

# Mars Exploration Rover Mission

**Spirit  
and  
Opportunity**



**Week in Review  
July 3 - July 9**

**Opportunity made it to the sixth layer of different rock and soil inside Endurance Crater, and began analyzing the layer's composition.**

**Front view**    **SAME LOCATION**    **Rear view**

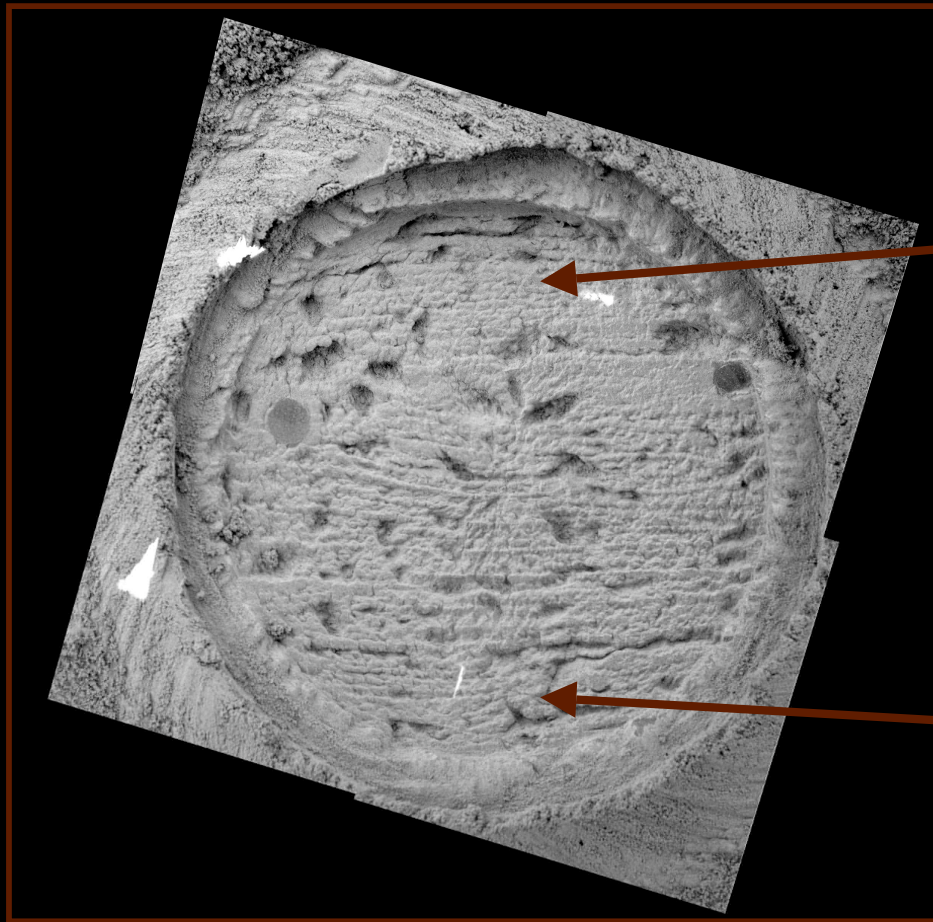


*Front hazard-avoidance camera image taken July 3, 2004.*



*Rear hazard-avoidance camera image taken July 3, 2004.*

**Rover scientists “read” the history of rock formation through vertical layer deposits. The rover is looking down on the crater slope, so the youngest material is actually at the bottom of the image.**



**The oldest material is further down the slope of the crater, and was deposited before the younger layers.**

**The youngest material was deposited more recently.**

*Microscopic image mosaic of the hole named “London,” looking down the slope of Endurance Crater. Image taken by Opportunity on June 24, 2004.*



Opportunity



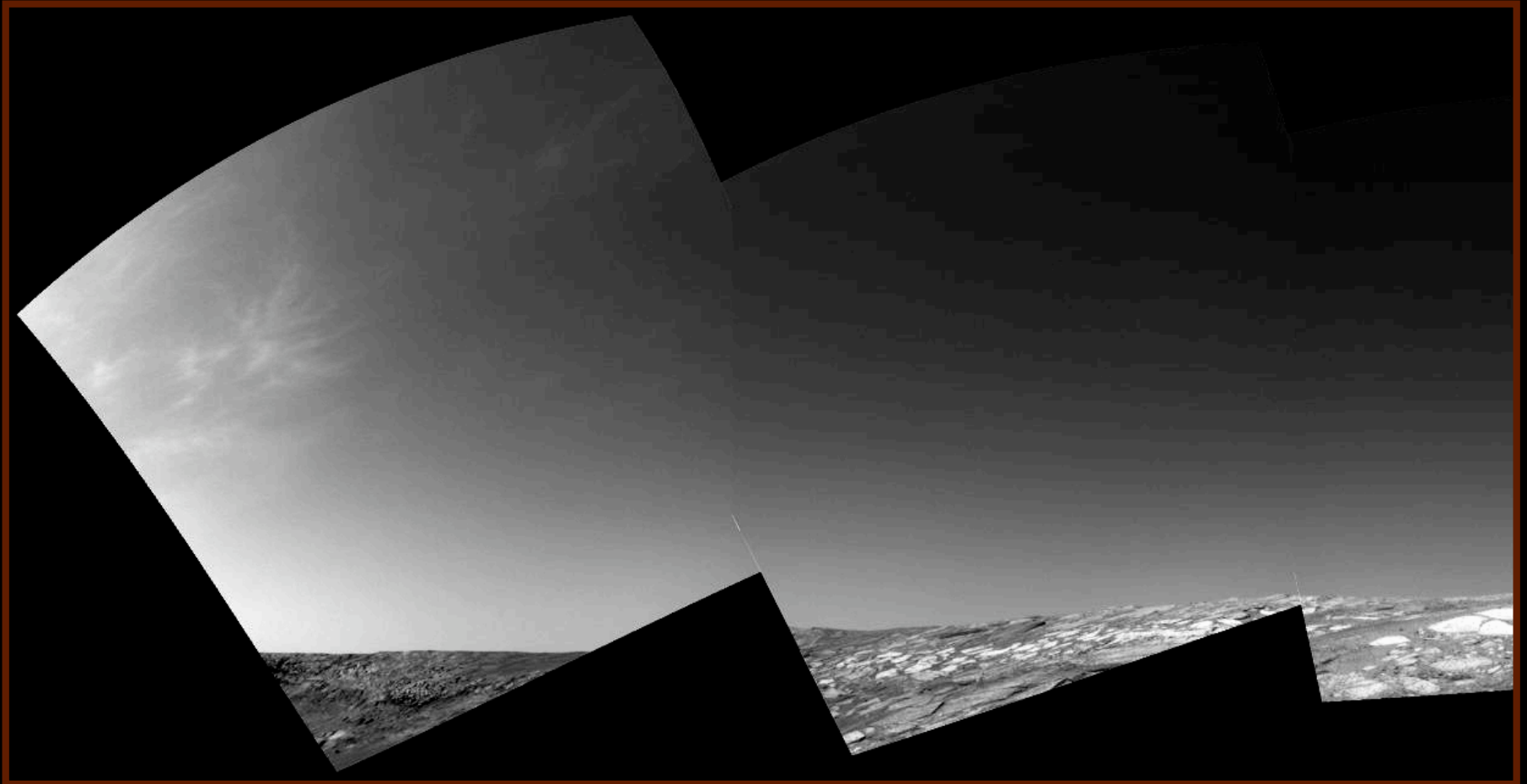
**Through their thorough investigations, scientists are also learning that the material inside Endurance Crater was affected by wind processes.**



*Navigation camera image taken on July 9, 2004  
By Opportunity inside Endurance Crater,.*



**Scientists spent the end of the week studying low clouds like these, which tell them a lot about weather on Mars.**

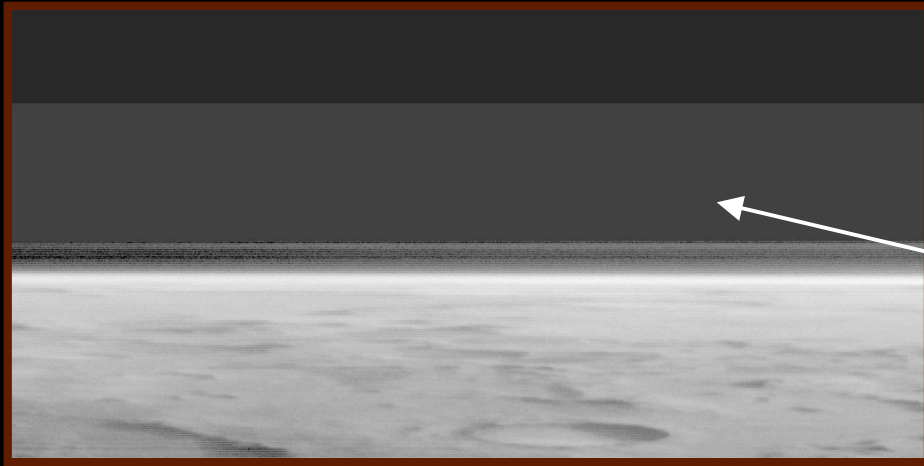


*Left navigation camera image taken by Opportunity inside Endurance Crater.*

**As winter sets in, the rovers can expect to see more clouds.**

## Mars has three kinds of clouds:

### 1) carbon dioxide clouds at very high altitudes

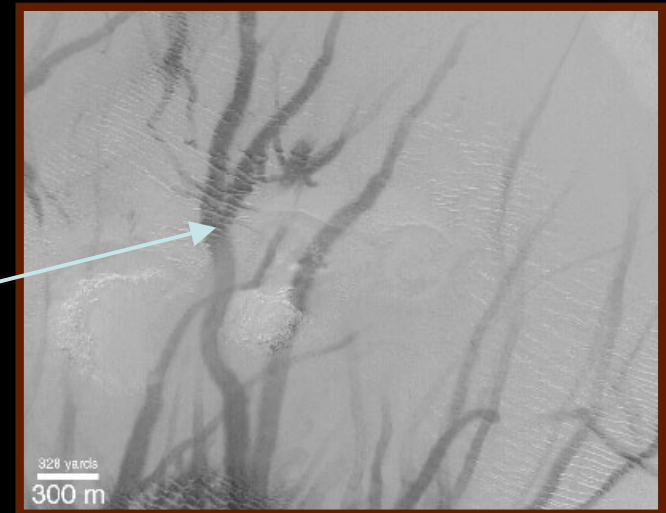


*Winter-time carbon dioxide haze, high in the martian atmosphere, Mars Orbiter Camera onboard the Mars Global Surveyor orbiter.  
Image credit: NASA/JPL/MSSS*

### 2) dust clouds low in the atmosphere



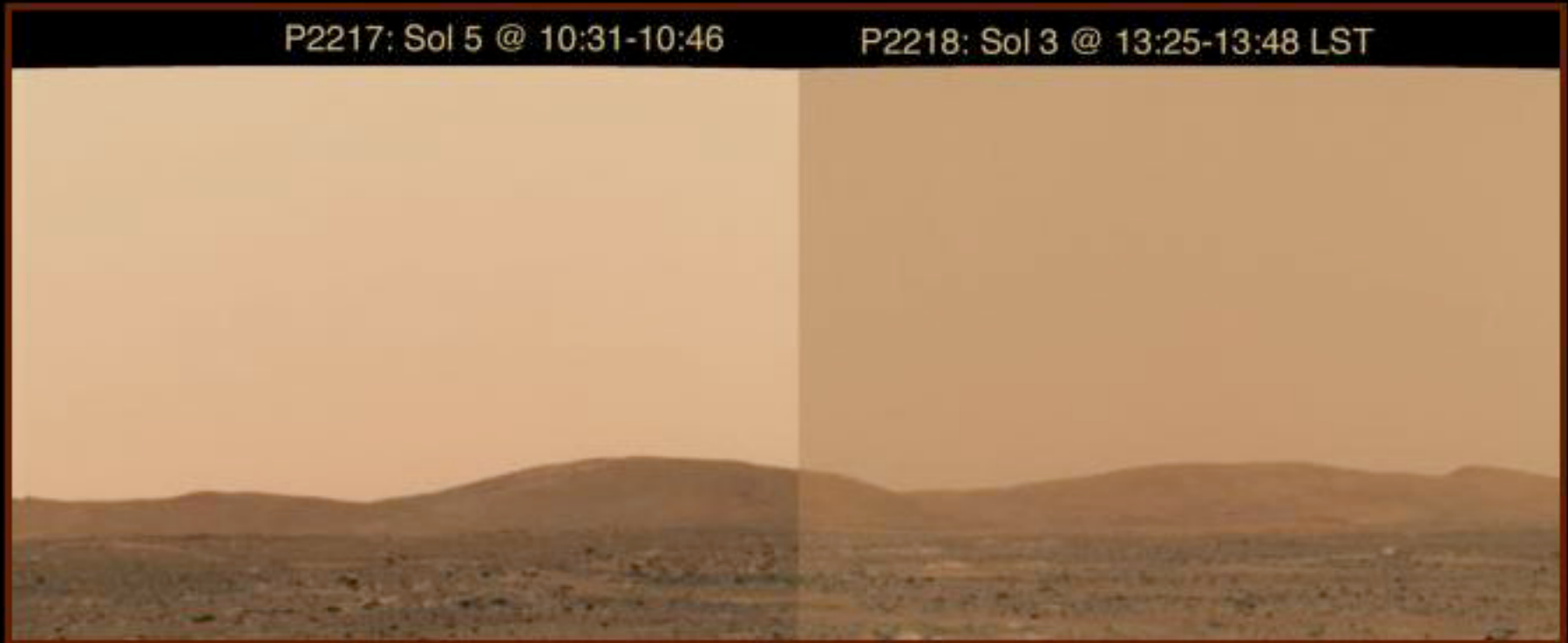
*Dark streaks on the surface of Mars formed by "dust devils" that are generated by wind and dust clouds  
Mars Orbiter Camera, Mars Global Surveyor  
Image credit: NASA/JPL/MSSS*



### 3) water clouds near the surface

*Morning clouds captured by the left navigation camera on Opportunity, inside Endurance Crater, June 28, 2004.*

**The rovers provide a unique opportunity to examine the lower portion of Mars' atmosphere, which is difficult to characterize from orbit.**

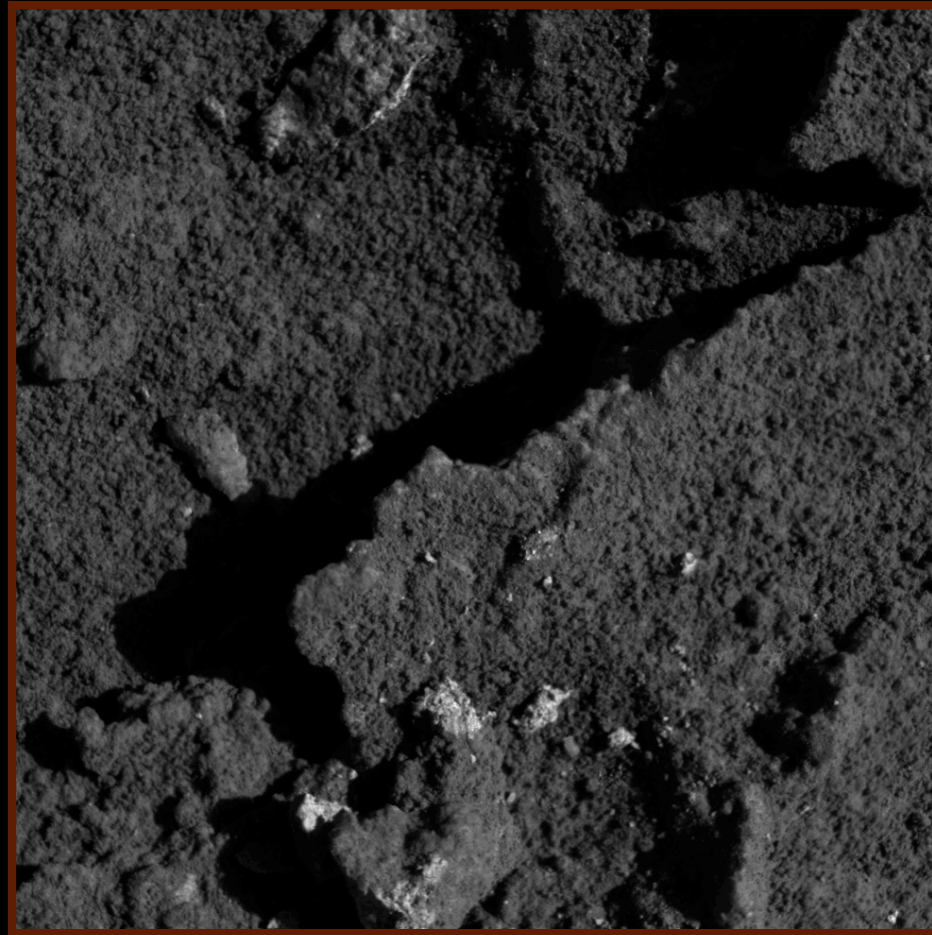


*Dusty martian skies captured by Spirit's panoramic camera on two different days in the first week of the mission.*

**The lower atmosphere is critical because that is where the atmosphere interacts with the surface.**



**Meanwhile, Spirit finished investigations of bright spots within the soil at the base of the Columbia Hills.**



*Microscopic image of "String of Pearls" taken on July 2, 2004.*

**Scientists believe the rocks exposed here may have been generated or modified by water-rich fluids.**

Spirit



**On July 7, 2004  
Spirit drove to  
“Engineering Flats”  
for a “tune up” that  
will last a few  
martian days.**



*Right navigation camera captures Spirit's shadow  
in the “Engineering Flats” area of Gusev Crater  
at 4:29 p.m. Local Solar Time on July 7, 2004.*

**During Spirit's "tune-up," engineers will heat and re-lubricate the right front wheel, because it is sticking, making it difficult to drive.**

*Rover assembly at  
Jet Propulsion Laboratory  
in 2003.*

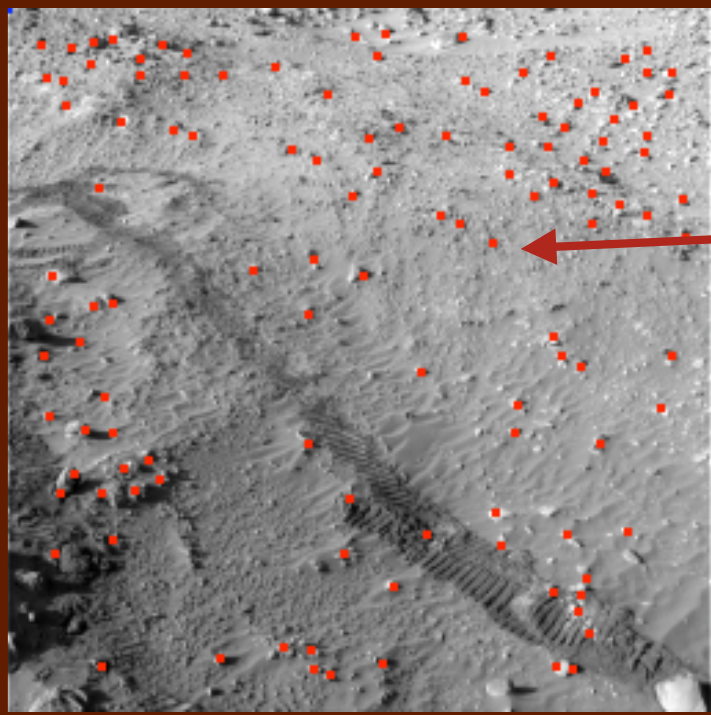


**Inside view of  
right front wheel.**

**In order to compensate for the slipping and sliding that is occurring with the sticky wheel, engineers have developed and are testing a new "visual odometry" technique.**



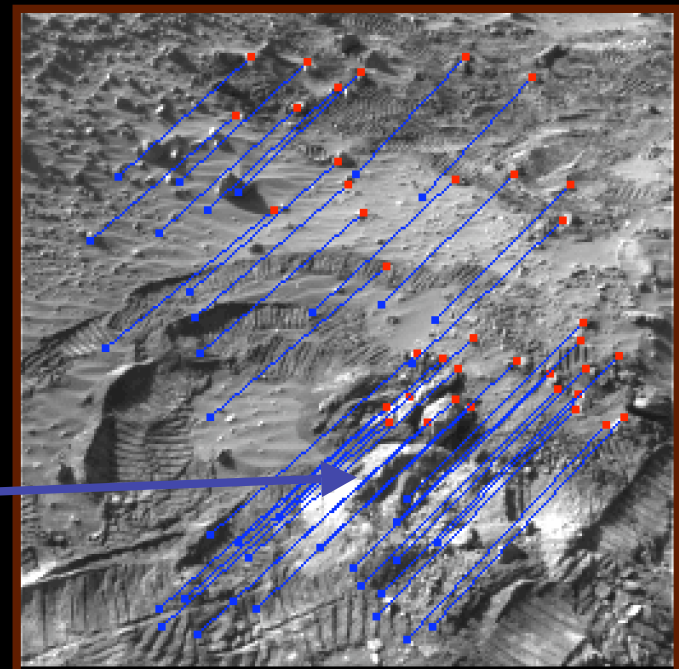
# Visual odometry uses navigation camera images to compute how far and in what direction the rover has moved while on “autopilot.”



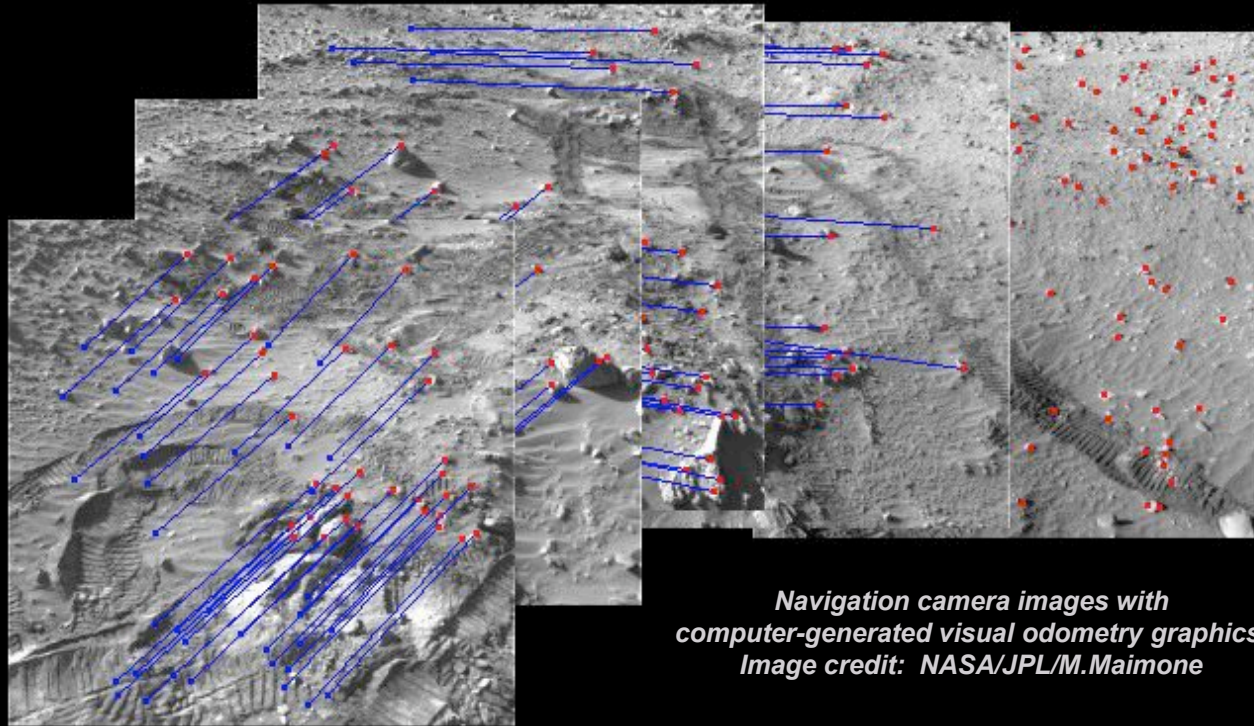
**Step 1: The onboard computer finds dozens of interesting features**

*Navigation camera images with computer-generated visual odometry graphics.  
Image credit: NASA/JPL/M.Maimone*

**Step 2: As the rover moves, it tracks the features across short steps (less than 1 meter or 3 feet).**



**Step 3: The onboard computer simultaneously measures distances and angles from the blue dots to the red dots, making a three-dimensional vector.**



*Navigation camera images with  
computer-generated visual odometry graphics.  
Image credit: NASA/JPL/M.Maimone*

**Due to slippage errors, this technique is better for Spirit to use while cruising on 5 wheels. Ordinarily, “wheel odometry” uses wheel rotation to calculate distance traveled, but a sticky wheel hinders accuracy.**

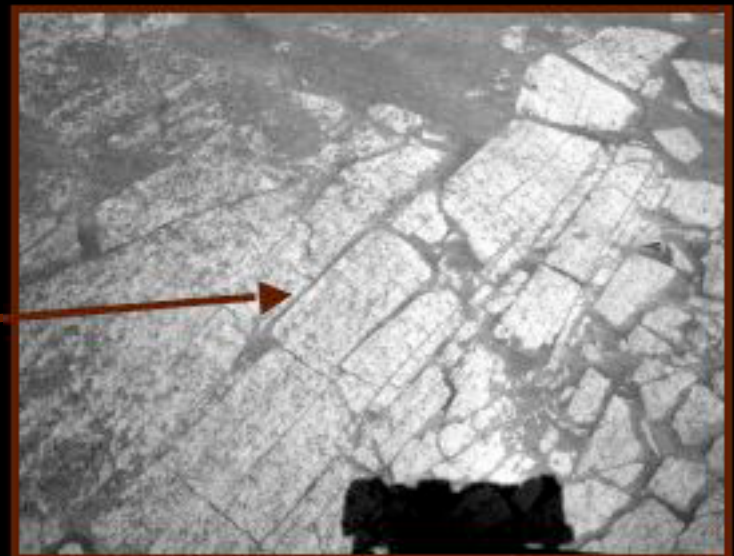


**Spirit will remain  
at “Engineering Flats”  
to continue its “tune-up.”**



*Front hazard-avoidance camera image  
taken by Spirit on July 9, 2004.*

**Opportunity will stay  
inside Endurance Crater  
to investigate more layers  
of rock and soil.**



*Navigation camera image  
with a shadow of Opportunity's camera mast  
taken July 9, 2004.*