20?? Mars Landing Site: The Silica-Rich Hydrothermal Deposits and Carbonates of the Columbia Hills

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Mars Landing Site Selection: A problem we don’t have

Alice came to a fork in the road. "Which road do I take?" she asked.
"Where do you want to go?" responded the Cheshire cat.
"I don't know," Alice answered.
"Then," said the cat, "it doesn't matter."

- Lewis Carroll, Alice in Wonderland
Returning to the Columbia Hills

To learn something new, take the path that you took yesterday. -John Burroughs

*I saw a sunset once. Didn't bother again

*I saw a breathtaking painting once. Why go to the same museum again?

*My favorite song is on the radio so I better turn it off

*Why would you want to win more than One National Championship? ROLL TIDE!

The road was new to me, as roads always are going back. -Sarah Orne Jewett, The Country Road of Pointed Firs, 1896
Spirit: Gusev Crater
Prime Science Objectives for Site Selection:

1. High habitability potential

2. High preservation potential for physical and chemical biosignatures

3. Diversity: Geomorphic and Lithologic

4. Testable Hypothesis
Spirit has already given us birds in the hand:
Reasons to Return to the Columbia Hills

1. Opaline Silica Deposits (up to 91 wt % SiO$_2$) located near Home Plate. These silica-rich deposits (light-toned soils & bedrock) are interpreted to have formed in hot springs. Terrestrial hydrothermal environments support thriving microbial ecosystems.

2. Mg-Fe Carbonate Outcrops (16 to 34 wt %) of Haskin Ridge located in the Inner Basin region of the Columbia Hills. Imply extensive aqueous activity under near-neutral pH conditions that would be conducive to habitable environments on early Mars.

Silica and Carbonate precipitation well known to promote biosignature preservation.
Reasons to Return to the Columbia Hills

3. Landing Site with Ultimate Ground Truth:
Know we can land safely here!!

Key advantage and unique aspect of this landing site is that we already know exactly where we need to go and have already found the significant astrobiologic and geologic samples to be collected, complements of Spirit.

* Important to recall that Spirit’s traverse across these basaltic plains was easily and rapidly accomplished. Terrain posed no significant challenges to driving and navigation and was accomplished without HiRISE resolution imagery.

* Abundant hi res data (Pancam, MI, HiRISE, CTX, CRISM) exist that covers the landing ellipse and nearby regions of interest without further data acquisition.
Reasons to Return to the Columbia Hills

4. Spirit found the Noachian Columbia Hills to be Geologically Diverse and Complex:
All Rock types showed various degrees of alteration due to aqueous fluids
Reasons to Return to the Columbia Hills

5. Gusev Plains are Hesperian olivine–rich basaltic plains.

While not primary science sampling objective these rocks would be important for dating a Hesperian age lava flow surface which can then be used to help calibrate Martian crater curves.
6. Investigate locales Spirit didn’t explore:

von Braun Butte

Goddard Crater (volcanic source vent?)

The Promised Land
von Braun Butte:
Forms layered butte (cliff and ledge forming members) appears to be capped with Home Plate-like material. von Braun interpreted to be erosional remnant of a once more extensive unit that covered the Inner Basin. Oberth, Korolev and Faget outcrops, located along the lower flanks of McCool Hill, appear morphologically similar to von Braun Butte and are located near the same elevations. These observations indicate that the Inner Basin may have once been filled to a depth of ~20 m with the material that makes up these outcrops.
Goddard Crater:
Elliptical depression 35 m x 25 m, ranging in depth from 2.6 to 3.5 m. Light toned outcrop inside eastern rim and blocky western interior. Crater also has rim collar ranging from 2.5 m to 5 m wide. Goddard Crater appears to be a volcanic vent and not an impact crater based on its morphology, geometry, context, and associated eroded materials interpreted to be pyroclastics.
PROMISED LAND
7. Extra incentive for revisiting site is that Spirit can be located and inspected (i.e., Apollo 12 and Surveyor III) By this time Spirit exposed to Martian environment at least 15 yrs. Excellent long duration exposure experiment providing long-term data on the Martian environment (weathering, micrometeorites) and its effects on materials degradation (SA, Optics, Actuators etc). Data will aid in design of surface systems, equipment and structures for both future robotic and manned exploration of Mars
Previous Long Duration Exposure Experiments

Apollo 12 retrieved components from S-3 exposed 2.5 yrs

LDEF: materials, coatings, electronics, optics, thermal systems exposed 5.7 yrs
MAXIMUM RETURN ON INVESTMENT!!!
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6. Permit investigation of features that Spirit didn’t explore: von Braun Butte, the Promised Land, and Goddard Crater (volcanic source vent?)

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