

## **STUDIES OF EARTH ANALOGS OF POTENTIAL EUROPEAN HABITATS: OPPORTUNITIES AND LIMITATIONS**

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The Europa Focus Group (EFG) Earth Analog Studies Team has been tasked with an initial survey aimed at identifying and characterizing relevant European analog environments on Earth and potential model organisms to study biological processes under quasi-European conditions. Ultimately, it is planned to discuss analog environments within the context of mission planning and to contribute to the identification of potential target areas that are in need of further consideration and study. The relevant sub-tasks are being led by Giles Marion (physico-chemical environmental conditions), Nicolas Glansdorff and Victor Parro (biology of analog environments and model organisms), with more detailed summaries provided in their respective contributions to this meeting.

In defining the aims of this group, we have to consider in particular the strengths and limitations of studying analogs of European environments. Here, it needs to be clearly stated that it is not the team's aim to employ the concept of the Earth analog in helping to establish whether and what type of lifeform might have evolved in European environments (i.e., in the sense discussed by Soare et al., 2001). On the other hand, neither do we aim to preclude the existence of life on Europa altogether extrapolating from studies of sterile environments on Earth. Rather, the team is in at least in part motivated by the fact that so far, a closer look or reexamination of Earth environments with more sophisticated techniques or employing novel approaches has almost invariably yielded remarkable and sometimes unexpected evidence for the sustainability of microbial life under even the most extreme conditions [e.g., 2, 3, 4].

In light of these comments, studies of terrestrial analogs are key insofar as they (1) are an integral component in the development and testing of conceptual models of the potential evolution, presence and detectability of life in European environments, (2) help in constraining scenarios of planetary evolution and composition, (3) further our understanding of the fundamental constraints on life at low temperatures and its evolution in extraterrestrial environments, (4) can be coordinated and synthesized from a variety of specific analogs and approaches to provide us with a more realistic, comprehensive model of potential European habitats, and (5) offer the opportunity to collect data necessary to validate and improve numerical models of planetary evolution and life in extreme environments. In the context of future missions to Europa, studies of terrestrial analogs help to (1) define and refine research hypotheses concerning the presence and detectability of life on Europa, (2) develop and test sampling methods for both planetary geology and astrobiological programs, (3) develop and test detection strategies of biomarkers through remote-sensing methods, and (4) identify and delineate the most promising study and sampling areas.

While current data on Europa surface and interior chemistry do not yet allow full constraint of chemical and hence phase composition, based on the available evidence it appears that a multi-component, multi-phase system with ice, brine and salt precipitates (Fig. 1) is an adequate representation of environments in and directly underlying the European ice crust. In correspondence with the EFG's immediate goals we currently only consider potential habitats that are accessible to remote sensing or direct sampling of the (sub)surface of the dynamic ice

crust. Given the wide range of temperatures present throughout the European ice crust and considering a broader range of chemical compositions, it is clear that a study of Earth analog environments would require examination of a wider range of different habitats, with sea ice and salt slush/crust environments of particular but not sole relevance. From existing knowledge on the survival and activity of bacteria in extreme low-temperature environments, it appears that in particular the base regions of the ternary diagram, as accessible in individual brine inclusions or highly saline environments equilibrated against ice may be particularly relevant.

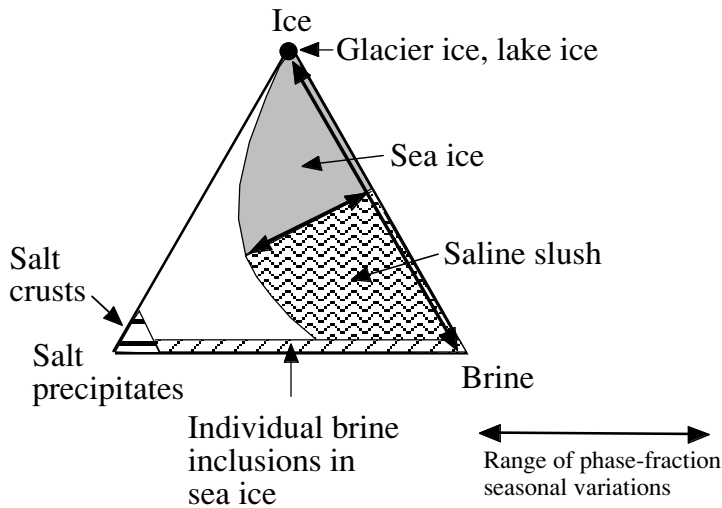


Figure 1: Ternary phase diagram depicting phase fractions of solid ice, liquid brine and salt precipitates in potential European analog environments.

**References:** [1] Soare, R. et al. (2001) Deductive model proposed for evaluating terrestrial analogues. *Eos, Transact. Am. Geophys. Un.* 82:501; [2] Karl, D. M. et al. (1999) Microorganisms in the accreted ice of Lake Vostok. *Science* 286:2144-2147; [3] Rivkina, E. M. et al. (2000) Metabolic activity of permafrost bacteria below the freezing point. *Appl. Environ. Microbiol.* 66:3230-3233; [4] Vreeland, R. H. et al. (2000) Isolation of a 250 million-year-old halotolerant bacterium from a primary salt crystal. *Nature* 407:897-900.