Evolving Technologies for In-situ Studies of Mars Polar Caps

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In-Situ Exploration Science and Technology for Mars Polar Regions

- **Climate**: History of Water, Ice, CO₂, Dust, Impacts, Etc
- **Atmospheric Processes**: The CO₂ & H₂O Annual Cycles; Dust
- **Astrobiology**: Interstitial Water & Nutrients in Warmer Climates

**Thoughts on Deep Subglacial Ice:**
- Control Ice Sheet Dynamics (Forced by Topography),
- Usually Older,
- Warmer,
- Protected From Surface Processes,
- Contain Interstitial Mineralogic Material and Liquid Water

**What Can We Learn about Methods by Analogy With Earth Science?**

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Mars Polar Caps: Fabulous Data from Orbit

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MARS ICE CAPS SUBSURFACE ACCESS

- Deep Subglacial Studies on Earth Have Been Revolutionary
  - Paleoclimate studies: Abrupt Climate Shift
  - Ice sheet dynamics
  - Subglacial lakes

- Mars Exploration: Comparably Interesting

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THE NEXT STEP IS IN-SITU SCIENCE: KEY TECHNOLOGIES ARE NEEDED

- Long-Range Surface Survey Capability
- Subsurface Access and Science
- Surface Science & Operations
- Development and Testing Opportunities
- Other Technologies (Planetary Protection, Power, Comm, Soft Landing)

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Recent Coring Depth
- 3623 m @ Vostok
- 3085 m @ NGRIP

Analysis
- Trace chemicals
- Isotopes
- Included gas & dust
- Ice Temp & Structure
- Ice Sheet-Bed interactions

More Cores are Planned

Petit et al 1999
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DEEP ICE EXPLORATION: THE JPL CRYOBOT, A ROBOTIC VEHICLE FOR ICE CAPS

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SIPR improves on the Cryobot:
- Reduced heat loss
- Better scientific profiling
- Simpler instrumentation

Although
- Can’t go as deep

Prototype on Athabasca Glacier on Wednesday!
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SIMPLE IN-SITU INSTRUMENTATION® JPL: CAMERA AND DUST NEPHELOMETER

3 X 5 cm; Ice Stream C

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Nuclear Fission Thermal Probe: PALMER QUEST Vision Mission Proposal

OBJECTIVES: Detection of Life Beneath North Polar Ice Cap (and other science)
BASELINE APPROACH: Deploy a Fission-Reactor Powered Thermal Probe into the N Polar Cap to Search for Life at Contact of Basal Units and Ice Cap
WORK PLAN: Examine/Asses Key Technologies

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SURFACE SCIENCE

MEASUREMENTS
- Polar Cap Albedo/Emissivity Measurements and Mechanisms
- Seasonal Ice Sheet Mass Balance Processes
- Ice-Dust Interactions
- Cloud Opacity
- Near-Surface Density, Porosity
- Close-Up Images: Cryptics, Dalmations, Black Spiders, Fried Eggs, Fans

INFRASTRUCTURE
- Instruments: PIDDP & MIDP Strong; Astrobiology is Strong
  - Methods for Ice-Dust Characterization?
- Environmental Development & Testing: Essential, Expensive, Challenging
- Platform Issues: Lander Interference, Long-Duration Stations

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EARTH SCIENCE EXAMPLE: GREENLAND FACIES

FIELD OBSERVATIONS BY BENSON ET AL, 1952-55
- 4 Traverses; 1850 km; over 600 days on the ice
- 146 Snow pits 3-6 m + drilling 10 m; 288 Ramsonde penetrations

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HISTORY: GREENLAND FACIES

Benson’s Facies are key to understanding Greenland Ice Sheet

Can Mars Ice Caps really be simpler?

We need long-range scientific traverse capability on Mars

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CONTEMPORARY TRAVERSES

ITASE Traverses

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CONCLUSIONS
- We have technology needs for Mars Polar Exploration
- The science enabled by these technologies is significant
- This technology is within reach
- Some technologies overlap in Earth Science, other planetary explorations
- NASA has plenty of technology money and skill
- We Must Provide Specific Rationale and Requirements to NASA

ACTIONS
- Call for
  - Development & Demonstration of Long-Range Autonomous Scientific Mobility
  - A Community Mars Surface-Environment Simulation Facility
  - Development & Demonstration of Subsurface Access and Science Technologies
- Produce Workshops/Articles on Key Science-Driven Technologies
- We Must Mobilize the Will of NASA

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