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Full-Depth Biogeosciences for Profound Life in Ultradeep Terrain of Ocean (PLUTO)

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t has been long believed that hadal zone is extraordinary geological and oceanographic place and biosphere in global ocean environment and represents some exceptional and specific geological, oceanographic and biological processes in the modern and even the past earth due to its quite limited space as compared to expansion of ocean. However, recent geological and geophysical investigations have revealed that ultradeep trench with hadal zone would be characterized by dynamic tectonic, seismogenic and even magmatic processes. The new image of ultradeep trench and hadal water and seafloor provokes that such geodynamic environments could host active biosphere. Nevertheless, many (micro)biologists still feel that ultradeep trench and hadal water and seafloor represent very quiet (inactive) biosphere simply as the last sinking stage of photosynthetic biological production into the earth interior.

To these unexplored deepest ocean environments, engineering and technological challenges have preceded scientific investigations. In 1989, JAMSTEC developed and launched a human occupied submersible vehicle (HOSV) Shinkai 6500 and conducted the scientific exploration of hadal water and seafloor. In 1995, a remotely operative vehicle (ROV) Kaiko of JAMSTEC successfully reached the world deepest ocean bottom at the Challenger Deep, Mariana Trench, for the first time after the adventure of Jacques Piccard and Don Walsh using a bathyscaphe, Trieste, in 1960. Once Kaiko lost in 2002, descendant JAMSTEC ROVs Kaiko 7000 and ABISMO and WHOI HROV Nereus have continued to explore the ultradeep trenches and hadal biospheres. In particular, yet-limiting but increasing studies have renewed our view of such ultradeep trench environments and extant hadal biospheres.

Historically, the hadal water and seafloor are characterized by quite little elemental and nutrient input from surface ocean and biological production. The extinction-to-consumption organic matters host quite low biomass and diversity of planktonic and benthic heterotrophic prokaryotes and thus narrower food web and lower biomass and diversity of faunal communities. However, recent (micro)biological investigations have indicated that not only vertical sinking of nutrients from surface and coastal waters and ecosystems but also episodic and continuing inputs of energy sources and nutrients by crustal fluid flows through the underlying crusts of the subduction zone sustain the active hadal ecosystems. Surprisingly, recent geochemical and microbiological investigations have pointed that the hadal biosphere is highly independent of other planktonic and benthic ecosystems in terms of the community- and species-level composition and genetic connectivity despite no apparent physical and chemical signatures for the environmental isolation. The existence of hadal biosphere and ecosystem is likely associated with the anaplelotic input of pooled nutrients of past coastal and surface ecosystems in the trench slope sediments with the decomposition and turbulence.

These challenges for ultradeep trench and hadal biosphere have been lead by technology and biogeosciences in Japan and are going to establish a kind of paradigm shift. To push the revolutionary paradigm shift for ultradeep trench and hadal biosphere, a Japanese multidisciplinary research project is now being assembled with a leadership of JAMSTEC biogeoscientists and me. Here, I would like to overview the scientific background of exploration of ultradeep trench and hadal biosphere and introduce the new multidisciplinary science stream and the leading project that has been just launched.

Keywords: Hadal zone, tectonic errosion, subduction zone, slope decomposition, crustal fluid, organic matter