Exploration for microorganisms in extreme environments has proved incredible prosperity of life in this planet. First of all, microbiology in deep-sea hydrothermal systems and deep subsurface biosphere has revolutionized our view to origin of Life and co-evolution of Life and Earth. I have been investigated microorganisms existing global deep-sea hydrothermal systems and subsurface biosphere together with members of our research project, called “SUGAR project”. Throughout the exploration of microorganisms in such two extremes in Earth, it has become convincing that the subsurface biosphere play an important role in co-evolution of Life and Earth and it is classified into two mode; the paleomicrobial relics and the presently active microbial communities. A considerable extent of subsurface biosphere may consist of dead or dormant microbial cells, or just their molecular remnants such as nucleic acids and lipids, which had been populated in the paleoenvironments in the past. Nevertheless, not all the subsurface microbial components are the silent paleomicrobial relics. Active subsurface environments might harbor active subsurface microbial communities. Where are active subsurface microbial communities? They might be present in hot spots and tectonic margins such as Mid Ocean Ridges (MOR), Subduction zone and Collision zone. Microbial ecosystem beneath active hydrothermal seafloor, so called “Subvent Biosphere” is likely the most primitive, productive and important entity.

Here, I introduce the mode of the subsurface microbial ecosystem associated with geological, geochemical and peleoenvironmental settings, with specifically focusing on the past microbial components buried in the subseafloor sediments and the subvent lithoautotrophic microbial ecosystem in the MOR deep-sea hydrothermal system.

2. Topics

Cold deep-sea pelagic sediments in the West Philippine Basin: A piston-core sample with distinct stratigraphic features (1410 cm long) was obtained from a depth of 5719 m and analyzed using a combination of molecular techniques. Magnetostratigraphic examination of the core showed that the deepest part, at a depth of 14 m, was deposited 2–2.5 million years ago (Figure 1). Beneath the surface
community of ubiquitous deep-sea Archaea (Marine Crenarchaeota Group I; MGI), an unusual archaeal community consisting of hyperthermophiles and the extreme halophiles was present.

**Mid Cretaceous black shale formation associated global Oceanic Anoxic Events (OAE):** A core sample containing Mid Cretaceous OAE black shale was obtained from the Southern France (Figure 2). It was recovered from terrestrial subsurface, but microbial components in the core represented the oceanic communities. The Mid Cretaceous OAE black shale layer specifically contained microorganisms preferably inhabiting under marine anoxic condition.

**A deep-sea hydrothermal vent – a window to subvent biosphere:** I have investigated microbial diversity in geologically and geographically distinct deep-sea hydrothermal systems. Each system has unique microbial ecosystem on the seafloor, which might be strongly associated with tectonic, geological and geochemical settings of the system. In addition, the seafloor microbial community is also associated with the subvent microbial ecosystem and the biogeochemical processes. Based on possible direct and indirect approach to the subvent biosphere, hypothetical models for subvent microbial ecosystems are proposed in several deep-sea hydrothermal systems. The subvent biosphere found in the Central Indian Ridge deep-sea hydrothermal system is likely a hydrogen-based, hyperthermophilic subsurface lithoautotrophic microbial ecosystem (HyperSLiME).

![Photograph of author and Shinkai 6500](image1.png)

Figure 1. A piston core obtained from the West Philippine Basin.

![Figure 2. Outcrop of black shale formation associated with global Oceanic Anoxic Event in the Mid Cretaceous.](image2.png)