

**EUROPA'S ICY CRUST AS A HABITAT AND REPOSITORY OF LIFE.** Jere H. Lipps. Department of Integrative Biology and Museum of Paleontology, University of California, Berkeley, California 94720, [jlipps@uclink4.berkeley.edu](mailto:jlipps@uclink4.berkeley.edu).

Life, if it exists or existed on Europa, could be abundant and varied [1-3], as well as preservable in the surface ice. Europa's probable sub-ice ocean would provide a large number of habitats. By analogy with Earth's icy habitats, many ecologic settings are likely in and on the ice, as well as the on the ocean's floor and in the water column [4-8]. All of these could have been preserved in place or transported to the icy crust through oceanographic, geologic, glaciologic or biologic processes.

Habitats in the ice include the large fissures and refrozen areas, areas below clear ice that transmits light, tiny cracks, brine channels, inter-crystal water films, ice surfaces in the water, and oases caused by impact, volcanic heat, or surface meltwater. Some of these places might be inhospitable to life because of extreme chemical, radiation or other conditions, but are included here for more careful consideration, given the tenacity of life in Earth's ice-influenced environments.

The ice would likely preserve current life and fossil organisms, traces or biomarkers once they were incorporated into it. Later geologic processes may have brought them close to, or exposed them, at the surface where they could be imaged and sampled. Europa's geology indicates a relatively young, dynamic crust that created many terrains and exposures [9] that could be targeted for further exploration. These sites include the areas of refrozen ocean, 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 wide variety of ice habitats. Pelagic life might be preserved abundantly. Because the ice on Europa varies in age and a stratigraphy can be assembled, a history of life may also be reconstructed.

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 detailed imaging of sites with probable preserved or extant ice habitats, followed by surface exploration with impactors, penetrators, ice clippers, or rovers to outcrop and surface materials.

**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] Krebs, W. N., J. H. Lipps, and L. H. Burckle. Ice diatom floras, Arthur Harbor, Antarctica. *Polar Biology* 7:163-171. [5] Lipps, J. H. W. N. Krebs. 1974. Planktonic foraminifera associated with Antarctic sea ice. *Jour. Foraminiferal Research* 4:80-85. [6] Lipps, J. H., W.N. Krebs, and N. K. Temnikow. 1977. Microbiota under Antarctic ice shelves. *Nature* 265:232-233. [7] Lipps, J.H., T. E. Ronan, Jr., and T. E. DeLaca. 1979. Life below the Ross Ice Shelf, Antarctica. *Science* 203:447-449. [8] Lizotte, M. P., and K. R. Arrigo (Eds.). 1998. Antarctic sea ice: biological processes, interactions and variability. *Antarctic Research Series* 73: 1-198. [9] Pappalardo, R. T., J. W. Head, and R. Greeley. 1999. The hidden ocean of Europa. *Scientific American* 281(4):54-63.