THE ROLE OF LARGE IMPACT CRATERS IN THE SEARCH FOR EXTANT LIFE ON MARS. H.E. Newsom[1,2], L.J. Crossey[1], M.E. Hoffman[1,2], G.E. Ganter[1,2], A.M. Baker[1,2]. Earth and Planetary Science Dept., [2]Institute of Meteoritics, Univ. of New Mexico, Albuquerque, NM, U.S.A.

Introduction: Large impact craters can provide conditions for access to deep life-containing groundwater reservoirs on Mars providing evidence for extant life on Mars. Mars habitability research focuses on identifying conditions where microbial life could have evolved or flourished, and organic molecular evidence of pre-biotic or biotic activity. Finding extant life is a more difficult question, as the current climate is either too cold or too dry on the surface [1]. However, the PREVCOM report [2] concluded the existence of favorable environments for microbial propagation on Mars could not be ruled out. They argued that habitable environments could form due to a disequilibrium condition, for example by a landslide or impact. Examination of such recent events in Mars history could lead to finding evidence that reservoirs containing extant life still exist on Mars. Deep aquifers have long been considered the most likely location for the current presence of life on Mars, and the detection of methane provides the most intriguing clue, but not definitive evidence for deep life.

Large Craters and access to deep reservoirs: Where to look then? Terrestrial analog studies and rover studies of craters on Mars show that large impact craters penetrated deep into Mars with likely connections to deep aquifers. Throughout Mars history heated lakes on Mars may have formed habitable Petri dishes where life could have potentially evolved in situ or flourished [3,4]. Lakes on Mars provided a habitat for organisms to flourish that evolved in another location on Mars, like deep aquifers or elsewhere in the solar system.

Lakes in impact craters could have remained liquid for thousands of years, even under cold conditions like today [3], especially with a denser atmosphere during favorable obliquity conditions or an impact induced atmospheric pressure increase. Larger diameter impact craters have more heat to power hydrothermal systems from impact processes, resulting in longer-lived lakes [3,4]. Larger and deeper lakes will also take longer to freeze under cold conditions. By analogy to Earth, deeply-sourced fluids could also have contained microbial life [5] and allowed the rapid colonization of a lake, even after the sterilization of the target rocks due to the impact. Additionally, deeply-sourced fluids can supply necessary components for life, including hydrogen, methane, hydrogen sulfide, and other elements used in chemolithotrophic metabolism [6, 7].

The discovery of phyllosilicates in martian terrains, including Gale crater lake sediments suggests relatively neutral pH surface water, conducive to terrestrial type life [8]. Furthermore, alteration materials in the relatively young basaltic martian meteorites suggest that waters equilibrated with basaltic rock in the deep crust will have a neutral pH [9]. Recent discovery of boron, a precursor for life, in veins of Gale Crater by ChemCam are also attributed to groundwater [10].

Supply of groundwater to a lake, in contrast to surface water, depends on the thickness of the penetrated aquifer, and the available supply of water. The largest uncertainty in groundwater flow calculations [11] is the regional permeability, which can vary over many orders of magnitude, especially if faults associated with craters penetrate the aquifers. Assuming a plausible permeability Harrison and Grimm, [11] calculate a flood volume of approximately 200 km^3 over a 30-day period delivered to a circular point source from a thick regional aquifer. This volume would fill a 70 km diameter crater to a depth of about 500 m in about 30 days. Shallow aquifers can also be accessed in craters, leading to late erosional features as seen on the Peace Vallis fan in Gale crater [12]. A recent denser atmosphere due to climate change may also have led to a better chance to preserve evidence of extant life from deep reservoirs [13].

Conclusions: Large impact crater formation can penetrate deep aquifers and create deep radial and concentric faults that can serve as fluid conduits, suggesting deposits on crater rims, central uplifts and on crater floors are likely places to look for evidence of extant life [4]. The ongoing mission of Curiosity in Gale and the possible traverse of the Mars 2020 rover from the floor of Jezero crater and up the crater wall could allow access to evidence of relatively recent life, although finding actual extant life is exceedingly unlikely. Studies of large terrestrial craters (e.g. Chicxulub) should be encouraged by NASA to better understand their deposits and deep structures that may be important on Mars.

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