SEEKING EARTH-DERIVED BIOSIGNATURES ON THE MOON: SCIENCE CASE AND OPERATIONAL CONSIDERATIONS P.J. Boston[1] and G.K. Schmidt[2], [1]NASA Astrobiology Institute (NAI) penelope.j.boston@nasa.gov, and [2]Solar System Exploration Virtual Institute gregory.schmidt@nasa.gov, NASA Ames Research Center, Moffett Field, CA 94035.

Introduction: We know that major impacts on Earth have the capability of lofting material out of Earth's gravity well and into space. Some of that material undoubtedly has made its way to the Moon and this notion has been suggested [1,2,3]. Further, we can conjecture that at least some of the ejecta from such events may contain biomolecular and possibly even structural paleontological information. However, questions immediately arise as to whether such materials could have been delivered in sufficient quantity in predictable locations [4] for us to find. Further, can such materials have survived the harsh lunar environment in a condition that would allow identification and interpretation?

In recent decades, mission prospects for direct examination of lunar materials has not presented itself and these ideas have been interesting intellectual exercises. However, our potentially enhanced cadence of lunar exploration in the near future, as we approach the second quarter of the 21st Century, provides impetus to contemplate further refinement of the broad scientific case. Critically, it is time to examine whether prospects exist for practical ways in which to search for fossil/biogeochemical/mineralogical evidence of Earth's many biological epochs, some of which are poorly represented on Earth because of the dynamism of our aqueously dominated geological context. Such collections of paleontological material on Earth that are derived from different locations and/or times is termed a thanatocoenosis (i.e. "death assemblage") and that is essentially what we posit for the moon [5, 6].

Relevant Scientific Advances: In the past 20 years, a few plausibility experiments have been conducted and models produced to attempt to understand prospects for various aspects of a lunar repository of biologically significant material from Earth [7]. Notably, work on the survivability of organics and microorganisms (at least as recognizable if not alive….) to various environmental challenges that would beset transfer of biologically significant materials from Earth to the Moon have been examined. For example, organics have been shown to survive impact including hopanes, pregnanes, steranes, anthracene, phenanthrene, methylanthrene, n-alkanes and more [e.g. 8, 9]. Microorganism survival under impact conditions has received some attention partially because of concerns about planetary protection but the results are relevant to the lunar preservation case [10-13]. Plant seeds have been shown to leave intact organic and structural remains upon simulated impacts, albeit no viable seeds survived [14, 15]. Finally, although not tested under impact conditions, lichens have shown ample capabilities to survive in space conditions [16] and are well known to be extremely structurally tough drying well, although not fossilizing well on Earth because they occur in non-depositional geological contexts where preservation has not occurred on Earth.

Very recently, the claim of an Earth-derived Apollo sample has been made [17]. If true, this lends credence to the notion that early Earth materials of significance to origins of life on Earth and astrobiology in general may be found on the moon. A previous paper, investigated another potential find of non-lunar material in a lunar meteorite and speculated about a planetary origin for the clast studied [18]. This leads us to wonder if some astrobiologically significant lunar material could even reside in our current repository of Apollo samples and lunar meteorites.

Protection and Possible Sites for Searches: We hypothesize that permanently shaded regions (PSRs) and their potential ice deposits, caves as lavatubes or pits, large buried intact clasts from impactors, and material deposited very early in the Earth-Moon system covered by later lunar material are protected locations that could conceivably yield specimens of paleobiological/astrobiological significance. Based on prior work [1, 4] and assessment of most likely locations of Permanently Shaded Regions and visible subsurface terrain (lavatube caves and pits), we suggest lunar sites where high probability of deposition overlaps with relatively more protected sites that are less subject to solar space weathering.

Suggested Approaches to Analyses: What next? Future missions will be of many different types, both robotic and crewed. We will present 4 possible scenarios under which astrobiologically/paleontologically significant material may be part of missions devoted to other primary goals. Additionally, we present a suggested set of ground-based studies that would enable the relevant scientific community to be ready to appropriately participate in the analysis of lunar materials for the purposes laid out here.

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