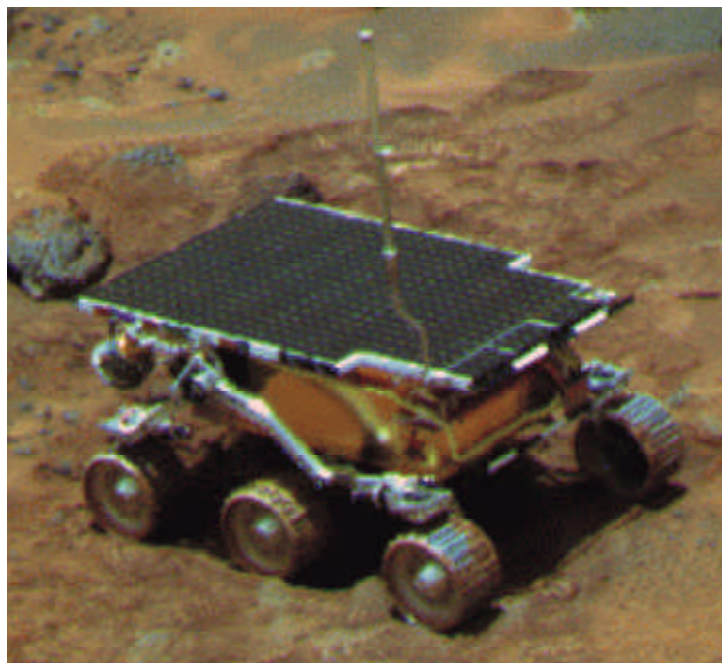


Results From Mars Show Electrostatic Charging of the Mars Pathfinder Sojourner Rover



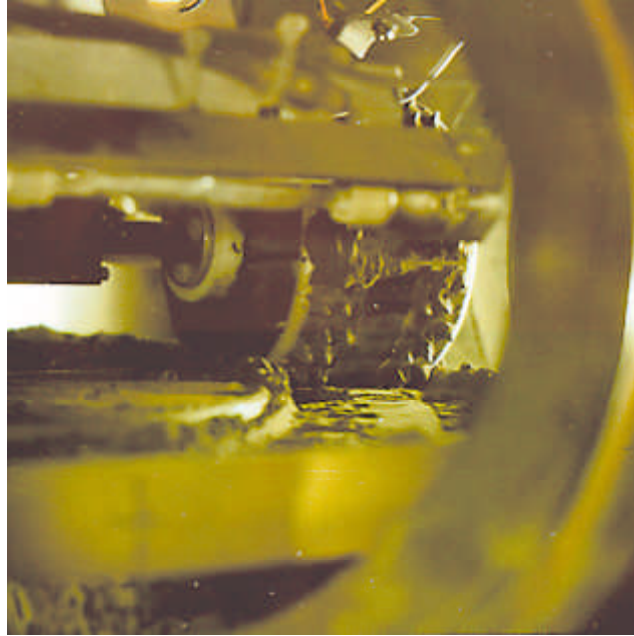
Sojourner rover at the end of sol 22. Fine red dust shows around the wheel edges.

Indirect evidence (dust accumulation) has been obtained indicating that the Mars Pathfinder rover, Sojourner, experienced electrostatic charging on Mars. Lander camera images of the Sojourner rover provide distinctive evidence of dust accumulation on rover wheels during traverses, turns, and crabbing maneuvers. The sol 22 (22nd Martian "day" after Pathfinder landed) end-of-day image (shown in the preceding image) clearly shows fine red dust concentrated around the wheel edges with additional accumulation in the wheel hubs. A sol 41 image of the rover near the rock "Wedge" (see the next image) shows a more uniform coating of dust on the wheel drive surfaces with accumulation in the hubs similar to that in the previous image. In the sol 41 image, note particularly the loss of black-white contrast on the Wheel Abrasion Experiment strips (center wheel). This loss of contrast was also seen when dust accumulated on test wheels in the laboratory (see the last image and ref. 1).



Sojourner rover on sol 41. Dust is uniform on the wheel drive surface. (Wheel detail is obscured.)

We believe that this accumulation occurred because the Martian surface dust consists of clay-sized particles, similar to those detected by Viking, which have become electrically charged. By adhering to the wheels, the charged dust carries a net nonzero charge to the rover, raising its electrical potential relative to its surroundings. Similar charging behavior was routinely observed in an experimental facility at the NASA Lewis Research Center, where a Sojourner wheel was driven in a simulated Martian surface environment. There, as the wheel moved and accumulated dust (see the following image), electrical potentials in excess of 100 V (relative to the chamber ground) were detected by a capacitively coupled electrostatic probe located 4 mm from the wheel surface. The measured wheel capacitance was approximately 80 picofarads (pF), and the calculated charge, 8×10^{-9} coulombs (C) (ref. 1). Voltage differences of 100 V and greater are believed sufficient to produce Paschen electrical discharge in the Martian atmosphere (ref. 2). With an accumulated net charge of 8×10^{-9} C, and average arc time of 1 msec, arcs can also occur with estimated arc currents approaching 10 milliamperes (mA). Discharges of this magnitude could interfere with the operation of sensitive electrical or electronic elements and logic circuits.



Sojourner rover wheel tested in laboratory before launch to Mars.

Before launch, we believed that the dust would become triboelectrically charged as it was moved about and compacted by the rover wheels. In all cases observed in the laboratory, the test wheel charged positively, and the wheel tracks charged negatively. Dust samples removed from the laboratory wheel averaged a few ones to tens of micrometers in size (clay size). Coarser grains were left behind in the wheel track. On Mars, grain size estimates of 2 to 10 μm were derived for the Martian surface materials from the Viking Gas Exchange Experiment. These size estimates approximately match the laboratory samples. Our tentative conclusion for the Sojourner observations is that fine clay-sized particles acquired an electrostatic charge during rover traverses and adhered to the rover wheels, carrying electrical charge to the rover. Since the Sojourner rover carried no instruments to measure this mission's onboard electrical charge, confirmatory measurements from future rover missions on Mars are desirable so that the physical and electrical properties of the Martian surface dust can be characterized.

Sojourner was protected by discharge points, and Faraday cages were placed around sensitive electronics. But larger systems than Sojourner are being contemplated for missions to the Martian surface in the foreseeable future. The design of such systems will require a detailed knowledge of how they will interact with their environment. Validated environmental interaction models and guidelines for the Martian surface must be developed so that design engineers can test new ideas prior to cutting hardware. These models and guidelines cannot be validated without actual flight data. Electrical charging of vehicles and, one day, astronauts moving across the Martian surface may have moderate to severe consequences if large potential differences develop. The observations from Sojourner point to just such a possibility. It is desirable to quantify these results. The various lander/rover missions being planned for the upcoming decade provide the means for doing so. They should, therefore, carry instruments that will not only measure vehicle charging but characterize all the natural and induced electrical phenomena occurring in the

environment and assess their impact on future missions.

References

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