Geophysical Research Abstracts
Vol. 12, EGU2010-2431-1, 2010
EGU General Assembly 2010


# Can a future mission detect a habitable ecosystem on Europa, or Ganymede?

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The considerable evidence for the presence of a liquid ocean over a silicate core makes Europa a candidate for the emergence of a second evolutionary pathway of autochthonous life. The most urgent question in astrobiology is the origin of habitable ecosystems—a question in geochemistry—rather than the alternative search for the origin of life itself—a question in chemical evolution (Chela-Flores, 2010). Since certain bodies may share a similar geophysical past with the Earth, a question suggests itself: Can available instrumentation be the 'pioneer' in the discovery of habitable ecosystems in geophysical environments similar to the early Earth, where oceans were in contact with a silicate core? A central aspect of this dilemma is the element sulphur (S). A reliable window on the nature of the early terrestrial habitable ecosystems is the Pilbara Craton (Australia), a rich fossiliferous archive of the early steps of evolution, having preserved details of ancient hydrothermal vents. It contains a 3.47 Ga barite deposit with microfossils of a complex set of sulphate-reducing bacteria (Shen and Buick, 2004). The large spread in the delta 34S values provides the earliest reliable biomarker from the early Earth. Europa may represent the only other case in the Solar System in which liquid water has been in contact with a silicate core over geologic time in perfect analogy with the early Earth (Bland et al., 2009). The following hypothesis is forced upon us:

The presence of hydrothermal activity at the interface of the silicate core and the Europan ocean can provide a variety of biogenic chemicals that play a role in sustaining microbial life at the ocean floor. This is the source of microbial life elsewhere in the ocean and of biomarkers on its icy surface.

This hypothesis is subject to a feasible experimental test: Europa's non-ice surficial elements were found to be widespread, patchy and, most likely, endogenous. We argue that penetrators should be inserted in orbital probes in the future exploration of Jupiter's System (Gowen et al., 2009). There are alternative views on the effect of space weather on the radiation-induced S-cycles produced on the surficial molecules; but S is common to both interpretations (Carlson et al., 1999; McCord et al., 1999). The largest known S-fractionations are due to microbial reduction, and not to thermochemical processes. Besides, sulphate abiotic reductions are generally not as large as the biogenic ones (Kiyosu and Krouse, 1990). From experience with a natural population, this type of biota is able to fractionate efficiently the S-isotopes up to delta 34S of -70 per mil (Wortmann et al., 2001).
Dissimilatory sulphate reducers are ubiquitous on Earth, producing the largest fractionations in the sulphur stable isotopes. These microbes are widely distributed in terrestrial anoxic environments.Consequently, sulphate reducers are the most evident candidates for the microorganisms populating a habitable Europan ecosystem. Microbial fractionation of stable S-isotopes argue in favour of penetrators for surveying the surface of not only Europa, but also of Ganymede, where surficial sulphur has been detected (McCord et al., 1997). The Europa-Jupiter System Mission (EJSM) intends to explore in the 2020s both of these satellites (Grasset et al., 2009). According to our hypothesis we predict that penetrators (supplied with mass spectrometry) should yield different results for fractionated sulphur. The icy patches on Europa should give substantial depletions of delta 34S, while measurements on Ganymede should give significantly lower values for the depletion of delta 34S. (Since the largest of the Galilean satellites lacks an ocean-core interface, according to our hypothesis it would not support life.) These diverging results—a large minus delta 34S for the Europan sulphur patches, and a small minus delta 34S for the Ganymede surficial sulphur—would provide a clear test for the hypothesis that a habitable ecosystem has emerged on Europa. The test is well within reach of available technology that is needed for planning the eventual penetrator payload.

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