Abstract, Mars surface environmental issues (Jones AsMA 2002 panel, scheduled for Wednesday, May 8 2002 2:12PM.)

Introduction: Planetary exploration by astronauts will require extended periods of habitation on a planet’s surface, under the influence of environmental factors that are different from those of Earth and the spacecraft that delivered the crew to the planet. Human exploration of Mars, a possible near-term planetary objective, can be considered a challenging scenario. Mission scenarios currently under consideration call for surface habitation periods of from 1 to 18 months on even the earliest expeditions. Methods: Environmental issues associated with Mars exploration have been investigated by NASA and the National Space Biomedical Research Institute (NSBRI) as part of the Bioastronautics Critical Path Roadmap Project (see http://criticalpath.jsc.nasa.gov).

Results: Arrival on Mars will immediately expose the crew to gravity only 38% of that at Earth’s surface in possibly the first prolonged exposure to gravity other than the 1G of Earth’s surface and the zero G of weightless space flight, with yet unknown effects on crew physiology. The radiation at Mars’ surface is not well documented, although the planet’s bulk and even its thin atmosphere may moderate the influx of galactic cosmic radiation and energetic protons from solar flares. Secondary radiation from activated components of the soil must also be considered. Ultrafine and larger respirable and non-respirable particles in Martian dust introduced into the habitat after surface excursions may induce pulmonary inflammation exacerbated by the additive reactive and oxidizing nature of the dust. Stringent decontamination cannot eliminate mechanical and corrosive effects of the dust on pressure suits and exposed machinery. The biohazard potential of putative indigenous Martian microorganisms may be assessed by comparison with analog environments on Earth. Even in their absence, human microorganisms, if not properly controlled, can be a threat to the crew’s health. Conclusions: Mars’ surface offers a substantial challenge to the health and safety of future human explorers.
Biomedically Relevant Features Of Mars' Surface Environment

Methods

Mars surface exploration environmental issues have been investigated by NASA and National Space Biomedical Research Institute (NSBRI) as part of the Bioastronautics Critical Path Roadmap Project (BCPR)

ref: http://criticalpath.jsc.nasa.gov

Introduction

- Planetary exploration by astronauts will require extended habitation on planet's surface
- Example: human exploration of Mars
  - Possible near-term planetary objective
  - A challenging scenario
  - Surface habitation of 1 to 18 months
  - Different environmental factors from either Earth or spacecraft
Physical Challenges

CPR Issues: Radiation

Bioastronautics
Critical Path Roadmap (CPR)

- HABitation systems
  - Advanced life support
  - Environmental health
  - Habitation
  - Food and nutrition
  - Medical care systems
  - Clinical syndromes
  - Microgravity (simplified)

- Adaptation and countermeasures systems
  - Sleep
  - Cardiovascular alterations
  - Human behavior and performance
  - Immunology, infection and "genetics"
  - Neuromuscular coordination
  - Respiration

Radiation

- Not well documented
- Planet’s bulk and thin atmosphere may moderate the influx of galactic cosmic radiation and energetic protons from solar flares
- Secondary radiation from activated components of the soil must also be considered

Critical Path Roadmap (CPR)

BCPR: blueprint for focused evolving research and technology for "risk reduction", to prevent or reduce the risks to humans in space environment
- Mars Design Reference Mission (1997) - "most challenging" standard
- Identified: 56 risks, 343 critical questions in 12 risk areas
Radiation Research

- Continuous monitoring of the radiation environment with dedicated equipment
  - The Phantom Torso (TORSO): monitors radiation absorption at brain, heart, stomach, thyroid, colon (2 month study)
  - Dosimetric mapping (DOSMAP): documents nature and distribution of radiation inside ISS and around crew-memories' bodies - German investigator, periodic data download (4 month study)
  - Bonner Ball Neutron Detector (BBND): monitors neutron radiation that may affect blood-forming bone marrow
  - NaI038 provide hardware - Increment 2 and 3 (ongoing 6 months)
- Medical research and care
  - Database of personal annual and lifetime exposure limits for crew members with regular medical examinations (ongoing)

Gravity

- 0.38 g
- Possibly the first prolonged exposure to hypogravity between 1 g and 0 g
- Unknown effects on crew physiology

Bone Integrity in Weightlessness

![Bone Integrity in Weightlessness](image)

- 0.38 g
- Possibly the first prolonged exposure to hypogravity between 1 g and 0 g
- Unknown effects on crew physiology
Physical Challenges

CPR Issues: Hypogravity

Strategy for Mars Surface Operations

Artificial Gravity (AG) Considerations

Conservative assumption:
- Only 3 out of 9 crew members will be immediately available after landing.
CPR Issues: Hypogravity

Current (1996) concepts

Gravity Augmentation
Exercise on Mars

Artificial Gravity Concepts
Continuous / Long Radius / Low $\omega$

"Gravity Augmentation"
During Exercise On Mars

Exercise in LBNP
(Hargens, NASA ARC)

Bionaut
(NASA ARC)

ISS Resistive Exercise Device
(NASA JSC)

Biomedically Relevant Features Of Mars' Surface Environment

Dust
- Ultrafine and larger respirable and non-respirable particles in Martian dust introduced into the habitat after surface excursions may induce pulmonary inflammation exacerbated by the additive reactive and oxidizing nature of the dust. Stringent decontamination cannot eliminate mechanical and corrosive effects of the dust on pressure suits and exposed machinery.
Biomedically Relevant Features Of Mars' Surface Environment

Biohazard
- potential of putative indigenous Martian microorganisms may be assessed by comparison with analog environments on Earth.
- Even in their absence, human microorganisms, if not properly controlled, can be a threat to the crew's health.

CPR Issues: Environmental

CPR Issues: Human Behavior and Performance

Biomedically Relevant Features Of Mars' Surface Environment

Circadian factors
CPR Issues:
Human Behavior and Performance

Issues:
- Small group size
- Multi-cultural composition
- Extended duration
- Remote location
- High autonomy
- High risk (both expensive and life-threatening)
- High visibility (e.g., high pressure to succeed)

Acute Medical Issues

Clinical Problems

- Expanded diseases and problems
- Orthopaedic and musculoskeletal problems (e.g., sprain, fracture)
- Infections, hematomas, and hemorrhage-related diseases
- Dermatological, ophthalmological, and ear infections
- Acute medical emergencies
- Wounds, fractures, and burns
- Traumatic syndromes and shock
- Acute respiratory illness
- Development and treatment of communicable diseases
- Dental, ophthalmologic, and psychiatric care

Autonomous Clinical Care

Clinical problems:
- Radiation-induced problems
- Responses to toxic exposure
- Preservation of organs
-Mechanical or chemical disease process
Conclusions:

Mars' surface offers a substantial challenge to the health and safety of future human explorers.