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The inventory of OH and H2O in the non-polar regions of the Moon

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The image of a bone-dry surface in the Moon's non-polar regions impinged by the Apollo missions was changed by the detection of widespread absorption near 3 μm in 2009, interpreted as a signature of hydration. However, debates persist on the relative contribution of molecular water (H_2O) and other hydroxyl (OH) compounds to this hydration feature, as well as the cause of the potential temperature-dependence of the OH/H_2O abundance. Resolving these debates will help to estimate the inventory of water on the Moon, a crucial resource for future space explorations. In this study, we measured the abundance and isotope composition of hydrogen within the outermost micron of Chang'e-5 soil grains, collected from the lunar surface and from a depth of 1 m. These measurements, combined with our laboratory simulation experiments, demonstrate that solar-wind-induced OH can be thermally retained in lunar regolith, with an abundance of approximately 48–95 ppm H_2O equivalent. This abundance exhibits small latitude dependence and no diurnal variation. By integrating our results with published remote sensing data, we propose that a high amount of molecular water (~360 ± 200 ppm H_2O) exists in the subsurface layer of the Moon's non-polar regions. The migration of this H_2O accounts for the observed latitude and diurnal variations in 3 μm band intensity. The inventory of OH and H_2O proposed in this study reconciles the seemingly conflicting observations from various instruments, including infrared/ultraviolet spectroscopies and the Neutral Mass Spectrometer (NMS). Our interpretation of the distribution and dynamics of lunar hydration offers new insights for future lunar research and space missions.