Searching for water at the south pole of the Moon with a lunar impactor

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The idea that water on the Moon's surface would eventually migrate to the lunar poles and be cold-trapped there indefinitely was first proposed in the 1960's, and subsequent modeling has generally confirmed this possibility. The existence of such polar water deposits is critical for planning future lunar exploration and it has important implications for lunar science as well. However observations from the Earth and orbiting spacecraft have not been able to categorically confirm or deny the existence of ice in permanently shadowed depressions at the lunar poles. The next generation of orbiters such as LRO, Chandrayaan and SELENE, while making important observations, will be capable only of providing circumstantial evidence of water and its concentration, and the challenges of landing and operating a spacecraft in the extreme conditions of permanent night are considerable. We have studied a low-cost alternative approach similar to NASA's Deep Impact mission for enabling a direct detection of the existence of water in the upper few meters of the lunar subsurface. Our mission uses a 1000-kg spacecraft to impact the lunar surface at 2.5-3 km/sec from a geocentric trajectory. This impact will excavate a crater ˜20 meters in diameter, ejecting over 50 cubic meters of regolith. Assuming a few volume percent water, this ejecta would include several metric tons of ice. Spectral evidence for water may be found across the electromagnetic spectrum from microwave and infrared to ultraviolet. This could be derived from the immediate impact flash, vapor produced through secondary sublimation in the heated ejecta, and subsequent deposition as frost on the surface. Detection would be attempted using a wide variety of measurement techniques and facilities (the spacecraft itself carries no instrumentation). Preliminary calculations of detection limits indicate that lunar orbiting spacecraft (e.g., LRO, Chandrayaan, SELENE), other space-based observatories (e.g., HST, Spitzer, Chandra, Odin) and terrestrial telescopes might all be able to contribute to an international observational campaign to verify the existence of water on the Moon.