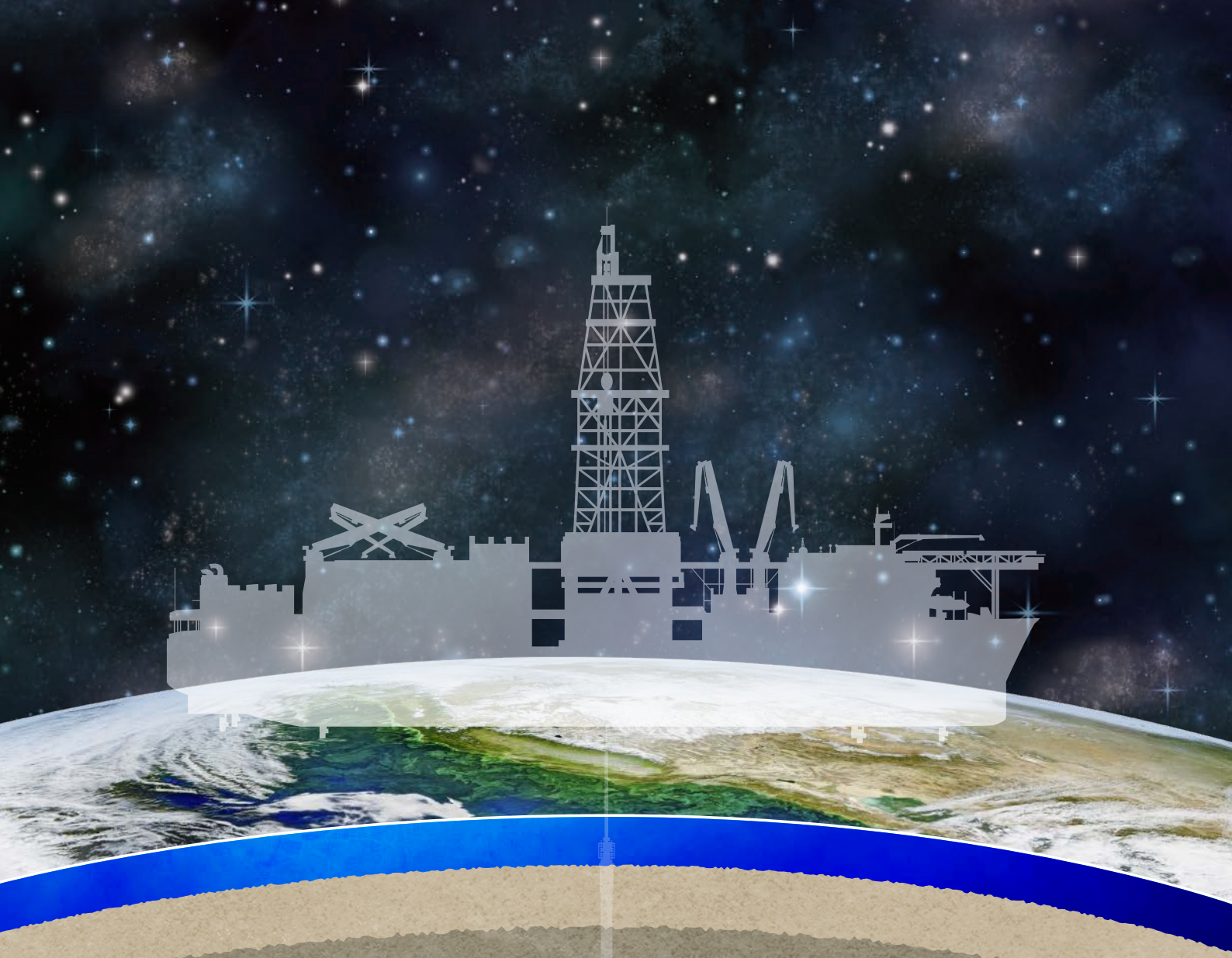
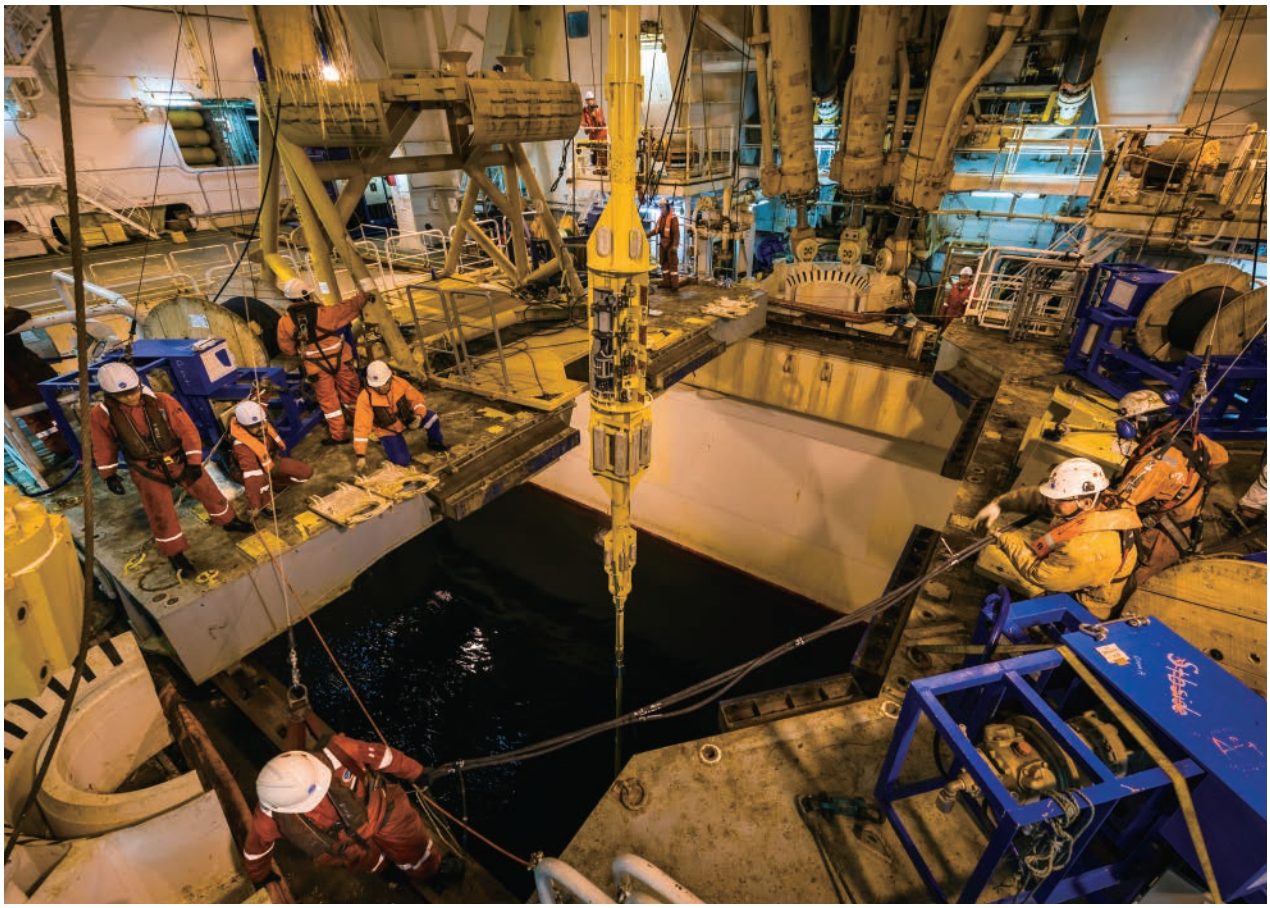


THE MOST CHALLENGING ENDEAVOR IN EARTH SCIENCE

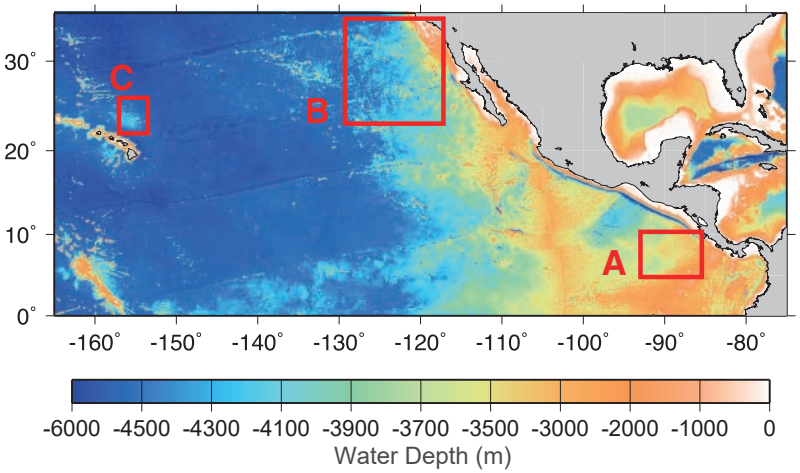
THE MANTLE DRILLING AND OBSERVATORY

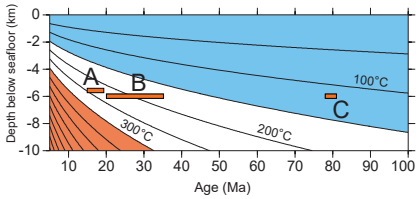
THE MANTLE OBSERVATORY: CONNECTING DATA FROM EARTH'S INTERIOR TO THE UNIVERSE

Illuminating long-run planetary habitability and its sustainability requires understanding interactions from inside Earth to the atmosphere to the Sun and beyond. The mantle drilling project will provide an unprecedented opportunity to establish monitoring of various environmental factors within the oceanic lithosphere and mantle. The mantle observatory data will be able to integrate into other observatory data from the ocean, biosphere, atmosphere, and the universe.



WHERE TO DRILL?





Bathymetric map showing the three potential areas for the mantle drilling project (A, B, and C). Expected temperature as a function of age and depth below seafloor. The red bars A, B and C show the approximate temperature at the presumed Moho depth. (Figures modified from Umino et al. (2013), doi:10.1063/PT.3.2082)

EXPLORING PRISTINE MANTLE BENEATH THE OCEAN

Reaching Earth's pristine mantle has been a frontier quest more than half a century in the making. Considered the most challenging endeavour in the history of Earth science, the mantle could hold clues to the origins and co-evolution of life and Earth and some of the other most compelling questions in all of science. for example,

- How far in the future will Earth remain suitable for life?
- What lies beneath the deep ocean floor?
- What are the reservoirs of energy in the mantle and their fluxes to the crust?

Now, scientists and engineers plan to achieve something never been done before—drilling into the next layer of our world, the mantle, through many kilometers of Earth's crust.

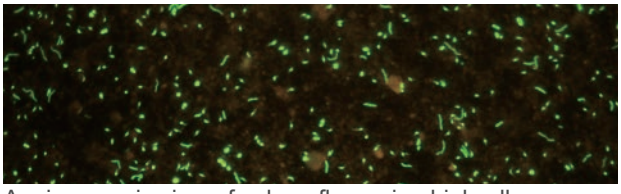
DEEP UNDERSTANDING OF THE MANTLE IS KEY

Since the 1950s, scientists and engineers have dreamt of crossing the terrestrial frontier to reach the mantle. The quest began in 1958 with *"Project Mohole"* , conceived as the equivalent in Earth science of Space science's moon shot. While it did not reach the mantle, *Project Mohole* cracked open the way for decades of discovery with new capabilities to retrieve and study cored samples of sediment and rock brought up from the ocean floor.

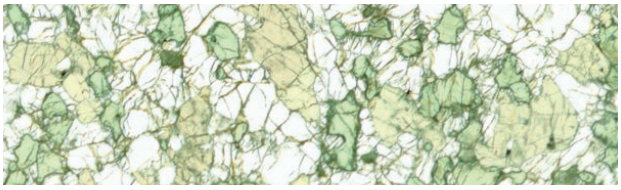
These studies have revealed insights into the chemistry of ancient oceans and Earth's past climate. They revealed the deep biosphere of microbial life surviving within the oceanic sediment and crust at temperatures and pressures previously unimagined. Since these pioneering efforts, stronger materials, new analytical technologies, and more sophisticated drilling techniques have steered the design of a new generation of scientific ocean drilling vessels. The *Chikyu* which will enable even greater discovery.

QUESTIONS

- **What is the nature of the Moho and Earth's interior?**
- **How and why does plate tectonics operate on Earth?**
- **How and why did life emerge and evolve on Earth?**
- **What will be our planet Earth, ocean, and life in the future?**



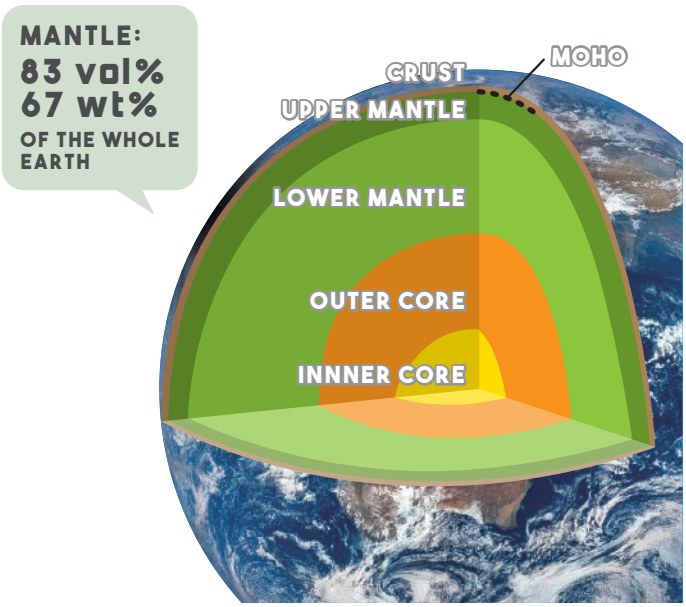
A microscopic view of subseafloor microbial cells



A microscopic view of a peridotite thin section

WHAT LIES DEEP BENEATH THE OCEAN?

There is one immense place in our planet we have never reached—Earth's mantle. Much of our knowledge about Earth's interior comes from interpreting measurements of seismic waves as they travel around and through the globe. These studies reveal that, deep below the surface, below Earth's crust, seismic waves abruptly change speed and direction. We call the region of this transition the Moho—short for the Mohorovičić discontinuity—and it marks the beginning of the mantle. Humans have flown to the moon and retrieved samples from an asteroid, but we have still not even attempted ultra-deep drilling into the mantle.



THE MANTLE–LAST VAST FRONTIER OF PLANET EARTH

The mantle—composed of solid and dense rocks—is the largest layer of Earth. 2,900 kilometers (1,800 miles) thick, it makes up about 83% in volume and 67% in weight of our planet. Within Earth's outer crust rocks remain rigid. Deeper, the temperatures and pressures increase until rocks soften and deform. On this viscous material, the crustal tectonic plates slide and collide over millions of years, forming new seafloor, building continents, and causing great earthquakes as crust sinks back into the mantle. These slow movements also exchange important substances—including water, carbon, and oxygen—among the deep Earth, ocean, atmosphere,and even biosphere.

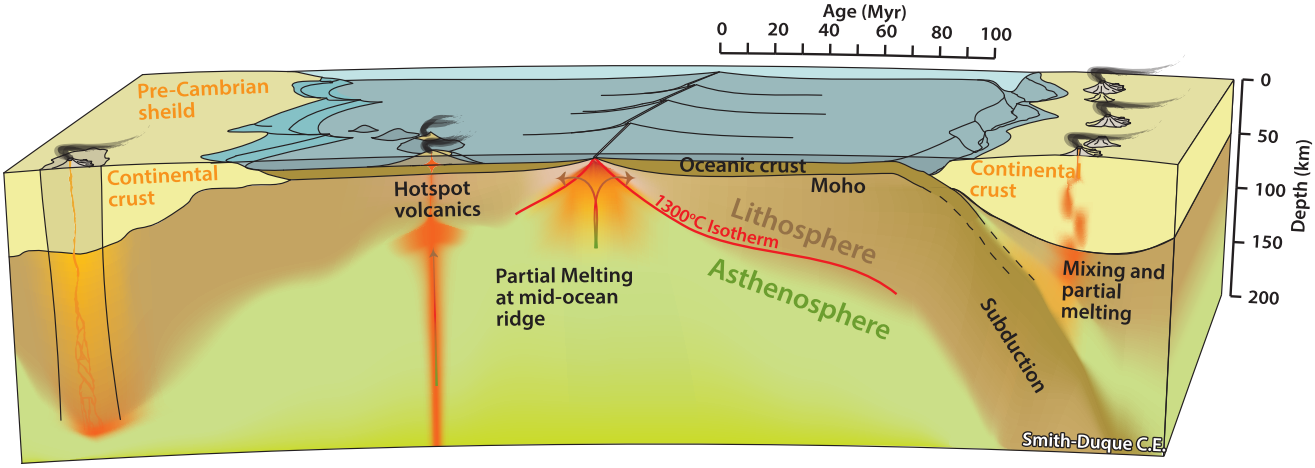
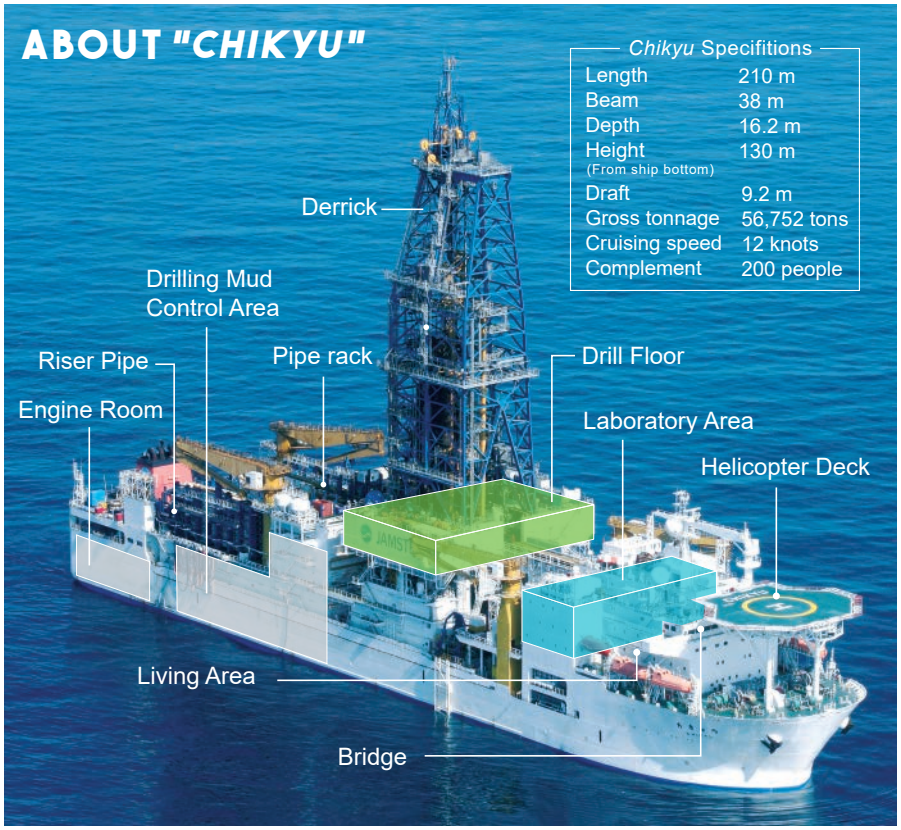


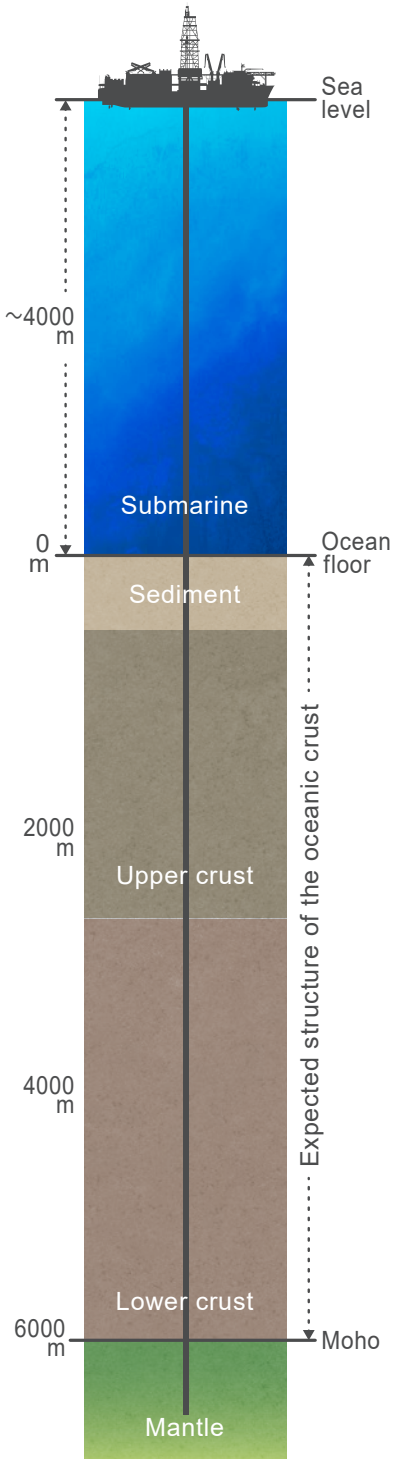
Illustration demonstrating some of the most important underlying crustal processes that formed and continue to shape our planet's surface and crustal geology. Great strides in our understanding of these crustal processes will be achieved by studying the nature and composition of directly sampled deep crust and mantle material up-to and beyond the Moho (figure courtesy of Smith-Duque C.E).

EXPLORING THE MANTLE WITH *"CHIKYU"*

The scientific drilling vessel *Chikyu*, which means *"Earth"* in Japanese, was launched in 2005 with mantle drilling in mind. The *Chikyu* holds the world records for scientific drilling of 7,740 meters (25,393 feet) below the sea surface and 3,262 meters (10,702 feet) into the ocean floor. Its large capacity for risers (vertical pipes) uniquely provide a closed mud-circulation system for establishing a deep borehole down to the upper mantle.

Because of numerous technological advances, for example in the design and durability of drill bits, the estimated total cost has dropped to well below 500M USD for 480-750 days of the mantle drilling operations (Integrated Ocean Drilling Program-Management International [IODP-MI], 2013).











JOIN US – ALL ROADS LEAD TO THE MANTLE

The International Ocean Discovery Program (www.iodp.org) is an international marine research partnership of 23 nations dedicated to advancing scientific understanding of Earth by sampling, instrumenting, and monitoring subseafloor environments.

The Mantle Drilling & Observatory is an international project concept that aims at integrating understanding of Earth from its deep interior and distant past to its far future as a livable planet.

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