Natural Terrain Shielding as Observed by MSL/RAD on the Surface of Mars

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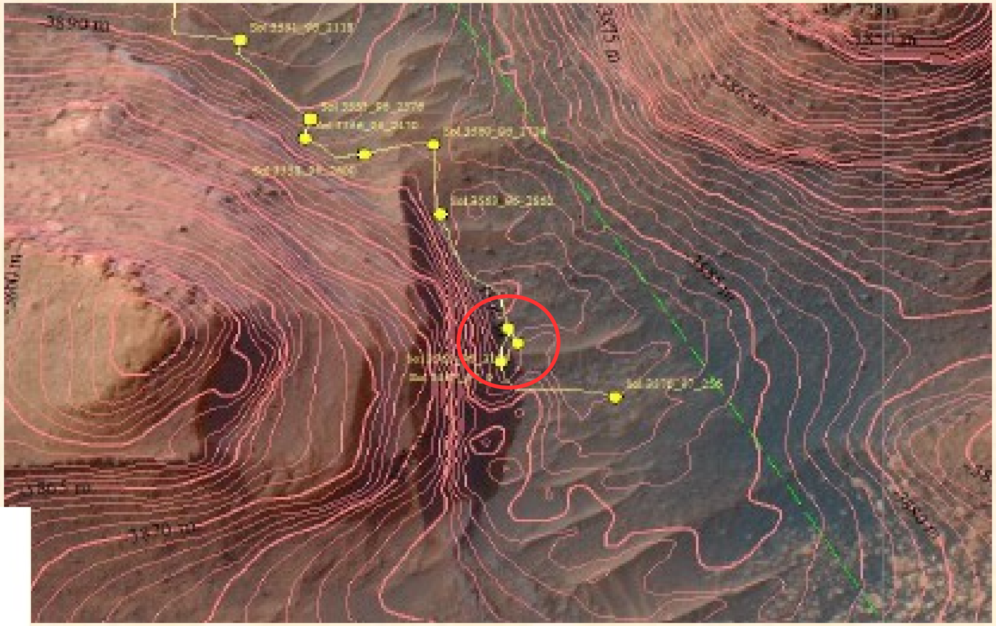
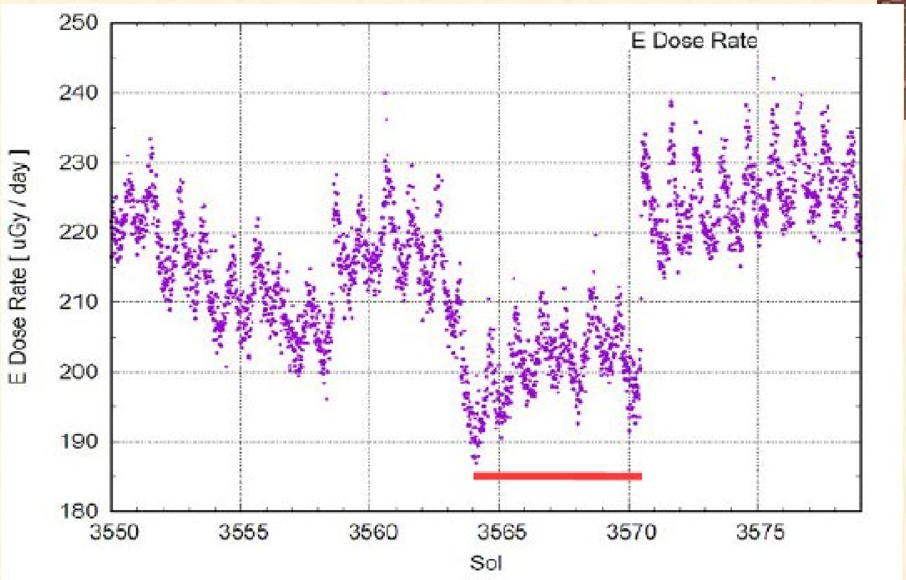
Radiation Shielding by Natural Terrain on Mars

- When Curiosity is operating close to large topographic features (buttes, canyon walls, …), RAD sees distinct decreases in the measured dose rate

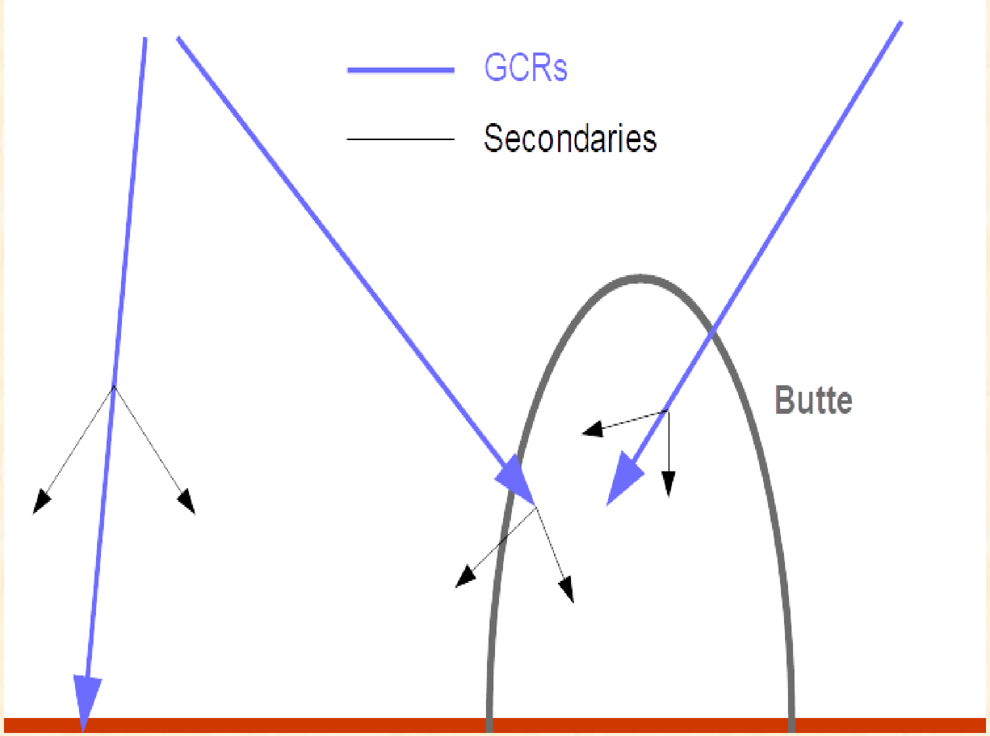




- Dose rates will increase again to expected levels, once Curiosity leaves the vicinity of the feature

Radiation Shielding by Natural Terrain on Mars

- Radiation field on the surface of Mars is made up of ***GCRs***, and secondaries created by ***GCR interactions*** with nuclei in atmosphere and soil
- GCRs passing through a topographic feature interact with the nuclei therein, losing energy & creating secondaries
- If the feature is thick enough, most GCRs will ***stop*** in the butte



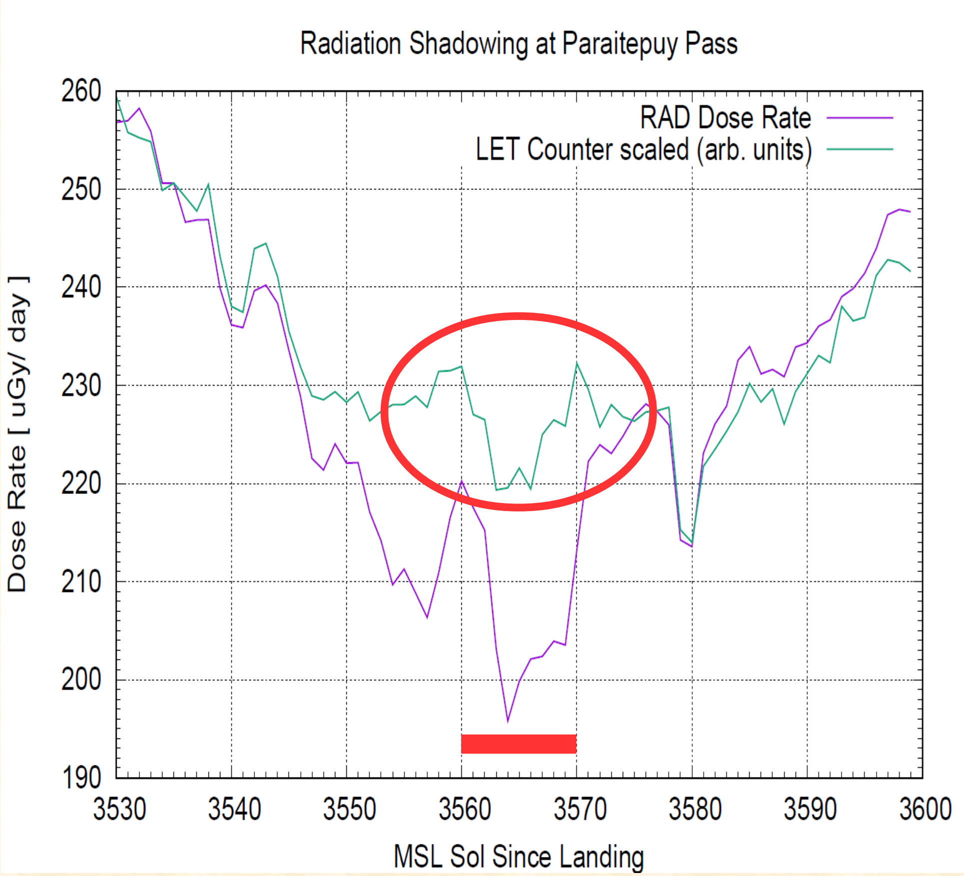
- Radiation decrease depends on percentage of blocked-out sky
- Some secondary radiation will ***back-scatter*** out of the rock and contribute to the radiation field
- This effect is much smaller, leading to a ***net decrease*** in dose

Assessing the Shielding Effect

- How can we assess the amount of shielding provided by a topographic feature?

- RAD's zenith-centered ***LET*** (A&B) counter has an opening angle of ~ 30° and thus its ***FOV*** shouldn't be ***affected*** by most encountered topography

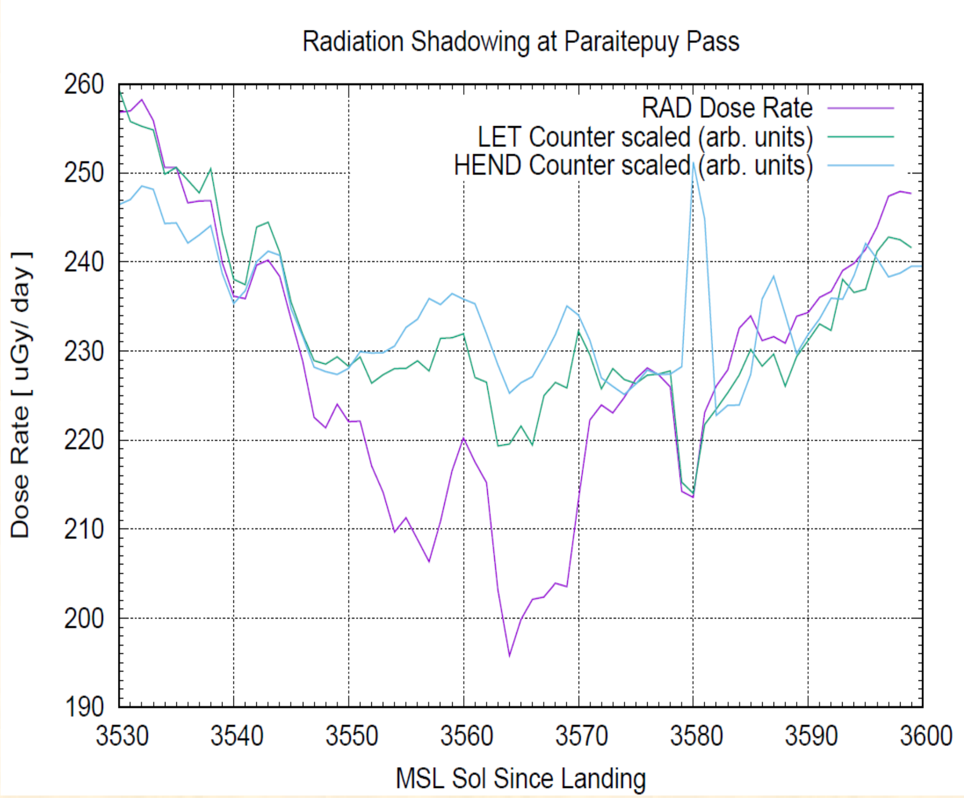
- ***Scaling*** the LET counter data to the measured dose rate should allow us to calculate the amount of ***shielded radiation***



- How can ensure that LET counter FOV is free of any obstruction from topographic features?

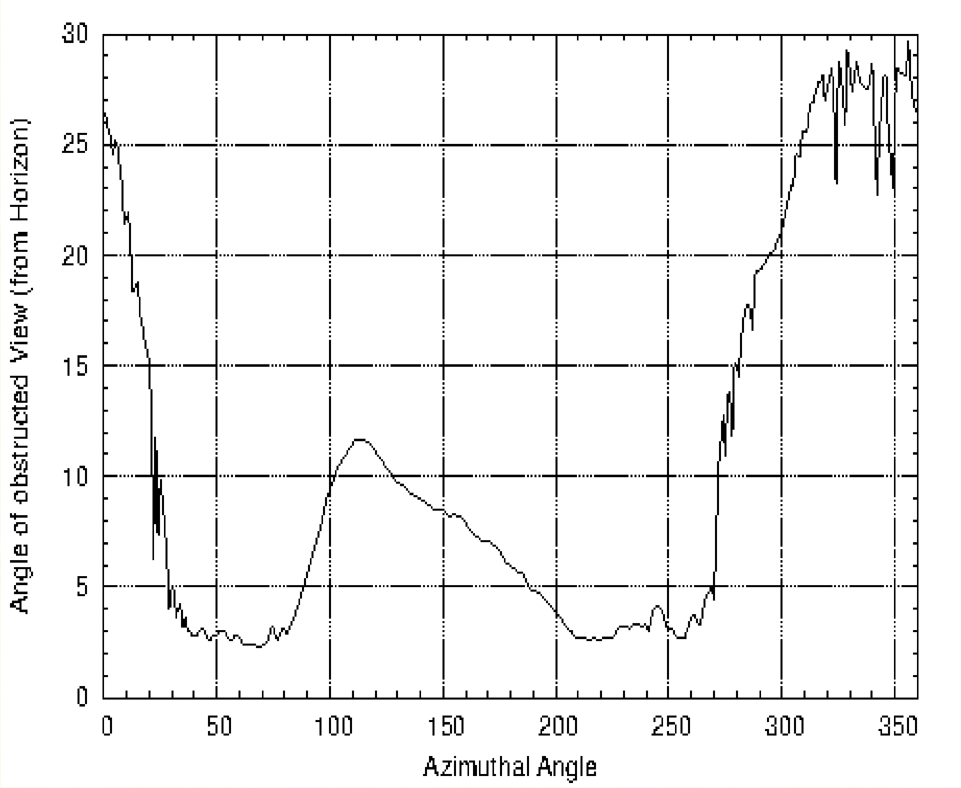
Assessing the Shielding Effect

- Data from orbit will not be affected by any local topography around Curiosity
- Measurements from HEND aboard Mars Odyssey thus provide an “un-shielded” data set
- We use the same approach as with the RAD LET counter to verify that the LET data can be used to estimate the radiation decrease



Assessing the Amount of Blocked Sky

- Using orbital altitude data (MOLA) allows us to determine the “angle of obstruction” around RAD / Curiosity in each azimuth angle
- By averaging over all angles we can then calculate the average angle of obstruction / amount of sky blocked
- This angle will never be zero even when no obstructing features are close by

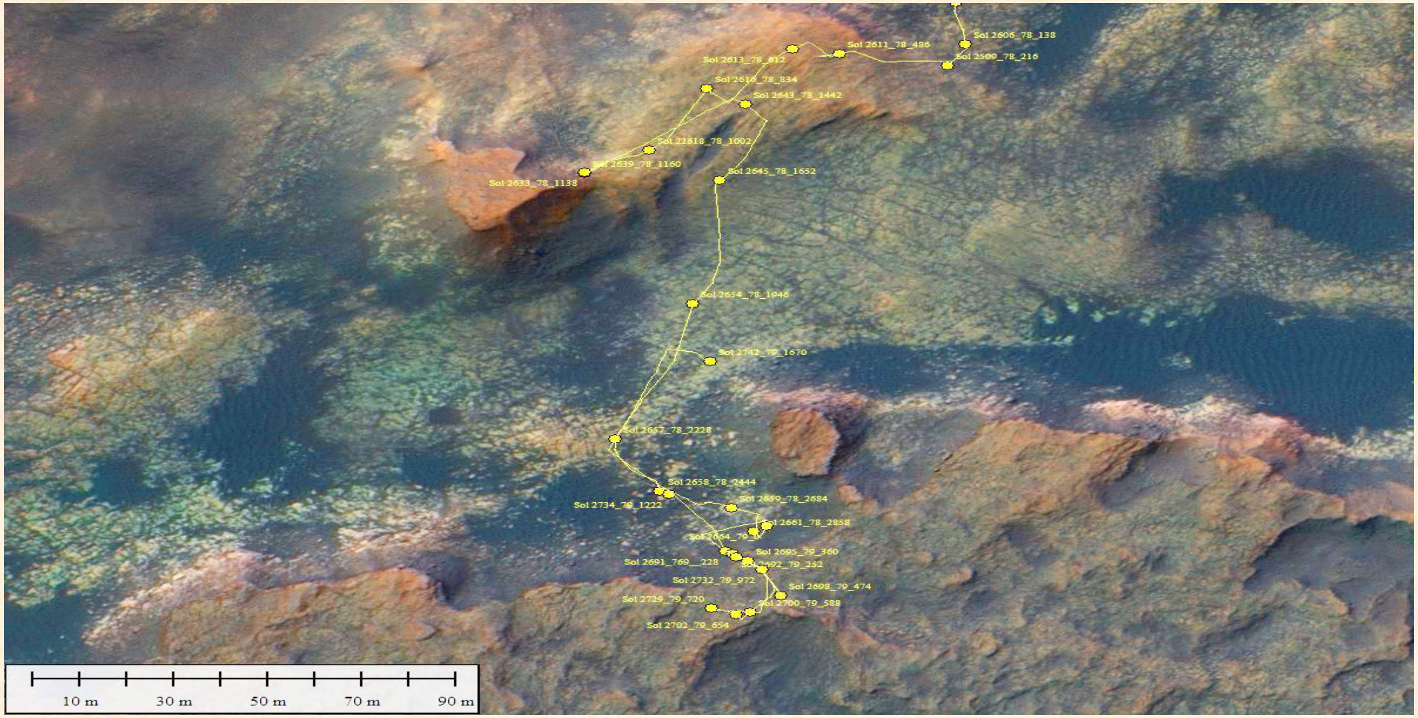


- Curiosity is located in Gale crater, so the crater rim and the central Mount Sharp will always provide a certain amount of sky blockage

Measured Instances of the Shielding Effect

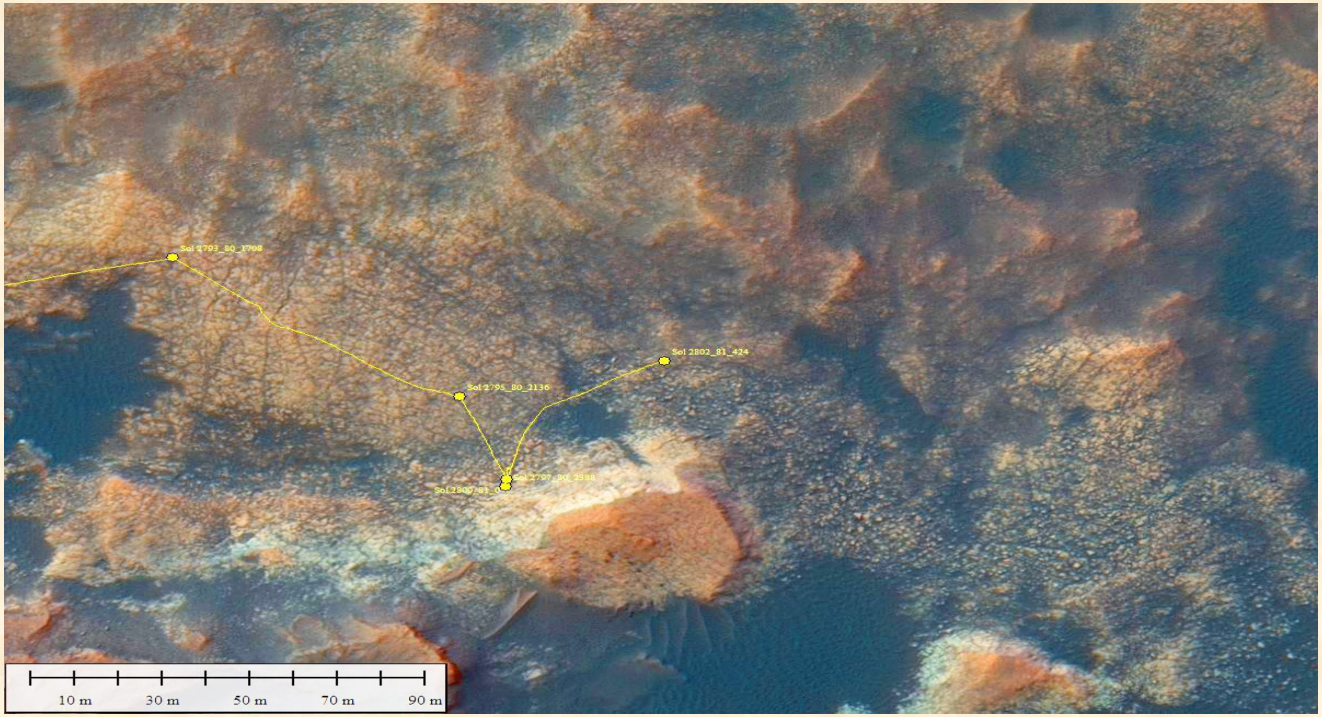
Murray Butte: MSL Sols 1456 - 1467

Measured Instances of the Shielding Effect



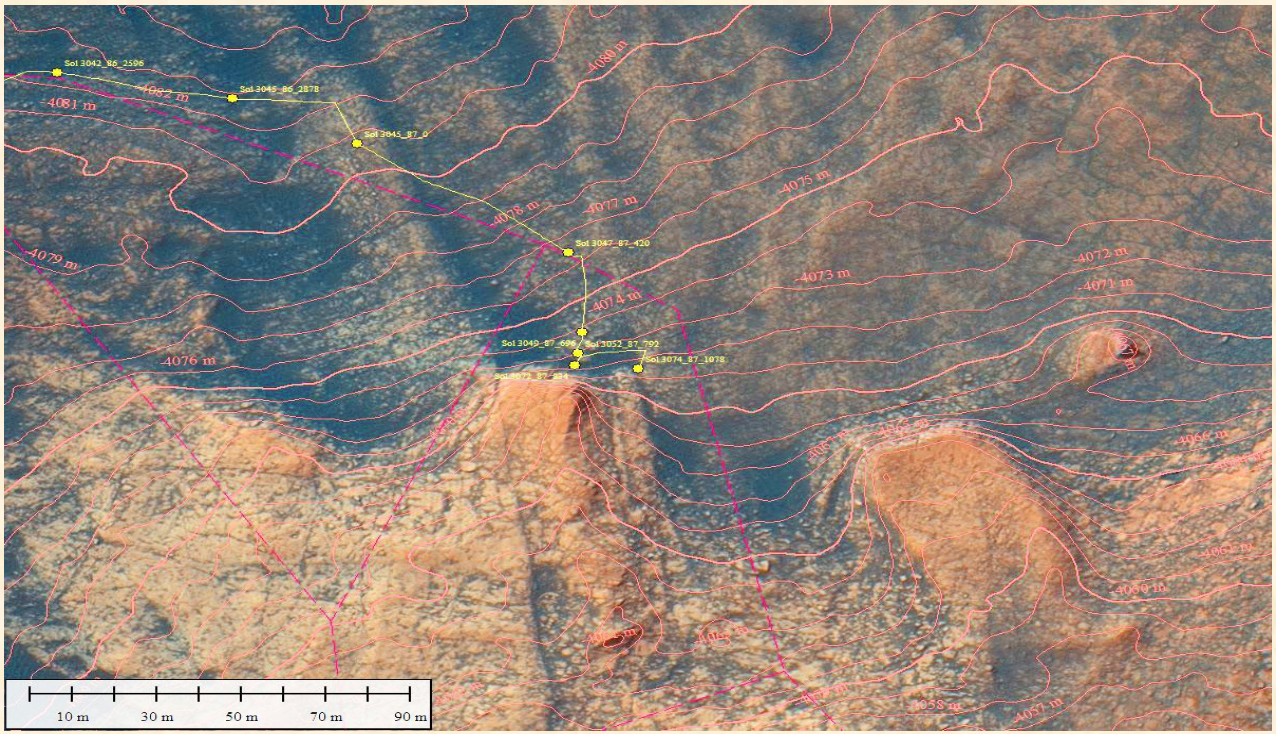
Tower Buttes: MSL Sols 2658 – 2692 & 2734 - 2742

Measured Instances of the Shielding Effect



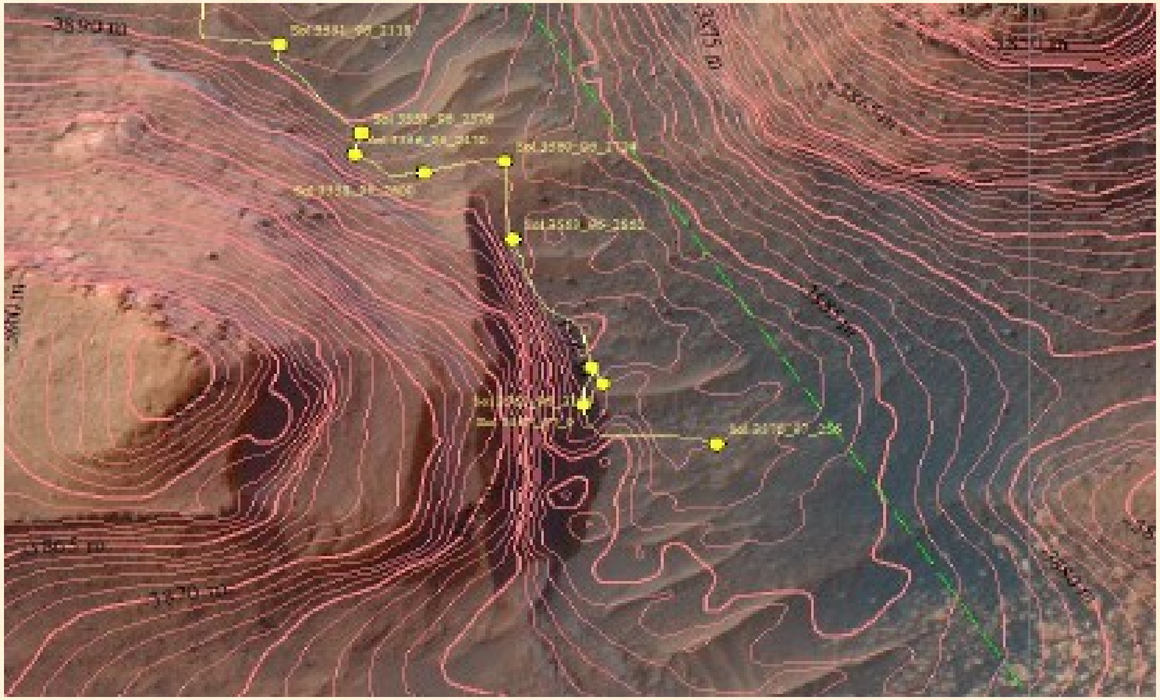
Bloodstone Hill: MSL Sols 2798 - 2802

Measured Instances of the Shielding Effect



Mount Mercou: MSL Sols 3052 - 3074

Measured Instances of the Shielding Effect



Paraitepuy Pass: MSL Sols 3551 - 3567

Measured Terrain Shielding Effects

Location	MSL Sol	Radiation Decrease	Average Obstruction Angle
Murray Butte	1456-67	4-5%	~ 11 deg
Tower Buttes (1)	2658-92 & 2734-42	3%	~ 6-8.5 deg
Bloodstone Hill	2798-2802	5%	TBD
Mt. Mercou Drilling	3052-3072	4.5%	TBD
Mt. Mercou Close Approach	3073	9%	TBD
Mt. Mercou Sec. Position	3074	5%	TBD
Maria Gordon Notch	3324-25	15%	TBD
Paraipetuy Pass Approach	3551-3562	7%	TBD
Paraipetuy Pass	3563-3567	9%	TBD

Importance of Radiation Shielding for Human Exploration

- Shielding humans from short- and long-term exposure to space radiation is one of the prime challenges for space exploration. Better shielding solutions → longer missions. Bringing shielding material to Mars is challenging as mass is a premium time and cost factor in space exploration. Therefore, utilization of natural resources has long been proposed.

- For example, using Phobos as a “staging area” for Mars exploration, and building the base on the slopes of the high-walled Stickney crater has been discussed. The crater walls could provide regolith shielding of estimated ~ 20%. Similarly, on Mars, rock walls or overhangs can provide vital “emergency” shelter during off-base exploration (especially important in case of spontaneous SEP events)

- To date, evaluation of such options relies solely on model calculations or radiation measurement in analogous places on Earth (which are not easily comparable)

- RAD measurements of the shielded radiation dose in combination with the calculated angle of sky blockage provides important ground-truth data for modeling and subsequently the design of Mars radiation shelters…

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