Center for In Situ Exploration and Sample Return

Environmental Challenges for Next Generation Exploration Missions

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Environmental Challenges

Challenges and Objectives

- What are the missions that provide these challenges?
- What are the expected environments?
- The challenge is to successfully take scientific measurements in there environments
  - Initially for a few weeks
  - Converting to "continuous presence"
  - Where should we test or before deploying landers?
Environmental Challenges

• Flyby and Orbiter missions must be designed for vacuum and solar/planetary radiation

• But, new In Situ or Sample Return missions face a different challenge with each destination

• Many different environments:
  – Some Extreme . . .
  – All variable - weather . .
  – Plus the issues of getting in and out of planetary gravity wells
Environmental Challenges

Planetary Extremes

Pressure, bars

Temperature, °C

Saturn
Deep Ocean Hydrothermal Vents
Venus
Nuclear Reactor
Volcanoes
Mercury
Io
Mars
Comets
Moon
Europa
Titan
Jupiter
Environmental Challenges
Planetary Extremes

Radiation

Saturn
Titan
Europa
Jupiter
Mars
Comets
Moon
Earth

Deep Ocean Hydrothermal Vents

Temperature, C

-300 -250 -200 -150 -100 -50 50 100 150 200 250 300 350 400 450 500

Venus
Mercury
Volcanoes

Nuclear Reactor

Io
Environmental Challenges
What will we measure?

- Integrate emerging technologies

- Micro-capillary electrophoresis
  chiral analysis
Environmental Challenges
The Astrobiology Connection

Need coordinated suites of micro-laboratories to characterize solar system bodies and enable the search for life beyond earth

Looking for life

STRUCTURE
Unexpected shapes or organization

CHEMISTRY
Complex molecules
High-energy molecules
Elemental or isotopic excess
Association of chemistry with structure

APPROACH
Develop analytical tools to solve biological, chemical and geological questions

Conduct tiered exploration in atmospheres, lithospheres, hydrospheres

- Move from broad to specific
- Low resolution to high resolution
- Non invasive to successively more invasive
Environmental Challenges
In Situ Geochronology Instrument

Scientific Goals of Instrument
1. Preselect samples for return from the surface of Mars
2. Calibrate Martian cratering record
3. Elucidate history of volcanism and Mars surface processes
4. Element ratios required to 6% or better; isotopic ratios to 0.1%

Measurements Made by Instrument
1. For at least two minerals in a rock, the isotopic ratio of $^{87}\text{Sr}$ to $^{86}\text{Sr}$
2. For the same two (or more) minerals, the ratio of Rb to Sr

Instrument Description
1. Laser ablation sampling of rock sample surface
2. Selective ionization of Rb and Sr
3. Measurement of ion beam in sector-type miniature mass spectrometer

Development Status
1. Experiments to optimize laser ablation parameters in progress
2. Experiments in progress to develop Rb-Sr selective ionization techniques suitable for in situ instrument
3. JPL effort to develop in situ ablation laser suitable for instrument deployment

Ready for Flight Development in 2003
Profile
Mass: 4 kg  Power: 0.5 W  Volume: 2000 cm$^3$
Environmental Challenges

Miniature Iron-Nuclear Magnetic Resonance ($^{57}$Fe-NMR) Spectrometer

Scientific Goals of Instrument
1. Characterization of magnetic phase minerals in Martian soil, rock samples

Measurements Made by Instrument
1. Detection of Hematite, Magnetite from soil, mineral samples
2. Sensitivity 0.1 wt%

Instrument Description
1. Detection of magnetic phase minerals through interaction of iron nuclear spins with unique internal magnetic field of sample
2. Consists of a radio frequency coil, continuous wave NMR circuit (marginal oscillator), digital signal processing circuit
3. Sample size: 1-2 cc

Development Status
1. Field tested in Lavic Lake, Mojave Desert with Rocky-7 in May 1997

Ready for Flight Development? ☒ now ☒ '03 ☐ '05 ☐ >'07

Profile
- Mass: 60 gm
- Power: 0.25 W
- Volume: 60 cm$^3$
Environmental Challenges
Learning to Study in Extreme Environments

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Environmental Challenges

Summary

• New technologies will be key to success just as they were in the past for remote sensing missions

• We need to leverage others investments to make these new missions affordable

• This is as big a step as going into space was 30 years ago ......
Acknowledgement

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