Mantle heterogeneity may control distribution of early life - a hypothesis

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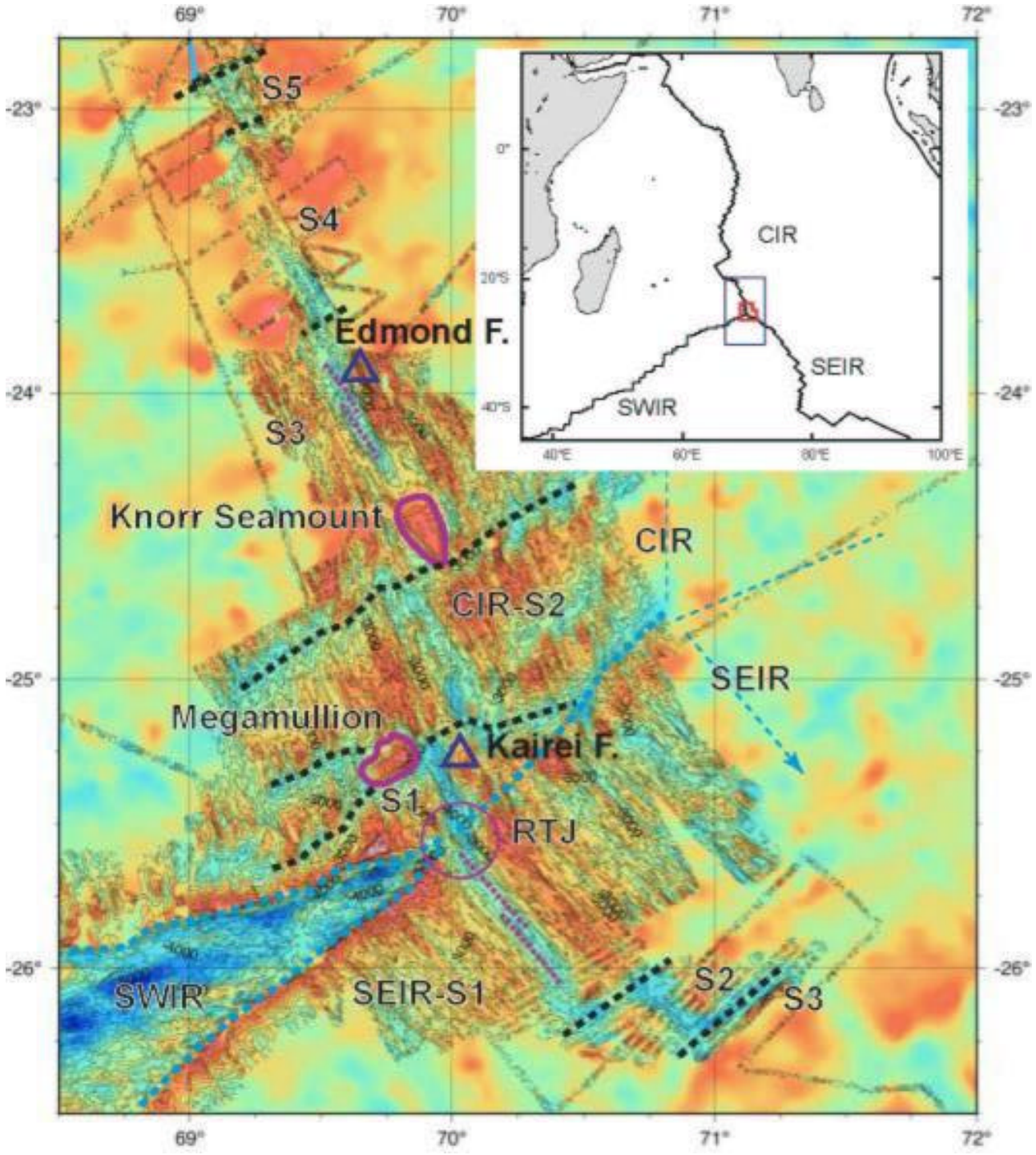
We propose a hypothesis on an evolutionary interaction between early life and heterogeneous mantle, which could be understood an linkage between Ultramafic rocks, Hydrothermal activity, Hydrogen, and Hyper SLiME (Ultra-H3 linkage). As pointed out by Takai et al. in this symposium, HyperSLiME, currently discovered beneath the Kairei-hydrothermal field on Central Indian Ridge (CIR), is interpreted to be metabolically approximated to our last universal common ancestor's community (LUCA). This chemolithoautotrophic ecosystem is interpreted to be driven by hydrogen which is probably generated by hydrothermal serpentinization of ultramafic rocks at high temperatures. Thus, elucidating Ultra-H3 linkage is very important to understand the genesis of the LUCA community.

Here, distribution of such a hydrogen-rich hydrothermal activity was, in turn, controlled by that of ultramafic rocks in shallow oceanic crust. In the modern Earth, local magma budget is an important factor for distribution of ultramafic rocks. When supply of mafic magma is insufficient, ultramafic mantle rocks are not completely replaced by mafic crustal rocks. Further, production of magma may be controlled by a heterogeneous chiemical compositions and temperatures in mantle. Turning into ancient earth, two types of ultramafic rocks should be taken account: 1) ultramafic exposure analogous to modern Earth, or 2) ultramafic-volcanism known as komatiites that is uniquely found in Archean and has not been found as in present day's activity. To investigate UltraH3-linkage in ancient to modern Earth, two types of investigations are planned: 1) field expeditions of biological, geological, geochemical, and geophysical expeditions around Kairei hydrothermal field, and 2) experimental investigation of hydrothermal reactions among hydrothermal solution, ultramafic rocks, and microorganisms related to HyperSLiME. The latter is presented by Nakamura et al. in this symposium.

Kairei-field is known as one of the unique hydrothermal field of extraordinary high concentration of hydrogen in the hydrothermal solution and existence of HyperSLiME. Although the geological settings of Kairei-field have been poorly constrained, the hydrogen concentration of hydrothermal fluid imply involvement of ultramafic rocks. In addition, a megamullion feature is found around Kairei-field. Megamullion is a mafic-ultramafic complex characterized by a dome-shape topography and large exposure of ultramafic rocks. It is usually regarded to be generated by tectonic extension of lithosphere under magma-poor condition. These facts suggest that Kairei-field is a potential area to investigate Ultra-H3 linkage in a modern active hydrothermal field.

Field expedition consisting of two sequential cruises is scheduled in early 2006: one for geology and geophysics and the other for microbiology and geochemistry. The study area is around Kairei-Field, near Rodriguez Triple Junction, Indian Ocean. The former expedition includes 15-dives of manned submersible Shinkai6500 and the dive targets are as follows: 1) across ridge transects for two hydrothermal sites - Kairei and Edmond, 2) Megamullion – located in western off of 1st segment of CIR, 3) Knorr Seamount - a point source volcano on present day's ridge axis, which are followed by along axis dive survey of CIR-RTJ-SEIR ridge system (see figure). The latter expedition focuses on the hydorthermal sites for microbiological and geochemical sampling and in-situ experiments. We anticipate these sequential two cruises will provide a key observation of understandings to evolution of our early ancestors from field expeditions.

Figure: Detailed topography and geological features of proposed field expedition area. Open Triangles: hydrothermal field.


69°
70°
71°
72°
-23°
-24°
-25°
-26°
S5
S4
Edmond F.
S3
Knorr Seamount
CIR
CIR-S2
SEIR
Megamullion
Kairei F.
S1
RTJ
SWIR
SEIR-S1
S2
S3
0°
20°S
40°S
40°E
60°E
80°E
100°E
CIR
SEIR
SWIR