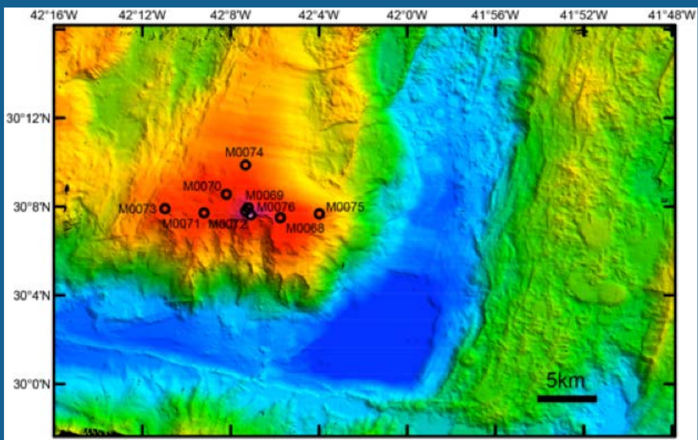
Atlantis Massif Serpentinization and Life Expedition

In October 2015, the *RRS James Cook* left Southampton, UK, with nine scientists from Expedition 357 Atlantis Massif Serpentinisation and Life onboard to begin coring and logging operations at eleven possible sites located on the Atlantis Massif - a prominent, nearly 4,000 m high, underwater mountain on the Mid-Atlantic Ridge, part of the world's longest mountain chain that extends from the Arctic Ocean to the South Atlantic.

Led by Gretchen Fruh-Green, Institute of Geochemistry and Petrology at ETH Zurich, Switzerland, and Beth Orcutt, Bigelow Laboratory for Ocean Sciences, USA, the offshore Science Party and ESO staff spent 28 days coring 9 sites (M0068 to M0076).



The Atlantis Massif is remarkable for several reasons. First, it is made up of rocks from the Earth's mantle, which have a distinct chemistry compared to most rocks at the seafloor. Second, mantle rocks react in the presence of seawater in a process called serpentinisation, which produces methane, hydrogen and heat, among other things. These rock reactions excite scientists because they represent possible sources to fuel life in the absence of sunlight and may be analogous to conditions found on other planets, or early in Earth's history

Scientific goals

1. **Life on the rocks:** What kind of life exists on and within rocks at the Atlantis Massif? Is life in this environment unique and different to life known from other environments on Earth? Does the diversity of life change in response to the type of rocks, the age of the rocks, or other factors?
2. **Follow the carbon:** How does carbon get transformed in this environment? What role does life play in the transformations?Do the reactions between rocks and seawater lead to carbon storage in the seafloor and thus impact the global carbon cycle?
3. **Faults and fluids:** How were mantle rocks brought from deep levels of the ocean crust to the seafloor? How much variability is there in rock type and deformation structures, and how do water and heat move through the system?

Dates: 26 October - 11 December 2015
Platform: *R/V James Cook* + MeBo and RD2
Maximum water depth: 1568 m
Number of boreholes: 17
Number of cores: 68
Core recovery: 57,13 m (52,84%)
http://www.ecord.org/expedition357

RRS James Cook


RockDrill2


MeBo

The expedition set out to recover rocks from E-W and N-S transects that would reveal the complexities of this deep and exciting environment. For the first time in IODP history the expedition used seabed rockdrills, (MeBo and RockDrill2) *(above)* equipped with sensors capable of monitoring *in-situ* fluid conditions during drilling, and with the potential to "plug" a borehole.

IODP INTERNATIONAL OCEAN DISCOVERY PROGRAM

ECORD EUROPEAN CONSORTIUM FOR OCEAN RESEARCH DRILLING

Scientific results

During the 47 day long offshore phase (28 days on location), and the Onshore Science Party held at the Bremen Core Repository in January - February 2016, an international team of 31 scientists analysed the cores to gain a deeper understanding of the workings of this dynamic system, and the relationships between variations in rocks types, deformation of those rocks, and how these changes are reflected in the microbes that inhabit this environment.

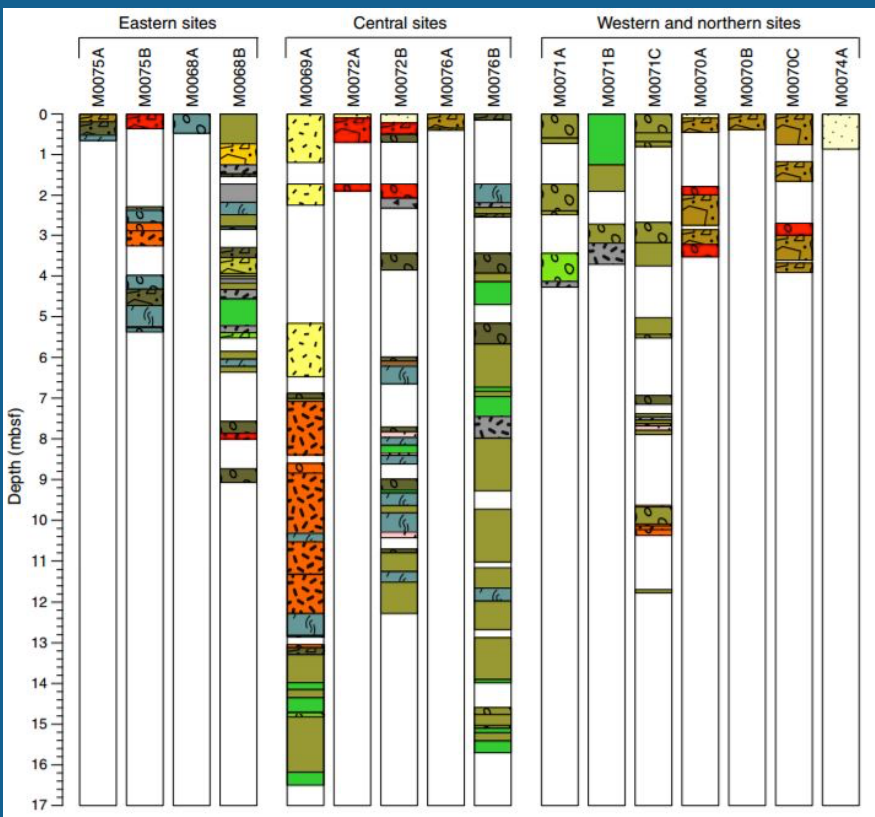
For an overview, multibeam data "painted" a picture of the seafloor at a much higher resolution than previously available across this large system. It revealed a submarine landscape comprising many features, from volcanic cones, to large debris flows that have moved down the flanks of the Massif through channels, changes in the geometry of the detachment faulting along-axis to mass wasting of the Massif and the formation of large scarps that dominate the southern flank where the spectacular Lost City hydrothermal field is found.

The lithologies recovered showed significant lateral and vertical variation in rock type (mafic, ultramafic and sedimentary) and also the degree of deformation and alteration *(below)*, both along the E-W transect, and when compared to previous cores acquired from the central dome during an earlier phase of IODP drilling. Five types of hydrothermal alteration were identified, with overprinting relationships suggesting a progression in the form of alteration with time and exposure to an oxidating environment (*i.e.* proximity to seawater), as a result of movement along the detachment fault.

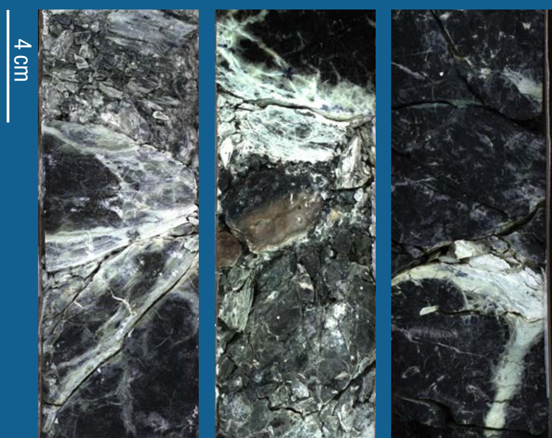
The Expedition Team at the Onshore Science Party in Bremen.

This expedition was also the first to enable long-term monitoring of some of the boreholes. A borehole plug was installed in some holes that can be accessed by a remotely-operated vehicle (ROV) at a later date. This will mean scientists in the future can study changes to the geochemistry of the fluids circulating through the borehole, and so gain a better understand of the circulation of fluids through the whole system.

As with all new data, it will take time to fully understand the new insights that this expedition will bring. However, with teams across the world working on the various scientific questions raised by the core material, new information is expected from areas including microbiology, petrology, geochemistry and structural geology.



Recovery and described lithology for all sites of Expedition 357.



Core images of a serpentinised peridotite with talc-amphibole-chlorite alterations (Site M0072B, 6R-1, 7R-1 and 8R-2).

April 2017 - credits: ECORD/IODP and Volker Diekamp, MARUM).

For further reading

- Früh-Green GL, Orcutt,BN, Green S, Cotterill C and the Expedition 357 Scientists, 2016. Expedition 357 Preliminary Report: Atlantis Massif Serpentinization and Life. International Ocean Discovery Program. doi:10.14379/iodp.pr.357.2016
- Früh-Green GL, Orcutt BN, Green SL, Cotterill C and the Expedition 357 Scientists, 2016. Atlantis Massif Serpentinization and Life. Proceedings of the International Ocean Discovery Program, 357: College Station, TX (International Ocean Discovery Program). doi:10.14379/iodp.proc.357.2017