HABITABILITY OF THE ICY GALILEAN SATELLITES:

EVOLUTIONARY BIOMARKERS WITH EJSM AND PENETRATORS

J. Chela-Flores

The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy and Instituto de Estudios Avanzados, Caracas, Republica Bolivariana de Venezuela.



Resurfacing on Europa: a key in the search for evolutionary biomarkers



A first Earth analog of Europa's icy surface: Ellesmere Island



Second and third Earth analogs of Europa's icy surface

NTARCTICA

6

LAKE VOSTOR

SUBGLACIAL LAKES Lake Vostok may represent a flooded rift valley, akin to Siberia's Lake Baikal or East Africa's Lake Malawi. Some 76 other subglacial lakes have been identified, most buried deep under the East Antarctic ice sheet.

O Subglacial lake

AURORA SUBGLACIAL BASIN

BELGICA SUBGLACIAL HIGHLANDS

VINCENNES SUBGLACIAL BASIN

ADVENTURE SUBGLACIAL TRENCH RESOLUTION SUBGLACIAL HIGHLANDS WILKES

SUBGIAC



DET VALLE

S ISLAND

GAMBURTSEV UBGLACIAL MTS

VOSTOK SUBGLACIAL HIGHLANDS



Resurfacing on terrestrial lakes: How do microbial mats reach the bottom of the lake icy surface?

Prostrate mats carrying a consortia of bacteria some not yet identified



Resurfacing on terrestrial lakes:

How do microbes reach from the bottom to the top of the lake icy surface?







Resurfacing on terrestrial lakes: Traffic of biogenic sulfur through the lake's icy cover

Dry Valley lakes	Chad	Hoare	Fryxell
Organic matter	8343.0	247.4	145 .0
Kjeldahl-N	188.5	33.1	5.0
Si	897.0	573.9	2640.0
Al	353.3	137.2	522.6
Ca	279.5	105.9	552.1
Fe	352.3	76.6	309.5
Mg	123.6	35.4	159.5
K	100.6	30.7	184.9
Na	49.4	18.6	147.4
P	18.5	10.2	31.2
S	104.0	56.0	40.1
Cl	9.2	4.6	419.4
- Mn	20.2	3.8	59.0
Cu	: 0	0.7	0.02
Zn	0	0.2	0.40
Со	. 0	0.05	0.20
Mo	0.07	0.002	0.01

Biogenic Sulfur in the Solar System



 We have shown how biogenic sulfur patches are produced by resurfacing of an Earth analog of Europa: Lake Hoare



Resurfacing on Europa: A dust cloud has been released by micrometeroid impacts





Possible sources of the stains

• **External source:** Ions may be implanted from the Jovian plasma.

• **Internal source:** Sulfur may be due to **microbes** living around hydrothermal vents, reaching the icy surface by cryovolcanism.

- What is the nature of biogenicity? One way to decide may be with penetrators.
- Could the source of the patches be bacteria, or even eukaryotes or metazoans?











Which eukaryotes, or metazoans, can live in extreme environments?

(deVere et al. 2003-2010)

Xanthoria Elegans, the elegant sunburst lichen, was outside the European Columbus laboratory. It is a macroscopic composite of a fungus and an alga.



Expose-E was carried back to Earth by Space Shuttle Discovery. These experiments investigate to what extent terrestrial organisms are able to cope with extreme environmental conditions.



Some extremophiles are more complex than single-celled eukaryotes

Animals with bilateral symmetry found in extreme environments include the Antarctic krill



Another extreme metazoan: Tardigrades (water bears)

(0.1-1.0mm in length, water-dwelling, segmented animals)

Scanning electron micrograph (SEM) of *Echiniscus testudo*, a marine species

Northern Rock Crawler

Grylloblatta campodeiformis

For most of the year, these ice insects remain frozen



Simple aquatic metazoans in extreme conditions

• In the Antarctic analog of Europa there is an ecosystem with simple metazoans.

• Our ecosystem is underneath McMurdo Sound:



Metazoans living underneath the icy surface of McMurdo Sound



With currrent instrumentation, how could we test for eukaryotes or metazoans in the Europan ocean?







Penetrators for the icy surface of Europa



Combined Raman/LIBS spectrometer (ExoMars)





The instrument design has a total mass smaller than 2kg

Instrument	Implication	Challenges
Penetrator	 Can probe the surficial sulfur for biogenicity in the presence of radiation 	 Mass budget is restricted
Mass spectrometry	•With geochemistry we can test for microbial life	 To guarantee accessibility in the mass budget of JEO
LIBS/Raman	 Can identify single molecules in a multicellular ensemble 	 The selection of molecules common to eukaryotes and simple metazoans, but absent in bacteria To develop protocols and to test them



The Europa Jupiter System Mission with penetrators





lo

Callisto