The Secret Life of Lake Vostok

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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
Mars Polar Cap

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

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

Hoffman & Schrag Terra Nova 2002, dropstone
Snowball Earth - Triggers Exploding Biodiversity

Joseph L. Kirschvink
California Institute of Technology
Tree of Life

H. Knoll, Science 1999
How Was Vostok Discovered?

- The Result of International Collaboration
- Merging of Diverse International Data Sets
The Earth should be studied as a planet.

Karl Weyprecht  1879
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
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
Establish Vostok Station

- Evseev
• Science Around the Edges for Decades
International Program of Airborne Exploration in 1970’s
Danish - British - American
Total Missions: 127
Airborne RES: 62
Overwater 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
- SPR/NSF/TUD
- Norwegian/British/Swedish
Radar Evidence

• Some Small Pools of Water

• 1970’s
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
Schlische et al. Compare other lakes in the world: ancient and modern.
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
Ice From Lake Shoreline

Pollen (Burckle)

Bacteria (Karl et al)
Thickness Change Along Flow Lines

a) between ice/water interface and internal layer:
- thinning: melting
- thickening: freezing

b) between internal layers:
- ice deformation
- divergence of flow

ICE

internal layers in ice sheet

melting

freezing

lake surface

WATER

ice flow
Subglacial Topography
Lake Elevation

Studinger et al
The Shape of the Lake - Dynamic Processes

Studinger et al
Interesting Water Characteristics:

- Maximum Melt Rate: $20 \pm 2$ Cm/yr
- Maximum Freezing Rate: $7 \pm 2$ Cm/yr

- Water Residence Time: 37,000 Years
- Age of Water Entering Lake: $\sim 400,000$ Years
Ice Flow Important to Understanding Water Sources and Fluxes

Calculate Budgets for Lake

Tikku 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