

Biomarker Production and Preservation on Europa

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Abstract

Here, I address the production of biomarkers, the evolutionary path such a signal may undergo, and what considerations this yields for the selection of landing sites, sampling techniques, and sample analyses that march us towards a definitive detection of life.

1. Introduction

Landing on the surface of Europa, and one day exploring its deeper subsurface, are lauded goals in the exploration of the solar system. For now it seems, we may be confined to the surface and shallow subsurface, where both endogenic and exogenic factors exist that could complicate our picture of the habitability of Europa and whether life itself can be detected. In order to assure high science return from a future landed mission, we must carefully consider what the nature of any material sampled may have been. A number of authors have discussed related topics in the literature, including considerations of surface age and roughness [1], radiation and chemical processing [2] and the chemistry of the ocean [3,4], etc.

2. A Working Model

It is difficult to confidently define a model for Europa (or other ocean worlds) from which we might hope to derive landing site selection and sampling techniques, given that most of our experience in searching for life is derived from a very different perspective—that of a terrestrial planet. For Mars, such a perspective is helpful. We understand sedimentology, hydrology, tectonics, wind erosion and other factors that effect the history of the planet that we experience. However, at least at the surface, the habitability of the systems we study are largely depositional, or at least constrained to the outer veneer of the planet. On Europa, the scenario is quite the opposite, where the surface is passively experiencing communications from the putative

habitable niches below that extend throughout the ice shell and ocean and sea floor. Europa, except in some limited cases, may not be “depositional.”

In this work, I approach Europa based on the many hypotheses we have that govern the generation or support of life, the processes that occur within the sea-floor, ocean, and ice and exchange between them, and the geologic hypotheses for the formation of its various surfaces to establish, for each case, what journey through the planet the biomarker, might take to arrive, if possible, at the surface where it is accessible to near-term landed mission.

Biomarker production: I first consider the nature of the environment, i.e. at the sea floor interface, the ocean, or ocean-ice interface, in order to establish what the likely “biomarker” could be for that system.

Biomarker pathways: Then I trace its path through the system: any downwelling through the subsurface, mixing through the ocean, and pathways to the surface. And while looking for surface deposits from plumes or emplaced material is part of the story, it is potentially dangerous to trust our intuition that the surface will be simple or easy to interpret without a three dimensional context.

Biomarker concentration or destruction: Importantly, many models exist for the production of Europa’s surface and subsurface geology that could affect the integrity of a putative biomarker. Often we modulate such considerations as a function of the time-scales over which the geologic process occurs, however such processes will vary in terms of transportation efficiency, and the processing of the ice and water that is incorporated into the ice shell. Thus I seek to provide simple constraints and considerations for leading mechanisms (i.e. diapirism, convection, subsumption).

3. Implications

The goal of this project is to construct a simple model through which to consider the context for

sampled material that will provide us with the ability to identify limitations in our intuition, understanding of the Europa system, our current hypotheses and data, and provide a road map for developing both areas for new research and identifying technology gaps that we must overcome before we can confidently select a landing site or analyze a sample from the near surface of Europa. There has been great progress in modernizing our ideas of how Europa works: its surface dynamics [5,6], ocean dynamics [7], and chemistry [4]. These new advancements improve the fidelity of the efforts described here. I will also comment on synergies between the upcoming JUICE and Europa Clipper missions, any putative landed mission, and how these missions could provide invaluable data that allows us to get beneath Europa's icy skin in relatively short order.

Figure 1: Regions of likely biomarker production, entrainment, and processing for a thick ice shell.

References

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