THE EVOLUTION OF HABITABILITY IN SMALL ROCKY BODIES S. West[1], J.L. Noviello[1], S. Glaser[1], S. Dibb[1], L.T. Elkins-Tanton[1], and E. Shock[1,2], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, [2]School of Molecular Sciences, Arizona State University, Tempe, AZ

Introduction: Life and the possibility for its existence beyond Earth are driving forces behind much of space exploration. Outer solar system moons and small icy bodies are often cited as potential present-day abodes for life, but an understanding of the evolution of the possibility of life on these and smaller planetesimals remains elusive **[1,2]**. We showcase a new paradigm for considering the habitability of small rocky bodies by modeling the evolution of conditions suitable for life on small planetary bodies.

Justification for Life on Small Bodies: We target small, rocky bodies in our study because of their presence throughout solar system history, evidence of aqueous alteration from meteorite samples, and remote sensing observations of water ice on some asteroid surfaces. Because terrestrial planets generally form within the dry part of the protoplanetary disk, volatiles are probably delivered to their surfaces via exogenic sources **[3]**. However, subsequent missions targeting comets have measured deuterium–hydrogen (D/H) isotope ratios that are at least twice as great as those found in Earth's hydrosphere, indicating that comets may not be the source of terrestrial volatiles. Recently, the idea that small bodies can contain independent reservoirs of water has been proposed as an alternative **[4]**. The meteoritic record shows evidence of the aqueous alteration of minerals, suggesting the presence of liquid water at some point in their history **[5]**. Furthermore, NASA's Dawn mission revealed the presence of water ice in the subsurface of the dwarf planet Ceres, and smaller asteroids that formed inside the snow line have water in the form of hydrated minerals **[6,7]**, providing more evidence for a potentially habitable environment. Future asteroid sample return missions will visit asteroids and measure their D/H ratios to test the hypothesis that small rocky bodies could have supplied volatiles such as liquid water to a terrestrial surface. We propose here that there is a size range of planetesimals that can sustain liquid water in their interiors.

Definitions and Method: Many complex factors affect the origin, evolution, and persistence of life. Our study focuses on temperatures ranging between 0 and 120 °C, conservative estimates for the temperature range survivable by known terrestrial life, with a pressure range that permits stable liquid water. In small planetary bodies, we define a spherical shell bound by two radii at which the conditions are met as the 'potentially habitable shell' (PHS). We define these bodies as undifferentiated and of rocky composition. To study the PHS, we visualize this shell and its migration over the history of a rocky body using an HS-diagram (Fig. 1), inspired by figures from **[8]** and **[9]**. This differs from previously reported plots in that pressure rather than depth is examined as a function of time. This diagram is applicable to the changing nature of any planetary body by plotting the changing depth at which conditions favorable for known life exist. The three regions represent different zones of solvent stability, including frozen, liquid, and vaporous, with internal heating initially provided by the decay of ^{26}Al **[10]**. Geophysical modeling of the internal evolution of bodies with a range of sizes and compositions is used to assess the potential habitability of objects falling within the range of known asteroids or Kuiper belt objects and the postulated range of planetesimals.

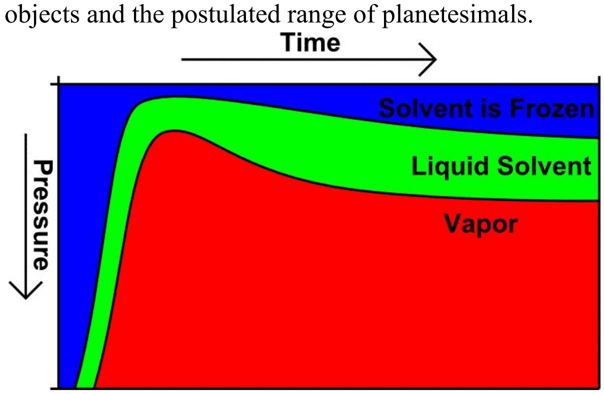

Figure 1. The Habitability Shell Diagram

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