Estimation of an environment for early life

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To understanding the origin and evolution of life, it is important to clarify an environment for the earliest life. The different environments (shallow or deep sea) for the oldest fossil record (3.5 Ga; [1] in the North Pole area, Western Australia have been proposed, and they are still controversial because the growth history of this area is not clarified. The purpose of this study is quantificational reconstructions of habitat for early life based on geological evidences obtained from detailed geological mapping, metamorphic petrology and microthermometry of fluid inclusions.

The North Pole area is composed of 5 units which are set of chert and greenstones, bounded by layer-parallel thrusts. At least 31 tectonic slices (horses) were recognized in this area. We defined map-, outcrop- and centimeter-scale duplex structures with top-to-the-east sense of shear. We divided the greenstones into two types (MORB- and OIB-type) based on oceanic plate stratigraphy. Seafloor hydrothermal system of the Early Archean was identified in the MORB-type greenstones, and the fossil-bearing cherts are involved with the greenstones. We recognized about 2000 silica dikes composed of fine-grained silica (<1 μm). Silica dike indicates ancient hydrothermal fluid path.

Greenstones have been subjected to metamorphism at Archean MOR. The metamorphic grade increases toward the stratigraphically lower level and three mineral zones (zone A, B and C) are defined [2]. Minimum pressure at zone A/B and A/C boundaries was calculated to be 260 bar by thermodynamic calculation and seawater depth at Archean MOR was estimated to be >1600 m. This depth consists with low vesicularity and thickness (>2500 m) of pillow basalts. Homogenization temperature of fluid inclusions indicates that phase-separation at 150 ˚C and XCO_2 is estimated to be 0.031-0.044. This value is at least six times higher than modern hydrothermal vent fluid. Volatiles in fluid inclusions such as CO_2, H_2S and minor CH_4 were identified by laser Raman. REE pattern of fluid inclusions was analyzed by ICP-MS with crush and leach method, and shows obvious Eu positive anomalies similar to modern MOR vent fluid.

These evidences indicate that the earliest life occurred at the Archean mid-ocean ridge which is deep-sea environment same as modern one and is chemosynthetic bacteria rather than oxygenic photoautotrophs.

References

[1] Awramik, S.M., Schopf, J.W., Walter, M.R. (1983). Filamentous fossil bacteria from the Archean of Western Australia. Precambrian Research. 20, 357-374

[2] Kitajima, K., Maruyama, S., Utsunomiya, S., Liou, J.G. (2001). Seafloor hydrothermal alteration at an Archean mid-ocean ridge. Journal of Metamorphic Geology. 19, 583-600

Does subsurface microbial community show positive relations to specific lithofacies?: Exemplified from sapropel beds in the Sea of Japan

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Exploring the subsurface biosphere is one of the main research themes for both IODP and ICDP. Various subsurface microbial communities have already been recognized in deeply drilled core samples. However, there are still many questions remaining in order to figure out the general features of the subsurface biosphere.

KT01-15 cruise was held in the southern part of the Japan Sea as one of the feasibility studies for understanding subsurface biosphere beneath the seafloor. The cruise aimed to elucidate what kind of microbial communities are preserved in sapropel beds that formed under euxinic environments during the last glacial age. Original microbial communities are expected to be preserved in sapropel beds. During the cruise, we collected four pistion core samples from the Oki Trough. Late Quaternary sapropel beds were distributed beneath the Holocene oxic massive muds. Hydrogen sulfide concentrations of interstitial water increased with depth within the cores. Bacterial numbers in core samples counted for more than 10^9 cells / ml. Microbial communities showed strikingly similar composition throughout the core. There are weak relations to lithofacies. Simple composition of bacterial biomarkers were also detected in the core. Bacterial-mediated framboidal pyrite, that crystalized under H_2S dominant environments, commonly occurs in chamber cavities of microfossils and also within the sediment. Two crystal shapes, both octahedron and octa-hexahedron combinations, were recognized among framboidal pyrite populations. Octahedron crystal types dominated in the sapropel beds, whereas octa-hexahedron combination crystals were distributed within massive muds. These phenomena suggest that major microbial communities are distributed in interstitial waters and deviate from lithofacies relationships. However, both bacterial-mediated crystals and/or microbial communities on crystal surfaces formed in keeping with strong relationship to bottom environments. Thus, studies on ancient bacterial communities should focus on bacterial-mediated crystals rather than interstitial water.