

Division for Planetary Sciences, American Astronomical Society  
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Vertical Transport through Europa's Crust: Implications for Oxidant  
Delivery and Habitability

To be presented at the meeting of the Div. for Planetary Sciences of  
the American Astronomical Society, October 9, 2009, in Fajardo, P.R.

by Richard Greenberg  
Professor of Planetary Sciences, University of Arizona.

Summary of presentation:

The global ocean on Jupiter's moon Europa contains about twice  
the liquid water of all the Earth's oceans combined. New research  
suggests that there may be plenty of oxygen available in that ocean to  
support life, a hundred times more oxygen than previously estimated.

The chances for life there have been uncertain, because Europa's  
ocean lies beneath several miles of ice, which separates it from the  
production of oxygen at the surface by energetic charged particles  
(similar to cosmic rays). Without oxygen, life could conceivably  
exist at hot springs in the ocean floor using exotic metabolic  
chemistries, based on sulfur or the production of methane. However it  
is not certain whether the ocean floor actually would provide the  
conditions for such life.

Therefore a key question has been whether enough oxygen reaches  
the ocean to support the oxygen-based metabolic process that is most  
familiar to us. An answer comes from considering the young age of  
Europa's surface. Its geology and the paucity of impact craters  
suggests that the top of the ice is continually reformed such that the  
current surface is only about 50 million years, roughly 1% of the age  
of the solar system.

Richard Greenberg of the University of Arizona has considered  
three generic resurfacing processes: gradually laying fresh material  
on the surface; opening cracks which fill with fresh ice from below;  
and disrupting patches of surface in place and replacing them with  
fresh material. Using estimates for the production of oxidizers at  
the surface, he finds that the delivery rate into the ocean is so fast  
that the oxygen concentration could exceed that of the Earth's oceans  
in only a few million years. The concentrations would be great enough  
to support not only microorganisms, but also "macrofauna", that is to  
say more complex animal-like organisms which have greater oxygen  
demands.

The continual supply of oxygen could support roughly 3 billion  
kilograms of macrofauna, assuming similar oxygen demands to  
terrestrial fish.

The good news for the question of the origin of life is that

there would be a delay of a couple of billion years before the first surface oxygen reached the ocean. Without that delay, the first pre-biotic chemistry and the first primitive organic structures would be disrupted by oxidation. Oxidation is a hazard unless organisms have evolved protection from its damaging effects. A similar delay in the production of oxygen on Earth was probably essential for allowing life to get started here.

Richard Greenberg is also the author of the recent book "Unmasking Europa: The Search for Life on Jupiter's Ocean Moon", which offers a comprehensive picture of Europa for the general reader.

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