Exploration of the Martian Subsurface:

CHALLENGES!! OPPORTUNITIES!!

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California Institute of Technology

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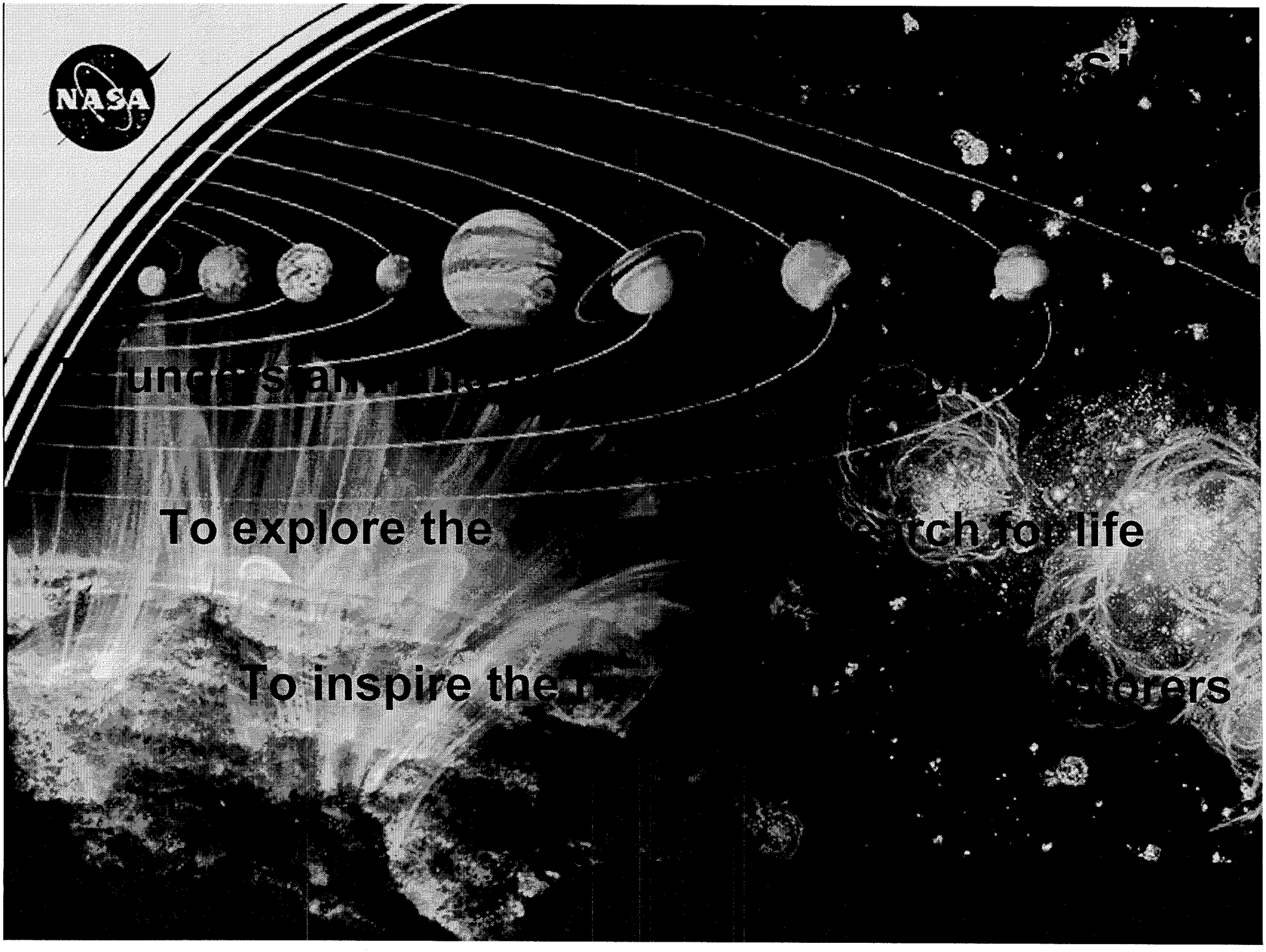
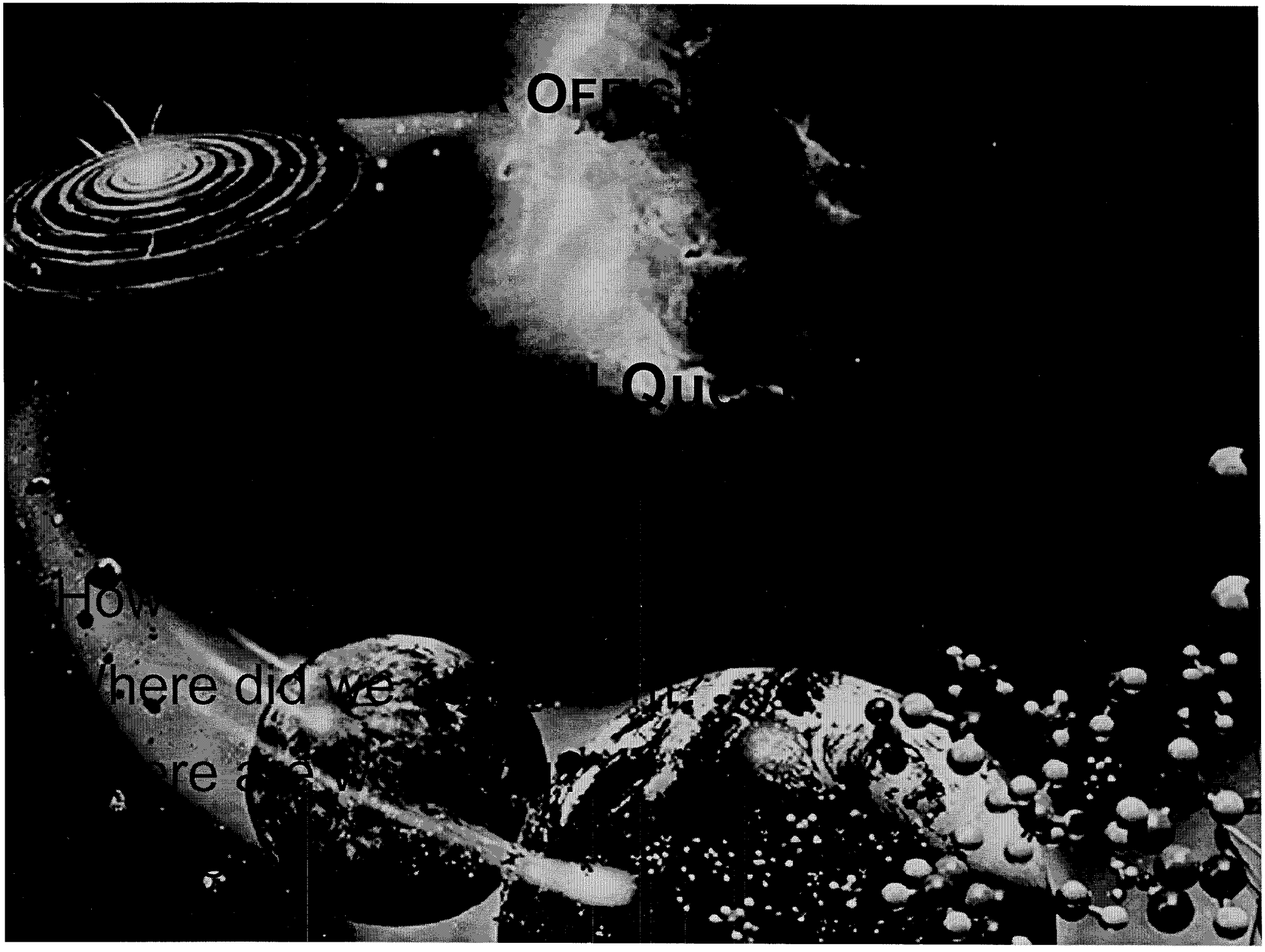
Question #1

Why do we care about the martian subsurface?


To explore the
To inspire the


OF
Qu
How
here did we
re a

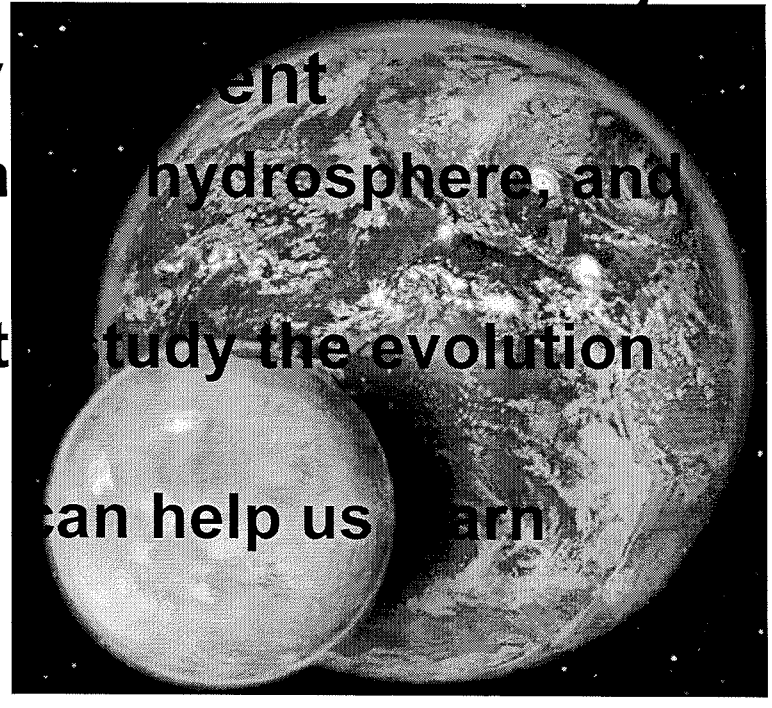
Why Mars?

ITABILITY - first planet for which we can alistically assess it

- Early Mars preserves record of conditions and materials from which LIFE could have started on Mars or on Earth
- There are places on Mars that are "habitable" today

RTH LIKE - yet surprisingly ent

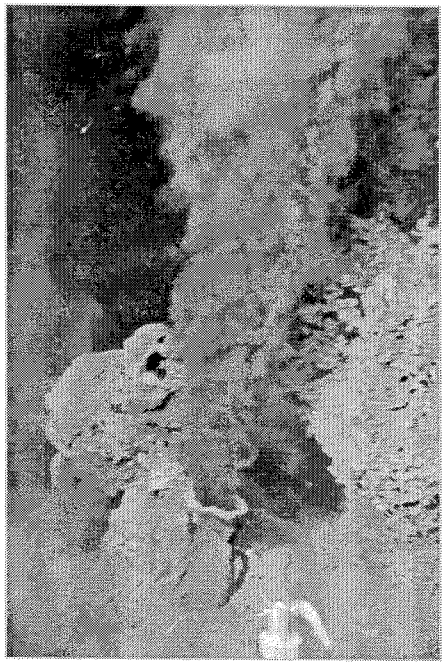
- Rocky planet with an atmosph hydrosphere, and climate
- Natural "control experiment" t tudy the evolution of a planet
- Comparing climate processes can help us arn about Earth

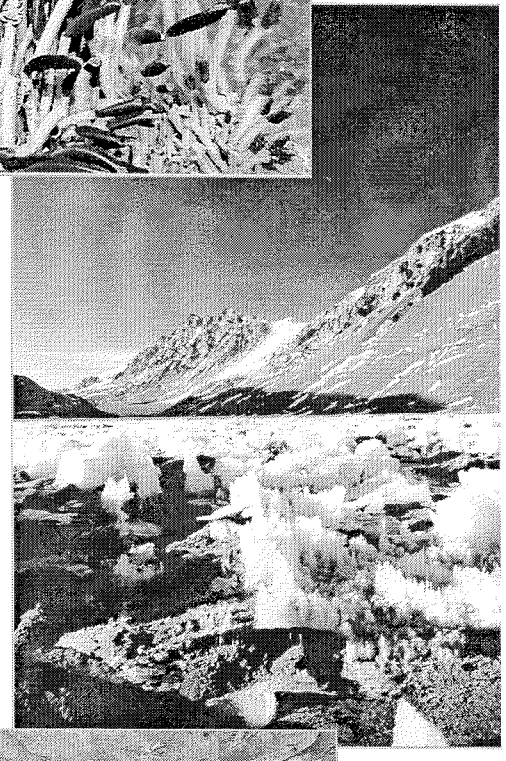


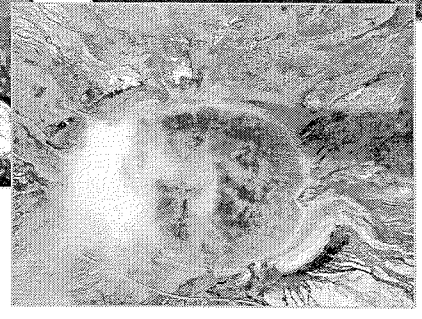
Water: Essential for Life

On Earth, where liquid water, basic nutrients, and energy are present, there is life.

In almost every extreme environment we look, life has found a way to flourish.

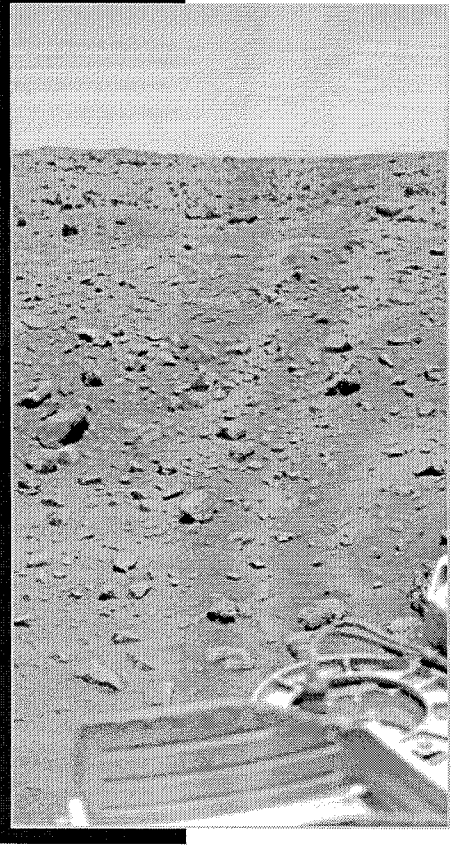


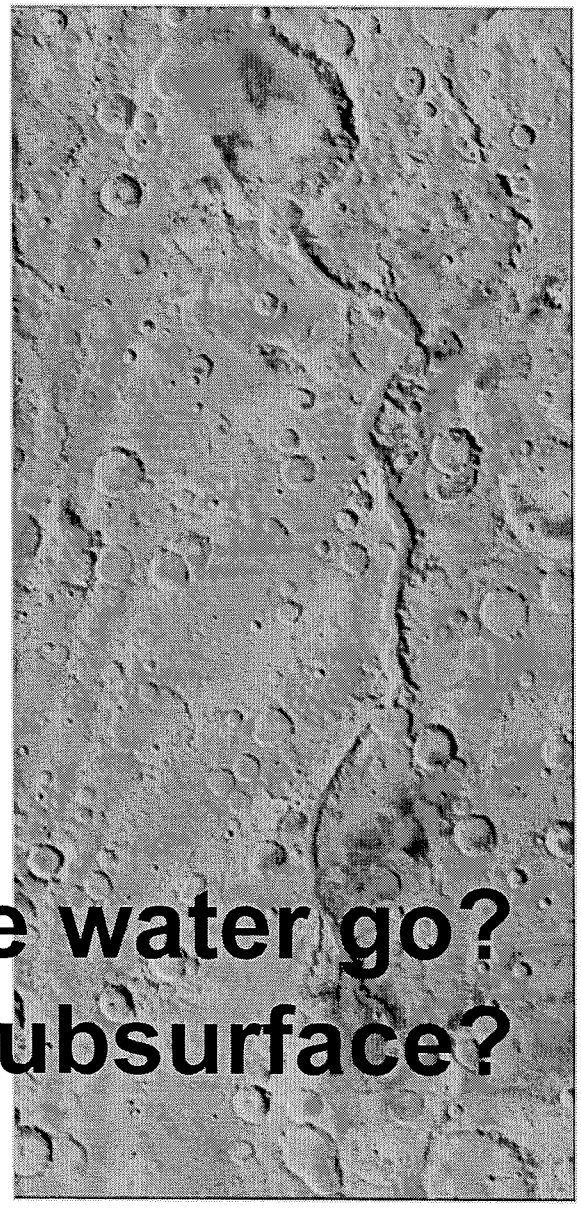




What we have learned about Mars...

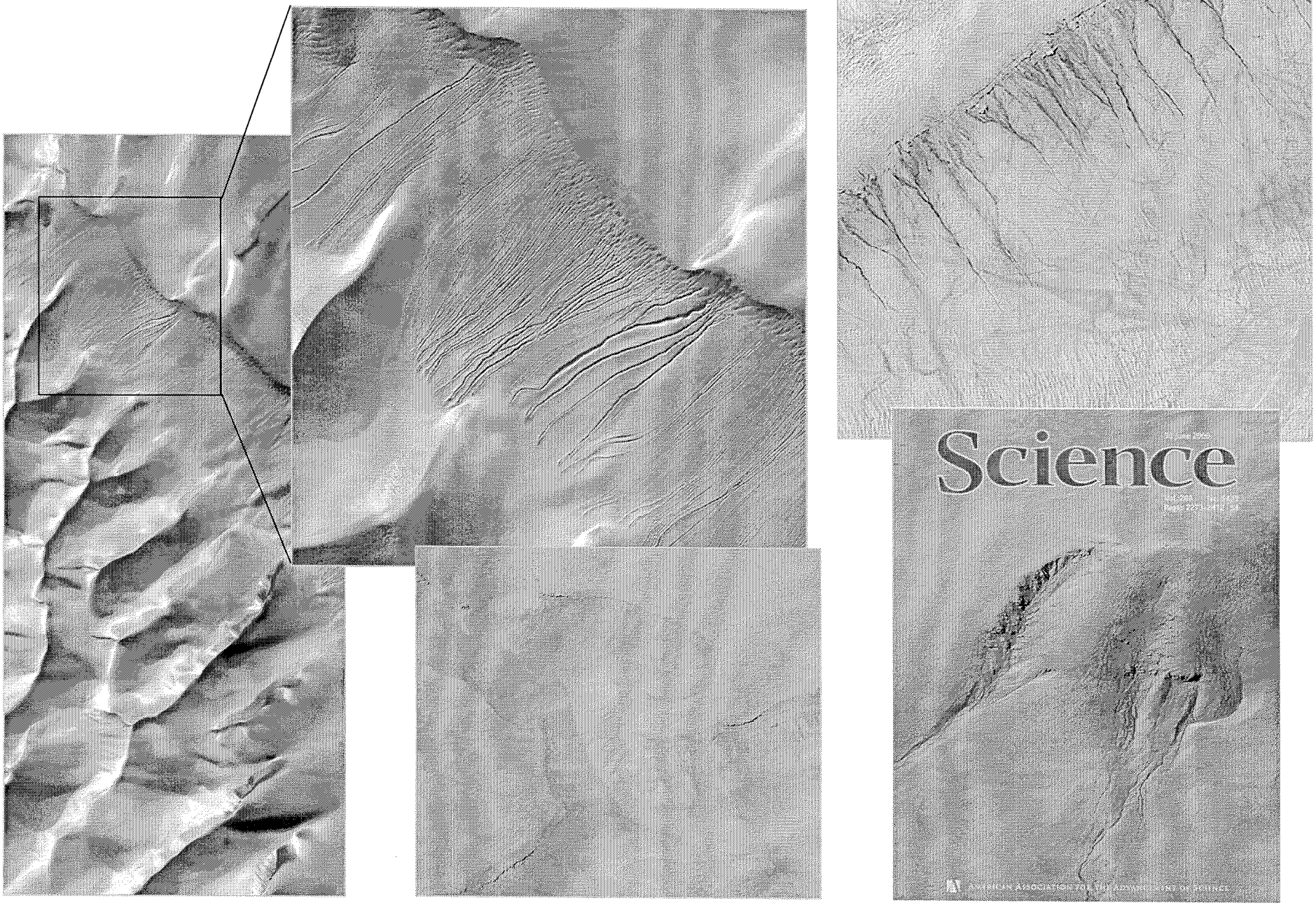
ars is presently a desert planet
h an oxidizing surface.
owever, there is evidence that
rs may have had abundant
rface water in the past.



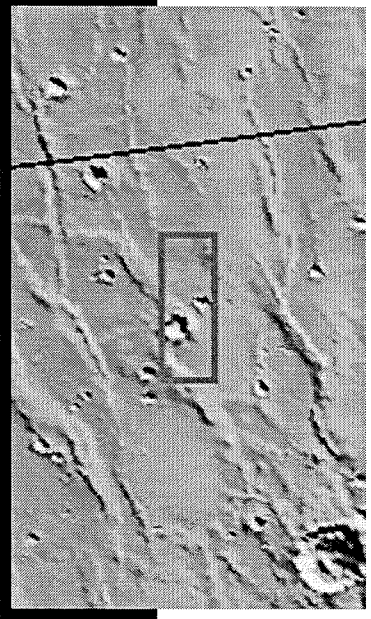


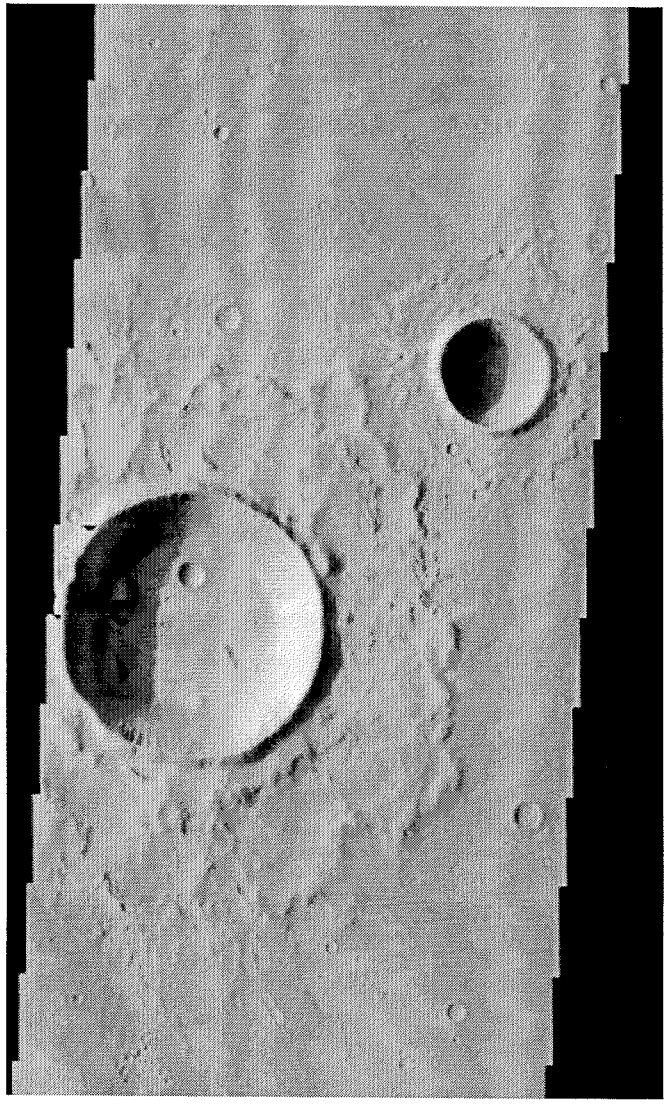
Where did the water go?
Into the subsurface?

Mystery of Martian Gullies



Volatiles in the Martian Subsurface



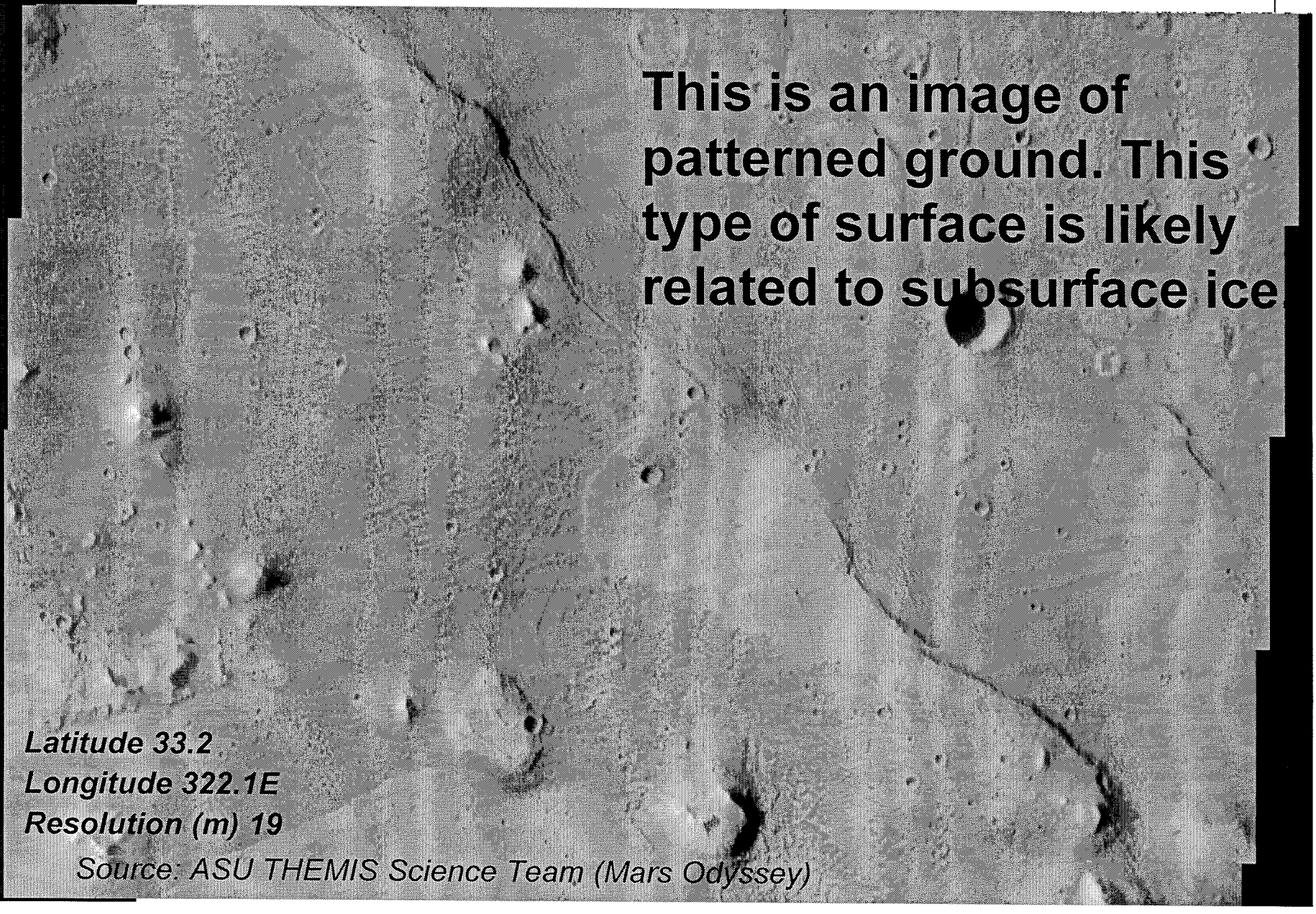


e 13.9
de 297.3E
ion (m) 19
Size (km)
5x23.4

rce: ASU THEMIS Science Team (Mars Odyssey)

The fluidized impact crater ejecta and flat crater floors suggest near surface volatiles played an important role in modifying the martian surface.

Volatiles in the Martian Subsurface

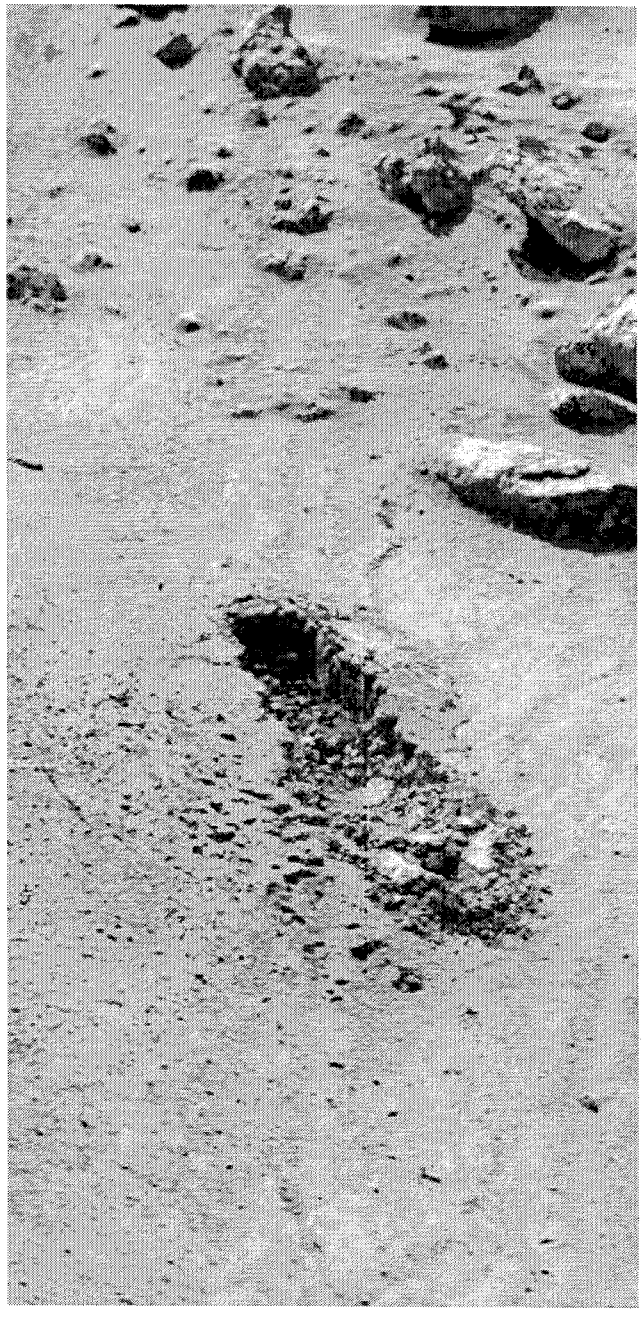


Answer #1

If life formed on Mars in the past, it may have followed the water into the subsurface.

Question #2

What is our exploration of the martian subsurface to date?



Our only penetration of the martian subsurface

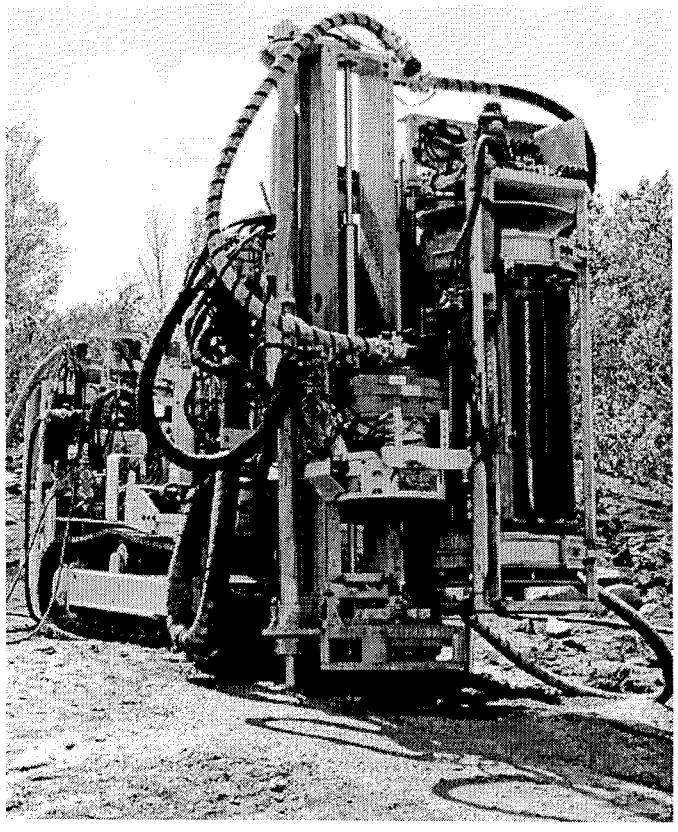
Trench excavated by Viking 1 lander surface sampler

Question #3

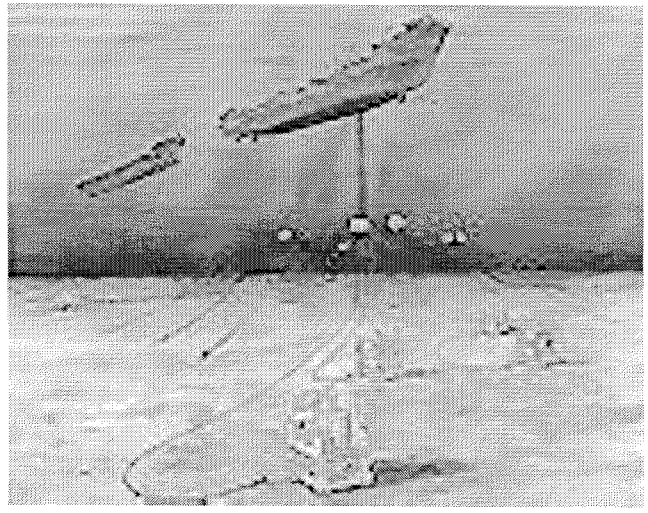
Can we design and build a robotic drill which will work on Mars?

Remote drilling technology on Earth

e have been important recent developments in drilling and autonomous drilling.



40 m autonomous drill, Sudbury, Ontario



Ocean bottom drilling, North Sea, controlled from Houston

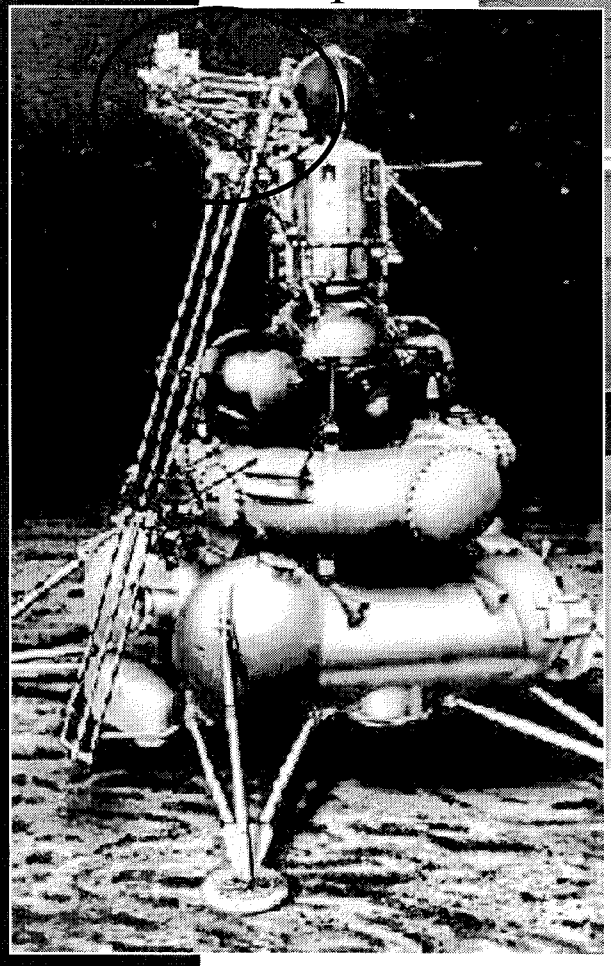
Drilling on Mars: Challenge

lling on Mars will present the following pecial challenges:

- **rill will need to be low mass, low power, low olume**
- **o viable circulation fluid**
- **urface material poorly characterized (wildcat to d all wildcats)**
- **ommunication delay up to 20 minutes one way**
- **nvironmental challenges:**
  - Dust storms
  - Shaking from launch and landing
  - Low temperature

Russian Luna Drill

owed position



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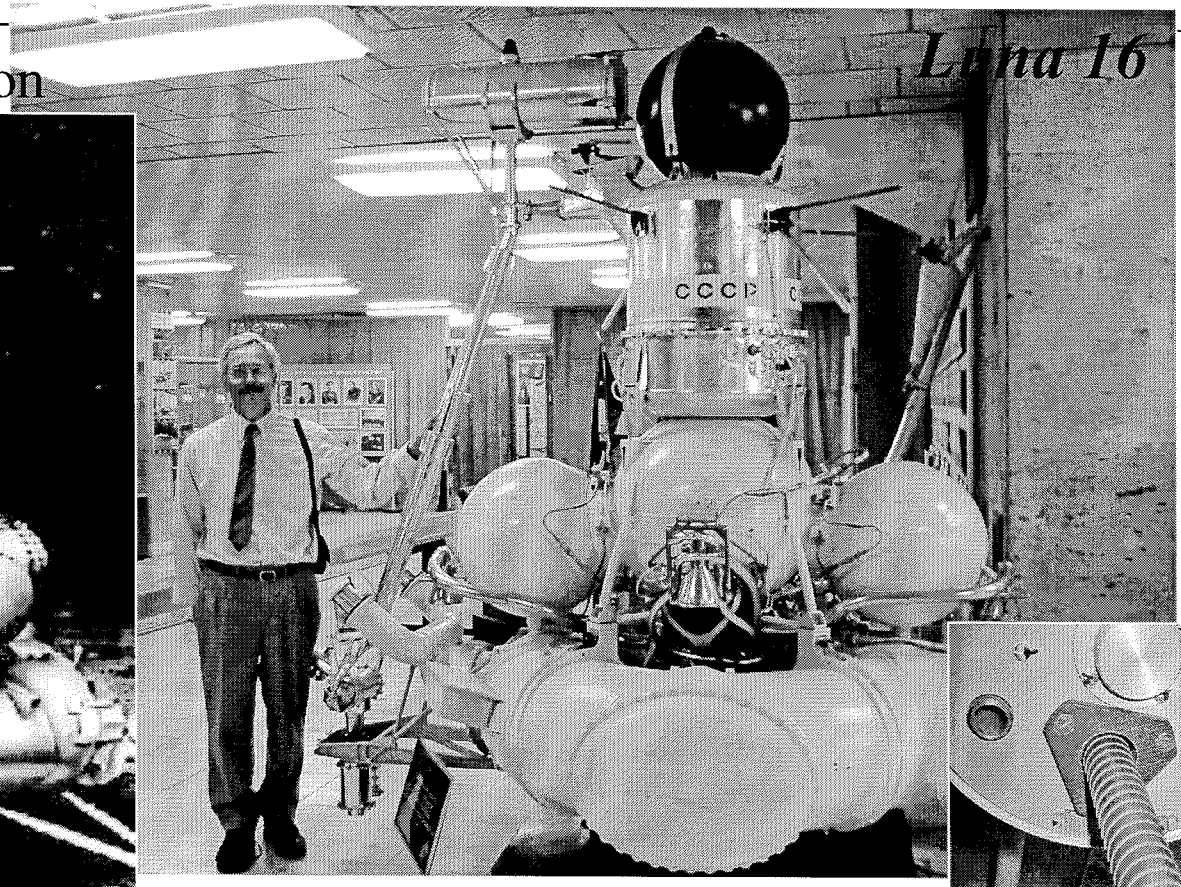
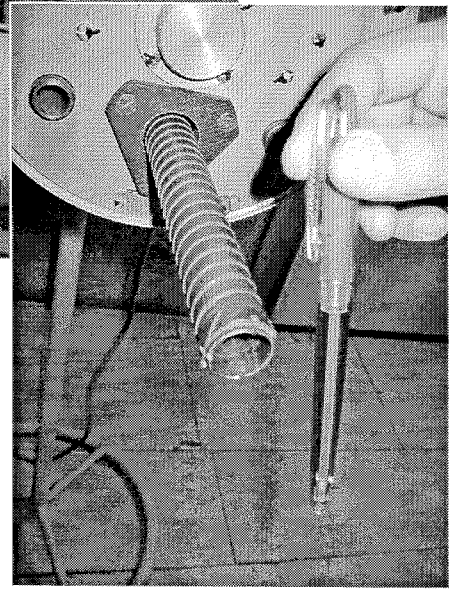


Luna 16



- Successfully drilled to 2 m on Moon in 1976

Recent Drill Technology Development

Several funding sources for drill development.

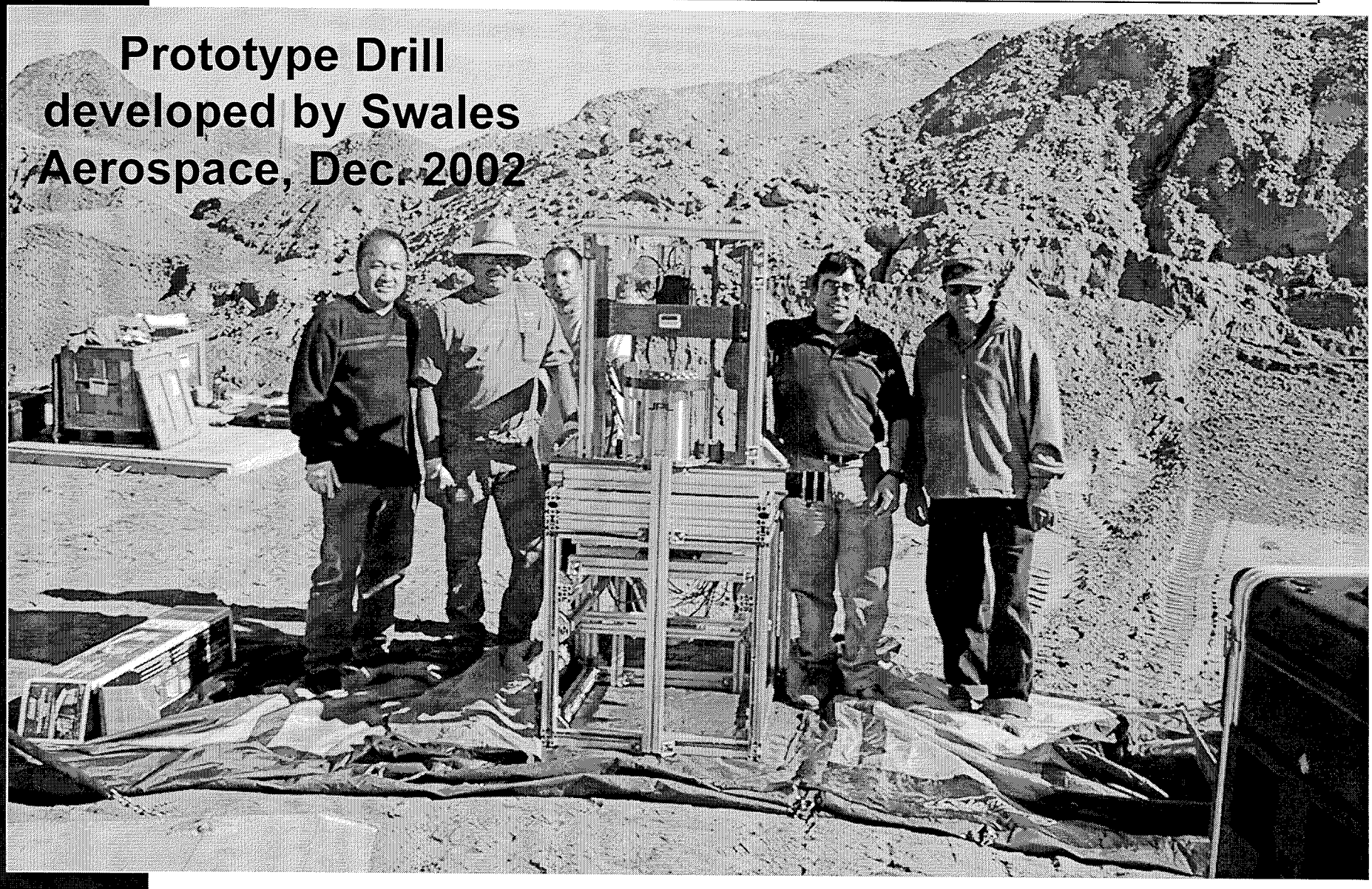
- NASA
- Other space agencies
- Private industry
- Other

Current goals of Mars Office:

- Achieve prototype which can drill to 10 meters, with appropriate resource constraints

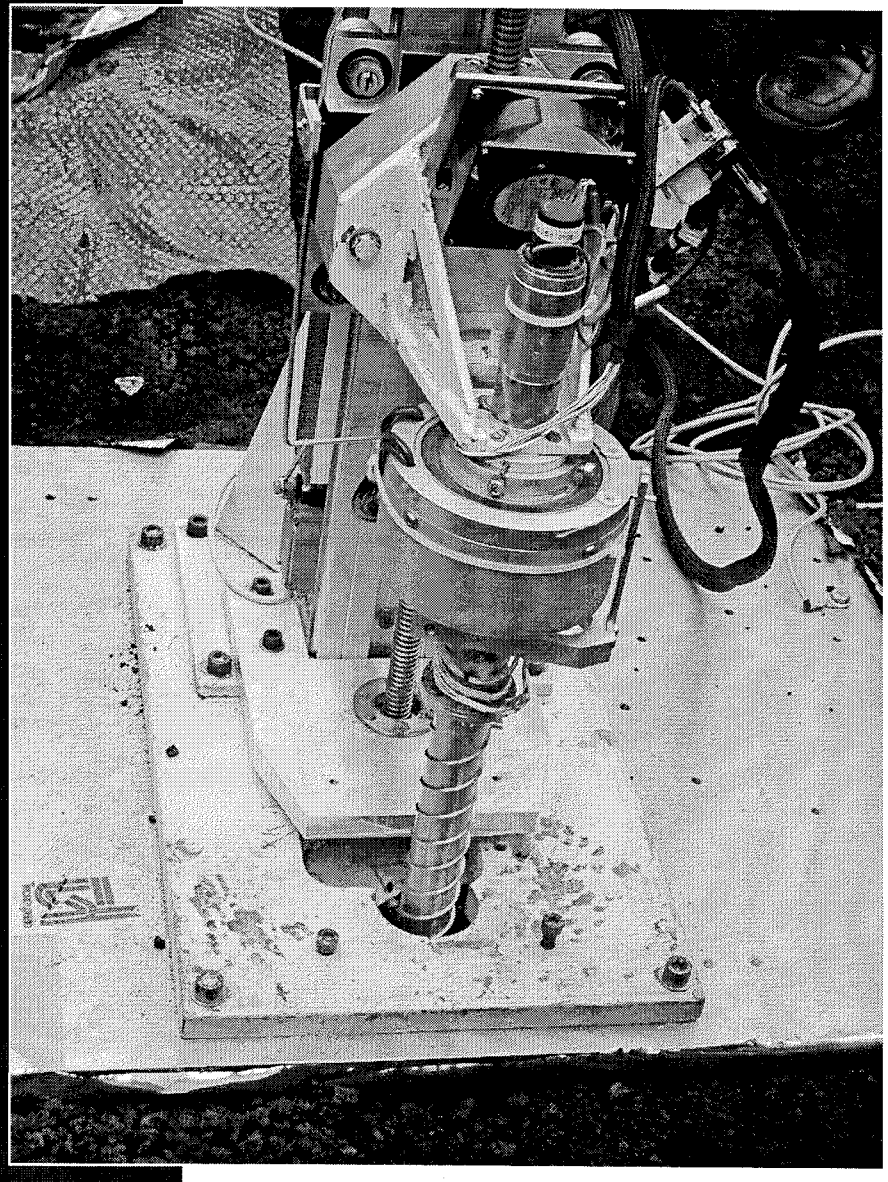
Significant progress has been made - Much more work to be done

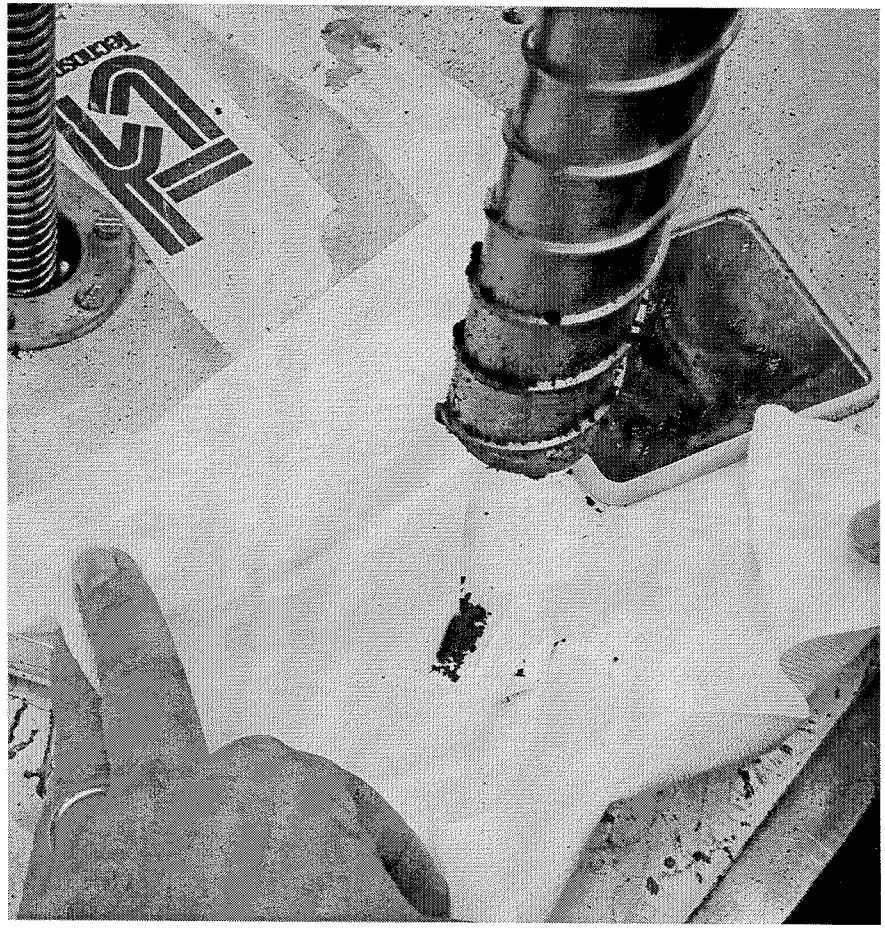
Example Drill



Example Drill

Example Drill



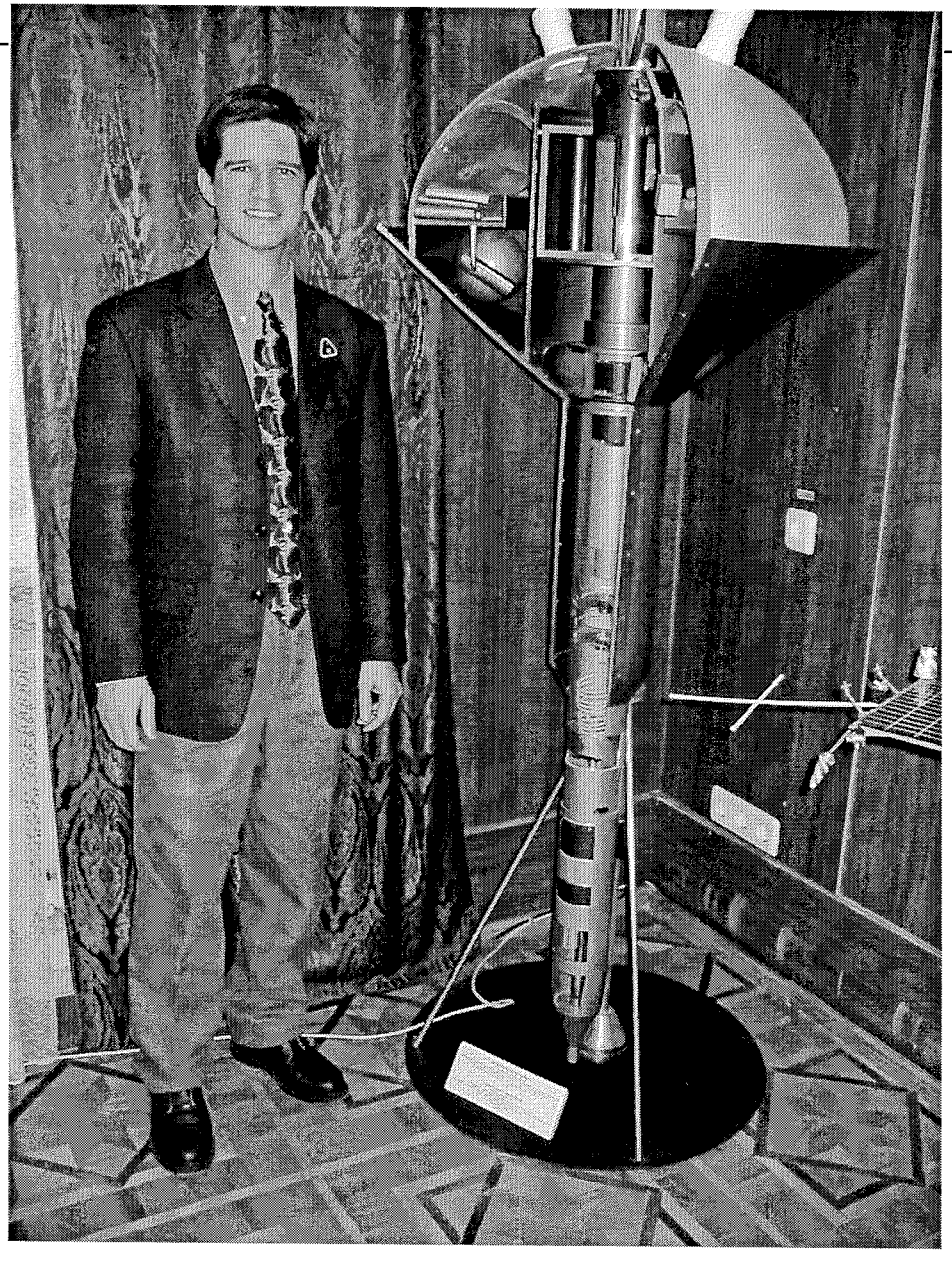


Italian Drill, Sept. 2002 (Mt. Etna field demo)

Other Hardware

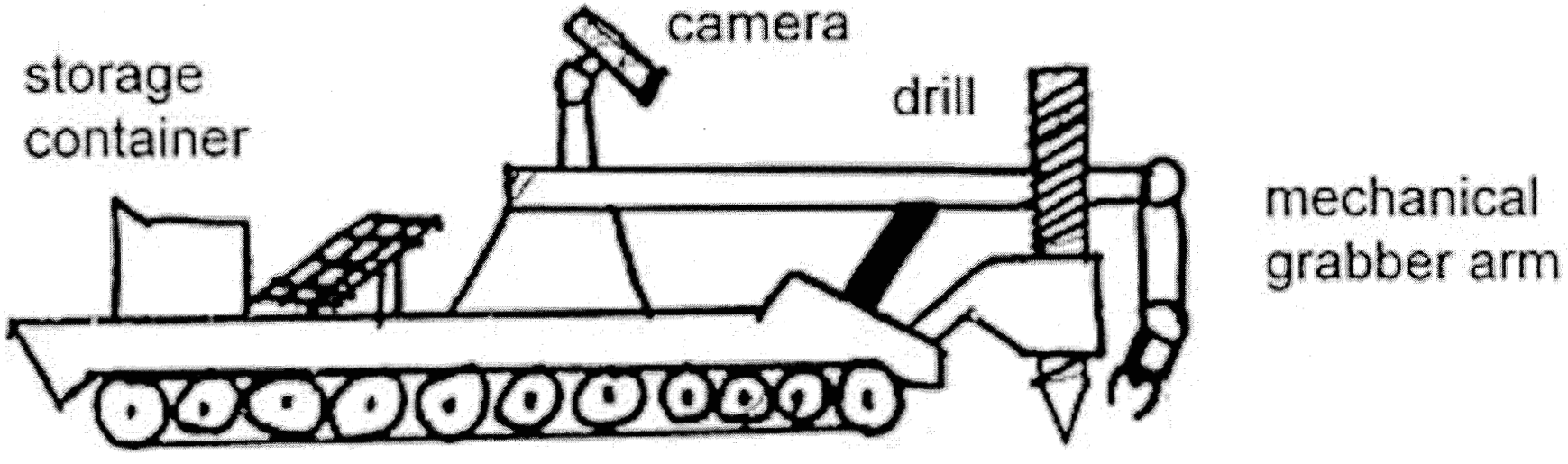
German mole, Sept. 2002, (Mt. Etna field demo)

Other Hardware



Russian Penetrator, June 2002

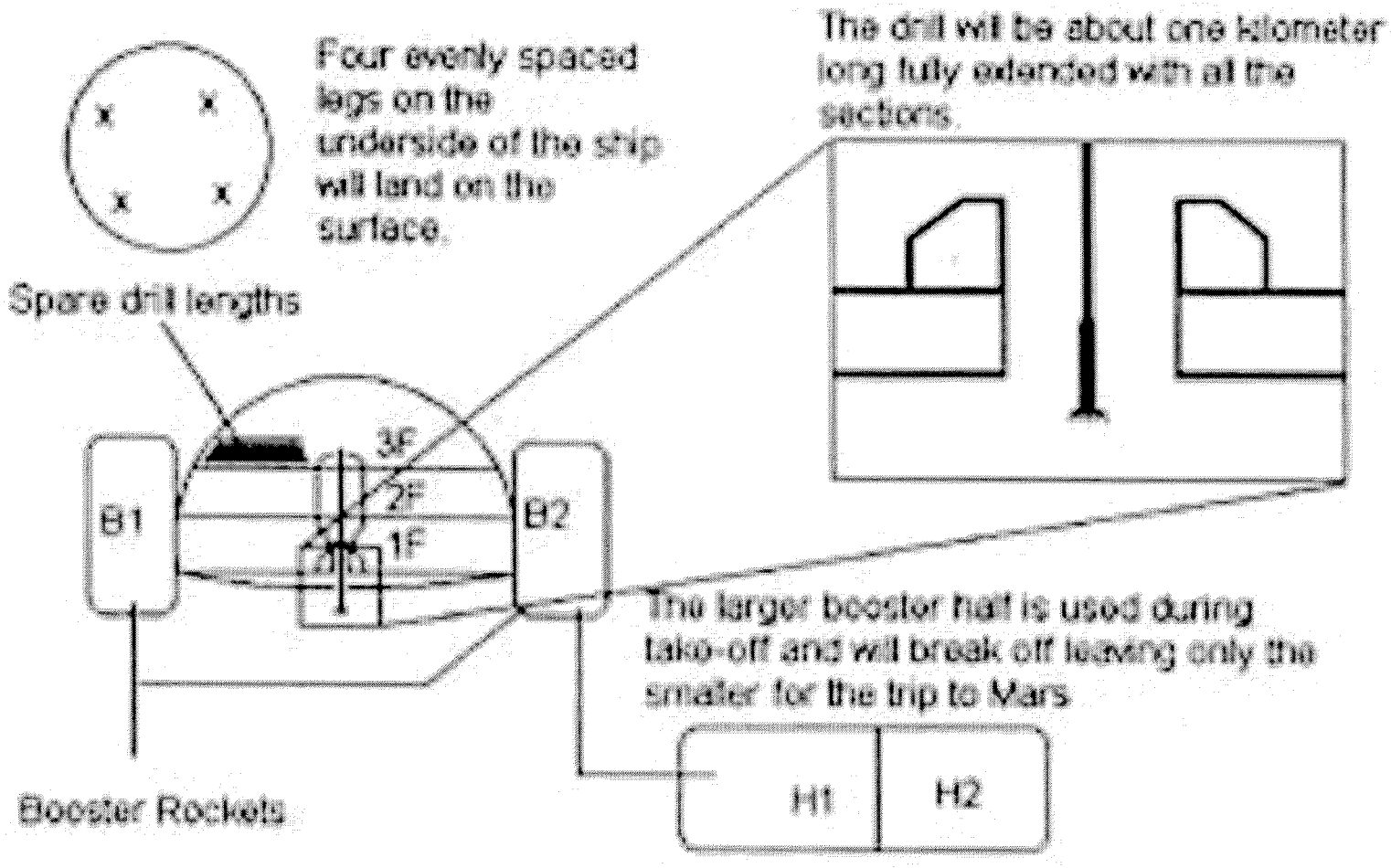
Mars Drilling—children's perspective



From Justin et al., Desert Canyon Middle School, Scottsdale , AZ

Source: Design a mission to Mars competition, 2001

Mars Drilling—children's perspective



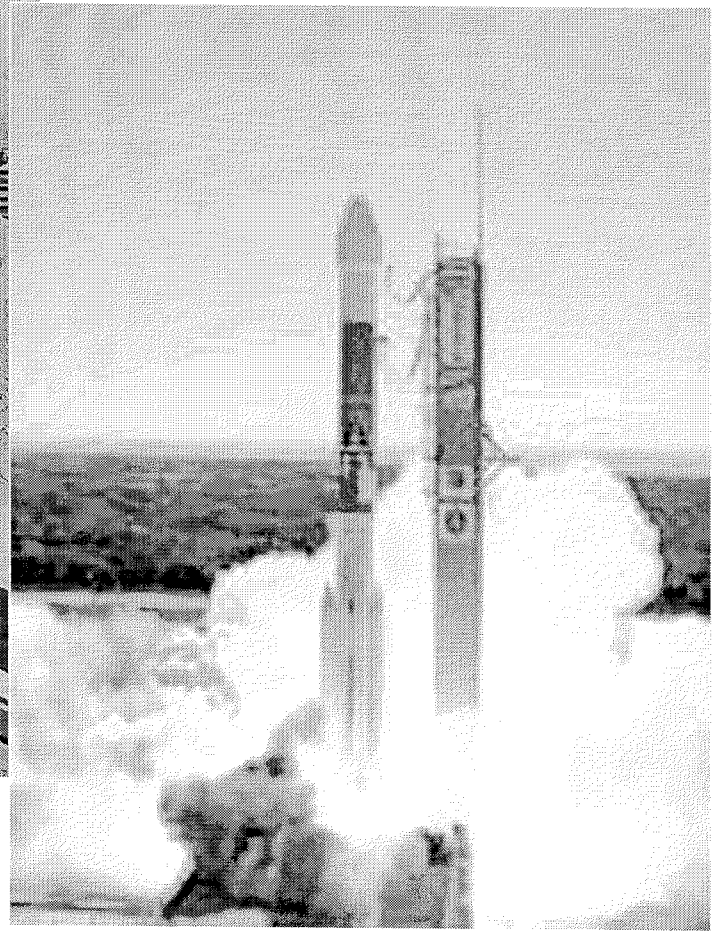
From: Chris, Brian and Andrew; Fox Creek Jr. High, Bullhead City , AZ

Source: Design a mission to Mars competition, 2001

The Drill Delivery System

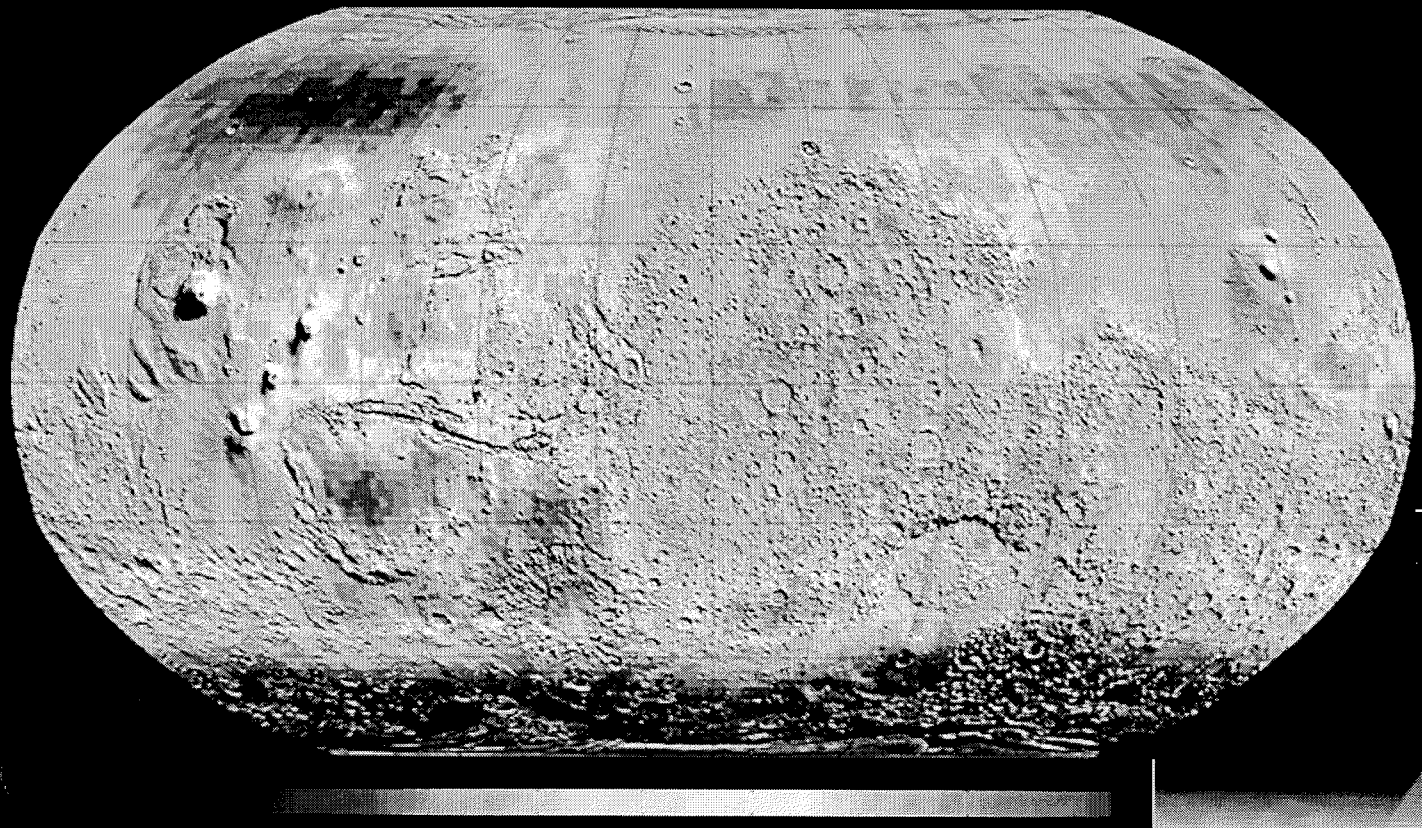
Delivery System #1

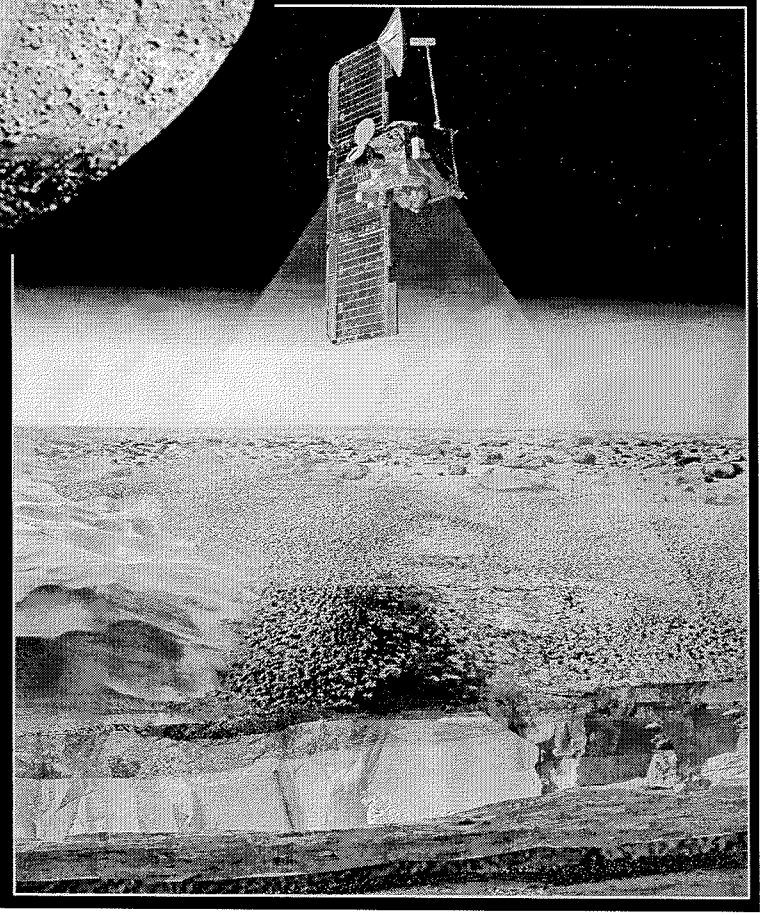
Delivery System #2



Question #4

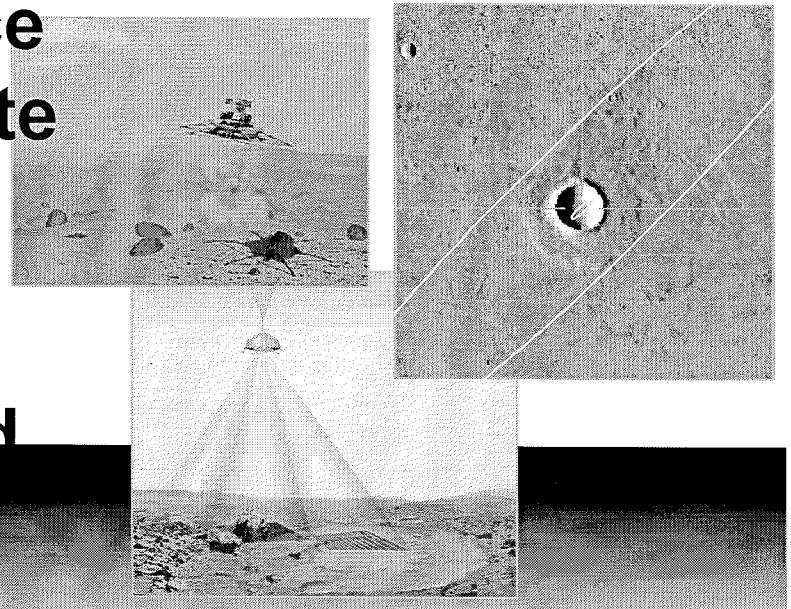
Where is the geophysics to tell us where to drill?

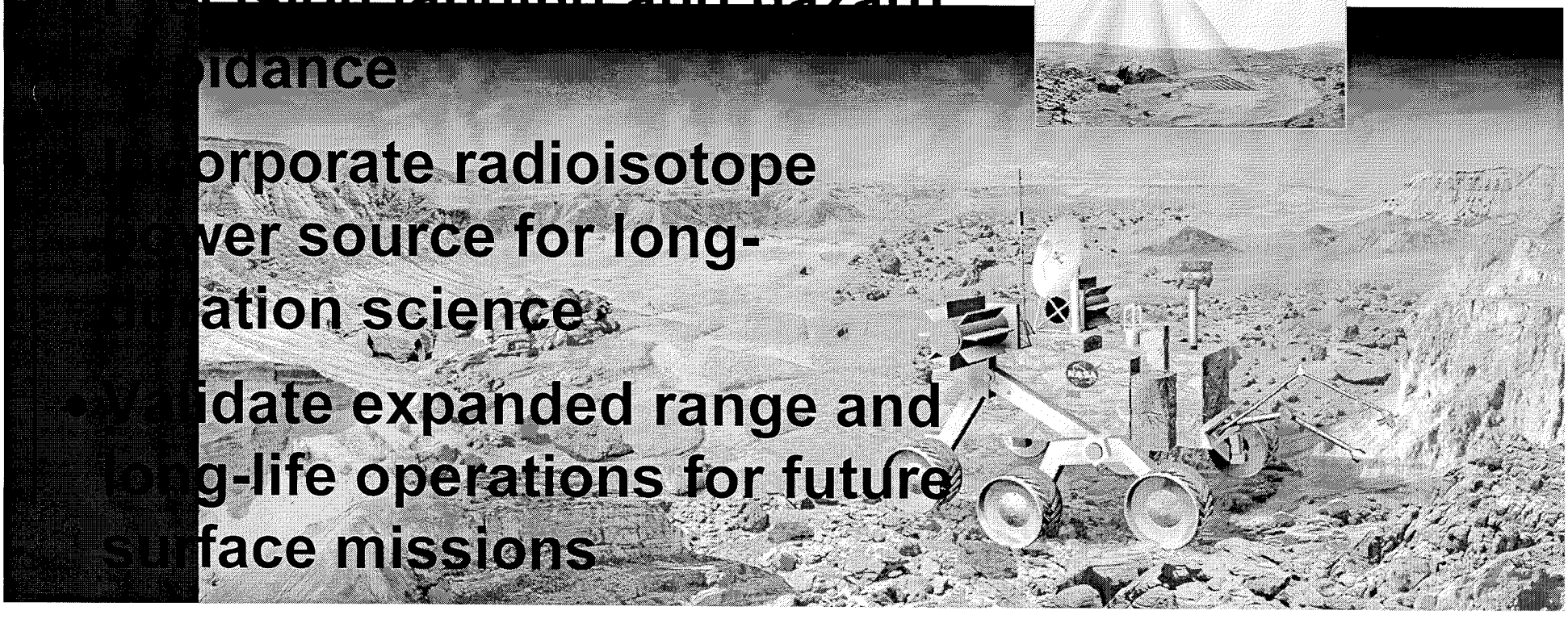




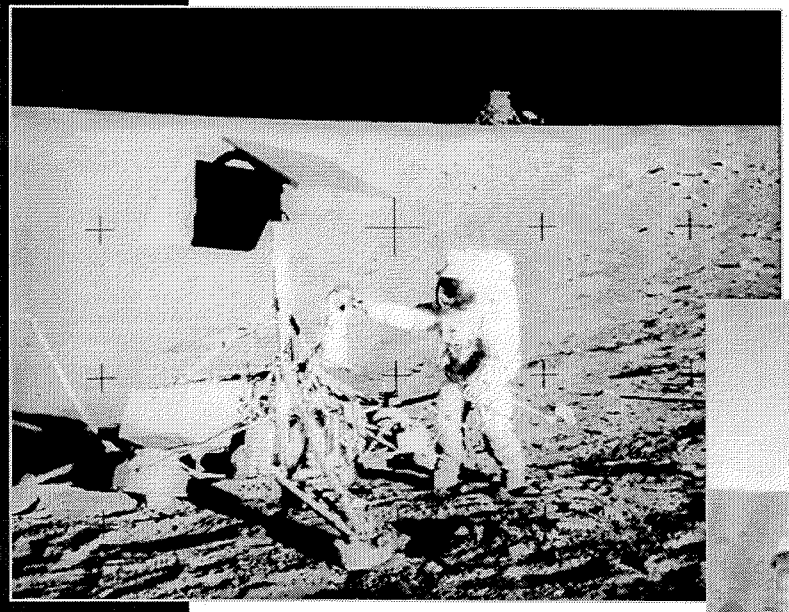
2009 Mars Science Laboratory

- te of the art in-situ science
- l life inference sensor suite
- Remote, Contact,
- nalytical
- ecision landing and hazard
- oidance
- orporate radioisotope
- wer source for long-
- ation science
- idate expanded range and
- g-life operations for future
- rface missions

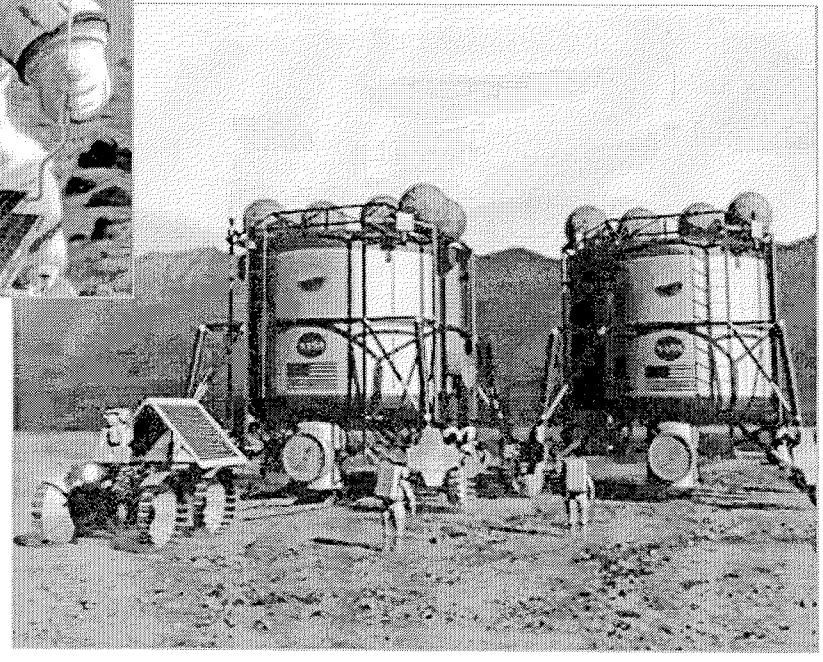




Future Mars Exploration: Human Exploration and Science



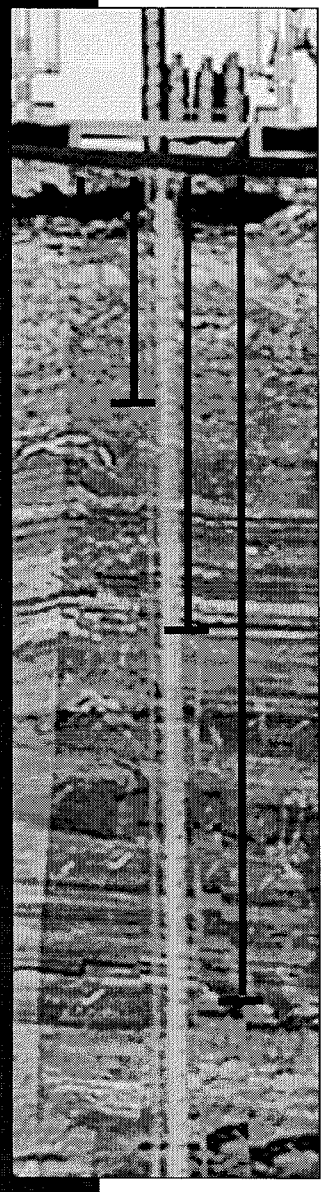
Just as with the exploration of the moon where we first sent robots…



Some day humans will get to explore, study, and experience the Red Planet

Backups

Subsurface Scientific Objectives



Surficial processes: min., petrology, physical props. (density, perm.), weathering/erosion processes, impact gardening, gradient in surficial oxidant, EM

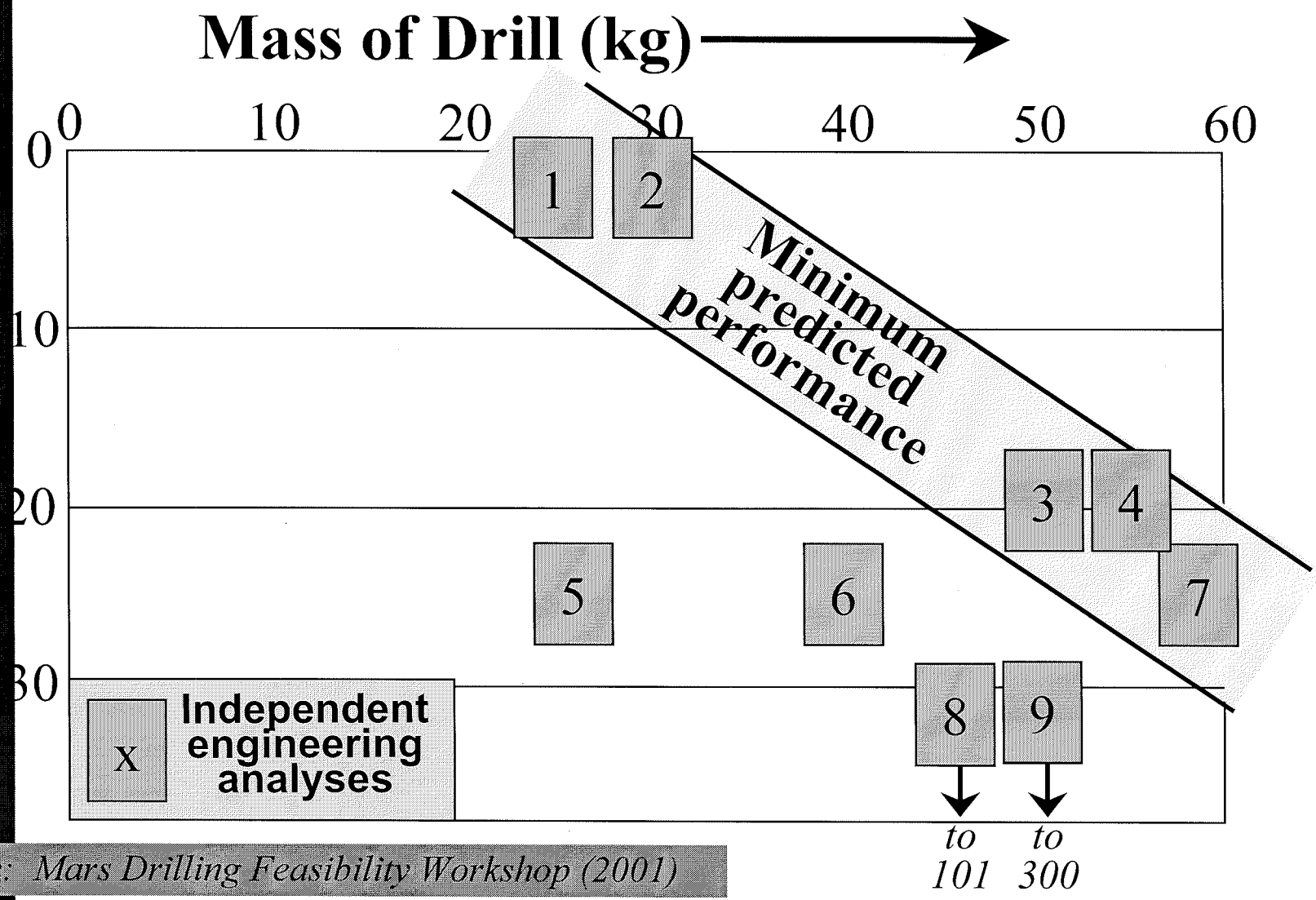
Pre-weathering processes
- sedimentation processes, stratigraphy
- past environments, history of volatiles
- Geophysics: Heat flow, thermal state, seismic, EM

- Organic geochem below oxidized zone
- presence of ice?

- Sample permafrost or massive, segregated ground ice, volatile hydrates
- Bedrock: Rock-forming processes

Source: Clifford, Bianchi, De Sanctis, Duke, Kim, Mancinelli, Ming, Passey, Smrekar, and Beaty (2001)

Analysis of <60 kg Drills



Source: Mars Drilling Feasibility Workshop (2001)