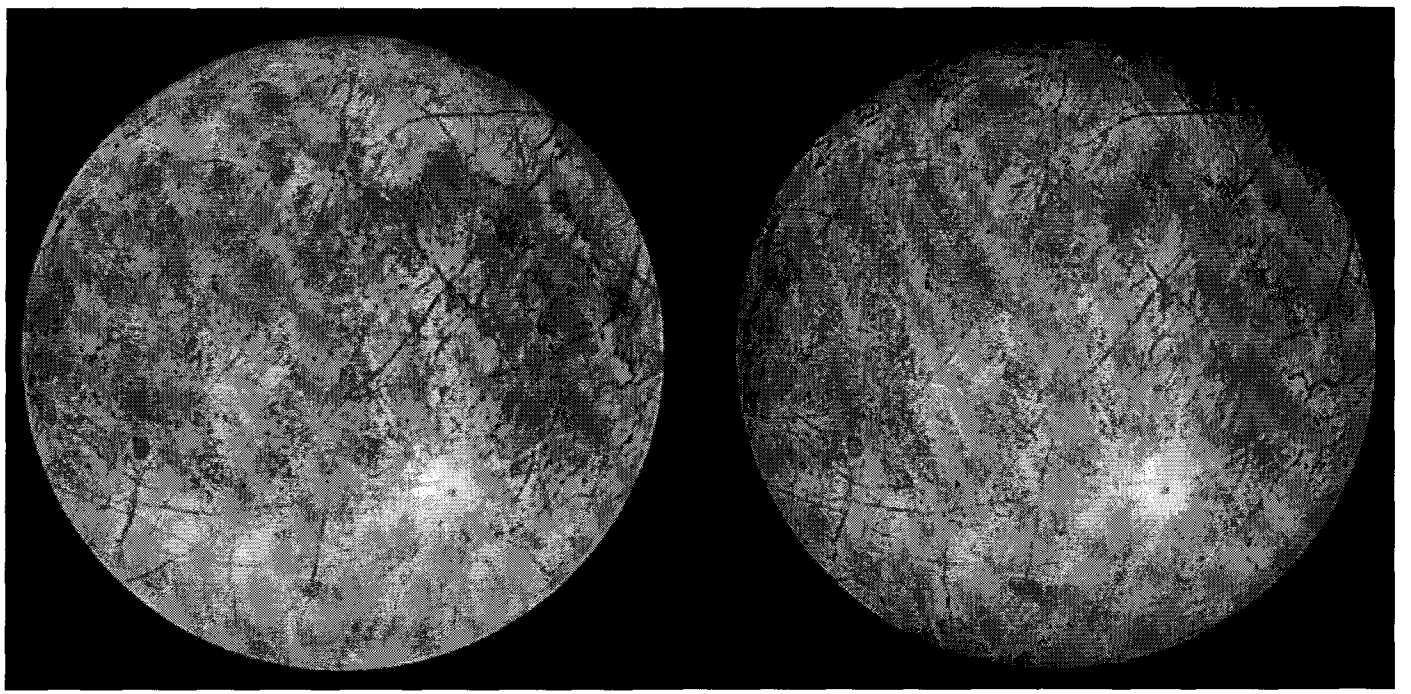
EXPLORING EXTREME ICY ENVIRONMENTS IN SPACE AND ON EARTH

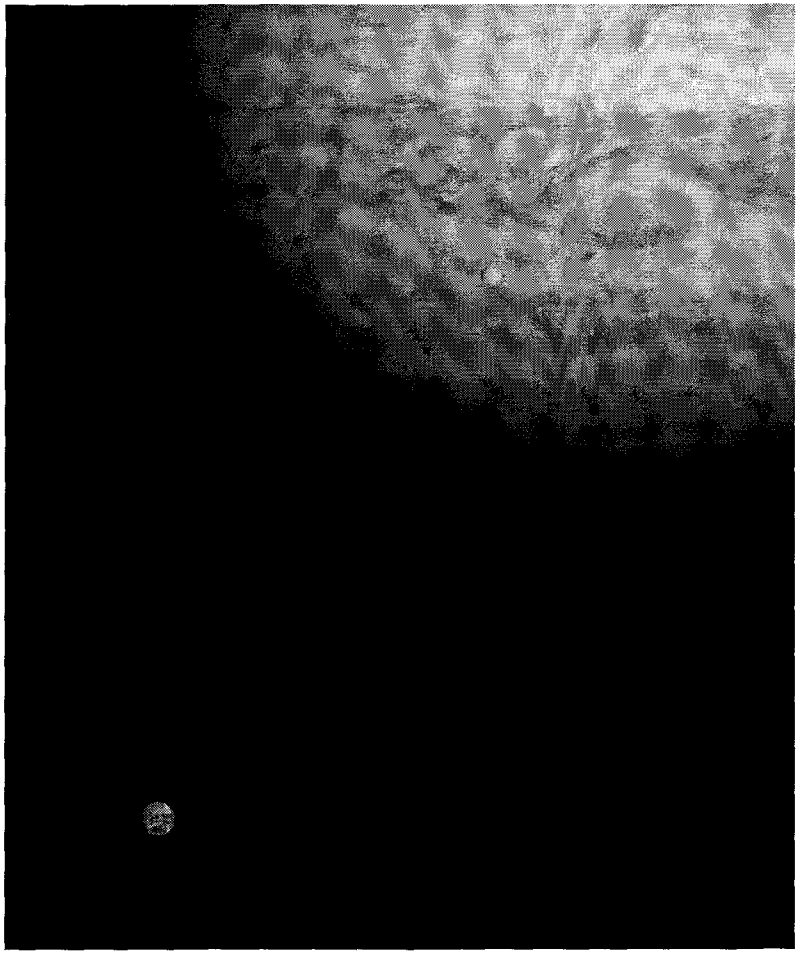
FRANK CARSEY
Polar Oceanography
Caltech JPL

Renewed Fascination in Ice with Galileo data of Europa

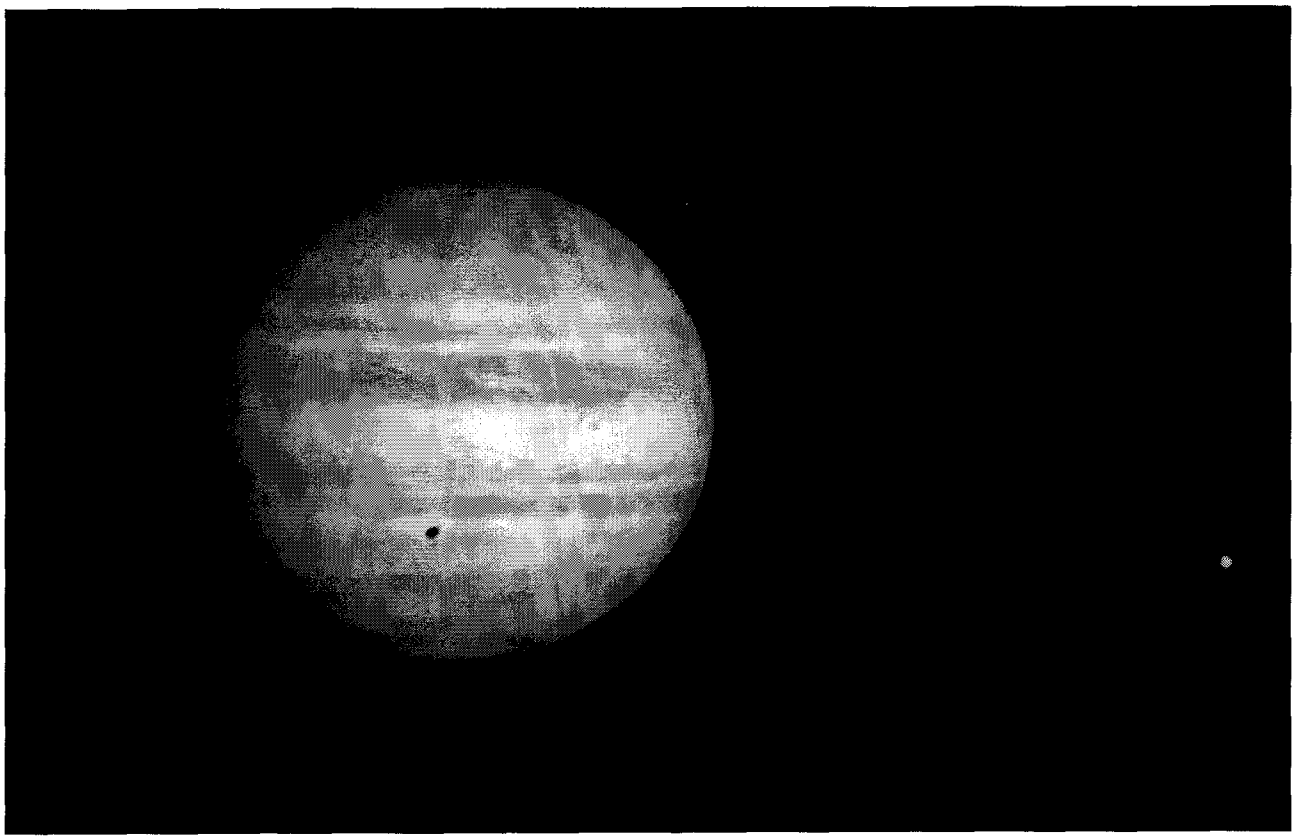


http://photojournal.jpl.nasa.gov/

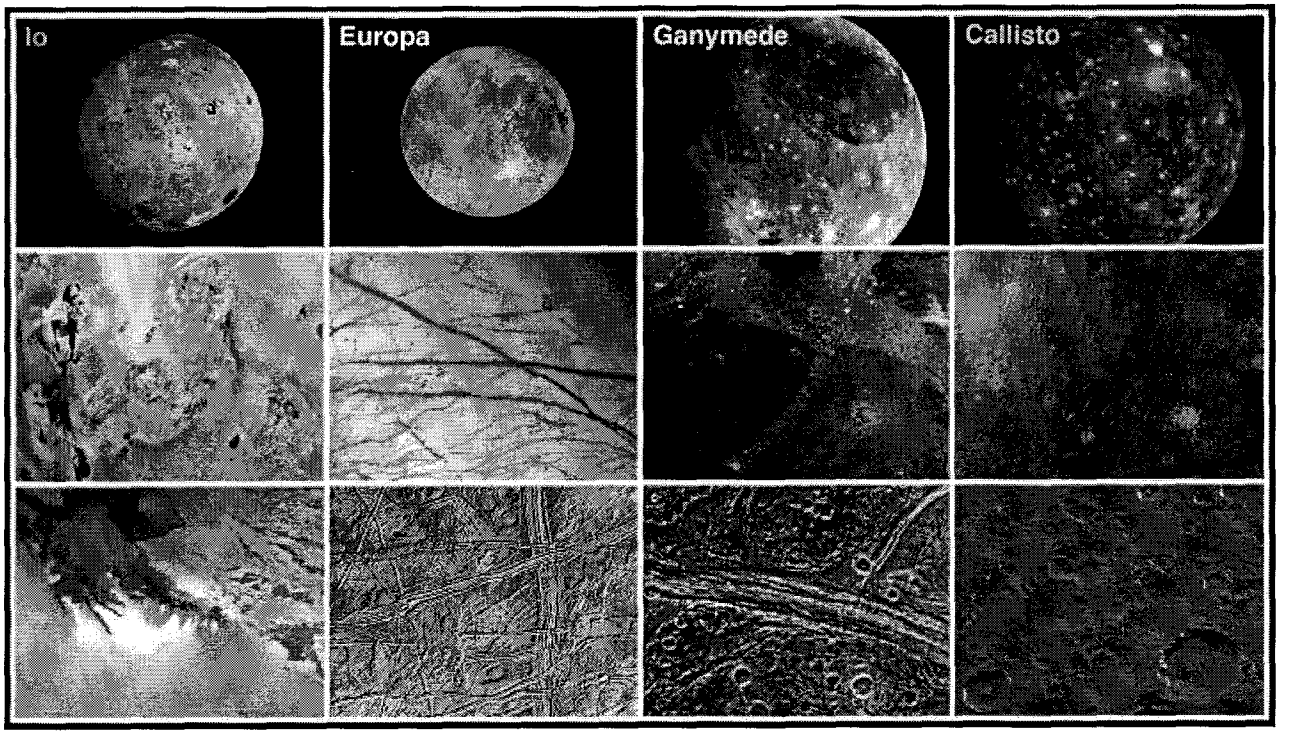
Exploration of Icy sites: Europa, Mars and Earth



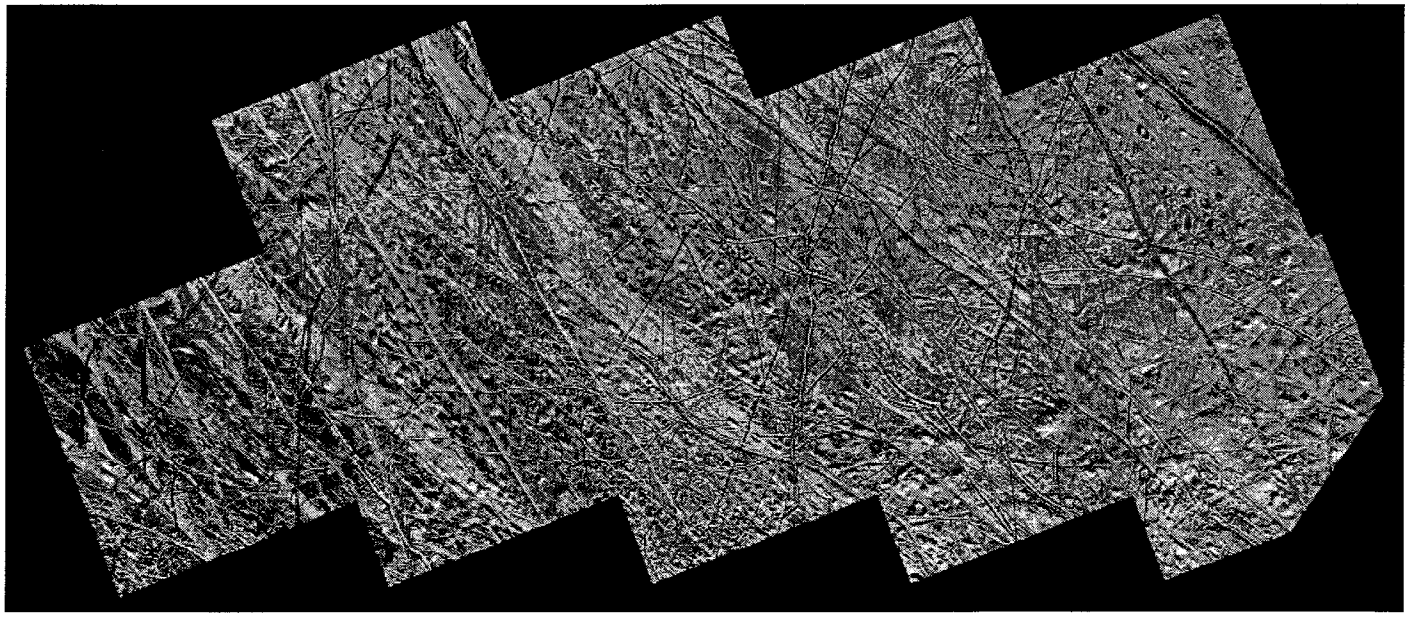
Europa, at Right, Casting a Shadow on Jupiter, Left (Cassini Data)



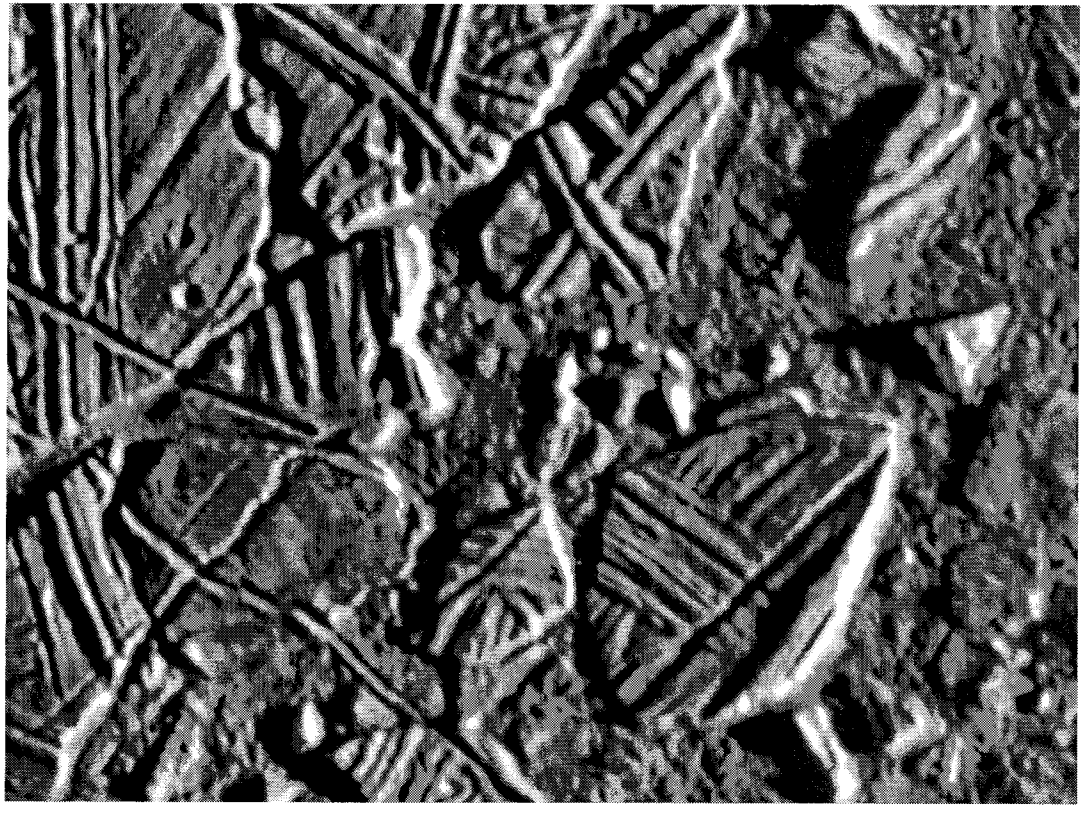
Fabulous Places: The Jovian Moons of Galileo



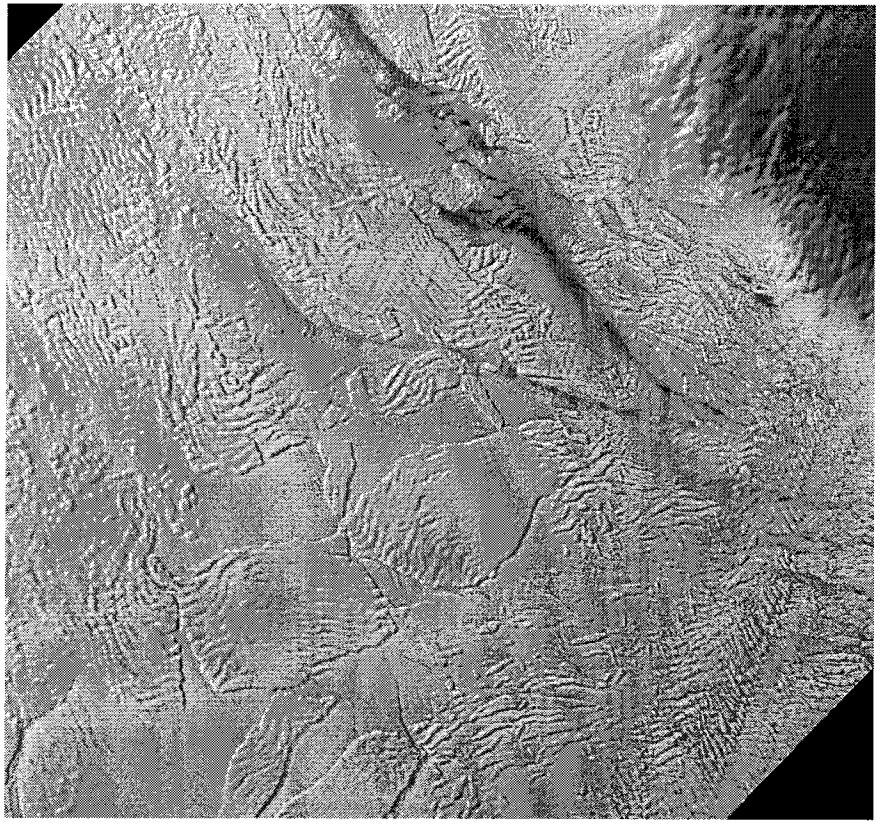
Europa surface Features



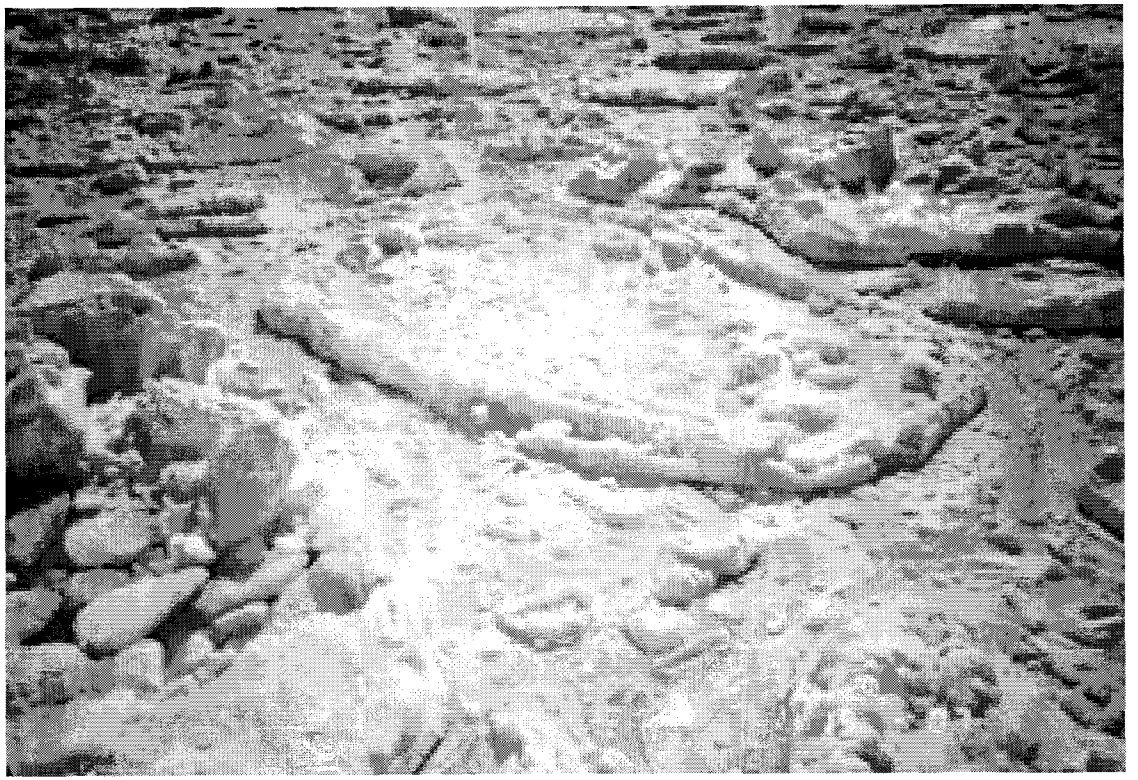
Especially First Europa Chaos Region



Compare to Antarctic Ice Shelf in SAR Image

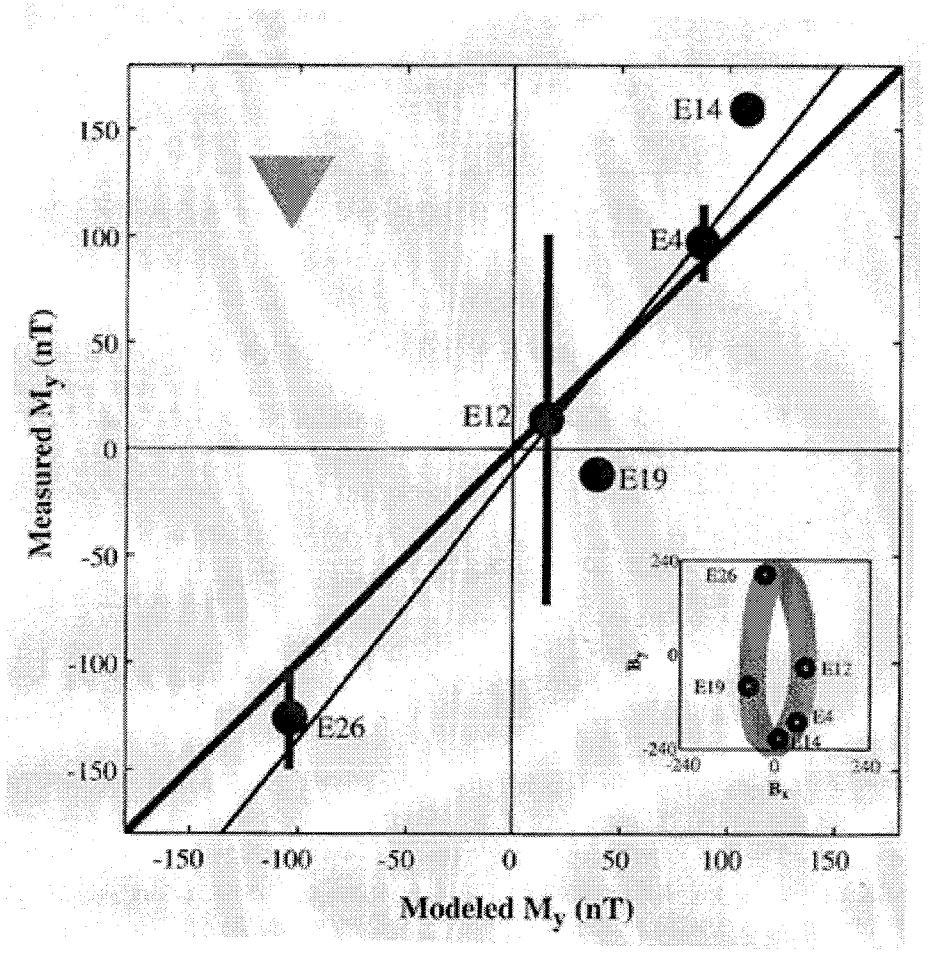


Compare to Sea Ice Cakes off Canada's East Coast

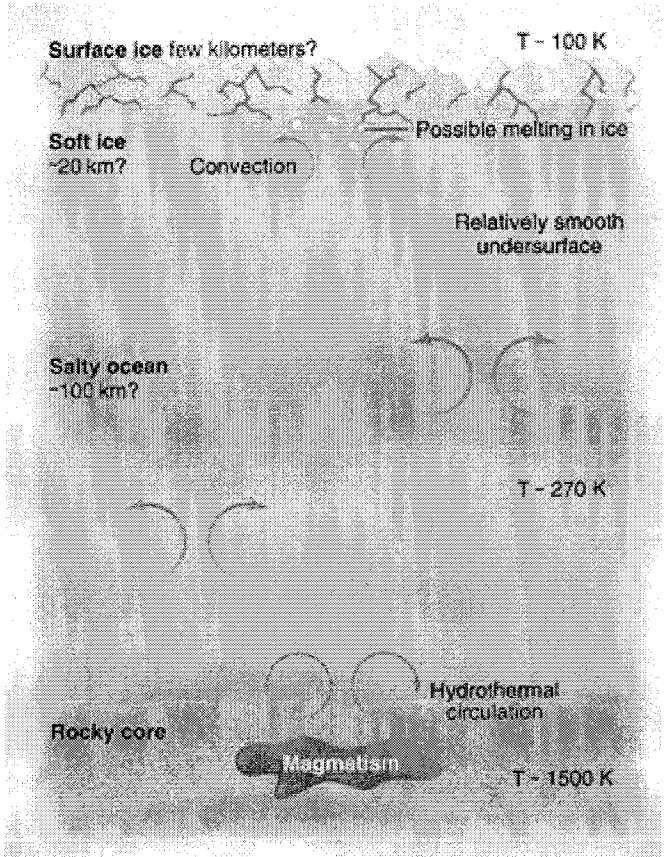


Europa Ridge Closeup; Parallel Cracks

The Jupiter-directed component of the induced magnetic field at Europa



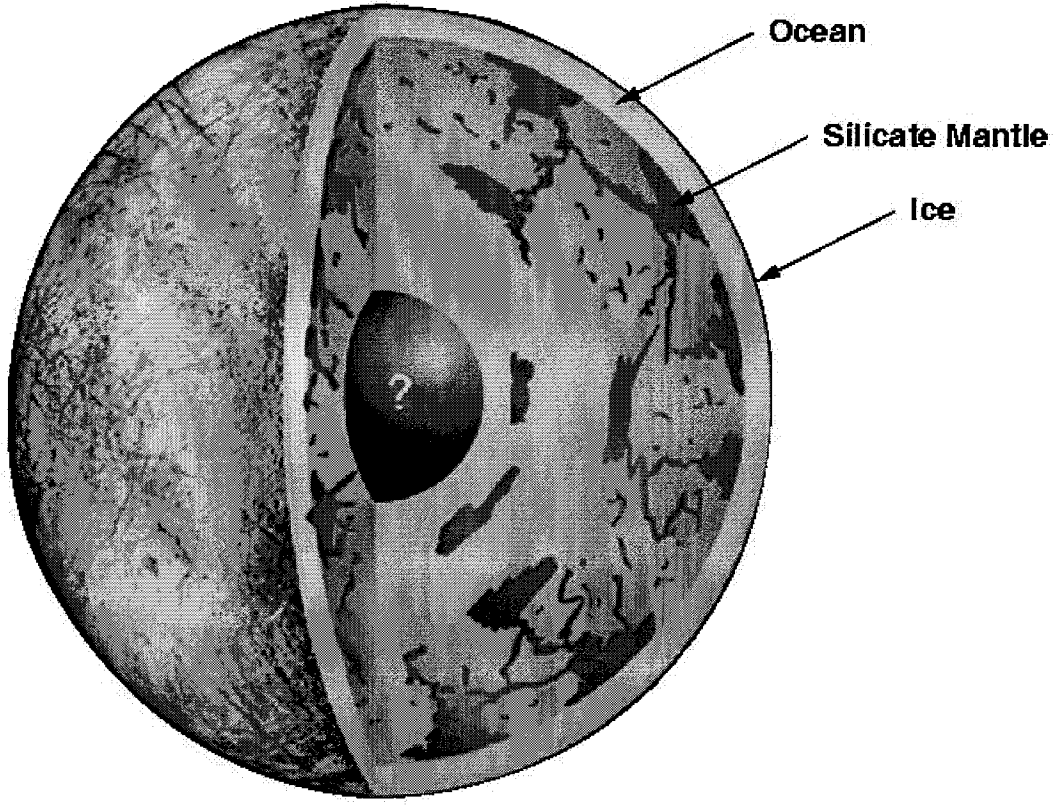
Kivelson et al, *Science* 289, 2000



Possible processes in Europa. This is a montage; it is unlikely that all of these processes happen in the same place at the same time.

A Concept of the Europa Ice and Ocean Due to David Stevenson of Caltech

A Europa Crossection



Status of Knowledge on The Europa Ocean

Gravity Analysis: The Low Density Shell is 60-120 Km Thick

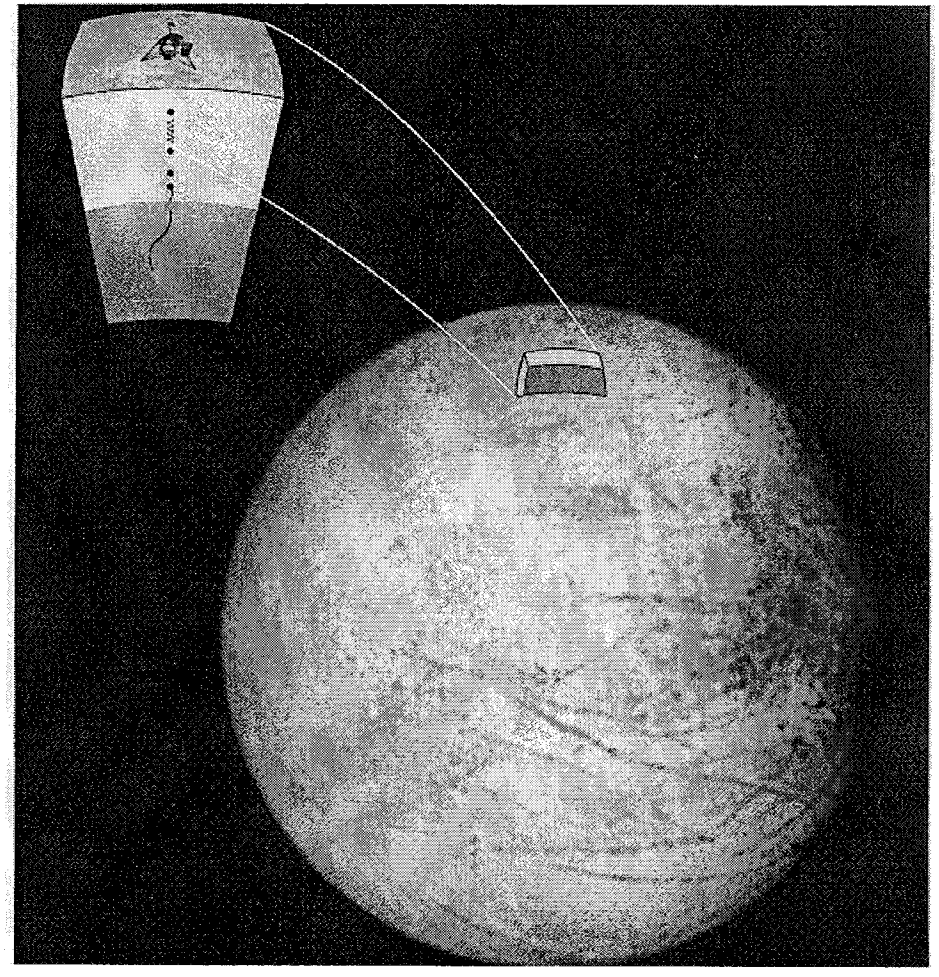
Image Analysis: There Surely **Was** an Ocean with an Ice Cover, Thickness a Few Kilometers

Surface Chemistry: Patterns Indicate Salts Associated with Surface Ridges

Fracture Analysis: Tidal Forces Deform the Ice to Produce Ridges, Depth a Few Kilometers

Lenticulae (Freckle): Size Distribution Suggests Convection in Ocean and/or Ice

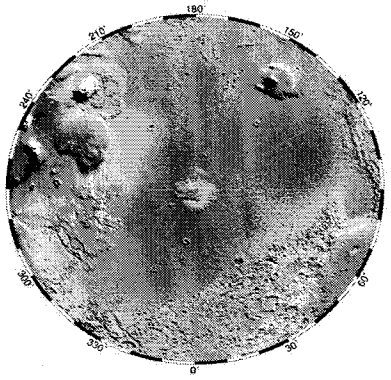
Magnetization: Data Require Near-Surface Conducting Layer, e.g. Salty Ocean

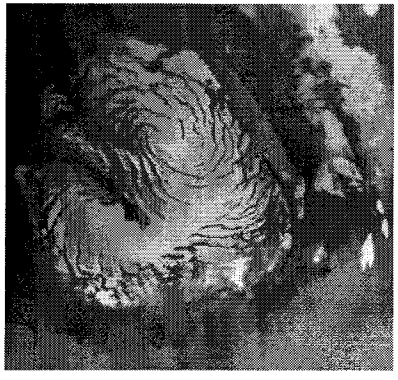


A Strategy for Exploration of Europa's Ocean, Under Its Thick Icy shell

Mars Poles

N





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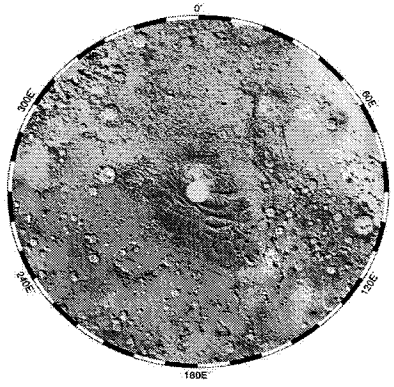
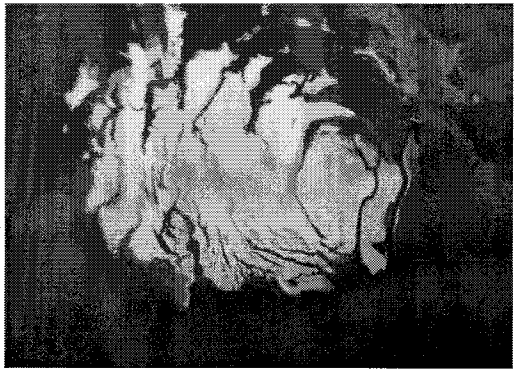
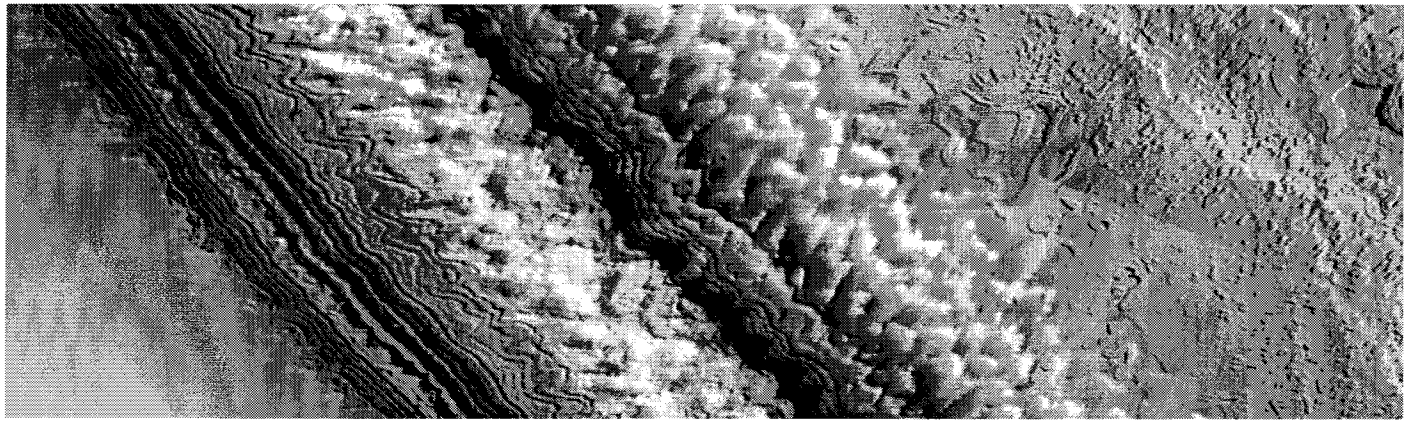
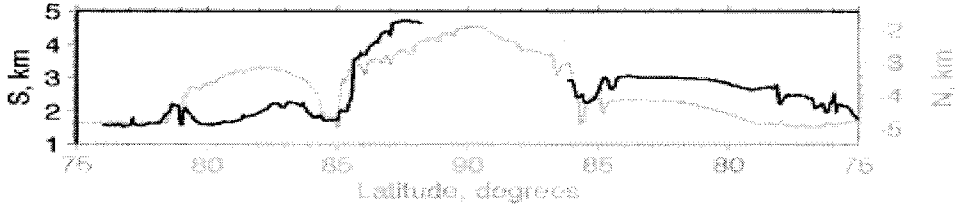


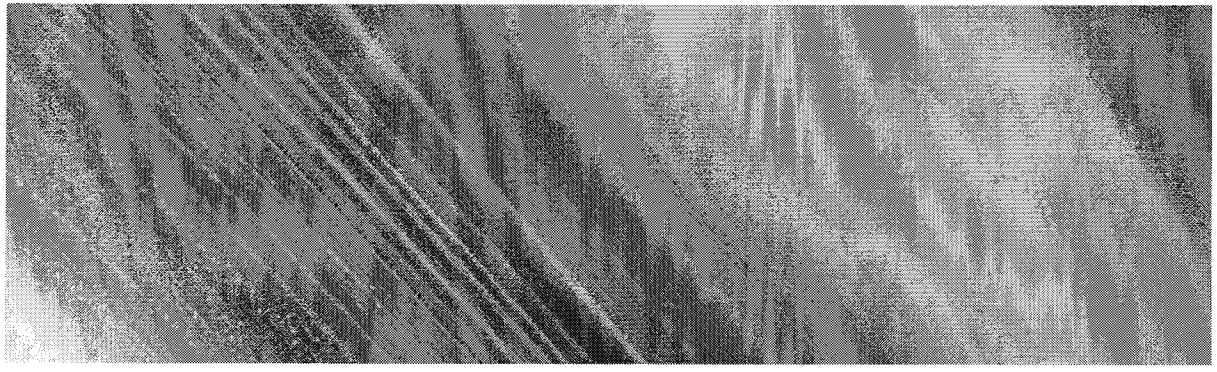


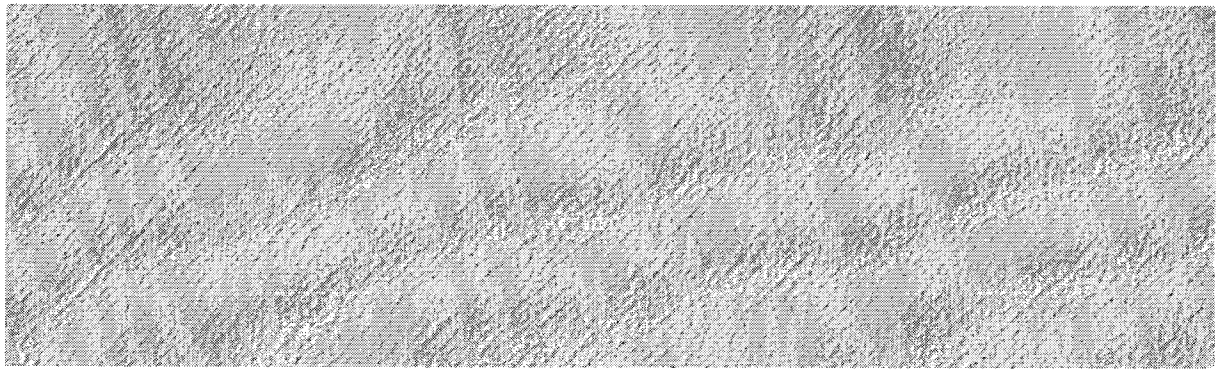
Mars South Pole from Mars Orbiting Camera



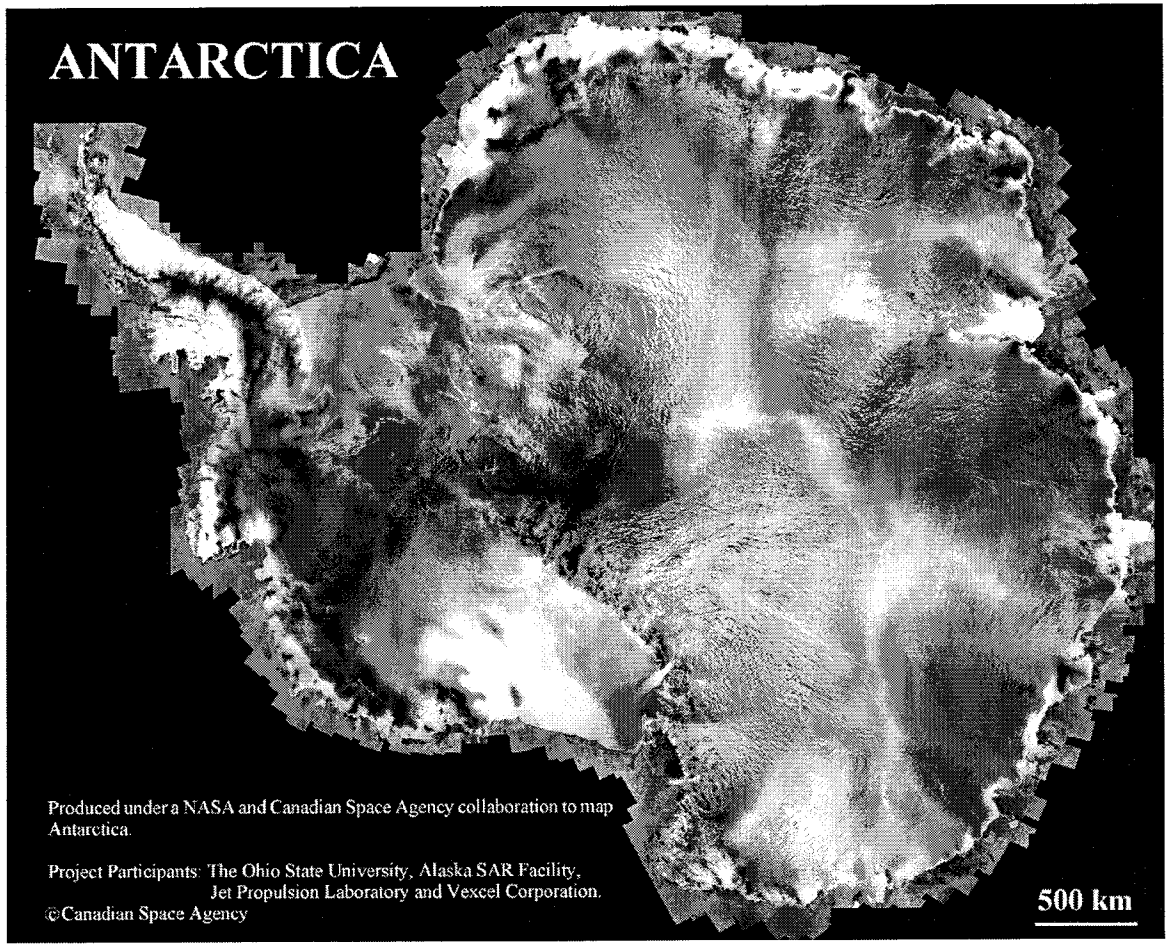


Mars North Polar Cap and Layered Terrain

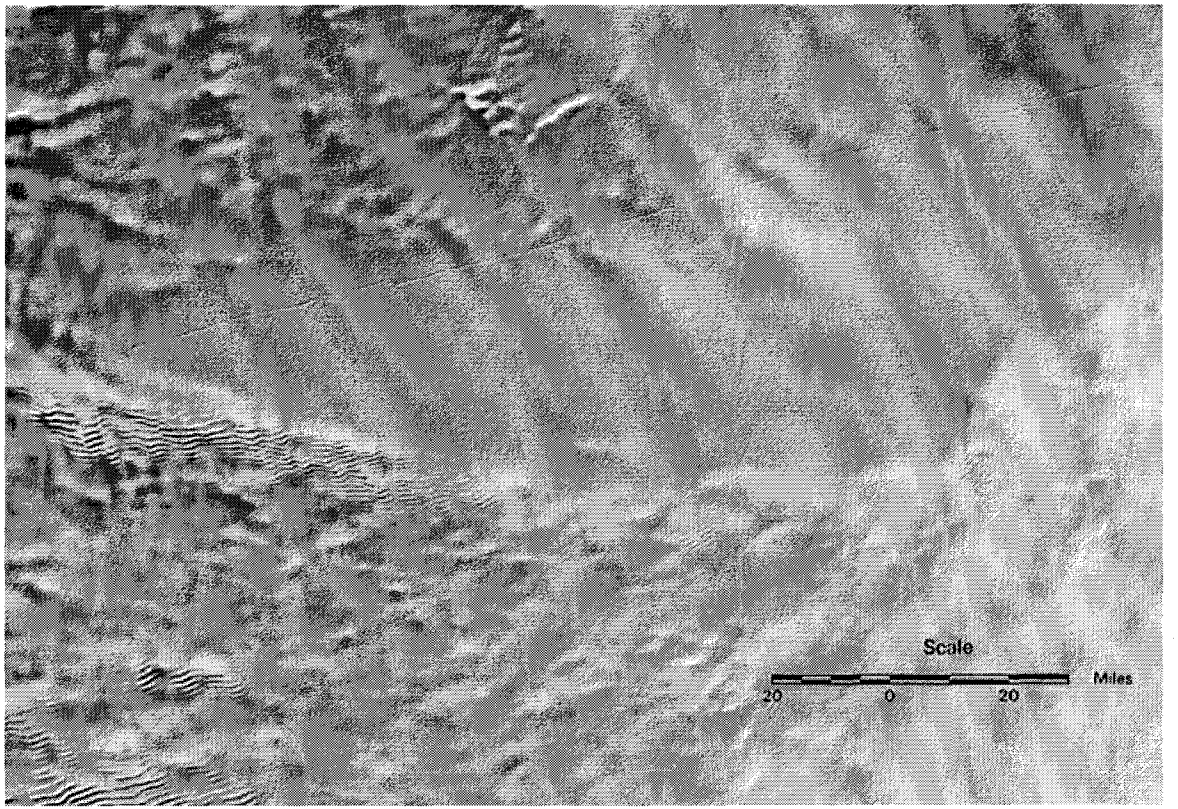




Exploration of Icy sites: Europa, Mars and Earth



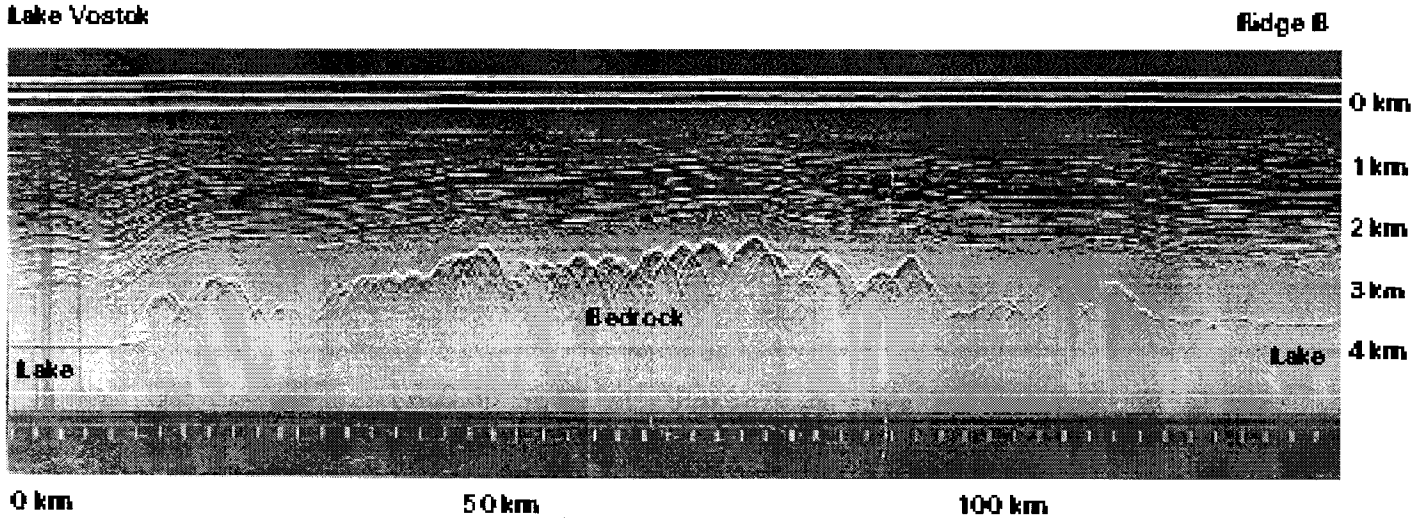
Imaging Radar View of Lake Vostok, East Antarctica



Imaging Radar View of Lambert Glacier, East Antarctica

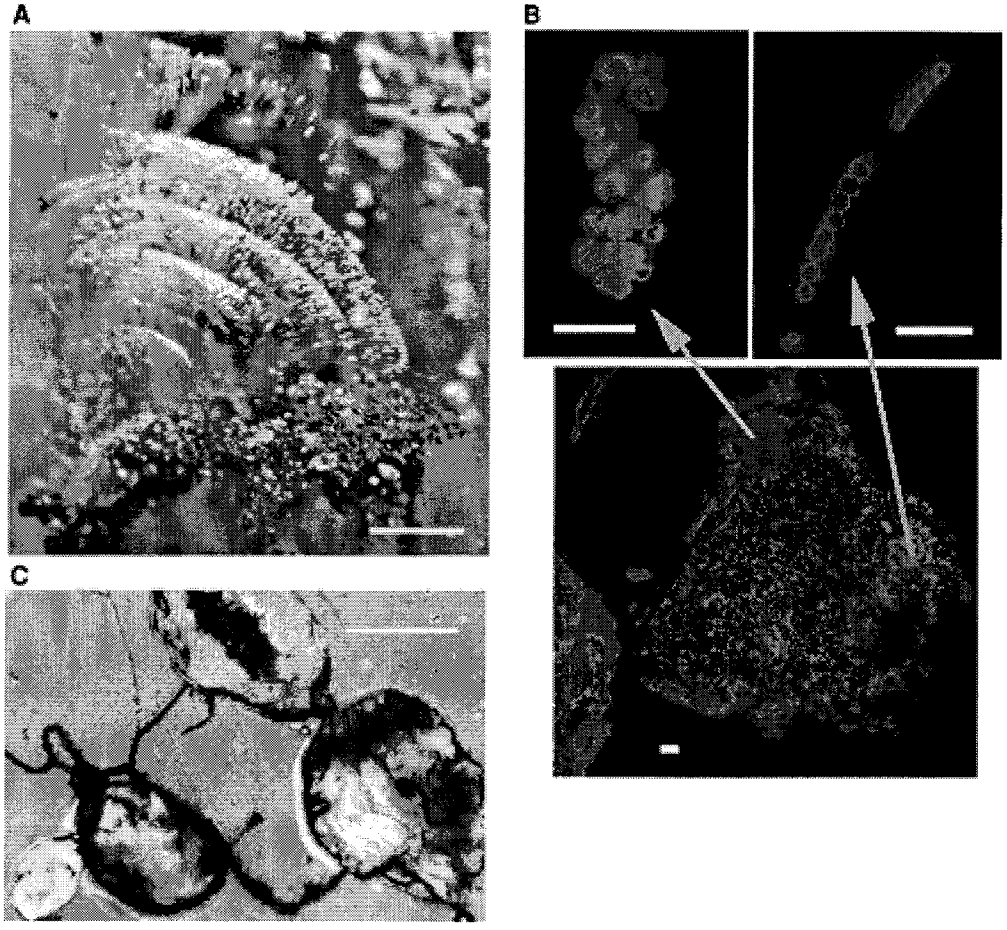
Image Courtesy of Canadian Space Administration

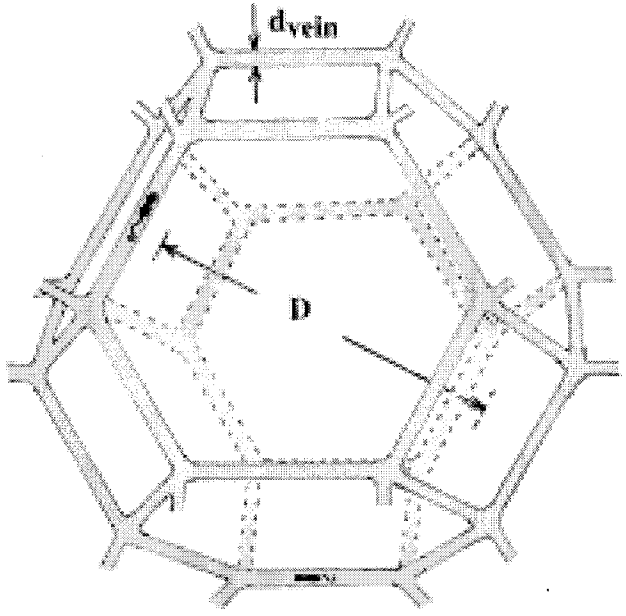
We Can Get a Look Into an Ice Sheet with Radar



Courtesy M. Siegert, U. Bristol

Exploration of Icy sites: Europa, Mars and Earth

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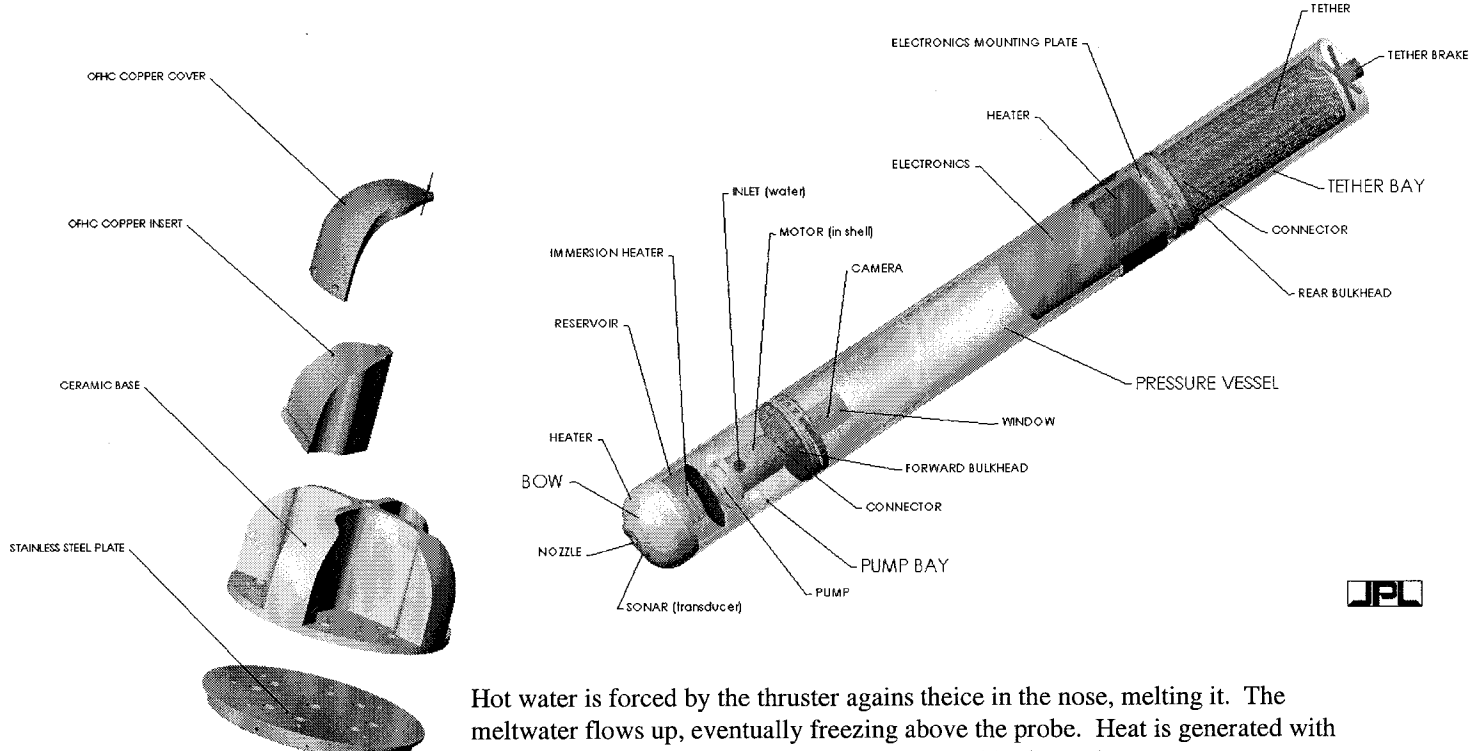
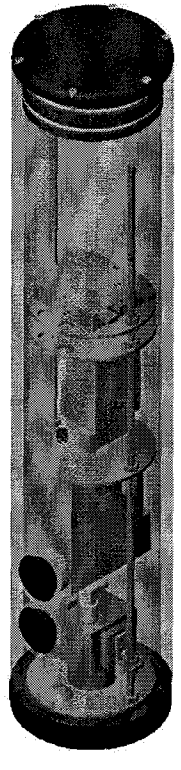
NASA-JPL Cryobot Design



Hot water is forced by the thruster agains theice in the nose, melting it. The meltwater flows up, eventually freezing above the probe. Heat is generated with electricity brought by the cable, which is stored in the probe.

Ice Camera Probe
Caltech-JPL West Antarctic Basal Ice Study



Antarctic Borehole Photography

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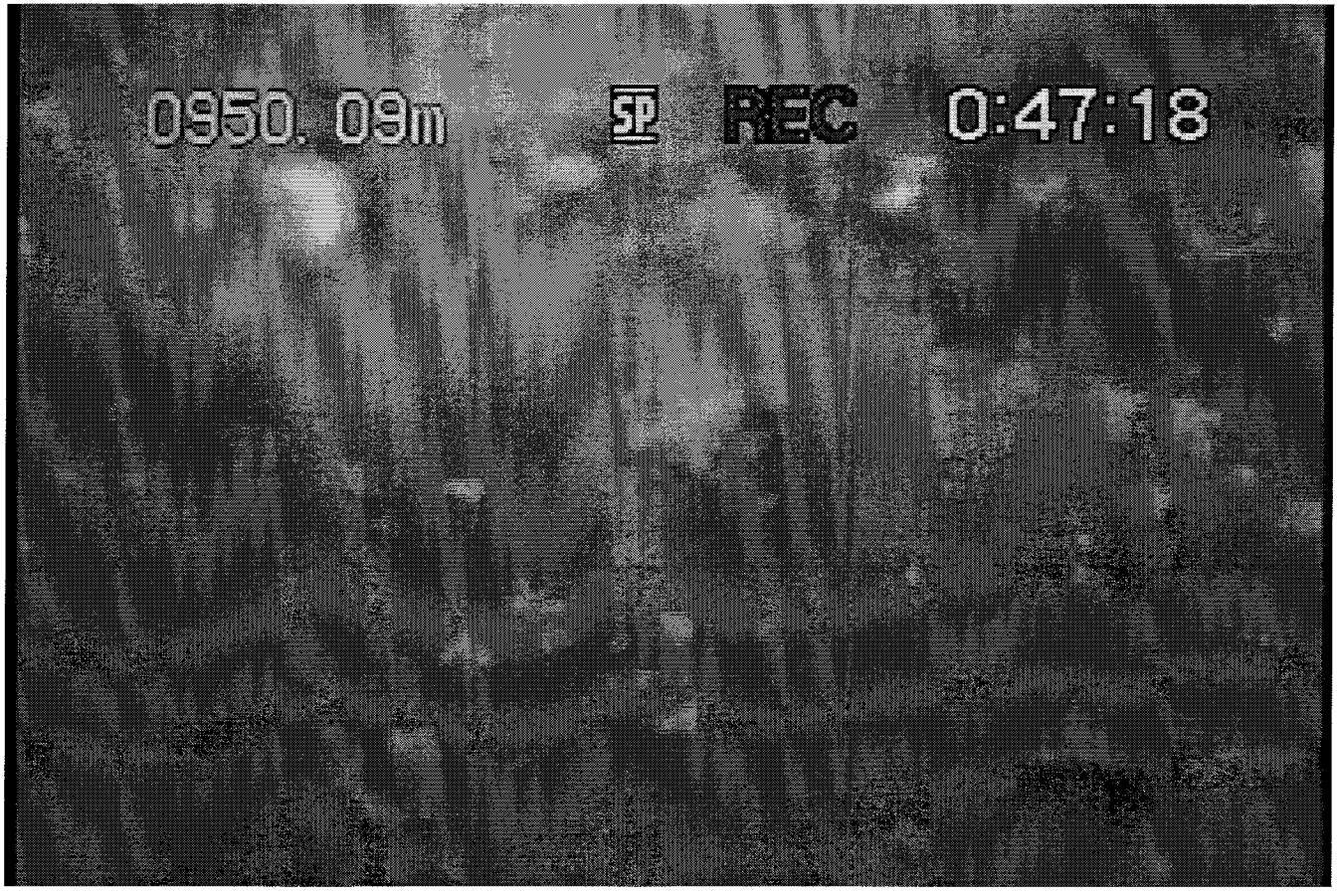
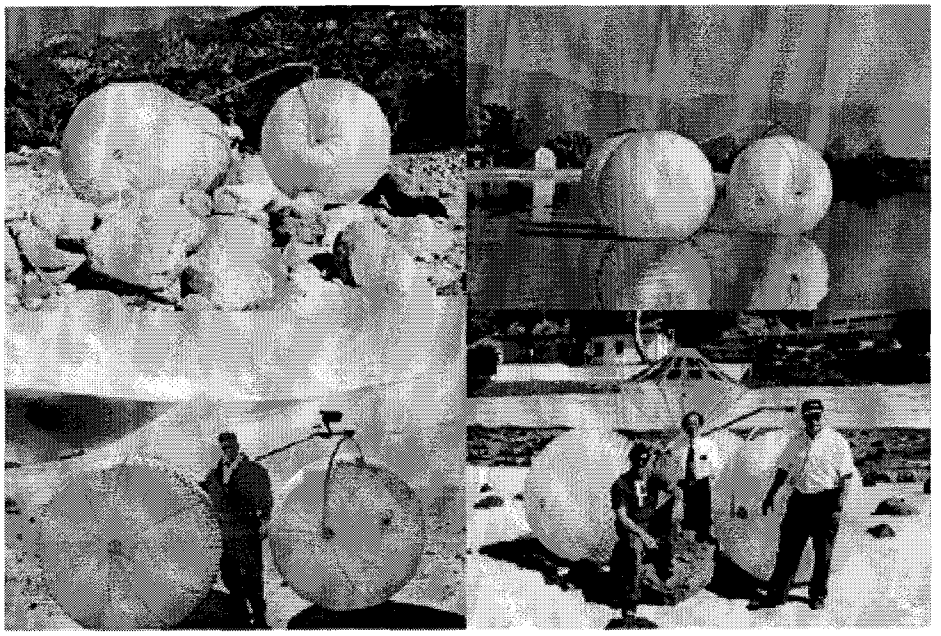


Figure 1 Inflatable Rover Engineering Model
Rover wheels are 1.5 m diameter. The proposed vehicle would probably have smaller wheels for stability in winds. JPL staff shown for scale; all scenes are in California where the trafficability of the rover was examined.



THE INFLATABLE ROVER DRIVES ON ALL TERRAINS

Polar Traverse Rover: Earth, Mars, Europa

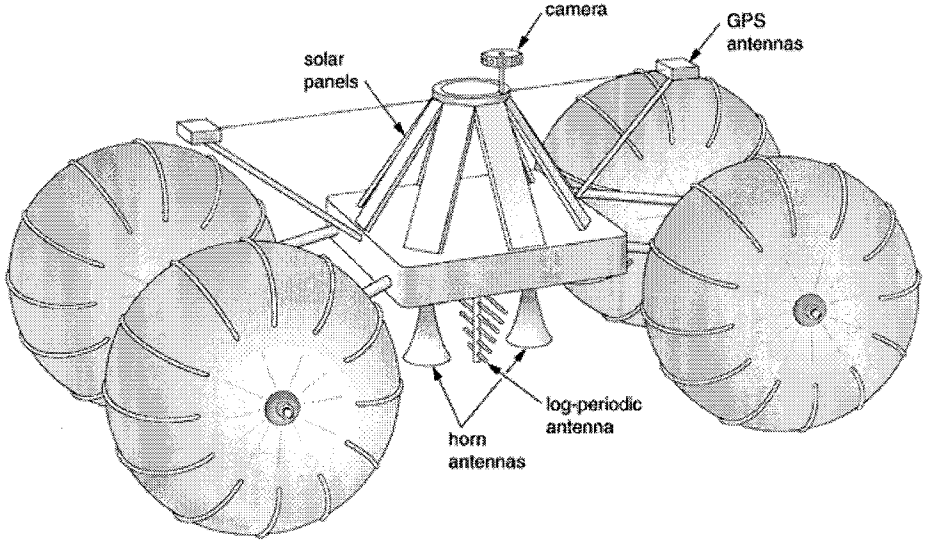
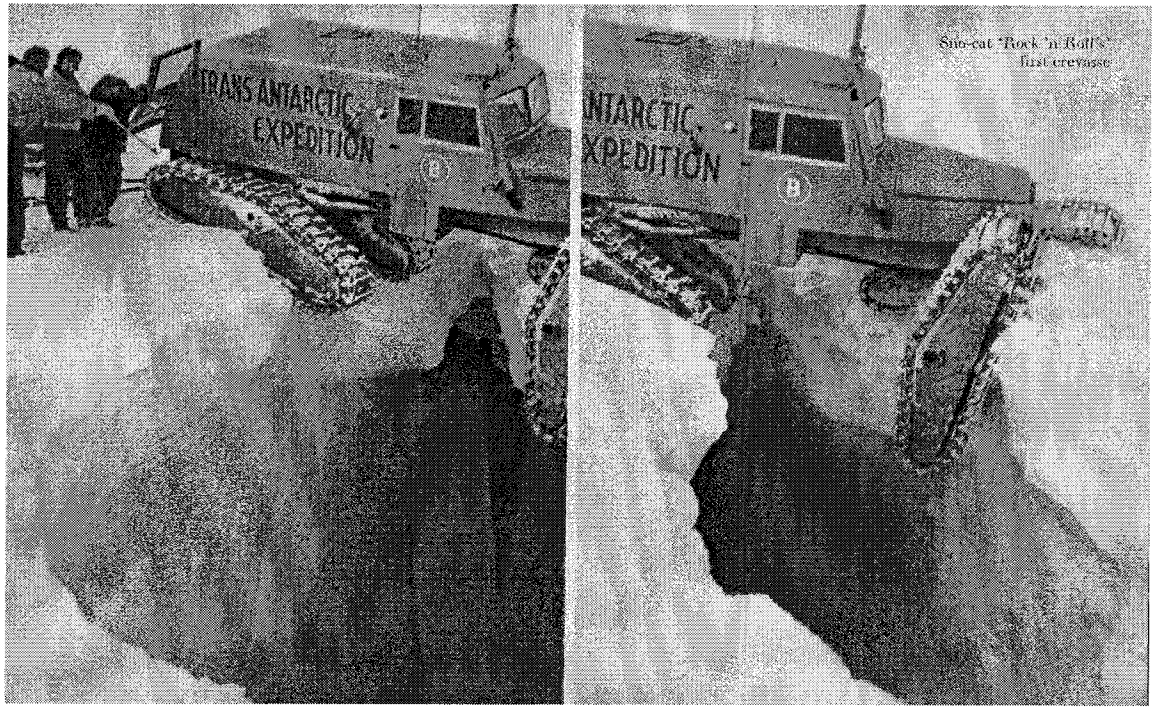


Figure 2. Schematic Diagram of Long-Range Rover.
To accomplish steering, each wheel is independently driven by motors that are not shown. Tire tread details are under study for traction on slopes and to hold against wind. The key electronic and software subsystems are derived directly from rover systems that have flown, such as Sojourner, or will fly in the next 5 years. Solar panel elements may be replaced by cylindrical array of somehwat smaller panels; cost, mass and windage are the issues.



Snowcat breaking show bridge, TAE (Fuchs and Hillary, 1958).

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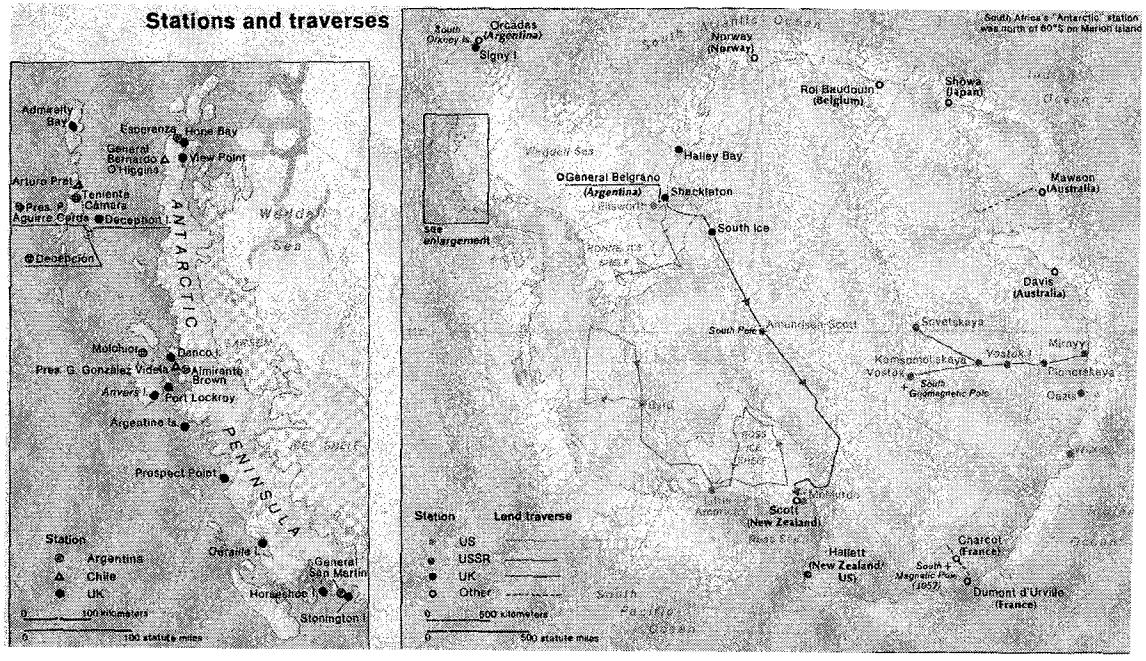

To Summarize

- Large Ice Masses on Europa, Mars and Earth are Interesting Sites That We are Just Beginning to Examine
- Particularly Interesting is the Deep Interior, Down Many Kilometers from the Surface We Can See
- We Are Building Tools to Explore These Sites To Learn About:
  - Earth Climate Processes
  - Planetary History
  - Life on Other Planets
- This Exploration Will Take Time:

Plan To Become Part Of It