Joint Workshop on Induced Special Regions

Curiosity Sol 1896 Dec 2017

Credit: NASA/JPL/Ken Kremer/Marco Di Lorenzo

Planetary Science Advisory Committee
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Disclaimer

- The following charts represent the results from the Joint Workshop on Induced Special Regions

- The report does not reflect NASA or Planetary Protection Policy

Joint Workshop on Induced Special Regions

- Scientists and planetary protection experts convened to assess the potential of inducing special regions through lander or rover activity.
  - Convenors: Cassie Conley, Robert Lindberg, Michael Meyer, and Clive Neal
- For the workshop's purpose, a Special Region is defined as a place where water activity and temperature are sufficiently high and persist for long enough to plausibly harbor life.
- The Workshop, sponsored by both the former Planetary Protection Subcommittee and the Planetary Science Subcommittee, was anticipated to be the first of a series spanning the intersection of planetary protection and science.

Workshop Participants

Name		Institution	Expertise (comment)
Corien	Bakermans	PSU, Altoona	microbiology, low-T biology
David	Beaty	JPL	geology, mission design
Douglas	Bernard	JPL	flight project systems engineering
Penny	Boston	NAI	astrobiology, caves, PP
Vincent F.	Chevrier	U Ark	water activity (remote*)
Cassie	Conley	NASA HQ	PPO, biology
Ingrid	Feustel	EPA HQ	toxicology communication
Raina	Gough	UC, Boulder	deliquescence (remote*)
Tim	Glotch	Stonybrook	spectroscopy, hydrated-minerals
Lindsay	Hays	ARC	astrobiology, Buried RTG model
Karen	Junge	APL-UW	microbiology, low-T biology
Robert	Lindberg	U Va	PPS chair, mechanics, robotics
Michael T.	Mellon	APL	modelling water on Mars
Michael	Meyer	NASA HQ	MEP, Astrobiology. microbiology
Michael	Mischna	JPL	Mars water/climate modelling
Clive	Neal	U Notre Dame	PSS chair, Lunar Petrology
Betsy	Pugel	NASA HQ	PPO, Flight Project Engineering
Richard	Quinn	NASA ARC	Regolith reactivity, deliquescence
Francois	Raulin	Université Paris Est Créteil	Astrobiology, astrochemistry, PP
Nilton	Renno	U. Michigan	Climate, thermodynamics
John	Rummel	SETI	PP, astrobiology
Mitch	Schulte	NASA HQ	Organic chemistry, MEP
Andy	Spry	SETI	PP
Perry	Stabekis	Retired	PP
Alian	Wang	Wash U	Mineralogy, hydrated minerals
Nathan	Yee	Rutgers	Geomicrobiology

Pre-Workshop Questions

Recognizing that the participants were approaching the concept of induced special regions from very different perspectives, the conveners decided to distribute a set of questions, to be answered by participants beforehand. Submitted answers were then anonymized and distributed back to the participants before the Workshop.

- **Questions about capabilities of Earth organisms: what do we know, and what additional information would be useful?**
  - Under what circumstances could the surface or spacecraft-accessible subsurface of Mars support growth of terrestrial microbes?
  - Are there other parameters, beyond temperature and water activity?
  - To what extent are conditions on Mars toxic to terrestrial microbes? Over what exposures/timescales?
- **Questions about natural conditions on Mars: what do we know, and what additional information would be useful?**
  - Do temporal and spatial disequilibria create the potential for transient/periodic 'Special Regions'?
  - Under what conditions could deliquescence contribute to creation of Special Regions?
  - Are Recurring Slope Lineae (RSL) Special Regions? Why and why not?
- **Questions about how spacecraft could alter condition on Mars: what do we know, and what additional information would be useful?**
  - What environments are present on/inside spacecraft that could provide habitable conditions?
  - How might spacecraft alter the natural surface of Mars to create environments that are habitable?
  - What effects does a perennial heat source (e.g., RTG) have on the surface of Mars?
  - How could microbes from spacecraft be transported to possible Special Regions?

Example from 26 Pages of Anonymized Answers

1. Questions about capabilities of Earth organisms: What do we know, and what additional information would be useful?

As an overall comment, generalization to "Earth organisms" may not always be helpful, as it always pushes the accommodations to the extreme cases. A structure that allowed consideration of "Earth organisms" in different bins might be useful (I'll let the microbiologists determine what those might be).

a) Under what circumstances could the surface or spacecraft-accessible subsurface of Mars support growth of terrestrial microbes?

temperatures of -20°C and above, access to water (a_w > 0.61), no oxidants/UV/toxins that damage cells, nutrients available (C, N, O, P, S, Fe). There isn't much new information since the SR-SAG2 report.

- Temperatures at or above -18°C (Bakermans, 2017)
- Water activities at or above 0.6 (Rummel et al., 2014; Stevenson et al., 2016)
- Presence of sufficient nutrients (fuel/oxidants, Rummel et al., 2014) for energy generation and growth (either chemoautotrophic [more likely]; or chemoheterotrophic)
- Shielded from UV exposure (Rummel et al., 2014)
- Solute type and concentrations that do not impede or are toxic for terrestrial microbial growth (depends on the type and concentration of solutes)

Many circumstances could support growth of terrestrial microbes. "Environmental factors restrict the distribution of microbial eukaryotes but the exact boundaries for eukaryotic life are not known. " Extremophiles, 13, 151–167 (2009)

Workshop

- The Workshop was hosted by USRA at their headquarters facilities in Columbia, MD, November 29 – December 1, 2017.
- In the first part of the workshop, the conveners and participants reviewed the goals of the workshop and definitions of terms in order to establish a common base for discussion, including a review of the answers to the questions distributed before the workshop.
- Conveners then introduced three new, more specific questions addressing items that could directly affect mission operations and design.
- This was followed by introductory presentations by participants with pertinent expertise on four major subjects at play concerning those questions.

Workshop Agenda

Day 1	
7:30	Registration Begins • Coffee & tea
8:00	Welcome and Introductions, Robert Lindberg
8:15	Overview of Special Regions, John Rummel
8:30	Purpose and Expected Outcome, Clive Neal
8:45	Review of Responses to Questions, Cassie Conley
9:15	New Questions to Guide Workshop Discussion, Michael Meyer
9:30	BREAK
9:45	Background Presentations Resource speakers give 30 minute overviews of key topics to inform workshop discussions • Water Activity, Michael Mellon & Vincent Chevrier • Deliquescence, Richard Quinn & Nilton Renno • Microbes in Extreme environments, Karen Jung & Penny Boston • Mars Environment, Michael Mischna • Mars Minerals, Timothy Glotch & Alian Wang
12:15	LUNCH
13:15	Questions and Procedure For the remainder of the workshop, participants will split into small groups to discuss each of the three new workshop questions. After small group sessions, participants will meet in plenary to touch base before moving on to the next question. Adjustments will be made as needed.
13:30	Lightning Talks; Buried RTG model, David Beaty & Lindsay Hays
14:00	Question 1 Discussion, Small Groups
17:00	Plenary Tag-up
17:30	Closing Remarks
18:00	Happy Hour

Workshop Agenda

Day 2	
7:30	Coffee & Tea
8:00	Opening Remarks Review question 1 and procedures
8:30	Question 2 Discussion, Small Groups
12:00	LUNCH
13:30	Question 3 Discussion, Small Groups
17:00	Plenary Tag-up
17:30	Closing Remarks
19:00	Group Dinner
Day 3	
7:30	Coffee & Tea
8:00	Final Plenary Review earlier discussion and identify areas of consensus and contention
11:00	Additional Items and Next Steps
12:00	Closing Remarks

Three Workshop Questions

- **What is a safe stand-off distance, or formula to derive a safe distance, to a purported Special Region?**
  - What is viability/distance for micro-organism transport?
  - Is there a residence time for a lander on Mars by when a rover/lander will be “safe”?
- **Questions about RTGs, other heat sources, and their ability to induce special regions:**
  - Can a rover RTG on the surface induce a special region? Under what specific conditions?
  - Can a buried RTG induce a special region? Does it pose a long-term contamination “threat?”
- **Is it possible to have an infected area on Mars that does not contaminate the rest of Mars?**
  - What would be a proper buffer zone?

Workshop Process

- After the presentations, the participants were divided into three subgroups, each possessing a balance of different expertise and personalities.
  - All three subgroups addressed each question separately, and presented their answers in plenary sessions.
  - workshop conveners hoped to create an environment where everyone in the subgroups would have a voice, and each of the subgroups would have the opportunity to develop unique answers, in order to highlight areas of consensus and divergence.
- The resulting presentations from each group provided the opportunity for in-depth discussion in areas of disagreement with all expertise represented.
- On the final day, the participants were remixed into three new groups
  - each group synthesized the responses to one of the workshop questions from material developed over the previous two days, with the goal of deriving the consensus view.
- In the final plenary session, the answers to the questions were reviewed, discussed, and consensus achieved.

General Consensus

- While a spacecraft on the surface of Mars may not be able to explore a special region during the prime mission, the safe stand-off distance would decrease with time because the sterilizing environment that is the martian surface would progressively clean the exposed surfaces.
  - However, the analysis supporting such an exploration should ensure that the risk to exposing interior portions of the spacecraft (i.e., essentially unsterilized) to the martian surface is minimized.
- An RTG at the surface of Mars would not create a Special Region but the result depends on kinetics of melting, freezing, deliquescence, and desiccation.
- While a buried RTG could induce a Special Region, it would not pose a long-term contamination threat to Mars, with the possible exception of a migrating RTG in an icy deposit.
- Induced Special Regions can allow microbial replication to occur (by definition), but such replication at the surface is unlikely to globally contaminate Mars. An induced subsurface Special Region would be isolated and microbial transport away from subsurface site is highly improbable.

Additional Research

- Although the end state of each of the situations described in this report are reasonably well known, kinetics determines the intermediate state in the transition and should be studied
  - For example, during an induced heating - how long, if at all, is water available in the liquid state? Does the ice only sublimate instead of also melting?
- Models are needed to understand details of atmospheric processes for surface transport rates
- Data are also needed on the abilities of Earth organism propagules to facilitate airborne dispersal and survival during dispersal
- Data are needed to understand small-scale features within the first 5 meters of the subsurface and if there are deep groundwater systems