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# NASA Perseverance Rover Detects Persistent 100-Nanometer Ultrafine Dust on Mars Spacesuit Samples

Mars * Perseverance Rover * Planetary Science

For more than four Earth years -- spanning 1,645 Martian days (sols) inside Jezero Crater -- NASA's Perseverance rover has carried five small swatches of astronaut spacesuit materials exposed directly to the Martian atmosphere. Mounted on the calibration target of the rover's robotic arm, these coupons of Vectran , Teflon (PTFE) , coated Teflon, Ortho-Fabric , and polycarbonate helmet visor plastic were designed to test how future spacesuits weather Martian ultraviolet radiation and surface grit.

In a study published in the Proceedings of the National Academy of Sciences (DOI: 10.1073/pnas.2620747123 ), planetary scientists analyzing microscopic images and X-ray fluorescence spectra from Perseverance's SHERLOC/WATSON and PIXL instruments report the first direct in situ detection of fine (<2.5 um) and ultrafine (100-300 nm) Martian dust grains clinging stubbornly to the spacesuit fabrics.

## Resolving the Sub-Micron Dust Regime

Prior to Perseverance's surface campaign, orbital spectrometers and lander sky-opacity cameras estimated the mean effective radius of suspended Martian atmospheric dust at roughly 1.5 to 3.0 micrometers (um) . By turning the WATSON microscopic imager and the Planetary Instrument for X-ray Lithochemistry (PIXL) onto the spacesuit calibration target, the research team resolved individual adhered particles down to 100 nanometers (0.1 um) -- roughly 700 times thinner than a human hair.

Time-series imaging across 1,645 sols revealed a sharp physical divergence between coarse and sub-micron dust behavior. While wind gusts, thermal convection vortices, and mechanical vibrations from rover driving periodically shook loose larger dust aggregates ("dust bunnies" exceeding 20-50 um), the 100-300 nm ultrafine fraction accumulated monotonically and remained permanently bound to the woven Teflon and Vectran fibers through triboelectric (electrostatic) charge attraction and van der Waals surface forces.

| Parameter / Particle Fraction | | Perseverance In Situ Measurement | | Engineering & Physiological Significance |

| Observation Baseline | | 1,645 Martian sols in Jezero Crater | | Continuous multi-season exposure on SHERLOC spacesuit calibration coupons |

| Coarse Aggregate Mode (>20 um) | | 20-100+ um flocculated "dust bunnies" | | Periodically shed by rover vibration and wind shear |

| Fine Respirable Fraction (PM 2.5 ) | | <2.5 um silicate and ferric oxide grains | | Bypasses human mucociliary clearance to reach deep pulmonary alveoli |

| Ultrafine Fraction (PM 0.1 ) | | 100-300 nm (0.1-0.3 um) | | Electrostatically

bound to Teflon/Vectran; capable of alveolar-capillary translocation |

| Elemental & Chemical Composition | | Fe-oxides, silicates, sulfates, Cl / perchlorates ($ClO_4$) | | Combines physical nanotoxicity with reactive oxidative and thyroid-disrupting chemistry |

## Respiratory Toxicology and Reactive Geochemistry

On Earth, occupational and environmental health standards distinguish between coarse thoracic particles (<10 um), fine respirable particles ( $PM_{2.5}$ , <2.5 um), and ultrafine particles ( $PM_{0.1}$ , <100 nm). While particles larger than 5 um are trapped in the upper nasopharynx and cleared by mucociliary transport, fine particles below 2.5 um penetrate deep into the gas-exchanging alveoli of the lungs. Ultrafine particles in the 100-300 nm window present an even steeper physiological challenge: their high surface-area-to-mass ratio allows them to cross the thin alveolar-capillary membrane directly into the bloodstream or migrate along the olfactory nerve tract.

PIXL elemental mapping confirmed that these sub-micron grains mirror the global geochemical signature of Martian regolith: an oxidizing mixture of amorphous silicates, nanophase ferric oxides (which give Mars its rust-red color), calcium and magnesium sulfates, and chlorine -bearing salts including perchlorates ($ClO_4$) , which competitively inhibit iodide uptake in the human thyroid gland.

## Designing Dust-Tolerant Habitats and Suitports

Because simple brushing or air-jet blowing inside a traditional airlock cannot dislodge electrostatically bound 100-nanometer particles from woven polymer fabrics, the Perseverance findings are directly informing NASA's Moon-to-Mars architecture. Countermeasures under development include suitport airlocks -- where the spacesuit remains docked to the exterior bulkhead of a pressurized rover or habitat while astronauts climb in and out through a rear backpack hatch -- alongside active electrodynamic dust shields (EDS) that use traveling high-voltage alternating-current waves to repel charged sub-micron grains before they can enter crew living quarters.

## References & Primary Sources

* [1] Proceedings of the National Academy of Sciences (PNAS). (2026). Fine and ultrafine Martian dust presents additional risks for future crewed missions to Mars. PNAS, 123, e2620747123. -- https://doi.org/10.1073/pnas.2620747123

* [2] NASA Jet Propulsion Laboratory (JPL). (2026). NASA's Perseverance Rover Measures Ultrafine Martian Dust on Spacesuit Material Samples. -- https://science.nasa.gov/mission/mars-2020-perseverance/

* [3] Bhartia, R., Beegle, L. W., DeFlores, L., et al. (2021). Perseverance's Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals (SHERLOC) Investigation. Space Science Reviews, 217(4), 58. -- https://doi.org/10.1007/s11214-021-00812-z

* [4] Allwood, A. C., Wade, L. A., Foote, M. C., et al. (2020). PIXL: Planetary Instrument for X-Ray Lithochemistry. Space Science Reviews, 216(8), 134. --

https://doi.org/10.1007/s11214-020-00767-7