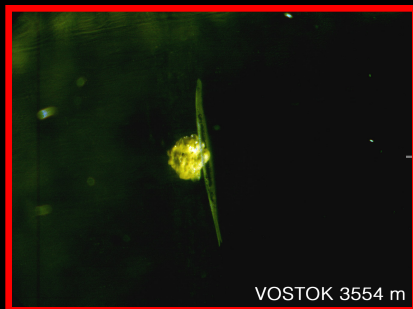


Tikku et al

Ice From Lake Shoreline



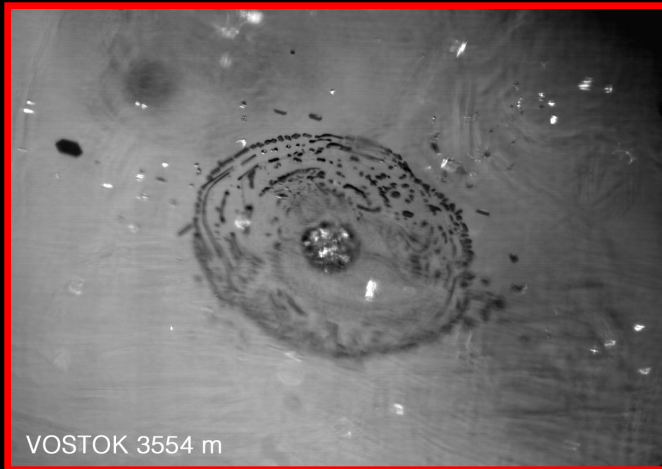
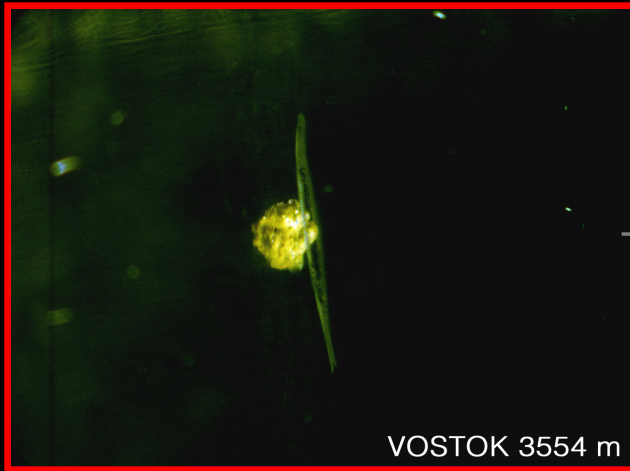
Pollen (Burckle)



Bacteria (Karl et al)

Melting In

Releases Sediments and Hydrates



Freezing Out

No Gases -- No Sediments
in Accretion Ice



**What Happens When Open
Pathway to Gas Saturated Lake??**

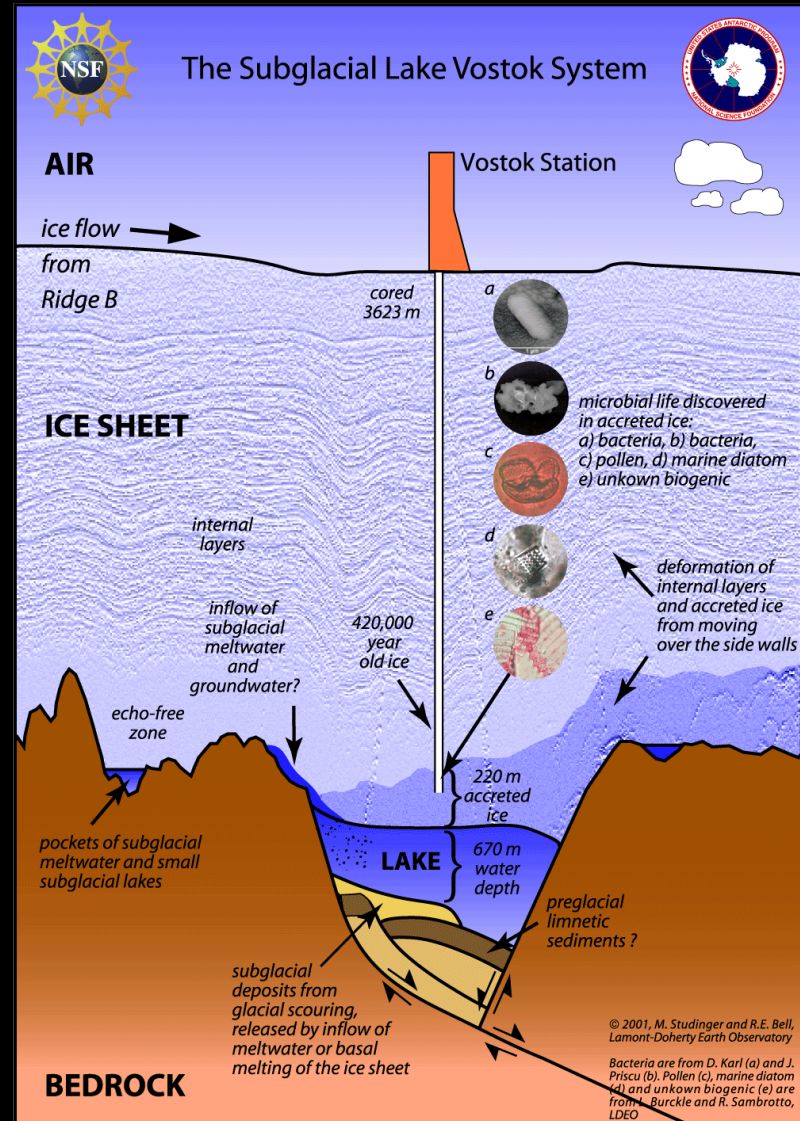
A Large Bottle of Coke

Carbon Dioxide in Cameroon Lakes



Lake Vostok

- Gases in Vostok Accumulating for Possibly 35 my
- Form Hydrates
- Gas Fountain if Open for Over 3 months
- Requires Careful Engineering



WHAT NEXT??

International Plans to Explore Subglacial Lakes

- Group of Experts from SCAR
 - French, British, Russian, Italian, American
- Target International Polar Year



Steps in Exploration Defined by International Group of Experts SCAR - SALE

Site Selection (Where to Look)

Observatories (What's Happening)

Recover Water & Shallow Sediments (Who
Lives There)

Recover Long Cores (How It Evolve)

**International Collaboration Is Crucial
to the Preservation of the Subglacial
Environment and Building New
Knowledge**

International Polar Year



2007 - 2008

www.ipy.org

