Strategic Issues Related to Martian Special Regions

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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 at the martian surface. Expressed differently, we have not found a single place on the martian surface that is habitable by Earth microbes. (However, it is widely hypothesized that the deep martian subsurface DOES have liquid water, and is a Special Region).
2. It has now been persuasively argued that many of the surface features previously thought to be potential Special Regions (RSL, gullies) formed by processes that are dry (and are uninhabitable by terrestrial microbes).
3. **Spacecraft-induced Special Regions.** 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. This conclusion was reviewed at a major PP workshop last year (attended by many PP folks), and was endorsed.
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?
5. **Human missions** 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?

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.**

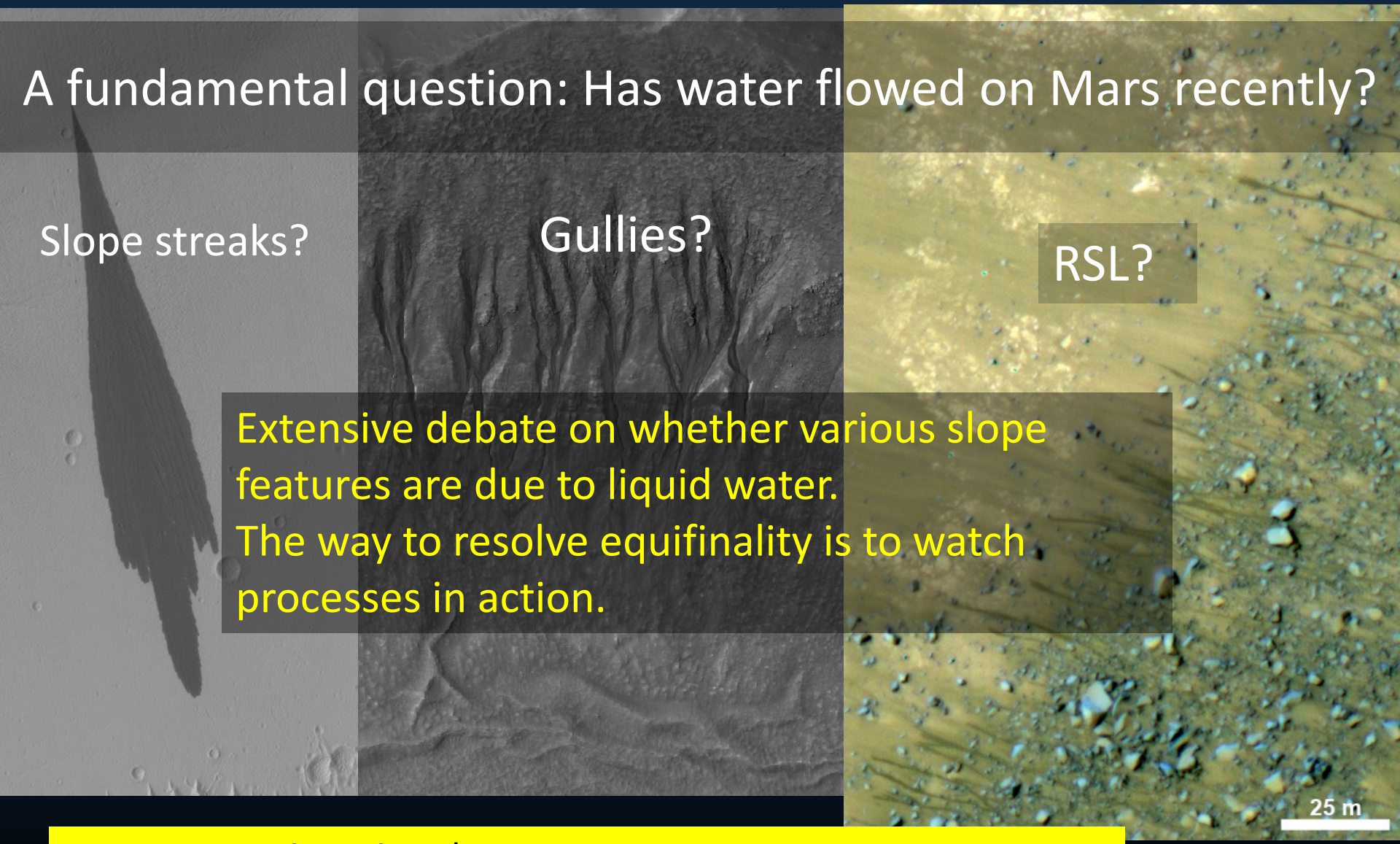
Part
Naturally Occurring Special Regions

Features evaluated in this section:

	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

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

A fundamental question: Has water flowed on Mars recently?



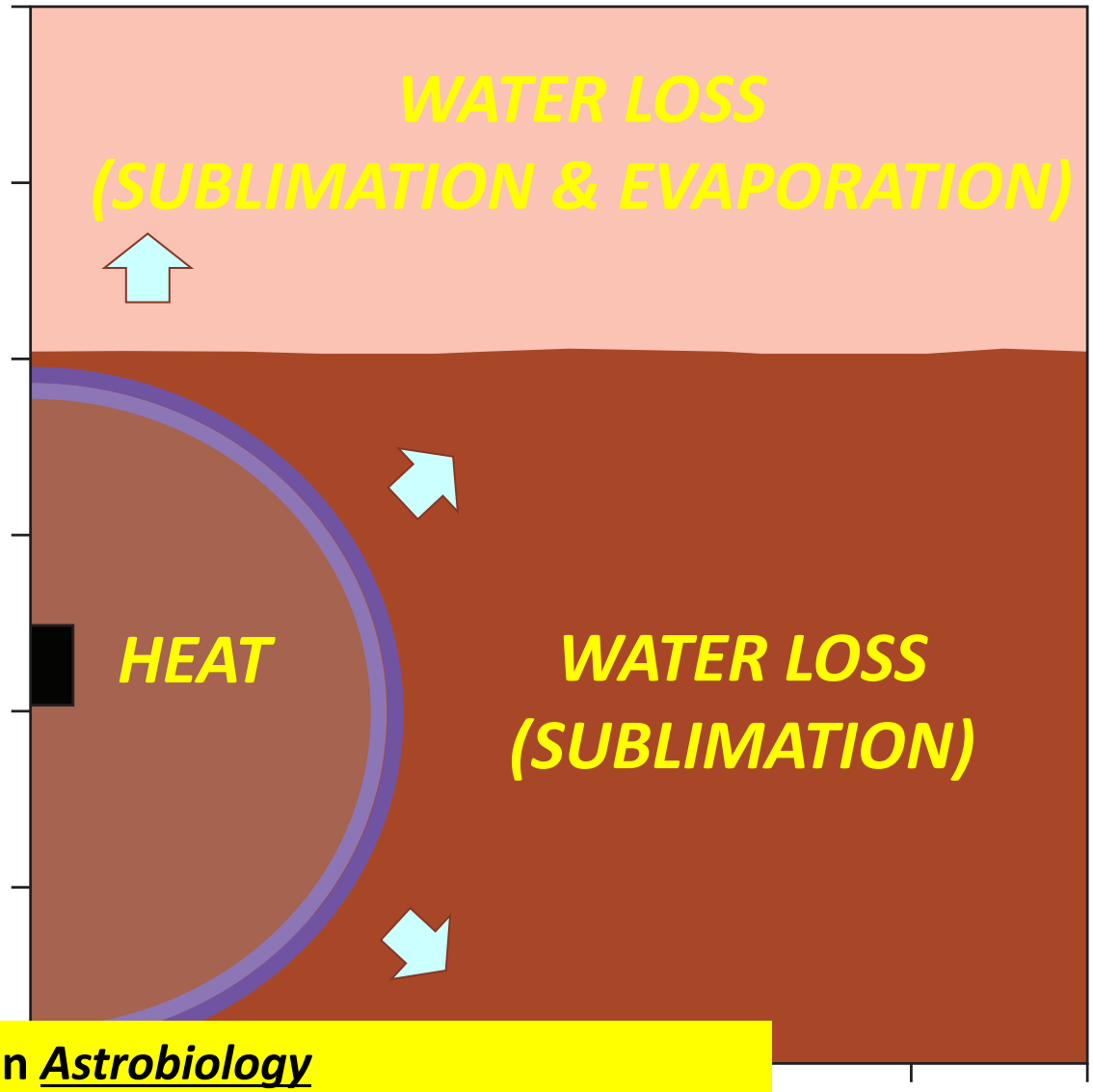
Extensive debate on whether various slope features are due to liquid water.
The way to resolve equifinality is to watch processes in action.

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. This conclusion was reviewed at a major PP workshop last year (attended by many PP folks), and was endorsed.**

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.
- The position of the ice shell would progressively wax, then wane, as the thermal anomaly builds, then declines with time.



From Shotwell et al. (2019)—in *Astrobiology*

Microbes and Dessiccation (1 of 2)

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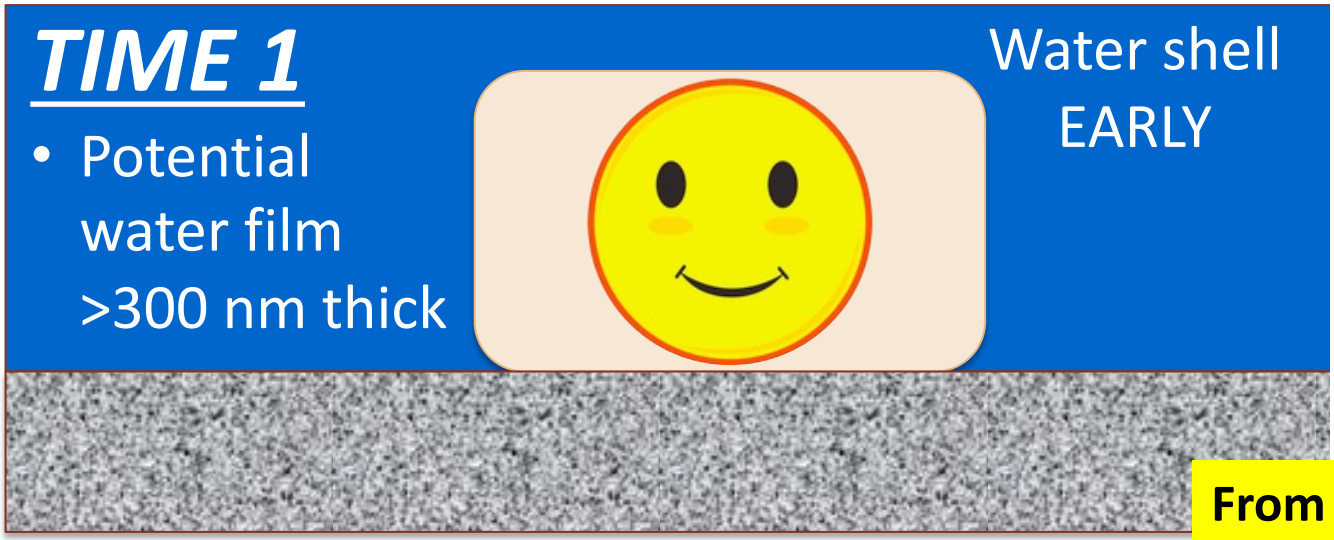
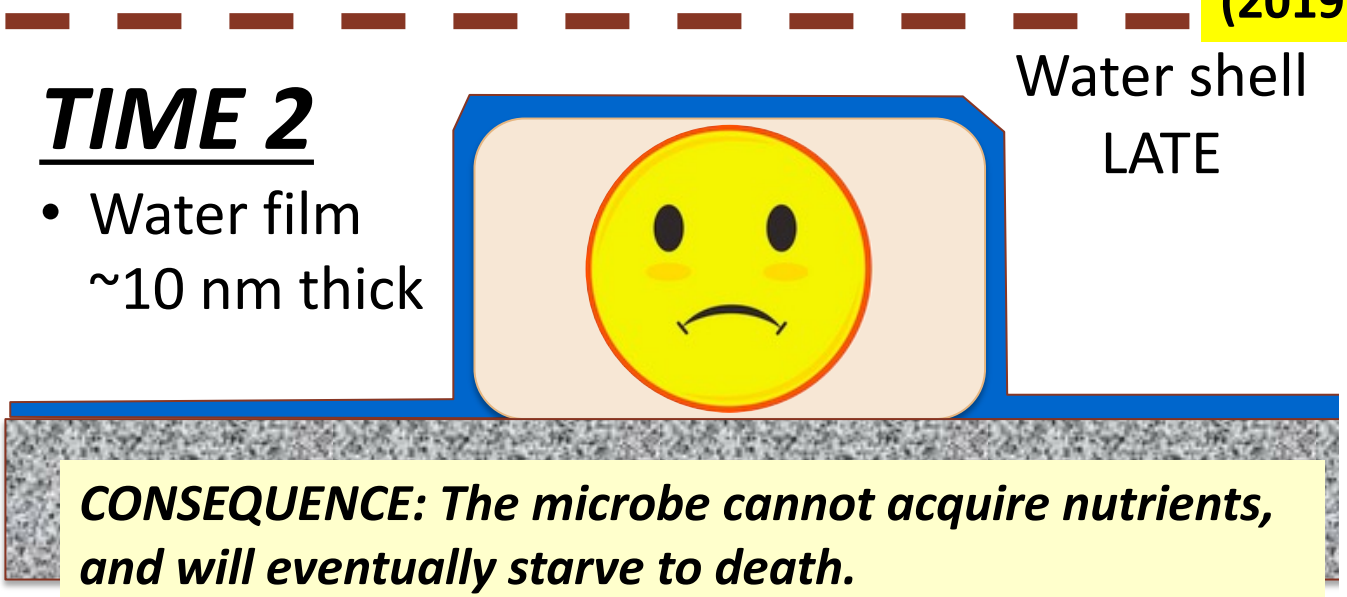


200 nm diameter microbe (a small terrestrial bacterium) on a solid surface in an unsaturated porous medium (e.g. martian regolith)

From Shotwell et al. (2019)—in *Astrobiology*



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.

4. **If the surface of Mars is lethal to Earth-sourced microbes, the quantitative terms of 3e5, 5e5, and 3e1 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.**

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. Two points:

1. **If there are no surface Special Regions, there is nothing 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 . . .**