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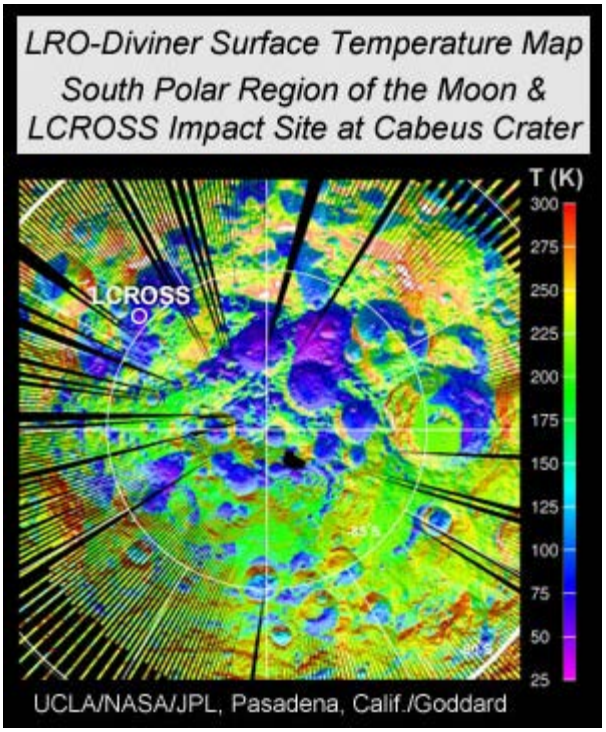
Quick Views of Big Advances

An Icy Treat--Water Ice Confirmed on the Moon

Six papers in the October 22, 2010 issue of *Science* report the newest combined evidence confirming water ice and a water cycle on the surface of the Moon. This conclusive confirmation comes from the results of seven science instruments on NASA's ***LCROSS/LRO*** mission that collected data from the plume of material kicked up from the two LCROSS impacts in 2009 into Cabeus crater located near the lunar south pole. The news comes a year after the announcement of the discovery of water and hydroxyl (OH) molecules on the Moon found by the Moon Mineralogy Mapper (M^3) instrument on the Indian Chandrayaan-1 spacecraft; a dozen years after the tantalizing indications of water, or at least hydrogen, in permanently shadowed craters gathered by spectrometers onboard the Lunar Prospector spacecraft and the radio experiment on the Clementine spacecraft before that. And some 40 years after the Moon was declared bone dry based on analyses of the rocks returned by the Apollo astronauts.



The LCROSS/LRO results show that 10-20% of the plume material was water and other important volatiles, including light hydrocarbons, sulfur-bearing species, ammonia, methane, carbon monoxide, and carbon dioxide. Never before have scientists considered the Moon to have such a complex and dynamic surface water cycle.

Lunar water ice is useful and a potential economic boon to future settlement and economic development. Considering that bringing a bottle of water to the Moon today would cost about $50,000--the cost per pound to launch anything off Earth to the Moon--accessible water at the lunar poles for use in life support systems or to make rocket fuel is a discovery of the greatest proportions. Speaking of proportions, there needs to be enough water. If the concentration of water in the lunar regolith is less than 1%, then it would hardly be cost effective to extract and use it. The LCROSS mission was designed to answer the questions of whether the concentration of water on the Moon is greater than 1% and where it is distributed. This month's *Science* articles report the answers. Using the combined thermal, infrared, visible, and ultraviolet spectral data, the research teams estimate the concentration of water ice in the regolith at the LCROSS impact site, Cabeus crater, is 5.6 ± 2.9% by mass. Yet some intensely cold craters, similar to Cabeus, have no sign of abundant hydrogen or water ice while other small patches of ice may lie outside the usual cold traps. The whole ensemble of available instruments indicate that water ice, though abundant in this permanently shadowed crater, is not uniformly distributed across the surface of the Moon. And more work is needed to understand how delivery processes or retention mechanisms may influence where the water ice survives on the surface of the Moon. Unquestionably, the discovery of the water and volatiles in the LCROSS ejecta plume is very exciting and the chemistry suggests a variety of sources (for example, solar wind, impacting asteroids or comets, or maybe even *in situ* chemical processing). The results of this research will spark new ideas and

ways to model and understand the lunar surface water cycle.

See: ***Science, v. 330, no. 6003***, p. 463-486, and the ***LCROSS website***.

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