Geophysical Research Abstracts,
Vol. 11, EGU2009-0, 2009
EGU General Assembly 2009

Can the biogenicity of Europa's surfical sulfur be tested simultaneously with penetrators and ion traps?

J. Chela-Flores (1,2), A. B. Bhattacherjee (3), S. Dudeja (1,3), N. Kumar (4), and J. Seckbach (5)

(1) The Abdus Salam ICTP, Applied Physics Scientific Section, Trieste, Italy (chelaf@ictp.it, +390-40-22 41 63), (2) Instituto de Estudios Avanzados, Caracas 1015A, República Bolivariana de Venezuela., (3) Department of Chemistry, ARSD College, University of Delhi, New Delhi-110021, India, (4) Raman Research Institute, Bangalore-560080, India, (5) The Hebrew University of Jerusalem, Israel.

We suggest a biogenic interpretation of the sulfur patches on the Europan icy surface. This hypothesis is testable by LAPLACE, or a later mission, in which the instrumentation on board are penetrators, or ion traps, with component selection including miniaturized mass spectrometry.

The argument in favor of such instrumentation and component selection is as follows: Extreme environments with microbes can act as models for extraterrestrial life (Seckbach et al., 2008). Suggestions have ranged from Venusian environments (Sagan, 1967, Seckbach and Libby, 1970) to Mars (Grilli Caiola and Billi, 2007). Active photosynthetic microbial communities are found on Antarctica, both in and on ice, in fresh water, in saline lakes and streams and within rocks. In the dry valley lakes of Antarctica close to the McMurdo Base, microbial mats are known to selectively remove a huge quantity of sulfur (Parker et al., 1982). Lake Vostok in Antarctica possesses a perennially thick (3 to 4 km) ice-cover that precludes photosynthesis, thus making this subglacial environment a good model system for determining how a potential Europan biota might emerge, evolve and distribute itself. Jupiter's moon Europa may harbor a subsurface water ocean, which lies beneath an ice layer that might be too thick to allow photosynthesis, just as in Lake Vostok. However, disequilibrium chemistry driven by charged particles from Jupiter's magnetosphere could produce sufficient organic and oxidant molecules for an Europan biosphere (Chyba, 2000). We restrict our attention to microbial mats that could still be thriving in spite of the extreme conditions of radiation on Europa. We are especially concerned with sulfur patches discovered by the Galileo mission. In the near future there are technologies available to settle the question of habitability on Europa, such as penetrators that are currently being developed for preliminary trials nearer to the Earth—the Moon-Lite mission (Smith et al., 2008). If analogies with microbial mats—well understood in the context of the Antarctic dry valley lakes for the expulsion of a large quantity of sulfur—are used in tests on the icy surface of Europa, it is pertinent to evaluate the stopping-depth for the harsh radiation on the Europan surface. Recently, we have estimated the stopping-depth that should be probed by penetrators in proposed missions, such as LAPLACE, or in future projects. We find, in agreement with others (Greenberg, 2005), that beyond a few millimeters a penetrator would be testing biogeochemistry without any interference from radiation effects (Dudeja et al., 2009).

Simultaneously with the penetrators there is an alternative suitable technology available. The isotopic S fractionation on the cloud surrounding Europa should reflect to a large extent the same biogenically-driven S fractionation that is taking place on the surface. We should recall that the origin of the cloud is due to particles that have been expelled by hypervelocity impacts of micrometeoroids on the surface. The instrumentation of ion-trap mass spectrometry has already been successfully completed for tests on a comet nucleus (the Ptolemy instrument and the Rosetta space mission). Ion traps have once again been in the planning stages for their eventual application in LAPLACE, or elsewhere (Todd et al., 2006; Taylor et al., 2007). Since the cloud around Europa is constantly being replenished by the above-mentioned micrometeorites, it would be reasonable to expect the cloud to mirror the large S-isotope deviations that may be caused locally by the assumed sulfate-reducing microorganisms. Consequently, dust detectors in orbit around this satellite should record similar large fluctuations of the Luria-Delbrück type that we have conjectured to take place on Europa's icy surface. This possibility has been explained in detail recently (Chela-Flores and Kumar, 2008). Consequently, we argue in favor that the instrumentation to be selected should include miniaturized mass spectrometry.

From these arguments we may conclude that a penetration of measuring instruments (penetrators) into the icy

surface of Europa just beyond the few millimeters beyond the stopping-depth would be sufficient for an accurate estimate of the delta-34 S parameter. This would be a possible way for rejecting, or supporting, the hypothesis of biogenicity of the Europan sulfur patches. The fact that missions such as LAPLACE, or others, can envisage, and undertake, such measurements (in the foreseeable future) is of the utmost importance for astrobiology's most significant question:

Are there other environments in our own Solar System where we could settle the question of habitability, by making use of the available technologies?

These results suggest that with the optimum stopping-depth we have calculated, sulfate-reducing bacteria would leave a measurable trace of their activity that is not affected by the harsh external environment. In addition, we have related sulfur transport in microbial mats that are known to take place in the Antarctica subglacial lakes with a mechanism that might rationalize what is taking place in the sulfur patches of the icy surface of Europa. Lake Vostok has given us preliminary hints from microorganisms retrieved from the accreted ice that lies just above its still-unexplored liquid water.

References (*)

Blanc, M. and the LAPLACE consortium (2008) LAPLACE: a mission to Europa and the Jupiter System, Astrophysical Instruments and Methods, in press, http://www.ictp.it/c̃helaf/ss186.html,Team Members http://www.ictp.it/c̃helaf/ss164.html.

Chela-Flores J. and Kumar N. (2008) Returning to Europa: Can traces of surficial life be detected? International Journal of Astrobiology 7: (3), 263-269, http://journals.cambridge.org/repo_A28gqjIw

Chyba, C. (2000) Energy for microbial life on Europa, Nature 403: 381-383.

Dudeja, S., Bhattacherjee, A. B. and Chela-Flores, J. (2009) Microbial mats in Antarctica as models for the search of life on the Jovian moon Europa. In: J. Seckbach and A. Oren (eds.) Microbial Mats, in the COLE series, to be published by Springer. http://www.ictp.it/c̃helaf/Dudeja.pdf

Greenberg, R. (2005) Europa-The Ocean Moon. Springer and Praxia Publishing, Chichester, p. 328

Grilli Caiola, M. and Billi, D. (2007) Chroococcidiopsis from Desert to Mars. In: Algae and Cyanobacteria in Extreme Environments. J. Seckbach (ed.) in the COLE series, Springer, Netherlands, pp. 553-568.

Parker, B. C. et al. (1982) Removal of organic and inorganic matter from Antarctic lakes by aerial escape of bluegreen algal mats. J. Phycol. 18: 72-78.

Sagan, C. (1967) Life on the Surface of Venus? Nature 216: 1198 - 1199.

Seckbach, J. and Libby, W. F. (1970) Vegetative life on Venus?. Origins of Life and Evolution of Biospheres 2: 121-143.

Seckbach, J. Oren, A. Chela-Flores, J. (2008) The extreme environments and their microbes as models for extraterrestrial life. 3rd European Planetary Science Congress, Münster, Germany, September. http://www.ictp.it/c̃helaf/Munster.pdf

Smith, A. et al. (2008) LunarEX – A proposal to cosmic vision. Experimental Astronomy 10.1007/s10686-008-9109-6 (August 21, 2008). http://www.ictp.it/c̃helaf/Penetrator.pdf

Sze, S. M. (1988) VLSI Technology, McGraw-Hill, New York, p. 333.

Taylor, E.A. et al. (2007). A combined dust impact detector and ion trap mass spectrometer for a Europa orbiter, Geophysical Research Abstracts, 9: 10928, SRef-ID: 1607-7962/gra/EGU2007-A-10928, EGU.

Todd, J.F.J. et al. (2007). Ion trap mass spectrometry on a comet nucleus: the Ptolemy instrument and the Rosetta space mission. J. Mass Spectrom. 42: 1–10.

(*) Please notice that in the website references to the Academic Page of the first author the symbol twiddle should be in front of chelaf and not above the letter c, as it appears in the pdf version of this Abstract.