



Mars Litter Inventory: Using HiRISE to Find our Stuff.

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“Kid, whad‘ya get?”

“I didn’t get nothing, I had to pay \$50 and pick up the garbage.”

“What were you arrested for, kid?”

“Littering.”

And they all moved away from me on the bench there... ...till I said,

“And creating a nuisance.”

And they all came back, shook my hand, and we had a great time on the bench...

-Arlo Guthrie, “Alice’s Restaurant”



Picking Landing Sites

*Vikings and MPF landing sites selected based solely on Viking Orbiter (and Mariner 9) images - tens of meters/pixel.

*Updated locations for the Viking Landers were proposed after the Pathfinder landing in 1997.

-These revised locations enabled precise targeting of the landers by the Mars Orbiter Camera (MOC) and HiRISE.

-Accurate locations are essential for determining the geologic nature of the landing sites.

-High resolution orbiter images - first MOC at up to $\sim 1.5\text{m/pixel}$, then HiRISE at less than 30cm/pixel - “bridge the gap” between the much lower, regional coverage provided by the Viking Orbiters and the ground views from the landers.



MPF Landing Site

About 1 km

Pathfinder Lander

268 m
(164.3°)

428 m
(141.1°)

Twin Peaks

957 m
(208°)

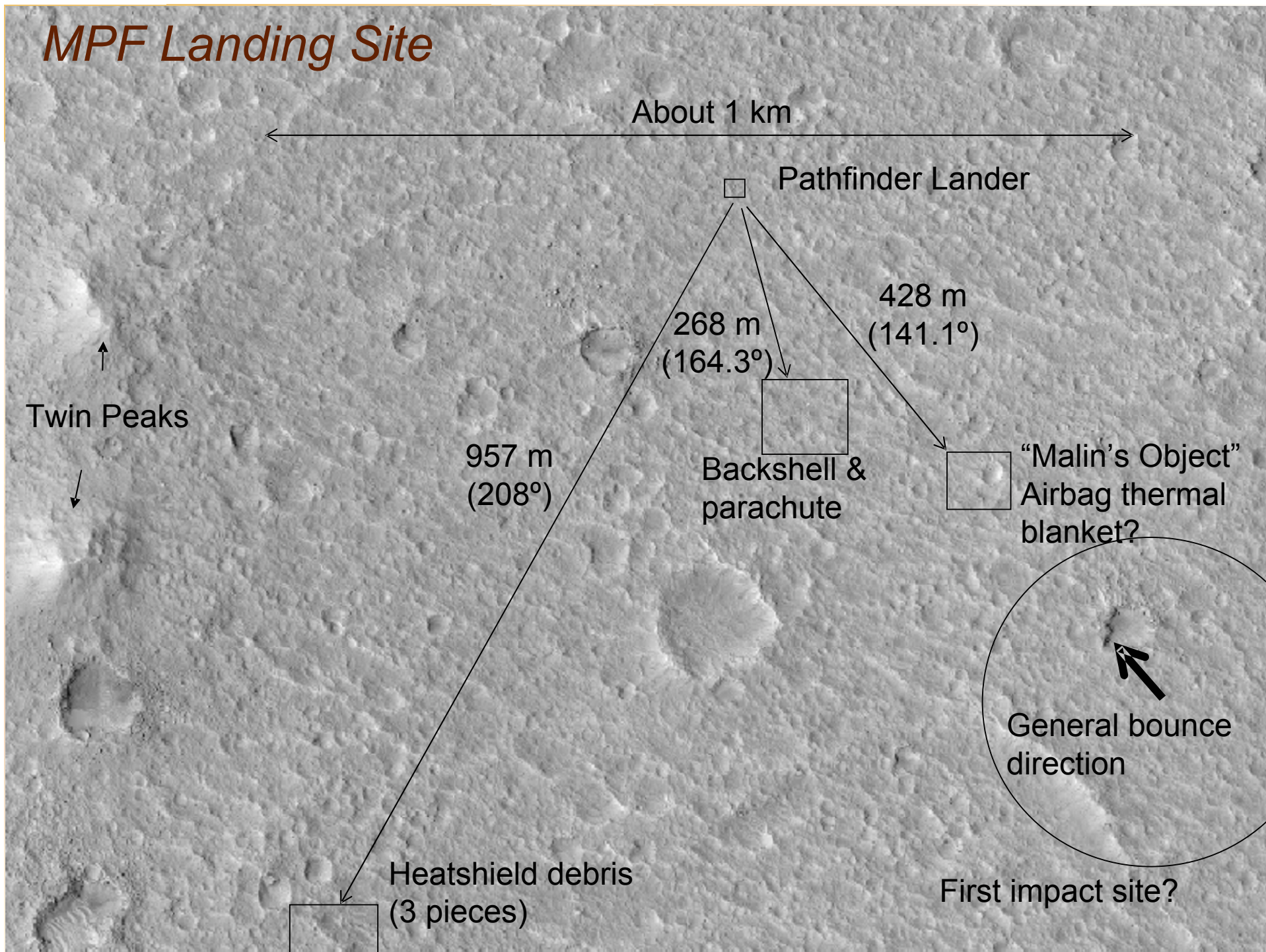
Backshell &
parachute

"Malin's Object"
Airbag thermal
blanket?

General bounce
direction

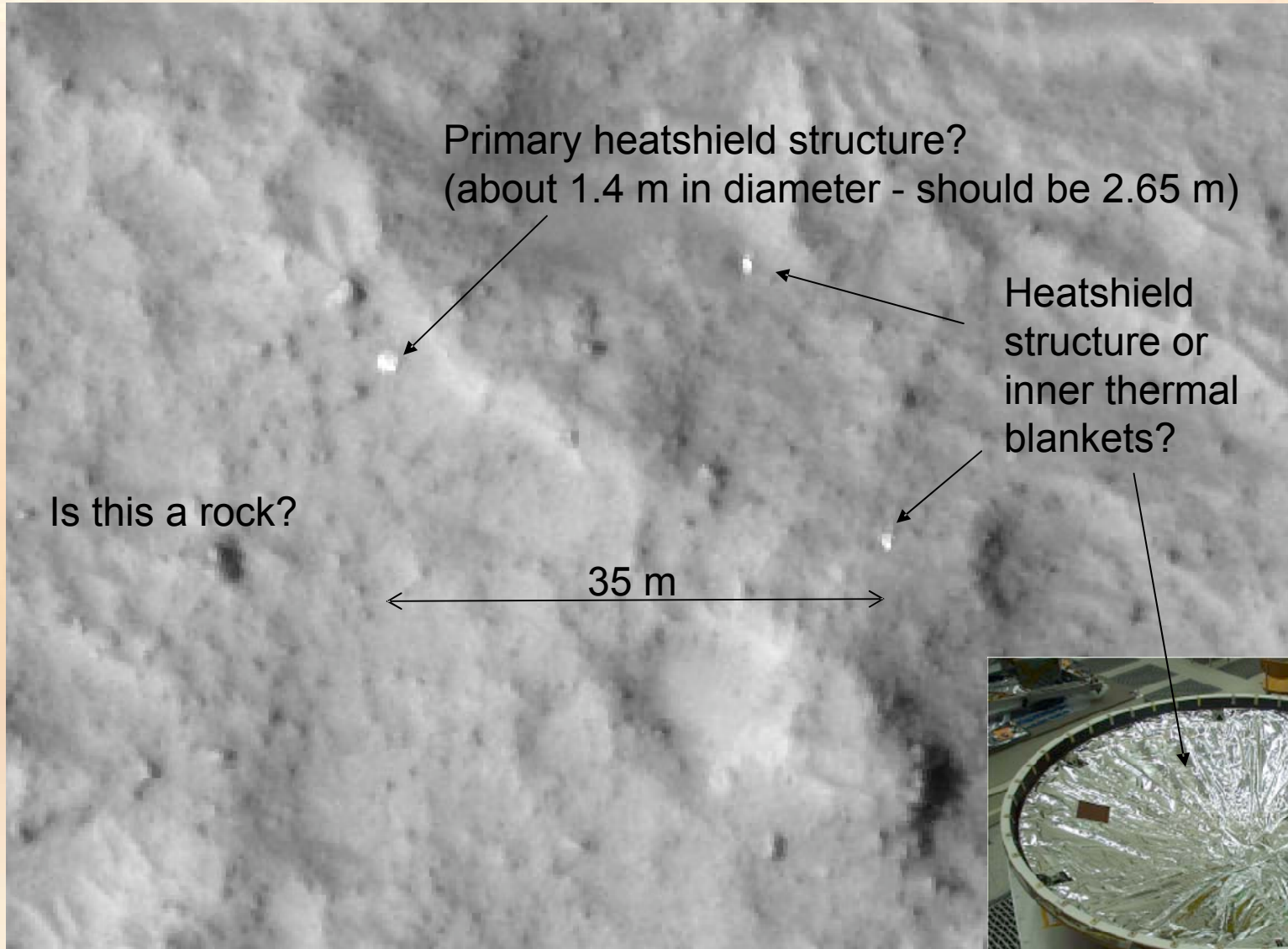
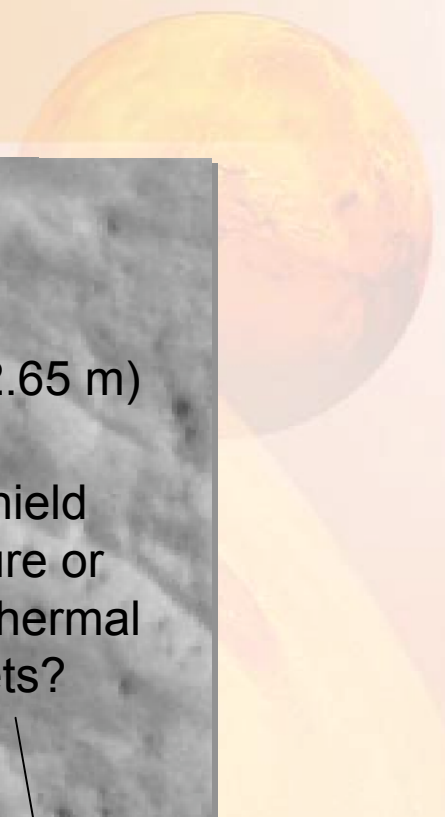
Heatshield debris
(3 pieces)

First impact site?





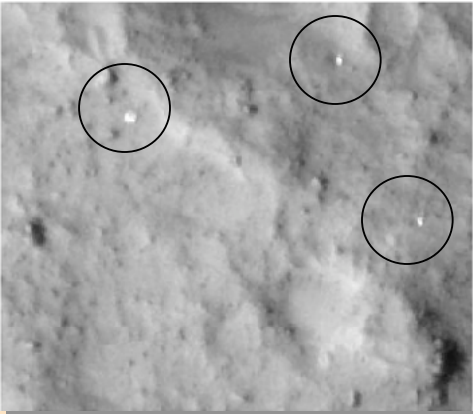
MPF Heatshield Debris



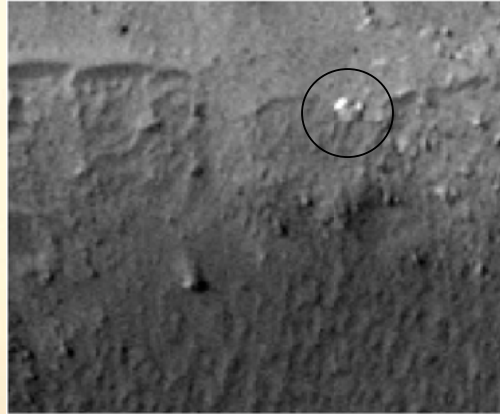


Heatshields as seen by HiRISE

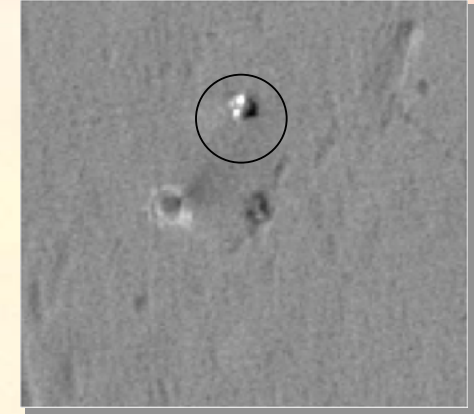
MPF



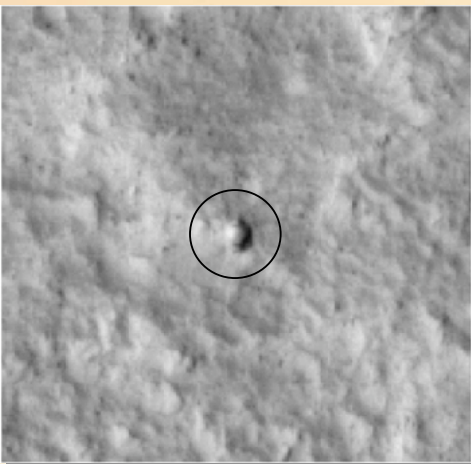
MER-A (Spirit)



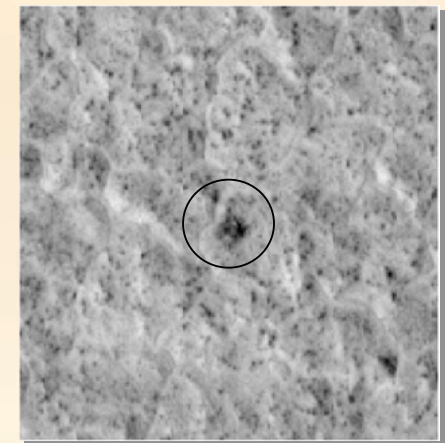
MER-B (Opportunity)



Viking 1



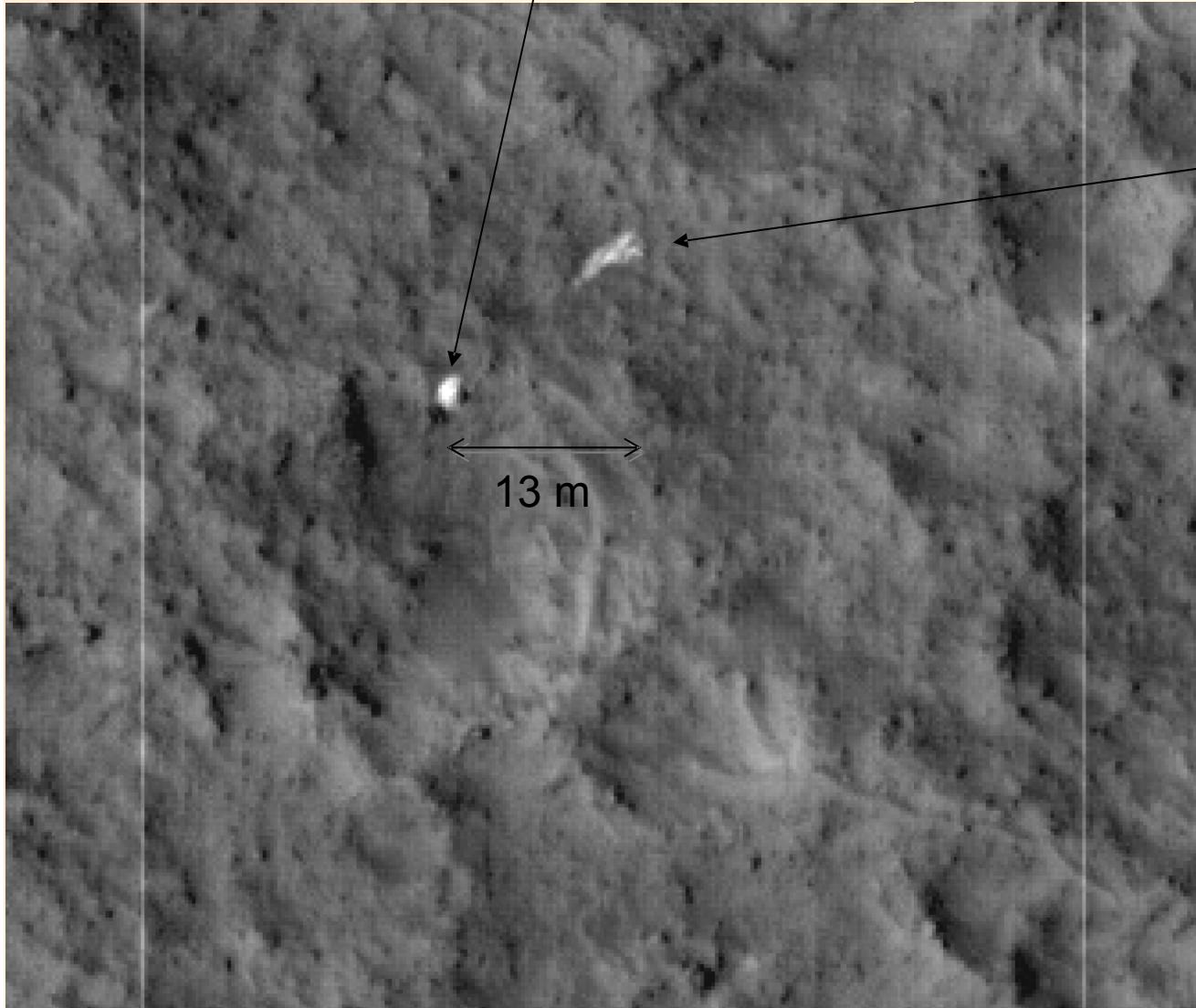
Viking 2





MPF's Backshell and Parachute

Backshell with parachute canister up.
(about 2.1 m in diameter - very close to true size)



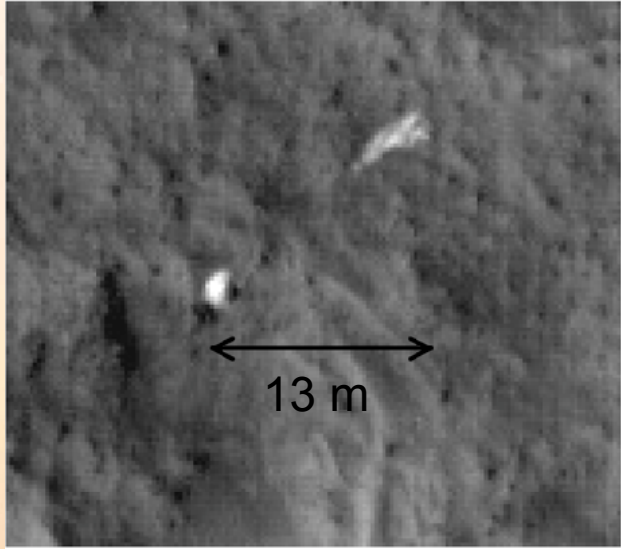
Parachute & suspension lines lies fully stretched out, apparently undamaged, on the ground.

Orientation is consistent with an arc trajectory from the North East (parachute trails backshell).

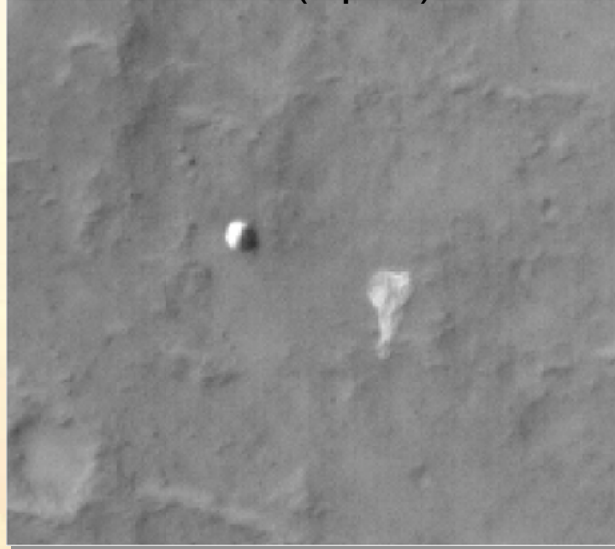


Backshell's & Parachutes as seen by HiRISE

MPF



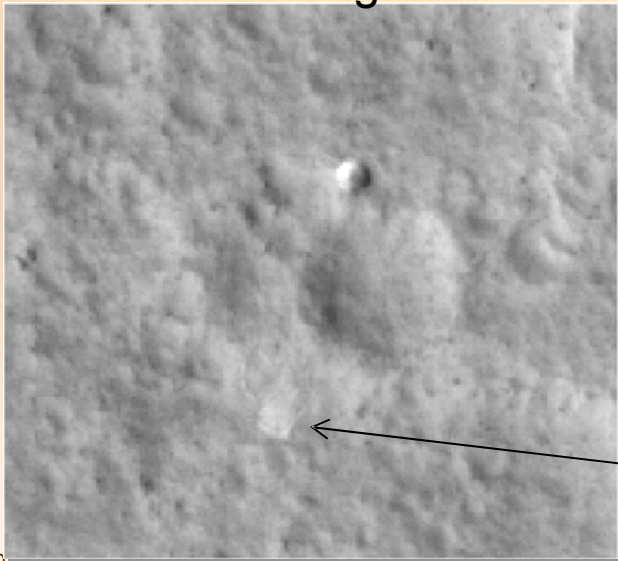
MER-A (Spirit)



MER-B (Opportunity)



Viking 1



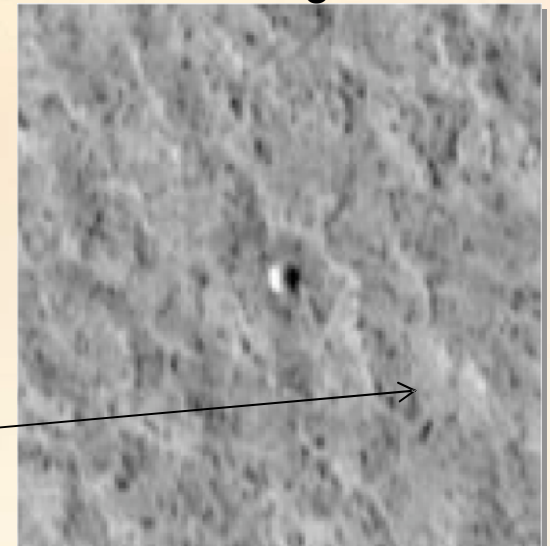
All but MER-B's backshell appear cone-pointed up.

VL-2's parachute is not clearly visible.

Dusty parachute

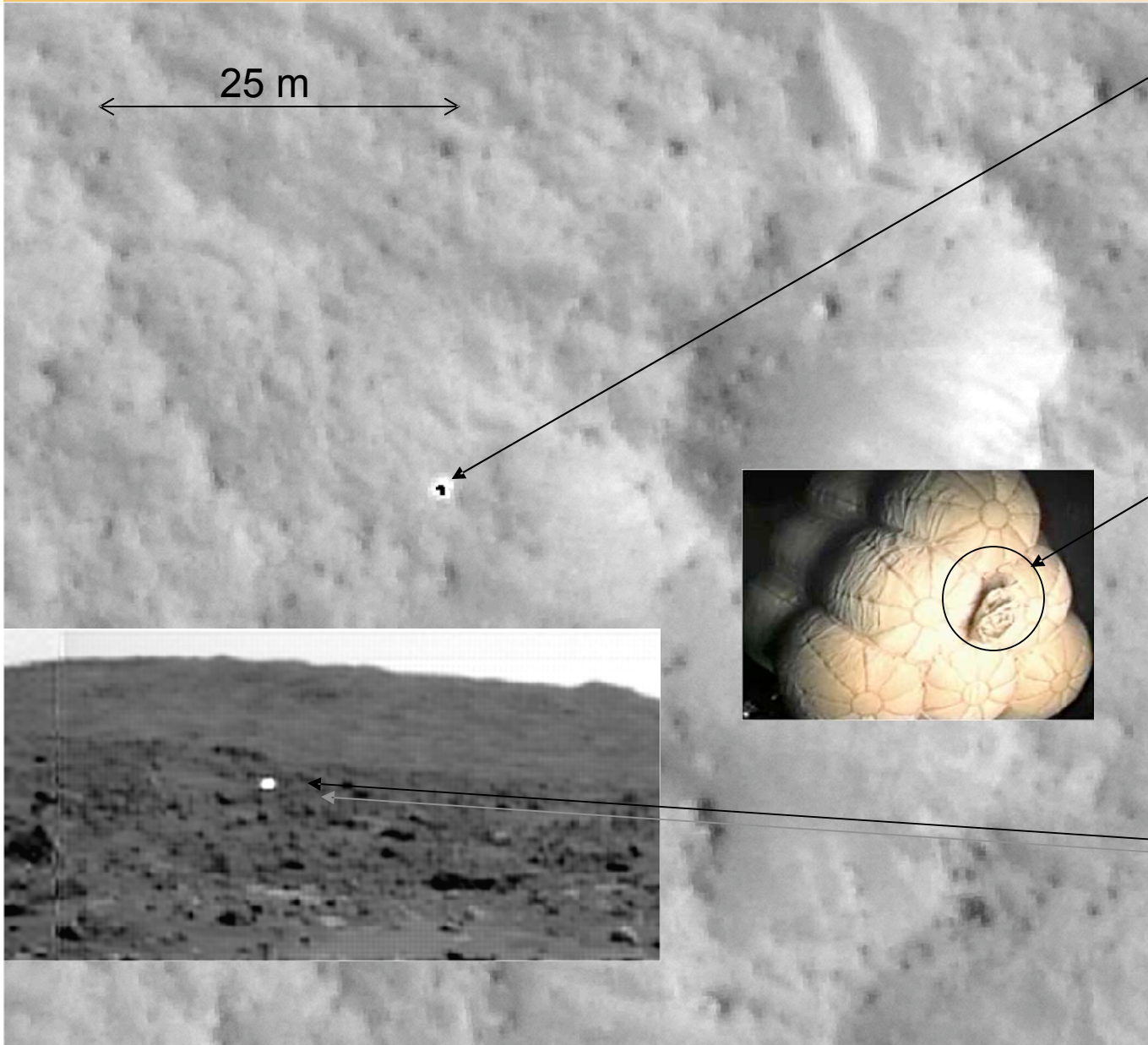
Is this it covered with dust?

Viking 2





“Malin’s Object”: MPF Airbag Blanket?



Object is about 1.1 m in diameter.

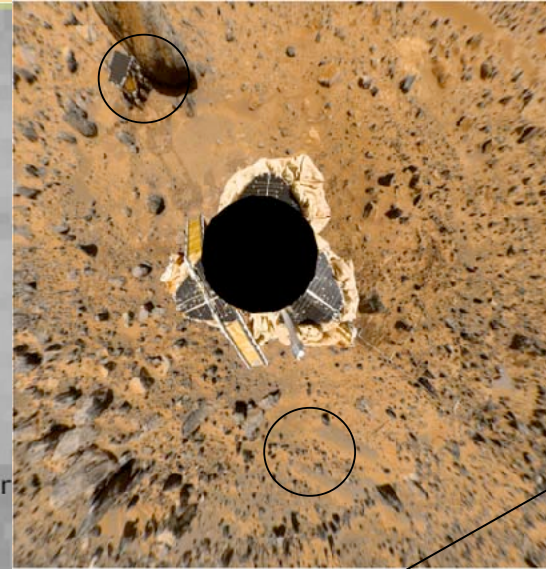
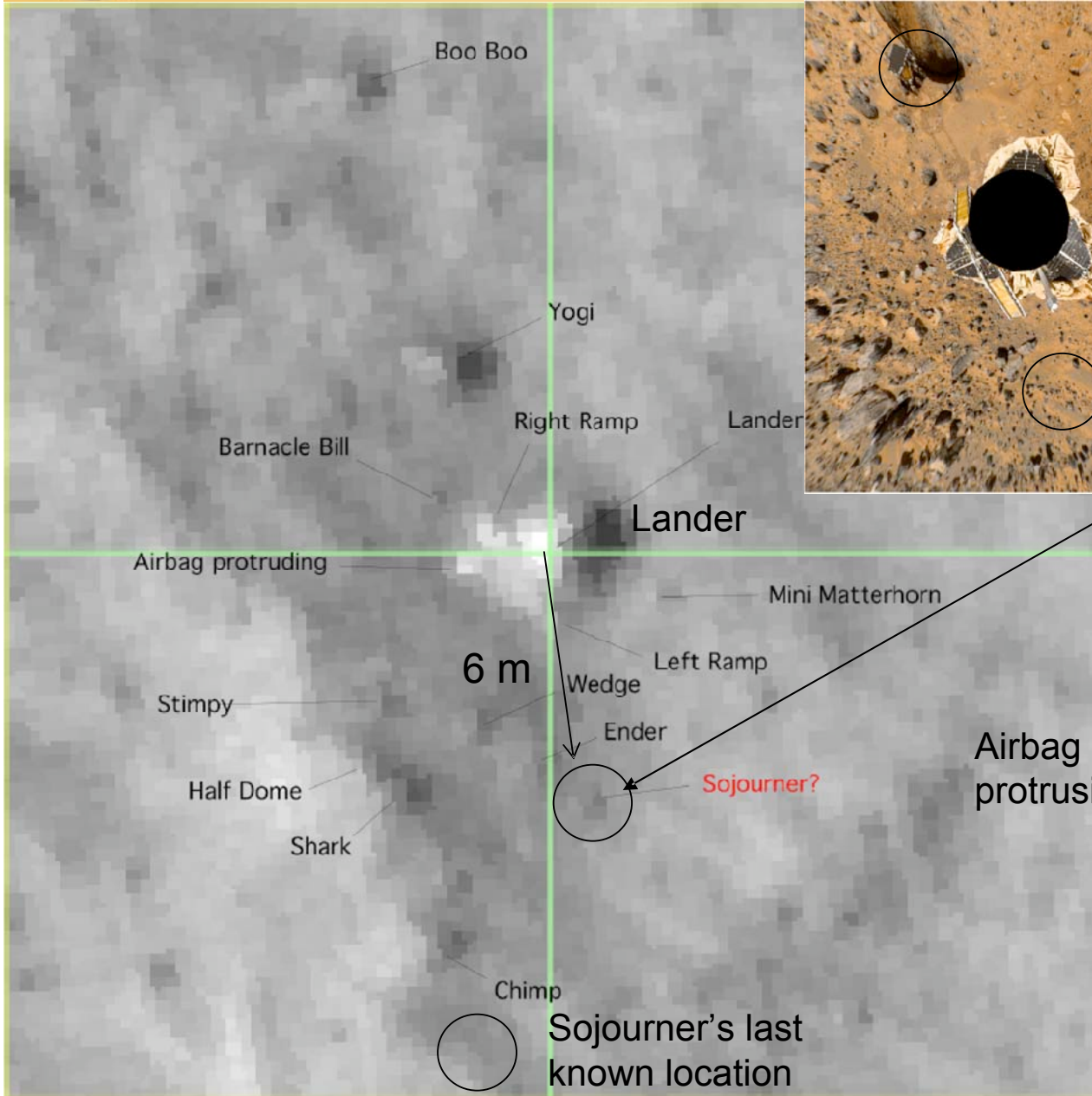
This is probably one of the four airbag “covers / thermal blankets” (each about 1.1 m in dia). The inside of this blanket was covered with highly reflective aluminized mylar.

It probably came off in one of the first stressful impacts and may be near the first impact location.

Same very bright object as seen in super-res image taken by MPF’s IMP camera (428 m away).

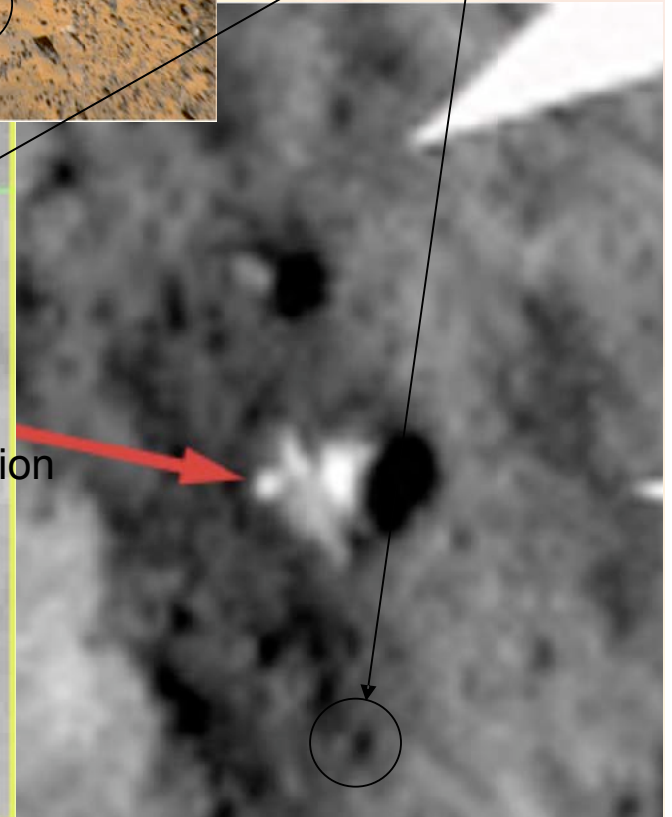


MPF Lander (& Sojourner?)



Is this Sojourner?

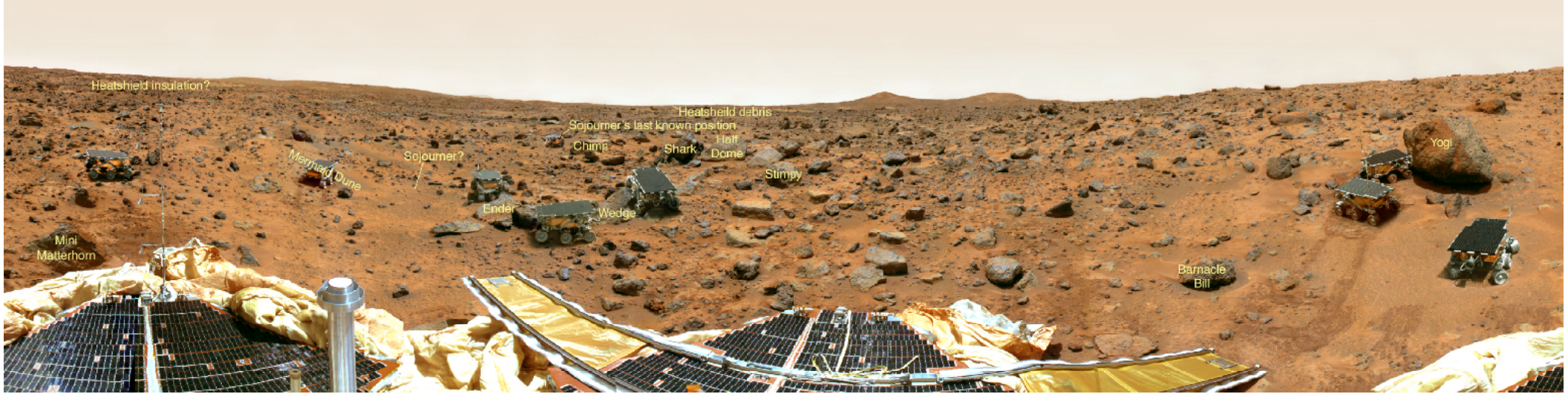
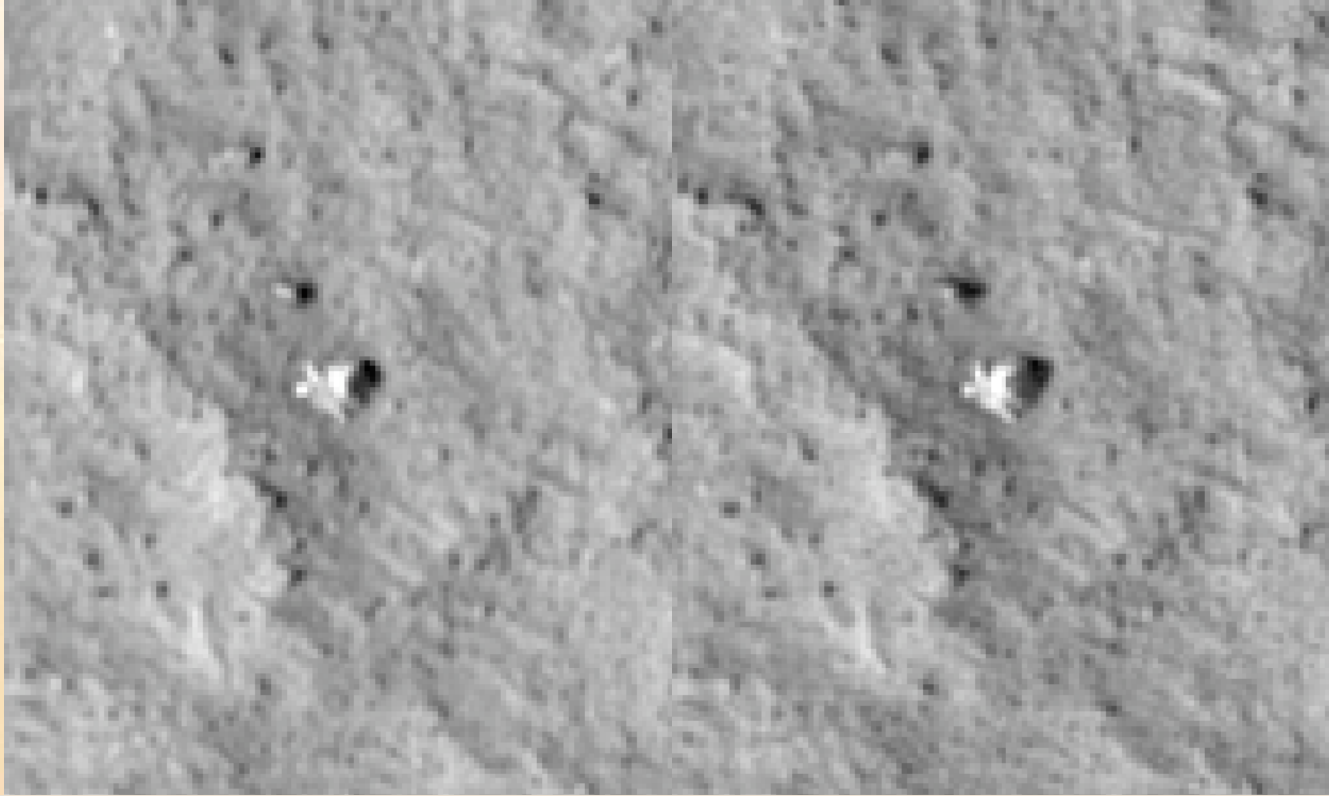
A color HiRISE image may confirm.

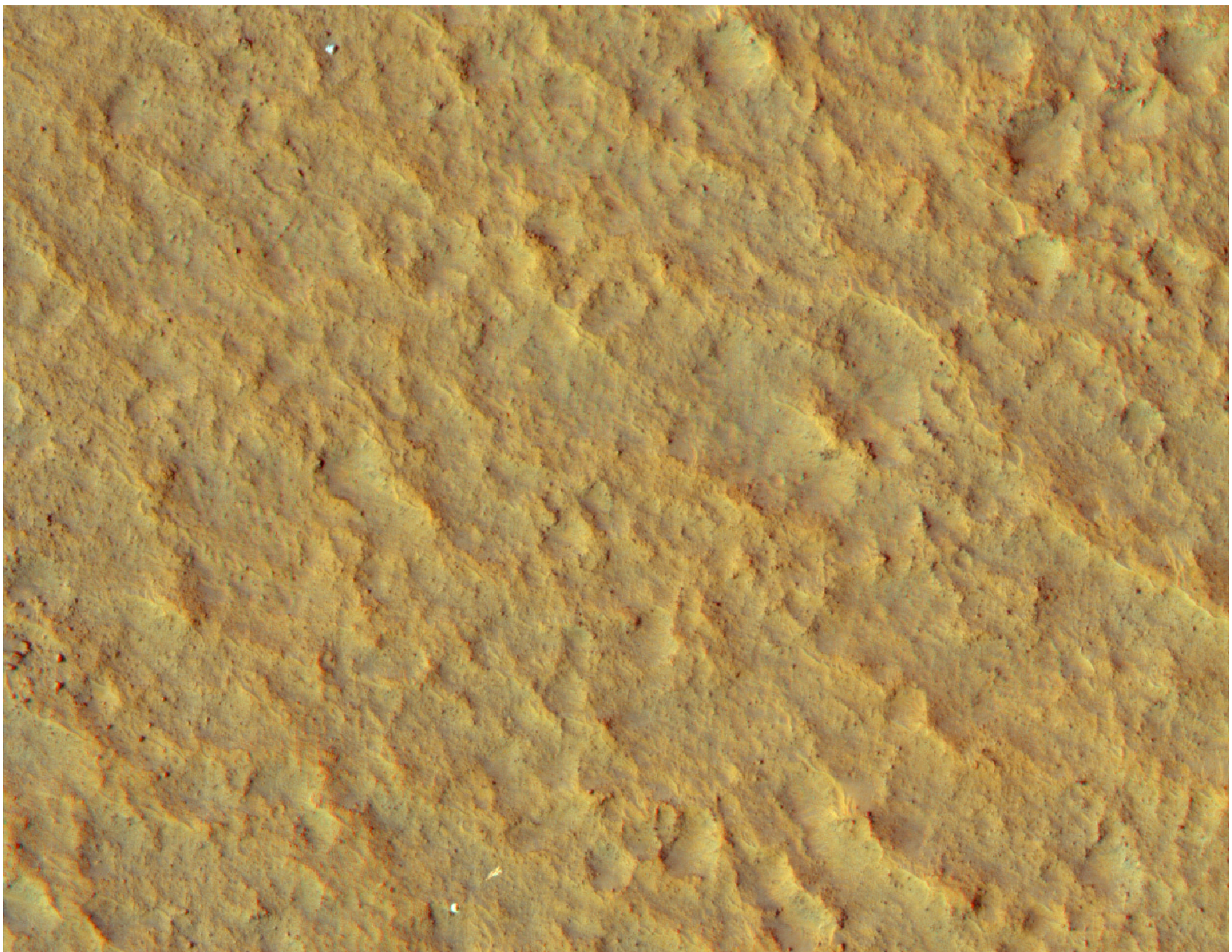


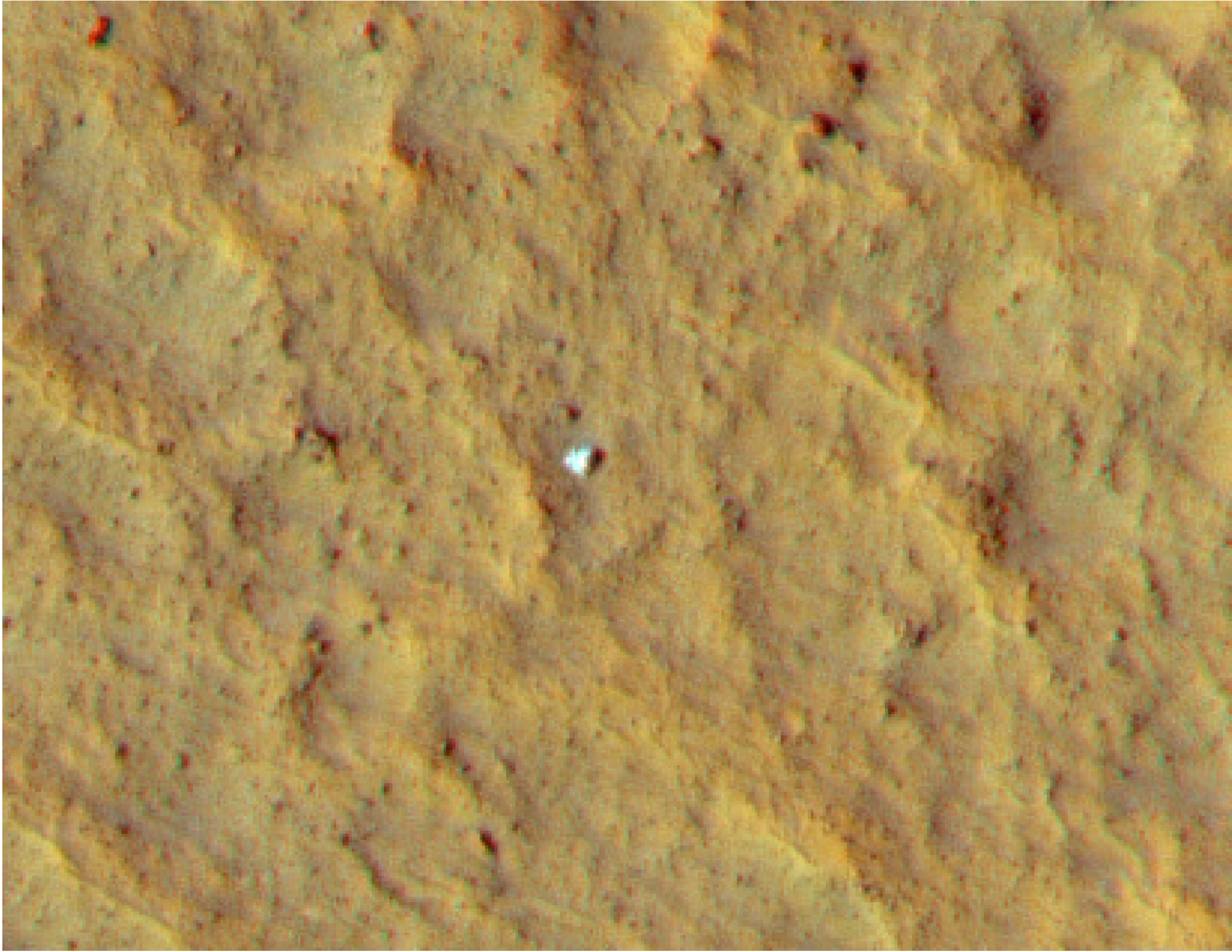
Airbag protrusion



MPF Lander (& Sojourner?)



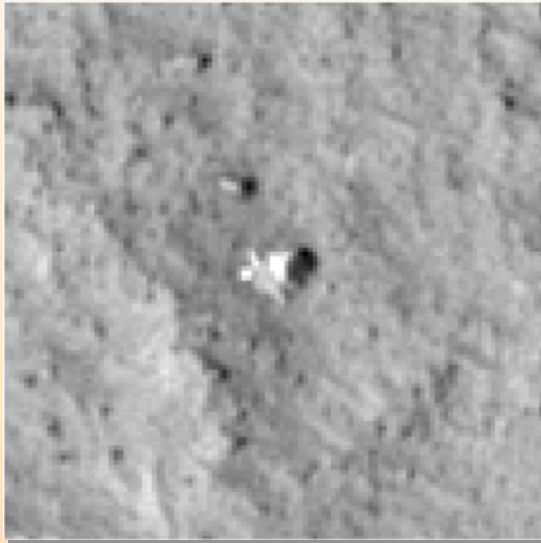




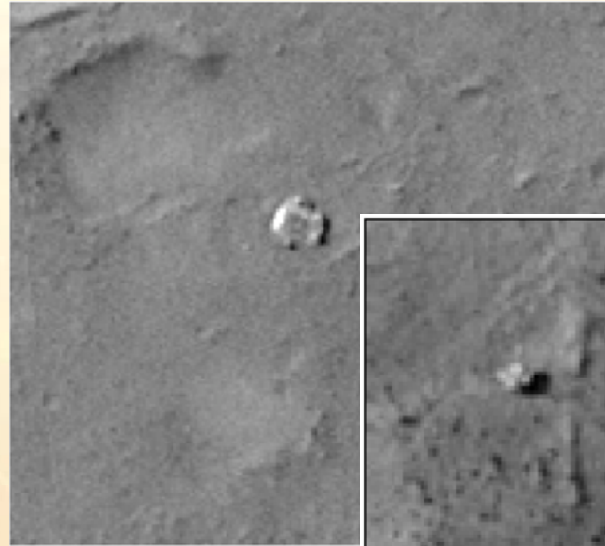


Landers & Rovers as seen by HiRISE

MPF



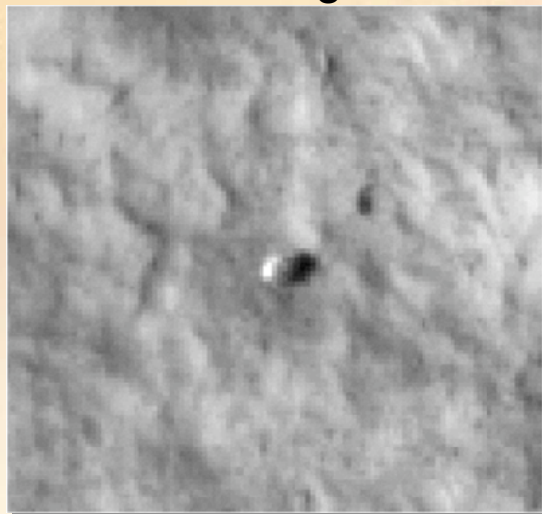
Spirit Lander & Rover



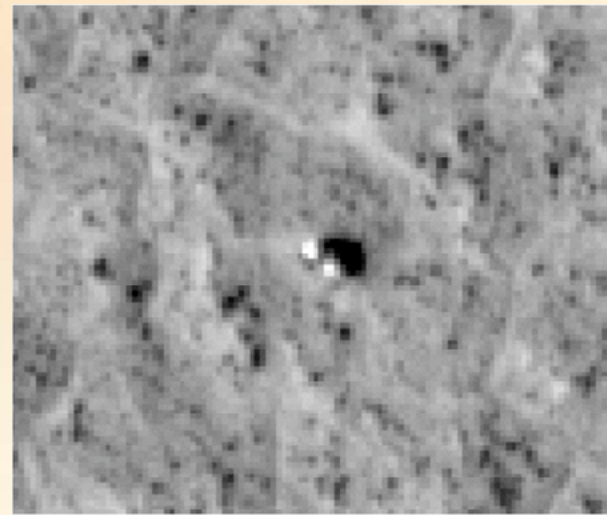
Opportunity Lander & Rover



Viking 1



Viking 2





Tentative MPF Conclusions

- *Positions of MPF's hardware are consistent with post-MPF trajectory reconstruction.*
 - *Per trajectory reconstruction in 1997, MPF arrived from the northeast (retrograde entry) - residual velocity and higher ballistic coefficient would have resulted in the heatshield landing around 1 km to the southwest of the first lander impact site.*
 - *Heatshield debris is about 0.9 km to the SE of the (presumed) airbag blanket*
 - *Per trajectory reconstruction in 1997, the best estimate of MPF first impact point was SE of the final MPF site. Rough estimates of acceleration during bouncing by Sam Thurman suggested NW initial direction and about 800 m of bouncing. (MPF did not have an IMU that could be integrated to gage position).*
 - *If the "Malin Object" (428 m from the lander) is indeed an airbag blanket and it came off in the early bounces, then the estimate of 1 km is long by a factor of 2, but it is in the correct direction. However the blanket may have come off half way during the bouncing. (bounced >15 times, for > 1 min)*
 - *Lander's airbags, ramps are clearly visible in the HiRISE image, however Sojourner is not so clearly visible. Why?*
 - *Dust on rover? However MPF parachute and airbag cover are still bright.*
 - *Future color HiRISE image will help.*
 - *Parachute and backshell appear nominal (very similar to MER's)*
- *No indication that MPF had any anomalies during EDL.*



Other Things And Stuff

*What are the Implications/prospects for locating other landers (Beagle 2, MPL, and the Soviet Mars 2, 3, and 6 landers) that didn't acquire ground images?

- HiRISE has shown us that landers, rovers, and even EDL hardware can be uniquely identified from Mars orbit,
*especially when we have ground images and radio tracking locations.
- For these other landers, we first have to know:
 - where on Mars to look
 - size of the search area
 - what to expect at those locations.
- Probably our best chance of identifying one of these landing sites is via the backshell and parachute. With the exception of VL-2, all of the successful landers' parachutes are bright objects in the HiRISE images (most of us expected the Viking, and possibly even the MPF parachutes to be obscured by dust after several years).
- It is likely that the MPL and Beagle 2 parachutes would also be bright, if they deployed, due to their relatively short time on Mars.





Other Things And Stuff (contd)

*What are the Implications/prospects for locating other landers (Beagle 2, MPL, and the Soviet Mars 2, 3, and 6 landers) that didn't acquire ground images?

- It will be interesting to see what HiRISE reveals at the site proposed by Malin in 2005 to be the MPL landing site (retracted by Malin a few months later).
- Beagle 2 may be impossible to definitively locate even if the landing site is captured with HiRISE, if the parachute didn't deploy.

*Of the three Soviet landers to reach Mars, Mars 2 is thought to have crashed, and its parachute is thought not to have deployed.

- Mars 2 and 3 weren't large vehicles - under 400kg. Mars 6 was over 600kg.
- Both Mars 3 and Mars 6 are thought to have successfully deployed their parachutes and reached the surface.
 - Mars 3 briefly transmitted telemetry data from the ground before failing.
 - Mars 6 is thought to have impacted at 60m/sec.

BUT: Conversations with Tom Duxbury and Randy Kirk suggest that our best knowledge of their locations is probably within an area on the order of 5 degrees in size.

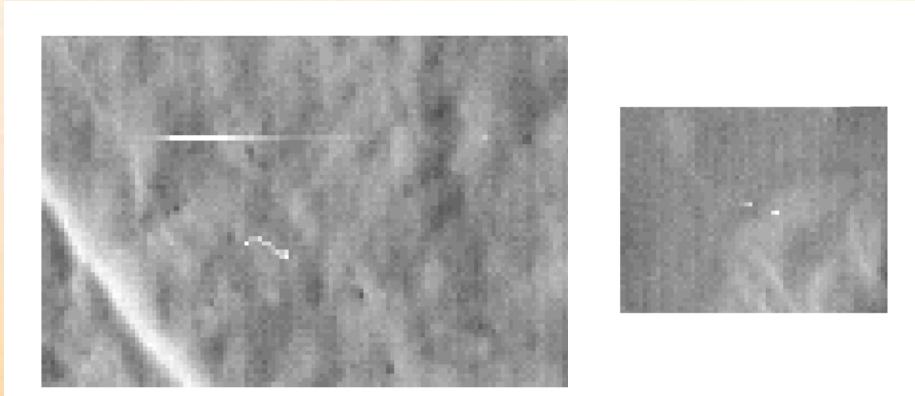
SO: If "data mining" old telemetry can't narrow the search areas down, it would take hundreds to thousands of HiRISE footprints to cover these large areas.

...but maybe we'll get lucky?



Parker gets an edjikashin

*Who'da thunk that cosmic ray hits on CCDs might look like "stuff"?



< Cosmic ray hits on Beagle 2 search image

Cosmic ray hits on star >
calibration images
(without Mars background)

