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REPORT AND PRELIMINARY RESULTS OF RV SONNE CRUISE SO 216, TOWNSVILLE (AUSTRALIA) - MAKASSAR (INDONESIA), JUNE 14 – JULY 23, 2011.
BAMBUS, Back-Arc Manus Basin Underwater Solfataras.

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CRUISE REPORT SONNE 216

BAMBUS

Wechselwirkungen zwischen Fluiden, Mineralen und Organismen in schwefeldominierten Hydrothermalquellen des östlichen Manus Beckens, Papua Neuguinea

Interactions between fluids, minerals, and organisms in sulfur-dominated hydrothermal vents in the eastern Manus Basin, Papua New Guinea

Townsville, Australia – Makassar, Indonesia
14 June – 23 July, 2011

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1. SUMMARY (Wolfgang Bach)

ROV-based sampling of hydrothermal systems in the eastern Manus Basin was the primary goal of cruise SO216. The cruise was a follow-up on an RV Melville cruise with ROV Jason2 in 2006, during which geophysical mapping, rock sampling, and reconnaissance fluid sampling were the primary goals. The specific focus of the SO216 cruise was vent fluid and biota sampling. The two working areas comprised North Su at 3°48.0'S, 152°06.05'E in about 1200 m water depth and PACManus at 3°43.5'S, 151°40.4'E in ~1700 m water depth. During nightly echosounding surveys with the ship-based EM-120 system, a comprehensive and detailed map of the eastern Manus Basin could be completed (Fig. 1.1). Twenty-two dives with the ROV MARUM Quest 4000m were conducted, ten in the PACManus und twelve in the North Su area. Sample collected comprise hydrothermal fluids (using gas-tight Seewald samplers and teflon KIPS bottles), biological specimen of vent macrofauna, microbial filaments and biofilms, as well as volcanic rocks and hydrothermal precipitates. A range of vent systems was sampled in both working areas. Geological mapping was carried out throughout the dives, and sections of some dives were specifically committed to mapping certain structures. At North Su, black smoker systems near the summit of the volcano, white smoker systems on the southern flank, and diffuse vent sites on the northern slope were visited repeatedly. Black smoker vents showed maximum temperatures ranging between 313 and 332°C, the latter corresponding to the boiling temperature of seawater at the ambient pressure (124 bar). White smoker vents revealed copious amount of native sulfur on the seafloor, both in solid and liquid state. The sulfur formed small chimney, and accumulated in m-sized knolls on the seafloor and in sills or buried flows within the volcaniclastic sediment. CO_2 bubbling was common at the white smoker vents. CO_2-clathrate formation could be confirmed visually at the interface of liquid CO_2 collected a bubble-catching device and water left in the device. Bubble flares were visualized using the ship-based Parasound system. CO_2 degassing was also observed during ROV dives at the Satanic Mills site in the PACManus area. Endmember hydrothermal fluids there were also boiling at a temperature of 345°C. Lower temperatures (304-314°C) were measured at the Fenway site, where fluid boiling at 356°C was observed in 2006. The Roman Ruins hydrothermal site was sampled during two dives, and also appeared less active than five years before. Hydrothermal sites discovered during exploration dives by Nautilus Minerals in 2007 were also sampled. These included Solwara 8, southeast of Fenway, and Solwara 7, northwest of Roman Ruins. The preliminary data and dive observations indicate substantial changes in the magmatic-hydrothermal systems. Drastic changes in the volcanic landscape and distribution and style of hydrothermal venting on the south flank of North Su stand out, as well as the apparent changes in gas content of the fluids at PACManus.

Incubation experiments using both glass slides and surfaces of sulfide and sulfur grains were deployed and left in areas of diffuse venting for 10 to 18 days. Biological sampling was carried out in the same areas. Moreover, an *in situ* mass spectrometer developed in Peter Girguis's laboratory at Harvard University, was used to determine the amounts of dissolved gas in the diffuse fluids from which samples were taken and into which the incubation experiments ere placed. Temperature and pH were also determined for these locations.

Four CTD casts were conducted to record the sound velocity of the water column in the eastern Manus Basin and to obtain reference deep-sea water samples. The hydrothermal plume on top of North Su was also sampled by Niskin rosette. Five TV-guided grab stations recovered rock material from the Bugave ridge, east of North Su, Sowara 9a, west of North Su, Sulfur slabs at North Su, Sulfide chimney talus from Solwara 8, south of Fenway, and a massive sulfate-sulfide rock from Fenway.

Sea state and weather conditions were excellent throughout the cruise, except for occasional tropic rain storms. All science goals of the cruise could be reached.

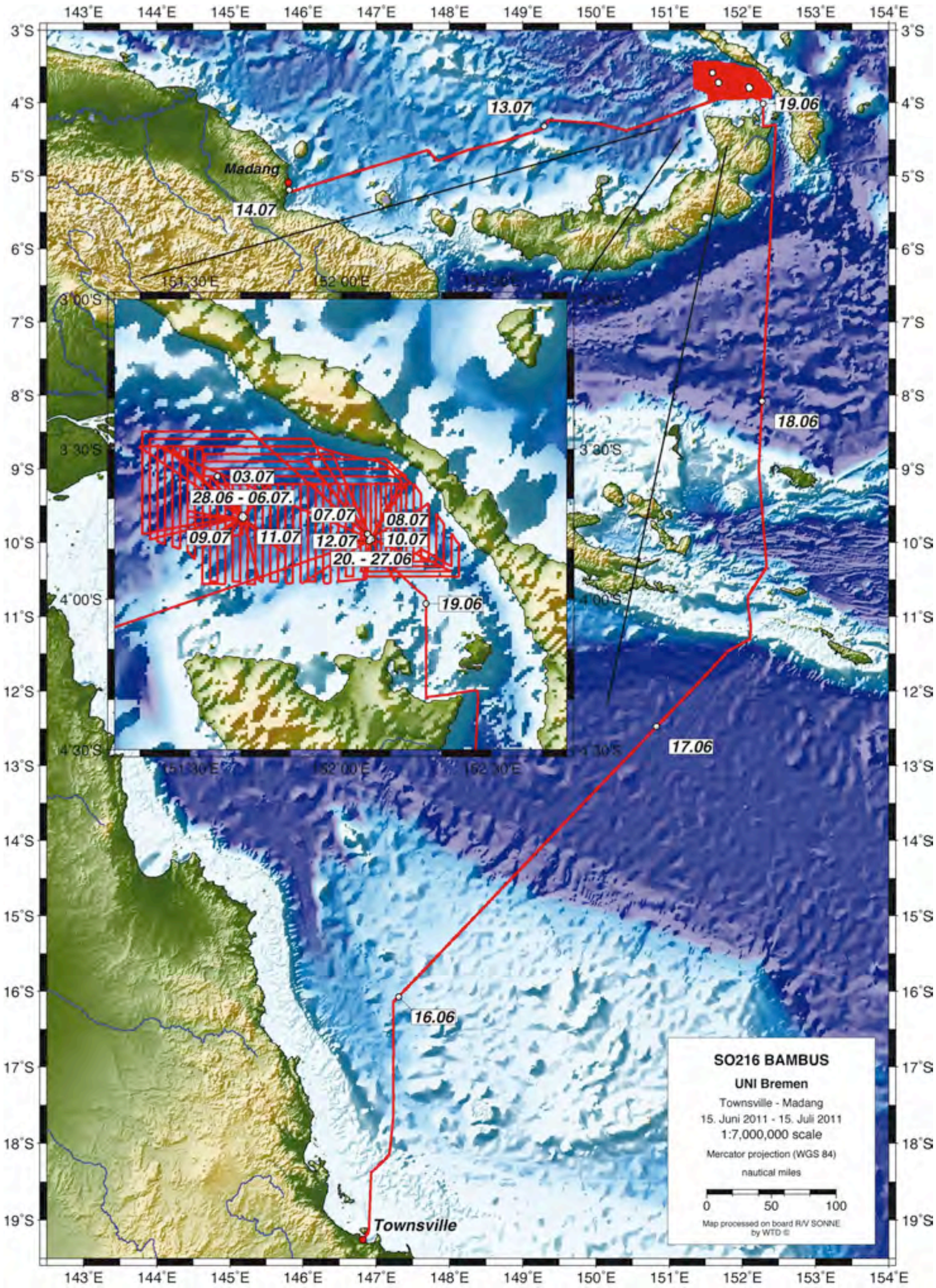

Fig. 1.1: Ship track of cruise SO216 from Townsville to Madang. Tracks of the bightly bathymetry surveys are depicted in the small inset.

2. PARTICIPANTS

Science Crew

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Thal, Janis	MARUM, University of Bremen, Geology
Zarrouk, Marcel	MARUM, University of Bremen, ROV

Ship's Officers and Crew

Mallon, Lutz	Captain		
Aden, Nils Arne	Chief 1st Officer	Kosanke, Patrick	2nd Stewart
Altendorf, Denis	Apprentice	Kraft, Jürgen	A.B.
Bolik, Torsten	Motorman	Leppin, Jörg	Chief Electr.
Borchert, Wolfgang	Systems Manager	Maak, Lars	Electrician
Dehne, Dirk	Motorman	Mohrdiek, Finn	A.B.
Dolief, Joachim	A.B.	Rex, Andreas	2nd Engineer
Fricke, Ingo	A.B.	Rosemeyer, Reiner	Fitter
Ganagaraj, Anthony	2nd Cook	Schmandtke, Harald	1st Stewart
Genschow, Steffen	2nd Engineer	Schrapel, Andreas	Bosun
Göbel, Jens	2nd Officer	Stängl, Günther	A.B.
Guzman-Navarrete, Werner	Chief Engineer	Thomsen, Sascha	2nd Engineer
Hofsommer, Lars	1st Officer	Tiemann, Frank	Chief Cook
Ide, Steven	Apprentice	Walter, Anke	Physician
Kohnke, Frank	A.B.		

3. SCIENTIFIC BACKGROUND AND CRUISE OBJECTIVES (Wolfgang Bach)

The eastern Manus Basin (EMB; see **Figure 3.1**) is located in a tectonically very active area and exhibits neovolcanic structures of extreme chemical variability. Active hydrothermalism in water depth of 1200-1700m has been observed at many of these volcanic structures.
The first mapping and identification of the major spreading zones was done by Taylor (1979). Additional mapping surveys by Auzende *et al.* (2000) and Tivey *et al.* (2006) and Herzig et al. (2003) have been conducted since. The basalt-hosted Vienna Woods System was the first hydrothermal system identified in the Manus Basin (Both *et al.*, 1986; Tufar, 1989; Lisitsyn *et al.*, 1993).
The PACManus (PacificAutraliaCanadaManus) hydrothermal field, situated on the dacitic to rhyodacitic Pual Ridge, was discovered by Binns & Scott (1993). Associated massive sulfide deposits are rich in Au, Cu, As and Sb (Moss & Scott, 2001). Sample material from the subseafloor of the PACManus field was also recovered by the Ocean Drilling Program (ODP), which drilled down to 364m below seafloor (Binns *et al.*, 2002; Roberts *et al.*, 2003).
The small Desmos hydrothermal field, located at the northern caldera wall of an andesitic volcano, shows evidence for an influence of magmatic degassing on the hydrothermal fluid chemistry (Gamo *et al.*, 1997). Argillitic alteration of andesites is seen as evidence for intense interaction with sulfuric fluids (Gena *et al.*, 2001). Similar observations have been made in the SuSu Knolls area by means of rock dredging and TV-sled surveys (Binns *et al.*, 1997; Yeats *et al.*, 2000). Three Japanese research expeditions, partly with French and Australian participation, used the Shinkai submersibles to address macrobiological questions. Additional French, German and Australian expeditions sampled e.g. sulfides from Vienna Woods (Tufar, 1989) and drill cores from the PACManus area (Herzig *et al.*, 2003).

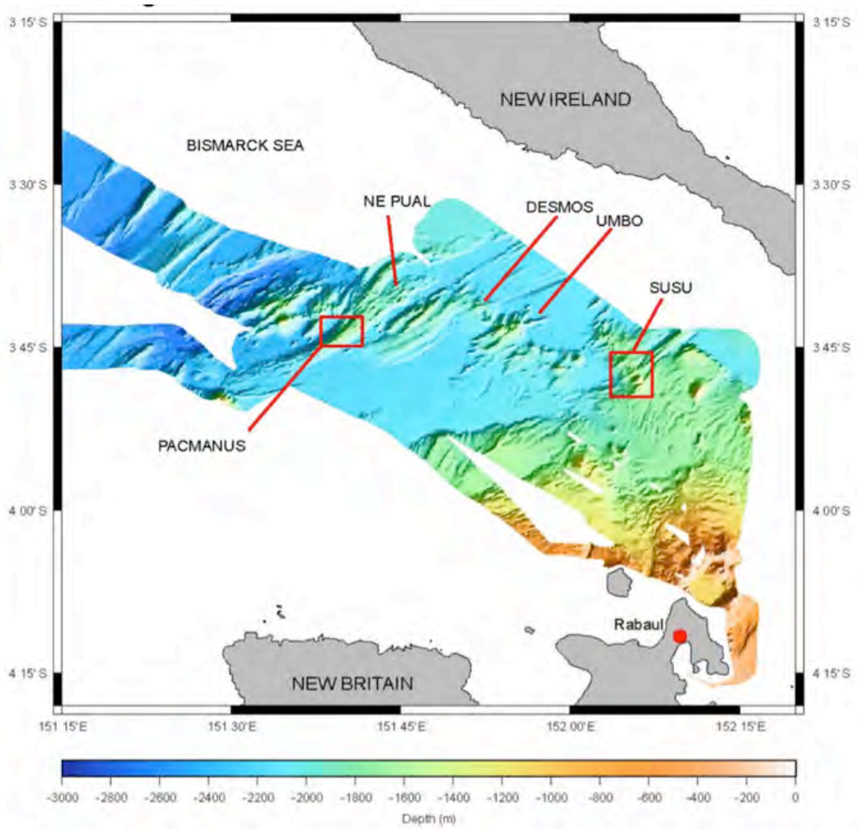


Figure 3.1: Overview bathymetric map of the eastern Manus Basin, showing locations of hydrothermal vent sites (Tivey et al., 2006).

During the MAGELLAN06 expedition (Tivey *et al.*, 2006), detailed mapping and hydrographic survey of the hydrothermal fields of the eastern Manus Basin with the Autonomous Benthic Explorer was performed. Systematic sampling of hydrothermal fluids, sulfide deposits and volcanic rocks indicated a highly diverse chemistry due to variable influence of subducted components, island arc lithosphere and magmatic degassing (Kamenetsky *et al.*, 2001; Yang & Scott, 2002; Sinton *et al.*, 2003; Shaw *et al.*, 2004; Sun *et al.*, 2007). Specifically, fluids and precipiates show a distinct geochemical signature of magma degassing (Reeves et al., 2011; Craddock et al., 2010; Craddock and Bach, 2010; Bach et al., 2004).
Former biological investigations in the Manus Basin are restricted to two microbiological studies (Takai *et al.*, 2001; Kimura *et al.*, 2003) and a phylogenetic examination of vent fauna (Kojima, 2002; Miyazaki *et al.*, 2004; Kojima *et al.*, 2006). There are just a few studies about the gastropods *Alviniconcha hessleri* and *Ifremeria nautilei* and their endosymbionts (Gal'chenko *et al.*, 1993; Urakawa *et al.*, 2005; Suzuki *et al.*, 2006), but none of these studies tried to correlate biological observations and geochemical data. Morphological and enzymatic surveys on *Ifremeria nautilei*, which commonly occurs in the western Pacific, point to dual symbiosis with sulfide- and methane-oxidizing bacteria (Gal'chenko *et al.*, 1993; Borowski *et al.*, 2002), which is supported by moderate methane and sulfide concentrations in diffuse hydrothermal fluids of the *I. nautilei* habitats in the North Fiji Basin (Koschinsky *et al.*, 2002). Comparable data from the Manus Basin do not exist. Furthermore, recent molecular genetic studies indicate that *Ifremeria* symbiosis involves at least five microbial symbionts (Borowski & Dubilier, unpublished), the function of three of which is completely unknown. Differences in the symbiont diversity between the Manus Basin and the North Fiji Basin point to either a bio-geographic separation or to different effects of the geochemical settings in the two distinct habitats. Nothing is yet known about the symbionts of the bivalves *Bathymodilus sp.* and *Calyptogena sp.* as well as the vestimentiferous tube-worms, which are common in the Manus Basin.
The main objective of Cruise So216 was geochemical, biogeochemical and biological sampling of active hydrothermal systems in the eastern Manus Basin. Hydrothermal fields at spreading axes and subduction zones are unique highly productive habitats within the generally nutrient-poor deep sea. Although characterized by extreme physical and chemical conditions as well as steep chemical gradients, these places host different chemolithoautotrophic microbial communities, which rely mainly on energy sources such as oxidation of hydrogen, methane, iron, and sulfur. Both the chemosynthetic free-living and symbiotic microbes are of significance for the ecology in hydrothermal environments. The microorganisms are primary producers of particulate organic compounds and thus provide the food for a variety of zooplankton and benthic organisms. Despite the great significance, our knowledge about these communities is only superficial and they need to be studied in greater detail.
Our work in the Manus Basin will address a variety of fundamental questions, the first set of which deals with supply and redistribution of energy sources and nutrients through geochemical processes:

- *What energy carriers in volcanic magma-hydrothermal systems reach the seafloor?*
- *What is the influence of sub-crustal mixing of seawater with hydrothermal fluids on material transport and heat flow?*
- *Can specific water-rock reactions and solution/precipitation processes be identified that control the chemistry of hydrothermal fluids? And how do they determine the physico-chemical living conditions of the vent faunae?*

These question will be tackled using fluid and rock geochemical analyses and geochemical modeling.

A second set of questions deals with the interplay of geochemical and biological systems:

- How do different chemical compositions of fluids influence the composition of biocoenoses?
- What are the dominant metabolic reactions in the different habitats and how much biomass can potentially be produced?
- What kinds of symbiotic relationships have evolved within the different systems of the Manus Basin and how are they influenced by the fluid chemistry?
- What are the biogeographic patterns within isolated basins of the Western Pacific?

A particular focus will lie on some fundamental biogeochemical questions and hypotheses:

- Characterization of sulfur species in fluids, with emphasis on sulfur redox intermediates and their roles as electron donors and/or as electron acceptors for microbial growth.
- The relation between abiotic and microbial processes along gradients in temperature and pH is poorly understood, especially the reduction of sulfate under extreme conditions (e.g., high T and low pH).
- Study of microbial processes, which take place in the redox potential between hydrothermal fluids and seawater and which can lead to a characteristic fractionation of sulfur and oxygen isotopes in sulfur-bearing compounds.
- The Manus Basin hydrothermal systems bear the chance for enrichment and cultivation of novel thermophile and acidophile sulfur-reducing bacteria, which might be of global biogeochemical importance.

By using cultivation-dependent and –independent methods, studying different habitats in the Manus Basin is aimed to increase our knowledge of hydrothermal communities. The following questions, among others, should be answered:

- What sulfur- and methane-oxidizing asymbiotic microorganisms dominate the geochemically distinct (in pH and temperature) diffuse vents of the Manus Basin? How do they fixate carbon?
- Do the genomes of free-living and symbiotic microorganisms, which are involved in sulfur- and methane-oxidation, feature characteristic genomic and operon patterns?
- Do chemosynthetic microorganisms exist within the Manus Basin, which could use other already know redox pairs for extraction of energy?

4. CRUISE NARRATIVE (Wolfgang Bach)

The science crew boarded the R/V Sonne in the morning hours of June 14, 2011 in Townsville, Australia. Much of the loading of the gear, including the ROV MARUM Quest 4000m with its winch as well as a workshop and control van, took place that day. A reefer had been loaded into the ship's hold and a dedicated lab container for isotope-labeling experiments had already been brought onboard the day before. The science party started unpacking the gear-boxes and setting up in the various labs onboard the Sonne. In the afternoon of June 14th, the ship moved to the bunker station, and the science party left to enjoy the last evening on land in a month. Bunkering continued on the 15th, but at 16:00 the Sonne left its berth and started steaming north. We began a multibeam bathymetry survey of the outer barrier reef and coral sea, following way points Dr. Robin Beaman from the

University of Cairns had given us.
During the four-day transit to the Manus Basin, the laboratories were organized and daily introductory science meetings were held in the ship's conference room. The sea state during the transit was fair, with generally low swells and clear skies. In the morning of June 19th, the PNG observer, Leo Jonda, was taken onboard after dinghy transfer out of Kokopo, near Rabaul. After steaming into the eastern Manus Basin for two hours, a CTD cast was carried out for a water column sound profile. A roll calibration of the EM120 multibeam echosounder system was conducted next, before the first in a series of multibeam surveys during the night hours was started. The first dive of the ROV took place in the morning of June 20th, but the seafloor was not reached, due to malfunctioning of the ROV electronics system. The roll calibration was repeated, because artifacts in the results of the first multibeam station were recognized. Also, another CTD sampling cast was conducted to obtain more deep-sea water for biology and geochemistry.
Due to continued problems with the ROV electronics, a TV-grab station was executed on June 21st. The grab was dropped over the southwestern end of the Bugave Ridge, where CTD tow-yo data available to Nautilus Minerals indicated hydrothermal activity. No evidence for hydrothermal venting was observed during three hours of surveying over sedimented area with occasional outcrops of volcanic rock. A sample of fresh, sparsely plagioclase-clinopyroxene bearing volcanic rock was retrieved, along with Mn-oxide stained sediment. The first dive to the seafloor (no. 296) took place in the afternoon of June 21st. Hydrothermal vents were located on the northwestern flank of North Su. However, the IGT fluid samplers did not respond due to communication problems and we aborted the dive. During a repeat dive (297) to the same vent source in the morning of June 22nd, the samplers, again, failed, but two pieces of friable hydrothermal barite-sulfide-sulfur crusts were recovered from the vent. We moved along the northern slope of North Su to a site of patchy diffuse venting with abundant snails, tubeworms, and mussels. We took two rock samples, a KIPS fluid sample and sampled Alviniconcha snails, after detecting elevated CO_2, H_2S, and CH_4 contents by ISMS. At this site, the first of two incubation experiments with sulfide and sulfur grains as substrates was deployed. We left Marker 30 there and moved south along the western flank of North Su. After traversing over steep terrain with numerous patches of white and orange staining with occasional biota, we encountered dense white smoke and detoured upslope in a northwesterly direction. That route took us up a near-vertical wall, which exposed hydrothermally cemented pyroclastic rocks. Near the northern fringe of the North Su summit we found a site of black smoker venting and issuing of clear fluids through cracks in hydrothermal slabs surrounding the smokers and ended the dive there.
Due to a temporary DGPS fault, ROV dive 298 on June 23rd started 550 m east of the intended landing site on the lower reaches of the east flank of North Su. Along a westward transect up the slope, we encountered volcanic rock and sulfur talus, of which we took four samples. Near the rim of a crater on the southeaster flank, we located the source of the sulfur clasts littered across the eastern slope. Slabs of massive sulfur were draped across the crater rim and small sulfur sills or buried flows protruded from volcanic ash. The inner wall of the crater exposed poorly sorted volcaniclastic material cemented by native sulfur. We took two filter samples of filamentous material covering the sulfur outcrops and collected six KIPS bottles of fluids seeping up through areas of orange and white staining. The ISMS (with pH meter) recorded elevated CO_2 levels and pH values between 6.3 and 6.6 at this site. In mid-afternoon, the dive was aborted due to technical difficulties with the ROV's manipulator arm. A TV-grab at the location of the sulfur slabs retrieved abundant sulfur as well as volcaniclastic sediment and talus cemented by sulfur.
Two dives on June 24 (299 and 300) were targeted to examine sites of white smokers, which delivered acid-sulfate waters in 2006. Although navigation was excellent, the smokers could

not be found. At the relevant waypoint, a smooth slope with volcanoclastic sediments was encountered, where steep headwalls and talus fans with numerous patches of venting were expected. Noticeably, the pH sensor recorded a drop of 1 to 1.5 units at the site, despite the lack of visible evidence for fluid discharge. We surveyed much of the southern flank throughout the day, but did not find white smoker activity.

The target of the dive 301 on June 25th was black smokers near the summit of North Su. Black smoker venting was found west of the summit on a very steep and rugged slope exposing near vertical cliffs of hydrothermally cemented pyroclastic rocks along with talus of volcanic rock and broken sulfide chimneys. The area of most vigorous venting showed flashing of light through the black smoke, indicative of fluid boiling. Temperatures up to 332°C were measured here, and the first IGT vent fluid sample of the cruise was collected. The summit area was approached with a southeasterly heading, but extremely poor visibility due to black and white smoke in addition to adverse currents prevented us from sampling the black smokers there. We eventually offset to the black smoker site discovered near the end of dive 297, and found much improved working conditions there. At a site of clear fluid venting through a fissure in hydrothermally indurated sediment, KIPS fluid samples were collected and ISMS measurements performed, which indicated high H_2S contents and pH values as low as 3.1. KIPS bottles and filters for microbiological studies were also sampled here. The temperatures during sampling ranged between 20 and 74°C. Background samples of ~7.5°C warm fluids from the top of the slabs were also taken. Two symbiont incubation devices (symcatchers) and a microbiological mineral substrate incubation devise were deployed around the crack and two pieces of the hydrothermally indurated sediments were collected. We dropped Marker 32 here before the dive ended.

Dive 302 on June 26th began with IGT fluid sampling of 169°C hot, clear to light gray vent fluids from the northwestern slope of North Su. Marker 30 site was visited next to deploy two symcatchers and collect Alviniconcha and Ifremeria snails from patches of diffuse venting. ISMS measurements indicated high H_2S concentrations of the fluids and a pH of 4.8. Temperatures ranged up to 44°C. We traversed south along the western slope of North Su to look for white smoker activity and found meter-thick flows of native sulfur on the southwest slope in 1220 m water depth. Immediately west of that site was an area of vigorous white smoker activity. The white smoke drifted off to the north, so that we were able to inspect the site more closely. Liquid sulfur oozed out from the sedimented seafloor and locally formed chimneys. White smoke and bubbles of presumed liquid CO_2 rose slowly from these vents. Anastomosing finger-thick flows of green and yellow sulfur accumulated locally to form dm- to m-thick aggregates on the seafloor. KIPS sampling of selected vents was attempted, but the system clogged. After retrieving a sulfur chimney, the dive was ended. While the ROV was brought on deck, the science party decided to name this spectacular site "Sulfur Candles".

Fluid sampling at the Sulfur Candles site was highest priority of the dive program on June 27th. Dive 303 had to be aborted because of problems with the manipulator arm, but during dive 304 on the same day we collected fluids with both IGT and KIPS bottles and sampled a piece of sulfur with presumed bacterial filaments attached to it with a shovel. ISMS measurements suggested high CO_2, low H_2S and very low CH_4 concentrations. KIPS bottle samples had pH values between 2.1 and 2.7 and temperatures between 20 and 50°C. IGT sampling recovered gassy fluids with maximum temperatures of 103°C and pH values as low as 1.2. CO_2 bubbling was obvious and there was visible formation of CO_2-clathrates on the metal parts of the KIPS intake system. Next, the southern slope of North Su was explored to obtain more information on the changes in landscape noted here during dives 299 and 300. It became obvious that a new ash cone has developed in a place where steep walls and talus slopes prevailed in 2006. At the contact between the new cone and the pre-existing steep walls, white smoker vent sites had developed. We followed the line of white smoker, which extended for 80 m along the western slope of North Su. Venting was vigorous in places and some spots showed intense bleaching of rocks around the sites of fluid discharge. We came up against a near-vertical E-W trending wall, where visibility was much reduced. It was decided to come up the wall, which turned out to be 20 m high and featured volcaniclastic material and talus. We moved to Marker 30 site next to deploy symcatchers there before ending the dive.

Dive 305 on June 28th was the first of the cruise in the PACManus area and the prime target was the Fenway hydrothermal field discovered during the Magellan06 cruise in 2006. A black smoker complex named Big Papi was visited first. Sparse venting of black smoker fluids along the fringe of the mound, which consists mostly of anhydrite, was spotted, but the overall activity of Big Papi was much reduced compared to 2006. IGT sampling of a 303°C smoker growing out of anhydrite rubble yielded a sample diluted with seawater (the nozzle came out of the orifice during sampling). The chimney had a beehive-type black diffuser top, which was removed before IGT sampling. Several pieces of the chalcopyrite-rich base of the chimney were sampled subsequently. Work continued in a large area of diffuse venting 50 m north of Big Papi. In that area, patches variably dominated by snails, mussels, tubeworms, as well as microbial filaments could be discerned. Snails were sampled here and three symcatchers were deployed. A scoop sample retrieved microbial filaments sitting on a slab of concreted volcaniclastic sediment. The ISMS data suggested high CO_2 and H_2S, but no CH_4 and H_2; pH was 6.3 to 7.4. KIPS sampling of the 5-12°C warm fluids took place in two different locations within the diffuse vent area.

On June 29th the Snowcap and Tsukushi vent sites within the PACManus hydrothermal area were the targets of dive 306. On top of the dome-like Snowcap area, we located two re-entry funnels left there by the Ocean Drilling Program in 2000 (Leg 193). The Holes underneath the funnnels are 180 m (Hole 1188A) and 364 m (Hole 1188F) deep. An octopus occupied the funnel at Hole 1188F. Dead snails littered the seafloor around that funnel. Transecting the Snowcap dome in a westerly direction, we spotted countless patches of diffuse venting inhabited by snails, mussels, and tubeworms. At the Snowcap site of discrete venting, two IGT samples were collected from an 8-m tall chimney sampled in 2006. The maximum temperature during sampling was 224°C. Another vent, located near Marker 6 of the 2006 cruise and issuing clear fluids through a patch of Alviniconchas was attempted to sample with KIPS (T max = 34°C), but the system had clogged. A sample of snails was recovered for molecular ecology. The ISMS detected elevated CO_2, little H_2S and no CH_4 and H_2; pH was as low as 5.5. Also recovered was a piece of massive sulfide from an inactive part of the chimney, consisting of dense chalcopyrite-bornite. A transect over variably sedimented block lava flows to the Tsukushi vent field was next. Tsuksuhi was found to be inactive and apparently has shut down venting within the past 12 year. Oxide mounds west of the dead Tsukushi chimneys issue clear shimmering water, which was sampled by KIPS. ISMS data indicated elevated CO_2 and pH values around 6. The temperature logger recorded a maximum of 53°C.

Dive 307 on June 30th began near the Solwara 8 vent field 350 m southeast of the Fenway hydrothermal area and confirmed the presence of active black smokers reported previously by Nautilus Minerals (unpublished report). The transect to Fenway indicated that the steep slope underneath Fenway is covered with volcanic rock and sulfide talus. At Fenway we took two IGT fluid samples from the same chimney at which fluid sampling had been attempted during dive 305, and obtained two 304°C samples. The beehive on top of the orifice excavated during sulfide sampling two days earlier had grown back and was removed yet again for fluid sampling. The remainder of the dive was used to do biological sampling and ISMS measurements (little H_2S, pH between 7.4 and 6.2). Moreover, four more symcatchers were deployed in the diffuse vent area north of Big Papi. KIPS bottle and filter sampling of the 4 to 11°C diffuse fluids was also carried out. Finally, two samples of polymetallic chimneys from a small smoker field on the southern end of the diffuse patch were collected.

Dive 308 on July 2nd took us to the Satanic Mills area 250 m north of Fenway. The landing site was southeast of Fenway, and mapping and diffuse fluid sampling (T max. = 35°C) at the small chimney cluster north of Big Papi took place on the way to Satanic Mills. There, diffuse and focused venting was accompanied by bubbling of CO_2. ISMS measurements at a diffuse vent patch situated on top of the small flange covered with white mat indicated very high CO_2 and H_2S contents, and pH values ranging down to 5. This low pH was surprising, because the vent fluid temperature was only 10°C. KIPS sampling (bottles and filters) was carried out there as well as rock collecting for geology and biology (white mats and Alviniconcha). Only 4 m northeast of the diffuse patch, an active black smoker chimney with beautiful chalcopyrite inner lining was sampled. The fluid issuing out of the excavated orifice showed flashing and bubbling and was successfully sampled by IGT bottles. The maximum temperature of venting measured was 345°C, which is close to boiling of seawater at the ambient pressure (171 bar in 1690 m water depth). A piece of chimney talus was also recovered, before we moved the ROV north to examine other areas of Satanic Mills. A black smoker complex was located about 60 m north of the previous sampling site. KIPS bottle and filter (T max. = 15°C) and Alviniconcha sampling was carried out here and a Cu-rich dead sulfide chimney was also collected.

On July 3, rock sampling by TV-grab was carried out in the Solwara 8 and Fenway areas. A grab from a talus pile next to a large chimney at Solwara 8 yielded variably Cu- and Zn-rich chimneys. Another grab retrieved a barite-pyrite-shalerite-rich massive rock from a rubble pile near the base of the south slope of Big Papi. In the evening, a CTD cast was carried out south of Pual Ridge to obtain more deep-sea water and a new sound velocity profile for improving on the multibeam bathymetry survey carried out during the night hours.

Dive 309 on July 4th took place in the northeastern part of the PACManus area. The dive began in the Solwara 7 area, a site discovered in 2007 by Nautilus Minerals in a water depth of 1780 m. We found black smoker venting from 12-m tall columnar chimneys, some with beehive-tips, and diffuse venting from the bases of chimney complexes with diverse macrofauna. IGT fluid sampling of a flashing, 348°C hot fluid was followed by the recovery of two sulfide samples, a piece of talus and an inactive spire from the immediate vicinity of the vent orifice sampled. Two KIPS bottles were filled with fluids of temperatures between 37 and 42°C. ISMS indicated elevated CO_2 concentrations and pH values around 6.7. The survey continued to the southeast towards the Roger's Ruins vent field upslope over sedimented block and pillow lavas. Roger's Ruins was reached after 250m. It featured up to 12-m tall columnar chimneys, some of which were highly branched and few of which were active. Overall, it appeared less active than in 2006. Continuing on for another 300 m to Roman Ruins, we crossed over sedimented lava, then volcaniclastic sediment and cratered seafloor morphology, and finally extensive oxide deposits surrounding the Roman Ruins vent field. Most of the many columnar chimneys in the northeastern part of Roman Ruins were inactive. We found the reentry cone of ODP Hole 1189A. There was a lot more hydrothermal activity here in 2006. We landed the ROV to sample a patch of diffuse venting from the basal parts of sulfide chimneys. ISMS indicated slightly decreased pH (6.7) and minor enrichment in H_2S and CO_2. KIPS bottles and filters were collected, and the maximum recorded temperature of the fluids was 15°C. A scoop sample of Alviniconcha was also taken.

Dive 310 on July 4th began in the southwestern part of the Roman Ruins hydrothermal vent field, which appeared much more active than the northeastern counterpart. A spiry chalcopyrite-rich chimney was sampled and the excavated orifice vented 333°C black smoker fluids, which were subsequently sampled with the IGT bottles. Upon retracting the IGT nozzle at the end of sampling, the large chimney topped without breaking and its top was then picked up by the rigmaster arm of the ROV. It was an unusually large and well-developed chimney sample, weighing 20 kg. We were next looking for diffuse venting with rich fauna in the Satanic Mills area, to examine the effects of the uncommonly high H_2S concentrations of the vent fluids. Unable to find suitable sampling sites there, the ROV was navigated further south to collect biota samples from the diffuse venting patch north of Fenway. A selection of snails from different areas within that patch was collected, while ISMS detected variable H_2S and CO_2 contents.

On July 5th, sampling in the Fenway vent field was the focus of Dive 311. IGT fluid sampling of a 314°C black smoker fluid from the small chimney cluster North of Big Papi was followed by the recovery of two chimney fragments from the same smoker. The remainder of the dive was spent sampling sites of clear fluid venting in three areas on the northwestern to southern fringe of Big Papi. KIPS sampling yielded two moderate temperature (88°C and 110°C) fluids with pH values between 4.3 and 4.5, high H_2S, CO_2, and some CH_4 and acetic acid (ISMS detection). A patch with shimmering water densely colonized by Paralvinella was also sampled with KIPS and probed with ISMS (T max. = 22°C, pH = 5.8). A scoop net sample was retrieved from the same patch and yielded fragments of pyrite-sphalerite-rich hydrothermal slabs with Paralvinella and Polynoids. A large boulder of anhydrite was also recovered during the dive.

The purpose of dive 312 on July 6th was fluid and biota sampling at Satanic Mills. The dive began with IGT fluid sampling of black smoker fluids issuing from spiry chimneys (T max. = 339°C). KIPS bottle and filter samples were collected from a large patch of diffuse venting southeast of the smoker field. The fluids had temperatures up to 22°C, a pH of 5.2 to 5.5, and high CO_2 and H_2S concentrations (ISMS detection). The patchy distribution of snails, mussels and tubeworms was noteworthy, and a sample of tubeworms was recovered. Sampling of snails and ISMS work in a diffuse vent site on the northern margin of the diffuse vent patch north of Big Papi happened next. That locale featured mainly dead Ifremeria, but a few small animals inhabited seepage spots of H_2S poor fluids. It was planned to continue biota sampling in the southern parts of the diffuse patch, but a long-line prevented the Sonne from moving south. Instead, we drove the ROV and ship 150 m north, then 300 m east to complete sampling at Snowcap. A lava sample from the north slope of the Snowcap dome was retrieved. A sulfur flow south of the discrete vent site at Snowcap was sampled next with the scoop net. Finally, three KIPS bottles were filled at the site of previous (dive 306) biota sampling near Marker 6. The pH values ranged from 5.6 to 6 and low levels of CO_2 and H_2S were detected by ISMS.

Back at North Su, Dive 313 on July 7th started with IGT fluid sampling of the black smoker fluids venting near Marker 32 near the summit. Temperatures around 313°C were measured, but the sampling was compromised as one IGT nozzle popped out of the orifice during sampling. Both symcatchers were recovered from this site and six KIPS bottles were filled for microbiology and geochemistry. ISMS probing indicated very high H_2S levels and detected CH_4 and acetic acid in the 73°C warm fluids with pH values around 3.3. We next moved down the slope to the Marker 30 site and picked up all incubation devices from there (two symcatchers and the microbial incubation on mineral substrates). KIPS sampling was also carried out here (T max. = 14°C, pH = 6.3). Throughout the dive, visibility was extremely poor making the intended white smoker sampling impossible and ROV piloting a challenge. The incubation devices could only be found because Posidonia navigation was superb during dive 313.

Dive 314 on July 8th began with biological sampling near the Marker 30 site. Ifremeria, Alviniconcha, Bathymodiolus and minature tubeworms were recovered with scoop nets, along with fragments of volcanic rock. The dive's main objective was repetitive sampling at sulfur candles, but, again, visibility there was near-zero, so sampling was unachievable. Moving west to the white smoker vents discovered during 304, we found similarly poor conditions at that site. Much of the white smoke there came from a westerly direction, so we looked for the source of it and found a new field of white smokers on the western flank of North Su. The smoker field extended 50 m to the northwest and comprised numerous patches of white smoker venting on a slope, which is part of the newly formed ash cone. IGT and KIPS sampling was conducted in the southernmost vent site, where IGT temperatures during sampling went up to 149°C. KIPS sampling was carried out at another site in this field, with maximum temperatures of 64°C. The white smoker field ends near the transition between the new cone and the old volcano flank. Trying to follow that transition zone move up the steep slope, we were forced to divert in a northeasterly direction by white-outs and encountered black smokers after having moved only 60 m from the site of white smoker sampling. We found the discharge site of boiling fluids IGT sampled during dive 301 and move a few meters south to a diffuse vent site in chimney talus to take a KIPS fluid sample and a piece of chimney talus.

Dive 315 on July 9th began at the Solwara 8 vent field, where hydrothermal venting had been documented during dive 307. IGT sampling of 305°C black smoker fluids was carried out and an inactive spire from the same chimney cluster was broken off and recovered. On our way to Fenway, we came across a site of diffuse venting through chimney trunks and from underneath flanges about 200 m northwest of Solwara 8. There were patches with dense tubeworm colonies and abundant snails around these springs. While traversing another 150 in a northwesterly direction, we mapped the transition from block lava flows on the lower tier to rock and chimney talus on the slope and sediments with diffuse venting on top of the upper tier, on which Big Papi is located. KIPS and biota sampling on a small ridge with white staining an polymetalic sulfide slabs retrieved 17°C warm fluids with elevated CO_2 and H_2S contents and pH=6.3 (ISMS logging) and Paralvinellas. This site had been visited before during 311, but more biota sample material was needed. The remainder of the dive was used to collect all seven symcatchers placed at different locations within the large diffuse vent patch north of Big Papi. ISMS measurements accompanied this operations and detected variable amounts of CO_2 and H_2S.

Dive 316 on July 10th was the final one at North Su and was arranged to retrieve the second microbial incubation experiment, which had been place at the Marker 32 site near the summit during Dive 301 fifteen days earlier. Once more, visibility at the site and throughout the dive was very poor. After the incubation device had been stowed, two KIPS bottles were filled with the 78°C warm fluid issuing from the prominent crack in the hydrothermally cemented sediment. Very high levels of CO_2, H_2S, and CH_4 were detected and the pH was as low as 2.9. The ROV was moved down the slope to collect Alviniconcha 50 m to the northeast from 14°C diffuse fluids with little H_2S and CO_2 and a pH of 6.2. Another diffuse vent site further down the slope and 30 m north of the previous sample site was selected for the collection of Ifremeria from 22°C fluids with much higher CO_2 and H_2S concentrations and a pH of 5.9. Sampling at the Sulfur Candles site was once again not possible, due to dense white and yellow smoke. The ROV was piloted up slope to the west, where we discovered a small vent issuing white smoke near the summit of the new ash cone. While KIPS sampling here, the ISMS recorded a pH of 2.2 and high CO_2 and H_2S levels. A scoop sample of sulfur and volcaniclastic material was recovered here and a scoop of ash was also taken from a spot 15 m to the southeast. The white smoker initially discovered during dive 304 were visited, but the density of smoke obstructed sampling here. We followed the line of white smokers to the west and found improved but still harsh conditions for sampling. Eventually, an IGT sample was taken (T max. = 104°C) from a white smoker that did not release CO_2 bubbles. The

sample location is within 30 m of the white smokers sampled during dive 314.
On July 11th, the final dive (317) of the cruise set off in the Solwara 6 area 800 m southeast of Roman Ruins. Only diffuse venting and rare dead chimneys could be observed at Solwara 6. In the large area of diffuse venting through rough block lava, many of the snails were dead or small, indicating that perhaps waning activity of venting.
Two pieces of sulfide talus were recovered before we moved across variably sedimented block lava to Roman Ruin. We collected a piece of oxide-coated chimney issuing shimmering water, before attempting IGT sampling of a black smoker fluid (T max. = 329°C). Due to technical problems no samples were collected, however. A sample of the chalcopyrite-rich active chimney was also secured.
The last day on-site was used to collect a TV-grab from the Solwara 9a hydrothermal area west of North Su in a water depth of 1650 m. The grab contained fresh, plagioclase-phyric lava, slightly altered (bleached) lava, barite-rich slabs, porous barite-sphalerite chimney fragments, and a single piece of native sulfur, which is probably derived from the upper slope of North Su. A CTD sampling cast on top of the North Su volcano concluded our scientific program. The plume was sample in 30 m intervals between 1170 and 800 m. Filtering of water samples returned large amounts of fine, whitish-yellowish sulfur, indicating that the plume was indeed sampled. Upon starting the transit, the Sonne traversed slowly across the coordinate of the Sulfur Candles site and the CO_2 bubble flare showed nicely in the Parasound image.
At 9:00 on July 14th, the Sonne arrived in Madang after an uneventful transit. Around midday, the majority of the scientists and technicians disembarked and were transferred to shore via banana boats. The Sonne anchored in Madang for a total of six hours and then began the passage to Makassar, where it arrived in the morning of July 22nd.

5. OPERATIONS (Wolfgang Bach, Niels Jöns, Volker Ratmeyer and ROV Team)

A detailed account of all operations at the 57 stations during cruise SO216, including time, latitude, longitude, depth, etc., is provided in Appendix A.

5.1. Bathymetry and navigation

For a comprehensive understanding of differences between hydrothermal vent sites, an evaluation of the seafloor morphology of the study area is essential. In the course of SO-216 extensive bathymetric mapping of the whole work area in the easternmost Manus Basin was performed. Although global bathymetric datasets (e.g. ETOPO2, GEBCO_08, SRTM30plus,…) are available and completely cover the global ocean floor, they do not have a high resolution (currently max. 30 arc seconds) and the quality of the underlying data is highly variable. For the eastern Manus Basin, detailed bathymetric surveying has been performed by French scientists at the end of the last century, but these data have not yet been published. Further bathymetry work was done in the course of cruises SO-166 and MAGELLAN06; however, although the covered area of this survey is large, the spatial resolution of the dataset is not sufficient for detailed analysis of smaller structures.

During SO-216 the 12 kHz Simrad EM120 multibeam system of RV Sonne was used. This system works with 191 beams, where the maximum total angle of the emission beam is 150° across track and 2° along track. To obtain a high data accuracy, however, lower beam angles across track have been used (either 120° during transits or 90° within the main working area). Furthermore, the system was calibrated to allow correction of the ship's motion. Twice a roll and pitch calibration procedure was started: the first calibration was on 19 June 2011 (Site 002MB; along a line from 3°51.50'S/ 152°08.00'E to 3°55.90'S/ 152°10.50'E), the second calibration was performed on 20 June 2011 (Site 006MB; along a line from 3°47.90'S/ 152°06.00'E to 3°44.90'S/ 152°06.00'E). In addition, it has to be taken into account that the sound velocity used for determination of water depth is dependent on water temperature and salinity.

Thus water sound velocity profiles were recorded to correct the raw EM120 data (see section 5.2). The CTD runs used to acquire such sound velocity profiles were at Site 001CTD (19 June 2011, 3°51.50'S/152°08.00'E, down to 1704m water depth, ca. 6.5km SSE of North Su), at Site 007CTD (20 June 2911, 3°51.50'S/ 152°08.00'E, down to 1704m water depth, same locality as 001CTD) and Site 035CTD (2 July 2011, 3°47.00'S/ 151°40.40'E, down to 2091m water depth, ca. 7km S of Fenway).

The raw bathymetric data was processed onboard during the cruise using the software "Caris HIPS & SIPS". In a first step the raw data of the EM120 were converted into a format that Caris can read. Next, tide information was applied to all data files. Data were then checked for outliers in the navigation. Such outliers were removed and replaced with interpolated values. Obvious outliers in the swath data were removed using the Swath Editor of the Caris software. After this procedure, xyz files were exported and used for preparation of preliminary maps using the software GMT (Wessel & Smith, 1995). However, time-consuming further cleaning of the data was performed during transit to Makassar. In this step, all raw data were inspected again and outliers and artifacts were flagged.

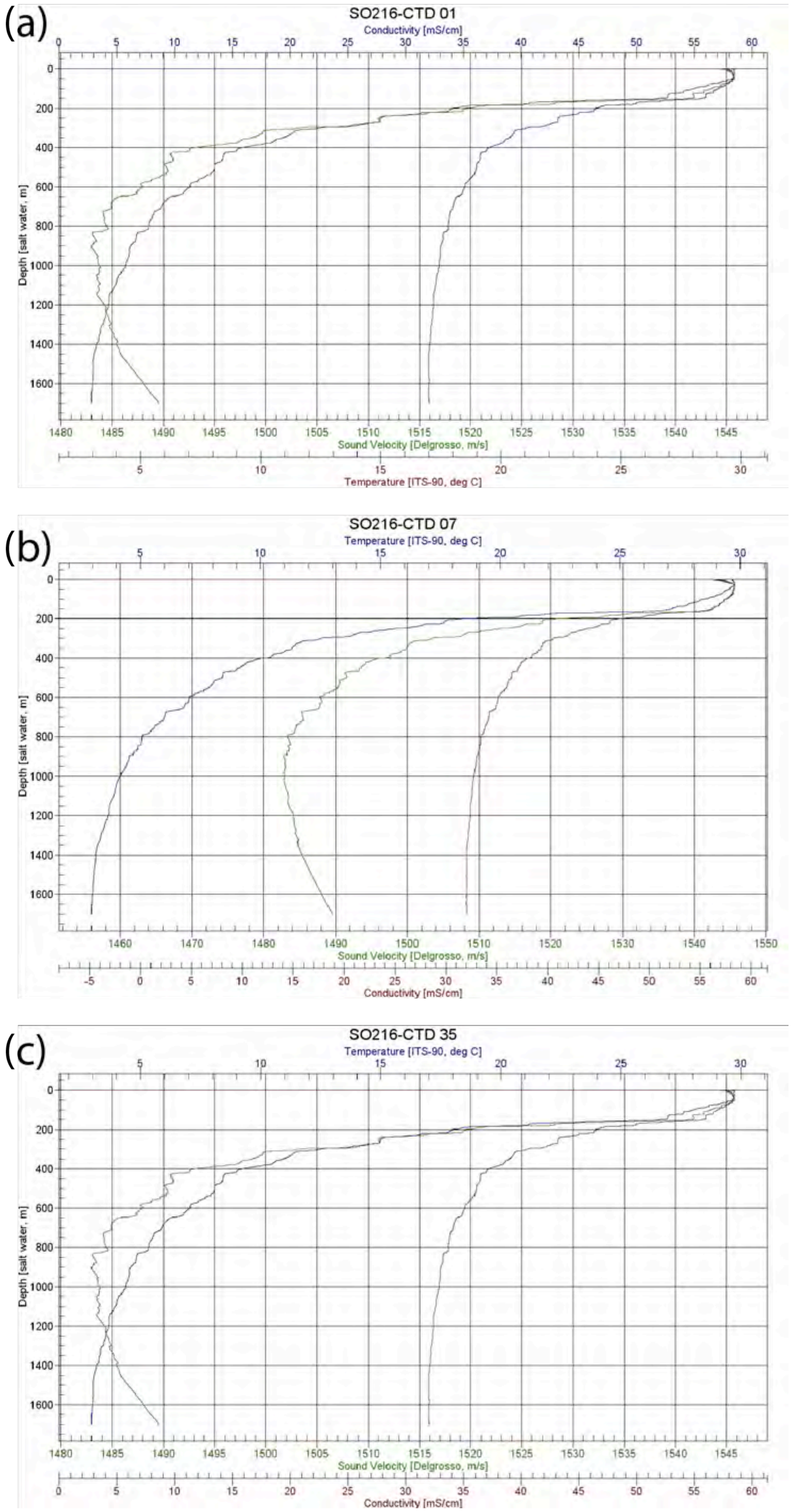
The FUGRO-RACAL SkiFix und FUGRO-RACAL MultiFix Differential Global Positioning System (DGPS) was used for dynamic positioning on station.

The Posidonia 6000 ultra-short base line (USBL) underwater positioning system provides precise positions of deep-sea instruments relative to the ship and was used for navigation during the ROV dives as well as the TV-grab and CTD stations.

5.2. CTD

A ship-based CTD Sea-Bird 911 plus was used to record conductivity, temperature, and pressure data from surface to bottom and generate a sound velocity profile of the water column. Potential temperatures, densities, and sound velocities were computed using the Sea-Bord supplied software. A Niskin 24-bottle rosette (10L) was used to collect water samples.

Four CTD casts were conducted during cruise SO216. The first three, 001CTD and 007CTD, and 035CTD, were mainly intended to collect a velocity profile for the multibeam echosounder survey. Water samples were collected during all casts: 001CTD (all 24 Niskin bottles were fired at 1680 mbsl), 007CTD (10 Niskin bottles were fired at 1680 mbsl)m and 035CTD (all 24 bottles were fired at 2090 mbsl) to collect deep-sea water for biological and geochemical work. The forth cast, 057CTD, sampled the water column above the summit of North Su volcano and collected samples from the following depths (in mbsl): 1178 (10 bottles), and (1 bottle each) 1156, 1127, 1097, 1067, 1037, 1008, 978, 948, 918, 888, 839, 789, 689, and 490.



continued on next page

Fig. 5.1: Results of CTD runs at Site 001CTD (a), 007CTD (b), 035CTD (c), and 057CTD (d). Diagrams show sound velocity, conductivity and seawater temperature versus water depth.

5.3. Parasound

An Atlas Parasound PS70 system was used to collect images of acoustic anomalies in the water column. The only places where water columns anomalies were detected are North Su and Satanic Mills. On July 12, the parasound system recorded a clear image of the gas flare over North Su, while the ship slowly (2 kn) traversed across the location of the Sulfur Candles vent field (Fig. 5.2).

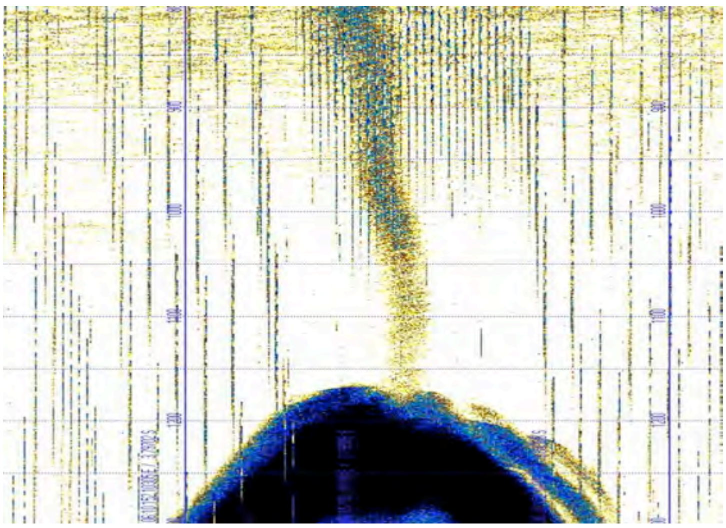


Fig. 5.2: Inverted parasound image depicting an acoustic flare in the water column above North Su. The flare is produced by bubbles of liquid CO_2.

5.5. TV-Grab

The TV-grab (Greifer A) by Preussag Meerestechnik was employed to collect rocks at four stations. It is TV-guided and illuminates the seafloor with four 150 W spotlights. With a weight in water of 2.6 metric tonnes, a volume of 1.1 cubic meters and a 3 kW DC-motor, the TV-grab can recover large samples, up to 2 metric tonnes of weight.

5.4. Remotely Operated Vehicle (ROV) „QUEST“

(Volker Ratmeyer, Phillip Franke, Oliver Herschelmann, Hoang Anh Mai, Ralf Rehage, Michael Reuter, Christian Reuter, Marcel Zarrouk)

The deepwater ROV (remotely operated vehicle) “QUEST 4000m” used during SO216 aboard RV SONNE, is installed and operated at MARUM, Center for Marine Environmental Sciences at the University of Bremen, Germany. The QUEST ROV is based on a commercially available 4000 m rated deepwater robotic vehicle designed and built by Schilling Robotics, Davis, USA. Since installation at Marum in May 2003, it was designed as a truly mobile system specially adapted to the requirements of scientific work aboard marine research vessels for worldwide operation. Today, QUEST has a total record of 317 dives during 26 expeditions, including this cruise.

During SO216, QUEST performed a total of 22 dives to depths between 1202 and 1815 m. QUEST was operated by a team of 8 pilots/technicians on a 12 hour basis. Overall, a resulting mean bottom time of 6.9 hrs was achieved, ranging from 1.3 to 10.2 hours bottom time per deployment. A total of 152 hrs bottom time (211 hrs total dive time) was achieved during the entire cruise (see table). Detailed data for the individual dives are listed within the dedicated scientific chapters of this report. The crew was prepared to performe regular intermediate dive and maintenance operations on a daily basis. A turn-over time of 12 hrs could be regularly maintained during the entire cruise.

Dive operations included geological, high temeprature fluid and specimen sampling, a variety of in-situ measurements, different instrument and experiment deployments, and high quality digital video and still photo documentation. The vehicle performed well during the entire cruise. For the first time, a new digital telemetry system and a completely new, re-designed control van were used and performed very well.

Close cooperation between ROV team and ships crew on deck and bridge allowed a smooth and professional handling during all deployment and recovery situations. During diving, this cooperation allowed precise positioning and navigation of both ship and ROV, which was essential for accurate sampling and intervention work such as sampling, instrument deployment and cable management with an additional umbilical beacon at depth. The ROV team is very grateful for this kind of steady support from the entire ships crew during the cruise.

QUEST System description

The total QUEST system weighs about 45 tons (including the vehicle, control van, workshop van, electric winch, 5000-m umbilical, and transportation vans) and can be transported in four standard ISO 20-foot vans. A MacArtney Cormac electric driven storage winch is used to manage up to 5000m of 17.6 mm NSW umbilical cable.

Quest internal equipment and online tooling
The space inside the QUEST 5 toolskid frame allows installation of mission-specific marine science tools and sensors. The initial vehicle setup includes two manipulators (7-function and 5-function), 7 color video cameras, a digital still camera (Insite SCORPIO, 3.3 Mega-Pixel), a light suite (with various high-intensity discharge lights, HMI lights, lasers, and low-power dimmable incandescent lights), a Sea&Sun online CTD, a tool skid with draw-boxes, and an acoustic beacon finder. Total lighting power is almost 3 kW, total additional auxiliary power capacity is 8 kW. In addition, the permanently installed Kongsberg 675kHz Type 1071 forward looking Scanning Sonar head provided acoustic information of bottom morphology and was also used for detection of gas emissions.

Video Setup, HDTV and vertical imaging
Continuous PAL video footage was continuously recorded on two MiniDV tapes with two color-zoom cameras (Insite PEGASUS or DSPL Seacam 6500). In order to gain a fast overview of the dive without the need of watching hours of video, video is frame-grabbed and digitized at 5sec intervals, covering both PAL and HD video material. For extremely detailed video close up filming, a near-bottom mounted broadcast quality (>1000 TVL) 3CCD HDTV 14 x Zoom video camera was used (Insite Zeus). Spatial Resolution of this camera is 2.2 Mega-Pixel at 59.94 Hz interlaced. Recording was performed on demand onto tapes in broadcast-standard digital Sony HDCAM format, using uncompressed 1.5 Gbit HD-SDI transmission over a dedicated fibre-optic connection. Additionally, all video takes were continuously recorded digitally based on H.264 compression, including HDTV.
As a standard still image camera, an Insite Scorpio Digital Still camera was used, providing 3.3. Mega-Pixel spatial image resolution and highly corrected underwater optics.
Video distribution was provided by dedicated CAT-5 based VGA transmission hardware, als well as by streaming the main tiled video image over the vessels network.

During SO216, the following scientific equipment was handled with QUEST:

ROV based tools, installed on vehicle:
- ROV interchangeable draw-box baskets with bio-box
- Sea and Sun CTD real-time probe with turbidity sensor
- Autonomous and realtime temperature loggers on frame and T-lance (IFM-Geomar)
- KIPS 9 fluid sampling system
- Realtime insitu mass spectrometer (ISMS) with pH Sensor, provided by P. Girgius, Harvard University
- 4 inductively coupled realtime gastight fluid samplers, by J. Seewald, WHOI
- “Hand”-Nets for mussle sampling
- diverse shovels for mussle sampling (MPI Bremen and IFM-Geomar)
- acoustic Beacon markers
- Simple site markers
- Simple “Freddy” knife for manipulator operations
- a variety of small experiments described above in the science chapters of this reports

Table 5.1: Summary of dives during cruise SO216

DIVE LOG Summary: **SO216** **"BAMBUS"**
Dates/Times UTC

No.	Dive No.	Date	Site		Depth (m)	Time Launch	Time Start (Bottom)	Time End (Bottom)	Time Recovery	Bottom Time	Total Dive Time	Bottom hours	Total Dive hours
1	296	6/21/11	3°47,892 S	152°6,043 E	1250	5:32	8:12	9:30	10:45	1:18	5:13	**1.30**	**5.22**
2	297	6/21/11	3°47,812 S	152°5,976 E	1274	22:21	1:50	8:45	9:42	6:55	11:21	**6.92**	**11.35**
3	298	6/22/11	3°48,507 S	152°6,025 E	1288	22:35	23:47	5:12	6:15	5:25	7:40	**5.42**	**7.67**
4	299	6/23/11	3°48,112 S	152°6,113 E	1270	23:02	0:10	3:03	3:52	2:53	4:50	**2.88**	**4.83**
5	300	6/24/11	3°48,077 S	152°6031 E	1280	5:32	6:32	10:00	10:47	3:28	5:15	**3.47**	**5.25**
6	301	6/25/11	3°48,033 S	152°6,019 E	1202	0:21	1:34	9:15	10:20	7:41	9:59	**7.68**	**9.98**
7	302	6/25/11	3°47,975 S	152°6,012 E	1260	22:27	23:34	8:42	9:50	9:08	11:23	**9.13**	**11.38**
8	303	6/26/11	3°48,061 S	152°6,087 E	1220	22:32	23:51	0:56	1:58	1:05	3:26	**1.08**	**3.43**
9	304	6/27/11	3°48,118 S	152°6,122 E	1241	2:20	3:16	9:52	10:52	6:36	8:32	**6.60**	**8.53**
10	305	6/27/11	3°43,660 S	151°40,259 E	1716	23:30	1:06	8:46	10:08	7:40	10:38	**7.67**	**10.63**
11	306	6/28/11	3°43,619 S	151°40,192 E	1647	22:30	0:28	9:02	10:20	8:34	11:50	**8.57**	**11.83**
12	307	6/29/11	3°43,891 S	151°40,478 E	1815	22:32	0:05	9:32	10:47	9:27	12:15	**9.45**	**12.25**
13	308	6/30/11	3°43,769 S	151°40,428 E	1747	22:55	0:19	9:12	10:33	8:53	11:38	**8.88**	**11.63**
14	309	7/3/11	3°42,996 S	151°40,338 E	1780	1:02	2:32	9:03	10:19	6:31	9:17	**6.52**	**9.28**
15	310	7/4/11	3°43,228 S	151°40,612 E	1705	0:30	2:01	9:17	10:37	7:16	10:07	**7.27**	**10.12**
16	311	7/4/11	3°43,708 S	151°40,350 E	1714	22:20	0:01	8:39	10:03	8:38	11:43	**8.63**	**11.72**
17	312	7/5/11	3°43,629 S	151°40,396 E	1707	22:43	0:12	9:07	10:25	8:55	11:42	**8.92**	**11.70**
18	313	7/7/11	3°47,992 S	152°6,082 E	1219	0:23	1:40	9:57	11:03	8:17	10:40	**8.28**	**10.67**
19	314	7/7/11	3°48,020 S	152°6,079 E	1226	22:48	23:53	8:49	9:50	8:56	11:02	**8.93**	**11.03**
20	315	7/8/11	3°43,803 S	151°40,398 E	1744	22:40	0:19	7:05	8:17	6:46	9:37	**6.77**	**9.62**
21	316	7/9/11	3°47,798 S	152°6,032 E	1180	22:22	23:42	9:56	10:58	10:14	12:36	**10.23**	**12.60**
22	317	7/10/11	3°43,586 S	151°40,872 E	1740	23:35	1:14	8:32	9:59	7:18	10:24	**7.30**	**10.40**
				Max. Dive depth (m):	**1815**				Mean bottom time per dive (hrs):	**6.90**	Total hours:	**151.90**	**211.13**

6. GEOLOGICAL MAPPING AND SAMPLING (Wolfgang Bach, Janis Thal, Niels Jöns, Sven Petersen)

6.1. Multibeam echosounder mapping in the eastern Manus Basin

The bathymetric survey can be subdivided into 3 parts:
1. Transit from Townsville (Australia) to Rabaul (Papua New Guinea)
2. Detailed mapping of the main work area in the eastern Manus Basin
3. Transit from the eastern Manus Basin to Madang (Papua New Guinea)

1) The multibeam survey during transit from Townsville through the Coral Sea towards Papua New Guinea was outside the main objectives of SO-216. However, Robin Beaman from James Cook University in Cairns/ Australia works on bathymetry of the Coral Sea (Project 3DGBR) and was asking us to conduct a survey along a dedicated line with the following waypoints:
    a. 18°08.3'S / 147°10.9'E
    b. 17°38.7'S / 147°14.1'E
    c. 16°08.6'S / 147°14.1'E
    d. 11°27.9'S / 151°48.6'E

   The speed during transit was ca. 13 knots. Robin Beaman provided modeled sound velocity profiles for use during the transit and therefore no CTD runs were performed prior to crossing the Coral Sea.
2) While on site in the easternmost Manus Basin, the time between the ROV dives was dedicated to multibeam surveying. The objective was to produce a high-resolution map of the whole area between the two major shear zones, the Weitin Transform Fault in the east and Djaul Transform Fault in the west. During 25 Sites along 1318 nautical miles track length and ca. 235 hours, RV SONNE mapped an area covering approximately 5680 km^2. To obtain a high resolution of the data, locations of parallel lines were chosen such that 100% overlapping was achieved. The average speed during surveys was 5.6 knots. Site numbers for EM120 multibeam surveys were: 004, 008, 011, 013, 016, 018, 020, 022, 024, 026, 028, 030, 032, 036, 038, 040, 042, 044, 046, 048, 050, 052 and 054.
3) The multibeam survey during transit from the eastern Manus Basin to Madang (Papua New Guinea) was performed on request of Nautilus Minerals, who are prospecting for mineral deposits in the Manus Basin. The transit was with a speed of 10 knots along a line with the following waypoints:
    a. 4°22.80'S / 150°25.42'E
    b. 4°16.99'S / 150°01.35'E
    c. 4°14.16'S / 149°21.81'E
    d. 4°21.37'S / 149°16.13'E
    e. 4°30.54'S / 148°48.76'E
    f. 4°41.54'S / 148°14.19'E
    g. 4°47.79'S / 147°50.71'E
    h. 4°38.94'S / 147°41.97'E
    i. 5°13.99'S / 145°47.27'E

The resulting map (Fig. 6.1) represents a major improvement compared to the previously available datasets. Major features of the mapped area are the two major transform faults (Weitin and Djaul faults) as well as the volcanic ridges that are located between both faults.

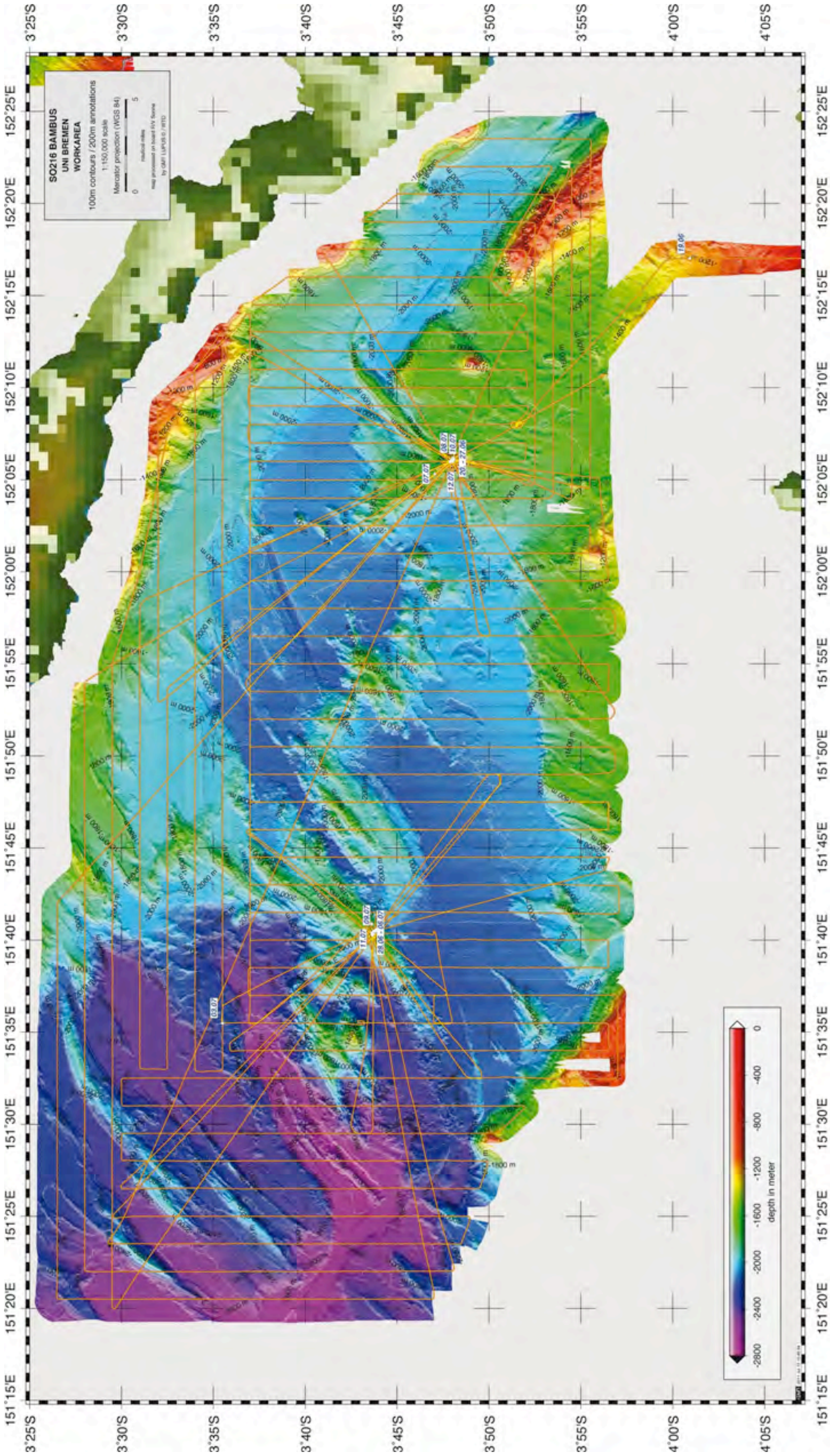


Fig. 6.1. Raw bathymetry data collected during cruise SO216 along the various track lines.

Volcanic centers, such as the North Su volcano are easily discernable, and the map provides an excellent basis for future work on hydrothermal systems of the area.

6.2. North Su

North Su is a conical-shaped volcano rising from 1700 m to 1150 m water depth. Dives 296 - 304, 313, 314, and 316 took place in the North Su area centered at 3°48.0'S, 152°06.05'E (**Fig. 6.2**). This large number of dives in a fairly small area is vindicated by the unusually large diversity in styles of venting and types of fluids. A preliminary geological map is presented in **Fig. 6.3.** The uppermost 100 m of the volcano flanks and the summit host countless hydrothermal vent sites, which fall into three categories: (i) black smoker vents, (ii) white smoker vents, and (iii) diffuse vents. While the black smokers cluster in the summit area, white smoker vents are common in a 120 m long and 50 m wide, east-west-trending area south of the main summit. The dense coverage with thick white smoke (most likely made up of sulfur particles) renders mapping and sampling in this area challenging.

The slopes expose predominantly volcaniclastic sediments and talus. Volcaniclastic sediments are variably blocky, and they tend to be dominated by ash near the summit. Erosional canyons, typically only a few m wide, cut into this landscape and serve as witnesses of mass wasting. Debris deposits are very poorly sorted, with individual blocks reaching meter-size. Such clasts are often difficult to distinguish from occasional outcrops of lava flows or sills. In the initial map (**Figure 6.3**) volcanic talus comprises both lithologies. More detailed mapping post-cruise will provide a more exhaustive analysis of the volcanic facies.

Steep walls and pinnacles of hydrothermally cemented pyroclastic rocks and talus form the slopes underneath the summit. The summit itself features active black smokers and broken dead chimneys **(Figure 6.4a)**. The black smokers are up to 9-m high spiry structures, which tend to tumble easily. They show an inner lining of dense chalcopyrite, surrounded by a pyrite-sphalerite-rich outer layer and an Fe-Mn-oxide coating. In the westernmost extension of the black smoker clusters is a vent at 1190 m water depth, which shows flashing typical of fluid boiling **(Figure 6.4b)**. The temperatures measured (332°C max.) correspond to the boiling temperature of seawater at 121 bar. These chimneys grow out of the steep wall of cemented talus.

The chimneys at the summit are hosted mainly in volcanic ash, which is often cemented by barite to form hard slabs. Where these slabs are broken up, clear fluids vent at the seafloor **(Figure 6.4c)**. These fluids have a lower pH than the hydrothermal endmember vent fluids, indicating subseafloor deposition of pyrite during mixing of upwelling hydrothermal fluids with entrained seawater. More fluid seepage has been observed in numerous locations downslope, in particular in large patch of diffuse venting 90 m northeast of the summit in 1200m water depth. This site (**Fig. 6.4d**) features a diverse fauna (snails, mussels, tubeworms, fish, barnacles), which is associated with the venting of 14-30°C warm fluids through fans of poorly sorted talus.

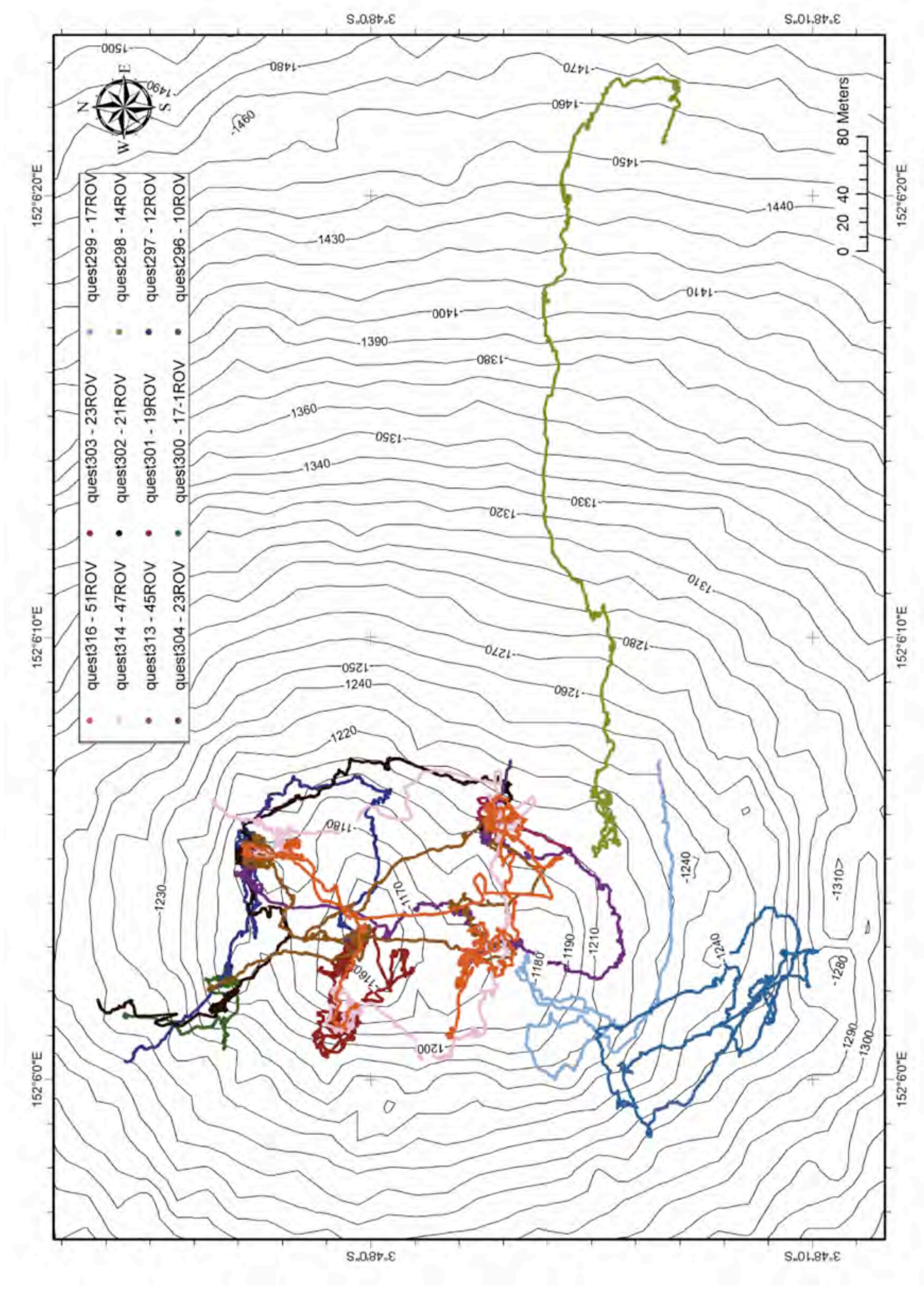


Fig. 6.2: Dive tracks for ROV MARUM Quest 4000m in the North Su area.

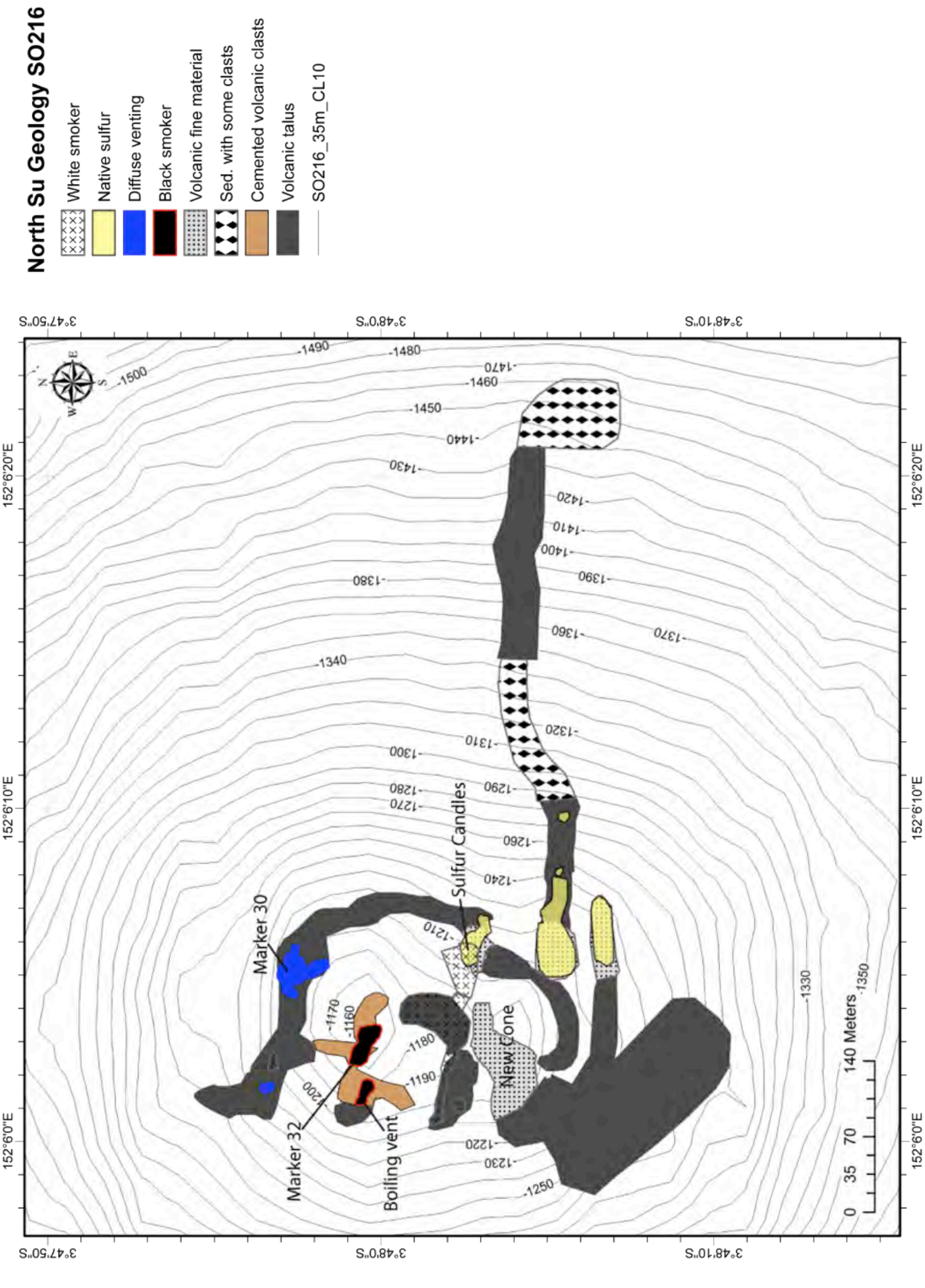


Fig. 6.3: Preliminary geological map based on visual identification of seafloor rock types. Note that certain stretches of dive track (cf. Fig. 6.2) are left blank in the map because visibility was to poor to allow the identification of lithologies.

Two areas of ash deposits have been identified at North Su. One is located 100 m south of the

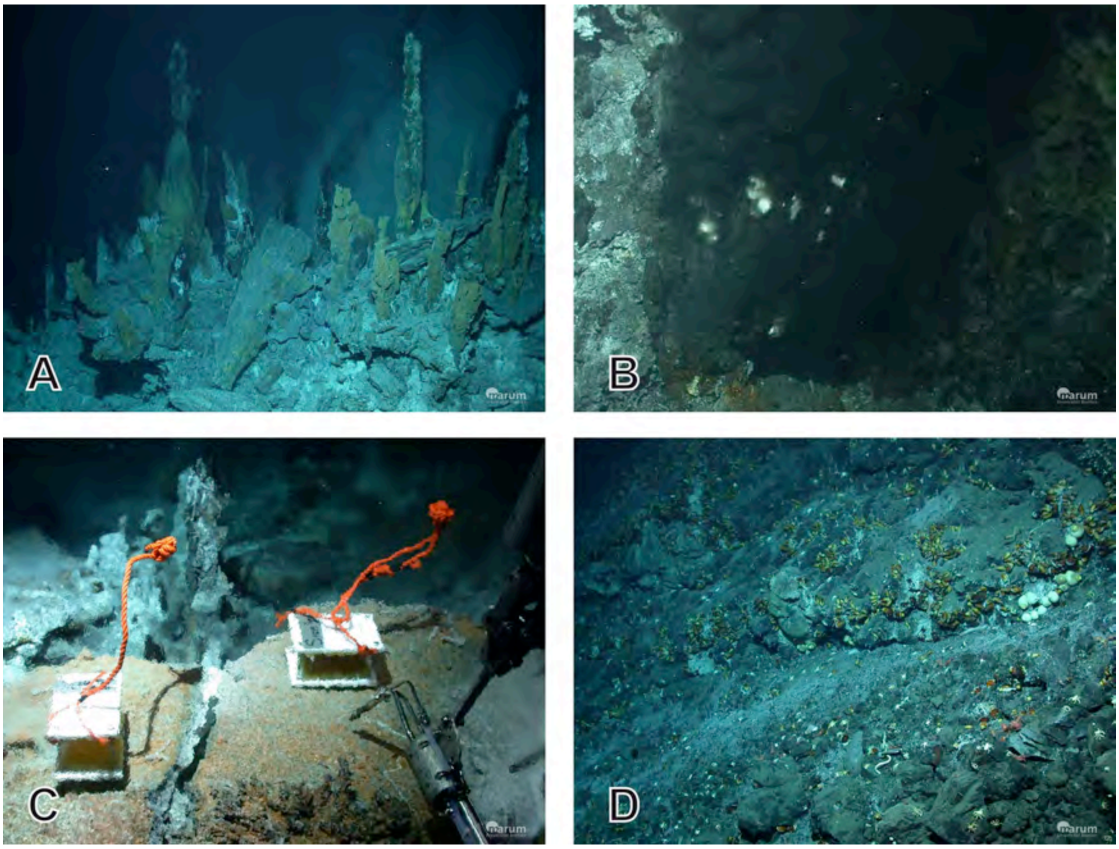


Fig. 6.4: Black smokers from the summit of North Su at 1153 m depth (A). The light shining through the this black smoker from an area west of the summit at North Su is reflected spotlight; these reflections indicate fluid boiling (B). A fissure in a hydrothermally cemented slab of sediment emanates 70°C hot water. A fluid sample is about to be collected by the KIPS (lower left). The two instruments on top of the slab are symcatchers (C). On the northeastern flank of North Su at 1200 m water is a large area of common diffuse venting on a slope made up of poorly sorted talus (D).

summit where it forms a cone with numerous small craters on the top (**Figure 6.5a**) and smooth flanks with more blocky pyroclastic deposits. The cratered summit features extensive white staining and currents have created ripples in the fine ash (**Figure 6.5b**). White staining can also be found in other areas of the new cone, along with orange staining, and rare accumulations of sulfur. This cone was not there, when North Su was mapped during the Magellan cruise in 2006. The ash cone buried steep walls and talus slopes with countless white smoker vents, some of which were sampled in 2006. Near the transition between new cone and pre-existing slope of North Su, white smoker vents are concentrated (**Figure 6.5c**). They occur within the steep, rugged wall, not in the smooth area with ash-rich material immediately south of it. There, hydrothermal activity is restricted to diffuse seepage on the seafloor, causing extensive staining. White smokers can also be found on the southwestern slope, where material from the new cone is present, but perhaps only as a thin veneer, so that the white smoker fluids could break through (**Figure 6.5d**).
Another accumulation of ash is around a narrow crater ~100m in diameter southeast of the new cone. The southern rim of that crater features large accumulations of sulfur, either as imbricated slabs and pods on the seafloor (**Figure 6.6a**) or as sulfur sills or buried flows in

volcanic ash and sand (**Figure 6.6b**). Clasts of this type of massive sulfur have rolled downhill and were retrieved in 1470 m depth on the eastern flank (**Figure 6.6c**) and in 1650 m depth on the base of the western flank of North Su in the Solwara 9a area (Station 056GTV).

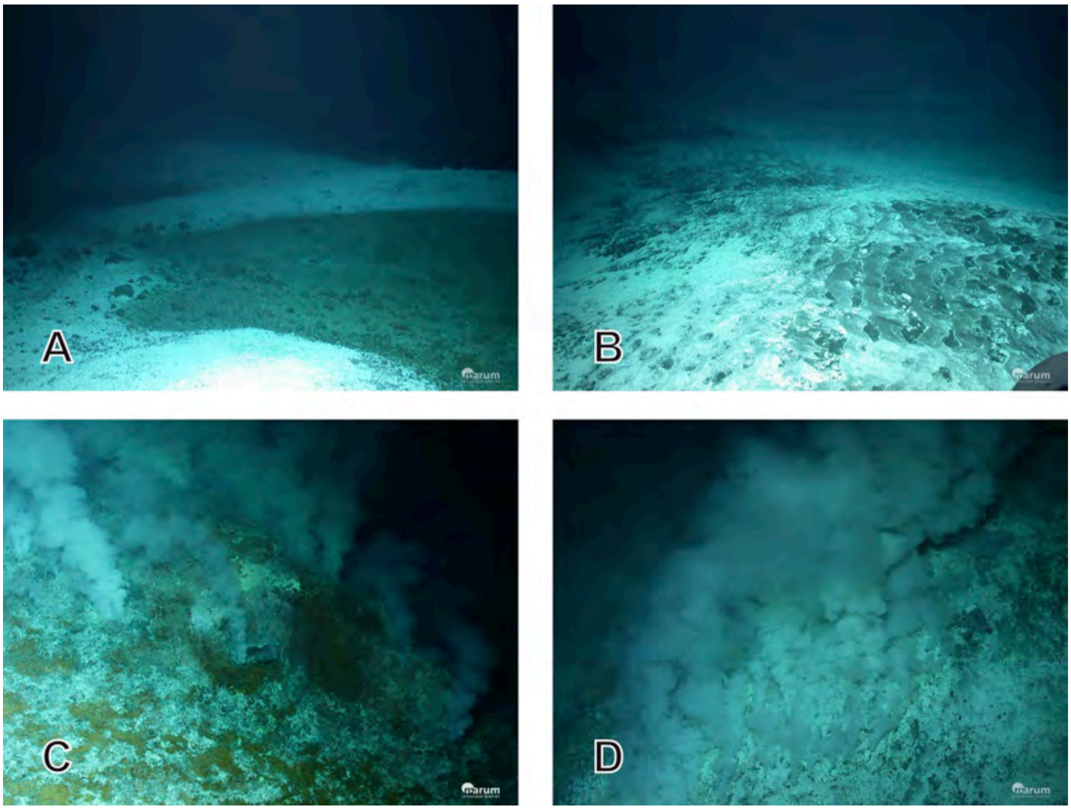


Fig. 6.5: Cratered landscape on top of a pyroclastic cone, which grew on the south flank of North Su in the past five years (A). Fine ash near the summit of the new cone shows ripple marks and extensive white staining (B). White smoker vents are abundant near the boundary of the old edifice (rugged terrain in background) and the fine pyrclastic material, which onlaps in the foreground of the foto (C). White smoker vents on the southwestern flank of North Su have developed on top of the recent pyroclastic deposit.

Sulfur Candles is the easternmost and most spectacular of the white smoker cluster. It features hundreds of white smoker vents, many of which also emanate what appears to be gas bubbles, but is likely supercritical CO_2 (**Figure 6.6d, e**). The bubbles rising up from hot vents move up very fast, those bubbling up through holes in the sediment rise much slower. We hypothesize that the slowly rising bubbles contain liquid CO_2, forming when the temperature drops below 31°C. At 3°C (ambient temperature at 1200 m depth), liquid CO_2 converts to CO_2-clathrate at the interface to seawater. This behavior was documented in a bubble-trapping device, which was built during the trip, and was used to collect liquid CO_2 bubbles at Sulfur Candles. The vent site is situated in volcaniclastic sediments, which are logged with liquid sulfur around the vents. The sulfur is dragged up by up-streaming water and bubbles and forms sub-meter-high, chimney-like structures (**Figure 6.6f**). These structures grow when splashes of liquid sulfur are thrown out of an orifice and accumulate around it. The liquid sulfur then runs down the structure a bit, much like droplets of wax on the outer side of a candle. This process gives the sulfur chimneys their distinct appearance.

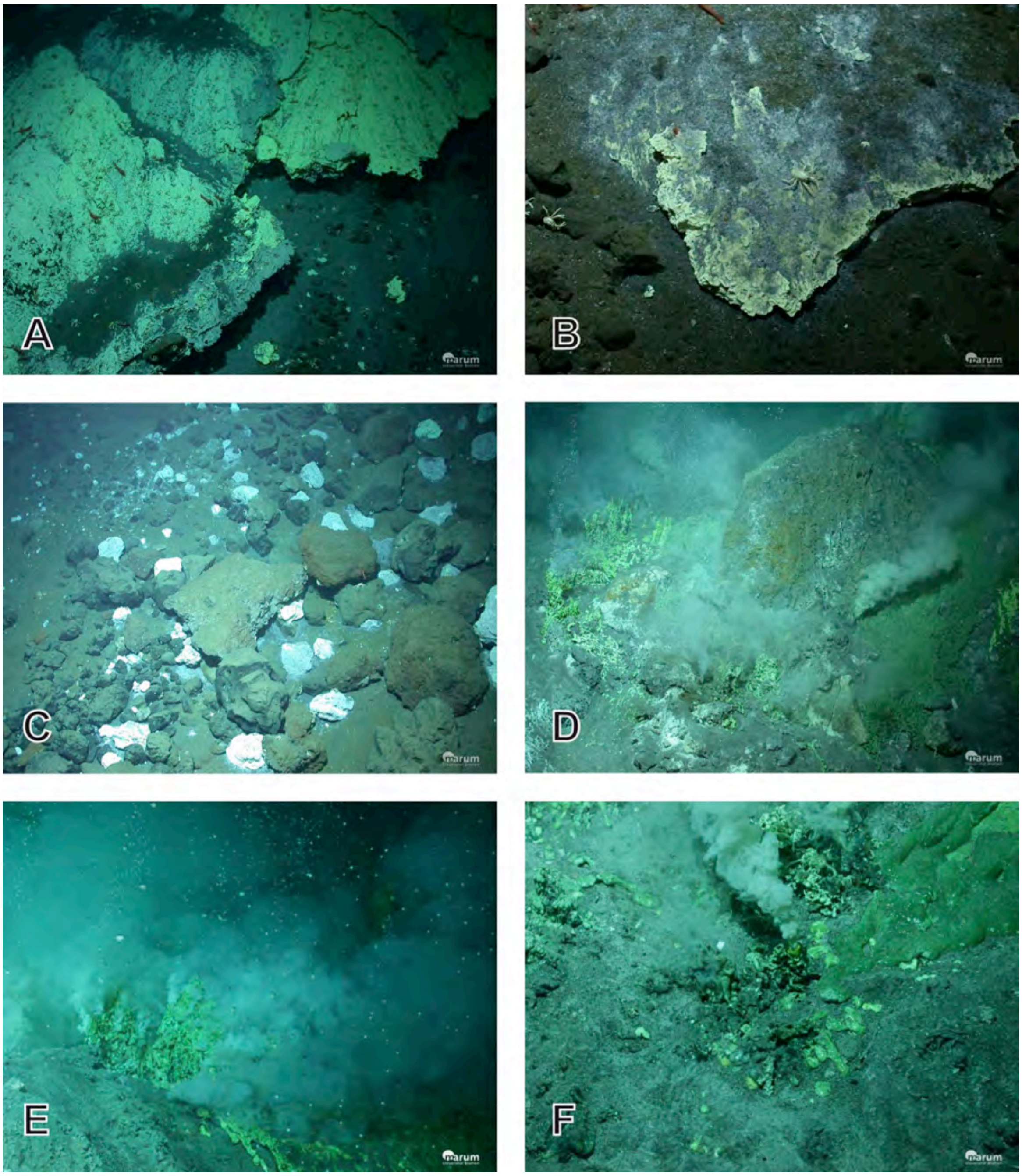
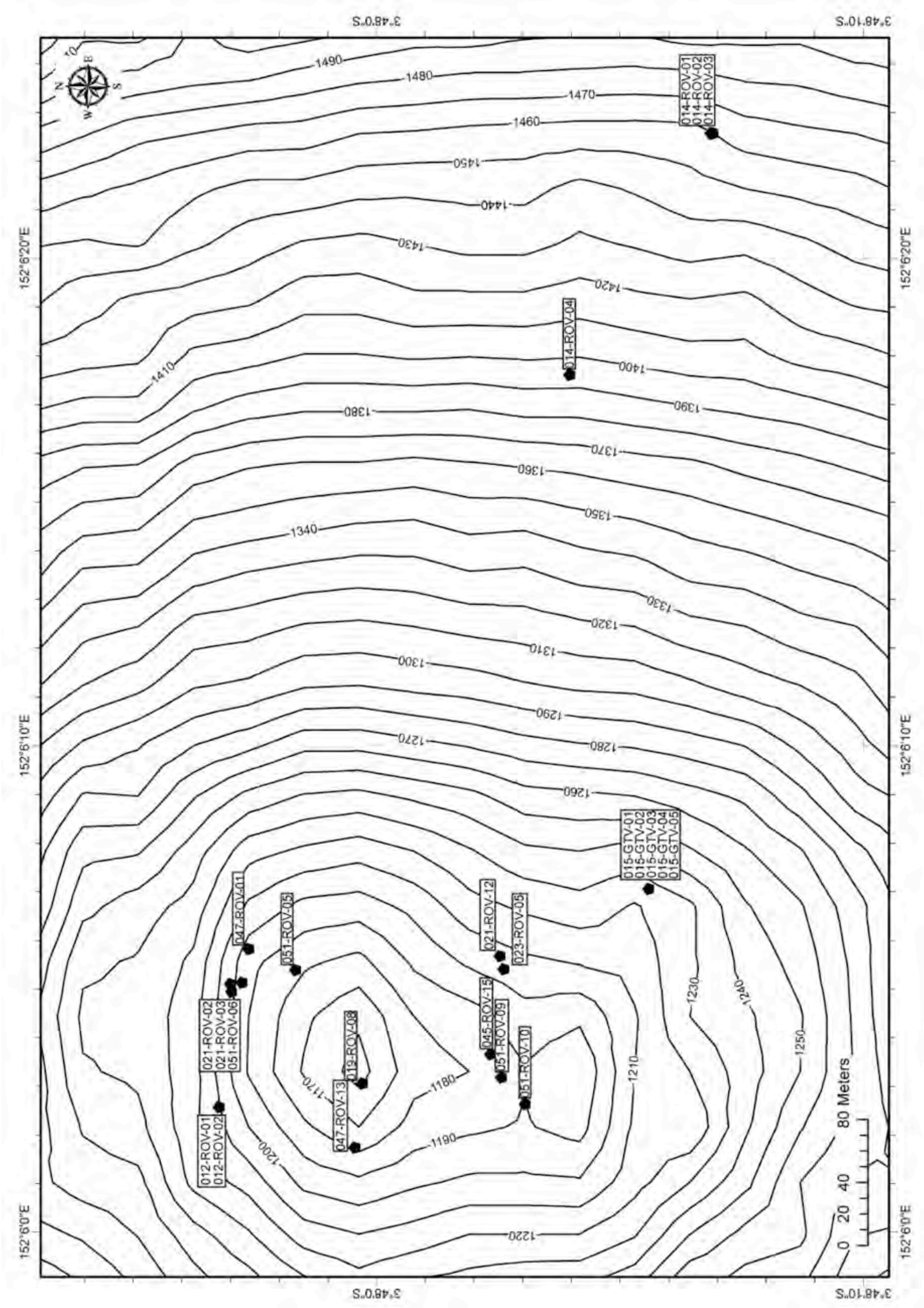


Fig. 6.6: Imbricated lenticular shaped bodies of sulfur crop at at the southern rim of a smal crater southeast of the new ash cone at North Su (A). Ash-dominated pyroclastic deposits exposing a sulfur sill (B). Talus of fresh rock, altered rock, and native sulfur is littered across the lower reaches of the slopes around North Su (C). The Sulfur Candles site features spectacular white smokers, CO_2 bubbles, and liquid sulfur at the seafloor (D, E). Small sulfur chimneys form, when liquid sulfur is spouted out of the ground by escaping fluids (F).

The sulfur chimneys grow fast (we could see one grow in minutes), but they do not get very tall, probably because the low viscous strain in the three-fluid systems (liquid water-liquid sulfur-supercritical CO_2) does not facilitate more spouting of the liquid sulfur. Most of the sulfur is hence not located in chimneys. The extra sulfur trickles downslope and pools in certain areas, where it forms dense aggregates composed of thousands of anastomosing finger-



thick sulfur flows that coalesced to irregular pods. The structures in (**Figure 6.6a**) are obviously remnants of such type of activity (cf. **Figure 6.6d)**

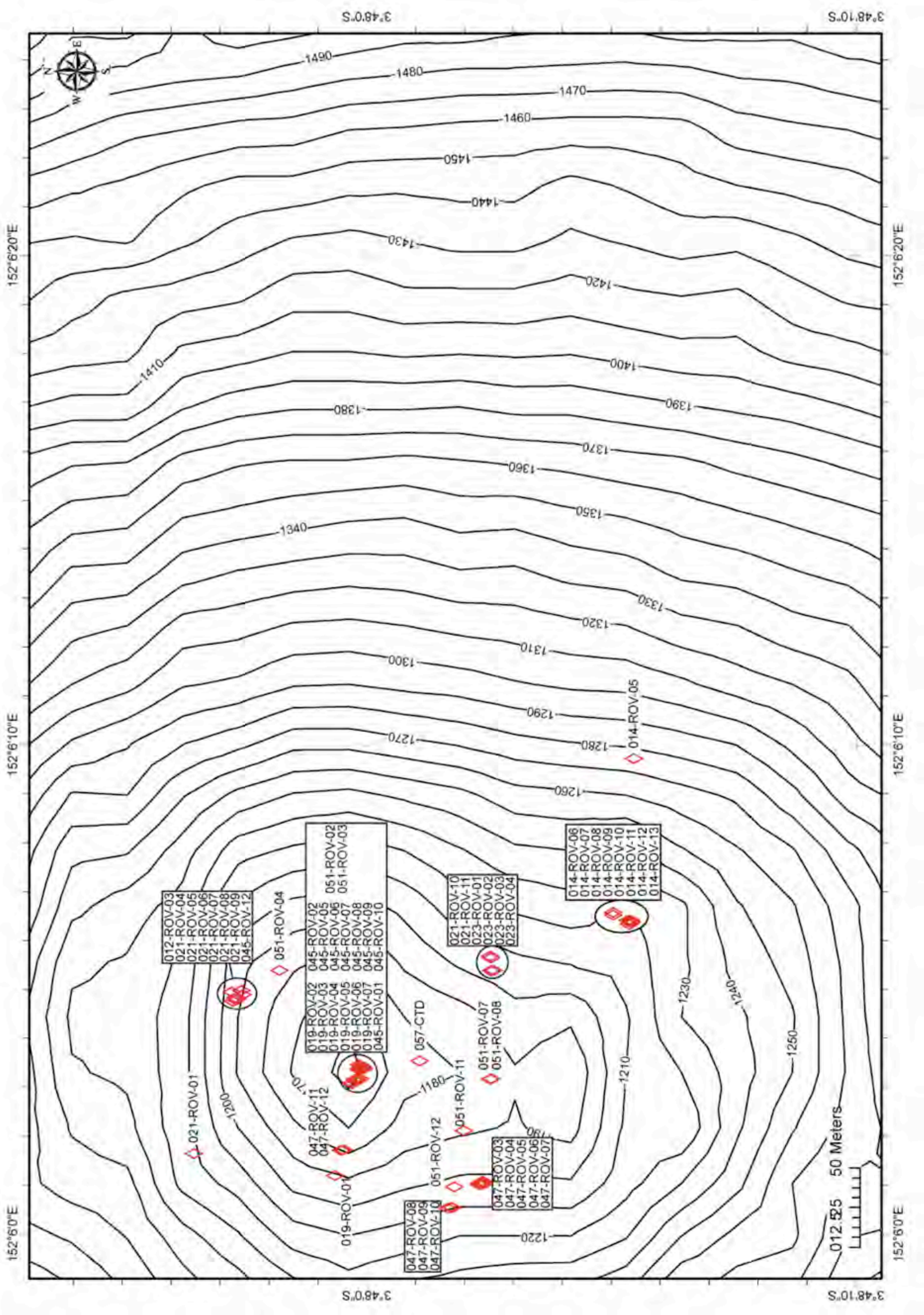


Fig. 6.8: Distribution of fluid samples in the North Su area.

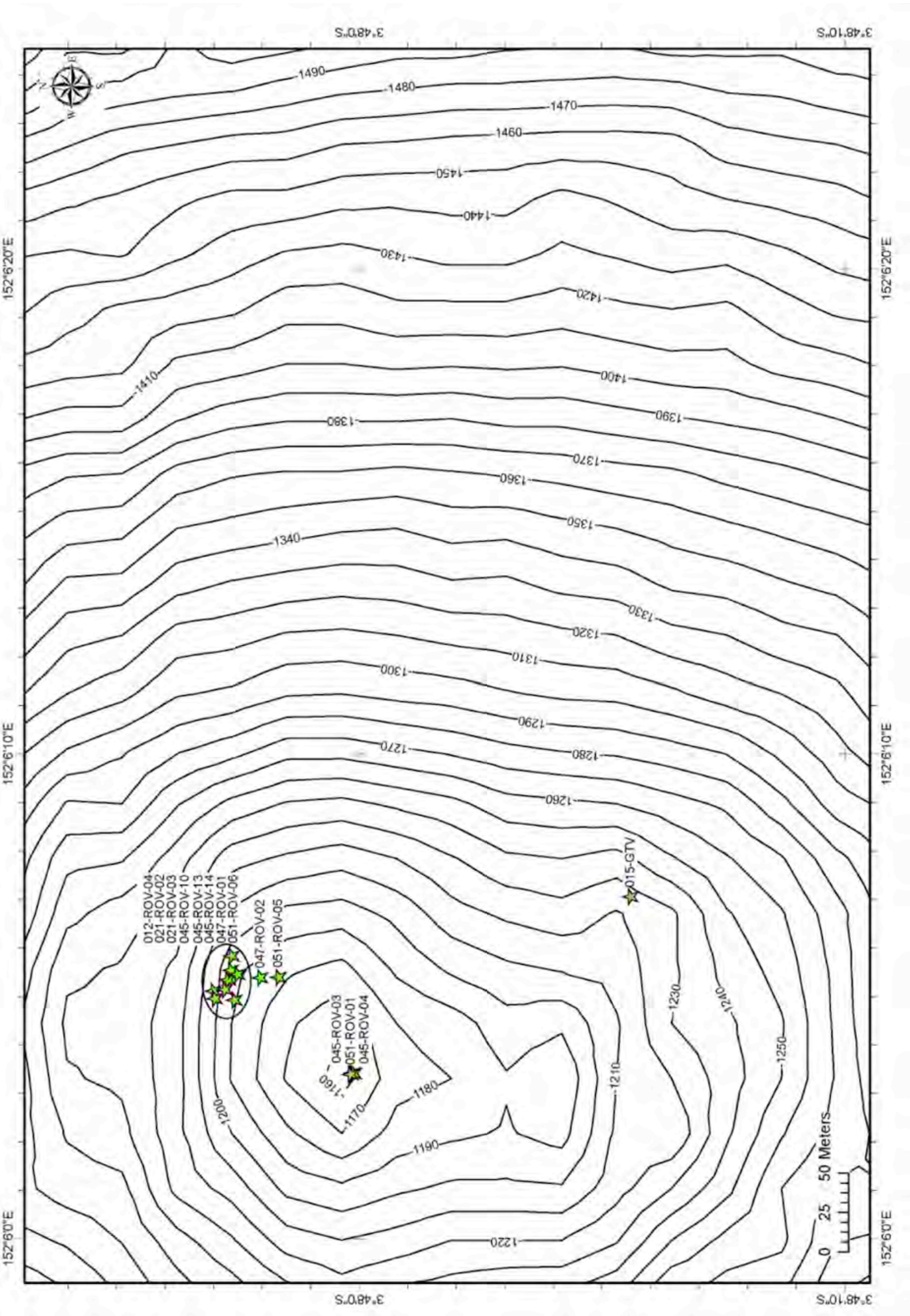


Fig. 6.9 Distribution of biota samples in the North Su area.

6.3. PACManus

The PACManus (PacificAustraliaCanadaManus) comprises several hydrothermal vent sites on the Pual Ridge in a 2.5 km^2 area centered at 3°43.5'S, 151°40.4'E in 1640 to 1780 m water depth. Dives 305 - 312, 315, and 317 examined the Fenway, Snowcap, Tsukushi, Satanic Mills, Roman Ruins, and Roger's Ruins hydrothermal vent sites (**Figs. 6.10, 6.11**). Rocks and fluids from these areas were sampled in 2006 (MAGELLAN06 cruise). In 2007, Nautilus Minerals discovered additional hydrothermal vent sites in the area, specifically Solwara 8 (350 m southeast of Fenway), Solwara 6 (800 m southeast of Roman Ruins), and Solwara 7 (400 northwest of Roman Ruins). These systems were sampled for the first time from a research party, including high-temperature fluid sampling of vents in Solwara 7 and 8 (**Fig. 6.11)**.

Fenway / Solwara 8

The Fenway hydrothermal field is about 200 m in diameter and comprises an anhydrite-hosted black smoker complex (Big Papi), two small chimney clusters 50 m northeast and northwest of Big Papi, and a large patch of diffuse venting in the northern part (**Fig. 6.11**). Big Papi vents 304°C black smoker fluids through sparse chimneys around the base of the anhydrite mound (**Fig. 6.12a**). Additional venting occurs through spiry chimneys on top of the mound. The activity of venting is much weaker than in 2006, when boiling (358°C) black smoker fluids emanated from countless orifices of the mound's summit (Reeves et al., 2011). The water-soluble anhydrite is strongly corroded and thus the Fenway hydrothermal mound is partly collapsed and covered with anhydrite blocks and sand. Through these deposits, venting of clear fluids occurs, which are likely derived from subcrustal mixing of black smoker fluids and cold seawater. Several samples of this type of fluid were collected during dive 311 and range in temperature between 70 and 110°C. The small black smoker cluster northwest of Big Papi showed a fluid temperature of 314°C. The sulfide chimney at Fenway exhibit a thick chalcopyrite lining and outer parts that is rich in sphalerite and marcasite with a Mn/Fe-oxide coating. Fenway is hosted predominantly in fine pyroclastic sediment, in particular the diffuse patch north of Big Papi. That area was a focus point of biological sampling and symcatcher incubation experiments. It features snails (mainly Ifremeria), mussles (Bathymodiolus) and several species of tubeworms, commonly in a patchy style of distribution (**Figs. 6.12b, c**). The volcaniclastic deposit underlying the vent animal colonies forms a smooth knoll with occasional clasts of lava. This knoll is surrounded by fresh block lava, which is usually barren of macrofaunal live (**Fig. 6.12d**).
Solwara 8 is 300m southeast of Big Papi and features clusters of chimneys up to 12 m high. Sampling by TV-grab yielded spiry, thin (2-3 cm diameter) Cu-rich chimneys and porous, more bulbous Zn-rich ones. A chalcopyrite lined orifice sticking out of a beehive structure crowning a tall chimney was sampled, and the fluids were 305°C hot.

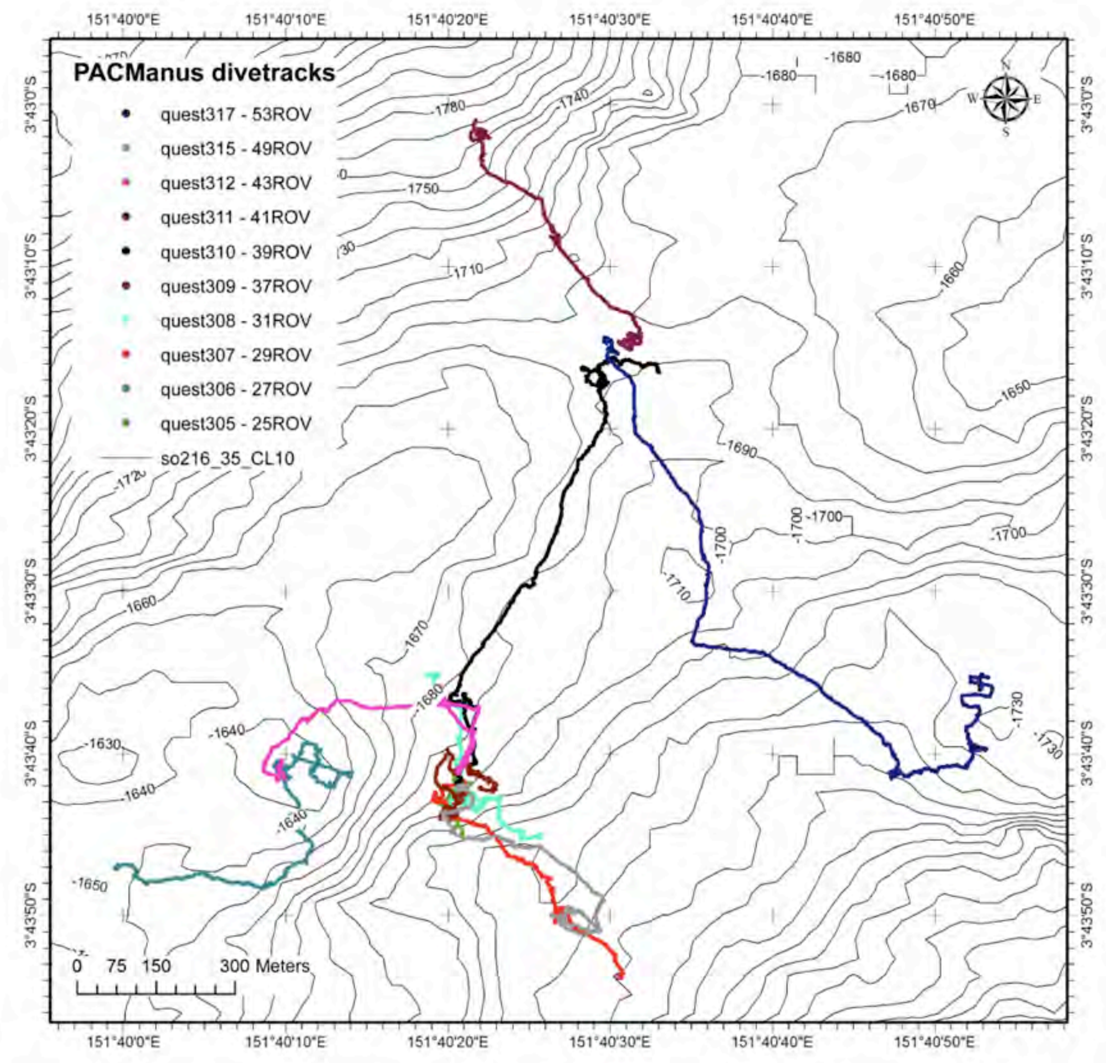


Fig. 6.10: Dive tracks of the ROV MARUM Quest 4000m in the PACManus area.

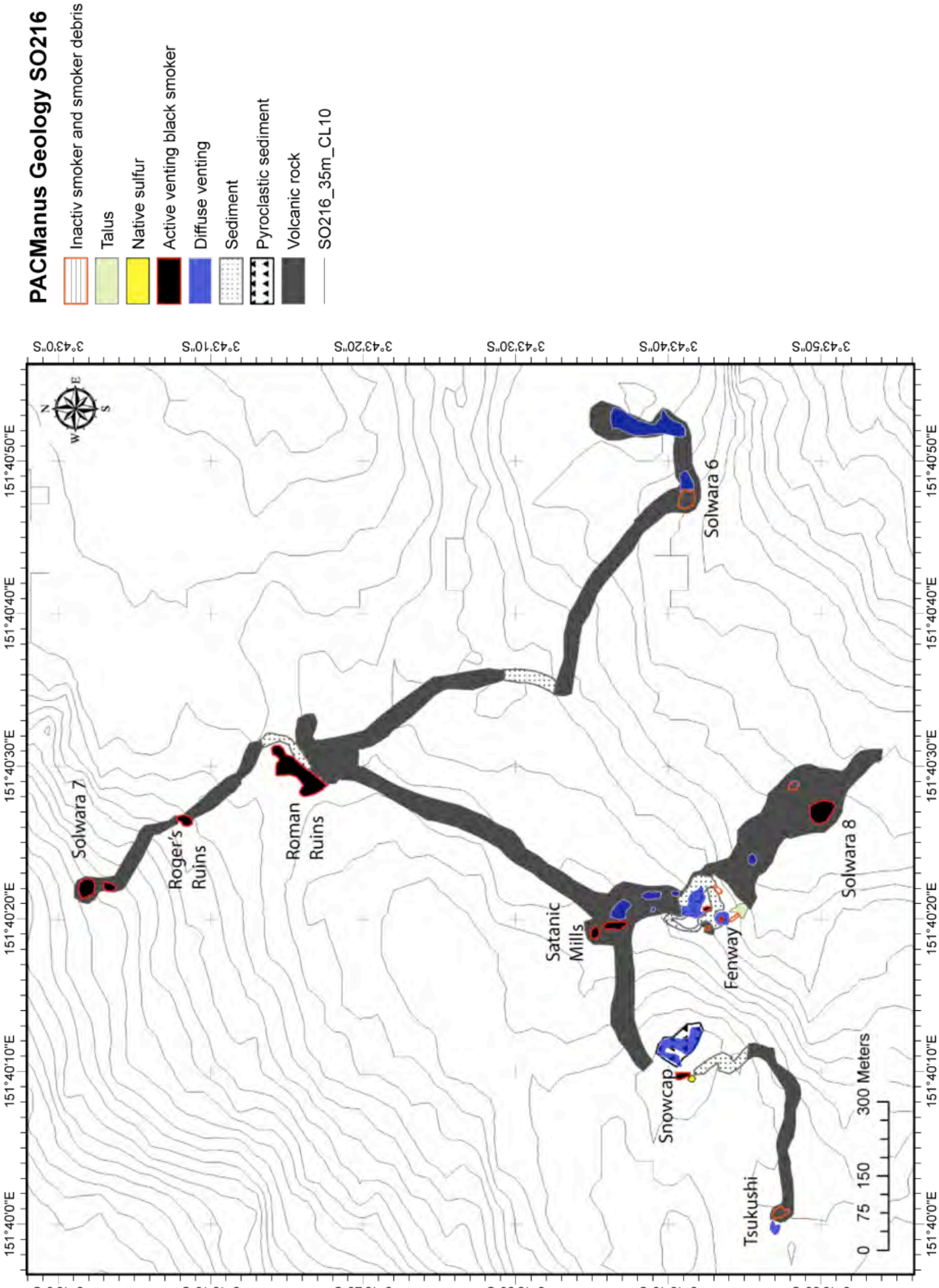


Fig. 6.11: Geological map of the PACMANUS area surveys during cruise SO216 with the most prominent vent sites.

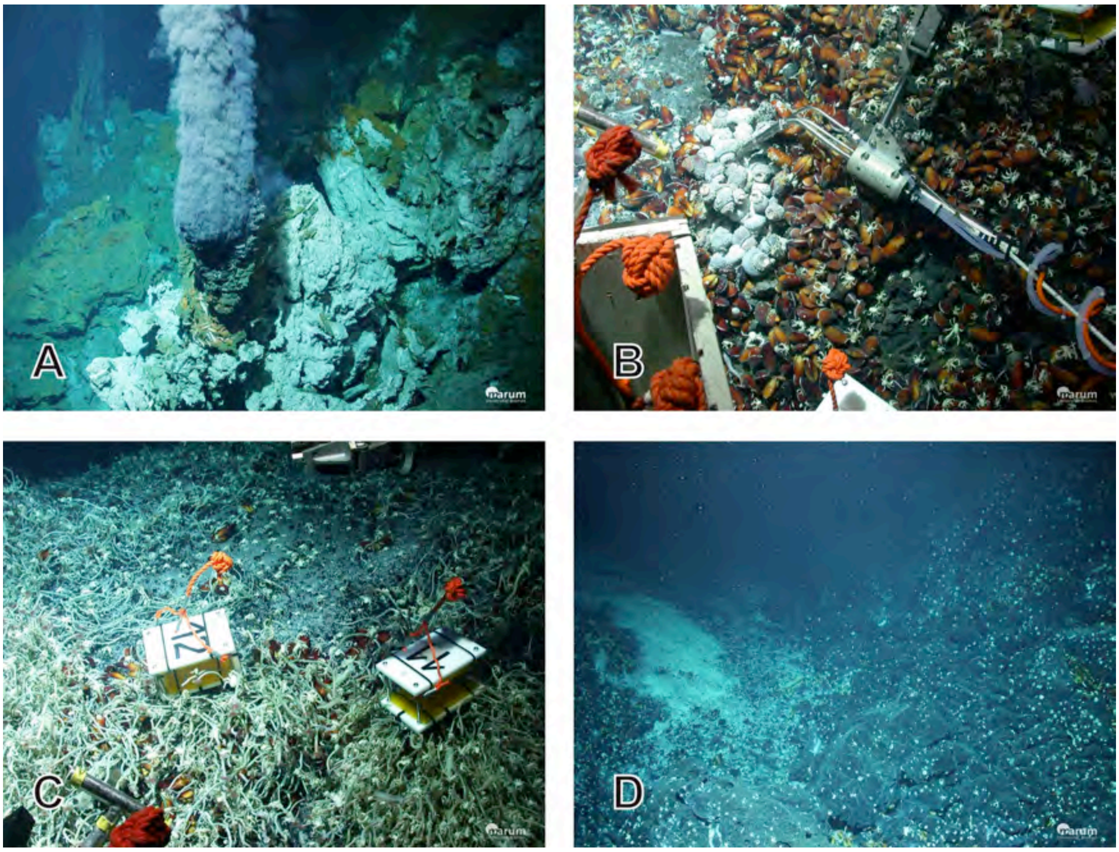


Fig. 6.12: Big Papi displays black smokers on the slopes of a mound of anhydrite and sulfide rubble (A). The patch of diffuse venting north of Big Papi is densely colonized with mussels and snails, which were examined by ISMS (B). Symcatchers were placed in different locations within the diffuse vent area, for instance in a tubeworm colony (C). The diffuse vent area is bordered by block lava, which is less populated and usually barren of life away for the contact.

Snowcap/Tsukushi/Satanic Mills

Like the diffuse patch at Fenway, the largest area of hydrothermal activity at Snowcap is diffuse venting through volcaniclastic sediments. On the northwestern side of Snowcaps lies a small field of sulfide chimneys (variably Cu- and Zn-rich) populated with snails and Paralvinella (**Fig. 6.13a**). These chimneys vent clear to light gray fluids with maximum measured temperatures of 224°C. Immediately southwest of the chimney cluster is a mound of native sulfur, which is densely populated by snails and is surrounded by sediments (**Fig. 6.13b**). The top of the Snowcaps knoll is decorated with countless patches of diffuse fluid seepage. Remarkable is a two reentry funnels (**Fig. 6.13c**), which mark ODP Site 1188 drilled to depths between 180 and 384 m in 2000.

Tsukushi (japanese for cat tail) is inactive, bar venting of moderate-temperature clear fluids though oxide mounds. A fluid and an oxide sample were collected there.

Satanic Mills features numerous clusters of sulfide chimneys; the largest one extends for 60 m from north to south and is about 10-15 m wide. The chimneys grow directly on top of fresh block lava, in particular near flow fronts of lava with little chimney debris lying around (**Fig. 6.13d**). Fluids are between 339 and 345°C hot and local CO_2 bubbling can be observed.

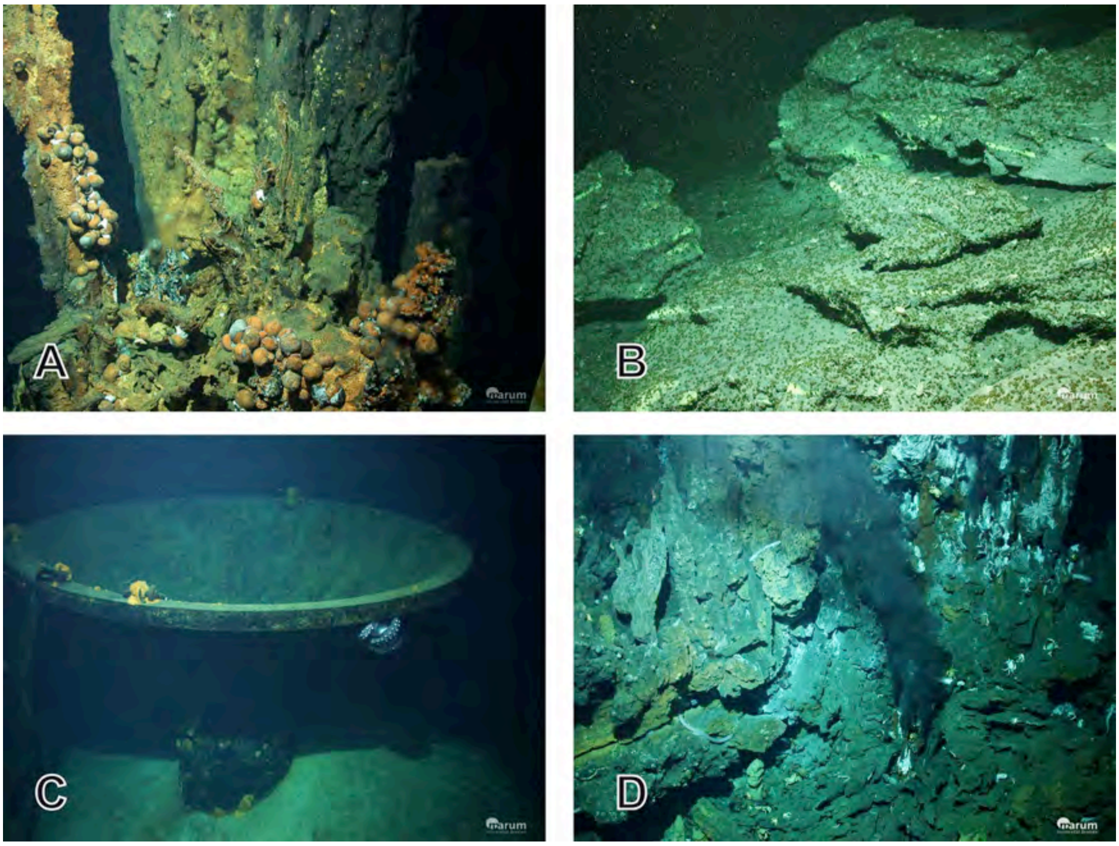


Fig. 6.13: Sulfide chimneys at Snowcap emit clear to light gray fluids up to 224°C (A). Slabs of native sulfur densely colonized by snails from Snowcap, just southwest of the active chimneys (B). A re-entry funnel sits on top of ODP Hole 1188F in the central part of Snowcap (C). Black smokers at Satanic Mills have maximum temperatures between 339 and 345°C (D).

Roman Ruins / Roger's Ruins / Solwara 6&7

These four vent sites form a northwest-southeast trending line, roughly perpendicular to the strike of Pual Ridge (**Fig. 6.11**). Solwara 7 is hosted in a field of block lava and consists of a 50-m diameter main cluster of vents and a smaller accumulation of active chimneys just south of it. Chimneys are tall and slender columnar structures with somewhat gnarly outer surfaces, which are commonly stained with Fe-oxyhydroxide. The highest temperature of venting was measured here in vigorously venting black smoker fluids issuing from a small chimney that grows on top of sulfide rubble (**Fig. 6.14a**). Roger's Ruins, located 200 m southeast of Solwara 7, comprises a small cluster of mostly inactive vents. Its activity was much greater in 2006, in particular in the area of Marker 8, which was very active and was repeatedly sampled in 2006, but appears inactive in 2011. Extensive areas around Roman Ruins are covered with Fe-oxyhydroxide deposits that occasionally form chimneys (**Fig. 6.14b**). Although there is abundant venting of shimmering water through these mounds, no macrofauna could be observed here. The northeastern part of Roman Ruins is mainly inactive, in contrast to the situation in 2006, when lots of black smoker activity was observed here. The central part of Roman Ruins features copious amounts of sulfide chimney rubble, which is exposed on the southeastern flank of the ridge with the active black smokers (**Fig. 6.14c**). In contrast, the southwestern extension of Roman Ruins has volcanic rock talus exposed on the slopes. This part is also more hydrothermally active than the northeastern end of the field. ISMS measurements indicate low H_2S contents of the fluids at Roman Ruins. The excess iron leads to staining of chimney walls and animal shells (**Fig. 6.14d**).

The area between Roman Ruins and Solwara 6 is covered by variably sedimented block lava. Solwara 6 is also situated in block lava flows. There are a few inactive chimneys in

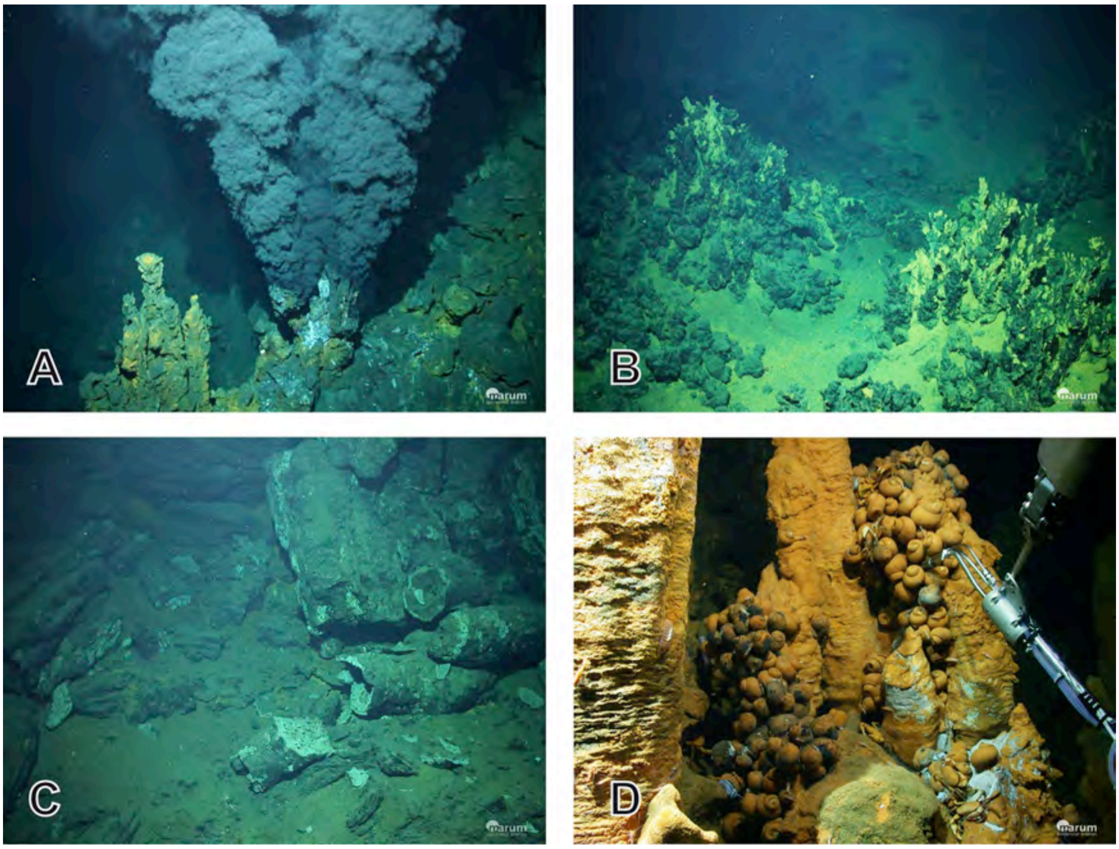


Fig. 6.14: This black smoker at Solwara 7 set the record high temperature of the cruise: 348°C (A). Fe-oxyhydroxide chimneys near Roman Ruins (B). Sulfide chimney rubble on the southeastern flank of a ridge hosting active black smokers (C). Fe-oxyhydroxide staining on chimney walls and snails at Roman Ruins (D).

the western part of the system; other areas show only diffuse venting. Nautilus Minerals, after their 2007 survey, reported more activity in this area, including active black smokers.

Numerous samples of fluids, rocks, and biota were collected during the dives in the PACManus area (**Figs. 6.15, 6.16, and 6.17**). A summary of the sampling site and sample description is provided in **Appendices B and C.**

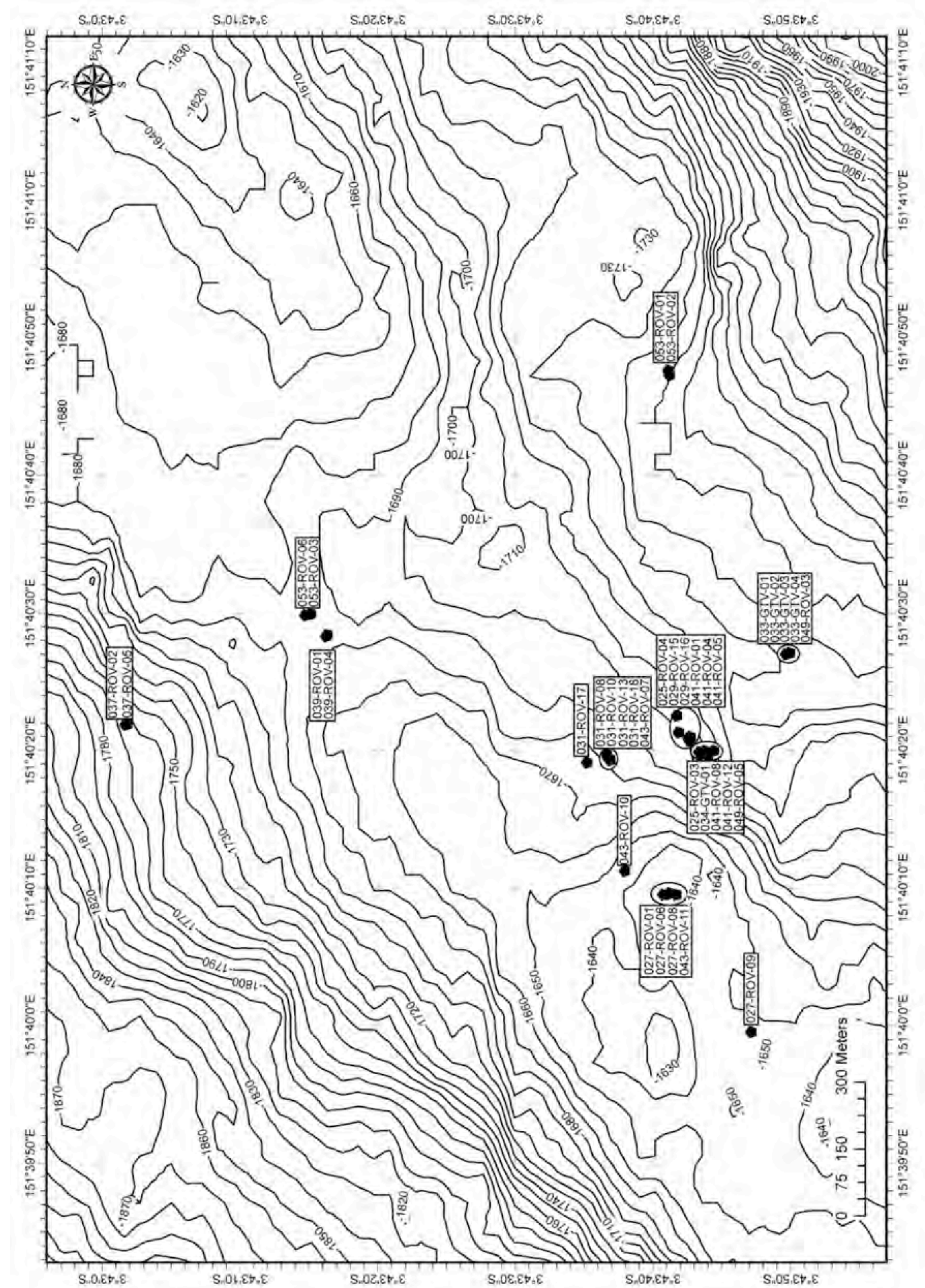


Fig. 6.15: Distribution of rock samples in the PACManus area.

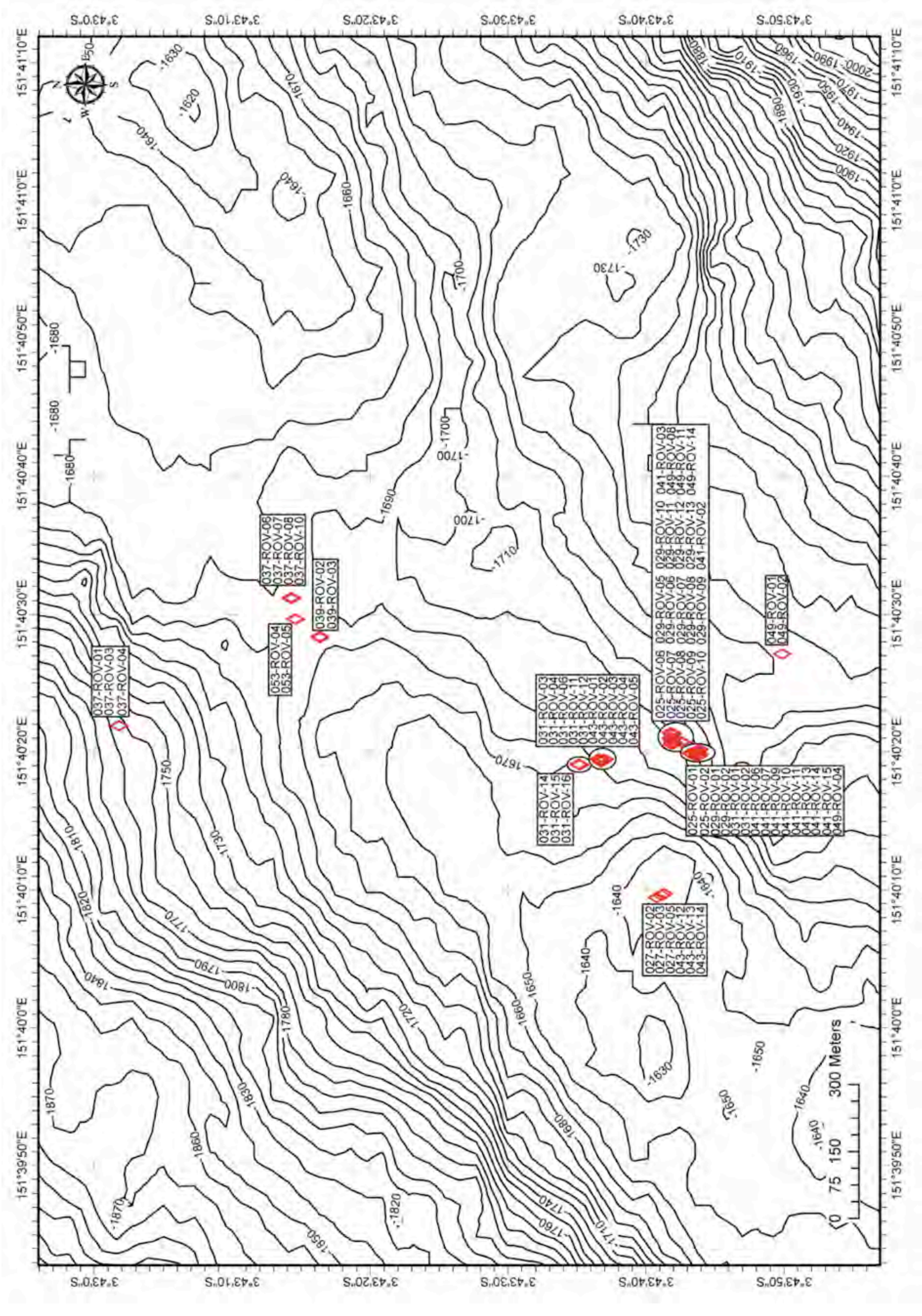


Fig. 6.16: Distribution of fluid samples in the PACManus area.

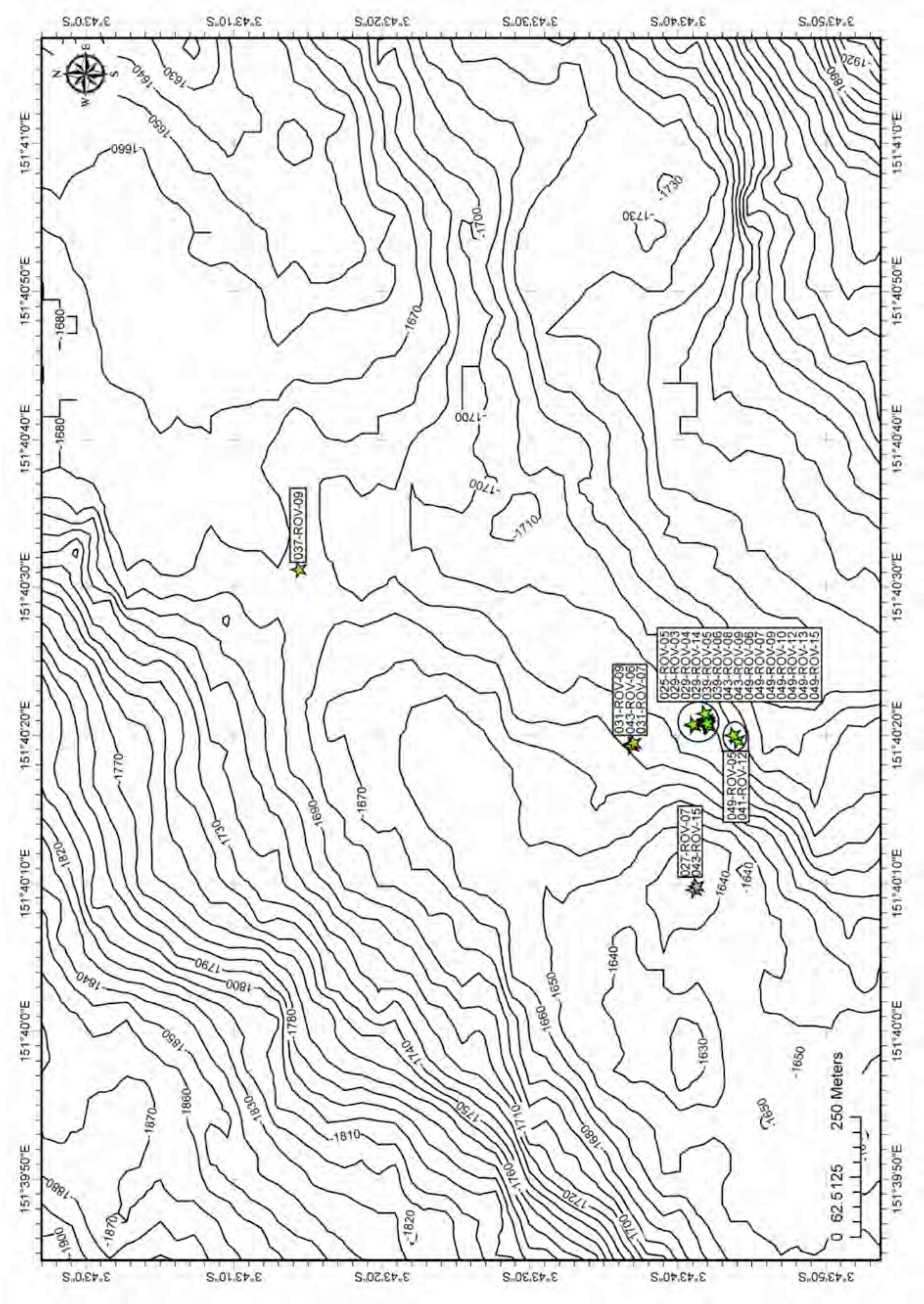


Fig. 6.17: Distribution of biota samples in the PACManus area.

7. FLUID GEOCHEMISTRY

7.1. Gas-tight fluid sampling (Eoghan Reeves)

This section discusses the sampling of hydrothermal fluids with Isobaric Gas-Tight (IGT) fluid samplers (Seewald et al. 2002) and preliminary geochemical results of shipboard analyses. These samplers, which allow for quantitative analysis of both dissolved gases and major/minor elements were provided through collaboration with Dr. Jeff Seewald, Woods Hole Oceanographic Institution, U.S.A. In addition to real-time temperature measurements during sample collection, shipboard analyses included measurement of dissolved H_2 concentrations (by gas chromatography), pH(25°C) and processing/archiving for shore-based analyses of other major and minor dissolved species (gases and inorganic anions/cations, sulfur species, arsenic species). A total of 8 successful IGT fluid samples were taken from 6 discrete vent orifices at SuSu Knolls, and 13 successful samples were taken from 8 discrete orifices at PACMANUS. A background bottom seawater IGT sample was also taken from the SuSu Knolls area.

The main goals of the IGT sampling campaign were to document temporal changes in endmember fluid chemistry compared to the 2006 MGLN06MV expedition (Tivey et al. 2006, Reeves et al. 2011) and to collect more diverse types of white smoker fluids at North Su in order to better constrain magmatic fluid compositional variability. Where possible fluid samples were collected in pairs to allow accurate endmember calculations and for black smoker fluids, the chimneys were typically excavated/cleared to allow access to the endmember fluid in the orifice. However, due to sampling difficulties and technical problems with the IGT's, in several cases only one sample from a vent was recovered. Owing to the absence of shipboard Mg analyses it was not possible to determine end-member fluid compositions (i.e. extrapolated to Mg = 0) at sea. Accordingly, the concentrations of aqueous species discussed below from this expedition represent measured values and are not corrected for seawater entrained either in the subsurface or during sample collection. The 2006 values taken from Reeves et al. (2011) are endmember values and comparisons should be therefore taken as purely qualitative. For several vents, replicate samples of the same vent fluid from this expedition yielded similar concentrations of dissolved species, suggesting near end-member fluids may have been collected in some cases during this expedition. For vents where there was a discrepancy between replicate samples, it is assumed that the lower concentration (higher pH values) reflects entrainment of ambient seawater during sampling. Thus, only the highest concentration value (lowest pH) for each set of replicate samples from a given edifice has been used to constrain the concentration ranges reported below. Only temperatures, pH(25°C) and H_2 concentrations are discussed as all other dissolved gas, major and minor element analyses will take place in shore-based laboratories.

SuSu Knolls (North Su)

Several different types of hydrothermal vents were sampled on the North Su neovolcanic dome, broadening the diversity of compositions relative to the 2006 expedition. Collectively, the findings of this cruise indicate extreme dissolved gas variability in white smoker fluids on very short spatial scales (<100 m), and tentatively suggest apparent temporal stability in the summit black smoker fluids at North Su.

Two black smoker vent fluids were sampled from the complex of such vents on the summit of the dome (S019-ROV-01 and S045-ROV-02), with maximum measured temperatures of 332°C and 313°C, respectively. These temperatures are similar to the range of temperatures observed there in 2006 (Tivey et al. 2006), and the hottest black smoker was observed to be visibly boiling (Fig. 6.4B), as evident by the 'flashing' phenomenon noted in

2006 (Reeves et al. 2011). Temperatures of flashing fluids in 2006 were slightly cooler (325°C) but due to heating of the IGT thermocouple apparatus by fluids during sample collection the actual temperatures from 2011 may be very similar. The 313°C vent had stable temperatures within ±1°C during repeat temperature measurements but seawater entrainment occurred during sampling. For both fluids, the range of dissolved H_2 (24 – 50μM) and pH (3.2 – 4.8 at 25°C) is very similar to that of samples collected in 2006. These observations suggest that, in addition to the persistence of near-boiling temperatures, at least some aspects of venting at the summit black smoker complex have remained constant.

Several clear/diffuse and white smoker smokers fluids were also sampled on the flanks of the North Su dome. White smoker fluids were sampled in the newly discovered 'Sulfur Candles' area of intense white smoker activity and liquid CO_2 venting to the southeast of the dome summit. At Sulfur Candles, two successful samples were taken (S023-ROV-01 & -02) from a relatively focused white smoker fluid emanating from a small orifice on the seafloor (Fig. 6.8). In contrast to white smokers sampled in 2006, the fluid sampled was clearly venting intermittent bubbles of liquid CO_2 with white smoke, similar to other vents in this area (Fig. 6.6). Due to the ubiquitous presence of molten sulfur beneath the surface (as well as within sulfur chimneys themselves), clogging of the snorkel occurred during/after sampling. The samples had similar maximum temperatures (95°C and 103°C) and pH values (1.4 and 1.2 at 25°C, respectively) suggesting this is close to the exit temperature of these fluids. During processing, large volumes of gas were exsolved from these fluids at surface pressures (10 – 20 volumes of gas per volume of fluid). Based on the presence of liquid CO_2 in the fluid (implying saturation), this is most likely due to exsolution of dissolved CO_2. H_2 was detected but observed to be extremely low (<5 μM) and no H_2S odor was detected.

In contrast to the fluids at Sulfur Candles, white smoker vent with no visible CO_2 bubbling was successfully sampled (S047-ROV-03 & -04) with two IGT's on the southwest flank, within ~30m of the area where very low pH fluids (0.87 at 25°C) were sampled in 2006 (Tivey et al. 2006). The landscape of this area had changed substantially with the growth of the pyroclastic cone since 2006 (Fig. 6.5) and these fluids may not be directly comparable to those previously collected. Maximum temperatures (129°C and 149°C) and pH (1.9 and 2.0 at 25°C, respectively) were comparable to Sulfur Candles, but these fluids were characterized by a noticeable H_2S odor and very little gas exsolution during processing. H_2 was detectable at extremely low levels (<1 μM) and solidified native sulfur was also recovered in the snorkel. During S051, an attempt to sample another white smoker venting with liquid CO_2 bubbles (S051-ROV-11) failed due to difficulties in safe vehicle positioning and seawater entrainment. However, upon moving ~30m west (Fig. 6.8) a 1–2m patch of white smokers with no visible liquid CO_2 was located and sampled (S051-ROV-12, maximum temperature of 104°C). Snorkel blockage with sulfur and seawater entrainment meant that only a partial sample of questionable purity was collected, however. This sample had a pH(25°C) of 2.5 and a noticeable H_2S odor but H_2 was not detectable.

In the area to the north of the summit previously suspected to contain 'hybrid' magmatic-hydrothermal fluids (i.e. fluids displaying characteristics of both black and white smokers on the basis of samples collected there in 2006 (Tivey et al. 2006)), a single poorly focused hydrothermal fluid emanating from a crack was sampled with a maximum temperature of 169°C. A single IGT sample (S021-ROV-01, Fig. 6.8) of the fluid had a pH lower than the summit black smokers (2.4 at 25°C) but higher than most white smoker fluids collected. In addition, H_2 was detected at extremely low levels (<1μM), providing further indication that the fluid is indeed a hybrid type.

PACMANUS (Pual Ridge)

IGT sampling at PACMANUS focused exclusively on collection of high temperature black/grey smoker fluids to characterize temporal changes in endmember fluid chemistry in addition to preliminary characterization of vent fluids in new areas of hydrothermal activity (Solwara 7 and Solwara 8) explored on this cruise.

Significant temporal changes were observed in fluids at the Satanic Mills vent area relative to the 2006 published data from Reeves et al. (2011). In 2006, sampled fluids had maximum temperatures below 295°C and elevated endmember TCO_2 concentrations of 160 – 274 mmol/kg (Reeves et al. 2011). During this expedition, two black smokers were sampled in the area between vents SM1 and SM2 (Fig. Reeves et al. 2011) with substantially hotter temperatures 345°C and 339°C (S031-ROV-12 and S043-ROV-01,02; Fig. 6.16). These temperatures were extremely stable during sample collection, indicating that they accurately reflect the maximum exit temperature of the vents. While this difference may simply reflect the accidental selection of lower temperature vents for sampling within the area in 2006, it is possible that the intensity of magmatic-hydrothermal activity has increased. Relatively weak release of what appeared to be liquid CO_2 globules was observed in the vicinity of the sampled vents. Though the intensity of such release was much less than at North Su, this suggests much greater concentrations of CO_2 are present at Satanic Mills than those observed in 2006, which were far below the level needed to exceed dissolved CO_2 solubility and form liquid droplets. The pH values of these fluids ranged from 2.8 to 3.0 (at 25°C) and H_2 concentrations ranged from 30 to 133 µM, higher than the range of endmember H_2 concentrations observed in 2006 (8.4 – 30 µM, Reeves et al. 2011). A chimney on the same vent structure as the S031 IGT samples was taken for organic geochemical analyses (S031-ROV-18), as well as an inactive chimney (S043-ROV-07) from nearby (<20m away) at Satanic Mills. The active chimney can be assumed to be a fluid-solid pair as the structure likely had a single main conduit feeding the small chimneys sampled on top.

At the Snowcap area, the large ~8m sulfide tower structure 'SC2' previously sampled in 2006 (Reeves et al. 2011) was resampled (S027-ROV-04 & -05, Fig. 6.16). Though the vent at the top that was sampled previously was no longer active, a vent on the side of the structure was sampled with two IGT's. The maximum temperature was 224°C, substantially hotter than the maximum in 2006 (180°C). However, due to difficulties in positioning the snorkel in the flow, the temperature observed on this expedition may be a minimum temperature as a constant temperature was not achieved during sampling. The lowest pH(25°C) was 4.0, within the range observed in 2006 samples (3.4 – 5.0), but measured H_2 was extremely low (<1 µM) relative to 2006 (20 – 49 µM in endmembers, Reeves et al. 2011).

At the Fenway mound, which hosted the hottest (boiling) fluids in 2006 (Reeves et al. 2011), no such boiling fluids were found during this expedition and the Big Papi structure at the summit of the mound was much less active. One black smoker fluid (Figs. 6.16 and 6.12A) was sampled (S029-ROV-01 & -02) on the flank of the mound after removal of the structure and gave consistent temperatures of 304°C between two IGT's. Previously, during S025, the temperature of this fluid had been found to be similar (303°C) and the sulfide structure was growing out of massive anhydrite. To the northeast of the mound, another smoker was sampled (S041-ROV-03, Fig. 6.16) in the area of the 2006 vent F1 (Reeves et al. 2011) with consistent temperatures of 314°C. Only one IGT successfully obtained a sample, however. H_2 concentrations (2.4 – 11 µM) were lower for both Fenway fluids relative to 2006 values, but pH values (2.4 to 2.7 at 25°C) were comparable.

A single fluid was sampled twice in the Roman Ruins area (S039-ROV-02 & -03) in the vicinity of vent RMR3 from Reeves et al. (2011). A small chimney on top of this 1.5m tall structure (not the exact orifice sampled for fluids) was removed for organic geochemical analysis (S039-ROV-01) and the entire upper section of the structure was then taken also (S039-ROV-04), revealing a single fluid conduit in the trunk that fed the small chimneys on top. The maximum temperature observed was 333°C but was not stable during sampling, and pH (2.6 at 25°C) and H_2 (25 µM) were similar and slightly lower than 2006 values, respectively. The temperature of a single fluid from a large sulfide tower in the vicinity of vents RMR4, RMR1 and RMR2 from Reeves et al. (2011) was measured to be 329°C (likely a minimum estimate) but no IGT samples were successfully taken. A nearby (<10m away) weakly venting chimney covered in orange Fe-oxide mat/biofilm was taken for organic geochemical analysis but no temperature measurements were made (S053-ROV-03). The range of temperatures at Roman Ruins was similar to that of 2006, indicating the persistence of high temperature activity at this area.

High temperature vent fluids were also collected from two new areas of activity, Solwara 7 (S037-ROV-01) and Solwara 8 (S049-ROV-01 & -02), which were discovered during surveys by Nautilus Minerals (Fig. 6.16). Visibly boiling fluid was collected from a large sulfide structure at Solwara 7 which gave a repeatable maximum temperature of 348°C (Fig. 6.14A). At Solwara 8, two IGT's with repeat temperatures of 305°C were taken from the top of a tall column-like sulfide structure. pH values (2.9 at 25°C) and H_2 (25 – 60 µM) were similar to other high temperature areas at PACMANUS.

Figure 7.1 Typical deployment of the IGT samplers with the starboard ROV manipulator: **(left)** sampling of a 104°C white smoker fluid at North Su during Dive 316 (S051) and **(right)** sampling of a 304°C black smoker (after excavation of the structure shown in Fig. 6.12A) on the flank the Fenway mound (PACMANUS) during Dive 305 (S025).

7.2. KIPS fluid pumping system

(Sven Petersen, Christian Breuer)

Fluid sampling of both diffuse and focussed hot fluids was achieved using the ROV-based fluid sampling system "KIPS" (Kiel Pumping System, KIPS), a remotely controlled flow-through system mounted on the ROV's tool sled. All materials coming into contact with the sampled fluid are inert [perfluoralkoxy (PFA), polyetheretherketone (PEEK), polytetrafluorethylene (PTFE, Teflon®)], and a short tube of high-purity titanium (99.9 % Ti)] and have lowest adsorption coefficients preventing systematic errors introduced by either contamination or losses due to adsorption. Precipitation during cooling of the sampled fluid, however, cannot completely be avoided, but transparency and the smooth surfaces of the used PFA allow a quantitative recovery of particles from the sample flasks. The parts of the system getting into contact with the sample withstand temperatures up to 260 °C (short-term 305 °C). Fluid enters via the titanium tube (40 cm length, 6 mm I.D., bent to 45°) inserted into a stainless steel protection tube and mounted to a T-handle that is guided by the ROV's arm. Coiled PFA tubing connects the nozzle to a remotely controlled multi-port valve (PEEK/ PTFE) delivering the fluid to the respective sampling flask. The valve is driven by a stepper motor and is controlled from the ROV control van. The software package FluidCtrl V. 3.0.0 by Jens Renken @ Marum Soft, Bremen was used.

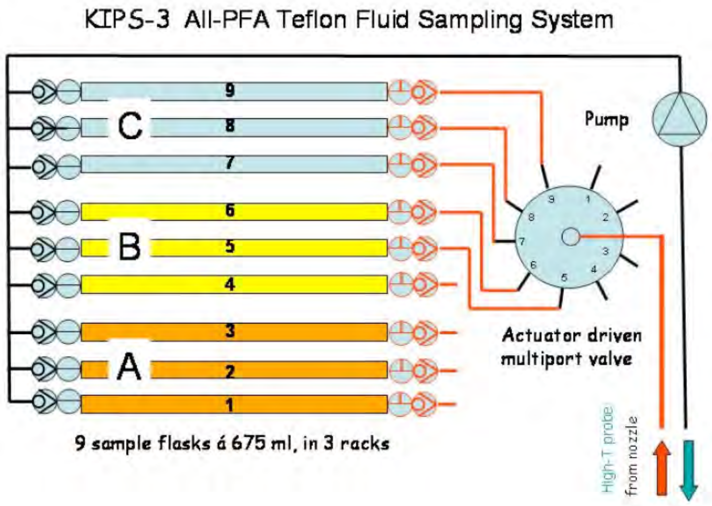


Fig. 7.2: Schematic configuration of the inert KIPS fluid sampling system (only tubing connections to flasks #5-#9 are shown for clarity). Fluid entering the nozzle is distributed by a motorized multiport-synchro-valve into 9 PFA sample flasks á 675 ml. The gear pump is positioned downstream.

The multiport synchro-valve has 1 inlet and 9 outlet ports connected to 9 PFA flasks with 675 ml volume each (Savillex, USA). The flasks are mounted in three racks A-C, with every rack containing three horizontally positioned bottles (A1-A3, B4-B6, C7-C9), allowing an easy transfer of the racks to the laboratory where sub-sampling was done. Flasks were pre-filled with de-ionized water and flushed during descend of the ROV with ambient seawater. A 24 V deep sea mechanical gear-pump, switched on and off through the ROV's telemetry, is mounted downstream to the sample flasks, thus, avoiding contamination of the samples. The pumping rate was approx. 1 L/min at 24 VDC. The standard pumping time per sample was set to 3 min. making sure that the flask volume was exchanged at least 4 times. The outlet of the KIPS system is located on the porch at the front of the ROV, where video control allows the observation of a flow mobile that was attached to the outlet tube.
Intermediate temperature (50-100°C) fluid samples were collected at Fenway in the Pacmanus field and at the white smokers at North Su. Diffuse fluids were sampled at various sites in cooperation with the biologists. During most dives up to two bottles were replaced with filtering devices for in-situ pumping of diffuse fluids (see chapters on microbiology).
Immediately after recovery of the ROV on deck KIPS sample racks A-C were transferred to the laboratory for sub-sampling. Each sample rack was homogenized by shaking before sub-sampling.
On-board measurements comprised pH and Eh in order to ascertain the quality of sampled hydrothermal fluids (i.e., the degree of admixed seawater for hot vents). The ex-situ pH ranges for the sampling bottles of the different sites are shown in the appendix with higher values showing the admixture of seawater related to the small orifices of certain vent sites.

7.3. Arsenic geochemistry of hydrothermal fluids

Christian Breuer (MARUM, Bremen)

Objectives -- Arsenic (As) concentrations in hydrothermal fluids are considerably elevated over normal marine background values. The most important factors controlling the amount and speciation of As in hydrothermal fluids are host rock composition and temperature of the system and emitting fluids. There is a lack of data on As concentration and speciation for the studied sites and hydrothermal systems at all. The investigations during and after this cruise will fill this gap in our knowledge. Hydrothermal fluids of hot black and white smokers as well as diffuse fluids were collected with the ROV in combination with Seewald/IGT samplers and KIPS. Unfortunately, As species cannot be measured onboard precisely, requiring preservation of fluid samples for analysis at Bremen University. Currently, the best method of preservation of water samples for determination of As speciation is under debate. Therefore, different types of preservation techniques were applied, including freezing, acidification and addition of EDTA.

All in all, 76 samples were taken during the cruise with 21 by Seewald/IGT and 55 by KIPS whereas the different preserved splits will be analyzed by ICP-(HR)MS and HPLC-ICP-(HR)MS for total and As species at the labs in Bremen and Bayreuth. Temperatures were between 3.1 and 348.0 °C and pH values range between 1.24 and 7.33.

For selected hydrothermal fluid venting sites, associated biota was sampled to investigate the relationship between the collected snails (Alviniconcha and Ifremeria), mussels (Bathymodiolus manusensis) and the emitted hydrothermal fluid. The snails and mussels were dissected onboard into gill, muscle and digestive gland and stored at -80 °C. In Bremen, the As species will be liberated from the tissues by methanol/water leaching steps, and total As and speciation will be determined.

7.4. Sulfur biogeochemistry of fluids

Inigo Müller, Benjamin Brunner (Max Planck Institute for Marine Microbiology)

Objectives -- The major dissolved and solid sulfur bearing phases at marine hydrothermal vent sites are sulfides, sulfates and elemental sulfur. Commonly, their abundance and assemblage in solid phases, and their concentration in hydrothermal fluids are well studied, and often these constituents are analyzed for their sulfur isotope composition. The objective of our study is to explore the sulfur biogeochemistry in more detail, thereby making a step beyond those classical approaches. Specifically, we aim to test two hypotheses:

(1) The oxygen isotope composition of sulfate from hydrothermal fluids provides information on biogeochemical processes in the subsurface that is complementary to the insights gained from sulfur isotope analyses.

A previous study (Reeves et al., 2010) on the investigated sites indicates that the sulfur isotope composition of most sulfate is very close to the sulfur isotope composition of seawater sulfate. Sulfate is presumed to be derived from dissolution of anhydrite, which originated from seawater sulfate, or directly from entrained seawater, either during sampling or by circulation of seawater through the subseafloor hydrothermal system. All the above scenarios are likely to have little impact on the sulfur isotope signature of sulfate found in the fluids. However, the case where seawater sulfate circulates through the subseafloor hydrothermal system bears the potential for oxygen isotope exchange between sulfate and water from the hydrothermal fluids. Such isotope exchange is known to occur at increased rates under strongly acidic conditions, as well as under elevated temperatures. Furthermore, we speculate that the presence of dissolved sulfide may also enhance oxygen isotope exchange between sulfate and water. These conditions are met in hydrothermal systems, and the question becomes if the residence time of entrained seawater – and thereby entrained seawater sulfate – is long enough to yield a measurable oxygen isotope effect.

For a few specific sites Reeves et al. (2010) report exhalation of acid fluids rich in sulfate, which apparently have been affected by disproportionation of sulfur dioxide into sulfate and sulfide, or sulfate and elemental sulfur. Evidence for the occurrence of this process is provided by the sulfur isotope composition of sulfide (Reeves et al., 2000), which is untypical for sulfide derived from degassing of melts, but consistent with the isotope effects attributed to disproportionation of sulfur dioxide (Kusakabe, 2000). For these sites, we aim to obtain sulfur isotope values of sulfates, which are expected to reflect an isotope signature complementary to the isotope composition of sulfides, as well as the oxygen isotope signature of sulfate. To the best of our knowledge, the oxygen isotope effects related to the disproportionation of sulfur dioxide in seafloor hydrothermal vent systems have not been studied; obtaining such measurements from this natural laboratory thus will provide first insights into a so far under-explored geochemical process.

(2) **Sulfur intermediates such as sulfite and thiosulfate in fluids affected by hydrothermal activity exist in higher concentrations than what would be expected from their thermodynamic stability.**
Sulfur dioxide is likely the substrate for the aforementioned acid sulfate fluids. Sulfur dioxide may not be fully consumed by the disproportionation reaction because the rapid ascent of such fluids may outcompete the kinetics of the disproportionation reaction. Thus, we speculate that bisulfite and dissolved sulfur dioxide may be a component of acid sulfate fluids. Thiosulfate, on the other hand, is a main product of abiotic sulfide oxidation, which may occur when fluids are mixed with entrained oxygenated seawater. We mainly target these two sulfur intermediates in our study because of their relevance for biochemical processes, thereby bridging insights into geochemical reactions affecting sulfur speciation and the consequences for living organisms: sulfite is a bactericide, and at higher concentrations harmful for all living organisms, whereas thiosulfate is a substrate that is readily metabolized by an amazing number of microbial species, despite the fact that thiosulfate is commonly only available in very low concentrations in the natural environment.

7.4. **In situ mass spectrometry of volatile compounds**

The objectives for the use of the In Situ Mass Spectrometer (ISMS) were to provide real-time information of the presence and abundance of volatile molecules in targeted areas before fluid sampling (KIPS), as well as survey these parameters in water close to animals before their collection or close to experimental deployments (sulfur bacterial colonization or SymCatchers). The pH values were also determined in real time, and recorded to be able to determine the total concentrations of H_2S and CO_2 in the water.
All volatiles and pH variations were also followed throughout the dives and could be used in GIS approaches to map them for the transit parts of the dives (data recorded while on the bottom could be greatly affected by focused sources near the inlet of the instrument).

The ISMS is essentially a membrane-inlet mass spectrometer whose membrane has been adapted to withstand the pressure in the deep-sea while still allowing gases to pass through. The instrument itself was set in the back of the ROV and the water in the area to be surveyed was flowed over the membrane by a SeaBird pump (~90 ml/min flow rate). From the inlet to the membrane, the water took about 2-3 minutes, yielding to a slight lag before the data regarding the area of interest could be viewed. The inlet itself was mated to the KIPS inlet and the temperature probe, allowing a single manipulation for temperature and

ISMS recording, as well as paired sampling with KIPS (Figure 1). Finally, a pH meter was mounted in-line and values recorded every 10 seconds.

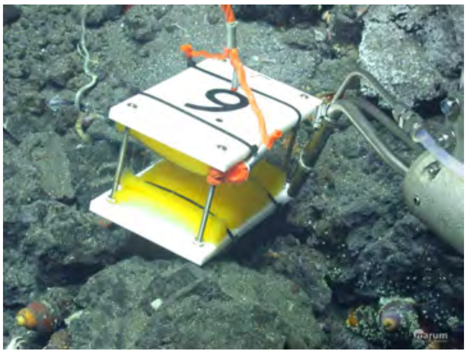


Fig. 7.3: Inlets of the ISMS (clear PFA tubing and titanium inlet), KIPS and temperature probe positioned near a SymCatcher during the BAMBUS cruise.

Inside the housing, the gases were ionized and the resulting ions separated by a Residual Gas Analyzer (SRS). The masses were scanned from AMU (atomic mass unit) 1 to 65, covering nearly all the gases of interest for hydrothermal vent settings. The data recovered corresponds to partial pressure of gases in the mass spectrometer, these pressures depending on the gas concentration in the water and on the permeability of the membrane for this gas. The data needs to then be processed to remove the drift occurring during the dive, the overlap of peaks, as well as possible temperature variations on the membrane. This range of masses was scanned throughout the dive, usually starting about 200 m above bottom, and a scan was recorded every 28 seconds.

The ISMS was deployed and used on every dive during the cruise. There were no major problems, although recurrent communications issues required the scanning to be manually re-started often. Overall, there should not be major gaps in the time series. The data for each scan (up to ~1200 scans for a full dive) have been exported from the RGA software and combined into Excel files for post-dive processing. This post-processing has been partially done on board but more work will be needed to get reliable concentration data.

For each dive, a log of events relevant for the ISMS data analyses was kept and later illustrated with *in situ* pictures. These logs are also available for the other scientists to facilitate future interactions when they will need concentration data for their samples, or experimental deployments.

Overall, hydrogen was not detected in significant amount in the fluids analyzed. Sulfide was usually detected in water with a hydrothermal influence. Methane was only detected at some locations on North Su, including close to some animal communities. A compound producing a peak at AMU 60 (possibly acetic acid) was also observed in some of the North Su fluid with methane.

Changes in activity at North Su -- A source of diffuse fluids was found on top of North Su, coming out of a crack identifed with Marker 32. This crack was visited three times, once at the beginning of the cruise (dive 301), and twice near the end (dives 313 and 316). The two latter visits revealed a general increase of activity in the area, with the ROV almost continuously in the plume (Figure 2). During each visit, some KIPS samples were collected and we have good records of the dissolved gases with the ISMS.

Fig. 7.4: Fissure next to Marker 32 on the summit of North Su, visited during dives 301 (left), 313 (middle), and 316 (right).

Preliminary analysis indicates that although some differences were obvious in the area surrounding the fissure (white bacterial growth on surfaces, almost complete disappearance of shrimp), the fluid coming out of the fissure was essentially unchanged as far as temperature, pH, as well as methane, sulfide, and carbon dioxide concentrations are concerned (Table 1). More detailed analyses will be needed to account for background values for the ISMS, but a first look at the data for the water above the bottom (altitude 2-3 meters) indicates a pronounced decrease in pH between the first dive (301) and the two following ones (dives 313 and 316; Table 1). Although CO_2 did not change in the water above the bottom, sulfide and methane were detected (Table 1). While sitting on the bottom, the values tend to indicate relatively similar conditions between the different dives (but proximity to diffuse flow sources can vary between dives). Overall, it seems the bacterial growth and disappearance of the shrimp are due rather to the influence of a more distant source that influences water characteristics (temperature, pH and chemistry) over a large area while the fluids emitted in this area remained unchanged. This is consistent with observations in the water that was tinged yellow with particles, reminiscent of the white smokers on the southern flank of the volcano.

Table 7.1: Characteristics of the water at Marker 32 near the summit of North Su.

	Dive 301 (Station 19)	**Dive 313 (Station 45)**	**Dive 316 (Station 51)**
Water from the fissure			
Temperature	67.9 ± 2.8	66.2 ± 3.1	66.6 ± 5.8
pH	3.29 ± 0.05	3.28 ± 0.07	3.20 ± 0.16
AMU 15 (x 10^{-7})*	2.67 ± 0.10	2.16 ± 0.09	2.50 ± 0.19
AMU 34 (x 10^{-6})*	2.51 ± 0.14	1.38 ± 0.09	1.67 ± 0.14
AMU 44(x 10^{-5})*	1.59 ± 0.06	1.12 ± 0.05	1.45 ± 0.12
Water 2-3 m above bottom			
Temperature	3.61 ± 0.25	4.76 ± 0.31	3.87 ± 0.33
pH	7.35 ± 0.08	6.84 ± 0.06	7.05 ± 0.07
AMU 15 (x 10^{-7})*	0.062 ± 0.004	0.109± 0.008	0.084 ± 0.003
AMU 34 (x 10^{-6})*	0.011 ± 0.0004	0.026 ± 0.0005	0.014 ± 0.0008
AMU 44(x 10^{-5})*	0.021 ± 0.002	0.019 ± 0.003	0.019 ± 0.003
Water while sitting on the bottom**			
Temperature	6.87 ± 0.93	6.71 ± 1.87	8.36 ± 2.7
pH	6.19 ± 0.08	6.31 ± 0.09	5.99 ± 0.11
AMU 15 (x 10^{-7})*	0.079 ± 0.045	0.136 ± 0.023	0.242 ± 0.091
AMU 34 (x 10^{-6})*	0.031 ± 0.019	0.038 ± 0.007	0.156 ± 0.208
AMU 44(x 10^{-5})*	0.063 ± 0.032	0.058 ± 0.013	0.065 ± 0.017

* partial pressure inside the ISMS for masses indicative of methane (atomic mass unit 15), sulfide (AMU 34), and carbon dioxide (AMU 44).
** proximity of the inlet to a diffuse source while on the bottom may vary and affect the data.

Detection of SO_2 -- During the cruise, we tried to detect SO_2 in the water. During ionization inside the mass spectrometer, sulfide (atomic mass unit 34) is oxidized to form SO_2 (AMU 64). The detection of this compound in the water was therefore not straight-forward. A preliminary analysis (figure 3) revealed that the ratio AMU64/AMU34 is relatively constant in fluids surrounding animals in high flow areas (dives 305, 307, 310, 314, and 315) and in high-temperature fluids (fissure at marker 32). More detailed analyses are necessary but the preliminary analyses revealed that fluids from the white smokers on the Southern flank of North Su contain greater-than-expected values for AMU 64, evidence that the ISMS was capable of detecting SO_2. Quantifying this compound would require further analyses and calibration of the membrane.

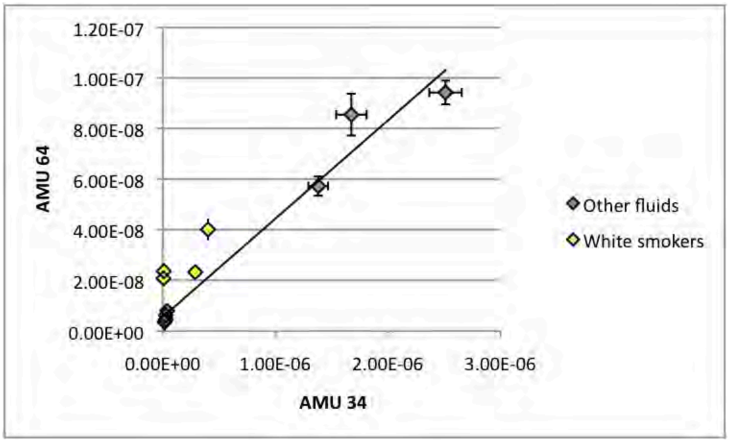


Fig. 7.5: Relationship between signals for AMU34 (corresponding to H_2S) and for AMU 64 (corresponding to SO_2) in fluids from white smokers and in other fluids. The straight line corresponds to the linear regression for fluids others than the white smokers.

8. BIOLOGICAL SAMPLING AND INVESTIGATIONS (Nicole Dubilier, Christian Borowski, Anke Meyerdierks, Petra Pjevac, Stephane Hourdez)

8.1 MICROBIOLOGY
(Anke Meyerdierks, Petra Pjevac)

Former microbiological investigations in the Manus Basin were restricted to two studies, one focusing on the distribution of microbes associated with a black smoker chimney structure (Takai *et al.*, 2001), and the other one reporting on deep subsurface microbial communities (Kimura *et al.*, 2003). Virtually nothing was known about chemolithoautotrophic microbial communities associated with hydrothermal fluids, surface sediments or diverse sulfides and rocks in the Manus Basin hydrothermal systems at the time of sampling.

Major goal of the microbiology group on cruise SO216 to the Manus Basin underwater solfataras was therefore sampling of such free-living microbial communities in the North Su and PACManus area, in order to expand our knowledge of microbial communities inhabiting these highly productive, geochemically and geophysically various systems. Samples should be obtained in a targeted manner, employing the ROV, the KIel Pumping System (KIPS), attached to the ROV, or a CTD/Rosette water sample. Bulk samples were planned to be retrieved with a TV-guided grab. It was planned to sample sediments, hydrothermal fluids and microbial biomass for microbial community structure analysis at geochemically well characterized sites preferably along gradients of e.g. pH, sulfide and/or temperature. Large biomass samples should thereby be taken from selected sites for a subsequent study of the genetic potential of the microbial community and key metabolic processes by metagenome analysis. Moreover, samples should be preserved for specific enrichments of e.g. low pH/high temperature adapted microorganisms involved in sulfur cycling (sulfide and sulfur oxidation and sulfate reduction) in the home laboratory. Incubation experiments with isotopic tracers should be conducted allowing for the assignment of metabolic capabilities to certain microbial groups. Finally, *in-situ* colonization of metal sulfides and sulfur under extreme environmental conditions should be investigated. In combination with the obtained physical and geochemical data, this would give us the possibility to assess the microbial community composition, its specific association with certain environmental conditions, the preferred energy sources, the specific activity and the genetic potential of the sampled communities.

A total of 60 different rock, crust and sulfide samples was collected from different sites in the Manus Basin. Nine samples were taken with a TV-guided grab, while all other samples were collected during ROV dives, with shovels, nets and the ROV arm. The samples origin from different diffuse venting sites, black smokers, white smokers and native sulfur taluses at North Su, Fenway, Snowcap/Tsukushi, Satanic Mills, Roman Ruins and Solwara 6. All retrieved samples were divided into several parts. The main part of each sample was immediately frozen for DNA extraction (-20°C). If enough material was retrieved, a fraction was stored at -80°C, for metagenomic analysis. For cell count determinations and community structure analysis, one part of each sample was fixed with 60% ethanol (EtOH) in phosphate buffer saline (PBS) and one in 1-4% formaldehyde (FA) in PBS. After FA fixation, samples were washed with PBS and stored at -20°C in 60% EtOH/PBS. If enough sample was available, another part of the sample was stored in 9% glycerol solution at -80°C e.g. for cultivation experiments and single cell sorting in the home laboratory. Important to note is that four whole chimneys (two at Fenway, one at Roman Ruins and one at Solwara 6), active as well as inactive ones, were collected and deep frozen for combined analysis of microbial diversity and lipid biomarkers in the home laboratories. A more detailed sample description is given in the sample list (see appendix).

Two *in-situ* colonization devices (Figure 8.1) carrying glas, sulfur and metal sulfide (pyrite, chalcopyrite, sphalerite, chalkosine, galena) particles were deployed at the seafloor for an incubation period of 15 days. The first device was deployed on the 22nd of June, during ROV dive 297 on a diffuse venting patch at the north slope of North Su. Elevated sulfide, methane and carbon dioxide levels were detected by *in-situ* mass spectrometry (ISMS) measurements in the venting fluid and a temperature of around 37°C was recorded. The second device was deployed during ROV dive 301 on the 25th of June on the south-western slope of North Su. The device was deployed over a crack out of which high temperature (up to 80°C logged), low pH (around pH 3) fluid was leveled. Elevated level of methane, carbon dioxide and very high sulfide levels, as well as presence of acetic acid were detected by ISMS. Both devices were successfully retrieved during ROV dives 314 (8th July) and 316 (10th July), respectively. After retrieval, particles were rinsed in PBS and divided into multiple subsamples. Untreated subsamples for DNA extraction, 60% EtOH in PBS and 1% FA fixed samples were stored at -20°C, while in 9% glycerol fixed samples were stored at -80°C. A last subsample of each particle type was incubated in sulfate and organic carbon source free artificial sea water (ASW) at close-to ambient temperature and subsampled regularly during a period of 72 h in order to determine concentrations of produced sulfate and thiosulfate in the home laboratory. The obtained samples were stored at -20°C.

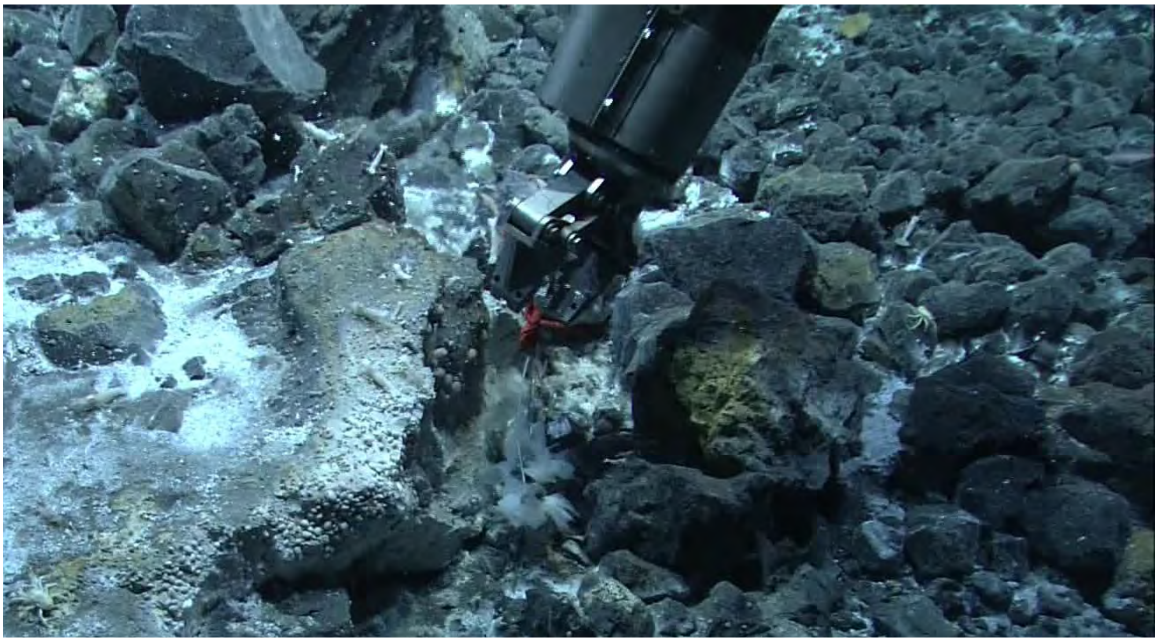


Figure 8.1: Deploing of an *in-situ* colonization device in a moderate temperature, diffuse venting fluid on the northern slope of North Su, during ROV dive 297.

Altogether, 37 different fluid samples were taken by filling up to seven 675 ml flasks of the KIPS systems. At eleven of these sites, additional sampling of large cell numbers for meta(genomics) was conducted by filtration through 47 mm or 142 mm cellulose acetate (CA) or polyethersulfone (PES) membrane filters (0.2 2µm pore size), which housings had been attached to the KIPS system. At North Su, where in contrast to PACManus methane could be detected by ISMS at some sites, fluids were repeatedly collected at the two sites where the incubation experiments had been deployed, as well as in the vicinity of these sites. Moreover, fluids were collected in the sulfur candle field, and at sites with high CO_2 or clear, high temperature venting. In the PACManus area, sampling focused mainly on Fenway. Here, repeatedly fluids were sampled close to symcatchers deployed by the symbiosis group above a patch of snails, in a tubeworm field, and above sediment covered by filamentous mats, exhibiting slightly different temperature and H_2S values. Additional low temperature fluids in the Fenway area were taken in a field of *Paralvinellida*, and hot, clear fluids were sampled close to Big Papi. Further fluids were sampled at Satanic Mills above a white flange with shimmering water and a snail patch, at Solwara 7 above an orange, Fe-rich crack, and at Roman Ruins and Snowcap above snails characterized by an iron containing crust on the shells. If possible, fluid sampling was combined with the sampling of surface structures (e.g. sediments, rocks, shells) from the same site. Additional samples were collected using a CTD/rosette water sampler. Worth mentioning here is a transect over North Su including a large sample taken from the sulfidic bottom water. Of the retrieved hydrothermal fluids and CTD samples a subsample was concentrated on 0.22 µm pore size CA or PES membrane filters for DNA extraction, and frozen. Another subsample was always fixed with 1% FA in PBS, and cells were concentrated on polycarbonate membrane filters (type GTTP, pore size 0.22 µm), which were subsequently stored at -20°C. Prior to filtration, cell concentrations in each sample were roughly determined by 4',6-diamidino-2-phenylindole (DAPI) staining on board. In order to preserve viable cells for enrichments in the home laboratory, between 300 ml and 500 ml of sample were filtered through Led techno "CellTrap" system, and cells were recovered by rinsing with 4% betain or 9% glycerol solution and stored at 4°C or -80°C, respectively. Aliquots of selected samples were sterile filtered and deep frozen for measurement of nitrogen species (nitrite, nitrate, ammonia), acetate and dissolved organic carbon concentration in the home laboratory. Main parts of the filters for metagenome analysis were deep frozen for subsequent DNA extraction, smaller parts were generally preserved in 60% EtOH/PBS, 9% glycerine, and/or 1% FA for diverse subsequent analyses. For several fluid samples, enrichment cultures with elemental sulfur and sulfide as energy source were started. Each enrichment was done in triplicates and replicates were stored at 4°C, room temperature (RT) and ambient temperature. If enough fluid was available, an untreated fluid sample was as well stored at 4°C. A complete list of fluid samples is provided in the appendix. Photos of the sites can be found in the appendix for the KIPS T-logger.

At three locations (the two incubation sites of the *in-situ* colonization devices at North Su, and in a tubeworm patch at Fenway) large volumes of sample were collected with KIPS and used for stable isotope incubations. Stable isotope incubations on hydrothermal fluid samples were conducted in order to investigate the activity and preferential carbon source for the sampled microbial community. Incubations were run in triplicates for each setup, at ambient temperature and under oxic conditions for 8-14 hours. Series of 150 ml sample with added ^{13}C-acetate as carbon source for organotrophe, or ^{13}C-bicarbonate as carbon source for lithotrophe microorganisms, with and without addition of sulfide as energy source and with ^{15}N-ammonia or ^{15}N-leucine as nitrogen source were set up for each site. Death controls, killed with 4% FA were run in parallel. One set of incubations was stopped by the addition of FA to a final concentration of 1% and transferred to 4°C for 2 h fixation. The other two sets were not treated with FA, but simply stopped by filtration onto filters. A hundred milliliter of each incubation were filtered on a combusted glass-fiber filter (GFF) and aliquots of 10-20 ml were filtered on gold coated GTTP filters (pore size 0.22 um). All filters were air dried and stored at -20°C.

All in all, samples from diverse hydrothermal vent associated microenvironments were successfully collected as planned and have been preserved for diverse types of downstream analyses in the home laboratory. This should enable us to gain a deeper insight into community composition, activity patterns and specific surface associations of the Manus Basin microbial community.

8.2 HYDROTHERMAL SYMBIOSES

(Christian Borowski, Nicole Dubilier, Stéphane Hourdez)

Our goal for the BAMBUS cruise was to investigate how geofuels in Manus Basin habitats with different geochemical regimes drive the production of symbiotic biomass. Our research focused on three main objectives: (*i*) characterization of the bacterial symbionts from various invertebrate hosts collected during the cruise; (*ii*) investigation of the metabolic activity of the symbiotic bacteria in relation to their geochemical environments; (*iii*) collection and characterization of free-living populations of symbiotic bacteria from the Manus Basin. For objectives (*i*) and (*ii*), animals were collected in diffuse flow sites and from black smoker chimney walls at the North Su volcano and in the PACManus area. Free-living symbionts (*iii*) were collected with colonization devices called “SymCatchers” that were deployed by the ROV. All sites of sampling and SymCatcher deployments were chosen on the basis of intensive in situ MassSpec (ISMS) measurements of diluted volatiles, temperature and pH. Animals were collected with scoop nets or by grabbing with the ROV Quest manipulator claw. Animal samples and deployed SymCatchers were brought to the surface in temperature insulated storage boxes. On board, the collections were stored in chilled seawater and processed within a few hours after recovery. Symbiont containing gills and other tissues were dissected and frozen at -80°C or -20°C, or fixed in various fixatives for molecular and isotopic analyses including DNA sequence analyses, fluorescence in situ hybridization (FISH), transmission electron microscopy (TEM), bulk measurements of isotopic signatures and nano-secondary ion mass spectrometry (nanoSIMS).

The main target of our collections and studies was the provannid snail ***Ifremeria nautilei***. This species occurs in the western back arc basins of North Fiji, Manus and Lau. Previous phylogenetic investigations based on the cytochrome c oxidoreductase I (COI) gene revealed that the North Fiji and PACManus populations are genetically distinct (Kojima *et al.*, 2000). Both host populations share the same gamma-proteobacterial sulfide-oxidizing symbiont based on 16S rRNA analyses (Borowski *et al.*, 2002; Urakawa *et al.*, 2005). Both populations also harbor methanotrophic symbionts (Borowski *et al.*, 2002; Gal'chenko *et al.*, 1993), but conclusive genetic data exist only for the North Fiji gammaproteobacterial methanotrophs. Other 16S rRNA sequence data indicate that PACManus and North Fiji *I. nautilei* populations also harbor alphaproteobacterial symbionts (C. Borowski, N. Dubilier, H. Urakawa unpublished data).

We also focused on provannid ***Alviniconcha*** snails, a genus that is widespread at hydrothermal vents in western Pacific back arc basins and the Indian Ocean. Several morphotypes are assumed to represent separate species of which some live in symbiosis with thiotrophic Gammaproteobacteria while others are associated with Epsilonproteobacteria. Recent investigations of *Alviniconcha* from the Lau Basin revealed that two host morphotypes associated with different symbiotic lineages may partition habitats at vents where they co-occur (unpublished data P. Girguis, Harvard Univ, USA). Other targets were the as yet uninvestigated symbioses of the mussel ***Bathymodiolus manusensis*** which is endemic to the Manus Basin vents, the vestimentiferan tube worm ***Arcovestia invanovi*** which occurs in Lau and Manus and a second **unidentified vestimentiferan tube worm** species.

Characterization of symbiotic diversity

By investigating symbiont diversity and phylogeny, we will gain first indications for which geofuels the symbionts use as a nutritional basis for feeding their hosts. For this purpose we collected the tube worms *A. ivanovi* and an unidentified tube worm species in Fenway, and *B. manusensis* mussels in Fenway and North Su. *I. nautilei* snails were collected at North Su and at PACManus sites Fenway, Snow Cap and Roman Ruins to examine the following questions: How does symbiont diversity differ between Manus and North Fiji *I. nautilei* populations? What is the metabolic function of their alphaproteobacterial symbionts? Does symbiotic diversity and metabolism differ between PACManus and North Su? The last question is particularly interesting because we measured methane in the diffuse fluids of PACManus vents but not at North Su. We can thus examine how the geofuel methane influences the abundance of methane-oxidizing symbionts in *I. nautilei* populations that are geographically very close and presumably highly similar or identical genetically. Together with our previously collected material from North Fiji and Lau, the new Manus Basin material will allow detailed studies on symbiont population genetics and give insight into the biogeography and evolution of the *I nautilei* symbiosis across western Pacific back arc basins. We also collected two different morphotypes of *Alviniconcha* sp. at North Su, Snow Cap and Fenway for Dr. P. Giguis (Harvard University) with whom we are collaborating on analyses of habitat partitioning and bacterial diversity in *Alviniconcha* from the Manus and Lau Basins.

Symbiotic activity patterns in relation to geochemical environment

To investigate the response of symbiont metabolism to geofuel availability we sampled *I. nautilei*, *Alviniconcha* sp. and *B. manusensis* in various geochemical environments that we characterized by detailed ISMS measurements. The sampling sites included diffuse flow sites and black smoker chimneys in North Su, Fenway, Snow Cap and Roman Ruins. Online readings of in situ measured temperature, pH and contents of sulfide, methane and CO_2 in the diluted fluids where the animals occurred served as qualitative proxies for discriminating microhabitats (**Fig. 8.2**). Dissected symbiont containing gill tissues of *I. nautilei* were incubated on board with sulfide as an electron donor and labeled bicarbonate (^{14}C and ^{13}C) as a carbon source. The analysis of these experiments with scintillation counting and nanoSIMS will give information on carbon fixation rates of chemoautotrophic symbionts from different sites. Symbiont abundances in gill tissues of *I. nautilei* and *B. manusensis* will be compared between sites using quantitative PCR, quantitative 3D FISH and TEM with specifically dissected and preserved tissues. The activities of metabolic pathways will be investigated by identifying transcription products of key enzymes with mRNA-FISH in host tissues. Gills of *I. nautilei* from Fenway and North Su were freshly homogenized immediately after collection for genomic and proteomic analyses in the home laboratory. Genomics will provide information on the metabolic potential of the symbionts, while proteomics will show which metabolic pathways are actually used by the symbionts in their in situ environment. Dissections of *Alviniconcha* sp. gills will serve for assays of hydrogenase activity in the lab of Dr. P. Girguis.

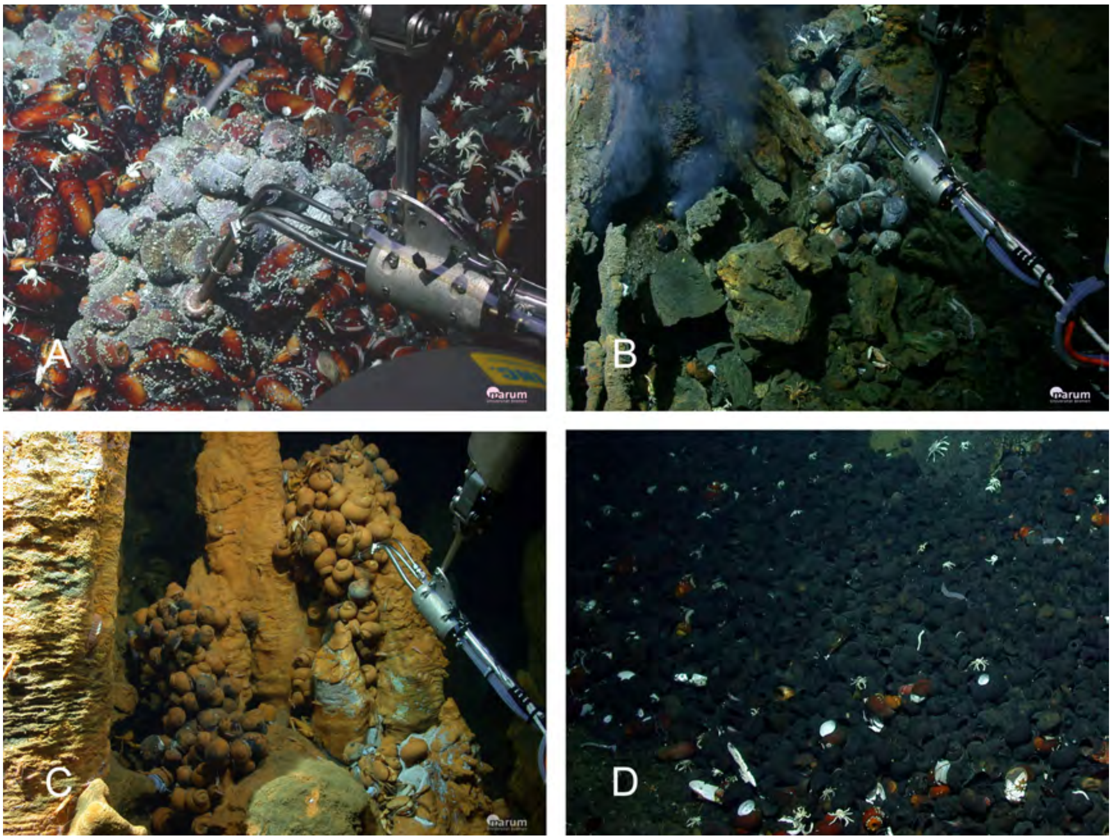


Fig. 8.2. Microhabitats of symbiotic invertebrates were characterized by in situ measurements with the ISMS. *I. nautilei* snails tend to gather directly above diffuse outflow where temperature and concentrations of sulfide and CO_2 are considerably elevated while pH can drop below 7. The shells of these animals are covered by an unidentified white coating while snails at the periphery or outside of direct diffuse flow lack this coating. Mussels seem to avoid direct contact with diffuse fluid flow. Diffuse flow site in North Su with *I. nautilei* and

B. manusensis (A). *I. nautilei* and *Alviniconcha* sp. on chimney in Fenway (B). *I. nautilei* and *Alviniconcha* sp. covered with brown precipitates on Roman Ruins chimney (C). Low diffuse flow site at edge of Fenway with a few living *I. nautilei* among massive aggregations of dead shells (D).

Search for free-living symbionts in the vent environment

Vestimentiferan tube worms and most likely also symbiotic mytilid mussels and provannid snails acquire their symbionts in each generation anew by uptake from the environment. We used "SymCatcher" colonization devices in which microscope slides provide a surface for bacteria to colonize. We deployed a total of 11 SymCatchers for 9 to 12 days among *Arcovestia* tube worms, *Ifremeria* snails and *Bathymodiolus* mussels in Fenway and North Su (**Fig. 8.3**). The microscope slides will be used for phylogenetic identification of biofilm bacteria with PCR techniques and FISH.

Population genetics of symbiotic hosts and other research on Manus Basin invertebrate species

Foot tissue samples of *I. nautilei* and collections of various limpets (Leptodrilidae *Olgasolaris* sp.) will be forwarded to Dr. C.L. Van Dover (Duke University, NC, USA) for analyses of population genetics across various Western Pacific back arc basins. Population genetics of this species will specifically complement our own research by elucidating whether PACManus and North Su share the same *I. nautilei* host population. Tissue samples of *I. nautilei* and *Alviniconcha* sp. will also serve as outgroups for completing a study by S. Hourdez and coworkers at the Biological Station Roscoff (France) that mainly focuses on Lau Basin populations. Tissue samples of *B. manusensis* will serve for a study of correlation between the genotype (alleles) and the expression levels of selected genes (phenotype) (Roscoff). Polychaetes collected together with symbiotic invertebrates will be analyzed for studies on taxonomy and population genetics. In particular, a collection of *Paralvinella* sp. will be used for population genetics and to complete the description of a possibly new species (S. Hourdez).

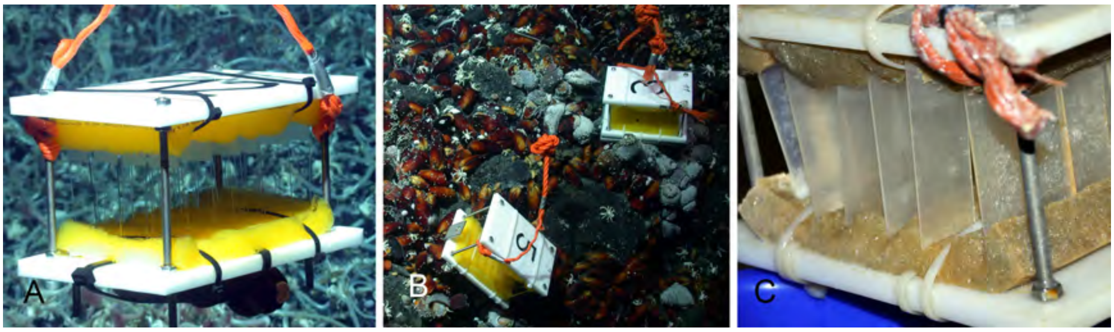


Fig. 8.3. "SymCatcher" frames hold microscopic slides that serve as colonization surfaces for free-living bacteria. The slides can be used directly for microscopic FISH analyses after fixation (A). SymCatchers in the environment among *Ifremeria* snails and *Bathymodiolus* mussels (B). Recovered SymCatcher with a thick biofilm cover after 12 days of deployment next to Marker 32 in North Su (C).

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Appendix -- overview

Appendix A: Station lists

Appendix B: Locales and descriptions of geological samples (Sven Petersen)

Appendix C: Full sample list
C1: geological samples,
C2: fluid samples
C3: biological samples

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/001-1	19/06/11	1:11	3° 51,48' S	152° 7,98' E	1704	SE 3	111	0.2	CTD	CTD	Beginn Station	
SO216/001-1	19/06/11	1:13	3° 51,48' S	152° 7,99' E	1703	ESE 3	98.6	0.1	CTD	CTD	zu Wasser	
SO216/001-1	19/06/11	2:01	3° 51,48' S	152° 7,99' E	1703	ESE 1	151.8	0.1	CTD	CTD	auf Tiefe	SLmax: 1707m
SO216/001-1	19/06/11	3:15	3° 51,48' S	152° 7,99' E	1704	NNE 4	25.2	0	CTD	CTD	an Deck	
SO216/001-1	19/06/11	3:16	3° 51,48' S	152° 7,99' E	1704	NNE 4	8.6	0.1	CTD	CTD	Ende Station	
SO216/002-1	19/06/11	3:17	3° 51,48' S	152° 7,99' E	1702	NNE 4	172.3	0.3	Kalibrierung	KAL	Beginn Station	
SO216/002-1	19/06/11	3:18	3° 51,48' S	152° 8,00' E	1704	N 5	174.1	0.5	Kalibrierung	KAL	Beginn Simrad Kalibrierung	rwK: 150°, d: 5nm
SO216/002-1	19/06/11	4:30	3° 56,09' S	152° 10,66' E	1570	NNE 4	318.7	3.7	Kalibrierung	KAL	Kursänderung	rwk: 330°, d: 5nm
SO216/002-1	19/06/11	5:40	3° 51,52' S	152° 8,00' E	1704	NNE 5	57.6	0.7	Kalibrierung	KAL	Ende Simrad Kalibrierung	
SO216/002-1	19/06/11	5:41	3° 51,51' S	152° 8,01' E	1704	NNE 5	357.2	0.7	Kalibrierung	KAL	Ende Station	
SO216/003-1	19/06/11	5:42	3° 51,51' S	152° 8,00' E	1704	N 5	155.2	0.2	Kalibrierung	KAL	Beginn Station	Posidonia
SO216/003-1	19/06/11	5:43	3° 51,51' S	152° 8,00' E	1703	N 6	284.2	0.6	Kalibrierung	KAL	Transponder z.W.	
SO216/003-1	19/06/11	6:40	3° 51,55' S	152° 8,05' E	1701	NE 6	138.5	1	Kalibrierung	KAL	Transponder a.D.	
SO216/003-1	19/06/11	6:57	3° 51,50' S	152° 8,00' E	1704	NE 7	49.2	0.6	Kalibrierung	KAL	Transponder z.W.	
SO216/003-1	19/06/11	7:18	3° 51,47' S	152° 8,02' E	1705	E 6	108.5	1.6	Kalibrierung	KAL	Beginn Drehkreis	
SO216/003-1	19/06/11	8:36	3° 51,49' S	152° 8,01' E	1685	NE 6	61.2	1.1	Kalibrierung	KAL	Ende Drehkreis	
SO216/003-1	19/06/11	9:13	3° 51,50' S	152° 8,01' E	1687	NE 5	118.9	0.7	Kalibrierung	KAL	Transponder a.D.	
SO216/003-1	19/06/11	9:15	3° 51,51' S	152° 8,02' E	1687	NE 5	140.5	0.5	Kalibrierung	KAL	Ende Station	
SO216/004-1	19/06/11	9:16	3° 51,52' S	152° 8,03' E	1686	ENE 5	107.9	0.9	Vermessung	EM / PS	Beginn Profil	rwk: 000°, d: 15sm
SO216/004-1	19/06/11	12:00	3° 37,34' S	152° 8,00' E	1965	NE 6	359.8	5.7	Vermessung	EM / PS	Kursänderung	ä/K auf rwk: 180°, d: 15 + 1 nm
SO216/004-1	19/06/11	14:58	3° 51,98' S	152° 6,98' E	1709	ENE 5	214.4	4.9	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/004-1	19/06/11	15:09	3° 51,95' S	152° 6,08' E	1720	E 4	302.6	5	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 15nm
SO216/004-1	19/06/11	17:53	3° 37,06' S	152° 5,98' E	1954	NE 9	338.8	4.9	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/004-1	19/06/11	18:04	3° 37,02' S	152° 5,02' E	1955	NE 8	232.6	5.1	Vermessung	EM / PS	Kursänderung	rwk: 180°, d: 15sm
SO216/004-1	19/06/11	20:49	3° 51,97' S	152° 5,00' E	1779	NNE 4	181.2	5.3	Vermessung	EM / PS	Ende Profil	
SO216/005-1	19/06/11	22:00	3° 47,59' S	152° 6,00' E	1526	ENE 5	19.5	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/005-1	19/06/11	22:58	3° 47,62' S	152° 5,99' E	1513	NNE 4	355.1	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/005-1	19/06/11	23:15	3° 47,61' S	152° 6,01' E	1515	NNE 4	77.6	0.2	Remote Operated Vehicle	ROV	an Deck	ROV defekt
SO216/005-1	20/06/11	1:00	3° 47,90' S	152° 6,00' E	1263	N 4	310.8	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/006-1	20/06/11	1:01	3° 47,90' S	152° 6,00' E	1264	N 5	136.3	0.1	Kalibrierung	KAL	Beginn Station	rwK: 000°, d: 3nm
SO216/006-1	20/06/11	1:01	3° 47,90' S	152° 6,00' E	1264	N 5	136.3	0.1	Kalibrierung	KAL	Beginn Simrad Kalibrierung	
SO216/006-1	20/06/11	1:48	3° 44,93' S	152° 6,00' E	1786	NNE 2	0.5	4.9	Kalibrierung	KAL	Kursänderung	rwK: 180°, d: 3nm
SO216/006-1	20/06/11	2:36	3° 47,92' S	152° 6,00' E	6447	N 2	181	5	Kalibrierung	KAL	Ende Simrad Kalibrierung	
SO216/006-1	20/06/11	2:36	3° 47,92' S	152° 6,00' E	6447	N 2	181	5	Kalibrierung	KAL	Ende Station	
SO216/007-1	20/06/11	4:13	3° 51,50' S	152° 8,00' E	1684	N 2	355.7	0.9	CTD	CTD	Beginn Station	
SO216/007-1	20/06/11	4:14	3° 51,50' S	152° 8,00' E	1686	N 3	173.4	0.4	CTD	CTD	zu Wasser	W4
SO216/007-1	20/06/11	5:03	3° 51,50' S	152° 8,00' E	1685	NNE 2	206.5	0.1	CTD	CTD	auf Tiefe	SL: 1707m
SO216/007-1	20/06/11	6:30	3° 51,50' S	152° 7,93' E	1695	ESE 7	284	0.6	CTD	CTD	an Deck	
SO216/007-1	20/06/11	6:33	3° 51,46' S	152° 7,94' E	1686	SE 10	59.5	1	CTD	CTD	Ende Station	

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/008-1	20/06/11	6:49	3° 52,03' S	152° 9,01' E	1689	E 6	7.4	4.9	Vermessung	EM / PS	Beginn Profil	rwk: 000°, d: 15sm
SO216/008-1	20/06/11	9:46	3° 37,02' S	152° 9,03' E	1927	NNW 4	1.6	4.7	Vermessung	EM / PS	Kursänderung	rwk: 090°, d: 1sm
SO216/008-1	20/06/11	9:59	3° 36,91' S	152° 10,00' E	1884	NW 4	109.9	4.8	Vermessung	EM / PS	Kursänderung	rwk: 180°, d: 15sm
SO216/008-1	20/06/11	12:53	3° 51,93' S	152° 10,00' E	1637	ESE 2	182.1	5.1	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 1nm
SO216/008-1	20/06/11	13:05	3° 52,03' S	152° 10,87' E	1644	SE 2	84.5	5.4	Vermessung	EM / PS	Kursänderung	rwK: 000°, d: 15nm
SO216/008-1	20/06/11	15:55	3° 37,03' S	152° 11,03' E	1718	NE 0	28.3	4.9	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 1nm
SO216/008-1	20/06/11	16:07	3° 37,04' S	152° 12,00' E	1498	NNE 2	138.1	4.4	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 15nm
SO216/008-1	20/06/11	18:53	3° 51,95' S	152° 11,99' E	1651	SSE 1	179.6	5.2	Vermessung	EM / PS	Kursänderung	rwk: 090°, d: 1sm
SO216/008-1	20/06/11	19:07	3° 52,09' S	152° 13,00' E	1689	SSE 2	51.4	4.6	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 15sm
SO216/008-1	20/06/11	22:00	3° 37,35' S	152° 13,03' E	1712	ENE 1	1.4	5.1	Vermessung	EM / PS	Ende Profil	
SO216/009-1	21/06/11	0:28	3° 46,32' S	152° 7,14' E	1660	ENE 0	107.7	0.1	TV-Grab Typ A	TVG	Beginn Station	
SO216/009-1	21/06/11	0:34	3° 46,32' S	152° 7,14' E	1657	SE 1	54	0.1	TV-Grab Typ A	TVG	zu Wasser	
SO216/009-1	21/06/11	1:14	3° 46,31' S	152° 7,15' E	1661	SSE 2	138.5	0.1	TV-Grab Typ A	TVG	Bodensicht	SL: 1673m
SO216/009-1	21/06/11	4:07	3° 46,54' S	152° 7,00' E	1654	W 2	203.5	0.1	TV-Grab Typ A	TVG	Zugriff	SL: 1688m
SO216/009-1	21/06/11	4:10	3° 46,54' S	152° 7,01' E	1655	WNW 1	124.5	0.1	TV-Grab Typ A	TVG	hieven	
SO216/009-1	21/06/11	4:51	3° 46,57' S	152° 7,00' E	1659	NW 3	80.6	0	TV-Grab Typ A	TVG	an Deck	
SO216/009-1	21/06/11	5:00	3° 46,57' S	152° 7,02' E	1661	NW 2	58.3	0.2	TV-Grab Typ A	TVG	Ende Station	
SO216/010-1	21/06/11	5:33	3° 47,90' S	152° 6,00' E	1270	WNW 4	259.7	1.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/010-1	21/06/11	5:45	3° 47,90' S	152° 6,00' E	1274	WNW 3	242.8	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/010-1	21/06/11	8:12	3° 47,90' S	152° 5,97' E	1307	W 6	39.1	0.2	Remote Operated Vehicle	ROV	Bosi	
SO216/010-1	21/06/11	9:30	3° 47,94' S	152° 5,98' E	1258	WNW 3	289.5	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/010-1	21/06/11	10:30	3° 47,91' S	152° 5,99' E	1268	NW 2	14.2	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/010-1	21/06/11	10:41	3° 47,91' S	152° 5,98' E	1264	NW 1	126.5	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/011-1	21/06/11	11:53	3° 51,96' S	152° 14,43' E	1673	S 4	50.3	5.1	Vermessung	EM / PS	Beginn Profil	rwK: 360°, d: 15nm
SO216/011-1	21/06/11	14:47	3° 37,16' S	152° 14,52' E	1351	S 2	30.4	4.6	Vermessung	EM / PS	Kursänderung	rwK: 143°, d: 2nm
SO216/011-1	21/06/11	15:12	3° 38,95' S	152° 15,96' E	1303	SSW 5	141.5	5.3	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 13nm
SO216/011-1	21/06/11	17:48	3° 51,98' S	152° 16,00' E	1288	SSW 2	135.6	4	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 1nm
SO216/011-1	21/06/11	18:06	3° 51,94' S	152° 17,44' E	941	SSE 3	20.3	4.1	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 11nm
SO216/011-1	21/06/11	20:17	3° 41,03' S	152° 17,48' E	835	S 2	346.9	4.2	Vermessung	EM / PS	Ende Profil	
SO216/012-1	21/06/11	22:00	3° 47,87' S	152° 5,98' E	1302	SE 2	349.1	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/012-1	21/06/11	22:26	3° 47,90' S	152° 5,99' E	1277	SSE 1	202.5	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/012-1	22/06/11	1:24	3° 47,99' S	152° 5,99' E	1215	SSE 4	197.1	0.3	Remote Operated Vehicle	ROV	Bosi	
SO216/012-1	22/06/11	8:40	3° 48,05' S	152° 6,09' E	1208	SE 7	107	0.2	Remote Operated Vehicle	ROV	Hieven	
SO216/012-1	22/06/11	9:40	3° 48,06' S	152° 6,12' E	1224	SE 6	165	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/012-1	22/06/11	9:50	3° 48,07' S	152° 6,11' E	1211	SE 6	141.9	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/013-1	22/06/11	10:29	3° 52,48' S	152° 4,94' E	1783	ESE 5	99.9	5.3	Vermessung	EM / PS	Beginn Profil	rwK: 090°, d: 14nm
SO216/013-1	22/06/11	13:14	3° 52,50' S	152° 18,82' E	1013	SE 6	89.6	5.1	Vermessung	EM / PS	Kursänderung	rwK: 000°, d: 10nm
SO216/013-1	22/06/11	15:09	3° 43,13' S	152° 19,02' E	1601	NNE 1	36.6	4.2	Vermessung	EM / PS	Kursänderung	rwK: 143°, d: 2nm
SO216/013-1	22/06/11	15:31	3° 44,98' S	152° 20,49' E	1739	NE 1	143.6	6.3	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 9nm

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/013-1	22/06/11	17:12	3° 53,48' S	152° 20,47' E	1165	ESE 2	198.5	4.7	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 16nm
SO216/013-1	22/06/11	20:25	3° 53,47' S	152° 4,15' E	1813	SE 4	298.1	4.8	Vermessung	EM / PS	Ende Profil	
SO216/014-1	22/06/11	22:00	3° 48,06' S	152° 5,99' E	1394	E 2	98.3	2.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/014-1	22/06/11	22:33	3° 48,11' S	152° 6,10' E	1501	ENE 3	121.5	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/014-1	22/06/11	23:54	3° 48,10' S	152° 6,12' E	1497	NE 3	99.8	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/014-1	23/06/11	0:38	3° 48,10' S	152° 6,17' E	1527	N 4	100.8	0.1	Remote Operated Vehicle	ROV	Probennahme	
SO216/014-1	23/06/11	5:00	3° 48,08' S	152° 6,14' E	1255	NE 1	62.5	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/014-1	23/06/11	6:03	3° 48,08' S	152° 6,15' E	1254	NE 4	136.7	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/014-1	23/06/11	6:10	3° 48,08' S	152° 6,14' E	1259	ENE 4	213.1	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/015-1	23/06/11	6:11	3° 48,08' S	152° 6,15' E	1259	ENE 5	20.3	0.1	TV-Grab Typ A	TVG	Beginn Station	
SO216/015-1	23/06/11	6:16	3° 48,08' S	152° 6,15' E	1259	ENE 4	233.1	0	TV-Grab Typ A	TVG	zu Wasser	W1
SO216/015-1	23/06/11	6:48	3° 48,08' S	152° 6,15' E	1253	NNE 4	330.4	0	TV-Grab Typ A	TVG	Bodensicht	SL: 1258m
SO216/015-1	23/06/11	7:06	3° 48,08' S	152° 6,12' E	1237	NE 6	253.1	0.1	TV-Grab Typ A	TVG	Zugriff	1. Griff, SL: 1242m
SO216/015-1	23/06/11	7:07	3° 48,08' S	152° 6,12' E	1229	NNE 6	335.3	0.3	TV-Grab Typ A	TVG	hieven	
SO216/015-1	23/06/11	7:34	3° 48,08' S	152° 6,12' E	1228	NNE 5	250.1	0	TV-Grab Typ A	TVG	an Deck	
SO216/015-1	23/06/11	7:55	3° 48,08' S	152° 6,12' E	1225	NNE 4	116	0.1	TV-Grab Typ A	TVG	Ende Station	
SO216/016-1	23/06/11	8:36	3° 54,48' S	152° 4,06' E	1597	NW 4	96.6	3.9	Vermessung	EM / PS	Beginn Profil	rwk: 090°, d: 18sm
SO216/016-1	23/06/11	11:42	3° 54,50' S	152° 21,80' E	1476	NE 2	90.7	5.8	Vermessung	EM / PS	Kursänderung	rwK: 297°, d: 8nm
SO216/016-1	23/06/11	13:04	3° 51,05' S	152° 15,10' E	1656	SSE 4	296.9	5.9	Vermessung	EM / PS	Kursänderung	rwK: 045°, d: 1nm
SO216/016-1	23/06/11	13:21	3° 50,06' S	152° 15,99' E	1746	S 2	91.7	5.2	Vermessung	EM / PS	Kursänderung	rwK: 120°, 7nm
SO216/016-1	23/06/11	14:32	3° 53,43' S	152° 21,97' E	1870	WSW 4	71.1	4.3	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 7nm
SO216/016-1	23/06/11	15:41	3° 47,14' S	152° 22,02' E	1834	S 1	24.4	5.3	Vermessung	EM / PS	Kursänderung	rwK: 143°, d: 2nm
SO216/016-1	23/06/11	16:07	3° 48,99' S	152° 23,47' E	1336	SSW 1	148.5	5.5	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 7nm
SO216/016-1	23/06/11	17:15	3° 55,50' S	152° 23,47' E	1739	WNW 3	217.6	4.4	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 19nm
SO216/016-1	23/06/11	20:34	3° 55,48' S	152° 4,60' E	1559	NNW 5	286.5	5.4	Vermessung	EM / PS	Kursänderung	rwk: 012°, d: 8sm
SO216/016-1	23/06/11	21:59	3° 48,02' S	152° 6,13' E	1238	WSW 3	101.4	1.1	Vermessung	EM / PS	Ende Profil	
SO216/017-1	23/06/11	22:00	3° 48,03' S	152° 6,15' E	1262	SW 4	123.8	0.9	Remote Operated Vehicle	ROV	Beginn Station	
SO216/017-1	23/06/11	23:07	3° 48,08' S	152° 6,09' E	1208	NNE 2	167.1	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/017-1	24/06/11	0:08	3° 48,07' S	152° 6,08' E	1199	NE 1	276.3	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/017-1	24/06/11	2:56	3° 48,03' S	152° 5,99' E	1240	NNE 2	156.7	0.1	Remote Operated Vehicle	ROV	Hieven	Auftauchen
SO216/017-1	24/06/11	3:54	3° 48,05' S	152° 5,98' E	1247	SE 1	227.9	0.2	Remote Operated Vehicle	ROV	an Deck	
SO216/017-1	24/06/11	3:55	3° 48,05' S	152° 5,98' E	1251	SE 1	214.5	0.2	Remote Operated Vehicle	ROV	Ende Station	
SO216/017-2	24/06/11	3:56	3° 48,05' S	152° 5,97' E	1254	SE 2	229.9	0.2	Remote Operated Vehicle	ROV	Beginn Station	
SO216/017-2	24/06/11	5:27	3° 48,03' S	152° 6,00' E	1221	NW 1	93.9	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/017-2	24/06/11	6:33	3° 48,03' S	152° 6,02' E	1202	NE 1	4.7	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/017-2	24/06/11	10:01	3° 48,03' S	152° 6,02' E	1182	S 3	281.8	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/017-2	24/06/11	10:58	3° 47,99' S	152° 6,06' E	1160	SSE 5	62.7	0.4	Remote Operated Vehicle	ROV	an Deck	
SO216/017-2	24/06/11	11:04	3° 47,99' S	152° 6,06' E	1161	SE 3	203.4	0	Remote Operated Vehicle	ROV	Ende Station	
SO216/018-1	24/06/11	11:34	3° 49,07' S	152° 4,04' E	1866	S 5	317.4	4.2	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 12nm

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/018-1	24/06/11	13:43	3° 37,17' S	152° 4,00' E	1989	SSE 3	360	5.5	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/018-1	24/06/11	14:00	3° 37,00' S	152° 2,71' E	1922	SSE 4	269.1	5.7	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 19nm
SO216/018-1	24/06/11	17:23	3° 55,44' S	152° 2,51' E	1555	ESE 1	192.6	4.6	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/018-1	24/06/11	17:41	3° 55,47' S	152° 1,03' E	1163	ESE 1	308	4.9	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 19nm
SO216/018-1	24/06/11	21:00	3° 37,03' S	152° 1,03' E	2075	E 5	18.8	5.4	Vermessung	EM / PS	Ende Profil	
SO216/019-1	24/06/11	23:30	3° 48,02' S	152° 5,99' E	1219	NW 1	187.5	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/019-1	25/06/11	0:22	3° 48,02' S	152° 6,00' E	1221	SSE 1	51.2	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/019-1	25/06/11	1:25	3° 47,94' S	152° 6,02' E	1229	SE 3	49.1	0	Remote Operated Vehicle	ROV	Bosi	
SO216/019-1	25/06/11	9:10	3° 47,95' S	152° 6,03' E	1206	ESE 5	29.3	0	Remote Operated Vehicle	ROV	Hieven	
SO216/019-1	25/06/11	10:18	3° 47,86' S	152° 5,99' E	1307	SE 6	315.6	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/019-1	25/06/11	10:24	3° 47,84' S	152° 5,97' E	1344	SE 7	339.8	0.4	Remote Operated Vehicle	ROV	Ende Station	
SO216/020-1	25/06/11	11:25	3° 56,00' S	152° 5,02' E	1681	SSE 6	241.6	4.6	Vermessung	EM / PS	Beginn Profil	rwK: 265°, d: 6nm
SO216/020-1	25/06/11	12:24	3° 56,49' S	151° 59,56' E	1511	SE 7	281.4	5.1	Vermessung	EM / PS	Kursänderung	rwK: 000°, d: 20nm
SO216/020-1	25/06/11	15:55	3° 37,01' S	151° 59,48' E	2081	ESE 4	318.6	4.4	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/020-1	25/06/11	16:12	3° 36,99' S	151° 58,05' E	2076	ESE 7	253.7	5.1	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/020-1	25/06/11	19:44	3° 56,43' S	151° 58,00' E	1531	ESE 6	181.5	5.8	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 2sm
SO216/020-1	25/06/11	20:00	3° 56,71' S	151° 56,70' E	1608	SE 6	325.1	5.7	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 7sm
SO216/020-1	25/06/11	21:17	3° 49,55' S	151° 56,60' E	2021	SSE 5	38.6	5.6	Vermessung	EM / PS	Ende Profil	
SO216/021-1	25/06/11	22:25	3° 47,90' S	152° 6,04' E	1244	SSE 7	16.6	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/021-1	25/06/11	22:31	3° 47,90' S	152° 6,04' E	1255	SE 7	114.5	0.3	Remote Operated Vehicle	ROV	Zu wasser	
SO216/021-1	25/06/11	23:34	3° 47,98' S	152° 6,11' E	1184	SE 6	340.1	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/021-1	26/06/11	8:44	3° 48,10' S	152° 6,13' E	1249	SSW 5	354.7	0	Remote Operated Vehicle	ROV	Hieven	
SO216/021-1	26/06/11	9:51	3° 48,15' S	152° 6,13' E	1282	SSE 3	201	0.2	Remote Operated Vehicle	ROV	an Deck	
SO216/021-1	26/06/11	9:55	3° 48,16' S	152° 6,12' E	1288	SE 2	245.9	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/022-1	26/06/11	10:54	3° 50,01' S	151° 56,52' E	2025	WNW 2	310.1	4.8	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 13nm
SO216/022-1	26/06/11	13:14	3° 37,10' S	151° 56,50' E	2095	SE 1	0	5.5	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/022-1	26/06/11	13:32	3° 37,00' S	151° 55,08' E	2110	NNE 3	261.3	5.2	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/022-1	26/06/11	17:04	3° 56,47' S	151° 54,98' E	1605	ESE 3	210.2	4.7	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/022-1	26/06/11	17:21	3° 56,51' S	151° 53,56' E	1622	ESE 4	276	5.3	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 20nm
SO216/022-1	26/06/11	20:49	3° 37,09' S	151° 53,51' E	2102	ENE 5	14	5.6	Vermessung	EM / PS	Ende Profil	
SO216/023-1	26/06/11	22:31	3° 48,08' S	152° 6,11' E	1231	NNE 4	193.8	0.3	Remote Operated Vehicle	ROV	Beginn Station	
SO216/023-1	26/06/11	22:34	3° 48,10' S	152° 6,11' E	1227	NE 4	186.4	0.3	Remote Operated Vehicle	ROV	Zu wasser	
SO216/023-1	26/06/11	23:49	3° 48,09' S	152° 6,15' E	1276	S 2	97	0	Remote Operated Vehicle	ROV	Bosi	
SO216/023-1	27/06/11	0:53	3° 48,09' S	152° 6,15' E	1266	N 8	2.4	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/023-1	27/06/11	2:00	3° 48,19' S	152° 6,15' E	1321	WNW 2	155.7	0.4	Remote Operated Vehicle	ROV	an Deck	
SO216/023-1	27/06/11	2:15	3° 48,26' S	152° 6,23' E	1401	NW 2	143.2	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/023-1	27/06/11	3:21	3° 48,02' S	152° 6,18' E	1281	W 1	291.7	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/023-1	27/06/11	9:53	3° 47,98' S	152° 6,01' E	1200	NW 4	103.3	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/023-1	27/06/11	10:54	3° 48,01' S	152° 6,00' E	1218	WNW 5	335.9	0.1	Remote Operated Vehicle	ROV	an Deck	

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/023-1	27/06/11	11:00	3° 47,98' S	152° 6,05' E	1175	WSW 11	52.1	0.9	Remote Operated Vehicle	ROV	Ende Station	
SO216/024-1	27/06/11	12:35	3° 56,52' S	151° 52,01' E	1616	NW 5	4.1	5.5	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 20nm
SO216/024-1	27/06/11	16:07	3° 37,05' S	151° 51,99' E	2140	N 4	342.3	4.9	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/024-1	27/06/11	16:23	3° 37,00' S	151° 50,59' E	2136	N 5	266.5	5.6	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/024-1	27/06/11	19:56	3° 56,48' S	151° 50,49' E	1682	E 9	183.9	5.5	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 2sm
SO216/024-1	27/06/11	20:12	3° 56,79' S	151° 49,21' E	1677	SE 6	312.5	5.3	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 6sm
SO216/024-1	27/06/11	21:00	3° 52,38' S	151° 48,99' E	2067	SE 9	0.8	5.6	Vermessung	EM / PS	Beginn Profil	
SO216/024-1	27/06/11	21:25	3° 50,03' S	151° 49,00' E	2092	ESE 10	344.1	5.6	Vermessung	EM / PS	Ende Profil	
SO216/025-1	27/06/11	22:36	3° 43,73' S	151° 40,34' E	1713	ESE 7	42.3	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/025-1	27/06/11	22:58	3° 43,71' S	151° 40,32' E	1697	ESE 6	306.1	0.3	Remote Operated Vehicle	ROV	Zu wasser	
SO216/025-1	27/06/11	23:05	3° 43,70' S	151° 40,32' E	1683	ESE 6	192.9	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/025-1	27/06/11	23:25	3° 43,70' S	151° 40,32' E	1687	ESE 6	20.3	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/025-1	28/06/11	1:06	3° 43,75' S	151° 40,41' E	1731	ESE 8	98.6	0	Remote Operated Vehicle	ROV	Bosi	
SO216/025-1	28/06/11	8:45	3° 43,69' S	151° 40,41' E	1766	ESE 6	328.3	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/025-1	28/06/11	10:07	3° 43,68' S	151° 40,40' E	1738	E 5	264.3	0.4	Remote Operated Vehicle	ROV	an Deck	
SO216/025-1	28/06/11	10:13	3° 43,71' S	151° 40,36' E	1714	ENE 5	132	0.9	Remote Operated Vehicle	ROV	Ende Station	
SO216/026-1	28/06/11	11:20	3° 50,60' S	151° 48,93' E	2095	ESE 9	46.6	5.2	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 14nm
SO216/026-1	28/06/11	13:44	3° 37,12' S	151° 49,00' E	2125	ESE 5	358.2	5.6	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/026-1	28/06/11	14:00	3° 37,00' S	151° 47,67' E	2066	ESE 5	269.1	5.8	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/026-1	28/06/11	17:32	3° 56,45' S	151° 47,49' E	1612	E 1	206	4.9	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/026-1	28/06/11	17:49	3° 56,48' S	151° 46,02' E	1709	ESE 2	306.7	4.7	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 20nm
SO216/026-1	28/06/11	21:24	3° 36,95' S	151° 46,00' E	1965	E 6	0.9	5.7	Vermessung	EM / PS	Ende Profil	
SO216/027-1	28/06/11	22:27	3° 43,62' S	151° 40,19' E	1652	E 5	358.6	0.2	Remote Operated Vehicle	ROV	Beginn Station	
SO216/027-1	28/06/11	23:03	3° 43,62' S	151° 40,25' E	1664	ESE 5	74	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/027-1	29/06/11	0:28	3° 43,65' S	151° 40,26' E	1661	E 6	77.5	0	Remote Operated Vehicle	ROV	Bosi	
SO216/027-1	29/06/11	9:05	3° 43,78' S	151° 40,09' E	1647	ENE 4	230.7	0	Remote Operated Vehicle	ROV	Hieven	
SO216/027-1	29/06/11	10:19	3° 43,79' S	151° 40,08' E	1652	ENE 4	94.2	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/027-1	29/06/11	10:24	3° 43,79' S	151° 40,09' E	1652	E 5	173.8	0	Remote Operated Vehicle	ROV	Ende Station	
SO216/028-1	29/06/11	11:30	3° 50,55' S	151° 48,94' E	2093	ENE 7	61.6	5.1	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 14nm
SO216/028-1	29/06/11	13:57	3° 37,13' S	151° 49,00' E	2124	E 7	359.7	5.6	Vermessung	EM / PS	Kursänderung	rwK: 270°, 1 nm
SO216/028-1	29/06/11	14:14	3° 37,02' S	151° 47,54' E	2068	E 4	237.6	4.9	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/028-1	29/06/11	17:47	3° 56,48' S	151° 47,48' E	1610	ESE 3	210.3	4.7	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/028-1	29/06/11	18:04	3° 56,48' S	151° 46,05' E	1718	SE 4	300.8	4.6	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 20nm
SO216/028-1	29/06/11	21:34	3° 37,11' S	151° 46,01' E	2013	NE 2	0.8	5.6	Vermessung	EM / PS	Ende Profil	
SO216/029-1	29/06/11	22:30	3° 43,90' S	151° 40,48' E	1741	E 6	344.7	0.3	Remote Operated Vehicle	ROV	Beginn Station	
SO216/029-1	29/06/11	22:35	3° 43,90' S	151° 40,47' E	1742	ESE 5	283.4	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/029-1	30/06/11	0:05	3° 43,89' S	151° 40,60' E	1756	E 4	252	0	Remote Operated Vehicle	ROV	Bosi	
SO216/029-1	30/06/11	9:21	3° 43,69' S	151° 40,43' E	1693	E 6	78.9	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/029-1	30/06/11	10:46	3° 43,68' S	151° 40,42' E	1703	ESE 8	187	0	Remote Operated Vehicle	ROV	an Deck	

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/029-1	30/06/11	10:51	3° 43,68' S	151° 40,42' E	1688	ESE 10	257.7	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/030-1	30/06/11	12:06	3° 56,52' S	151° 44,33' E	1886	ESE 4	114.5	6.4	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 20nm
SO216/030-1	30/06/11	15:38	3° 37,07' S	151° 44,49' E	1900	ESE 8	344.9	5.3	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/030-1	30/06/11	15:54	3° 37,00' S	151° 43,08' E	1880	SE 9	259.5	5.3	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/030-1	30/06/11	19:28	3° 56,78' S	151° 42,96' E	1877	ENE 5	181.4	5.6	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 1sm
SO216/030-1	30/06/11	19:44	3° 57,09' S	151° 41,69' E	1894	ENE 6	268.8	6.4	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 13sm
SO216/030-1	30/06/11	22:07	3° 44,11' S	151° 41,49' E	2010	ESE 5	358.3	5.5	Vermessung	EM / PS	Ende Profil	
SO216/031-1	30/06/11	22:34	3° 43,75' S	151° 40,41' E	1733	NE 5	168.9	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/031-1	30/06/11	22:40	3° 43,76' S	151° 40,41' E	1728	ENE 5	98.7	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/031-1	01/07/11	0:19	3° 43,72' S	151° 40,48' E	1720	ENE 5	222.4	0	Remote Operated Vehicle	ROV	Bosi	
SO216/031-1	01/07/11	9:12	3° 43,51' S	151° 40,37' E	1670	SW 4	342.7	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/031-1	01/07/11	10:31	3° 43,50' S	151° 40,38' E	1677	SW 3	321	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/031-1	01/07/11	10:36	3° 43,50' S	151° 40,37' E	1676	SW 3	129.6	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/032-1	01/07/11	10:58	3° 45,03' S	151° 41,53' E	2060	S 3	357.9	2.5	Vermessung	EM / PS	Beginn Profil	rwK: 000° , d: 8nm
SO216/032-1	01/07/11	12:25	3° 37,08' S	151° 41,50' E	2071	SW 4	351.1	5.1	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/032-1	01/07/11	12:42	3° 37,00' S	151° 40,09' E	2372	WSW 2	270.1	5.4	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/032-1	01/07/11	16:17	3° 56,42' S	151° 40,00' E	1828	WSW 11	187.4	4.8	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/032-1	01/07/11	16:36	3° 56,48' S	151° 38,51' E	1940	SSW 9	309.7	4.6	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 20nm
SO216/032-1	01/07/11	20:07	3° 36,99' S	151° 38,50' E	2431	SE 4	343.7	4.8	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 1sm
SO216/032-1	01/07/11	20:24	3° 36,91' S	151° 37,04' E	2470	SE 5	258.6	5	Vermessung	EM / PS	Kursänderung	rwk: 180°, d: 11nm
SO216/032-1	01/07/11	22:18	3° 47,47' S	151° 37,00' E	2176	ENE 7	178.7	5.3	Vermessung	EM / PS	Ende Profil	
SO216/033-1	01/07/11	22:57	3° 43,81' S	151° 40,43' E	1728	ESE 7	61.1	0.2	TV-Grab Typ A	TVG	Beginn Station	
SO216/033-1	01/07/11	23:00	3° 43,81' S	151° 40,43' E	1732	SE 7	49.5	0.1	TV-Grab Typ A	TVG	zu Wasser	
SO216/033-1	01/07/11	23:35	3° 43,83' S	151° 40,46' E	1738	ESE 6	344.2	0.3	TV-Grab Typ A	TVG	Bodensicht	SL: 1734m
SO216/033-1	01/07/11	23:48	3° 43,83' S	151° 40,46' E	1730	ESE 6	216	0.2	TV-Grab Typ A	TVG	Zugriff	1. zugriff SL: 1744m,
SO216/033-1	01/07/11	23:49	3° 43,83' S	151° 40,46' E	1735	ESE 6	114.8	0.2	TV-Grab Typ A	TVG	hieven	SZmax: 42,2kN
SO216/033-1	02/07/11	0:27	3° 43,80' S	151° 40,42' E	1731	E 7	340.2	0.3	TV-Grab Typ A	TVG	an Deck	
SO216/033-1	02/07/11	0:27	3° 43,80' S	151° 40,42' E	1731	E 7	340.2	0.3	TV-Grab Typ A	TVG	Ende Station	
SO216/034-1	02/07/11	0:44	3° 43,72' S	151° 40,33' E	1698	ESE 7	139.7	0.2	TV-Grab Typ A	TVG	Beginn Station	
SO216/034-1	02/07/11	0:45	3° 43,72' S	151° 40,33' E	1699	E 9	81.8	0.2	TV-Grab Typ A	TVG	zu Wasser	
SO216/034-1	02/07/11	1:22	3° 43,72' S	151° 40,34' E	1704	E 9	154.8	0.1	TV-Grab Typ A	TVG	Bodensicht	SL: 1711m
SO216/034-1	02/07/11	2:11	3° 43,73' S	151° 40,35' E	1694	E 9	161.9	0.1	TV-Grab Typ A	TVG	Zugriff	1. Zugriff: SL: 1724m
SO216/034-1	02/07/11	2:15	3° 43,73' S	151° 40,35' E	1724	ESE 10	34	0	TV-Grab Typ A	TVG	Zugriff	2. Zugriff: SL: 1716m
SO216/034-1	02/07/11	2:16	3° 43,73' S	151° 40,35' E	1724	ESE 10	271	0.2	TV-Grab Typ A	TVG	hieven	
SO216/034-1	02/07/11	2:57	3° 43,73' S	151° 40,34' E	1699	ESE 12	263.5	0.2	TV-Grab Typ A	TVG	an Deck	
SO216/034-1	02/07/11	3:03	3° 43,73' S	151° 40,34' E	1708	ESE 11	114.9	0.2	TV-Grab Typ A	TVG	Ende Station	
SO216/035-1	02/07/11	3:32	3° 46,98' S	151° 40,44' E	2163	SE 11	77.3	0.8	CTD	CTD	Beginn Station	
SO216/035-1	02/07/11	3:33	3° 46,98' S	151° 40,44' E	2164	SE 13	301.8	0.2	CTD	CTD	zu Wasser	W4
SO216/035-1	02/07/11	4:30	3° 47,00' S	151° 40,45' E	2163	SE 12	90.2	0.1	CTD	CTD	auf Tiefe	SL: 2100m

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/035-1	02/07/11	4:32	3° 47,00' S	151° 40,45' E	2164	SE 10	76.6	0.2	CTD	CTD	Hieven	
SO216/035-1	02/07/11	5:53	3° 47,00' S	151° 40,45' E	2163	ESE 7	147	0.1	CTD	CTD	an Deck	
SO216/035-1	02/07/11	6:00	3° 47,00' S	151° 40,45' E	2163	ESE 8	121.7	0.4	CTD	CTD	Ende Station	
SO216/036-1	02/07/11	6:50	3° 47,98' S	151° 35,51' E	2175	ESE 8	304	6.7	Vermessung	EM / PS	Beginn Profil	rwk: 000°, d: 12sm
SO216/036-1	02/07/11	10:10	3° 35,56' S	151° 35,50' E	2212	SE 7	11.2	5.3	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 37nm
SO216/036-1	02/07/11	16:33	3° 35,49' S	152° 12,92' E	1000	SSE 9	56.7	5.5	Vermessung	EM / PS	Kursänderung	rwK: 307°, d: 2nm
SO216/036-1	02/07/11	16:57	3° 34,05' S	152° 11,08' E	816	SSE 7	307.1	6.3	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 38nm
SO216/036-1	02/07/11	23:16	3° 34,00' S	151° 33,09' E	2423	ESE 11	271	6.1	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 2nm
SO216/036-1	02/07/11	23:33	3° 35,43' S	151° 32,89' E	2401	E 8	156.4	5.4	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 4nm
SO216/036-1	03/07/11	0:08	3° 35,50' S	151° 36,34' E	2215	SE 9	92.4	6.6	Vermessung	EM / PS	Ende Profil	
SO216/037-1	03/07/11	1:00	3° 43,00' S	151° 40,40' E	1765	E 7	297.7	0.4	Remote Operated Vehicle	ROV	Beginn Station	
SO216/037-1	03/07/11	1:05	3° 43,00' S	151° 40,40' E	1757	ESE 7	127.1	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/037-1	03/07/11	2:36	3° 43,06' S	151° 40,45' E	1724	ESE 7	58.7	0	Remote Operated Vehicle	ROV	Bosi	
SO216/037-1	03/07/11	9:06	3° 43,28' S	151° 40,62' E	1692	ESE 4	72.2	0	Remote Operated Vehicle	ROV	Hieven	
SO216/037-1	03/07/11	10:20	3° 43,26' S	151° 40,64' E	1696	SW 5	230.3	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/037-1	03/07/11	10:25	3° 43,26' S	151° 40,63' E	1689	SSW 5	165.6	0	Remote Operated Vehicle	ROV	Ende Station	
SO216/038-1	03/07/11	11:23	3° 35,95' S	151° 33,99' E	2262	S 3	218.8	4.8	Vermessung	EM / PS	Beginn Profil	rwK: 180°, d: 21nm
SO216/038-1	03/07/11	15:06	3° 56,49' S	151° 34,01' E	1054	WSW 1	160.1	4.8	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 1nm
SO216/038-1	03/07/11	15:24	3° 56,50' S	151° 35,42' E	1039	ESE 3	79.9	4.9	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 10nm
SO216/038-1	03/07/11	17:08	3° 47,02' S	151° 35,52' E	2114	S 1	31.4	4.5	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 1nm
SO216/038-1	03/07/11	17:26	3° 47,01' S	151° 36,92' E	2189	ENE 2	95.4	4.8	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 10nm
SO216/038-1	03/07/11	19:15	3° 56,94' S	151° 37,00' E	1389	NE 4	187.9	5.3	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 4sm
SO216/038-1	03/07/11	20:03	3° 56,99' S	151° 32,56' E	986	E 3	283.8	5.3	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 14sm
SO216/038-1	03/07/11	21:32	3° 49,06' S	151° 32,51' E	2120	ENE 3	0.3	5.9	Vermessung	EM / PS	Ende Profil	
SO216/039-1	03/07/11	22:34	3° 43,29' S	151° 40,53' E	1697	E 3	97.7	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/039-1	04/07/11	0:32	3° 43,26' S	151° 40,55' E	1687	ESE 3	0.1	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/039-1	04/07/11	2:00	3° 43,23' S	151° 40,61' E	1679	ENE 5	41.8	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/039-1	04/07/11	9:19	3° 43,66' S	151° 40,45' E	1722	E 3	65.1	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/039-1	04/07/11	10:34	3° 43,66' S	151° 40,45' E	1714	ESE 3	37.4	0	Remote Operated Vehicle	ROV	an Deck	
SO216/039-1	04/07/11	10:42	3° 43,64' S	151° 40,44' E	1718	ESE 4	307.5	0.2	Remote Operated Vehicle	ROV	Ende Station	
SO216/040-1	04/07/11	11:35	3° 49,58' S	151° 32,55' E	2091	SW 2	275.9	5.5	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 20nm
SO216/040-1	04/07/11	14:58	3° 30,10' S	151° 32,49' E	2410	ENE 4	353.9	5.4	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/040-1	04/07/11	15:14	3° 30,01' S	151° 31,10' E	2163	E 3	263.9	5.9	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 22nm
SO216/040-1	04/07/11	19:02	3° 51,92' S	151° 30,98' E	1605	W 6	224.3	4.3	Vermessung	EM / PS	Kursänderung	rwk: 315°, d: 2sm
SO216/040-1	04/07/11	19:25	3° 50,51' S	151° 29,56' E	1333	SW 5	332.3	5.5	Vermessung	EM / PS	Kursänderung	rwk: 000°, d: 8sm
SO216/040-1	04/07/11	20:47	3° 42,92' S	151° 29,49' E	2378	SSW 4	3.8	5.7	Vermessung	EM / PS	Ende Profil	
SO216/041-1	04/07/11	22:00	3° 43,71' S	151° 40,35' E	1701	SSW 1	292.6	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/041-1	04/07/11	22:24	3° 43,70' S	151° 40,35' E	1705	SSW 1	325.8	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/041-1	04/07/11	23:41	3° 43,67' S	151° 40,34' E	1697	WSW 2	172.8	0	Remote Operated Vehicle	ROV	an Deck	

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/041-1	05/07/11	1:25	3° 43,69' S	151° 40,32' E	1695	SSW 4	201.4	0.4	Remote Operated Vehicle	ROV	Zu wasser	
SO216/041-1	05/07/11	2:47	3° 43,75' S	151° 40,33' E	1730	SW 4	9.7	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/041-1	05/07/11	8:40	3° 43,77' S	151° 40,28' E	1725	NW 4	313	0.2	Remote Operated Vehicle	ROV	Hieven	
SO216/041-1	05/07/11	10:03	3° 43,71' S	151° 40,28' E	1695	NW 6	314.7	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/041-1	05/07/11	10:08	3° 43,69' S	151° 40,25' E	1652	WNW 5	316.9	0.4	Remote Operated Vehicle	ROV	Ende Station	
SO216/042-1	05/07/11	11:15	3° 43,54' S	151° 29,52' E	2523	N 5	340.2	3.6	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 14nm
SO216/042-1	05/07/11	13:33	3° 30,07' S	151° 29,50' E	2065	SW 6	350	5.3	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 1nm
SO216/042-1	05/07/11	13:52	3° 30,01' S	151° 28,04' E	2373	SSW 5	238.9	4.5	Vermessung	EM / PS	Kursänderung	rwK: 180°, d: 20nm
SO216/042-1	05/07/11	17:18	3° 49,92' S	151° 27,97' E	1883	NE 1	210	4.8	Vermessung	EM / PS	Kursänderung	rwK: 289°, d: 2nm
SO216/042-1	05/07/11	17:36	3° 49,50' S	151° 26,55' E	2095	N 3	304.9	5.2	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 20nm
SO216/042-1	05/07/11	20:55	3° 30,14' S	151° 26,48' E	2405	NW 3	359.5	5.9	Vermessung	EM / PS	Ende Profil	
SO216/043-1	05/07/11	22:38	3° 43,58' S	151° 40,32' E	1685	SW 2	114.4	0.6	Remote Operated Vehicle	ROV	Beginn Station	
SO216/043-1	05/07/11	22:48	3° 43,58' S	151° 40,32' E	1689	WNW 1	10.9	0.1	Remote Operated Vehicle	ROV	Zu wasser	
SO216/043-1	06/07/11	0:09	3° 43,63' S	151° 40,40' E	1700	WNW 2	93.1	0.2	Remote Operated Vehicle	ROV	Bosi	
SO216/043-1	06/07/11	9:08	3° 43,68' S	151° 40,24' E	1665	ESE 9	121.5	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/043-1	06/07/11	10:24	3° 43,67' S	151° 40,23' E	1654	ESE 11	353.1	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/043-1	06/07/11	10:30	3° 43,68' S	151° 40,23' E	1661	ESE 11	250.7	0	Remote Operated Vehicle	ROV	Ende Station	
SO216/044-1	06/07/11	11:19	3° 37,02' S	151° 35,45' E	2526	SE 8	11	5.5	Vermessung	EM / PS	Beginn Profil	rwK: 090°, d: 38nm
SO216/044-1	06/07/11	17:57	3° 36,99' S	152° 13,91' E	1555	SE 10	80.4	5.6	Vermessung	EM / PS	Kursänderung	rwK: 315°, d: 7nm
SO216/044-1	06/07/11	19:10	3° 32,08' S	152° 9,04' E	1049	SSE 6	309.1	5.6	Vermessung	EM / PS	Kursänderung	rwk: 270°, d: 16sm
SO216/044-1	06/07/11	21:55	3° 31,99' S	151° 53,13' E	1976	E 6	270.4	6	Vermessung	EM / PS	Ende Profil	
SO216/045-1	07/07/11	0:20	3° 47,99' S	152° 6,08' E	1181	E 5	311.4	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/045-1	07/07/11	0:31	3° 47,97' S	152° 6,09' E	1208	ESE 7	16.1	0.3	Remote Operated Vehicle	ROV	Zu wasser	
SO216/045-1	07/07/11	2:40	3° 47,95' S	152° 6,10' E	1204	ESE 6	95.8	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/045-1	07/07/11	9:58	3° 47,95' S	152° 6,14' E	1249	SE 12	153.6	0.2	Remote Operated Vehicle	ROV	Hieven	
SO216/045-1	07/07/11	11:03	3° 47,94' S	152° 6,13' E	1245	SSE 12	350	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/045-1	07/07/11	11:08	3° 47,94' S	152° 6,13' E	1250	SSE 12	261.5	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/046-1	07/07/11	12:48	3° 32,50' S	151° 53,59' E	1981	SE 12	281.9	6	Vermessung	EM / PS	Beginn Profil	rwK: 270°, d: 20nm
SO216/046-1	07/07/11	16:18	3° 32,49' S	151° 33,05' E	2442	SSE 7	287.6	5.4	Vermessung	EM / PS	Kursänderung	rwK: 360°, d: 2nm
SO216/046-1	07/07/11	16:35	3° 31,06' S	151° 33,01' E	2443	SSE 5	28.2	5	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 27nm
SO216/046-1	07/07/11	20:54	3° 31,01' S	151° 58,01' E	1870	ESE 7	91.1	5.8	Vermessung	EM / PS	Ende Profil	
SO216/047-1	07/07/11	22:39	3° 48,00' S	152° 6,09' E	1193	ESE 7	145.1	0	Remote Operated Vehicle	ROV	Beginn Station	
SO216/047-1	07/07/11	22:44	3° 48,01' S	152° 6,09' E	1189	ESE 8	161.7	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/047-1	07/07/11	23:54	3° 48,01' S	152° 6,18' E	1293	SE 9	122.9	0.2	Remote Operated Vehicle	ROV	Bosi	
SO216/047-1	08/07/11	8:49	3° 48,05' S	152° 6,06' E	1190	SE 8	266.7	0.2	Remote Operated Vehicle	ROV	Hieven	
SO216/047-1	08/07/11	9:51	3° 48,04' S	152° 6,05' E	1189	SE 9	12.3	0.2	Remote Operated Vehicle	ROV	an Deck	
SO216/047-1	08/07/11	9:56	3° 48,04' S	152° 6,06' E	1197	SE 10	155.3	0	Remote Operated Vehicle	ROV	Ende Station	
SO216/048-1	08/07/11	11:07	3° 36,55' S	152° 12,12' E	1359	SE 6	17.1	5.5	Vermessung	EM / PS	Beginn Profil	rwK: 319°, d: 4nm
SO216/048-1	08/07/11	11:49	3° 33,54' S	152° 9,54' E	1220	SE 7	318.1	5.9	Vermessung	EM / PS	Kursänderung	rwK: 297°, d: 2nm

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/048-1	08/07/11	12:13	3° 32,50' S	152° 7,51' E	1234	E 6	294.4	5.8	Vermessung	EM / PS	Kursänderung	rwK: 281°, d: 8nm
SO216/048-1	08/07/11	13:31	3° 31,01' S	152° 0,05' E	1501	E 6	282.9	5.7	Vermessung	EM / PS	Kursänderung	rwK: 287°, d: 5nm
SO216/048-1	08/07/11	14:26	3° 29,50' S	151° 55,02' E	1698	NNW 4	285.4	5.7	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 35nm
SO216/048-1	08/07/11	20:23	3° 29,49' S	151° 20,10' E	2555	E 3	269.6	5.8	Vermessung	EM / PS	Ende Profil	
SO216/049-1	08/07/11	22:40	3° 43,82' S	151° 40,41' E	1747	NNE 4	171.5	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/049-1	08/07/11	22:49	3° 43,81' S	151° 40,41' E	1749	NE 5	276.7	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/049-1	09/07/11	0:19	3° 43,80' S	151° 40,57' E	1758	NNW 7	61.9	0.3	Remote Operated Vehicle	ROV	Bosi	
SO216/049-1	09/07/11	6:52	3° 43,69' S	151° 40,44' E	1719	WNW 0	45	0.1	Remote Operated Vehicle	ROV	Hieven	
SO216/049-1	09/07/11	8:09	3° 43,69' S	151° 40,45' E	1724	WNW 1	37.4	0.2	Remote Operated Vehicle	ROV	an Deck	
SO216/049-1	09/07/11	8:18	3° 43,67' S	151° 40,42' E	1712	WSW 1	342.1	0.6	Remote Operated Vehicle	ROV	Ende Station	
SO216/050-1	09/07/11	10:00	3° 29,55' S	151° 25,01' E	2101	WNW 0	266.8	6.4	Vermessung	EM / PS	Beginn Profil	rwk: 180°, d: 20sm
SO216/050-1	09/07/11	13:18	3° 48,85' S	151° 25,00' E	2115	SE 3	182.3	6.1	Vermessung	EM / PS	Kursänderung	rwK: 289°, d: 2nm
SO216/050-1	09/07/11	13:35	3° 48,52' S	151° 23,57' E	2162	SE 4	289.4	5.8	Vermessung	EM / PS	Kursänderung	rwK: 000°, d: 19nm
SO216/050-1	09/07/11	16:57	3° 29,34' S	151° 23,50' E	2447	ESE 6	7.6	5.7	Vermessung	EM / PS	Ende Profil	
SO216/051-1	09/07/11	22:00	3° 48,02' S	152° 6,05' E	1182	SE 6	119.3	0.5	Remote Operated Vehicle	ROV	Beginn Station	
SO216/051-1	09/07/11	22:27	3° 47,99' S	152° 6,04' E	1170	SE 5	84.8	0.3	Remote Operated Vehicle	ROV	Zu wasser	
SO216/051-1	09/07/11	23:47	3° 48,02' S	152° 6,12' E	1224	ESE 5	297.1	0	Remote Operated Vehicle	ROV	Bosi	
SO216/051-1	10/07/11	9:54	3° 48,10' S	152° 6,08' E	1230	SE 9	99.4	0.2	Remote Operated Vehicle	ROV	Hieven	
SO216/051-1	10/07/11	10:58	3° 48,09' S	152° 6,07' E	1245	SSE 8	239.2	0.1	Remote Operated Vehicle	ROV	an Deck	
SO216/051-1	10/07/11	11:03	3° 48,09' S	152° 6,08' E	1227	SSE 8	153.4	0.1	Remote Operated Vehicle	ROV	Ende Station	
SO216/052-1	10/07/11	13:00	3° 28,07' S	151° 54,06' E	1499	ESE 6	324.6	8.2	Vermessung	EM / PS	Beginn Profil	rwK: 270°, d: 32nm
SO216/052-1	10/07/11	18:29	3° 28,01' S	151° 22,05' E	2489	ENE 3	235.9	4.9	Vermessung	EM / PS	Kursänderung	rwk: 180°, d: 20sm
SO216/052-1	10/07/11	21:51	3° 47,91' S	151° 22,02' E	2193	NNE 1	180.8	8.1	Vermessung	EM / PS	Ende Profil	
SO216/053-1	10/07/11	23:33	3° 43,59' S	151° 40,87' E	1736	SE 4	200.5	0.1	Remote Operated Vehicle	ROV	Beginn Station	
SO216/053-1	10/07/11	23:43	3° 43,60' S	151° 40,86' E	1736	SE 4	183.4	0.2	Remote Operated Vehicle	ROV	Zu wasser	
SO216/053-1	11/07/11	1:13	3° 43,63' S	151° 40,99' E	1742	ESE 2	353.4	0.1	Remote Operated Vehicle	ROV	Bosi	
SO216/053-1	11/07/11	8:34	3° 43,27' S	151° 40,59' E	1686	S 1	228	0	Remote Operated Vehicle	ROV	Hieven	
SO216/053-1	11/07/11	9:56	3° 43,27' S	151° 40,59' E	1681	SSW 3	134.7	0.3	Remote Operated Vehicle	ROV	an Deck	
SO216/053-1	11/07/11	10:00	3° 43,28' S	151° 40,62' E	1690	SW 2	103.1	0.8	Remote Operated Vehicle	ROV	Ende Station	
SO216/054-1	11/07/11	12:05	3° 46,98' S	151° 20,55' E	2258	SE 1	292.1	6.2	Vermessung	EM / PS	Beginn Profil	rwK: 000°, d: 21nm
SO216/054-1	11/07/11	15:32	3° 26,55' S	151° 20,51' E	2432	ESE 6	15.6	5.2	Vermessung	EM / PS	Kursänderung	rwK: 090°, d: 21nm
SO216/054-1	11/07/11	19:14	3° 26,53' S	151° 42,04' E	1834	SSE 7	107.2	6.3	Vermessung	EM / PS	Ende Profil	
SO216/055-1	11/07/11	22:13	3° 47,59' S	152° 5,58' E	1612	SE 5	127.1	2.1	Vermessung	EM / PS	Beginn Profil	rwK: 135, d: 1nm
SO216/055-1	11/07/11	22:47	3° 48,38' S	152° 6,39' E	1444	SE 5	110.2	1.6	Vermessung	EM / PS	Kursänderung	rwK: 000°, d: 1nm
SO216/055-1	11/07/11	23:06	3° 47,63' S	152° 6,38' E	1628	ESE 7	335.7	3.1	Vermessung	EM / PS	Kursänderung	rwK: 225°, d: 1nm
SO216/055-1	11/07/11	23:42	3° 48,39' S	152° 5,61' E	1661	E 7	217.1	1.3	Vermessung	EM / PS	Ende Profil	
SO216/056-1	11/07/11	23:50	3° 48,39' S	152° 5,69' E	1629	SSE 6	52.3	0.2	TV-Grab Typ A	TVG	Beginn Station	
SO216/056-1	11/07/11	23:53	3° 48,39' S	152° 5,70' E	1637	SE 6	263.6	0.1	TV-Grab Typ A	TVG	zu Wasser	W1
SO216/056-1	12/07/11	0:28	3° 48,41' S	152° 5,71' E	1634	ESE 6	357.7	0	TV-Grab Typ A	TVG	Bodensicht	SL: 1634m

Appendix 2: Staion list of cruise SO216

Station	Date	UTC	PositionLat	PositionLon	Depth [m]	Wind [m/s]	COG [°]	v [kn]	Equipment used	Abbrev.	Action	Remarks
SO216/056-1	12/07/11	2:37	3° 48,42' S	152° 5,70' E	1645	SSE 7	209.6	0.1	TV-Grab Typ A	TVG	Zugriff	1. Zugriff, SL: 1657m
SO216/056-1	12/07/11	2:38	3° 48,42' S	152° 5,70' E	1644	SE 6	42.7	0.1	TV-Grab Typ A	TVG	hieven	
SO216/056-1	12/07/11	3:16	3° 48,42' S	152° 5,70' E	1648	SE 7	323.2	0	TV-Grab Typ A	TVG	an Deck	
SO216/056-1	12/07/11	3:20	3° 48,42' S	152° 5,70' E	1648	SE 8	103.9	0	TV-Grab Typ A	TVG	Ende Station	
SO216/057-1	12/07/11	3:40	3° 48,02' S	152° 6,03' E	1194	SE 9	82.5	0.4	CTD	CTD	Beginn Station	
SO216/057-1	12/07/11	3:50	3° 48,02' S	152° 6,05' E	1196	SSE 8	270.9	0.1	CTD	CTD	zu Wasser	W4
SO216/057-1	12/07/11	4:36	3° 48,02' S	152° 6,06' E	1190	SE 7	239.2	0	CTD	CTD	auf Tiefe	SL: 1192m
SO216/057-1	12/07/11	4:37	3° 48,02' S	152° 6,06' E	1171	SE 7	69.7	0.1	CTD	CTD	Hieven	
SO216/057-1	12/07/11	5:50	3° 48,02' S	152° 6,06' E	1171	SSE 7	102.9	0	CTD	CTD	an Deck	
SO216/057-1	12/07/11	5:54	3° 48,02' S	152° 6,06' E	1192	SE 7	27	0.2	CTD	CTD	Ende Station	

Abkürzungen / Abbreviation

z.W	ininto Water / ininto water
o.D.	on Deck / on deck
SL (max.)	(maximale)Seillänge / max. rope-length
LT	Lottiefe nach EM 120 / Depth of EM 120
W x	eingesetzte Winde / Winch used
nm	Simrad - Multibeam - Lot / EM 120
PS	Parasound
rwk / COG:	RechtweisEndr Kurs / true course
d:	Distanz / distance
v:	Geschwindigkeit in Knoten / SOG in knots
SL:	Seillänge / rope-length
KL:	Kabellänge / cable-length
SZ:	Seilzug / rope tension

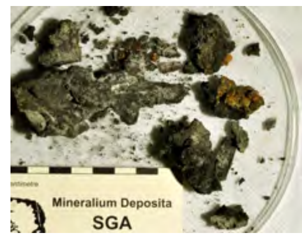
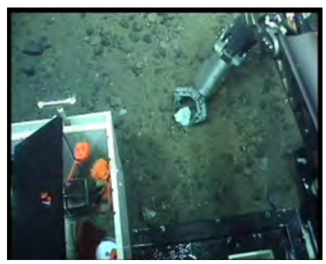
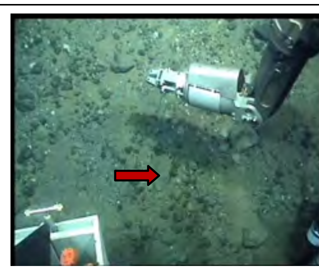
Eingesetzte Geräte / Equiopment used — **Einsätze / tasks**

EM120/Parasound Profil		all the time
CTD		4
ROV	Remotely Operated Vehicle	22
SL	Schwerelot	0
OFOS	Ocean Floor Observation System	0
TV-A	TV - Greifer	5

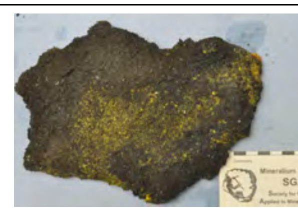
Geräteverluste / lost Equipment none

Winde	D/M	Type	RF-Nr	SO 216 Tasks	intotal tasks	SO 216 length	intotal length	Condition	SO 216 max. length	max. rope length ever lowered
W 1	18,2	LWL	110600488	14 h	398 h	8071 m	144690 m	3	1744 m	3652 m
W 2	18.2	LWL	071000295	0 h	0 h	0 m	0 m	1	0 m	0 m
W 4	11	Koax	61000273	9 h	156 h	6706 m	101598 m	3	2100 m	5157 m
W 5	11	Koax	80700329	0 h	0 h	0 m	0 m	1	0 m	0 m
W 6	18,2	Drako	40800193	0 h	1099 h	0 m	1077456 m	3	0 m	7938 m

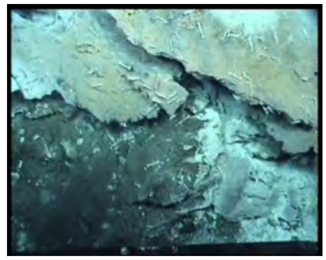
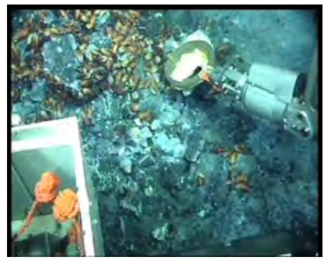
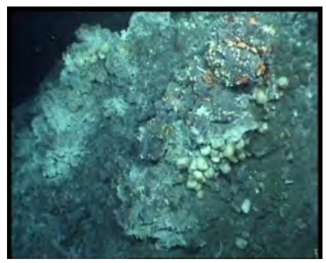
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 09GTV-01 (21062011/ 04:06)	Bugave Ridge 03°46.538'S/ 152°07.019'E 1672m Sedimented volcanic ridge	Fresh vesicular basalt covered by light grey-brownish cohesive mud with dark bands (carbonaceous?)		
SO216 12ROV-01 (22062011/ 02:30)	Northwestern slope of North Su 03°47.946'S/ 152°06.043'E 1207m	Hydrothermal crust: Fibrous barite-rich chimney next to white smoker, partially coated with yellow native sulphur, oxidised on the outside.		
SO216 12ROV-02 (22062011/ 02:34)	Northwestern slope of North Su 03°47.946'S/ 152°06.043'E 1207m	Chimney: Bladed barite-rich chimney with an orifice/conduit partially coated with yellow native sulphur, coated outside by white mat. Highly friable.		
SO216 14ROV-01 (23062011/ 00:37)	Eastern slope of North Su 03°48.115'S/ 152°06.376'E 1480m	Boulder of white sulfur-rich material coated by biofilm; sample collected from eastern slope of volcano		
SO216 14ROV-02 (23062011/ 00:40)	Eastern slope of North Su 03°48.114'S/ 152°06.376'E 1480m	Elongated boulder of vesicular, plagioclase-bearing dacite; sample collected from eastern slope of volcano		
SO216 14ROV-03 (23062011/ 00:42)	Eastern slope of North Su 03°48.115'S/ 152°06.376'E 1480m	Boulder of vesicular, plagioclase-bearing dacite, slightly lighter than sample 14ROV-2; sample collected from eastern slope of volcano		

Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 14ROV-04 (23062011/ 01:48)	Eastern slope of North Su 03°48.066'S/ 152°06.294'E 1404m	Broken boulder of massive native sulfur; sample collected from large talus fan		
SO216 15GTV-01 (23062011/ 07:06)	Crater rim south of North Su summit 03°48.093'S/ 152°06.118'E 1230m	Group of 0.5-2mm Plagioclase porphyrictic dacite? Massive and light grey in color. Few pieces are light grey, less dense and more vesicular (type 1b)		
SO216 15GTV-02 (23062011/ 07:06)	Crater rim south of North Su summit 03°48.093'S/ 152°06.118'E 1230m	Group of clast-supported dacite-breccias cemented by volcaniclastics and black sulphur. Few bleached fragments.		
SO216 15GTV-03 (23062011/ 07:06)	Crater rim south of North Su summit 03°48.093'S/ 152°06.118'E 1230m	Group of hydrothermally altered dark lithic rich volcaniclastic material with coarse, sub angular grains 2-5mm, clast supported. Evidence of black sulphurous cement.		
SO216 15GTV-04 (23062011/ 07:06)	Crater rim south of North Su summit 03°48.093'S/ 152°06.118'E 1230m	2-3cm thick variable colored (yellow-dark grey) sulphurous slabs with a spongy texture. Contains abundant black and yellow native sulphur plus volcaniclastic material		
SO216 15GTV-05 (23062011/ 07:06)	Crater rim south of North Su summit 03°48.093'S/ 152°06.118'E 1230m	>95% pure native yellow elemental sulphur with a flow-ropy like texture. Some fragments are sub-blocky, possibly infill voids, fissures etc.		

Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 19ROV-08 (25062011/ 08:43)	Near summit of North Su 03°47.995'S/ 152°06.051'E 1155m	Crust: 2-3cm thick light grey, poorly sorted (0.5-3mm) volcaniclastic slab with Fe-oxide coating. Few sulfur droplets (mm) and disseminated tiny (<<1mm) sulfide particles		
SO216 21ROV-02 (26062011/ 02:04)	Northern slope of North Su 03°47.950'S/ 152°06.085'E 1201m	Rocks collected with bionet. Dark grey-black, weakly hydrothermally altered porphyritic dacite with plagioclase phenocrysts (0.5-2mm) and elongated vesicles.		
SO216 21ROV-03 (26062011/ 03:11)	Northern slope of North Su 03°47.950'S/ 152°06.082'E 1200m	Rocks collected with bionet. Dark grey, weakly hydrothermally altered porphyritic dacite with plagioclase phenocrysts (0.5-2mm) plus elongated vesicles and brownish- grey silt coating		
SO216 21ROV-12 (26062011/ 08:41)	Southern slope of North Su 03°48.043'S/ 152°06.094'E 1220m	Sulfur chimneys collected with bionet, liquid sulfur was present underneath. Bright yellow >95% solidified native sulfur droplets and quenched grey flakes/fragments with grey to silvery (metallic luster)		
SO216 21ROV-13 (26062011/ __:__)	Northern slope of North Su 03°48.043'S/ 152°06.095'E __m	Collected in ROV frame on bottom contact. Dark grey-black, weakly altered porphyritic dacite with plagioclase phenocrysts (0.5-2mm), elongated vesicles, oxidized surface and sulphur infills along fractures and cavities. Also present are fragments of oxidized chimney walls.		

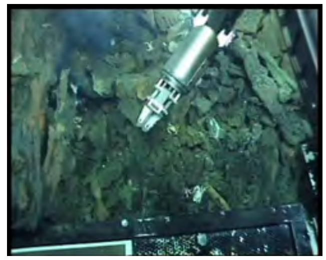
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 25ROV-03 (28062011/ 03:13)	PacManus/ Fenway 03°43.722'S/ 151°40.331'E 1716m	Large piece of recent Cu-rich chimney talus; fine grained brassy chalcopyrite with abundant anhydrite and pyrite, some sphalerite+anhydrite clogging conduits; outer marcasite crust		
SO216 27ROV-01 (29062011/ 03:06)	PacManus/ Snowcap 03°43.679'S/ 151°40.158'E 1644m	Small piece from beehive of SC2 chimney (T_{max}=224°C); Greenish-grey pyrite-sphalerite-chalcopyrite with outer marcasite crust; very friable		
SO216 27ROV-06 (29062011/ 05:40)	PacManus/ Snowcap 03°43.685'S/ 151°40.159'E 1647m	Bulbous small chimney from SC1 (Marker 6); fragments of conduits partially lined by pale brassy fine grained chalcopyrite; outer part with spahlerite to tarnished marcasite, highly friable		
SO216 27ROV-07 (29062011/ 05:52)	PacManus/ Snowcap 03°43.685'S/ 151°40.159'E 1647m	Sampled in bionet. porous sphalerite+ barite+silica; outer Fe-oxyhydroxide coating		
SO216 27ROV-08 (29062011/ 06:07)	PacManus/ Snowcap 03°43.686'S/ 151°40.160'E 1647m	elongated massive and dense Cu-rich chimney (talus piece) with chalcopyrite showing a purple-bluish outer bornite rim +/- tarnishing		
SO216 27ROV-09 (29062011/ 08:58)	PacManus/ Tsukushi 03°43.785'S/ 151°39.992'E 1664m	Weathered Fe-Mn-oxyhydroxides associated with diffuse venting (Tmax = 53.1°C)		

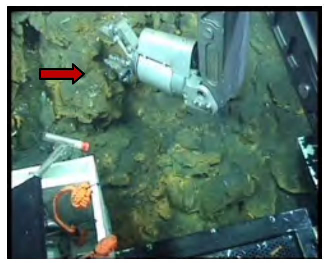
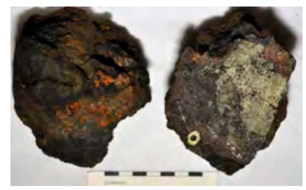
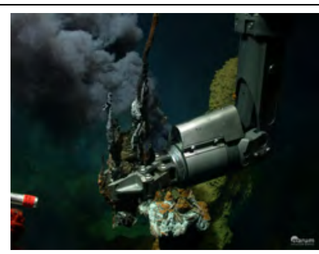
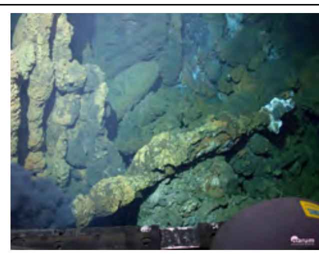
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 29ROV-15 (30062011/ 08:48)	PacManus/ Fenway NE 03°43.711'S/ 151°40.349'E 1719m	Porous former chalcopyrite chimney altered to secondary bornite and chalcocite; core of the chimney is very friable. Orange-brown Fe-Mn oxyhydroxide crust.		
SO216 29ROV-16 (30062011/ 08:54)	PacManus/ Fenway NE 03°43.709'S/ 151°40.348'E 1719m	Large stump of polymetallic chimney with porous chalcopyrite infilled with dark sphalerite and secondary Cu-sulfides plus barite; orange-brown Fe-Mn oxyhydroxide crust.		
SO216 31ROV-08 (01072011/ 06:01)	PacManus/ Satanic Mills 03°43.613'S/ 151°40.323'E 1692m	Top of small flange covered in white mat; porous sphalerite showing beehive-texture with outer Fe-oxyhydroxide layer		
SO216 31ROV-10 (01072011/ 06:48)	PacManus/ Satanic Mills 03°43.614'S/ 151°40.322'E 1689m	Top of active chimney (345°C); fragment of a chimney with very brassy, porous chalcopyrite ~1cm thick and a 1-2mm Fe-Mn crust. Large part went to Eoghan for biomarker study.		
SO216 31ROV-13A (01072011/ 07:34)	PacManus/ Satanic Mills 03°43.614'S/ 151°40.321'E 1691m	Talus piece; polymetallic chimney with porous chalcopyrite + sphalerite + bornite		
SO216 31ROV-13B (01072011/ 07:38)	PacManus/ Satanic Mills 03°43.615'S/ 151°40.321'E 1691m	Talus piece; massive porous chalcopyrite with multiple conduits. Thin outer layer of bornite in places.		

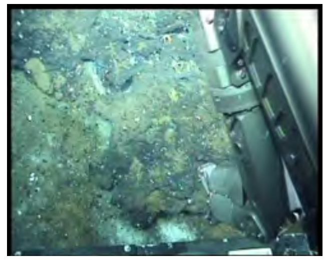
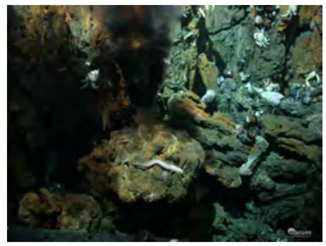
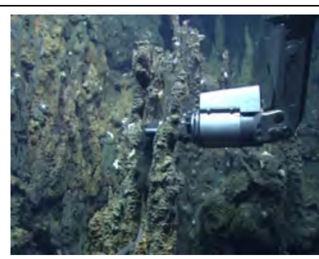
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 31ROV-13C (01072011/ 07:38)	PacManus/ Satanic Mills 03°43.615'S/ 151°40.321'E 1691m	Talus piece recovered on the front porch while driving into the talus pile; massive dense chalcopyrite showing mm-size layering along central conduits; outer surface tarnished and partially transformed to bornite		
SO216 31ROV-17 (01072011/ 09:10)	PacManus/ Satanic Mills 03°43.586'S/ 151°40.319'E 1687m	Talus piece; friable chimney with brassy chalcopyrite-bornite-atacamite-marcasite. Minor fibrous white to black anhydrite filling vugs. Chimney wall is between 1 cm to 1mm thick		
SO216 33GTV-01 (01072011/ 23:48)	PacManus/ Solwara 8 03°43.827'S/ 151°40.450'E 1740m	talus; Group 1 comprises dense, thin chalcopyrite-dominated conduits showing minor bornite and/or chalcocite rims and atacamite on the outside, no porous outer walls present		
SO216 33GTV-02 (01072011/ 23:48)	PacManus/ Solwara 8 03°43.827'S/ 151°40.450'E 1740m	talus; Group 2; dense, purple secondary Cu-sulfides with chalcocite, bornite and minor chalcopyrite; pieces range from very dense to porous		
SO216 33GTV-03 (01072011/ 23:48)	PacManus/ Solwara 8 03°43.827'S/ 151°40.450'E 1740m	talus; Group 3; Miscellaneous friable and porous chimney fragments; chalco-pyrite-bornite-chalco-cite-Fe-Mn oxyhy-droxide, rare atacamite		
SO216 33GTV-04 (01072011/ 23:48)	PacManus/ Solwara 8 03°43.827'S/ 151°40.450'E 1740m	talus; Group 4; outer chimney walls; porous consisting of sphalerite (?) with secondary Cu-sulfides		

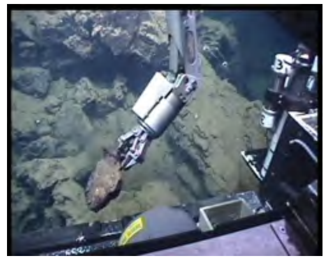
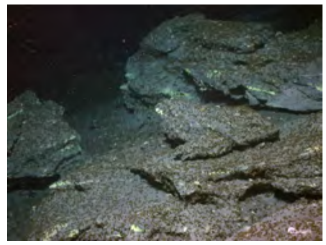
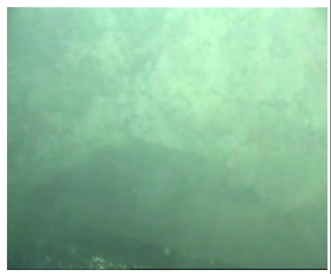
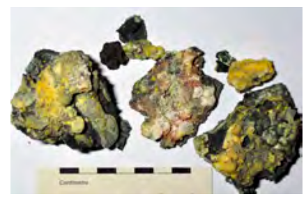
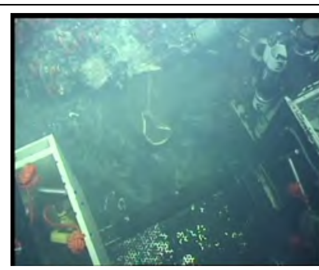
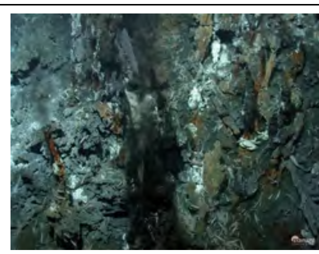
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 34GTV-01 (02072011/ 02:17)	PacManus/ Fenway 03°43.740'S/ 151°40.333'E 1713m	TV-grab on outcrop next to fault dissecting the mound; massive and dense sphalerite + barite and pyrite, silicified		
SO216 37ROV-02 (03072011/ 03:46)	PacManus/ Solwara 7 03°43.027'S/ 151°40.364'E 1773m	Top of inactive chimney (left) next to active 348°C smoker; interior consists of porous chalcopyrite showing a 1 cm wide conduit lined with coarse cpy; outer rim is 5-10 mm thick Fe-Mn-crust		
SO216 37ROV-05 (03072011/ 04:57)	PacManus/ Solwara 7 03°43.030'S/ 151°40.365'E 1774m	Mound piece with thick Mn-Fe-coating; 5-6 cm subangular clast of pyrite + chalcopyrite intergrowth set in a matrix of sphalerite + barite; single dense cpy-conduit (1 cm) is present in the matrix		
SO216 39ROV-01 (04072011/ 03:34)	PacManus/ Roman Ruins 03°43.270'S/ 151°40.472'E 1682m	Top of active chimney measured at 338°C with thin pipe-like dense cpy conduits. Large part for biomarker study (Eoghan)		
SO216 39ROV-04 (04072011/ 04:17)	PacManus/ Roman Ruins 03°43.270'S/ 151°40.472'E 1682m	Middle to top section of the same smoker with 1-2cm conduit zoned by fine grained chalcopyrite; middle part with dark sphalerite and minor anhydrite + barite (?) and a thin layer of Fe-oxyhydroxide crust. Minor occurrence of white staining		

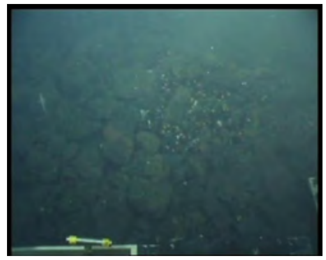
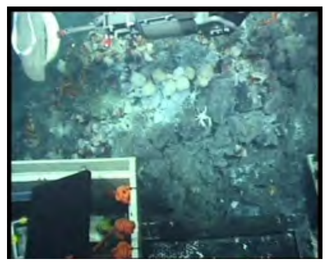
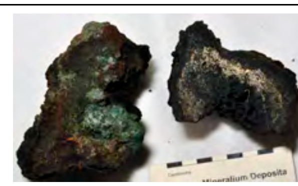
Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 41ROV-01 (05072011/ 03:32)	PacManus/ Fenway NE 03°43.695'S/ 151°40.375'E 1710m	Sample of slab-like rock from mound; dark fresh aphyric dacite with minor vesicles.		
SO216 41ROV-04 (05072011/ 05:35)	PacManus/ Fenway NE 03°43.710'S/ 151°40.345'E 1714m	Small piece from cpy-lined conduit at base of chimney (top fell off prior to sampling) with 314°C fluid; chalco-pyrite-sphalerite with Fe-oxyhydroxde crust		
SO216 41ROV-05 (05072011/ 05:37)	PacManus/ Fenway NE 03°43.711'S/ 151°40.345'E 1714m	Piece from the top of the same chimney (314°C); friable with 1-2 cm conduit zoned by fine grain dense chalcopyrite and a more porous middle layer, thin Fe-oxyhy-droxide crust. Minor occurrence of white staining		
SO216 41ROV-08 (05072011/ 07:06)	PacManus/ Fenway 03°43.724'S/ 151°40.329'E 1715m	Large block of anhydrite from slope of Big-Papi; predomi-nantly massive 1-5mm pale grey euhedral anhydrite with fine-medium grained disseminated pyrite and rare sphalerite (?)		
SO216 41ROV-12 (05072011/ 08:04)	PacManus/ Fenway 03°43.733'S/ 151°40.327'E 1715m	Bionet with clay-like material and fragments and slabs of medium grained pale brassy pyrite and marcasite with abundant tubeworms. Some fragments contain fine-grained chalcopyrite, sphalerite and possibly galena		
SO216 43ROV-07 (06072011/ 04:26)	PacManus/ Satanic Mills 03°43.610'S/ 151°40.329'E 1689m	Weathered inactive chimney with porous chalcopyrite in interior (small mm to cm conduits) rimmed by dark sphalerite + pyrite. Thin Fe-oxyhydroxide coating. Main part for biomarker study (Eoghan)		

Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 43ROV-10 (06072011/ 07:11)	PacManus/ Snowcap 03°43.632'S/ 151°40.187'E 1650m	Large fragment of prominent lava flow from northern slope of Snowcap; vesicular andesite with sparse plagioclase phenocrysts in a very fine grained dark groundmass; flow banding; few olivine xenocrysts		
SO216 43ROV-11 (06072011/ 08:06)	PacManus/ Snowcap 03°43.694'S/ 151°40.158E 1650m	Bionet taken on sulfur flow just west of Snowcap with native grey to yellow sulfur showing flow textures and small wispy fragments of pumiceous lava; outcrop was covered in tiny snails		
SO216 45ROV-15 (07072011/ 03:50)	North Su/ Western slope 3°48.039'S/ 152°06.061'E 1197m	Native sulfur crusts accidentally recovered on porch; layers of dark grey-black native sulfur with yellow surface showing flow textures; white and red staining		
SO216 47ROV-01 (08072011/ 00:35)	North Su/ 3°47.756'S/ 152°06.097'E 1198m	Rock sampled in net in association with mussels, tubeworms and snails		No photo
SO216 47ROV-13 (08072011/ 08:44)	North Su/ western slope 3°47.992'S/ 152°06.029'E 1188m	Cu-rich chimney from western end of E/W trending chimney ridge with 0.5-1cm conduit with thin layer of cpy followed by porous chalcopyrite, rimmed by a thin layer <0.5cm sphalerite-pyrite with thin outer Fe-Mn oxyhydroxide crust		
SO216 49ROV-03 (09072011/ 02:10)	PacManus/ Solwara 8 03°43.832'S/ 151°40.451'E 1742m	inactive spire near base of larger structure. Core of former porous chalcopyrite largely gone. Middle and outer part consists of porous, silicified pyrite + cpy + sphalerite; Fe-oxide rim with abundant silica		

Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 49ROV-05 (09072011/ 04:32)	PacManus/ Solwara 8 03°43.728'S/ 151°40.333'E 1715m	Net taken on gentle ridge south of Big Papi containing fragments and slabs of fine grained euhedral to collomorphic pyrite-marcasite with dark grey to black poly-metallic sulfides, likely Pb- and Zn-sulfides, coating surfaces.		
SO216 51ROV-05 (10072011/ 01:58)	North Su 03°47.971'S/ 152°06.090'E 1181m	Talus pieces of vesicular plg-phyric andesite (?) recovered in net; some surface coated by Fe-oxyhydroxides		
SO216 51ROV-06 (10072011/ 03:09)	North Su 03°47.954'S/ 152°06.086'E 1199m	Talus pieces of vesilcular plg-phyric andesite (?) recovered in net; sample is coated with small tubeworm; white biofilm on surfaces exposed		
SO216 53ROV-01 (11072011/ 03:33)	PacManus/ Solwara 6 03°43.685'S/ 151°40.794'E 1763m	Sampled talus on top of flanges; Porous, black chimney, polymetallic incl. isocubanite (?)		
SO216 53ROV-02 (11072011/ 04:25)	PacManus/ Solwara 6 03°43.686'S/ 151°40.788'E 1767m	Elongated, weathered piece with cpy + bornite in the core; enriched in black secondary Cu-sulfides with outer surface coated in atacamite		
SO216 53ROV-03 (11072011/ 06:59)	PacManus/ Roman Ruins 03°43.252'S/ 151°40.499'E 1684m	Inactive chimney for biomarker analyses, (went to Eoghan)		

Appendix B: Summary of rocks and precipitates collected during cruise SO216.

sample ID	location	description	bottom photo	sample photo
SO216 53ROV-06 (11072011/ 07:32)	PacManus/ Roman Ruins 03°43.252'S/ 151°40.499'E 1689m	Black smoker (329°C) at trunk of chimney; knocked of and later retrieved; chimney with cm-wide conduits lined by thick chalcopyrite layer. Porous cpy with some anhydrite. Outer pyrite/mc and coated by Fe-oxyhydroxides		
SO216 56GTV-01 (12072011/ 02:36)	North Su/ Solwara 9a 03°48.414'S/ 152°05.689'E 1652m	TV-grab on inactive chimney; group one, vesicular plagioclase-phyric and xenolith-bearing andesite (?); very fine grained ground mass, 1-2mm plagioclase and rare occurrences of ~4mm olivine phenocrysts.		
SO216 56GTV-02 (12072011/ 02:36)	North Su/ Solwara 9a 03°48.414'S/ 152°05.689'E 1652m	Porous barite-sphalerite chimney material; outer surface coated in Fe-oxyhydroxides		
SO216 56GTV-03 (12072011/ 02:36)	North Su/ Solwara 9a 03°48.414'S/ 152°05.689'E 1652m	Slab of grey, porous baritic material		
SO216 56GTV-04 (12072011/ 02:36)	North Su/ Solwara 9a 03°48.414'S/ 152°05.689'E 1652m	Few pebbles of weakly altered, bleached, pale grey volcanic (rhyolite?) with a fine grained groundmass and <1mm possibly feldspar phenocrysts. Some with thin Fe-oxyhydroxide coating		
SO216 56GTV-05 (12072011/ 02:36)	North Su/ Solwara 9a 03°48.414'S/ 152°05.689'E 1652m	Single piece of porous subrounded native sulfur; vesicular and flow textured; possibly transported material from North Su (?)		

Appendix C1 Geological Samples Master SO-216

Sample #	Station	Location	Date	Time (UTC)	Latitude	Longitude	Dive #	Depth (m)	Comments
009-GTV-01	SO-216-009	flank of Bugave ridge	2011-06-21	4:06:53 AM	S 03°46.53800'	E 152°07.01920'		-1674	Pl-Cpx-phyric volcanic rock; gray mud with black portions
012-ROV-01	SO-216-012	North Su	2011-06-22	2:30:00 AM	S 03°47.94600'	E 152°06.04300'	297	-1207	dark-gray rock with reddish stained surface
012-ROV-02	SO-216-012	North Su	2011-06-22	2:34:00 AM	S 03°47.94600'	E 152°06.04300'	297	-1207	small pieces of a dark, fine-grained, porous rock
014-ROV-01	SO-216-012	North Su	2011-06-23	12:37:00 AM	S 03°48.11496'	E 152°06.37608'	298	-1480	irregularly shaped dark rock
014-ROV-02	SO-216-014	North Su	2011-06-23	12:40:00 AM	S 03°48.11430'	E 152°06.37608'	298	-1480	dark rock
014-ROV-03	SO-216-014	North Su	2011-06-23	12:42:00 AM	S 03°48.11472'	E 152°06.37632'	298	-1480	grayish rock
014-ROV-04	SO-216-014	North Su	2011-06-23	1:48:00 AM	S 03°48.06600'	E 152°06.29352'	298	-1404	native sulfur
015-GTV-01	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	massive, fine-grained, slightly vesicular volcanic rock
015-GTV-02	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	dark volcanic rock with minor amounts of sulfur
015-GTV-03	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	clastic volcanic rock
015-GTV-04	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	native sulfur, both black and yellow
015-GTV-05	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	native yellow sulfur with flow texture
019-ROV-08	SO-216-019	North Su	2011-06-25	8:45:00 AM	S 03°47.99500'	E 152°06.05100'	301	-1155	platy dark crust
021-ROV-02	SO-216-021	North Su	2011-06-26	2:04:00 AM	S 03°47.94980'	E 152°06.08510'	302	-1202	rock samples in mussel net
021-ROV-03	SO-216-021	North Su	2011-06-26	3:15:00 AM	S 03°47.95025'	E 152°06.08254'	302	-1200	plastic net with Alviniconchia snails + some Ifremeria + rocks
021-ROV-12	SO-216-021	North Su	2011-06-26	8:38:00 AM	S 03°48.04202'	E 152°06.09469'	302	-1220	sulfur chimney (sulfur chimney area)
021-ROV-13	SO-216-021	North Su	2011-06-26				302		volcanic rocks collected accidentally
023_ROV-05	SO-216-023	North Su	2011-06-27	5:32:00 AM	S 03°48.04337'	E 152°06.09020'	304	-1221	sulfur-bearing sediment sample with bacterial filaments taken with shovel
025-ROV-03	SO-216-025	Fenway	2011-06-28	3:13:00 AM	S 03°43.72200'	E 151°40.33100	305	-1716	sulfide chimney with inner lining of chalcopyrite + some anhydrite
025-ROV-04	SO-216-025	Fenway	2011-06-28	5:12:00 AM	S 03°43.69734'	E 151°40.35504'	305	-1703	sediment, partially solidified, taken with net
027-ROV-01	SO-216-027	Snowcap/Tsukushi	2011-06-29	3:06:00 AM	S 03°43.67853'	E 151°40.15835'	306	-1644	crumbled pieces of beehive-chimney from sc2-chimney-structure
027-ROV-06	SO-216-027	Snowcap/Tsukushi	2011-06-29	5:40:00 AM	S 03°43.68503'	E 151°40.15939'	306	-1647	small sulfide chimney
027-ROV-08	SO-216-027	Snowcap/Tsukushi	2011-06-29	6:06:00 AM	S 03°43.68582'	E 151°40.16044'	306	-1646	small sulfide piece (second largest one)
027-ROV-09	SO-216-027	Snowcap/Tsukushi	2011-06-29	8:58:00 AM	S 03°43.78496'	E 151°39.99211'	306	-1665	net with surface of oxide mound
029-ROV-15	SO-216-029	Fenway area	2011-06-30	8:48:00 AM	S 03°43.71100'	E 151°40.34940'	307	-1719	top of inactive standing chimney
029-ROV-16	SO-216-029	Fenway area	2011-06-30	8:54:00 AM	S 03°43.70948'	E 151°40.34826'	307	-1718	top of inactive standing chimney
031-ROV-08	SO-216-031	Fenway area	2011-07-01	6:01:00 AM	S 03°43.61269'	E 151°40.32328'	308	-1691	rock sample in bucket
031-ROV-10	SO-216-031	Fenway area	2011-07-01	6:50:00 AM	S 03°43.61382'	E 151°40.32168'	308	-1689	top of active chimney
031-ROV-13	SO-216-031	Fenway area	2011-07-01	7:34:00 AM	S 03°43.61399'	E 151°40.32105'	308	-1690	chimney talus; pipe-like chimney
031-ROV-17	SO-216-031	Fenway area	2011-07-01	9:10:00 AM	S 03°43.58602'	E 151°40.31875'	308	-1687	Cu-rich sulfide chimney
031-ROV-18	SO-216-031	Satanic Mills	2011-07-01	7:20:00 AM	S 03°43.61313'	E 151°40.32317'	308	-1688	top of chimney paired with IGT
033-GTV-01	SO-216_033	Solwara 8	2011-07-01	11:47:00 PM	S 03°43.82700'	E 151°40.45000'		-1740	talus pile next to large chimney; group 1
033-GTV-02	SO-216_033	Solwara 8	2011-07-01	11:47:00 PM	S 03°43.82700'	E 151°40.45000'		-1740	talus pile next to large chimney; group 2
033-GTV-03	SO-216_033	Solwara 8	2011-07-01	11:47:00 PM	S 03°43.82700'	E 151°40.45000'		-1740	talus pile next to large chimney; group 3
033-GTV-04	SO-216_033	Solwara 8	2011-07-01	11:47:00 PM	S 03°43.82700'	E 151°40.45000'		-1740	talus pile next to large chimney; group 4
034-GTV-01	SO-216_033	Fenway	2011-07-02	2:17:00 AM	S 03°43.74000'	E 151°40.33300'		-1712	mixed sulfate-sulfide rock

Appendix C1 Geological Samples Master SO-216									
Sample #	Station	Location	Date	Time (UTC)	Latitude	Longitude	Dive #	Depth (m)	Comments
037-ROV-02	SO-216-037	Roman Ruins	2011-07-03	3:46:00 AM	S 03°43.02738'	E 151°40.36446'	309	-1774	top of inactive chimney, from immediate vicinity of vent sampled with IGT (037-ROV-01)
037-ROV-05	SO-216-037	Roman Ruins	2011-07-03	4:59:00 AM	S 03°43.02966'	E 151°40.36506'	309	-1774	talus piece (gray) with Fe-staining
039-ROV-01	SO-216-039	Roman Ruins	2011-07-04	3:34:00 AM	S 03°43.27164'	E 151°40.47318'	310	-1680	chimney tip, venting gray smoke; sample is from same structure as fluid sample 039-ROV-02
039-ROV-04	SO-216-039	Roman Ruins	2011-07-04	4:17:00 AM	S 03°43.27026'	E 151°40.47156'	310	-1680	tip of chimney
041-ROV-01	SO-216-041	Fenway area	2011-07-05	3:32:00 AM	S 03°43.69488'	E 151°40.37520'	311	-1710	glass-like rock from top of diffuse venting mound, N of Big Papi
041-ROV-04	SO-216-041	Fenway area	2011-07-05	5:35:00 AM	S 03°43.70982'	E 151°40.34544'	311	-1715	small piece of chimney from orifice sampled with IGT (041-ROV-03); represents middle part of chimney
041-ROV-05	SO-216-041	Fenway area	2011-07-05	5:37:00 AM	S 03°43.71066'	E 151°40.34496'	311	-1714	larger piece of chimney removed before fluid sampling; white coating; represents upper part of chimney
041-ROV-08	SO-216-041	Fenway area	2011-07-05	7:06:00 AM	S 03°43.72440'	E 151°40.32906'	311	-1715	large anhydrite clump
041-ROV-12	SO-216_041	Fenway area	2011-07-05	8:04:00 AM	S 03°43.73250'	E 151°40.32732'	311	-1715	bionet with altered rock (clay) + fauna
043-ROV-07	SO-216-043	Fenway area	2011-07-06	4:26:00 AM	S 03°43.60998'	E 151°40.32864'	312	-1689	dead chimney in blue bucket, severely damaged; biomarker chimney for Eoghan
043-ROV-10	SO-216-043	Fenway area	2011-07-06	7:11:00 AM	S 03°43.63188'	E 151°40.18716'	312	-1649	fragment of prominent lava flow from north slope of SNowcap
043-ROV-11	SO-216-043	Fenway area	2011-07-06	8:07:52 AM	S 03°43.69410'	E 151°40.15836'	312	-1650	net with native sulfur and dacite flakes
045-ROV-15	SO-216-045	North Su	2011-07-07	3:50:00 AM	S 03°48.03882'	E 152°06.06108'	313	-1197	native sulfur crust, accidentally recovered on ROV porch
047-ROV-01	SO-216-047	North Su	2011-07-08	12:35:00 AM	S 03°47.95608'	E 152°06.09714'	314	-1198	Ifremeria + mussels + rock with small tubeworms
047-ROV-13	SO-216-047	North Su	2011-07-08	8:45:00 AM	S 03°47.99238'	E 152°06.02904'	314	-1188	Cu-rich chimney; heading 77
049-ROV-03	SO-216-049	Solwara 8 / Fenway	2011-07-09	2:10:00 AM	S 03°43.83174'	E 151°40.45110'	315	-1741	broke tip off an inactive spire from base of chimney IGT-sampled before
049-ROV-05	SO-216-049	Solwara 8 / Fenway	2011-07-09	4:32:40 AM	S 03°43.72812'	E 151°40.33314'	315	-1716	sulfide rock in bionet
051-ROV-05	SO-216-051	North Su	2011-07-10	1:59:00 AM	S 03°47.97210'	E 152°06.08988'	316	-1180	scoop net with Ifremeria snails + rocks
051-ROV-06	SO-216-051	North Su	2011-07-10	3:09:00 AM	S 03°47.95380'	E 152°06.08556'	316	-1199	scoop net with Alviniconcha + rocks
051-ROV-09	SO-216-051	North Su	2011-07-10	6:55:00 AM	S 03°48.04254'	E 152°06.05304'	316	-1193	scoop with shovel in highly altered material
051-ROV-10	SO-216-051	North Su	2011-07-10	7:37:00 AM	S 03°48.05070'	E 152°06.04392'	316	-1193	shovel with volcaniclastic material
053-ROV-01	SO-216-053	Solwara 6 area	2011-07-11	3:33:00 AM	S 03°43.68468'	E 151°40.79352'	317	-1764	inactive chimney talus piece
053-ROV-02	SO-216-053	Solwara 6 area	2011-07-11	4:26:00 AM	S 03°43.68600'	E 151°40.78776'	317	-1766	elongated chimney piece
053-ROV-03	SO-216-053	Solwara 6 area	2011-07-11	6:59:00 AM	S 03°43.25191'	E 151°40.49851'	317	-1684	shimmering orange chimney for Eoghan; weakly venting
053-ROV-06	SO-216-053	Solwara 6 area	2011-07-11	8:30:00 AM	S 03°43.24494'	E 151°40.49700'	317	-1677	chimney in mid-f??? chamber from same orifice (cp. 053-ROV-05)
056-GTV-01	SO-216-056	Solwara 9	2011-07-12	2:36:51 AM	S 03°48.41399'	E 152°05.68898'		-1652	
056-GTV-02	SO-216-056	Solwara 9	2011-07-12	2:36:51 AM	S 03°48.41399'	E 152°05.68898'		-1652	
056-GTV-03	SO-216-056	Solwara 9	2011-07-12	2:36:51 AM	S 03°48.41399'	E 152°05.68898'		-1652	
056-GTV-04	SO-216-056	Solwara 9	2011-07-12	2:36:51 AM	S 03°48.41399'	E 152°05.68898'		-1652	
056-GTV-05	SO-216-056	Solwara 9	2011-07-12	2:36:51 AM	S 03°48.41399'	E 152°05.68898'		-1652	

Appendix C2: Fluids Master SO-216

Sample #	Station	Location	Date	Time (UTC)	Latitude	Longitude	Dive #	Depth (m)	Type	Comments
001-CTD	SO-216-001	eastern Manus Basin	2011-06-19	1:11:46 AM	S 03°51.48000'	E 152°07.99000'		div	CTD	SVP; water samples
007-CTD	SO-216-007	eastern Manus Basin	2011-06-10	4:14:59 AM	S 03°51.51000'	E 152°08.00000'		div	CTD	SVP; water samples
012-ROV-03	SO-216-012	North Su	2011-06-22	4:06:20 AM	S 03°47.95759'	E 152°06.08164'	297	-1199	ROV-KIPS	KIPS- 6 --> wrong bottle sampled
014-ROV-05	SO-216-014	North Su	2011-06-23	2:35:00 AM	S 03°48.09096'	E 152°06.16200'	298	-1289	ROV-IGT	IGT-7, next to sulfur ledge; seawater; ca.4°C
014-ROV-06	SO-216-014	North Su	2011-06-23	3:48:30 AM	S 03°48.09000'	E 152°06.10656'	298	-1230	ROV-KIPS	KIPS-6; over white mat
014-ROV-07	SO-216-014	North Su	2011-06-23	3:52:30 AM	S 03°48.08898'	E 152°06.10692'	298	-1231	ROV-KIPS	KIPS-5; over white mat
014-ROV-08	SO-216-014	North Su	2011-06-23	3:58:30 AM	S 03°48.09000'	E 152°06.10686'	298	-1230	ROV-KIPS	KIPS-8; over white mat
014-ROV-09	SO-216-014	North Su	2011-06-23	4:14:50 AM	S 03°48.08940'	E 152°06.10554'	298	-1230	ROV-KIPS	KIPS-4; over orange mat
014-ROV-10	SO-216-014	North Su	2011-06-23	4:18:30 AM	S 03°48.09012'	E 152°06.10608'	298	-1229	ROV-KIPS	KIPS-3;over orange mat
014-ROV-11	SO-216-014	North Su	2011-06-23	4:24:00 AM	S 03°48.08988'	E 152°06.10614'	298	-1230	ROV-KIPS	KIPS-7
014-ROV-12	SO-216-014	North Su	2011-06-23	4:45:45 AM	S 03°48.08400'	E 152°06.10956'	298	-1225	ROV-KIPS	KIPS-2
014-ROV-13	SO-216-014	North Su	2011-06-23	4:49:45 AM	S 03°48.08400'	E 152°06.10866'	298	-1225	ROV-KIPS	KIPS-1
019-ROV-01	SO-216-019	North Su	2011-06-25	3:05:00 AM	S 03°47.98904'	E 152°06.01998'	301	-1192	ROV-IGT	boiling black smoker fluid (T up to 332°C)
019-ROV-02	SO-216-019	North Su	2011-06-25	6:11:30 AM	S 03°47.99464'	E 152°06.05150'	301	-1154	ROV-KIPS	KIPS-6; diffuse fluid coming through fissure in slab
019-ROV-03	SO-216-019	North Su	2011-06-25	6:15:15 AM	S 03°47.99499'	E 152°06.05125'	301	-1155	ROV-KIPS	KIPS-5; diffuse fluid coming through fissure in slab, pH=4.1-4.6, high H2S
019-ROV-04	SO-216-019	North Su	2011-06-25	6:22:04 AM	S 03°47.99498'	E 152°06.05157'	301	-1155	ROV-KIPS	KIPS-9; diffuse fluid coming through fissure in slab, pH as low as 3.1
019-ROV-05	SO-216-019	North Su	2011-06-25	7:25:50 AM	S 03°47.99601'	E 152°06.05246'	301	-1155	ROV-KIPS	KIPS-4; background water sample, taken ca. 10cm away from fissure
019-ROV-06	SO-216-019	North Su	2011-06-25	7:30:30 AM	S 03°47.99629'	E 152°06.05290'	301	-1156	ROV-KIPS	KIPS-3; 2nd background water sample, taken ca. 30cm away from fissure
019-ROV-07	SO-216-019	North Su	2011-06-25	7:37:00 AM	S 03°47.99595'	E 152°06.05227'	301	-1155	ROV-KIPS	KIPS-8; white staining pumped onto filter
021-ROV-01	SO-216-021	North Su	2011-06-26	12:24:00 AM	S 03°47.94100'	E 152°06.02748'	302	-1228	ROV-IGT	IGT-3; clear fluid from fissure, Tmax= 169°C, mostly 130-140°C
021-ROV-04	SO-216-021	North Su	2011-06-26	4:12:00 AM	S 03°47.95536'	E 152°06.08064'	302	-1200	ROV-KIPS	KIPS-8; in crack below colonialization deployment; pH4.8, highH2S
021-ROV-05	SO-216-021	North Su	2011-06-26	4:17:00 AM	S 03°47.95560'	E 152°06.07975'	302	-1199	ROV-KIPS	KIPS-6
021-ROV-06	SO-216-021	North Su	2011-06-26	4:20:00 AM	S 03°47.95438'	E 152°06.07925'	302	-1200	ROV-KIPS	KIPS-5
021-ROV-07	SO-216-021	North Su	2011-06-26	4:25:00 AM	S 03°47.95522'	E 152°06.07993'	302	-1200	ROV-KIPS	KIPS-4, moving + repositioning after sampling
021-ROV-08	SO-216-021	North Su	2011-06-26	4:35:00 AM	S 03°47.95408'	E 152°06.08252'	302	-1199	ROV-KIPS	KIPS-3; ISMS indicates different chemistry compared to 021-ROV-07 after repositioning
021-ROV-09	SO-216-021	North Su	2011-06-26	4:44:00 AM	S 03°47.95565'	E 152°06.08012'	302	-1199	ROV-KIPS	KIPS-9, turbulence after ca. 20s; pH5.2
021-ROV-10	SO-216-021	North Su	2011-06-26	8:10:00 AM	S 03°48.04217'	E 152°06.09400'	302	-1220	ROV-KIPS	KIPS-2, short pump time, KIPS dodged partially; sulfur chimney area
021-ROV-11	SO-216-021	North Su	2011-06-26	8:15:00 AM	S 03°48.04202'	E 152°06.09469'	302	-1220	ROV-KIPS	KIPS-1, short pump time, KIPS dodged partially; sulfur chimney area
023-ROV-01	SO-216-023	North Su	2011-06-27	4:14:00 AM	S 03°48.04240'	E 152°06.08975'	304	-1220	ROV-IGT	IGT-3
023-ROV-02	SO-216-023	North Su	2011-06-27	4:34:00 AM	S 03°48.04240'	E 152°06.08978'	304	-1220	ROV-IGT	IGT-7
023-ROV-03	SO-216-023	North Su	2011-06-27	4:56:30 AM	S 03°48.04313'	E 152°06.08987'	304	-1220	ROV-KIPS	KIPS-6, ph2.7, no methane, high CO2
023-ROV-04	SO-216-023	North Su	2011-06-27	5:05:30 AM	S 03°48.04243'	E 152°06.08978'	304	-1220	ROV-KIPS	KIPS-5, ph2.7, no methane, high CO2
025-ROV-01	SO-216-025	Fenway	2011-06-28	2:35:49 AM	S 03°43.72109'	E 151°40.33128'	305	-1714	ROV-IGT	IGT-2, 303°C, bottle did not trigger --> no sample
025-ROV-02	SO-216-025	Fenway	2011-06-28	2:54:13 AM	S 03°43.72179'	E 151°40.33116'	305	-1714	ROV-IGT	IGT-4, max 295°C, commonly lower T, nozzle came out of orifice during sampling --> no sample!
025-ROV-06	SO-216-025	Fenway	2011-06-28	6:59:30 AM	S 03°43.70000'	E 151°40.34500'	305	-1709	ROV-KIPS	KIPS-6, afterwards move 1cm to left
025-ROV-07	SO-216-025	Fenway	2011-06-28	7:04:30 AM	S 03°43.70051'	E 151°40.34436'	305	-1709	ROV-KIPS	KIPS-5, closer to Symcatch, afterwards nozzle moved significantly
025-ROV-08	SO-216-025	Fenway	2011-06-28	7:17:45 AM	S 03°43.69998'	E 151°40.34364'	305	-1709	ROV-KIPS	KIPS-7, large filter, ph6.7 still dropping to 6.5,...
025-ROV-09	SO-216-025	Fenway	2011-06-28	8:10:30 AM	S 03°43.69843'	E 151°40.35630'	305	-1704	ROV-KIPS	KIPS-4; filamentous bacteria
025-ROV-10	SO-216-025	Fenway	2011-06-28	8:14:20 AM	S 03°43.69757'	E 151°40.35462'	305	-1704	ROV-KIPS	KIPS-1
027-ROV-02	SO-216-027	Snowcap/Tsukushi	2011-06-29	3:47:00 AM	S 03°43.67945'	E 151°40.15774'	306	-1644	ROV-IGT	IGT-3, fluid sample at SC2, clear fluid, diffuse venting, max. 60-80°C
027-ROV-03	SO-216-027	Snowcap/Tsukushi	2011-06-29	4:02:00 AM	S 03°43.67989'	E 151°40.15768'	306	-1644	ROV-IGT	IGT-7; same spot as IGT-3; max. T 224°C
027-ROV-04	SO-216-027	Snowcap/Tsukushi	2011-06-29	5:06:00 AM	S 03°43.68515'	E 151°43.66931'	306	-1647	ROV-KIPS	KIPS-6,high CO2, little H2S, little methane, pH5.8? --> no sample from bottle (only seawater)
027-ROV-05	SO-216-027	Snowcap/Tsukushi	2011-06-29	5:12:00 AM	S 03°43.68544'	E 151°40.15980'	306	-1647	ROV-KIPS	KIPS-5, close to KIPS-6; KIPS is clogged --> no sample from bottle (only seawater)
029-ROV-01	SO-216-029	Fenway area	2011-06-30	3:17:00 AM	S 03°43.72041'	E 151°40.33271'	307	-1715	ROV-IGT	IGT-3; T const. @303°C, max. 304°C; popped out at the very end when bottle was closing
029-ROV-02	SO-216-029	Fenway area	2011-06-30	3:25:00 AM	S 03°43.72091'	E 151°40.33233'	307	-1714	ROV-IGT	IGT-7, T very stable between 303 and 304°C, T dropped to 270°C when bottle closed
029-ROV-05	SO-216-029	Fenway area	2011-06-30	6:20:00 AM	S 03°43.69735'	E 151°40.34281'	307	-1707	ROV-KIPS	KIPS-7; above snails with white shell, pH6.3, H2S in uM range, CH4, H2
029-ROV-06	SO-216-029	Fenway area	2011-06-30	6:24:00 AM	S 03°43.69772'	E 151°40.34889'	307	-1708	ROV-KIPS	KIPS-6;
029-ROV-07	SO-216-029	Fenway area	2011-06-30	6:28:00 AM	S 03°43.69818'	E 151°40.34316'	307	-1708	ROV-KIPS	KIPS-8; pH6.2
029-ROV-08	SO-216-029	Fenway area	2011-06-30	7:08:00 AM	S 03°43.69666'	E 151°40.35021'	307	-1706	ROV-KIPS	KIPS-5;
029-ROV-09	SO-216-029	Fenway area	2011-06-30	7:12:00 AM	S 03°43.69671'	E 151°40.34872'	307	-1705	ROV-KIPS	KIPS-4;
029-ROV-10	SO-216-029	Fenway area	2011-06-30	7:15:00 AM	S 03°43.69708'	E 151°40.35058'	307	-1706	ROV-KIPS	KIPS-3; failure --> repositioning, new sample in KIPS-3
029-ROV-11	SO-216-029	Fenway area	2011-06-30	7:23:00 AM	S 03°43.69709'	E 151°40.35079'	307	-1706	ROV-KIPS	KIPS-2;
029-ROV-12	SO-216-029	Fenway area	2011-06-30	7:26:00 AM	S 03°43.69732'	E 151°40.35017'	307	-1706	ROV-KIPS	KIPS-1; pH6.8
029-ROV-13	SO-216-029	Fenway area	2011-06-30	7:31:00 AM	S 03°43.69787'	E 151°40.34970'	307	-1705	ROV-KIPS	KIPS-8; filter
031-ROV-01	SO-216-031	Fenway area	2011-07-01	3:13:00 AM	S 03°43.72726'	E 151°40.33423'	308	-1717	ROV-KIPS	KIPS-7, over chimney
031-ROV-02	SO-216-031	Fenway area	2011-07-01	3:17:00 AM	S 03°43.72798'	E 151°40.33352'	308	-1717	ROV-KIPS	KIPS-6 (ISMS signal is slightly weaker)
031-ROV-03	SO-216-031	Fenway area	2011-07-01	5:14:30 AM	S 03°43.61157'	E 151°40.32330'	308	-1692	ROV-KIPS	KIPS-5; at white flange with shimmering water, pH5.2-5.0
031-ROV-04	SO-216-031	Fenway area	2011-07-01	5:17:50 AM	S 03°43.61211'	E 151°40.32110'	308	-1692	ROV-KIPS	KIPS-4; at white flange with shimmering water, pH5.2-5.0
031-ROV-05	SO-216-031	Fenway area	2011-07-01	5:24:45 AM	S 03°43.61146'	E151°40.32131'	308	-1692	ROV-KIPS	KIPS-3;over snails on top of flange
031-ROV-06	SO-216-031	Fenway area	2011-07-01	5:34:30 AM	S 03°43.61253'	E 151°40.32133'	308	-1692	ROV-KIPS	KIPS-8; filter
031-ROV-11	SO-216-031	Fenway area	2011-07-01	7:15:00 AM	S 03°43.61305'	E 151°40.32172'	308	-1689	ROV-IGT	IGT-3; T up to 270°C
031-ROV-12	SO-216-031	Satanic Mills	2011-07-01	7:21:00 AM	S 03°43.61313'	E 151°40.32317'	308	-1688	ROV-IGT	IGT-7; T up to 345°C
031-ROV-14	SO-216-031	Fenway area	2011-07-01	8:19:20 AM	S 03°43.58493'	E 151°40.31898'	308	-1688	ROV-KIPS	KIPS-2; over snail patch, Alviniconcha
031-ROV-15	SO-216-031	Fenway area	2011-07-01	8:23:25 AM	S 03°43.58524'	E 151°40.31808'	308	-1687	ROV-KIPS	KIPS-1; over snail patch, Alviniconcha

Appendix C2: Fluids Master SO-216

Sample #	Station	Location	Date	Time (UTC)	Latitude	Longitude	Dive #	Depth (m)	Type	Comments
031-ROV-16	SO-216-031	Fenway area	2011-07-01	8:28:35 AM	S 03°43.58704'	E 151°40.31803'	308	-1687	ROV-KIPS	KIPS-9; filter; stopped pump for 1 minute
035-CTD-01	SO-216-035	eastern Manus Basin	2011-07-02	4:28:00 AM	S 03°47.00200'	E 151°40.45000'		-2091	CTD	water samples
037-ROV-01	SO-216-037	Roman Ruins	2011-07-03	3:32:00 AM	S 03°43.02864'	E 151°40.36512'	309	-1774	ROV-IGT	IGT-7 (IGT-3 failed); T const at 348°C
037-ROV-03	SO-216-037	Roman Ruins	2011-07-03	4:34:15 AM	S 03°43.02990'	E 151°40.36494'	309	-1774	ROV-KIPS	KIPS-8; pH6.8
037-ROV-04	SO-216-037	Roman Ruins	2011-07-03	4:38:20 AM	S 03°43.02984'	E 151°40.36548'	309	-1773	ROV-KIPS	KIPS-6; pH6.7, higher CO2 than KIPS-8
037-ROV-06	SO-216-037	Roman Ruins	2011-07-03	8:11:15 AM	S 03°43.23792'	E 151°40.51848'	309	-1686	ROV-KIPS	KIPS-5; pH6.9 dropping, CO2?
037-ROV-07	SO-216-037	Roman Ruins	2011-07-03	8:14:45 AM	S 03°43.23798'	E 151°40.52022'	309	-1685	ROV-KIPS	KIPS-4; ph7.0, tiny H2S?
037-ROV-08	SO-216-037	Roman Ruins	2011-07-03	8:18:30 AM	S 03°43.23708'	E 151°40.51992'	309	-1685	ROV-KIPS	KIPS-3
037-ROV-10	SO-216-037	Roman Ruins	2011-07-03	8:45:11 AM	S 03°43.23834'	E 151°40.51878'	309	-1685	ROV-KIPS	KIPS-7; filter, pH7.1 (due to higher pump rate)
039-ROV-02	SO-216-039	Roman Ruins	2011-07-04	3:45:00 AM	S 03°43.27212'	E 151°40.47330'	310	-1679	ROV-IGT	IGT-3; T between 270 and 334°C, mostly 310-320°C
039-ROV-03	SO-216-039	Roman Ruins	2011-07-04	3:55:00 AM	S 03°43.27224'	E 151°40.47132'	310	-1680	ROV-IGT	IGT-7; T between 310 and 320°C; nozzle came out twice during sampling; chimney collapsed
041-ROV-02	SO-216-041	Fenway area	2011-07-05	5:15:00 AM	S 03°43.70940'	E 151°40.34580'	311	-1714	ROV-IGT	IGT-3; T@ 313°C steady, black smoker fluid, pefect sampling
041-ROV-03	SO-216-041	Fenway area	2011-07-05	5:25:00 AM	S 03°43.70976'	E 151°40.34448'	311	-1714	ROV-IGT	IGT-7; T@ 313°C steady, not sure if bottle closed --> it did close
041-ROV-06	SO-216-041	Fenway area	2011-07-05	6:45:50 AM	S 03°43.72734'	E 151°40.32942'	311	-1715	ROV-KIPS	KIPS-8; H2S mmol, CO2 increasing, little methane, acetic acid; pH4.5
041-ROV-07	SO-216-041	Fenway area	2011-07-05	6:49:40 AM	S 03°43.72704'	E 151°40.32864'	311	-1714	ROV-KIPS	KIPS-7; pH4.5, no change in chemistry (compared to KIPS-8)
041-ROV-09	SO-216-041	Fenway area	2011-07-05	7:37:20 AM	S 03°43.73076'	E 151°40.33692'	311	-1716	ROV-KIPS	KIPS-6; on small mound with Paralvinella, pH5.8; Posidonia is weak!
041-ROV-10	SO-216-041	Fenway area	2011-07-05	7:41:20 AM	S 03°43.72956'	E 151°40.33506'	311	-1715	ROV-KIPS	KIPS-5; H2S + CO2, pH5.8; Posidonia is weak
041-ROV-11	SO-216-041	Fenway area	2011-07-05	7:45:20 AM	S 03°43.73136'	E 151°40.33086'	311	-1716	ROV-KIPS	KIPS-4; no change in chemistry (cp. to KIPS-5); followed by ISMS over Alviniconcha
041-ROV-13	SO-216-041	Fenway area	2011-07-05	8:25:20 AM	S 03°43.72968'	E 151°40.32990'	311	-1715	ROV-KIPS	KIPS-3; pH4.4, umol H2S, CO2 high, some methane
041-ROV-14	SO-216-041	Fenway area	2011-07-05	8:28:45 AM	S 03°43.72974'	E 151°40.32984'	311	-1715	ROV-KIPS	KIPS-2; slightly lower pump rate; additional acetic acid
041-ROV-15	SO-216-041	Fenway area	2011-07-05	8:32:15 AM	S 03°43.72998'	E 151°40.32912'	311	-1715	ROV-KIPS	KIPS-1; no change in chemistry; pH4.3
043-ROV-01	SO-216-043	Fenway area	2011-07-06	1:06:00 AM	S 03°43.60914'	E 151°40.32528'	312	-1688	ROV-IGT	IGT-3; fluid from small black smoker, Tmx= 291°C, T= 250-290°C during sampling
043-ROV-02	SO-216-043	Fenway area	2011-07-06	1:34:00 AM	S 03°43.60950'	E 151°40.32492'	312	-1689	ROV-IGT	IGT-7; fluid from same structure as 043-ROV-01; Tmx= 339°C steady during sampling
043-ROV-03	SO-216-043	Fenway area	2011-07-06	2:20:20 AM	S 03°43.61646'	E 151°40.32468'	312	-1691	ROV-KIPS	KIPS-8; over crack at Satanic Mills; pH5.2, CO2, H2S, no CH4, no H2; Tmax=21.6°C
043-ROV-04	SO-216-043	Fenway area	2011-07-06	2:25:42 AM	S 03°43.61514'	E 151°40.32468'	312	-1689	ROV-KIPS	KIPS-7; pH5.1-5.3, after sampling repositioning; Tmax=21.6°C
043-ROV-05	SO-216-043	Fenway area	2011-07-06	2:32:50 AM	S 03°43.61574'	E 151°40.32402'	312	-1690	ROV-KIPS	KIPS-9 (filter); pH ??? to 5, ????????; Tmax=21.6
043-ROV-12	SO-216-043	Fenway area	2011-07-06	8:46:15 AM	S 03°43.68774'	E 151°40.16244'	312	-1647	ROV-KIPS	KIPS-6; over Alviniconcha snailsM low H2S, pH 6.0 decreasing; at marker #6 site, snowcap
043-ROV-13	SO-216-043	Fenway area	2011-07-06	8:50:15 AM	S 03°43.68726'	E 151°40.16220'	312	-1647	ROV-KIPS	KIPS-5; same location as 043-ROV-12; pH stable at 5.7
043-ROV-14	SO-216-043	Fenway area	2011-07-06	8:54:00 AM	S 03°43.68744'	E 151°40.16256'	312	-1648	ROV-KIPS	KIPS-4; pH5.6; littel H2S, little CO2?
045-ROV-01	SO-216-045	North Su	2011-07-07	6:09:00 AM	S 03°47.99772'	E 152°06.05286'	313	-1154	ROV-IGT	IGT-3; T= 314°C, very stable
045-ROV-02	SO-216-045	North Su	2011-07-07	6:09:00 AM	S 03°47.99772'	E 152°06.05286'	313	-1154	ROV-IGT	IGT-7; T= 312°C, snorkel popped out during sampling, seawater entrainment
045-ROV-05	SO-216-045	North Su	2011-07-07	7:33:05 AM	S 03°47.99760'	E 152°06.05640'	313	-1155	ROV-KIPS	KIPS-6; pH3.6, lots of H2S, little CH4 + acetic acid
045-ROV-06	SO-216-045	North Su	2011-07-07	7:37:25 AM	S 03°47.99862'	E 152°06.05712'	313	-1155	ROV-KIPS	KIPS-5; values stable
045-ROV-07	SO-216-045	North Su	2011-07-07	7:40:58 AM	S 03°47.99898'	E 152°06.05628'	313	-1155	ROV-KIPS	KIPS-4; values stable
045-ROV-08	SO-216-045	North Su	2011-07-07	7:44:29 AM	S 03°47.99802'	E 152°06.05730'	313	-1155	ROV-KIPS	KIPS-3; values stable
045-ROV-09	SO-216-045	North Su	2011-07-07	7:47:59 AM	S 03°47.99832'	E 152°06.05664'	313	-1155	ROV-KIPS	KIPS-2; all values stable; + acidic (?acetic?) acid
045-ROV-10	SO-216-045	North Su	2011-07-07	7:51:24 AM	S 03°47.99802'	E 152°06.05628'	313	-1155	ROV-KIPS	KIPS-1; all values stable; + acidic (?acetic?) acid
045-ROV-12	SO-216-045	North Su	2011-07-07	9:13:00 AM	S 03°47.95728'	E 152°06.08298'	313	-1200	ROV-KIPS	KIPS-8
047-ROV-03	SO-216-047	North Su	2011-07-08	5:10:00 AM	S 03°48.03906'	E 152°06.01752'	314	-1218	ROV-IGT	IGT-3; Tmax ca. 90°C, snorkel popped out
047-ROV-04	SO-216-047	North Su	2011-07-08	5:15:00 AM	S 03°48.03936'	E 152°06.01812'	314	-1218	ROV-IGT	IGT-7; Tmax ca. 100°C, little drift
047-ROV-05	SO-216-047	North Su	2011-07-08	5:30:30 AM	S 03°48.03828'	E 152°06.01686'	314	-1218	ROV-KIPS	KIPS-8; heading 42; ISMS nozzle is out of flow
047-ROV-06	SO-216-047	North Su	2011-07-08	5:34:30 AM	S 03°48.03984'	E 152°06.01722'	314	-1218	ROV-KIPS	KIPS-7; heading 42; ISMS nozzle is out of flow
047-ROV-07	SO-216-047	North Su	2011-07-08	5:38:45 AM	S 03°48.03846'	E 152°06.01746'	314	-1217	ROV-KIPS	KIPS-6; heading 42; ISMS nozzle is out of flow
047-ROV-08	SO-216-047	North Su	2011-07-08	6:24:40 AM	S 03°48.02760'	E 152°06.00882'	314	-1225	ROV-KIPS	KIPS-5; smoker in boulder fan next to ridge; abundant strong intense smoke
047-ROV-09	SO-216-047	North Su	2011-07-08	6:28:25 AM	S 03°48.02868'	E 152°06.00912'	314	-1224	ROV-KIPS	KIPS-4; smoker in boulder fan next to ridge; abundant strong intense smoke
047-ROV-10	SO-216-047	North Su	2011-07-08	6:32:40 AM	S 03°48.02904'	E 152°06.00902'	314	-1227	ROV-KIPS	KIPS-3; smoker in boulder fan next to ridge; abundant strong intense smoke
047-ROV-11	SO-216-047	North Su	2011-07-08	8:33:40 AM	S 03°47.99130'	E 152°06.02862'	314	-1188	ROV-KIPS	KIPS-2; T shows too low values
047-ROV-12	SO-216-047	North Su	2011-07-08	8:38:00 AM	S 03°47.99202'	E 152°06.02868'	314	-1188	ROV-KIPS	KIPS-1; no acetic acid; high H2S + CO2
049-ROV-01	SO-216-049	Solwara 8 / Fenway	2011-07-09	1:55:00 AM	S 03°43.83090'	E 151°40.45206'	315	-1740	ROV-IGT	IGT-3; stable 305°C max T; brief snorkel popout
049-ROV-02	SO-216-049	Solwara 8 / Fenway	2011-07-09	1:58:00 AM	S 03°43.83096'	E 151°40.45170'	315	-1740	ROV-IGT	IGT-7; stable 305°C max T; no popout
049-ROV-04	SO-216-049	Solwara 8 / Fenway	2011-07-09	4:23:20 AM	S 03°43.72764'	E 151°40.33230'	315	-1715	ROV-KIPS	KIPS-8; on mound with abundant paralvinella; pH6.3; Tmax 16.8 before KIPS
049-ROV-08	SO-216-049	Solwara 8 / Fenway	2011-07-09	5:31:00 AM	S 03°43.69674'	E 151°40.35114'	315	-1705	ROV-KIPS	KIPS-7; 3.5°C; near SymC 11 & 12
049-ROV-11	SO-216-049	Solwara 8 / Fenway	2011-07-09	6:09:38 AM	S 03°43.69800'	E 151°40.34562'	315	-1709	ROV-KIPS	KIPS-6; on top of white snails; sulfide ca. 200uM; nothing else; pH6.3; Tmax 14.3°C
049-ROV-14	SO-216-049	Solwara 8 / Fenway	2011-07-09	6:35:00 AM	S 03°43.69602'	E 151°40.35714'	315	-1705	ROV-KIPS	KIPS-5; on crust next to SymC-8; Tmax 3.1°C
051-ROV-02	SO-216-051	North Su	2011-07-10	12:18:10 AM	S 03°47.99700'	E 152°06.05616'	316	-1154	ROV-KIPS	KIPS-8; very high CO2, H2S, CH4, pH ca. 2.9; pump is fine
051-ROV-03	SO-216-051	North Su	2011-07-10	12:22:10 AM	S 03°47.99730'	E 152°06.05778'	316	-1155	ROV-KIPS	KIPS-6; pH3.2
051-ROV-04	SO-216-051	North Su	2011-07-10	12:59:45 AM	S 03°47.97024'	E 152°06.08976'	316	-1181	ROV-KIPS	KIPS-9; filtering twice restarted
051-ROV-07	SO-216-051	North Su	2011-07-10	6:42:30 AM	S 03°48.04230'	E 152°06.05292'	316	-1193	ROV-KIPS	KIPS-5; pH2.2 --> pH2.1
051-ROV-08	SO-216-051	North Su	2011-07-10	6:46:30 AM	S 03°48.04212'	E 152°06.05268'	316	-1193	ROV-KIPS	KIPS-4; pH2.2; slightly weaker pumping, clogged?
051-ROV-11	SO-216-051	North Su	2011-07-10	9:25:00 AM	S 03°48.03294'	E 152°06.03528'	316	-1202	ROV-IGT	IGT-3; max T 79°C, snorkel popped out --> bad sample
051-ROV-12	SO-216-051	North Su	2011-07-10	9:45:00 AM	S 03°48.02982'	E 152°06.01614'	316	-1220	ROV-IGT	IGT-7; ca. 5-10m west of IGT-3 in non-bubbling white smoker; max T 104°C; 20-104°C sample
053-ROV-04	SO-216-053	Solwara 6 area	2011-07-11	8:00:00 AM	S 03°43.24200'	E 151°40.49436'	317	-1680	ROV-IGT	IGT-3; max T 329°C; sample 260-300°C; bad oriice
053-ROV-05	SO-216-053	Solwara 6 area	2011-07-11	8:20:00 AM	S 03°43.24380'	E 151°40.49382'	317	-1680	ROV-IGT	IGT-7; max T 325°C; sample 310-320°C stable
057-CTD	SO-216-057	North Su	2011-07-12	4:36:00 AM	S 03°48.01800'	E 152°06.05900'		-1166	CTD	seawater samples

Appendix C3: Biologic Samples Master SO-216										
Sample #	Station	Location	Date	Time (UTC)	Latitude	Longitude	Quest dive #	Depth (m)	Type	Comments
012-ROV-04	SO-216-012	North Su	2011-06-22	6:06:25 AM	S 03°47.95480'	E 152°06.08891'	297	-1198	ROV	Ifremeria nautilii
015-GTV	SO-216-015	North Su	2011-06-23	7:07:05 AM	S 03°48.09300'	E 152°06.11760'		-1230	GTV	Munidopsis + Shrimp
017-ROV	SO-216-017	North Su	2011-06-24				299		ROV	Munidopsis; no Lat/Long and time
021-ROV-02	SO-216-021	North Su	2011-06-26	2:20:00 AM	S 03°47.94980'	E 152°06.08510'	302	-1202	ROV	cotton net with snails (Ifremeria) and mussels (matching)
021-ROV-03	SO-216-021	North Su	2011-06-26	3:15:00 AM	S 03°47.95025'	E 152°06.08254'	302	-1200	ROV	plastic net with Alviniconchia snails + some Ifremeria + rocks
025-ROV-05	SO-216-025	Fenway	2011-06-28	6:36:00 AM	S 03°43.69873'	E 151°40.34356'	305	-1703	ROV	net with snails; pH7.4, sulfide, CO2, no methane, no hydrogen
027-ROV-07	SO-216-027	Snowcap/Tsukushi	2011-06-29	6:02:00 AM	S 03°43.68445'	E 151°40.15876'	306	-1647	ROV	bionet with snails
029-ROV-03	SO-216-029	Fenway area	2011-06-30	5:11:00 AM	S 03°43.69861'	E 151°40.34678'	307	-1706	ROV	net with white Ifremeria and mussels
029-ROV-04	SO-216-029	Fenway area	2011-06-30	5:56:00 AM	S 03°43.69796'	E 151°40.34429'	307	-1708	ROV	net with brown Ifremeria and mussels
029-ROV-14	SO-216-029	Fenway area	2011-06-30	8:25:00 AM	S 03°43.69790'	E 151°40.34868'	307	-1706	ROV	bionet with crabs
031-ROV-07	SO-216-031	Fenway area	2011-07-01	5:59:00 AM	S 03°43.61294'	E 151°40.32281'	308	-1691	ROV	sampling with brush
031-ROV-09	SO-216-031	Fenway area	2011-07-01	6:14:00 AM	S 03°43.61343'	E 151°40.32141'	308	-1692	ROV	net with Alvinichonchae
037-ROV-09	SO-216-037	Roman Ruins	2011-07-03	8:37:00 AM	S 03°43.23888'	E 151°40.51998'	309	-1685	ROV	net with snails + one crab
039-ROV-05	SO-216-039	Roman Ruins	2011-07-04	8:28:00 AM	S 03°43.69902'	E 151°40.34598'	310	-1707	ROV	net with snails (white)
039-ROV-06	SO-216-039	Roman Ruins	2011-07-04	9:13:14 AM	S 03°43.70010'	E 151°40.34376'	310	-1707	ROV	net, 2nd snail patch
041-ROV-12	SO-216_041	Fenway area	2011-07-05	8:04:00 AM	S 03°43.73250'	E 151°40.32732'	311	-1715	ROV	bionet with altered rock (clay) + fauna
043-ROV-06	SO-216-043	Fenway area	2011-07-06	3:34:00 AM	S 03°43.61598'	E 151°40.32426'	312	-1690	ROV	tube worms
043-ROV-08	SO-216-043	Fenway area	2011-07-06	5:40:00 AM	S 03°43.68258'	E 151°40.34412'	312	-1707	ROV	Ifremeria from "dead" patch
043-ROV-09	SO-216-043	Fenway area	2011-07-06	6:00:00 AM	S 03°43.68276'	E 151°40.34514'	312	-1706	ROV	small provamnid (???) snails
043-ROV-15	SO-216-043	Fenway area	2011-07-06	9:04:00 AM	S 03°43.68696'	E 151°40.16310'	312	-1648	ROV	Alviniconcha
045-ROV-03	SO-216-045	North Su	2011-07-07	6:55:00 AM	S 03°47.99760'	E 152°06.05700'	313	-1151	ROV	1st symcatcher (No. 5?)
045-ROV-04	SO-216-045	North Su	2011-07-07	7:00:00 AM	S 03°47.99808'	E 152°06.05670'	313	-1154	ROV	2nd symcatcher
045-ROV-10	SO-216-045	North Su	2011-07-07	9:01:00 AM	S 03°47.95692'	E 152°06.08202'	313	-1200	ROV	Petra's experiment from close to marker 17
045-ROV-13	SO-216-045	North Su	2011-07-07	9:40:00 AM	S 03°47.95578'	E 152°06.09222'	313	-1199	ROV	symcatcher #9
045-ROV-14	SO-216-045	North Su	2011-07-07	9:55:00 AM	S 03°47.95794'	E 152°06.09090'	313	-1198	ROV	symcatcher #7
047-ROV-01	SO-216-047	North Su	2011-07-08	12:35:00 AM	S 03°47.95608'	E 152°06.09714'	314	-1198	ROV	Ifremeria + mussels + rock with small tubeworms
047-ROV-02	SO-216-047	North Su	2011-07-08	2:15:00 AM	S 03°47.96586'	E 152°06.08964'	314	-1187	ROV	white Ifremeria + Alviniconchia
049-ROV-05	SO-216-049	Solwara 8 / Fenway	2011-07-09	4:32:40 AM	S 03°43.72812'	E 151°40.33314'	315	-1716	ROV	bionet with paralvinella
049-ROV-06	SO-216-049	Solwara 8 / Fenway	2011-07-09	5:13:00 AM	S 03°43.69770'	E 151°40.34826'	315	-1706	ROV	SymCatcher-1; Tmax 3.4°C (?)
049-ROV-07	SO-216-049	Solwara 8 / Fenway	2011-07-09	5:15:00 AM	S 03°43.69746'	E 151°40.34862'	315	-1706	ROV	SymCatcher-6; Tmax 3.4°C (?)
049-ROV-09	SO-216-049	Solwara 8 / Fenway	2011-07-09	5:42:00 AM	S 03°43.69674'	E 151°40.35114'	315	-1707	ROV	SymCatcher-11
049-ROV-10	SO-216-049	Solwara 8 / Fenway	2011-07-09	5:47:00 AM	S 03°43.69716'	E 151°40.35126'	315	-1706	ROV	SymCatcher-12
049-ROV-12	SO-216-049	Solwara 8 / Fenway	2011-07-09	6:16:00 AM	S 03°43.69824'	E 151°40.34706'	315	-1710	ROV	SymCatcher-5; Tmax 14.3°C
049-ROV-13	SO-216-049	Solwara 8 / Fenway	2011-07-09	6:19:00 AM	S 03°43.69884'	E 151°40.34664'	315	-1709	ROV	SymCatcher-3; Tmax 14.3°C
049-ROV-15	SO-216-049	Solwara 8 / Fenway	2011-07-09	6:47:00 AM	S 03°43.69596'	E 151°40.35756'	315	-1704	ROV	SymCatcher-8; Tmax 3.1°C
051-ROV-01	SO-216-051	North Su	2011-07-10	12:07:00 AM	S 03°47.99694'	E 152°06.05640'	316	-1155	ROV	retrieved incubation experiment
051-ROV-05	SO-216-051	North Su	2011-07-10	1:59:00 AM	S 03°47.97210'	E 152°06.08988'	316	-1180	ROV	scoop net with Ifremeria snails + rocks
051-ROV-06	SO-216-051	North Su	2011-07-10	3:09:00 AM	S 03°47.95380'	E 152°06.08556'	316	-1199	ROV	scoop net with Alviniconcha

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