IFM-GEOMAR REPORT

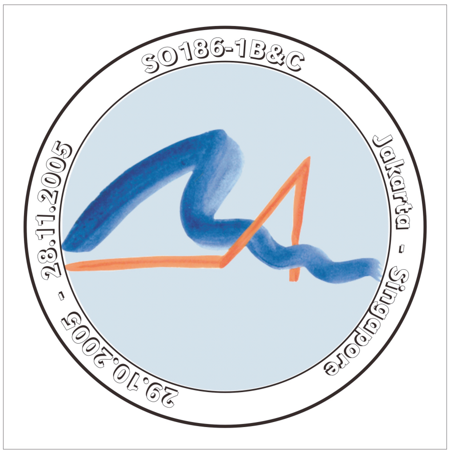
IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS Sonne
Fahrtbericht / Cruise Report
SO186 B, C & D
GITEWS

German Indonesian Tsunami Early Warning System

Jakarta-Jakarta & Jakarta-Singapore & Singapore-Singapore

28.10.-13.11.2005 & 15.11-28.11.2005 & 07.01-20.01.2006



Berichte aus dem Leibniz-Institut
für Meereswissenschaften an der
Christian-Albrechts-Universität zu Kiel

Nr. 5
März 2006

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Edited by
Ernst R. Flueh, Tilo Schoene & Wilhelm Weinrebe

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1.1 Summary

The active Sunda Arc subduction zone stretches for some 5,000 km and is the expression of the converging Indo-Australian and Eurasian tectonic plates where oceanic lithosphere is subducted beneath the Indonesian Archipelago. Its great importance is stressed by the catastrophic mega-earthquake of Boxing Day 2004 and the related tsunami that took about 300,000 lives mostly in Indonesia. On the other hand, because of the oblique subduction, this feature provides a unique opportunity to investigate subduction processes in detail.

Early in 2005 the German government announced that they would contribute to the installation of a Tsunami Early Warning System (TEWS) in the Indian Ocean, with emphasis on the Indonesian Coast. This project is called GITEWS (German Indonesian Tsunami Early Warning System) and comprises a multitude of sensors to be installed on- and offshore as well as the establishment of a Warning Centre and the related efforts of warning the population of a potential danger.

All the cruises SO186-1B, 1C & 1D contributed to the overall goals of GITEWS. Since tsunami modelling will be an important part of GITEWS, bathymetric measurements of the area under investigation are an important contribution, too. Such measurements were the focus of the first leg, they are also closely related to the project SEACAUSE that comprises the SONNE cruises SO186-1, SO186-2&3, realized immediately before and after the GITEWS cruises. Furthermore, the bathymetric measurements were closely coordinated with British and French data collection efforts. By the end of Leg SO186-1D about 50% of the deep water regions (>3000 m) along Sumatra were mapped; the data show considerable lateral variability along the margin.

Only a few months after the Cooperation Agreement between Germany and Indonesia had been signed on March 14, 2005 did the Federal Republic of Germany’s government hand over two experimental buoys to the Government of the Republic of Indonesia. These buoys are equipped with GPS and ocean bottom units with pressure sensors as part of the TEWS. The hand-over ceremony had already been conducted at Tanjung Priok Harbour on October 10th 2005, when Dr. Kusmayanto Kadiman - Minister of Research and Technology and coordinator of TEWS development in Indonesia - received the buoy system from Prof. Frieder Meyer Krahmer, representative of the State Secretary of BMBF (Minister of Research and Education of the Federal Republic of Germany), on board the German Research Vessel SONNE.

Both systems, ocean bottom units and buoys, were successfully deployed during leg SO186-1C. Until the beginning of leg SO186-1D in January 2006 the system performance was closely monitored; first modifications have been proposed to adapt it to specific environment and tasks. The maintenance of all system components was the main task of this last leg. Additionally, more tests for the underwater communication were carried out. Underwater communications still need further improvements before it can be regarded as reliable and functional.

As part of SEACAUSE, a seismological network had been installed around Simeulue Island in October 2005. During the GITEWS cruises several instruments were serviced, they shall all be recovered in March 2006 during SEACAUSE Leg 3. Furthermore, as part of GITEWS, five methane sensors were installed on the continental slope near Simeulue Island to monitor methane concentrations in the bottom water. In the future such measurements may be a potential indicator of slope instability and thus tsunami generation.

1.2 Zusammenfassung

Die etwa 5.000 km lange, aktive Sunda-Arc-Subduktionszone ist Ausdruck der konvergenten indo-australischen und eurasischen tektonischen Platten, dort, wo die ozeanische Lithosphäre unter den indonesischen Archipel subduziert. Die Wichtigkeit dieses Gebietes hat sich besonders bei dem katastrophalen Mega-Erdbeben vom 26. Dezember 2004 und dem dadurch verursachten Tsunami erwiesen, der ca. 300.000 Menschenleben vor allem in Indonesien forderte. Andererseits bietet die schräg verlaufende Subduktion eine einzigartige Gelegenheit, Subduktionsprozesse im Detail zu erforschen.

Zu Beginn des Jahres 2005 kündigte die deutsche Regierung an, dass sie einen Beitrag zur Installation eines Frühwarnsystems, des "Tsunami Early Warning System (TEWS)" im Indischen Ozean, hauptsächlich an der Indonesischen Küste, leisten werde. Dies Projekt läuft unter der Bezeichnung GITEWS (German-Indonesian Tsunami Early Warning System). Es beinhaltet eine Vielfalt an Sensoren für den Betrieb auf See und an Land sowie die Errichtung eine Warnzentrums und den damit verbundenen Aufwand, mit dem sichergestellt werden soll, dass eventuelle Warnungen die Bevölkerung auch erreichen.

Die Forschungsfahrten SO186-1B, 1C & 1D haben alle zur Erreichung der Ziele des GITEWS beigetragen. Da die Modellierung von Tsunamis einen wesentlichen Bestandteil des GITEWS bildet, leisten auch die bathymetrischen Messungen im Forschungsgebiet einen wichtigen Beitrag. Solche Messungen bildeten den Schwerpunkt der ersten Expedition; sie stehen auch in engem Zusammenhang mit mit dem Projekt SEACAUSE, das die direkt vor und nach den GITEW-Fahrten durchgeführten SONNE-Fahrten SO186-1, SO186-2&3 umfasst. Außerdem bestand bei den bathymetrischen Messungen eine enge Zusammenarbeit mit britischen und französischen Projekten zur Datenaufnahme. Beim Abschluß von Leg SO186-1D waren etwa 50% der Tiefseegebiete (>3000 m) entlang Sumatra kartiert; die Daten weisen eine beträchtliche laterale Variabilität entlang des Randes auf.

Nur wenige Monate nach Unterzeichnung der Kooperationsvereinbarung zwischen Deutschland und Indonesien am 14. März 2005 übergab die Regierung der Bundesrepublik Deutschland der Regierung der Republik Indonesien 2 Versuchsbojen. Diese Bojen, ausgerüstet mit GPS und Ocean Bottom Units, auf denen Drucksensoren montiert sind, bilden Bestandteil des TEWS. Die Übergabe-Feierlichkeiten hatten bereits am 10. Oktober 2005 im Hafen Tanjung Priok stattgefunden. An Bord des deutschen Forschungsschiffes SONNE übernahm dort Dr. Kusmayanto Kadiman – Minister für Forschung und Technologie und Koordinator für die Entwicklung von TEWS in Indonesia - das Bojensystem von Prof. Frieder Meyer Krahmer, dem Repräsentanten des Staatssekretärs des BMBF (Ministerium für Bildung und Forschung der Bundesrepublik Deutschland).

Beide Systeme, die Ocean Bottom Units und die Bojen, wurden während Leg SO186-1C erfolgreich ausgesetzt. Die Systemleistung wurde bis zum Beginn von Leg SO186-1D im Januar 2006 genau überwacht; erste Modifizierungen sind inzwischen vorgeschlagen worden, um das System seiner spezifischen Umgebung und seinen Aufgaben anzupassen. Die Hauptaufgabe bei dieser zuletzt durchgeführten Expedition bestand in der Wartung aller Systemkomponenten. Darüber hinaus wurden weitere Tests zur Unterwasserkommunikation durchgeführt, die noch weiter verbessert werden muss, bevor sie als verlässlich und funktionell bezeichnet werden kann.

Als Teil von SEACAUSE war im Oktober 2005 ein seismologisches Netzwerk um die Insel Simeulue herum installiert worden. Während der GITEWS-Fahrten wurden etliche Instrumente gewartet, die alle im März 2006 im Verlauf von Leg 3 des Projektes SEACAUSE wieder geborgen werden sollen. Weiterhin wurden im Rahmen von GITEWS fünf Methan-Sensoren am Kontinentalhang in der Nähe von Simeulue Island installiert, um die Konzentration von Methan im Bodenwasser zu überwachen. Messungen dieser Art könnten in Zukunft Indikatoren für Hanginstabilität sein und somit auf die Entstehung von Tsunamis hinweisen.

2. Introduction

2.1 Objectives of cruise SO186 Leg 1-B, C, D

The main objective of the cruise SO186-1B&C was to contribute substantially to the implementation of the German-Indonesian Tsunami Early Warning System (GI-TEWS). After the devastating tsunami of December 26, 2004 that took about 300,000 lives, the Indonesian and the German government agreed upon the installation of a Tsunami Early Warning System in Indonesia for the Indian Ocean. Among other components, the system comprises about 40 additional seismometer stations onshore, ten tide gauges along the coasts and the necessary communication links and data centres. The installation of additional GPS land stations on islands and on Sumatra will allow to closely monitor the tectonic and earthquake related land motion so that, together with the existing Indonesian network of GPS stations, detailed surface stress maps can be compiled. This setup is supplemented offshore by 10 GPS-buoys and Ocean bottom units (OBU), which are equipped with a seismometer and a pressure sensor to detect tsunami waves at the seafloor. The first two buoys of the TEWS were handed over to the Indonesian Government on October 10, 2005. They were installed in the Indian Ocean near the Sunda Arc subduction zone during this cruise. The OBUs, which communicate with the GPS-buoys via an acoustic link, had to be deployed below the buoys.

The main objective of the first part of the cruise (1-B) was a comprehensive site survey of the area in order to find suitable positions for the OBUs. This required extensive bathymetric mapping as most parts of the Sunda Arc subduction zone have not been mapped in detail so far. In addition, bathymetric information is essential for modelling tsunami wave propagation through the Indian Ocean which is another task in the framework of the GI-TEWS project. During the second part of the cruise (1-C) the buoys and the bottom stations were actually deployed. It was further planned to service some of the ocean bottom seismological stations in the network deployed around Simulue Island during the previous cruise. The third cruise (1-D) was meant for servicing the buoys.

Furthermore, these cruises were also closely linked to the project *SEACAUSE: "Geo-Risk Potential Along the Active Convergence Zone Between the Eastern and Indo-Australian Plates off Indonesia".* This project was set about to gain insight into the natural hazard potential of the Sunda Arc subduction zone, to better understand the mechanism of the December 26, 2004 earthquake, to find out differences to the March 28, 2005 earthquake, to constrain possible mechanisms that generate tsunamis, to delineate the obvious segmentation of the overriding plate, and to find indications of mass-wasting processes along the continental margin. The cruises SO186-1B, C&D substantially contributed to achieve these objectives by bathymetric mapping and the subsequent interpretation of the morphology.

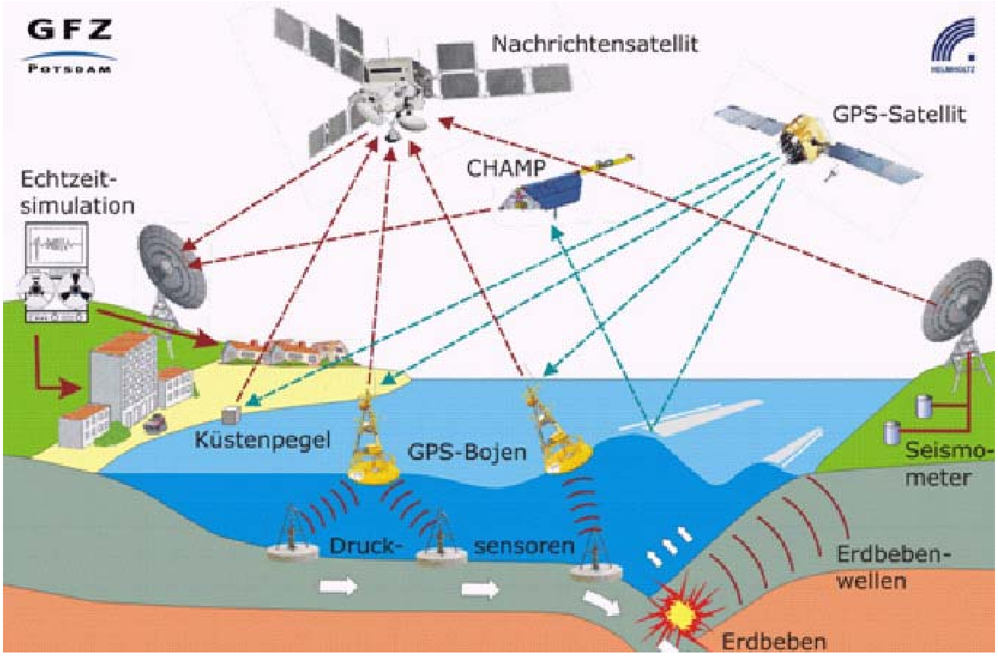

Fig. 2.1.1: Installation of a Tsunami Early Warning System in the Indian Ocean (Off West Coast Sumatra-Indonesia).

2.2 Tectonic framework of the Sunda Arc Subduction Zone

The Sunda Arc is characterized by deep fore-arc basins, which extend between an outer arc high and the island arc (Susilohadi et al., 2005), see Figure 2.2.1. The hydrocarbon potential and basin evolution of the basins off northern Sumatra is well constrained (Izart et. al., 1994) while the evolution of the fore arc basins of southern Sumatra and south west Java are poorly understood.

The Sunda Arc comprises the Sunda Trench, outer arc high or fore-arc ridge, the fore-arc basins, the active volcanic arc and the Cenozoic foreland northeast Sumatra and northern Java (Hamilton, 1979). Parts of the outer arc high rise above sea level and form the outer arc islands off western Sumatra, whereas they lie below sea level south of Java. Karig et al. (1980) and Moore and Karig (1980) have attributed the rapid outgrowth of the fore-arc ridge in the western part of Sumatra to the accretion of thick Bengal and Nicobar fan sediments since the Late Miocene. The fore-arc basins extend from Burma in the North to eastern Indonesia in the South (Moore et al., 1980, 1982). They are bordered by the outer arc high and by the margin of the Sunda Island Arc. This system resulted from plate convergence along the subducting oceanic Indian-Australian Plate beneath the continental Eurasian Plate (Hamilton, 1979).

The relative movement between the Indo-Australian and Eurasian Plates during the Cenozoic is well constrained by the paleomagnetic data and ocean floor magnetic anomalies on which various regional plate tectonic reconstructions have been proposed (e.g. Daly et al., 1987; Rangin et al., 1999; Longley, 1997; Hall, 1996, 1997). In the Early Cenozoic India and Australia became a single plate and moved northward against the Eurasian Plate (Liu et al., 1983; Hall, 1997, 1998). The subduction system along the southwest Sunda margin was initiated in the

Cretaceous (Katili, 1975; Hamilton, 1979), and became very active during the Paleocene when the subduction rate exceeded 15 cm/yr (Molnar and Tapponier, 1975; Karig et al., 1979). In the Middle Eocene a slow-down of the convergence rate to 3 cm/yr occurred when the Indian continent started to collide with Eurasia (Karig et al., 1979). The decrease in the convergence rate led to the development of many extensional basins in Southeast Asia (Daly et al., 1991; Hall, 1996, 1997). In the Late Eocene – Early Oligocene a renewed spreading in the Indian Ocean led to the change of convergence direction to nearly NE and to an increase in the subduction rate along the Sumatra and Java margins to a steady 5 – 6 cm/yr. (Liu et al., 1983; Karig et al., 1979; Daly et al., 1987; Hall, 1996, 1997). This, in turn, initiated the Neogene fore-arc basin development along the margin of the Sunda arc. The late Oligocene – Early Miocene collision of India and Eurasia caused massive amounts of terrigenous sediment to be dumped into the Indian Ocean and Sunda Trench. These sediments were rapidly accreted creating the large accretionary prism (Matson and Moore, 1992).

Two models are discussed to explain the oblique subduction along the western Sunda Arc margin: (1) a significant counter-clockwise rotation of Sumatra, southern Malaysia and Kalimantan in the Middle Miocene (Ninkovich, 1976; Hall, 1997), and (2) the renewal of spreading in the Indian Ocean accompanied by the change of convergence direction of the Indian Plate with respect to the Eurasian Plate to NE (Huchon and Le Pichon, 1984; Jarrad, 1986; Malod et al., 1995). Both models led to increased obliquity that was accompanied by initiation of strong magmatic activity (Simanjuntak and Barber, 1996; Hall, 1996, 1997). The oblique subduction beneath Sumatra caused the partition of strain into an orthogonal component resulting in thrust faulting in the accretionary wedge and a right lateral strike-slip component expressed by the Sumatra Fault (Katili, 1973; Hamilton, 1979; Moore et al., 1980; Malod et al., 1980; Mc Caffrey, 1991, 2000; Malod et al., 1995) and Mentawai Fault (Diament et al., 1992) systems. The Sunda Strait region represents the transition zone from the oblique convergence along Sumatra to nearly normal convergence off southern Java. It is interpreted either as related to rotation of Sumatra relative to Java in the Late Cenozoic (Ninkovich, 1976; Zen, 1985), or as an extensional feature (Huchon and Le Pichon, 1984) resulting from northwestward displacement of the southern Sumatra block along the Sumatra Fault.

This active Sunda Arc subduction zone stretches over some 5,000 km and is the expression of the converging Indo-Australian and Eurasian tectonic plates where oceanic lithosphere is subducted beneath the Indonesian Archipelago. Its great importance is stressed by the catastrophic mega-earthquake of Boxing Day 2004 and the related tsunami that took about 300,000 lives the great majority of which in Indonesia. On the other hand, this feature bears also a considerable potential of hydrocarbon resources and a unique opportunity to investigate subduction processes in detail.

Due to the extreme variation in fore-arc structures and tectonic framework of the Sunda Arc, this work will also be a major contribution to the general understanding of the mechanisms governing the tectonic development of subduction zones. The massive concentration of work along the Sunda Arc with three projects within the time span of 15 months has to be seen as a part of the implementation process of a *Tsunami Early Warning System (TEWS)* for Indonesia. This requires a detailed knowledge of the bathymetry and geological structures along the continental margin and which can only be provided by ship-based research work as laid out in this research.

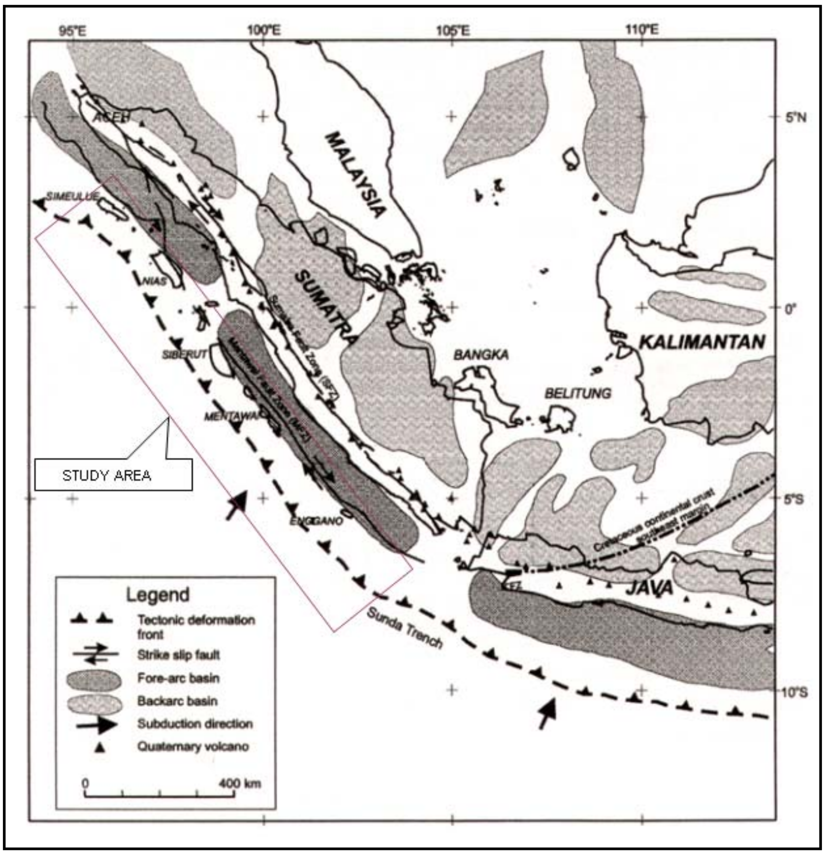

Fig. 2.2.1.: Generalized tectonic map of western Indonesia and location of study area. Structures on Sumatra are based on Sieh and Natawijaya (2000), and the Mentawai Fault Zone is based on Diament et al. (1992)
Limit of Cretaceous continental is taken from Hamilton (1979).
(Figure taken from Susilohadi et al., 2005).

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Rainer Rosemeyer	Motorman
Holger Zeitz	Motorman
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Artur Derda	2nd Steward
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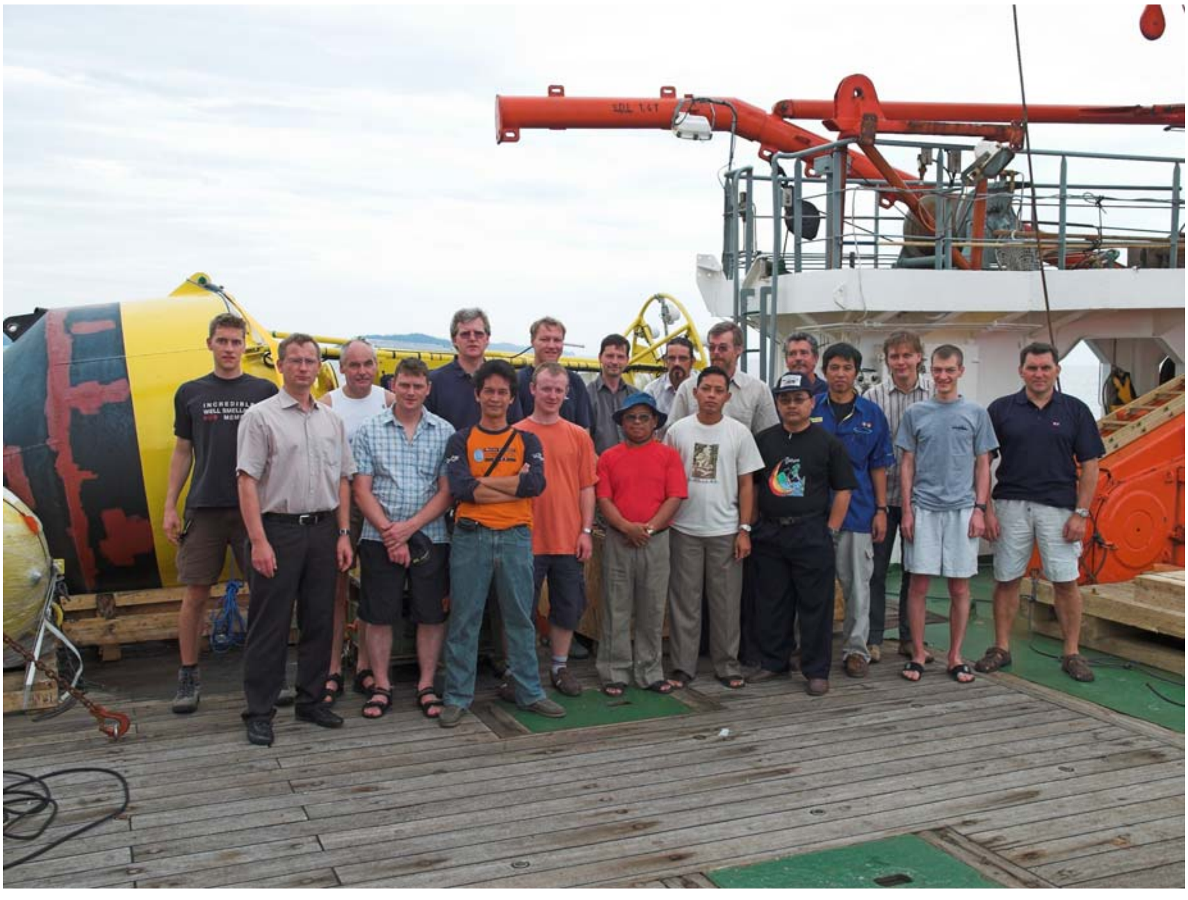
Rainer Rosemeyer	Motorman
Holger Zeitz	Motorman
Frank Tiemann	Chief Cook
Wilhelm Wieden	Cook
Werner Slotta	1st Steward
Artur Derda	2nd Steward
Peter Mucke	Bosum
Torsten Bierstedt	A. B.
Dirk Dehne	A. B.
Detlef Etdorf	A. B.
Werner Hödl	A. B.
Jürgen Kraft	A. B.
Andreas Schrapel	A. B.

CREW SO186-1D

Lutz Mallon	Master
Detlef Korte	Chief Mate
Ulrich Büchele	1st Mate
Matthias Linnenbecker	2nd Mate
Dr. Mathias Gräßle	Surgeon
Werner Guzman-N.	Chief Engineer
Norman Lindhorst	2nd Engineer
Klaus-Dieter Klinder	2nd Engineer
Jörg Leppin	Chief Electrician
Hans-J. Stepputtis	Electrician
Rudi Angermann	System Operator
Matthias Grossmann	System Operator
Volker Blohm	Motorman
Przem Marcinkowski	Motorman
Holger Zeitz	Motorman
Wilhelm Wieden	Chief Cook
Ryszard Kornaga	Cook
Gerlinde Grübe	1st Steward
Ryszard Kuzon	2nd Steward
Peter Mucke	Bosum
Torsten Bierstedt	A. B.
Dirk Dehne	A. B.
Jürgen Kraft	A. B.
Jan Marx	A. B.
Hans-Jürgen Vor	A. B.
Robert Noack	Apprentice
Tim Stegmann	Apprentice

Scientists SO186-1B



Scientists SO186-1C

Scientists SO186-1D

5. Agenda of the Cruises

Cruise SO186-B started on October 28, 2005 in Jakarta, Indonesia. Four scientists and one officer of the Indonesian Navy embarked on RV SONNE in Jakarta, whereas nine participants of leg SO186-1A stayed onboard and completed the German-Indonesian scientific team. As this leg was actually a continuation of the work done on the previous cruise, most of the scientific equipment was already set up and nearly no preparatory work was necessary in port.

At 08:00 in the morning of October 29 SONNE left the port of Jakarta and steamed towards the research area off Northern Sumatra. After Sunda Strait had been passed, the hydro-acoustic systems – Simrad EM120 multibeam echosounder, ATLAS Parasound parametric sediment echosounder as well as the magnetometer and gravity meter were turned on to extend the survey of the previous leg. Waypoints for the 3-day transit into the research area were carefully planned to optimally extend the area mapped during the transits of the previous leg. Generally the track followed the Sunda Trench along the subduction zone, seaward of the islands of Enggano, Selatan, Utara, Sipura, Siberut, Tanahbala and Nias to the area off Simeulue, which was reached on November 2 in the morning.

During the previous leg SO186-1A 20 ocean bottom recorder instruments (OBS / OBH) had been deployed around the island Simeulue in order to set up a submarine seismological network for monitoring the seismic activity. Five of those had to be recovered for maintenance and to be deployed again at the same position. OBS03 (Fig. 4.1) was successfully recovered in the morning of November 2. In this system the MBS data recorder was to be replaced by a newer MLS data recorder of much less energy consumption in order to extend the operational time. However, due to a misfit of plugs and sockets we first continued to OBS10 which was recovered in the evening. In the meantime the problem with OBS03 had been tackled so that this unit could be deployed at the position of OBS10. For the recovered system the same procedure was planned, which could be finished with the help of the electronic engineer of RV SONNE during the transit to OBS11, which was recovered at 2:00 on November 3. There we followed the same schedule and deployed the upgraded system at this position. At night we steamed to the position of OBH13, which was successfully recovered in the morning of November 3. For this system just a change of the energy pack was planned, which was accomplished during a boat drill. Following a successful deployment of this unit at the same position, SONNE returned to the position of OBS03, which was reached at 02:00 on November 4, where the unit, which had been equipped with a new MLS data recorder in the meantime, was deployed. During all of the transits between the OBS positions, mapping with EM120 multibeam system, Parasound subbottom profiler, magnetometer and gravity meter continued except for the shallow areas around OBH13, where the magnetometer was not in operation. In addition, parallel profiles were run to supplement and extend the survey area. Thus a large portion of the upper and middle slope seaward of Simeulue was mapped.

The OBS maintenance operations were finished on November 5. At 13:00, OBS06 was recovered. This system also holds a pressure sensor to detect tsunami waves at the seafloor. OBS06 was recovered to get a first set of pressure data recorded during the past weeks, which data will be analysed and used for a first quality control. In addition, the data could also help to tune the tsunami detection algorithm. The time to service OBS06 was used to take a water sound velocity profile at position 1°49.15'N, 95°56.07'E in the trench and to perform a roll- and pitch-calibration of the EM120 multibeam system. Following this, OBS06 was deployed again at 19:00 at the same position as before.

Work was continued with survey profiles SO186-46 to SO186-50 in the area Southwest of Simeulue, by recording magnetic, gravity and hydroacoustic data. The bathymetric coverage was extended with these profiles up to the upper slope off Simeulue. After finishing these surveys on November 7 at 10:30 a.m. local time, mapping was continued along profiles SO186-51 to SO186-55 on the middle and upper slope off the island Nias. In this area, the lower slope and the trench had already been mapped during leg 1. Running 5 profiles, each about 200 km in length, the complete area up to the upper slope three miles off the coast of Nias was mapped. The survey was finished on November 9 at 17:00 local time. From here on, the track back to Jakarta was planned to extend the survey of leg 1 and other previous cruises. However, at 20:30 local time on November 9, the scheduled profiles had to be skipped, as it was decided to recover OBS06 again. The analysis of the data of the new pressure sensor of OBS06, which had been recovered once and deployed again on November 5, indicated a fatal malfunction of the system. Additional tests are required to locate the error. As this sensor forms an important component of the new Ocean Bottom Unit (OBU) of the Tsunami Early Warning System, the recovery of this unit was given priority. SONNE turned and steamed back with full speed to the position of OBS06, which was reached on November 10 at 09:30 local time. Both OBS06 and the pressure sensor were safely recovered at 10:30 on November 10.

To reach the port of Jakarta despite this detour at the scheduled date and time, the third engine was turned on, and SONNE steamed with up to 14 knots along the shortest possible track back to Jakarta. Sunda Strait was passed during the night of November 12 to November 13. SONNE moored at the pier in Jakarta at 08:30 in the morning of November 13.

Cruise SO186-C started on November 15, 2005 in Jakarta.The intention of this part of the cruise was to install the two experimental GI-TEWS buoys. For the passage from Jakarta to Sunda Strait representatives of the media and partner institutions were invited. Due to increased paper work the departure was delayed from 09:00 to 13:30. Besides the crew and 24 scientists a total of 21 guests were onboard.
Near the island of Pulau Tunda one of the buoys was deployed for demonstration purposes to the media. Later on, the guests left the vessel in the port of Cigading, and at 01:00 Sonne left Cigading. A few hours later the Simrad system was activated and it recorded continuously throughout the cruise.

Just after midnight on 17.11 we reached the Sunda Trench where the waterdepth was around 6200 m, i.e. suitable for deep-water tests of releasers and acoustic links. Two tests down to 6000 m completed during this day were not entirely successful. During both passes a CTD was attached to the rope. A preliminary data analysis suggested that due to ship-induced noise a reliable acoustic link could not be established. It was therefore decided to test the systems again after some modifications when attached to the buoy, drifting away from Sonne.

The buoy, with its anchor chain reaching to the subsurface float, was deployed at 06:30 on 18.11. Soon after deployment was finished, wind was getting up to reach 18m/s, and swell developed rapidly. Acoustic communication was only tested with the EvoLogics modem, because attempts to switch the modem on the floating buoy failed due to sea state. It was then decided to run a few bathymetric profiles and wait for better conditions. Also, a new seismometer was deployed for a test period, since several bugs had already been found in the software of the new MTS recorders. An attempt to reach the buoy had to be abandoned, but we managed to attach a rope to the buoy and thus keep it close to the vessel.

Early in the morning of 19.11 another attempt to recover the buoy had to be abandoned due to sea-state. Later, around 14:00, this had improved considerably, and the buoy could be recovered safely.

Further tests of the acoustic links were initiated immediately, again accompanied by a CTD measurement. These test were continued until 04:00 on 20.11, when for the first time data were transmitted from a depth of 5600 m to the vessel under poor weather conditions.

The deployment of the GITEWS-1 buoy was started at 09:30 on 20.11, the water depth was around 5.250 meters. Just before 18:00 the anchor was slipped, and Sonne followed the buoy, moving at a speed of up to three knots to its final destination at 3°43,7´ S//99°14.0´E. Soon after, the Ocean Bottom Unit (OBU) and an additional OBS as a reference station were deployed and Sonne headed toward the port of Padang, where scientists were to disembark and also some offical representatives to be met – but without any knowledge of the planned details of what was to be expected.

We arrived at Padang at 12:30, and Sonne was parked next to the Indonesian RV Baruna Jaja 1. There was considerable interest in our port call: about 300 people, including the major of Padang, visited the vessel. Sonne left Padang just after 08:00 on 22.11, and reached Sunda Trench at 04:00 the following day. Two more modem tests were made, and the deployment of the second buoy finally started at 15:00. At 23:00 this work was completed, including the deployment of the two bottom stations. Sonne then transited toward the Island of Simeulue, where a seismological network had been deployed on a previous cruise. Here four stations were recovered and 20 were deployed to increase the coverage. Among these stations were 5 instruments equipped with a methane sensor. At 07:00 the following day (25.11) work was completed and Sonne started her transit to Singapore, where we berthed at 10:20 on 28.11. 2005.

Cruise SO186-d started in Singapore on January 07, 2006. The intention of this part of the cruise was to service the two experimental GI-TEWS buoys and some of the 35 ocean bottom instruments that were deployed during previous legs. After three days of transit Sonne arrived close to the Island Simeulue on 10.01 in the morning. During this day, a total of 11 instruments were picked up, while three were redeployed immediately. We then continued our transit to the south to TEWS02, which was reached at 15:30 on 11.01, with a fishing vessel parking next to it. The buoy was recovered safely, with no sign of damage, corrosion and surprisingly little bio-fauling. Subsequently the bottom unit was also recovered and Sonne headed south to position TEWS01, which was reached on 12.01 at 20:00. The following night was used for an extensive testing of the acoustic links. In the next morning the acoustic modem of TEWS01 was recovered for further testing. Subsequently, the buoy TEWS02B was deployed between 16:00 and 21:99 on 13.01.

Following a short bathymetric survey, buoy TEWS01 was recovered on 14.01. After another test of the acoustic link for buoy TEWS02B, we decided to recover the acoustic modem; this was accomplished in the evening of the same day.

After transit to the north, buoy TEWS01B was deployed between 18:00 and 23:00 on 15.01, and Sonne started her transit back to Singapore.

Three additional OBS were recovered close to Simeulue Island, and another 9 instruments were deployed here. At the entrance of Malacca Strait the Simrad System was turned off. Sonne berthed in Singapore 20.01.06 at 10:00.

Trackplots of all three legs are shown in Figures 5.1 to 5.3.

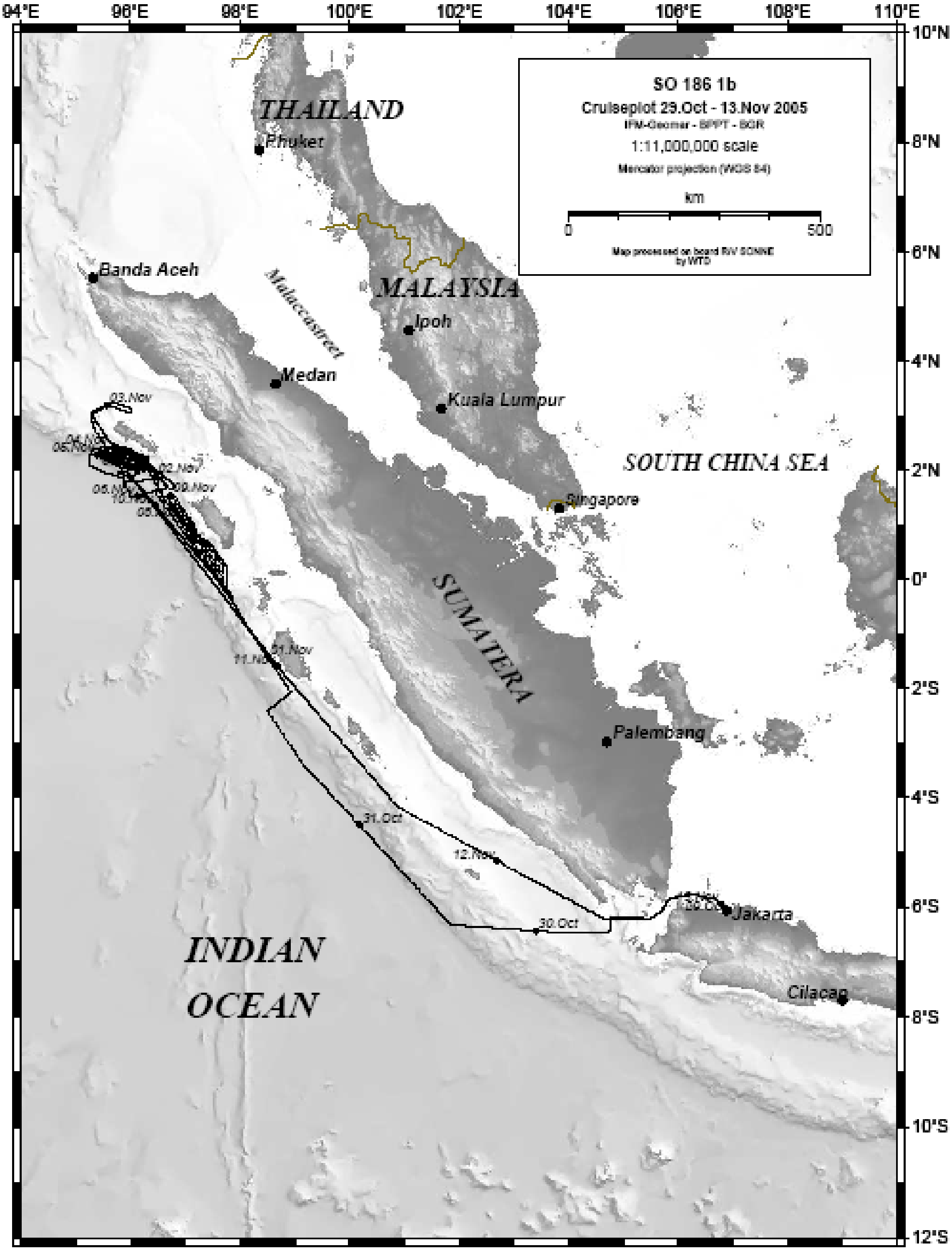


Fig. 5.1: Cruise Plot 29.Oct – 13.Nov 2005

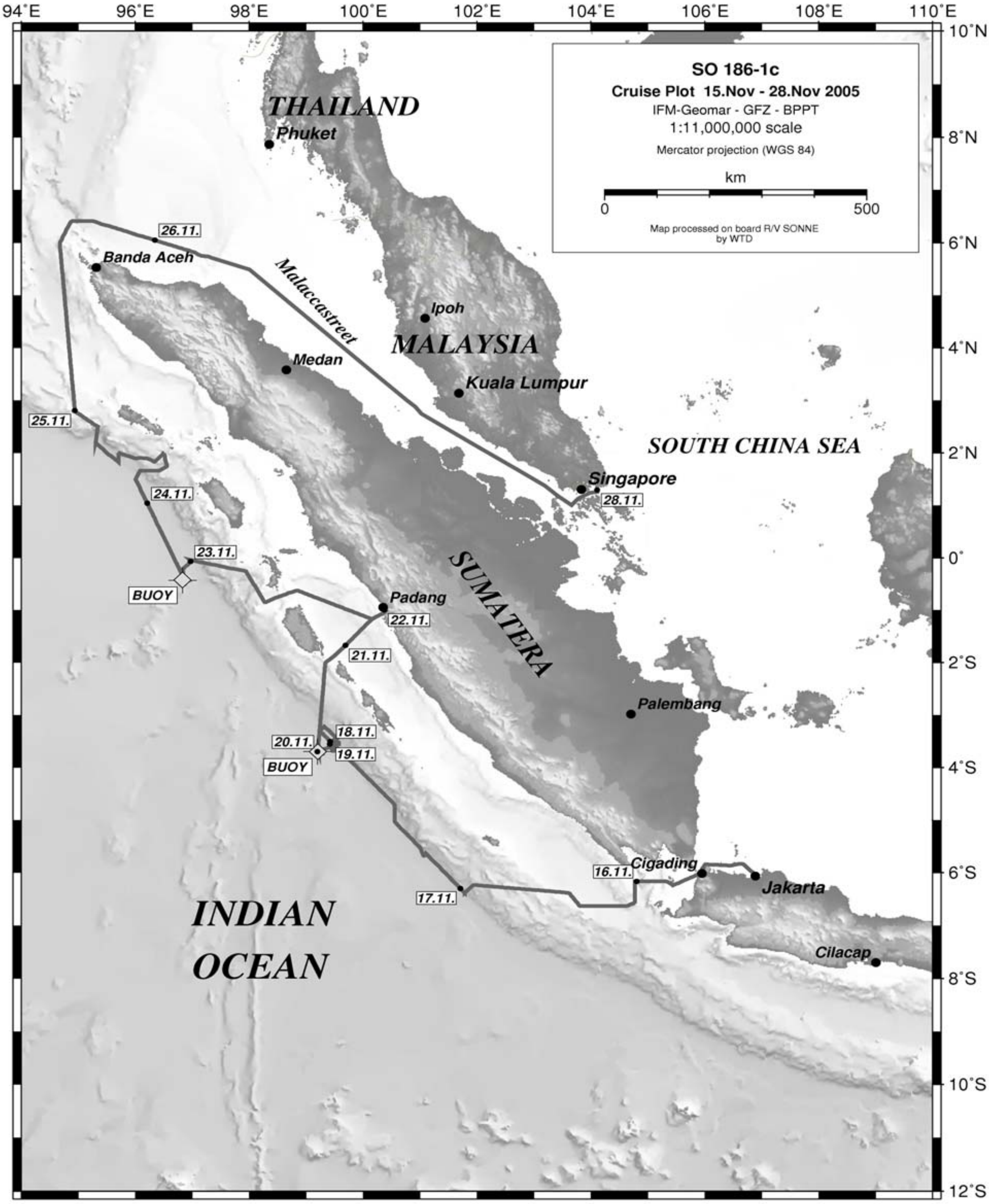


Fig. 5.2: Cruise Plot 15. Nov – 28. Nov 2005

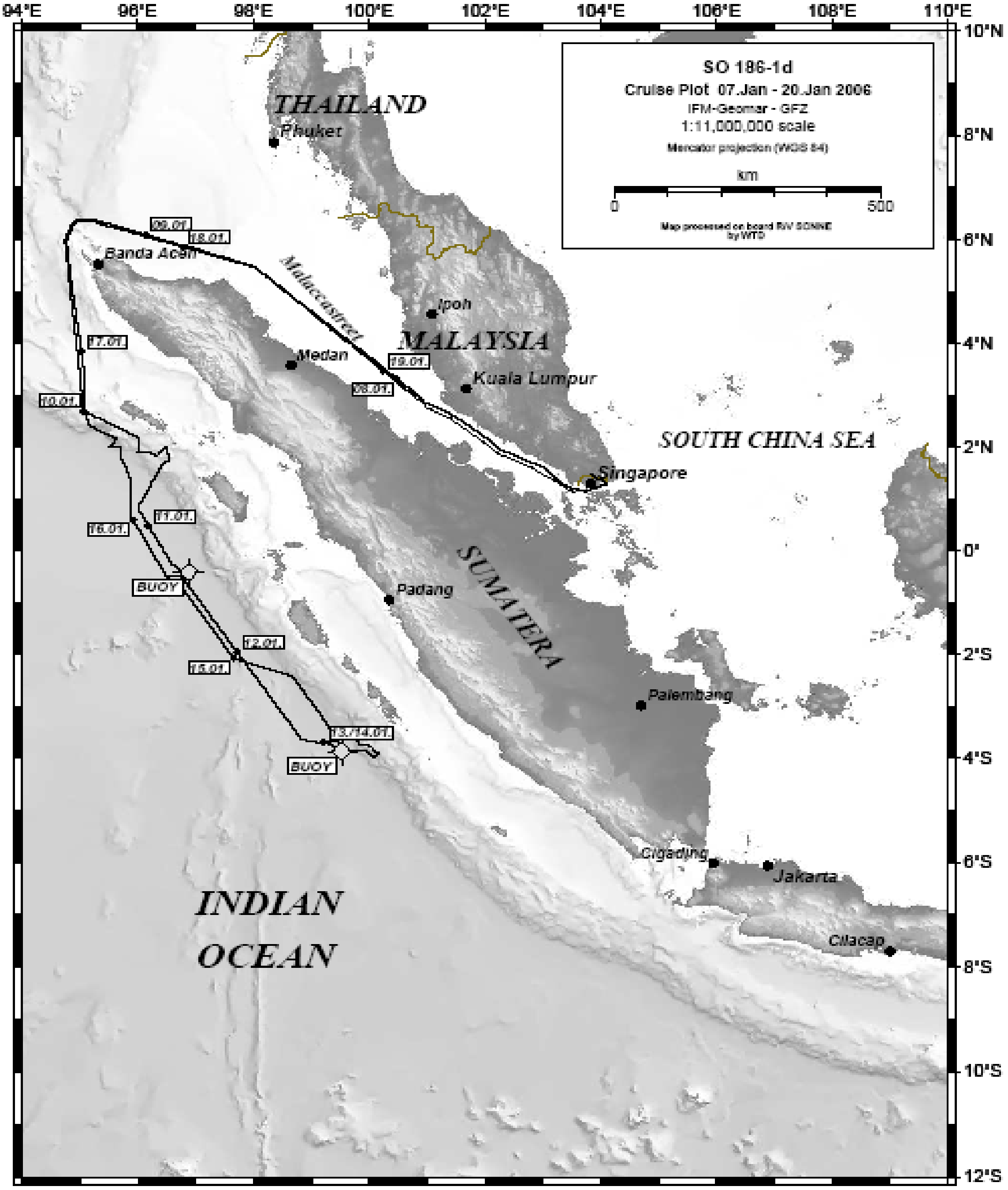


Fig. 5.3: Cruise Plot 07. Jan – 20. Jan. 2006

6. SCIENTIFIC INSTRUMENTATION

6.1 Shipboard Instrumentation

6.1.1 Navigation and positioning

During cruise SO-186-1B standard GPS positioning a Trimble 4000 DS receiver was used. Differential GPS (DGPS) with an accuracy that is an order of magnitude higher than standard GPS is available on SONNE, but the use of this system is relatively expensive and should therefore be limited to operations which require the highest possible positioning accuracy. Since May 2000 the GPS signals have been available without the intentional degradation called ‘selected availability’ and since then GPS positioning has reached an accuracy on the order of 15 meters without DGPS. GPS signals were received throughout cruise SO-186-1B&C without notable interruptions and in good quality.

6.1.2 Simrad EM-120 multibeam bathymetry system

The EM 120 system is a deep-water multibeam echosounder providing accurate bathymetric mapping up to full ocean depth. A system overview is presented in Fig. 6.1. Basic components of the system are two linear transducer arrays in a Mills cross configuration with separate units for transmit and receive. The nominal sonar frequency is 12 kHz with an angular coverage sector of up to 150° and 191 beams per ping. The emission beam is 150° wide across track, and 2° along track direction. The reception is obtained from 191 beams, with widths of 2° across track and 20° along track. Thus the actual footprint of a single beam has a dimension of 2° by 2°. Achievable swath width on a flat bottom will normally be up to six times the water depth dependent on the character of the seafloor. The angular coverage sector and beam pointing angles may be set to vary automatically with depth according to achievable coverage. This maximizes the number of usable beams. The beam spacing is normally equidistant with equiangle available.

For depth measurements, 191 isolated depth values are obtained perpendicular to the track for each ping. Using the 2-way-travel-time and the beam angle known for each beam, and taking into account the ray bending due to refraction in the water column by sound speed variations, depth is calculated for each beam. A combination of amplitude (for the central beams) and phase (slant beams) is used to provide a measurement accuracy practically independent of the beam pointing angle.

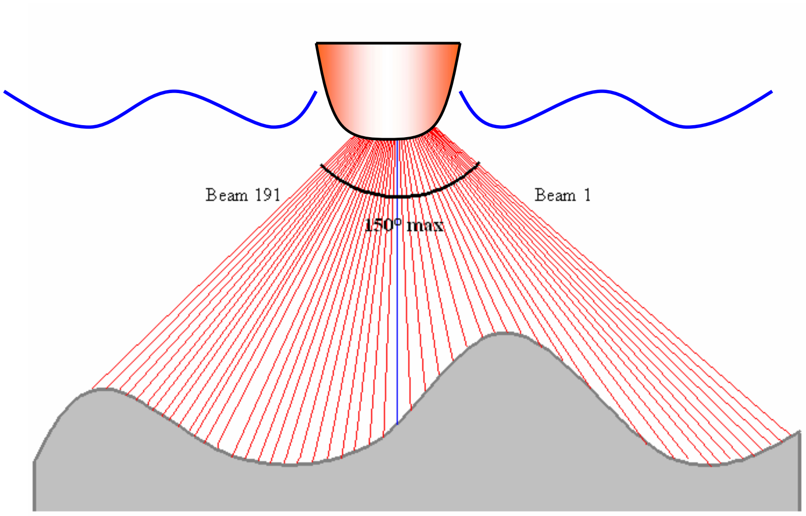


Fig. 6.1.1: *Overview of the SIMRAD beam width*

EM-120 Multibeam data processing.

The raw data from the Simrad EM-120 were directly processed on RV Sonne. Generally, processing of multibeam data requires two sequences of processing steps: a profile –oriented sequence followed by an area-based processing. The profile-oriented processing of the EM-120 data comprises the check of navigation data, interpolating missing navigation values, the calculation of the water depth and position of the footprints of the beams by raytracing through the water-column taking into account the sound velocity profile, and removing artefacts and erroneous data points. Area-based processing comprises the calculation of a digital terrain model (DTM) and the visualisation of the data in various different presentations. For these purposes a software package from Simrad is available onboard RV Sonne. On cruise SO-186-1B, the “open software” packages MB-System (Caress and Chayes, 1996) and GMT (Wessel and Smith, 1995) were used beside the SIMRAD applications for the processing of the multibeam data during cruise SO-186-1B.

Data of the multibeam system Simrad EM-120 are stored continuously during operation on the disks of the operator workstation in a vendor specific raw-data format. Data are organized in SURVEYS. A survey is initiated by the operator on the operator console. Generally, a new survey was initiated when working in a new area started, when a new profile started, or during continuous profiling over many days, once a day. In the MB-System software the Simrad vendor specific raw data format is defined as format 56. Further processing of the data requires the conversion of the data to the MB-System format 57. In addition, some auxiliary files have to be created containing meta information for each file. These files speed up further processing steps. In MB-System the management of the data is maintained by so-called datalist-files which contain names, paths, format-ID and a weighting factor for each file. Datalist files can be set up recursively, i.e. entries in a datalist refer to another datalist which points to the actual data files. This structure helps to easily keep track of all data files which can grow to several thousand files for a normal-sized area project.

Two steps follow in the processing sequence which has to be carried out interactively. The cleaning of the raw data by flagging outliers and artefacts (simultaneously to the CARIS HIPS & SIPS software) are done with the programme “mbedit – I <survey_name>” for each of the raw data files.
An area in the context of “area based multibeam data processing” is a rectangular survey area defined by its geographical coordinates (minimum and maximum latitude, minimum and maximum longitude). All processed multibeam data that fall within this box will be integrated in the calculation of a digital terrain model (DTM) for this survey area. For each survey area a directory with its name is created. Key parameters for a survey area (name, boundaries, scale) are stored in the file “.hsdefaults” in that directory. The access to the processed data files is accomplished by a datalist file as already introduced above. For calculation of the DTM of the area the script “process.cmd” is executed. The DTM is represented by a regular grid. Basic parameters for the DTM calculations are the name of the datalist file, the grid size in latitude and longitude as well as the number of grid cells without data which will be filled by interpolation. The basic script for the presentation of the DTM is “fig_bathy.cmd”.

6.1.3 Parasound

The Parasound system works both as a low-frequency sediment echosounder and as a high-frequency narrow beam sounder to determine the water depth. It utilizes the parametric effect, which produces additional frequencies through nonlinear acoustic interactions of finite amplitude waves. For example two sound waves of similar frequencies (in our case 18 kHz und 22 kHz) are emitted simultaneously. The signal of the difference frequency (4 kHz) is generated for sufficiently high primary amplitudes. The new component is travelling within the emission cone of the original high frequency waves, which are limited to an angle of only 4° for the equipment used. Therefore, the footprint size of 7% of the water depth is much smaller than for conventional systems and both vertical and lateral resolution is significantly improved.

The hull-mounted transducer array has 128 elements on an area of ~1 m^2. It requires up to 70 kW of electric power due to the low degree of efficiency of the parametric effect. In 2 electronic cabinets beam forming, signal generation, and the separation of primary (18, 22 kHz) and secondary frequencies (4 kHz) is carried out. With the third electronic cabinet in the echosounder control room the system is operated on a 24-hour watch schedule.

Since the two-way travel time in the deep sea is long compared to the length of the reception window of up to 266 ms, the PARASOUND System sends out a burst of pulses at 400 ms intervals before the first echo returns. The coverage of this discontinuous mode depends on the water depth and produces non-equidistant shot distances between bursts.

The first attention of the operators is system and quality control and the adjustment of the upper limit of the reception window because only a small depth window close to the sea floor is recorded (normally set to 200 m). The reason is the limited penetration of the echosounder signal into the sediment.

At the University of Bremen the digital data acquisition system ParaDigMA was developed by Spieß (1993). On RV Sonne this system was equipped with the Parasound System in addition to the analogue recording features with the b/w DESO 25 device. The data were stored using the standard, industry-compatible SEGY-format. The PC allows the buffering, transfer, and storage of the digital seismograms at very high repetition rates. From the emitted series of pulses, usually the pulse could be digitised and stored, resulting in recording intervals of 800 ms within a pulse sequence. The seismograms were sampled at a frequency of 40 kHz and with a registration length of 266 ms for a depth window of ~200 m. Already during the acquisition of the data an online processing was carried out. For all profiles Parasound sections were plotted with a vertical scale of several hundred meters. Most of the changes in window depth could thereby be eliminated. From these plots a first impression of variations in sea floor morphology, sediment coverage and sedimentation patterns along the ships track could be gained. In addition the data were normalised to a constant value much smaller than the maximum average amplitude, to amplify in particular deeper and weaker reflections. The main aim of using the Parasound system was the selection of suited sites for sediment sampling.

6.2 Computer facilities and data acquisition system

During cruise SO-186-1B&C the data acquisition was fully based on PC computers while until recently DIGITAL AlphaServer workstations had been used for this purpose by BGR. Modern PC’s are capable of handling the data volume that is being produced during BGR’s marine magnetic and gravimetric measurements. They are easy to integrate into SONNE’s Ethernet network so that shipboard facilities like printers and plotters and the e-mail server can directly be used without problems. On the downside, PC operating systems are still not as stable as the OpenVMS which was used on the workstations.

In addition to a shipboard computer installed in the Magnetic Laboratory, a total of one industrial computer, three desktop computers and three laptop computers were used by the magnetics and gravity group from BGR. All PC’s used operating system Windows XP, one could alternatively be run under Linux 9.1. The data acquisition PC is equipped with a large number of serial and other ports and was used for the main data acquisition which included navigation data, gravity data, gradiometer data, depth, and water sound velocity. At the same time the industrial computer controlled the gradiometer operation. The data pre-processing was performed on various computers. All data which are part of BGR’s standard operations were transformed into special data format within a procedure that checks, reformats, and collects the data items to one data set each 20 seconds.

The shipboard computer provided the following data from the ship’s navigation system once per second:

- position, speed and course from GPS
- heading from the gyro
- speed from the Doppler-sonar (DO-Log)
- water depth values from the SIMRAD EM120 mutlibeam echosounder (center beam only) and from PARASOUND
- weather data

The following data are read over serial lines:

- precise time marks (UTC) from a GPS controlled clock once per second
- magnetic total intensity for both sensors and the gradient between the sensors
- raw gravity values from the marine gravimeter

Each of the data strings was written into the memory of the data acquisition PC by real time programs developed under LabView. Analogue recordings were produced for the magnetic total intensity, the gradient, and the raw gravity. A navigation program (Nobeltec Visual Mariner) was run with online navigation data input on one of the PC's. This program permanently displayed the ship's position on a map with the planned and the already finished profiles.

The processing of the multibeam bathymetry data was carried out on three IFM-GEOMAR PCs under LINUX operating system (SuSe 9.3). On these systems the processing software MB-System and GMT were installed.

For the communication with the deployed buoys TS1 & TS2 special modems were used. ACeS, a satellite communication service povider, operating the geostationary GERUDA-1 satellite (135°E), provided the FR-190G modems allowing an easy data transfer even from off-shore plattforms. During the leg SO186c the TS1 buoy was operated without any problems. During leg 186d problems with the modem system of TS2 were tackled, both buoys can now be operated remotely.

6.3 Magnetics

On cruise SO-186-1B we operated the extended BGR magnetometer system which consists of the Marine Magnetics SeaSpy Gradiometer with two Overhauser magnetometer sensors. The sensors measure the scalar absolute value of the total magnetic field.

6.3.1 Marine Magnetics SeaSpy Gradiometer

The SeaSpy Marine Gradiometer System manufactured by Marine Magnetics Corp consists of two proton precession magnetometers, enhanced with the Overhauser effect, towed in-line at distances of 700 m and 850 m astern of the ship, respectively (Fig. 6.3.1). In the standard configuration during the survey, the BGR system was operated via an outrigger on portside of R/V SONNE. The gradiometer principle is based on the fact that, in a uniform field, two identical and perfectly aligned and synchronized sensors will give identical outputs which can be subtracted one from another to give zero output, effectively eliminating the presence of the field. Provided the sensors remain solidly fixed in relation to one another, the assembly can be rotated in space without producing an orientation output. If, however, there is a small field gradient (from magnetic anomalies derived from rocks beneath the sea bottom) superimposed on the uniform field (the main Earth magnetic field), the output of the sensor combination will change as a function of magnitude and direction of that gradient.

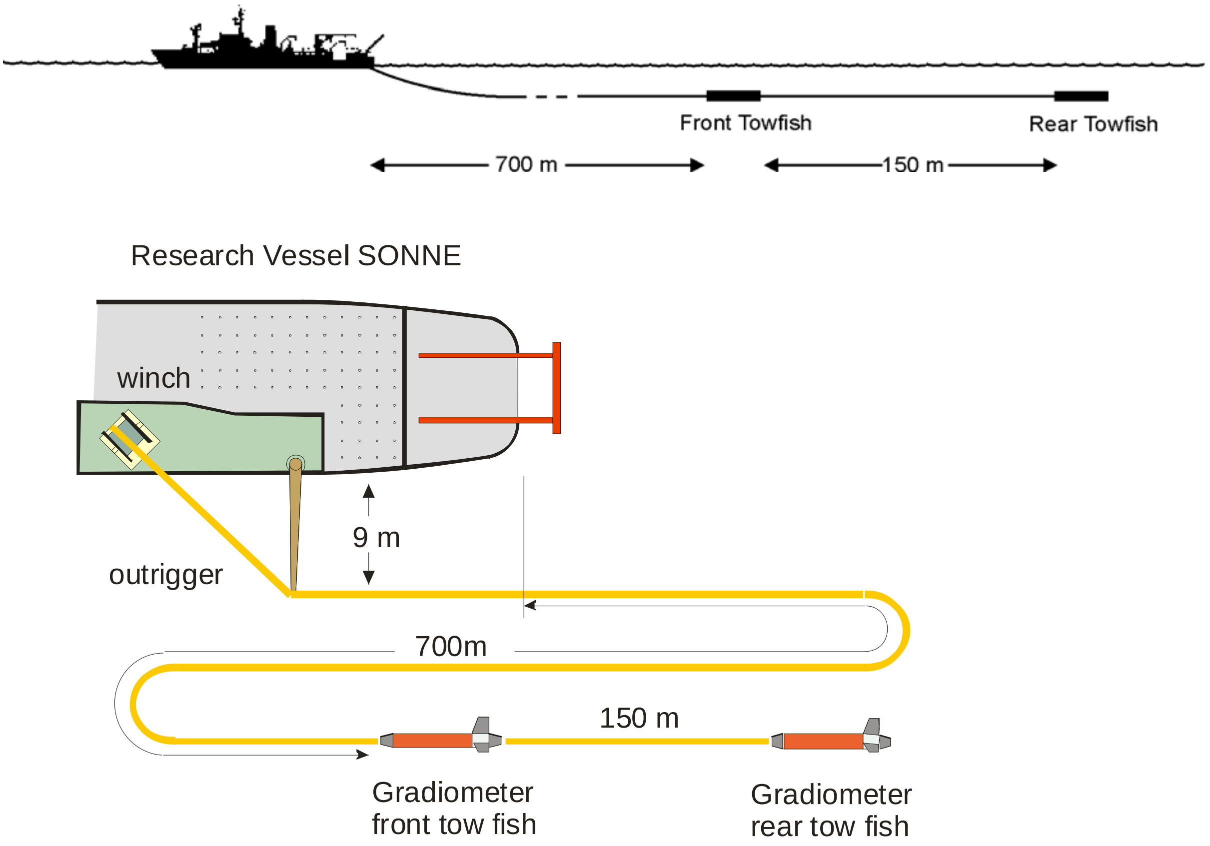


Fig. 6.3.1: Schematic sketch of the SeaSpy Gradiometer System setup in side-view and from above.

‘Integration’ of the differences of the two sensors along the line provides theoretically a total intensity curve that is free of variations (time dependent changes of the earth’s magnetic field). A standard proton precession magnetometer uses a strong DC magnetic field to polarize itself before each reading can be taken. An Overhauser sensor uses an AC magnetic field of radio frequency to polarize. The polarization power required is much smaller and the AC field may be left active while the sensor is producing a valid output signal. This allows the sensor to cycle much faster and produces more precise results than a standard sensor. The signal is digitized by the electronics assembly which then transmits the digital data string via the coaxial connection. The tow cable is connected to a deck leader which is in turn connected to the power supply and logging computer. The Overhauser sensors have a sensitivity of 0.015 nT and an absolute accuracy of 0.2 nT. For this survey a cycle time of one second was used. The system was operated in ‘gradient mode’ using both sensors, i.e. front tow fish and rear tow fish.

The total intensity values were reduced to magnetic anomalies using the geomagnetic reference field IGRF2005. Corrections for the magnetic effect of the ship were not necessary because the cable length (600 m) to the nearest sensor towed behind the ship was long enough to exclude any significant influence on the magnetic anomalies.

6.3.2 Noise pick-up

During the previous cruises we very often had severe problems with strong noise mostly on the front sensor. In case of such a noisy signal the manufacturer suggests to carefully ‘ground’ all cables between the sensors, the ‘Smart Transceiver’ and the data acquisition computer as well. According to the manufacturer, ‘unbalanced stray currents’ cause the low quality of the data. The manual offers a variety of solutions to the problem with different types of ‘grounding’. We found out that none of them is really capable of solving the problem.

On several occasions we tried to connect the cables to different grounding lines, but the effort was of no avail. The quality of the data improved for a few days but decreased abruptly when the system had to be switched off/on for some reason. Then another ‘grounding line’ had to be found. We never knew which line was the best for grounding and it always took some time until we had detected a new and appropriate grounding connection.

Finally we found a very simple solution to get rid of ‘unbalanced stray currents’ (Fig. 6.3.2). Just a small transformer is needed for the ac-input of the Smart Transceiver. The electronic-box Smart Transceiver of the gradiometer runs on 230 V ac. A built-in power supply converts 230V ac to 24 V dc by means of an electronic power-module. We found out that the power-module obviously had no sufficient insulation between input and output, thus transmitting 50 Hz injection noise to the marine cable. This seems to be a general problem with this type of power-module and we assume the manufacturer has never considered this important.

Any transformer with 230 V input and 230 V output will do, but it is essential to use transformers with 2 independent coils. No ‘step-down transformer’ should be used.

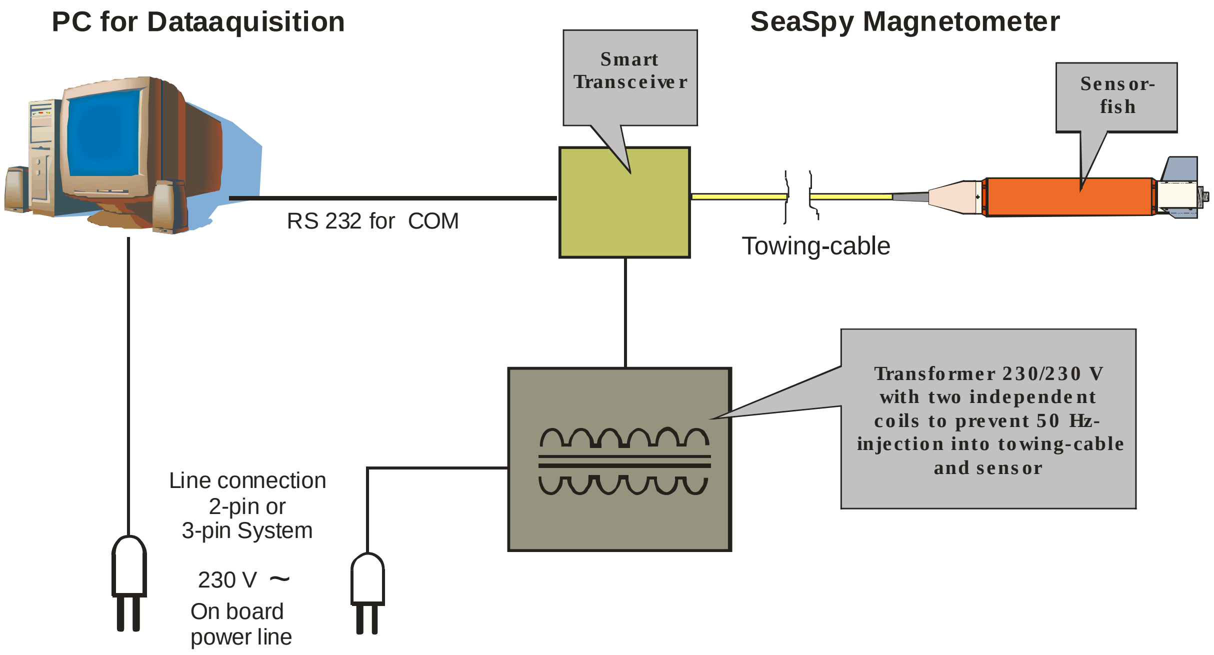


Fig. 6.3.2: Schematic sketch of the onboard connection of the SeaSpy system. Note the installation of a transformer with two coils to avoid ac-transmission to the towing cable.

6.4. Gravity

6.4.1 Bodenseewerke KSS31 Seagravimeter

During the cruise SO186-1B the sea gravimeter system KSS31M, owned by BGR, was installed in the Gravity Laboratory one level below the main deck. The sea gravimeter was located approximately at the vessel's nominal waterline, 1.5 m to portside from the middle line, and 48 m forward of the stern.

The gravimeter system KSS31M is a high-performance instrument for marine gravity measurements, manufactured by the company Bodenseewerk Geosystem GmbH. While the sensor is based on the Askania type GSS3 sea gravimeter designed by Prof. Graf in the 60ties, the horizontal platform and the corresponding electronic devices were developed by the Bodenseewerk Geosystem in the second half of the 70ties. The system was modernized and modified in 2001 by the successor company Bodensee Gravitymeter Geosystem GmbH. The KSS31M system consists of two main assemblies: the gyro-stabilized platform with gravity sensor and the data handling subsystem.

The gravity sensor (Fig. 6.4.1) consists of a tube-shaped mass that is suspended on a metal spring and guided frictionless by 5 threads. It is non-astatized and particularly designed to be insensitive to horizontal accelerations. This is achieved by limiting the motion of the mass to the vertical direction. Thus it is a straight line gravity meter avoiding cross-coupling effects of beam-type gravity meters. The main part of the total gravity acceleration is compensated by the mechanical spring, but gravity changes are detected and compensated by an electromagnetic system. A displacement of the spring-mass assembly with respect to the outer casing of the instrument is measured using a capacitance transducer. The output from the transducer is fed back into an electromagnetic moving coil system used for feedback control. A P-I feedback (P=Proportional, I=Integration) suppresses the accelerations caused by sea motion. An I-acting feedback provides a signal which drives the system to the zero position and represents an overcritical damping of the system. The current flowing through the moving coil is the measure for the gravity change.

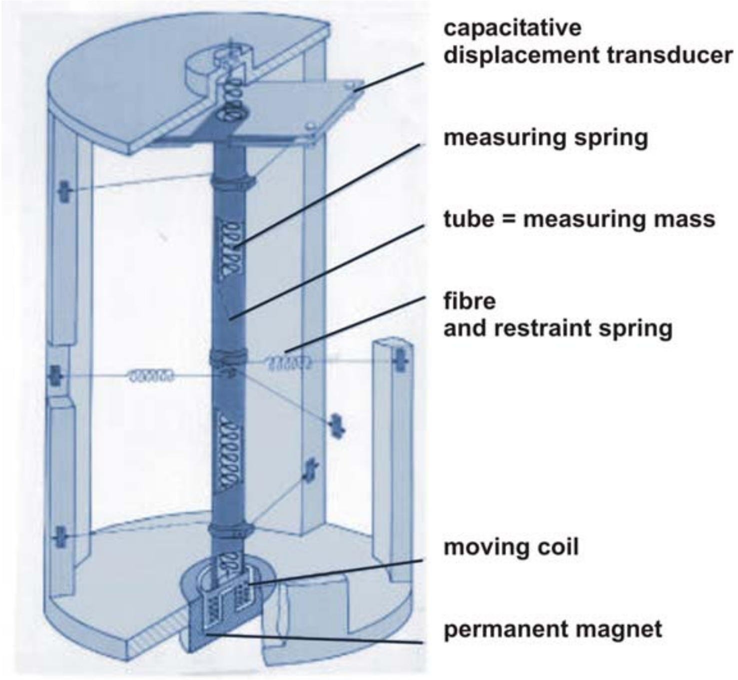


Fig. 6.4.1: Gravity Sensor GSS30 of the sea gravimeter system KSS31M.

In addition to the spring-mass assembly serving as gravity detector,0000 the sensor housing contains the control electronics that converts the current signal to voltage output and forwards it to the data handling subsystem. The power supply of the gravity sensor contains a sealed buffered battery unit with sufficient capacity to maintain the internal temperature stabilization of the sensor for 24 hours in case of main power loss. In case of system failure the sensor electronics activates automatically a caging mechanism preventing the spring-mass assembly from damage.

The leveling subsystem consists of a platform stabilized in two axes by a vertical electrically erected gyro. The stabilization during course changes can be improved by providing the system with online navigation data. The control electronics and the power supply of the platform are located in the data handling subsystem unit. Functions like gyro run-up and -down sequences and the automatic platform caging are performed by the system controller unit, which is located in the data handling subsystem, too.

The stabilized platform will keep the sensor in an upright position with an accuracy of leveling in the order of 0.5 minutes of arc. This is particularly important as the sensor is very sensitive to tilting due to its very high accuracy. Vertical acceleration, however, cannot be eliminated. Luckily on a shipborne gravity system the vertical acceleration will periodically oscillate with a period of some seconds. This signal can be eliminated easily by means of lowpass filtering.

The data are transmitted to the BGR data acquisition and processing system (see 6.2) in the magnetic laboratory, and online navigation data from this system are received with a rate of 1 Hz to support the stabilizing platform. The support is realized as follows: The horizontal position of the gyro-stabilized platform is controlled by two orthogonal horizontal accelerometers. The platform is leveled in such a manner that the horizontal accelerations are zero. If the ship curves, the additional horizontal acceleration will cause the platform to be leveled according to the resulting apparent vertical axis. This axis may differ substantially from the true vertical axis and will result in too small gravity values and additionally in an effect of horizontal accelerations on the measured gravity. This effect is eliminated by supplying the KSS31M system with online navigation data. From this input, a microprocessor calculates the leveling errors and enters them into the platform electronics which accordingly corrects the platform.

6.4.2 Data Processing

Processing of the gravity data consists essentially of the following steps:
- a time shift of 76 seconds due to the overcritical damping of the sensor,
-conversion of the output from reading units (r.u.) to mGal by applying a conversion factor of 0.94542 mGal/r.u.; on this cruise this was done in the system itself by hardware setting
- connection of the harbour gravity value to the world gravity net IGSN 71(see 6.4.3)
- correction for Eötvös effect using the navigation data,
- correction for the instrumental drift (not performed until completion of the cruise)
- subtraction of the normal gravity (WGS67).

As a result, we get the so-called free-air anomaly (FAA) which in the case of marine gravity is simply the Eötvös corrected observed absolute gravity minus the normal gravity. According to the selectable time interval of the data acquisition system, gravity values are available every 20 seconds. These anomalies are named BEARB anomalies in the following.

Additionally the gravity anomalies, which are provided every second directly by the data handling subsystem of the KSS31M, were recorded with a separate laptop computer. Free-air gravity anomalies are obtained when the KSS31M is supplied with the necessary navigation data (geographical latitude and longitude, speed and course over ground). These anomalies are named KSS31M anomalies in the following.

6.4.3 Gravity ties to land stations

To compare the results of different gravity surveys the measured data have to be tied in a world-wide accepted reference system. This system is represented by the International Gravity Standardization Net IGSN71 (MORELLI, 1974). The IGSN71 was established in 1971 by the International Union of Geodesy and Geophysics IUGG as a set of world-wide distributed locations with known absolute gravity values better than a few tenths of mGal. According to the recommendations of the IUGG, every gravity survey, marine or land-based, should be related to the datum and to the scale of the IGSN71.

Therefore, gravity measurements on land have to be carried out to connect the gravity measurements at sea with the IGSN71. The marine geophysical group of BGR uses for the gravity connections a LaCoste&Romberg gravity meter, model G, no. 480 (LCR G480).

The point description and gravity value of reference IGSN71 station in Jakarta was kindly provided by the Bureau of Meteorology and Geophysics (Jakarta, Indonesia).

R/V SONNE moored from Oct. 7 to 11 at the pier of Tanjung Priok (Jakarta) at the eastern side of ‘No. 2 Basin’, next to shed 211 (Fig. 6.4.2). On Oct. 10, tie measurements to point **A** on the pier opposite the Gravity Laboratory on R/V SONNE have been made. Point **A** is located about 400 m from the northeastern end of the pier.

The connection measurements resulted in an average absolute gravity value of 978146.79 mGal (with water level –0.9 m, IGSN71) for point **A** at the water level. The reading of the KSS31 at the leaving time (October 10, 2005, 23:30 UT) from the pier was
–1787.70 mGal.

Table 6.4.1: Observation report of the gravity tie measurements in Jakarta and Tanjung Priok.

Station	Observer	Date	Time UTC	Reading units	Gravity value [mGal]
BGR	K	25.08.05	08:35	4812.35	4893.317
A	H	10.10.05	01:45	1748.52	1774.458
BMG.0	H	10.10.05	02:45	1751.59	1777.576
A	H	10.10.05	03:35	1748.49	1774.428
B	H	27.10.05	03:00	1747.64	1773.565
A	H	27.10.05	03:10	1747.67	1773.595
B	H	13.11.05	03:06	1747.75	1773.676

Observers: K = Kewitsch, H = Heyde
Gravity in mGal was calculated using LCR G 480 scaling table.

Reference Stations:

BGR:	Pillar, Room No. VB11	981267.73 mGal (IGSN71)
BMG.0:	Pillar, Meteorological Park, Bureau of Meteorology and Geophysics (BMG)	978149.68 mGal (IGSN71)

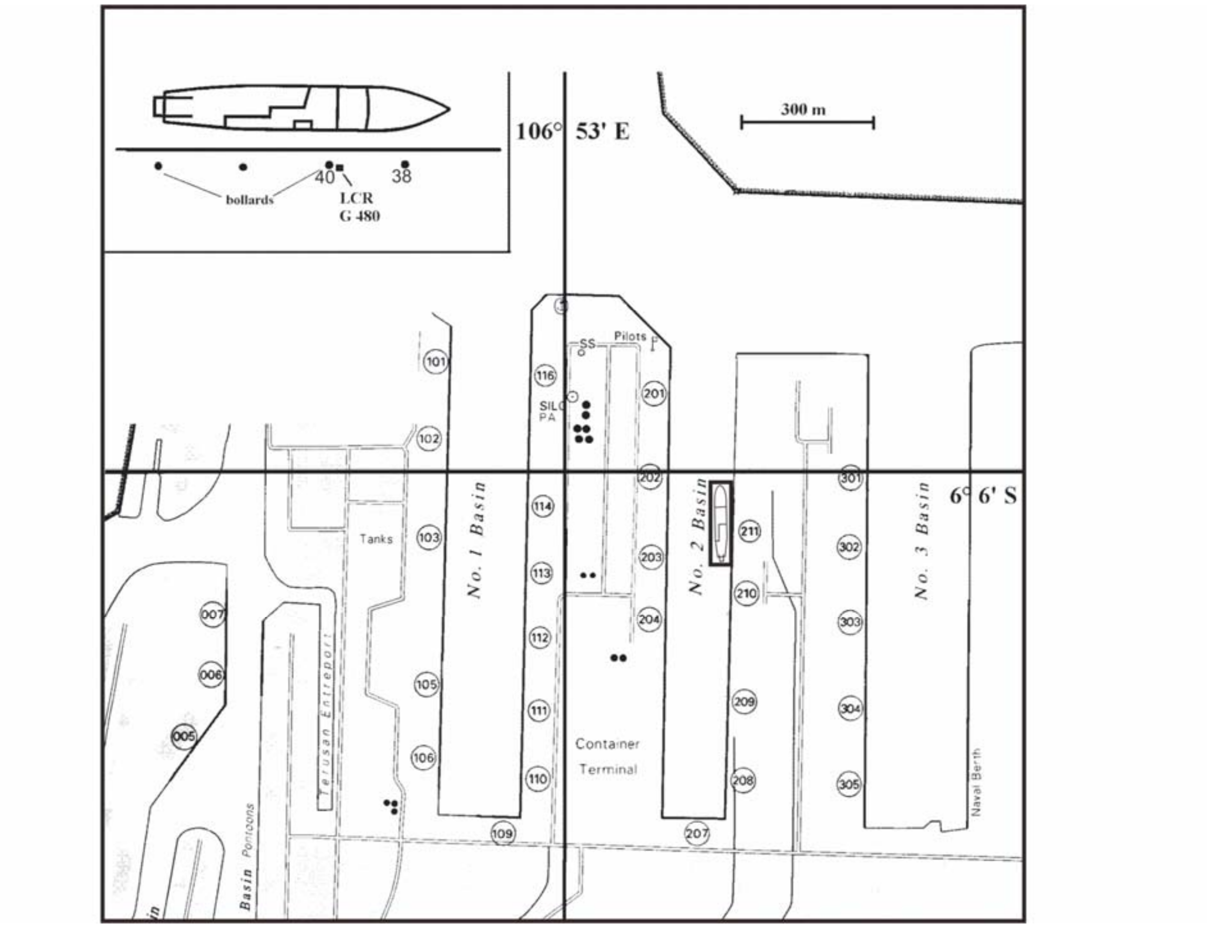


Fig. 6.4.2: Location of the mooring site of R/V SONNE at the pier of Tanjung Priok (from the Admiralty chart 932, Pelabuhan Tanjung Priok, scale 1:12500).

Gravity station:

A: Tanjung Priok ,eastern side of Basin No. 2, 400 m from northwestern end of the pier, opposite shed No. 211

B: Tanjung Priok, eastern side of Basin No. 2, 380 m from northwestern end of the pier

Differences between reference/gravity stations:

BMG.0 – A = - 3.12 mGal

Absolute gravity at **A**: 978146.56 mGal

Absolute gravity for **A** (reduced to water level –0.9 m) 978146.80 mGal (IGSN71 system) used for the gravity tie on 10.10.2004 (23:30 UT). Reading of sea gravimeter KSS31M at the same time: -1787.70 mGal

BGR – BMG.0 = + 3115.74 mGal (own measurements)
= + 3118.05 mGal (according to given IGSN71 values)

The difference between the reference points **BGR** and **BMG.0** derived from our own measurements seems to be quite far off the value calculated from the given ISGN71 values. But it has to be taken into consideration that the reading at **BGR** was taken two months prior to the cruise and that the gravity meter was transported to Jakarta in the meantime with the sensor heating switched off. Under these circumstances an instrumental drift of 2.3 mGal between the readings at **BGR** and at **BMG.0** seems possible. The absolute gravity found for point **A** differs by less than 0.3 mGal from the values derived for two points at the neighbouring pier where R/V SONNE was moored during the cruises SO-137/138 (1998) and SO-179 (2004).

On Oct. 27, 2005, R.V. SONNE returned to the harbour Tanjung Priok and moored again at shed 211 (Fig. 6.4.2). The mooring site was located just about 20 m to the north from the mooring site of Oct. 6-11, 2005. The tie measurements were done the bollard 380 (point **B**).

Difference between gravity stations:

B – **A** = -0.03 mGal

Absolute gravity at **B**: 978146.53 mGal

Absolute gravity for **B** (reduced to water level –1.0 m) 978146.80 mGal (IGSN71 system) used for the gravity tie on 29.10.2005 (00:00 UTC). The reading of sea gravimeter KSS31M at the same time: -1789.30 mGal

On Nov. 13, 2005, R.V. SONNE returned to Tanjung Priok and moored at the same site where she departed. Consequently the tie measurements were done again at point **B**. For the gravity tie at 03:10 UTC with water level -0.8 m an absolute gravity value of 978146.74 mGal (IGSN71) was used. The reading of sea gravimeter KSS31M at the same time was -1789.78 mGal. The instrumental drift for cruise SO-186-1B can be derived from the repeated readings to -0.42 mGal / 15.132 days or -0.028 mGal/day (-0.833 mGal/month). This drift rate is rather small and lies within the general inaccuracy of marine gravity measurements. Nevertheless, it will be applied to the data. On the previous leg the drift of the instrument was much higher (-2.664 mGal/month). Probably the instrument was not completely shaked down when the port was left.

6.5 OBH/OBS Seismic instrumentation

The Ocean Bottom Hydrophone (OBH)

The first IFM-GEOMAR Ocean Bottom Hydrophone was built in 1991 and tested at sea in January 1992. This type of instrument has proved to have a high reliability; more than 3000 successful deployments were conducted since 1991. A total of 5 OBH and 15 OBS instruments were available for SO186. Altogether 20 sites were deployed for a seismological network during the SO186 cruise.
The principle design and a photograph showing the instrument upon deployment are shown in Figure 6.5.1. The design is described in detail by Flueh and Bialas (1996).

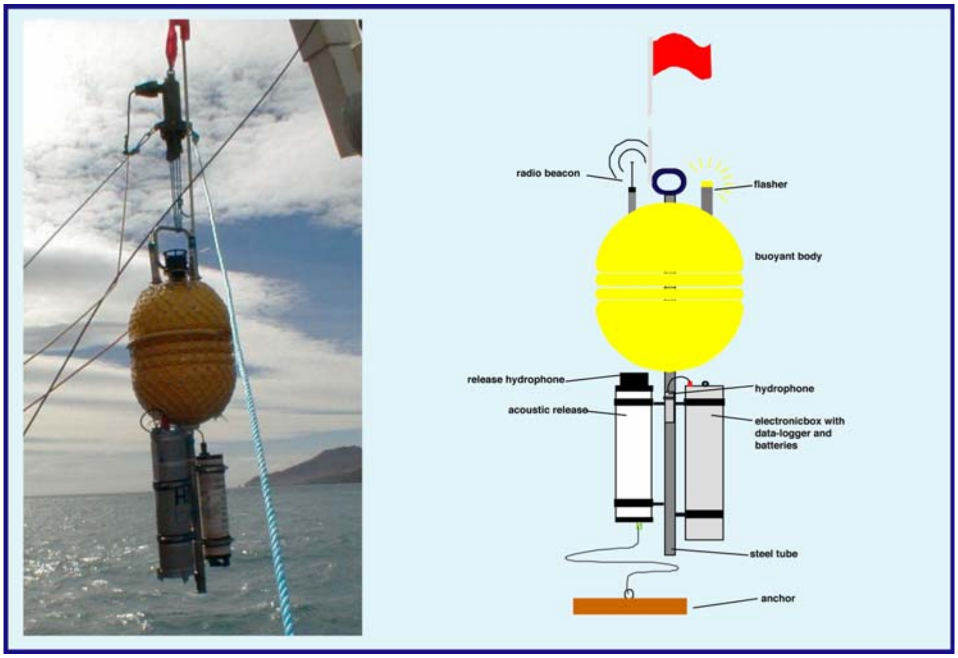


Fig. 6.5.1: Principle design of the IFM-GEOMAR OBH (right panel, after Flueh and Bialas, 1996) and the instrument upon deployment (left panel).

The system components are mounted on a steel tube, which holds the buoyancy body on its top. The buoyancy body is made of syntactic foam and is rated, as are all other components of the system, for a water depth of 6000 m. Attached to the buoyant body are a radio beacon, a flash light, a flag and a swimming line for retrieving from aboard the vessel. The hydrophone for the acoustic release is also mounted here. The release transponder is a model *RT661CE* or *RT861* made by *MORS Technology* which recently became *IXSea*, or alternatively a *K/MT562* made by *KUM GmbH*. Communication with the instrument is possible through the ship's transducer system, and even at maximum speed and ranges of 4 to 5 miles release and range commands are successful. For anchors, we use pieces of railway tracks weighing about 40 kg each. The anchors are suspended 2 to 3 m below the instrument. The sensor is an *E-2PD* hydrophone from *OAS Inc.*, the *HTI-01-PCA* hydrophone from *HIGH TECH INC* or the *DPG* hydrophone, and the recording device is an *MBS, MLS* or *MTS* recorder of *SEND GmbH*, which is contained in its own pressure tube and mounted below the buoyant body opposite the release transponder (see Figure 5.3.1).

The IFM-GEOMAR Ocean Bottom Seismometer 2002

The IFM-GEOMAR Ocean Bottom Seismometer 2002 (OBS-2002) is a new design based on experiences gained with the IFM-GEOMAR Ocean Bottom Hydrophone (OBH; Flueh and Bialas, 1996) and the IFM-GEOMAR Ocean Bottom Seismometer (OBS, Bialas and Flueh, 1999). For system compatibility the acoustic release, pressure tubes, and the hydrophones are identical to those used for the OBH. Syntactic foam is used as floatation body again but this time in a less expensive cylinder shape. The entire frame can be dismounted for transportation, which allows storage of more than 50 instruments in one 20” container. Upon cruise preparation onboard all parts are screwed together within a very short time. Four main floatation cylinders are fixed within the system frame, while additional disks can be added to the sides without changes. The basic system is designed to carry a hydrophone and a small seismometer for higher frequency active seismic profiling. The sensitive seismometer is deployed between the anchor and the OBS frame, which allows good coupling with the sea floor. While the OBS sits on the seafloor, the only connection from the seismometer to the instrument is a cable and an attached wire, which retracts the seismometer during ascent to the sea surface. The three component seismometer (*KUM*) is housed in a titanium tube, modified from a package built by Tim Owen (Cambridge) earlier. Geophones of 4.5 or 15 Hz natural frequency are available. The signal of the sensors is recorded by use of the *Marine Longtime Recorder (MLS),* and *Marine Tsunameter Seismocorder (MTS)*, which are manufactured by *SEND GmbH* and specially designed for long-time recordings of low frequency bands. The hydrophone can be replaced by a differential pressure gauge (DPG) as described by Cox et al (1984).

During cruise SO186 Leg 1a, two deployments of *Paroscientific Intelligent Depth* sensors, manufactured by *DIGIQUARZ,* were performed when Ocean Bottom Seismometers were deployed for passive seismic recording to measure the absolute pressure. For this purpose the sensor was mounted on one of the OBS frames from IFM-GEOMAR. Data will be available after the instruments will have been recovered in March 2006.

While deployed to the seafloor the entire system rests horizontally on the anchor frame. After releasing its anchor weight the instrument turns 90° into the vertical and ascends to the surface with the floatation on top. This ensures maximal reduced system height and water current sensibility at the ground (during measurement). On the other hand the sensors are well protected against damage during recovery and the transponder is kept under water, allowing permanent ranging, while the instrument floats at the surface.

The Ocean Bottom Unit (OBU)

The Ocean Bottom Unit (OBU) is a modified OBS 2002 (see above), designed to adapt new sensors and acoustic devices and therefore to fulfill the requirements of the tsunami-warning buoy system. The OBU is one of the two main marine systems; the second is the tsunami buoy. The OBU is equipped with a *Güralp*-Seismometer (see below) and a Differential Pressure Gauge (DPG). Additionally, it measures pressure data with the Paroscientific depth sensor. It is the acoustic device, mounted on the OBU, that makes it different from the conventional OBS system. This acoustic device (modem) is responsible for the communication between the OBU bottom station and the surface buoy.
An additional power supply (lithium battery), which makes the OBU bigger compared to the smaller OBS, is attached to the OBU to compensate for its extra energy consumption. Four additional floats are mounted to the OBU to counterbalance the extra weight and to ensure a safe rise for recovery.

Fig. 6.5.3: Instrument setup of the Ocean Bottom Unit. In addition to the Güralp Seismometer and a Differential Pressure Gauge, an acoustic device is mounted at the OBU to communicate with the surface buoy.

Marine Broadband Seismic Recorder (MBS)

The so-called *Marine Broadband Seismic* recorder *(MBS;* Bialas and Flueh, 1999*)*, manufactured by *SEND GmbH*, was developed based upon experience with the DAT-based recording unit Methusalem (Flueh and Bialas, 1996) over previous years. This recorder involves no mechanically driven recording media, and the PCMCIA technology enables static flash memory cards to be used as non-powered storage media. Read/write errors due to failure in tape handling operations should not occur with this system. In addition, a data compression algorithm is implemented to increase data capacity. Redesign of the electronic layout enables decreased power consumption (1.5 W) of about 25% compared to the *Methusalem* system. Depending on the sampling rate, data output could be in 16 to 18 bit signed data. Based on digital decimation filtering, the system was developed to serve a variety of seismic recording requirements. Therefore, the bandwidth reaches from 0.1 Hz for seismological observations to the 50 Hz range for refraction seismic experiments and up to 10 kHz for high resolution seismic surveys. The basic system is adapted to the required frequency range by setting up the appropriate analogue front module. Alternatively, 1, 2, 3 or 4 analogue input channels may be processed. Operational handling of the recording unit is similar to that of the *Methusalem* system, or a file can be loaded via command or automatically after power-on. The time base is based on a DTCXO with a 0.05 ppm accuracy over temperature. Setting and synchronising the time as well as monitoring the drift is carried out automatically by synchronisation signals (DCF77 format) from a GPS-based coded time signal generator. Clock synchronisation and drift are checked after recovery and compared with the original GPS units. After software pre-amplification the signals are low-pass filtered using a 5-pole Bessel filter with a -3 dB corner frequency of 10 kHz. Then each channel is digitised using a sigma-delta A/D converter at a resolution of 22 bits producing 32-bit signed digital data. After delta modulation and Huffman coding the samples are saved on PCMCIA storage cards together with timing information. Up to 4 storage cards may be used. Data compression allows increase of this capacity. Recently, technical specifications of microdrives (disk drives of PCMCIA type II technology) have been modified to operate below 10 °C, therefore 2 GB drives are now available for data storage. After recording the flashcards need to be copied to a PC workstation. During this transcription the data are decompressed and data files from a maximum of four flash memories are combined into one data set and formatted according to the PASSCAL data scheme used by the *Methusalem* system. This enables full compatibility with the established processing system. While the *Methusalem* system did provide 16 bit integer data, the 18 bit data resolution of the *MBS* can be fully utilised using a 32 bit data format.

The Marine Longtime Seismograph (MLS)

For the purpose of low-frequency recordings such as seismological observations of earthquakes during long-term deployments of about one year time a new data logger, the Marine Longtime Seismograph (MLS) was developed by *SEND GmbH* with support from IFM-GEOMAR.

The MLS is again a four channel data logger whose input channels have been optimised for 3-component seismometers and one hydrophone channel. Due to the modular design of the analogue front end it can be adapted to different seismometers and hydrophones or pressure sensors. Currently front ends are available for the Spahr Webb, PMD and Guralp seismometers as well as for a differential pressure gauge (DPG), a pressure sensor of high sensitivity, and the OAS/HTI hydrophone. With these sensors we are able to record events between 50 Hz and 120 s. The very low power consumption of 250 mW during recording together with a high-precision internal clock (0.05 ppm drift) allows data acquisition for one year. Data storage is done on up to 12 PCMCIA type II flashcards or microdrives, now available with a capacity of up to 2 GB. The instrument can be parameterised and programmed via a RS232 interface. After low-pass filtering the signals of the input channels are digitised using Sigma-Delta A/D converters. A final decimating sharp digital low-pass filter is realised in software by a Digital Signal Processor. The effective signal resolution depends on the sample rate and varies between 18.5 bit at 20 ms and 22 bits at 1 s. Playback of the data is done according to the scheme described for the MBS above. After playback and decompression data is provided in PASSCAL format from where it can be easily transformed into standard seismological data formats.

The Marine Tsunameter Seismocorder (MTS)

This data logger is based on the experiences with the MBS and MLS devices. The GEOLON-MTS has been developed by *SEND GmbH* and is a high precision instrument for acquisition, processing, storage of seismic signals and additionally pressure data. Like the MLS it is optimised for long time (more than 1 year) standalone operation on the ocean bottom, data storage capacity is also up to 12 PCMCIA cards. The four channel data logger is prepared for connection with a hydrophone (also different types like e.g. HTI, OAS, or the Differential Pressure Gauge, DPG) and different types of three component seismometers as described above for the MLS.
Additionally, a digital absolute pressure gauge can be connected to the auxiliary connector. During SO186 the *Paroscientific* digital pressure sensor was deployed for the first time.
Playback of the data is done according to the scheme described for the MBS and MLS above. After playback and decompression data is provided in PASSCAL format.

The METS (Capsum) Methane sensor

The detector is a semi-conductor. Adsorption of hydrocarbons on the active layer leads to electron exchange with oxygen and thus to modification of the conductivity of the active layer, which the electronics converts into a voltage. A membrane desorbs dissolved gases of the surrounding water into the gas phase containing the detectors. The diffusion is driven by Henry's Law. The direction is conditioned to the concentration gradient between water and gas phase, and within the membrane itself. The sensor is calibrated at a relative humidity of 100%. Operational temperature range: -2°C to +60°C, calibration range 2 – 20°C; Methane: 50 nanomol/l – 10 µmol/l Response: Reaction time: 1 to 3 sec. t90-time: 5 to 30 min dependent on turbulences. Typical range limits are concentrations between 50 nmol/l and 10 µmol/l, and temperatures between 2 and 20°C.

The data logger is different to those of the seismic and pressure recorders. Therefore the methane sensors are mounted on separate OBS instruments, which are deployed close to OBS collecting seismic and/or pressure data. The configuration of the data logger and the download management is run under Windows-based software. For data storage, a 512 MB Secure Digital Card (SD-Card) is used. The logging interval is the time between two records of data on the SD-card. It can be set between 1 and 90 min, and between 1 and 24 hours. The acquisition time is the time within the logging interval during which measurement values are acquired and averaged.

The Paroscientific Pressure Sensor

The pressure or depth sensor consists of a pressure transducer and a serial interface board in a rugged waterproof package. Commands are sent and measurement data are received via one RS-232 and one RS-485 serial port. Measurement data are provided directly in user-selectable engineering units with a typical accuracy of 0.01% or better over a wide temperature range. Pressure measurements are fully temperature compensated using a precision quartz crystal temperature sensor. Each intelligent depth sensor is pre-programmed with calibration coefficients for full plug-in interchangeability.

The device can be switched to a low-power “sleep” state after a user-defined period of serial inactivity to conserve power. After serial activity, the unit will “awake”, allowing normal operation.

The IFM-GEOMAR OBS and OBU systems can be equipped with MTS data loggers and these pressure sensors. The MTS data loggers (see above) are especially designed to read out the pressure data (the accuracy is 0.1 mBar) in addition to the conventional 4C recordings.

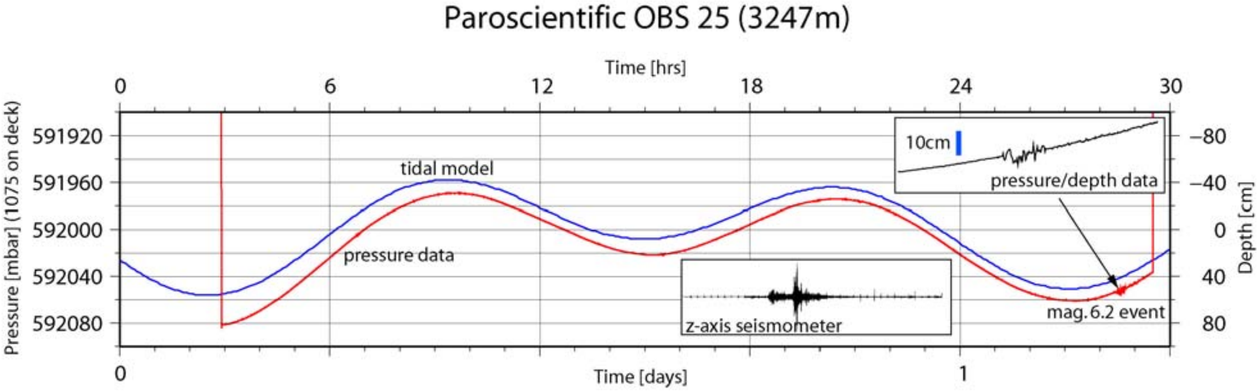


Fig 6.5.4: Example of pressure data, recorded with the Paroscientific Pressure (Depth) Sensor (red line). A synthetic tidal model (GOTT 2000.2), based on 8 partial tides, is plotted (blue line) over the measured data. An earthquake (mag 6.2) was recorded on both sensors, seismometer (vertical component, lower inlet panel displayed) and the pressure sensor (arrow and zoomed box).

The Güralp Seismometer (CMG-OBS40T)

The OBS40T is a low-power, true broadband ocean bottom seismometer system consisting of three sensors housed in a *Nautilus* "Vitrovex" glass sphere 150mm in diameter.

The spherical gimbal is mounted in a stainless steel base. This mount has a number of holes in it to allow water to flow.

Once the seismometer has come to rest on the seabed, it is supplied with power causing it to level itself automatically after a delay of 30 seconds. This procedure is supervised by an on-board micro-controller and consists of several stages. 1. The gimbal's brake mechanism is released, allowing the sensors to swing freely. 2. After 45 seconds, once the sensors have come to rest, the brakes are re-applied. 3. The microcontroller measures the mass positions and compares them with satisfactory values. 4. If mass positions are significantly off-center, steps 1-3 are repeated until they improve, or to a maximum of 3 levelling attempts. Additionally, the levelling routine can be repeated at any time, depending on the configuration parameters.

6.6 Acoustic Data Transfer

For communication between the OBU at the ocean bottom and the buoy, acoustical modems are being used. It has been clear from the very beginning of the GITEWS project that this link constitutes the weak element of the system.

Acoustical communication from the deep ocean to the surface buoy has to overcome the following obstacles:

- A distance up to 6000m,
- surface noise due to wave activity and rain-drops,
- air bubbles on the surface that extend down to 15m depending on wind conditions,
- a sharp transition zone between cold deep ocean water at about 3°C and warm surface water at about 20°C in 100-140m depth that creates a complex reflection/refraction situation, and
- signal reflection on the water surface, modulated by waves, interacting in complex ways with the Doppler Effect due to quickly changing buoy movements that moves the modem itself in all spatial directions.

Develogic Modem mounted on the anchor chain

In order to decouple the buoy modems from surface noise effects, they have been mounted on the anchor chain, 28m distant from the buoy modem cable connector; therefore, we assume that the buoy modem operates at a water depth of about 20m.

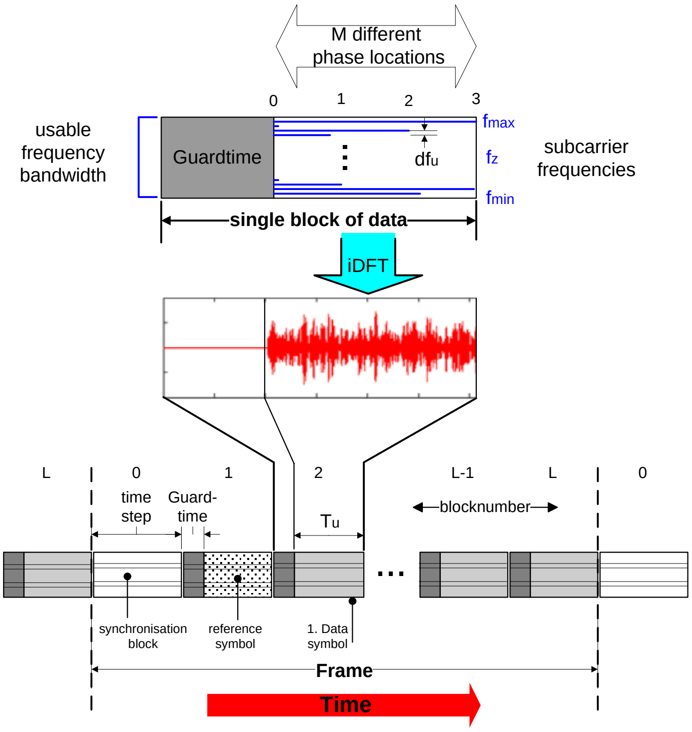
Only little experience exists for deep ocean acoustical communication and therefore, two different modem types using different modulation schemes have been used in the project:

a) the Hydro Acoustic Modem "HAM.Node" from Develogic GmbH, and

b) the "Sweep Spread Carrier (S2C) Acoustic Modem" from EvoLogics GmbH.

Hydro Acoustic Modem "HAM.Node" from Develogic GmbH

The HAM.Node is a system for acoustic underwater transmission of digital data. The transmission is based on the modulation method OFDM-MDPSK (orthogonal frequency division multiplexing with m-ary differential phase shift keying) and has been supplemented with components for correcting variable Doppler-induced frequency shifting and for reducing the effects of multipath propagation. The Doppler correction consists of a two stage method followed by a very short time-scale phasetracking to correct up to ±12 m/s relative speed and accelerations up to 1g.



Structure of sub-carrier frequencies of OFDM Method

Data transmission is bi-directional. Packets containing transmission errors that cannot be corrected will be resent by the handshake protocol. If an error-free transmission is not possible, the host will be notified correspondingly.

The transmission parameters can be varied between large boundaries to suit the desired transmission situation.
Besides, the pure acoustic parameters (frequency range, power) - modulation and coding parameters above all - have considerable influence on the transmission efficiency and reliability.

The modem for the GITEWS project has been configured for a bandwidth of 4.9 kHz at a central frequency at 10.5 kHz. Thus the data is distributed over 100 sub-carrier frequencies. To make the protocol robust the modulation of phase angles has been limited to 180 degrees differences.

Factsheet: Hydro Acoustic Modem “HAM.node“ by develogic GmbH

HAM.Node – Hydro Acoustic Modem Technical Details

The Hydro Acoustic Modem is a highly flexible multi purpose system for underwater communication and data transmission. The choice of transducer most suited for your purpose and the possibility to add extended with features to suit your needs makes it of special value for non-standard applications.

- Powerful M-DPSK coding with flexible parameterisation to adapt to environmental conditions.
- Various housings with fixed or separate (changeable) transducer to suit your system.
- Standard connectors from SUBCONN (BH and MCBH series) for robust and flexible connections.

Data transmission

Broadband data transmission via **OFDM MDPSK**
Multi track compensation (Echo)
2 Phase **Doppler compensation** for relative movements **up to ± 12m/s**
including long and short period movements and acceleration up to 1 g.
Convolutional Coding with adaptive configuration (channel dependent)
Data protocol with **error correction** and checksum validation.
Further data correction with automatic multiple send-receive transfers
in **bi-directional communication** mode.

Powermanagement:

Power supply input: 9-36 V (reduced transmitting power below 22V)

Power consumption:	**Sleep mode**: (host and timer wakeup only)	**< 720**	**uW**
	Listening mode: (acoustic wakeup enabled)	**<180**	**mW**
	Receive mode: (active data communication)	**3**	**W**
	Transmit mode:	up to 220	W
	configurable dynamic transmission power management.		
	Typical transmission power for 2000m vertical channel	35	W
Efficient and controllable high voltage supply			
Max. output voltage for transducer:		780	V_{pp}
Max. electric short-term over load (thermal controlled):		400	W_{rms}

Specification and dimensions with ITC3013 Transducer:

Seawater resistant housing alternatives: ceramic coated aluminium or titanium

dimensions of titanium housing	
max. diameter:	118 mm
length (including transducer):	530 mm
pressure rating:	up to 750 bar or 6000 m

dimensions of ceramic coated aluminium housing	
max. diameter:	110 mm
length (including transducer):	530 mm
pressure rating:	21 bar or 200 m
temperature: (working environment)	-2 bis 35°C
weight (incl. transducer):	4,5 kg
weight in water:	1,2 kg

specifications	
frequency range:	7,5-13 kHz
range:	up to 6500 m
net data rate: (adaptive parameterisation)	up to 7650 bit/s
RS232/422 data rate:	max.115 kbit/s

"Sweep Spread Carrier (S2C) Acoustic Modem" from EvoLogics GmbH

The sweep-spread carrier (S2C) acoustic modems were initially designed to provide a reliable acoustic link in a complex multipath environment. EvoLogics has modified the existing S2C systems for the GITEWS project. The main technical requirements were:

- to reach relatively high bit rates at 6000m water depth;
- to keep the transmission power at a moderate level;
- to minimize the modem’s power consumption in standby mode;
- to guarantee error-free user data delivery.

The communication system is self-adaptive, because the first contact sweeps and later acknowledgement packets are used to analyze the actual transmission properties of the channel (multipath structure due to reflections etc.) adjusting the signal structure accordingly. Special algorithms have been developed to permanently observe and readjust channel properties while transferring data.

From a technical point of view, the present configuration should be capable of transmitting up to 6.5 kbps at best. In sea trials peak values of 3-4 kbps have been observed. The communication system consists of two devices: Surface Station model S2C M7/17H and deep-water station model S2C MD7/17H. Both devices are equipped with hemispherical transducers that operate in a frequency band from 7kHz to 17kHz. The main technical characteristics of the modems are tabulated in the factsheet.

Factsheet: Sweep Spread Carrier (S2C) Acoustic Modems
Model M: Surface Station Model S2C M7/17H
Model MD: OBU Station Model S2C MD7/17H deep rated

Features:

- S2C signal processing for advanced multipath rejection and transmission reliability;
- designed for high-datarate reliable digital communications in multipath environment;
- Model M: lightweight, robust integrated design;
  Model MD: robust titanium housing, integrated design;
- guaranteed data delivery (Automatic Repeat Request), built-in Forward Error Correction;
- adaptive in-situ communication algorithms;
- built-in relative speed and distance measurements capability;
- signal integrity and multipath structure diagnostics;
- transparent serial interface or advanced commands set;
- basic UW network features, software configuration.

Technical Specifications:

Working range	up to 8000 m*
Maximum operating depth	up to 200 m
Hydroacoustic link	up to 6.5 kbit/s*
Interface	RS232 or RS422/Ethernet (optional)
Internal data buffer (user configurable)	1 Mbytes
Error rate with correction algorithm	10^{-7}
Error rate without correction algorithm	10^{-2}
Power consumption	less than 1W in “Wait for Acoustic Switch On” mode; less than 3W in “Receive” mode; up to 100W in “Send” mode (user configurable)
Acoustic Source Level in “Send” mode	up to 191dB re 1uPa at 1m
Operating frequency band	From 7kHz to 17kHz
Transducer beamwidth	hemispherical
Power supply	from 19VDC up to 25VDC (24VDC-nominal)
Dimensions	526x120 (mm, LxD)

* - environment dependent

6.7 The GITEWS Buoys

6.7.1 System Description

During the SONNE leg SO186-1c two newly developed buoys were deployed. They will serve as a test bed for the installation of the ocean component for the establishment of an Indian Ocean Tsunami Warning System.

For many years tsunami warnings were solely based on the magnitude and depth of earthquakes; supplemented with information from shore based tide gauges, e.g. in the Pacific, this data formed the basis for the warning system. However, the false alarm rate had a ratio of 1:4 resulting in an increased insensibility for evacuation measures. A few years ago, the sensor system of the Pacific Tsunami Warning System was extended with ocean bottom pressure sensors and buoys as a relay for communication. Ocean bottom pressure sensors, accurate to a mm, are able to detect rapid changes in pressure. The data is then transmitted by acoustic modems to the buoy and further to the warning center. Currently, two out of six buoys are in operation in the Pacific, but by decision of the U.S. President 32 more buoys will be developed and installed in the coming years.

In the beginning of the 90ies, performance and accuracy of GPS technology developed rapidly. In 1992, first attempts were made to mount GPS to off-shore buoys in order to calibrate satellite based radar altimeters. In the following years only little progress was made, but in the beginning of 1999 an initiative by NOAA, NGS (both US) and GFZ Potsdam resulted in the establishment of a working group for GPS water level measurements. Different types of GPS buoys were developed. For the post-launch calibration of ENVISAT and JASON-1 radar altimetry these buoys were used with good success. Today, GPS is able to measure the absolute sea level accurate to a cm over long distances.

In January 2005 a proposal suggesting the combination of technologies, i.e. ocean bottom pressure sensors and GPS forming a single system, was submitted to the German Government. Especially for Indonesia, with only a limited warning time of 10 minutes, the employment of different sensor types increases the reliability. In May, IFM-Geomar and GFZ started to define and develop such a system.

The buoy made from aluminum is 7 meter in height and 2 meter in diameter. The buoyancy is about 2 tons. There are several sensors mounted. The main systems are (1) the underwater acoustic modem for a high-speed two-way communication to the ocean bottom unit (OBU), (2) GPS receiver, fiber optic gyro and dipping sensors, (3) meteorological devices (air pressure, air temperature, humidity, wind speed/gust, wind direction) as well as measuring devices for water temperature and salinity. Additional sensors like radar reflector and flashing light are mounted for safety reasons.

The main processing unit is based on the PC104 computing unit. Ten COM-Ports and one Ethernet port are available for external sensors. Communication is based on FR-190G modems from ACeS via the geostationary communication satellite GERUDA-1. The bandwidth for data transfer is, therefore, limited to 4 times 2.4kB/sec. The buoy serves two different power systems, 24V for submerged acoustic modems and 12V for all other devices. The 24V-System is recharged by two solar cells with 10Wp each. A battery with 33Ah is used as an accumulator. Based on the predefined scenario for underwater communication, the system can be operated for more than 10 days without having to be recharged. The 12V-System with 750Ah batteries is recharged by two different systems, solar and wind power. Wind power only serves as backup; the main power is supplied by 4 solar cells 56Wp each.

On the cruise the first buoys were mainly used for testing. During the first days the buoy was operated with all devices operating in order to test the thermal system and the recharging capability. The first results gave us good reason for optimism: The temperature in the battery compartment is less than 32°C, i.e. only slightly higher than the water temperature. Most of the electronics is operating up to 80°C. The load- and discharge capacity is still under closer investigation, but the power consumption is lower than the recharge capability.

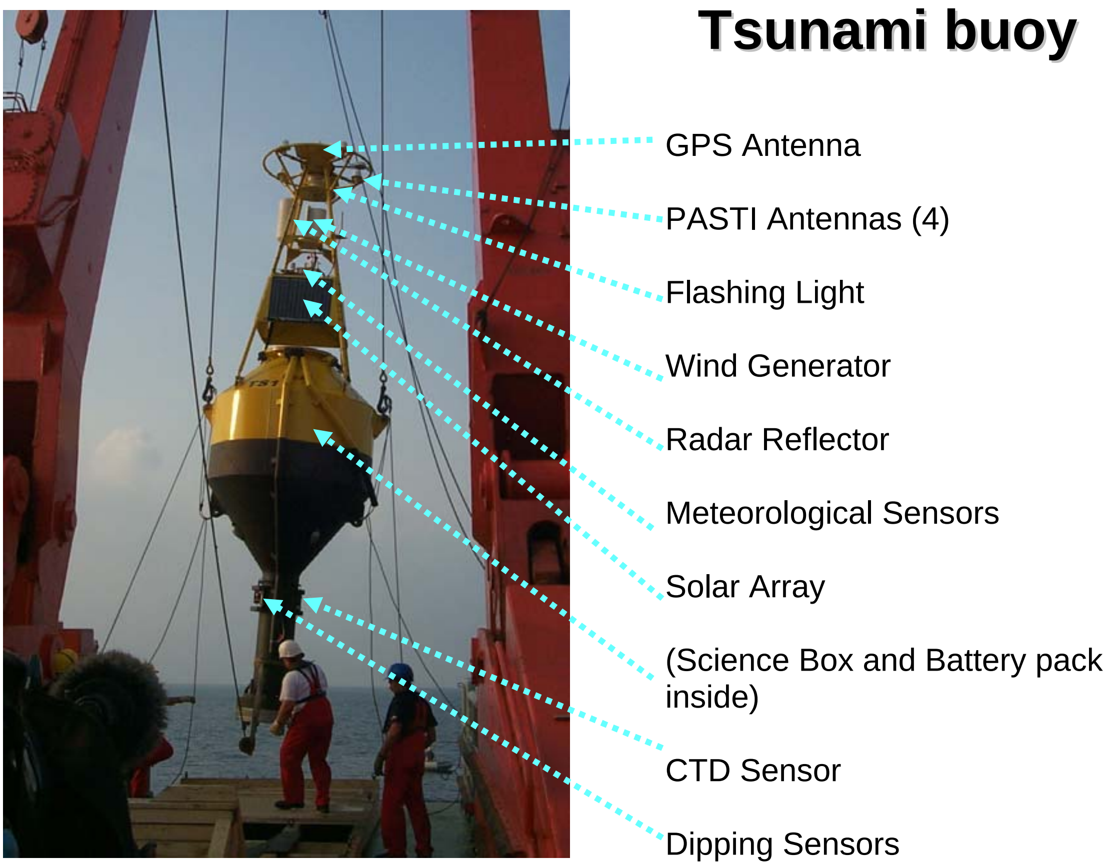


Fig. 6.7.1: The buoy and its main sensors

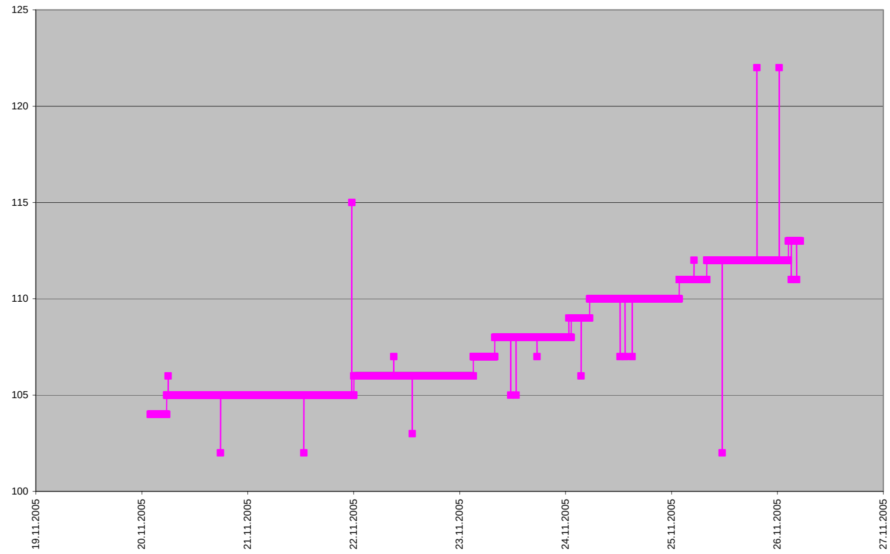


Fig. 6.7.2: Uncorrected state of charge curve for the 12V power system. Gradually the batteries are charged towards their maximum capacity.

6.7.2 Deployments during SO186c

The first test system TS1 was deployed on November 20th, 2005 at the position of 03°43,41'S and 099°14,02'E at a water depth of 5200m. The flash period of the buoys is F(5).20s. The deployment took about 8 hours of working time. The mooring consists of a chain connected to the buoy, followed by floating wire to a subsurface float. From there a PE-coated wire leads to a rope and float system which provides positive buoyancy in any location. The synthetic ropes are adjusted to the water depth of 5250m. The lower end consists of a 440m long elastic PA rope leading to the acoustic release and sinker. All components provide a breaking load of 8 tons. Components exposed to wear-and tear have a good safety margin in excess of 8 tons.

The second test system TS2 was deployed on November 23rd, 2005 at a water depth of 3500m. The flash period of the buoys is F(6)+Bl.15s. The mooring consists of a chain connected to the buoy, followed by floating wire to a subsurface float. From there a PE-coated wire leads to a rope and float system which provides positive buoyancy in any location. The synthetic ropes are adjusted to the water depth of 3600m. The lower end consists of a 440m long elastic PA rope leading to the acoustic release and sinker. All components provide a breaking load of 8 tons. Components exposed to wear-and tear have a good safety margin in excess of 8 tons.

Both buoys have IMO-approved radar reflectors with a reflection surface of 18sqm.

6.7.2 Work during SO186d

After the first fifty days of ocean operation, leg SO186d was used to service and check the conditions of the two buoys. Based on the remote checks of the buoys' condition made from Potsdam via the satellite communication, some design modifications had to be made. The inclination of the solar panels had to be decreased in order to improve the solar recharging capability.

At first TS2 was recovered on January 11th. The system was found in good condition without any damage. Although the buoy had most of the time been unreachable via the satellite communication, almost all systems had worked properly. The system was checked intensively and a damaged antenna cable was found, which had caused the communication problems. The system was reconfigured accordingly.

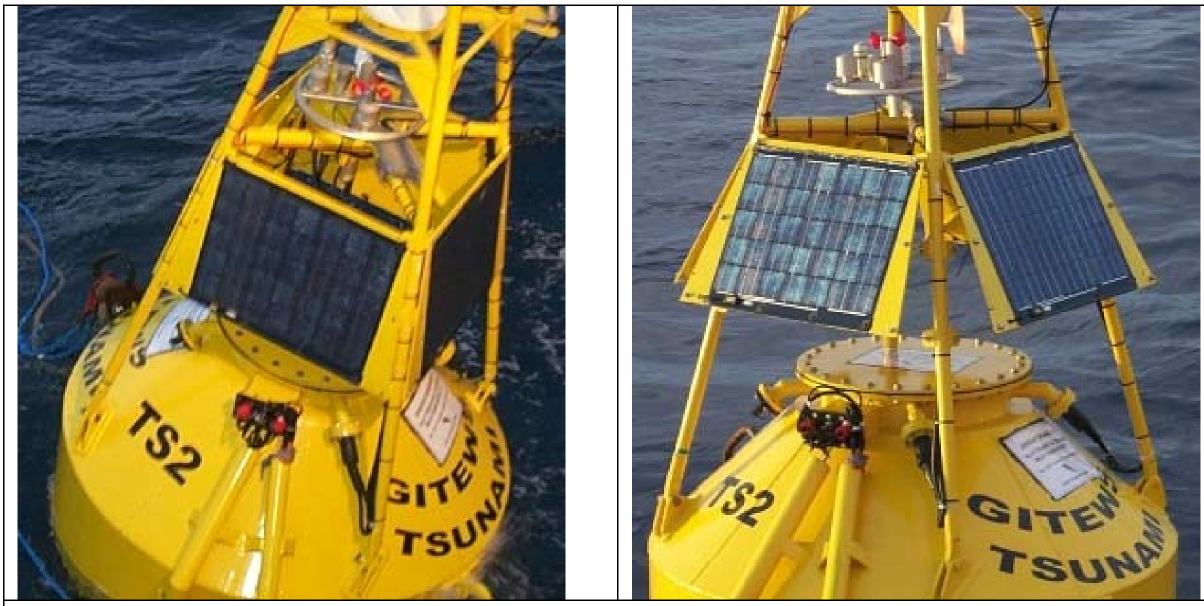


Fig. 6.7.3: Inclination of the solar arrays before and after the modifications; the lesser inclination will increase the recharging capability by about 10%.

6.7.3 Mooring System

The mooring system shall provide:
- station keeping of the buoy
- lifetime up to 1 year
- easy handling
- small sway radius
- small drag
- resistance against damage (fish-bite) in the near-surface area

Due to size and residual buoyancy of the TS-buoys it was necessary to reduce the weight of the mooring system to a minimum. This is achieved by using floats which are separated to obtain positive buoyancy in every location of the system. This allows the system to surface even when it breaks. It also allows the acoustic release to be lifted to the surface and to start retrieving the mooring from its lower end.

The upper end of the “vertical” mooring is the sub-surface float. From there, a 150m long steel rope with floats attached leads to 30m of mooring chains, which are connected to the buoy. The lower end of the steel rope is positively buoyant, the upper end sinking to provide an S-shape.

In very deep water, current is the determining factor. The drag on the mooring system itself is mainly originated by the size of the mooring rope. To minimise it and to get a high working load a DYNEEMA rope of 12mm diameter has been selected. Its breaking load is >8t.
The steel rope was entered into the mooring system to avoid damage caused by fish-bite in the upper 1100m of the water column. The steel rope is made of stainless steel and coated by PE to expose as little SS to the water as possible to avoid electrolytic corrosion. Its total diameter is 14mm and its breaking load >8t.

At the lower end a 440m long PA rope is used to provide the necessary elasticity of up to 20% of its length. Its diameter is 20mm and its breaking load >8t.

The concrete sinker weighs 2,5t; this allows the mooring system to work with a safety margin of 4-5. In order to prevent the sinker from being lifted from the bottom due to very heavy sea, a 13mm chain and a high holding force anchor keep it in place.

The chains connected to the buoy provide elasticity for wave motion and sufficient material thickness to compensate chafe.

Shackles, links and swivel are of such size that a breaking load of >8t as well as a good margin for chafe are achieved.

The system was prepared on shore by spooling the long ropes onto a big reel which fits a spooling winch as common on some research vessels. RV SONNE is equipped with an electro-hydraulic spooling winch dimensioned for reels up to a width of 1.85m and a diameter of 1.80m.

As the upper and the lower part of each mooring, independent of the water depth at the deployment site, are identical, it is only the DYNEEMA part of the system that is different.

The upper part is always to be considered to be **20m** below sea level at the point of the subsurface float. The lower part is always **456** m long. This adds up to **476m**. The center part of the mooring is:

Length of center mooring [m] = Water Depth [m] – 476m + Safety Length

With this formula the system can be adapted to the relevant deployment depths.

During SO186-1D both moorings were retrieved with the buoys and redeployed at different water depths. A careful inspection of all components showed no significant signs of chafe or damage. The hot galvanized shackles though had lost part of the coating.

It is assumed that the mooring system will survive one year of deployment.

Retrieval and deployment was well handled by the skilled and careful crew and the ship’s equipment.

Spooling Winch deploying steel wire

Subsurface float after 50 days of deployment

Buoy Connection Shackle, chafe in center

Cable floats after 50 days of deployment

7. Work Done and Preliminary Scientific Results

7.1 Bathymetric Survey

For a better understanding of subduction zone processes, a detailed knowledge of the morphology of the continental margin and the incoming oceanic plate is essential. Thus extensive bathymetric mapping is necessary in order to be able to create an image of the ocean floor morphology. The main objective of the cruise SO186-1B was to extend the area with reliable bathymetric coverage along the Sunda Arc subduction zone off Southwest Sumatra.

The bathymetric survey of this leg was carefully planned in close cooperation with the previous as well as the following leg in order to avoid duplicate mapping. In addition, bathymetric data of the cruises SO137, SO138, SO139 and SO184 were available and were used for the final compilation of the maps. Fig. 7.1.1 shows a compilation of all bathymetric data mapped with RV SONNE.

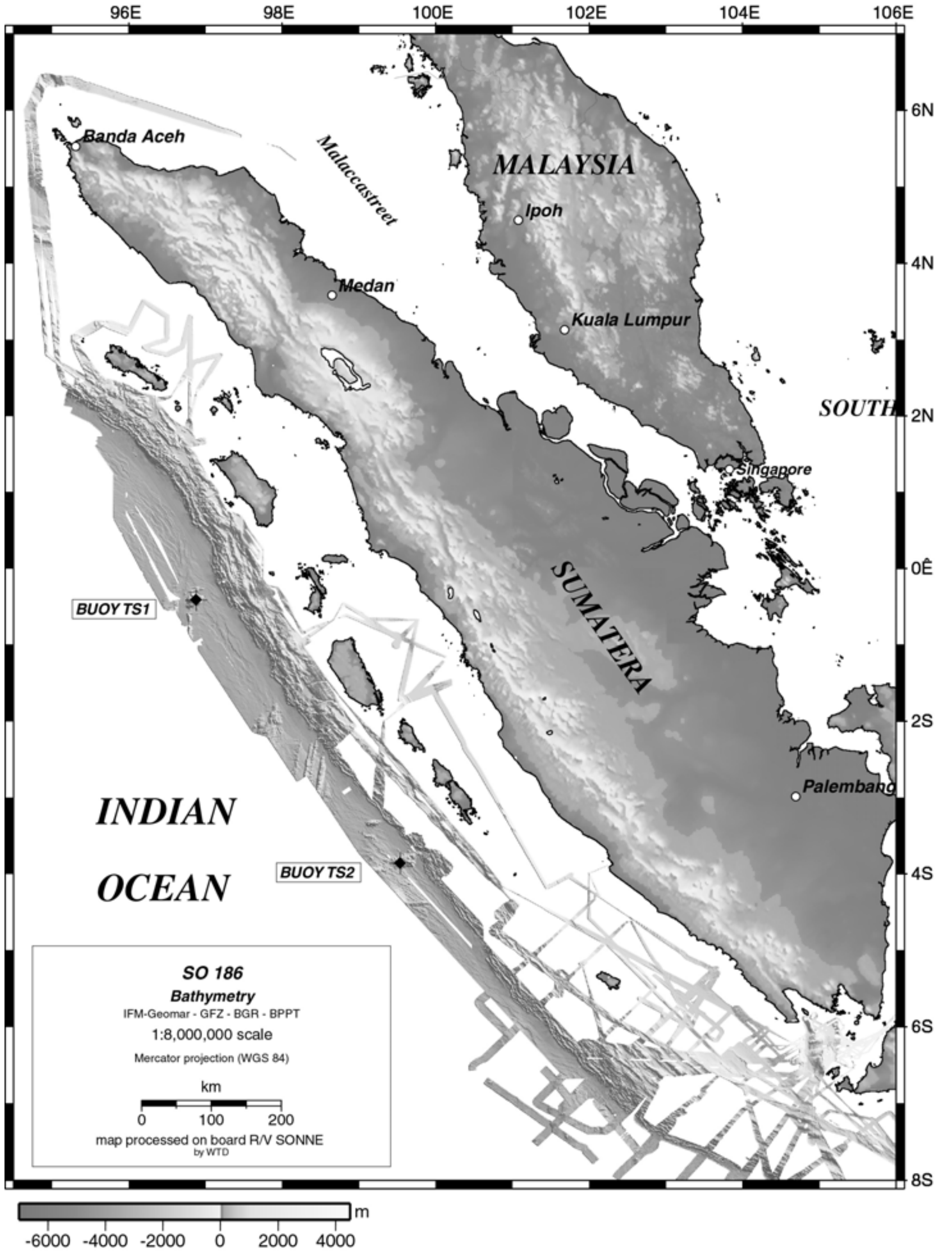


Fig. 7.1.1: Compilation of bathymetric data mapped with RV SONNE.

In addition to German activities with RV SONNE, British, French, and Japanese groups have mapped considerable parts of the area off Sumatra since December 26, 2004. As a mutual data exchange is planned with these groups, we avoided mapping the areas of those surveys. In fig. 7.1.2 a complete compilation of all available data together with the different names of the projects is shown.

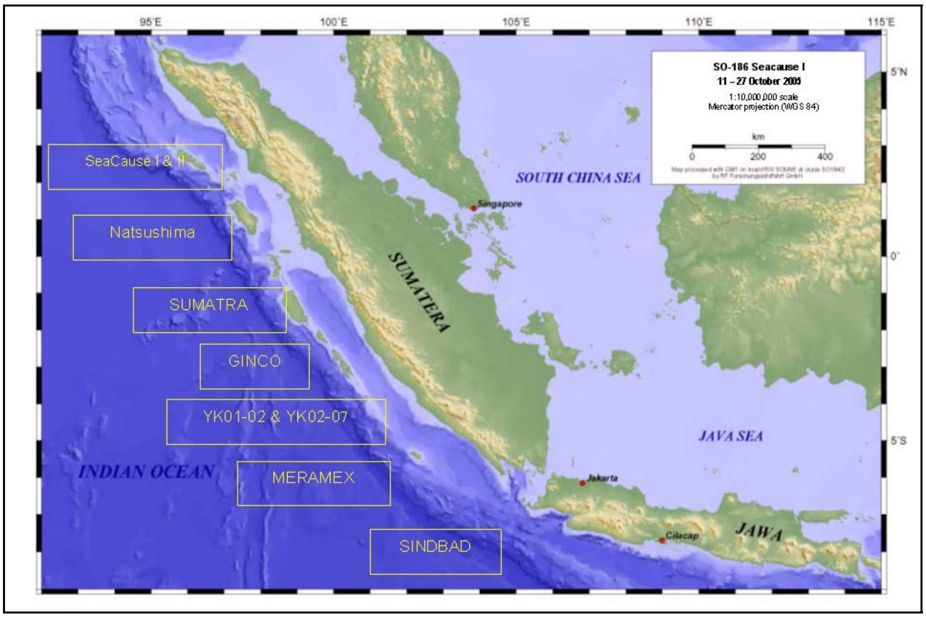


Fig. 7.1.2: This map shows a complete compilation of all available data. A mutual data exchange is planned with British, French, and Japanese groups, who also mapped parts of the Sunda Arc subduction zone.

The Simrad EM120 multibeam system of RV SONNE was switched on when Sunda Strait had been passed on October 29 at 17:23 local time at the beginning of survey profile 21. The system was continuously in operation until November 9, 20:41 local time, on profil 56, when the remainder of the survey programme had to be skipped for a recovery operation of OBS06. During the whole survey programme of SO186-1B, a constant speed of 10 knots was maintained to achieve sufficient bottom coverage along-track and to get data of better quality. The total survey length sums up to 2,546 nautical miles, yielding an estimated areal coverage of about 45,000 km^2. This was later extended during cruises SO186-1C & D.

To ensure reliable depth determinations of the EM120 system, a roll- and pitch-calibration procedure was performed on November 5 at 16:09 local time. The results showed that the offset angle for pitch (0.95°) used so far was still correct. The offset angle for roll required a minor change of 0.07° (new value: 1.03°). In addition, a water sound velocity profile was measured at the same position (fig. 7.1.3).

During leg SO186-1C several CTD runs were made while the acoustic modems were tested. These results are shown in figures 7.1.4 – 7.1.8.

Soundprofiles SO186-1A and So186-1B

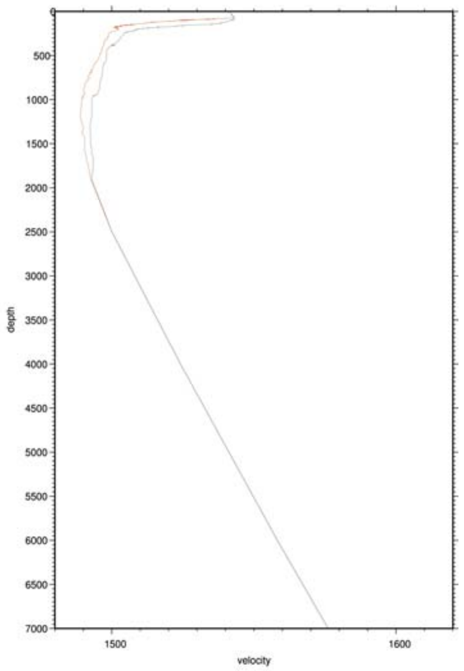


Fig. 7.1.3: Sound velocity profile 1A-1 (12.10.2005- black), 1A-2 (17.10.2005, red), 1B-1 (05.11.2005, black, identical to 1A-1)

Soundprofiles SO186-1C

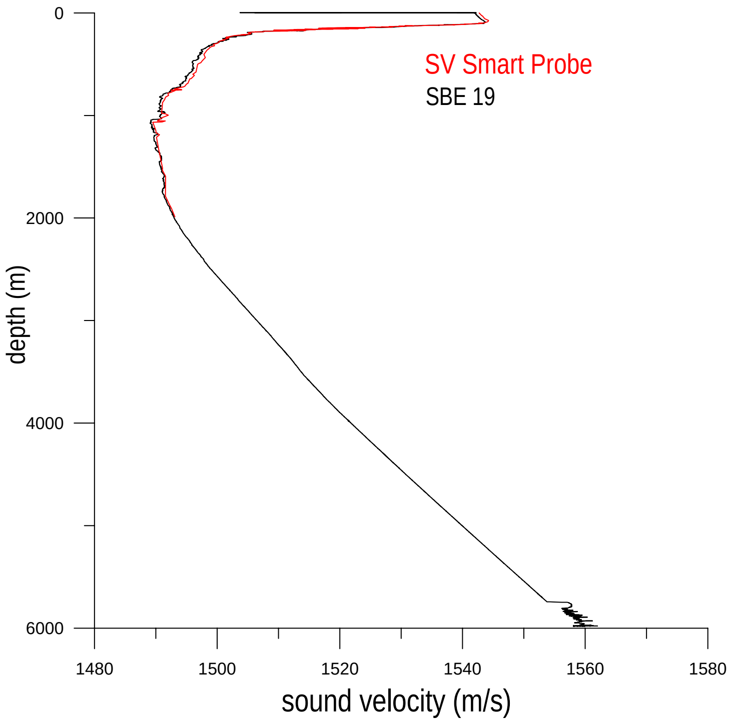


Fig. 7.1.4: Soundprofile 1, SO186-1C on 16.11.05
6°23,03’ S // 101°46,91’ E

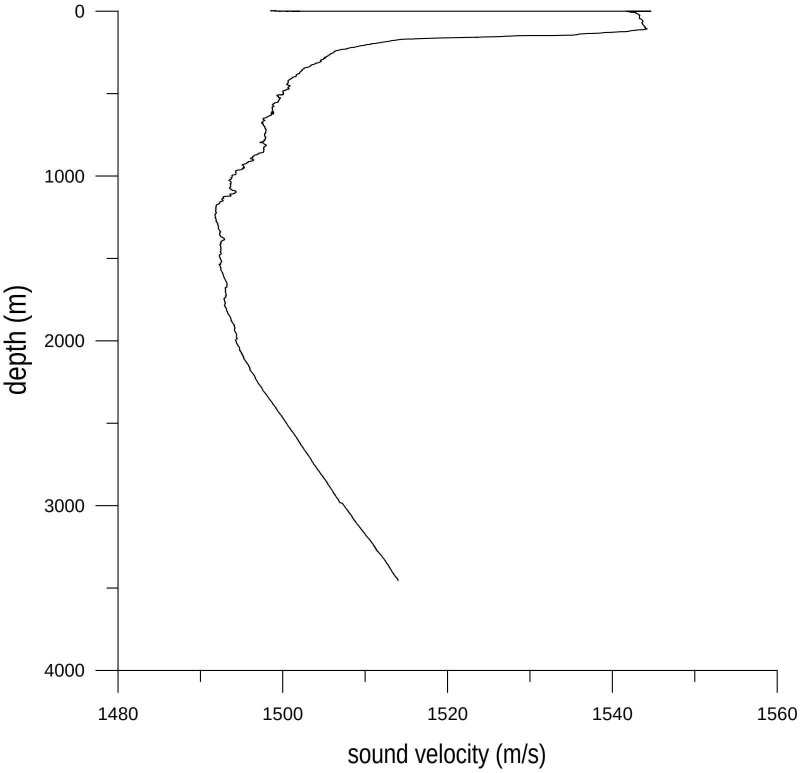


Fig. 7.1.5: Soundprofile 2, SO186-1C on 18.11.05
3°30,51' S // 99°25,06' E

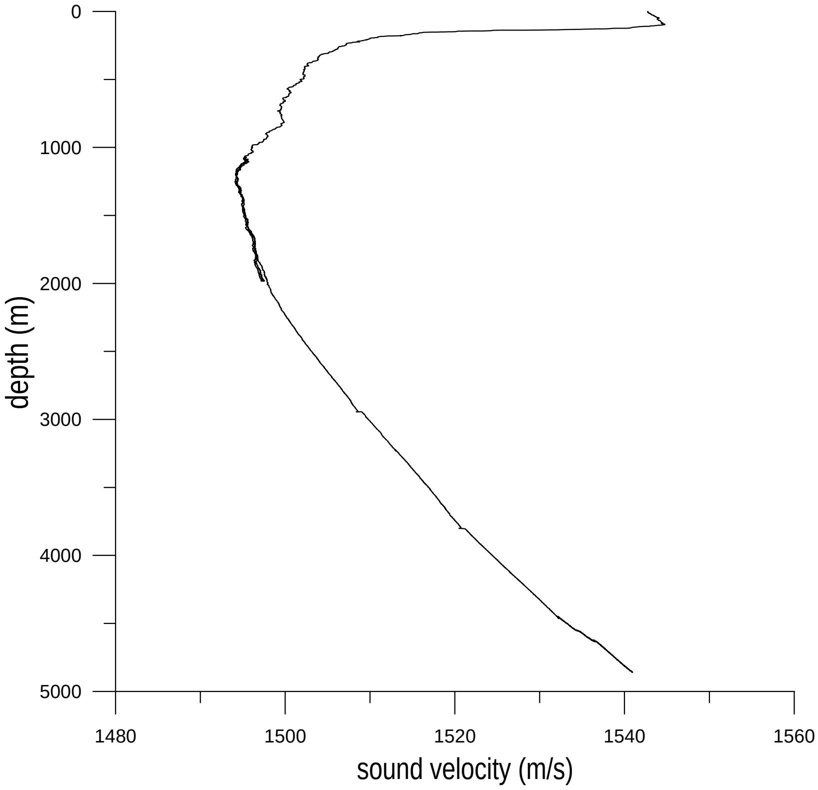


Fig. 7.1.6: Soundprofile 3, SO186-1C on 19.11.05
3°28,75' S // 99°29,44' E

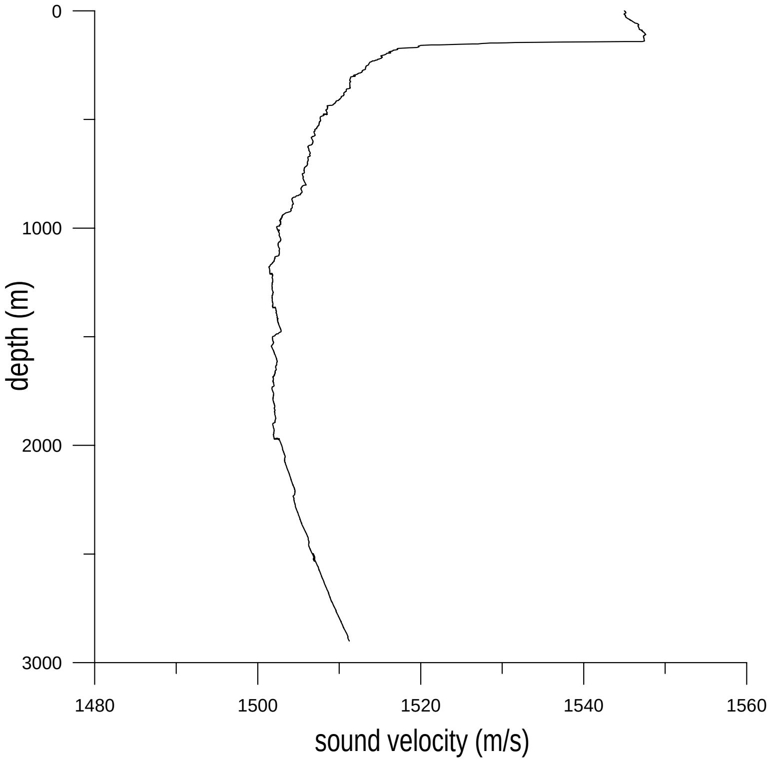


Fig. 7.1.7: Soundprofile 4, SO186-1C on 19.11.05
3°33,06' S // 99°29,95' E

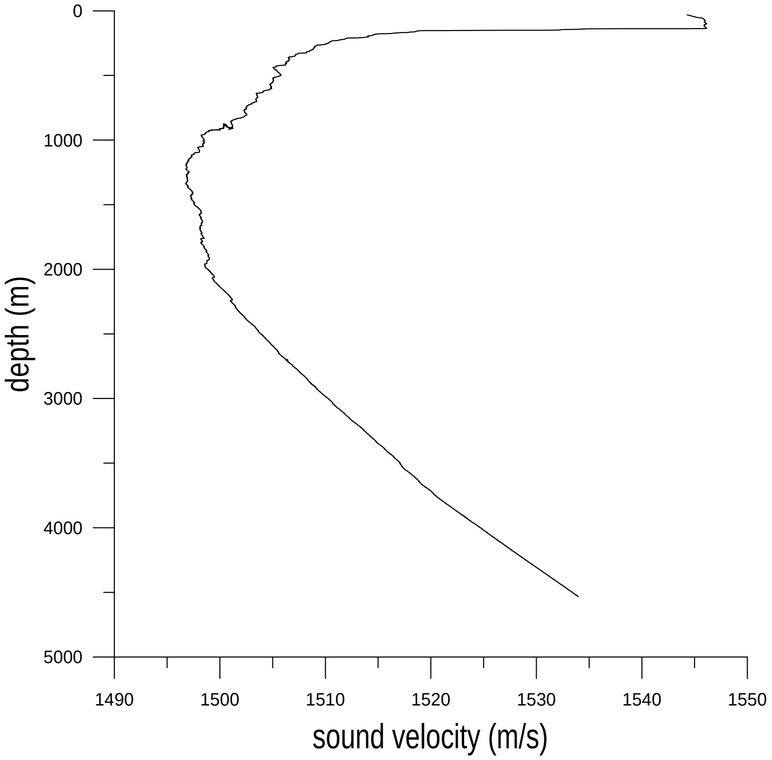


Fig. 7.1.8: *Soundprofile 5, SO186-1C on 22.11.05*
0°2,65' S // 96°57,75' E

The raw bathymetric data was processed onboard during the cruise according to the scheme outlined in 6.1.2. Though the acquired data was of constantly good quality, a visual inspection and outlier removal of all recorded beams was necessary to improve data quality. This process is really time consuming, generally it takes roughly the same amount of time as the data acquisition itself, but it pays, as cleaned data allows for a creation of maps with higher resolution.

The total area, which had been surveyed so far with RV SONNE, is shown in fig. 7.1.1. Work concentrated on the area southwest of the islands of Simeulue and Nias. To illustrate the geological context of the area, fig. 7.1.9 shows a perspective view of the mapped area. In that parts of the area, which had not been surveyed so far, the morphology is shown based on the Etopo-2 global dataset.

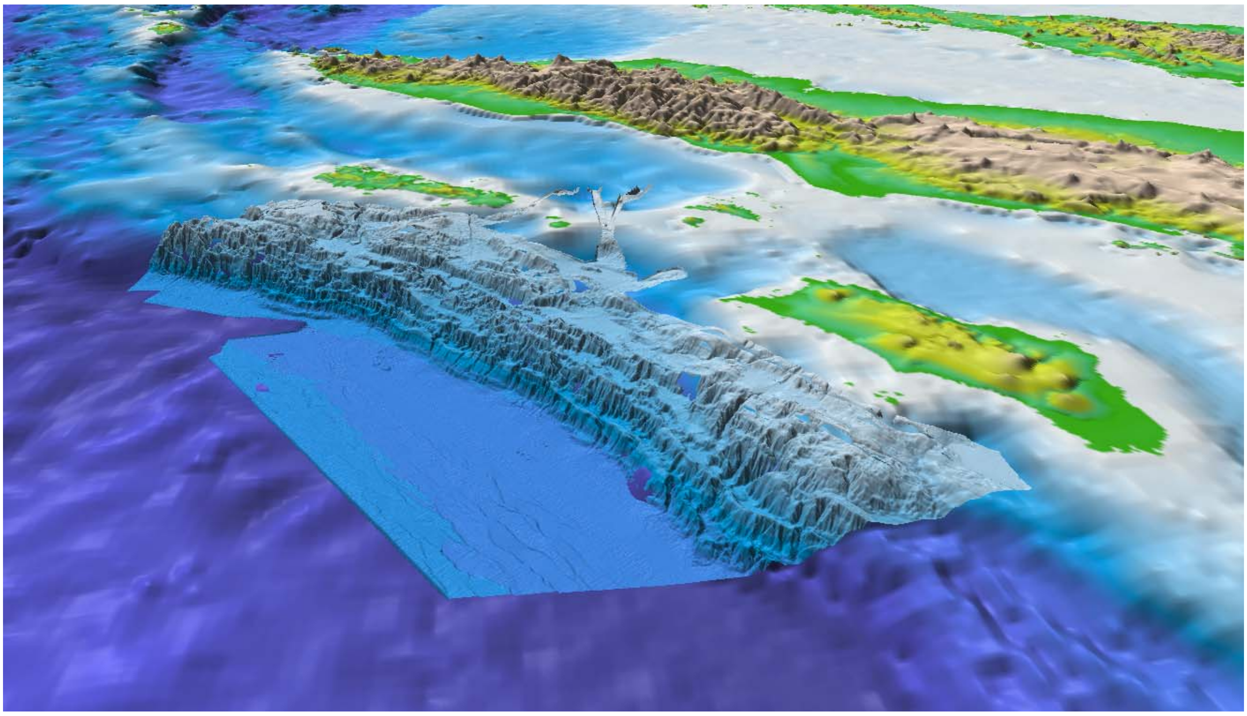


Fig. 7.1.9: Perspective view of the area mapped with RV SONNE extended by Etopo-2-data.

The morphology of the main survey area off Simeulue and Nias is shown in figs. 7.1.10 to 7.1.14. In this area, the generally NW – SE striking continental margin, roughly parallel to the coast of Sumatra, bends distinctly towards a more westerly direction. Though this part of the subduction zone is generally believed to be of the accretionary type, the deformation front does not show the characteristic structure of a classical accretionary margin along all parts. Adjacent to sections with typical accretionary folds, areas are found showing an oversteepened lower slope with numerous small gullies and canyons, several of those have formed fans in the trench, documenting considerable mass wasting downslope. Generally, the slope is characterized by large NW – SE trending steps (normal faults ?) forming large intraslope basins. At the middle slope these basins seem to be wider and filled with sediments, displaying an extremely smooth surface. The upper slope is cut by canyons and gullies at several places. Two very prominent canyons are deeply incised in the upper slope, they probably have fed the large midslope basin in the middle of fig: 7.1.13. The obviously chaotic morphology in this part of the margin seems to reflect the complex nature of the oblique subduction of the oceanic Indian-Australian plate beneath the continental Eurasian plate.

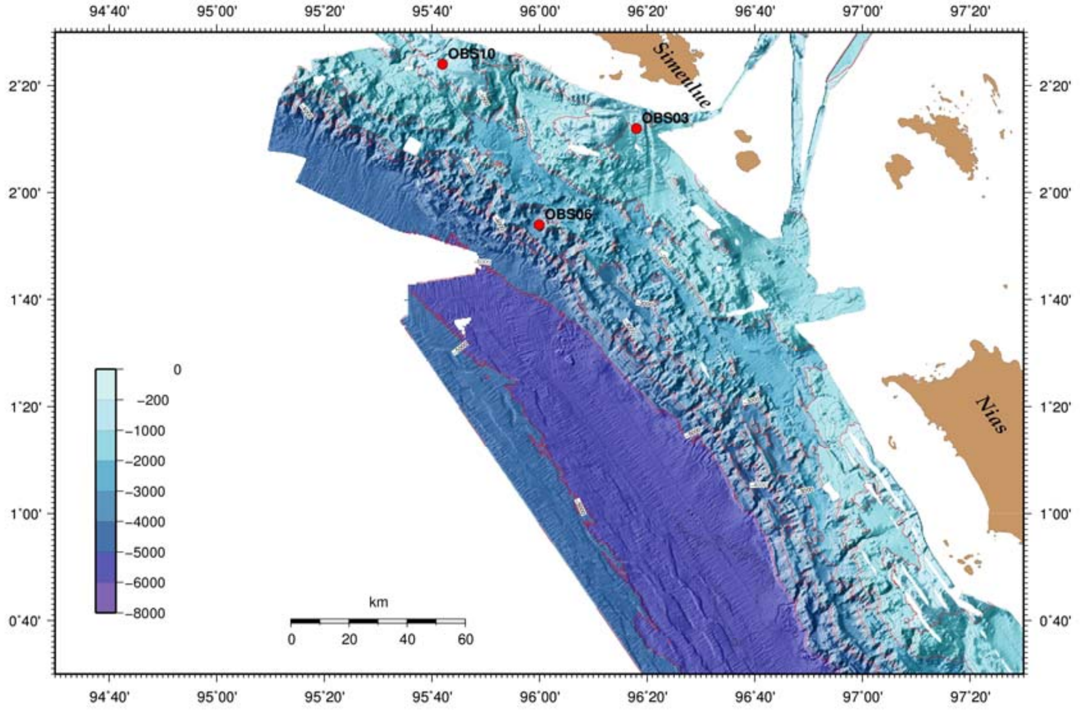


Fig. 7.1.10: The morphology of the main survey area off Simeulue and Nias

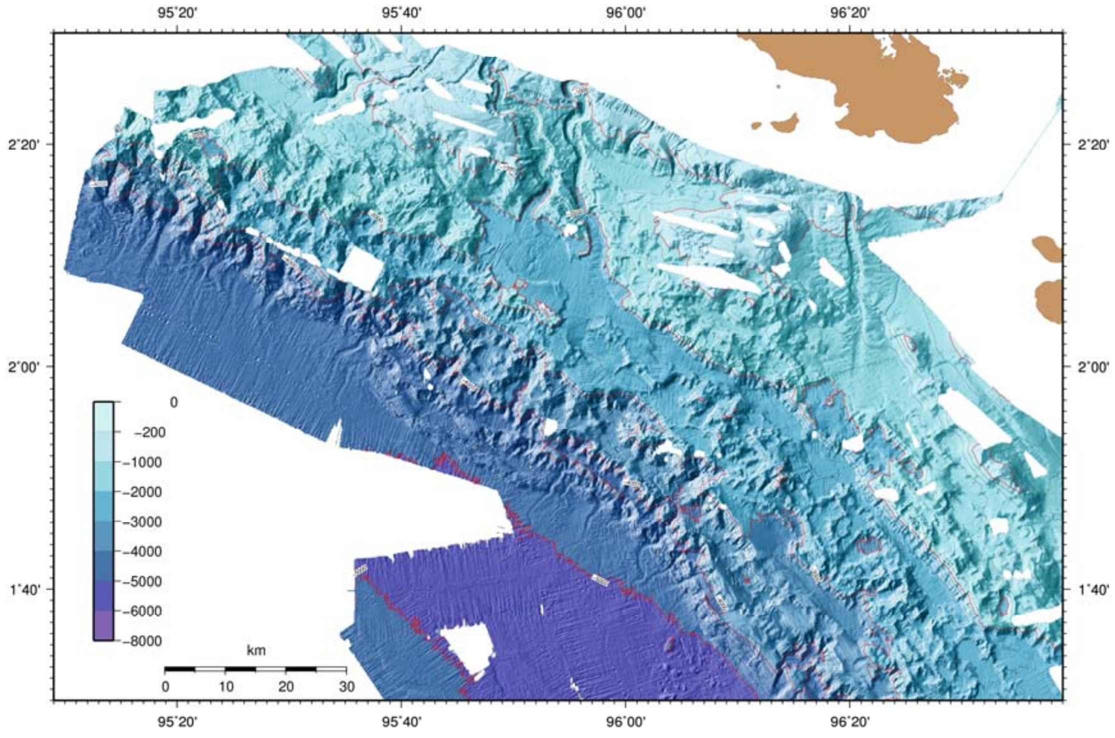


Fig. 7.1.11: The morphology of the main survey area off Simeulue

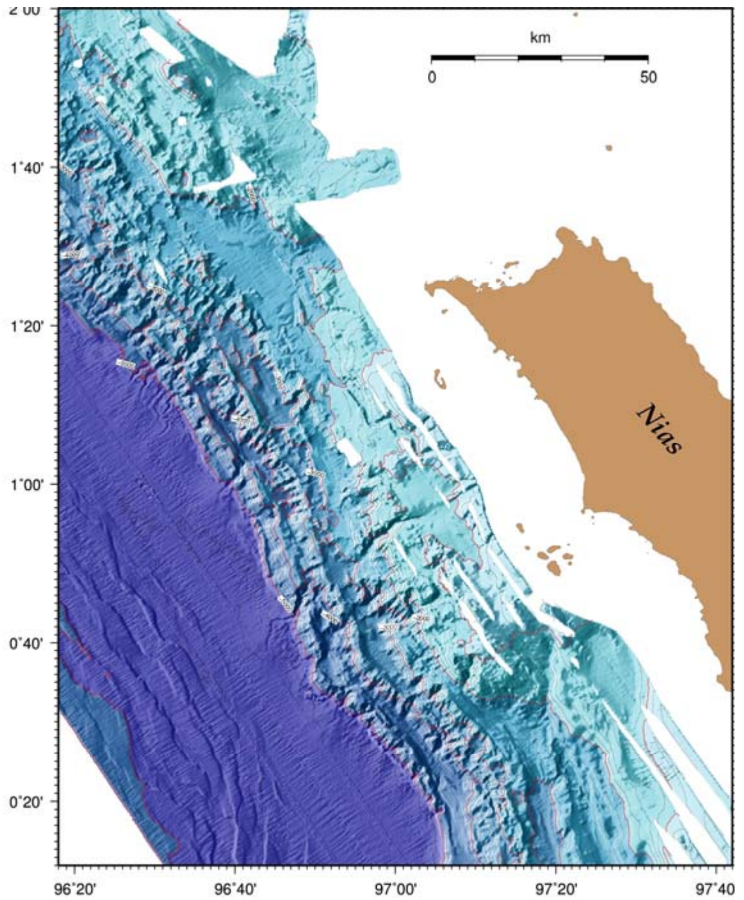


Fig. 7.1.12: The morphology of the main survey area off Nias

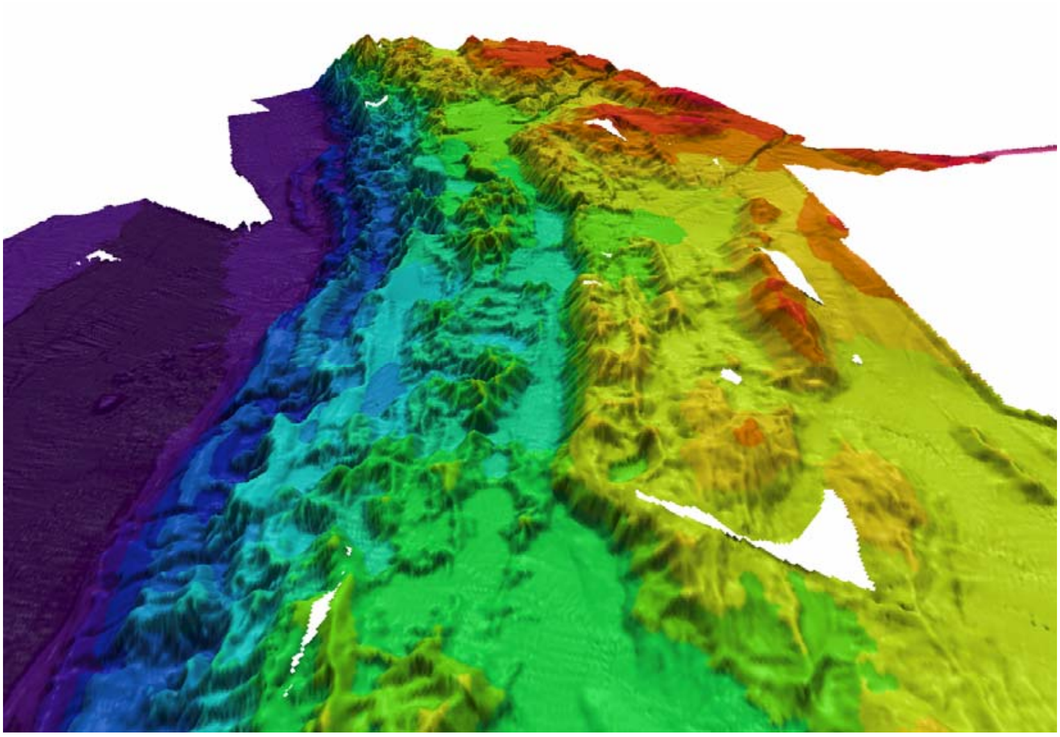


Fig. 7.1.13: Perspective view of the morphology of the main survey area off Simeulue and Nias

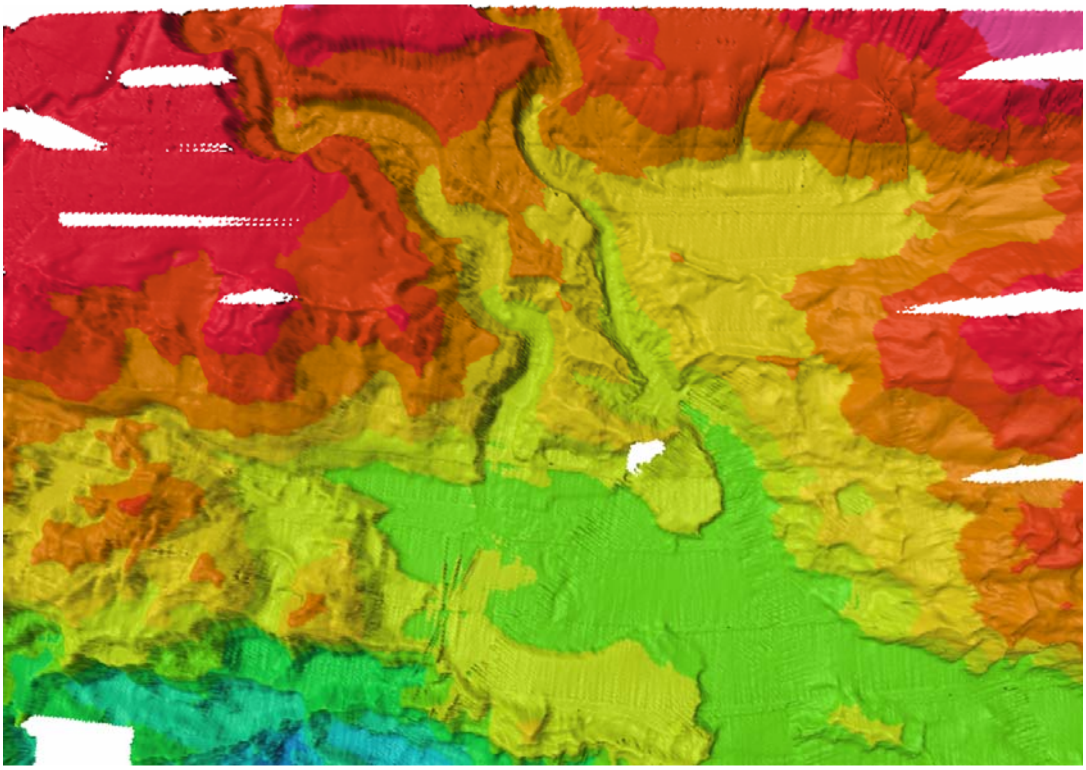


Fig. 7.1.14: View from above of the morphology of the main survey area off Simeulue showing two steep canyons and the sediment filled plain.

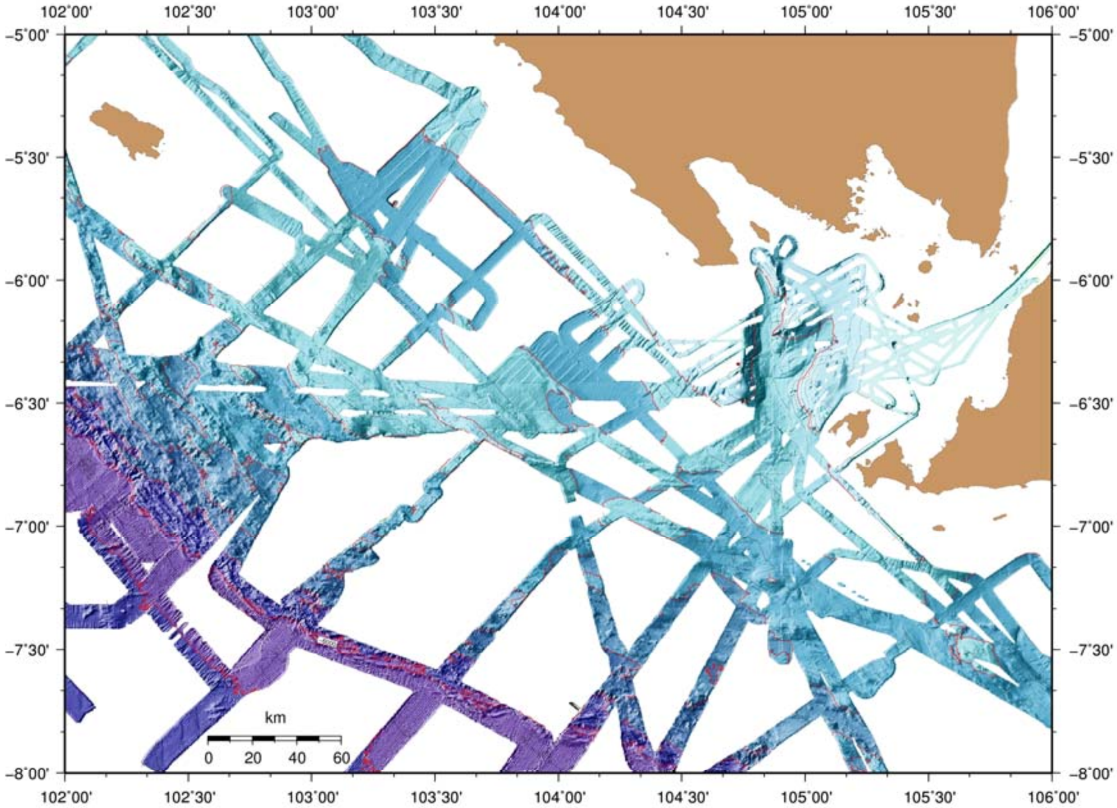


Fig. 7.1.15 shows a compilation of all available data of the southern entrance to the Sunda Strait. The data is of strongly varying quality, however, the deep sea trench, the lower fore-arc slope are clearly outlined. The entrance to the Sunda Strait is characterized by the steep Mentawai fault.

7.2 Parasound

The PARAmetric survey echoSOUNDer PARASOUND, which is available on board R/V SONNE for geological mapping of the uppermost layer as well as high resolution horizontal mapping of the seafloor topography, was continuously collecting data from the sea floor during the SEACAUSE cruise SO186-1B. Since the narrow beam angle allows mapping of slopes of less than 4° inclination, Parasound is not suited for areas of high topographic relief and rapid changes of water depths indicating steep submarine slopes.

From the flat ocean floor, good Parasound images were obtained. The records of the trench and the oceanic plate west of it and the Simeulue fore-arc basin show good results. In these areas the oceanic crust is covered with well stratified tubiditic sediments with a thickness of up to nearly 50 m.

In the area of Simeulue and Nias several vertical reverse faults of neotectonic age were identified. The offsets of these faults are up to 10 m. Slides were recorded on the slopes of Sumatra, Simeulue and Nias. Transpressional processes produced small folding (updoming) structures See Fig. 7.2.1, page 69.

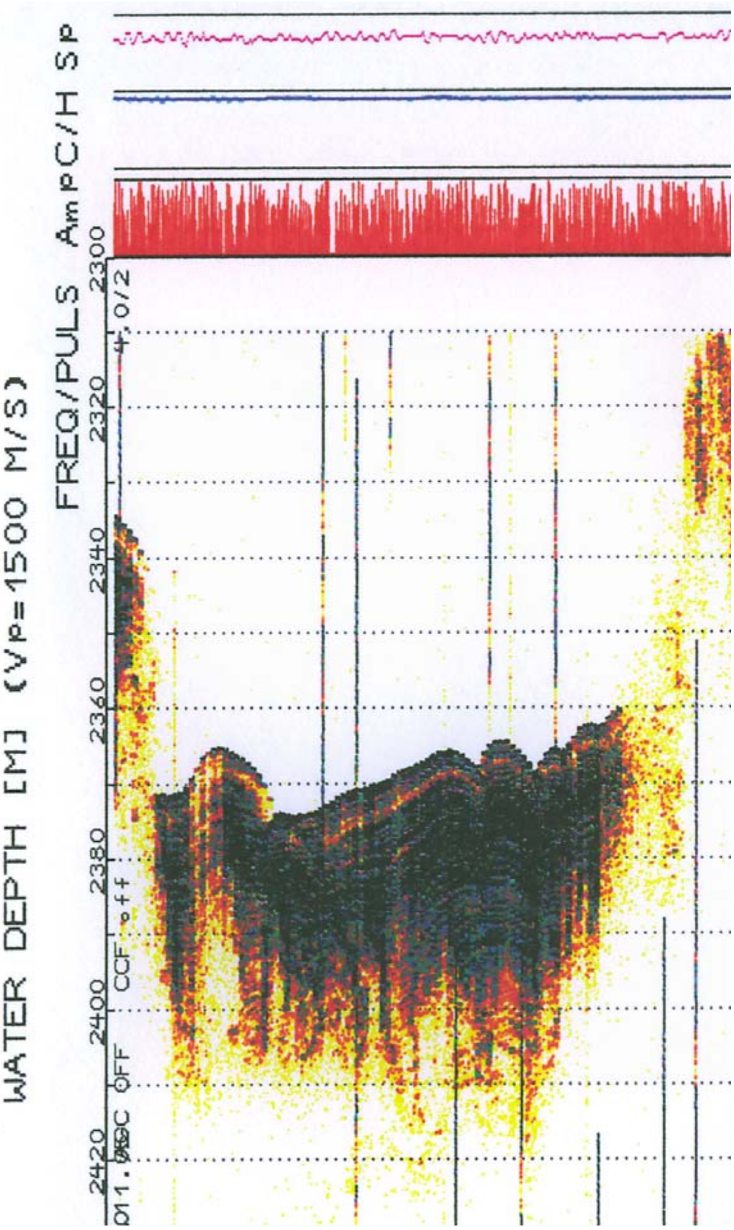


Fig. 7.2.1: Small folding structure, slope of Nias

7.3 Magnetic data: description and preliminary interpretation

7.3.1 Magnetic maps

Magnetic measurements were carried out on 32 profiles along a total length of 3927 km. Together with the data acquired during SO-186 Leg 1 we have magnetic data from along 9534 profile kilometres. The magnetic data have not yet been corrected for daily variations caused by time-varying external components of the earth's magnetic field.

As the coverage of the survey area is rather uniform, a preliminary map of the total magnetic field anomalies was prepared. Fig. 7.3.1 shows the map based on a 1 x 1 (arc-)minutes grid together with the survey profiles.

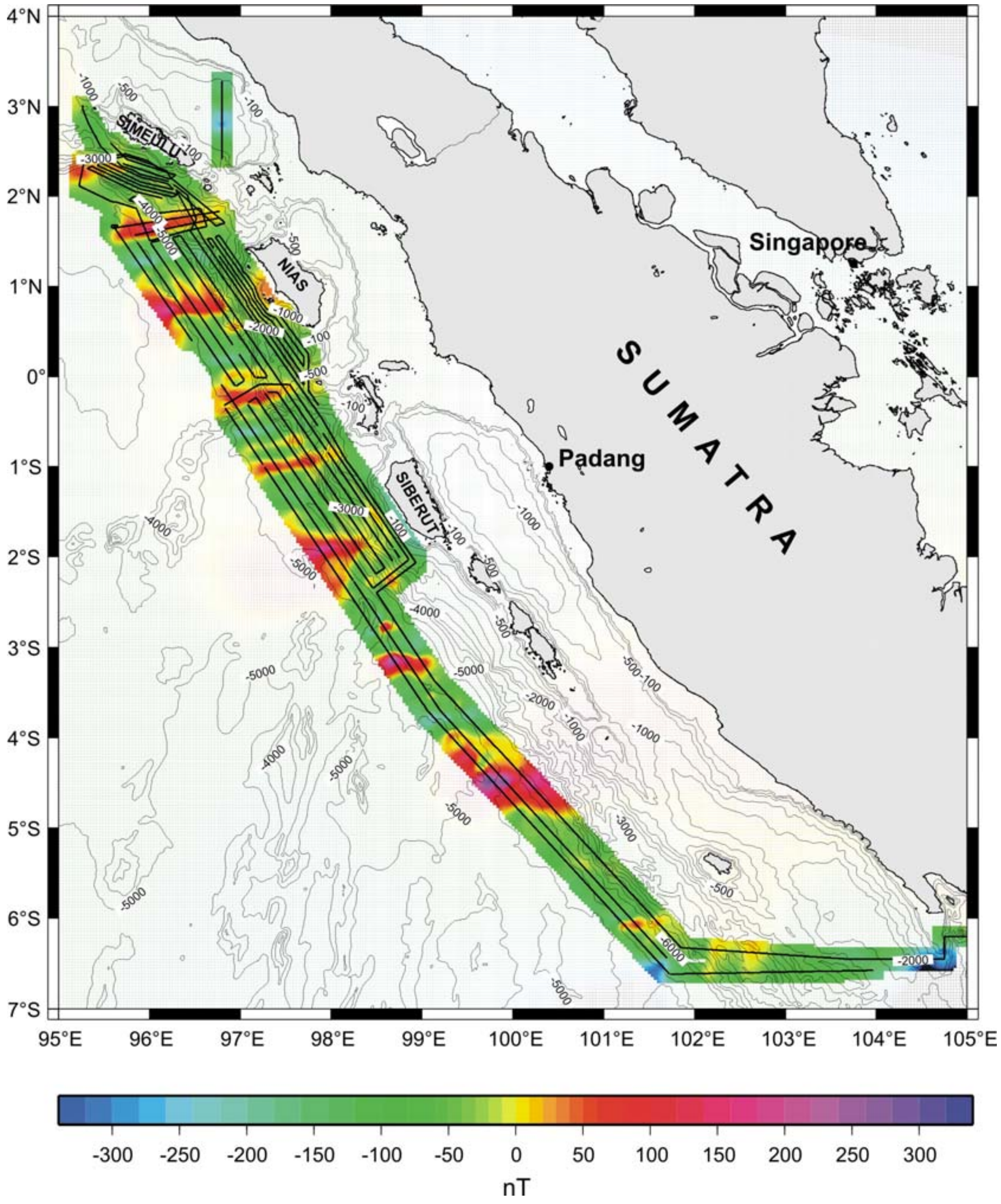


Fig. 7.3.1: Map of the total magnetic field anomalies in the survey area of cruise SO-186 I and IB. The map is drawn up to a distance of 10 (arc-)minutes (about 18.5 km) from the tracks. The map is underlain by the GEBCO bathymetry (IOC, IHO, and BODC, 2003).

The map is drawn up to a distance of 10 minutes (about 18.5 km) from the survey track. The map mainly shows E-W striking seafloor spreading anomalies of the oceanic Indo-Australian plate. The area mapped systematically covers a region between two major transform faults at about 95.25°E and 98.5°E (Fig. 7.3.2).

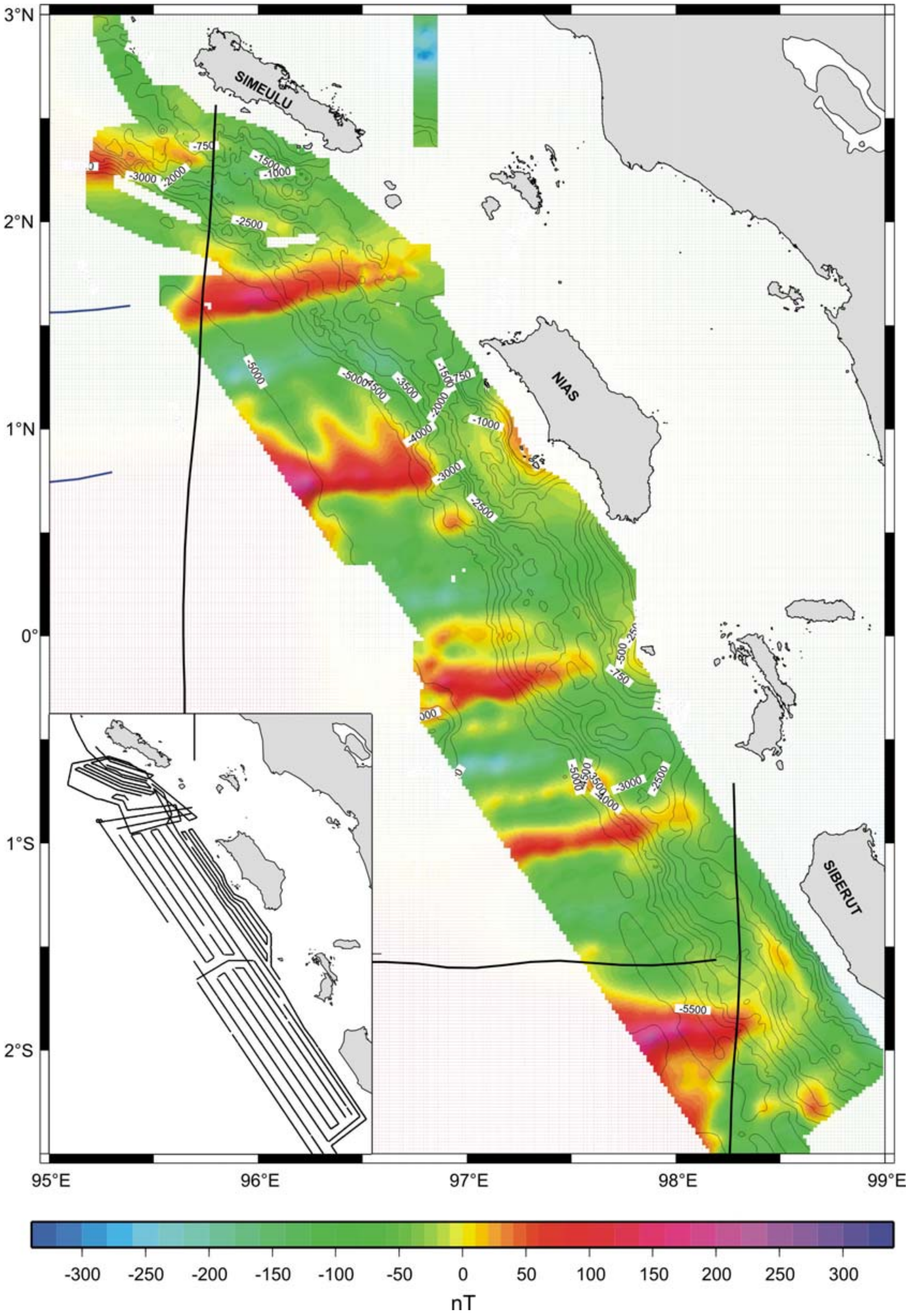


Fig. 7.3.2: Free-air gravity anomaly map of the detailed surveyed area. A 0.5 x 0.5 (arc-) minutes grid is used. The map is drawn up to a distance of 5 (arc-)minutes from the track. The bathymetry according to the SIMRAD EM120 central beam is underlain. The fault zones (black) and magnetic lineations (blue) were taken from Cande et al. (1989).

In case of the latter the termination of a prominent positive magnetic anomaly along the fracture zone is clearly visible. Between 0.5°N and 1°N the magnetic anomalies seem to have a structure paralleling the ship tracks. This is an artefact of the diurnal variations caused by the fact that each of the profiles took ~12 hours to complete which means that one direction was always sailed during the night and the opposite direction during the day. The daytime profiles are affected by a reduction of the magnetic field of roughly 100 nT around noon time which is a typical diurnal variation pattern at this low geomagnetic latitude.

The anomaly pattern does not change significantly from West to East down to a water depth of about 2500 m. In this area of the continental slope the oceanic crust is at depths of several kilometres already. The only obvious observation is a slight reduction in the anomalies' amplitudes combined with an increase of their wavelength. This is the effect of the increasing distance between the source of the anomalies in the igneous oceanic crust and the sensors which were towed at the sea surface. On the easternmost profiles, however, the anomalies' amplitudes are considerably reduced but still visible.

There are no signs of local anomalies which can be attributed to source bodies in the upper plate. This leads to the assumption that the surveyed parts of the continental slope are built up entirely of sedimentary rocks which typically have no magnetic signature.

7.3.2 Magnetic seafloor spreading anomalies off Sumatra

Magnetic lineations constrain the age of the oceanic Indo-Australian plate. The magnetic lineations in Fig. 7.3.3 were taken from Cande et al. (1989). The magnetic data measured during SO-186 show a number of additional lineations. Detailed model calculations are necessary to name the lineations correctly. First rough estimates show that from SE to NW up to the eastern transform fault the lineations 31 to 27 can be identified. That means the age of the oceanic crust decreases from 68 Ma to 62 Ma (Harland et al., 1990). At the transform fault we have an extinct spreading centre of lineation 21 age (48 Ma). Towards NW lineations up to 25 can be identified. That means the age of the oceanic crust increases to about 56 Ma. The run of the western transform is not this obvious both in the magnetic data and the bathymetric data.

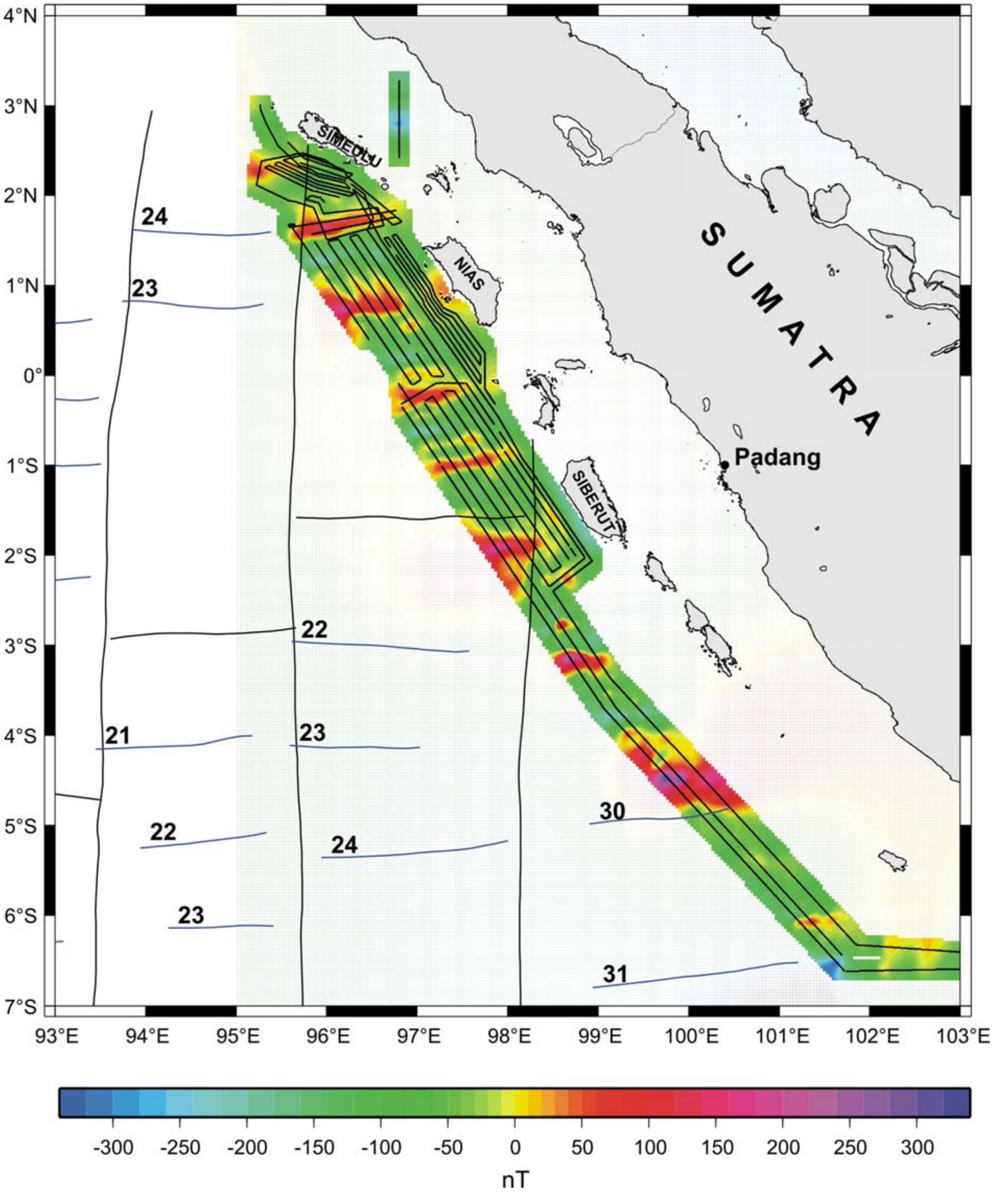


Fig. 7.3.3: Map of the total magnetic field anomalies in the survey area of cruise SO-186 I and IB. The map is drawn up to a distance of 10 (arc-)minutes (about 18.5 km) from the tracks. The fault zones (black) and magnetic lineations (blue) were taken from Cande et al. (1989).

7.4 Gravity data: description and preliminary interpretation

7.4.1 Gravity database

Gravity measurements were carried out on 35 profiles along a total length of 4207 km. In addition about 2300 km were measured along transits. Together with the data acquired during SO-186 Leg 1 gravity data were measured along 13300 kilometres. The distribution of the survey profiles can be seen in the track chart in Fig. 5.?. As the coverage of the survey area is rather uniform, a map of the free-air gravity anomalies was prepared. Fig. 7.4.1 shows the map based on a 1 x 1 (arc-)minutes grid together with the survey tracks. The map is drawn up to a distance of 15 minutes (about 27.8 km) from the survey track.

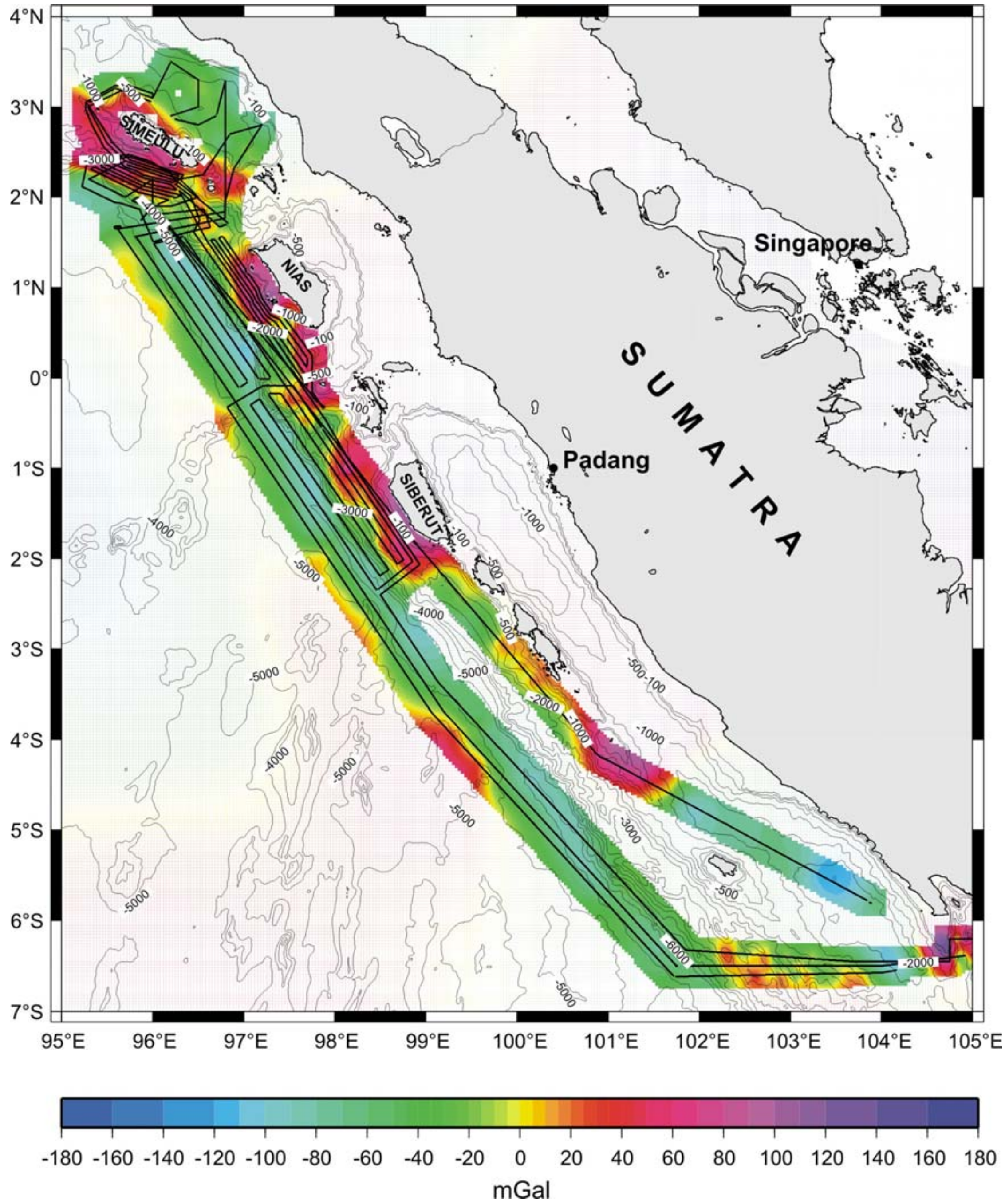


Fig. 7.4.1: Map of the free-air gravity anomalies in the survey area of cruise SO-186 I and IB. The map is drawn up to a distance of 15 (arc-)minutes (about 27.8 km) from the tracks. The map is underlain by the GEBCO bathymetry (IOC, IHO, and BODC, 2003).

7.4.2 Gravity anomaly maps

Combined free-air gravity map

A satellite altimeter uses pulse-limited radar to measure the altitude of the satellite above the closest point to the sea surface. Global precise tracking coupled with orbit dynamic calculations provide an independent measurement of the height of the satellite above the ellipsoid. The difference between these two measurements is equal to the geoid height. In marine areas the free-air anomaly can be calculated from the slope of the geoid. Closely spaced satellite altimeter profiles collected during the Geosat Geodetic Mission (~ 6 km) and the ERS 1 Geodetic phase (~ 8 km) were used by Sandwell and Smith (1997) to calculate a grid of the free-air gravity anomalies between 72°N and 72°S with a bin spacing of 1 x 1 minutes. The data set is referred to as SDW in the following. We have used their latest version 13.1.

In order to get a complete idea of the gravity field in the survey area the SDW gravity data were included in areas where no SO-186 shipboard data are available for the compilation of the free-air gravity map in Fig. 7.4.2. Shipboard data of other cruises were not considered yet. The map is based on a 1 x 1 (arc-)minutes grid and is underlain by the GEBCO bathymetry by IOC, IHO, and BODC (2003). The gravity map is dominated by the anomalies of the main topographic features in the survey area.

The oceanic crust in the SW is characterized by free-air gravity anomalies of -30 to +80 mGal. The water depth is uniformly about 5000 m. However, isostasy requires that normal oceanic crust environment does not cause large free-air gravity anomalies. This is confirmed by worldwide observations of marine gravity. The positive free-air anomalies in this part of the survey area result from the influence of the subduction bulge due to the downgoing lithosphere. Additionally, there are topographic N-S striking highs on the oceanic crust, as for example the Investigator Ridge at about 97°E, which result in an increase of the free-air gravity anomalies. A comparison with the magnetic anomaly identifications from the seafloor-spreading world map of Cande et al. (1989) showed that these highs do not correlate with seafloor spreading axes, as they run perpendicular to them. They may represent transform faults.

Landward, an about 50 km wide negative anomaly runs from NW to SE, whereby the gravity values increase from about -100 mGal to about -60 mGal. They reflect the Sunda trench with water depths of about 6000 m off Southern Sumatra decreasing to about 5000 m off Northern Sumatra. This suggests that the thickness of the trench fill with relatively low density sediments increases considerably from South to North. Landward, the gravity anomalies increase in the area of the accretionary unit and reach a zone of relative maxima from +60 to +100 mGal in the outer arc high. The positive anomalies reflect the decreasing water depth. Off Sumatra this zone is about 120 km wide, whereby the outer arc high is less pronounced in the South than in the North, where big islands like Siberut and Nias belong to the outer arc high.

Further to the NE the free-air anomaly map shows an elongated minimum zone parallel to the trench. It corresponds to forearc basins filled with sediments of relatively low density. SE of Enggano values of –140 mGal are reached within a basin about 500 m deeper than the surrounding seafloor (about 2000 m). The basin can be followed to about 0°30'S. North to about 1°N no forearc basin has been developed. Further north a pronounced basin is present again. Towards the coast the gravity values increase rapidly reflecting the slope of the sea bottom.

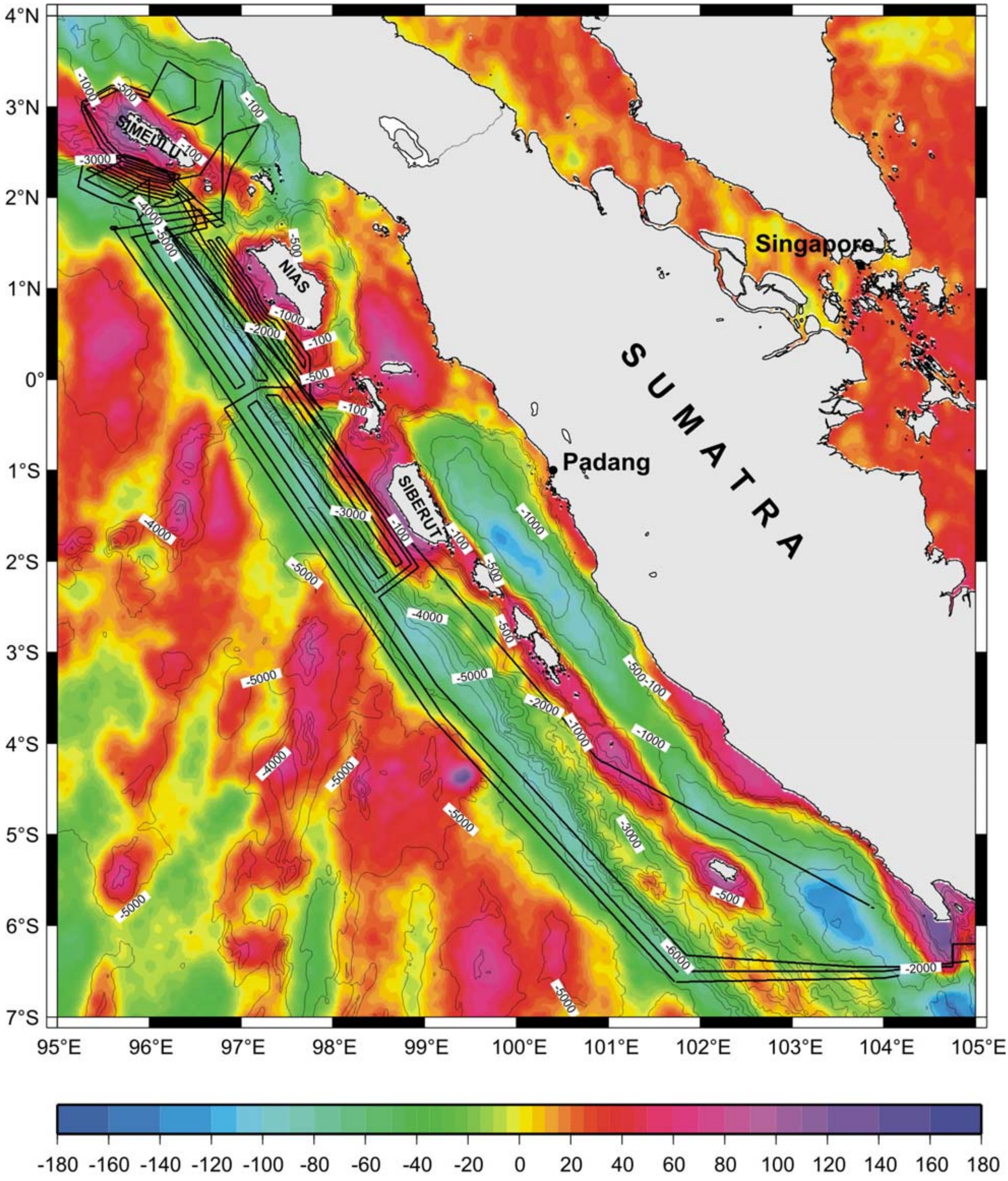


Fig. 7.4.2: Free-air gravity anomaly map. The underlying grid of gravity was compiled by merging SO-186 gravity observations and SDW 13.1 gravity data derived from satellite altimetry. The map is underlain by the GEBCO bathymetry (IOC, IHO, and BODC, 2003). The survey track of cruise SO-186 I and IB is marked.

Detailed map

The convergent plate boundary area between about 3°N and 2°30'S was covered by dense trench parallel profiles along a width of 40 to 65 nm. In order to present more details a close-up of the free-air gravity anomalies in this region is given in Fig. 7.4.3.

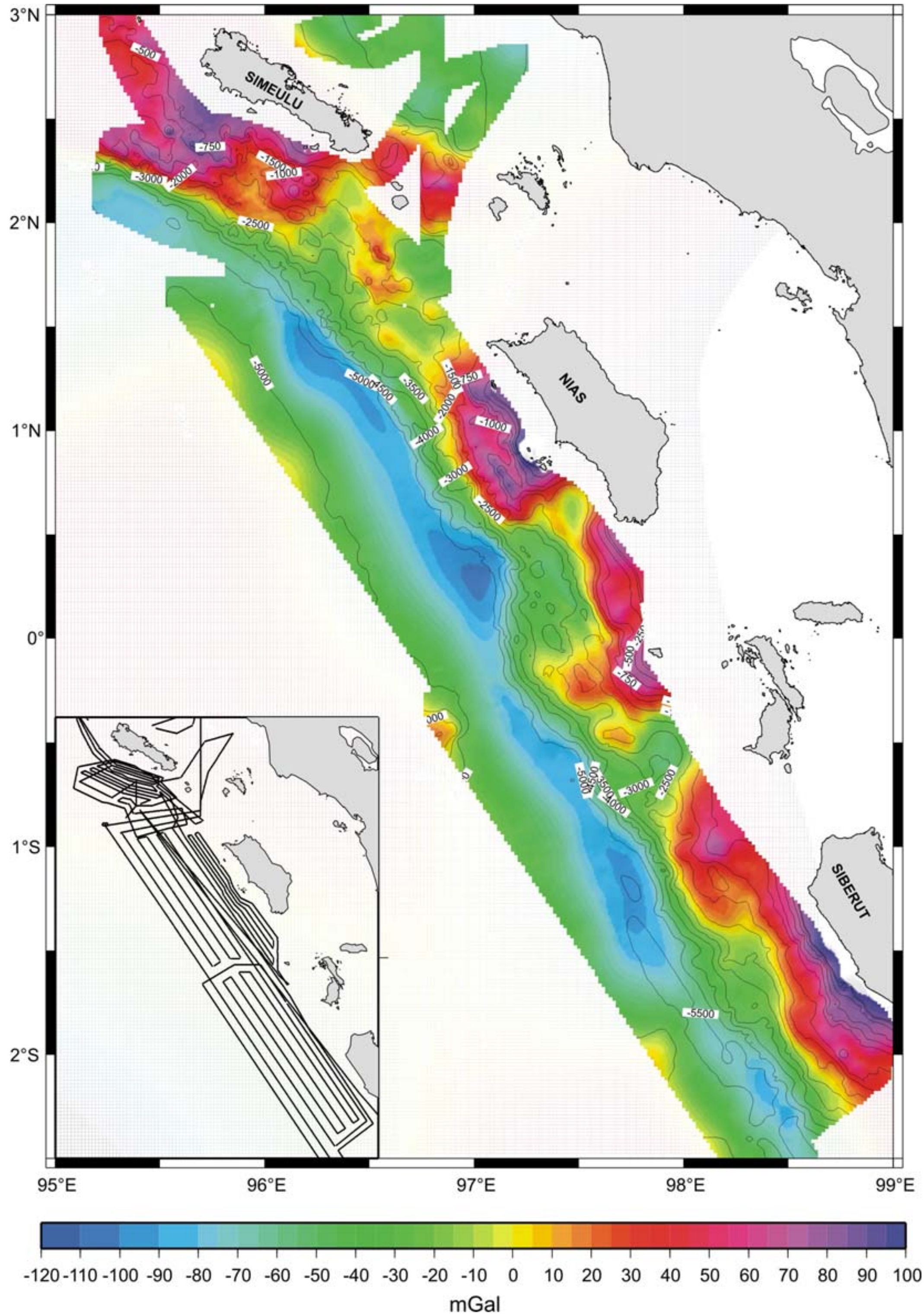


Fig. 7.4.3: Free-air gravity anomaly map of the detailed surveyed area. A 0.5 x 0.5 (arc-) minutes grid is used. The map is drawn up to a distance of 10 (arc-)minutes from the track. The bathymetry according to the SIMRAD EM120 central beam is underlain.

The map is shown up to a distance of 10 (arc-)minutes (about 18.5 km) from the profile tracks. The map is underlain by isolines of the bathymetry. Therefore the SIMRAD EM120 depths of the central beam were used.

The elongated negative anomaly reflects the Sunda trench, whereby the gravity values in the southeastern part with water depths of 5500 m are higher than in the northwestern part with water depths of 5000 m only. This indicates that the sediment thickness of the trench infill increases northward. Landward, the gravity anomalies increase with decreasing water depth strongly towards the outer arc high. The built-up of the outer arc high is rather heterogenous. Off the islands Simeulue, Nias and Siberut the gradient is generally higher than off the segments in between. But also off central and southwest Simeulue and even stronger pronounced off southwestern Nias gravity minima belonging to basin structures can be seen. At about 0°20'S the positive gravity anomaly corresponds to a bathymetric high. In how far this high is connected to the positive anomaly on the adjacent oceanic crust is not clear. The connection would imply an eastward bend of the N-S trending structural bathymetric high on the oceanic crust during the subduction process. Fig. 7.4.4 shows the area around Simueulue in detail.

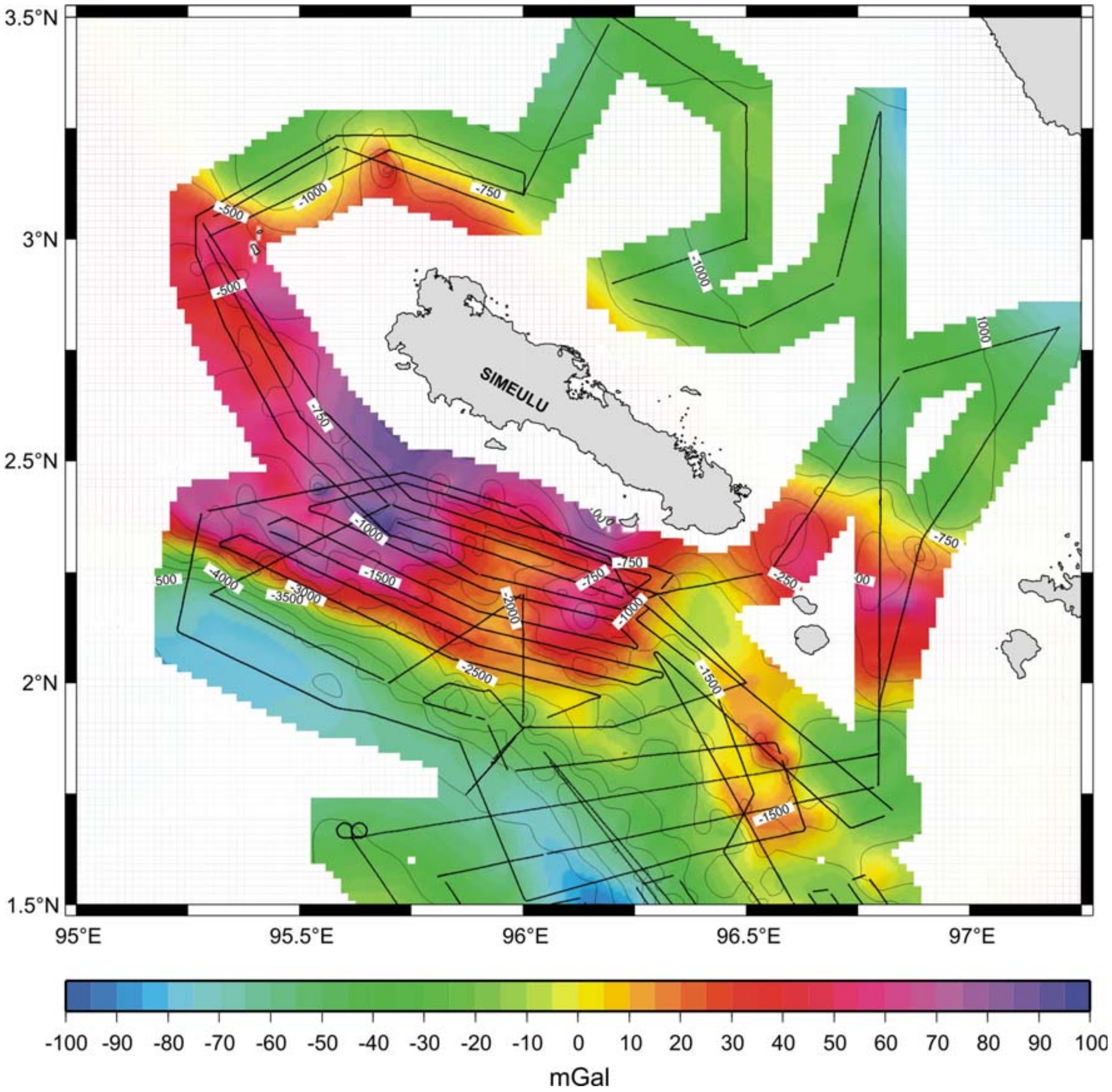


Fig. 7.4.4: Free-air gravity anomaly map of the area around Simeulue. A 0.5 x 0.5 (arc-) minutes grid is used. The map is drawn up to a distance of 5 (arc-)minutes from the track. The bathymetry according to the SIMRAD EM120 central beam is underlain.

In the detailed surveyed area our shipboard data can serve nicely as a reference for the SDW gravity data derived from satellite altimetry. Subtracting the 1 x 1 minute grid of the SDW data from the 1 x 1 minute grid of the shipboard data one obtains the map of the differences shown in Fig. 7.4.5.

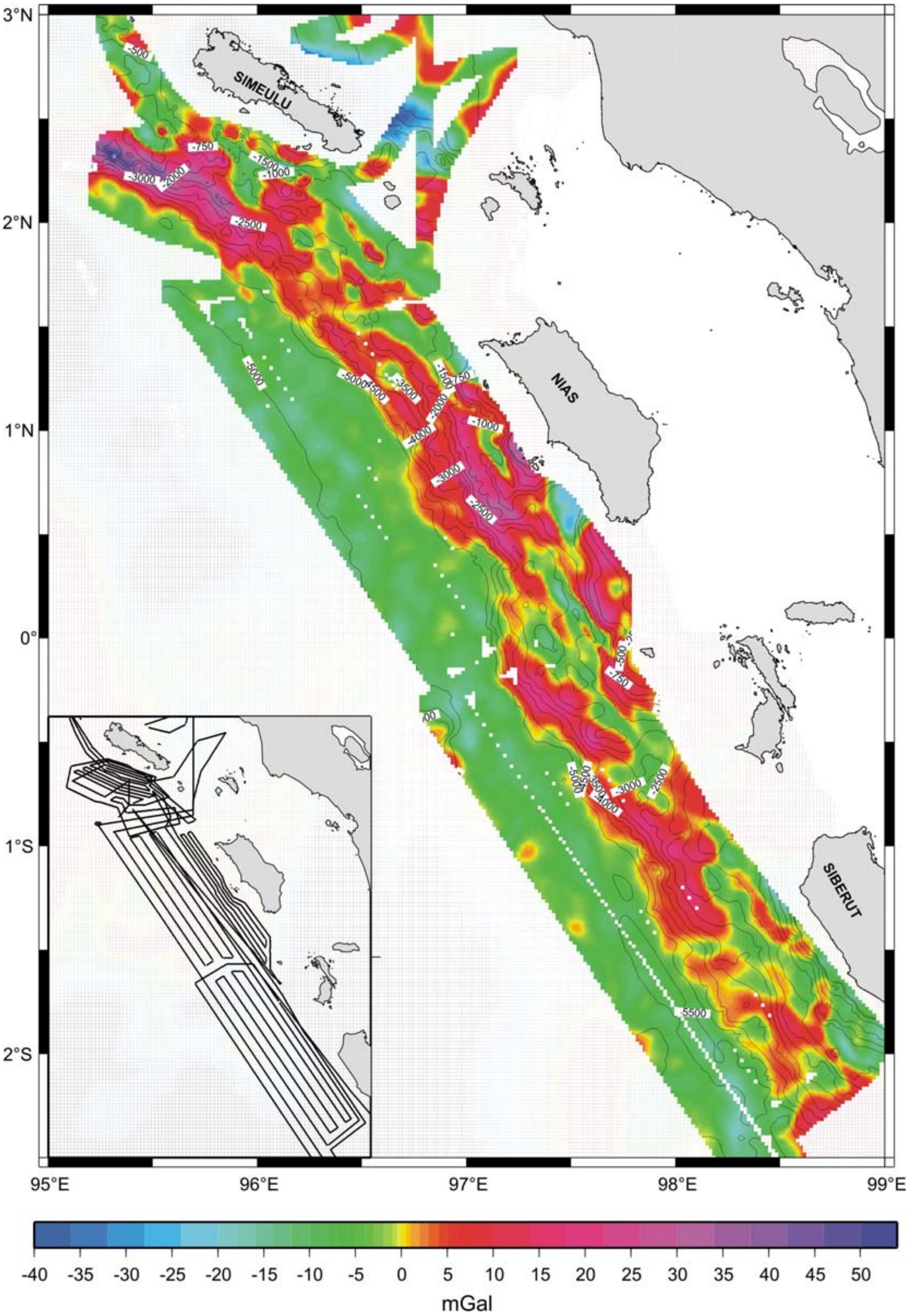


Fig. 7.4.5: Map of the differences of SO-186/1 shipboard free-air gravity data minus gravity data derived from satellite altimetry. The map is drawn up to a distance of 3 (arc-)minutes from the run of the track. The map is underlain by the isolines of the SIMRAD EM120 system depth.

The differences in the trench area are mostly negative, landward the differences are predominantly positive. That means that the satellite gravity data are too high in the trench area and too low on the accretionary unit. Moreover, an additional NS trend in the differences can be seen. The reason is probably the strongly different resolution in NS- and in EW-direction. As at the equator, satellite tracks run approximately N-S, the E-W component of the geoid slope is determined less accurately than the N-S component. Calculating the satellite gravity anomalies along the complete tracks of SO-186 I and IB with bicubic interpolation out of the 1 x 1 minute grid, the mean gravity value is -16.7 mGal, compared to -16.5 mGal of the shipboard data. This indicates no systematic deviation between both data sets. However, the standard deviation (1σ) of the difference is 13.2 mGal.

Thus, the free-air gravity anomalies derived from satellite altimetry are of great importance to get an overview of the gravity field in an oceanic area. For detailed investigations, however, shipboard gravity measurements are indispensable. Generally lower differences in other survey areas suggest that especially in equatorial areas the gravity data derived from satellite altimetry should be regarded with care.

7.5. Seismic data

7.5.1 Maintenance Work for OBS and OBH

During the cruise SO186-1A, an array of 15 ocean bottom seismometers (OBS) and 5 ocean bottom hydrophones (OBH) was deployed around the island of Simeulue (Fig. 7.5.1.1). These instruments record the seismicity in the epicentral region of the December 26, 2004 earthquake for five months in order to get detailed information about the fault plane that ruptured during the devastating earthquake. In addition, some of the instruments also carry a prototype of the pressure sensor which will be used in the Tsunami Early Warning System and which is being tested here. During leg SO186-1B, for maintenance reasons, five of these instruments had to be recovered and deployed again, after several service operations had been carried out. The positions of the five stations are shown in Fig. 7.5.1.2.

OBS03, OBS10 and OBS11 had to be recovered to change the data recorder. These instruments were originally equipped with a MBS recorder. After recovery, this recorder was exchanged with a newer MLS recorder, which uses much less energy so that the operation time at the seafloor is extended considerably. At OBH13 just the battery pack was changed to use newer lithium cells - also to extend the operation time at the seafloor. OBS06 holds a prototype of the new pressure sensors which will also be used in the ocean bottom units (OBU) of the Tsunami Early Warning System. The purpose of this recovery was to read out the first recorded data and analyse them so that a proper function of the system could be checked. Actually this test failed, so four days after OBS06 had been deployed again we were asked to recover it for a second time for extended tests. OBS06 was not deployed again during this cruise.

During Leg SO186-1C four instruments equipped with a pressure sensor and the MTS-recorder were picked up, because it was apparent that a software problem would prevent a proper transfer of the data. After an update, these instruments were redeployed, and additional 11 stations were added to the seismic network (Fig. 7.5.1.3). Also, for the first time five methan sensors (OBM) were deployed, the locations are shown in Figure 7.5.1.3. In addition, at each of the two buoy locations, an OBU and an additional OBS with broadband-sensors were deployed.

During Leg SO186-1D 10 instruments of the Simeulue network were recovered for maintenance, and the five OBM were as well recovered. Also the four instruments at the two buoy locations were recovered. It turned out that all broadband-seismometers, which were housed in a glass sphere, had considerable water leakage. They were exchanged (as planned anyhow) by slightly improved seismometers, which are now mounted inside a Titanium sphere. At one Tsunami buoy location an OBS was deployed and at the other Tsunami buoy an OBU and additionally an OBS were deployed.
The Simeulue seismological network was extended with 12 OBS stations (Fig. 7.5.1.4). No OBM was deployed during this leg. All stations will be recovered in late February to early March 2006.

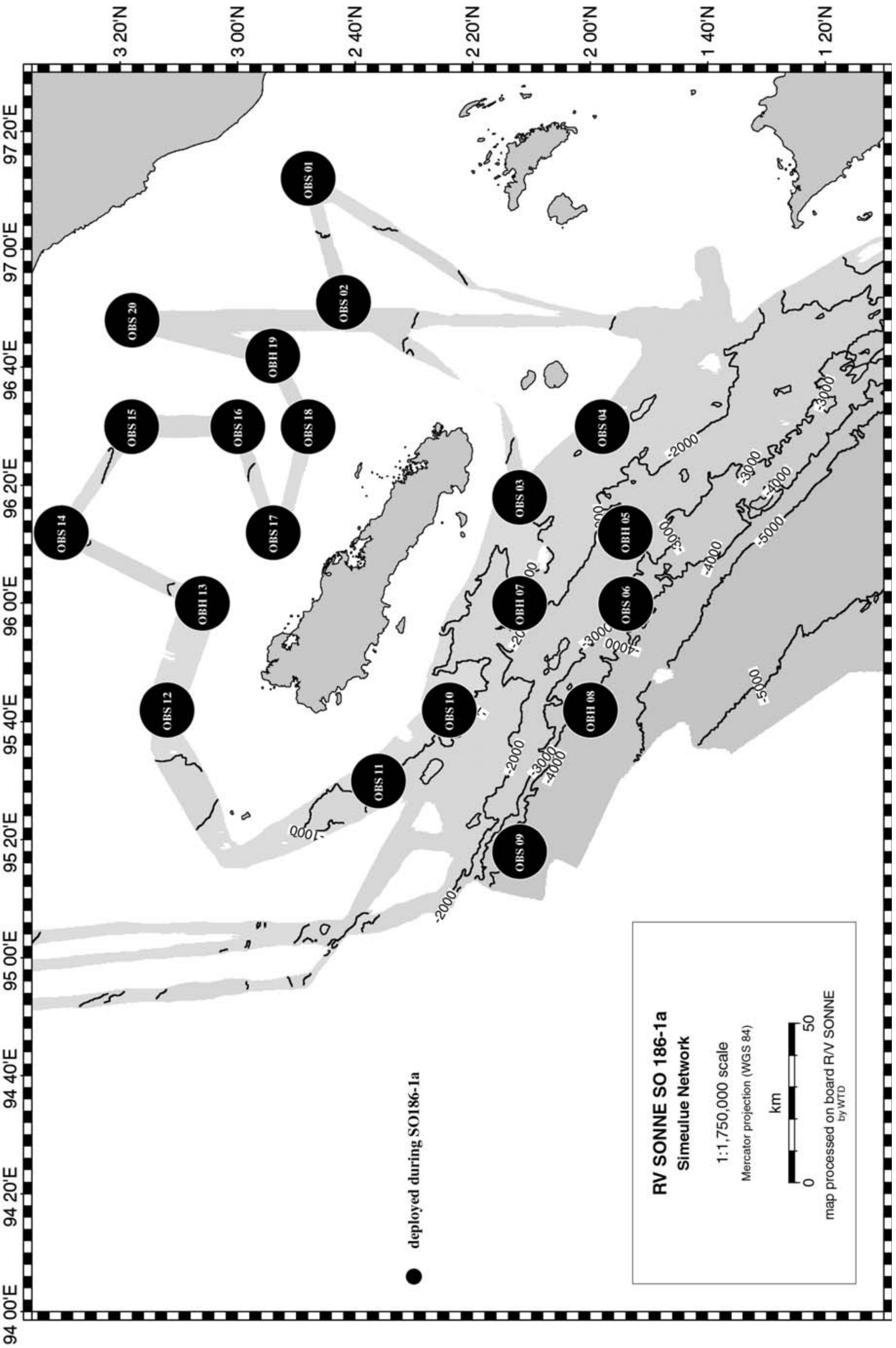


Fig. 7.5.1.1: *Location map of OBS instruments deployed during SO186-1A.*

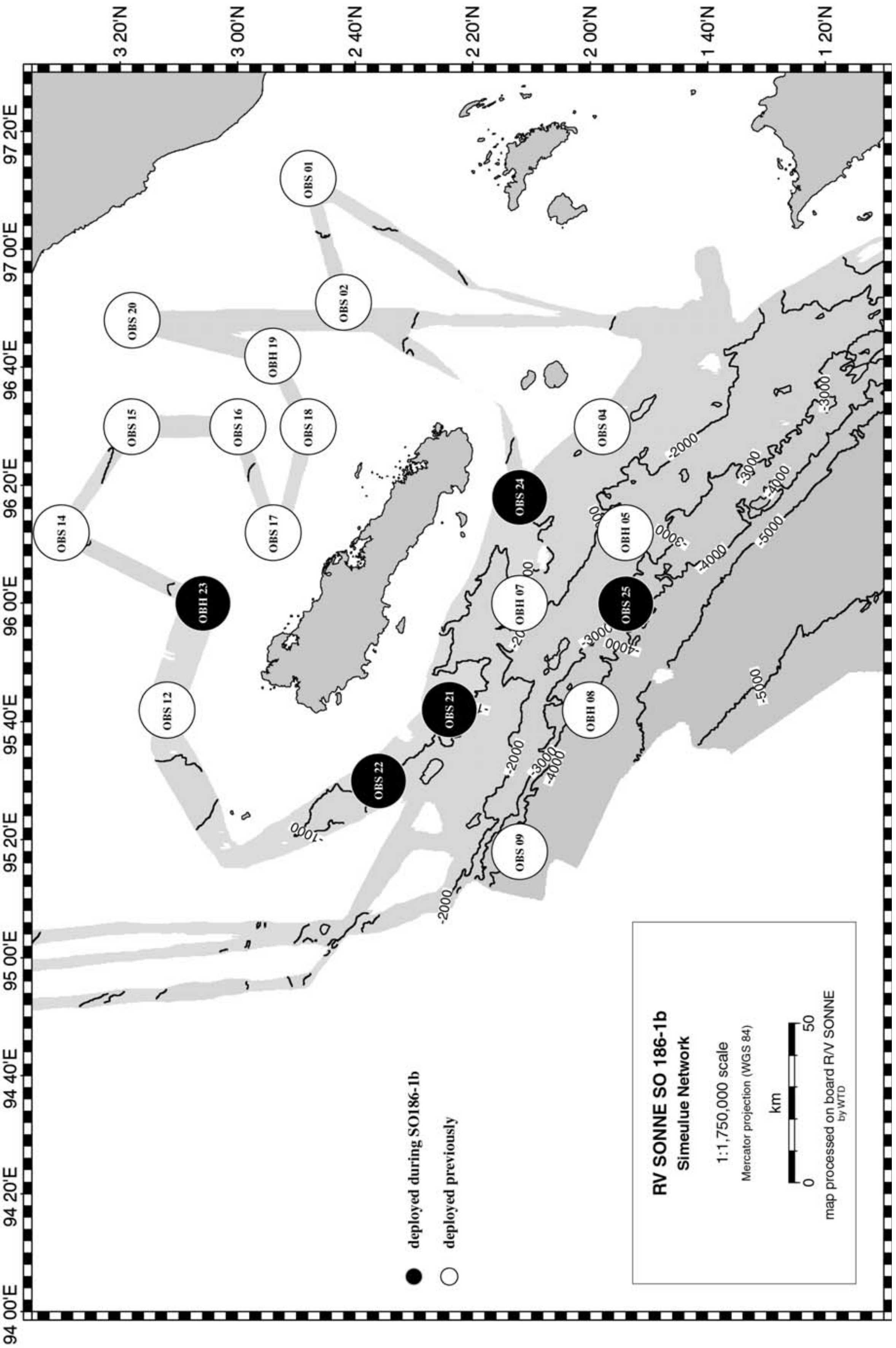


Fig. 7.5.1.2: *Location map of OBS instruments deployed (black dots) during SO186-1B. White dots mark locations of instruments deployed during the previous cruise.*

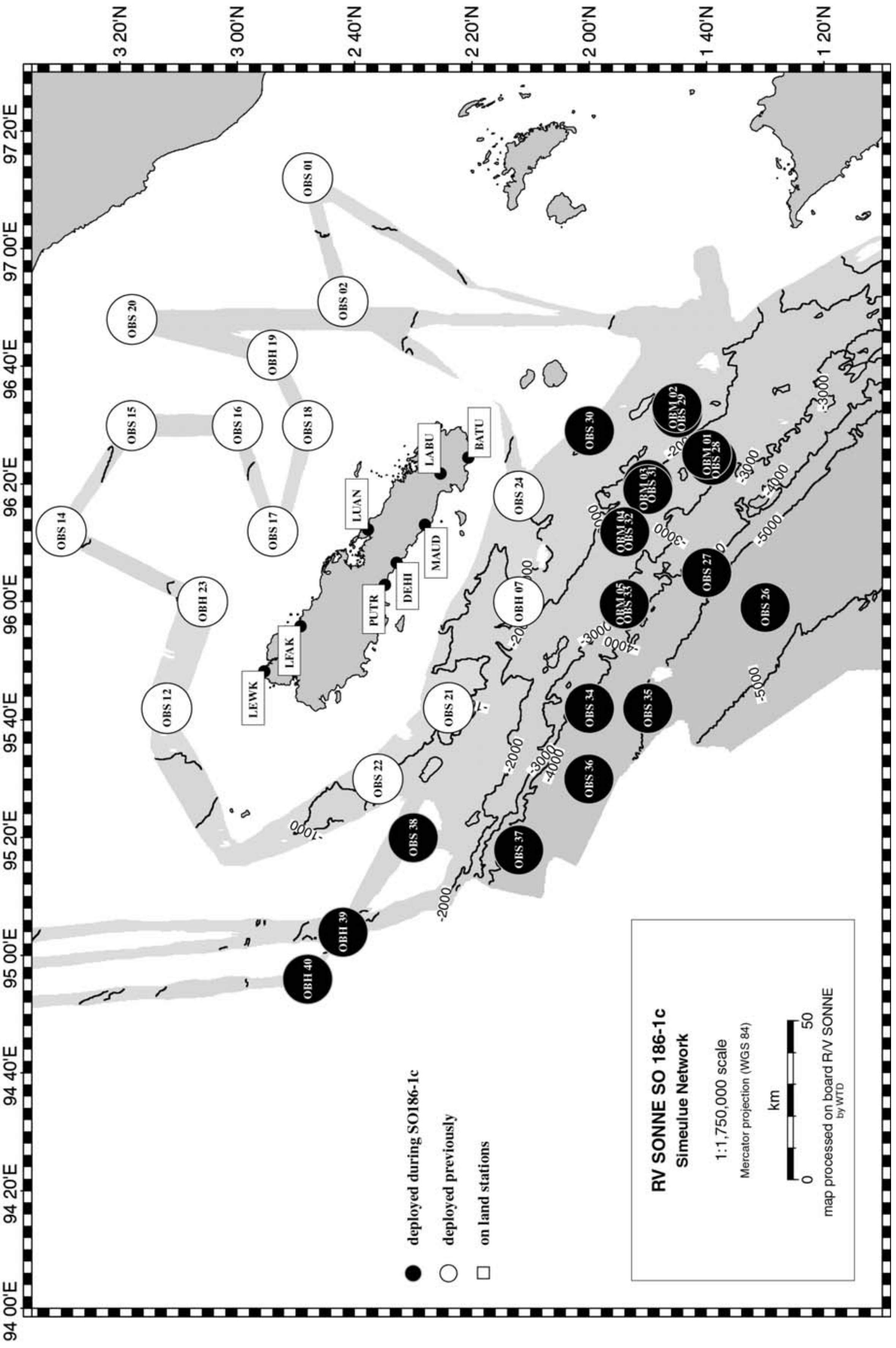


Fig. 7.5.1.3: *Location map of OBS/OBM instruments deployed (black dots) during SO186-1C. White dots mark locations of instruments deployed during the previous cruise.*

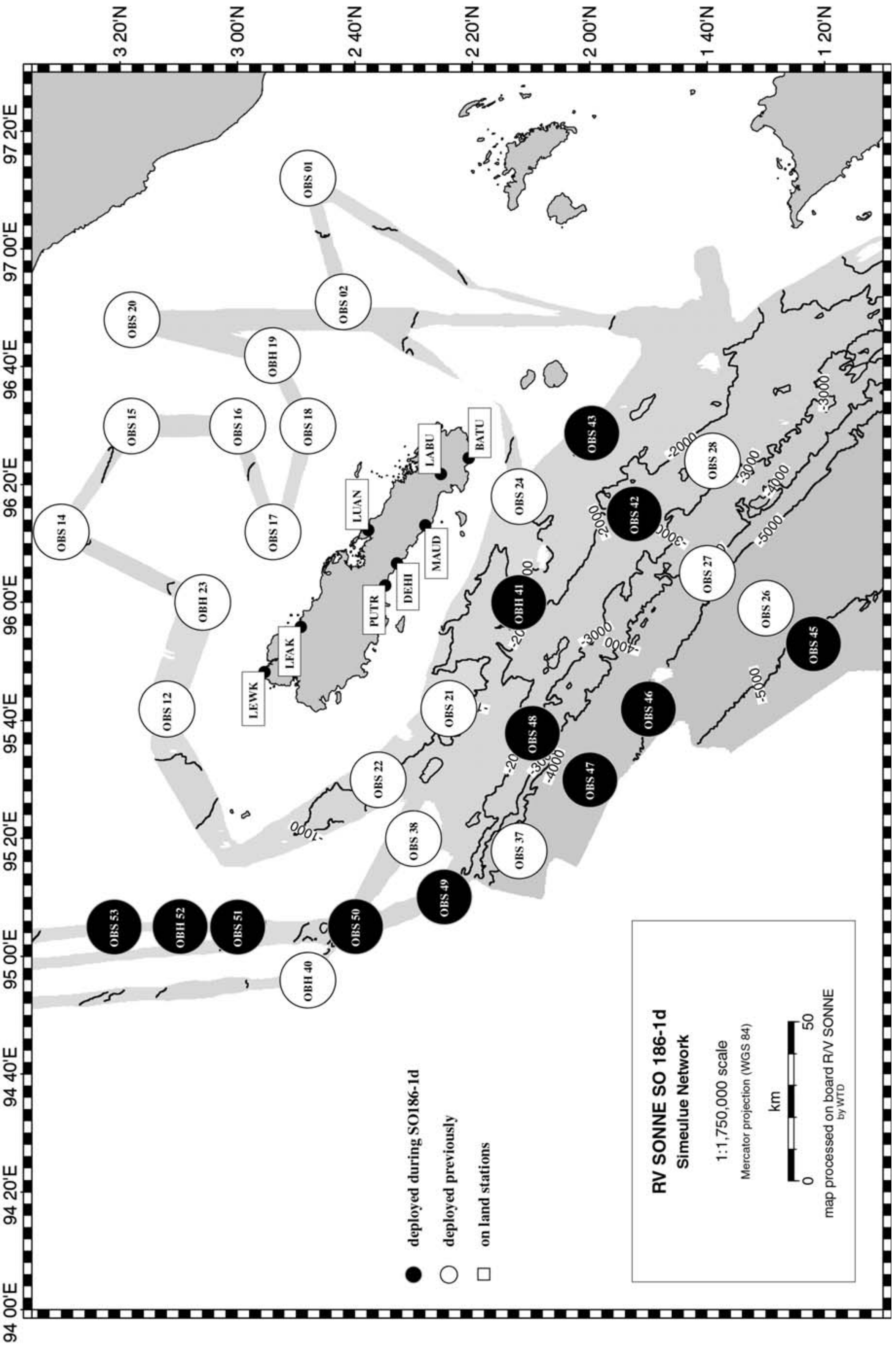


Fig. 7.5.1.4: *Location map of OBS instruments deployed (black dots) during SO186-1D. White dots mark locations of instruments deployed during the previous cruise.*

7.5.1.1 Data of recovered OBS and OBH

The data of the instruments, which were recovered during legs SO186-1B to SO186-1D, show overall good quality. OBS 30 (Figs. 7.5.1.1.1 - 7.5.1.1.3) and TOBS 02 (one of the Tsunami buoy stations, Figs. 7.5.1.1.4 - 7.5.1.1.5) are shown here as representative examples. OBS 30 was equipped with an Owen Seismometer and an OAS hydrophone, whereas a broadband seismometer and a DPG-hydrophone were mounted to TOBS 02. For each station data of 400000 s (4.6 days) is displayed in an overview plot (Figs. 7.5.1.1.1 and 7.5.1.1.4), 4 channels are shown, the hydrophone component on top, the two horizontal components, and the vertical component of the seismometer below. Several earthquakes were recorded.

Selected events are shown in Figs. 7.5.1.1.2, 7.5.1.1.3, 7.5.1.1.5. Some events show relatively higher amplitudes in the hydrophone components (e.g. Fig. 7.5.1.1.3) whereas others have relatively higher amplitudes in the seismometer components (e.g. Fig. 7.5.1.1.2). The hydrophone channel of the TOBS 02 station shows peaks every 15 s, which is noise generated by the recorder while writing the pressure data every 15 s from the Paroscientific pressure sensor, which was additionally mounted to the OBS frame (e.g. Fig. 7.5.1.1.5). This 15 s noise only appears on instruments, where the data was collected with a MTS recorder and a Paroscientific pressure sensor and a broadband seismometer were mounted. The noise starts only after levelling of the seismometer, but there is no consistency as to which channel is affected. For example, TOBS 02 data: only the hydrophone channel is disturbed by the 15 s peaks, whereas at instrument OBU 01 the two horizontal components are affected by the 15 s noise.

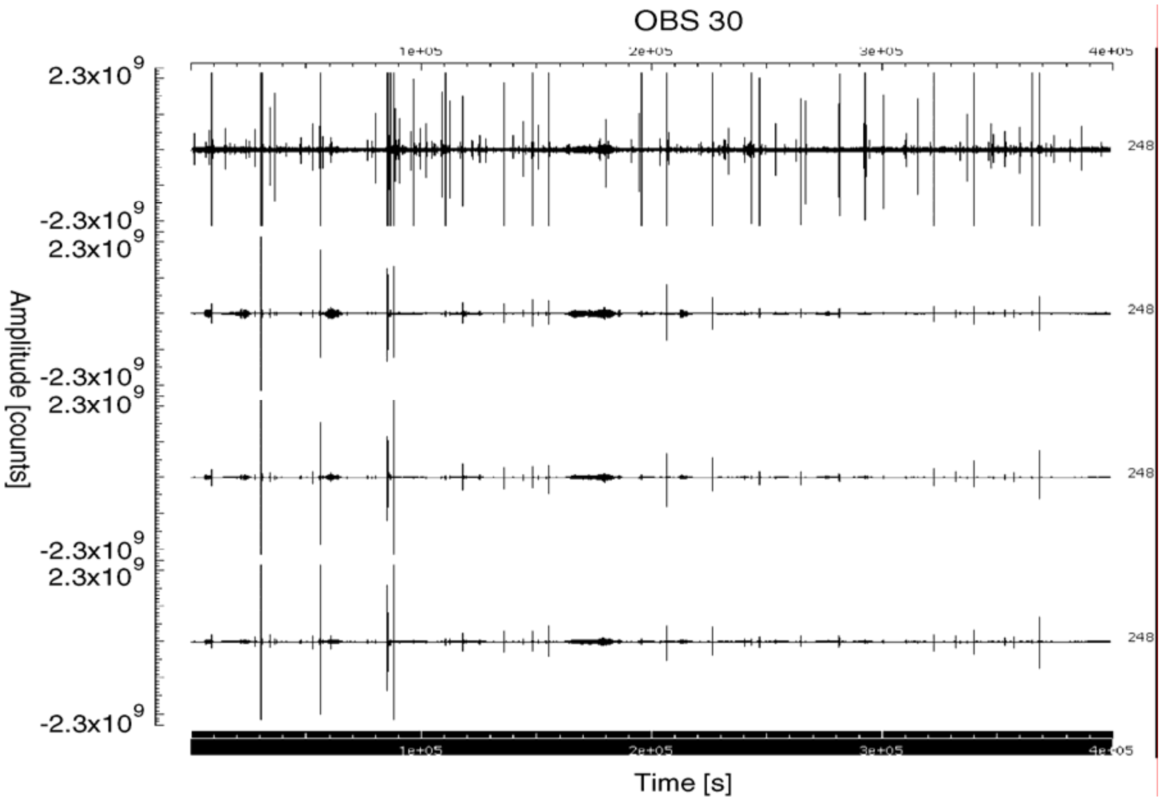


Fig. 7.5.1.1.1: *Seismic data, OAS hydrophone component (top), horizontal component 1 (upper middle), horizontal component 2 (lower middle), and vertical component (bottom) of the Owen seismometer, recorded at station OBS 30.*

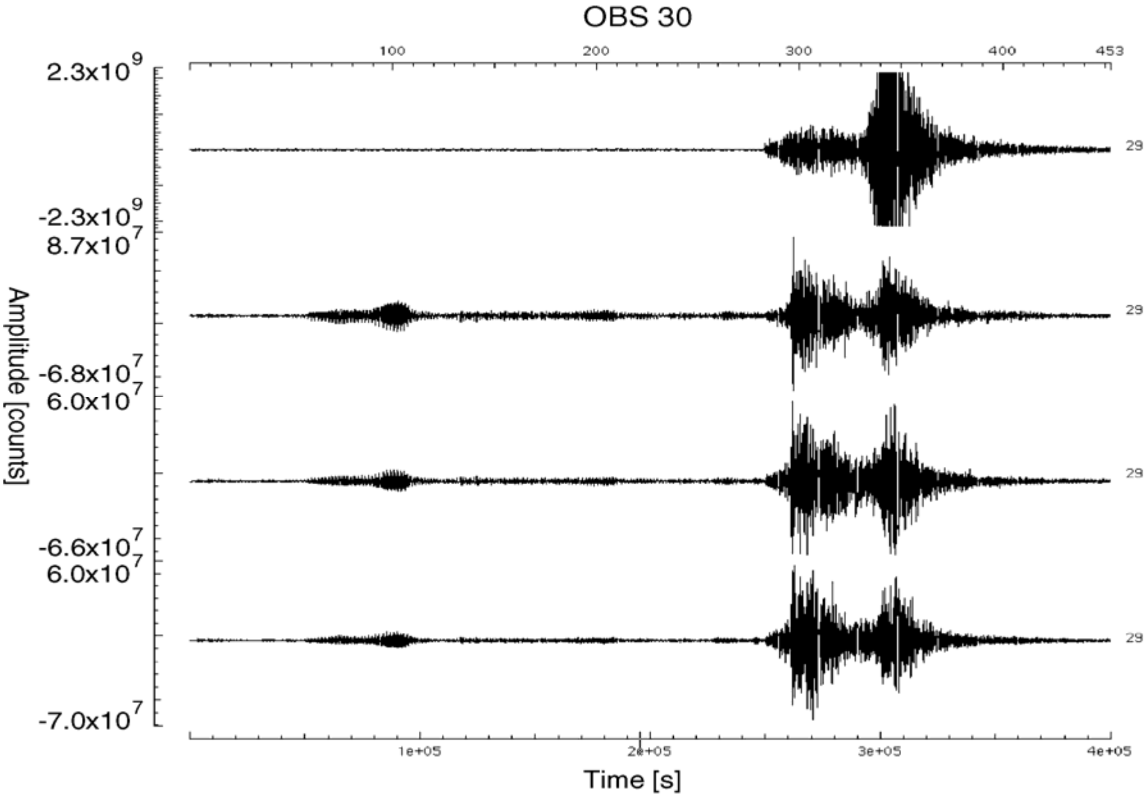


Fig. 7.5.1.1.2: *Seismic data recorded at station OBS 30, selected part of Fig. 7.5.1.1.1. OAS hydrophone component (top), horizontal component 1 (upper middle), horizontal component 2 (lower middle), and vertical component (bottom) of the Owen seismometer.*

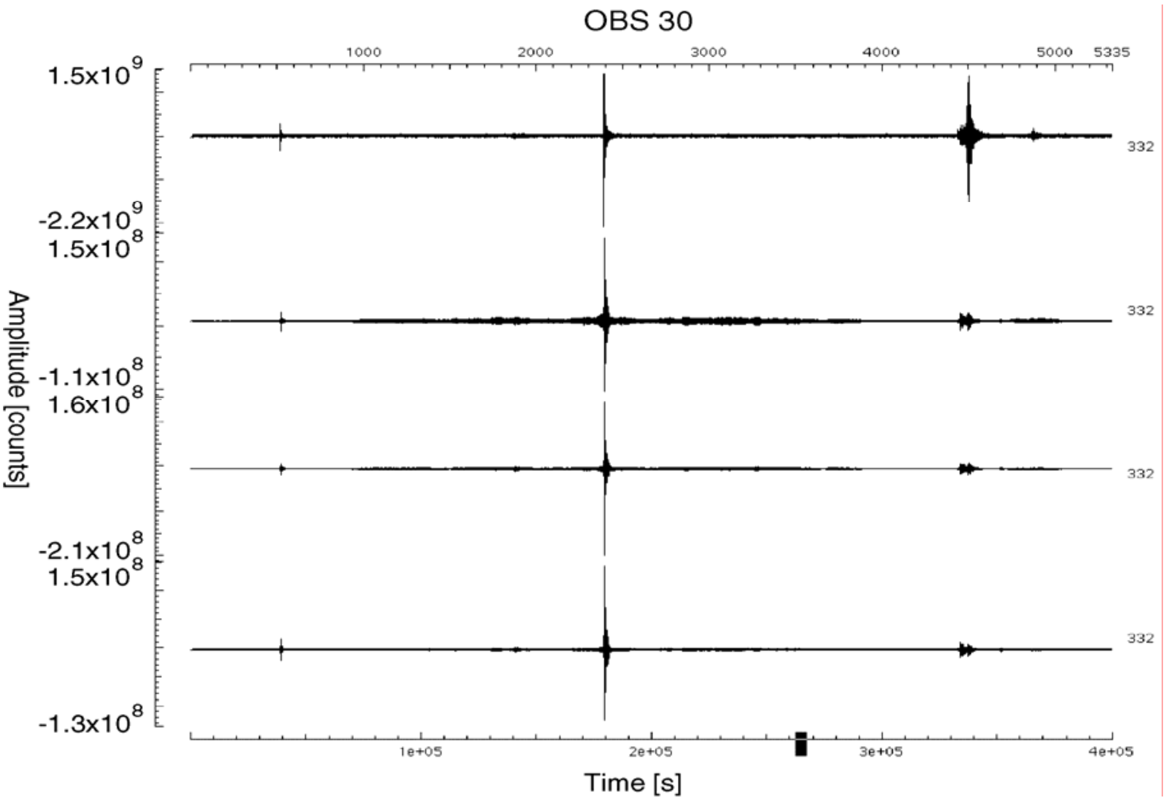


Fig. 7.5.1.1.3: *Seismic data recorded at station OBS 30, selected part of Fig. 7.5.1.1.1. OAS hydrophone component (top), horizontal component 1 (upper middle), horizontal component 2 (lower middle), and vertical component (bottom) of the Owen seismometer.*

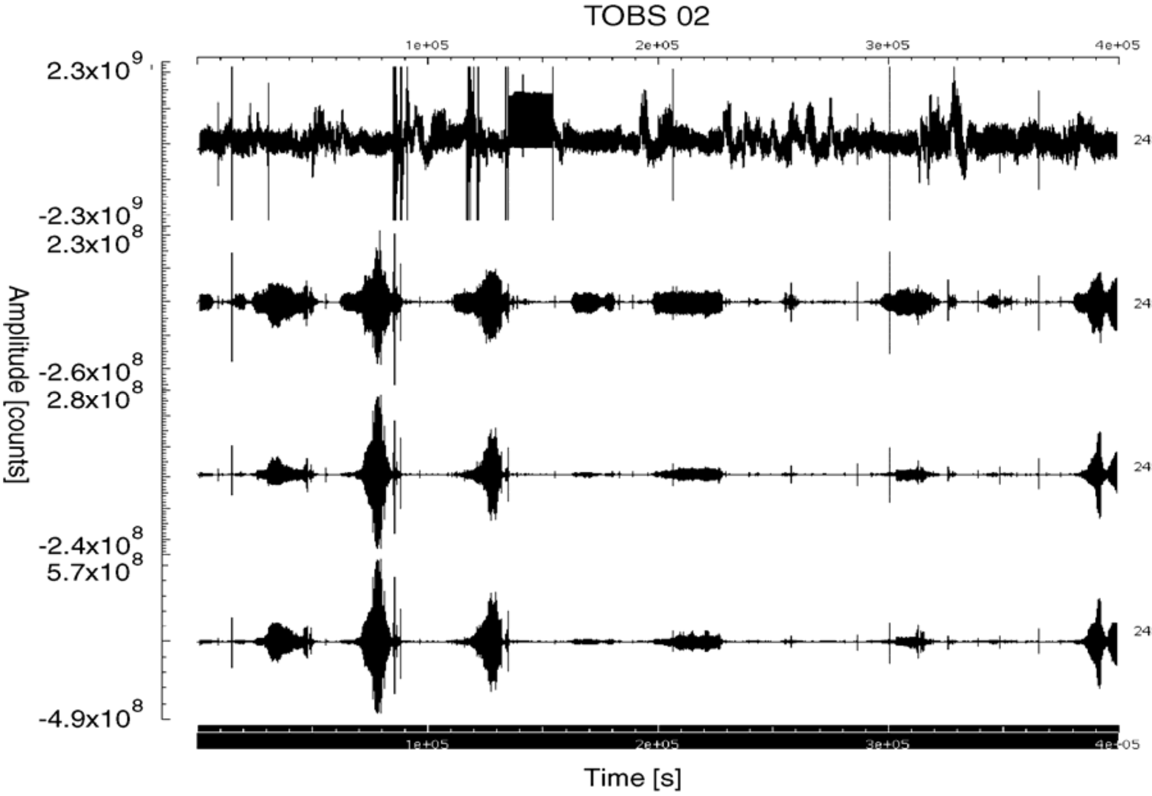


Fig. 7.5.1.1.4: *Seismic data, DPG hydrophone component (top),horizontal component 1 (upper middle), horizontal component 2 (lower middle), and vertical component (bottom) of the Güralp seismometer, recorded at station TOBS 02.*

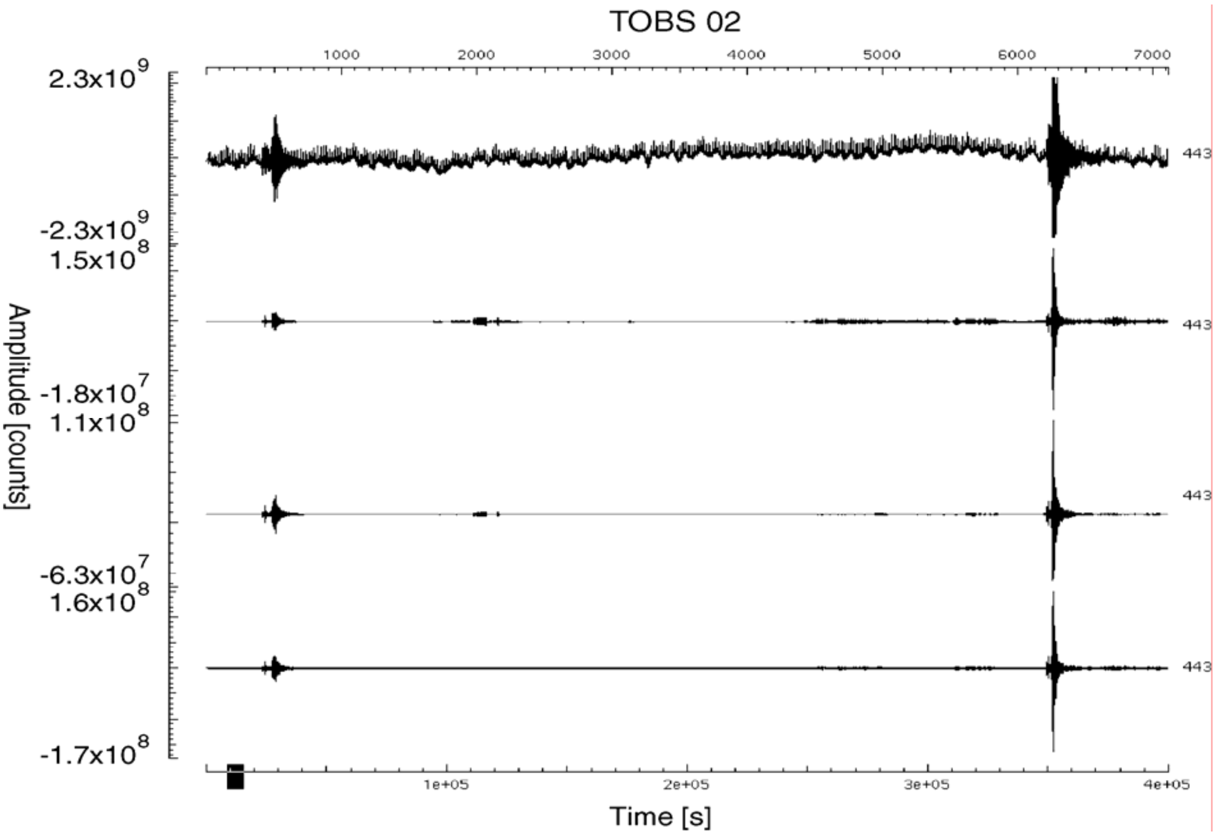


Fig. 7.5.1.1.5: *Seismic data recorded at station TOBS 02, selected part of Fig. 7.5.1.1.4. DPG hydrophone component (top),horizontal component 1 (upper middle), horizontal component 2 (lower middle), and vertical component (bottom) of the Güralp seismometer.*

7.5.1.2 Paroscientific pressure data

Stations OBS 33, OBU 01, OBU 02, and TOBS 02, recovered for maintainance during leg SO186-1D, were equipped, besides the hydrophone and geophone, with an additional Paroscientific pressure sensor; the data recorded are displayed in Figures 7.5.1.2.1 to 7.5.1.2.4. The pressure sensors worked reliably, only instrument OBU 01 shows a data gap in the first 100 hours. Recording at OBU 01 stopped after 27 days due to battery failure.

The upper panel of each Figure shows the entire pressure range, including the pressure during the descent in the beginning and the rising of the instrument at the end of the recording. The water depth obtained from the SIMRAD echo sounding system during deployment of the instrument was 3448 m at OBS 33, 5241 m at OBU 01, 3259 m at OBU 02, and 3440 m at TOBS 02. The deviations (30 m at OBU 02 to 200 m maximum difference at OBS 33) in the water depth of the instruments from the registered pressure (and therefore water depth) measured by the Paroscientific pressure sensor might result from the drifting of the instrument during descent after deployment or from an improper calibration of the Simrad system.

The diurnal tides are registered as well as the monthly cycles as consequence of the gravitational forces acting between the Earth, the Moon, and the Sun. The distances of the Sun, Earth, and Moon vary due to their elliptical orbits (Fig. 7.5.1.2.5). Increased gravitational influences and tide-raising forces are produced when the Moon is at position of perigee, its closest approach to the Earth (once each month) or the Earth is at perihelion, its closest approach to the Sun (once each year). The perihelion clearly produced the largest tides at all stations (marked in Figs. 7.5.1.2.1, 7.5.1.2.3, and 7.5.1.2.4), where the tidal ranges are enhanced. When the Earth is farthest from the sun (aphelion), the tidal ranges will be reduced. The diagram in Figure 7.5.1.2.5 also shows the possible coincidence of perigee with perihelion to produce tides of augmented range.

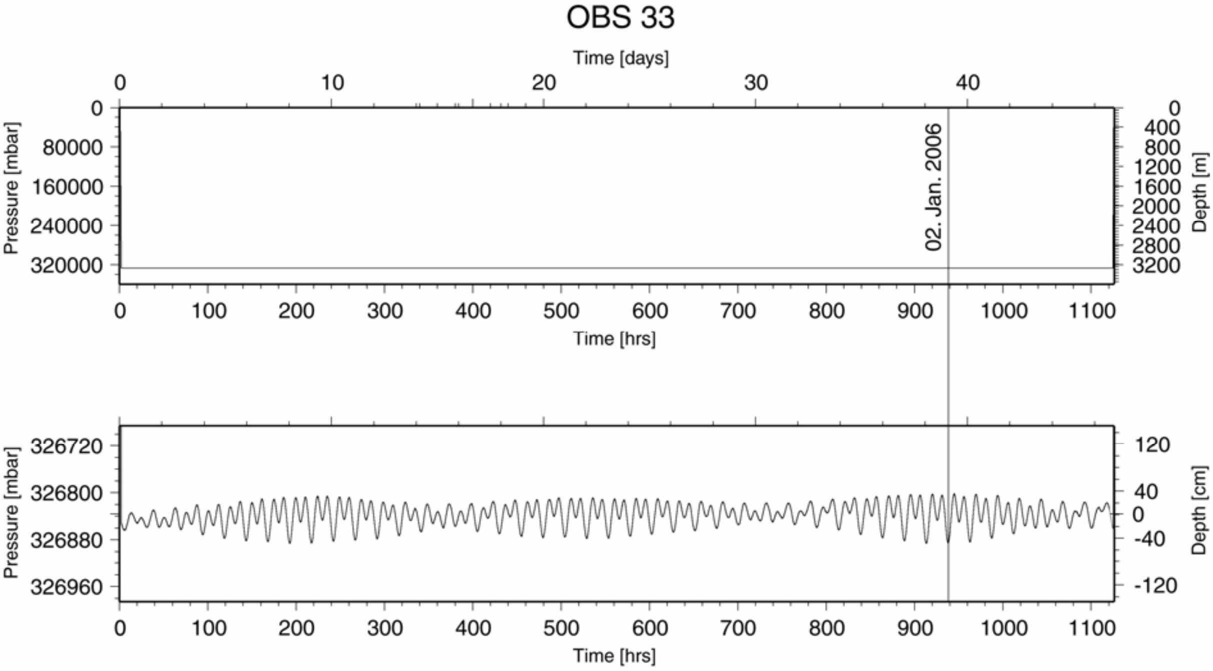


Fig. 7.5.1.2.1: *Pressure data of OBS 33. Total range (top panel) and zoom (lower panel).*

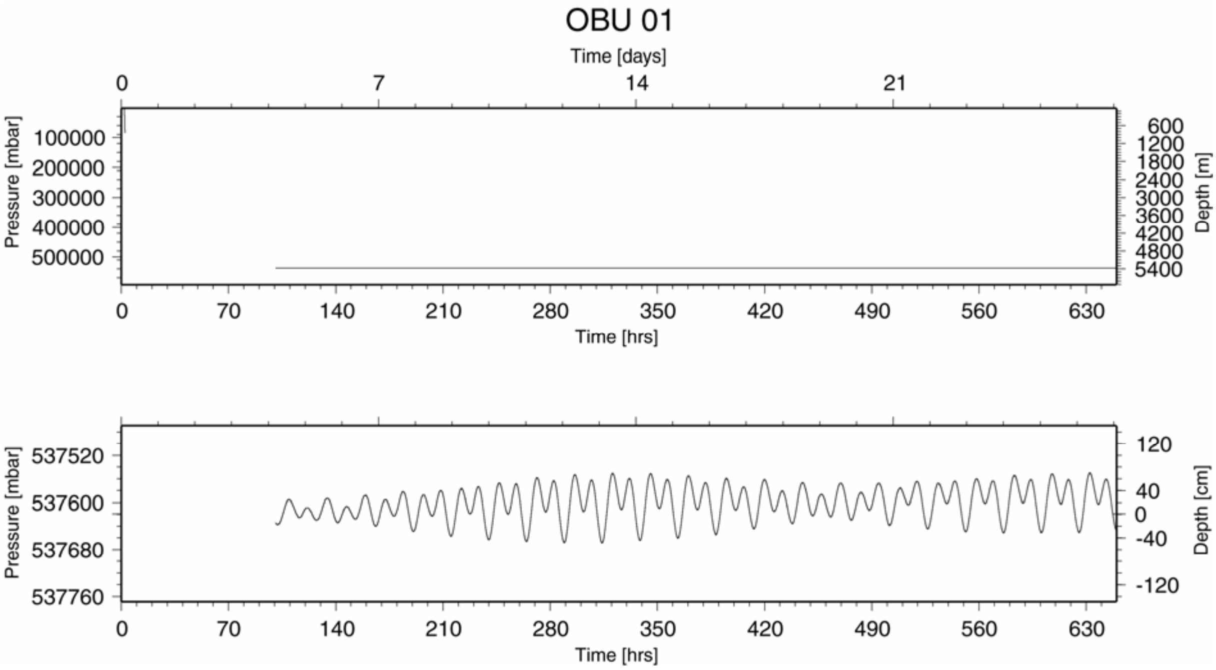


Fig. 7.5.1.2.2: *Pressure data of OBU 01. Total range (top panel) and zoom (lower panel).*

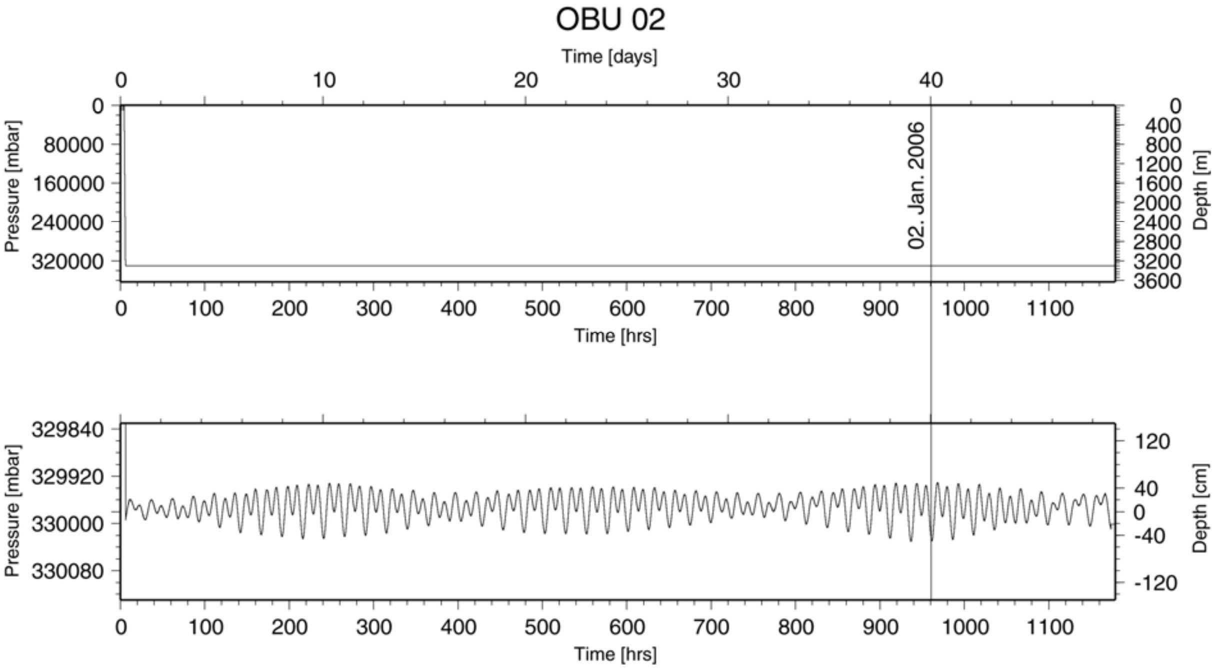


Fig. 7.5.1.2.3: *Pressure data of OBU 02. Total range (top panel) and zoom (lower panel).*

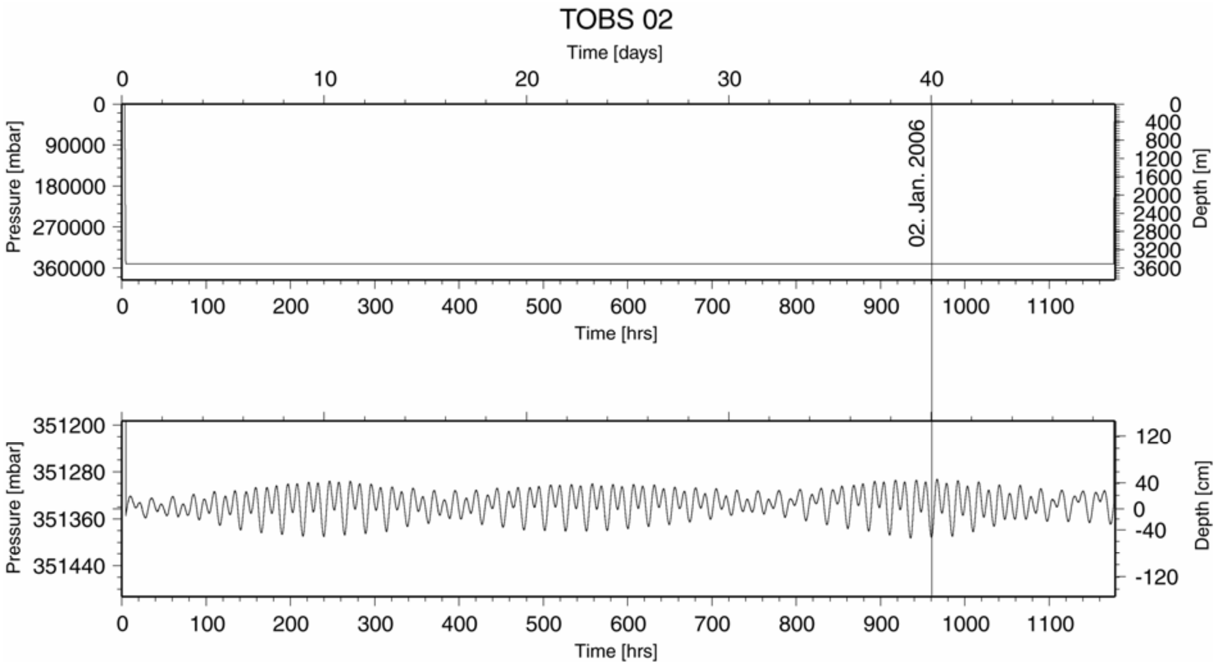


Fig. 7.5.1.2.4: *Pressure data of TOBS 02. Total range (top panel) and zoom (lower panel).*

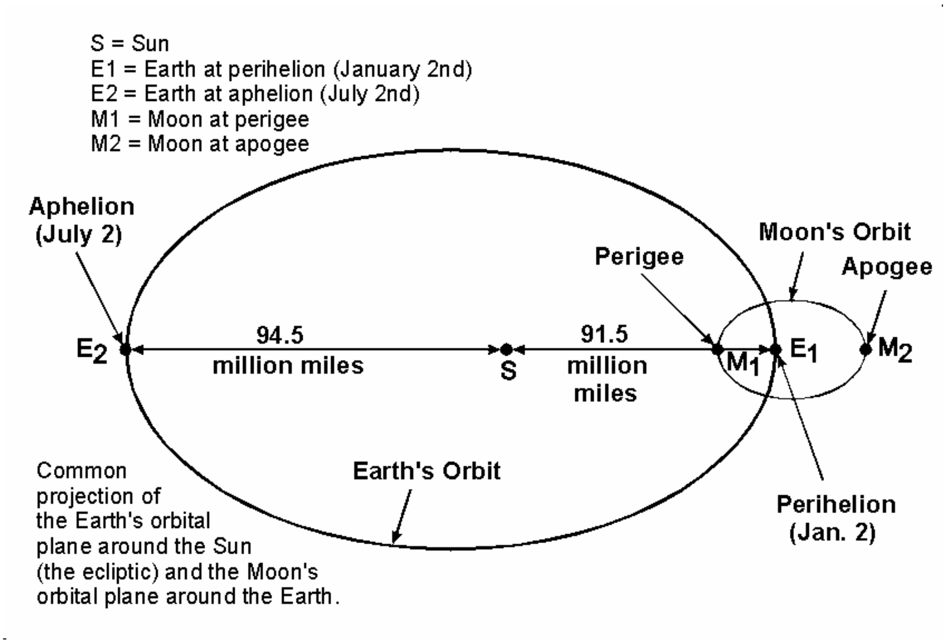


Fig. 7.5.1.2.5: *Elliptical orbits of Sun, Earth, and Moon, and the distances from their centers of attraction (Fig. from http://www.co-ops.nos.noaa.gov/restles4.html).*

7.5.2 The Simeulue seismic network

Overview

This report describes the deployment of seismic stations on Simeulue. The deployment partly overlaps in time with a deployment of 20 oceanbottom instruments offshore Northern Sumatra and Simeulue by IFM-GEOMAR and the BGR (Project Seacause). Based on preliminary rupture models the southern termination of the Aceh earthquake (December 26, 2004) and northern termination of the Nias earthquake (March 28, 2005) appear to be near Simeulue island (Ammon et al. 2005). Indications from the historical record indicate that this boundary might have been the same in the previous earthquake cycle (Newcomb & McCann, 1987). The primary objective of the deployment is the characterisation of the local seismicity in this presumed segmentation boundary; a secondary objective is the determination of the velocity structure in the forearc. With this information, the following questions related to segmentation will be addressed: what are the updip limits of microearthquake activity in the interplate seismogenic zones of the two segments? What is the variation of the geometry of the plate interface, and are they identifiable differences associated with the segmentation. Because of instrumental problems only 8 of the planned 10 Güralp CMG6TD sensors were deployed. Road access to parts of the island was limited due to tsunami and earthquake damage but a reasonable distribution could be achieved by using a boat to reach the northern part of the island.

Personnel

Fieldwork:
Frederik Tilmann, University of Cambridge
Max ShawChampion,
University of Cambridge
Bambang Suwargadi, GeotekLIPI
Yusi Firmansyah (Student) Institut Teknologi Bandung
Administrative Support:
Hery Harjono, Director GeotekLIPI
Lina Handayani, GeotekLIPI

Equipment

10 Güralp CMG6TD instruments with 3 GB internal flash memory.
10 GPS antennas
11 solar panels
10 Ah dry cell batteries
2 Palm tops, 2 Lacie disks and 1 laptop for programming and testing instruments
This equipment is on loan from SeisUK, part of the NERC geophysical equipment pool.

Huddle Test

The huddle tests were performed on consecutive days for 5 instruments each at the offices of SMAC airlines in Medan on December 7 and 8. Recording time was for approximately 4 and 3 hours, respectively. The data from the huddle test were archived in gcf format (Güralp propriatry format).

Instrumental Problems

- Sensor 6049 could not receive GPS signal and rebooted at random during the huddle test
- Sensor 6038 did not power up when deployed in the field. During the huddle test this sensor worked except that the timing of this sensor was 1s ahead of the other stations (with GPS G4145). The reason for the failure to power up is unknown. No click could be heard when connecting this instrument to the battery, and no communication with the palm top was possible.

The two sensors affected by instrumental problems were not deployed.

- All times are known to be delayed with respect to the true GPS time by exactly one second until December 31, 2005 because of the GPS bug common to the GPS system used in Güralp CMG6TD instruments (early application of the leap second). Theoretically, they should be in sync with true GPS time again from January 1, 2006 because of the application of the leap second.

Deployment procedures

All stations were deployed on private land, with a nominal amount (Rp 125000, approx. £ 7.50, per month and station) paid to the owners for safekeeping. We follow the recommended SeisUK procedure for nonbed rock deployments: a sensor pit is dug out to about 60 cm depth (Fig. 7.5.2.1, left). The bottom of the pit is covered with sand, and the sensor, which is protected by a plastic bag, is placed on the sand layer, oriented, and levelled. Sand is backfilled to about half the height of the instrument, and the sensor pit then backfilled. The top of the instrument was 1520 cm below the surface. For all sensor pits, drainage channels were dug. All cable is buried or protected by flexible orange tubing. Solar panels and GPS antennae were mounted on poles or tree trunks (except LEWK where we use the power from the Caltech continuous GPS station). Where deemed necessary, livestock deterrents (fences or stakes) were erected (Fig. 7.5.2.1, right).

Fig. 7.5.2.1: Sensor pit and drainage channel at LABU (left). Solar panel pole and protective fence at DEHI (right).

- Sampling rate: 50 Hz, instrument response set to 30 sec mode (normal response).
- GPS cycle:1 hour. After achieving a lock, the GPS is powered down, but reactivated every 60 minutes to keep the time synchronized.
- WriteOnce FIFO mode, i.e., should the 3Gb internal memory buffer of the instruments become exhausted, no more data is going to be recorded.
- Instruments oriented along magnetic north. The magnetic declination at 2.6° N, 96.2° E on 18/12/2005: 0° 58' W
- (http://www.ngdc.noaa.gov/seg/geomag/magfield.shtml), i.e., the difference between grid and magnetic north is less than the estimated alignment precision.

See the station list and Map (Fig. 5.7.2.2) for details of Simeulue network stations.

Stationlist

Site	Lat (N)	Lon (E)	Elevation (m)	Date installed	Sensor ID	GPS ID	Power
LEWK	2°44.4147'	95°48.2460'		12.12.2005	6197	G4149	Piggy back on Caltech. 2 solar panels and 2 dry-cell batteries
LFAK	2°49.2083'	95°55.8539'	62	12.12.2005	6351	G4145	1 solar panel, 10 Ah dry-cell battery
LABU	2°25.3359'	96°21.7974'	38	13.12.2005	6119	G4151	2 solar panel, 10 Ah dry-cell battery
MAUD	2°28.0439'	96°13.0878'	14	14.12.2005	6043	G3858	1 solar panel, 10Ah dry-cell battery
PUTR	2°34.8536'	96°02.9258'	28	15.12.2005	6111	G3741	2 solar panel, 10Ah dry-cell battery
DEHI	2°32.8784'	96°06.6925'	15	15.12.2005	6091	G3811	2 solar panel, 10Ah dry-cell battery
BATU	2°20.6638'	96°24.5215'	14	16.12.2005	6041	G3887	2 solar panel, 10Ah dry-cell battery
LUAN	2°37.7052'	96°12.213'	-2	16.12.2005	6118	G3781	1 solar panel, 10Ah dry-cell battery

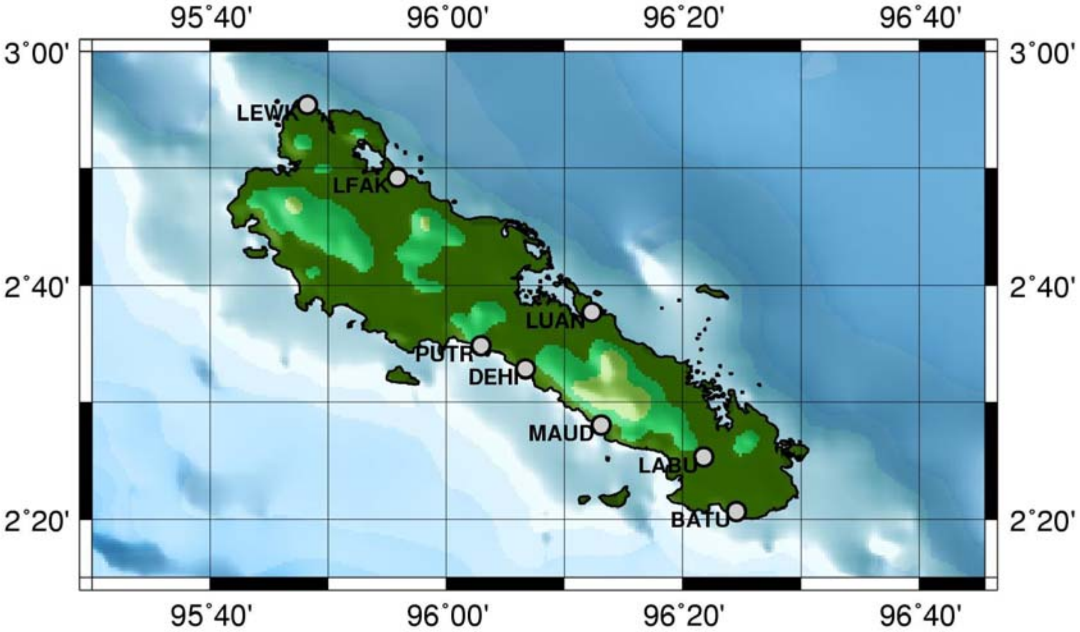


Fig. 7.5.2.2: *Location map of Simeulue land stations.*

7.5.3 Methane Sensors

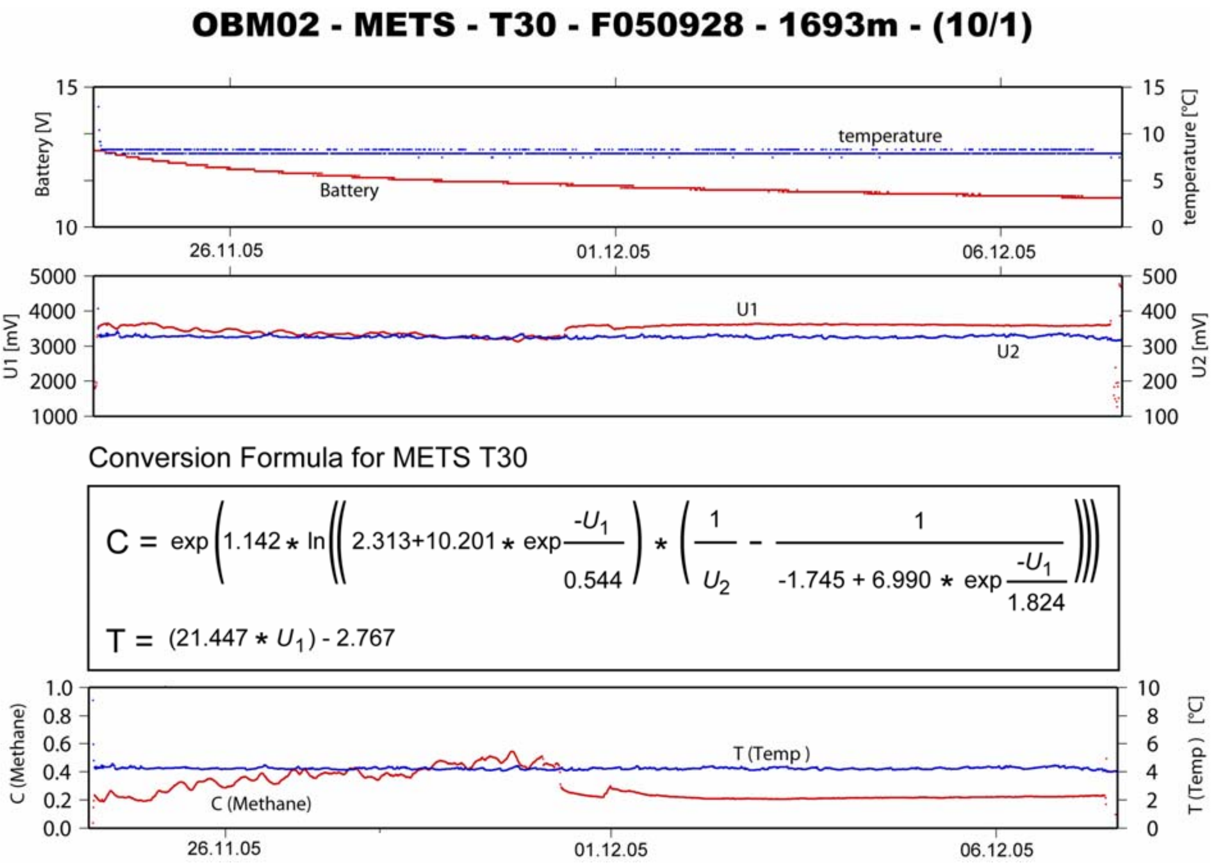
In addition to the OBS, five methane sensors were deployed during SO-186C to measure the methane output at the seafloor. The sensors were mounted to the conventional OBS-frame, now called OBM (Ocean Bottom Methane sensor), and deployed as a “packet” close to an OBS. After 45 days, during SO-186D, all sensors were recovered and the data was read out. Unfortunately 2 data loggers stopped recording after 10-15 days for a still unknown reason (see Table 7.5.3.1). The sensor T30, mounted on OBM02, showed strong corrosion damage (Fig. 7.5.3.1) and probably caused a battery breakdown.

Fig. 7.5.3.1: *Strongly corroded methane sensor T30, mounted on OBM02.*

Each sensor is calibrated under reference condition (25°C, 1 bar, 0 ‰ salinity) for a sensor-specific conversion formula. The output conversion formula describes the relation between the sensor signal output-voltage (U1 and U2) and the concentration of dissolved methane. U1 and U2, methane and temperature voltage, are converted to the methane concentration C (in µmol/l) and gas temperature T (in °C). Only one station, OBM02, provided accurate output values for 13 days, which could be converted to reasonable methane concentrations (Fig. 7.5.3.2). All other sensors failed to record proper output voltages (example OBM05, Fig. 7.5.3.3).

Station	S/N	Recorder	Next to	Data recorded	Remarks
OBM01	T31	B050928	OBS28	24.11.05 – 10.01.06	Negative voltage
OBM02	T30	F050928	OBS29	24.11.05 – 07.12.05	Corrosion
OBM03	T28	C050928	OBS31	24.11.05 – 10.01.06	
OBM04	T29	A000000	OBS32	24.11.05 – 10.01.06	
OBM05	T27	A050928	OBS33	23.11.05 – 04.12.05	Negative voltage

Table 7.5.3.1.: *Methane stations, sensors and recorders.*

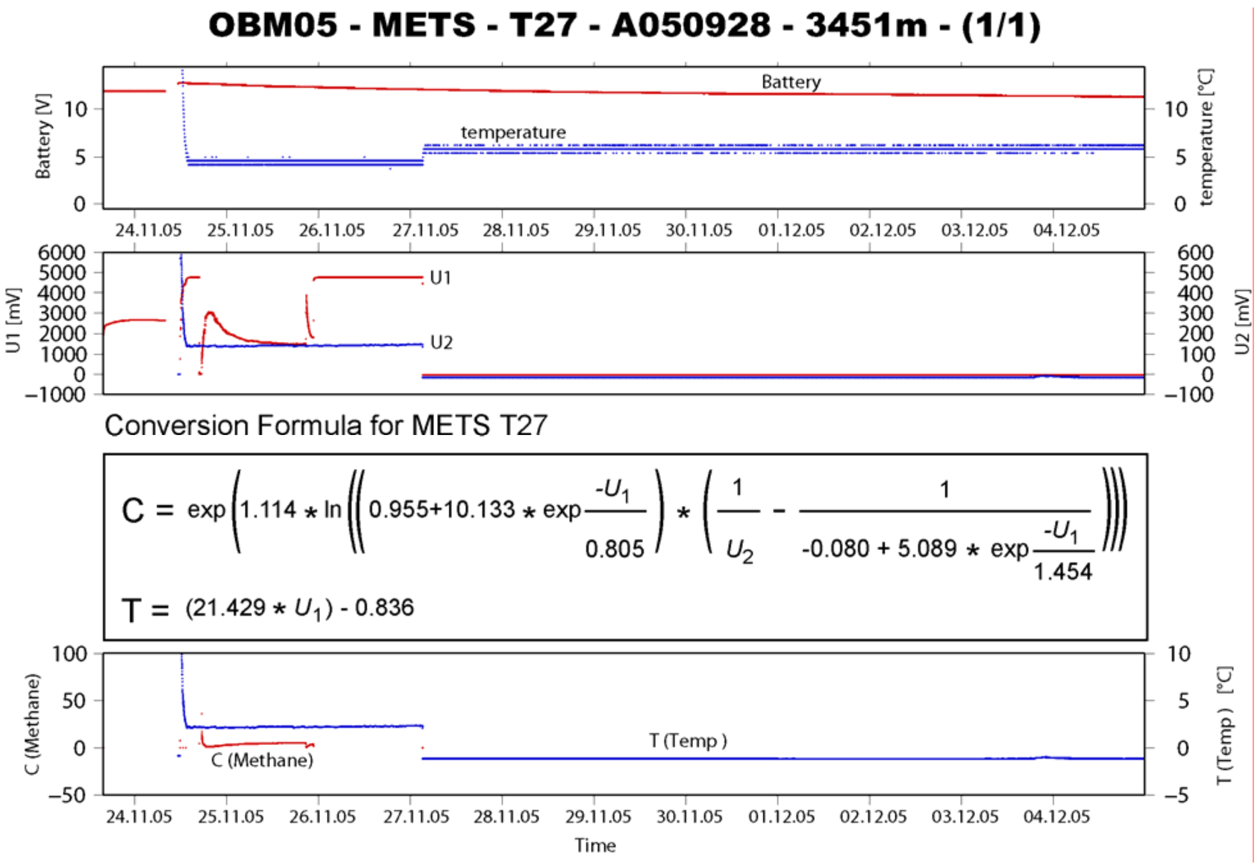


Conversion Formula for METS T30

$$C = \exp\left(1.142 * \ln\left(\left(2.313+10.201 * \exp\frac{-U_1}{0.544}\right) * \left(\frac{1}{U_2} - \frac{1}{-1.745 + 6.990 * \exp\frac{-U_1}{1.824}}\right)\right)\right)$$

$$T = (21.447 * U_1) - 2.767$$

Fig. 7.5.3.2: *Raw data (top), conversion formula and methane data (bottom), OBM02.*



Conversion Formula for METS T27

$$C = \exp\left(1.114 * \ln\left(\left(0.955+10.133 * \exp\frac{-U_1}{0.805}\right) * \left(\frac{1}{U_2} - \frac{1}{-0.080 + 5.089 * \exp\frac{-U_1}{1.454}}\right)\right)\right)$$

$$T = (21.429 * U_1) - 0.836$$

Fig. 7.5.3.3: *Raw data (top), conversion formula and methane data (bottom), OBM05.*

Conversion Formula

METS T27

$$C = \exp\left(1.114 * \ln\left(\left(0.955+10.133 * \exp\frac{-U_1}{0.805}\right) * \left(\frac{1}{U_2} - \frac{1}{-0.080 + 5.089 * \exp\frac{-U_1}{1.454}}\right)\right)\right)$$

$$T = (21.429 * U_1) - 0.836$$

METS T28

$$C = \exp\left(1.086 * \ln\left(\left(-0.156+14.417 * \exp\frac{-U_1}{0.901}\right) * \left(\frac{1}{U_2} - \frac{1}{-1.514 + 6.922 * \exp\frac{-U_1}{1.583}}\right)\right)\right)$$

$$T = (21.501 * U_1) - 0.796$$

METS T29

$$C = \exp\left(1.097 * \ln\left(\left(-0.752+10.568 * \exp\frac{-U_1}{1.058}\right) * \left(\frac{1}{U_2} - \frac{1}{-0.277 + 5.621 * \exp\frac{-U_1}{1.471}}\right)\right)\right)$$

$$T = (21.465 * U_1) - 0.794$$

METS T30

$$C = \exp\left(1.142 * \ln\left(\left(2.313+10.201 * \exp\frac{-U_1}{0.544}\right) * \left(\frac{1}{U_2} - \frac{1}{-1.745 + 6.990 * \exp\frac{-U_1}{1.824}}\right)\right)\right)$$

$$T = (21.447 * U_1) - 2.767$$

METS T31

$$C = \exp\left(1.075 * \ln\left(\left(2.654+13.835 * \exp\frac{-U_1}{0.746}\right) * \left(\frac{1}{U_2} - \frac{1}{-0.922 + 6.153 * \exp\frac{-U_1}{1.589}}\right)\right)\right)$$

$$T = (21.501 * U_1) - 2.215$$

7.6 Modem Trials Report

The performance of the acoustic communication of the two modem systems HAM.NODE (*develogic GmbH*) and S2C (EvoLogics GmbH) were tested during SO186C. The EvoLogics modems were also tested during SO186D. The surface modem from develogic suffered from an unrecoverable hardware failure during maintenance, not permitting any further tests on SO186D.

During SO186C several tests were conducted with bottom modems attached to the CTD-frame and lowered on the winch cable. The surface modems were deployed from the side of the vessel. Acoustic transmission was tested e.g. during descend by EvoLogics and during ascent by develogic or vice versa. At certain depth steps the winch was stopped tests were performed by both modem pairs alternatively.

In order to reduce the effect of ship noise a test with surface modems attached to the surface buoy was conducted with bottom modems lowered on the CTD frame. Only one modem at a time could be connected to the buoy unit starting with the EvoLogics modem. Due to bad weather conditions it was not possible to switch the buoy unit to the develogic modem.

The Evologics modems were attached and finally deployed to the TS1 buoy and the OBU1 at the southern location of TEWS1. The develogic modems were attached and deployed to the TS2 buoy and OBU2 at the northern location of TEWS2. Satellite communication was established to TS1 only, while TS2 remained silent until it was recovered during SO186D. Thus no information on the *in-situ* performance of the develogic modems attached to TS2 is available.

Summary of results from SO186-C

Communication tests from the ship to the CTD frame indicated that both modem operated down to a depth of 5400m but data transfer was erratic and unreliable.

The EvoLogics modems have been used for TEWS1 that was deployed at 5400m. Immediately after deployment, by using the WLAN connection to the buoy and in the following days by using the satellite link, communication could be established with the OBU exchanging "simple" commands (like "Ping"), but no real data could be retrieved because the modem connection would time out due to too many communication errors.

Summary of results from SO186-D

During SO186d the Develogic modems could not be used at all because of a hardware failure of the OBU modem that could not be repaired during the cruise.

The Evologics modems have been redeployed for buoy TS1 at location TEWS1B at a depth of 3740m. As before, "simple" commands could be exchanged easily but no real data communication is possible due to too many transmission errors. Shortly before the end of SO186d we were able to retrieve 1/8th of a Pressure History data set (100 out of 780 bytes) using the satellite link.

Test results for the HAM.NODE modems (develogic GmbH)

SO186c Trials report

The bidirectional communication of the two types of acoustic modem pairs was first tested in conjunction with an acoustic release test using the shipboard CTD-frame. The bottom modem components of the HAM.node modem from develogic GmbH and the S2C modem of Evologics GmbH was mounted to the frame. The surface modems have been deployed of the side of the ship to water depth between 5 and 55m. The CTD-frame was lowered and raised by the winch at 1m/s with communication testing while descending and ascending as well as during several stops in between. Three winch tests of this kind have been conducted on Nov 16, 19 and 23.

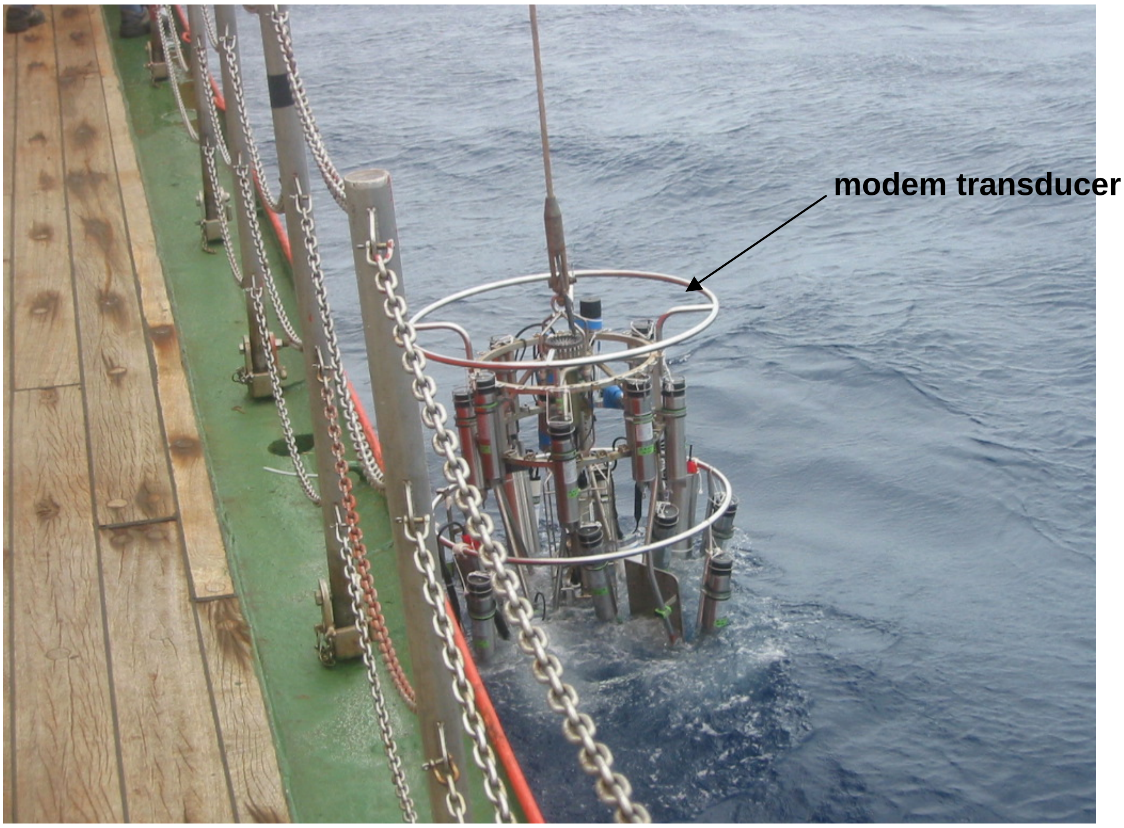


Fig. 7.6.1: Modem mounted to the CTD frame for communication test

Tests of the HAM.NODE (*develogic GmbH*) modem

Test 1: Nov 16/17, 2005

At fair weather conditions with 2-3bft wind and about 1m swell the surface modem was operated at 12m water depth and the CTD frame was lowered to 6000m (length of winch cable). The initial tests of both pairs of modems autonomous (without MTS-recorder) demonstrated the develogic modem with good communication up to 5600m depth on moving wire with both winch and ship thrust for position keeping operational. Up to the full depth of 6000m data communication was acknowledged as bad by the bottom modem, hence the communication was ok from bottom to surface, but data transmission from top to bottom suffered from data loss in the range from 5600m to 6000m.

Test 2: Nov 19, 2005

The second test was performed at moderate weather conditions with wind of 4-5bft and increased swell (1-2m), slightly worsening during tests. The bottom modem was connected with the MTS-recorder for this test. Ping requests, status reports were successfully sent and received up to the depth of 1600m during subsequent tests while the winch was operating. The data transmission error rate was 7%, i.e. 93% of the data packages have been received and acknowledged. The error rate could be further reduced to 2% by multiple transmission requests (max 3 retries). Tsunami alarm messages were received during descend at about 1200m depth. From one moment to the other the bottom modem stopped responding at about 1600m depth (Fig. 7.6.2). Later analysis of the pressure data from the recorder revealed that the pressure recording of the recorder stopped at the same time. This leads to the conclusion that the handshake communication between the MTS-recorder and the develogic modem ceased abruptly and stopped both the recorder and the modem from working. This problem was fixed by updating the MTS recorder with the latest firmware release, which had unfortunately not been done prior to the test.

```
402769:WKP;0000;CHK;YES
402789:RCV;0000;BEG;
415456:CRC ok
415475:RCV;0000;END;DATA
415560:SND;0001;ACK;BEG

PRESSURE_TASK  Tsunami
 \PI
recordi418084:SND;0001;;END
418503:RCV;0000;BEG;
4030956:CRC ok
030975:RCV;0000;END;DATA
031064:SND;0001;ACK;BEG
```

```
143419:WKP;0000;CHK;
pi
149258:WKP;0000;BEG;
159965:WKP;0000;END;
161354:SND;0001;BEG;
162550:SND;0001;END;
162569:RCV;0001;ACK;BEG
174466:ACK Wakeup TMOUT <- Timeout answer
174485:RCV;0001;ACK;END_NODATA
175918:SND;0001;BEG;
177117:SND;0001;END;
177136:RCV;0001;ACK;BEG
189092:ACK Wakeup TMOUT
```

Fig. 7.6.2: log file extract prior and after the handshake failure (Timeout)

Test with modem at the surface buoy

The test with a surface modem attached to the buoy could not be performed with the develogic modem. At deployment of the buoy the develogic and Evologics surface modems were attached, but only the Evologics modem was connected to the buoy unit. Later attempts to switch the connection to the develogic modem had to be abandoned due to bad weather conditions and subsequently due to lack of time.

Test 3: Nov 23, 2005

A third series of tests with the CTD frame and the surface modem was deployed from the side of the ship at moderate weather conditions. Two descents to 3100m and 3650m were performed. During the first descent the communication was established up to 2600m depth, deteriorating with increasing depth. No answer was received at full depth and data transmission was rather sporadically than reliable.

After recovery the bottom modem configuration was changed for the second trial increasing the carrier frequency.

The second trial significantly improved the success rate of data transmission at greater depth. The pressure history of the data recorder as well as the status log of the recorder was ordered and received repeatedly. A log extract of the pressure history retrieved at 3200m is shown in Fig. 7.6.5, however the analysis of the data validity might be difficult due to the coded binary compression of the pressure history data.

During this test the same data packets had been received repeatedly from the bottom modem several times (Fig 7.6.3). This indicates that the data was sent, but the acknowledgement signal was not received by the bottom modem which then resends the data. This affects the order of data packets received and large overhead of multiple send data. This issue was addressed with software modifications to include adjustable sending parameters to compensate the signal level automatically in this case. Also data packet identification, history and sorting was added to avoid the multiple and unsorted delivery of data packages.

```
084181:SND;0001;;END
084601:RCV;0000;BEG;
094600:RCV;0000;END;NO_DATA
094690:WKP;0000;CHK;
095373:AMP;0010;;
095392:WKP;0000;CHK;NO
st

       <-   request status with st
098372:WKP;0000;BEG;
109079:WKP;0000;END;
109098:LAST
110489:SND;0002;BEG;
111689:SND;0002;END;
111708:RCV;0002;ACK;BEG
116626:CRC ok
116645:RCV;0002;ACK;END_NODA
TA
116729:LAST
118093:SND;0002;BEG;
119295:SND;0002;END;
119314:RCV;0002;ACK;BEG
124161:CRC ok
124180:LAT;1108;;
124199:SWT;0157;;
124220:RCV;0002;ACK;END_OK
124302:WKP;0000;CHK;
```

```
137703:CRC ok
137722:RCV;0000;END;DATA
137807:SND;0001;ACK;BEG


                          <-
Status answer  begins (Date &
Unit, etc)
Date & Unit  23.11.2005
05:2139827:SND;0001;;END
140246:RCV;0000;BEG;
142366:CRC ok
142385:RCV;0000;END;DATA
142474:SND;0001;ACK;BEG


                          <-
Status is resend due to missing or bad
ACK
Date & Unit  23.11.2005
05:2144487:SND;0001;;END
144906:RCV;0000;BEG;
149834:CRC ok
149853:RCV;0000;END;DATA
149943:SND;0001;ACK;BEG

Date & Unit  23.11.2005
05:2151956:SND;0001;;END
152375:RCV;0000;BEG;
156386:CRC ok
156405:RCV;0000;END;DATA
156493:SND;0001;ACK;BEG
```

```
171053:RCV;0000;BEG;
173230:CRC ok
173249:RCV;0000;END;DATA
173335:SND;0002;ACK;BEG
6:12  050807
Synchronized
22175356:SND;0002;;END
175775:RCV;0000;BEG;
180648:CRC ok
180668:RCV;0000;END;DATA
180751:SND;0003;ACK;BEG
.11.2005 05:43:00
Channels
182772:SND;0003;;END
183191:RCV;0000;BEG;
185312:CRC ok
185331:RCV;0000;END;DATA
185417:SND;0003;ACK;BEG
.11.2005 05:43:00
Channels
187438:SND;0003;;END
187857:RCV;0000;BEG;
192731:CRC ok
192751:RCV;0000;END;DATA
192840:SND;0004;ACK;BEG
   all
Sampling     50 Sps,
1194852:SND;0004;;END
195271:RCV;0000;BEG;
197342:CRC ok
```

Fig. 7.6.3: Extract from logfile: Nov 23 2005
This log entry shows that the status information from the bottom unit was resent several times, indicating, that the acknowledged received signal from the surface modem was not received by the bottom modem. Solution: Software modification to increase the signal level of the surface modem for sending the acknowledge command as well as the packet identification and history with sorting algorithm to ensure that packets are only delivered once was added for the SO186-1D test cruise.

Deployment of TS2:

The surface modem was thoroughly tested and in good working condition when it was attached to and deployed with the buoy TS2 on Nov 23. Unfortunately the satellite link to the buoy could not be established and subsequently the contact between the bottom modem of the OBU and the surface modem at the buoy could not be checked.

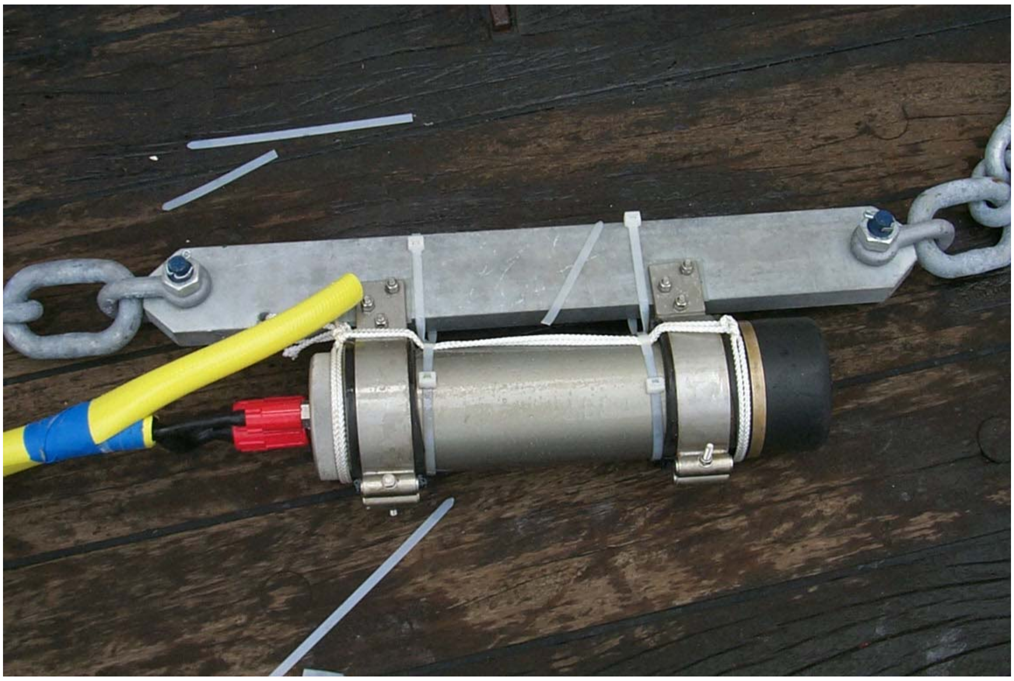


Fig. 7.6.4: Develogic modem attached to anchor chain

Key results from the test series are:

- Pressure history data and status reports could be transmitted repeatedly in a depth range up to ~ 3600m. Data transmission deteriorated and remained unreliable at greater depth during the first tests. Modem communication (pings) was established to depth exceeding 5600m. However data transmission to depth exceeding 3600m must be further tested and it is still unclear whether the parameter optimization could enhance the data transmission at greater depth.
- Tests of communication under *in-situ* conditions between the buoy and the OBU could not be performed due to bad weather and missing satellite links during this cruise. The high-accuracy doppler correction remains to be tested in these conditions.

```
1484724:AMP;0010;;
1484743:WKP;0000;CHK;NO
1489768:WKP;0000;CHK;
1490454:AMP;0010;;
1490473:WKP;0000;CHK;NO
pi
1494742:WKP;0000;BEG;
1505449:WKP;0000;END;
1505468:LAST
1506846:SND;0001;BEG;
1508043:SND;0001;END;
1508062:RCV;0001;ACK;BEG
1514617:CRC ok
1514636:LAT;1964;;
1514656:SWT;0152;;
1514676:RCV;0001;ACK;END_OK
1514759:WKP;0000;CHK;
1515442:AMP;0009;;
1515461:WKP;0000;CHK;YES
1515481:RCV;0000;BEG;
1527749:CRC ok
1527768:RCV;0000;END;DATA
1527851:SND;0001;ACK;BEG
 \PI
recording
 \TA
0g,U1529872:SND;0001;;END
1530291:RCV;0000;BEG;
1532561:CRC ok
1532580:RCV;0000;END;DATA
1532668:SND;0001;ACK;BEG
 \PI
recording
 \TA
0g,U1534681:SND;0001;;END
1535100:RCV;0000;BEG;
1536855:CRC ok
1536874:RCV;0000;END;DATA
1536956:SND;0001;ACK;BEG
 \PI
recording
 \TA
0g,U1538976:SND;0001;;END
1539395:RCV;0000;BEG;
1540652:CRC ok
1540671:RCV;0000;END;DATA
1540758:SND;0001;ACK;BEG
 \PI
recording
 \TA
0g,U1542772:SND;0001;;END
1543191:RCV;0000;BEG;
1545910:CRC ok
1545929:RCV;0000;END;DATA
1546015:SND;0001;ACK;BEG
 \PI
recording
 \TA
0g,U1548035:SND;0001;;END
1548454:RCV;0000;BEG;
1558454:RCV;0000;END;NO_DATA
1558543:WKP;0000;CHK;
1559226:AMP;0010;;
1559245:WKP;0000;CHK;NO
1564270:WKP;0000;CHK;
1564956:AMP;0010;;
1564975:WKP;0000;CHK;NO
1570000:WKP;0000;CHK;
1570687:AMP;0010;;
1570706:WKP;0000;CHK;NO
pd
1576263:WKP;0000;BEG;
1586971:WKP;0000;END;
1586990:LAST
1588379:SND;0002;BEG;
1589573:SND;0002;END;
1593402:RCV;0002;ACK;BEG
1596053:CRC ok
1596072:RCV;0002;ACK;END_NODATA
1596154:LAST
1597524:SND;0002;BEG;
1598720:SND;0002;END;
1602609:RCV;0002;ACK;BEG
1605157:CRC ok
1605177:RCV;0002;ACK;END_NODATA
1605265:LAST
1606633:SND;0002;BEG;
1607829:SND;0002;END;
1611718:RCV;0002;ACK;BEG
1614269:CRC ok
1614288:RCV;0002;ACK;END_NODATA
1614373:LAST
1615741:SND;0002;BEG;
1616938:SND;0002;END;
1620827:RCV;0002;ACK;BEG
1623379:CRC ok
1623398:LAT;1898;;
1623417:SWT;0152;;
```

```
1623437:RCV;0002;ACK;END_OK
1623523:WKP;0000;CHK;
1624205:AMP;0009;;
1624224:WKP;0000;CHK;YES
1624244:RCV;0000;BEG;
1636927:CRC ok
1636947:RCV;0000;END;DATA
1637036:SND;0001;ACK;BEG
 \PD
 T0g VEV?EQäEN5EJàEF,EB
1639049:SND;0001;;END
1639468:RCV;0000;BEG;
1641683:CRC ok
1641702:RCV;0000;END;DATA
1641791:SND;0001;ACK;BEG
 \PD
 T0g VEV?EQäEN5EJàEF,EB
1643804:SND;0001;;END
1644223:RCV;0000;BEG;
1645833:CRC bad
1645852:RCV;0000;END;DATA
1645936:SND;26949;NCK;BEG
1647958:SND;26949;;END
1648377:RCV;0000;BEG;
1650645:CRC ok
1650664:RCV;0000;END;DATA
1650752:SND;0002;ACK;BEG
E> E;.E*±E..DËeD…ŠD><Cø
C²*Ckm1652765:SND;0002;;END
1653184:RCV;0000;BEG;
1654738:CRC ok
1654757:RCV;0000;END;DATA
1654844:SND;0002;ACK;BEG
E> E;.E*±E..DËeD…ŠD><Cø
C²*Ckm1656864:SND;0002;;END
1657283:RCV;0000;BEG;
1659551:CRC ok
1659570:RCV;0000;END;DATA
1659659:SND;0003;ACK;BEG
C&—
Bà B›†BVïB  AÌŒAŸ®Au»A4]@ï#1661671:
SND;0003;;END
1662090:RCV;0000;BEG;
1663641:CRC bad
1663660:RCV;0000;END;DATA
1663750:SND;33069;NCK;BEG
1665762:SND;33069;;END
1666181:RCV;0000;BEG;
1668444:CRC ok
1668463:RCV;0000;END;DATA
1668553:SND;0004;ACK;BEG
@©³@d›@J?Úý?•Ô?Pl?
 >Ç->ƒ&>>ê1670565:SND;0004;;END
1670984:RCV;0000;BEG;
1672472:CRC ok
1672491:RCV;0000;END;DATA
1672580:SND;0004;ACK;BEG
@©³@d›@J?Úý?•Ô?Pl?
 >Ç->ƒ&>>ê1674593:SND;0004;;END
1675012:RCV;0000;BEG;
1677325:CRC ok
1677344:RCV;0000;END;DATA
1677427:SND;0005;ACK;BEG
=û==¶ =r!=-
˜= 4<ÚÃ<šÇ<YÅ< ÞÞ;×F1679448:SND;000
5;;END
1679867:RCV;0000;BEG;
1681359:CRC ok
1681378:RCV;0000;END;DATA
1681463:SND;0005;ACK;BEG
=û==¶ =r!=-
˜= 4<ÚÃ<šÇ<YÅ< ÞÞ;×F1683483:SND;000
5;;END
1683902:RCV;0000;BEG;
1686216:CRC ok
1686235:RCV;0000;END;DATA
1686321:SND;0006;ACK;BEG
;•V;T“; ”:Ð>:  :JU: Ü9Æ69ƒi9A|16883
42:SND;0006;;END
1688761:RCV;0000;BEG;
1690255:CRC ok
1690274:RCV;0000;END;DATA
1690364:SND;0006;ACK;BEG
;•V;T“; ”:Ð>:  :JU: Ü9Æ69ƒi9A|16923
76:SND;0006;;END
1692795:RCV;0000;BEG;
1695052:CRC ok
1695072:RCV;0000;END;DATA
1695160:SND;0007;ACK;BEG
8þÖ8»q8x68Jö8%37ê¼7¥œ7d27!µ6ß416971
73:SND;0007;;END
1697592:RCV;0000;BEG;
1699144:CRC bad
1699163:RCV;0000;END;DATA
1699252:SND;20836;NCK;BEG
1701265:SND;20836;;END
1701684:RCV;0000;BEG;
1711710:CRC ok
```

```
1711730:RCV;0000;END;DATA
1711814:SND;0007;ACK;BEG
8þÖ8»q8x68Jö8%37ê¼7¥œ7d27!µ6ß4171383
5:SND;0007;;END
1714254:RCV;0000;BEG;
1720603:CRC bad
1720622:RCV;0000;END;DATA
1720711:SND;0007;NCK;BEG
1722724:SND;0007;;END
1723144:RCV;0000;BEG;
1733174:CRC ok
1733193:RCV;0000;END;DATA
1733281:SND;0007;ACK;BEG
8þÖ8»q8x68Jö8%37ê¼7¥œ7d27!µ6ß4173529
4:SND;0007;;END
1735713:RCV;0000;BEG;
1742058:CRC ok
1742078:RCV;0000;END;DATA
1742162:SND;0007;ACK;BEG
8þÖ8»q8x68Jö8%37ê¼7¥œ7d27!µ6ß4174418
2:SND;0007;;END
1744601:RCV;0000;BEG;
1754601:RCV;0000;END;NO_DATA
1754691:WKP;0000;CHK;
1755373:AMP;0010;;
1755392:WKP;0000;CHK;NO
1760417:WKP;0000;CHK;
1761103:AMP;0010;;
1761122:WKP;0000;CHK;NO
1766147:WKP;0000;CHK;
s1766832:AMP;0010;;
1766851:WKP;0000;CHK;NO
t
1767831:WKP;0000;BEG;
1778538:WKP;0000;END;
1778557:LAST
1779943:SND;0003;BEG;
1781140:SND;0003;END;
1784839:RCV;0003;ACK;BEG
1788845:RCV;0003;ACK;END_NODATA
1788933:LAST
1790300:SND;0003;BEG;
1791498:SND;0003;END;
1795257:RCV;0003;ACK;BEG
1799265:RCV;0003;ACK;END_NODATA
1799354:LAST
1800720:SND;0003;BEG;
1801920:SND;0003;END;
1805679:RCV;0003;ACK;BEG
1809686:ACK Wakeup TMOUT
1809705:RCV;0003;ACK;END_NODATA
1809792:LAST
1811157:SND;0003;BEG;
1812357:SND;0003;END;
1816117:RCV;0003;ACK;BEG
1820124:ACK Wakeup TMOUT
1820143:RCV;0003;ACK;END_NODATA
1820230:LAST
1821593:SND;0003;BEG;
1822787:SND;0003;END;
1826556:RCV;0003;ACK;BEG
1830561:ACK Wakeup TMOUT
1830580:RCV;0003;ACK;END_NODATA
1830667:LAST
1832037:SND;0003;BEG;
1833231:SND;0003;END;
1836990:RCV;0003;ACK;BEG
1840999:ACK Wakeup TMOUT
1841018:RCV;0003;ACK;END_NODATA
ABORTED
1841044:DSP RESET!
000114:
*** START ***

000139:Wakeup cause: RESET
000172:WKP;0000;CHK;
000821:AMP;0010;;
000840:WKP;0000;CHK;NO
pi
003976:WKP;0000;BEG;
014683:WKP;0000;END;
014702:LAST
016076:SND;0001;BEG;
017275:SND;0001;END;
017294:RCV;0001;ACK;BEG
020469:CRC bad
020488:RCV;0001;ACK;END_NODATA
020571:LAST
021931:SND;0001;BEG;
023127:SND;0001;END;
023146:RCV;0001;ACK;BEG
029218:CRC ok
029237:LAT;1720;;
029257:SWT;0157;;
029277:RCV;0001;ACK;END_OK
029363:WKP;0000;CHK;
030045:AMP;0009;;
030064:WKP;0000;CHK;YES
```

Fig 7.6.5a: Log file extract with transmission of pressure history and status reports

```
030084:RCV;0000;BEG;
042346:CRC ok
042365:RCV;0000;END;DATA
042454:SND;0001;ACK;BEG
 \PI
recording
044466:SND;0001;;END
044885:RCV;0000;BEG;
054885:RCV;0000;END;NO_DATA
054968:WKP;0000;CHK;
055651:AMP;0010;;
055670:WKP;0000;CHK;NO
060695:WKP;0000;CHK;
061381:AMP;0010;;
061400:WKP;0000;CHK;NO
st
063692:WKP;0000;BEG;
074399:WKP;0000;END;
074418:LAST
075815:SND;0002;BEG;
077009:SND;0002;END;
080348:RCV;0002;ACK;BEG
083053:CRC ok
083072:RCV;0002;ACK;END_NODATA
083160:LAST
084530:SND;0002;BEG;
085725:SND;0002;END;
089124:RCV;0002;ACK;BEG
091770:CRC ok
091790:LAT;1701;;
091810:SWT;0150;;
091830:RCV;0002;ACK;END_OK
091917:WKP;0000;CHK;
092600:AMP;0010;;
092619:WKP;0000;CHK;NO
097644:WKP;0000;CHK;
098330:AMP;0009;;
098349:WKP;0000;CHK;YES
098368:RCV;0000;BEG;
105542:CRC bad
105561:RCV;0000;END;DATA
105648:SND;0001;NCK;BEG
107661:SND;0001;;END
108080:RCV;0000;BEG;
115442:CRC bad
115461:RCV;0000;END;DATA
115544:SND;0002;NCK;BEG
117564:SND;0002;;END
117983:RCV;0000;BEG;
125391:CRC ok
125411:RCV;0000;END;DATA
125496:SND;0003;ACK;BEG
.11.2005 05:43:00
Channels  127517:SND;0003;;END
127936:RCV;0000;BEG;
135398:CRC ok
135417:RCV;0000;END;DATA
135502:SND;0001;ACK;BEG

Date & Unit  23.11.2005
05:0137524:SND;0001;;END
137943:RCV;0000;BEG;
145352:CRC bad
145371:RCV;0000;END;DATA
145456:SND;0002;NCK;BEG
147477:SND;0002;;END
147896:RCV;0000;BEG;
155356:CRC ok
155375:RCV;0000;END;DATA
155462:SND;0004;ACK;BEG
   all
Sampling     50 Sps,
1157483:SND;0004;;END
157902:RCV;0000;BEG;
165261:CRC ok
165280:RCV;0000;END;DATA
165368:SND;0005;ACK;BEG
9 bits
Capacity     1052064
k167381:SND;0005;;END
167800:RCV;0000;BEG;
175214:CRC bad
175233:RCV;0000;END;DATA
175322:SND;0002;NCK;BEG
177336:SND;0002;;END
177755:RCV;0000;BEG;
185166:CRC bad
185185:RCV;0000;END;DATA
185277:SND;0004;NCK;BEG
187289:SND;0004;;END
187708:RCV;0000;BEG;
195121:CRC ok
195141:RCV;0000;END;DATA
195231:SND;0006;ACK;BEG
B total, 26351 kB recorded
St197243:SND;0006;;END
197662:RCV;0000;BEG;
205019:CRC ok
```

```
205039:RCV;0000;END;DATA
205122:SND;0002;ACK;BEG
1:13  050807
Synchronized
22207142:SND;0002;;END
207561:RCV;0000;BEG;
214973:CRC ok
214992:RCV;0000;END;DATA
215076:SND;0004;ACK;BEG
   all
Sampling     50 Sps,
1217097:SND;0004;;END
217516:RCV;0000;BEG;
224878:CRC bad
224897:RCV;0000;END;DATA
224984:SND;0007;NCK;BEG
226998:SND;0007;;END
227417:RCV;0000;BEG;
234824:CRC bad
234843:RCV;0000;END;DATA
234930:SND;0008;NCK;BEG
236944:SND;0008;;END
237363:RCV;0000;BEG;
244774:CRC bad
244793:RCV;0000;END;DATA
244883:SND;0008;NCK;BEG
246896:SND;0008;;END
247315:RCV;0000;BEG;
254725:CRC bad
254744:RCV;0000;END;DATA
254827:SND;0013;NCK;BEG
256848:SND;0013;;END
257267:RCV;0000;BEG;
264679:CRC bad
264699:RCV;0000;END;DATA
264789:SND;18184;NCK;BEG
266801:SND;18184;;END
267220:RCV;0000;BEG;
274635:CRC ok
274655:RCV;0000;END;DATA
274741:SND;0009;ACK;BEG
  After 1 hours
Status      276761:SND;0009;;END
277180:RCV;0000;BEG;
284538:CRC ok
284557:RCV;0000;END;DATA
284640:SND;0007;ACK;BEG
art         22.11.2005
05:51:43286661:SND;0007;;END
287080:RCV;0000;BEG;
294485:CRC ok
294504:RCV;0000;END;DATA
294593:SND;0008;ACK;BEG

Levelling    Every 1 hours
296606:SND;0008;;END
297025:RCV;0000;BEG;
304433:CRC ok
304452:RCV;0000;END;DATA
304539:SND;0009;ACK;BEG
  After 1 hours
Status      306560:SND;0009;;END
306979:RCV;0000;BEG;
314385:CRC bad
314404:RCV;0000;END;DATA
314492:SND;0010;NCK;BEG
316505:SND;0010;;END
316924:RCV;0000;BEG;
324335:CRC bad
324354:RCV;0000;END;DATA
324438:SND;0011;NCK;BEG
326459:SND;0011;;END
326878:RCV;0000;BEG;
334231:CRC ok
334250:RCV;0000;END;DATA
334337:SND;0012;ACK;BEG

Comment   336358:SND;0012;;END
336777:RCV;0000;BEG;
344188:CRC ok
344208:RCV;0000;END;DATA
344298:SND;0010;ACK;BEG
  recording
Pressure
2642346310:SND;0010;;END
346729:RCV;0000;BEG;
354094:CRC bad
354113:RCV;0000;END;DATA
354198:SND;14347;NCK;BEG
356218:SND;14347;;END
356637:RCV;0000;BEG;
364051:CRC ok
364070:RCV;0000;END;DATA
364159:SND;0013;ACK;BEG
   Modemtest Anfahrt TEWS 02
366173:SND;0013;;END
366592:RCV;0000;BEG;
373900:CRC bad
```

```
373919:RCV;0000;END;DATA
374007:SND;0014;NCK;BEG
376019:SND;0014;;END
376438:RCV;0000;BEG;
383849:CRC ok
383868:RCV;0000;END;DATA
383951:SND;0011;ACK;BEG
70.7 mbar
Experiment   TEWS
385971:SND;0011;;END
386390:RCV;0000;BEG;
393855:CRC bad
393874:RCV;0000;END;DATA
393958:SND;0006;NCK;BEG
395979:SND;0006;;END
396398:RCV;0000;BEG;
403752:CRC bad
403771:RCV;0000;END;DATA
403857:SND;0014;NCK;BEG
405878:SND;0014;;END
406297:RCV;0000;BEG;
413707:CRC bad
413726:RCV;0000;END;DATA
413817:SND;0015;NCK;BEG
415830:SND;0015;;END
416249:RCV;0000;BEG;
423659:CRC bad
423678:RCV;0000;END;DATA
423763:SND;0014;NCK;BEG
425784:SND;0014;;END
426203:RCV;0000;BEG;
433561:CRC bad
433580:RCV;0000;END;DATA
433663:SND;52239;NCK;BEG
435684:SND;52239;;END
436103:RCV;0000;BEG;
443510:CRC bad
443529:RCV;0000;END;DATA
443613:SND;33537;NCK;BEG
445634:SND;33537;;END
446053:RCV;0000;BEG;
453413:CRC bad
453432:RCV;0000;END;DATA
453520:SND;0127;NCK;BEG
455532:SND;0127;;END
455951:RCV;0000;BEG;
463366:CRC bad
463386:RCV;0000;END;DATA
463474:SND;0014;NCK;BEG
465486:SND;0014;;END
465905:RCV;0000;BEG;
473265:CRC bad
473284:RCV;0000;END;DATA
473374:SND;0015;NCK;BEG
475387:SND;0015;;END
475806:RCV;0000;BEG;
485806:RCV;0000;END;NO_DATA
485895:WKP;0000;CHK;
486578:AMP;0007;;
486597:WKP;0000;CHK;NO
491623:WKP;0000;CHK;
492307:AMP;0007;;
492326:WKP;0000;CHK;NO
497351:WKP;0000;CHK;
498037:AMP;0007;;
498056:WKP;0000;CHK;NO
503081:WKP;0000;CHK;
503767:AMP;0007;;
503786:WKP;0000;CHK;NO
508811:WKP;0000;CHK;
```

Fig 7.6.5b: Log file extract with transmission of pressure history and status reports (cont'd.)

SO186d Trials report

The HAM.node modems consisting of a surface unit (OM) and an ocean bottom unit (BM) were sited at the northerly buoy position on TWS2 respective OBU02.

In the course of cruise SO186d from 5 to 20 of January 2006 the modems were recovered for maintenance purposes. The outward condition after 50 days of exposure to the tropical waters of the area showed only little fouling on the housing and no fouling on the transducers (Figure 7.6.6).

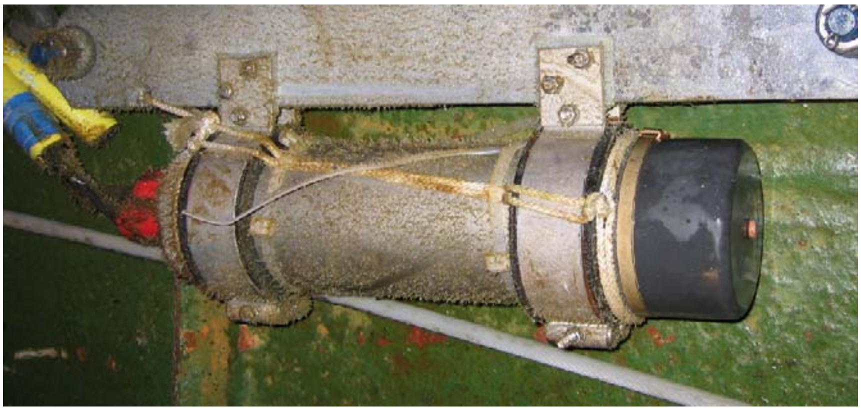


Fig. 7.6.6: Fouling condition of the surface modem

The hose that had been applied in the course of SO186c to enhance robustness against mechanical damage to the modem cables had separated almost completely and was therefore without function, although there was no damage found at the cables.

Unfortunately the malfunctioning of the satellite link to the buoy prevented any check on modem functionality. Furthermore the power supply to the OM remained switched off. This led to a premature drainage of the backing lithium battery, which was completely emptied and the modem was therefore found to be not functional. Meanwhile the modem software was modified to prevent repeated modem startup when the buoy unit was not in operation. Thus the backup power supply should now be lasting for > 4 years without external power supply from the buoy.

After recovery of the OBU02 with the BM it was asserted that the working voltage of the power supply battery has dropped to 17V. It turned out that the modem was triggered to send for about 8 hours due to a permanently incoming alarm signal. This caused the premature emptying of the batteries. Nevertheless the BM was found fully functional and ready for operation.

After maintaining both OM and BM a hardware failure occurred to the OM that could not be corrected in the available time. The BM was fully functional.

For the purpose of testing the RS422 interface functionality OM to buoy the BM was converted to OM. The tests showed up complete fulfillment of interface specifications and functionality of the OM. There were no further tests concerning transmission between OM and BM.

Key results from the deployment are:

- The power supply for the bottom modem is capable to supply power for a long period transmission (8h). Data transmission could be maintained despite a significant drop in supply voltage. However, further measures to reduce power consumption during stand-by mode could help to increase the servicing intervals.
- The cable connection between the buoy and the OM attached to its anchor chain is vulnerable to mechanical damage. Cable protection must be enhanced.
- Power supply backup to the OM was significantly increased to sustain functionality over periods without external connection.
- Fouling on the transducer membrane was not severe and should not harm the data transmission substantially.

Conclusions

The HAM.node modem was thoroughly tested and improved during the test cruise SO186-1c and proved the functionality to transmit and receiver pressure history data in the vertical channel crossing the strong thermocline layers in the Indian Ocean offshore Sumatra. Problems with multiple and unordered delivery of the transmitted data have been resolved for future tests.

Unfortunately the operability of the communication at in-situ conditions from the OBU to the surface buoy could not yet be verified due to hardware failures first in the buoy communication and secondly in the surface modem cable and hardware after recovery on SO186-1d.

However, the functionality of transmitting pressure history data could be demonstrated on the wire frame and we are confident that the Doppler correction algorithm is well suited to compensate all buoy movements; this ultimate test is of great importance. We refrained from computing any packet transmission statistics since we had no means to validate the transmitted pressure history data due to its binary coded compression and uncertainty of packet sorting in the previous software. While transmission rates of single data packages are satisfactory, it is most important that full data integrity is preserved during transmission. We are confident that the modified HAM.node modem software and hardware is fully capable to provide loss-free data transmission, yet the proof as well as the quantitative transfer rate testing is still outstanding for the in-situ condition.

Further improvements are envisioned regarding the power consumption. To date the backing power supply capacity of the OM has been adapted to last for about 4 years with current power requirements.

Further reduction of the standby and receive mode power consumption can be developed in the near future. This will further reduce the very low power consumption of the acoustic modem to allow much longer operation cycles.

Test results for the Sweep Spread Spectrum (S2C) Acoustic Modem (Evologics GmbH)

The task of EvoLogics' team has been the modification of the existing S2C underwater data telemetry systems to fit the requirements raised by TEWS project carried out by IFM-Geomar and GFZ. The main technical requirements were:

- to reach a relatively high bit rates along 6000m track;
- to keep the transmission power at moderate level;
- to minimize modem's power consumption in standby mode;
- to guarantee error-free user data delivery;
- to provide transparent RS232 interfacing at the ocean-bottom station, and transparent (modified) RS422 interfacing at the surface station;
- Primary power supply for both modem units was defined by customer as 24VDC (nominal).

Our main development efforts primarily focused on the problems involved in a vertical hydroacoustic communication in long-range vertical deep-water channels. As long as the reliability has the same priority as bit rate, the application of sweep spread carrier signals looks very useful in the given project. A new quality could be achieved by making the communication system self-adaptive. This means that the first contact sweeps are used to analyze the actual transmission properties of the hydro-acoustic channel (multipath structure etc.) and to adjust the signal structure accordingly in order to minimize possible inter-symbol interferences as well as to exploit the maximum transmission capacity of the channel. Special algorithms were developed to find the optimal solution for these contradicting requirements, to permanently watch the channel properties in the background of data transmission and to readjust the signal parameters, if necessary. The initial hand-shake as well as the frequently interposed sync- and / or acknowledgment signals ensure both stations are using the same parameter constellation. In practical multipath environment, the optimal opportunity will be selected automatically. In this way, S2C modems achieve the highest reliability physically possible. Simultaneously, the quality of the received signals was also improved. More sophisticated modulation methods were applied, hence the bit rate increased distinctly.

Although it may be tempting to advertise some of our extraordinary results, we would like to avoid any misunderstanding. Even the most intelligent approach cannot change the physics. Using advanced spread spectrum techniques, clever signal processing and making the whole telemetry adaptive is - for sure - the best way to get the maximum benefit from what the nature provides, but still one has to live with some uncertainties. From the technical point of view, we can say that in the present configuration our system is capable to transmit up to 6.5 kbps (good propagation). In sea trials (practical conditions), peak values up to 3-4 kbps could be achieved. In view of the practical oceanographic applications, however, we can only state that the bit rate will be the highest possible under the given circumstances.

SO-186C Trials results

Environmental conditions: Test area: Indian Ocean, equatorial waters in vicinity Sumatra. Ocean depth: 5000-6000 meters, wind 5-14 m/s. Measured water temperature profile and sound velocity profile are shown below.

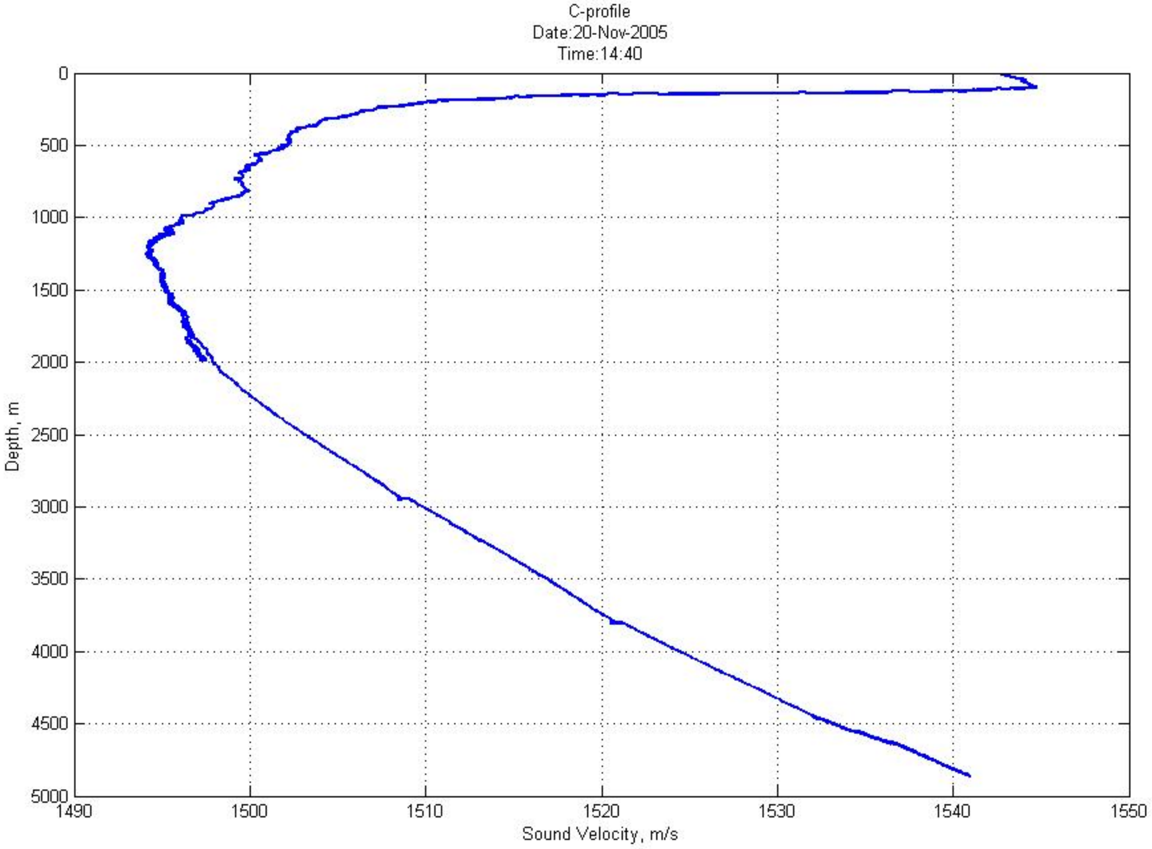


Fig. 7.6.7: Sound Velocity profile

The surface modem was placed into the water from the ship being at the depth of 7…15 m. The ship draught is 7 m.

It is clearly visible from Fig. 7.6.7 that the surface thermocline is situated at the depth of approx. 100 m. Consequently, the optimal surface modem position could be at the depths under this value, 150 m for instance – see Fig. 7.6.8. Placing the surface station under the thermocline, we can estimate much better quality of the incoming acoustic signals.

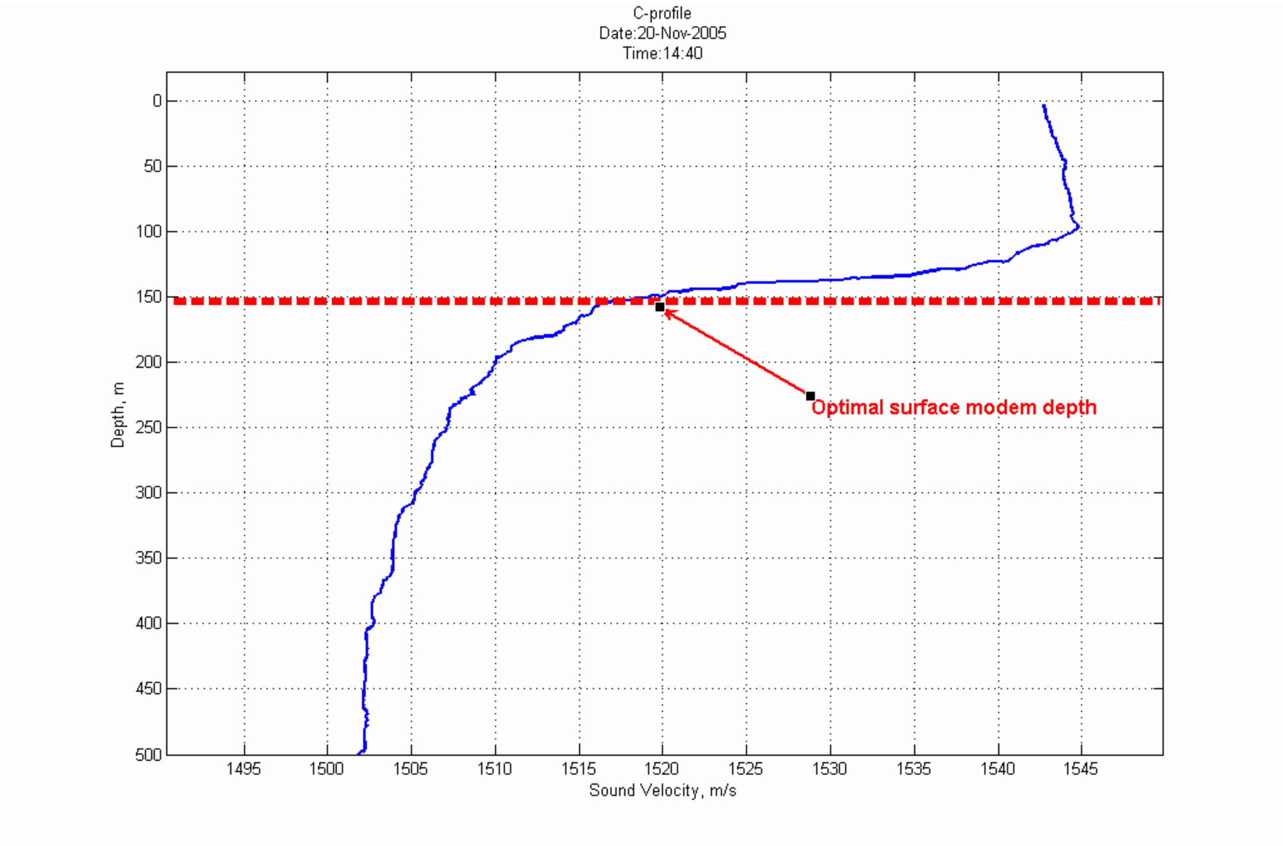


Fig. 7.6.8: Sound Velocity profile up to 500 m

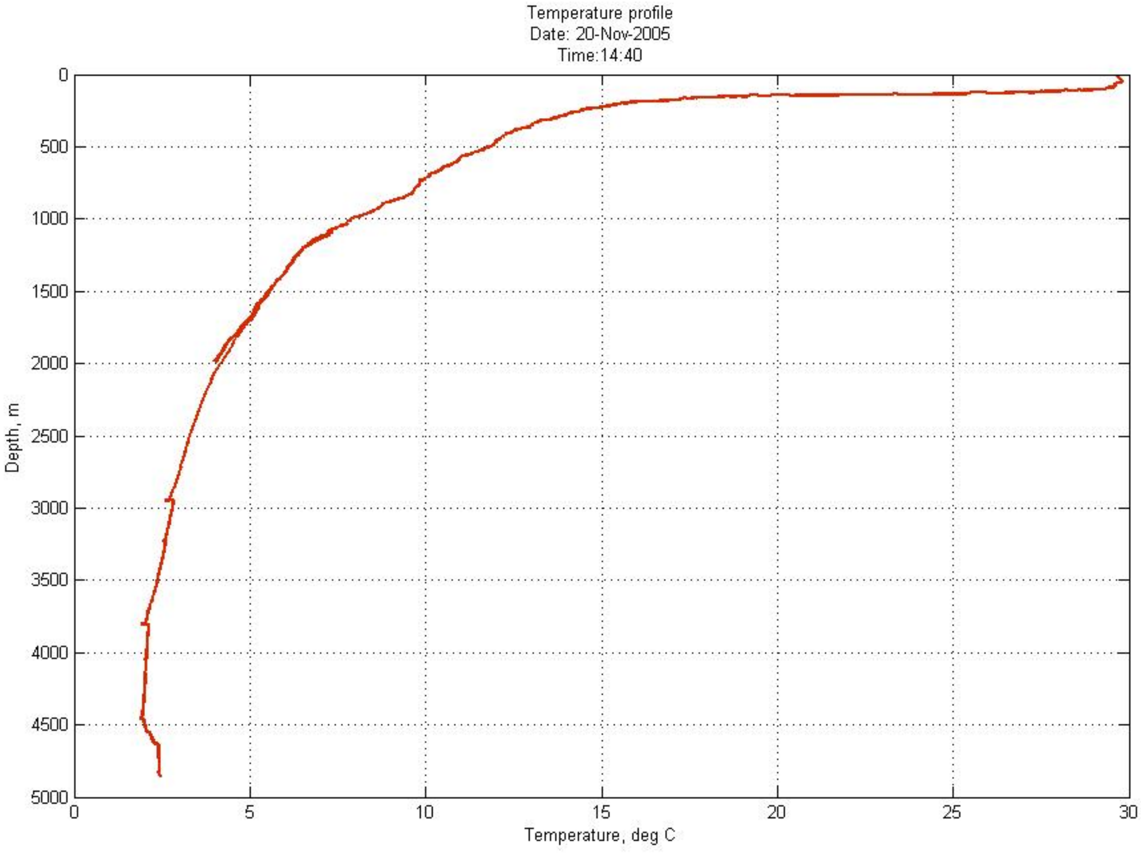


Fig. 7.6.9: Temperature profile

Although there was a good sound propagation in the vertical channel, the problem came from another side. Sometimes we had to deal with up to 8 very strong multipath arrivals. The multipath structure (measured on the surface station) showed a fast and strong fluctuation due to air-bubbled water, strong water flows and presence of multiple reflecting objects like waved sea surface, ship's bottom, etc. The fluctuation was much stronger than we had estimated. Another peculiarity of these experiments was that the surface modem's receiver was exposed by high-level broadband noise produced by ship mechanisms.

Determination of the maximum data rate at short distance:

Both modems were initially fixed vertically 200 m apart from each other. The standard MTS program was used for these tests, automatic S2C package mode (the data stream submitted by the host computer is automatically subdivided into data packages, the packages were FEC (Forward Error Correction) activated (this feature can be optionally switched off if not needed).

The link was stable. The measured nominal bit rate was between 3000 and 5000 bps, occasionally even up to 6000 bps (Note: *nominal bit rate* is a bit rate defined by the actual symbol length, no overhead like FEC or protocol delays are taken into account).

Communication range:

The S2C modem trials were carried out twice during SO-186C: 17.11.2005 and 19.11.2005/20.11.2005. After the first test (17.11.2005) the wrong modem's source level settings were detected. So, the first try was done under minimal possible output power. This software configuration error was fixed before the second test.

The dipping platform was diving at a speed of approx. 1 m/s down to the deep. An acoustic link was established permanently during submerging and during stops at ranges of 2000 m, 4000 m and 5600 m. The ocean depth was reported as 6000m. The measured nominal bit rate values and other link parameters were automatically logged by the surface modem during the trials. Depending on the actual signal structure permanently adjusted to the present multipath configuration, the bit rate fluctuated between 500 and 4000 bps (transmission of pings and other user data). Due to the self-adaptation feature of the S2C modems, the bit rate changes permanently during operation. The plots of the measured bit rates are shown below.

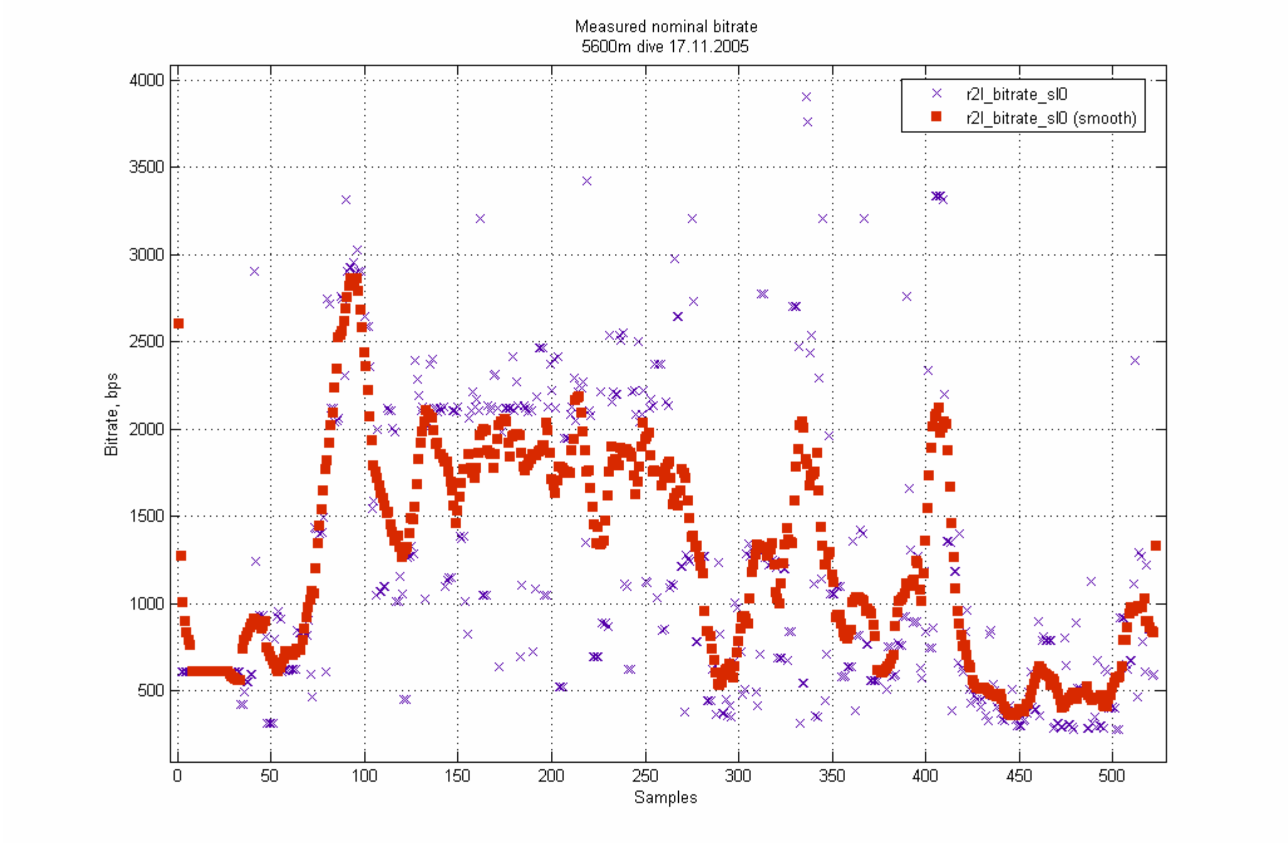


Fig. 7.6.10: Bit rates acquired during test 17.11.2005

Analysis of the log-file of 17.11.2005 has shown that there were 29 user data packets sent in direction from the surface modem to the dipping unit. The surface modem has delivered the incoming user data within 47 packets transmissions. 18 transmissions were quitted by NACK's (Not Acknowledged). That means that there were 61% successive transmissions from the whole amount of attempts.

Unfortunately it was not possible (during these tests) to analyze the log statistics at the dipping modem unit. But we have to remember that primarily the data flow is directed from the dipping modem unit up to the surface unit. The surface unit transmits only requests and service data.

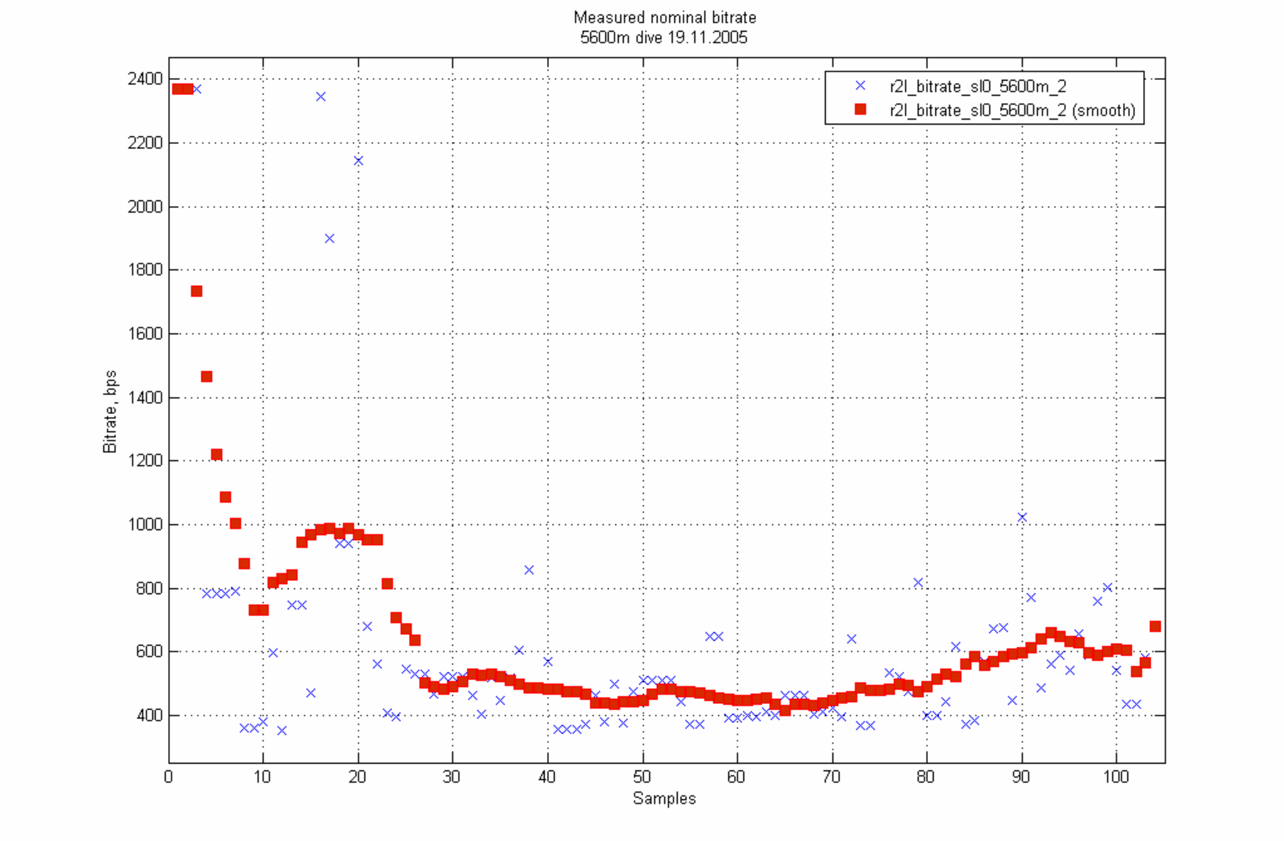


Fig. 7.6.11: Bit rates acquired during test 19.11.2005/20.11.2005

Analysis of the log-file from 19.11.2005 has shown that there were 46 user data packets sent in direction from the surface modem to the dipping unit. The surface modem has delivered the incoming user data within 103 packets transmissions. 57 transmissions were quitted by NACK's. That means that there were 44% successive transmissions out of the whole amount of attempts.

In addition to nominal bit rate measurements, the Signal Level and Signal Integrity parameters were measured. Corresponding plots are shown below.

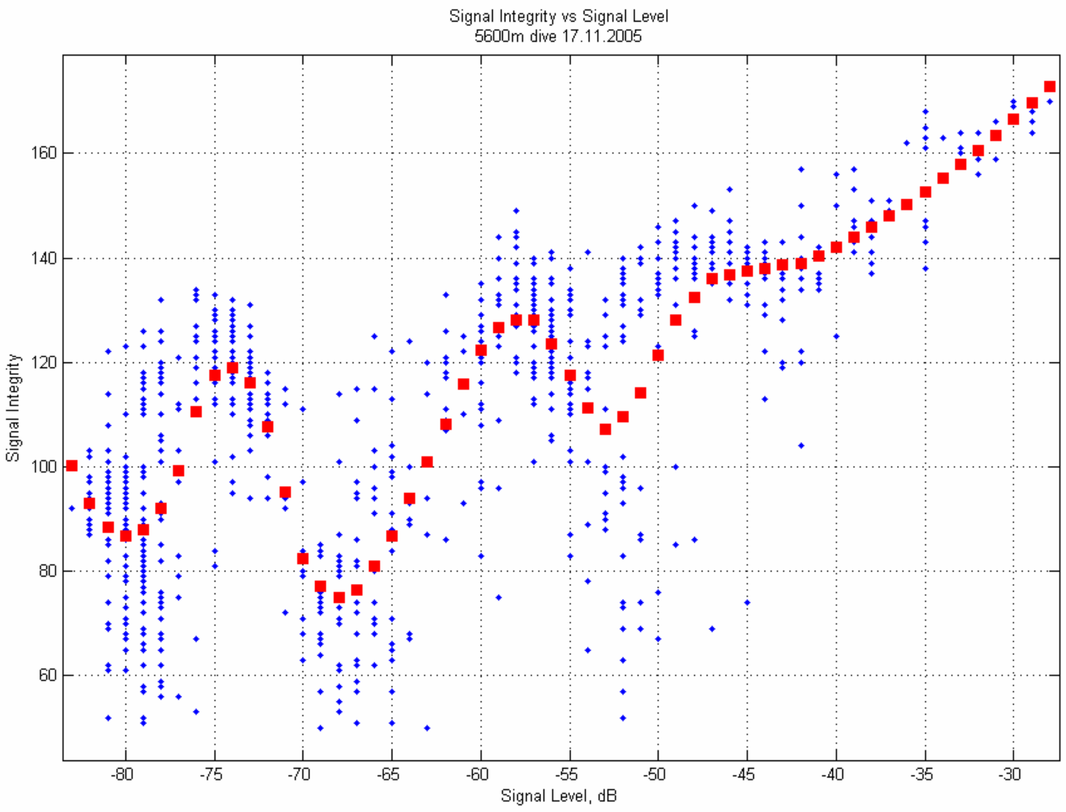


Fig. 7.6.12: Signal Integrity vs. Signal Level. Test 17.11.2005

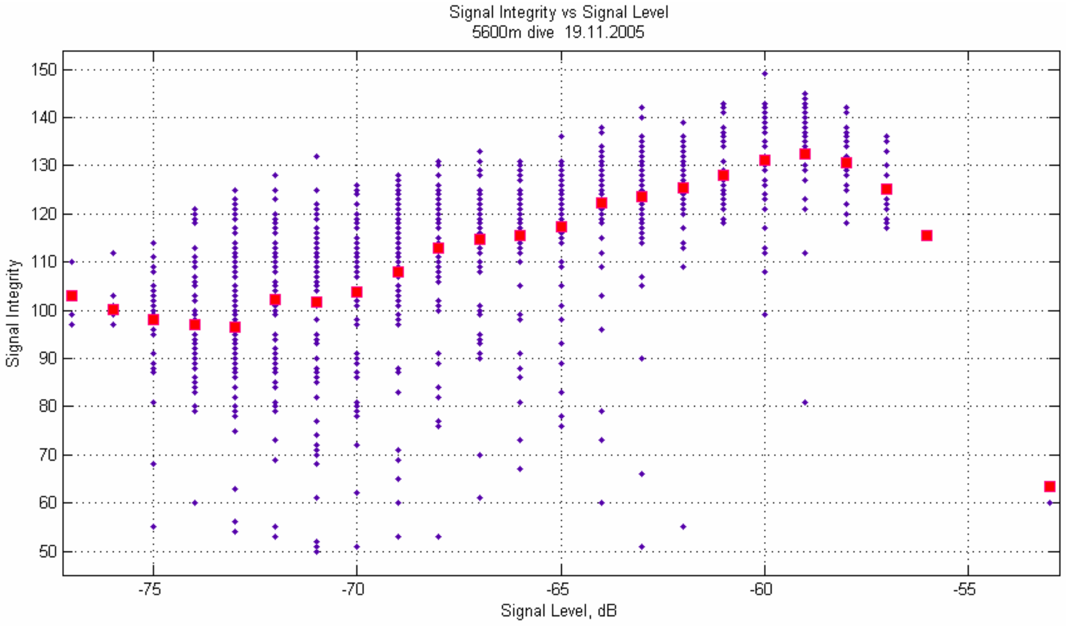


Fig. 7.6.13: Signal Integrity vs. Signal Level. Test 19.11.2005/20.11.2005

The Signal Level parameter illustrates the amount of energy in the receiving signal at the surface modem. The Signal Integrity parameter corresponds to the correlation response of the receiving signal at the surface modem. All data samples were collected during dive from 200 m down to 5600 m depth. The blue points on the plots above correspond to measured values, the red squares correspond to moving average values. The critical value of Signal Integrity parameter is 75. It is obvious that the Signal Integrity hardly falls under the critical (for the S2C modems) line during trials.

The Signal Level parameter illustrates the receiving signal level. The operational range of Signal Level is from -95dB to -20dB. The measured Signal Level was higher than -85dB during trials.
The plots of the received signals in time domain and after S2C processing are represented below.

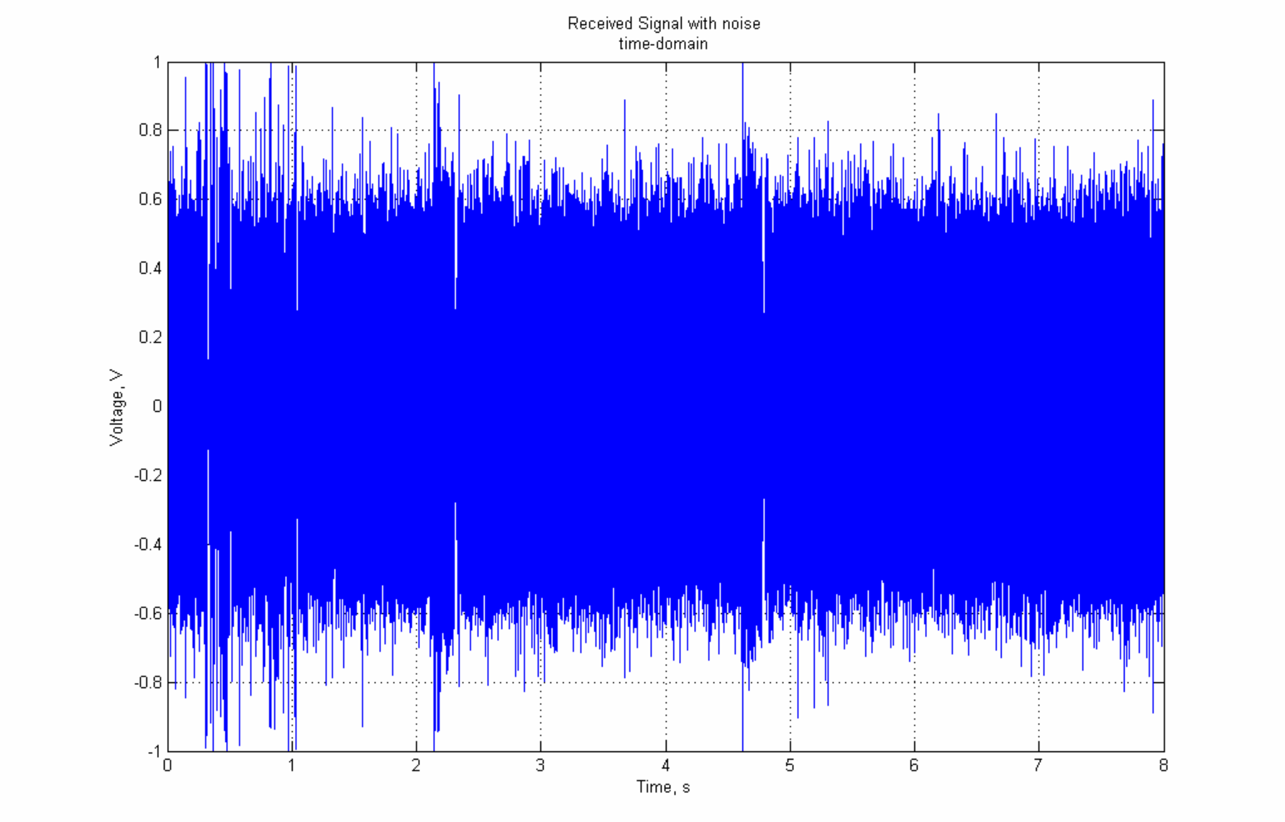


Fig. 7.6.14: Received Signal waveform (time-domain)

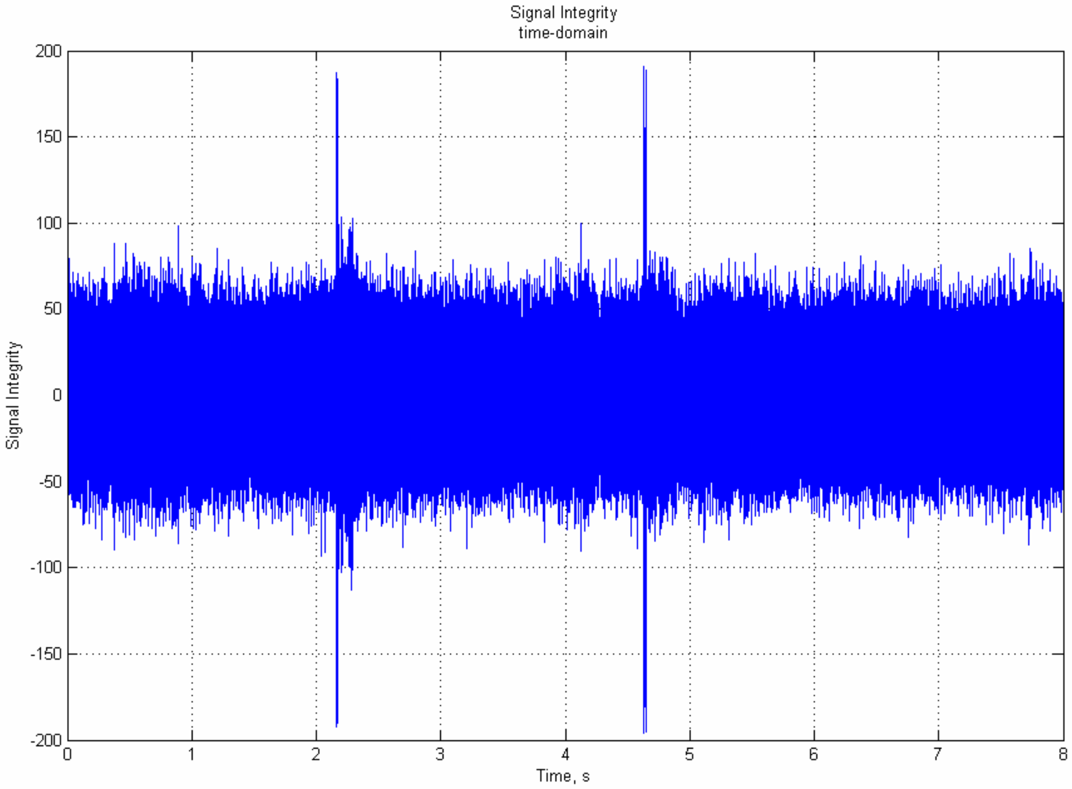


Fig.7.6.15: Signal Integrity function (time domain)

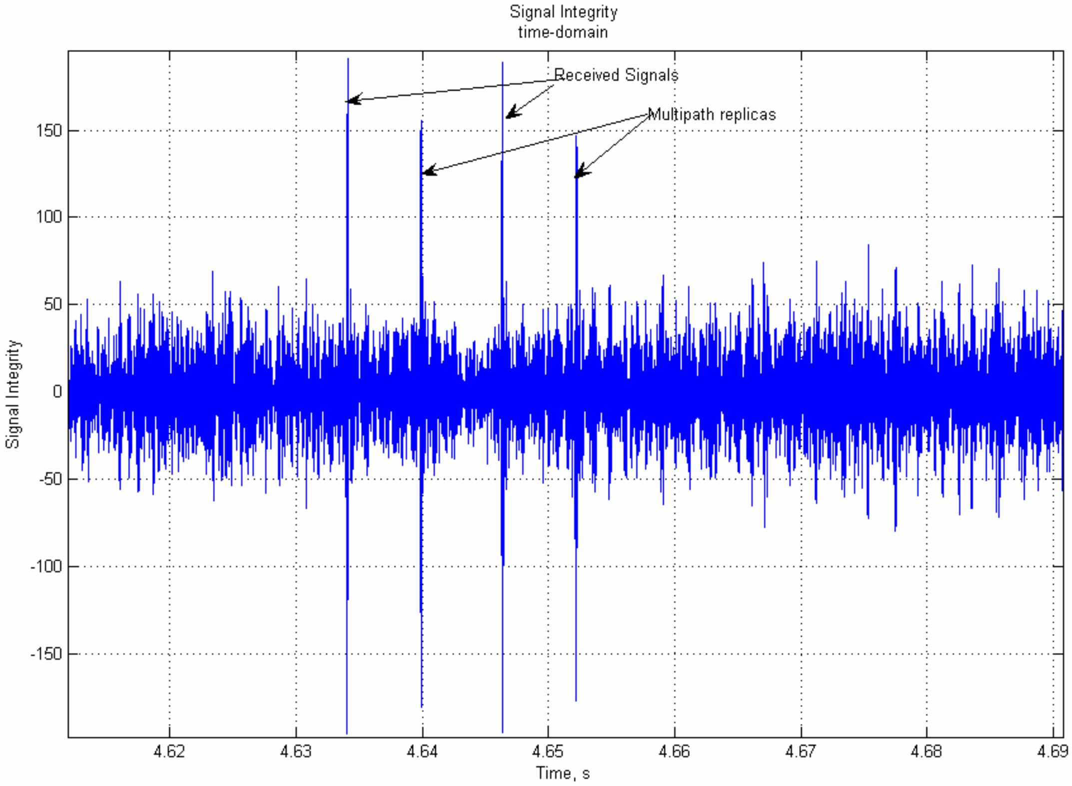


Fig. 7.6.16: Signal Integrity function (time domain zoomed).

The noise reduction effect after S2C processing is clearly visible on Fig. 7.6.16: Signal Integrity function (time domain zoomed). (Fig.7.6.15, Fig. 7.6.16)

(Keep in mind that all trials were made under extremely noisy conditions, with unpredictable movements of the surface modem due to both ship's maneuvers and current).

During S2C modems tests, the deep-water modem unit was powered from the battery pack built on Alkaline Procell MN1300 cells, 182 cells, with a nominal voltage of 21 Volt and a nominal capacity of 234 Ah. After the first trial on 17.11.2005 the voltage of the idle battery was 20.5V.

During the second trial on 19.11.2005/20.11.2005 we found that the deep-water modem unit interrupts its activity when the long data packets were transmitted. After recovery of the dipping platform the battery voltage was measured immediately. The measured idle voltage was 20.7V, the voltage under load (modem in transmission mode) was 18.88V. It was concluded that the Alkaline batteries discharge rapidly, even more so at low temperatures (+1..+3 degr. C at a depth of 5600 m). The existing versions of S2C modems are configured for 24VDC supply voltage, thus the type of used cells is critical during modem operation, especially at low temperatures.

After the tests the battery pack for the deep-water modem unit was replaced by a Lithium battery with a nominal voltage of 25.2V. The Lithium battery has a nearly “rectangular” discharge curve that allows to hope for a better battery performance at low temperatures.

On page 116, a fragment of the log file is given, received during getting pressure data from the depth of 5600 meters:

```
mac.c:1489:(local_tiarr_done) TIARR_DONE
mac.c:1519:(local_tiarr_done) attributes: r2l_bit rate = 2347, speed = -5
mac.c:1521:(local_tiarr_done) local_mps =
0    56 121    0     0     0     0     0      ← measured Multipath Structure
mac_codec.c:164:(code_ctrl_golay) ->MPS_PART(2)
mmac_codec.c:209:(code_ctrl_golay) len = 10, buf: 22  0 80 12 80 32 e0 40 1e 4c
mac.c:1671:(send_done) spread_time = 121913695, state = MPS_STATE, action = SEND_ACTION
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -73, signal_integrity = 93
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 126
mac.c:988:(decode_data)
mac_codec.c:384:(decode_ctrl_golay) subtype = 4, crc = d672, service_length = 44, len = 38, hlen =
92
mac_codec.c:435:(decode_ctrl_golay) <-ACK_PART(1)
mac_codec.c:439:(decode_ctrl_golay) <-mask = ()/0
mac.c:1023:(decode_data) connect_mode = CM_NORMAL
mac.c:1053:(process_handshake)
mac.c:1345:(process_cluster) subtype = 4
mac.c:1346:(process_cluster) Warning! Irrelevant signal successfully decoded! Ignore?
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -76, signal_integrity = 96
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 456
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 17, buf: 1b 5c 50 49  d  a 72 65 63 6f 72 64 69 6e 67  d  a
mac_codec.c:530:(decode_message) .\PI..recording..
queue.c:968:(rq_add) rq_add: id = 0, cid = 0
queue.c:903:(_rq_add) mask = (1)/1
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
queue.c:1172:(rq_recv) item->id = 0, rq_last_id = 126, rs = 1
mac.c:1753:(get_data) err_code = SYNC_2_LOSS, bits_count = 0
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_CATCH_ERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -73, signal_integrity = 86
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 918
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: 83 fa 87 84 82 fd fe ff 8e f6 81 fd f4 ff 8d fb 86 f8
82 80 86 85 fe 80 80 87 80 fc 81 fb 87 85 81 f9 81 83 85 83 fa 81 87 86 fe fe 81 f6 80 80 81 87
mac_codec.c:530:(decode_message) ..................................................
queue.c:968:(rq_add) rq_add: id = 2, cid = 2
queue.c:903:(_rq_add) mask = (101)/3
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -75, signal_integrity = 100
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 908
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mmac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: ff fd 81 f9 82 82 fc 80 84 fa ff 83 89 82 f8 fa fd 81
ff 81 83 fe 81 85 8b 86 f9 f8 84 f6 84 ff 8f f3 f9 fb 80 81 81 84 84 84 f1 82 87 81 84 80 84 f6
mac_codec.c:530:(decode_message) ..................................................
queue.c:903:(_rq_add) mask = (1011)/4
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
```

```
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -73, signal_integrity = 97
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 940
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: 8e fd 81 fb 82 f2 80 89 80 86 89 fa ff f1 82 87 86
f8 88 80 f5 87 f8 f8 88 83 ff 85 fd 81 80 82 88 f4 82 f8 80 82 fb 8d fe f6 fb 8b 83 fd fa 8b 83 80
mac_codec.c:530:(decode_message) .................................................
queue.c:903:(_rq_add) mask = (10111)/5
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -73, signal_integrity = 82
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 914
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mmac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: 87 83 f8 87 fa fe 80 fd ff 88 fe ff fc 81 fd 83 88 f9
f6 8e fe 84 f8 84 82 fd 83 83 88 fe fe ff f8 89 81 ff f8 ff fc 86 87 82 81 85 fa fe f8 81 80 89
mac_codec.c:530:(decode_message) .................................................
queue.c:903:(_rq_add) mask = (101111)/6
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -73, signal_integrity = 92
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 908
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mmac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: 87 fd f5 81 fb f5 fa fa 89 fd 90 ff 87 81 86 f1 ff f9
85 f9 83 fe 87 f7 89 85 f7 88 f7 87 82 fb 80 88 81 81 f9 81 80 f8 84 8e 82 ff fa 82 fa f9 86 f7
mac_codec.c:530:(decode_message) .................................................
queue.c:903:(_rq_add) mask = (1011111)/7
mac.c:966:(recv_dispatch_cluster) recv_flag = RECV_NOERROR
mac.c:1704:(wait_data) wait
mac.c:2586:(wait_time) 10600000
mac.c:2415:(tel_ack_decode) signal_rms = -75, signal_integrity = 87
mac.c:1753:(get_data) err_code = SIGNAL_LOSS, bits_count = 984
mac.c:988:(decode_data)
mac_codec.c:505:(decode_message) <-PACKET
mac_codec.c:515:(decode_message) FEC ON
mac_codec.c:529:(decode_message) len = 50, buf: 80 88 f9 fc 81 84 fb ed 8a 81 88 81 87 82 fa f7 81
f2 96 f9 f6 85 8c 81 f9 ff 84 84 f7 83 fa 85 87 f9 fa 80 85 81 ff fe fe 87 fe 80 82 82 85 fe 83 f6
mac_codec.c:530:(decode_message) .................................................
queue.c:903:(_rq_add) mask = (10111111)/8
```

In accordance with the presented log fragment, the multipath structure of the acoustic channel had 3 multipath components at the considered point of time. These components were relatively stable during data transmission, but the structure became complicated from time to time by additional 3-5 multipath arrivals.

After an adaptation process to the given multipath structure the modem received and successfully demodulated successively 8 user data packets - except the second packet. This packet was sent again by the remote modem. The nominal bit rate at the considered point of time was 2347 bits per second, relative velocity between modems was measured as 0.5 m/s.

Analysis of the modem operation, deployed under buoy

Unfortunately the only possibility to analyse the modem operation at the moment is the log of the OBUD program, running on the buoy computer. Log line output of the modem was not correctly connected to the buoy computer.

OBUD was started at night after buoy deployment. The next day the following OBUD log file was downloaded from the buoy:

```
ts1:/usr/local/bin/buoy # ./obud-ts
OBUD  0.122 28.10.2005
Sun Nov 20 05:41:25 2005 LOGM : ***starting tty_ :
Sun Nov 20 05:41:25 2005 LOGM : ***DTR off:
Sun Nov 20 05:41:25 2005 LOGM : ***DTR on:
Sun Nov 20 05:41:25 2005 LOGM : ***clear RTS:
Sun Nov 20 05:41:25 2005 LOGM : ***starting server :
Sun Nov 20 05:41:25 2005 LOGM : ***waiting for connect :
Sun Nov 20 05:42:11 2005 LOGM : ***client connected :
Sun Nov 20 05:42:13 2005 LOGM : service command :Rev_
:□
Sun Nov 20 05:42:17 2005 LOGM : Req_Version:
ABORTED
Sun Nov 20 05:44:47 2005 MODEM: ABORTED!
ABORTED
Mon Nov 21 01:41:20 2005 MODEM: ABORTED!
ABORTED
Mon Nov 21 02:00:37 2005 MODEM: ABORTED!
ABORTED
Mon Nov 21 02:14:51 2005 MODEM: ABORTED!
ABORTED
Mon Nov 21 02:30:28 2005 MODEM: ABORTED!
Mon Nov 21 02:31:46 2005 LOGM : Req_StartSelftest:
Mon Nov 21 02:34:54 2005 LOGM : Req_GetSelftestResult:
Mon Nov 21 02:38:58 2005 LOGM : Req_GetSelftestResult:
```

Till the morning of 21 Nov 2005 the OBUD operated in passive mode. That means that OBUD had waited for data from OBU, and didn’t send any data to the modem. But, as can be seen, the buoy modem received some data from an unknown source, sent it over the acoustic channel, and from time to time closed the acoustic session and reported to OBUD "ABORTED". There is only this single reason for such modem operation to send ABORTED without any data transmission from the OBUD. After that, OBUD was terminated till the next test session carried out in the evening of 24 Nov 2005.

```
ts1:/usr/local/bin/buoy # ./obud-ts
OBUD  0.122 28.10.2005
Thu Nov 24 11:47:10 2005 LOGM : ***starting tty_ :
Thu Nov 24 11:47:10 2005 LOGM : ***DTR off:
Thu Nov 24 11:47:10 2005 LOGM : ***DTR on:
Thu Nov 24 11:47:10 2005 LOGM : ***clear RTS:
Thu Nov 24 11:47:10 2005 LOGM : ***starting server :
Thu Nov 24 11:47:10 2005 LOGM : ***waiting for connect :
Thu Nov 24 11:48:10 2005 LOGM : ***client connected :
Thu Nov 24 11:48:32 2005 LOGM : Req_StartSelftest:
Thu Nov 24 11:50:45 2005 LOGM : Req_GetSelftestResult:
Thu Nov 24 11:50:45 2005 LOGM : MTS ? : ■PI ?:
Thu Nov 24 11:51:42 2005 LOGM : Req_StartSelftest:
Thu Nov 24 11:52:41 2005 LOGM : MTS ? : ■■PI ?:
Thu Nov 24 11:53:16 2005 LOGM : Req_StartSelftest:
Thu Nov 24 11:54:48 2005 LOGM : MTS:PING:
```

```
Thu Nov 24 11:54:48 2005 LOGM : MTS:PING:
Thu Nov 24 11:54:48 2005 LOGM : OBU Status : recording:
Thu Nov 24 11:58:06 2005 LOGM : service command :ph
:
ABORTED

Thu Nov 24 12:00:48 2005 MODEM: ABORTED!
Thu Nov 24 12:03:29 2005 LOGM : service command :ph

:
ABORTED

Thu Nov 24 12:27:31 2005 MODEM: ABORTED!
```

This second test confirms the above mentioned assumption**: the modem receives some “garbage” over rs422 interface between buoy computer and the modem**. As can be seen from the OBUD log file, useful data, sent by OBUD (“PI<cr>”) is mixed with “garbage” sent to the OBU, and OBU answers with strings “■PI ?” and “■■PI ?”, which means that MTS received strings “■PI<cr>”, “■■PI<cr>” and couldn’t recognize it as any known command. We didn’t receive such a string in the previous test, because MTS was waiting for carrier return symbol, as the “command end” symbol, and this symbol was not sent. The third try was successful – OBUD had received correct answer on the “PI<cr>” request. The answer to the next tries requesting pressure data was ABORTED, but with a lag of more than 2.5 minutes that corresponds also to the described problem.

SO-186D Trials results

During the cruise SO-186D the buoy system was recovered for inspection. It was detected that the cable line from the buoy to the acoustic modem is damaged – see photographs below.

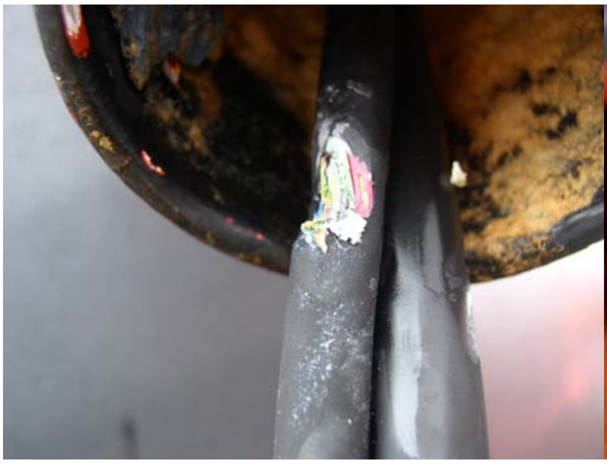


Fig. 7.6.17

Fig. 7.6.18

Fig. 7.6.19: Damaged cables and UW connectors after recovery

After the damaged cables had been repaired and replaced, the acoustic modem was installed under the buoy again. The technical problems connected to malfunction in a buoy modem log-interface were fixed.

The acoustic data transmission sessions via satellite link were carried out after the buoy deployment. All acoustic modem’s activity was documented in log-files on a buoy host computer and then these log-files were transmitted to the operator’s computer for storage and analysis. Some data transfers taken from the recorded logs are illustrated on page 123 in a graphical form.

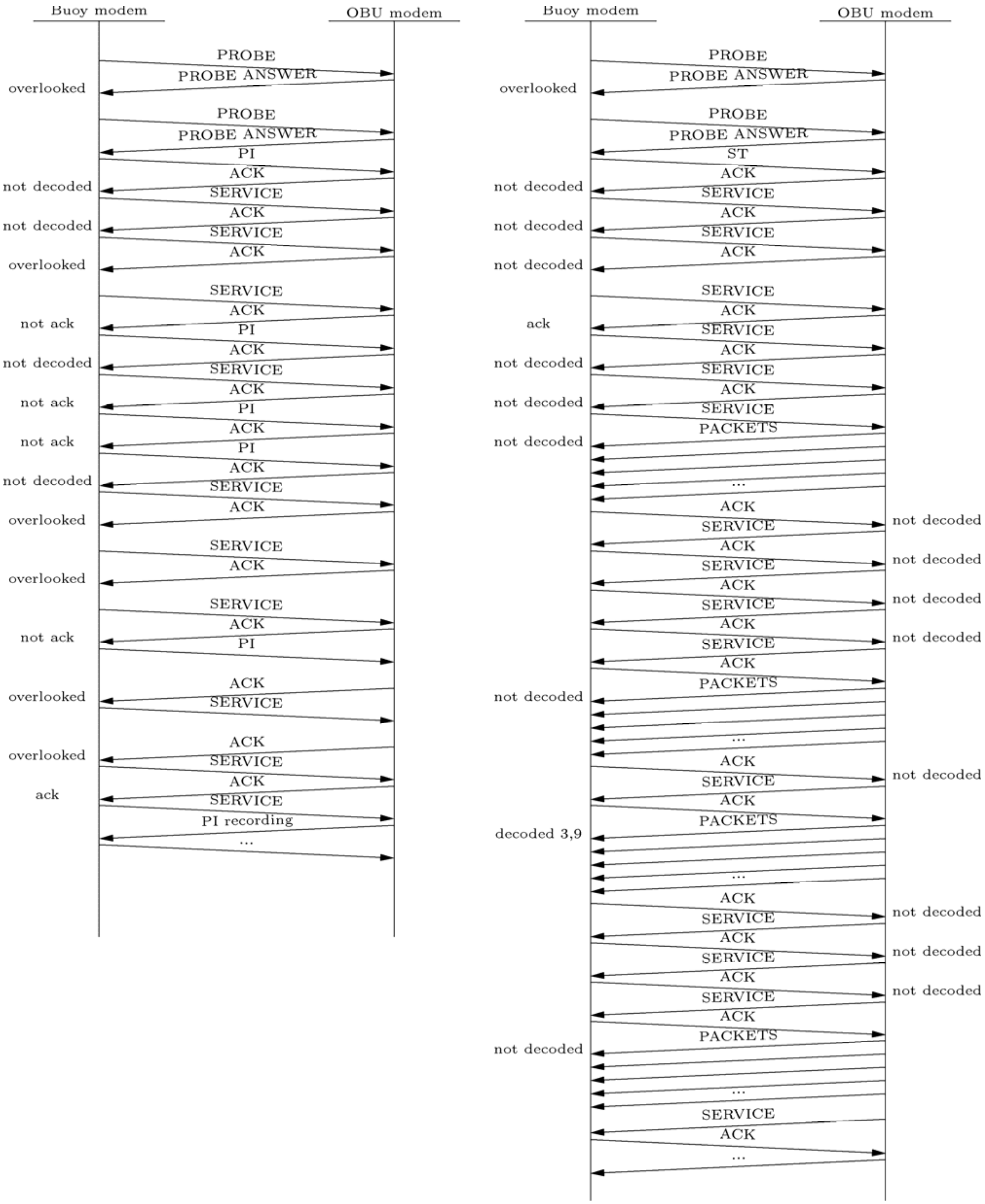


Fig. 7.6.20: Acoustic data transmissions logs

Key results:

- The represented S2C modems have shown the features and performance required. An acoustic link over the depth range of up to 5600 m was established.
- The S2C modem interfacing fully corresponds to the hardware and software specifications. No interfacing problems with OBU/OBUD were detected.
- Time problems with link instability during the communication from the ship to the submerged unit were detected. These problems were probably caused by an unstable positioning of the surface modem due to strong current, ship maneuvers, and ship noise (more than 20 dB higher as estimated), as well as by a positioning of the unit in the shallow water layer above the surface thermocline. To solve the problem of link instability, some additional “in-situ” parameterizations are required – i.e. adjustment of packet size, number of data packets in cluster, etc.
- The second problem detected is connected with the modems' power supply. The nominal power supply voltage and the battery’s discharge characteristic must correspond to the voltage range specified for the modem’s power supply.
- To provide a stable surface modem operation in presence of the high-level environmental noises (ship noise, etc.), the preamplifier stage must be redesigned and more robust signals detection algorithms must be developed.
- Unfortunately, it was not possible to proceed with a detailed analysis of the modem operations as long as the modem remained installed under the buoy during SO-186C because of a technical problem with a log-interface. During SO-186D the problems caused by the absence of a log interface were fixed and all modem-to-buoy interfaces were revised and carefully tested “in system”.
- With regard to the analysis of measured environmental data (c-profile) it is recommended that the surface modem be installed under the surface thermo-wedge layer, i.e. 120…150 m. Thus, the link stability and bit rate could be improved and the power consumption (in Transmit mode) could be reduced.

Conclusions

Up to now only the buoy <-> OBU communication using the Evologics modems could be tested. Therefore, a comparison of test results versus actual buoy <-> OBU communication can only be done for the Evologics modem.

When reading through Evologics test report (see below), one would expect a reasonable data transfer from the OBU to the buoy under real life conditions. Unfortunately, this does not hold. Data communication during tests even under the condition of substantial ship noise is substantially better than in the eventual buoy <-> OBU setup.

So, what is the difference? In order to find a clue, we will first list what is not different:

- OBU deployment depth is the same (about 5400m after SO186C, about 3700m after SO186D).
- Buoy modem depth is also the same (about 20m).

- Buoy noise should be quite a bit lower than ship noise, although no quantitative assessment has been conducted due to lack of time - the anchor chain noise may be substantial!
- Sea-state is the same due to very stable weather conditions.

Therefore, we can conclude:

The difference between the test and the "real" environment is the rapid movement of the buoy modem due to the "dancing" behaviour of the buoy compared to the slowly moving ship due to its high inertia.

This conclusion is backed by the service channel data that could be logged during SO186C tests and SO186D buoy modem communication: In the latter case, the multi-path signal structure changes much faster than during the tests - it changes so rapidly that the modems cannot keep up informing each other of the new situation due to the long communication delay (about 2 * 2.5 seconds after SO186D and a depth of 3700m).

7.7 Data from the GITWES buoys

For the moment both buoys are operating in a test mode. During Leg SO186C, buoy TS1 was deployed at 3°43.7’S/99°13.5’E, water depth ca. 5200m (TS1a). TS2 was deployed in much shallower water at about 3600m water depth at 0°27’S/96°51’E (TS2a). During leg SO186D the southern most position was changed to shallower water, and both buoys were exchanged in location, now being TS1b and TS2b. The position of TS1b is now at 0°25’S/96°52.5’E, while the position of TS2b is at 3°51’S/99°32.5’E.

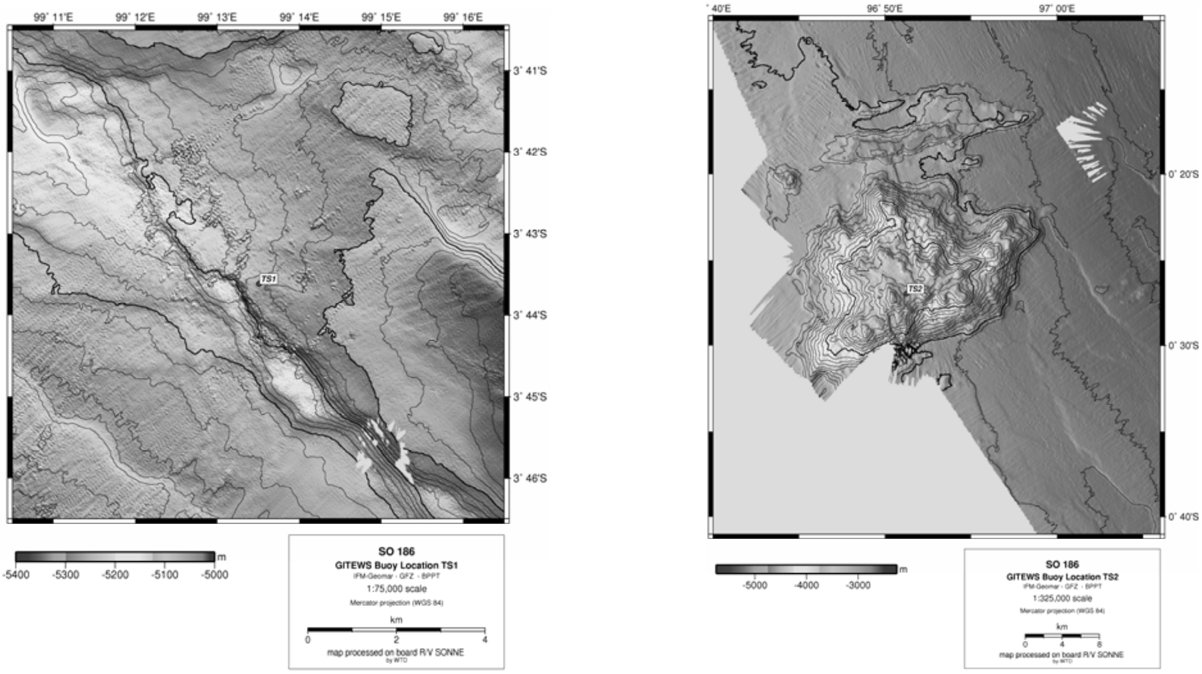


Fig. 7.7.1: Location maps for TS1 and TS2 from November 2005 till January 2006.

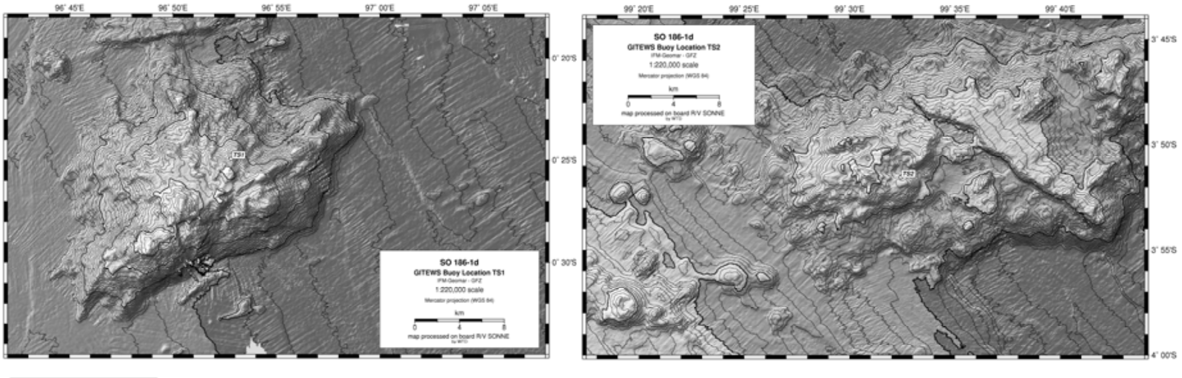


Fig. 7.7.2: Location maps for TS1 and TS2 from January 2006 onwards.

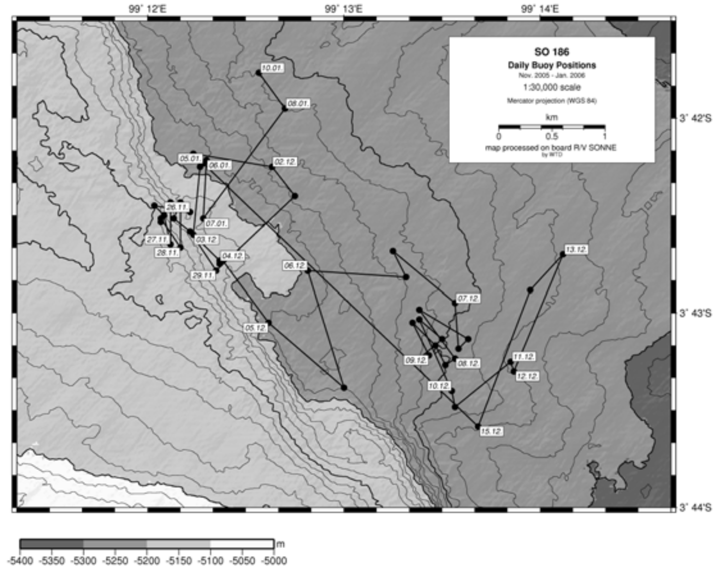


Fig. 7.7.3: Daily positions of TS1

Fig. 7.7.3 shows daily positions of TS1 between November 2005 and January 2006. Due to the mooring concept, the buoy can move freely around its anchoring with a relatively large radius.

The main parameters for system monitoring during the past 50 days have been power supply and inside temperature. Due to the communication problems with TS2 in the beginning only the most recent days are available.

Fig. 7.7.4 shows the recharge capacity of both buoys. In average, the daily recharge for TS1 was 23 Ah/day, while for TS2 a value of 29 Ah/day was observed. This difference must be studied in more detail, since both buoys are only 300 km apart.

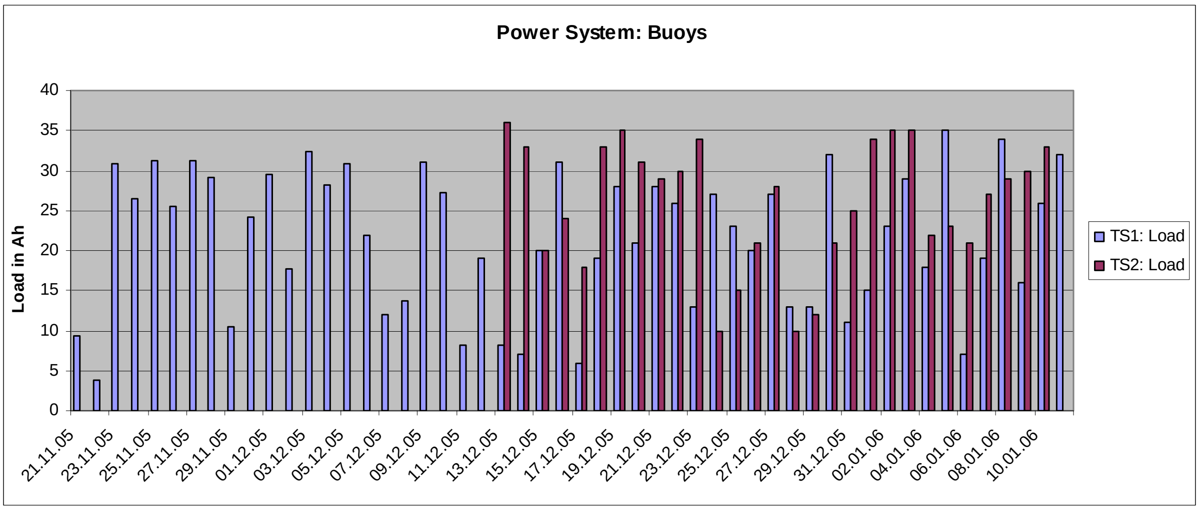


Fig. 7.7.4: Recharge in Ampere hours per day for TS1 and TS2

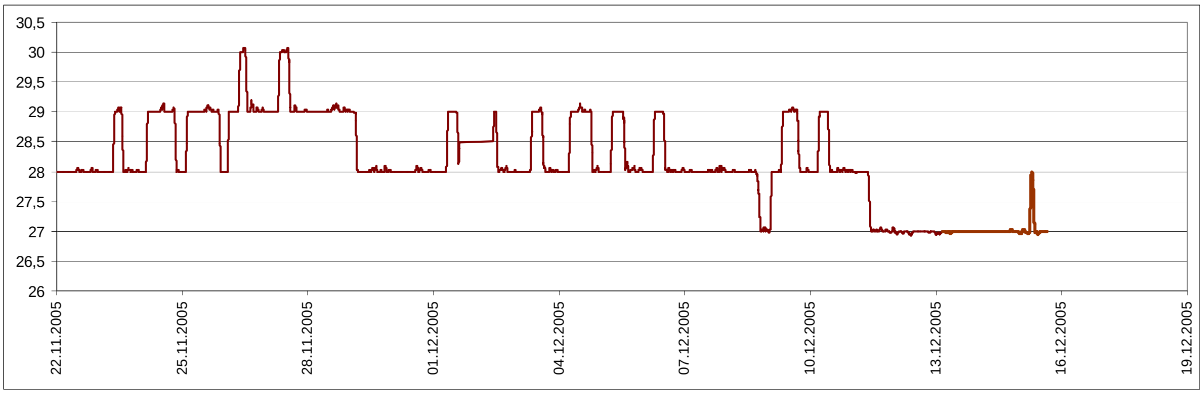


Fig. 7.7.5: Temperature (°C) behavior inside the seal science box

The second parameter, the buoys' inside temperature, is also important to the long-term operation. While most parts of the computer system are designed for up to 80°C, other parts are not. However, from our temperature measurements we found a very close agreement with the outside water temperature (Figure 7.7.5).

For TS1, meteorological data is also available till December 12th, when the data acquisition was stopped.

Neither GPS data nor OBU data is available for the moment due to the test operation and the delay in establishing land-based reference stations.

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Abkürzungen / Abbreviation

z.W	zu Wasser
a.D.	an Deck
SL (max.)	(maximale)Seillänge
LT	Lottiefe nach Hydrosweep
W x	eingesetzte Winde
SM	Simrad - Multibeam - Lot
PS	Parasound
rwk:	Rechtweisender Kurs
d:	Distanz
v:	Geschwindigkeit in Knoten
SL:	Seillänge
KL:	Kabellänge

	Eingesetzte Geräte	**Einsätze**
Dummy	Wasserschallprofil mit SVP-Sonde	1
Magn	2 x Magnetometersonden in Reihe	32
Gravi	Gravimeter im Schiff installiert	48
Vermess.	SM / PS- Vermessungsprofile	37
OBS / H	Aussetzen OBS / H	5
OBS / H	Aufnehmen OBS / H	6

Geräteverluste: **Keine**

Winde	**D/M**	**Typ**	**RF-Nr**	**SO 186-1b Einsatz**	**Gesamt Einsatz**	**SO 186-1b S`länge**	**Gesamt S`länge**	**Zust.**	**SO 186-1b gefierte max. L**	**jemals gefierte max. Länge**
W 1	18,2	LWL	812001	0 h	478 h	0 m	241232 m	3-4	0 m	8022 m
W 2	18,2	LWL	120301500	0 h	0 h	0 m	0 m	1	0 m	0 m
W 4	11	NSW	818045	0 h	308 h	0 m	268589 m	3-4	0 m	8081 m
W 5	11	NSW	818237	0 h	106 h	0 m	100537 m	2	0 m	5861 m
W 6	18,2	Koax	815286	1 h	313 h	2000 m	401048 m	2	2000 m	4744 m

Station	**Datum**	**UTC**	**PositionLat**	**PositionLon**	**Tiefe [m]**	**Windstärke [m/s]**	**Kurs [°]**	**v [kn]**	**Gerät**	**Gerätekürzel**	**Aktion**	**Bemerkung**
SO186/021-1	29.10.05	10:23	6° 12,38' S	105° 21,68' E	106	SSE 9	285	4,4	Magnetometer	MAGN	Beginn Station	
SO186/021-1	29.10.05	10:39	6° 11,98' S	105° 19,97' E	110	SE 5	273	10,4	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 21,**rwk: 270°, d: 35 sm
SO186/021-1	29.10.05	10:42	6° 11,97' S	105° 19,46' E	113	SE 7	268	10,6	Magnetometer	MAGN	Magnetometer zu Wasser	2 Sonden, SL : 750 m
SO186/021-1	29.10.05	14:07	6° 12,04' S	104° 45,13' E	100	SE 8	256	9,9	Magnetometer	MAGN	Ende Profil	
SO186/022-1	29.10.05	14:07	6° 12,04' S	104° 45,13' E	100	SE 8	256	9,9	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 22,**rwk: 180° d: 15sm
SO186/022-1	29.10.05	15:39	6° 26,87' S	104° 44,91' E	371	S 13	228	7,8	Magnetometer	MAGN	Ende Profil	
SO186/023-1	29.10.05	15:39	6° 26,87' S	104° 44,91' E	371	S 13	228	7,8	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 23**,rwk: 270° d: 65sm
SO186/023-1	29.10.05	22:12	6° 27,00' S	103° 40,05' E	1513	SSE 10	276	10,1	Magnetometer	MAGN	Ende Profil	
SO186/024-1	29.10.05	22:12	6° 27,00' S	103° 40,05' E	1513	SSE 10	276	10,1	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-24**, rwk: 274°, d: 109sm
SO186/024-1	30.10.05	09:06	6° 19,50' S	101° 51,12' E	5342	SE 7	285	9,6	Magnetometer	MAGN	Ende Profil	
SO186/025-1	30.10.05	09:06	6° 19,50' S	101° 51,12' E	5342	SE 7	285	9,6	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-25,** rwk: 318°, d: 217 sm
SO186/025-1	31.10.05	09:00	3° 22,19' S	99° 8,16' E	5256	N 11	313	9,5	Magnetometer	MAGN	Ende Profil	
SO186/026-1	31.10.05	09:00	3° 22,19' S	99° 8,16' E	5256	N 11	313	9,5	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-26**,rwk: 327°, d: 69 sm
SO186/026-1	31.10.05	15:52	2° 24,08' S	98° 30,14' E	5643	N 9	9	9,4	Magnetometer	MAGN	Ende Profil	
SO186/027-1	31.10.05	15:52	2° 24,08' S	98° 30,14' E	5643	N 9	9	9,4	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-27,**rwK: 052° d: 33sm
SO186/027-1	31.10.05	19:11	2° 4,00' S	98° 55,87' E	1509	NW 7	21	9,6	Magnetometer	MAGN	Ende Profil	
SO186/028-1	31.10.05	19:11	2° 4,00' S	98° 55,87' E	1509	NW 7	21	9,6	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-28**,rwk: 326°, d: 72 sm
SO186/028-1	01.11.05	02:24	1° 4,07' S	98° 16,05' E	1415	N 11	330	10	Magnetometer	MAGN	Kursänderung	rwk: 323°, d: 10 sm
SO186/028-1	01.11.05	03:24	0° 55,99' S	98° 10,00' E	910	N 12	334	9,3	Magnetometer	MAGN	Ende Profil	
SO186/029-1	01.11.05	03:24	0° 55,99' S	98° 10,00' E	910	N 12	334	9,3	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-29**,rwk: 330°, d:32 sm
SO186/029-1	01.11.05	06:38	0° 27,89' S	97° 53,94' E	2749	NW 11	325	9,6	Magnetometer	MAGN	Kursänderung	KÄ: rwK: 325°, d: 152 sm
SO186/029-1	01.11.05	21:53	1° 36,98' N	96° 27,01' E	2748	NNW 11	332	10,2	Magnetometer	MAGN	Ende Profil	
SO186/030-1	01.11.05	21:53	1° 36,98' N	96° 27,01' E	2748	NNW 11	332	10,2	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b-30.**rwk: 027°, d: 9 sm

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/030-1	01.11.05	22:45	1° 44,86' N	96° 30,94' E	1833,1	W 8	18	10,2	Magnetometer	MAGN	Kursänderung	rwk: 339°, d: 17sm
SO186/030-1	02.11.05	00:29	2° 0,92' N	96° 25,01' E	1407,5	NW 12	317	9,7	Magnetometer	MAGN	Kursänderung	rwk: 308°, d: 13sm
SO186/030-1	02.11.05	01:58	2° 8,51' N	96° 15,31' E	1233,4	W 10	305	2,4	Magnetometer	MAGN	Magnetometer an Deck	
SO186/030-1	02.11.05	01:58	2° 8,51' N	96° 15,31' E	1233,4	W 10	305	2,4	Magnetometer	MAGN	Ende Profil	
SO186/030-2	02.11.05	01:58	2° 8,51' N	96° 15,31' E	1233,4	W 10	305	2,4	OBS/OBH	OBS/OBH	Beginn Station	**Anf. OBS/OBH, rwk: 049°, d: 5 sm**
SO186/030-2	02.11.05	02:16	2° 10,25' N	96° 17,14' E	879,5	W 6	50	13,5	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 03**
SO186/030-2	02.11.05	02:31	2° 11,81' N	96° 18,58' E	1020	W 9	293	2,1	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/030-2	02.11.05	02:46	2° 11,98' N	96° 18,18' E	1015	WNW 8	101	0,8	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/030-2	02.11.05	02:46	2° 11,98' N	96° 18,18' E	1015	WNW 8	101	0,8	OBS/OBH	OBS/OBH	Ende Station	
SO186/031-1	02.11.05	03:16	2° 12,01' N	96° 18,01' E	1021	WNW 9	328	0,3	Vermessung	EM / PS	Beginn Profil	**Profil SO 186-1b - 31**,rwk:288°, d: 38 sm
SO186/031-1	02.11.05	07:17	2° 23,97' N	95° 42,62' E	737	W 14	301	4,5	Vermessung	EM / PS	Ende Profil	
SO186/031-2	02.11.05	07:20	2° 24,01' N	95° 42,45' E	875	W 14	284	3,1	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS #10**
SO186/031-2	02.11.05	07:32	2° 24,05' N	95° 42,33' E	0	W 10	102	0,7	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/031-2	02.11.05	07:46	2° 24,12' N	95° 42,15' E	0	WNW 11	58	0,9	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/031-3	02.11.05	07:57	2° 24,05' N	95° 42,04' E	0	W 11	320	0,3	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 03**
SO186/032-1	02.11.05	07:57	2° 24,05' N	95° 42,04' E	0	W 11	320	0,3	Magnetometer	MAGN	Beginn Station	rwk: 180^, d: 2 sm
SO186/032-1	02.11.05	08:17	2° 22,10' N	95° 42,13' E	762	W 13	147	10	Magnetometer	MAGN	Magnetometer zu Wasser	2 Sonden, SL: 750 m
SO186/032-1	02.11.05	08:17	2° 22,10' N	95° 42,13' E	762	W 13	147	10	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 32**,rwk: 108°, d: 33 sm
SO186/032-1	02.11.05	11:33	2° 11,60' N	96° 13,23' E	539	W 6	107	9,9	Magnetometer	MAGN	Kursänderung	rwk: 054°, d: 4sm
SO186/032-1	02.11.05	12:01	2° 14,07' N	96° 17,03' E	909	WSW 9	39	9,9	Magnetometer	MAGN	Ende Profil	
SO186/033-1	02.11.05	12:01	2° 14,07' N	96° 17,03' E	909	WSW 9	39	9,9	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 33**, rwk: 288°, d: 34sm
SO186/033-1	02.11.05	15:28	2° 24,75' N	95° 45,12' E	676	NW 10	301	10,7	Magnetometer	MAGN	Ende Profil	
SO186/034-1	02.11.05	15:28	2° 24,75' N	95° 45,12' E	676	NW 10	301	10,7	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 34**,rwK: 316 d: 17sm
SO186/034-1	02.11.05	17:10	2° 36,16' N	95° 33,82' E	724	NNW 8	309	3,4	Magnetometer	MAGN	Ende Profil	
SO186/034-1	02.11.05	17:18	2° 36,50' N	95° 33,37' E	726	NNW 9	327	5	Magnetometer	MAGN	Magnetometer an Deck	
SO186/034-1	02.11.05	17:21	2° 36,60' N	95° 33,20' E	730	NW 8	276	4,5	Magnetometer	MAGN	Kursänderung	rwK: 252°, d: 3 sm
SO186/034-2	02.11.05	17:36	2° 36,16' N	95° 31,33' E	730	NNW 10	251	10,9	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS #11**
SO186/034-2	02.11.05	17:51	2° 35,88' N	95° 30,14' E	729	WNW 7	332	1,9	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/034-2	02.11.05	18:14	2° 36,17' N	95° 30,02' E	728	NW 6	79	1	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/034-2	02.11.05	18:22	2° 36,06' N	95° 30,02' E	730	NW 5	127	0,8	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS #22**
SO186/034-2	02.11.05	18:23	2° 36,06' N	95° 30,03' E	730	WNW 6	14	0,3	OBS/OBH	OBS/OBH	Ende Station	
SO186/035-1	02.11.05	18:23	2° 36,06' N	95° 30,03' E	730	WNW 6	14	0,3	Vermessung	EM / PS	Kursänderung	rwk: 072°, d: 3 sm
SO186/035-1	02.11.05	18:24	2° 36,06' N	95° 30,04' E	729	WNW 4	115	1,5	Vermessung	EM / PS	Beginn Profil	**Profil SO 186-1b - 35**,rwk: 072°, d: 3 sm
SO186/035-1	02.11.05	18:49	2° 37,01' N	95° 33,00' E	710	W 5	10	8,4	Vermessung	EM / PS	Kursänderung	rwK: 327°, d: 30 sm
SO186/035-1	02.11.05	21:54	3° 2,04' N	95° 17,01' E	371	WNW 8	349	10,6	Vermessung	EM / PS	Ende Profil	
SO186/036-1	02.11.05	21:54	3° 2,04' N	95° 17,01' E	371	WNW 8	349	10,6	Vermessung	EM / PS	Beginn Profil	**Profil SO 186-1b - 36**, rwk: 060°, d: 21sm
SO186/036-1	02.11.05	23:57	3° 12,41' N	95° 35,05' E	778	SW 2	61	10,7	Vermessung	EM / PS	Kursänderung	rwk: 111°, d: 25sm
SO186/036-1	03.11.05	02:31	3° 3,54' N	95° 58,90' E	594	S 6	84	8,3	Vermessung	EM / PS	Ende Profil	
SO186/036-2	03.11.05	02:52	3° 4,78' N	95° 59,52' E	648	SE 3	26	6,1	OBS/OBH	OBS/OBH	Beginn Station	
SO186/036-2	03.11.05	02:55	3° 5,02' N	95° 59,63' E	649	ESE 3	35	3,9	OBS/OBH	OBS/OBH	OBH ausgelöst	**OBH 13**
SO186/036-2	03.11.05	03:13	3° 5,93' N	96° 0,02' E	648	ESE 2	84	0,5	OBS/OBH	OBS/OBH	OBH gesichtet	
SO186/036-2	03.11.05	03:19	3° 5,92' N	96° 0,08' E	648	ESE 3	87	0,8	OBS/OBH	OBS/OBH	OBH an Deck	**OBH 13**
SO186/036-3	03.11.05	04:25	3° 5,96' N	96° 0,05' E	649	SSE 4	49	0,5	OBS/OBH	OBS/OBH	OBH zu Wasser	**OBH 13**

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/036-3	03.11.05	04:28	3° 5,95' N	96° 0,07' E	649	SSE 5	179	1,2	OBS/OBH	OBS/OBH	Ende Station	
SO186/037-1	03.11.05	05:00	3° 8,96' N	96° 0,00' E	950	ESE 2	304	9,4	Vermessung	EM / PS	Beginn Profil	**Profil SO 186-1b - 37,**rwK: 289° d: 16sm
SO186/037-1	03.11.05	06:36	3° 14,00' N	95° 44,95' E	688	S 5	276	10,2	Vermessung	EM / PS	Kursänderung	rwK: 270°, d: 10 sm
SO186/037-1	03.11.05	07:38	3° 14,00' N	95° 35,03' E	791	S 10	273	8,6	Vermessung	EM / PS	Kursänderung	rwK: 240°, d: 22 sm
SO186/037-1	03.11.05	09:51	3° 3,03' N	95° 16,05' E	364	SW 6	225	7,1	Vermessung	EM / PS	Ende Profil	
SO186/038-1	03.11.05	09:51	3° 3,03' N	95° 16,05' E	364	SW 6	225	7,1	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 38**, rwk: 180° d: 5 sm
SO186/038-1	03.11.05	10:11	3° 0,39' N	95° 16,00' E	400	SW 8	180	9,4	Magnetometer	MAGN	Magnetometer zu Wasser	2 Sonden, SL: 750 m
SO186/038-1	03.11.05	10:26	2° 57,99' N	95° 16,02' E	511	SSW 10	168	9,9	Magnetometer	MAGN	Kursänderung	rwk: 158^, d: 11 sm
SO186/038-1	03.11.05	11:30	2° 48,10' N	95° 19,96' E	919	NNW 0	156	11,1	Magnetometer	MAGN	Kursänderung	rwk: 152°, d: 17sm
SO186/038-1	03.11.05	13:12	2° 33,02' N	95° 28,00' E	1205	S 43	131	9,1	Magnetometer	MAGN	Kursänderung	rwK: 133° d: 19sm
SO186/038-1	03.11.05	15:04	2° 19,85' N	95° 42,30' E	974	SE 29	105	10	Magnetometer	MAGN	Ende Profil	
SO186/039-1	03.11.05	15:04	2° 19,85' N	95° 42,30' E	974	SE 29	105	10	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 39,**rwK: 108° d: 8sm
SO186/039-1	03.11.05	15:48	2° 17,50' N	95° 49,49' E	1118	ESE 29	112	10,2	Magnetometer	MAGN	Kursänderung	rwK: 122° d: 5sm
SO186/039-1	03.11.05	16:16	2° 14,83' N	95° 53,63' E	1666	SSE 6	122	11	Magnetometer	MAGN	Kursänderung	rwK: 104° d: 20sm
SO186/039-1	03.11.05	18:13	2° 10,00' N	96° 13,01' E	826	E 7	101	8,7	Magnetometer	MAGN	Kursänderung	rwK: 068°, d: 5 sm
SO186/039-1	03.11.05	18:14	2° 10,00' N	96° 13,14' E	848	NE 7	75	7,3	Magnetometer	MAGN	Ende Profil	
SO186/039-1	03.11.05	18:35	2° 10,72' N	96° 14,84' E	876	ENE 4	70	5	Magnetometer	MAGN	Magnetometer an Deck	
SO186/039-2	03.11.05	19:03	2° 12,00' N	96° 18,01' E	1028	ENE 4	75	0,9	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS 03**
SO186/039-2	03.11.05	19:05	2° 12,00' N	96° 18,03' E	1020	NE 3	113	1,6	OBS/OBH	OBS/OBH	Ende Station	
SO186/040-1	03.11.05	19:05	2° 12,00' N	96° 18,03' E	1020	NE 3	113	1,6	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 40**, rwk: 037°, d: 3 sm
SO186/040-1	03.11.05	19:40	2° 14,80' N	96° 20,00' E	1011	NE 3	37	9	Magnetometer	MAGN	Kursänderung	rwk: 289, d: 31 sm
SO186/040-1	03.11.05	21:23	2° 20,17' N	96° 4,75' E	759	ENE 4	284	9	Magnetometer	MAGN	Magnetometer zu Wasser	2 Sonden, SL: 750 m
SO186/040-1	03.11.05	22:53	2° 24,99' N	95° 51,01' E	680	NNE 8	286	8,8	Magnetometer	MAGN	Kursänderung	rwk: 286°, d: 7 sm
SO186/040-1	03.11.05	23:36	2° 26,97' N	95° 44,15' E	634	ENE 4	287	9,8	Magnetometer	MAGN	Kursänderung	rwk: 256° d: 13sm
SO186/040-1	04.11.05	00:55	2° 23,77' N	95° 31,39' E	1721	ENE 3	241	9,1	Magnetometer	MAGN	Ende Profil	
SO186/041-1	04.11.05	00:56	2° 23,66' N	95° 31,29' E	1722	NNE 3	216	8,3	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 41,**rwk: 115°, d: 26sm
SO186/041-1	04.11.05	03:36	2° 12,62' N	95° 54,97' E	1657	ESE 7	116	10,2	Magnetometer	MAGN	Kursänderung	rwk: 104°, d: 18 sm
SO186/041-1	04.11.05	05:18	2° 8,51' N	96° 11,88' E	1017	SSE 6	114	10	Magnetometer	MAGN	Kursänderung	rwK: 135°, d: 6 sm
SO186/041-1	04.11.05	05:47	2° 5,02' N	96° 15,37' E	1427	SSW 6	163	10	Magnetometer	MAGN	Ende Profil	
SO186/042-1	04.11.05	05:48	2° 4,86' N	96° 15,37' E	1436	SSE 6	195	9,2	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 42,**rwK: 283°, d: 23 sm
SO186/042-1	04.11.05	08:07	2° 9,68' N	95° 54,06' E	2161	SE 4	289	9,8	Magnetometer	MAGN	Kursänderung	rwK: 296°, d: 29 sm
SO186/042-1	04.11.05	10:58	2° 22,30' N	95° 28,23' E	1582	SSE 4	291	9	Magnetometer	MAGN	Kursänderung	rwk: 245°, d: 3 sm
SO186/042-1	04.11.05	11:17	2° 21,20' N	95° 25,44' E	1312	ESE 4	243	8,8	Magnetometer	MAGN	Ende Profil	
SO186/043-1	04.11.05	11:17	2° 21,20' N	95° 25,44' E	1312	ESE 4	243	8,8	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 43**, rwk: 115°, d: 32sm
SO186/043-1	04.11.05	14:29	2° 7,46' N	95° 53,88' E	2142	S 7	116	10,6	Magnetometer	MAGN	Kursänderung	rwK: 104° d: 26sm
SO186/043-1	04.11.05	16:55	2° 1,26' N	96° 18,77' E	1836	ESE 6	146	10,4	Magnetometer	MAGN	Kursänderung	rwK: 247° d: 4sm
SO186/043-1	04.11.05	17:19	1° 59,74' N	96° 15,31' E	1845	ESE 6	255	10	Magnetometer	MAGN	Ende Profil	
SO186/044-1	04.11.05	17:20	1° 59,74' N	96° 15,31' E	1845	ESE 4	284	10	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 44**, rwK: 284°, d: 22 sm
SO186/044-1	04.11.05	19:29	2° 4,98' N	95° 54,08' E	1921	ESE 5	288	10,1	Magnetometer	MAGN	Kursänderung	rwK: 295°, d: 32 sm
SO186/044-1	04.11.05	22:59	2° 19,89' N	95° 22,22' E	1992	NW 39	293	9	Magnetometer	MAGN	Kursänderung	rwk: 249°, d: 3sm
SO186/044-1	04.11.05	23:18	2° 18,96' N	95° 19,40' E	1879	ESE 3	235	10,6	Magnetometer	MAGN	Ende Profil	
SO186/045-1	04.11.05	23:18	2° 18,96' N	95° 19,40' E	1879	ESE 3	235	10,6	Magnetometer	MAGN	Beginn Profil	**Profil 186-45, rwk: 116°, d: 35sm**
SO186/045-1	05.11.05	02:53	2° 3,46' N	95° 50,06' E	2682	SE 8	115	9,5	Magnetometer	MAGN	Kursänderung	rwk: 104°, d: 21 sm

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/045-1	05.11.05	05:14	1° 58,27' N	96° 10,25' E	2519	ESE 6	90	4,8	Magnetometer	MAGN	Magnetometer an Deck	
SO186/045-1	05.11.05	05:14	1° 58,27' N	96° 10,25' E	2519	ESE 6	90	4,8	Magnetometer	MAGN	Ende Profil	
SO186/045-1	05.11.05	05:15	1° 58,25' N	96° 10,32' E	2556	ESE 6	92	4,5	Magnetometer	MAGN	Ende Station	
SO186/045-2	05.11.05	05:55	1° 55,23' N	96° 3,06' E	3164	SE 5	248	10,5	OBS/OBH	OBS/OBH	Beginn Station	
SO186/045-2	05.11.05	05:58	1° 55,07' N	96° 2,67' E	3162	ESE 3	246	7,8	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 06**
SO186/045-2	05.11.05	06:49	1° 54,20' N	96° 0,13' E	3165	ENE 4	177	1,1	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/045-2	05.11.05	07:02	1° 53,99' N	95° 59,74' E	3166	E 4	275	1,6	OBS/OBH	OBS/OBH	OBS an Deck	**OBS # 06**
SO186/045-2	05.11.05	07:03	1° 53,99' N	95° 59,72' E	3164	E 5	274	1	OBS/OBH	OBS/OBH	Ende Station	Anfahrt rwk: 220°, d: 6 sm
SO186/045-3	05.11.05	07:46	1° 49,15' N	95° 56,07' E	4710	E 5	244	0,6	Dummy	Dummy	Beginn Station	**W6, Wasserschallprofil, SVP-Sonde**
SO186/045-3	05.11.05	07:47	1° 49,15' N	95° 56,06' E	4715	E 4	258	0,7	Dummy	Dummy	zu Wasser	Dummy, Sonde bei SL: 20 m
SO186/045-3	05.11.05	08:25	1° 49,23' N	95° 55,77' E	4767	ESE 4	296	0,6	Dummy	Dummy	auf Tiefe	SL: 2000 m
SO186/045-3	05.11.05	09:06	1° 49,22' N	95° 55,97' E	4758	SE 4	105	0,5	Dummy	Dummy	an Deck	
SO186/045-3	05.11.05	09:06	1° 49,22' N	95° 55,97' E	4758	SE 4	105	0,5	Dummy	Dummy	Ende Station	
SO186/045-4	05.11.05	09:09	1° 49,23' N	95° 55,99' E	4757	ESE 4	0	1,3	Kalibrierung	KAL	Beginn Station	**Simrad Kalibrierung**
SO186/045-4	05.11.05	09:15	1° 49,17' N	95° 56,10' E	4759	S 5	218	3,3	Kalibrierung	KAL	Beginn Simrad Kalibrierur	rwk: 220°, d: 6 sm
SO186/045-4	05.11.05	09:50	1° 44,87' N	95° 52,31' E	4998	ESE 5	218	9,2	Kalibrierung	KAL	Kursänderung	rwk: 040°, d: 11 sm
SO186/045-4	05.11.05	11:00	1° 52,70' N	95° 59,02' E	3827	ESE 8	36	9,9	Kalibrierung	KAL	Kursänderung	rwk: 220°, d: 5 sm
SO186/045-4	05.11.05	11:35	1° 48,98' N	95° 55,96' E	4629	ESE 5	220	10,4	Kalibrierung	KAL	Ende Simrad Kalibrierung	
SO186/045-4	05.11.05	11:35	1° 48,98' N	95° 55,96' E	4629	ESE 5	220	10,4	Kalibrierung	KAL	Ende Station	
SO186/045-5	05.11.05	12:17	1° 53,94' N	95° 59,99' E	3162	ENE 3	22	0,9	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 25**
SO186/046-1	05.11.05	12:20	1° 53,99' N	95° 59,91' E	3214	E 3	323	3	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 46**, rwk: 319°, d: 6sm
SO186/046-1	05.11.05	12:42	1° 55,82' N	95° 58,37' E	3816	ESE 4	316	10	Magnetometer	MAGN	Magnetometer zu Wasser	2 Sonden, SL: 750m
SO186/046-1	05.11.05	13:06	1° 58,77' N	95° 55,76' E	2659	E 3	313	9,9	Magnetometer	MAGN	Kursänderung	rwK: 284°, d: 6sm
SO186/046-1	05.11.05	13:41	1° 59,93' N	95° 50,07' E	3172	ESE 2	257	10,3	Magnetometer	MAGN	Kursänderung	rwK: 238°, d: 5sm
SO186/046-1	05.11.05	14:07	1° 57,62' N	95° 46,59' E	4240	E 6	176	9,2	Magnetometer	MAGN	Kursänderung	rwK: 105°, d: 9sm
SO186/046-1	05.11.05	15:03	1° 55,00' N	95° 54,93' E	3671	SE 9	130	9,8	Magnetometer	MAGN	Kursänderung	rwK: 157°, d: 8sm
SO186/046-1	05.11.05	15:49	1° 48,09' N	95° 58,01' E	4756	ESE 8	125	9,5	Magnetometer	MAGN	Kursänderung	rwK: 084°, d: 36sm
SO186/046-1	05.11.05	19:24	1° 51,86' N	96° 33,83' E	1232	SSE 7	122	9,1	Magnetometer	MAGN	Kursänderung	rwK: 162°, d: 13 sm
SO186/046-1	05.11.05	20:43	1° 40,00' N	96° 37,72' E	1531	SSE 7	229	10,1	Magnetometer	MAGN	Kursänderung	rwK: 258°, d: 14 sm
SO186/046-1	05.11.05	22:08	1° 36,99' N	96° 23,97' E	2600	SSE 4	258	10,3	Magnetometer	MAGN	Kursänderung	rwk: 254°, d: 25sm
SO186/046-1	06.11.05	00:32	1° 30,52' N	96° 0,71' E	5111	ESE 4	263	10,6	Magnetometer	MAGN	Ende Profil	
SO186/047-1	06.11.05	00:32	1° 30,52' N	96° 0,71' E	5111	ESE 4	263	10,6	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 47**, rwk: 338°, d: 23sm
SO186/047-1	06.11.05	02:55	1° 51,93' N	95° 51,52' E	4623	SE 3	326	9,7	Magnetometer	MAGN	Kursänderung	rwk: 288°, d: 13 sm
SO186/047-1	06.11.05	04:12	1° 55,98' N	95° 39,05' E	4851	SSE 4	286	10,5	Magnetometer	MAGN	Kursänderung	rwK: 279° d: 4sm
SO186/047-1	06.11.05	04:35	1° 56,58' N	95° 35,11' E	4942	SSE 4	277	10,4	Magnetometer	MAGN	Kursänderung	rwk: 296° d: 24sm
SO186/047-1	06.11.05	06:55	2° 6,99' N	95° 13,67' E	4868	SSE 3	329	9,6	Magnetometer	MAGN	Ende Profil	
SO186/048-1	06.11.05	06:56	2° 7,13' N	95° 13,61' E	4866	SSE 2	340	8,9	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 48**, rwk: 012°, d. 16 sm
SO186/048-1	06.11.05	08:32	2° 22,98' N	95° 16,94' E	1919	S 4	50	9,6	Magnetometer	MAGN	Kursänderung	rwk: 079°, d: 28 sm
SO186/048-1	06.11.05	11:21	2° 28,37' N	95° 43,92' E	689	S 6	95	9,7	Magnetometer	MAGN	Ende Profil	
SO186/049-1	06.11.05	11:21	2° 28,37' N	95° 43,92' E	689	S 6	95	9,7	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 49**, rwk: 107°, d: 16sm
SO186/049-1	06.11.05	12:57	2° 23,72' N	95° 58,93' E	753	S 8	115	10,1	Magnetometer	MAGN	Kursänderung	rwk: 124°, d: 7sm
SO186/049-1	06.11.05	13:42	2° 19,53' N	96° 5,16' E	847	S 8	130	9,8	Magnetometer	MAGN	Kursänderung	rwK: 112° d:7sm
SO186/049-1	06.11.05	14:21	2° 17,05' N	96° 11,40' E	345	S 8	103	10,8	Magnetometer	MAGN	Kursänderung	rwK: 152° d: 5sm

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/049-1	06.11.05	14:53	2° 12,42' N	96° 13,94' E	474	SSW 8	155	9,6	Magnetometer	MAGN	Kursänderung	rwK: 128° d: 4sm
SO186/049-1	06.11.05	15:16	2° 10,11' N	96° 16,91' E	1159	S 8	137	10,8	Magnetometer	MAGN	Kursänderung	rwK: 130° d: 43sm
SO186/049-1	06.11.05	19:39	1° 42,54' N	96° 49,67' E	1817	SSW 8	187	10,6	Magnetometer	MAGN	Ende Profil	
SO186/050-1	06.11.05	19:40	1° 42,39' N	96° 49,61' E	1813	SSW 8	213	9,6	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 50**, rwK: 250°, d: 6 sm
SO186/050-1	06.11.05	20:15	1° 40,39' N	96° 44,03' E	1687	SSE 6	277	9,7	Magnetometer	MAGN	Kursänderung	rwK: 313°, d: 36 sm
SO186/050-1	06.11.05	23:45	2° 4,19' N	96° 17,90' E	1572	SSE 3	279	8,4	Magnetometer	MAGN	Ende Profil	
SO186/051-1	06.11.05	23:45	2° 4,19' N	96° 17,90' E	1572	SSE 3	279	8,4	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 51**,rwk: 151°, d: 38sm
SO186/051-1	07.11.05	03:36	1° 30,78' N	96° 35,96' E	2481	SSE 9	150	10,9	Magnetometer	MAGN	Kursänderung	rwk: 145°, d: 49 sm
SO186/051-1	07.11.05	08:37	0° 50,05' N	97° 3,97' E	1029	SSE 9	145	10	Magnetometer	MAGN	Kursänderung	rwk: 166°, d: 3 sm
SO186/051-1	07.11.05	08:54	0° 47,29' N	97° 4,67' E	1081	S 9	163	10,6	Magnetometer	MAGN	Kursänderung	rwk: 146°, d: 13 sm
SO186/051-1	07.11.05	10:11	0° 36,60' N	97° 11,94' E	1055	S 9	139	9,9	Magnetometer	MAGN	Kursänderung	rwk: 133°, d: 5 sm
SO186/051-1	07.11.05	10:40	0° 33,24' N	97° 15,46' E	1864	SSE 9	133	10,5	Magnetometer	MAGN	Kursänderung	rwk: 146°, d: 47 sm
SO186/051-1	07.11.05	15:19	0° 5,28' S	97° 41,85' E	921	SE 9	85	9,5	Magnetometer	MAGN	Ende Profil	
SO186/052-1	07.11.05	15:19	0° 5,28' S	97° 41,85' E	921	SE 9	85	9,5	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 52**, rwk: 360° d: 6sm
SO186/052-1	07.11.05	15:49	0° 0,16' S	97° 42,00' E	865	SSE 2	1	11	Magnetometer	MAGN	Kursänderung	rwK: 326° d: 42sm
SO186/052-1	07.11.05	19:55	0° 35,12' N	97° 18,01' E	1607	SE 2	321	9,5	Magnetometer	MAGN	Kursänderung	rwK: 314°, d: 7 sm
SO186/052-1	07.11.05	20:39	0° 40,09' N	97° 12,91' E	922	SE 3	319	9,4	Magnetometer	MAGN	Kursänderung	rwK: 326°, d: 12 sm
SO186/052-1	07.11.05	21:48	0° 49,50' N	97° 6,49' E	862	SE 3	339	9,9	Magnetometer	MAGN	Kursänderung	rwk: 342°, d: 3sm
SO186/052-1	07.11.05	22:06	0° 52,39' N	97° 5,54' E	965	SE 3	338	10	Magnetometer	MAGN	Kursänderung	rwk: 325°, d: 48sm
SO186/052-1	08.11.05	02:53	1° 31,45' N	96° 38,37' E	2453	ESE 2	348	9,4	Magnetometer	MAGN	Ende Profil	
SO186/053-1	08.11.05	02:54	1° 31,60' N	96° 38,38' E	2459	SSE 3	24	8,4	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 53**, rwk: 080°, d: 3 sm
SO186/053-1	08.11.05	03:11	1° 31,95' N	96° 40,93' E	2376	SSE 8	125	8,8	Magnetometer	MAGN	Kursänderung	rwk: 145°, d: 44 sm
SO186/053-1	08.11.05	07:27	0° 55,52' N	97° 6,07' E	1106	S 10	150	9,6	Magnetometer	MAGN	Kursänderung	rwK: 153°, d: 4 sm
SO186/053-1	08.11.05	07:52	0° 51,76' N	97° 7,96' E	1055	S 11	156	9,7	Magnetometer	MAGN	Kursänderung	rwK: 146°, d: 13 sm
SO186/053-1	08.11.05	09:08	0° 41,18' N	97° 15,03' E	1035	SSW 9	137	10,1	Magnetometer	MAGN	Kursänderung	rwK: 126°, d: 7 sm
SO186/053-1	08.11.05	09:52	0° 36,80' N	97° 20,95' E	1316	SSW 8	119	10,5	Magnetometer	MAGN	Kursänderung	rwk: 145°; d: 37 sm
SO186/053-1	08.11.05	13:25	0° 7,11' N	97° 41,74' E	288	ESE 9	77	9	Magnetometer	MAGN	Ende Profil	
SO186/054-1	08.11.05	13:26	0° 7,18' N	97° 41,87' E	292	SE 8	53	9,4	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 54,** rwk: 360° d: 7sm
SO186/054-1	08.11.05	13:59	0° 12,87' N	97° 41,99' E	417	SSE 3	3	10,5	Magnetometer	MAGN	Kursänderung	rwK: 325° d: 32sm
SO186/054-1	08.11.05	17:00	0° 38,75' N	97° 23,71' E	1277	ESE 3	318	10,9	Magnetometer	MAGN	Kursänderung	rwK: 296° d: 7sm
SO186/054-1	08.11.05	17:43	0° 41,97' N	97° 17,27' E	879	ESE 3	298	10,2	Magnetometer	MAGN	Kursänderung	rwK: 325°, d: 12 sm
SO186/054-1	08.11.05	18:54	0° 51,99' N	97° 10,11' E	1026	ESE 4	322	10,4	Magnetometer	MAGN	Kursänderung	rwK: 341°, ,d: 6 sm
SO186/054-1	08.11.05	19:32	0° 58,04' N	97° 7,98' E	980	ENE 8	333	9,8	Magnetometer	MAGN	Kursänderung	rwK: 325°, d: 43 sm
SO186/054-1	08.11.05	23:47	1° 32,86' N	96° 43,67' E	2296	E 4	355	9,7	Magnetometer	MAGN	Ende Profil	
SO186/055-1	08.11.05	23:47	1° 32,86' N	96° 43,67' E	2296	E 4	355	9,7	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 55,** rwk: 070°, d: 3sm
SO186/055-1	09.11.05	00:04	1° 33,94' N	96° 46,00' E	1477	ESE 6	106	9,2	Magnetometer	MAGN	Kursänderung	rwk: 145°, d: 26sm
SO186/055-1	09.11.05	02:43	1° 12,15' N	97° 1,25' E	360	WNW 5	165	10	Magnetometer	MAGN	Kursänderung	rwk: 166°, d: 2 sm
SO186/055-1	09.11.05	02:56	1° 10,06' N	97° 1,83' E	312	WNW 5	149	9,7	Magnetometer	MAGN	Kursänderung	rwk: 129°, d: 3 sm
SO186/055-1	09.11.05	03:13	1° 8,23' N	97° 4,01' E	513	WSW 5	132	9,9	Magnetometer	MAGN	Kursänderung	rwK: 146°, d: 9 sm
SO186/055-1	09.11.05	04:09	1° 0,50' N	97° 9,27' E	731	WNW 4	157	10	Magnetometer	MAGN	Kursänderung	rwK: 160° d: 9sm
SO186/055-1	09.11.05	04:57	0° 53,03' N	97° 11,99' E	515	W 4	153	9,8	Magnetometer	MAGN	Kursänderung	rwK: 146° d: 10sm
SO186/055-1	09.11.05	05:56	0° 44,96' N	97° 17,57' E	440	SW 5	119	9,8	Magnetometer	MAGN	Kursänderung	rwK: 116°, d: 10 sm
SO186/055-1	09.11.05	06:52	0° 40,82' N	97° 26,16' E	1400	SW 5	121	10	Magnetometer	MAGN	Kursänderung	rwK: 144°, d: 32 sm

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/055-1	09.11.05	10:05	0° 15,10' N	97° 44,90' E	234	WSW 6	143	10,1	Magnetometer	MAGN	Ende Profil	
SO186/056-1	09.11.05	10:06	0° 14,95' N	97° 44,99' E	230	SW 5	164	10	Magnetometer	MAGN	Beginn Profil	**Profil SO 186-1b - 56,** rwk: 180°, d: 24 sm
SO186/056-1	09.11.05	12:28	0° 8,91' S	97° 45,02' E	410	WSW 5	175	9,8	Magnetometer	MAGN	Kursänderung	rwk: 147°, d: 19sm
SO186/056-1	09.11.05	13:41	0° 18,98' S	97° 51,52' E	1159	SSE 6	144	10,3	Magnetometer	MAGN	Ende Profil	
SO186/057-1	10.11.05	02:44	1° 50,65' N	96° 2,77' E	3864	NNW 9	320	9,1	OBS/OBH	OBS/OBH	Beginn Station	OBS # 25
SO186/057-1	10.11.05	02:45	1° 50,76' N	96° 2,68' E	3865	NW 9	314	8,3	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS # 25
SO186/057-1	10.11.05	03:31	1° 53,78' N	96° 0,19' E	3155	NW 4	340	1	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/057-1	10.11.05	03:43	1° 54,03' N	95° 59,97' E	3165	NW 4	358	0,2	OBS/OBH	OBS/OBH	OBS an Deck	OBS # 25
SO186/057-1	10.11.05	03:43	1° 54,03' N	95° 59,97' E	3165	NW 4	358	0,2	OBS/OBH	OBS/OBH	Ende Station	
			Anfahrt Jakarta									

Station SO 186-1b	CTD / Ro	Magnetometer	Aussetzen OBS/H	Aufnehmen OBS / H	Gravimeter	SVP - Sonde	Bb. Magnetometerausleger	Hilfskräne	EM 120 / Parasound - Profil	Hilfskräne Einsatzzeit (h)	Stationszeit gesamt (h)	W 6 Zeit (h)	EM 120 / Parasound- Zeit (h)	Stationszeit in sm	Länge W 6	EM 120 / Parasound-Verm. in	Bemerkungen
SO 186-1b - 21		1			1		1		1				3,7			35	EM 120 / Magnetometerprofil
SO 186-1b - 22		1			1		1		1				1,5			15	EM 120 / Magnetometerprofil
SO 186-1b - 23		1			1		1		1				6,6			65	EM 120 / Magnetometerprofil
SO 186-1b - 24		1			1		1		1				10,9			109	EM 120 / Magnetometerprofil
SO 186-1b - 25		1			1		1		1				23,9			217	EM 120 / Magnetometerprofil
SO 186-1b - 26		1			1		1		1				6,9			69	EM 120 / Magnetometerprofil
SO 186-1b - 27		1			1		1		1				3,3			33	EM 120 / Magnetometerprofil
SO 186-1b - 28		1			1		1		1				8,2			82	EM 120 / Magnetometerprofil
SO 186-1b - 29		1			1		1		1				18,5			184	EM 120 / Magnetometerprofil
SO 186-1b - 30-1		1			1		1		1				4,1			44	EM 120 / Magnetometerprofil
SO 186-1b - 30-2				1	1			1		0,1	0,8			5			Aufnahme OBS # 03
SO 186-1b - 31-1					1				1				4,0			38	EM 120 Profil
SO 186-1b - 31-2				1	1			1		0,1	0,4			2			Aufnahme OBS # 10
SO 186-1b - 31-3			1		1			1		0,1	0,1						Auslegen OBS # 03
SO 186-1b - 32-1		1			1		1		1				4,1			39	EM 120 / Magnetometerprofil
SO 186-1b - 33-1		1			1		1		1				3,5			34	EM 120 / Magnetometerprofil
SO 186-1b - 34-1		1			1		1		1				2,1			20	EM 120 / Magnetometerprofil
SO 186-1b - 34-2				1	1			1		0,1	0,8			2			Aufnahme OBS # 11
SO 186-1b - 34-3			1		1			1		0,1	0,1						Auslegen OBS # 22
SO 186-1b - 35-1					1				1				3,5			33	EM 120 Profil
SO 186-1b - 36-1					1				1				5,0			48	EM 120 Profil
SO 186-1b - 36-2				1	1			1		0,1	0,5			2			Aufnahme OBH 13
SO 186-1b - 36-3			1		1			1		0,1	0,1						Aussetzen OBH 13
SO 186-1b - 37-1					1				1				4,9			48	EM 120 Profil
SO 186-1b - 38-1		1			1		1		1				5,2			52	EM 120 / Magnetometerprofil
SO 186-1b - 39-1		1			1		1		1				4,0			38	EM 120 / Magnetometerprofil
SO 186-1b - 39-2			1		1			1		0,1	0,1						OBS # 03
SO 186-1b - 40-1		1			1		1		1				5,8			54	EM 120 / Magnetometerprofil
SO 186-1b - 41-1		1			1		1		1				4,9			50	EM 120 / Magnetometerprofil
SO 186-1b - 42-1		1			1		1		1				5,5			55	EM 120 / Magnetometerprofil
SO 186-1b - 43-1		1			1		1		1				6,0			62	EM 120 / Magnetometerprofil
SO 186-1b - 44-1		1			1		1		1				6,0			57	EM 120 / Magnetometerprofil

Appendix 10.2
Einsätze von Geräten und Winden
SO 186-1b

Station SO 186-1b	CTD / Ro	Magnetometer	Aussetzen OBS/H	Aufnehmen OBS / H	Gravimeter	SVP - Sonde	Bb. Magnetometerausleger	Hilfskräne	EM 120 / Parasound - Profil	Hilfskräne Einsatzzeit (h)	Stationszeit gesamt (h)	W 6 Zeit (h)	EM 120 / Parasound- Zeit (h)	Stationszeit in sm	Länge W 6	EM 120 / Parasound-Verm. in	Bemerkungen
SO 186-1b - 45-1		1			1		1		1				5,9			56	EM 120 / Magnetometerprofil
SO 186-1b - 45-2				1	1			1		0,1	1,8			12			Aufnahme OBS # 06
SO 186-1b - 45-3					1	1					2,0	1,3		6	2000		Wasserschallprofil mit Simrad - Sonde
SO 186-1b - 45-4					1				1				2,4			22	Simradkalibrierung
SO 186-1b - 45-5			1		1			1		0,1	0,8			6			OBS # 25
SO 186-1b - 46-1		1			1		1		1				12,2			122	EM 120 / Magnetometerprofil
SO 186-1b - 47-1		1			1		1		1				6,4			64	EM 120 / Magnetometerprofil
SO 186-1b - 48-1		1			1		1		1				4,4			42	EM 120 / Magnetometerprofil
SO 186-1b - 49-1		1			1		1		1				8,3			82	EM 120 / Magnetometerprofil
SO 186-1b - 50-1		1			1		1		1				4,1			42	EM 120 / Magnetometerprofil
SO 186-1b - 51-1		1			1		1		1				15,6			155	EM 120 / Magnetometerprofil
SO 186-1b - 52-1		1			1		1		1				11,6			118	EM 120 / Magnetometerprofil
SO 186-1b - 53-1		1			1		1		1				10,5			108	EM 120 / Magnetometerprofil
SO 186-1b - 54-1		1			1		1		1				10,4			107	EM 120 / Magnetometerprofil
SO 186-1b - 55-1		1			1		1		1				10,3			104	EM 120 / Magnetometerprofil
SO 186-1b - 56-1		1			1		1		1				3,6			43	EM 120 / Magnetometerprofil
SO 186-1b - 57-1				1				1		0,1	1,0			4			Aufnahme OBS # 25
																	Anfahrt Jakarta
Total:	**0**	**32**	**5**	**6**	**48**	**1**	**32**	**11**	**37**	**1**	**8**	**1**	**258**	**39**	**2000**	**2546**	
maximal gefierte															0		
Seillänge SO 186																	

Abkürzungen / Abbreviation

z.W	zu Wasser
a.D.	an Deck
SL (max.)	(maximale)Seillänge
LT	Lottiefe nach Hydrosweep
W x	eingesetzte Winde
SM	Simrad - Multibeam - Lot
PS	Parasound
rwk:	Rechtweisender Kurs
d:	Distanz
v:	Geschwindigkeit in Knoten
SL:	Seillänge
KL:	Kabellänge

Ohne Profilnummern wurde während der gesamten Reise EM 120 Vermessung durchgeführt

	Eingesetzte Geräte	Einsätze
CTD	Releaser- / Modemtest / Wasserschallprofil mit Sonden	7
OBS / H	Aussetzen OBS / H	17
OBS / H	Aufnehmen OBS / H	5
OBU	Aussetzen OBU	2
OBM	Aussetzen OBM	5
TEWS	Tsunami Early Warning System - Verankerungen	2

Geräteverluste: **Keine**

Winde	D/M	Typ	RF-Nr	SO 186-1c Einsatz	Gesamt Einsatz	SO 186-1c S`länge	Gesamt S`länge	Zust.	SO 186-1c gefierte max. L	jemals gefierte max. Länge
W 1	18,2	LWL	812001	0 h	478 h	0 m	241232 m	3-4	0 m	8022 m
W 2	18,2	LWL	120301500	0 h	0 h	0 m	0 m	1	0 m	0 m
W 4	11	NSW	818045	0 h	308 h	0 m	268589 m	3-4	0 m	8081 m
W 5	11	NSW	818237	0 h	106 h	0 m	100537 m	2	0 m	5861 m
W 6	18,2	Koax	815286	35 h	348 h	33282 m	434330 m	2	6000 m	6000 m

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
TEWS 1	**15:11.05**		**Aussetzen der TEWS 1 Boje für Gäste und Journalisten**									
ohne #			**Anfahrt AG auf verschiedenen Kursen mit Simrad EM 120 Aufzeichnungen**									d: 295 sm
SO186/058-1	16.11.05	16:50	6° 23,03' S	101° 46,91' E	6223	ENE 8	176	1,1	CTD	CTD	Beginn Station	**Releasertest**
SO186/058-1	16.11.05	17:24	6° 23,06' S	101° 46,99' E	6223	SE 9	114	0,2	CTD	CTD	zu Wasser	W6
SO186/058-1	16.11.05	19:37	6° 23,07' S	101° 47,01' E	6218	SE 8	140	0,8	CTD	CTD	auf Tiefe	SL=6000m (WT ca. 6230m)
SO186/058-1	16.11.05	23:19	6° 22,87' S	101° 46,90' E	6210	SSE 10	236	0,9	CTD	CTD	an Deck	
SO186/058-1	16.11.05	23:22	6° 22,91' S	101° 46,94' E	6210	SSE 11	107	2,6	CTD	CTD	Ende Station	
SO186/059-1	17.11.05	04:44	5° 41,12' S	101° 4,46' E	6060	ESE 8	328	0,4	CTD	CTD	Beginn Station	**Releasertest**
SO186/059-1	17.11.05	04:50	5° 41,14' S	101° 4,45' E	6055	SE 8	126	0,6	CTD	CTD	zu Wasser	W6
SO186/059-1	17.11.05	07:08	5° 40,93' S	101° 4,14' E	6045	SE 7	284	1,2	CTD	CTD	auf Tiefe	SL= 5800m
SO186/059-1	17.11.05	09:31	5° 40,63' S	101° 3,48' E	6025	SE 67	231	0,9	CTD	CTD	an Deck	
SO186/059-1	17.11.05	09:31	5° 40,63' S	101° 3,48' E	6025	SE 67	231	0,9	CTD	CTD	Ende Station	
SO186/060-1	17.11.05	23:27	3° 29,95' S	99° 25,37' E	5800	NE 6	147	1,9	Verankerung	VERANK.	Beginn Station	**TEWS 1**
SO186/060-1	17.11.05	23:31	3° 30,04' S	99° 25,38' E	5803	ENE 5	176	1,1	Verankerung	VERANK.	Gerät z.W.	Kette + Vorlauf
SO186/060-1	17.11.05	23:54	3° 30,29' S	99° 25,31' E	5800	N 7	167	1,5	Verankerung	VERANK.	Kopfboje z.W.	Anfahrt CTD, d: 6 sm
SO186/060-1	17.11.05	23:54	3° 30,29' S	99° 25,31' E	5800	N 7	167	1,5	Verankerung	VERANK.	Ende Station	
SO186/060-2	18.11.05	00:19	3° 30,51' S	99° 25,06' E	5799	NE 9	310	0,5	CTD	CTD	Beginn Station	
SO186/060-2	18.11.05	00:19	3° 30,51' S	99° 25,06' E	5799	NE 9	310	0,5	CTD	CTD	zu Wasser	
SO186/060-2	18.11.05	01:45	3° 31,38' S	99° 24,98' E	5998	N 14	28	0,5	CTD	CTD	auf Tiefe	SL: 3532 m
SO186/060-2	18.11.05	04:42	3° 32,34' S	99° 24,87' E	0	N 10	298	1,1	CTD	CTD	an Deck	
SO186/060-2	18.11.05	04:42	3° 32,34' S	99° 24,87' E	0	N 10	298	1,1	CTD	CTD	Ende Station	
SO186/060-3	18.11.05	10:41	3° 32,81' S	99° 29,51' E	5811,1	NNE 8	34	0,4	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 26**
ohne #			schleppen der Verankerungsboje wegen schlechtem Wetter									d: 18 sm

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/060-4	19.11.05	05:48	3° 28,42' S	99° 30,07' E	5790,1	NNW 9	251	1,3	Verankerung	VERANK.	Beginn Station	
SO186/060-4	19.11.05	07:06	3° 28,81' S	99° 29,46' E	5797,2	N 6	231	1,1	Verankerung	VERANK.	Kopfboje a.D	
SO186/060-4	19.11.05	07:15	3° 28,78' S	99° 29,34' E	5798,5	NNE 7	322	1,5	Verankerung	VERANK.	Gerät a.D.	Kette
SO186/060-4	19.11.05	07:29	3° 28,84' S	99° 29,31' E	5798,9	N 7	291	0,9	Verankerung	VERANK.	Verank. a.D.	Vorlauf
SO186/060-4	19.11.05	07:29	3° 28,84' S	99° 29,31' E	5798,9	N 7	291	0,9	Verankerung	VERANK.	Ende Station	
SO186/061-1	19.11.05	08:19	3° 28,75' S	99° 29,44' E	5797,3	N 6	100	0,6	CTD	CTD	Beginn Station	**W6, CTD zum Modem test**
SO186/061-1	19.11.05	08:20	3° 28,74' S	99° 29,43' E	5797,4	N 6	313	1,2	CTD	CTD	zu Wasser	Modem + Releaser
SO186/061-1	19.11.05	12:13	3° 31,24' S	99° 32,28' E	0	WNW 8	61	0,7	CTD	CTD	auf Tiefe	SL: 5600m
SO186/061-1	19.11.05	15:14	3° 33,23' S	99° 34,28' E	5793,2	NNW 7	169	2,2	CTD	CTD	an Deck	
SO186/061-1	19.11.05	15:14	3° 33,23' S	99° 34,28' E	5793,2	NNW 7	169	2,2	CTD	CTD	Ende Station	
SO186/062-1	19.11.05	15:19	3° 33,36' S	99° 34,26' E	5793	N 7	260	3,7	OBS/OBH	OBS/OBH	Beginn Station	**OBS #26**
SO186/062-1	19.11.05	15:20	3° 33,38' S	99° 34,20' E	5788	N 9	249	4,2	OBS/OBH	OBS/OBH	OBS ausgelöst	
SO186/062-1	19.11.05	16:44	3° 33,13' S	99° 29,60' E	5806	NNW 10	26	1,1	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/062-1	19.11.05	17:06	3° 33,02' S	99° 29,80' E	5810	NNW 8	105	0,7	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/062-1	19.11.05	17:10	3° 33,06' S	99° 29,88' E	5809	NNW 7	145	0,9	OBS/OBH	OBS/OBH	Ende Station	
SO186/063-1	19.11.05	17:17	3° 33,06' S	99° 29,95' E	0	NNW 8	217	0,6	CTD	CTD	Beginn Station	**W6, CTD zum Modem test**
SO186/063-1	19.11.05	17:18	3° 33,07' S	99° 29,95' E	0	NNW 8	243	0,6	CTD	CTD	zu Wasser	
SO186/063-1	19.11.05	19:00	3° 33,09' S	99° 29,94' E	0	NNW 8	321	0,3	CTD	CTD	auf Tiefe	**SL= 5600m**
SO186/063-1	19.11.05	21:28	3° 33,74' S	99° 30,41' E	0	NNW 13	256	0,5	CTD	CTD	an Deck	
SO186/063-1	19.11.05	21:31	3° 33,75' S	99° 30,40' E	0	NNW 13	188	0,1	CTD	CTD	Ende Station	
SO186/064-1	20.11.05	02:38	3° 44,64' S	99° 13,25' E	5091	NW 10	319	1	Verankerung	VERANK.	Beginn Station	**TEWS 1**
SO186/064-1	20.11.05	02:49	3° 44,55' S	99° 13,33' E	5108	NW 10	7	0,3	Verankerung	VERANK.	Kopfboje z.W.	
SO186/064-1	20.11.05	03:04	3° 44,48' S	99° 13,44' E	5141	NW 9	135	1,7	Verankerung	VERANK.	Gerät z.W.	Drahtseil mit Floats
SO186/064-1	20.11.05	03:25	3° 44,54' S	99° 13,77' E	5156	WNW 9	112	0,7	Verankerung	VERANK.	Gerät z.W.	SubSurface Float SO 962
SO186/064-1	20.11.05	04:35	3° 43,77' S	99° 13,25' E	5163	NW 10	117	0,4	Verankerung	VERANK.	Gerät z.W.	1. AK-Modul 5-fach (Benthos)
SO186/064-1	20.11.05	05:03	3° 43,51' S	99° 13,11' E	5225	NW 12	54	0,6	Verankerung	VERANK.	Gerät z.W.	2. AK-Modul 5-fach (Benthos)
SO186/064-1	20.11.05	05:34	3° 43,25' S	99° 12,95' E	5217	NNW 13	131	1,1	Verankerung	VERANK.	Gerät z.W.	3. AK-Modul, 5-fach (Benthos)
SO186/064-1	20.11.05	06:02	3° 43,04' S	99° 12,82' E	5213	NW 13	7	1,5	Verankerung	VERANK.	Gerät z.W.	4. AK-Modul, 5-fach (Benthos)
SO186/064-1	20.11.05	06:29	3° 42,84' S	99° 12,76' E	5204	NW 11	256	0,6	Verankerung	VERANK.	Gerät z.W.	5. AK-Modul 5-fach (Benthos)
SO186/064-1	20.11.05	06:51	3° 42,65' S	99° 12,67' E	5198	NNW 11	256	1,3	Verankerung	VERANK.	Gerät z.W.	6. AK-Modul 3-fach (Benthos)
SO186/064-1	20.11.05	07:34	3° 42,28' S	99° 12,52' E	5212	NNW 12	133	0,6	Verankerung	VERANK.	Gerät z.W.	7. AK-Modul, 2-fach (Benthos)
SO186/064-1	20.11.05	08:05	3° 42,14' S	99° 12,49' E	5217	NNW 12	135	0,7	Verankerung	VERANK.	Gerät z.W.	8. AK-Modul, 3-fach (Benthos)
SO186/064-1	20.11.05	09:55	3° 42,37' S	99° 12,53' E	5210	NNW 13	279	0,5	Verankerung	VERANK.	Gerät z.W.	9. AK-Modul, 2-fach (Benthos)
SO186/064-1	20.11.05	10:17	3° 42,55' S	99° 12,49' E	5204	NNW 11	208	1,7	Verankerung	VERANK.	Gerät z.W.	10. AK-Modul, 5-fach (Benthos)
SO186/064-1	20.11.05	10:23	3° 42,62' S	99° 12,47' E	5194	NNW 14	147	1,2	Verankerung	VERANK.	Auslöser z.W	
SO186/064-1	20.11.05	10:48	3° 42,91' S	99° 12,47' E	5209	NNW 12	77	1,4	Verankerung	VERANK.	Ankerstein z.W.	2,4 to, Fallschirm + Britanny Anker
SO186/064-2	20.11.05	12:08	3° 43,91' S	99° 13,81' E	5288	NW 10	91	1,5	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBU # TS 01**
SO186/064-1	20.11.05	12:13	3° 43,73' S	99° 14,02' E	5289	WNW 12	40	7,6	Verankerung	VERANK.	Verankerung in Position	G**esamtlänge: 5530 m**
SO186/064-3	20.11.05	12:26	3° 43,00' S	99° 14,03' E	5268	NW 11	230	1,3	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # TS 01**
SO186/064-3	20.11.05	12:27	3° 43,00' S	99° 14,05' E	5265	NW 9	155	1,7	OBS/OBH	OBS/OBH	Ende Station	
SO186/065-1	22.11.05	21:00	0° 2,65' S	96° 57,75' E	5297	SW 5	158	1,4	CTD	CTD	Beginn Station	**W6, CTD zum Modem test**
SO186/065-1	22.11.05	21:21	0° 2,79' S	96° 57,74' E	5293	SW 5	221	0,6	CTD	CTD	zu Wasser	
SO186/065-1	22.11.05	23:09	0° 3,99' S	96° 58,12' E	5295	NNE 3	184	1,2	CTD	CTD	auf Tiefe	SL: 3100m

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/065-1	23.11.05	00:04	0° 4,42' S	96° 58,10' E	5289	ENE 5	142	0,3	CTD	CTD	an Deck	
SO186/065-2	23.11.05	02:04	0° 13,95' S	96° 48,19' E	5071	NE 2	135	0,5	CTD	CTD	zu Wasser	**W6, CTD zum Modem test**
SO186/065-2	23.11.05	04:10	0° 15,94' S	96° 49,40' E	5055	NNW 0	159	1,2	CTD	CTD	auf Tiefe	SL: 3650m
SO186/065-2	23.11.05	06:10	0° 17,70' S	96° 50,16' E	4848	WNW 6	175	2	CTD	CTD	an Deck	
SO186/065-2	23.11.05	06:10	0° 17,70' S	96° 50,16' E	4848	WNW 6	175	2	CTD	CTD	Ende Station	
SO186/065-3	23.11.05	09:00	0° 27,41' S	96° 52,38' E	3792	W 6	269	0,3	Verankerung	VERANK.	Beginn Station	
SO186/065-3	23.11.05	09:29	0° 27,31' S	96° 52,30' E	3627	W 7	335	0,5	Verankerung	VERANK.	Kopfboje z.W.	**TEWS 2, mit Kette + Drehwirbel**
SO186/065-3	23.11.05	09:56	0° 27,15' S	96° 52,18' E	3512	W 7	309	0,7	Verankerung	VERANK.	Gerät z.W.	Drahtseil mit Floats + SubSurface Float SO 9
SO186/065-3	23.11.05	10:52	0° 26,82' S	96° 51,86' E	3523	W 6	164	0,4	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	11:13	0° 26,70' S	96° 51,72' E	3556	WSW 6	135	0,5	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	11:32	0° 26,58' S	96° 51,60' E	3565	SW 5	205	0,6	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	11:54	0° 26,49' S	96° 51,49' E	3558	SW 4	314	0,6	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	12:16	0° 26,34' S	96° 51,38' E	3555	SW 4	214	0,4	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	12:36	0° 26,21' S	96° 51,23' E	3549	SSW 4	257	0,6	Verankerung	VERANK.	Gerät z.W.	3 x Benthos
SO186/065-3	23.11.05	13:22	0° 25,87' S	96° 50,93' E	3557	SW 3	165	0,3	Verankerung	VERANK.	Gerät z.W.	3 x Benthos
SO186/065-3	23.11.05	13:36	0° 25,81' S	96° 50,81' E	3557	WSW 3	298	0,7	Verankerung	VERANK.	Gerät z.W.	2 x Benthos
SO186/065-3	23.11.05	13:51	0° 25,71' S	96° 50,70' E	3560	SW 3	45	0,2	Verankerung	VERANK.	Gerät z.W.	5 x Benthos
SO186/065-3	23.11.05	13:56	0° 25,72' S	96° 50,70' E	3562	SW 3	153	0,5	Verankerung	VERANK.	Gerät z.W.	Releaser
SO186/065-3	23.11.05	14:16	0° 25,67' S	96° 50,67' E	3560	SW 3	248	0,2	Verankerung	VERANK.	Ankerstein z.W.	2,5 to, Fallschirm + Britanny Anker
SO186/065-3	23.11.05	15:09	0° 26,89' S	96° 51,27' E	3475	SSW 4	226	0,6	Verankerung	VERANK.	Verankerung in Position	**Gesamtlänge: 4040 m**
SO186/065-4	23.11.05	15:33	0° 27,11' S	96° 50,74' E	3274	SW 5	255	1,3	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBU # TS2**
SO186/065-5	23.11.05	15:51	0° 26,67' S	96° 52,25' E	3425	SW 3	126	2	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # TS2**
SO186/065-5	23.11.05	15:51	0° 26,67' S	96° 52,25' E	3425	SW 3	126	2	Verankerung	VERANK.	Ende Station	
SO186/066-1	24.11.05	02:23	1° 29,99' N	96° 0,00' E	5121	SE 2	353	1,5	OBS/OBH	OBS/OBH	Beginn Station	
SO186/066-1	24.11.05	02:23	1° 29,99' N	96° 0,00' E	5121	SE 2	353	1,5	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 31**
SO186/066-2	24.11.05	03:25	1° 39,99' N	96° 4,99' E	4854	SE 5	48	1,9	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 32**
SO186/066-3	24.11.05	05:14	1° 39,99' N	96° 24,98' E	2396	ESE 5	126	1,6	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 33**
SO186/066-3	24.11.05	05:20	1° 40,01' N	96° 25,07' E	2261	ENE 4	54	1,2	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBM # 01**
SO186/066-5	24.11.05	06:20	1° 45,00' N	96° 32,99' E	1676	SE 5	6	0,9	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 32**
SO186/066-6	24.11.05	06:24	1° 45,05' N	96° 33,01' E	1690	SE 5	39	0,5	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBM # 02**
SO186/066-7	24.11.05	07:38	1° 59,38' N	96° 29,80' E	1248	SE 3	329	12,9	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 04 (alt)**
SO186/066-8	24.11.05	07:48	2° 0,15' N	96° 29,73' E	1176	SSE 7	158	1,1	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 04 (neu)**
SO186/066-7	24.11.05	07:53	2° 0,09' N	96° 29,80' E	1171	SE 6	87	1,3	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/066-7	24.11.05	08:03	2° 0,08' N	96° 29,89' E	1154	SSE 5	178	0,4	OBS/OBH	OBS/OBH	OBS an Deck	**OBS # 04 (alt)**
SO186/066-9	24.11.05	09:20	1° 50,08' N	96° 20,01' E	2771	SE 7	267	1,3	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 34**
SO186/066-10	24.11.05	09:24	1° 50,02' N	96° 19,96' E	2771	SE 6	205	0,9	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBM # 03**
SO186/066-11	24.11.05	09:57	1° 52,73' N	96° 14,64' E	2558	SE 3	294	7,4	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 05 (alt)**
SO186/066-12	24.11.05	10:22	1° 53,98' N	96° 11,99' E	2351	SSE 3	288	1,8	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBM # 04**
SO186/066-11	24.11.05	10:26	1° 54,00' N	96° 11,89' E	2382	SE 5	286	1,3	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/066-13	24.11.05	10:27	1° 54,00' N	96° 11,86' E	2396	SE 5	293	1,6	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 05 (neu)**
SO186/066-11	24.11.05	10:40	1° 54,07' N	96° 11,85' E	2458	SE 4	239	0,8	OBS/OBH	OBS/OBH	OBS an Deck	**OBS # 05 (alt)**
SO186/066-14	24.11.05	11:44	1° 54,00' N	95° 59,92' E	3185	SE 5	286	1,4	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 06**
SO186/066-15	24.11.05	11:54	1° 54,07' N	95° 59,73' E	3380	ESE 3	299	1,1	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBM # 05**

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/066-16	24.11.05	13:05	1° 58,77' N	95° 45,74' E	3852	ESE 2	292	6,2	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/066-16	24.11.05	13:07	1° 58,84' N	95° 45,55' E	4055	ESE 2	285	5,8	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 08 alt**
SO186/066-17	24.11.05	13:34	2° 0,00' N	95° 41,92' E	0	E 2	276	2,3	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 08 neu**
SO186/066-16	24.11.05	14:44	2° 0,05' N	95° 41,91' E	4444	SE 2	159	0,2	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/066-16	24.11.05	14:54	2° 0,14' N	95° 41,86' E	4440	SE 2	274	0,3	OBS/OBH	OBS/OBH	OBS zu Wasser	
SO186/066-18	24.11.05	15:57	1° 50,03' N	95° 42,00' E	5018	SE 5	161	1,4	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 36**
SO186/066-19	24.11.05	17:16	2° 0,04' N	95° 30,00' E	4917	SSE 1	313	1,6	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 37**
SO186/066-20	24.11.05	18:34	2° 11,01' N	95° 18,88' E	4694	ESE 0	307	6,9	OBS/OBH	OBS/OBH	OBS ausgelöst	**OBS # 09 alt**
SO186/066-21	24.11.05	18:50	2° 12,04' N	95° 17,96' E	4669	SE 2	346	1,8	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 09 neu**
SO186/066-20	24.11.05	19:38	0° 0,00' N	0° 0,00' E	0	N 0	0	0	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/066-20	24.11.05	19:53	2° 12,05' N	95° 17,71' E	4672	SSE 4	269	1	OBS/OBH	OBS/OBH	OBS an Deck	**OBS # 09 alt**
SO186/066-22	24.11.05	21:27	2° 30,04' N	95° 20,04' E	1322	SSE 5	26	1,1	OBS/OBH	OBS/OBH	OBS zu Wasser	**OBS # 38**
SO186/066-23	24.11.05	23:03	2° 42,03' N	95° 3,98' E	1104	SSE 4	305	2,5	OBS/OBH	OBS/OBH	OBH zu Wasser	**OBH # 39**
SO186/066-24	24.11.05	23:53	2° 48,02' N	94° 56,01' E	854	S 4	315	2,5	OBS/OBH	OBS/OBH	OBH zu Wasser	**OBH # 40**
SO186/066-24	24.11.05	23:54	2° 48,05' N	94° 55,98' E	865	S 5	330	2,4	OBS/OBH	OBS/OBH	Ende Station	

Appendix 10.4
Einsätze von Geräten und Winden SO 186-1c

Station SO 186-1c	CTD / Ro	Aussetzen OBU	Aussetzen OBS/H	Aufnehmen OBS / H	TEWS - Verankerung	SVP - Sonde	OFOS - CTD	Aussetzen OBM	Hilfskräne	EM 120 / Parasound - Profil	Hilfskräne Einsatzzeit (h)	Stationszeit gesamt (h)	W 6 Zeit (h)	EM 120 / Parasound- Zeit (h)	Stationszeit in sm	Länge W 6	EM 120 / Parasound-Verm. in	Bemerkungen
ohne #					1				1		1,3	1,3						TEWS-Boje z.W. für Gäste und Journalisten
ohne #										1							282	Anfahrt AG
SO 186-1c - 58-1	1					1	1						5,9			6000		Releaser-/Modemtest
ohne #										1				5,3			38	Anfahrt Station
SO 186-1c - 59-1	1					1	1					4,8	4,7			5800		Releaser-/Modemtest
ohne #										1				13,9			170	Anfahrt Station
SO 186-1c - 60-1					1				1		0,5	0,5			1			Aussetzen TEWS 1 zu Testzwecken
SO 186-1c - 60-2	1					1	1					4,4	4,4			3532		Releaser-/Modemtest
ohne #										1				6,0			58	Anfahrt Station
SO 186-1c - 60-3			1						1		0,1	0,1						OBS # 26
ohne #										1				19,2			18	Schleppen der TEWS 1
SO 186-1c - 60-4					1				1		1,7	1,7			2			Aufnahme TEWS 1
SO 186-1c - 61-1	1						1					6,9	6,9			5600		Releaser-/Modemtest
SO 186-1c - 62-1				1					1		0,1	1,9			0,5			OBS # 26
SO 186-1c - 63-1	1						1					4,2	4,2			5600		Releaser-/Modemtest
SO 186-1c - 64-1					1				1	1	9,0	9,6			7		10	TEWS - Verankerung TS 1
SO 186-1c - 64-2		1							1	1	0,1	0,1			1			OBU # TS 01
SO 186-1c - 64-3			1						1	1	0,1	0,1			2			OBS # TS 01
SO 186-1c - 65-1	1						1					3,1	3,0			3100		Releaser-/Modemtest
SO 186-1c - 65-2	1						1					6,1	6,1			3650		Releaser-/Modemtest
SO 186-1c - 65-3					1				1	1	6,1	6,1		6,1	16			TEWS - Verankerung TS 2
SO 186-1c - 65-4		1							1	1	0,1	0,1			0,5			OBU # TS 02
SO 186-1c - 65-5			1						1	1	0,1	0,1			1			OBS # TS 02
ohne #										1				10,5			127	Anfahrt Station
SO 186-1c - 66-1-24			15	4				5	1	1	2,4	21,5		21,5	201		201	Aussetzen/Aufnehmen OBS / H / M
Total:	**7**	**2**	**18**	**5**	**5**	**3**	**7**	**5**	**12**	**13**	**22**	**73**	**35**	**83**	**232**	**33282**	**904**	
maximal gefierte Seillänge SO 186-1c																6000		

Abkürzungen / Abbreviation

z.W	zu Wasser
a.D.	an Deck
SL (max.)	(maximale)Seillänge
LT	Lottiefe nach Hydrosweep
W x	eingesetzte Winde
SM	Simrad - Multibeam - Lot
PS	Parasound
rwk:	Rechtweisender Kurs
d:	Distanz
v:	Geschwindigkeit in Knoten
SL:	Seillänge
KL:	Kabellänge

Ohne Profilnummern wurde während der gesamten Reise EM 120 Vermessung durchgeführt

	Eingesetzte Geräte	**Einsätze**
CTD	Releaser- / Modemtest / Wasserschallprofil mit Sonden	7
OBS / H	Aufnehmen / Aussetzen OBS / H	14 / 13
OBU	Aufnehmen / Aussetzen OBU	2 / 2
OBM	Aufnehmen / Aussetzen OBM	5 / 0
TEWS	Tsunami Early Warning System - Verankerungen / Aufnahme	2
TEWS	Tsunami Early Warning System - Verankerungen / Auslage	2

Geräteverluste: **Keine**

Winde	D/M	Typ	RF-Nr	SO 186-1d Einsatz	Gesamt Einsatz	SO 186-1d S`länge	Gesamt S`länge	Zust.	SO 186-1d gefierte max. L	jemals gefierte max. Länge
W 1	18,2	LWL	812001	0 h	478 h	0 m	241232 m	3-4	0 m	8022 m
W 2	18,2	LWL	120301500	0 h	0 h	0 m	0 m	1	0 m	0 m
W 4	11	NSW	818045	0 h	308 h	0 m	268589 m	3-4	0 m	8081 m
W 5	11	NSW	818237	0 h	106 h	0 m	100537 m	2	0 m	5861 m
W 6	18,2	Koax	815286	6 h	354 h	3590 m	437920 m	2	2000 m	6000 m

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
Am 08.01.2006 um 14:41 UTC Beginn der wissenschaftlichen Aufzeichnungen mit Simrad EM 120												
SO186/067-1	10.01.06	00:00	2° 43,84' N	95° 3,78' E	898	NNE 2	175	5,5	OBS/OBH	OBS/OBH	Beginn Station	
SO186/067-1	10.01.06	00:01	2° 43,75' N	95° 3,80' E	1124	NNE 2	175	4,9	OBS/OBH	OBS/OBH	OBH ausgelöst	OBH 39
SO186/067-1	10.01.06	00:23	2° 42,57' N	95° 3,99' E	1191	N 2	157	2,1	OBS/OBH	OBS/OBH	OBH gesichtet	
SO186/067-1	10.01.06	00:42	2° 41,84' N	95° 4,16' E	1077	N 2	165	1,4	OBS/OBH	OBS/OBH	OBH an Deck	
SO186/067-2-1	10.01.06	05:44	2° 12,97' N	95° 58,11' E	1789	S 6	115	8,4	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 07
SO186/067-2-2	10.01.06	06:02	2° 12,11' N	96° 0,04' E	1607	SW 3	216	1	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 41
SO186/067-2-1	10.01.06	06:07	2° 12,09' N	95° 59,95' E	1622	WSW 3	300	2,4	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 07
SO186/067-2-1	10.01.06	06:18	2° 12,08' N	96° 0,01' E	1618	SW 3	238	1,2	OBS/OBH	OBS/OBH	OBS an Deck	OBS 07
SO186/067-3-1	10.01.06	07:34	1° 58,09' N	95° 59,99' E	2611	S 9	179	12	OBS/OBH	OBS/OBH	OBS ausgelöst	OBM 5
SO186/067-3-2	10.01.06	07:38	1° 57,28' N	95° 59,99' E	3128	S 9	179	11,5	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 33
SO186/067-3-1	10.01.06	08:20	1° 54,09' N	95° 59,87' E	0	SW 3	160	0,3	OBS/OBH	OBS/OBH	OBS gesichtet	OBM 5
SO186/067-3-2	10.01.06	08:24	1° 54,03' N	95° 59,79' E	0	W 4	285	2,3	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 33
SO186/067-3-1	10.01.06	08:30	1° 54,12' N	95° 59,60' E	0	SSW 3	280	0,8	OBS/OBH	OBS/OBH	OBS an Deck	OBM 5
SO186/067-3-2	10.01.06	08:45	1° 54,03' N	95° 59,69' E	0	SW 4	282	1,1	OBS/OBH	OBS/OBH	OBS an Deck	OBS 33
SO186/067-4-1	10.01.06	09:33	1° 54,00' N	96° 7,52' E	0	SSW 4	94	6,5	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 32
SO186/067-4-2	10.01.06	09:34	1° 54,01' N	96° 7,62' E	0	SW 4	97	5,1	OBS/OBH	OBS/OBH	OBS ausgelöst	OBM 04
SO186/067-4-2	10.01.06	10:04	1° 54,08' N	96° 11,63' E	0	WSW 4	82	0,8	OBS/OBH	OBS/OBH	OBS gesichtet	OBM 04
SO186/067-4-1	10.01.06	10:10	1° 54,13' N	96° 11,83' E	0	SW 4	70	3,9	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 32
SO186/067-4-1	10.01.06	10:23	1° 54,38' N	96° 12,04' E	0	SW 3	20	1,2	OBS/OBH	OBS/OBH	OBS an Deck	OBS 32
SO186/067-4-2	10.01.06	10:40	1° 54,46' N	96° 11,84' E	2593,2	SW 6	336	1	OBS/OBH	OBS/OBH	OBS an Deck	OBM 04
SO186/067-5	10.01.06	11:16	1° 52,44' N	96° 15,07' E	2572,5	SSW 5	134	1,6	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 42

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/067-6-1	10.01.06	11:23	1° 52,17' N	96° 15,73' E	0	SSW 8	114	10,8	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 31
SO186/067-6-2	10.01.06	11:26	1° 51,92' N	96° 16,25' E	0	SSW 9	108	12	OBS/OBH	OBS/OBH	OBS ausgelöst	OBM 03
SO186/067-6-1	10.01.06	11:54	1° 50,21' N	96° 19,61' E	0	SW 6	108	1,1	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 31
SO186/067-6-2	10.01.06	12:04	1° 50,42' N	96° 19,86' E	0	WSW 2	107	4,2	OBS/OBH	OBS/OBH	OBS gesichtet	OBM 03
SO186/067-6-1	10.01.06	12:16	1° 50,19' N	96° 19,78' E	0	SW 6	255	1,6	OBS/OBH	OBS/OBH	OBS an Deck	OBS 31
SO186/067-6-2	10.01.06	12:26	1° 50,18' N	96° 19,80' E	0	SSW 4	328	1,3	OBS/OBH	OBS/OBH	OBS an Deck	OBM 03
SO186/067-7-1	10.01.06	13:21	1° 57,13' N	96° 26,32' E	1650,7	S 4	45	12,4	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 30
SO186/067-7-2	10.01.06	13:43	1° 59,65' N	96° 28,82' E	1304,9	SSW 4	51	2,8	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 43
SO186/067-7-1	10.01.06	13:44	1° 59,65' N	96° 28,85' E	1302,3	SSW 5	119	1,3	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/067-7-1	10.01.06	14:09	2° 0,11' N	96° 29,84' E	0	SSW 3	249	0,1	OBS/OBH	OBS/OBH	OBS an Deck	OBS 30
SO186/067-8	10.01.06	15:10	1° 49,44' N	96° 31,95' E	0	SSW 12	170	12,6	OBS/OBH	OBS/OBH	OBS ausgelöst	OBM 2
SO186/067-8	10.01.06	15:47	1° 45,42' N	96° 32,89' E	0	SSW 4	135	0,5	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/067-8	10.01.06	16:00	1° 45,07' N	96° 32,80' E	0	SSW 5	244	0,3	OBS/OBH	OBS/OBH	OBS an Deck	OBM 2
SO186/067-9	10.01.06	16:25	1° 42,48' N	96° 28,96' E	2250	WSW 5	236	8,5	OBS/OBH	OBS/OBH	OBS ausgelöst	OBM 01
SO186/067-9	10.01.06	17:15	1° 40,20' N	96° 25,07' E	2254	WSW 4	270	1,5	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/067-9	10.01.06	17:25	1° 40,10' N	96° 24,94' E	2255	W 4	256	1,1	OBS/OBH	OBS/OBH	OBS an Deck	OBM 01
SO186/067	10.01.06	17:25	1° 40,10' N	96° 24,94' E	2256	W 4	256	1,1	OBS/OBH	OBS/OBH	Ende Station	
ohne #	149 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/068	11.01.06	06:20	0° 26,39' S	96° 50,41' E	3416	NW 3	298	1	Verankerung	VERANK.	Beginn Station	TEWS 02
SO186/068-2	11.01.06	06:32	0° 26,52' S	96° 50,42' E	3367	W 4	22	1,4	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 44
SO186/068-1	11.01.06	06:42	0° 26,47' S	96° 50,39' E	3383	WNW 5	296	0,4	Verankerung	VERANK.	Ausgelöst	
SO186/068-1	11.01.06	08:11	0° 26,17' S	96° 50,68' E	3530	W 4	94	0,6	Verankerung	VERANK.	Auslöser a.D.	5 Benthos
SO186/068-1	11.01.06	08:38	0° 26,19' S	96° 50,93' E	3525	W 4	181	0,7	Verankerung	VERANK.	Gerät a.D.	2 Benthos
SO186/068-1	11.01.06	08:45	0° 26,22' S	96° 50,91' E	3518	W 4	194	0,7	Verankerung	VERANK.	Gerät a.D.	3 Benthos
SO186/068-1	11.01.06	09:03	0° 26,29' S	96° 50,87' E	3521	W 4	337	0,3	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	09:27	0° 26,42' S	96° 50,82' E	3522	W 4	228	0,6	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	09:45	0° 26,54' S	96° 50,82' E	3413	WNW 8	295	0,3	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	10:04	0° 26,62' S	96° 50,80' E	3406	W 4	256	0,6	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	10:21	0° 26,67' S	96° 50,71' E	3348	WNW 4	282	0,8	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	10:45	0° 26,71' S	96° 50,60' E	3329	W 3	4	0,3	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/068-1	11.01.06	11:29	0° 26,81' S	96° 50,48' E	3249	WNW 4	247	0,4	Verankerung	VERANK.	Gerät a.D.	SS Float
SO186/068-1	11.01.06	12:16	0° 27,16' S	96° 50,72' E	3242	NW 2	142	0,6	Verankerung	VERANK.	Kopfboje a.D	TEWS 2
SO186/068-1	11.01.06	12:27	0° 27,29' S	96° 50,78' E	3230	NW 2	181	0,6	Verankerung	VERANK.	Verank. a.D.	TEWS 2 geborgen
SO186/068-3	11.01.06	12:21	0° 27,22' S	96° 50,75' E	3236	NW 2	163	0,8	OBS/OBH	OBS/OBH	OBS ausgelöst	TOBU 02
SO186/068-4	11.01.06	13:01	0° 27,42' S	96° 50,83' E	3260	N 3	169	0,4	OBS/OBH	OBS/OBH	OBS ausgelöst	TOBS 02
SO186/068-3	11.01.06	13:30	0° 27,41' S	96° 50,28' E	3242	NNE 4	313	1,6	OBS/OBH	OBS/OBH	OBS gesichtet	TOBU 02
SO186/068-3	11.01.06	13:46	0° 27,13' S	96° 50,60' E	0	N 3	355	0,7	OBS/OBH	OBS/OBH	OBH an Deck	TOBU 02
SO186/068-5	11.01.06	13:47	0° 27,14' S	96° 50,60' E	0	N 4	208	0,7	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 44
SO186/068-4	11.01.06	13:59	0° 27,17' S	96° 50,65' E	0	NNE 4	122	1,7	OBS/OBH	OBS/OBH	OBS gesichtet	TOBS 02
SO186/068-4	11.01.06	14:25	0° 26,56' S	96° 51,91' E	0	NNE 4	216	0,9	OBS/OBH	OBS/OBH	OBS an Deck	TOBS 02

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/068-5	11.01.06	14:44	0° 26,72' S	96° 51,23' E	0	NNE 2	253	3,6	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 44
SO186/068-5	11.01.06	15:06	0° 26,46' S	96° 50,20' E	3358	NNE 3	268	0,5	OBS/OBH	OBS/OBH	OBS an Deck	OBS 44
SO186/068	11.01.06	15:06	0° 26,46' S	96° 50,20' E	3358	NNE 3	268	0,5	OBS/OBH	OBS/OBH	Ende Station	
ohne #	254 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/069-1	12.01.06	12:24	3° 43,27' S	99° 11,09' E	5115	ESE 10	98	12,1	OBS/OBH	OBS/OBH	OBS ausgelöst	TOBS 01
SO186/069-2	12.01.06	12:44	3° 43,68' S	99° 13,70' E	0	ESE 4	56	0,2	CTD	CTD	zu Wasser	W6 Modemtest
SO186/069-2	12.01.06	12:55	3° 43,60' S	99° 13,71' E	0	ESE 4	6	0,2	CTD	CTD	auf Tiefe	SL: 120m
SO186/069-3	12.01.06	13:04	3° 43,57' S	99° 13,72' E	0	ESE 5	311	0,6	OBS/OBH	OBS/OBH	OBS ausgelöst	TOBU 01
SO186/069-2	12.01.06	13:18	3° 43,49' S	99° 13,76' E	0	ESE 4	297	0,4	CTD	CTD	an Deck	
SO186/069-1	12.01.06	13:50	3° 42,78' S	99° 13,70' E	0	ESE 4	347	2,2	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/069-1	12.01.06	14:02	3° 42,66' S	99° 13,85' E	0	SE 5	84	0,3	OBS/OBH	OBS/OBH	OBS an Deck	TOBS 01
SO186/069-3	12.01.06	14:53	3° 43,26' S	99° 13,45' E	0	ESE 5	249	0,6	OBS/OBH	OBS/OBH	OBS gesichtet	
SO186/069-3	12.01.06	15:07	3° 43,48' S	99° 13,49' E	0	ESE 5	328	0,5	OBS/OBH	OBS/OBH	OBS an Deck	TOBU 01
SO186/069-4	12.01.06	15:43	3° 42,08' S	99° 12,31' E	0	SE 6	314	1,7	CTD	CTD	zu Wasser	W6 Modem
SO186/069-4	12.01.06	15:52	3° 41,91' S	99° 12,15' E	0	SE 5	316	1,9	CTD	CTD	auf Tiefe	SL:120m
SO186/069-4	12.01.06	16:05	3° 41,69' S	99° 12,01' E	0	SE 4	332	1	CTD	CTD	an Deck	
SO186/069-5	12.01.06	16:12	3° 41,55' S	99° 11,96' E	0	ESE 4	343	1,2	CTD	CTD	zu Wasser	W6 Modem
SO186/069-5	12.01.06	16:17	3° 41,45' S	99° 11,93' E	0	SE 4	337	1,8	CTD	CTD	auf Tiefe	SL= 200m
SO186/069-5	12.01.06	16:42	3° 40,94' S	99° 11,80' E	0	SE 5	348	1,8	CTD	CTD	auf Tiefe	SL= 2000m
SO186/069-5	12.01.06	17:46	3° 40,09' S	99° 11,47' E	0	SE 5	310	1	CTD	CTD	auf Tiefe	SL= 1000m
SO186/069-5	12.01.06	18:09	3° 39,74' S	99° 11,25' E	0	SSE 4	346	1,3	CTD	CTD	an Deck	
SO186/069-6	12.01.06	19:00	3° 41,81' S	99° 12,33' E	0	SSE 5	35	0,8	CTD	CTD	zu Wasser	W6 Modem
SO186/069-6	12.01.06	19:20	3° 41,79' S	99° 12,41' E	0	SSE 4	75	0,2	CTD	CTD	an Deck	
SO186/069-7	12.01.06	19:48	3° 41,86' S	99° 12,38' E	0	SSE 5	137	0,6	CTD	CTD	zu Wasser	W6 Modem
SO186/069-7	12.01.06	20:19	3° 41,71' S	99° 12,52' E	0	S 5	16	0,3	CTD	CTD	auf Tiefe	SL= 300m
SO186/069-7	12.01.06	20:50	3° 41,64' S	99° 12,67' E	0	S 5	144	0,7	CTD	CTD	auf Tiefe	SL 1000 m
SO186/069-7	12.01.06	21:31	3° 40,85' S	99° 12,94' E	0	S 5	3	1,3	CTD	CTD	an Deck	
ohne #	37 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/070-1	13.01.06	06:15	3° 50,80' S	99° 31,54' E	4535	S 4	164	0,9	Verankerung	VERANK.	Beginn Station	
SO186/070-1	13.01.06	08:02	3° 50,82' S	99° 31,59' E	4555	SSW 5	255	0,3	Verankerung	VERANK.	Kopfboje z.W.	TEWS 02 B
SO186/070-1	13.01.06	08:29	3° 50,85' S	99° 31,59' E	4554	SW 4	272	0,2	Verankerung	VERANK.	Gerät z.W.	SS-Float SO 962
SO186/070-1	13.01.06	09:09	3° 50,83' S	99° 31,59' E	4555	WSW 5	77	0,1	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	09:30	3° 50,83' S	99° 31,58' E	4554	SW 4	45	0,1	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	09:55	3° 50,93' S	99° 31,54' E	4514	SW 4	101	0,2	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	10:19	3° 51,02' S	99° 31,54' E	4537	WSW 4	176	0,2	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	10:38	3° 51,10' S	99° 31,53' E	4541	SW 4	95	0,3	Verankerung	VERANK.	Gerät z.W.	3 Benthos
SO186/070-1	13.01.06	10:57	3° 51,17' S	99° 31,54' E	4545	SW 4	157	0,2	Verankerung	VERANK.	Gerät z.W.	2 Benthos
SO186/070-1	13.01.06	11:38	3° 51,41' S	99° 31,53' E	4556	WSW 4	219	0,6	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	11:58	3° 51,51' S	99° 31,52' E	4517	SW 4	292	0,1	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/070-1	13.01.06	12:28	3° 51,73' S	99° 31,48' E	4478	SSW 4	190	0,4	Verankerung	VERANK.	Gerät z.W.	2 Benthos

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/070-1	13.01.06	12:46	3° 51,85' S	99° 31,49' E	4488	SSW 5	178	0,3	Verankerung	VERANK.	Auslöser z.W	3 Benthos
SO186/070-1	13.01.06	13:15	3° 51,87' S	99° 31,46' E	4535	S 5	238	0,1	Verankerung	VERANK.	Ankerstein z.W.	2 x 2,5 to
SO186/070-1	13.01.06	13:59	3° 50,20' S	99° 31,67' E	4448	SSE 8	188	1,6	Verankerung	VERANK.	Verankerung in Position	
SO186/070-1	13.01.06	14:00	3° 50,22' S	99° 31,66' E	4388	SSE 8	187	1,1	Verankerung	VERANK.	Ende Station	
ohne #	98 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/071-1	14.01.06	00:00	3° 41,54' S	99° 12,86' E	5258	S 5	125	0,9	Verankerung	VERANK.	Beginn Station	TEWS 01
SO186/071-1	14.01.06	00:09	3° 41,55' S	99° 12,89' E	5264	S 6	84	0,5	Verankerung	VERANK.	Ausgelöst	TEWS 01
SO186/071-1	14.01.06	01:38	3° 42,60' S	99° 12,61' E	5200	SSW 6	339	0,7	Verankerung	VERANK.	Auslöser a.D.	5 Benthos
SO186/071-1	14.01.06	01:55	3° 42,43' S	99° 12,55' E	5215	SSW 6	272	0,5	Verankerung	VERANK.	Gerät a.D.	2 Benthos
SO186/071-1	14.01.06	02:31	3° 42,45' S	99° 12,40' E	5197	SSW 5	335	0,4	Verankerung	VERANK.	Gerät a.D.	3 Benthos
SO186/071-1	14.01.06	02:47	3° 42,46' S	99° 12,31' E	5195	SSW 5	191	0	Verankerung	VERANK.	Gerät a.D.	2 Benthos
SO186/071-1	14.01.06	03:20	3° 42,47' S	99° 12,12' E	5155	WSW 4	244	0,6	Verankerung	VERANK.	Gerät a.D.	3 Benthos
SO186/071-1	14.01.06	03:37	3° 42,33' S	99° 12,05' E	5162	W 3	350	0,7	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/071-1	14.01.06	03:57	3° 42,18' S	99° 11,95' E	5171	WSW 3	313	0,7	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/071-1	14.01.06	04:13	3° 42,01' S	99° 11,85' E	5158	SW 3	318	0,7	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/071-1	14.01.06	04:31	3° 41,72' S	99° 11,76' E	5163	SW 2	15	2	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/071-1	14.01.06	05:01	3° 41,02' S	99° 11,82' E	5243	SW 3	89	0,5	Verankerung	VERANK.	Gerät a.D.	5 Benthos
SO186/071-1	14.01.06	05:36	3° 40,67' S	99° 11,92' E	5298	SW 4	13	0,4	Verankerung	VERANK.	Gerät a.D.	SS Float SO 962
SO186/071-1	14.01.06	06:15	3° 39,49' S	99° 12,11' E	5340	SW 3	352	2,2	Verankerung	VERANK.	Kopfboje a.D	
SO186/071-1	14.01.06	06:22	3° 39,22' S	99° 12,06' E	5342	WSW 3	4	2,9	Verankerung	VERANK.	Verank. a.D.	
SO186/071-1	14.01.06	06:36	3° 39,20' S	99° 12,46' E	5354	W 2	116	2,2	Verankerung	VERANK.	Ende Station	
SO186/072-1	14.01.06	08:37	3° 50,57' S	99° 31,26' E	4467	WNW 2	140	1,2	OBS/OBH	OBS/OBH	OBS zu Wasser	TOBS 02B
SO186/073-1	14.01.06	08:58	3° 50,62' S	99° 31,49' E	4489	NW 3	337	1	CTD	CTD	Beginn Station	Modem-Tests
SO186/073-1	14.01.06	09:00	3° 50,60' S	99° 31,49' E	4491	W 3	14	0,7	CTD	CTD	zu Wasser	
SO186/073-1	14.01.06	09:05	3° 50,60' S	99° 31,49' E	0	W 3	246	0,5	CTD	CTD	auf Tiefe	SL 100 m
SO186/073-1	14.01.06	09:19	3° 50,61' S	99° 31,50' E	0	W 2	156	0,3	CTD	CTD	an Deck	
ohne #	237 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/074-1	15.01.06	05:48	1° 2,21' S	96° 58,87' E	4973	SW 4	239	0,8	CTD	CTD	Beginn Station	
SO186/074-1	15.01.06	05:50	1° 2,22' S	96° 58,86' E	0	WSW 4	205	0,2	CTD	CTD	zu Wasser	CTD / Modemtest
SO186/074-1	15.01.06	05:52	1° 2,22' S	96° 58,86' E	0	WSW 3	176	0,2	CTD	CTD	auf Tiefe	SL= 100m
SO186/074-1	15.01.06	06:14	1° 2,19' S	96° 58,86' E	0	WSW 2	339	0,4	CTD	CTD	an Deck	
SO186/074-1	15.01.06	06:15	1° 2,19' S	96° 58,86' E	0	W 2	144	0,1	CTD	CTD	Ende Station	
ohne #	46 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/075-1	15.01.06	10:03	0° 27,36' S	96° 51,73' E	3613	NW 2	61	0,5	OBS/OBH	OBS/OBH	OBS zu Wasser	TOBS 01B
SO186/075-2	15.01.06	10:10	0° 27,36' S	96° 51,72' E	3602	WNW 3	352	0,5	Verankerung	VERANK.	Beginn Station	TEWS 01B
SO186/075-2	15.01.06	10:20	0° 27,37' S	96° 51,67' E	3619	WNW 2	305	0,2	Verankerung	VERANK.	Kopfboje z.W.	TEWS 01 B
SO186/075-2	15.01.06	10:39	0° 27,24' S	96° 51,74' E	3573	WNW 1	45	0,8	Verankerung	VERANK.	Gerät z.W.	SS Float SO 962
SO186/075-2	15.01.06	11:20	0° 26,78' S	96° 52,02' E	3476	WNW 2	25	0,4	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	11:41	0° 26,61' S	96° 52,09' E	3465	WNW 2	17	0,4	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	11:58	0° 26,44' S	96° 52,17' E	3503	WNW 1	30	0,7	Verankerung	VERANK.	Gerät z.W.	5 Benthos

Station	Datum	UTC	PositionLat	PositionLon	Tiefe [m]	Windstärke [m/s]	Kurs [°]	v [kn]	Gerät	Gerätekürzel	Aktion	Bemerkung
SO186/075-2	15.01.06	12:15	0° 26,28' S	96° 52,23' E	3574	NW 2	12	0,7	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	12:32	0° 26,08' S	96° 52,28' E	3607	WNW 2	2	0,9	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	12:46	0° 25,89' S	96° 52,34' E	3555	WNW 2	4	1	Verankerung	VERANK.	Gerät z.W.	2 Benthos
SO186/075-2	15.01.06	14:14	0° 24,97' S	96° 52,51' E	3676	W 2	319	0,3	Verankerung	VERANK.	Gerät z.W.	3 Benthos
SO186/075-2	15.01.06	14:26	0° 24,90' S	96° 52,50' E	3757	WNW 2	24	0,7	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	14:38	0° 24,81' S	96° 52,50' E	3775	W 2	34	0,2	Verankerung	VERANK.	Gerät z.W.	5 Benthos
SO186/075-2	15.01.06	14:39	0° 24,81' S	96° 52,50' E	3788	W 3	0	0,3	Verankerung	VERANK.	Auslöser z.W	
SO186/075-2	15.01.06	14:56	0° 24,76' S	96° 52,48' E	3818	W 3	301	0,4	Verankerung	VERANK.	Ankerstein z.W.	3 to
SO186/075-3	15.01.06	15:05	0° 24,74' S	96° 52,46' E	3816	W 4	5	0,6	OBS/OBH	OBS/OBH	OBS zu Wasser	TOBU auf 30 m zum testen, W6
SO186/075-3	15.01.06	15:18	0° 24,72' S	96° 52,43' E	3842	WSW 4	294	0,6	OBS/OBH	OBS/OBH	OBS an Deck	
SO186/075-2	15.01.06	15:51	0° 25,54' S	96° 52,16' E	3495	W 7	226	6,2	Verankerung	VERANK.	Verankerung in Position	
SO186/075-2	15.01.06	15:51	0° 25,54' S	96° 52,16' E	3495	W 7	226	6,2	Verankerung	VERANK.	Ende Station	
SO186/075-4	15.01.06	16:05	0° 25,51' S	96° 51,66' E	3648	SW 6	334	0,2	OBS/OBH	OBS/OBH	OBS zu Wasser	TOBU, W6
ohne #	145 Seemeilen Profilfahrt mit EM 120											Profilfahrt
SO186/076-1	16.01.06	03:47	1° 21,91' N	95° 52,98' E	4945	SW 4	353	0,9	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS45
SO186/076-2	16.01.06	05:55	1° 45,75' N	95° 43,68' E	5039	SW 6	340	12,5	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 35
SO186/076-2	16.01.06	06:27	1° 49,99' N	95° 42,01' E	5021	SW 4	47	0,6	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 46
SO186/076-2	16.01.06	07:06	1° 50,08' N	95° 42,22' E	0	SW 5	353	0,3	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 35
SO186/076-2	16.01.06	07:32	1° 49,99' N	95° 41,86' E	0	SW 6	234	0,5	OBS/OBH	OBS/OBH	OBS an Deck	OBS 35
SO186/076-3	16.01.06	08:02	1° 55,24' N	95° 42,00' E	0	SW 6	0	12,7	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 34
SO186/076-3	16.01.06	09:03	2° 0,12' N	95° 42,22' E	0	SSW 4	185	0,2	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 34
SO186/076-3	16.01.06	09:13	2° 0,14' N	95° 41,88' E	0	SW 4	310	1	OBS/OBH	OBS/OBH	OBS an Deck	OBS 34
SO186/076-4	16.01.06	09:56	1° 59,98' N	95° 34,28' E	4866	SW 10	268	12,4	OBS/OBH	OBS/OBH	OBS ausgelöst	OBS 36
SO186/076-5	16.01.06	10:23	2° 0,00' N	95° 30,01' E	4921	SW 6	271	1,9	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 47
SO186/076-4	16.01.06	11:14	2° 0,04' N	95° 30,15' E	4925	SW 4	56	0,3	OBS/OBH	OBS/OBH	OBS gesichtet	OBS 36
SO186/076-4	16.01.06	11:25	2° 0,11' N	95° 29,91' E	4922	SSW 6	290	0,6	OBS/OBH	OBS/OBH	OBS an Deck	OBS 36
SO186/076-6	16.01.06	12:37	2° 9,82' N	95° 37,88' E	2769	SSW 5	332	1,2	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 48
SO186/076-7	16.01.06	15:26	2° 24,84' N	95° 10,12' E	1457	S 3	294	1,9	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 49
SO186/076-8	16.01.06	17:00	2° 39,94' N	95° 5,06' E	811	WSW 9	117	1,2	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 50
SO186/076-9	16.01.06	18:51	3° 0,00' N	95° 5,01' E	781	S 2	5	0,5	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 51
SO186/076-10	16.01.06	19:52	3° 10,00' N	95° 5,00' E	474	S 1	305	0,8	OBS/OBH	OBS/OBH	OBH zu Wasser	OBH 52
SO186/076-10	16.01.06	20:02	3° 9,96' N	95° 4,99' E	473	S 4	161	0,7	OBS/OBH	OBS/OBH	OBH gesichtet	OBH 52
SO186/076-10	16.01.06	20:15	3° 9,71' N	95° 5,13' E	477	SSW 3	165	1	OBS/OBH	OBS/OBH	OBH an Deck	OBH 52
SO186/076-10	16.01.06	20:26	3° 9,76' N	95° 5,07' E	472	S 1	319	0,6	OBS/OBH	OBS/OBH	OBH zu Wasser	OBH 52
SO186/076-11	16.01.06	21:32	3° 21,00' N	95° 5,01' E	801	ENE 4	24	1,1	OBS/OBH	OBS/OBH	OBS zu Wasser	OBS 53
ohne #	340 Seemeilen Profilfahrt mit EM 120											Profilfahrt

Station SO 186-1d	CTD zum Modemtest	Aussetzen OBU	Aussetzen OBS/H	Aufnehmen OBS / H	Aufnahme OBU	Aufnahme TEWS - Verank.	Auslage TEWS - Verank.		Aussetzen OBM	Aufnehmen OBM	Hilfskräne	EM 120 / Parasound - Profil	Hilfskräne Einsatzzeit (h)	Stationszeit gesamt (h)	W 6 Zeit (h)	EM 120 / Parasound- Zeit (h)	Stationszeit in sm	Länge W 6	EM 120 / Parasound-Verm. in s	Bemerkungen
ohne #												1				33,3			426	Anfahrt AG, EM 120 Profil
SO 186-1d - 67-1				1							1		0,1	0,7			0,5			OBH 39
SO 186-1d - 67-2-1				1							1		0,1	0,6			0,5			OBS 07
SO 186-1d - 67-2-2			1								1		0,1	0,1			0,1			OBS 41
SO 186-1d - 67-3-1										1	1		0,1	0,9			0,5			OBM 05
SO 186-1d - 67-3-2				1							1		0,1	1,1			1			OBS 33
SO 186-1d - 67-4-1				1							1		0,1	0,8			0,5			OBS 32
SO 186-1d - 67-4-2										1	1		0,1	1,1			1			OBM 04
SO 186-1d - 67-5			1								1		0,1	0,1			0,1			OBS 42
SO 186-1d - 67-6-1				1							1		0,1	0,9			1			OBS 31
SO 186-1d - 67-6-2										1	1		0,1	1,0			1			OBM 03
SO 186-1d - 67-7-1				1							1		0,1	0,8			0,9			OBS 30
SO 186-1d - 67-7-2			1								1		0,1	0,1			0,1			OBS 43
SO 186-1d - 67-8										1	1		0,1	0,8			1			OBM 02
SO 186-1d - 67-9										1	1		0,1	1,0			1			OBM 01
ohne #												1				12,9			149	EM 120 Profil
SO 186-1d - 68-1						1					1		6,1	6,1			8			TEWS 02, Verankerung aufgenommen
SO 186-1d - 68-2			1								1		0,1	0,1			0,1			OBS 44
SO 186-1d - 68-3					1						1		0,1	1,4			1			TOBU 02
SO 186-1d - 68-4				1							1		0,1	1,4			1			TOBS 02
SO 186-1d - 68-5				1							1		0,1	1,3			1			OBS 44
ohne #												1				21,3			254	EM 120 Profil
SO 186-1d - 69-1				1							1		0,1	1,6			1			TOBS 01
SO 186-1d - 69-2	1										1			0,6	0,6			120		Modemtest
SO 186-1d - 69-3					1						1		0,1	2,1			1			TOBU 01
SO 186-1d - 69-4	1										1		0,4	0,4	0,4			120		Modemtest
SO 186-1d - 69-5	1										1		2,0	2,0	2,0			2000		Modemtest
SO 186-1d - 69-6	1										1		0,3	0,3	0,3			120		Modemtest
SO 186-1d - 69-7	1										1		1,7	1,7	1,7			1000		Modemtest
ohne #												1				8,7			37	EM 120 Profil
SO 186-1d - 70-1							1				1		7,8	7,8			8			TEWS 02 B, Verankerung ausgelegt
ohne #												1				10,0			98	EM 120 Profil
SO 186-1d - 71-1						1					1		6,6	6,6			6			TEWS 01, Verankerung aufgenommen
SO 186-1d - 72-1			1								1		0,1	0,1			0,5			TOBS 02 B

Station SO 186-1d	CTD zum Modemtest	Aussetzen OBU	Aussetzen OBS/H	Aufnehmen OBS / H	Aufnahme OBU	Aufnahme TEWS - Verank.	Auslage TEWS - Verank.		Aussetzen OBM	Aufnehmen OBM	Hilfskräne	EM 120 / Parasound - Profil	Hilfskräne Einsatzzeit (h)	Stationszeit gesamt (h)	W 6 Zeit (h)	EM 120 / Parasound- Zeit (h)	Stationszeit in sm	Länge W 6	EM 120 / Parasound-Verm. in s	Bemerkungen
SO 186-1d - 73-1	1										1		0,4	0,4	0,4			100		Modemtest
ohne #												1				20,5			237	EM 120 Profil
SO 186-1d - 74-1	1										1		0,5	0,5	0,5			100		Modemtest
ohne #												1				3,8			46	EM 120 Profil
SO 186-1d - 75-1				1							1		0,1	0,1			0,2			TOBS 01 B
SO 186-1d - 75-2							1				1		5,7	5,7			5			TEWS 01 B, Verankerung ausgelegt
SO 186-1d - 75-3		1									1		0,2	0,2	0,2			30		TOBU Test
SO 186-1d - 75-4		1									1		0,1	0,1			0,2			TOBU 01 B
ohne #												1				11,7			145	Profilfahrt
SO 186-1d - 76-1			1								1		0,1	0,1			0,1			OBS 45
SO 186-1d - 76-2			1	1							1		0,2	1,6			3			OBS 46 z.W. / OBS 35 a.D.
SO 186-1d - 76-3				1							1		0,1	1,2			5			OBS 34
SO 186-1d - 76-4				1							1		0,1	1,5			9			OBS 36
SO 186-1d - 76-5			1								1		0,1	0,1			0,2			OBS 47
SO 186-1d - 76-6			1								1		0,1	0,1			0,2			OBS 48
SO 186-1d - 76-7			1								1		0,1	0,1			0,2			OBS 49
SO 186-1d - 76-8			1								1		0,1	0,1			0,2			OBS 50
SO 186-1d - 76-9			1								1		0,1	0,1			0,2			OBS 51
SO 186-1d - 76-10				1							1		0,1	0,6			3			OBH 52
SO 186-1d - 76-11			1								1		0,1	0,1			0,2			OBS 53
ohne #												1				29,8			340	Profilfahrt
Total:	**7**	**2**	**13**	**14**	**2**	**2**	**2**	**0**	**0**	**5**	**46**	**9**	**35**	**56**	**6**	**152**	**63,5**	**3590**	**1732**	
maximal gefierte Seillänge SO 186-1d																		0		

Appendix 10.7 - Seacause / GITEWS - OBS Deployment

	INST.	LAT (N) D:M	LON (E) D:M	DEPLOY. DATE	RECOV. DATE	DEPTH (m)	REL. CODE	ANT. CH.	REC. NO.	SKEW (ms)	SENSORS
SEACAUSE 1A	OBS 01	2° 48,024	97° 12,036	15.10.05		834	131351	D	MLS 040602		HTI 55 + Owen(4,5Hz)
	OBS 02	2° 42,008	96° 51,044	15.10.05		1123	133563	C	MLS 040603		OAS 41 + Owen(4,5Hz)
	OBS 03	2° 12,009	96° 18,012	15.10.05	02.11.05	1021	250177	C	MBS 010701	-220	OAS 29 + Owen(4,5Hz)
	OBS 04	1° 57,987	96° 29,981	15.10.05	24.11.05	1155	131317	D	MTS 050815	15	OAS 17 + Owen(4,5Hz)
	OBH 05	1° 54,020	96° 12,004	15.10.05	24.11.05	2364	A324 (mode A)	D	MTS 050814	23	DPG 92
	OBS 06	1° 53,990	95° 59,981	15.10.05	05.11.05	3164	133770	C	MTS 050811	23	DPG 95 + Paroscientific
	OBH 07	2° 12,047	96° 00,004	15.10.05	10.01.06	1616	C444 (mode A)	D	MTS 050816	+ 989 *	DPG 77
	OBH 08	2° 00,001	95° 42,002	15.10.05	24.11.05	4444	D634 (mode A)	D	MTS 050812	28	DPG 75
	OBS 09	2° 12,000	95° 17,997	15.10.05	24.11.05	4668	133736	D	MTS 050813	52	DPG 73 + Paroscientific
	OBS 10	2° 24,022	95° 42,004	15.10.05	02.11.05	749	133664	D	MBS 000614	-104	HTI 57 + Owen 27 (4,5Hz)
	OBS 11	2° 36,050	95° 29,984	15.10.05	02.11.05	1057	131245	C	MBS 001006	-30	HTI 51 + Owen 23 (4,5Hz)
	OBS 12	3° 12,002	95° 41,957	16.10.05		470	133623	C	MLS 010408		HTI 56 + Owen(4,5Hz)
	OBH 13	3° 06,003	96° 00,001	16.10.05	03.11.05	657	C464 (mode A)	D	MLS 020601	60	OAS 07
	OBS 14	3° 30,000	96° 11,984	16.10.05		859	134037	D	MLS 040304		OAS 45 + Owen(4,5Hz)
	OBS 15	3° 18,037	96° 29,950	16.10.05		1013	134123	D	MLS 040803		HTI + Owen(4,5Hz)
	OBS 16	3° 00,026	96° 30,007	16.10.05		1087	145206	C	MLS 010406		OAS 03 + Owen(4,5Hz)
	OBS 17	2° 53,991	96° 11,983	16.10.05		770	131415	D	MLS 010404		HTI + Owen(4,5Hz)
	OBS 18	2° 48,006	96° 29,996	16.10.05		1052	131203	C	MLS 000708		OAS 30 + Owen(4,5Hz)
	OBH 19	2° 54,006	96° 41,996	16.10.05		1112	03B3 + 0355	D	MLS 000712		OAS 35
	OBS 20	3° 17,988	96° 48,002	16.10.05		996	134071	C	MLS 040102		HTI + Owen(4,5Hz)
SO-186 1B	OBS 21	2° 24,047	95° 42,044	02.11.05		752	250177	C	MLS 991233		OAS 29 + Owen(4,5Hz)
	OBS 22	2° 36,062	95° 30,023	02.11.05		1060	133664	D	MLS 991234		HTI 57 + Owen 27 (4,5Hz)
	OBH 23	3° 05,964	96° 00,042	03.11.05		647	C464 (mode A)	D	MLS 020601		OAS 07
	OBS 24	2° 12,004	96° 18,011	03.11.05		1022	131245	C	MLS 991258		HTI 51 + Owen 23 (4,5Hz)
	OBS 25	1° 53,944	95° 59,984	05.11.05	10.11.05	3162	133770	C	MTS 050811	5	DPG95 + Paro
SO-186 1C (GITEWS)	OBSTEST	3° 32,791 S	99° 29,562 E	18.11.05	20.11.05	5812	427562	C	MTS 050805	1	DPG72 + Gü + Paro 98495
	OBS 26	1° 30,01	95° 59,99	24.11.05		5121	430067	C	MTS 050810		DPG 65 + Owen -071 (4,5 Hz)
	OBS 27	1° 40,00	96° 05,01	24.11.05		4793	427623	C	MTS 050809		DPG 68 + Owen -075 (4,5 Hz)
	OBS 28	1° 39,97	96° 24,99	24.11.05		2379	430173	D	MTS 050817		DPG 62 + Owen (4,5 Hz)
	OBS 29	1° 45,00	96° 32,99	24.11.05		1702	427260	D	MTS 050818		DPG 63 + Owen -072 (4,5 Hz)
	OBS 30	2° 00,13	96° 29,74	24.11.05	10.01.06	1178	427430	D	MLS 010403	1053 *	OAS 44 + Owen -077 (4,5 Hz)
	OBS 31	1° 50,08	96° 20.01	24.11.05	10.01.06	2770	131317	D	MLS 991243	1076 *	OAS 17 + Owen 20 (4,5 Hz)
	OBS 32	1° 54,000	96° 11,854	24.11.05	10.01.06	2364	430232	D	MLS 040806	no skew	HTI 31 + Owen -076 (4,5 Hz)
	OBS 33	1° 54,104	95° 59,451	24.11.05	10.01.06	3448	430326	D	MTS 050815	1033	DPG 67 + Owen (4,5 Hz) + Paro
	OBS 34	2° 00,006	95° 41,998	24.11.05	16.01.06	4383	133770	D	MLS 991246	no skew	OAS31 + Owen 10 (4,5 Hz)
	OBS 35	1° 50,006	95° 42,001	24.11.05	16.01.06	5017	145331	D	MLS 991236	no skew	OAS 25 + Owen (4,5 Hz)
	OBS 36	2° 00,065	95° 29,984	24.11.05	16.01.06	4916	C504 (mode A)	D	MLS 991257	no skew	DPG 95 + Owen (4,5 Hz)
	OBS 37	2° 12,04	95° 17,958	24.11.05		4674	427476	D	MTS 050814		DPG 66 +Owen (4,5 Hz)
	OBS 38	2° 30,05	95° 20,04	24.11.05		1324	133736	D	MTS 050812		DPG 73 + Owen -079 (4,5 Hz)
	OBH 39	2° 42,04	95° 3,953	24.11.05	10.01.06	1104	D634 (mode A)	dauer	MLS 991235	-1089187470	DPG 75
	OBH 40	2° 48,046	94° 55,986	24.11.05		865	4A49	D	MLS 991259		DPG 92
	TOBU 01	3° 43,900 S	99° 13,800 E	20.11.05	12.01.06	5241	133525	C	MTS-M 050808	no skew	DPG 61 + Gü + Paro 98469
	TOBS 01	3° 43,000 S	99° 14,050 E	20.11.05	12.01.06	5228	427562	C	MTS 050805	no skew	DPG 72 + Gü + Paro 98495
	TOBU 02	0° 27,132 S	96° 50,757 E	23.11.05	11.01.06	3259	430135	C	MTS-M 050807	-638858	DPG 64 + Gü + Paro 98607
	TOBS 02	0° 26,687 S	96° 52,270 E	23.11.05	11.01.06	3440	145240	C	MTS 050811	1065 *	DPG 71 + Owen -073 (4,5Hz) + Paro 98621

Appendix 10.7 - Seacause / GITEWS - OBS Deployment

	INST.	LAT (N)	LON (E)	DEPLOY.	RECOV.	DEPTH	REL.	ANT.	REC.	at OBS	SENSORS
		D:M	D:M	DATE	DATE	(m)	CODE	CH.	NO.	#	
SO-186 1C	**OBM 01**	1° 40,014	96° 25,075	24.11.05	10.01.06	2260	427226	D	B050928	OBS 28	METS T31
	OBM 02	1° 45,58	96° 33,15	24.11.05	10.01.06	1693	427524	C	F050928	OBS 29	METS T30
	OBM 03	1° 50,02	96° 19,96	24.11.05	10.01.06	2771	430274	C	C050928	OBS 31	METS T28
	OBM 04	1° 53,985	96° 11,940	24.11.05	10.01.06	2373	430424	C	A000000	OBS 32	METS T29
	OBM 05	1° 54,067	95° 59,666	24.11.05	10.01.06	3451	427737	D	A050828	OBS 33	METS T27

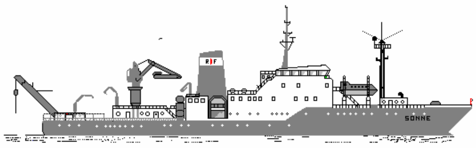
	INST.	LAT (N)	LON (E)	DEPLOY.	RECOV.	DEPTH	REL.	ANT.	REC.	SKEW	SENSORS
		D:M	D:M	DATE	DATE	(m)	CODE	CH.	NO.	(ms)	
SO-186 1D	**OBH 41**	2°12,107 N	96°00,038 E	10.01.06		1608	D634 (mode A)	D	MLS 991235		DPG 75
	OBS 42	1°52,444 N	96°15,074 E	10.01.06		2573	430326	D	MTS 050815		DPG 67 + Owen (4,5 Hz) + Paro 8b
	OBS 43	1°59,652 N	96°28,812 E	10.01.06		1303	430232	D	MLS 040806		HTI 31 + Owen -076 (4,5Hz)
	OBS 44	0°26,520 S	96°50,420 E	11.01.06	11.01.06	3367	430424	C	MTS 050806	0	DPG 77 + Gü + Paro
	TOBS 02B	3°50,585 S	99°31,282 E	14.01.06		4469	427562	C	MTS 050806		DPG 72 +Gü + Paro 98495
	TOBS 01B	0°27,356 S	96°51,733 E	15.01.06		3625	427226	C	MTS 050811		DPG 77 + Gü 04 + Paro 98609
	TOBU 01B	0°25,515 S	96°51,658 E	15.01.06		3649	430135	C	MTS 050508		DPG 61 + Gü + Paro 98469
	OBS 45	1°21,918 N	95°52,974 E	16.01.06		4941	145240	C	MTS 050816		DPG 71 + Owen (4,5 Hz) + Paro 98621
	OBS 46	1°49,989 N	95°42,003 E	16.01.06		5021	131317	D	MLS 991243		OAS 17 + Owen (4,5 Hz)
	OBS 47	2°00,005 N	95°30,000 E	16.01.06		4923	427430	D	MLS 010403		OAS 44 + Owen (4,5 Hz)
	OBS 48	2°09,828 N	95°37,874 E	16.01.06		2762	427737	D	MTS 050813		HTI 42 + Owen (4,5 Hz)
	OBS 49	2°24,840 N	95°10,120 E	16.01.06		1460	430424	C	MTS 050807		DPG 64 + Gü 03 + Paro 476
	OBS 50	2°39,950 N	95°05,050 E	16.01.06		811	145331	D	MLS 991236		OAS 2 + Owen 72 (4,5 Hz)
	OBS 51	2°59,990 N	95°05,010 E	16.01.06		786	427524	D	MTS 050805		DPG 95 + Owen 78 (4,5 Hz) + Paro 98488
	OBH 52	3°09,760 N	95°05,070 E	16.01.06		472	C444 (mode A)	D	MLS 991257		HTI 46
	OBS 53	3°21,000 N	95°05,010 E	16.01.06		801	133770	D	MLS 991246		OAS + Owen (4,5 Hz)

* : 1 extra second at 01.01.2006 (00:00:00)

Table 10.8: This table shows SO 186 Leg 1-B Cruise track information.

Line Number	date	time	latitude	longitude	course	Profile km	methods
SO186-21	29.10.2005	10:40:00	6° 11.971 S	105° 19.813 E			
	29.10.2005	14:06:00	6° 12.024 S	104° 45.311 E	270°	63.51 km	M,G,B
SO186-22	29.10.2005	14:06:00	6° 12.024 S	104° 45.311 E			
	29.10.2005	15:36:00	6° 26.441 S	104° 45.016 E	181°	26.69 km	M,G,B
SO186-23	29.10.2005	15:36:00	6° 26.441 S	104° 45.016 E			
	29.10.2005	22:25:00	6° 26.986 S	103° 39.566 E	270°	120.43 km	M,G,B
SO186-24	29.10.2005	22:15:00	6° 26.986 S	103° 39.566 E			
	30.10.2005	09:06:00	6° 19.499 S	101° 51.131 E	274°	199.92 km	M,G,B
SO186-25	30.10.2005	09:06:00	6° 19.499 S	101° 51.131 E			
	31.10.2005	09:01:00	3° 22.068 S	99° 08.058 E	317°	445.40 km	M,G,B
SO186-26	31.10.2005	09:01:00	3° 22.068 S	99° 08.058 E			
	31.10.2005	15:50:00	2° 24.394 S	98° 30.251 E	327°	127.54 km	M,G,B
SO186-27	31.10.2005	15:57:00	2° 23.483 S	98° 30.671 E			
	31.10.2005	19:09:00	2° 04.255 S	98° 55.674 E	52°	58.38 km	M,G,B
SO186-28	31.10.2005	19:14:00	2° 03.575 S	98° 5.674 E			
	01.11.2005	03:24:00	0° 55.994 S	98° 10.009 E	326°	151.08 km	M,G,B
SO186-29	01.11.2005	03:24:00	0° 55.994 S	98° 10.009 E			
	01.11.2005	21:52:00	1° 36.838 N	96° 27.104 E	326°	341.05 km	M,G,B
SO186-30	01.11.2005	21:56:00	1° 37.443 N	96° 27.093 E	27°/		
	02.11.2005	01:55:00	2° 08.419 N	96° 15.404 E	339°/308°	61.30 km	M,G,B
SO186-31	02.11.2005	03:23:00	2° 12.119 N	96° 17.665 E			
	02.11.2005	07:13:00	2° 23.826 N	95° 42.870 E	289°	67.93 km	G,B
SO186-32	02.11.2005	08:22:00	2° 21.744 N	95° 42867 E			
	02.11.2005	11:32:00	2° 11.659 N	96° 13.075 E	108°	56.93 km	M,G,B
SO186-33	02.11.2005	12:09:00	2° 14.696 N	96° 16.503 E			
	02.11.2005	15:27:00	2° 24.687 N	95° 45.287 E	288°	60.64 km	M,G,B
SO186-34	02.11.2005	15:27:00	2° 24.687 N	95° 45.287 E			
	02.11.2005	16:56:00	2° 35.500 N	95° 34.490 E	315°	28.18 km	M,G,B
SO186-35	02.11.2005	18:51:00	2° 37.220 N	95° 32.893 E			
	02.11.2005	21:54:00	3° 02.035 N	95° 17.033 E	327°	54.51 km	G,B
SO186-36	02.11.2005	21:54:00	3° 02.035 N	95° 17.033 E			
	03.11.2005	02:30:00	3° 03.587 N	95° 58.747 E	60°/111°	77.19 km	G,B
SO186-37	03.11.2005	05:02:00	3° 09.086 N	95° 59.702 E			
	03.11.2005	09:51:00	3° 03.036 N	95° 16.057 E	288/270/240°	81.47 km	G,B
SO186-38	03.11.2005	09:51:00	3° 03.086 N	95° 16.057 E	180/158/152/		
	03.11.2005	15:02:00	2° 19.992 N	95° 42.005 E	133°	93.02 km	M,G,B

SO186-39	03.11.2005	15:02:00	2° 19.992 N	95° 42.005 E			
	03.11.2005	18:12:00	2° 10.040 N	96° 12.859 E	108/122/104°	59.89 km	M,G,B
SO186-40	03.11.2005	19:37:00	2° 14.891 N	96° 19.653 E			
	03.11.2005	23:36:00	2° 26.969 N	95° 44.158 E	289°/286°	69.37 km	M,G,B
SO186-41	04.11.2005	01:13:00	2° 22.494 N	96° 33.591 E			
	04.11.2005	05:17:00	2° 08.565 N	96° 11.712 E	115°/104°	75.10 km	M,G,B
SO186-42	04.11.2005	05:55:00	2° 04.851 N	96° 14.485 E			
	04.11.2005	10:58:00	2° 22.286 N	95° 28.240 E	283°/296°	91.45 km	M,G,B
SO186-43	04.11.2005	11:39:00	2° 19.550 N	95° 28.138 E			
	04.11.2005	16:51:00	2° 01.504 N	96° 18.149 E	115°/104°	98.39 km	M,G,B
SO186-44	04.11.2005	17:22:00	1° 59.767 N	96° 15.000 E			
	04.11.2005	23:00:00	2° 19.930 N	95° 22.077 E	284°/295°	104.80 km	M,G,B
SO186-45	04.11.2005	23:42:00	2° 17.139 N	95° 22.366 E			
	05.11.2005	04:46:00	1° 55.643 N	95° 58.510 E	116°/104°	91.43 km	M,G,B
SO186-46	05.11.2005	12:41:00	1° 55.643 N	95° 58.510 E			
	06.11.2005	00:31:00	1° 30.566 N	96° 00.889 E	div	217.42 km	M,G,B
SO186-47	06.11.2005	00:31:00	1° 30.566 N	96° 00.889 E			
	06.11.2005	06:53:00	2° 06.790 N	95° 13.917 E	div	118.99 km	M,G,B
SO186-48	06.11.2005	06:53:00	2° 06.790 N	96° 00.889 E			
	06.11.2005	11:20:00	2° 28.339 N	95° 43.753 E	div	81.45 km	M,G,B
SO186-49	06.11.2005	11:20:00	2° 28.339 N	95° 43.753 E			
	06.11.2005	19:36:00	1° 42.947 N	96° 49.446 E	div	150.85 km	M,G,B
SO186-50	06.11.2005	20:17:00	1° 40.530 N	96° 49.446 E			
	07.11.2005	23:44:00	2° 04.110 N	96° 18.044 E	313°	64.58 km	M,G,B
SO186-51	06.11.2005	23:44:00	2° 04.110 N	96° 18.044 E			
	07.11.2005	15:17:00	0° 05.117 S	97° 41.585 E	147°	285.00 km	M,G,B
SO186-52	07.11.2005	15:54:00	0° 05.595 N	97° 41.585 E			
	08.11.2005	02:52:00	1° 31.295 N	96° 38.444 E	325°	204.63 km	M,G,B
SO186-53	08.11.2005	03:15:00	1° 31.467 N	96° 41.317 E			
	08.11.2005	13:23:00	0° 07.240 N	97° 41.476 E	144°	191.65 km	M,G,B
SO186-54	08.11.2005	14:02:00	0° 13.310 N	97° 41.779 E			
	08.11.2005	23:46:00	1° 32.699 N	96° 43.730 E	324°	182.10 km	M,G,B
SO186-55	09.11.2005	00:19:00	1° 32.128 N	96° 47.518 E			
	09.11.2005	10:05:00	0° 15.102 N	97° 44.899 E	143°	177.84 km	M,G,B
SO186-56	09.11.2005	12:31:00	0° 09.339 S	97° 45.230 E			
	08.11.2005	13:45:00	0° 19.357 S	97° 51.763 E	147°	22.15 km	M,G,B



S O N N E / DFCG
RF Forschungsschiffahrt GmbH
Blumenthalstraße 15
28209 Bremen / Germany

Reise SO 186-1c

Verankerungsprotokoll der Verankerungsauslage

Verankerung Nr. **TEWS 1** Zeitmeridian: UTC + 7 h

Wetter: Wind **330° / 12 m/s**

Dünung aus **320° / 2-3 m**

Magnetische Mißweisung laut Seekarte: **- 0,6°**

Stationsnummer: SO 186-1c – 64/1 TEWS 01

Lottiefen:	Simrad:	**5200 m**		Parasound: **5179 m**
Stationsbeginn:	am	**20.11.05**	**02:38** UTC	Driftversuch: **Ja**
Auslage:	am	**20.11.05**	**02:49** UTC	
Stationsende:	am	**20.11.05**	**12:13** UTC	

		UTC	WT (m)	Positionen nach GPS
Boje mit Sender zu Wasser		**02:49**	**5091**	**03° 44,64' S 099° 13,25' E**
Releaser zu Wasser		**10:23**	**5193**	**03° 42,62' S 099° 12,47' E**
Ankerstein zu Wasser		**10:48**	**5209**	**03° 42,91' S 099° 12,47' E**
Boje mit Sender+Flash				
Stationsende am:	**20.11.05**	**12:13**	**5289 m**	**03° 43,73' S 099° 14,02' E**

Verankerungsposition wurde bestimmt mit : 03° 43,41' S 099° 13,52' E

Akustischer Anruf nach der Auslage: **Nein** Zeit: - UTC

Bemerkungen: **Die TEWS 1 Oberflächenboje ist 3,5 m hoch (über Wasser) und 2 m im Durchmesser, gelb gestrichen und ist ausgerüstet mit Radarreflektor, Blitz (5) 20 s gelb und GPS. Die Position der Boje wird über Satellit überwacht.**

auf See, 20.11.2005 Kapitän Lutz Mallon

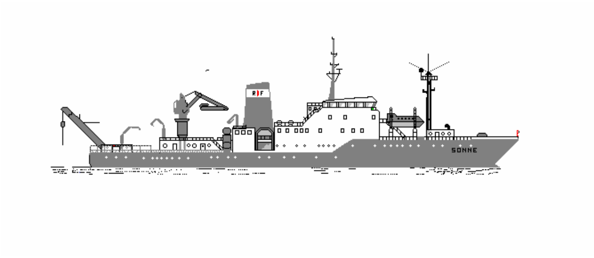
Hier sind die Angaben zu dem Release, der für die Verankerung der TS 1 verwendet wurde:

Acoustic Release Specifications

Type: IXSEA OCEANO S-2500 universal AR 861 B2S
Buoy Mooring TS 1
Position 03°43,73'S 99 14,02 ' E
Water Depth 5225m

S/N 424
FR0 9,0 kHz
FR1 10,5 kHz
CAF 12,0 kHz
Pinger 12,0 kHz

Function / Codes
Arm/Ranging 147E
Command Codes (must be preceeded by an ARM code)
Releasse 1455
Release w/Pinger 1456
Pinger ON 1447
Pinger OFF 1448
Dyagnostic 1449



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Reise SO 186-1c

Verankerungsprotokoll der Verankerungsauslage

Verankerung Nr. **TEWS 2** Zeitmeridian: UTC + 7 h

Wetter: Wind **300° / 4 m/s**

Dünung aus **220° / 1 – 1,5 m**

Magnetische Mißweisung laut Seekarte: **- 0,6°**

Stationsnummer: **SO 186-1c – 65/3 TEWS 02**
Lottiefen: Simrad: **3538 m** Parasound: **3527 m**
Stationsbeginn: am **23.11.** **09:00** UTC Driftversuch: **Ja**
Auslage: am **23.11.** **09:29** UTC
Stationsende: am **23.11.** **15:09** UTC

	UTC	WT (m)	Positionen nach GPS
Boje mit Sender zu Wasser	**09:29**	**3627**	**00° 27,31’ S 096° 52,30’ E**
Releaser zu Wasser	**13:56**	**3562**	**00° 25,72’ S 096° 50,70’ E**
Ankerstein zu Wasser	**14:16**	**3560**	**00° 25,67’ S 096° 50,67’ E**
Boje mit Sender+Flash	**15:09**	**3475**	**00° 26,89’ S 096° 51,27’ E**
Stationsende am: **23.11.05**	**15:09**	**3475**	**00° 26,89’ S 096° 51,27’ E**

Verankerungsposition wurde bestimmt mit : 00° 26,89’ S 096° 51,27’ E

Akustischer Anruf nach der Auslage: **Nein** Zeit: - UTC

Bemerkungen: **Die TEWS 2 Oberflächenboje ist 3,5 m hoch (über Wasser) und 2 m im Durchmesser, gelb gestrichen und ist ausgerüstet mit Radarreflektor, Blitz (6) + Blk. 15 s gelb und GPS.**
Die Position der Boje wird über Satellit überwacht.

auf See, 23.11.2005 Kapitän Lutz Mallon
Hier sind die Angaben zu beiden Releasern, die für die Verankerung der TS 1 und TS 2 verwendet wurden:

Acoustic Release Specifications

Type: IXSEA OCEANO S-2500 universal AR 861 B2S

Buoy Mooring	TS 1	TS 2
Position	03°43,73'S 99 14,02 ' E	0°26,2'S 96°50'E
Water Depth	5225m	3600m

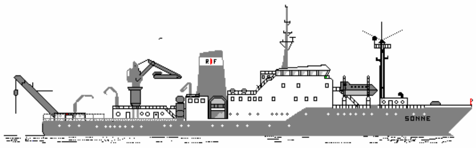
S/N	424	423
FR0	9,0 kHz	9,0 kHz
FR1	10,5 kHz	10,5 kHz
CAF	12,0 kHz	12,0 kHz
Pinger	12,0 kHz	12,0 kHz

Function / Codes

Arm/Ranging	147E	147D

Command Codes (must be preceeded by an ARM code)

Releasse	1455	1455
Release w/Pinger	1456	1456
Pinger ON	1447	1447
Pinger OFF	1448	1448
Dyagnostic	1449	1449



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28209 Bremen / Germany

Reise SO 186-1d

Verankerungsprotokoll der Verankerungsauslage

Verankerung Nr. **TEWS 01 B** Zeitmeridian: UTC + 8 h

Wetter: Wind **288 ° / 2,8 m/s** Strom in: **N'l / 0,5 kn**

Dünung aus **180 ° / 0,5 m**

Magnetische Mißweisung laut Seekarte: **- 0,6°**

Stationsnummer: SO 186-1d – 75-2 TEWS 01
Lottiefen: Simrad: **3608 m** Parasound: **m**
Stationsbeginn: am **15.01.06** **10:10** UTC Driftversuch: **Ja**
Auslage: am **15.01.06** **10:20** UTC
Stationsende: am **15.01.06** 15:51 UTC

		UTC	WT (m)	Positionen nach GPS
Boje mit Sender zu Wasser		**10:20**	**3618**	**00° 27,37'S 096° 51,67'E**
Releaser zu Wasser		**14:39**	**3787**	**00° 24,81'S 096° 52,50'E**
Ankerstein zu Wasser		**14:56**	**3817**	**00° 24,76'S 096° 52,48'E**
Boje mit Sender+Flash				
Stationsende am:	**15.01.06**	**15:51**	**3495**	**00° 25,54'S 096° 52,16'E**

Verankerungsposition wurde bestimmt mit : 00° 24,93' S 096° 52,80' E

Akustischer Anruf nach der Auslage: **Nein** Zeit: - UTC

Bemerkungen: **Die TEWS 01 B Oberflächenboje ist 3,5 m hoch (über Wasser) und 2 m im Durchmesser, gelb gestrichen und ist ausgerüstet mit Radarreflektor, Blitz (5) 20 s gelb und GPS.**
Die Position der Boje wird über Satellit überwacht.

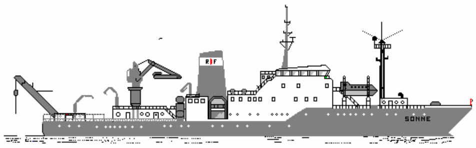
auf See, 15.01.2006 Kapitän Lutz Mallon

Hier sind die Angaben zu dem Release, der für die Verankerung der TS 1 und TS 2 verwendet wurde:

Acoustic Release Specifications

Type: IXSEA OCEANO S-2500 universal AR 861 B2S

Buoy Mooring Position	TS 1	TS 2
Water Depth	5225m	3600m
S/N	424	423
FR0	9,0 kHz	9,0 kHz
FR1	10,5 kHz	10,5 kHz
CAF	12,0 kHz	12,0 kHz
Pinger	12,0 kHz	12,0 kHz
Function / Codes		
Arm/Ranging	147E	147D
Command Codes (must be preceeded by an ARM code)		
Releasse	1455	1455
Release w/Pinger	1456	1456
Pinger ON	1447	1447
Pinger OFF	1448	1448
Dyagnostic	1449	1449



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28209 Bremen / Germany

Reise SO 186-1d

Verankerungsprotokoll der Verankerungsauslage

Verankerung Nr. **TEWS 02 B** Zeitmeridian: UTC + 8 h

Wetter: Wind **210° / 4 m/s**

Dünung aus **180° / 1 m**

Magnetische Mißweisung laut Seekarte: **- 4°**

Stationsnummer: SO 186-1d – 70 TEWS 02 B

Lottiefen:	Simrad:	**4555 m**		Parasound:	**m**
Stationsbeginn:	am	**13.01.**	**06:15** UTC	Driftversuch:	**Ja**
Auslage:	am	**13.01.**	**08:02** UTC		
Stationsende:	am	**13.01.**	**14:00** UTC		

	UTC	WT (m)	Positionen nach GPS
Boje mit Sender zu Wasser	**08:02**	**4554**	**03° 50,82' S 099° 31,59' E**
Releaser zu Wasser	**12:46**	**4487**	**03° 51,85' S 099° 31,49' E**
Ankerstein zu Wasser	**13:15**	**4535**	**03° 51,87' S 099° 31,46' E**
Boje mit Sender+Flash	**13:59**	**4488**	**03° 50,20' S 099° 31,67' E**
Stationsende am: **13.01.06**	**14:00**	**4388**	**03° 50,22' S 099° 31,66' E**

Verankerungsposition wurde bestimmt mit : 03° 51,53' S 099° 32,43' E

Akustischer Anruf nach der Auslage: **Nein** Zeit: - UTC

Bemerkungen: **Die TEWS 02 B Oberflächenboje ist 3,5 m hoch (über Wasser) und 2 m im Durchmesser, gelb gestrichen und ist ausgerüstet mit Radarreflektor, Blitz (6) + Blk. 15 s gelb und GPS.**
Die Position der Boje wird über Satellit überwacht.

auf See, 13.01.2006 Kapitän Lutz Mallon

Hier sind die Angaben zu beiden Releasern, die für die Verankerung der TS 2 verwendet wurden:

Acoustic Release Specifications

Type: IXSEA OCEANO S-2500 universal AR 861 B2S

Buoy Mooring	TS 2 B
Position	03°50,83’ S 099°31,40’ E
Water Depth	4500 m

S/N	423
FR0	9,0 kHz
FR1	10,5 kHz
CAF	12,0 kHz
Pinger	12,0 kHz

Function / Codes

Arm/Ranging	147D

Command Codes (must be preceeded by an ARM code)

Releasse	1455
Release w/Pinger	1456
Pinger ON	1447
Pinger OFF	1448
Dyagnostic	1449

Research Procedures for Foreign Researchers

LEMBAGA ILMU PENGETAHUAN INDONESIA / LIPI
(INDONESIAN INSTITUTE OF SCIENCE)

INTRODUCTION

The purpose of the Decree of the President of the Republic of Indonesia No.100/1993, dated on November 1, 1993, is to enable researchers of other countries to carry out research in the Republic of Indonesia. This applies to all types of research. Initial clearance for research proposals is given by the Indonesian Institute of Science (LIPI). LIPI, assisted by other concerned agencies within the Government of Indonesia known as Coordinating Team, holds a monthly meeting to review research proposals. The application takes up to two months mainly because of the security clearances needed.

APPLICATION

Researches must submit their applications and the following supporting documents to do research in Indonesia to LIPI to enable the Coordinating Team to review a research proposal:

1. A formal letter of request to do research in Indonesia, a copy of which is addressed to the Indonesian representative abroad, (e.g. Indonesian Ambassador, Consul General, or Consul).
2. Six copies of detailed research proposal which should have a title, stated objectives and description of the methodology and concepts, as well as locations (including a listing of village(s), town(s) and or city(ies) where field research will be done) and the starting date and duration. This should be written in either English or Bahasa Indonesia.
3. A page brief research summary containing title, purpose of research, methodology and location.
4. Six copies of researcher's curriculum vitae including a list of publications.
5. Two letters of recommendation, one from a professor or equivalent senior researcher in the researcher's discipline and the other from an official of the researcher's home institute or university.
6. Letter/s of recommendation supporting the research plan from the Indonesian sponsor/s. A letter from an Indonesian academic institution and/or a Research & Development Center agreeing to serve as sponsor for the researcher's tenure in the country is a key document required by LIPI before the application can be forwarded to the Coordinating Team. If a researcher cannot arrange a sponsor, LIPI will act as a sponsor but it will take a more time consuming process.
7. A letter guaranteeing sufficient funds to cover research and living expenses in Indonesia and fees for the Indonesian counterpart/s. The letter is optional and should be arranged between the researcher and his counterpart/s.
8. Health certificate stating that the researcher is in a good health, both physically and mentally, to carry out research.
9. Letter of recommendation from Indonesian representative abroad, usually the Indonesian Ambassador or Consulate.
10. Three recent photographs (passport size).

11. Three copies of researcher's passport.

12. A list of the equipments that would be brought to Indonesia if any to support the research. The value of these equipments should be stated in US dollars.

13. If researcher plans to bring his or her spouse and children with him/her to Indonesia, the researcher must submit a copy of marriage certificate, spouse's resume, photographs and clear photocopies of his/her family's passport.

APPROVAL

When request for a research permit has been approved, LIPI will request the Directorate General of Immigration to issue a visa authorization number which will be sent to the Indonesian Embassy or Consulate where the researcher will apply for a visa. This place should be explicitly nominated by the researcher.

Note that for visits of less than four months, you will be issued with a "kunjungan sosial budaya" visa. This still means that you must visit LIPI, security offices, etc. in Jakarta to obtain permit letters.

RESEARCH VESSEL

Permits for research vessel to enter Indonesian waters should be obtained from:

Directorate for Regional Defense
Ministry of Defense
Jl. Dr. Wahidin I No.1/11
Jakarta Pusat

ARRIVAL IN JAKARTA

Upon arrival in Jakarta, it is essential that researcher informs the Immigration Officials at the Soekarno-Hatta Airport his/her research site/s. The researcher will be given three to seven days by the Immigration Officials to report to the Immigration Office in the research site/s.

Within the given period of time, the researcher must report to LIPI at the following address :

Head, Bureau of Science & Technology Cooperation
Lembaga Ilmu Pengetahuan Indonesia (LIPI)
Sasana Widya Sarwono Building, 7th Floor, Rm. 716
Jl. Gatot Suboto No.10
Jakarta Selatan
Phone (021) 5225711 ext. 237/240

Having reported to LIPI the researcher will be provided with the following necessary documents:

1. A letter to be taken to the Police Headquarters at Direktorat INTELPAM. Jl. Trunojoyo No.3, Kebayoran Baru, Jakarta Selatan, to obtain a Surat Keterangan Jalan.

2. A letter to the local immigration office nearest to the research site in order to obtain KITAS, if a researcher is going to stay in Indonesia for 6 (six) months or more.

3. A letter to the Department of Home Affairs, Division of Social and Political Affairs, Jl. Medan Merdeka Utara No.7-8. Jakarta Pusat. The Department of Home Affairs will issue a supporting document the following day.
4. A letter to the researcher's Indonesian counterpart, and
5. A research permit (Surat Ijin Penelitian).

ADMINISTRATIVE FEE

For the services provided by LIPI an administrative fee is payable by researcher to LIPI upon arrival in Jakarta. Payment should be done in cash of US $ 100. For spouse is US $ 25 and for extension is US $ 50.

ARRIVAL AT THE LOCAL RESEARCH SITE/S

Immediately upon arrival at the research site, researchers must report to the following offices, to present:

1. A letter from LIPI to the sponsor.
2. A letter from LIPI to the local immigration office.
3. A letter from the Departemen Dalam Negeri to the local municipal administration (Pemerintah Daerah) Division of Social and Political Affairs.
4. A copy of "Surat Keterangan Jalan" issued by Police Headquarters in Jakarta.

REPORTING ON RESEARCH PROGRESS

Researchers are required to submit to LIPI 6 (six) copies of a Quarterly Progress Report. Failure to fulfill this requirement will oblige LIPI to revoke the research permit and its support. Consequently, the researcher will be advised to leave the country.

EXTENDING OF RESEARCH ACTIVITY

Should researchers need to extend their researches and stay permits, they have to submit the following documents to LIPI three months prior to the expiration date of the initial permit:

1. A letter explaining the reason for an extension
2. Six copies of Provisional Final Report, and
3. A letter of support from the researcher's Indonesian Counterpart.
4. A copy of a temporary stay permit (KITAS) for long-term researcher.

THE OBLIGATION OF RESEARCHER/S

1. The researcher is prohibited to undertake activities other than stipulated in his/her research permit.

2. The researcher is required to respect the custom, tradition, and cultural values prevailing in the region.

3. When travelling within the country, the researcher should take with him/her copies of all immigration and police documents. Researcher should also take along his/her letters of permission to conduct research from LIPI and "Surat Keterangan Jalan" from the Police Headquarters in Jakarta.

COMPLETION OF RESEARCH

Upon completion of the research, researchers must obtain an Exit Permit Only (EPO) from the Immigration and fiscal exemption from the tax office. The fiscal exemption exempts researchers from paying the Indonesian exit fee or fiscal. It is only given by the Indonesian tax office and only to researchers when they complete their researches.

Following is the procedure to obtain an EPO and fiscal exemption through LIPI:

1. One month prior to the completion of the research, the researcher should submit an interim report to LIPI and inform LIPI of the exact date of departure from Indonesia. He/she and his/her counterpart should write directly to Kepala Biro Kerjasama Iptek LIPI, notifying that his/her research is almost done and he/she plans to leave Indonesia on (his/her departure date). Attached to the counterpart's letter is an interim research report in five copies consisting of 25-30 pages. In the letter, the counterpart should request LIPI to prepare a cover letter to the Immigration Office requesting to issue an EPO and a cover letter to the Tax Office for a tax exemption for the researcher.

2. Researcher should submit LIPI's cover letter and a completed application form, passport, Immigration document (KITAS) and the letter from the sponsoring institution on the Immigration Office that issue KITAS

3. Researcher should submit LIPI's letter to the Tax Office in Jakarta three days prior to his/her departure

FURTHER INFORMATION

Any further information on research procedure for foreign researcher in Indonesia may be obtained from:

Bureau of Science & Technology Cooperation
Sasana Widya Sansono Building, 7th Floor
Jl. Gatot Subroto No.10
Jakarta 12710
Phone: 62 21 5225711
Fax : 62 21 5207226
E-mail: foreign.researcher@bkpi.lipi.go.id

FLOW OF APPLICATION OF RESEARCH PERMIT

1. Application received from Research or Indonesian Representative

2. Researcher may send proposal through Indonesian Representative

3. If proposal sent to LIPI a copy of which sent to Indonesian Representative
4. Application reviewed by Coordinating Team (CT) for Research Permit
5. Result of review sent to LIPI
6. LIPI request visa authorization to Immigration Office
7. Visa authorization sent to Indonesian Representative
8. A copy of visa authorization sent to LIPI
9. LIPI request Indonesian Representative to issue visa for Researcher
10. LIPI informs Researcher to consult Indonesian Representative
11. Researcher obtained visa authorization from Indonesian Representative
12. Researcher comes to Indonesia and reports to LIPI. Necessary documents provided by LIPI

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IFM-GEOMAR Reports

No.	Title
1	RV Sonne Fahrtbericht / Cruise Report SO 176 & 179 MERAMEX I & II (Merapi Amphibious Experiment) 18.05.-01.06.04 & 16.09.-07.10.04. Ed. by Heidrun Kopp & Ernst R. Flueh, 2004, 206 pp. In English
2	RV Sonne Fahrtbericht / Cruise Report SO 181 TIPTEQ (from The Incoming Plate to mega Thrust EarthQuakes) 06.12.2004.-26.02.2005. Ed. by Ernst R. Flueh & Ingo Grevemeyer, 2005, 533 pp. In English
3	RV Poseidon Fahrtbericht / Cruise Report POS 316 Carbonate Mounds and Aphotic Corals in the NE-Atlantic 03.08.–17.08.2004. Ed. by Olaf Pfannkuche & Christine Utecht, 2005, 64 pp. In English
4	RV Sonne Fahrtbericht / Cruise Report SO 177 - (Sino-German Cooperative Project, South China Sea: Distribution, Formation and Effect of Methane & Gas Hydrate on the Environment) 02.06.-20.07.2004. Ed. by Erwin Suess, Yongyang Huang, Nengyou Wu, Xiqiu Han & Xin Su, 2005, to be published summer 2006. In English and Chinese

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