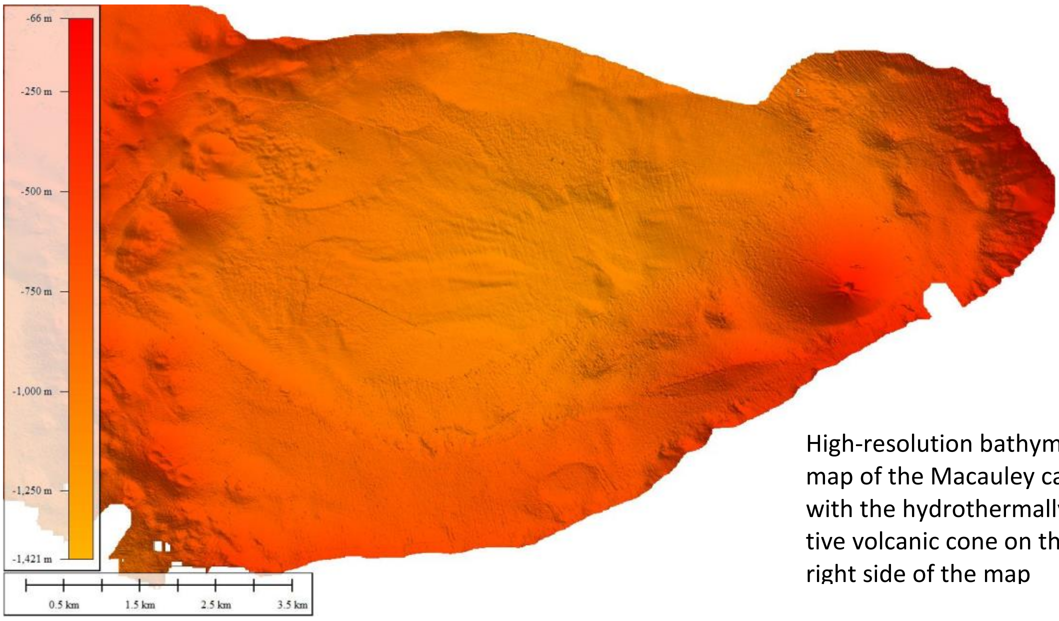
SO253 2. Weekly Report 26.12.2016 – 02.01.2017

We finished work in our first working area Macauley on 30 December and based on the multitude of equipment deployments, including four ROV Quest dives and intense multidisciplinary lab work on recovered samples we already have a detailed picture of this shallow hydrothermally active site.

Mapping of the seafloor using a multi beam echo sounder was done in the region of Macauley caldera volcano and later over neighbouring Giggenbach cone volcano. Both were re-mapped with the higher resolution echo sounder aboard the Sonne and we also infilled gaps in the regional bathymetric data base while transiting to and from these volcanoes. We also investigated whether the seafloor structure has changed due to volcanic activity or collapse of volcano flanks since they were last mapped. Based on the analysis of acoustic data in the water column gas flares can be made seen, which help us pinpoint the exact location of the hydrothermal fluid vent sites. Gravity measurements have been recorded ever since we entered New Zealand's EEZ. A magnetometer has also been deployed on every ROV dive. Heat flow blankets were deployed at two sites at Macauley (main cone and SW cone) for a total 10 deployments. The geophysics data have yet to be analysed.



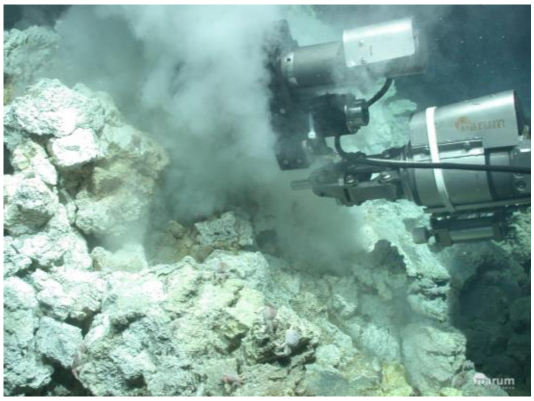
High-resolution bathymetric map of the Macauley caldera with the hydrothermally active volcanic cone on the right side of the map

CTD operations at Macauley caldera mapped and sampled the plume from the summit of Macauley Cone (250-300 m deep) with two tows of 5-6 km length each, and several vertical casts directly over the summit vents. The more distal extent of the plume originating at the main cone summit, along with water above and below the plume depth, was also sampled with two additional vertical casts about 500 m to the east and west of the Macauley Cone summit. There was evidence from previous surveys that a smaller, deeper cone to the west of the main cone also hosts active vents. The tow that passed over this cone detected and sampled this plume at a depth of ~685 m depth and another vertical CTD cast was done. Water current measurements during all CTD profiles will be used to interpret the plume distribution. Water samples from the CTD Niskin bottles were taken proximal and distal from within, below, and above the two distinct plume signals identified at Macauley.

ROV dives confirmed intense venting in the pit crater of the main cone and while lots of evidence for low temperature alteration and abundant vent-related animals were seen atop the SW cone summit, no actual venting was found.

The geology at Macauley Cone is characterized by aphyric, vesicular volcanic rocks (lavas) as well as pyroclastic units. In the hydrothermally active crater there are also extremely bleached rocks of quartz and alunite, formed by the reaction of the lavas with the rising acid sulfate solutions. We found yellow sulphur adhering to these rocks (see photo), which also form in the solutions when magmatic sulfur dioxide mixes with seawater forming elemental sulfur and sulfuric acid.

The hot fluids at Macauley Cone discharge from a White Smoker in about 270 m water depth itself consisting of blocky, yellow-whitish elemental sulphur. Onboard analyses have shown that hydrothermal activity at Macauley Cone is characterized by sulphuric acid solutions. The venting fluids area have a very low pH (<1.5), very high in dissolved sulphide, silica and iron contents, and chloride concentrations significantly higher than in seawater indicative of a brine. The magnesium concentration which is usually zero in mid-ocean ridge vent fluids, here is twice as high as in seawater, which can be attributed to the very acidic nature of the fluids. Samples from specifically designed gas-tight samplers showed low, but well quantifiable concentrations in hydrogen (H_2) and methane (CH_4). From this initial characterization we can already conclude that the hydrothermal fluids at Macauley are rather unique compared to other known vent sites.



Fluid sampling at the sulphur chimney, area Macauley; source: MARUM, Univ. Bremen

Fluid samples from ROV and CTD deployments were also measured for alkalinity, nitrate, nitrite, phosphate and ammonia. Aliquots for shore-based analysis for further general chemical characterisations, trace metals, stable isotopes including iron isotopes, manganese (III) and metal-binding organic ligands were preserved for storage. Aliquots of all fluids were also subsampled for amino acid, dissolved organic carbon (DOC) and total dissolved nitrogen (TDN) analysis and dissolved organic matter (DOM) was preconcentrated to enable geo-metabolomic characterization. Shore-based analysis and further evaluation will help to understand how this type of hydrothermal system affects marine DOM composition, what role DOM plays for complexation and Fe supply to the ocean, and how imposed changes affect bioavailability of DOM to heterotroph microorganisms.

Radium isotopes in the water samples have also been analysed onboard. Compared to the natural background the vent fluids are enriched by a factor of 200 for the short-lived radium isotopes (Ra-224 with a half live of 3,7 and Ra-223 at 11 days). The preliminary estimate for the age of the volcanic plume is on average 7 days in the vicinity where the ROV operated whereas on the outer margins of the plume the age increases up to around 27 days.

Many work groups sample the Niskins from the CTD deployments for onboard and home lab analyses of plume tracers and other hydrothermally derived components.

In the water samples recovered from the CTD casts and ROV dives, the noble gas helium (He) is used to study the dispersal of hydrothermal signals in the water column. Helium from the earths' mantle has a different isotopic signature than He from the atmosphere. Noble gases are not altered by biological or chemical processes, thus the hydrothermal signal can be traced over vast distances (up to hundreds of kilometres) by its isotopic signature. The results from He analysis will be used to estimate the amount of plume water that reaches the ocean surface layer, and the horizontal distribution of the plume.

A strong focus of the fluid geochemistry is on trace metals. To allow for trace-metal clean work onboard, a clean-room container is operated on the working deck. It houses the flow injection analysis to measure dissolved iron concentrations down to 0.1 nanomolar along the entire gradient from the vent to ambient open ocean background. The trace metal clean sampling rosette makes sure that samples can be collected free of contamination. The trace metal clean McLane in-situ pumps allow the collection of enough particulate matter to conduct iron isotope analysis, and are also used to collect radium samples. So far, four in-situ pump stations have been run.

Searching for chemosynthetic fauna, i.e. invertebrates that live in symbiosis with primary producing bacteria, we found two mussel species. Our first dive showed that the Macauley cone is host to juveniles and mid-sized specimens of *Gigantidas gladius* (see photo) and *Vulcanidas insolatus*, while from older animals there only dead shells remained. This may indicate that both species are again building up populations on Macauley cone after a breakdown that happened a few years ago. Our second dive on the other active albeit smaller cone located only 1500 m away, in contrast, showed aggregations of large and old *Gigantidas gladius*, but no juveniles, which raises the question whether this population is waning. We collected animals from both sites and will analyse the hosts and their bacterial symbionts in the shore-based laboratories using molecular methods. Samples of free-living microbes were taken from plumes, fluids and surfaces of hydrothermal precipitates for cultivation dependent and independent analysis.

We left Macauley in the afternoon of 30 December, and after a short drone flight over neighboring Curtis Island to record geothermal activity in its crater, we started the 15-hour transit to our second working area, Haungaroa. Both the multibeam echosounder and the magnetometer were deployed in transit between Macauley volcano and Hungaroa volcano and during a subsequent survey of the Haungaroa area until the morning of January 1, 2017. This allowed us to enjoy a barbecue on deck in the evening of 31 December, to watch “Dinner for One” together and to welcome the New Year with a glass of sparkling wine at midnight. We are presently running our second successful ROV dive on this largely unexplored volcano Haungaroa and have already found plenty of fascinating lava structures, hot fluid discharge and low-temperature diffuse vent sites host to abundant life. The first chemical analyses of these fluids suggest that their composition is completely different to those sampled at Macauley.

The good track record of deployments and initial results are only possible because of the excellent cooperation among the different scientific groups and skills of the ROV team and the ship’s captain and crew. Thank you to everyone!

With best regards from board FS Sonne
Andrea Koschinsky (chief scientist SO253)