
axis 3

# “Geobiological interactions in extreme environments”

## Keywords

- Extreme environments
- Geobiological interactions
- Hydrothermal circulation
- Biogeochemical cycles
- Deep sea mineral resources
- Deep sea ecosystems

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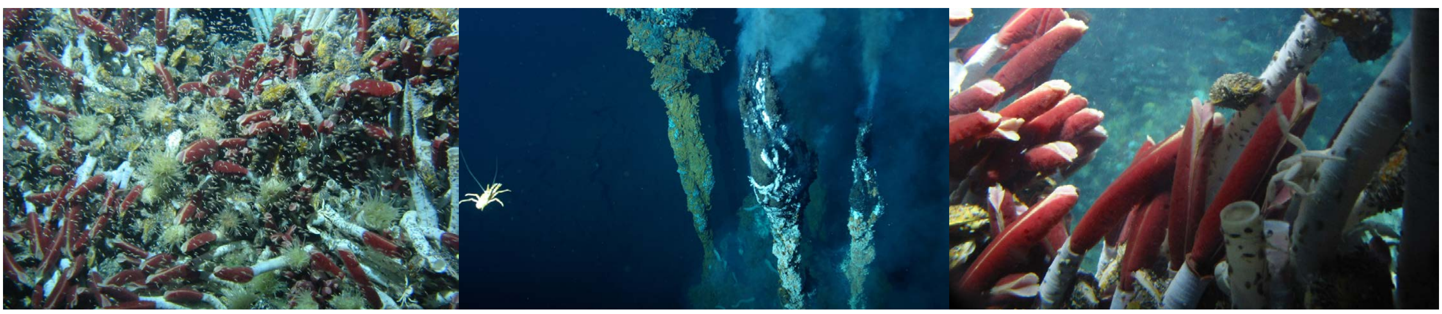
## SCIENTIFIC CONTEXT

Understanding the deep ocean is a critical issue for the international scientific community because of the important geological and environmental processes that occur there, its potential in terms of biological and geological resources, the unique richness of it’s biodiversity, and the technological challenges of accessing it.



## ROADMAP

LabexMER axis 3 activities are guided by three over-arching scientific questions:

- What are the tectonic, magmatic and sedimentary processes that control fluid circulation and its spatial and temporal variability?

Fluid circulation and tectono-magmatic setting are the determining factors in the construction and spatio-temporal evolution of deep-sea/extreme ocean habitats. Understanding the relationship between faults, magmatic events and fluid circulation requires in-depth studies of diverse geological settings. Questions include the depth of fluid penetration in the ocean lithosphere, how fluids and different types of substrata interact, the geometry of circulation, the relationship between deep fluid circulation and the deep biosphere, and the relationships between the development of faults and magmatism. This research is absolutely crucial for understanding chemical and heat exchanges between the earth’s crust and the ocean, the origin and nature of the biosphere in these extreme environments as well as the energy sources and the mineral resources that are concentrated at the deep ocean-crust interface.

- What impact does microbial community activity have on the environment and the major biogeochemical cycles?

It is now well known that submarine hydrothermal and cold-seep environments host very diverse microbial communities that are based on chemosynthesis, involving in particular $CO_2$-fixing metabolisms and metabolisms based on the reduction-oxidation of locally available chemical species, such as hydrogen, sulphur, methane and iron. These ecosystems in deep-sea environments are still poorly characterized and raise basic questions on the limits, evolution and global impact of life on the seafloor, whether in deep sediments, volcanic oceanic crust, mantle rocks or hydrothermal vents. Axis 3 also deals with the biogeochemical cycles of carbon, sulphur and certain metals (as electron acceptors/donors and as enzyme co-factors) in seafloor hydrothermal fields and ridge flank settings, which are accessible using multidisciplinary approaches to determine the relationships between microbial community structure and activity and the mineral, chemical and stable isotope characteristics (both light and heavy) of diverse extreme environments. Understanding the evolution of these biogeochemical cycles in deep geological time, when hydrothermalism was more important than at present, constitutes another important method for evaluating their organization and operation, and provides an alternative means of studying extreme conditions of biogeochemical cycling that may be difficult to observe in the modern. Finally, microbial communities attached on mineral surfaces are generally organized into biofilms; their structure, function, and communication networks (e.g. signalling molecules) are of particular interest in terms of their potential role for the concentration of metals.

- What are the environmental factors that control the dynamics of biological and functional diversity of deep-sea ecosystems?

Chemosynthesis-based ecosystems thriving at ocean ridges (via hydrothermalism) and continental margins (via cold-seep fluids, reducing environments) constitute fragmented habitats that are difficult to access and remain poorly understood. They are under the influence of varied and extreme environmental parameters that structure the diversity of biological communities and control the functioning of these ecosystems. Understanding the interactions between the biological compartments and their environment in these complex ecosystems requires an interdisciplinary, multi-scale approach (from ecosystem to molecule) that is innovative in terms of sampling technology and data acquisition strategies. Assessing the connectivity among communities retrieved from different sites is also crucial for understanding their spatio-temporal dynamics. In addition to exploration at the regional scale it requires studies of reproduction, dispersal and gene flow, recruitment, succession, demographic dynamics, symbiotic associations, and community evolution.

## EXPECTED RESULTS

The results of axis 3 initiatives are expected to contribute to a better understanding of geobiological interactions in extreme marine environments, such as those found at mid-ocean ridges, submarine volcanoes, abyssal plains (including nodule fields), and continental margins (e.g., cold seeps, gas hydrates). Axis 3 initiatives examining extreme environments often involve innovative technological development, including continuous monitoring systems, sub-seafloor geological mapping, microbial culturing techniques at high pressure, and high-precision isotope geochemistry. The research undertaken by axis 3 initiatives should lead to a more informed approach to the exploration and utilization of biological, mineral, and energy resources of the deep ocean, at the same time helping establish the critically-needed scientific basis for defining conservation strategies for these unique ecosystems.