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Limits and Habitability of the Deep Subseafloor Biosphere: New Insights from IODP Expeditions 329 and 337

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In the past decade, the Integrated Ocean Drilling Program (IODP) has offered unique opportunities to explore how life persists and evolves in ecosystems of the Earth interior. There are very few natural environments on surface of the Earth where life is absent; however, the limits to life are expected in the subsurface world. Processes that mediate genetic and functional evolutions of the deep subseafloor life may be very different to those in the Earth surface ecosystems. Previous studies of subseafloor sedimentary habitats demonstrated that activity of microbial communities is generally extremely low, mainly because of the limit of nutrient and energy supply. Nevertheless, microbial activity plays important ecological roles in biogeochemical element cycles over geological timescale.

In 2010, during Expedition 329, we explored limits and habitability of life in deep-sea sediments and basalts in the South Pacific Gyre, the largest oceanic province where surface chlorophyll concentrations and primary productivity in the gyre are lower than any other regions of the world ocean. In 2012, during Expedition 337, we also explored the deep subseafloor coalbed biosphere off the Shimokita Peninsula of Japan. Using riser system of the *Chikyu*, we successfully drilled, cored and logged down to the depth of 2,466 meters below the seafloor.

The IODP Expeditions 329 and 337 represent aerobic and anaerobic subseafloor microbial ecosystems on our planet, respectively, both of which realms have never been explored by previous scientific drilling; therefore, these provide unprecedented opportunities to address the issue of limits and habitability in the deep subseafloor biosphere. A variety of geophysical and geochemical properties, such as temperature, pH, pressure, salinity, porosity, and availability of nutrient and energy are conceivable to constrain biomass and activity of deep life and extent of the subseafloor biosphere. These are systematically investigated by international and multidisciplinary teams of the Expedition 329 and 337 scientists.