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Impact glasses as a major reservoir for multi-sourced water on the Moon: Evidence from Chang'e-5 lunar soil

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Infrared spectrometers on Cassini, Deep Impact, and Chandrayaan-1 revealed widespread hydration on the lunar surface, primarily sourced from solar wind implantation. Solar wind implantation damages lunar grain structures, enabling implanted protons to form OH and H_2O, or exist as hydrogen atoms, referred to as solar wind-derived water. Additional contributions may come from indigenous lunar water and exogenous delivery by meteorites/micrometeorites, and comets. SOFIA observations at 6 μm confirmed the existence of molecular H_2O, which is more abundant at high latitudes and likely formed in situ from preexisting OH during micrometeorite impacts. Apollo and Chang'e-5 samples provided direct evidence of solar wind-derived water in minerals and impact glasses, though molecular H_2O has been identified only in one plagioclase grain. Impact glasses, formed during meteorite impacts, can retain solar wind-implanted water and record both impact and implantation processes. They serve as an important reservoir of solar wind–derived water, but the specific species and potential additional sources of water remain unclear, limiting understanding of lunar surface water formation and preservation. We report that large amounts of OH and molecular H_2O related to solar wind and other multiple sources are preserved in impact glasses from Chang'e-5 (CE5) lunar soil based on reflectance infrared spectroscopy and nanoscale secondary ion mass spectrometry analyses. The estimated water content contributed by impact glasses to CE5 lunar soil was ~72 ppm, including molecular H_2O of up to 15 to 25 ppm. Our studies revealed that impact glasses are the main carrier of molecular H_2O in lunar soils. Moreover, water in CE5 impact glasses provides a record of complex formation processes and multiple water sources, including water derived from solar wind, deposited by water-bearing meteorites/micrometeorites, and inherited from lunar indigenous water. Our study provides a better understanding of the evolution of surficial water on airless bodies and identifies potential source and storage pathways for water in the terrestrial planets.