THE ASTROBIOLOGICAL SIGNIFICANCE OF IMPACTS ON THE MOON. D. Schulze-Makuch[1], [1]Center of Astronomy and Astrophysics, Technical University Berlin, Germany, dirksm@astro.physik.tu-berlin.de

Introduction: The Moon is thought to have formed by a gigantic impact about 4.5 billion years ago [1], which explains its inclined orbit, the high spin of the Earth-Moon system, the Moon's relatively low density, and the very low volatile and refractory elemental abundances [2]. The impact sputtering by solar wind ions, vaporization of lunar surface materials and outgassing from the surface produced an extremely thin atmosphere [3]. Due to its lack of water, the Moon is not considered to be a likely candidate for the origin or persistence of life. However, particularly the impact craters on the Moon are of importance to astrobiology, because many of their interiors hold lunar ice, and that ice may reveal evidence for the early evolution of life on Earth [4]. In addition, the ice will be critical for any future human habitation of the Moon [3]. Some of the interior of the craters may also hold preserved water from the Late Heavy Bombardment, especially if lunar rocks are not as dry as previously thought [5].

Lunar Ice in Impact Craters: The possibility for the preservation of ice deposits or other volatiles over geologic time scales on the Moon has been suggested previously [6], not only by degassing from the early Moon, but also by deposition from water-rich meteorite impacts near lunar poles [7]. Temperatures have been estimated to not exceed 40K in shadowed Moon craters holding frozen water molecules [8]. Presence of ice has been verified based on data from the Clementine and Lunar Prospector missions and some radar measurements with the Arecibo radio telescope, though some of the detected hydrogen may instead be solar wind implanted hydrogen and other volatiles rather than water ice [8,9]. Either way, Lunar Prospector instruments indicate unambiguous evidence for concentrations of hydrogen at both poles, especially in permanently-shaded areas at the south pole [9]. In analogy with Mars at least some of this hydrogen should be in the form of water ice [3].

Importance of Lunar Ice: The presence of lunar water ice provides future explorers the advantage for it to be converted into hydrogen and oxygen for rocket fuel. Several mining techniques have been discussed in the past such as mining the regolith-ice mixture from the permanently shadowed areas by using a transport rover, drag line bucket, or a combination of both. The material can then be loaded into a sealed vessel and heated by a solar furnace, while the released gasses are recovered and condensed into water. However, there is a better option if the goal is also to recover organic compounds within the water ice. Such a separation of organics from water, but also heavy metals and particulates, could be done using surfactant modified zeolite or nanofilters [3]. This approach would provide water that could be used for human consumption, but also ensure that its organic endowment can be analyzed. Thus, not only would we be able to recover organic material from comets that impacted the Moon long ago, but also determine the composition of ices from lunar craters, which are the *only* location where we might find evidence of very early Earth life. By discovering a rock fragment that was dislodged from Earth during a meteorite impact, which later landed on the Moon, we might unravel the origin of life riddle, and possibly even detect macromolecules before the first life form originated on Earth.

An Early Lunar Hydrosphere? Water seems to be more abundant in lunar rocks than previously thought [5] and some of the rocks also contain phyllosilicates [10], providing evidence of an early exposure to liquid water. This observation may be linked to vapor transport during degassing of a magmatic source region, or from a hybrid endogenic-exogenic process when gases were released during an impacting asteroid or comet impact [11]. A more speculative suggestion, entertained here, would be a significant accumulation of liquid water after an impact, or even the existence of an early Moon or Earth-Moon system hydrosphere. Evidence for larger-scale hydrological processes would be hard to find, because any resulting surface topography would be long erased by 4 billion years of pounding with solar wind and cosmic radiation. Nevertheless, the idea should be tested as it would be critical to know what happened to the water on the Moon early on, how much water the Moon retained, and for how long.

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