MARIA S. MERIAN-Berichte

TRISTAN: Electromagnetic, gravimetric and seismic measurements to investigate the Tristan da Cunha hot spot and its role in the opening of the South-Atlantic.

Cruise No. MSM20/2

January 17, 2012 – February 15, 2012
Walvis Bay (Namibia) – Recife (Brazil)

M. Jegen, W. Geissler, M. Maia, K. Baba, H. Kirk

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1 Summary

According to classical plume theory, the Tristan da Cunha hotspot is thought to have played a major role in the rifting of the South Atlantic margins and the creation of the aseismic Walvis Ridge by impinging at the base of the continental lithosphere shortly before or during the breakup of the South Atlantic margins. But Tristan da Cunha is enigmatic, as it cannot be clearly identified as a hot-spot but classifies also highly as a more shallow type of anomaly that may actually have been caused by the opening of the South Atlantic. The equivocal character of Tristan is largely due to lack of geophysical data in this region. To understand the tectonic processes of the opening of the South Atlantic, the formation of the Walvis ridge and to understand whether Tristan da Cunha is the cause or the consequence of rifting, it is of central importance to characterize the region around Tristan da Cunha in a more coherent way. Within this research cruise we deployed 26 ocean bottom electromagnetic stations (OEBM) and 24 ocean bottom seismometer (OBS) for a long term acquisition (1 year) of magnetotelluric and seismological data, acquired bathymetry and gravity data and performed geological sampling on Tristan da Cunha. The data will be interpreted in the context of geochemical data and tectonic models developed within the SPP1375, **S**outh **A**tlantic **M**argin **P**rocesses and **L**inks with onshore **E**volution (SAMPLE).

Zusammenfassung

Nach klassischer Plume-Theorie wird dem Auftreffen des Tristan da Cunha Hotspots eine zentrale Rolle im Aufbruch des Süd-Atlantiks und bei der Kreation des aseismischen Walvis Rücken zugeschrieben. Jedoch konnte Tristan da Cunha bis heute nicht zweifelsfrei als Hotspot identifiziert werden. Andere Studien gehen davon aus, dass es sich bei Tristan da Cunha eher um eine flachere Anomalie handelt, die sich als Konsequenz des Aufbruchs des Kontinents entwickelt hat. Die zweifelhafte Rolle Tristan da Cunha ist auch dem Mangel an geophysikalischen Daten in dieser Region zuzuschreiben. Um die Dynamik des Aufbruchs des Süd- Atlantik besser verstehen zu können und um abzuklären, ob Tristan da Cunha die Ursache oder Konsequenz des Aufbruchs ist, ist es von zentraler Bedeutung, die Region um Tristan da Cunha genauer zu untersuchen. Im Rahmen dieser Ausfahrt wurden deshalb 26 OBEM und 24 OBS Stationen für eine einjährige Aufzeichnung von magnetotellurischen und seismologischen Daten, bathymetrische und gravimetrische Daten aufgenommen sowie eine geologische Beprobung der Insel Tristan da Cunha durchgeführt. Die Daten werden im Rahmen des Schwerpunktprogramms SPP1375 SAMPLE (**S**outh **A**tlantic **M**argin **P**rocesses and **L**inks with onshore **E**volution) im Kontext mit geochemischen und tektonischen Modellen interpretiert.

2 Participants

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Dr. Jegen, Marion	Marine Geophysics / Chief Scientist	GEOMAR
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WSP:	Southafrican Coastal Engineering Company
LIEBHERR:	Crane Manufacturing Company, Nenzing, Austria

3 Research Program

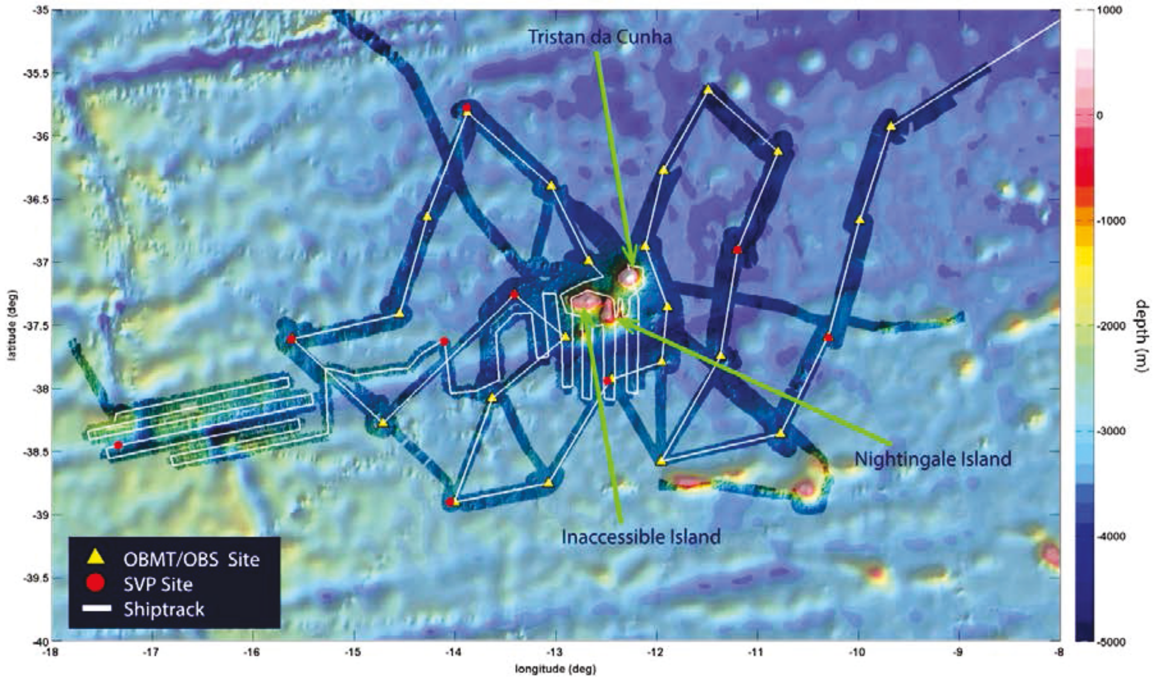

Fig. 3.1 Track chart of R/V MARIA S. MERIAN Cruise M17/2. Bathymetry from Smith and Sandwell (1997).

The research program on Tristan da Cunha comprised geophysics and geochemistry.

Geophysics:

Two characteristics of a mantle plume are an increase in temperature and the presence of partial melt in the mantle region. Elevated temperatures lower the seismic velocity, density and decrease the electrical resistivity (Constable, 1993, Duba 1993, Schmeling, 1985a and Schmeling 1986). The same is true for the presence of partial melt. Important complementary information in seismic velocity and electrical resistivity exist to identify these areas. While seismic velocities in the partial melt zone mainly depend on the melt fraction, the electric resistivity in turn depends on the melt fraction, and the connectivity of the partial melt, such that a joint interpretation of data would make the determination of both the fraction of melting and connectivity of the partial melt possible. As the fraction of melting, and the connectivity of strongly buoyant melt in particular, determine the dynamics of the system, the knowledge of these factors is of outmost importance for the understanding of the dynamics of the system as a whole. The sampling of the anomaly at mantle depth requires the use of passive electromagnetic and seismic methods and the acquisition of marine gravity data. A planned active source seismic experiment had unfortunately to be cancelled due to lack of funding. Accordingly, we modified the initially planned layout of the OBS along profiles towards a grid structure, which better accommodated the 3D seismological aspect and MT data acquisition. To capture sufficient earthquakes as well as acquire sufficiently low frequency electromagnetic data, the OBEM and OBS stations were deployed for a long-term data acquisition

of 1 year. Altogether 26 OBMT (18 from GEOMAR and 8 from University of Tokyo) and 24 OBS (AWI) were deployed in a region of approximately 500 km x 500 km to capture the potential plume. Additionally two seismic and one MT land stations on the neighbouring uninhabited Nightingale Island were installed for the same period of time. The land stations are on loan from the German geophysical instrumentation pool at the Geoforschungszentrum Potsdam. The recovery of all stations is planned for January/February 2013 during a second MARIA S. MERIAN Cruise.
For gravimetric measurements a marine gravimeter of the type KSS-32-M by the Bodensee Gravimeter System has been implemented on MARIA S. MERIAN and been operated during the cruise.
The geophysical data acquisition is accompanied by bathymetric data acquisition in an effort to map seafloor expressions of the volcanic hot-spot activity. Due to the extra days of ship time available after the active source seismic experiment had to be cancelled, we intensified our bathymetric mapping towards a region south of Nightingale, along the Tristan da Cunha fracture zone and towards the ridge and furthermore included geochemical investigations in our scientific work plan.

Geochemistry:
The objective of onshore sampling of the main island of the Tristan da Cunha archipelago was to obtain lava samples suitable for (1) extraction of noble gases for a study of the isotopic composition of He and Ne, and (2) investigation of geochemical diversity of parental magmas by means of microprobe studies of early olivine and pyroxene phenocrysts, and olivine-hosted melt inclusions.

4 Narrative of the Cruise

January 17th:
We left the port of Walvis Bay at around 9AM local time to start our research cruise towards Tristan da Cunha. During the first days of the transit, the unpacking of gear in the different laboratories began and the instruments checked for proper electronic functioning and damage from transit.

January 18th:

Still on transit to working area. Acquisition of sound velocity profile:

18/01	07:45	25° 23.515’ S	010° 07.038’ E	1800 m

January 19th:

Acquisition of sound velocity profile:

19/01	07:43	28° 00.434’ S	005° 23.569’ E	1800 m

To test the functionality of the releaser, all releasers for the OBEM and OBS stations were tested. The test consisted of tying closed releasers in a wire box (OBS) and SPUTNIK electromagnetic source (OBEM), lowering the contraptions to 3000 m, sending an open release signal to each releaser and checking whether the release hook has opened once the releasers were back on deck.

January 20th:

Acquisition of sound velocity profile:

20/01	07:54	29° 49.717' S	002° 01.285' E	600 m

Bathymetric reading reduced from about 4000m to 1500 m, as we joined up with Walvis Ridge, a volcanic mountain chain produced by the Tristan Hot-Spot, which connects Africa with Tristan da Cunha.

January 21st:

Acquisition of sound velocity profile:

21/01	09:33	32° 05.081' S	002° 13.607' W	800 m

January 22nd:

We have reached the investigation area. The first deployment of OBEM (TRIS01) and OBS (TDC01) stations took place between 22:30 and 22:45 UTC.

January 23th:

Deployment of three OBS stations (TDC02, TDC03, and TDC04) and OBEM stations (TRIS02-G, TRIS03-G, TRIS04-T).

Fig. 4.1 First sighting of Tristan da Cunha, late afternoon on January 24th.

January 24th:
Deployment of five OBS stations (TDC05 to TDC09) and five OBEM stations (TRIS05-G, TRIS06-G, TRIS07-G, TRIS08-T and TRIS09-G) and first sighting of Tristan da Cunha (see figure 4.1)

January 25th:
In the morning, the immigration officer of Tristan da Cunha was picked up at Tristan Island and ferried to R/V MARIA S. MERIAN by our first officer and immigration formalities were taken care of for the researchers and crew. Captain R. Schmidt, first engineer A. Schüler, chief scientist Marion Jegen and co-chief scientist Wolfram Geissler then left with the officer to Tristan and met the UK governor Sean Burns and the Tristan Island Council to organize the land expedition to

Nightingale Island where land seismic and magnetotelluric stations were to be installed. For the land operation, Tristanians offered the use of two of their local ships to ferry the equipment from Tristan to Nightingale Island. The land expedition to Nightingale was to be accompanied by three Tristanians. M. Jegen and W.Geissler furthermore visited the local geomagnetic observatory on Tristan da Cunha.

Fig. 4.2 RV MARIA S. MERIAN in front of Tristan da Cunha.

Upon return on the MARIA S. MERIAN, two geologists, Dr. I. Vexler and Dr. J. Kleiding were ferried to Tristan da Cunha accompanied by C. Rannou to collect samples for the geochemical analysis for the coming 5 days. Furthermore, our passenger engineers, G. Kapp, M.Retief and D. Madlener left for Tristan da Cunha to start their work on the Tristan's harbor fortification.

Deployment of three OBS stations (TDC10 to TDC12) and four OBEM stations (TRIS11-T, TRIS12-G, TRIS13-T).

January 26th:

Deployment of four OBS stations (TDC14 to TDC17) and four OBEM stations (TRIS14-G, TRIS15-T, TRIS16-G, TRIS17-G).

January 27th:

Deployment of three OBS stations (TDC18 to TDC20) and three OBEM stations (TRIS18-G, TRIS19-T, TRIS20-G).

January 28th:

Deployment of four OBS stations (TDC21, TDC22, TDC23, TDC25) and five OBEM stations (TRIS21-T, TRIS22-G, TRIS23-G, TRIS24-T and TRSI25-G).

January 29th:

Deployment of last OBS station (TDC26) and OBEM station (TRIS26-G) and return to Tristan da Cunha. In exchange for the hospitality of the Tristanians, we invited them for a visit on the RV MARIA S. MERIAN in the afternoon. The offer was accepted by eleven Tristanians (including the governor Sean Burns and his wife). Marion Jegen, W. Geissler, Henning Kirk, Martin Wollatz-Vogt and Kioshi Baba were transferred then with the land station equipment to Tristan da Cunha from where the expedition to Nightingale was to be started early the following morning. In exchange, the geologist I. Vexel and J. Kleiding and C. Rannou returned from Tritsan da Cunha to RV MARIA S. MERIAN.

January 30th:
Land expedition: Equipment and scientists were ferried with two small Tristanian vessels onto Nightingale Island, which is the remenance of a former volcanic edifice. Due to the fact that there is no water source on the island and it is uninhibited, however, various huts have been erected by Tristanians as a summer holiday getaway. The only possible landing was flat rocks on the east shore of Nightingale. From there a trail leads into the island and the bird sanctuary on Nightingale. Nightingale Island is densely populated by birds, large colonies of rock hopper penguins, thrushes and albatross and is also the home of a large seal population. Along the trail, we installed two OBS land stations (see section 5.3) and one MT stations (see section 5.2) on the very day powered by solar panels. Installations were finished in the early evening and we spent the night in Tristanian hut (see figure 4.3).

The RV MARIA S. MERIAN crew and remaining scientists ferried to Tristan da Cunha to explore the island for one day (see figure 4.4). One of the tour organized by the Tristanians took the participants to the site of the volcanic eruption in 1961. At that time the eruption destroyed the only natural harbor and the lobster factory on the island and forced the Tristanians to evacuate to Great Britain. However, most of them returned within a few years to Tristan, where they constructed a new harbor and fish factory.

Fig. 4.3 Landing at the east shore of Nightingale (top left) and huts, in which we stayed overnight (top right). View on Nightingale and landing spot taken from one of the small fishing vessels that picked us up (bottom right) and of the vessel Edinburgh (bottom left), which ferried us back to Tristan (background bottom left).

In the late evening, after crew and scientists returned to RV MARIA S. MERIAN, bathymetric profiling mapping around Tristan continued in an effort to find the site of a 2004 underwater volcanic eruption. The eruption at the time caused tremors felt by Tristanians and a wash up of pumice a few days after the eruption on the eastern beaches of Tristan da Cunha.

January 31st:

Land expedition: In the morning of the next day, we checked that the stations are still running and then waited at the landing site to be picked up the Edinburgh, a lobster fishing boat in the area (see figure 4.3). Transfer to the vessel was achieved via small fishing boats belonging to the Edinburgh that are used to check the numerous lobster traps in the vicinity. We arrived back at Tristan in the late afternoon. Meanwhile the RV MARIA S. MERIAN continued its bathymetric mapping.

Fig. 4.4 View from the walk to the potato patches (top left), the site of the volcanic eruption (top right), inside of the fish factory (bottom left) and the harbor (bottom right).

February 1st:

The land expedition members were ferried back to RV MARIA S. MERIAN together with a much appreciated return gift by the Tristanians consisting of 50 fresh lobsters. During the day, a newly developed marine electromagnetic source called Sputnik was tested in the shallow water before Tristan.

In the evening, we started a closed bathymetric mapping on a site south of Nightingale, where in the previous mapping from January 30th/31st bathymetric readings seemed to deviate from satellite data. Within the region, we found indeed an edifice of a volcanic eruption (see figures 5.1.6 and 5.1.7).

February 2nd:

We continued our bathymetric mapping and left in the evening the working area towards the Mid-Atlantic Ridge. Our stay at Tristan da Cunha was suitable commemorated by a splendid lobster dinner, which were excellently prepared and presented by the cooks of RV MARIA S. MERIAN.

February 3rd:

Transit to Mid-Atlantic Ridge and bathymetric mapping along the Tristan Fracture zone.

February 4th:

Arrival at Mid-Atlantic Ridge in the early morning and start of a bathymetric mapping at the Mid-Atlantic Ridge from the south to the north across the intersection of the Tristan Fracture zone with the Mid-Atlantic Ridge. On February 4th at 16.25 W and 38.4 S a core complex structure could be identified (see figure 5.1.8).

February 5th and 6th:

Bathymetric mapping of Mid-Atlantic Ridge segment.

February 7th:

End of bathymetric mapping. After another test of Sputnik transmitter (see figure 4.5) we left the working area for transit to Recife, Brazil.

Fig. 4.5 Newly developed electromagnetic Sputnik transmitter which was undergoing last testing at the Mid-Atlantic Ridge.

February 9th:

Enjoyable day spent with a Barbeque on deck.

February 12th to 14th:

Packing and cleaning of lab space.

February 15th:
Arrival at Suape, Brazil. Gravimetric tie measurement at the pier in Suape.

Fig. 4.6 Scientific crew photo before arrival at Suape.

Another narrative of the cruise can be found in the Tristan and Isolde Blog on the GEOMAR website, which is also included as an attachment to this document.

5 Preliminary Results

5.1 Bathymetry

(Marcia Maia)

The echo sounder of MSM is an EM120 from Simrad-Konsberg with 191 beams mounted on the keel of the ship. Data was acquired almost continuously during the cruise, acquisition being interrupted during stations for deployments and for sound velocity profiles. The ship's speed varied from 13 kn during the transits and during the deployments to 8 kn during the surveys around Tristan da Cunha, the Tristan da Cunha Fracture Zone and the Mid-Atlantic Ridge. The quality of the data varied considerably during the cruise, being extremely noisy during the fast speed lines (see section Data Quality Evaluation). The maximum opening angle also varied during the cruise, being set to 56-56 for the fast speed lines and up to 64-64 for the slow speed survey lines, since most of the external beams were lost at fast speeds. This resulted in an extremely variable ratio width/depth for the swath.

Sound Velocity Profile

13 sound velocity profiles (SVP) were acquired during the cruise, 4 during the transit from Walvis Bay to the deployment area (figure 5.1.1), 7 on the deployment area and 2 near the Mid-Atlantic Ridge (MAR) (see figures 5.1.2 and 5.1.3). In the deployment area and at the MAR, the strategy for the choice of the SVP stations was geographical, trying to cover the area in a relatively homogeneous way. During the transit, we chose to perform one station/day. The sound velocity was measured with the help of a SVPlus from Applied Microsystems, which measures directly the sound speed every 1s during the deployment and stands up to 200 bar pressure (~2000 m depth).

Two casts reached 1800 m depth, the majority being between 800 to 1000 m where the strongest variations in the upper water layer occur. The instrument is deployed with the ship stopped, using a lateral winch the lowers it at a speed of 0.8m/s. Please refer to table in section 7 for a complete listing of SVP stations.

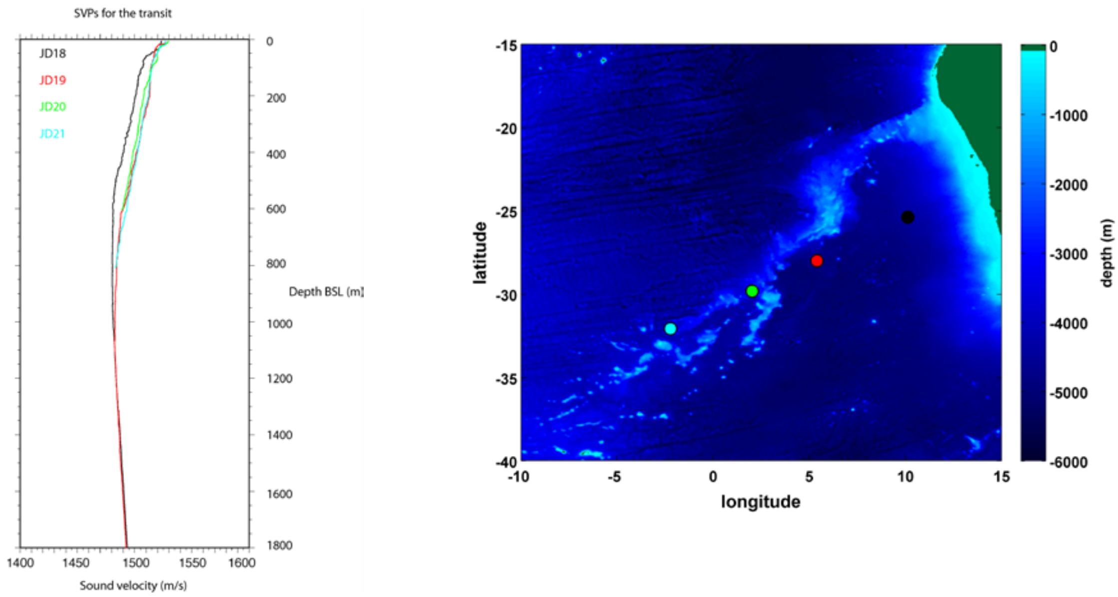

Fig. 5.1.1 Sound velocity profiles on transit from Walvis Bay to Tristan da Cunha.

The profiles made during the transit show strong variability between the first day, when we were still close to the coast and the following days, where the water column was more uniform. The two first casts went down to 1800 m but the profiles were identical for depths below 1000m. We thus chose to limit our casts to this depth for time reasons.

SV profiles around Tristan da Cunha, on the deployment area, show a large variability, especially between the north (JD24 and 28b) and the south and west. Significant differences exist for the depth range of 200 to 600 m, as well as in the upper layers. The profiles were entered in the sounder software according to the ship's location during this part of the mapping and during the following surveys.

Two additional SVPs were made during the survey one north of the Tristan da Cunha FZ and one near the axis of the MAR. These profiles were used together with the westernmost SVPs of the deployment area (JD26b and JD28b) to correct for the sound speed in this part of the survey. The main differences occur in the upper water layer and at greater depths (200 to 600 m) two groups can be distinguished: profiles JD28b and JD34 (03/02) and JD26b and JD36 (05/02).

The sound velocity was, as expected, very heterogeneous over the study area, probably due to mixing of water masses by strong currents at both the surface and at intermediate depths.

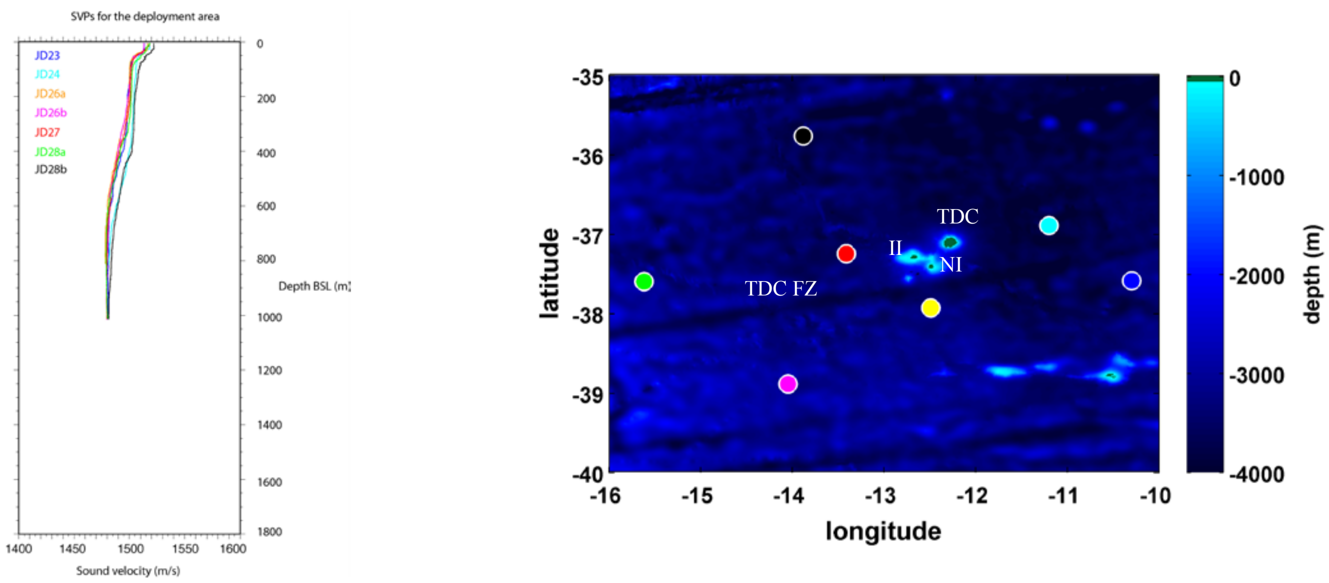

Fig. 5.1.2 Sound velocity profiles in deployment area around Tristan da Cunha (TDC), Nightingale Island (NI), Inaccessible Island (II) and Tristan da Cunha Fracture Zone (TDC FZ).

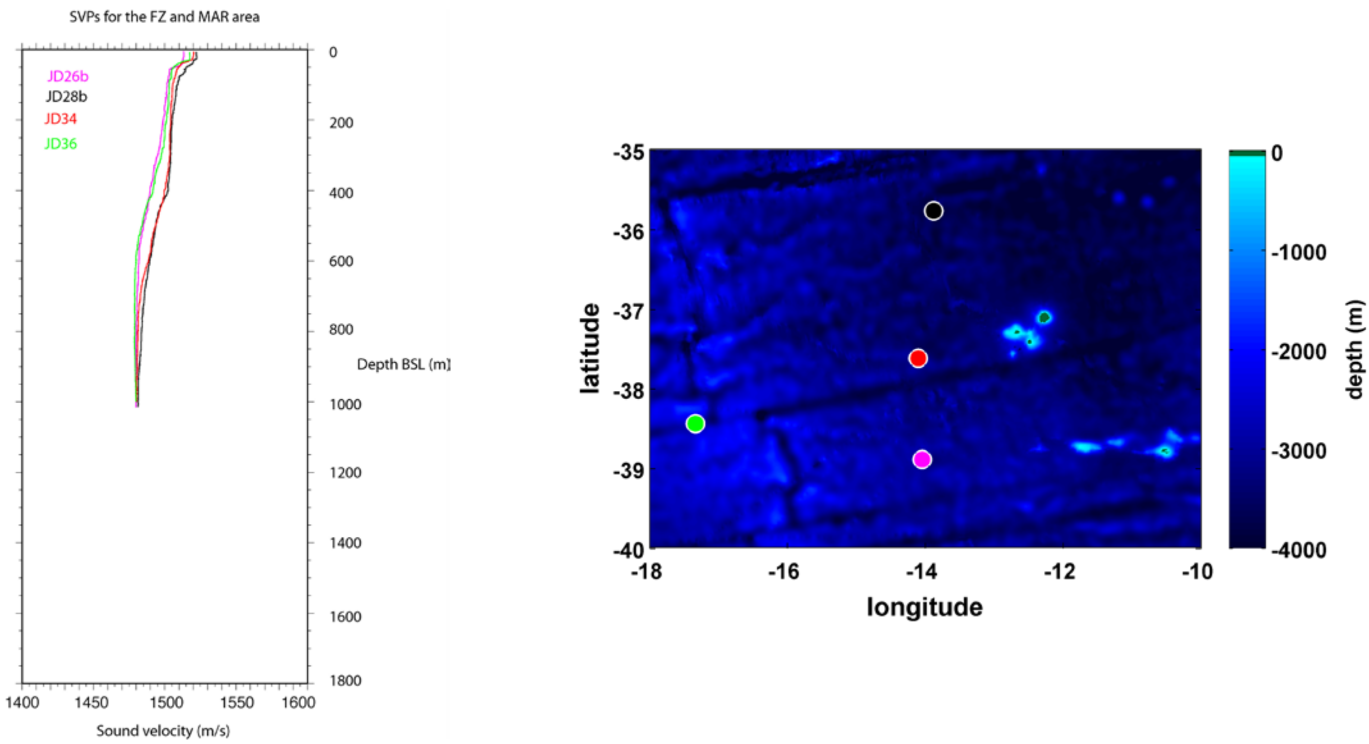

Fig. 5.1.3 Sound velocity profiles on Tristan da Cunha Fracture Zone (TDC FZ) and Mid-Atlantic Ridge. Also shown are the locations of Tristan da Cunha (TDC), Nightingale Island (NI) and Inaccessible Island (II).

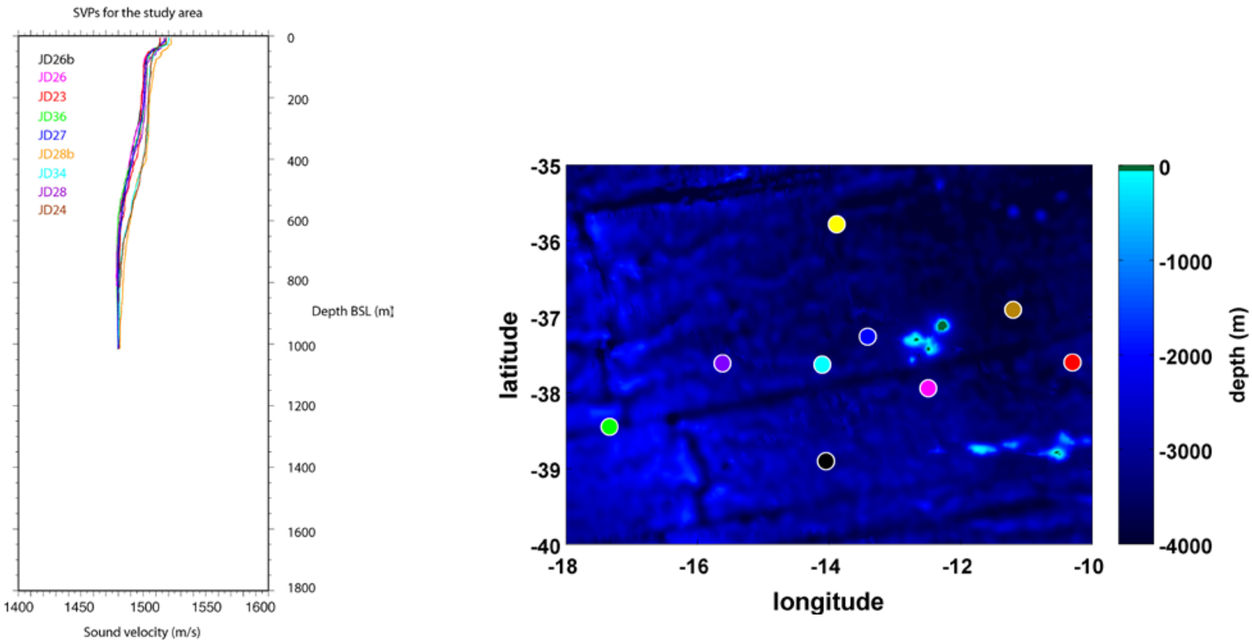

Fig. 5.1.4 Overview of sound velocity profiles in area of investigation. TDC, II and NI denote the positions of Tristan da Cunha, Nightingale Island and Inaccessible Island, TDC FZ the Tristan da Cunha fracture zone.

Data Quality Evaluation

Multibeam data was extremely noisy during most of the cruise. While part of this can be due to the fast speed of the ship during transit between deployment stations (12 to 13 kn) and to rough weather, some characteristic problems were also observed during the slower survey lines (8 kn) and in good sea states (see figure 5.1.5). These problems consist of a sudden trough or peak (most often a trough) over a certain number of beams. The pings located at about 1000 m from the keel both at port and starboard sides often presented these anomalies. These artefacts were not always easy to identify in the beam profiles when close to high topography and considerably lengthened the time allowed to the data processing. Part of the problem with the pings may arise from cavitation near the hydrophones that may trouble the reception of the signal. However, the fact that the problem was also observed at slow speed and calm seas suggest that a verification of the sounder by the constructor should be considered.

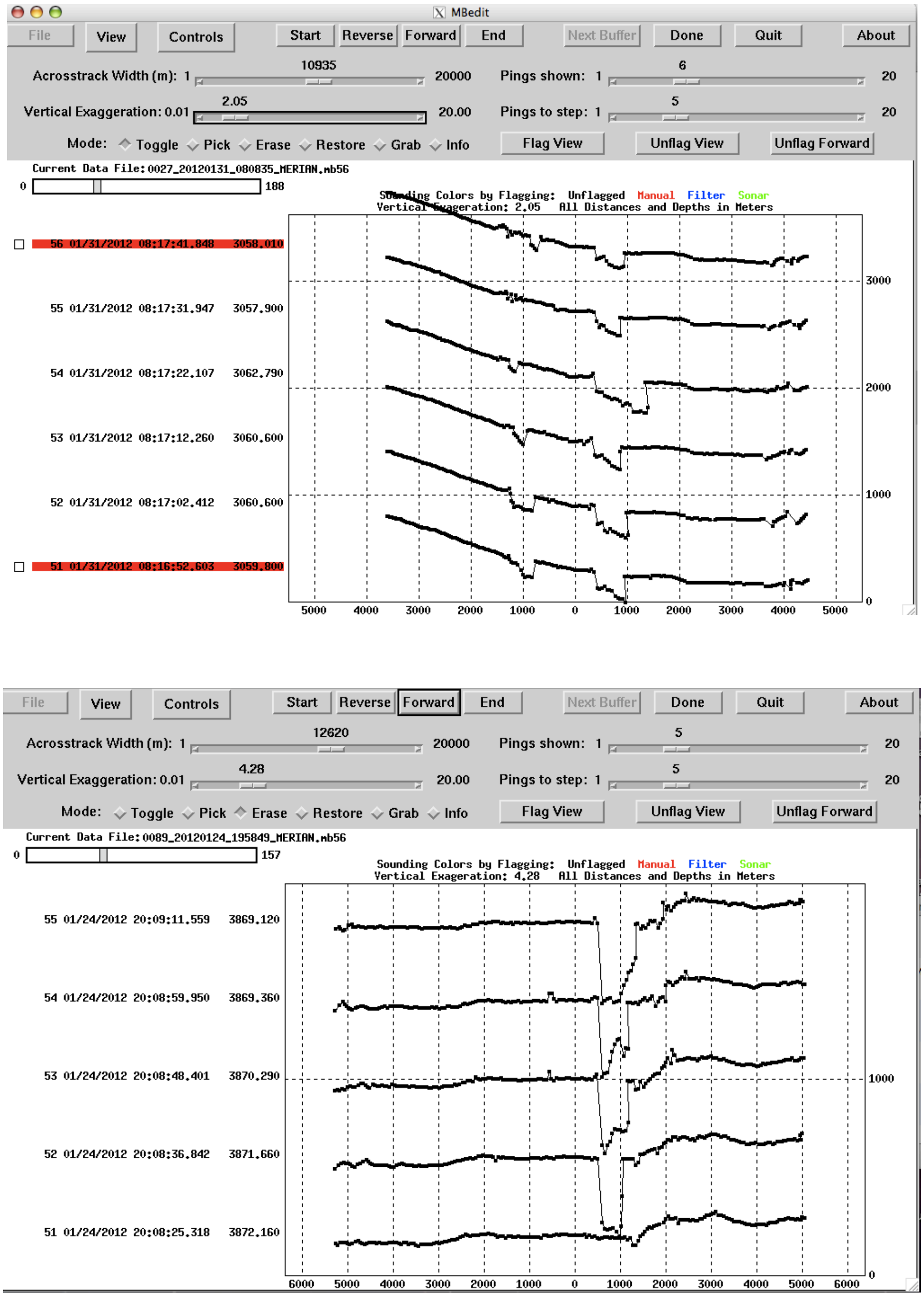

Fig. 5.1.5 Above: Example of noisy pings for a survey line at 8 kn. Below: The same for 12.8 kn.

External beams were sometimes noisy, especially during rougher sea states or headings facing the wind and at these conditions we chose to narrow the sounder angle to prevent excessive ping loss.

Survey Lines and Processing

Additional ship time allowed surveying the area around the islands of Tristan, Inaccessible and Nightingale, the Tristan da Cunha Fracture zone and the adjacent segments of the MAR. These survey lines were made at 8 kn to reduce the noise on the data. The profile spacing was variable. At the MAR, a 5 miles spacing allowed an almost full coverage of two ridge segments. The fracture zone was partly surveyed, with close spacing south of the Tristan group, where the predicted bathymetry suggested possible volcanic infill of the trough, and a more lose crossing between the islands and the MAR. The location of the transits between the deployment stations help to improve this part of the survey. Close to Nightingale, the survey was designed to cover the potential site of the 2004 submarine eruption, east-northeast of the island.

Data was processed using the MBSystem software. The navigation parameters were checked for each file and found to be good. Due to the high noise level of the data, we chose not to apply automatic filters and to edit the data manually using mbedit.

Preliminary Results

Nightingale Volcano:

The Tristan authorities provided us with a report from the British Geological Survey by Hards, 2004 (BGS International and Corporate Development Commissioned Report CR/04/235), which investigated a potential volcanic eruption in late July/August 2004. It states that during the time the inhabitants of the island felt a suite of tremors, furthermore pumice was discovered by cray fishers on Sandy Point Beach (figure 5.1.6), located at the East of the island (see figure 5.5.1). Prevailing currents suggest a source of the volcanic eruption south or southwest of Tristan da Cunha. Volcanic activity has also been indicated by seismic activity recorded by the seismometers on Tristan [maintained by the Comprehensive Test Ban Treaty Organisation (CTBTO) as part of the International Monitoring System (IMS)] on 29/30 July and attributed to pressurization due to magma ascent beneath the vent area. Concern of the imminent eruption of Tristan volcano itself were mitigated since there was no sign of increased thermal activity or ground deformation - such as increased rock fall activity or disruption of any man-made structures on the island.

Based on the report and bathymetric survey around the island, we have found a strong deviation in the GEBCO bathymetric and ship board bathymetric data ESE of Nightingale Island (Figures 5.1.7 and 5.1.8). Subsequent analysis of the ship bathymetric data showed the presence of a volcano reaching 200 m below the sea surface. Location and topography of the volcano suggest that it might be the source of the 2004 eruption.

Fig. 5.1.6 Left: Pumice deposits in the inter-tidal and splash zones on Runaway Beach, 18 September 2004. Right: Fresh pumice collected from the surface of the sea by island's fisherman on August 3rd, 2004 (left) and pumice found around the high-tide mark on the beach St. Cave point on Sept. 23rd (from Hards, 2004).

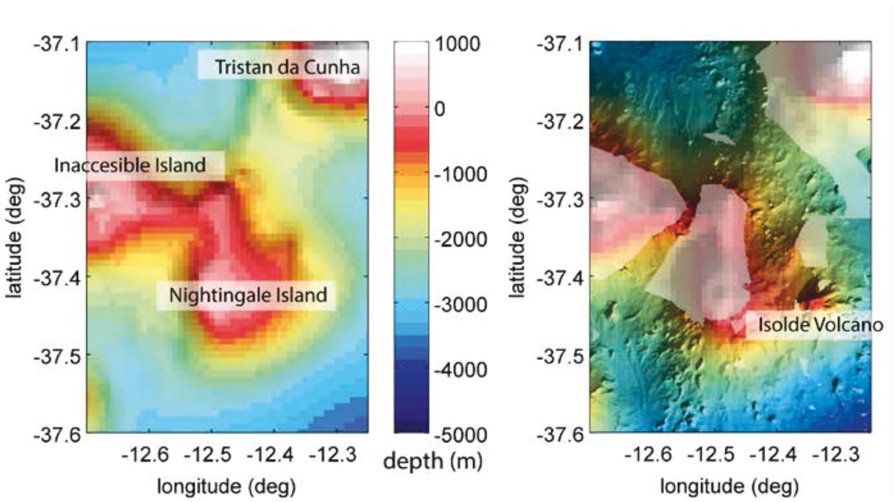

Fig. 5.1.7 Comparison of GEBCO bathymetric data (left) with ship board bathymetry (right). In ship-board bathymetry a newly discovered volcano named Isolde, which reaches up to approx. 200 m below seasurface, is outlined SSW of Tristan. The location of Isolde agrees well with the predicted direction inferred from pummice distributions on Tristan's coast by an eruption in 2004.

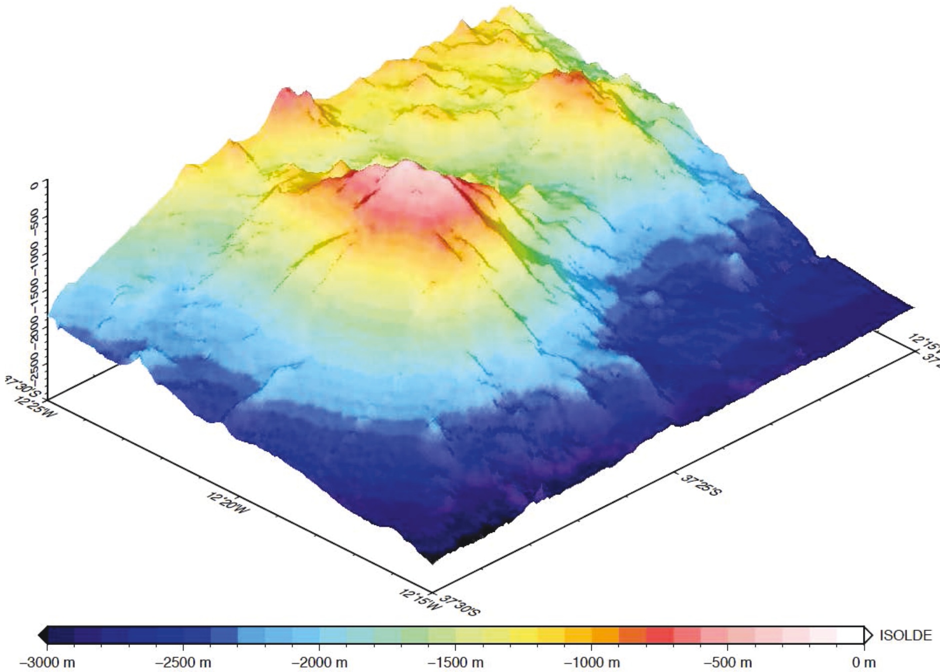

Fig. 5.1.8 Coloured 3D view from south east of the site of possible eruption in 2004.

Core Complex:

Another geologically interesting feature was observed at the MAR, where a core complex was identified at the northern end of the section south of the Tristan da Cunha fracture zone (see figure 5.1.9). The existence of such a core complex indicating a magma starved section of the MAR is surprising given the proximity of the Tristan da Cunha volcanic complex and the associated temperature anomaly in the region. It might indicate a somewhat decreased thermal anomaly in the region. The core complex is rather large with an east-west extension of approx. 15 km and a north-south extension of about 12 km. Elevation with respect to the surrounding mean seafloor level is approx. 700m.

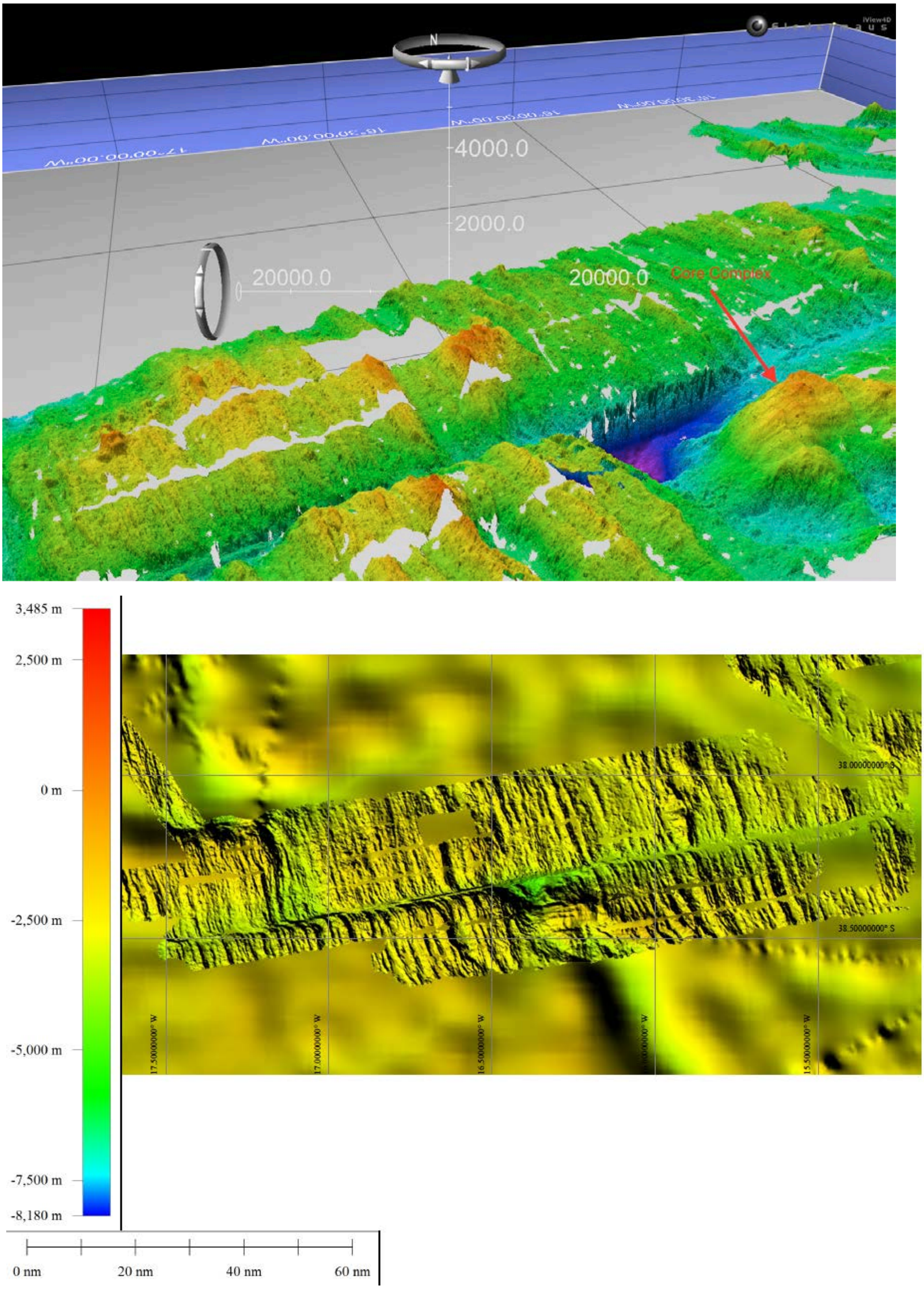

Fig. 5.1.9 Bathymetric data showing the core complex in a 3D view from south-west (top) and as shaded relief map (bottom).

5.2 OBEM Deployment and Installation of MT Land Station Nightingale

(M. Jegen and K. Baba)

Magnetotellurics is a passive electromagnetic geophysical method for imaging the electrical resistivity structure (reciprocal to conductivity) of the subsurface. Electrical resistivity varies strongly due to temperature and presence of melt, such that this type of measurement is of great interest in the investigation of Tristan da Cuna. The method is founded on the observation that naturally occurring fluctuations of the Earth's magnetic external field induce electric currents whose strength and distribution depend on the subsurface resistivity.

Variations of the horizontal electric and three-component magnetic fields are recorded on the ocean bottom to derive a spectral, complex-valued impedance tensor $\underline{\mathbf{Z}}$ given by $\underline{\mathbf{Z}}\ \underline{H}_h = \underline{E}_h$ where $\underline{E}_h$ and $\underline{H}_h$ denote the frequency-dependent horizontal electric ($\underline{E}_h$) and magnetic ($\underline{H}_h$) field vectors. In a homogenous half-space, the so-called skin depth δ is a crude estimate of detection depth with δ = sqrt (ρ T) in kilometers, (where T is the period in seconds and ρ is the bulk resistivity). At periods shorter than approximately 1 s, seafloor electromagnetic signals are very small. This is due to the high conductivity of the sea water above, which causes attenuation according to skin depth and thus reduces the resolvability of shallower sea-bottom features. To have some estimates of shallow features at least locally, we have installed a land station (provided by GFZ Potsdam) on Nightingale Island.

For the experiment it was essential to cover a possibly large region around Tristan da Cunha. To ensure sufficient number of instrumentation and for scientific reasons, we collaborated with one of the leading marine electromagnetic groups in the world in the Earthquake Research Institute (ERI) at the University of Tokyo. Prof. H. Utada and Prof. K. Baba were able to raise Japan's funding for the project and could thus join the cruise with 8 marine MT instruments. From the German side we deployed 18 stations, which were all instruments available during that period.

Instrument description

GEOMAR OBEM

The instrument carrier is based on the OBS DEPAS pool 'LOBSTER' design and consists of a titanium frame on which syntactic foam elements are mounted to give the frame a positive buoyancy. For deployment, a concrete slab is attached to the frame as an anchor (anchors consisting railway racks usually used for seismic deployments cause a disturbance/bias in the magnetic field readings) through a releaser. The frame is equipped with a titanium cylinder containing the battery pack and with a smaller titanium cylinder containing the 3 component fluxgate magnetometer with a precision of 10 pT/sqrt(Hz) and a data logger (provided by Magson GmbH, Berlin). The latter records magnetic and electric field variations, tilt variations, temperature and time. Timing of the measurement is kept via a Seascan temperature controlled crystal which is synchronized to GPS prior to deployment (typical drift < 500 ms/year). The logged data is stored on a removable SMD card. Orthogonal horizontal electric field measurements are performed through voltage difference measurements between non-polarizable silver-silver chloride electrodes (Clover Tech Ltd, Japan) separated by plastic pipes mounted between frame and anchor to span a 10 m electric dipole. The consumption of the data logger and fluxgate magnetometer is on the order of 800 mW, such that the battery is sufficient to power the instrument for a period of 5 months. After this point in time the logging is shut off and merely the timing crystal remains powered. Data sampling has been set to 10 sec. Figure 5.2.1 shows a photo of a GEOMAR OBEM station during deployment.

ERI, University of Tokyo OBEM

The ERI OBEM, made by Tierra Tecnica, Ltd., consists of two pressure glass spheres and four plastic pipes mounted on a titanium frame (Figure 5.2.2). It has a magnetometer and electrometer in one of the glass spheres and the acoustic electronics and batteries in the second glass sphere. Silver-silver chloride electrodes (productions of Clover Tech, Ltd.) are fastened into the ends of the 2.5m plastic pipes, giving total span of 5.4 m for the measurement of two horizontal components of the electric field. Because the voltage differences between four electrodes on the end of the pipes to a reference electrode fastened on the middle of a pipe are measured, it has redundancy to reproduce the two horizontal components of the electric field even if one channel fails to record good data. The OBEM also measure the two components of the instrumental tilts and temperatures near the flux-gate magnetic sensor and the data logger. The resolutions are 0.01 nT for the magnetic field, 0.0002 µV/m for the electric field, 0.00026 degrees for the tilts, and 0.00014 ºC and 0.01ºC for the temperature near the magnetic sensor and the data logger, respectively.

All data are recorded internally on a flash card. The sampling interval is set 60 seconds for five OBEMs deployed at the stations Tris04, 08, 15, 21, and 24 and is switched from 10 seconds to 60 seconds after one month from the start of the measurement and switched to 10 seconds again after further 10 months for three OBEMs deployed at the stations Tris11, 13, and 19. The magnetometer runs just ±3 seconds of every sampling interval and sleeps in the other periods to save the power consumption, which is 186.5 mA during the measurements and 6.4 mA during idling for 12 V. The acoustic transponder triggers the burn-wire to release ~80 kg concrete ballast weight, allowing the instrument to float back to the surface for recovery. A radio beacon and a flashing light are also mounted on the titanium frame, which help to find the instrument on sea surface.

Fig. 5.2.1 GEOMAR OBEM.

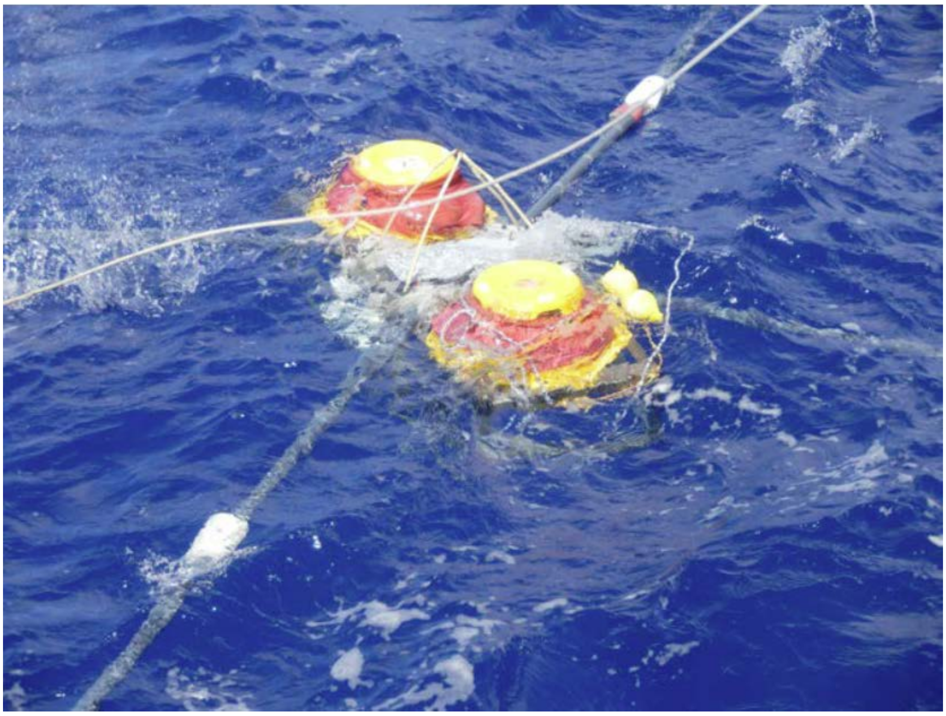

Fig. 5.2.2 ERI OBEM.

Installation of Magnetotelluric Land Station on Nightingale

The magnetotelluric instrument was supplied by the Geophysical Instrument Pool of the GFZ in Potsdam. The configuration used for the low frequency MT signal recording were a Geomagnet Fluxgate Magnetometer , 4 silver-silver chloride electrodes in holes filled with bentonite and aligned north-south and east-west to form two orthogonal dipoles with a length of 53.16 m and 40 m respectively, a signal preconditioning board (Castle E-Sensor Box) and a GFZ Earth Data Logger (EDL). The station was powered through a 12 V battery recharged by solar panels. Time line of the recording was supplied through a GPS signal and the data sampling rate was set to 1 Hz. As the location for the instrumentation we chose a site along the path into the interior of the island (see figure 5.2.3) which was flat such that the dipoles could be layed out approximately horizontally. The station was installed on January 30th and checked whether it was still working on January 31st.

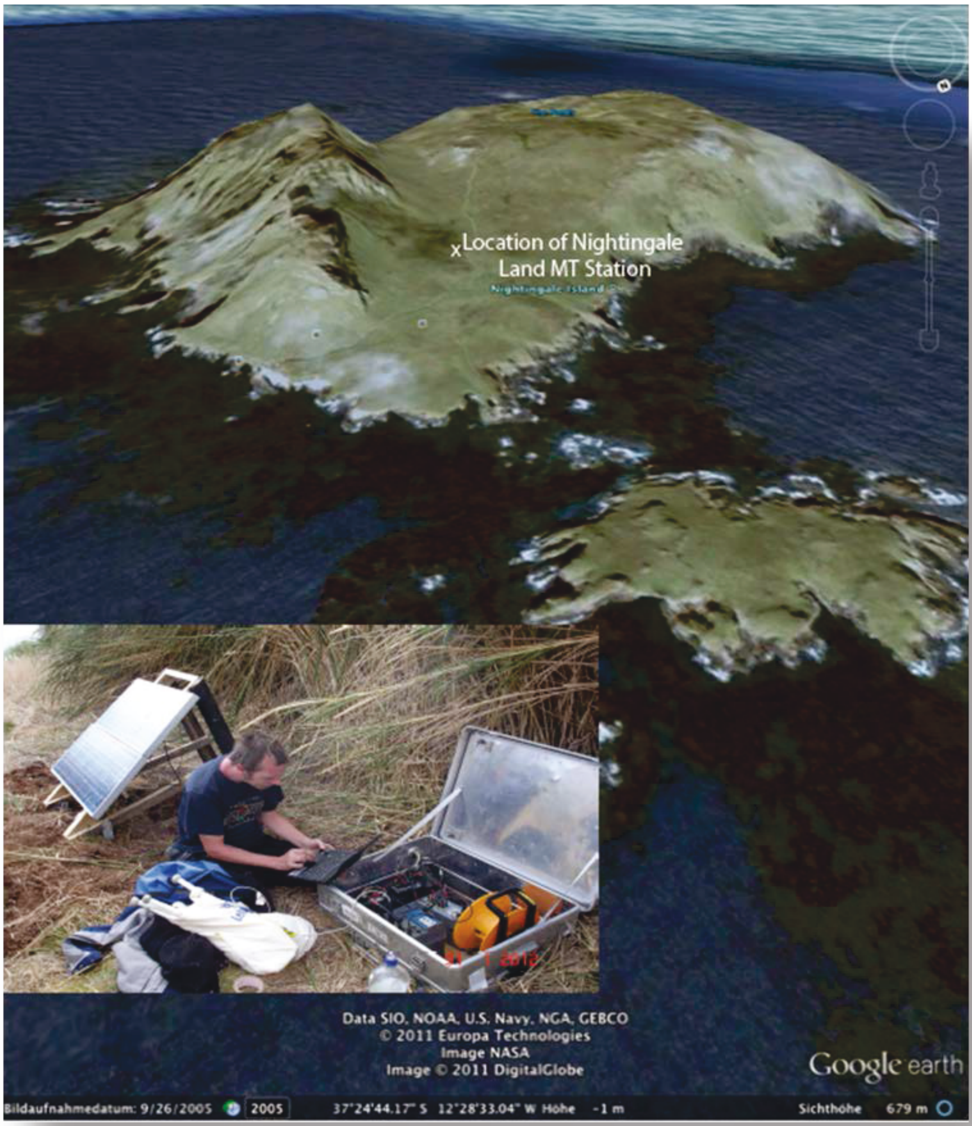

Fig. 5.2.3 Location of Nightingale land MT station (view from approx. north) and photo of station (photo insert).

Deployment of marine OBEM:

The deployment of the marine OBEM were optimized to achieve a good 3D coverage of the potential plume area (see figure 5.2.4) and OBEM and OBS were collocated to ensure similar data coverage for the seismic and electromagnetic data. Please refer to section 7 for a complete listing of coordinates of stations.

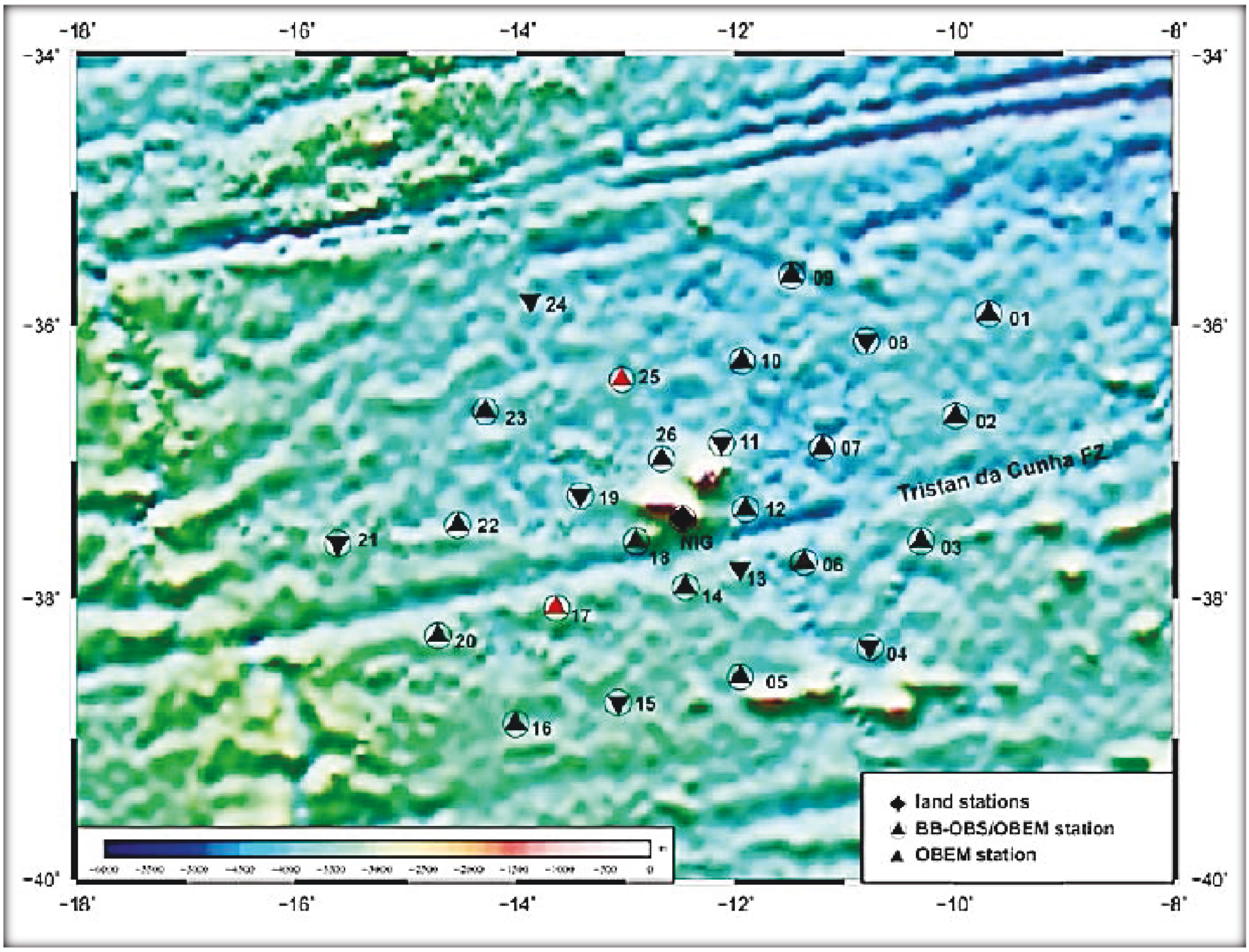

Fig. 5.2.4 Locations of jointly occupied seafloor BBOBS/OBEM stations (encircled triangles), OBEM stations only (triangles) and jointly occupied MT and seismic station on Nightingale Island (encircled diamond) around Tristan da Cunha.

5.3 OBS Deployment and Installation of Land Seismometer Nightingale

(W.H. Geissler, H. Kirk, K. Sigloch, K. Hosseini, S. Stähler, W. Bloch)

One major tasks of the ISOLDE project is the deployment of ocean-bottom seismometers around Tristan da Cunha. They will be used to study the deep lithospheric and upper mantle at the present position of the Tristan da Cunha hotspot (mantle plume) by means of passive seismic methods. During MSM20/2 we deployed 24 broadband ocean bottom seismometers (OBS) from the German DEPAS instrument pool coordinated by the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven and GFZ Potsdam.

Instrumentation

24 DEPAS LOBSTER (**L**ongterm **O**cean **B**ottom **S**eismometer for **T**sunami and **E**arthquake **R**esearch, see figure 5.3.1) K/MT 510 manufactured by K.U.M. Umwelt- und Meerestechnik Kiel GmbH, Germany, are used during the experiment. They are equipped with a Güralp CMG-40T broadband seismometer incorporated in a titanium pressure housing, a hydrophone, and a

GEOLON MCS (**M**arine **C**ompact **S**eismocorder) data logger from SEND GmbH Hamburg, Germany. The electric power supply for the recorder and the seismometer is granted by 180 lithium power cells. Generally each sensor channel is sampled at 50 Hz, however, larger disk space allowed a sampling at 100 Hz for 2 OBS stations. The preamplifier gain of the hydrophone channel is set to 4 and is set to 1 for the three seismometer components. The total disk space of the stations is 20 GB (2 OBS with 32 GB). The disk space should be enough for a recording time of >12 months, also taking into account that there might be an increased noise level around the islands. The clock of the data loggers were synchronized by GPS time before deployment and will be synchronized again after recovery of the instruments. The time difference during the recording period will then be corrected linearly. The seismometers are equipped with a cardanic levelling mechanism, which will be initiated a few hours after deployment, when the OBS is located on the seafloor, and then every 21 days.

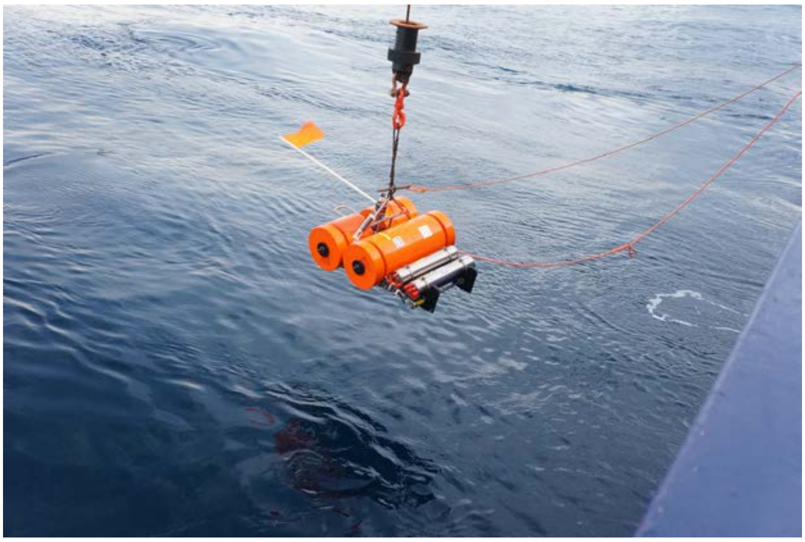

Fig. 5.3.1 Photograph of the LOBSTER during deployment (Photograph by K. Ota).

Releaser Test

The KUMQUAT release unit is the most important part of the OBS for a secure recovery. To assure the proper operation of the release units under deployment conditions in the deep sea, we performed two release tests with 13 and 15 release units, respectively. The releasers were fixed with clamps and cable straps in an iron cage (see figure 5.3.2) and brought down to 3000 m depth using the winch (in the Hangar). At first we tried to communicate via the ship's mounted transducer/hydrophone with the release units. But, we did not get answers from the release units. Therefore, we decided to use the mobile cable-based transducer (hydrophone). Normally, the acoustic release code of each release unit was sent twice. Then we got answers from almost all release units. After recovery on board all release hooks were open, confirming the proper operation of the release units at the average operation depth.

Fig. 5.3.2 Photograph of the releaser test configuration (Photograph by M. Retief).

Parameters of test 1: station MSM20/016-2

19.01.2012, 08:44 – 10:46 UTC

27° 54.456' S, 05° 34.074' E, 3000 m depth

all tested13 releaser units released

test 2: station MSM20/017-2

20.01.2012, 08:44 – 10:09 UTC

29° 50.074' S, 02° 0.824' E, 3000 m depth

all tested15 releaser units released

No	MCS SN	GPS Sync Date	GPS Sync Time	GPS skew Date	GPS skew Time	Skew (us)	Pred. Skew per year (sec)
1	050902	26.01.2012	11:45:51	28.01.2012	12:45:53	1718	0,31
2	050906	26.01.2012	10:32:36	27.01.2012	09:54:32	-63	-0,02
3	050907	24.01.2012	15:03:30	25.01.2012	21:14:28	-907	-0,26
4	050921	19.01.2012	19:18:00	20.01.2012	16:08:16	1062	0,45
5	050924	26.01.2012	12:50:09	28.01.2012	12:52:54	406	0,07
6	050930	26.01.2012	10:06:38	26.01.2012	21:17:44	-219	-0,17
7	060704	24.01.2012	20:04:06	27.01.2012	09:39:30	-5844	-0,83
8	060708	26.01.2012	08:55:32	26.01.2012	19:55:47	93	0,07
9	060713	25.01.2012	19:35:50	26.01.2012	14:19:19	156	0,07
10	060715	24.01.2012	15:58:24	25.01.2012	21:56:43	468	0,14
11	060720	21.01.2012	15:38:13	22.01.2012	18:40:43	250	0,08

No	MCS SN	GPS Sync Date	GPS Sync Time	GPS skew Date	GPS skew Time	Skew (us)	Pred. Skew per year (sec)
12	060723	26.01.2012	13:04:33	27.01.2012	13:42:30	125	0,04
13	060724	26.01.2012	11:21:52	27.01.2012	13:30:18	-282	-0,09
14	060725	19.01.2012	13:25:25	22.01.2012	14:11:01	5031	0,61
15	060728	25.01.2012	20:00:00*)	26.01.2012	13:56:46	-625	-0,31
16	060729	19.01.2012	13:40:06	22.01.2012	10:03:00	-1438	-0,18
17	060734	28.01.2012	15:16:08	28.01.2012	18:23:34	-719	-2,02
18	060735	24.01.2012	08:37:48	24.01.2012	14:37:53	31	0,05
19	060735	18.01.2012	13:57:23	20.01.2012	14:02:26	-282	-0,05
20	060738	17.01.2012	13:07:32	22.01.2012	15:10:38	-2594	-0,19
21	060739	19.01.2012	19:32:29	20.01.2012	16:15:07	93	0,04
22	060740	18.01.2012	18:42:46	22.01.2012	14:59:47	-29969	-2,84
23	060740	23.01.2012	14:57:46	24.01.2012	13:50:15	-7344	-2,81
24	060742	18.01.2012	18:24:07	22.01.2012	09:57:06	2031	0,20
25	060743	18.01.2012	09:28:00	21.01.2012	14:02:55	156	0,02
26	091104	18.01.2012	12:44:52	20.01.2012	13:49:13	-2813	-0,50
27	091107	17.01.2012	19:02:55	20.01.2012	13:19:14	1125	0,15

*) time estimated

Table 5.3.1: *Results of GPS synchronisation tests*

Due to the problems with synchronisation of the internal clock, we decided to perform tests of all recorders (see table 5.3.1). This was possible due to the long transit from Walvis Bay to the first deployment site. We mounted the recorders in the pressure tubes and started recording as it is usually done for deployment. In some cases seismometers and hydrophones were also mounted and connected to the recording unit. For almost all recorders we got acceptable skew values (drift of the internal clock). Assuming a linear behaviour, the estimated drift for one year of operation will hopefully result in values less than +-0.5 s. Two recorders show drift values above -2 s. For one of these recorders this high value was confirmed by a second short test. Most probably this clock drift is real and might be caused by a previous re-calibration. Due to some problems with another recorder, one recorder had to be mounted shortly before final deployment of a station. Therefore, it had not been tested for GPS synchronisation. This has to be done after recovery in 2013. GPS synchronisation was done with the antenna on the winch control room or with the antenna at the working deck (airgun deployment run).

Station Preparation and Deployment

Leaving Walvis Bay we started to mount the first twelve instruments parallel to the testing of recorders. More instruments could not be mounted at the same time due to limited space on the working deck (there were additional 26 OBMT stations from GEOMAR Kiel and ERI Tokyo). Fixing the anchor and cables was done without problems. Before the final programming the GPS quality was checked. Normally we got >9 satellites and an HDOP value of less than 1.0. Sometimes, mostly in the evenings, only 7 satellites were available and the HDOP was then about 1.3. For the final synchronisation we used the GPS antenna on the roof of the winch control room and sometimes at the airgun deployment run. Programming of the recording units was done without major problems; all sensors seemed to work properly. Finally, deployment of all 24 BB-OBS was done with starboard crane and release hook without major problems (see figure 5.2.4) . At positions 13 and 24 no OBS were deployed (only OBMT stations). Please refer to section 7 for a complete listing of the stations' coordinates.

Nightingale Island Land Seismometer Installation

To complement the ocean-bottom network and the existing station on Tristan da Cunha, Dr. W. Geissler and H. Kirk also installed two land instruments on Nightingale Island. We prepared the first site NIG01 completely during the first day, and later also prepared the basement of the second site NIG02. In the morning of January 31st, we finished the second site and controlled the proper operation of NIG01 before we left the island at noon.

Land Instrumentation

Two land stations from DEPAS instrument pool were installed. Each of it is composed of a seismometer (Guralp-3ESP Compact 60s), data logger (Earth Data), GPS antenna, breakout box, two solar panels, and rechargeable battery (65 Ah). The solar panels were placed on steel racks prepared in the AWI workshop. The angle for the panels was chosen to get the best insulation during the austral winter month. Hopefully, at least one station will get enough solar power to record until next year. As recording parameters we chose 100 Hz sampling rate and low gain (0.4).

Land Deployment Sites

The first station was deployed on the trail starting from the east landing point. The second was installed at the crossroad, where the trails from east and west landing meet (see figures 5.2.3, 5.3.3 and 5.3.4). The groundings of the station were not perfect, at least for the second site. Since there was no space to put the station on hard rock cropping out at the coastline (e.g., due to a penguin colony), we decided to place the station into the ground along the trail. At two spots we dug holes to prepare a small basement of concrete (app. 13 litre at each site). At the first site the concrete was placed on most probably re-deposited weathered bedrock (epiclastic material), which seems to be a rather good grounding for the station (see figure 5.3.3). At the second site we dug the hole in a thick sequence of soil and something similar to peat (little bit oily, former lake deposits?). Due to the limited time, missing alternatives and breeding birds everywhere aside from the trail, we decided to install both stations in the already prepared hole.

station	date (UTC)	time (UTC)	latitude	longitude	elevation (m)
NIG01	30.01.12	22:43	37° 25.063' S	12° 28.547' W	40
NIG02	31.01.12	05:15	37° 25.078' S	12° 28.654' W	(>40)

Table 5.3.2: *Land station deployment parameters*

(Mis-)Orientation of the Land Seismometers

The seismometers were oriented using a magnetic compass (±5°) knowing already that there might be a problem with a potential mis-orientation in the South Atlantic and on volcanic rocks. Additionally we measured the North direction with a GPS based compass. We got a deviation of about 22 degrees (measured from magnetic North). According to the magnetic maps of RV Maria S. MARIA S. MERIAN, the magnetic mis-orientation is -23.5° in the study area. That's why the acquired data has to be corrected for that value before analyses.

Fig. 5.3.3 Preparation of seismometer basement at site NIG01.

Fig. 5.3.4 Final setup of station NIG01. The seismometer is placed beneath the solar panels. This might be a potential problem during windy days.

5.4 Gravimetry

(H. Kirk, M. Maia and W.H. Geissler)

During the entire cruise leg MSM20/2 gravimetric measurements were carried out. An exception is the 200 miles zone of Brazil, where data acquisition has been stopped, besides a spot measurement in the harbour of Suape.

The instrument of type KSS-32-M used on the survey delivers values of relative gravity only. To gain absolute values and to correct for instrumental drift, two tie measurements at the beginning and at the end have been performed with a land gravimeter La Coste & Romberg (L&R) model G, S/N 877 in Walvis Bay, Namibia and Recife, Brazil, respectively.

The error estimations are consisting of the sum of the instrument error by factory and a maximum error assumption, gained by observing fluctuations during the measurements (e.g. caused by road traffic. In parts, errors are reduced the common way by averaging. A tide correction was not applied, which may increase the errors by 0.1mgal.

Gravity Tie Measurements

Measurements in Walvis Bay, Namibia

In Walvis Bay, three onshore measurements, both manually and with a feedback unit, at two different sites were taken with the L&R land gravimeter. For reasons of consistency, only the feedback values will be used for the determination of absolute gravity. At each spot, the instrument was placed on a tripod-plate. The internal temperature of the instrument showed a constant value of 49,8°C during the measurements.

Taking into account, that the sites belong to a cargo harbour with a high amount of activities, vibrational disturbance was low. By observation it is estimated to ±0.05 mgal. Factory repetitivity is given within ±0.02 mgal, which sums to an error of ±0.07 mgal.

The total relative gravity $G_{tot,rel}$ for each measurement with the L&R land gravimeter was derived by the help of the instrument's specific interpolation table as follows: All measured values M lay in-between 2400 and 2500 counter units (CU), which means to have a scale fix value of 2400 CU and thereby a calibration fix C of 2454.6 mgal. The valid calibration factor f is 1.02327. Additionally, the feedback unit delivers the offset FO straight in mgal. So, we have:

$G_{tot,rel}$ = C + f(M-2400) + FO = 2454.6 mgal + 1.02327(M-2400) + FO

WAL A, Harbour Pier, Walvis Bay, Namibia
(Gravity: 978822.839±0,06 mgal)

WAL A was chosen next to the ship on the pier between the bollards No. 42 and No. 43 at closest distance to the sea gravimeter on board R/V Maria S. MARIA S. MERIAN (figure 5.4.1). This distance was calculated to be 11,80±0,2m horizontally. The vertical distance, of course, changed in between the two measurements due to the tide and to bunkering fuel meanwhile. Fixed vertical distance is from the bottom of the sea gravimeter's sensor to the top of the reeling of the working deck, which equals to R_S = 3.34±0.05m.
With the measured, time dependant, distances R_W (top of reeling – water surface) and L_W (land gravity meter – water surface) we retrieve the instruments vertical distance to

$D = - R_S - (L_W - R_W)$,

whereby a negative D has the meaning of a lower altitude of the sea gravimeter, compared to the L&R.

Station	Description	Date	Time UTC	Rel. Gravity $G_{tot,rel}$ [mgal]	Abs. Gravity G_{abs} [mgal]
WAL A	Harbour Pier, next to ship 22°57'11.7" S 14°29'33.6" E	15.01.12	11:25 – 11:35	2485.000 ± 0,03	**978822.852±0.06**
WAL B	Harbour, Gravity Base, Code No. 431AAD 22°56'56.8" S 14°29'56.7" E	15.01.12	12:24 – 12:48	2484.900 ± 0,03	**978822,752** (no error declared)
WAL A	Harbour Pier, next to ship 22°57'11.7" S 14°29'33.6" E	15.01.12	14:45 – 15:03	2484.974 ± 0,03	**978822.826±0.06**

Table 5.4.1: *Parameters of Tie measurement in Walvis Bay*

Fig. 5.4.1 Tie measurement site at the pier in Walvis Bay. The yellow stripe at the ship marks the horizontal position of the gravimeter inside the ship.

At this site WAL A, the measurements have been carried out twice: First at the very beginning and a second repetitive measurement after intermediate activities at WAL B. The two tables below show the results. A minor error might have been affected to this data by the fact, that the counter values have not been approached from the same side. The manually taken values of WAL A, 1st measurement, vary from 2485.24 mgal to 2485,37 mgal and though show an offset of roughly 0.3 mgal compared to the feedback measurements. The manually taken values of WAL A, 2nd measurement, vary from 2485.30 mgal to 2485,39 mgal and though show an offset of roughly 0.35 mgal compared to the feedback measurements.

Time UTC	Counter Reading [CU]	Feedback Offset ±0.05 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.07 [mgal]
11:27:45	2428.00	+1.745	2483.252	2484.997
11:26:15	2428.50	+1,240	2483.763	2485.003
11:25:00	2429.00	+0.745	2484.275	2485.020
11:25:??	2429.50	+0.230	2484.786	2485.016
11:30:00	2430.00	-0.240	2485.298	2485.058
11:31:45	2430.50	-0.760	2485.810	2485.050
11:33:35	2431.00	-1.420	2486.321	2484.901
11:34:30	2431.50	-1.920	2486.913	2484.913

Table 5.4.2: *First feedback measurement at site WAL A, Jan 15th, 2012, 11:25 – 11:35 UTC*

Time UTC	Counter Reading [CU]	Feedback Offset ±0.05 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.07 [mgal]
14:45:45	2431.50	-1.855	2486.833	2484.978
14:48:00	2431.00	-1.391	2486.321	2484.930
14:51:00	2430.50	-0.790	2485.810	2485.020
14:55:30	2430.00	-0.290	2485.298	2485.008
14:57:45	2429.50	+0.200	2484.786	2484.986
14:59:45	2429.00	+0.685	2484.275	2484.960
15:02:30	2428.50	+1.175	2483.763	2484.938

Table 5.4.3. *Second feedback measurement at site WAL A, Jan 15th, 2012, 14:45 – 15:03 UTC*

WAL B, Harbour of Walvis Bay, Namibia, Gravity Base, Station Code 431AAD
(Gravity: 978822,752 mgal)

WAL B is a gravity station in the harbour area of Walvis Bay close to the harbour masters office. It was set up in May 1997, named WALVIS-W17 with the Code No. 431AAD, published in GIMDG-97-032. It is no IGSN station. The station consists of a nail in a concrete strip in between a berthing and a parking area. Further marks are missing, but the position could be confirmed by use of a GPS handheld Garmin Oregon 450t. Table 4 lists the measurements.
The manually taken values of WAL B vary from 2485.216 mgal to 2485.287 mgal and show again an offset of roughly 0.35 mgal compared to the feedback measurements.

Fig. 5.4.2 Gravity tie point WALVIS-W17. The measurement table stands above the marking nail.

Fig. 5.4.3 Gravity tie point WALVIS-W17. Note the marking nail in the centre.

Time UTC	Counter Reading [CU]	Feedback Offset ±0.05 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.07 [mgal]
12:24:30	2431.50	-1.985	2486.833	2484.848
12:25:45	2431.00	-1.435	2486.321	2484.886
12:27:15	2430.50	-0.915	2485.810	2484.894
12:28:30	2430.00	-0.390	2485.298	2484.908
12:30:35	2429.50	+0.140	2484.786	2484.926
12:33:00	2429.00	+0.650	2484.275	2484.924
12:34:55	2428.50	+1.135	2483.763	2484.898
12:36:05	2428.00	+1.645	2483.252	2484.897

Table 5.4.4. *Feedback measurement at site WAL B, Jan 15th, 2012, 12:24 – 12:48 UTC*

Absolute Gravity at Sea Gravitymeter's Position in Walvis Bay

With the above gained values, the absolute gravity at the pier can be determined:

$G_{abs}(WAL\ A,1^{st}) = G_{abs}(WAL\ B) + (G_{tot,rel}(WAL\ A,1^{st}) - G_{tot,rel}(WAL\ B))$
$= 97882.752$ mgal $+(2485.000 \pm 0.03$ mgal $- 2484.900 \pm 0.03$ mgal)
$= 978822.852 \pm 0.06$ mgal

and

$G_{abs}(WAL\ A,2^{nd}) = G_{abs}(WAL\ B) + (G_{tot,rel}(WAL\ A,2^{nd}) - G_{tot,rel}(WAL\ B))$
$= 97882.752$ mgal $+(2484.974 \pm 0.03$ mgal $- 2484.900 \pm 0.03$ mgal)
$= 978822.826 \pm 0.06$ mgal

That gives by averaging the absolute gravity at the pier in Walvis Bay next to the ship:

$G_{abs}(WAL\ A) = 978822.839 \pm 0.06$ mgal

The sea gravimeter was continuously in operation, while the onshore measurements were conducted. In parallel to both measurements at WAL A, the vertical distance D of the instruments has been derived. With L_{w1} = 4.235±0.05 m and R_{w1} = 4.37±0.05m, one get D_1 = -3.19±0.15 m and likewise with L_{w2} = 3.825±0.05 m and R_{w2} = 4.17±0.05m follows **D_2 = 2.92±0.15 m**, which gives two opportunities for free air correction, in order to gain the absolute gravity at the sea gravimeter's location G_{abs}(KSS):

$G_{abs}(KSS,1^{st}) = G_{abs}$ (WAL A) + 0.3086 mgal/m * D_1
= 978822.839±0.06 mgal + 0.3086 mgal/m * 3.19±0.15m
= 978823.823±0.11 mgal
$G_{abs}(KSS,2^{nd}) = G_{abs}$(WAL A) + 0.3086 mgal/m * D_2
= 978822.839±0.06 mgal + 0.3086 mgal/m * 2.92±0.15m
= 978823.740±0.11 mgal

Finally, by averaging, the absolute gravity at the sea gravimeter in Walvis Bay is:

G_{abs}(KSS, WAL A) = 978823.78 ±0.11 mgal

The mean of the readings of KSS32 during time period of the land-based measurements gives -1609.804±0.02 mgal. The error of the KSS is declared to be 0.5 mgal for each single measurement and so decreases the common way by taking the average. So, with the K-factor of the instrument of 0.901:

$G_{tot,rel}$(KSS,WAL A) = -1450.433±0.02 mgal ,

which corresponds to 978823.78 ±0.11 mgal on 15.01.2012 at 15:03 UTC.

Measurements in Suape and Recife, Brazil

The tie measurements in Brazil were carried out the same way like in Namibia. The first measurement was done next to ship on the pier in Suape. Afterwards we went to the old town of Recife, where an absolute gravity station is situated. This is roughly 50 km away from the harbour of Suape, where no reference gravity station is installed by now. The final measurement was taken again next to the ship.

During the whole procedure no problems aroused. The L&R was put on the plate again. Its temperature showed a slight fluctuation between 49.7°C and 49.8°C. The vibrations in the harbour had a stronger effect compared to Walvis Bay and caused an error of ±0.08 mgal. In Recife it was again ±0.05 mgal. With the help of the interpolation table, we calculate the gravity with C = 1738.51 mgal and f = 1.02280:

Gtot,rel = C + f(M-1800) + FO = 1738.51 mgal + 1.0228(M-1800) + FO

Station	Description	Date	Time UTC	Rel. Gravity $G_{tot,rel}$ [mgal]	Abs. Gravity G_{abs} [mgal]
SUA	Harbour Pier, next to ship 08º23'24.6" S 34º58'12.3" W	15.02.12	13:30 – 13:42	1826.828±0.04	**978164.910±0.09**
REC B	Recife, Old Town, Gravity Base "Recife B" Code No. 101109 08º03'47.3" S 34º52'16.1" W	15.02.12	15:17 -15:37	1823.634±0.02	**978161.716±0.031**
SUA	Harbour Pier, next to ship 08º23'24.6" S 34º58'12.3" W	15.02.12	17:20 -17:30	1826.725±0.04	**978164.807±0.09**

Table 5.4.5: *Parameters of Tie measurement in Suape and Recife, Brazil*

SUA, Harbour Pier, Suape, Brazil
(Gravity: 978164.859±0.09 mgal)
The site SUA on the pier of the harbour of Suape, between bollard no. 4 and no. 5, had the same relative position to the ship like in Walvis Bay. Therefore, the horizontal distance is again 11.80±0.2 m and the vertical distances are given by D = - RS - (LW – RW) (s.a.).
The single feedback measurements are shown in tables 6 and 7. A manual measurement at this site was done only once. Values spread from 1827.123 mgal to 1827.192 mgal with a mean offset of 0.34 mgal compared to the feedback measurements.

Time UTC	Counter Reading [CU]	Feedback Offset ±0.08 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.10 [mgal]
13:30	1788.0	-1.688	1828.516	1826.828
13:31	1787.5	-1.183	1828.005	1826.822
13:34	1787.0	-0.673	1827.494	1826.821
13:36	1786.5	-0.170	1826.982	1826.812
13:37	1786.0	+0.348	1826.471	1826.819
13:39	1785.5	+0.887	1825.959	1826.846
13:40	1785.0	+1.386	1825.448	1826.834
13:42	1784.5	+1.903	1824.937	1826.840

Table 5.4.6: *First feedback measurement at site SUA, Feb 15th, 2012, 13:30 – 13:42 UTC*

Time UTC	Counter Reading [CU]	Feedback Offset ±0.08 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.10 [mgal]
17:20:04	1788.0	-1.725	1828.516	1826.791
17:2?:??	1787.5	-1.285	1828.005	1826.720
17:2?:??	1787.0	-0.779	1827.494	1826.715
17:2?:??	1786.5	-0.277	1826.982	1826.705
17:24:15	1786.0	+0.235	1826.471	1826.706
17:22:26	1785.5	+0.777	1825.959	1826.736
17:28:09	1785.0	+1.267	1825.448	1826.715
17:29:07	1784.5	+1.773	1824.937	1826.710

Table 5.4.7: *Second feedback measurement at site SUA, Feb 15th, 2012, 17:20 – 17:30 UTC*

REC B, Old Town of Recife, Brazil, Gravity Base, Official Station Name "Recife B", Station Code 101109
(Gravity: 978161.716±0.031 mgal)

Recife B is an IGSN station in the middle of the place "Placa do Marco Zero", which is the major place of the old town. The station is easy to identify, because it is a monument as well, consisting of a bronze disc of roughly 1 m in diameter. Although at that time, there was a buzz of activities in order to prepare for the carnival, the measurement ran without any problems. The manually taken values of REC B vary from 1824.010 mgal to 1824.093 mgal and show in average an offset of 0.42 mgal compared to the feedback measurements.

Time UTC	Counter Reading [CU]	Feedback Offset ±0.08 [mgal]	Counter Reading ±0.02 [mgal]	Total Gravity $G_{tot,rel}$ ±0.10 [mgal]
15:17:15	1788.0	-4.865	1828.516	1823.651
15:20:00	1787.5	-4.405	1828.005	1823.600
15:22:00	1787.0	-3.860	1827.494	1823.634
15:23:45	1786.5	-3.371	1826.982	1823.611
15:25:45	1786.0	-2.845	1826.471	1823.626
15:27:25	1785.5	-2.325	1825.959	1823.634
15:29:45	1785.0	-1.790	1825.448	1823.658
15:31:45	1784.5	-1.300	1824.937	1823.637
15:33:45	1782.0	+1.279	1822.380	1823.659
15:36:35	1781.0	+1.270	1821.357	1823.627

Table 5.4.8: *Feedback measurement at site REC B, Feb 15th, 2012, 15:17 – 15:37 UTC,*

Absolute Gravity at Sea Gravimeter's Position in Suape

$$\begin{aligned} G_{abs}(SUA,1^{st}) &= G_{abs}(REC\ B) + (G_{tot,rel}(SUA,1^{st}) - G_{tot,rel}(REC\ B)) \\ &= 978161.716 \pm 0.031\ mgal + (1826.828 \pm 0.04\ mgal - 1823.634 \pm 0.02\ mgal) \\ &= 978164.910 \pm 0.09\ mgal \end{aligned}$$

and

$$G_{abs}(SUA,2^{nd}) = 978164.807 \pm 0.09\ mgal$$

That gives by averaging the absolute gravity at the pier in Suape next to the ship:

$G_{abs}(SUA) = 978164.859 \pm 0.09$ mgal

At site SUA D_1 is calculated to –1.50±0.15 m with L_{w1} = 2.70±0.05 m and R_{w1} = 4.54±0.05 m, and D_2 = –2.44±0.15 m with L_{w2} = 3.60±0.05 m and R_{w2} = 4.50±0.05 m. It follows:

G_{abs}(KSS,1st) = G_{abs} (SUA) + 0.3086 mgal/m * D_1
= 978164.859±0.09 mgal + 0.3086 mgal/m * 1.50±0.15 m
= 978165.322±0.14 mgal
G_{abs}(KSS,2nd) = 978165.612±0.14 mgal ,

which gives by averaging the absolute gravity at the sea gravimeter in Suape:

G_{abs}(KSS, SUA) = 978165.47 ±0.14 mgal

The mean of the readings of KSS32 during time period of the land-based measurements gives –2334.994±0.02 mgal. Again, we have to multiply with the K-factor of the instrument of 0.901:

$G_{tot,rel}$(KSS,SUA) = –2103.83±0.02 mgal ,

which corresponds to 978165.47 ±0.14 mgal on 15.02.2012 at 17:30 UTC.

Work at Sea

During the cruise leg MSM20/1 the sea gravimeter KSS32 was set up and tested in the provided gravimeter room of the ship, situated on the tween deck, almost levelled to the sea surface. Inside this room, a stage is installed, where the instrument is mounted on. To fit to the mounting holes of the stage, a wooden plate of 4 cm thickness was manufactured by the crew and placed in between the gravimeter and the stage.

The stage is not crossed by the centreline of the ship. According to the "dimensional survey report no. 2 of the ship, provided by Bloom Maritime (2005) and Overrath Ship Surveyors (2010), the center of mass is appointed in the storage room on the tween deck. Taking the same coordinate system (positive directions: x: to bow; y to starboard; z to top), we find the centre of the top of the motion reference unit (MRU) of the ship, which is mounted in the gravimeter room as well, at x=9.011 m, y=0.023 m, z=-0.53 m. The distances from the bottom of the sensor of the KSS to the centre of the MRU were measured to be 1.33±0.01 m to the bow; 0.935±0.01 m to port side and 0.04±0.01m lower. With the height of the MRU of 0.20 m, the displacement of the gravimeter to the centre line of the ship is determined to y = -0.958±0.01 m and z = -0.57±0.01 m. Additionally, for the x-axis, the distance to the centre of mass is x = 10.341±0.01m.
The orientation of the instrument is done following the manual instructions with the panel pointing to the ship's stern.

Fig. 5.4.4 Installation of the sea gravimeter in the gravimeter room. View in direction towards bow.

After switching the sensor from manual caging to automatic mode, the initial start up ran as expected. A problem occurred by finding the correct parking angles. In Y-direction, the angle was measured by the instrument for all tries to be ~ 6°, which is not fitting to lock the table. After a heating up of three days, the sensor was degassed. The ambient room temperature is regulated and constant to ±0.1°C. The -passive- integration into DSHIP via the RS323 interface and a terminal server, which is provided by the ship, worked without any problems and the instrument is receiving all needed navigation data by a NMEA telegram. By reaching the harbour of Walvis Bay, the instrument was fully operational. It measured without any interruption until the EZ of Brazil was reached on February 13th. By then, data recording was stopped. A restart of recording was done only for the tie measurement in Suape. The instrument was checked at least once every day.

During the disassembling in the harbour of Suape, the measurement of the correct parking angle of the table for the y-direction failed again (~ 6°) and hence a matching value was entered manually. This malfunction might have coherency with another observation that has to be investigated later, because not all needed data is logged yet: There is some evidence that the load current for the y-directional motor of the table is asymmetrical shifted to negative values, although the mainly corresponding roll angle is not. This may play a role in particular during periods of higher sea state.

The Data

Most of the time, the sea state of MSM20/2 was low. The roll and pitch are visible in the raw data with the typical period of ~15 s and small amplitudes. A higher sea state, like on the Feb 6th, causes a very clear signal of the heave as well with a period of several minutes and amplitudes of 100 mgal and more. However, these effects can be filtered out later within the final data processing. The noise is increasing with the sea state, higher than expected and hence data quality decreases for these periods. Although the instrument samples with 1 Hz, each hour gives roughly only ~3100 data points. It is not clear by now, if this due to a malfunction in the instruments software or to the DSHIP channel. Besides these minor problems, the data is reliable: With the first tie measurement in Walvis Bay and satellite gravity measurements, it was succeeded to confirm the K-factor of 0.901 for the cruise part of the transit to Tristan Da Cunha, which gives a high range of latitude change. The preliminary data processing and comparisons with satellite data is described in an extra chapter of this report.

Drift of the KSS32 during the Cruise and Reliability

The official values of absolute gravity at sites WAL B and REC B differ by 978822.752 mgal – 978161.716±0.031 mgal = 661.036±0.031 mgal. Unfortunately, there is no error available for WAL B. The difference for the same sites determined by the L&R land gravimeter is 2484.900±0.03 mgal – 1823.634±0.02 mgal = 661.266±0.05 mgal, and so, a small deviation of 0.23 mgal is given, which is not covered fully by the estimated errors. This might be due to the uncertainties of the station WAL B or due to an underestimation of the errors of our measurements. However, it is not seriously affecting the drift calculation: The retrieved values of absolute gravity at the KSS deliver:

$$G_{abs}(KSS, WAL\ A) - G_{abs}(KSS, SUA) = 978823.78 \pm 0.11\ mgal - 978165.467 \pm 0.14\ mgal = 658.313 \pm 0.25\ mgal$$

The KSS by itself measured

$$G_{tot,rel}(KSS, WAL\ A) - G_{tot,rel}(KSS, SUA) = -1450.433 \pm 0.02\ mgal - (-2103.83 \pm 0.02\ mgal) = 653.39 \pm 0.04\ mgal,$$

which leads finally to the drift Δ of the sea gravimeter during the cruise from 15.01.2012, 15:03 UTC to 15.02.2012, 17:30 UTC:

$$\Delta = 653.39 \pm 0.04\ mgal - 658.313 \pm 0.25\ mgal = -4.923 \pm 0.29\ mgal$$

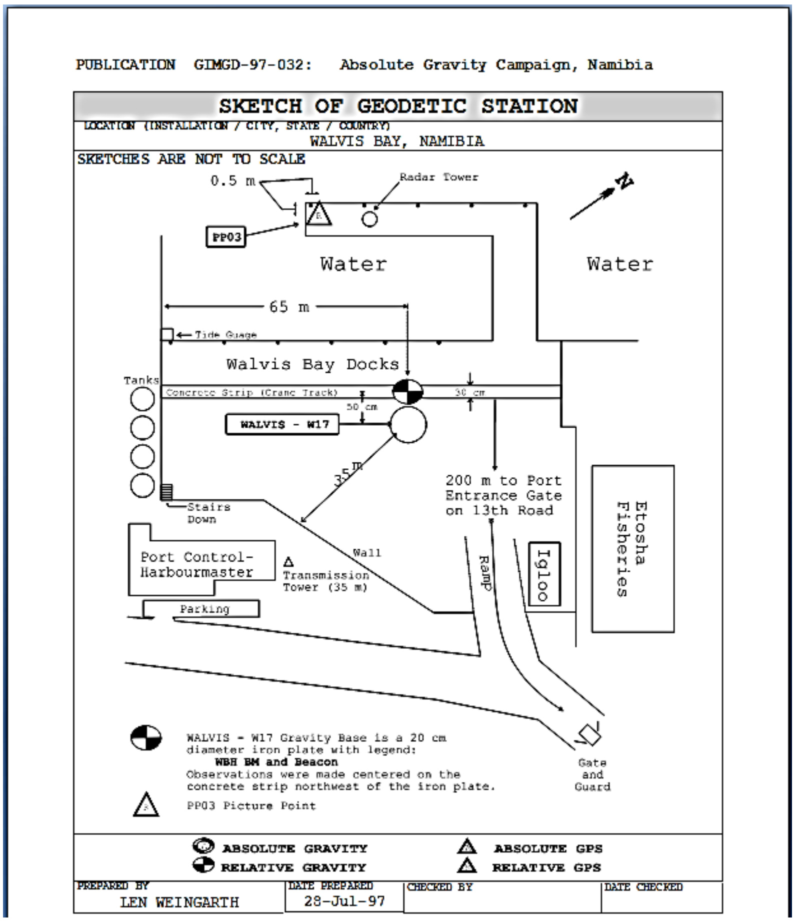

Fig. 5.4.5 Details of gravity base station in Walvis Bay, Namibia

5.5 Rock Sampling of the Tristan da Cunha Island for Geochemical Analysis

(I. Vexler and J. Kleiding)

The objective of onshore sampling of the main island of the Tristan da Cunha archipelago was to obtain lava samples suitable for (1) extraction of noble gases for a study of the isotopic composition of He and Ne, and (2) investigation of geochemical diversity of parental magmas by means of microprobe studies of early olivine and pyroxene phenocrysts, and olivine-hosted melt inclusions. Ankaramite, a strongly porphyric and the least evolved rock of the Tristan archipelago with abundant phenocrysts of olivine, clinopyroxene and Ti-magnetite, was the main target of the sampling operation. However, a few samples of other rock types were also collected. Ankaramite constitutes only a small fraction of the exposed part of the Tristan volcano, which is dominated by more evolved basanite. Good outcrops are rare, and the main sampling locations were chosen on the basis of field descriptions published by Baker et al. (1964) and Le Roex et al. (1990). Whenever possible, samples were collected 0.5-1 m below the surface or from fresh outcrops (e. g., recent landslides), which have not been exposed to cosmic rays or solar radiation for a long time. Sampling at protected locations is important for the studies of He and Ne isotopes because the isotopic composition can be modified by a long exposure to cosmic rays. The list of collected samples and GPS coordinates is presented below in Table 5.5.1. The main sampling locations are also shown on the map (Figure 5.5.1).

Sample #	Rock type	Location	Latitude	Longtitude
TDC12-01	Tephriphonolite	1961 lava flow	37°.06670 S	12°.29851 W
TDC12-02	Ankaramite	Pigbite gulch	37°.06613 S	12°.28677 W
TDC12-03	Basanite	“	37°.06666 S	12°.28710 W
TDC12-04	Ankaramite	“	37°.06894 S	12°.28669 W
TDC12-05	Ankaramite	“	37°.06557 S	12°.28629 W
TDC12-06	Phonotephrite	Big Point beach	37°.06272 S	12°.28168 W
TDC12-07	Ankaramite	“	37°.06418 S	12°.28387 W
TDC12-08	Ankaramite	Sandy Point	37°.12488 S	12°.22486 W
TDC12-09	Basanite	“	37°.12158 S	12°.22145 W
TDC12-10	Ankaramite	Wash gulch	37°.10043 S	12°.33286 W

Table 5.5.1: *List of the geochemical rock samples collected on the main island of the Tristan da Cunha archipelago.*

At the Pigbite gulch (“gulch” is a local name for a steep ravine), ankaramite crops out in at least three lava flows within the lower 100 m of the vertical section of the main cliffs, which surround the island from all sides (Figure 5.5.2).

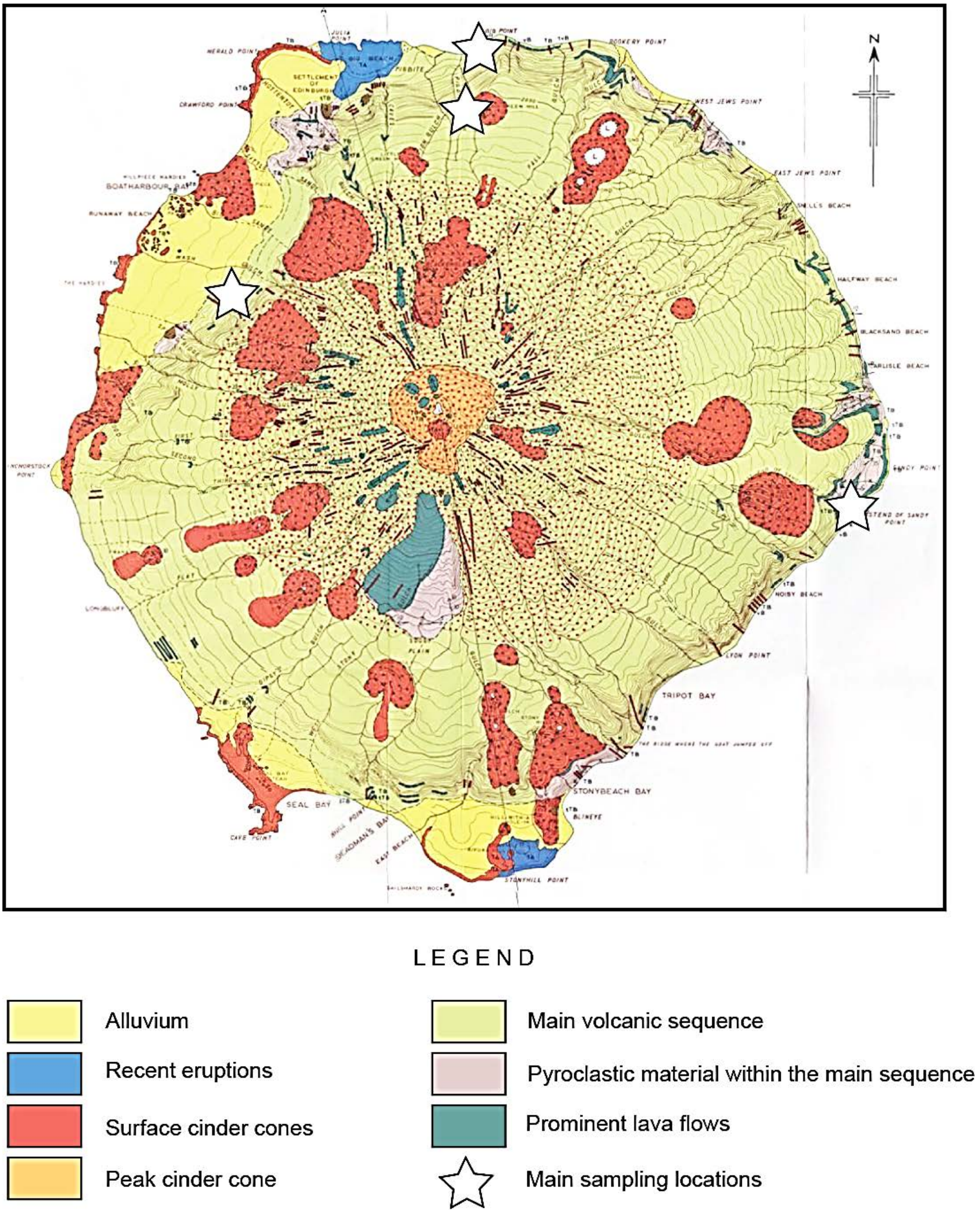

Fig. 5.5.1 The geological map of the Tristan da Cunha island (from Baker, 1965) and the main sampling locations.

Similar lava flows are exposed at the bottom of the cliffs along the Big Point beach, approximately 500 m to the east. At the Wash gulch, to the west of the Settlement, the ankaramite sample was collected from a large block, which may not be in place but represented a fragment of a lava flow higher in stratigraphy. At the Sandy Point, ankaramite forms a small outcrop at the foot of the cliff at the southern end of the beach. The rock is coarse-grained and strongly porphiric but the size and the modal proportion of the phenocrysts vary significantly in the vertical direction and along the strike of the lava flows. The degree of weathering and olivine alteration also varies. Reasonably fresh, green-coloured olivine crystals are not uncommon. All the sampling sites, with the exception of the Sandy Point, are not far from the single road going to the west and to the east of the Settlement, and can be easily reached by foot. The Sandy Point can be reached by boat but the landing is possible only in calm weather and with eastward wind.

Fig. 5.5.2 Sampling at the Pigbite gulch.

6 Ship's Meteorological Station

No meteorological observer was on board.

7 Station List MSM20/2

Velocity Profiles

Station No.	Date	Time [UTC]	Position Lat	Position Lon	Depth [m]	Station ID	Gear Abbreviation	Depth of profile (m)
MSM20/2_015-1	18/01/12	07:45	25° 23.52' S	10° 07.04' E	4436.4	JD18	SVP	1800
MSM20/2_016-1	19/01/12	07:43	27° 54.45' S	5° 34.07' E	4853.9	JD19	SVP	1800
MSM20/2_017-1	20/01/12	07:54	29° 49.78' S	2° 1.20' E	3693.6	JD20	SVP	600
MSM20/2_018-1	21/01/12	09:33	32° 5.72' S	2° 13.76' W	4197.1	JD21	SVP	800
MSM20/2_022-3	23/01/12	11:58	37° 35.47' S	10° 18.49' W	3358.4	JD23	SVP	1000
MSM20/2_026-3	24/01/12	11:17	36° 54.55' S	11° 12.43' W	3788	JD24	SVP	800
MSM20/2_034-2	26/01/12	05:55	38° 1.12' S	12° 31.94' W	3300.9	JD26a	SVP	800
MSM20/2_036-3	26/01/12	18:24	38° 54.43' S	14° 0.84' W	3094.9	JD26b	SVP	1000
MSM20/2_039-3	27/01/12	08:38	37° 15.62' S	13° 24.78' W	3584.8	JD27	SVP	1000
MSM20/2_041-3	28/01/12	01:11	37° 36.63' S	15° 37.30' W	3225.8	JD28a	SVP	1000
MSM20/2_044-2	28/01/12	17:00	35° 49.03' S	13° 52.97' W	3655.5	JD28b	SVP	1000
MSM20/2_049-2	03/02/12	14:01	37° 36.80' S	14° 6.55' W	3132.7	JD34	SVP	1000
MSM20/2_049-4	05/02/12	13:52	38° 26.98' S	17° 20.45' W	3238.7	JD36	SVP	1000

OEBM Deployments

Station No.	Date	Time [UTC]	Position Lat	Position Lon	Depth [m]	Station ID	Gear Abbreviation	Station Owner
MSM20/2_020-1	22/01/12	22:33	35° 55.77' S	9° 40.90' W	3937.5	Tris01-G	OBMT	GEOMAR
MSM20/2_021-1	23/01/12	05:08	36° 40.21' S	9° 59.39' W	3635.8	Tris02-G	OBMT	GEOMAR
MSM20/2_022-1	23/01/12	10:49	37° 35.69' S	10° 18.14' W	3365.2	Tris03-G	OBMT	GEOMAR
MSM20/2_023-1	23/01/12	17:18	38° 21.68' S	10° 46.59' W	3534.8	Tris04-T	OBMT	U of Tokyo
MSM20/2_024-1	24/01/12	00:30	38° 34.78' S	11° 57.55' W	3161.4	Tris05-G	OBMT	GEOMAR
MSM20/2_025-1	24/01/12	05:35	37° 44.68' S	11° 22.17' W	3560.3	Tris06-G	OBMT	GEOMAR
MSM20/2_026-1	24/01/12	10:08	36° 54.26' S	11° 12.13' W	3813.1	Tris07-G	OBMT	GEOMAR
MSM20/2_027-1	24/01/12	15:39	36° 7.75' S	10° 48.04' W	3949.4	Tris08-T	OBMT	U of Tokyo
MSM20/2_028-1	24/01/12	21:44	35° 38.33' S	11° 29.62' W	4169.4	Tris09-G	OBMT	GEOMAR
MSM20/2_029-1	25/01/12	01:42	36° 16.45' S	11° 56.21' W	3721.4	Tris10-G	OBMT	GEOMAR
MSM20/2_030-1	25/01/12	15:51	36° 52.62' S	12° 7.09' W	3571.1	Tris11-T	OBMT	U of Tokyo
MSM20/2_031-1	25/01/12	20:17	37° 21.52' S	11° 53.81' W	3671.3	Tris12-G	OBMT	GEOMAR
MSM20/2_032-1	25/01/12	22:56	37° 47.53' S	11° 57.27' W	3286.1	Tris13-T	OBMT	U of Tokyo
MSM20/2_033-1	26/01/12	03:06	37° 55.73' S	12° 26.89' W	3301.8	Tris14-G	OBMT	GEOMAR
MSM20/2_035-1	26/01/12	11:03	38° 45.21' S	13° 4.58' W	3181	Tris15-T	OBMT	U of Tokyo
MSM20/2_036-1	26/01/12	17:19	38° 54.16' S	14° 0.27' W	3110.3	Tris16-G	OBMT	GEOMAR
MSM20/2_037-1	26/01/12	23:31	38° 4.83' S	13° 38.07' W	3391.3	Tris17-G	OBMT	GEOMAR
MSM20/2_038-1	27/01/12	03:57	37° 35.80' S	12° 54.52' W	3154.9	Tris18-G	OBMT	GEOMAR
MSM20/2_039-1	27/01/12	07:20	37° 15.60' S	13° 24.75' W	3583.5	Tris19-T	OBMT	U of Tokyo
MSM20/2_040-1	27/01/12	17:59	38° 16.61' S	14° 43.04' W	3216.1	Tris20-G	OBMT	GEOMAR
MSM20/2_041-1	28/01/12	00:03	37° 36.63' S	15° 36.95' W	3225.7	Tris21-T	OBMT	U of Tokyo
MSM20/2_042-2	28/01/12	06:20	37° 24.69' S	14° 33.17' W	3338.5	Tris22-G	OBMT	GEOMAR
MSM20/2_043-1	28/01/12	10:54	36° 38.61' S	14° 16.74' W	3674.7	Tris23-G	OBMT	GEOMAR
MSM20/2_044-1	28/01/12	16:06	35° 49.14' S	13° 52.93' W	3655.5	Tris24-T	OBMT	U of Tokyo
MSM20/2_045-1	28/01/12	22:53	36° 23.92' S	13° 2.91' W	3545.1	Tris25-G	OBMT	GEOMAR
MSM20/2_046-1	29/01/12	02:29	36° 59.49' S	12° 40.72' W	3515.6	Tris26-G	OBMT	GEOMAR

OBS Deployments

Station No.	Date	Time [UTC]	Position Lat	Position Lon	Depth [m]	Station ID	Gear Abbreviation	Station Owner
MSM20/2_020-2	22/01/12	22:43	35° 55.47' S	9° 41.26' W	3944.5	TDC01	OBS	AWI-DPAS
MSM20/2_021-2	23/01/12	05:16	36° 40.11' S	9° 59.63' W	3633.9	TDC02	OBS	AWI-DPAS
MSM20/2_022-2	23/01/12	10:59	37° 35.53' S	10° 18.54' W	3357	TDC03	OBS	AWI-DPAS
MSM20/2_023-2	23/01/12	17:25	38° 21.81' S	10° 46.92' W	3534.3	TDC04	OBS	AWI-DPAS
MSM20/2_024-2	24/01/12	00:37	38° 34.86' S	11° 57.72' W	3162.7	TDC05	OBS	AWI-DPAS
MSM20/2_025-2	24/01/12	05:44	37° 44.83' S	11° 22.47' W	3560.3	TDC06	OBS	AWI-DPAS
MSM20/2_026-2	24/01/12	10:16	36° 54.49' S	11° 12.37' W	3800.3	TDC07	OBS	AWI-DPAS
MSM20/2_027-2	24/01/12	15:45	36° 7.93' S	10° 48.14' W	3951.2	TDC08	OBS	AWI-DPAS
MSM20/2_028-2	24/01/12	21:52	35° 38.57' S	11° 29.68' W	4168.3	TDC09	OBS	AWI-DPAS
MSM20/2_029-2	25/01/12	01:50	36° 16.56' S	11° 56.39' W	3713.6	TDC10	OBS	AWI-DPAS
MSM20/2_030-2	25/01/12	15:57	36° 52.66' S	12° 7.33' W	3569.6	TDC11	OBS	AWI-DPAS
MSM20/2_031-2	25/01/12	20:26	37° 21.64' S	11° 54.12' W	3673.2	TDC12	OBS	AWI-DPAS

MSM20/2_033-2	26/01/12	03:15	37° 55.79' S	12° 27.11' W	3307.6	TDC14	OBS	AWI-DPAS
MSM20/2_035-2	26/01/12	11:11	38° 45.17' S	13° 4.91' W	3183.8	TDC15	OBS	AWI-DPAS
MSM20/2_036-2	26/01/12	17:25	38° 54.10' S	14° 0.67' W	3104.2	TDC16	OBS	AWI-DPAS
MSM20/2_037-2	26/01/12	23:38	38° 4.94' S	13° 38.33' W	3390.6	TDC17	OBS	AWI-DPAS
MSM20/2_038-2	27/01/12	04:07	37° 35.81' S	12° 54.77' W	3159	TDC18	OBS	AWI-DPAS
MSM20/2_039-2	27/01/12	07:29	37° 15.44' S	13° 25.08' W	3595.4	TDC19	OBS	AWI-DPAS
MSM20/2_040-2	27/01/12	18:08	38° 16.47' S	14° 43.30' W	3225.4	TDC20	OBS	AWI-DPAS
MSM20/2_041-2	28/01/12	00:12	37° 36.65' S	15° 37.23' W	3225.4	TDC21	OBS	AWI-DPAS
MSM20/2_042-1	28/01/12	06:12	37° 24.88' S	14° 32.91' W	3333.9	TDC22	OBS	AWI-DPAS
MSM20/2_043-2	28/01/12	11:01	36° 38.81' S	14° 17.05' W	3673.1	TDC23	OBS	AWI-DPAS
MSM20/2_045-2	28/01/12	23:00	36° 24.16' S	13° 2.83' W	3548.8	TDC25	OBS	AWI-DPAS
MSM20/2_046-2	29/01/12	02:36	36° 59.71' S	12° 40.77' W	3507.4	TDC26	OBS	AWI-DPAS

Bathymetry Survey Tristan/Nightingale

Station	Date	Time	Position	Position	Depth	Gear	Action	Comment
MSM20/2_047-1	30/01/12	18:10	37° 7.12' S	12° 31.95' W	2901.6	MB+PS	start profil	
MSM20/2_047-1	30/01/12	19:26	37° 9.75' S	12° 43.78' W	2396.7	MB+PS	alter course	new course 242°
MSM20/2_047-1	30/01/12	21:00	37° 15.56' S	12° 57.63' W	3055.5	MB+PS	alter course	new course 159°
MSM20/2_047-1	30/01/12	22:10	37° 24.15' S	12° 54.13' W	2830.2	MB+PS	alter course	new course 104°
MSM20/2_047-1	30/01/12	23:10	37° 26.20' S	12° 44.52' W	2201.7	MB+PS	alter course	new course 183°
MSM20/2_047-1	31/01/12	00:15	37° 34.63' S	12° 44.48' W	562.6	MB+PS	alter course	new course 180°
MSM20/2_047-1	31/01/12	04:01	38° 4.72' S	12° 44.50' W	3279.9	MB+PS	alter course	new course 090°
MSM20/2_047-1	31/01/12	04:35	38° 5.40' S	12° 39.32' W	3152.6	MB+PS	alter course	new course 360°
MSM20/2_047-1	31/01/12	09:01	37° 30.47' S	12° 38.49' W	2716.6	MB+PS	alter course	new course 090°
MSM20/2_047-1	31/01/12	09:41	37° 30.00' S	12° 32.12' W	1826.8	MB+PS	alter course	new course 180°
MSM20/2_047-1	31/01/12	14:06	38° 4.98' S	12° 31.49' W	3315.2	MB+PS	alter course	new course 090°
MSM20/2_047-1	31/01/12	14:44	38° 5.50' S	12° 25.42' W	3340.7	MB+PS	alter course	new course 000°
MSM20/2_047-1	31/01/12	19:23	37° 28.58' S	12° 24.80' W	1756.4	MB+PS	alter course	new course 090°
MSM20/2_047-1	31/01/12	20:06	37° 28.17' S	12° 18.19' W	2106	MB+PS	alter course	new course 180°
MSM20/2_047-1	01/02/12	00:20	38° 1.88' S	12° 17.99' W	3250.2	MB+PS	alter course	new course 090°
MSM20/2_047-1	01/02/12	01:00	38° 2.50' S	12° 11.74' W	3342.1	MB+PS	alter course	new course 000°
MSM20/2_047-1	01/02/12	06:43	37° 17.57' S	12° 11.00' W	2973.9	MB+PS	profile end	

Bathymetry Survey Tristan Fracture Zone and MAR

Station	Date	Time	Position	Position	Depth	Gear	Action	Comment
MSM20/2_049-1	01/02/12	18:40	37° 1.46' S	12° 17.72' W	1260.9	MB+PS	start profil	
MSM20/2_049-1	01/02/12	19:36	37° 2.88' S	12° 8.50' W	2527.5	MB+PS	alter course	new course 180°
MSM20/2_049-1	01/02/12	20:42	37° 11.28' S	12° 7.90' W	2759.7	MB+PS	alter course	new course 231°
MSM20/2_049-1	01/02/12	21:50	37° 17.13' S	12° 16.39' W	2677.1	MB+PS	alter course	new course 180°
MSM20/2_049-1	01/02/12	22:54	37° 25.49' S	12° 16.80' W	2295.4	MB+PS	alter course	new course 270°
MSM20/2_049-1	01/02/12	23:18	37° 26.00' S	12° 20.46' W	515.5	MB+PS	alter course	new course 000°
MSM20/2_049-1	02/02/12	00:21	37° 17.80' S	12° 20.99' W	2241.3	MB+PS	alter course	new course 270°
MSM20/2_049-1	02/02/12	00:36	37° 17.21' S	12° 22.93' W	1974.7	MB+PS	alter course	new course 180°
MSM20/2_049-1	02/02/12	01:43	37° 25.83' S	12° 23.60' W	1219.2	MB+PS	alter course	new course 270°
MSM20/2_049-1	02/02/12	01:55	37° 26.40' S	12° 24.97' W	1112.9	MB+PS	alter course	new course 000°
MSM20/2_049-1	02/02/12	02:56	37° 18.56' S	12° 25.70' W	1396.2	MB+PS	alter course	new course 316°

Station	Date	Time	Position	Position	Depth	Gear	Action	Comment
MSM20/2_049-1	02/02/12	03:15	37° 16.68' S	12° 27.71' W	1363.7	MB+PS	alter course	new course 286°
MSM20/2_049-1	02/02/12	04:41	37° 13.57' S	12° 41.48' W	847.6	MB+PS	alter course	new course 243°
MSM20/2_049-1	02/02/12	05:47	37° 17.33' S	12° 51.35' W	1251.7	MB+PS	alter course	new course 169°
MSM20/2_049-1	02/02/12	06:32	37° 23.13' S	12° 50.40' W	2112.4	MB+PS	alter course	new course 180°
MSM20/2_049-1	02/02/12	11:02	37° 59.03' S	12° 50.40' W	3085.1	MB+PS	alter course	new course 270°
MSM20/2_049-1	02/02/12	11:38	37° 59.49' S	12° 56.18' W	3321.4	MB+PS	alter course	new course 000°
MSM20/2_049-1	02/02/12	14:09	37° 39.60' S	12° 56.71' W	3314.4	MB+PS	alter course	new course 353°
MSM20/2_049-1	02/02/12	17:15	37° 15.02' S	13° 0.42' W	92.4	MB+PS	alter course	new course 266°
MSM20/2_049-1	02/02/12	18:05	37° 14.98' S	13° 8.00' W	3378.1	MB+PS	alter course	neuer Krus 174°
MSM20/2_049-1	02/02/12	21:53	37° 44.98' S	13° 4.57' W	3789.6	MB+PS	alter course	new course 265°
MSM20/2_049-1	02/02/12	22:37	37° 45.96' S	13° 11.49' W	3772.8	MB+PS	alter course	new course 354°
MSM20/2_049-1	03/02/12	01:24	37° 24.14' S	13° 14.71' W	3398.5	MB+PS	alter course	new course 261°
MSM20/2_049-1	03/02/12	02:31	37° 24.77' S	13° 25.23' W	3565.1	MB+PS	alter course	new course 223°
MSM20/2_049-1	03/02/12	04:03	37° 33.57' S	13° 35.94' W	3434.2	MB+PS	alter course	new course 176°
MSM20/2_049-1	03/02/12	06:53	37° 56.10' S	13° 34.04' W	3612.3	MB+PS	alter course	new course 246°
MSM20/2_049-1	03/02/12	08:28	38° 1.44' S	13° 47.85' W	3125.7	MB+PS	alter course	new course 265°
MSM20/2_049-1	03/02/12	09:58	38° 2.41' S	14° 2.89' W	3343.9	MB+PS	alter course	new course 354°
MSM20/2_049-1	03/02/12	13:17	37° 36.80' S	14° 6.55' W	3143.4	MB+PS	profile break	
MSM20/2_049-1	03/02/12	14:03	37° 36.81' S	14° 6.56' W	3137.3	MB+PS	continue the profile	course 238°
MSM20/2_049-1	03/02/12	15:48	37° 43.95' S	14° 20.89' W	3189.1	MB+PS	alter course	new course 220°
MSM20/2_049-1	03/02/12	16:53	37° 50.55' S	14° 27.92' W	2931.3	MB+PS	alter course	new course 270°
MSM20/2_049-1	03/02/12	17:39	37° 50.81' S	14° 35.46' W	2887.3	MB+PS	alter course	new course 260°
MSM20/2_049-1	03/02/12	20:07	37° 53.98' S	14° 59.82' W	2569.8	MB+PS	alter course	new course 287°
MSM20/2_049-1	03/02/12	21:05	37° 51.83' S	15° 9.17' W	2966.7	MB+PS	alter course	new course 281°
MSM20/2_049-1	03/02/12	21:55	37° 50.52' S	15° 17.38' W	2984	MB+PS	alter course	new course 177°
MSM20/2_049-1	04/02/12	01:50	38° 21.46' S	15° 15.75' W	2561.2	MB+PS	alter course	new course 259°
MSM20/2_049-1	04/02/12	03:20	38° 24.11' S	15° 30.00' W	2757	MB+PS	alter course	new course 258°
MSM20/2_049-1	04/02/12	11:24	38° 36.70' S	16° 47.91' W	2803.6	MB+PS	alter course	new course 349°
MSM20/2_049-1	04/02/12	12:07	38° 32.26' S	16° 49.56' W	2543.5	MB+PS	profile break	
MSM20/2_049-1	04/02/12	13:06	38° 32.34' S	16° 49.51' W	2569.2	MB+PS	continue the profile	Course 078°
MSM20/2_049-1	04/02/12	20:53	38° 19.56' S	15° 32.29' W	2820.8	MB+PS	alter course	new course 347°
MSM20/2_049-1	04/02/12	21:33	38° 14.45' S	15° 33.29' W	3303.2	MB+PS	alter course	new course 258°
MSM20/2_049-1	05/02/12	02:20	38° 21.97' S	16° 19.56' W	3517.2	MB+PS	Information	Kursänderungen . Löcher zufahren
MSM20/2_049-1	05/02/12	03:56	38° 20.61' S	16° 11.61' W	3331.9	MB+PS	Information	zurück auf Profil - Kurs 258°
MSM20/2_049-1	05/02/12	11:28	38° 33.41' S	17° 26.06' W	3241.6	MB+PS	alter course	new course 348°
MSM20/2_049-1	05/02/12	12:06	38° 28.67' S	17° 27.86' W	3323.8	MB+PS	alter course	new course 078°
MSM20/2_049-1	05/02/12	12:59	38° 26.98' S	17° 20.45' W	3239.7	MB+PS	profile break	
MSM20/2_049-1	05/02/12	13:52	38° 27.20' S	17° 20.15' W	3229.8	MB+PS	continue the profile	course 078°
MSM20/2_049-1	06/02/12	01:30	38° 7.51' S	15° 24.75' W	2923.6	MB+PS	alter course	new course 345°
MSM20/2_049-1	06/02/12	02:10	38° 2.76' S	15° 25.59' W	2875.9	MB+PS	alter course	new course 258°
MSM20/2_049-1	06/02/12	04:43	38° 6.35' S	15° 50.39' W	3144.7	MB+PS	Information	Probleme beim Parasound. Reduzierung auf 4 kn

Station	Date	Time	Position	Position	Depth	Gear	Action	Comment
MSM20/2_049-1	06/02/12	04:48	38° 6.43' S	15° 50.84' W	3141.9	MB+PS	Information	Problem behoben. Geschwindigkeit 8 kn
MSM20/2_049-1	06/02/12	15:34	38° 24.45' S	17° 37.48' W	2453.1	MB+PS	alter course	new course 349°
MSM20/2_049-1	06/02/12	16:06	38° 20.45' S	17° 38.83' W	2223.2	MB+PS	alter course	new course 078°
MSM20/2_049-1	07/02/12	04:17	37° 59.21' S	15° 39.05' W	3030.7	MB+PS	alter course	new course 347°
MSM20/2_049-1	07/02/12	04:53	37° 54.80' S	15° 39.63' W	3116.2	MB+PS	alter course	new course 258°
MSM20/2_049-1	07/02/12	15:07	38° 11.97' S	17° 21.88' W	2015.1	MB+PS	profile end	

EM Transmitter Sputnik Test 1

Station	Date	Time	Position	Position	Depth	Gear	Gear	Action
MSM20/2_048-1	01/02/12	11:27	37° 1.60' S	12° 17.46' W	1237.1	Controlled Source EM	SPUTNIK	at surface
MSM20/2_048-1	01/02/12	12:08	37° 1.60' S	12° 17.45' W	1237.1	Controlled Source EM	SPUTNIK	at seafloor
MSM20/2_048-1	01/02/12	13:10	37° 1.60' S	12° 17.45' W	1237.5	Controlled Source EM	SPUTNIK	information
MSM20/2_048-1	01/02/12	13:11	37° 1.60' S	12° 17.45' W	1235.5	Controlled Source EM	SPUTNIK	start heaving
MSM20/2_048-1	01/02/12	13:47	37° 1.60' S	12° 17.45' W	1237.3	Controlled Source EM	SPUTNIK	back to deck
MSM20/2_048-2	01/02/12	15:24	37° 1.60' S	12° 17.45' W	1233.3	Controlled Source EM	SPUTNIK	at surface
MSM20/2_048-2	01/02/12	16:05	37° 1.60' S	12° 17.45' W	1232.9	Controlled Source EM	SPUTNIK	at seafloor
MSM20/2_048-2	01/02/12	16:13	37° 1.60' S	12° 17.45' W	1231	Controlled Source EM	SPUTNIK	start heaving
MSM20/2_048-2	01/02/12	16:34	37° 1.65' S	12° 17.44' W	1195.7	Controlled Source EM	SPUTNIK	information
MSM20/2_048-2	01/02/12	16:35	37° 1.65' S	12° 17.43' W	1191.7	Controlled Source EM	SPUTNIK	start lowering
MSM20/2_048-2	01/02/12	16:44	37° 1.65' S	12° 17.44' W	1196	Controlled Source EM	SPUTNIK	at seafloor
MSM20/2_048-2	01/02/12	16:55	37° 1.65' S	12° 17.44' W	1197.3	Controlled Source EM	SPUTNIK	start heaving
MSM20/2_048-2	01/02/12	17:25	37° 1.66' S	12° 17.43' W	1195.5	Controlled Source EM	SPUTNIK	back to deck

EM Transmitter Sputnik Test 2

Station	Date	Time	Position	Position	Depth	Gear	Gear	Action
MSM20/2_050-1	07/02/12	15:42	38° 15.64' S	17° 22.68' W	2184.5	Controlled Source EM	SPUTNIK	at surface
MSM20/2_050-1	07/02/12	16:28	38° 15.64' S	17° 22.69' W	2188.5	Controlled Source EM	SPUTNIK	at seafloor
MSM20/2_050-1	07/02/12	16:40	38° 15.64' S	17° 22.69' W	2189.3	Controlled Source EM	SPUTNIK	start heaving
MSM20/2_050-1	07/02/12	16:54	38° 15.64' S	17° 22.69' W	2187.7	Controlled Source EM	SPUTNIK	start lowering
MSM20/2_050-1	07/02/12	17:10	38° 15.64' S	17° 22.69' W	2189.4	Controlled Source EM	SPUTNIK	at seafloor
MSM20/2_050-1	07/02/12	17:13	38° 15.64' S	17° 22.69' W	2189.9	Controlled Source EM	SPUTNIK	start heaving
MSM20/2_050-1	07/02/12	18:00	38° 15.65' S	17° 22.68' W	2189.9	Controlled Source EM	SPUTNIK	back to deck

8 Data and Sample Storage and Availability

In Kiel a joint data management team of GEOMAR and Kiel University organises and supervises data storage and publication by marine science projects in a webbased multi-user system. In a first phase bathymetric and parasound data are only available to the project user groups. The data management team will publish the parasound and processed bathymetric data and by dissemination to national and international data archives, i.e. the data will be submitted to PANGAEA no later than July, 2015.

Seismological data will be available on the Open Access Seismological Archive GEOFON (http://www.geofon.gfz-potsdam.de) by the end of 2017. Bathymetric data are archived at Bundesamt für Seeschifffahrt und Hydrographie (BSH). ADCP and PARASOUND data will be archived at the Alfred Wegener Institute, and information about these data will be made available via PANGAEA Open Access library (http://www.pangaea.de/).

The MT data will be submitted to PANGAEA no later than January 2016. Digital object identifiers (DOIs) are automatically assigned to data sets archived in the PANGAEA Open Access library making them publically retrievable, citeable and reusable for the future. All metadata are immediately available publically via the following link pointing at the GEOMAR portal (https://portal.geomar.de/metadata/leg/show/314267).

In addition the portal provides a single downloadable KML formatted file (https://portal.geomar.de/metadata/leg/kmlexport/314267) which retrieves and combines up-to-date cruise (MSM20/2) related information, links to restricted data and to published data for visualisation e.g. in GoogleEarth.

Rock samples collected at Tristan da Cunha, geochemical and chronological data will be archived by the Thermochronology and Archaeometry Research Group (contact: Ulrich A. Glasmacher, Ulrich.A.Glasmacher@geow.uni-heidelberg.de). Samples are available on request latest 5 years after the cruise.

9 Acknowledgements

We sincerely thank Cpt. Schmidt and his crew for their professional assistance at sea. The Tristan cruise is funded through the Deutsche Forschungsgemeinschaft DFG in the framework of the SPP 1375 - **S**outh **A**tlantic **M**argin **P**rocesses and **L**inks with onshore **E**volution (SAMPLE). The authors wish to express their gratitude to S. Burns, Governor of Tristan da Cunha and Robin Repetto, who has been of great help to organize the land expeditions

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Attachment 1: Tristan and Isolde Blog

Der Tristan & Isolde Blog

Hier können Sie unserer Forschungsreise nach Tristan da Cunha und von dort weiter nach Recife (Brasilien) folgen. Wir bieten Ihnen Einblicke in unser wissenschaftliches Projekt, in die Freuden und Herausforderungen des Bordlebens und in unsere Erkenntnisse über die Geophysik des Südatlantiks.

17. Januar 2012: Auslaufen aus Walvis Bay

RV MARIA S. MARIA S. MERIAN in Walvis Bay (Namibia). Foto: Cathrine Rannou

Das Forschungsschiff MARIA S. MARIA S. MERIAN ist auf dem Weg zur "abgelegensten Insel der Welt". Heute gegen 9:00 Uhr morgens haben wir den Hafen von Walvis Bay in Namibia verlassen. Kurs: Tristan da Cunha, in der Mitte des Südatlantiks. Die Insel mit einem Durchmesser von nur 12 Kilometern wird von 262 britischen Bürgern bewohnt. Sie leben auf einem äußerst aktiven, etwa fünf Kilometer hohen Vulkan, der sich knapp 2 Kilometer über die Wasseroberfläche erhebt. Die restlichen 3 Kilometer liegen unterhalb des Meeresspiegels (mit dem Suchbegriff "Tristan da Cunha, St. Helena" kann man sich auf google maps die beinahe perfekte Kegelform der Insel anzeigen lassen). St. Helena, der einstige Verbannungsort von Napoleon Bonaparte, ist die nächste bewohnte Insel und der offizielle Verwaltungssitz. Die Entfernung von rund 3000 Kilometern bis dorthin brachte Tristan den Beinamen "abgelegenster bewohnter Ort der Erde" ein.

Wir sind 18 deutsche, französische und japanische Wissenschaftler an Bord der MARIA S. MARIA S. MERIAN. Hinzu kommen 23 Mann Besatzung. Als Geophysiker und Geologen interessieren wir uns für den tiefen Untergrund unter Tristan da Cunha. Was hat den starken

Vulkanismus an diesem ungewöhnlichen Ort über eine so extrem lange Zeit (mehr als 130 Millionen Jahre) begünstigt? Möglicherweise ist Tristan das oberflächliche Zeichen eines sogenannten "Mantel Plumes", eines Aufstiegskanals für heißes Material, das aus rund 3000 km Tiefe (von der Grenze zwischen dem soliden Erdmantel und dem flüssigen Eisenkern) nach oben steigt. Es gibt weltweit nur ein paar Dutzend derartige Stellen. Die bekanntesten sind Hawaii und Island. Ihre Rolle und Funktion ist unter Geowissenschaftlern auch 40 Jahre, nachdem die Existenz von Mantelplumes erstmals hypothetisch formuliert wurde, umstritten. Tristan wäre ein besonders klassisches Fallbeispiel. Deshalb ist der Vulkan ein Forschungsobjekt im DFG-Schwerpunktprogramm "SAMPLE", das sich mit der Entwicklung des Südatlantiks beschäftigt.

In diesem Blog können Sie unserer Reise nach Tristan da Cunha und von dort weiter nach Recife (Brasilien) folgen. Wir geben Einblicke in unsere wissenschaftlichen Projekte, die Freuden und Herausforderungen des Bordlebens und in unsere Erkenntnisse über den Südatlantik.

Karin Sigloch

18. Januar 2012: Testing

Scientists testing their devices on the way to Tristan da Cunha. Photo: Cathrine Rannou/Karin Sigloch

Scientists testing their devices on the way to Tristan da Cunha. Photo: Cathrine Rannou/Karin Sigloch

Scientists testing their devices on the way to Tristan da Cunha. Photo: Cathrine Rannou/Karin Sigloch

The day was dedicated to the testing of scientific instruments. Once we arrive near Tristan da Cunha, we will throw over board 26 electromagnetic and 24 seismic sensors, which will cross the water column in free fall, and hopefully land on smooth patches of seafloor. They will sit there for the next year, recording electromagnetic and seismic signals that are generated by natural sources (space weather and earthquakes), and are modified by the earth's crust and mantle. Analyzing the exact ways in which the signals are modified allows us to draw conclusions on the structure of the subsurface beneath Tristan.

Something the two geophysical sensing methods share are the worries by their owners whether all instruments can be successfully recovered a year from now. They are not connected to the sea surface by cable, and the only way to communicate with them is to send Morse-code-like acoustic signals down through the water column. This prompts a release mechanism to unhook the buoyant instrument package from the heavy anchor that originally caused it to sink. If the release mechanism fails, the expensive instruments stays on the seafloor, so much attention is paid to the proper functioning of these releasers. Today we had a wild concert of the sharp, high releaser beeps sounding through the ship's hangar while three different groups were dry-testing their instruments. The German groups from Kiel and Bremerhaven prefer mechanical unhooking, whereas our colleagues from Tokyo melt corrosively through a piece of wire by application of an electric current. In the dry tests, all instruments recognized their acoustic codes and released, so tomorrow the ship's winch will lower them into the ocean for a more realistic rehearsal. Strapped to cages or metal frames, they will descend to 4000 m depth and hopefully all release on command, before the cable is pulled up again to check on the results.

The day also served to settle into a working routine among the groups, and to get to know each other better. We agreed on plans for the daily and nightly watch shifts. Yesterday, the ship doctor had met with a good number of customers regarding sea-sickness remedies, and the results were a conversation topic today. One colleague reported that he only became really sick after having to get into the claustrophobic life boat in yesterday's safety drill. The fact that we had no emergency alarm today may have helped improve the health situation on board significantly.

Karin Sigloch

19. Januar 2012: Sputnik's first mission

The releaser tests in the water were mostly successful. At 9:00 am, the ship winch lowered the first dozen of releasers into the ocean, strapped to a metal basket. After about one hour, they had arrived at 3000 m water depth, and could be pinged acoustically by their owners, the seismology group. One didn't answer, but when the basket arrived back at the surface an hour later, it turned out that all had released properly. Another instrument kept beeping even after it was back onboard, as if it had an urgent undersea story to tell. For this chattiness, it was classified “unreliable”, since in a long-term deployment, it might quickly burn through its battery power and have none left to release at the right moment.

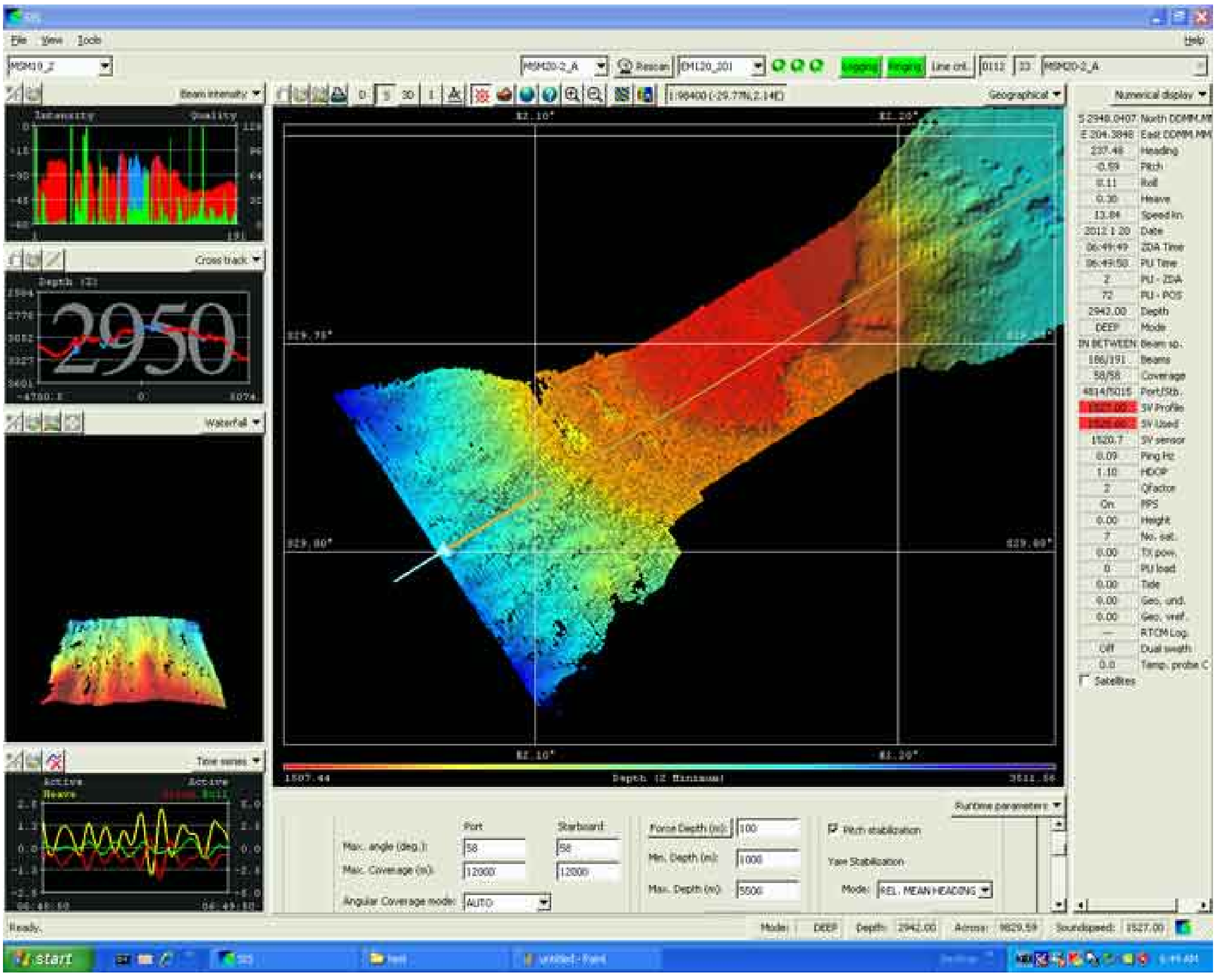
Next, the electromagnetics group winched their own releasers into the sea. Not in a simple basket, but strapped to an extravagant titanium frame (see photo), which is an electromagnetic wave source under construction. It has been baptized “Sputnik”, and was already in good shape to dangle many releasers from it. Sputnik dived a successful mission and returned to the surface with 26 devices that had all unhooked as hoped for.

Karin Sigloch

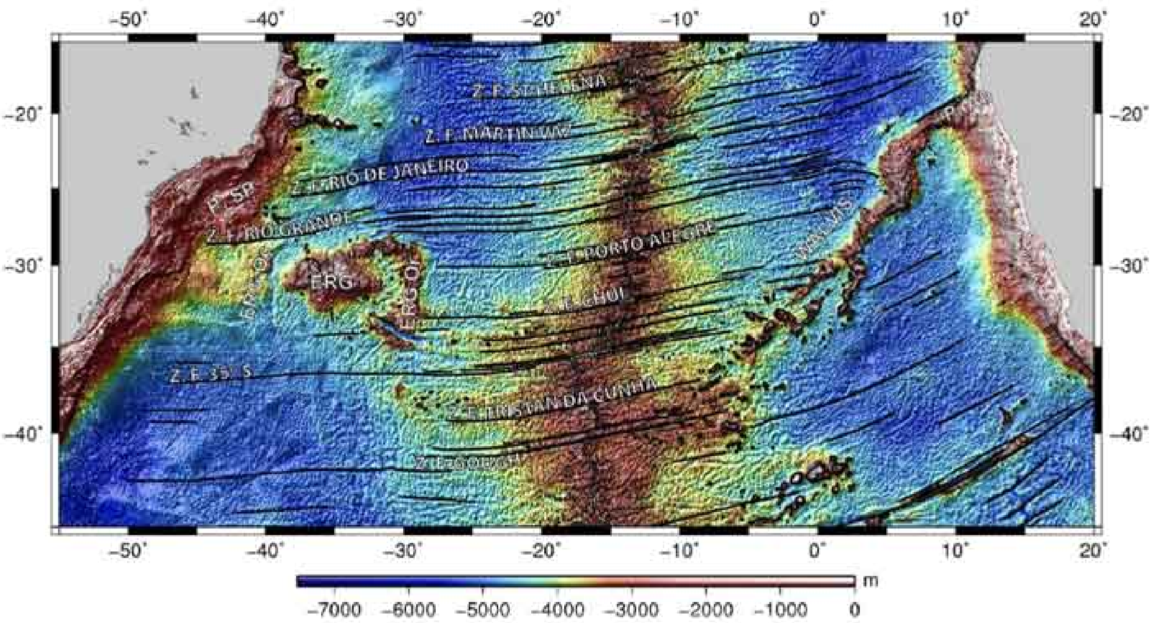
Mostly successful: Releaser tests under real deep sea conditions. Photo Cathrine Rannou

"Sputnik" of the electromagnetic group. Photo: Cathrine Rannou

20. Januar 2012: On the way to the smoking gun



Navigating by bathymetry...



...along the Walvis Ridge to Tristan da Cunha.

We joined up with the Walvis Ridge today. We had been cruising over 4000-5000 m deep water after leaving the Namibian shelf, but this morning, the ship's bathymeter indicated only 1000-2000 meters depth and a very rough seafloor. From here on, we could in principle navigate by bathymetry (seafloor elevation): always follow the direction of the shallowest water; it would lead us straight to Tristan da Cunha. The Walvis Ridge is a major mountain chain on the seafloor, measuring about 3000 km from the northern Namibian coast to the island of Tristan. It consists of extinct undersea volcanoes, which -- very crucially -- show an age progression: the seamounts closest to Namibia were active about 130 million year ago; the ones we are currently cruising over, 100 million years ago. The seamounts ahead of us have ages progressively younger than 100 million years, and the last one, Tristan, is active now.

Such an age-progressive chain of ancient volcanoes is one of the strongest indications that a deep mantle plume is operating at its far end. The plume hypothesis provides the most elegant explanation: a strong, localized source of heat sits stationary in the deep mantle for very long periods of time (>100 million years). The mobile tectonic plates at the surface constantly move across this hotspot. The piece of crust that happens to overlie the hotspot at a given time receives a "burn mark" -- it is volcanically active. But not for long: a few million years later, it will have moved away from the plume site, and the volcano will have died out. Instead, a new volcano will be forming on the adjacent crust that is now overlying the heat source. The African plate has been moving across the Tristan hotspot in northeastern direction for 130 million years, leaving a 3000-km long track of extinct volcanoes: the Walvis Ridge.

The large majority of solid-earth geoscientists endorse this theory, though there is a small but vocal minority who are opposed. In any case, it is an open question whether deep mantle plumes play a major or a marginal role in the earth's heat budget. This is something our expedition wants to help clarify, by directly imaging the extent of hot material in the deep mantle.

Just looking at seafloor elevations (for example the "satellite" mode in Google maps), the Walvis Ridge may appear like a highway from Namibia to Nowhere in the Atlantic. But knowing that the end of the track is an active volcano, with progressively younger seamounts leading towards it, the picture is changed: the Walvis Ridge resembles the trail that leads the detective to the smoking gun.

Karin Sigloch

21. Januar 2012: Very important guests on board

The harbour of Edinburgh of the Seven Seas, photo: Catherine Rannou

The three guests on board, photo: Catherine Rannou

Besides the 18 scientists, we have three guests on board who are catching a ride to Tristan. They are two coastal engineers and one crane technician, who were called to help re-inforce and maintain the small harbor of the island's only settlement, Edinburgh of the Seven Seas. One of them, Marthinus Retief, introduced us to their work at tonight's evening meeting. Tristan, which is only about 12 km in diameter, is exposed to the full force of Atlantic storms, especially those originating from the Southern Ocean to the southwest. They do not have a large enough harbor or natural cove to protect their fishing boats, only two “breakwaters”, jetty-like structures that protrude some hundred meters out into the ocean. This means they can only go fishing for crawfish (Rock Lobster) 60 days of the year. It also means that in case of rough weather, we may well have trouble getting to the island, since the MARIA S. MERIAN did not bring a helicopter. (We'd be so disappointed if we just had to steam past that unique place!)

Tristan's harbor problems were more serious: in 2010, several dolosse on one of the artificial breakwaters were washed away in a storm. (Dolosse are big concrete blocks of a 3D shape optimized to interlock with their neighboring dolosse.) This meant the whole breakwater embankment might suffer severe damage in the next large storm, and so the company of our coastal engineering guests was called to manage an emergency repair. Marthinus’ pictures were amazing: how they took apart a 100-ton crane into 31 pieces so that they would fit onto the only ship available; how they loaded half-dolos made in South Africa plus hundreds of tons of concrete, and set up their first-ever dolos-joining plant on the island; and how packed a neat embankment with the new dolosse. This was done in early 2011, a time during which a commercial vessel called MS

Oliva happened to be ship-wrecked offshore Nightingale, the smaller companion island of Tristan. This caused a bad oil spill that affected a colony of thousands of rockhopper penguins. The 260 inhabitants of Tristan tried to rescue the animals, cleaning and feeding them by hand on the main island. In short, we passed a very entertaining evening with Marthinus' slides and explanations. We can't wait to see the place for ourselves now!

Karin Sigloch

<u>22. Januar 2012: Anticipating the first deployment</u>

The research vessel on gorgeous, deep blue sea, photo: Catherine Rannou

Working by night, photo: Catherine Rannou

8 p.m. -- Excitement is rising, only a couple of hours to go to our first deployment. It is several hundreds of kilometers northeast of Tristan island where we will deploy this first pair of seismic and electromagnetic sensors. The work day has been busy finalizing the setup of the first instruments. From now on, we should be deploying a pair of sensors every 4-6 hours, probably nine times in a row, before we get to make a first stop at Tristan on the 25th. The entire scientific party just switched to working around-the-clock shifts, as the ship's crew always does.

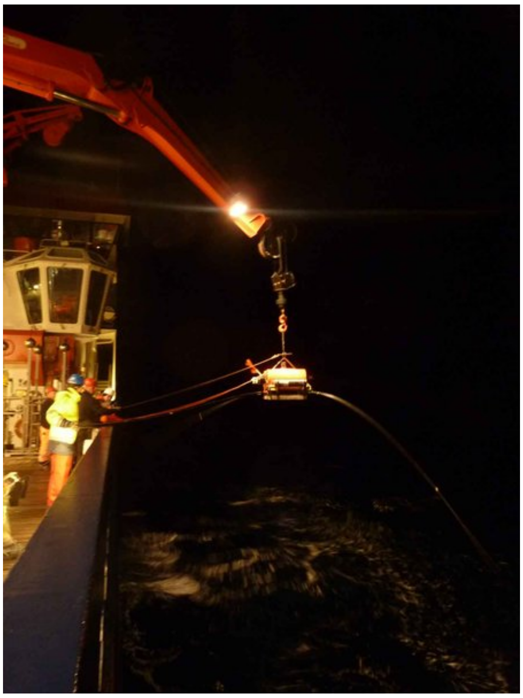
The day was beautifully sunny and warm, and the sea is calm again. The water is of a gorgeous, deep blue. A couple of us spotted a ship today, the first one we noticed since leaving the coastal waters. It was sailing just below the horizon, with only the uppermost deck sticking out in white and black. Another colleague spotted a whale, or rather a hump in the distance and a fountain of water blowing up into the air. So the neighborhood is quiet, but most of the time, at least one or two sea birds can be seen going about their business. Yesterday morning, when the ship stopped for its daily measurement of the water column's velocity profile, we came to a halt over a huge, winding object that turned out to be an abandoned, drifting fishing net. It felt embarrassing -- we stop in this completely random spot in one of the remotest oceans, and what we encounter is human debris. We had to wait and let it drift past, before daring to lower our sounding instrument into the water.

Karin Sigloch

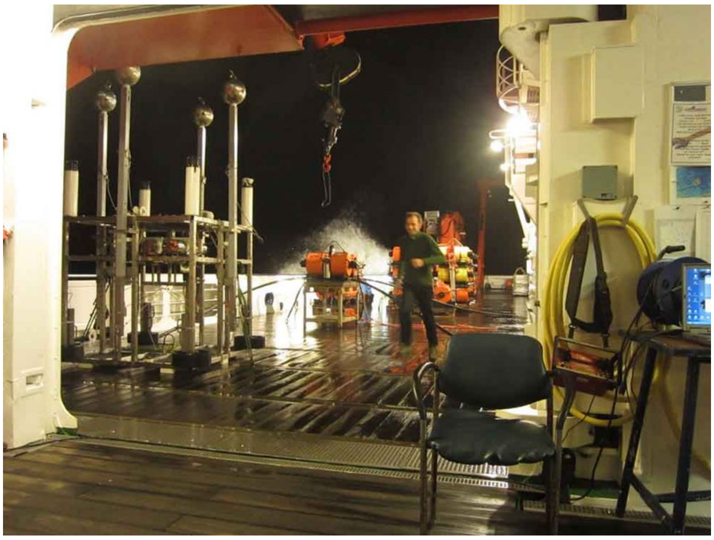
23. Januar 2012: The time has come

Preparing the OBEM system, photo: Catherine Rannou

Deployment of an OBS, photo: Catherine Rannou



Deployment of the OBEM system, photo: Catherine Rannou



Difficult working conditions, photo: Catherine Rannou

The first instruments are out! Around 10:30 p.m. last night, the ship winch lifted the first ocean-bottom electromagnetic sensor (OBEM) off its assembly table. The deck was brightly lit and most scientists were out to watch the spectacle, to the backdrop of a windy night and a lively sea. The OBEM looked like a giant four-legged insect with its five-meter long antennas dangling in the wind. Once the winch hook was fastened, it was a matter of minutes for a couple of sailors and the OBEM group to maneuver the creature over the railing and lower it onto the water. One sailor pulled out the rod securing the loop between hook and instrument, and the bright orange assembly went off into the deep within seconds. It is an exhilarating moment -- releasing the tension of the physical balancing act, and rewarding for the long preparations. Mixed in is slight anxiety: it's gone -- will it be back a year from now?

Karin Sigloch

24. Januar 2012: Tristan in the distance

Painting the ship, photo: Catherine Rannou

Mechanic workshop, photo: Catherine Rannou

Painting even the most difficult parts, photo: Catherine Rannou

The ship's decks and its hangar are workplaces for both the scientists and the ship crew. When the sailors are not helping us lower some instrument into the water or to lug bulky objects around, they are busy with the maintenance of ship infrastructure. They never seem to run out of paint jobs, which all need to be executed with high-tech, heavy-duty paint to face the salty winds and waters. Besides a well-stocked paint storage, there is also a fully equipped mechanic workshop, an electronics workshop, machines for carpentry, and skilled people to operate all the equipment. The ship is run by self-sufficient generalists.

News of the day: we saw Tristan in the distance this morning. It took a while before we could agree that it was not a cloud, and we don't have a presentable photo yet.

Karin Sigloch

25. Januar 2012: Disembarking for Tristan

An eventful day, we arrived at Tristan da Cunha! In the morning, the ship had stationed about 2 km off of the island. The day in pictures:

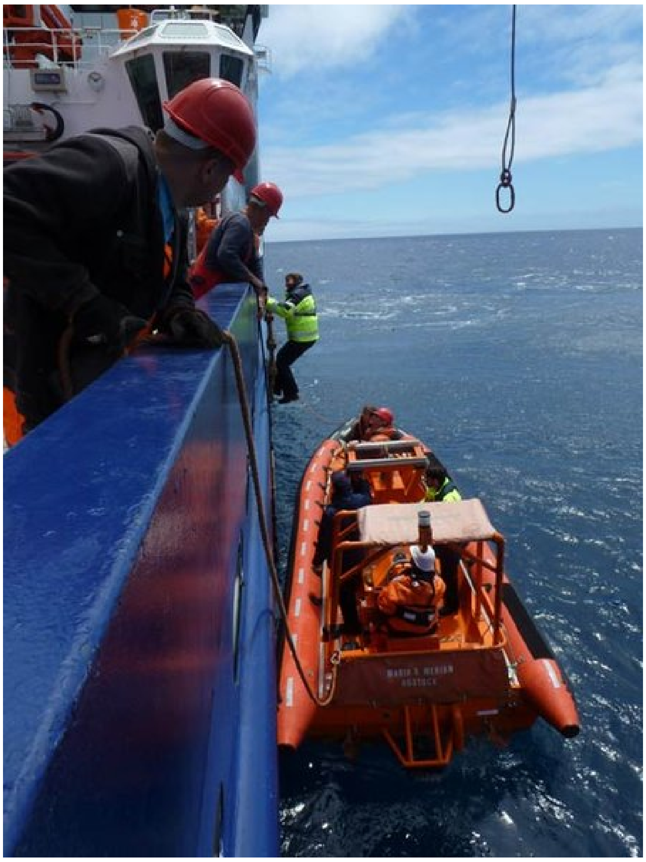
The MARIA S. MERIAN's first and second officers speed away towards the island to pick up Tristan's police/immigration officer. Background shows the western part of the island with its only settlement, Edinburgh of the Seven Seas. The volcanic peak is still covered in clouds.

The boat returns with the immigration officer. View of the northern coast. Most of the coastline is consists of steeply eroded cliffs such as these, which nicely cut through and display the basaltic lava layers that the island is made of.

The immigration formalities are done, our official delegation is getting ready to meet the governor on the island. From left to right: Gent Wichmann (second officer); Wolfram Geissler (co-chief scientist); Marion Jegen (chief scientist and cruise leader); Philip Glass (Tristan police chief); Ralf Schmidt (captain); Achim Schüler (chief engineer); Eberhard Stegmaier (first officer).

It started to rain, the weather changes quickly here. Our science, engineering and art delegation has to wait until they can be shuttled to the island. Ilya Veksler (right), a geologist who will collect rock samples over the next five days, explains the volcanic history of Tristan. Cathrine Rannou, artist-in-residence (second from right), records his fiery story, to images of a gray island in gray clouds. The other appreciative listeners (from left to right) are Kasra Hosseini and Simon Stähler, seismologists, and Marthinus Retief, an engineer called in for harbor maintenance.

The ship hangar has turned into a waiting room. Last chance to say bye to our engineering guests from South Africa, and to the three colleagues who will spend the next week on Tristan.



Our official delegation returns. They got a warm reception from the islanders, and we will post some of their photos tomorrow. Getting on and off the MARIA S. MERIAN required some ingenuity and exercise all day long.

The rest of us kept deploying ocean-bottom instruments. Towards the end of the day, the volcano is cloaked in clouds again, sublimely backlit by the evening sun.

26. Januar 2012: Small World

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Our cruise leaders spent yesterday on the island to arrange with the locals how our plans for land instrumentation might proceed. They were graciously received in the Island Council Hall by Sean

Burns, the governor of Tristan da Cunha. In order to deploy a land seismometer and a magnetotelluric station on the neighboring Nightingale Island, we need the help of native guides and their fishing boats, since there is no easy landing spot on the rocky coastline. This could be arranged for early next week, weather permitting. It was also agreed that a delegation from Tristan should visit us on the MARIA S. MERIAN, and that most of us would spend a free day on the island.

The Tristanians are quite experienced in shepherding geoscientific instrumentation. Since they are the only inhabited land for thousands of kilometers around, it is natural to concentrate sensors there: weather data, seismic, electromagnetic,... The "science meadow" that holds all this high-tech equipment was shown to our colleagues by Robin Repetto, who takes charge of maintaining the infrastructure and of transmitting the data per internet. A while ago, a magnetotelluric station of a colleague from Frankfurt had failed. Small world, Robin handed it neatly packaged to our science chief Marion for return to Germany.

While the existing instruments mainly act to fill an otherwise large hole in global data coverage, our primary interest is to study the solid earth under the Tristan da Cunha region itself. Hence we are distributing instruments over a footprint that spans several hundreds of kilometers in each direction.

The visit ended in the post and tourist office, sending our colleagues back to their boat shuttle with full shopping bags.

Karin Sigloch

27. Januar 2012: The Engine Room, part I

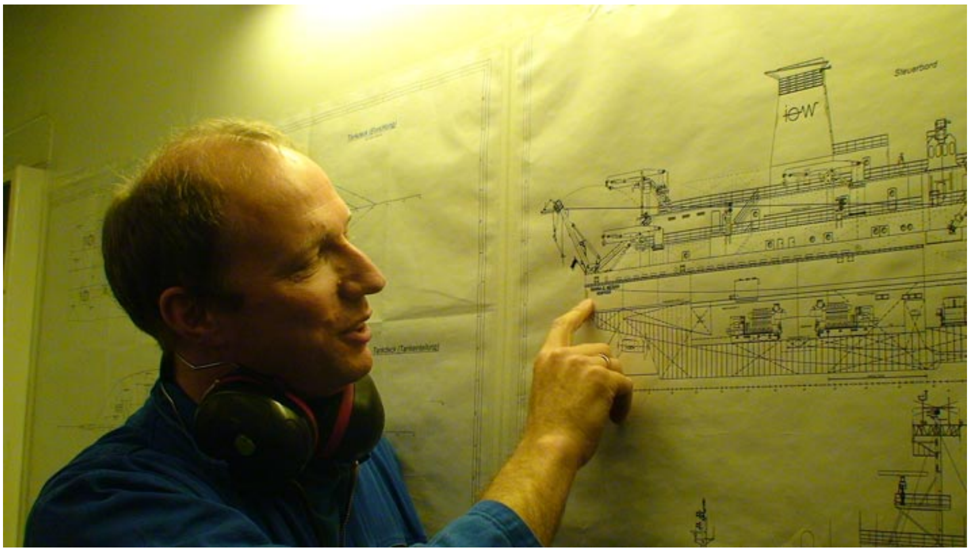


Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

Photo: Science Party MSM20/2

The MARIA S. MERIAN's chief engineer, Achim Schüler, gave us a tour of the ship's engine rooms. It started with an intro in the engine control room, one floor down from the main deck, which is packed from bottom to top with technical manuals. The chief engineer is not just in charge of the ship engines and propulsion systems, but also of heating and cooling, electrical infrastructure, sanitary facilities, water desalination and waste water treatment, and waste treatment facilities. In short, he is responsible for managing the interplay of all technical components and technical staff that keep this little floating town running, under all circumstances. Officers like Achim train at a university of applied sciences (Fachhochschule), typically after an apprenticeship as ship mechanic. With enough experience as ship engineers, they can advance to chief engineers, and since many of them also find attractive jobs onshore, they are in high demand in the nautical industry.

The ship is highly computerized, so that people can concentrate on handling the more demanding situations. In case of a serious problem, the ship could be run manually from the engine room. In fact, there is not just one engine room, but two nearly identical ones, so that the ship stays functional in case of fire in one of them, for example. Achim explained that redundancy has been a general design principle for the MARIA S. MERIAN, which was launched in 2005. The electrical and climatisation systems also exist in two instances; there are two different kinds of propulsion systems, a large variety of different winch systems, and so on. Besides a higher margin of safety, it also means that science operations are hardly ever interrupted due to ship maintenance.

Karin Sigloch

28. Januar 2012: The Engine Room, part II - Ein Umweltengel

Photo: Science Party MSM20/2

RV MARIA S. MARIA S. MERIAN in a dry dock showing its special propulsion systems.
Photo: Achim Schüler

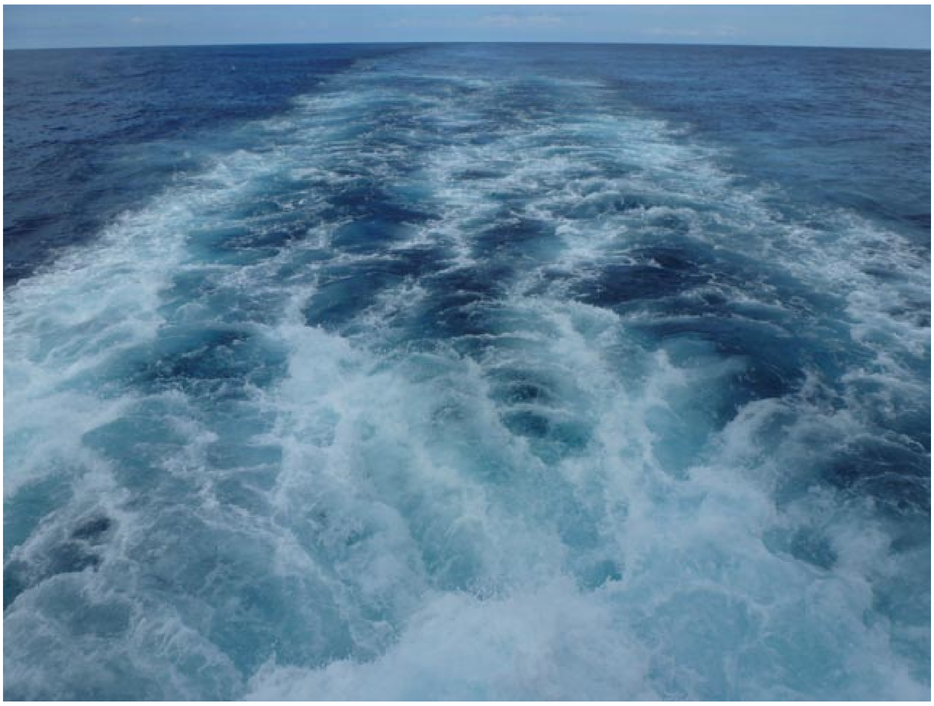


Photo: Science Party MSM20/2

MARIA S. MARIA S. MERIAN has a certificate to operate on the ice margin. Photo: Achim Schüler

During the engine room tour of the MARIA S. MERIAN, our group was particularly fascinated by the two propulsion systems. Neither of them is standard. Unlike commercial ships, which want to go quickly from A to B, a research ship must hold its position in the water about 70% of the time, while scientists experiment in their chosen locations. This requires sophisticated, custom-made steering solutions. In the rear, there are two pod drives that can rotate by 360 degrees. The second propulsion system is completely contained inside the ship hull. It sucks in water and expels it again in directed streams. Since it does not protrude into the water, this propulsion is unlikely the get damaged, thus providing another margin of safety. Both propulsion solutions were partly chosen in view of the MARIA S. MERIAN's designation for operating on the ice margin and breaking young nsea ice (“Eisrandschiff”).

Achim Schüler, the chief engineer, is also proud of their certification by the “Blauer Umweltengel” (proof of high environmental standards). This means that no waste whatsoever is disposed of into the sea. In order to store it on board, everything needs to be strictly sorted and then treated separately. Achim demonstrated the latest upgrade, a paper treatment machine that produces neatly compressed pellets. DFG and BMBF, the agencies that operate the ship, agreed to purchase it recently when certification requirements became stricter, so that the MARIA S. MERIAN would keep its “Umweltengel” status. Currently it is the only ship that holds the certificate in all categories.

Karin Sigloch

<u>29. Januar 2012: Ein Sonntag zwischen verschiedenen Projekten</u>

In den frühen Morgenstunden haben wir das letzte Paar Ozeanboden-Sensoren ausgesetzt. Im Verlauf des kommenden Jahres werden die 24 Seismometer und die 26 elektromagnetischen Messgeräte Signale aus der Erdkruste und dem Erdmantel aufnehmen

Am späten Morgen ereichte die MARIA S. MERIAN wieder Tristan und positionierte sich wenige hundert Meter vor der Küste.

Messgeräte und Nachschub für die Landstation auf Nightingale Island werden gepackt. Die Fahrtleiterin und vier weitere Kollegen werden die kommenden zwei Tage auf der unbewohnten Insel verbringen. Sie setzen am Abend nach Tristan über und verlassen die Insel am nächsten Morgen mit lokalen Fischerboote und einheimischen Seeleuten Richtung Nightingale.

Im Verlauf des Nachmittags pendelt das Speed-Boat der MARIA S. MERIAN zwischen Schiff und Hafen, um verschiedene Gruppen hin- und her zu transportieren. Unsere zwei Geologen Ilya Veksler und Jacob Kloeve kehrten an Bord zurück: nass aber glücklich. Sie hatten fünf Tage lang die Insel erkundet. Die Fotografin Catherine Rannou hat diese Arbeit dokumentiert.

Jeder an Bord untersucht die Funde der Geologen.

Ralf Schmidt, Kapitän der MARIA S. MERIAN (links) hat die Einwohner Tristans zu Besichtigungstouren an Bord eingeladen. Dazu gibt es Kaffee und Kuchen.

Gruppenfoto mit Besuchern, Schiffscrew und Wissenschaftlern.

Einige Seeleute haben tagsüber die Angel ausgeworfen - mit einigem Erfolg.

30. Januar 2012: Tristan da Cunha entdecken

Unser erster freier Tag wurde genutzt, um die Insel Tristan da Cunha zu erkunden. Natürlich waren wir neugierig, wie es eine Bevölkerung von rund 260 britischen Bürgern schafft, auf so begrenztem Platz hauptsächlich als Selbstversorger zusammenzuleben - und das seit 200 Jahren. Hier einige Fotos von der Insel. (Die "Tristanians" betreiben auch eine sehr informative Webseite: www.tristandc.com)

Ansicht des Hafens. Das Speed-Boat der MARIA S. MERIAN (orange) diente als Shuttle.

Blick auf die Siedlung

Das Ortszentrum: Die Prinz Philipp Halle und die Albatross Bar

Geführte Wanderung zu den Kartoffel-Feldern. Zwei Kilometer außerhalb der Siedlung hinter dem malerischen Vulkankegel bearbeitet jede Familie mehrere Landflächen. Sie bauen Kartoffeln und Gemüse für den Eigenbedarf an.

Während einer anderen geführten Wanderung klettern wir auf die Lavafelder des Ausbruchs von 1961. Diese Flankeneruption nahe der Siedlung hatte die Einwohner überrascht. Es gab keine Opfer, aber die Tristanians wurde zunächst nach Nightingale Island und schließlich nach Großbritannien evakuiert. Sie kehrten erst zwei Jahre später zurück. Die Lava zertörte den alten Naturhafen sowie die damalige Fischfabrik. Sie wird heute als Steinbruch und als Müllkippe genutzt.

Der Supermarkt bietet eine große Anzahl von Wollartikeln, die von Einheimischen angefertigt werden.

Jungen Felsenpinguine in den Klippen am Strand

Felsen-Menschen: Jill Repetto, nach zwei Jahrzehnten in Großbritannien wieder in die Heimat zurückgekehrt, führt uns zu den Felsenpinguinen.

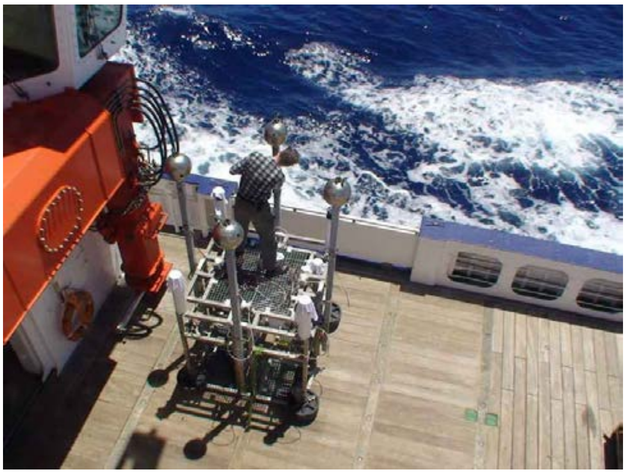
Letztes Highlight des Tages: Ein Besuch in der Langustenfabrik. Dies war einer der wenigen Tage, an dem das Wetter die Fischerei möglich machte. Ein Boot war gerade mit einem frischen Fang in den Hafen zurück gekehrt

31. Januar 2012: Kleine Verschnaufpause

Heute beschäftigen wir uns nur mit leichten wissenschaftlichen Arbeiten. Unsere Fahrtleiter sind immer noch auf der Nightingale Insel und viele von uns haben gestern ein wenig zu viel Sonne auf Tristan abbekommen. Ein ruhiger Tag auf dem Schiff.

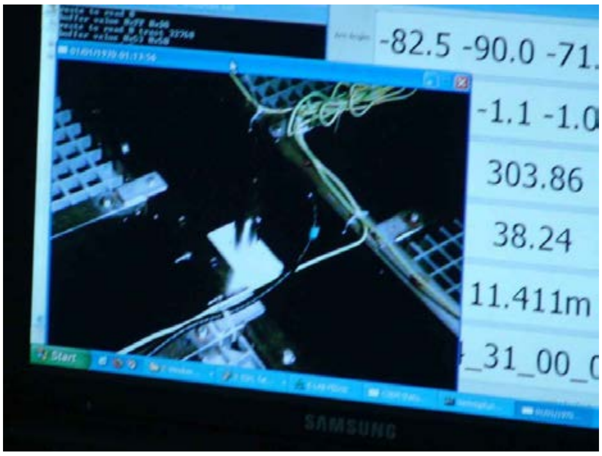
1. Februar 2012: "Sputnik" im Test

Ein letztes Mal wird noch geschraubt



Der "Sputnik" wird vorbereitet

Der "Sputnik" geht über Bord



Die ersten Aufnahmen

Der “Sputnik” ist das Hauptgesprächsthema auf dieser Ausfahrt. Mit seiner bestimmenden Präsenz an Deck und als dekorativer Hintergrund auf Fotos weiß er zu inspirieren. Unsere Künstlerin Catherine, die über die Legende von Tristan und Isolde sinniert hat, vergleicht ihn gerne mit dem “Thron des Königs Marke”.

Aber ohne diese romantische Stimmung zu verderben, wollen wir es nicht unterlassen über die Technik zu sprechen, obwohl der Sputnik im ISOLDE-Projekt keine wissenschaftliche Rolle spielt. Es handelt sich um eine elektromagnetische Quelle in Entstehung (im Prinzip fertig, wie die Besitzer immer wieder versichern), welches zum Testen mitgenommen wurde. Heute wurde der Sputnik ausgesetzt und zog eine beträchtliche Zuschauermenge an. Fast alles funktionierte, sogar die Dinge, die vorher noch nie funktioniert hatten. Wir bekamen perfekte klare Bilder von dem Schlamm auf dem Meeresboden in 1200 m Tiefe zu sehen. Doch nichts ist perfekt und so tauchte ein altes Problem wieder auf, aber insgesamt wurde der Tag als Erfolg betrachtet. Sputnik sah die ganze Zeit über toll aus, natürlich.

Karin Sigloch

2. Februar 2012: Tristan Geology - Day 1

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

We left for Tristan on Wednesday with our geologic, photographic and video equipment. We are staying in a cottage where every detail reminds us that we are in the United Kingdom, but far off the beaten track nevertheless. The tartan of our landlords, the Glass family, is on the wall, recipes from Cornwall are printed on a kitchen towel. We'll be bedded and fed royally, to our great delight.

Thursday, the first morning, is spent on visiting the administrator's office, and the group of fishermen who will accompany us to Sandy Point, a site targeted by Ilya and Jakob for their rock sampling. This beach is hard to access as soon as the weather turns rough, and only experienced mariners can take us there. It will be feasible if the weather cooperates.
In the meantime, we seek out the lava flow of 1961 to take some samples. Ilya and Jakob are looking for olivine inclusions, markers that will tell them whether the lava originates from a deep magma source, which would imply that Tristan is underlain by a mantle plume, or whether the magma source is superficial.

For my part, I take photos with my pinhole camera. It allows for shots of large focal depth, capturing the geologists in their element, completely immersed in this sea of lavas. Each exposure, made directly on cibachrome color paper, takes me 15 minutes. While this may seem like an eternity in the era of the internet, it amounts to nothing on the time scale of a geologist.

Cathrine Rannou

3. Februar 2012: Tristan Geology - day 2

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

Foto: Catherine Rannou

At seven in the morning, one of the fishermen confirms that our departure is imminent. The "Wave Dancer", a boat that lives up to its name, will take us to the east of the island. Landing on the beach in a rowboat with five fishermen, one as skilled as the other. We relive a moment from the adventure books of our childhood, of pirate landings in quest of hidden treasures on the beach.

The geologists, helped by the fishermen, locate their target at the steep base of the volcano. This gives occasion for an improvised lecture in geology. Swarms of albatross are gliding overhead, the rockhopper penguins barely move as we pass them by. Following a request by the administrator, I take digital pictures of the damage caused by a micro-tornado in October. The small pine forest uphill from the beach, which used to protect a farm house, is divided by a corridor of tree stumps that resemble broken match sticks. Pine trees more than 20 meters high have been unrooted. An unlucky cabin has been buried beneath a fallen tree.

Our return is just as acrobatic, and on the way, we pick up some Scottish botanists who are doing field work in the south of the island. They had been out for nine days on the flanks of the volcano, living completely cut off from the settlement.

Cathrine Rannou

4. Februar 2012: Tristan Geology - day 3

Foto: Catherine Rannou

Foto: Catherine Rannou

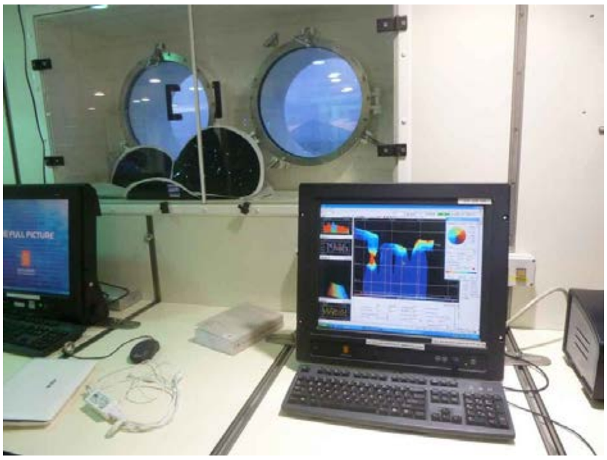
Foto: Catherine Rannou

Foto: Catherine Rannou

The most important rock samples have been taken. Today we visit the western part of the island, but this time by public transport: the island's only bus. A bucolic, sunny day, calmer than the previous one. Along little valleys and volcanoes, we encounter cows, ducks, donkeys, before arriving at the Potato Patches. At this place of subsistence farming, we find an assemblage of small cabins built from boulders of lava, roofs made from salvaged pieces of corrugated metal, or from pieces of driftwood. The geologists keep taking rock samples on a beach a bit further off, while I take my own "samples", photographic and videographic, in these little patches of earth. A family is piling up a low wall using lava pieces; a tractor has come directly to the beach in order to get building material. Another family is pulling out potatoes. It feels like a present-day utopia, a self-sufficient society where every thing, every action, keeps to a human scale. Only the volcano and the ocean reach beyond this scale. They are awe-inspiring, and they are the reason that the scientists of "ISOLDE" are here.

Cathrine Rannou

5. Februar 2012: Bathymetry I



Results of the multi-beam on the screen, Foto: Catherine Rannou

The scientist Marcia Maia tracing the course, Foto: Catherine Rannou

We switched to a different working mode, once the seafloor deployments and the field work on the islands had finished. The ship has slowed to 8 knots, and now we are mapping the mountains and valleys of the seafloor with a tool called multi-beam bathymetry. Acoustic sources are fixed to the outside of the ship's hull, and every ten seconds they send out short sound pulses at 12 kHz frequency. Then they measure the time it takes for the echos to return. This wait time is related to the distance to the seafloor and back -- if the velocity of sound at all water depths is known, the time can be converted into a water depth. (We measure the water velocity profile every day or two, by lowering a sounding instrument to 1000 m depth – see third photo.) The sounding method is called multi-beam because the MARIA S. MERIAN actually sends out and receives back 196 pings at once, at different angles. They simultaneously map a whole swath of seafloor that is a few kilometers wide to either side of the ship.

The results are displayed almost immediately to a computer screen (very gratifying, compared to the year-long wait times for OBS and OBEM data). Every ten seconds, a new colored line appears, corresponding to seafloor elevations just below the ship, and out to ~8 km to its left and right. Even a non-specialist can immediately pick out special features, for example the cone-shaped elevation above the average seafloor when we cross an undersea volcano, or the narrow, linear depressions that signify a tectonic transform fault. Marcia Maia from the University of Brest is the bathymetry specialist on board. She is charting the MARIA S. MERIAN's course for the moment, in carefully designed zig-zag lines aimed at covering as many promising features as possible.

Only a tiny fraction of the world's oceans has been mapped in this state-of-the-art manner, and our survey region is no exception. Marcia does not have to fly blindly in choosing the course, because predictions of seafloor elevation, although blurry ones, can be calculated using geodesy satellite data. There is still a lot of guesswork involved, what these blobs on the map might actually mean, and whether they are worth checking out. That is where Marcia's expertise and intuition enter the picture. Those of us interested were invited to participate in the discussions and decision making, so people feel the corresponding emotional involvement, now that some exciting features have been discovered (see next blog).

Karin Sigloch

6. Februar 2012: Discovering a new undersea volcano

The mapping software showing the elevation, Foto: Catherine Rannou

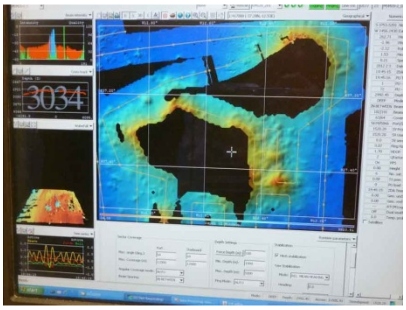


Foto: Catherine Rannou

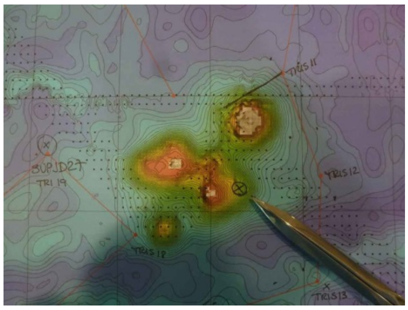


Foto: Catherine Rannou

The most exciting discovery of our bathymetry survey so far has been a new undersea volcano. Last Tuesday night, during our colleagues' field trip to Nightingale, the MARIA S. MERIAN was cruising around the island group for some initial seafloor soundings. The colleagues on bathymetry watch noticed that water depth at the outer edge of one multi-beam did not taper down as predicted by the satellite map. So we returned two days later to map the whole area, and discovered a sizeable undersea volcano just east of Nightingale Island. It rises from ~1500 m depth to almost 250 meters below the surface.

Independently, the Tristanians had told our Nightingale colleagues that in 2004, there had been worries that the volcano on Tristan might erupt again. In the Settlement, they had started feeling tremors, seemingly originating from the south, the direction of Tristan's big volcano. Some days later, fresh pumice (volcanic rock lighter than water) came ashore on the eastern beaches, near Sandy Point. The British Geological Survey was called in to investigate. They concluded that Tristan itself showed no signs of volcanic unrest, but that there must have been an underwater eruption, most likely towards the south, the direction of Nightingale.

So it is very likely that we have discovered the source of this 2004 eruption, since our newly mapped seamount lies ~30 km south of Tristan, and 10 km east of Nightingale. Now the new volcano needs a name -- we are leaning towards "Isolde".

Karin Sigloch

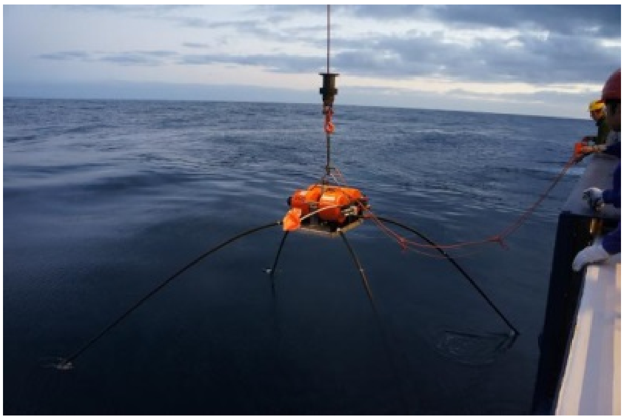
08 Februar 2012 - Bye Bye, Tristan!

We are in transit to Brazil now. Yesterday afternoon, the last dedicated bathymetry was collected, and Sputnik took another dive. Then the ship accelerated to 13 knots, taking course for Recife. We should arrive there on Feb. 15, to hand over the ship to the next group of scientists.

The daily routine is quieter now, and while we are still acquiring routine bathymetry during transit (to help improve geodetic satellite maps), this only requires infrequent night shifts of the scientists. People are catching up on sleep, or staying up longer at night. We process the bathymetry data, finish up deployment protocols and cruise reports. We also resumed our pre-deployment habit of giving short science presentations every evening. Since we come from different fields and institutions, we don't routinely work together. Now is an excellent opportunity for some focused exchange of ideas on Tristan, mantle plumes, break-up of continents, and the methods to study them. Our blog is likely to be less action-driven from here on, and instead mirror these reflections about the why's and wherefore's.

Karin Sigloch

09. Februar 2012: Geophysical methods I



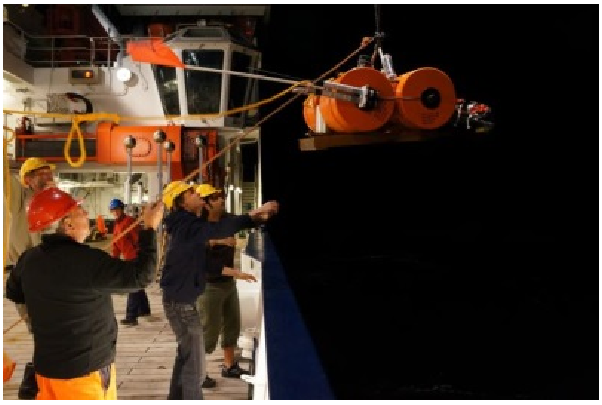
It is relatively simple to explain how bathymetric sounding of the seafloor works, because it is (almost) a direct measurement. We want to know the water depth, the apparatus counts the time it takes for the acoustic pings to run down to the seabed and back, and the only intervening variable is the sound velocity of water, which is relatively easy to measure. (Every other day, we lower a sounding probe into the ocean.)

Our other two geophysical methods are less intuitive, because they make indirect measurements. The problem is that geophysics has no methods to directly measure the quantities in the earth's deep interior that are of primary interest. Questions like: “How hot is it at 1000 km depth beneath Tristan?”, “What is the rock composed of at that depth?”, “Is a column of hot rock moving up towards the surface?” -- such questions cannot be answered by direct measurement. They probably never will, since humans are unlikely to ever penetrate to 1000 km depth.

Instead, we have to rely on indirect messengers, waves that travel through the deep earth. In the ISOLDE project, we are using two kinds: seismic waves (i.e. mechanical waves that propagate through solid bodies and fluids), and electromagnetic waves. Either wave type has a natural source, since humans do not generate waves of sufficient strength. The seismic waves are generated by small and large earthquakes. Those need not occur close to Tristan, on the contrary: often the earthquakes that occur thousands of kilometers away are the most useful signal sources for us. They cannot be felt at these distances, but a large earthquake is registered by seismometers anywhere on earth. The electromagnetic waves are generated by the sun, which always emits jets of charged particles, the so-called solar wind. The fluctuating solar wind impinges on the earth's own magnetic field, thus causing it to fluctuate. The constant changes in magnetic field are felt on the ocean floor as well -- they are the source signal for the electromagnetic sounding of the mantle.

Karin Sigloch

10. Februar 2012: Geophysical methods II



How do seismic or electromagnetic waves give information about the structure of the earth's deep interior? The principle is this: we have some default assumption on what the mantle and crust under Tristan might look like -- some informed guess from earlier studies, or just the idea that it is “average” mantle. Some physical law must describe how seismic or electromagnetic waves would propagate through such mantle, assuming a wave source existed (an earthquake or the solar wind). Then computers can simulate this wave propagation, generating a prediction of what the wavefield would look like if we recorded it on the seafloor or on an island.

We do have actual instruments on the seafloor, but they will always record wave signals that are different from those predicted by the computer. This is because the structure of the real mantle and crust differs from that assumed in our simulation (if it weren't so, we would already know everything, no need to do the experiment). So the differences between the observed and predicted wave recordings somehow reflect the mantle structure that is still missing from our picture, but these waveform differences are not equal to the thing we want. They are just some indirect expression of what we want (say, rock composition in the mantle), and the link is the physical law by which rock composition affects the shape of seismic waves, for example.

Such indirect inference problems (“inverse problems”) are much more difficult to treat than direct measurements. Usually there is not enough data to determine everything we want to know. For example, we had better deployed 1000 OBS and OBEM instead of 25, but this is not feasible. Instruments inside the mantle would be more useful than at the surface -- impossible. It would be better to have a physical law that relates temperature (a very interesting quantity) directly to electromagnetic signal strength. But there is only a law that invokes mantle conductivity (not so interesting), and temperature only indirectly, along with other quantities.

So these kinds of experiments involve imperfections, trade-offs, and usually a lot of computer simulations. The challenge is to squeeze as much information as possible out of the data, while also clearly identifying the aspects that we cannot know. “Inverse methods” are frustrating if you have a low tolerance for uncertainty, but they are the most advanced tools that geophysics has to offer for exploring the deep interior.

Karin Sigloch

11. Februar 2012: Reaching the tropics

On transit to Brazil, it has been getting warmer rapidly. Last night, the MARIA S. MERIAN crossed the nominal boundary from the subtropics to the tropics (latitude 23° S). From Namibia up to Tristan (at latitude 37.5°S), the temperature had been 20°C plus/minus 2°C every day. A rather abrupt rise in temperature and humidity occurred already on the first few hundred kilometers of the way north -- we must have changed into a warmer ocean current then. Now it is above 25°C, and it is still ways to go until Recife at latitude 8° S, where we will land during carnival week.

Summer in the southern hemisphere: Thursday's dinner took place on deck, as a barbeque. Chief cook Johann Ennenga and his assistants grilled the self-caught fish from Tristan, along with other delicacies. The ship crew have mounted an ultra-sturdy pool of about 3x3 m^2 on the rear deck, which is regularly refilled with fresh seawater that keeps getting warmer. A perfect way to end the day: in the heaving and rolling water, with a cold beverage, watching the sunset!

Karin Sigloch

12. Februar 2012: Rückblick Nightingale Island I

Image 1: Nightingale Island

Image 2: Landing on Nightingale

Image 3: Station site on Nightingale

Image 4: Rockhopper Penguin

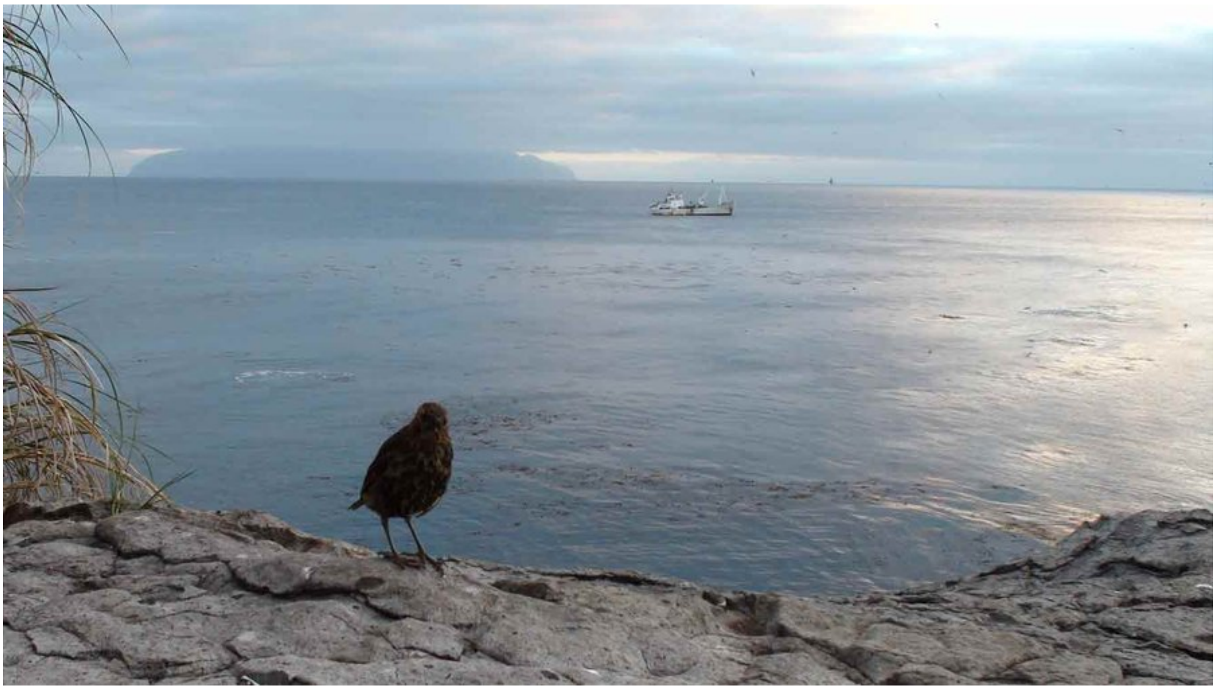


Image 5: Tristan Thrush

Image 6: Yellow Nosed Albatross

Image 7: Albatross chick

Image 8: Martin Wollatz-Vogt preparing the land station site. He does not care to know what exactly is sticking to his fingers.

Now that the scientific activity has decreased, it is time to report on another highlight of the cruise, our little land expedition to Nightingale Island. Five scientists and technicians had debarked the MARIA S. MERIAN on Jan. 30 to install electromagnetic and seismic land stations on the uninhabited island of Nightingale, which is situated ~30 km south of Tristan da Cunha (image 1). Guided by three Tristanians, we boarded two little ships in the morning of Jan. 31 for the one-hour ride from Tristan to Nightingale. While a swell may look relatively small from a ship like the MARIA S. MARIA S. MERIAN, it feels a lot more exciting when experienced on a small rubber boat equipped with a 400-horse power engine. Luckily the fresh wind, sunshine, breath-taking scenery and sightings of flying fish prevented a return of seasickness.

The landing point on Nightingale (image 2) was a bare rock inhabited by seals and rockhopper penguins. We had disassembled our land stations in waterproof packages that were as small as possible, ranging from a few to 20 kg weight, which were offloaded with speed and dexterity by the Tristanians.

A good, level site for the land station was found ~300 m from the landing point, up along a rocky and steep path (image 3). Lugging the equipment up there was rather exhausting. We were watched closely by penguins, very curious little Tristan thrushes, which had to be chased out of the equipment from time to time, and by albatrosses. At first the notion of an undisturbed sanctuary of what seemed like thousands of birds seemed rather romantic, but the reality of hundreds of dead birds in various stages of decomposition put a somewhat pungent smell to our work, and took a few hours to get used to (images 4-7)

Marion Jegen

13. Februar 2012: Rückblick Nightingale Island II

Image 1: Digging holes for the instruments

Image 2: Marion Jegen and Martin Wollatz-Vogt with land station

Image 3: Cabins

Image 4: View from cabins

Image 5: Waiting for pick up

Image 6: Approaching the "Edinburgh"

Image 7: Tristan da Cunga seen from the "Edinburgh"

We had to dig holes to bury the instruments in the ground, program their data loggers, and set up the solar panels (images 1 -2). The land data are an important addition to our marine data, especially to the electromagnetics, since land data are not affected by the wave damping and sometimes noise-inducing effect of the ocean layer. They also allow extracting higher-resolution information about the earth.

After most of the installation was accomplished, we retired to a row of little shacks, which have been built by the Tristanians for vacation and nature reserve work on the cliffs of Nightingale (images 3-4). The lodging and its amenities did not exactly amount to 5 stars, but the unhindered view of the ocean, hunting seals and birds, with Tristan da Cunha on the horizon definitely did.

After checking the land stations in the morning, we radioed the nearby fishing vessel Edinburgh, whether they could give us a lift back to Tristan. They were kind enough to send three of their little boats that checked on lobster traps to ferry us to the ship (images 5-6). Back on Tristan in the evening, a long hot shower and delicious food cooked by our Tristan hosts, prepared us well for a visit to the local bar, where Tristanians of all ages gather in the evening for a friendly chat, and a few sodas and beers.

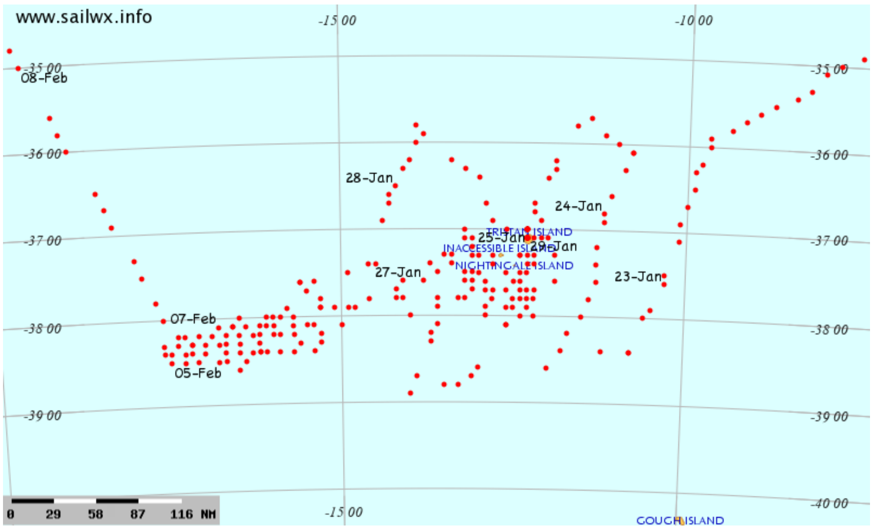
Marion Jegen

14. Februar 2012: Wiedereintritt in die reale Welt

Die Fahrt nähert sich ihrem Abschluss: Wir räumen die Labore und die Kabinen auf, sichern alle Daten und beenden die Berichte. Morgen werden wir den Hafen von Suape 50 Kilometer südlich von Recife erreichen, wo unsere Container von Bord und die der nächsten Expedition an Bord gebracht werden. Vor zwei Tagen haben wir am Horizont ein Schiff gesichtet - es war erst das zweite, seit wir die Küstengewässer Namibias verlassen haben. Heute haben wir noch eines gesehen. Gestern war das Schiff wieder in Reichweite eines Internet-Satelliten, und wir konnten uns durch eine Monatsflut an E-Mails wühlen. Eine Erfahrung außerhalb von Raum und Zeit geht zuende. Wir sind dabei, wieder in die reale Welt einzutreten - mit gemischten Gefühlen.

Karin Sigloch

The journey of the expedition, from Namibia to Recife from sailwx.info



A zoom into our work area around Tristan da Cunha

15. Februar 2012: Suape, Brasilien

Gruppenbild der MSM20/2-Wissenschaftler

Brasilien in Sicht

Unsere Überquerung des Südatlantiks ist vollendet. Nach 30 Tagen auf See erreichten wir heute Morgen den Hafen von Suape in Brasilien. Eine tropische Sonne brennt bei Temperaturen um 30 °C auf uns herab, aber es ist sehr feucht und fühlt sich eher wie 40°C an. Das Abladen der Container läuft. Die Fahrt ist sehr gut verlaufen: Wir haben eine beeindruckende Region der Erde erlebt, alle Experimente konnten wie erhofft ausgeführt werden. Die MARIA S. MERIAN hat sich als ideale Plattform für die Arbeit, aber auch für das Leben auf See bewährt und die Gemeinschaft an Bord war angenehm. Wir freuen uns darauf, die ausgelegten Instrumente in einem Jahr wieder zu bergen. In der Zwischenzeit hat jeder von uns einen erstklassigen Gesprächseinstieg: "Ich war auf Tristan da Cunha, der abgelegensten Insel der Welt."

Karin Sigloch