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Life habitability in the solar system: testing the universality of biology on Europa with microprobes or landers

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Introduction

We discuss whether it is possible to test the universality of biology, a quest that is of paramount relevance for one of its most recent branches, namely astrobiology. We review this topic in terms of the relative roles played on the Earth biota by contingency and evolutionary convergence. We raise the related question of whether the molecular events that were precursors to the origin of life on Earth are bound to occur elsewhere in the solar system, wherever the environmental conditions are similar to the terrestrial ones. The set of hypotheses for addressing the question of the universality of biology can be tested by future experiments that are feasible with current technology. We focus on landing on the Jovian satellite Europa and its broader implications, including selecting a landing site. We also discuss the corresponding miniaturized equipment that is already in existence. The significance of these arguments needs to be put in a wider scientific perspective, which is one of the main objectives of this work (Chela-Flores, 2007). The second objective is to discuss in more detail whether sulphur traces on Jupiter's moon Europa could be of biogenic origin, and could be tested with the present level of technology readiness (Chela-Flores, 2006, Cosmic Vision, 2005).

Core

The compounds detected by the Galileo mission on the icy surface of Europa have been conjectured to be endogenic, most likely of cryovolcanic origin, due to their non-uniform distribution in patches. We argue that the study of these patches should be one of the priorities of the Jupiter exploration programme envisioned in the ESA report (Cosmic Vision, 2005). The Galileo space probe first detected the sulphur compounds, and at the same time revealed that this moon almost certainly has a volcanically heated and potentially habitable ocean, hiding beneath a surface layer of ice. In planning future exploration of Europa there are options for sorting out the source of the surficial sulphur. For instance, one possibility is searching for the sulphur source in the context of the study of the "Europa Microprobe In Situ Explorer", EMPIE (Velasco et al, 2005), which has been framed within the ESA Jupiter exploration programme (Cosmic Vision, 2005, Sec. 5.1.3). It is conceivable that sulphur may have come from the nearby moon Io, where sulphur and other volcanic elements are abundant. Secondly, volcanic eruptions in Europa's seafloor may have brought sulphur to the surface. Can waste products rising from bacterial colonies beneath the icy surface be a third significant alternative factor in the origin of the sulphur patches on the Europan surface? Provided that microorganisms on Europa have the same biochemical pathways as those on Earth (evolutionary convergence), it is possible over geologic time that autochthonous microbes can add substantially to the sulphur deposits on the surface of Europa. We raise several questions: Why should the search for biosignatures focus mainly on the sulphur isotopes? Would a combination of sulphur and carbon isotope anomalies give the best biosignature that would show that biology is involved? We argue that sulphur is unique amongst the main biogenic elements, in the sense that sulphur, unlike carbon, shows a very narrow range of values (about zero per mil) in isotopic fractionation in extraterrestrial material (lunar fines and meteorites). An additional question raised by our proposed selection of sulphur isotopic fractionation, rather than the corresponding analysis in terms of carbon, is: Can you accept some contribution of sulphur from Io, and still find the biogenic fraction in those sulphur deposits? We are assuming from terrestrial and meteoritic data that only biogenic processes can alter the standard (CDM) null values of the isotopic sulphur fractionation. Consequently, the contribution from the exogenous sulphur originating from the volcanic activity of Io would not give the telltale signals for life that would otherwise be produced by endogenous sulphur, if it were the product of bacterial metabolism. The proposed tests for biosignatures can tolerate some exogenous sulphur, and still identify biogenic sulphur, as we have suggested above by searching along vents or cracks, where sulphur would be concentrated. This approach suggests significant strategies for identifying those places where future microprobes, or landers, could search for the biosignatures. The most likely sites would be where the salt deposits, or organics are concentrated, as suggested by the Galileo data. For instance, the search for biosignatures could be focused on the area north of the equatorial region, between 0˚ and 30˚ N, and between the longitudes 240˚ and 270˚ (cf., McCord *et al.* 1998, Fig. 2A). But a more intriguing, and smaller patch, would be the narrow band with a significant high-concentration of non-ice elements that lies east of the Conamara Chaos, between the

Belus and Asterius lineae, namely, between 18˚ - 20˚ N, and longitudes 198˚ - 202˚ (cf., McCord *et al.* 1998, Fig. 2D).

Conclusion

To achieve reliable biosignatures in the solar system in the foreseeable future, it seems essential to go back to Europa, in addition to continuing the multiple well-funded Mars programmes. Our work highlights the type of biogenic signatures that can be searched, when probing Europa's icy and patchy surface. Definite answers can be retrieved *in situ* on the icy surface with instrumentation for the corresponding biogeochemistry. The measurements can be performed by, for instance, microprobes (cf., Cosmic Vision, 2005, Fig. 5.1.3.3), or by landers (of the type of the original JPL studies that sadly have been suspended). Such on-site measurements could make a modest contribution to the overall question of settling one of the most significant problems in astrobiology, namely the origin of the surficial sulphur on Europa.

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