Is It Time to Update our Interpretations of Martian Special Regions?

Dave Beaty
Mars Program Office
Jet Propulsion Laboratory, California Institute of Technology

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Special Regions and PP policy—updating the logic

1. Despite a concentrated search since 2006, we have been unable to find a single Special Region <u>at the martian surface</u>.
2. It has now been persuasively argued that many of the surface features previously thought to be <u>potential</u> Special Regions (RSL, gullies) formed by processes that are dry (and are uninhabitable by terrestrial microbes).
3. **<u>Spacecraft-induced Special Regions.</u>** It has been shown that spacecraft can create conditions that temporarily exceed the T and a_w S.R. thresholds. However, it has also been argued that such zones would remain effectively isolated and therefore not have a "harmful" effect (this word is from the Outer Space Treaty of 1967) on the planet as a whole.
4. If the surface of Mars is lethal to Earth-sourced microbes, the quantitative terms of 3 e5, 5 e5, and 3 e1 microbial spores in our present forward PP policy may no longer make sense. If X delivered microbes would eventually die, why would not 2X? Or 10^5X?
5. **<u>Human missions</u>** will certainly deliver a much higher contamination load than robotic missions, and will certainly induce temporary, local Special Regions. However, is there a reason this is unacceptable?

2. **It has now been persuasively argued that many of the surface features previously thought to be potential Special Regions formed by processes that are dry (and are uninhabitable by terrestrial microbes).**

This list of "potential" Special Regions was prepared by Rummel et al. in 2014. Since then,

- **The first four have "gone dry"**
- **#5 and #7 have not been identified in extended surveys by THEMIS**
- **#6 and #8 are widely considered to be valid, but (by definition) do not occur at the martian surface.**

	Geomorphic Feature	Why evaluated?
1	RSLs	New discovery since 2006
2	Pristine gullies	Significant new understanding
3	Slope streaks	Significant new understanding
4	Polar dark dune streaks	Significant new understanding
5	Recent craters that are still warm	Greatly improved crater database
6	Deep groundwater	New data from MARSIS, SHARAD
7	Thermal zones	New data from THEMIS
8	Caves	Not previously considered

A fundamental question: Has water flowed on Mars recently?

Slope streaks?

Gullies?

RSL?

Extensive debate on whether various slope features are due to liquid water.
The way to resolve equifinality is to watch processes in action.

Note added by DWB: Emerging consensus that the answer is NO

25 m

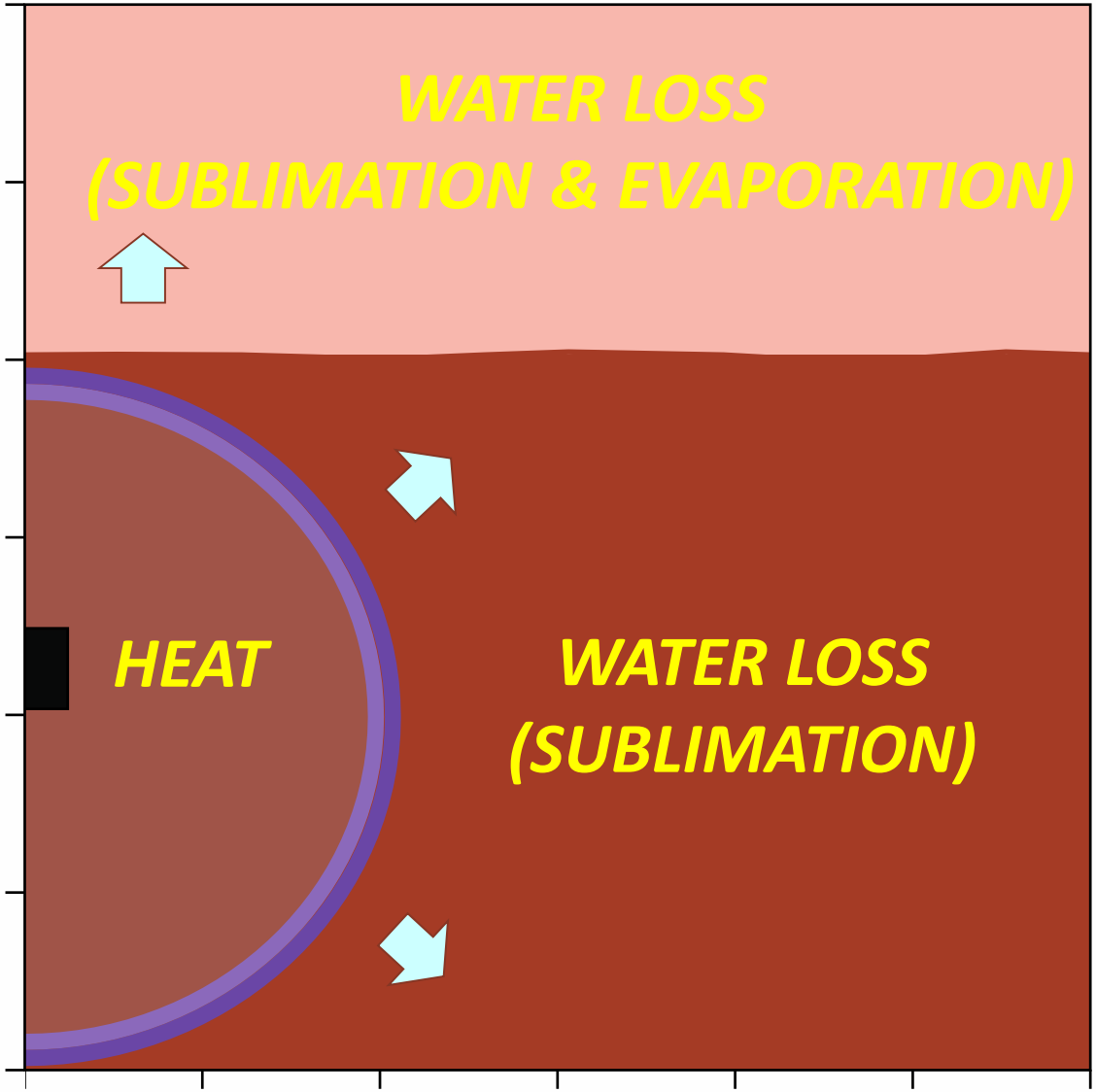
From Dundas (2019)—9th International Mars Conference

3. **<u>Spacecraft-induced Special Regions.</u> A recent paper shows that it is possible for spacecraft to create conditions that temporarily exceed the T and a_w thresholds. However, it has also been argued that such zones would remain effectively isolated and therefore not have a "harmful" effect (this word is from the Outer Space Treaty of 1967) on the planet as a whole.**

Example: Embedding an RTG

- The volume heated initially contains hydrated minerals, but neither ice nor liquid water.
- The water vapor would condense/freeze to water/ice at the appropriate thermal conditions, leaving a dehydrated zone at the core.
- No new water is added at the core, and water would be lost around the periphery due to sublimation and evaporation, so the net effect would be one of drying.
- Is this HARMFUL?

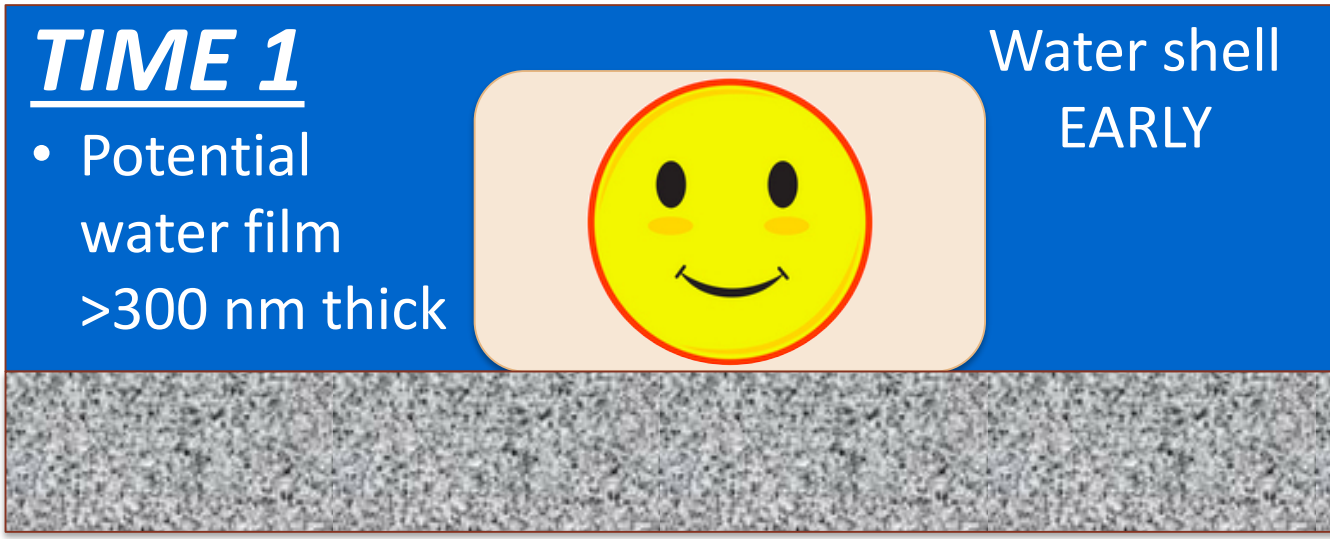
From Shotwell et al. (2019)—in Astrobiology



Microbes and Dessiccation

TIME 1

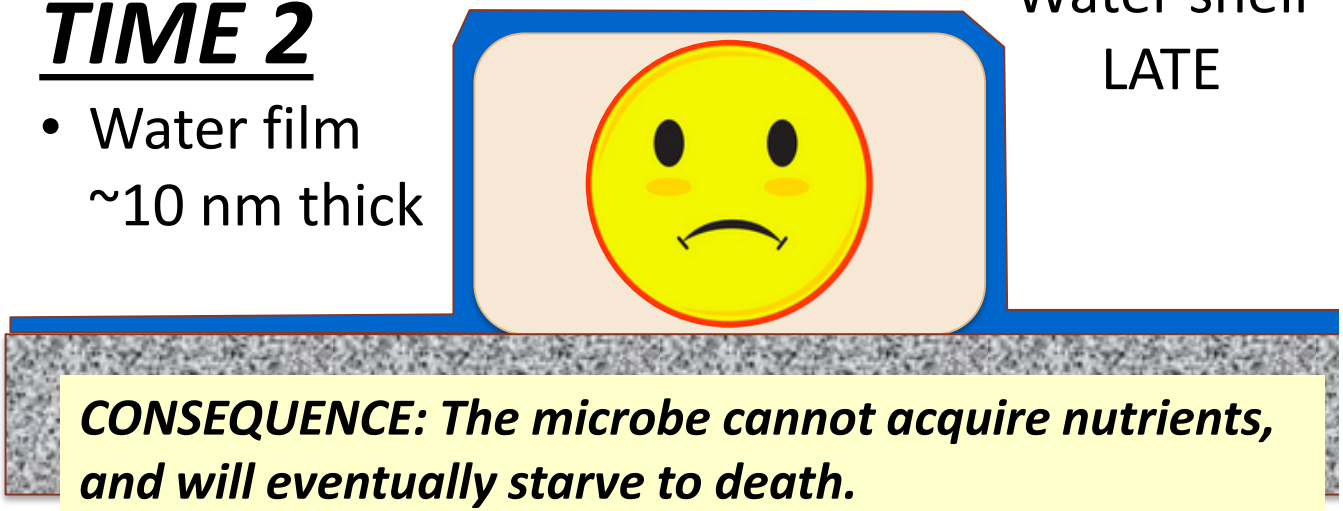
- Potential water film >300 nm thick



200 nm diameter microbe (a small terrestrial bacterium) on a solid surface

TIME 2

- Water film ~10 nm thick



Same microbe, after desiccation, with thin water film, ~10 nm thick at a_w = 0.89. Diffusivity in the film is nearly zero. Effective viscosity increases as the water film thins.

CONSEQUENCE: The microbe cannot acquire nutrients, and will eventually starve to death.

From Shotwell et al. (2019)—in Astrobiology

4. **If the surface of Mars is lethal to Earth-sourced microbes, the quantitative terms of 3 e5, 5 e5, and 3 e1 microbes in our present forward PP policy may no longer make sense. If X delivered microbes would eventually die, why would not 2X? Or 10^5X?**

- **The above figures were all capability-driven numbers representing mid-1970s <u>state-of-the-art 45 years ago</u>. None were derived from mid-1970s knowledge of Mars.**
- **The fact that we CAN implement the above figures for most kinds of robotic missions, is not an argument that we SHOULD.**
- **These figures CANNOT be implemented in human missions.**

5. **Human missions will certainly deliver a much higher contamination load than robotic missions, and will induce temporary, local Special Regions. However, is there a reason this is unacceptable?**

The surface of Mars is a sterilizing environment (see e.g. Report of the Joint Workshop on Induced Special Regions, Meyer et al., in press) that will surround a delivered bioload of any size, and prevent live microbes from spreading.

1. **If there are no surface Special Regions, is there anything at the surface that needs protecting?**
2. **Without the opportunity to replicate, Earth microbes delivered to the martian surface will eventually die.**
3. **Forward PP is still required, but should focus on the subsurface**
4. **A pathway to align PP for robotic and human missions?**