THE SEARCH FOR LIFE ON EUROPA: JUPITER ICY MOONS ORBITER OBJECTIVES

Jere H. Lipps, Curtis Pehl and Sarah Rieboldt
Department of Integrative Biology and Museum of Paleontology, University of California, Berkeley, California 94720, jlipps@uclink4.berkeley.edu

On Europa, present and past life preserved in the icy crust might be abundant and varied. Indeed, analogous icy habitats on Earth suggest that many opportunities for life and ecosystem development are possible on Europa. Possible habitats include benthic soft and rocky substrates on the ocean's floor, pelagic ones in the water column, and cryophilic types in various ecologic settings in the ice cover itself.

These habitats have potential for transportation to and preservation at the surface of Europa, thus making them accessible to a surface sampler. Surface sites that might contain life or fossils include the areas of refrozen ocean, chaotic terrains, the ridges and rills associated with fissures, low areas where water may have collected, and "dirty" ice that may include benthic material floated to the surface by bottom anchor ice or gouged by ice, as well as the variety of ice habitats. Because the ice on Europa varies in age and a stratigraphy can be reconstructed, evolutionary patterns of life may also be sampled.

Thus, a sampling strategy for life and its history on Europa should include paleontological and molecular biological objectives that would clearly document the present and former existence of life on Europa. The strategy should include pre-landing study of probable preserved or extant ice habitats, followed by robotic landers equipped to sample surface materials and image them after appropriate processing. The Jupiter Icy Moons Orbiter and possible associated lander should obtain high resolution images, laser altimeter mapping, chemical analysis of materials, radar penetration of specific sites in likely areas where life might be preserved. These will allow detailed analysis of the geology and structure of the ice to determine the potential for a successful search for life. Objectives for a lander should include the ability to land in rough terrains, to roam 10's to 100's of kms, to traverse steep slopes, to withstand chemical and radiation attack, and to sample to depths greater than one meter. These objectives present engineering challenges and vision for the construction of a lander that will require new approaches to locomotion, power, command, specimen acquisition and analysis, and data processing at Europa.

References: **[1]** Chyba, C. F. 2000. Energy for microbial life on Europa - A radiation-driven ecosystem on Jupiter's moon is not beyond the bounds of possibility. Nature 403(6768): 381-382. **[2]** Chyba, C. F. and C. B. Phillips. 2001. Possible ecosystems and the search for life on Europa. Proc. National Acad. Sciences USA 98(3): 801-804. **[3]** Chyba, C. F. and C. B. Phillips. 2002. Europa as an abode of life. Origins of Life and Evol. Biosphere 32(1): 47-68. **[4]** Figueredo, P. H., et al. Locating potential biosignatures on Europa from surface geology observations. Asrobiology in press. **[5]** Krebs, W. N., J. H. Lipps, and L. H. Burckle. Ice diatom floras, Arthur Harbor, Antarctica. Polar Biology. 7:163-171. **[6]** Lipps, J. H. W. N. Krebs. 1974. Planktonic foraminifera associated with Antarctic sea ice. Jour. Foraminiferal Research. 4:80-85. **[7]** Lipps, J. H., W.N. Krebs, and N. K. Temnikow. 1977. Microbiota under Antarctic ice shelves. Nature. 265:232-233. **[8]** Lipps, J.H., T. E. Ronan, Jr., and T. E. DeLaca. 1979. Life below the Ross Ice Shelf, Antarctica. Science. 203:447-449. **[9]** Lizotte, M. P., and K. R. Arrigo (Eds.). 1998. Antarctic sea ice: biological processes, interactions and variability. Antarctic Research Series 73: 1-198. **[10]** Pappalaroo, R. T., J. W. Head, and R. Greeley. 1999. The hidden ocean of Europa. Scientific American. 281(4):54-63.