MARNAUT CRUISE REPORT

13/05/2007-11/06/2007

Istanbul (Turkey)-Istanbul (Turkey)

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1. Summary

A- Background and objectives

MARNAUT is a cruise of Ifremer/Genavir RV Atalante in the Sea of Marmara, with manned submersible Nautile. It is a multidisciplinary cruise with objectives centred on the relationships between active faults, fluid emissions, and landslides. French institutions involved are CNRS/INSU, Ifremer and College de France. Turkish partner institutions involved in MARNAUT are ITU (Istanbul Technical University) and MTA (Maden Tetkik ve Arama, Ankara). International participants are SIO (Scripps Institution of Oceanography, San Diego, USA), ISMAR (Istituto di Scienze Marine, Bologna, Italy), Berlin Free University, and Geomar (Germany). MARNAUT is also a step toward the development of permanent seafloor observatories on the North Anatolian Fault in the Sea of Marmara, within the European framework of the ESONET Network of Excellence. Turkish ESONET partners are ITU, KOERI (Kandili Observatory and Earthquake Research Institute, Bogaziçi University), and DEU (Dokuz Eylul University, Izmir).

The Sea of Marmara and Istanbul area is the only one along the North Anatolian Fault system that did not experience a large earthquake during the XXth century. It thus presents an exceptionally high earthquake risk (Ambraseys and Jackson, 2000; Hubert-Ferrari et al., 2000; Parsons et al., 2000). Following the Kocaeli (Izmit) and Düzce earthquakes in 1999, the Turkish-French Cooperation Program on the seismotectonics and the seismic risk in the Sea of Marmara and Istanbul area was launched. Cruises MARMARA (bathymetry and SAR-Pasisar), SEISMARMARA (multichannel seismics) and MARMARASCARPS (ROV Victor) showed the geometry of the fault system (Le Pichon et al., 2001, 2003, Rangin et al., 2001, 2004; Imren et al., 2001; Armijo et al., 2002; Demirbag et al., 2003; Carton et al., 2007) and found probable earthquake ruptures at the bottom of the Sea of Marmara (Armijo et al., 2005). Based on these investigations, an earthquake of magnitude Mw = 7.2 or more is expected. Important remaining questions are: what is the extent and timing of past earthquakes ruptures in the Sea of Marmara? What is the geometry of the deep crustal faults? What is the possible role of co-seismic landslides as tsunami sources? The next stage of Turkish-French cooperation comprises the development of sea-floor observatories, which will complement the seismological network operated by KOERI on land. Observatory demonstration operations and scientist exchange will take place from 2007 to 2010 within the ESONET framework.

Methane gas outflow in the water column, associated with slope instabilities had been observed in the Izmit Gulf after the 1999 eartquake (Alpar, 1999; Kuscu et al., 1999). In the Sea of Marmara, investigations with towed camera (RV Meteor, cruise 44) and remotely operated vehicle (MARMARASCARPS cruise of RV Atalante), found fluid expulsion along the active fault scarps (Halbach et al., 2002; Armijo et al., 2005). While the water expelled at the vents was never sampled, sediment cores taken in the Sea of Marmara (e.g. cruise MARMARA VT/MARMACORE II of RV Marion-Dufresne) contain brackish water at more than 10 m depth below the seafloor. The peculiar history of the Sea of Marmara, which was a lake during glacial times (e.g. Cagatay et al., 2000) could explain this observation, as well as the unusual water expulsion activity observed along the seafloor trace of the Main Marmara Fault. We wonder how this activity varies throughout the earthquake cycle and aim to set a seafloor observatory combining seismology with measurements of strain, pore pressure and fluid fluxes.

The specific objectives of the MARNAUT cruise are:

1. To perform an initial test of seafloor observatory concept, developed within the framework of ESONET Network of Excellence, and provide the initial conditions.
2. To assess the influence of the earthquake cycle on fluid movements in the sediment, and also investigate other factors (climate change and paleoceanography).
3. To measure fluid fluxes along the fault zone and determine the relationship between fluid emissions at the seafloor and deep processes in the seismogenic zone (zone of earthquake slip at depth) and mantle.
4. To identity landslides and zones of instability, assess their recent activity and measure current pore fluid pressure conditions within or above the landslides.
5. To recognize in the sedimentary record recent earthquake and tsunami events (particularly in Çinarçik basin) and correlate them with the historical record (Sari and Çagatay, 2006; McHugh et al., 2006; Beck et al., 2007).
6. To study biogeochemical processes at seafloor vent sites, and evaluate their influence on environmental conditions in the Sea of Marmara.

One practical question asked is whether the deployment of a permanent observatory on seafloor vent sites in the Sea of Marmara is relevant for the study of fluid-deformation coupling in fault zones. Long term (4 months to 1 year) monitoring experiments performed at the occasion of MARNAUT cruise in 2007 and of the MARMESONET cruise, projected in 2009, will gather data to answer this question. Better understanding of fluid-fault coupling processes may, hypothetically, lead to the recognition of earthquake precursors and also improve assessment of slope instability. However, the outcome of this approach for earthquake and tsunami risk assessment should be considered in the very long term.

B-Operation overview

Most technical objectives of the cruise were reached and several of them were realized beyond expectations.

The good meteorological conditions and the remarkable efficiency of the crew allowed us to make all of the 30 *Nautile* dives that had been planned. Only one technical incident should be noted as the submersible rudder got stuck at a 90° angle near the beginning of Dive 1646. However, the dive was continued and observations were made, although along a shorter track than planned. Over the duration of the cruise, the *Nautile* sampling plan was full filled. It included sampling of fluids to determine their nature and origin, of carbonate crusts, considered as testimonies of the passed activity of fluid outflow, and of microbial and macro biological activity associated with fluid emission sites. Two *Nautile* dives (1642, 1668) were part of Subtech project, a technical test of OBS sensors, sponsored by Ifremer and CGG. Although these dives are not formally included in the Marnaut project, the corresponding dive reports are included.

Deployment of instruments for fluid and microseismicity monitoring went as planned. Flowmeters and osmosamplers (SIO instruments) were deployed at three sites with the Nautile submersible: 3 instruments at a brackish water seep on the main fault trace in Tekirdag Basin (Site 3), 2 on a gas and hydrocarbon seep on the Western High (Site 6b), and 2 at seepage sites at the base of the North Cinarcik fault scarp (Site 13a). A piezometer and a mini-network of four OBSs (Ifremer instruments) were deployed from the ship around the Tekirdag Basin brackish water seep for 3 months and have now been recovered. The piezometer and three of the OBSs yielded usable data.

Acoustic detection of gas emission sites was an important operational objective. Acoustic anomalies had been identified before the cruise on SAR side scan sonar data from MARMARA 1 Suroît cruise (by Stephanie Dupré at Ifremer). More anomalies were observed during MARNAUT with a Simrad EK60 sounder, and ground-truthed as gas bubble emission sites with the Nautile submersible. Chirp (3.5 kHz) profiles and stations were performed to complement the existing data set and for site surveys at coring and piezometer sites. A short swath of EM12 reflectivity was done for comparison with existing EM300 data to investigate frequency dependency of reflectivity.

Heat flow measurements were performed in the three deep basins (Tekirdag, Central and Cinarcik Basins) and are, to our knowledge, the first acquired in the Sea of Marmara. Other equipments operated from the ship were Piezometers (pore pressure instruments) in yo-yo mode, Kuellenberg, interface and multitube corers, CTD and rosette for water column sampling. Kuellenberg coring was performed with a 10 m tubeand 35 cores were taken, usually with very good recovery, for different purposes: pore fluid extraction and analysis (13 cores), paleoseismology and seismoturbidite studies (16 cores), shore based geotechnical studies (6 cores).

All collected samples are reported in the annex **Marnaut_sample_database.xls**

C-Preliminary science results.

The observations from the Nautile submersible confirm the association between fluid outflow sites and active faults (Fig. 1.1). Manifestations of fluid outflow are diverse and the brackish water seeps previously known from the Marmarascarps cruise represent one end-member type. The *Nautile* submersible also explored zones of outflow of gas where bubbles escape in the water through a multitude of narrow conduits piercing through black sediments. Microbiological and biological activity (polychaetes and bivalvs) is found in association (Fig. 1.2). The analysis of the samples obtained should allow us to determine the nature of the gases and their depth of origin. However, the deep origin of the fluids outflowing at one of the sites is already established by the presence of significant traces of hydrocarbons. One can already, and prior to a more complete analysis of the data, mention a few other surprising results. The extension toward the west of the rupture of the seafloor related to the 1999 Kocaeli earthquake in the Izmit Gulf does not reach its western extremity, even if rupture was shown by seismological and geodetic studies to have occurred there at depth. The Northern Cinarcik cliff exposes a section of Paleozoïc sedimentary rocks of the Istanbul basin all the way to the fault scarp at its base. Important sites of fluid outflow have been found along this fault scarp, only a few hundreds of meters away from zones explored by remotely operated vehicle in 2002, as well as on fault scarps along the southern edge of the Cinarcik Basin. At the base of the northern Tekirdag slope, methane bubbles escape along tension gashes affecting lithified sediments (Eocene Kesan formation), rather than from recent deposits (Fig. 1.3). Finally, gas hydrates have been found on the sea floor at depths that were completely unexpected (666 m and 14,5°C), outside of the stability field of methane hydrate (Fig. 1.4).

Three abstracts (included in this report) were submitted to AGU fall meeting in session B19, Cold Seeps at Continental Margins: Past and Present.

P Henry et al., Manned submersible observations at cold seeps in the North Anatolian Fault zone, Sea of Marmara.

M D Tryon et al., Pore fluid chemistry of cold seeps in the Sea of Marmara.

L Geli et al., Acoustic detection of gas emissions within the submerged section of the North Anatolian Fault Zone in the Sea of Marmara.

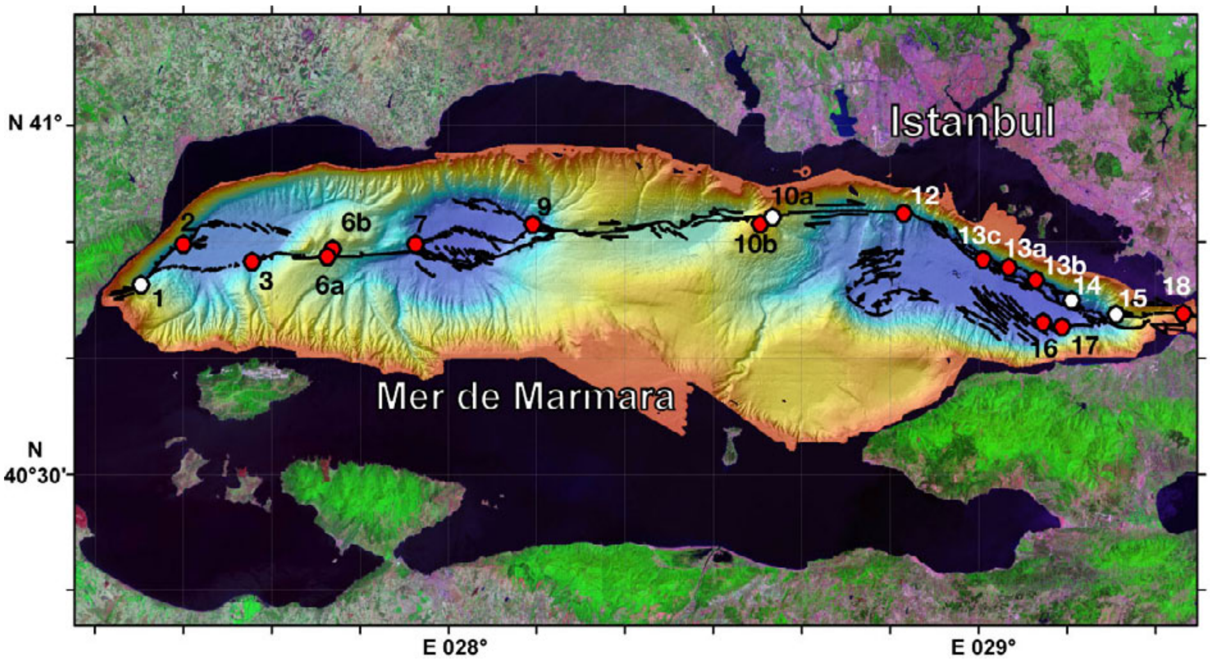


Fig. 1.1: Bathymetric map of the Sea of Marmara and active fault trace over a Landsat image of the area . The Nautile dive sites explored during Marnaut are shown in red dots where fluid seepage were observed, and in white dots otherwise. Numbers refer to dive sites and follow the definition of dive targets in the cruise plan (http://cdf.u-3mrs.fr/~henry/marmara/marnaut_web/meeting1.html) ©CNRS. Pierre Henry.

Fig. 1.2: Bacterial mat and polychaetes tubes over a black patch of reduced sediments. ©MARNAUT.IFREMER.CNRS.

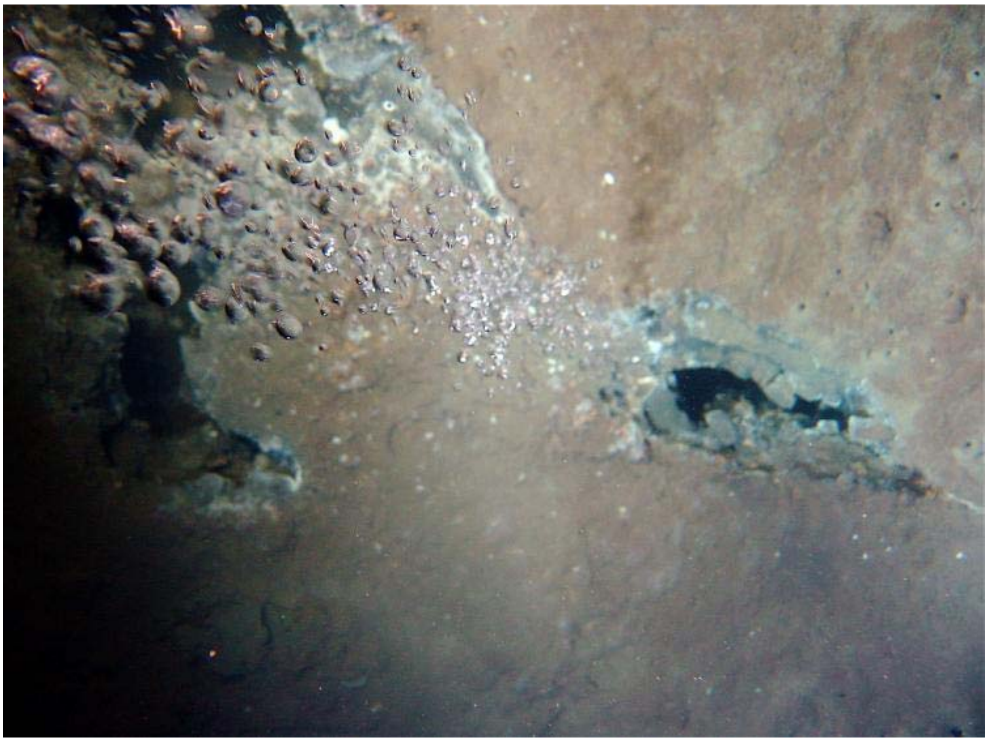


Fig.1.3: Bubbles escaping from a cavity (Boris's Bubblers) © MARNAUT. IFREMER. CNRS

Fig. 1.4: Hydrates (from Kullenberg core KS25) burning on the deck ©MARNAUT. IFREMER.CNRS.

Abstract submitted to AGU 2007 Fall Meeting, session B19: Cold seeps at continental margins: past and present.

Manned submersible observations at cold seeps in the North Anatolian Fault zone, Sea of Marmara.

P. Henry, T.A.C Zitter*, X. Le Pichon (CEREGE, College de France), A.M.C. Sengor, N. Gorur (Istanbul Technical University), L. Gasperini (ISMAR), L. Geli (Ifremer), M. D. Tryon (Scripps Institution of Oceanography), B. Mercier de Lepinay (Geosciences Azur), and the Marnaut Scientific Party

Cold seeps in the Sea of Marmara are associated with active deformation within the North Anatolian Fault system, a transcurrent plate boundary. The Marnaut cruise of Ifremer RV *L'Atalante* took place in May June 2007 with objectives (1) to locate gas outflow sites through acoustic means; (2) to better define the relations between active faults and fluid outlets using the *Nautile* manned submersible; (3) to sample these fluids to determine their nature and origin; (4) to install instruments to monitor the activity of three fluid outflow sites as well as the microseismicity during several months; (4) to sample carbonate crusts, testimonies of the passed activity of fluid outflow; (5) to evaluate the impact of fluid outflow on the present biological and microbiological activity on the seafloor and within the water column; (6) to sample through coring the sediment deposited during the previous earthquakes. Several new zones of fluid emission were found including unexpected locations in areas previously explored with ROV and deep towed cameras. In the Cinarcik Basin, seeps were found along outcrops of Paleozoic sedimentary rocks at the base of the fault-controlled northern cliff, and on en-echelon normal faults extending over the southern slope. In the Tekirdag Basin, bubble emissions were found at the base of the Ganos cliff along NW-SE tension gashes affecting Eocene turbidites of the Kesan formation. On the topographic highs the most active fluid emission sites were found on the top of NE-SW anticlinal ridges at some distance (100-2000 m) from the main fault trace. Active fault scarps were explored at several locations. Very little cold seep activity and no evidence for seafloor rupture from 1999 or 1912 earthquakes was found at the entrance of the Ganos and Izmit Gulf.

Observations suggest basement structures along the edges of the subsiding basins and compressive structures on the topographic highs contribute to fluid channeling and expulsion. Cold seeps are found along the main fault scarps in Cinarcik and Tekirdag basins, but also along less prominent fault zones along the opposite side of the basins. The strike-slip fault segment cutting the Central High (west of Istanbul) has comparatively little cold seep activity and we wonder whether this relates to the seismic gap there.

Abstract submitted to AGU 2007 Fall Meeting, session B19: Cold seeps at continental margins: past and present.

Pore fluid chemistry of cold seeps in the Sea of Marmara

M. D. Tryon* (Scripps Institution of Oceanography), M. N. Cagatay (Istanbul Technical University), P. Henry, T.A.C. Zitter (CEREGE, Collège de France), L. Geli (Ifremer), J.-L. Charlou (Ifremer) and the Marnaut Scientific Party

During the MARNAUT cruise in the Marmara Sea, south of Istanbul, fluid and gas seeps were identified and explored along the Main Marmara Fault, the submerged western extension of the North Anatolian Fault Zone that cuts across the entire length of the sea. Our objective was to study the relationship between fluid expulsion sites and active faults at a transform plate boundary. Utilizing the Nautile submersible, ten cold seep sites spanning the fault zone were explored. The tectonic environments of the seeps included strike-slip faults in transtensional and transpressive contexts, normal faults, folds and landslides. Most seeps were extensive, patchy, and diffuse, displaying patches of black sulfidic sediment with typically white to yellow/orange microbial mat on the surface. One endmember type was highly focused, emitted ambient temperature shimmering fluids of low salinity that precipitated chimney structures. At other sites gas bubbles were seen coming from both the sediment cover and from open fractures. Another type had the appearance of a mud volcano with bacteria covered sediment and a fan morphology extending downslope from the seep. This latter site was associated with very high salinity fluids and significant traces of hydrocarbons and included shallow gas hydrate well outside its normal stability field. Hypothetically, the brackish water seeps (already known from Marmarascarps ROV cruise) can be explained by a local fluid source of lake water trapped in the first 100 m of sediment during the last glaciation. However, deeper sources are required at the hydrocarbon emission site and, probably, contribute to steady gas bubble flow at other sites.

Push cores were collected, where possible, at the seeps for chemical and biological analysis. As all seeps had carbonate crusts or outcrops to a varying degree this was not always successful. Kullenberg piston cores of up to 10 m were also collected in the seep areas during night operations. Fluids were extracted at intervals along the cores using vacuum extraction (Rhizon). Pore fluids from these cores exhibit chlorinities from 100 to over 1000 mM and a comparably wide range of other major and trace ion compositions. We will report the preliminary results of these core pore fluid analyses.

Abstract submitted to AGU 2007 Fall Meeting, session B19: Cold seeps at continental margins: past and present.

Acoustic detection of gas emissions within the submerged section of the North Anatolian Fault zone in the Sea of Marmara.

L. Geli (Ifremer), P. Henry (CEREGE, Collège de France), S. Dupré (Ifremer), D. Volker (Geomar), T.A.C. Zitter*(CEREGE, Collège de France), X. Le Pichon (Collège de France, CEREGE), M. D. Tryon (Scripps Institution of Oceanography), M. N. Cagatay (Istanbul Technical University) and the Marnaut Scientific Party

The 38 kHz, single beam, echo-sounder SIMRAD EK-60 was operated during the Marnaut cruise (May-June 2007) onboard the RV L'Atalante to detect acoustic anomalies related to the presence of gas bubbles in the water column. In the south Cinarcik Basin, strong acoustic anomalies have been found along N140 normal faults within a 3 km wide swath oriented N100. The swath trend corresponds to the orientation of a buried fault system identified in MCS data (Carton and Singh, 2007). Ground-truthing of these anomalies with Nautile submersible enables the founding of gas seeps and bubbles emissions at seafloor. Acoustic anomalies are apparently weaker on the main fault scarp on the northern side of the Cinarcik Basin. In the Central High and Kumburgaz Basin, no acoustic anomalies were detected along the main fault trace. Instead, a cluster with very strong amplitude anomalies was identified at about 1 km away from the fault, on top of a broad anticline. On the Western High, a cluster of acoustic anomalies characterizes the top of an anticline located near 40°49'N, 28°46.8'E, where shallow gas hydrates have been sampled at unexpected water depth of 660 m, well outside their stability field. In the Tekirdag and Central basins, EK-60 lines were implemented along the fault scarps and the acoustic records indicate the presence of gas seeps at fault escarpments. This new set of data confirms previous results obtained with RV Le Suroit in September 2000 with a 112 kHz side-scan sonar towed 200 m above seafloor. Most active sites identified in 2000 were still active in 2007. We note that the only place where no acoustic anomaly was found on the main fault trace corresponds to the Central High and Kumburgaz Basin area. This segment did not rupture during the last century.

2. Operations Summary

Tab 2.1: MARNAUT operations log book

N/O L'ATALANTE Cruise :MARNAUT LEG 1 Report

Task	Latitude		Longitude		Date	GMT Time
Start LEG 1						
EK60 + 3.5 kHz sounding					**13/05/07**	
begin EK60 and 3.5 kHz acquisition	40°	48,800	29°	0,000	13/05/07	7:23
End EK60 and 3.5 kHz acquisition	40°	47,800	29°	0,300	13/05/07	8:39
Nautile Exploration Dive, Site 13, P.Henry						
Nautile dive start	40°	47,060	29°	0,350	13/05/07	9:53
dive end	40°	48,350	29°	2,850	13/05/07	15:53
EK60 + 3.5 kHz sounding						
begin EK60 and 3.5 kHz acquisition	40°	50,820	28°	2,000	13/05/07	20:45
End EK60 and 3.5 kHz acquisition	40°	49,070	27°	54,567	13/05/07	23:02
OBS Deployment					**14/05/07**	
drop point K - LOTOBS	40°	45,669	27°	39,586	14/05/07	0:23
drop point L - LOTOBS	40°	48,262	27°	33,868	14/05/07	0:57
drop point M - LOTOBS	40°	50,797	27°	39,821	14/05/07	1:38
drop point J - LOTOBS	40°	48,233	27°	37,740	14/05/07	2:10
OBS pole deployment	40°	48,237	27°	37,689	14/05/07	2:36
Begin subtech needle deployment	40°	48,201	27°	37,645	14/05/07	3:28
End subtech needle deployment	40°	48,151	27°	37,630	14/05/07	5:50
Nautile Exploration Dive, Site 3, C.Leveque						
Nautile dive start	40°	48,501	27°	37,737	14/05/07	8:04
dive end	40°	48,280	27°	37,340	14/05/07	13:46
Piezometer measurements (on station)						
Piezometer Yoyo 1 Point 1	40°	48,211	27°	37,614	14/05/07	17:50
Piezometer Yoyo 1 Point 2	40°	48,414	27°	37,529	14/05/07	23:35
Piezometer measurements (on station)					**15/05/07**	
Piezometer Yoyo 1 Point 3	40°	48,757	27°	37,215	15/05/07	3:31
Nautile Photography Dive, Site 3, C.Gerick						
Nautile dive start	40°	48,299	27°	38,049	15/05/07	7:43
dive end	40°	48,561	27°	37,790	15/05/07	15:04
End LEG 1						

Task	Latitude		Longitude		Date	GMT Time
Start LEG 2						
EM12 + 3.5 kHz sounding					**15/05/07**	
Begin EM12 and 3.5 kHz acquisition	40°	54,313	29°	39,197	15/05/07	18:39
End EM12 and 3.5 kHz acquisition	40°	48,899	29°	46,750	15/05/07	23:09
EK60						
Begin EK60 acquisition	40°	48,931	28°	48,906	15/05/07	22:33
End EK60 acquisition	40°	48,296	27°	42,904	15/05/07	23:59
					16/05/07	
Begin EK60 acquisition	40°	48,243	28°	37,930	16/05/07	0:41
End EK60 acquisition	40°	47,887	27°	35,564	16/05/07	2:20
3.5 kHz sounding						
Begin EM12 and 3.5 kHz acquisition	40°	47,774	29°	35,330	16/05/07	2:28
End EM12 and 3.5 kHz acquisition	40°	49,756	29°	28,735	16/05/07	5:21
Nautile Exploration Dive, Site 2, B.Natalyn						
Nautile dive start	40°	49,780	27°	35,330	16/05/07	7:16
dive end	40°	49,830	27°	28,661	16/05/07	14:03
Piezometer measurements (on station)						
Piezometer Yoyo 2 Point 1	40°	46,287	27°	32,155	16/05/07	15:26
Piezometer Yoyo 2 Point 2	40°	47,038	27°	32,442	16/05/07	21:00
					17/05/07	
End acquisition	40°	47,201	27°	32,252	17/05/07	0:48
EK60						
Begin EK60 acquisition	40°	48,246	28°	27,707	17/05/07	1:32
End EK60 acquisition	40°	47,909	27°	35,204	17/05/07	5:11
Nautile Exploration Dive, Site 1, M.Tryon						
Nautile dive start	40°	48,360	27°	37,840	17/05/07	8:00
dive end	40°	48,573	27°	37,190	17/05/07	14:31
EK60						
Begin EK60 acquisition	40°	48,790	27°	47,444	17/05/07	16:03
End EK60 acquisition	40°	48,724	27°	44,949	17/05/07	16:44
Piezometer measurements (on station)						
Piezometer Yoyo 3 Point 1	40°	48,341	27°	44,301	17/05/07	18:23
EK60						
Begin EK60 acquisition	40°	48,340	27°	44,299	17/05/07	22:32
End EK60 acquisition	40°	48,733	27°	45,383	17/05/07	23:23
Piezometer measurements (on station)						
Piezometer Yoyo 3 Point 2	40°	48,731	27°	45,386	17/05/07	23:48
					18/05/07	
End acquisition	40°	48,751	27°	45,384	18/05/07	4:16
Nautile Exploration Dive, Site 1, B.Mercier						
Nautile dive start	40°	46,841	27°	25,267	18/05/07	7:07
dive end	40°	46,004	27°	24,737	18/05/07	13:20
HF profile in Tekirdag						
Begin HF1.1	40°	48,274	27°	37,655	18/05/07	15:04
Begin HF1.2	40°	48,311	27°	37,581	18/05/07	16:44
Begin HF1.3	40°	48,394	27°	37,543	18/05/07	17:22
Begin HF1.4	40°	48,467	27°	37,461	18/05/07	18:09
End HF (carrotier tordu)	40°	48,580	27°	37,390	18/05/07	18:54
EK60						
Begin EK60 acquisition	40°	48,278	27°	37,828	18/05/07	20:40
End EK60 acquisition	40°	48,877	27°	42,022	18/05/07	21:53
HF profile in Tekirdag						
Begin HF1bis-1	40°	48,600	27°	37,350	18/05/07	23:41
					19/05/07	
Begin HF1bis-2	40°	48,680	27°	37,280	19/05/07	0:12
Begin HF1bis-3 (BUC out of order)	40°	48,787	27°	37,207	19/05/07	0:40
Begin HF1bis-4 (BUC out of order)	40°	49,201	27°	36,778	19/05/07	1:33
Begin HF1bis-5	40°	49,660	27°	36,338	19/05/07	2:26
Begin HF1bis-6	40°	50,111	27°	35,911	19/05/07	3:20
End HF	40°	50,103	27°	35,965	19/05/07	3:45
EK60						
Begin EK60 acquisition	40°	49,444	27°	30,918	19/05/07	4:47
End EK60 acquisition	40°	50,357	27°	30,510	19/05/07	6:28
Nautile Exploration Dive, Site 3, P.Burnard						
Nautile dive start	40°	49,926	27°	30,181	19/05/07	7:27
dive end	40°	49,769	27°	29,935	19/05/07	14:24
Drop Micro OBS	40°	48,248	27°	37,769	19/05/07	15:49
HF profile in Central Basin						

Begin HF 2.1	40°	50,317	28°	1,426	19/05/07	18:43
Begin HF 2.2	40°	50,609	28°	1,680	19/05/07	19:28
Begin HF 2.3	40°	50,923	28°	1,934	19/05/07	20:13
Begin HF 2.4	40°	51,219	28°	2,200	19/05/07	20:52
Begin HF 2.5	40°	51,500	28°	2,450	19/05/07	21:35
Begin HF 2.6	40°	51,824	28°	2,712	19/05/07	23:01
Begin HF 2.7	40°	52,110	28°	2,965	19/05/07	23:46
					20/05/07	
Begin HF 2.8	40°	52,411	28°	3,225	20/05/07	0:31
Begin HF 2.9	40°	52,706	28°	3,475	20/05/07	1:31
Begin HF 2.10	40°	53,009	28°	3,725	20/05/07	2:08
End HF	40°	53,091	28°	3,567	20/05/07	3:02
EK60						
Begin EK60 acquisition	40°	50,949	27°	59,443	20/05/07	3:38
End EK60 acquisition	40°	49,327	27°	54,841	20/05/07	5:23
Nautile Exploration Dive, Site 6, L.Geli						
Nautile dive start	40°	48,841	27°	47,042	20/05/07	6:57
dive end	40°	49,190	27°	46,391	20/05/07	13:32
HF profile in Central Basin						
Begin HF 3.2	40°	49,952	28°	1,207	20/05/07	16:12
Begin HF 3.3	40°	49,574	28°	0,995	20/05/07	16:59
Begin HF 3.4	40°	49,156	28°	0,775	20/05/07	17:54
Begin HF 3.5	40°	48,786	28°	0,505	20/05/07	18:39
Begin HF 3.6	40°	48,503	28°	0,377	20/05/07	19:16
Begin HF 3.7	40°	48,099	28°	0,174	20/05/07	22:28
Begin HF 3.8	40°	47,742	27°	59,969	20/05/07	23:06
Begin HF 3.9	40°	47,347	27°	59,729	20/05/07	23:47
					21/05/07	
Begin HF 3.10	40°	46,964	27°	59,507	21/05/07	0:33
Begin HF 3.11	40°	46,601	27°	59,298	21/05/07	1:16
End HF	40°	46,614	27°	59,292	21/05/07	2:10
EK60						
Begin EK60 acquisition	40°	47,669	27°	59,918	21/05/07	2:49
End EK60 acquisition	40°	53,919	28°	4,481	21/05/07	5:58
Nautile Exploration Dive, Site 7, T.Zitter						
Nautile dive start	40°	49,855	27°	57,010	21/05/07	6:55
dive end	40°	50,007	27°	56,158	21/05/07	13:48
EK60						
Begin EK60 acquisition	40°	49,524	27°	47,595	21/05/07	15:05
End EK60 acquisition	40°	47,824	27°	43,515	21/05/07	17:30
Piezometer measurements (on station), Western High						
Piezometer Yoyo 3 Point 3	40°	47,820	27°	43,541	21/05/07	18:20
End acquisition	40°	47,820	27°	43,544	21/05/07	22:24
					22/05/07	
Piezometer measurements (on station), Central Basin						
Piezometer Yoyo 4 Point 1	40°	48,728	28°	0,517	22/05/07	1:46
End acquisition	40°	48,814	28°	0,582	22/05/07	5:40
Nautile Exploration Dive, Site 9, C.Pierre						
Nautile dive start	40°	51,575	28°	9,375	22/05/07	7:24
dive end	40°	51,264	28°	9,208	22/05/07	14:25
EK60						
Begin EK60 acquisition	40°	51,644	28°	8,688	22/05/07	15:59
End EK60 acquisition	40°	51,245	28°	9,041	22/05/07	17:00
Piezometer measurements (on station), Central Basin						
Piezometer Yoyo 5 Point 1	40°	51,430	28°	9,380	22/05/07	18:40
Piezometer Yoyo 5 Point 2	40°	51,570	28°	9,520	22/05/07	22:20
3.5 kHz sounding						
Begin 3.5 kHz acquisition	40°	51,572	28°	9,521	22/05/07	22:56
					23/05/07	
End 3.5 kHz acquisition	40°	51,570	28°	9,519	23/05/07	0:00
Begin 3.5 kHz acquisition	40°	51,671	28°	9,488	22/05/07	3:30
End 3.5 kHz acquisition	40°	55,040	28°	36,432	23/05/07	5:30
End Yoyo acquisition	40°	51,570	28°	9,520	23/05/07	2:28
Nautile Exploration Dive, Site 10, G.Ukarcus						
Nautile dive start	40°	52,148	28°	36,844	23/05/07	7:23
dive end	40°	52,335	28°	35,107	23/05/07	13:57
EK60						
Begin EK60 acquisition	40°	52,331	28°	37,272	23/05/07	15:30
End EK60 acquisition	40°	52,237	28°	37,159	23/05/07	15:47
Begin EK60 acquisition	40°	45,404	28°	43,960	23/05/07	17:57
End EK60 acquisition	40°	45,052	28°	46,230	23/05/07	18:35
Begin EK60 acquisition	40°	44,212	28°	50,468	23/05/07	19:35

End EK60 acquisition	40°	43,654	28°	55,774	23/05/07	21:59
Begin EK60 acquisition	40°	44,282	28°	58,114	23/05/07	22:22
					24/05/07	
End EK60 acquisition	40°	42,798	29°	11,390	24/05/07	3:20
Begin EK60 acquisition	40°	43,562	29°	13,377	24/05/07	3:46
End EK60 acquisition	40°	44,413	29°	12,231	24/05/07	6:17
Nautile Exploration Dive, Site 14, S.Sengor						
Nautile dive start	40°	44,978	29°	10,528	24/05/07	6:55
dive end	40°	45,899	29°	10,886	24/05/07	13:42
MultiCorer						
Start operation	40°	43,956	29°	10,115	24/05/07	16:16
End operatin	40°	44,038	29°	9,881	24/05/07	17:50
3.5 kHz sounding						
Point 265	40°	42,132	29°	8,964	24/05/07	18:38
Point 264	40°	43,035	29°	9,827	24/05/07	18:46
Point 280	40°	43,490	29°	13,134	24/05/07	19:02
Point 281	40°	41,609	29°	19,918	24/05/07	19:35
End acquisition (problem with keops device)					24/05/07	19:37
Piezometer measurements (on station), Western High						
Piezometer Yoyo 6 Point 1	40°	41,950	29°	18,398	24/05/07	21:10
					25/05/07	
End acquisition	40°	41,948	29°	18,400	25/05/07	5:03
Nautile Exploration Dive, Site 15, S.Ozeren						
Nautile dive start	40°	42,700	29°	9,414	25/05/07	6:57
dive end	40°	42,553	29°	9,607	25/05/07	14:05
HF profile in Central Basin						
Begin HF 4.1	40°	42,000	29°	5,098	25/05/07	16:01
Begin HF 4.2	40°	42,400	29°	5,187	25/05/07	16:43
EK60						
Begin EK60 acquisition	40°	42,790	29°	5,277	25/05/07	17:14
Begin HF 4.3	40°	42,786	29°	5,268	25/05/07	17:25
Begin HF 4.4	40°	43,200	29°	5,360	25/05/07	18:09
Begin HF 4.5	40°	43,400	29°	5,200	25/05/07	18:40
Begin HF 4.6	40°	43,608	29°	5,451	25/05/07	19:13
Begin HF 4.7	40°	44,007	29°	5,538	25/05/07	19:55
Begin HF 4.8	40°	44,401	29°	5,620	25/05/07	20:43
Begin HF 4.9	40°	45,200	29°	5,796	25/05/07	21:41
Begin HF 4.10	40°	45,602	29°	5,884	25/05/07	22:35
Begin HF 4.11	40°	45,998	29°	5,968	26/05/07	23:21
					26/05/07	
Begin HF 4.12	40°	46,400	29°	6,055	26/05/07	0:06
Begin HF 4.13	40°	46,694	29°	6,174	26/05/07	0:49
Begin HF 4.14	40°	46,805	29°	6,133	26/05/07	1:30
End EK60 acquisition	40°	46,839	29°	6,151	26/05/07	2:20
End HF	40°	46,800	29°	6,168	26/05/07	2:30
EK60						
Begin EK60 acquisition	40°	46,868	29°	6,107	26/05/07	2:37
End EK60 acquisition	40°	46,332	29°	6,271	26/05/07	5:50
Nautile Exploration Dive, P.Henry						
Nautile dive start	40°	46,573	29°	6,201	26/05/07	6:44
dive end	40°	47,443	29°	5,782	26/05/07	13:16
3.5 kHz sounding						
Begin EM12 and 3.5 kHz acquisition	40°	47,924	29°	5,365	26/05/07	13:43
End EM12 and 3.5 kHz acquisition	40°	45,148	28°	52,282	26/05/07	14:45
EK60						
Begin EK60 acquisition	40°	45,128	28°	52,359	26/05/07	15:06
End EK60 acquisition	40°	45,600	28°	52,436	26/05/07	15:24
Begin EK60 acquisition	40°	44,521	28°	58,056	26/05/07	16:06
					27/05/07	
End EK60 acquisition	40°	43,578	28°	58,377	27/05/07	1:27
Begin EK60 acquisition	40°	44,501	29°	3,421	27/05/07	2:17
End EK60 acquisition	40°	44,254	29°	4,123	27/05/07	4:49
Nautile Exploration Dive, Site 12, S.Bourlange						
Nautile dive start	40°	52,096	28°	52,858	27/05/07	6:48
dive end	40°		29°		27/05/07	
EK60						
Begin EK60 acquisition	40°	47,426	29°	5,416	27/05/07	15:50
End EK60 acquisition	40°	47,819	29°	2,808	27/05/07	16:49

End LEG 2

Task	Latitude		Longitude		Date	GMT Time
Start LEG 3						
EK60						
Begin EK60 acquisition	40°	44,331	28°	54,429	27/05/07	18:47
profile 323 completed	40°	42,520	28°	52,487	28/05/07	
End EK60 acquisition	40°	42,520	28°	52,487	28/05/07	2:15
Deploying flowmeter R with acoustic release	40°	47,748	29°	3,371	28/05/07	3:40
Flowmeter R on seafloor	40°	47,789	29°	3,298	28/05/07	4:18
Deploying flowmeter M with acoustic release	40°	47,771	29°	3,322	28/05/07	4:45
Flowmeter M on seafloor	40°	47,788	29°	3,310	28/05/07	5:19
Deploying flowmeter J with acoustic release	40°	47,788	29°	3,319	28/05/07	5:45
flowmeter J on seafloor	40°	47,789	29°	3,319	28/05/07	6:23
Nautile Exploration Dive, Site 13, Mike Tryon, N°1656						
Nautile dive start	40°	47,700	29°	3,380	28/05/07	7:03
dive end	40°	47,538	29°	3,258	28/05/07	13:24
Nautile on board	40°	48,216	29°	2,8011	28/05/07	14:05
Carrotier Kullenberg KS et interface KI						
MNT-KS-01 in water	40°	46,791	29°	6,104	28/05/07	16:14
MNT-KS-01 in declenchement	40°	46,791	29°	6,100	28/05/07	16:53
MNT-KS-01 on board	40°	46,780	29°	6,033	28/05/07	17:41
MNT-KS-02 in water	40°	44,690	29°	7,492	28/05/07	19:17
MNT-KS-02 in declenchement	40°	44,698	29°	7,493	28/05/07	19:36
MNT-KS-02 on board	40°	44,690	29°	7,477	28/05/07	20:30
MNT KI01 in water	40°	44,695	29°	7,497	28/05/07	20:51
MNT KI01 in seafloor	40°	44,694	29°	7,489	28/05/07	20:21
MNT KI01 in board	40°	44,694	29°	7,489	28/05/07	21:44
MNT-KS-03 in water	40°	44,048	29°	6,937	28/05/07	22:45
MNT-KS-03 in declenchement	40°	44,050	29°	6,940	28/05/07	23:32
MNT-KS-03 on board	40°	44,052	29°	6,935	29/05/07	0:21
MNT KI02 in water	40°	44,050	29°	6,935	29/05/07	0:41
MNT KI02 in seafloor	40°	44,050	29°	6,936	29/05/07	1:17
MNT KI02 in board	40°	44,116	29°	6,833	29/05/07	1:48
sonde CTD (bathysonde)						
CTD 1 in water	40°	43,212	29°	7,159	29/05/07	2:16
CTD 1 in board	40°	43,272	29°	7,308	29/05/07	3:31
CTD 2 in water	40°	42,646	29°	7,146	29/05/07	4:07
CTD 2 in board	40°	42,764	29°	7,245	29/06/07	5:17
Nautile Exploration Dive, Site 15, Lucas Gasperini, N°1657						
Nautile in water	40°	43,780	29°	15,588	29/05/07	6:30
dive end	40°	43,554	29°	18,722	29/05/07	12:57
Nautile on board	40°	43,701	29°	18,266	29/05/07	13:16
Carrotier Kullenberg KS et interface KI						
MNT KI03 in water	40°	43,741	29°	19,890	29/05/07	13:57
MNT KI03 in board	40°	43,717	29°	20,003	29/05/07	14:18
MNT-KS-04 in water	40°	41,950	29°	18,400	29/05/07	15:20
MNT-KS-04 in declenchement	40°	41,950	29°	18,390	29/05/07	15:32
MNT-KS-04 on board	40°	41,980	29°	18,370	29/05/07	15:58
MNT-KS-05 in water	40°	42,988	29°	9,952	29/05/07	17:26
MNT-KS-05 in declenchement	40°	42,430	29°	9,966	29/05/07	18:10
MNT-KS-05 on board	40°	43,142	29°	9,868	29/05/07	19:05
MNT KI04 in water	40°	44,056	29°	7,490	29/05/07	19:57
MNT KI04 in seafloor	40°	44,046	29°	7,495	29/05/07	20:35
MNT KI04 in board	40°	44,027	29°	7,496	29/05/07	21:15
MNT-KS-06 in water	40°	44,030	29°	7,489	29/05/07	21:33
MNT-KS-06 in declenchement	40°	44,027	29°	7,494	29/05/07	22:15
MNT-KS-06 on board	40°	44,357	29°	7,651	29/05/07	23:17
EK60						
Begin EK60 acquisition	40°	43,030	29°	7,501	29/05/07	23:52
End EK60 acquisition	40°	42,950	29°	6,978	30/05/07	1:18
sonde CTD (bathysonde)						
CTD 3 in water	40°	42,930	29°	6,944	30/05/07	1:27
CTD 3 in board	40°	42,878	29°	6,993	30/05/07	2:50
CTD4-1 water	40°	47,926	29°	2,932	30/05/07	3:44
CTD4-1 board	40°	47,953	29°	2,947	30/05/07	4:49
CTD4-2 water	40°	47,950	29°	2,940	30/05/07	5:22
CTD4-2 board	40°	47,950	29°	2,940	30/05/07	5:45
Nautile Exploration Dive, Site 13, Naci Gorur, N°1658						

Nautile in water	40°	48,477	29°	0,474	30/05/07	6:42
dive end	40°	49,108	29°	0,208	30/05/07	13:08
Nautile on board	40°	49,289	29°	0,705	30/05/07	13:43
Carottier multitube						
MTB02 in water	40°	47,849	29°	2,861	30/06/07	14:49
MTB02 declenchement	40°	47,967	29°	2,939	30/06/07	15:28
MTB02 in board	40°	48,040	29°	2,799	30/06/07	16:09
MTB03 in water	40°	46,640	29°	6,089	30/06/07	17:03
MTB03 declenchement	40°	46,798	29°	6,138	30/06/07	17:51
MTB03 in board	40°	49,977	29°	6,044	30/06/07	18:38
3.5 KHz						
Start	40°	41,855	29°	5,815	30/05/07	19:30
Stop	40°	42,817	29°	29,277	30/06/07	0:05
EK60						
EK60 in water	40°	43,531	29°	10,179	30/05/07	23:24
Begin EK60 acquisition	40°	43,424	29°	10,181	30/05/07	23:27
End EK60 acquisition	40°	45,075	28°	58,450	31/05/07	2:46
EK60 in board	40°	45,073	28°	58,438	31/05/07	2:48
Carrotier interface KI						
MNT-KI-05 in water	40°	47,932	29°	2,956	31/05/07	3:39
MNT-KI-05 board	40°	47,932	29°	2,956	31/05/07	4:36
MNT-KI-06 in water	40°	47,851	29°	3,308	31/05/07	5:03
MNT-KI-06 in declenchement	40°	47,848	29°	3,313	31/05/07	5:29
MNT-KI-06 on board	40°	47,888	29°	3,319	31/05/07	6:01
Nautile Exploration Dive, Site 16, Pierre Henry, N°1659						
Nautile in water	40°	43,116	29°	7,283	31/05/07	7:10
dive end	40°	42,725	29°	7,230	31/05/07	13:21
Nautile on board	40°	42,595	29°	6,558	31/05/07	14:02
sonde CTD (bathysonde)						
CTD 5 in water	40°	42,918	29°	6,906	31/05/07	14:23
CTD5 in board	40°	42,911	29°	6,854	31/05/07	15:39
Carrotier Kullenberg KS et interface KI						
MNT-KS-07 in water	40°	42,938	29°	6,850	31/05/07	16:37
MNT-KS-07 in declenchement	40°	42,940	29°	6,849	31/05/07	17:21
MNT-KS-07 on board	40°	42,938	29°	6,859	31/05/07	18:03
MNT KI07 in water	40°	42,942	29°	6,842	31/05/07	18:50
MNT KI07 in seafloor	40°	42,942	29°	6,847	31/05/07	19:21
MNT KI07 in board	40°	42,943	29°	6,854	31/05/07	19:51
3.5 KHz (2 knts)						
WP 341	40°	42,036	29°	6,061	31/05/07	20:13
WP 342	40°	42,036	29°	8,015	31/06/2007	20:42
Carrotier Kullenberg KS et interface KI						
MNT-KS-08 in water	40°	43,107	29°	17,268	31/05/07	22:10
MNT-KS-08 in declenchement	40°	43,696	29°	17,274	31/05/07	22:27
MNT-KS-08 on board	40°	43,711	29°	17,384	31/05/07	22:56
MNT-KS-09 in water	40°	41,027	29°	11,780	31/05/07	23:53
MNT-KS-09 in declenchement	40°	41,040	29°	11,802	31/05/07	0:30
MNT-KS-09 on board	40°	41,055	29°	11,829	31/05/07	1:02
MNT-KS-10 in water	40°	44,043	29°	10,796	31/05/07	1:54
MNT-KS-10 in declenchement	40°	44,034	29°	10,782	31/05/07	2:30
MNT-KS-10 on board	40°	44,038	29°	10,791	31/05/07	3:20
MNT KI08 in water	40°	44,040	29°	10,805	31/05/07	3:45
MNT KI08 in seafloor	40°	44,033	29°	10,777	31/05/07	4:15
MNT KI08 in board	40°	43,997	29°	10,711	31/05/07	4:46
Nautile Microbiology, Site 13, Puri Lopez, N°1660						
Nautile in water	40°	46,751	29°	6,453	1/06/07	6:53
dive end	40°	46,484	29°	6,348	1/06/07	13:42
Nautile on board	40°	46,737	29°	5,828	1/06/07	4:19
Carrotier Kullenberg KS						
MNT-KS-11 in water	40°	45,465	29°	13,840	1/06/07	16:12
MNT-KS-11 in declenchement	40°	45,480	29°	13,819	1/06/07	16:32
MNT-KS-11 on board	40°	45,432	29°	13,627	1/06/07	17:07
EK60						
EK60 in water	40°	52,211	28°	36,592	1/06/07	20:37
EK60 in board	40°	52,522	28°	25,363	1/06/07	23:57
sonde CTD (bathysonde)						
CTD 6-1 in water	40°	51,452	28°	9,460	2/06/07	3:41
CTD 6-1 in board	40°	51,474	28°	9,461	2/06/07	4:35
CTD 6-2 in water	40°	51,599	28°	10,554	2/06/07	5:31

CTD 6-2 in board	40°	51,598	28°	10,544	2/06/07	5:35
CTD 7 in water	40°	51,596	28°	10,543	2/06/07	5:35
CTD 7 in board	40°	51,606	28°	10,549	2/06/07	6:35
Nautile Sampling and exploration Dive, Site 9, Namik Cagatay, N°1661						
Nautile in water	40°	51,425	28°	9,327	2/06/07	7:06
dive end	40°	51,383	28°	10,586	2/06/07	13:02
Nautile on board	40°	51,377	28°	9,991	2/06/07	13:37
EK60						
EK60 in water	40°	51,487	28°	9,546	2/06/07	14:05
EK60 end profile	40°	48,559	28°	0,571	2/06/07	18:27
EK60 in board	40°	48,576	28°	0,606	2/06/07	18:34
3.5 KHz						
Mise en route au point n°62	40°	48,674	28°	0,484	2/06/07	18:40
Arrêt	40°	49,040	27°	46,700	3/06/07	4:20
Carrotier Kullenberg KS						
MNT-KS-12 in water	40°	50,134	27°	59,890	2/06/07	19:03
MNT-KS-12 in declenchement	40°	50,190	27°	59,870	2/06/07	19:56
MNT-KS-12 on board	40°	50,186	27°	59,839	2/06/07	20:41
MNT-KS-13 in water	40°	48,533	27°	59,489	2/06/07	21:51
MNT-KS-13 in declenchement	40°	48,641	27°	59,491	2/06/07	23:04
MNT-KS-13 on board	40°	48,638	27°	59,491	2/06/07	23:53
sonde CTD (bathysonde)						
CTD 8 in water	40°	49,035	27°	46,712	3/06/07	2:25
CTD 8 in board	40°	49,044	27°	46,720	3/06/07	3:14
EK60						
EK60 in water	40°	50,061	27°	47,148	3/06/07	5:24
EK60 end profile	40°	48,992	27°	46,816	3/06/07	6:32
EK60 in board	40°	48,957	27°	46,772	3/06/07	6:33
Nautile bubble hunting, western high, Sylvain Bourlange, N°1662						
Nautile in water	40°	49,359	27°	46,727	3/06/07	7:51
dive end	40°	49,242	27°	46,509	3/06/07	13:03
Nautile on board	40°	49,147	27°	46,096	3/06/07	13:32
Carottier Interface KI						
MNT KI09 in water	40°	49,061	27°	46,743	3/06/07	14:04
MNT KI09 in seafloor	40°	49,054	27°	46,769	3/06/07	14:26
MNT KI09 in board	40°	49,040	27°	46,766	3/06/07	14:48
Carrotier Kullenberg KS						
MNT-KS-14 in water	40°	49,043	27°	46,759	3/06/07	15:08
MNT-KS-14 in declenchement	40°	49,052	27°	46,767	3/06/07	15:34
MNT-KS-14 on board	40°	49,122	27°	46,725	3/06/07	16:04
MNT-KS-15 in water	40°	51,608	27°	35,680	3/06/07	17:22
MNT-KS-15 in declenchement	40°	51,601	27°	35,723	3/06/07	18:06
MNT-KS-15 on board	40°	51,519	27°	35,670	3/06/07	18:50
MNT-KS-16 in water	40°	51,100	27°	35,992	3/06/07	19:47
MNT-KS-16 in declenchement	40°	51,110	27°	35,977	3/06/07	20:25
MNT-KS-16 on board	40°	50,970	27°	35,734	3/06/07	21:14
MNT-KS-17 in water	40°	48,200	27°	36,970	3/06/07	22:18
MNT-KS-17 in declenchement	40°	48,239	27°	36,999	3/06/07	23:08
MNT-KS-17 on board	40°	48,416	27°	36,807	3/06/07	23:46
MicroOBS recovery						
MicroOBS in water	40°	50,301	28°	1,388	4/06/07	0:08
MicroOBS in board	40°	50,293	28°	1,385	4/06/07	4:41
sonde CTD (bathysonde)						
CTD 9 in water	40°	50,301	28°	1,388	4/06/07	3:29
CTD 9 in board	40°	50,293	28°	1,385	4/06/07	4:31
3.5 KHz						
point n°367	40°	50,938	28°	7,354	4/06/07	5:05
point n°368	40°	51,262	28°	9,690	4/06/07	5:26
point n°369	40°	51,789	28°	10,975	4/06/07	5:39
Arrêt	40°	51,446	28°	9,252	4/06/07	5:57
Nautile microbo/bio dive, Central Basin, I. Boulabassi, Site 9, N°1663						
Nautile in water	40°	51,491	28°	9,558	4/06/07	6:09
dive end	40°	51,258	28°	9,293	4/06/07	13:27
Nautile on board	40°	51,778	28°	9,311	4/06/07	14:02
Carrotier Kullenberg KS						
MNT-KS-18 in water	40°	49,369	28°	0,814	4/06/07	15:52
MNT-KS-18 in declenchement	40°	49,398	28°	0,831	4/06/07	16:34

MNT-KS-18 on board	40°	49,520	28°	0,748	4/06/07	17:21
MNT-KS-19 in water	40°	51,505	28°	9,429	4/06/07	18:48
MNT-KS-19 in declenchement	40°	51,508	28°	9,444	4/06/07	19:31
MNT-KS-19 on board	40°	51,556	28°	9,388	4/06/07	20:20
3.5 KHz						
Début de profil 362-363	40°	51,977	28°	9,757	4/06/07	20:31
point n°363	40°	53,371	28°	10,446	4/06/07	20:51
point n°364	40°	56,332	28°	10,993	4/06/07	21:25
point n°366	40°	55,039	28°	8,672	4/06/07	22:07
Arrêt	40°		28°		4/06/07	
EK60						
EK60 in water	40°	51,075	28°	34,367	4/06/07	1:28
EK60 in board	40°	51,760	28°	34,023	4/06/07	5:04
Nautile bubble hunting, Kronenbourg, Louis Geli, N°1664						
Nautile in water	40°	51,965	28°	34,979	5/06/07	6:33
dive end	40°	51,268	28°	34,765	5/06/07	12:45
Nautile on board	40°	51,677	28°	34,967	5/06/07	13:08
sonde CTD (bathysonde)						
CTD 10 in water	40°	51,704	28°	35,013	5/06/07	13:28
CTD 10 in board	40°	51,717	28°	35,007	5/06/07	13:59
Carrotier Kullenberg KS						
MNT-KS-20 in water	40°	51,719	28°	34,992	5/06/07	14:49
MNT-KS-20 in declenchement	40°	51,724	28°	35,005	5/06/07	14:58
MNT-KS-20 on board	40°	51,773	28°	34,937	5/06/07	15:17
3.5 KHz						
Début de profil 398	40°	53,045	28°	32,142	5/06/07	15:54
point n°397	40°	52,295	28°	30,335	5/06/07	16:20
point n°396	40°	53,253	28°	30,172	5/06/07	16:43
point C1	40°	52,293	28°	30,710	5/06/07	17:08
point C2	40°	52,295	28°	30,335	5/06/07	17:11
Fin de profil	40°	52,289	28°	30,265	5/06/07	17:16
Carrotier Kullenberg KS						
MNT-KS-21 in water	40°	52,274	28°	30,195	5/06/07	17:25
MNT-KS-21 in declenchement	40°	52,284	28°	30,217	5/06/07	18:06
MNT-KS-21 on board	40°	52,692	28°	30,555	5/06/07	19:19
3.5 KHz						
Début de profil 396	40°	53,167	28°	30,154	5/06/07	19:30
point n°395	40°	50,099	28°	30,316	5/06/07	20:12
Fin de profil	40°	49,420	28°	27,930	5/06/07	21:40
EK60						
EK60 in water	40°	51,133	28°	23,096	5/06/07	22:16
EK60 end profile	40°	50,084	28°	6,006	6/06/07	2:40
EK60 in board	40°	50,098	28°	5,889	6/06/07	2:44
sonde CTD (bathysonde)						
CTD 11-1 in water	40°	50,293	28°	1,401	6/06/07	13:28
CTD 11-1 board	40°	50,301	28°	1,383	6/06/07	4:36
CTD 11-2 in water	40°	50,2880	28°	1,390	6/06/07	5:29
CTD 11-2 in board	40°	50,244	28°	1,243	6/06/07	5:51
CTD 12	40°	51,255	28°	7,008	6/06/07	7:06
CTD 12	40°	51,198	28°	7,590	6/06/07	7:49
Nautile microbio/bio dive, Central Basin, B.Ritt, N°1665						
Send elevator	40°	51,270	28°	10,167	6/06/07	8:13
Nautile in water	40°	51,370	28°	10,220	6/06/07	8:30
dive end	40°	51,099	28°	10,065	6/06/07	14:51
Nautile on board	40°	51,547	28°	9,903	6/06/07	15:28
Interface KI						
MNT KI10 in water	40°	51,251	28°	10,122	6/06/07	15:52
MNT KI10 in seafloor	40°	51,260	28°	10,155	6/06/07	16:21
MNT KI10 in board	40°	51,227	28°	10,159	6/06/07	16:52
MNT KI11 in water	40°	51,267	28°	10,196	6/06/07	17:05
MNT KI11 in seafloor	40°	51,278	28°	10,186	6/06/07	17:36
MNT KI11 in board	40°	51,281	28°	10,195	6/06/07	18:07
Carrotier Kullenberg KS						
MNT-KS-22 in water	40°	51,280	28°	10,182	6/06/07	18:19
MNT-KS-22 in declenchement	40°	51,276	28°	10,187	6/06/07	19:02
MNT-KS-22 on board	40°	51,275	28°	10,189	6/06/07	19:41
MNT-KS-23 in water	40°	51,131	28°	8,305	6/06/07	20:36
MNT-KS-23 in declenchement	40°	51,132	28°	8,310	6/06/07	21:11

MNT-KS-23 on board	40°	51,505	28°	8,075	6/06/07	22:00
MNT-KS-24 in water	40°	55,811	28°	8,943	6/06/07	22:41
MNT-KS-24 in declenchement	40°	55,831	28°	8,971	6/06/07	23:16
MNT-KS-24 on board	40°	55,620	28°	8,790	6/06/07	23:49
EK60						
EK60 in water	40°	49,415	27°	57,541	7/06/07	1:13
EK60 in board	40°	48,772	27°	49,864	7/06/07	3:20
Deploying flowmeter with acoustic release	40°	49,069	27°	46,765	7/06/07	3:59
Flowmeter on board	40°	49,078	27°	46,779	7/06/07	4:36
Deploying flowmeter with acoustic release	40°	49,077	27°	46,776	7/06/07	4:38
Flowmeter on board	40°	49,084	27°	46,775	7/06/07	6:08
Nautile flowmeter dive, Mike Tryon, N°1666						
Nautile in water	40°		27°		7/06/07	6:42
dive end	40°	48,855	27°	46,317	7/06/07	13:01
Nautile on board	40°	49,249	27°	46,59	7/06/07	13:32
Carrotier Kullenberg KS						
MNT-KS-25 in water	40°	48,854	27°	46,667	7/06/07	14:29
MNT-KS-25 in declenchement	40°	45,894	27°	46,641	7/06/07	14:50
MNT-KS-25 on board	40°	48,957	27°	46,455	7/06/07	15:20
MNT-KS-26 in water	40°	48,734	27°	46,055	7/06/07	16:38
MNT-KS-26 in declenchement	40°	48,740	27°	46,053	7/06/07	17:21
MNT-KS-26 on board	40°	48,732	27°	46,013	7/06/07	17:53
MNT-KS-27 in water	40°	48,895	27°	46,635	7/06/07	18:45
MNT-KS-27 in declenchement	40°	48,892	27°	46,640	7/06/07	19:11
MNT-KS-27 on board	40°	48,986	27°	46,622	7/06/07	19:40
3.5 KHz						
Début de profil 390	40°	50,357	27°	41,803	7/06/07	20:12
point n°391	40°	48,623	27°	36,657	7/06/07	20:39
point n°392	40°	45,832	27°	25,580	7/06/07	21:38
point n°393	40°	46,750	27°	25,200	7/06/07	21:38
point n°394	40°	46,038	27°	25,220	7/06/07	22:04
Fin de profil	40°	46,240	27°	26,203	7/06/07	22:15
Carrotier Kullenberg KS						
MNT-KS-28 in water	40°	46,083	27°	25,550	7/06/07	14:29
MNT-KS-28 in declenchement	40°	46,074	27°	25,552	7/06/07	14:50
MNT-KS-28 on board	40°	46,074	27°	25,550	7/06/07	23:54
MNT-KS-29 in water	40°	48,518	27°	37,381	8/06/07	1:24
MNT-KS-29 in declenchement	40°	48,512	27°	37,328	8/06/07	2:01
MNT-KS-29 on board	40°	48,660	27°	36,982	8/06/07	2:47
EK60						
EK60 in water	40°	47,644	27°	34,386	8/06/07	3:13
EK60 in board	40°	47,598	27°	33,212	8/06/07	3:33
Lower 1 osmosampler on cable						
OSMO in water	40°	48,233	27°	37,867	8/06/07	4:11
cable on board	40°	48,253	27°	37,595	8/06/07	5:03
Nautile sampling and osmosampler setting dive, Jack the smoker, T. Zitter N°1667						
Nautile in water	40°	48,295	27°	37,770	8/06/07	6:40
dive end	40°	47,862	29°	36,772	8/06/07	12:53
Nautile on board	40°	48,384	29°	36,936	8/06/07	13:29
3.5 KHz						
begin profile	40°	47,739	27°	38,160	8/06/07	13:54
end profile	40°	52,920	27°	33,373	8/06/07	15:10
End LEG 3						

Task	Latitude		Longitude		Date	GMT Time
Start LEG 4						
3.5 KHz						
Begin profile 103	40°	55,140	27°	33,700	8/06/07	18:05
Long term piezometer deployment						
Deploying piezometer	40°	48,238	27°	37,748	8/06/07	19:33
Declenchement	40°	48,197	27°	37,734	8/06/07	20:17
LOTOBS Recovery						
OBS M largué	40°	50,510	27°	39,580	8/06/07	22:41
OBS M on board	40°	50,820	27°	39,890	8/06/07	23:22
OBS K largué	40°	46,122	27°	39,250	9/06/07	0:09
OBS K on board	40°	45,740	27°	39,700	9/06/07	0:28
OBS L largué	40°	47,640	27°	34,410	9/06/07	0:58
OBS L on board	40°	48,273	27°	33,799	9/06/07	1:35
sonde CTD (bathysonde) Tekirdag						
CTD 13-1 in water station 13	40°	48,242	27°	37,735	9/06/07	2:09
CTD 13-1 in board	40°	48,249	27°	37,766	9/06/07	3:05
CTD 13-2 water	40°	48,210	27°	37,774	9/06/07	3:31
CTD 13-2 board	40°	48,250	27°	37,763	9/06/07	3:48
3.5 KHz						
point n°396	40°	47,934	27°	31,300	9/06/07	4:53
point n°397	40°	46,924	27°	31,580	9/06/07	5:06
point n°398	40°	47,185	27°	31,729	9/06/07	5:09
point n°399	40°	47,966	27°	31,842	9/06/07	5:20
point A	40°	48,053	27°	36,108	9/06/07	5:55
Arrêt	40°	48,143	27°	37,550	9/06/07	6:06
Nautile technical Dive on OBSs, A. Massol, N°1668						
Send elevator	40°	48,265	27°	37,700	9/06/07	6:14
Nautile in water	40°	48,215	27°	37,804	9/06/07	6:41
LOTOBS on board	40°	48,233	27°	37,708	9/06/07	8:11
dive end	40°	48,125	27°	37,616	9/06/07	13:01
Nautile on board	40°	48,041	27°	38,034	9/06/07	13:15
LOTOBS Redeployment						
OBS I in water	40°	48,256	27°	37,753	9/06/07	15:21
OBS K in water	40°	45,675	27°	39,700	9/06/07	16:00
OBS L in water	40°	48,245	27°	33,861	9/06/07	16:43
OBS M in water	40°	50,814	27°	39,697	9/06/07	17:28
Carrotier Kullenberg KS						
MNT-KS-30 in water	40°	48,322	27°	37,700	9/06/07	18:06
MNT-KS-30 in declenchement	40°	48,216	27°	37,786	9/06/07	18:59
MNT-KS-30 on board	40°	48,190	27°	37,637	9/06/07	19:39
MNT-KS-31 in water	40°	48,153	27°	37,714	9/06/07	20:21
MNT-KS-31 in declenchement	40°	48,156	27°	37,779	9/06/07	21:09
MNT-KS-31 on board	40°	48,245	27°	36,762	9/06/07	21:56
Interface						
MNT KI12 in water	40°	49,723	27°	36,692	9/06/07	22:30
MNT KI12 in seafloor	40°	49,741	27°	36,680	9/06/07	23:01
MNT KI12 in board	40°	49,741	27°	36,680	9/06/07	23:30
Carrotier Kullenberg KS						
MNT-KS-32 in water	40°	49,737	27°	36,680	9/06/07	23:50
MNT-KS-32 in declenchement	40°	49,737	27°	36,680	10/06/07	0:30
MNT-KS-32 on board	40°	50,073	27°	36,332	10/06/07	1:17
3.5 KHz						
Mise en route	40°	50,081	27°	36,201	10/06/07	1:24
Arrêt	40°	48,625	27°	46,948	10/06/07	5:23
Carrotier Kullenberg KS						
MNT-KS-33 in water	40°	49,040	27°	46,781	10/06/07	3:39
MNT-KS-33 in declenchement	40°	49,046	27°	46,813	10/06/07	4:02
MNT-KS-33 on board	40°	49,053	27°	46,612	10/06/07	4:30
Nautile Dive, Microbiologie, Western High, N. Chevalier, N°1669						
Nautile in water	40°	48,897	27°	46,830	10/06/07	6:45
dive end	40°	48,825	27°	46,452	10/06/07	13:21
Nautile on board	40°	49,213	27°	46,507	10/06/07	13:51
Carrotier Kullenberg KS						
MNT-KS-34 in water	40°	49,737	28°	36,680	10/06/07	20:28
MNT-KS-34 in declenchement	40°	49,737	28°	36,680	10/06/07	20:39
MNT-KS-34 on board	40°	23,599	28°	57,521	10/06/07	20:56

Interface						
MNT KI13 in water	40°	23,595	28°	57,515	10/06/07	21:18
MNT KI13 in seafloor	40°	23,599	28°	57,519	10/06/07	21:22
MNT KI13 in board	40°	23,714	28°	57,349	10/06/07	21:30
Carrotier Kullenberg KS						
MNT-KS-35 in water	40°	47,967	29°	2,925	11/06/07	3:12
MNT-KS-35 in declenchement	40°	47,968	29°	2,940	11/06/07	3:44
MNT-KS-35 on board	40°	47,972	29°	3,008	11/06/07	4:23
Nautile Dive, Izmit gulf entrance, X. Le Pichon, N°1670						
Nautile in water	40°	43,878	29°	23,183	11/06/07	6:19
dive end	40°	43,815	29°	24,239	11/06/07	10:03
Nautile on board	40°	44,39	29°	21,907	11/06/07	10h45
End LEG 4 End Cruise						

2.1. Dives

30 dives of about 7 hours each (5.5 hours on seafloor on average) took place during the 30 days of the MARNAUT cruise. Explored water depth range from 120 m to 1265 m. The average distance explored during one dive is about 3 km (*see Tab 2.1.1 and Fig. 2.1.1*). The Nautile dives covered 18 sites, of which 13 are on the main fault zone. Evidence for fluid emission was found at 14 of the dive sites. Four dives were dedicated to the deployments of flowmeters and osmosamplers (see 2.8). Two dives were dedicated to Subtech OBS deployment and recovery.

Available embarked equipments for sampling sediments, fluids and gases were: push cores, blade cores, sealed containers for biological sampling, a titanium water sampler (4x250ml bottles), titanium syringes and Pegaz pressure cells. Additionnaly, a MicroCAT C-T recorder was used for measuring the seawater temperature and salinity continuously during dives. Graphs are found in Annex **microcat_figs.pdf**. A handle was fitted on the instrument for manipulation with the arm at venting sites. The MicroCAT could function in autonomous mode, or be interfaced with the Nautile through a cable. This possibility was tested successfully during dive 1645 but was not used afterwards. The cable connection was considered inconvenient when many instruments had to be set in the basket and manipulated during one dive. The different instruments embarked on each dive are detailed on *Tab. 2.1.1*.

Geological cross sections and systematic sampling of sedimentary rock outcrops were performed on the northern slopes of Tekirdag Basin (Dive 1644) and of Cinarcik Basin (Dives 1652 and 1658). Authigenic carbonate crusts were sampled at ten different dive sites over the whole Sea of Marmara. Water and dissolved gas were sampled at seepage sites with gas tight water bottles. Dissolved gases were extracted on board from these bottles at 11 different dive sites, primarily for noble gas analysis. Dissolved methane concentrations on samples from the second leg were determined shore based. Pressure gas samples were collected with the Nautile at four sites with the Pegaz system. One of the five Pegaz cells brought on board was used to store a gas hydrate sample from core KS27. Push cores were taken for pore fluid and sediment analysis. Two methods of extraction were used: porous polymer tubes (Rhyzon) and centrifugation. Chlorinity was measured on board on push cores from dives 1645, 1649, 1662 and 1663. Five dives at three sites were devoted to sampling for the microbiological and biological studies. During these dives, a lift was used to bring additional sampling equipment on the bottom (blade corers, bio box, additional push core rack, titanium syringes) and return the samples. The lift was also used during dive 1664 to provide a spare Pegaz and during dive 1642 to bring OBSs down. The sites selected for this approach are: a brackish water seep in the Central Basin (Site 9, dives 1650, 1661, 1663 and 1665), black patches at the base of the Northern scarp in Cinarcik Basin (Site 13b, dives 1654 and 1660) and a hydrocarbon seep site with gas hydrates located on the western high (Site 6b, dives 1662, 1666 and 1669)

Dive reports are compiled in annex **MARNAUT_dive_reports.pdf**

Following pages:
Tab. 2.1.1: List of the 30 MARNAUT dives.
Tab. 2.1.2: List of the dive rock sample and storage location of the subsamples
Fig. 2.1.1: Location map of the 30 MARNAUT dive sites

Dive #	Date	Scientist	Institution	Pilot	Co-pilot	Site	Prof Max (m)
1641	13/05/2007	Pierre HENRY	CNRS Cerege	Jean -Paul JUSTINIANO	Franck ROSAZZA	13a	1265
1642	14/05/2007	Claude LEVEQUE	IFREMER	Patrick CHEILAN	Xavier PLACAUD	3	1114
1643	15/05/2007	Christoph GERIGK	free lance photographer	Jean -Paul JUSTINIANO	Franck ROSAZZA	3	1117
1644	16/05/2007	Boris NATALIN	ITU	Patrick CHEILAN	Xavier PLACAUD	2	1120
1645	17/05/2007	Mike TRYON	SCRIPPS	Franck ROSAZZA	Olivier FAUVIN	3	1114
1646	18/05/2007	Bernard MERCIER DE LEPINA\`	CNRS Geoscience Azur	Patrick CHEILAN	Séverine BERAUD	1	1028
1647	19/05/2007	Pete BURNARD	CNRS CRPG	Jean -Paul JUSTINIANO	Xavier PLACAUD	2	1145
1648	20/05/2007	Louis GELI	IFREMER	Franck ROSAZZA	Patrick CHEILAN	6a	710
1649	21/05/2007	Tiphaine ZITTER	CNRS Cerege	Jean -Paul JUSTINIANO	Xavier PLACAUD	7	1228
1650	22/05/2007	Catherine PIERRE	CNRS LOCEAN	Patrick CHEILAN	Olivier FAUVIN	9	1176
1651	23/05/2007	Gulsen UCARKUS	ITU	Jean -Paul JUSTINIANO	Franck ROSAZZA	10a	490
1652	24/05/2007	Celal SENGOR	ITU	Patrick CHEILAN	Séverine BERAUD	14	1198
1653	25/05/2007	Sinan OZEREN	ITU	Franck ROSAZZA	Xavier PLACAUD	17	1240
1654	26/05/2007	Pierre HENRY	CNRS Cerege	Jean -Paul JUSTINIANO	Patrick CHEILAN	13b	1224
1655	27/05/2007	Sylvain BOURLANGE	CRPG	Xavier PLACAUD	Séverine BERAUD	12	1025
1656	28/05/2007	Mike TRYON	SCRIPPS	Jean -Paul JUSTINIANO	Franck ROSAZZA	13a	1200
1657	29/05/2007	Luca GASPERINI	ISMAR	Patrick CHEILAN	Xavier PLACAUD	15	958
1658	30/05/2007	Naci GORUR	ITU	Franck ROSAZZA	Olivier FAUVIN	13c	1230
1659	31/05/2007	Pierre HENRY	CNRS Cerege	Jean -Paul JUSTINIANO	Xavier PLACAUD	16	1248
1660	01/06/2007	Purificacion LOPEZ	CNRS	Patrick CHEILAN	Franck ROSAZZA	13b	1197
1661	02/06/2007	Namik CAGATAY	ITU	Jean -Paul JUSTINIANO	Xavier PLACAUD	9	1178
1662	03/06/2007	Sylvain BOURLANGE	CRPG	Franck ROSAZZA	Patrick CHEILAN	6b	657
1663	04/06/2007	Ioanna BOULOUBASSI	CNRS LOCEAN	Jean -Paul JUSTINIANO	Xavier PLACAUD	9	1180
1664	05/06/2007	Louis GELI	IFREMER	Patrick CHEILAN	Olivier FAUVIN	10b	347
1665	06/06/2007	Bénédicte RITT	IFREMER	Jean -Paul JUSTINIANO	Franck ROSAZZA	9	1130
1666	07/06/2007	Mike TRYON	SCRIPPS	Xavier PLACAUD	Patrick CHEILAN	6b	665
1667	08/06/2007	Tiphaine ZITTER	CNRS Cerege	Jean -Paul JUSTINIANO	Franck ROSAZZA	3	1115
1668	09/06/2007	Alain MASSOL	IFREMER	Patrick CHEILAN	Xavier PLACAUD	3	1113
1669	10/06/2007	Nicolas CHEVALIER	LOCEAN	Jean -Paul JUSTINIANO	Franck ROSAZZA	6b	690
1670	11/06/2007	Xavier LE PICHON	Collège de France	Patrick CHEILAN	Séverine BERAUD	18	190

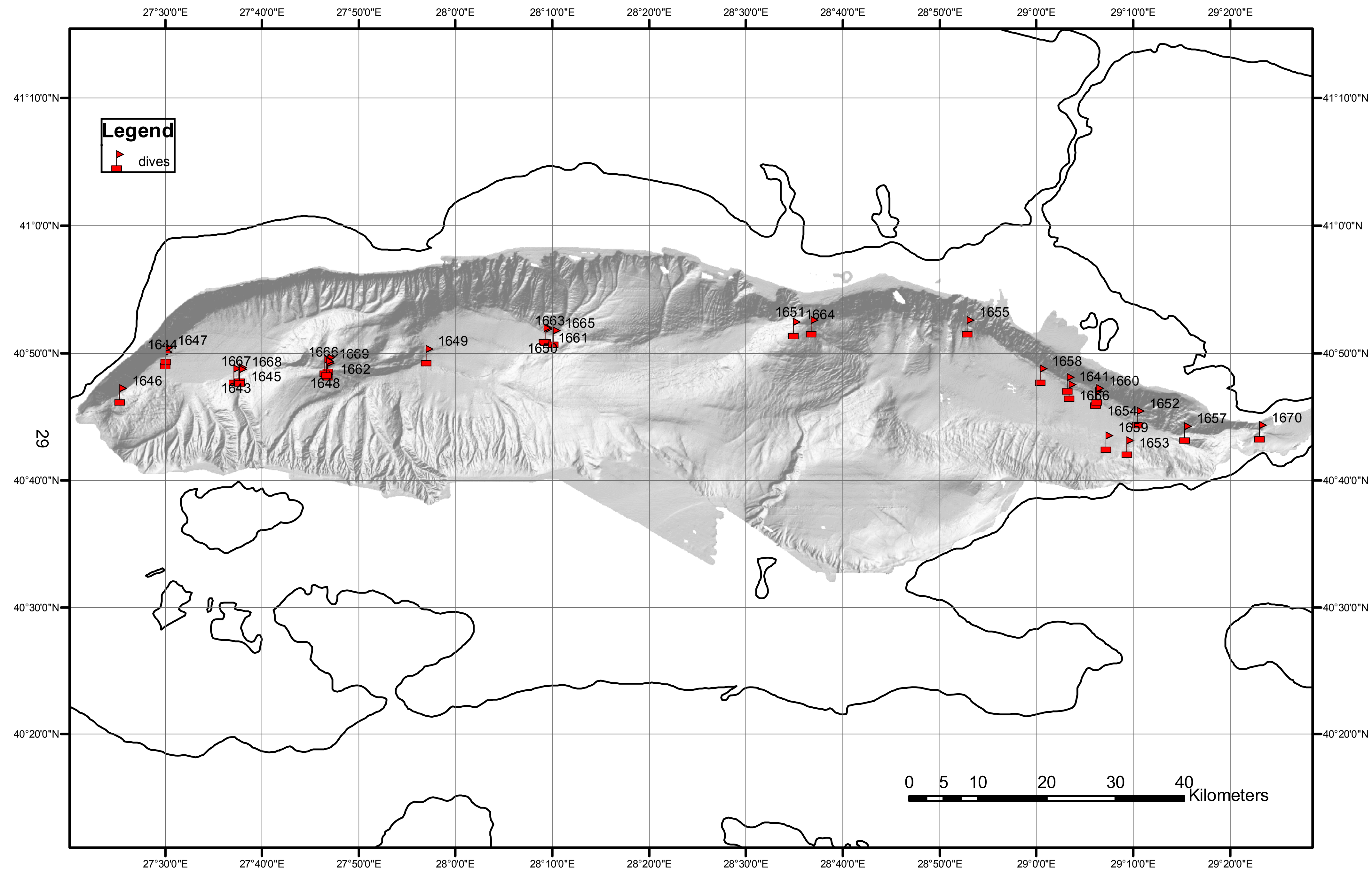
Dive #	Objectives of the dives	Area	Latitude, longitude arrival on SF		Total time	Time	Distance (m)
1641	Exploration, seeps	North Cinarcik off Princess	40,7846	29,0588	06:04	04:24	2570
1642	Subtech OBS deployment	South Tekirdag- Jack site	40,8052	27,6208	06:34	04:46	3000
1643	Photography	South tekirdag- Jack Site	40,8062	27,6285	07:33	05:59	2500
1644	Exploration, tectonics	Ganos slope	40,8268	27,5023	07:15	06:00	4380
1645	Flowmeter deployment	South tekirdag- Jack Site	40,807	27,6297	06:53	05:32	2300
1646	Exploration, tectonics	South eastern Tekirdag landslide	40,7794	27,4238	06:35	05:30	4000
1647	Gas sampling	Ganos slope	40,8326	27,5026	07:17	05:55	3150
1648	Gas sampling	Western High	40,8129	27,7817	06:52	05:50	4400
1649	Exploration, cold seeps	West Central Basin	40,8314	27,9512	07:07	05:46	5700
1650	Sampling, cold seeps	NE Central Basin-chimney site	40,8588	28,1573	07:24	06:03	2400
1651	Exploration, tectonics	Central High	40,8693	28,6151	07:00	06:06	4500
1652	Exploration, geology	NE Cinarcik landslide	40,7497	29,1763	07:09	05:55	4300
1653	Exploration, cold seeps	SE Cinarcik landslide	40,7115	29,1586	07:13	05:44	3500
1654	Exploration, cold seeps	Cinarcik N scarp	40,7756	29,104	06:52	05:31	3900
1655	Exploration, cold seeps	North Cinarcik -S istanbul	40,8691	28,8832	07:13	05:56	4100
1656	Flowmeter deployment	North Cinarcik	40,7942	29,056	07:02	05:38	2800
1657	Exploration, tectonics	Izmit termination	40,73	29,2582	06:54	05:49	4800
1658	Exploration, geology	North Cinarcik	40,8051	29,009	07:01	05:39	1230
1659	Gas sampling	South Cinarcik	40,7181	29,1228	06:53	05:27	1248
1660	Biology, microbiology sampling	Cinarcik N scarp	40,7797	29,107	07:27	06:04	2400
1661	Exploration and sampling, cold seeps	NE Central Basin-chimney site	40,8574	28,1579	06:39	05:13	3200
1662	Gas sampling	Western High	40,8201	27,7826	06:39	05:37	3300
1663	Biology, microbiology sampling	NE Central Basin-chimney site	40,8582	28,1544	07:10	05:49	2500
1664	Gas sampling	Central High	40,8661	28,5837	06:36	05:52	814
1665	Biology, microbiology sampling	North east Central Basin	40,8552	28,17	07:01	05:40	2850
1666	Flowmeter deployment	Western High	40,8173	27,7765	06:53	05:50	2800
1667	Flowmeter deployment	South tekirdag- Jack Site	40,8049	27,6298	06:51	05:36	3000
1668	Subtech OBS recovery	South tekirdag- Jack Site	40,8045	27,6299	06:35	05:18	2900
1669	Biology, microbiology sampling	Western High	40,8149	27,7803	07:07	06:09	2700
1670	Exploration, tectonics	Izmit termination	40,7312	29,387	04:08	03:25	2410

Dive #	Instruments									Lift	Samples						DVD	Problems
	Mcat	WS	TB	PC	BC	BB	Pgaz	OBS	FM		PC	R	BC	BB	FS	Pgaz		
1641	-	-	-	4	-	-	-	-	-		1	2	-	-	-	-	6	
1642	-	-	-	4	-	-	-	3 (L)	-	x	-	-	-	-	-	-	6	
1643	-	-	-	4	-	-	-	-	-		-	-	-	-	-	-	6	
1644	-	-	-	4	-	-	-	-	-		-	8	-	-	-	-	6	
1645	x	4	-	4	-	-	-	-	2 (W)		4	-	-	-	4	-	6	microcat handle broke
1646	-	-	-	4	-	-	-	-	-		2	-	-	-	-	-	6	gear technical problem
1647	x	4	-	4	-	-	1	-	-		-	1	-	-	2	1	6	microcat malfunction
1648	x	4	-	4	-	-	1	-	-		4	-	-	-	-	-	6	
1649	-	4	-	4	-	-	1	-	-		1	1	-	-	4	-	6	
1650	x	4(L)	-	4	2 (L)	2	1 (L)	-	-	x	-	-	2	1	2	-	6	
1651	x	4	-	4	-	-	-	-	-		4	-	-	-	2	-	6	
1652	-	-	-	4	-	-	-	-	-		-	12	-	-	-	-	6	
1653	x	4	-	4	-	-	1	-	-		2	5	-	-	4	-	6	
1654	x	4	-	4	-	-	1	-	-		-	3	-	-	2	-	6	
1655	x	4	-	4	-	-	-	-	-		2	-	-	-	3	-	6	no visibility
1656	x	4	-	4	-	-	-	-	3 (W)		4	-	-	-	-	-	6	
1657	x	4	-	4	-	-	1	-	-		3	4	-	-	-	-	6	
1658	x	4	-	4	-	-	1	-	-		-	6	-	-	2	-	6	
1659	x	4	-	4	-	-	2	-	-		4	1	-	-	4	1	6	
1660	x	4	2	4+4(L)	2 (L)	1(L)	-	-	-	x	8	1	2	1	6	-	6	
1661	x	4	-	4	-	-	1	-	-		2	8	-	-	-	-	6	
1662	x	4	-	4	-	-	1	-	-		4	5	-	-	3	1	6	
1663	x	4	-	4+4(L)	2 (L)	1+2(L)	-	-	-	x	2	1	2	1	4	-	6	
1664	x	4	-	4	-	-	1+1(L)	-	-	x	2	2	-	-	4	1	6	1 pegaz malfunction
1665	x	4	2	4+4(L)	4(L)	1(L)	-	-	-	x	8	3	4	-	6	-	6	
1666	x	4	-	4	-	-	-	-	2 (W)		2	-	-	-	-	-	6	
1667	x	4	-	4	-	-	-	-	1 (W)		2	3	-	-	-	-	6	
1668	-	-	-	4	-	-	-	-	-	x	-	-	-	-	-	-	6	
1669	x	-	-	4+4(L)	2 (L)	2	-	-	-	x	7	-	2	1	-	-	6	
1670	-	-	-	4	-	-	-	-	-		-	-	-	-	-	-	4	

Mcat: Microcat, WS: watersampler, TB: titanuim bottle, PC: push cores, BC: Blade cores, BB: Biobox, Pgaz: Pegaz
OBS: ocean bottom sismometer, FM: flowmeter, FS: fluid samples, (L): lift, (W): deployed by wire

Sample number	photo	Sub sample	description
R-1641-1	Y	ITU, Cerege	Greenish gray sandstone
R-1641-2	Y	ITU, Cerege	Carbonate cemented breccia
R-1644-1	Y	ITU, Cerege	sedimentary rock
R-1644-1a	Y	ITU, Cerege	sediment with bivalvs
R-1644-2	Y	ITU, Cerege	Rock sample
R-1644-3	Y	ITU, Cerege	Rock sample
R-1644-4	Y	ITU	quartzite w/ calcareous coating, black Mg coating
R-1644-5	Y	ITU, Cerege	calcareous fine-grained sandstone
R-1644-6	Y	ITU, Cerege	Sediment
R-1644-7	Y	ITU, Cerege	Sediment
R-1644-8	N	ITU	sandstone?, gray w/ iron and Mg coatings
R-1646-1	Y	Cerege, ITU	Massive obscure rock
R-1646-2	Y	Cerege	Light gray soft sedimentary rock (marl? pelite?)
R-1647-1	Y	Cerege, LOCEAN	breccia covered with white carbonate precipitate (botryoidal aragonite and needles) from active venting fluid
PCS-1648-5	N	LOCEAN	concretion in dark grey sediment
PCS-1648-8	N	LOCEAN	concretion in dark grey sediment
PCS-1648-7	N	LOCEAN	concretion in dark grey sediment
R-1649-1	Y	ITU, LOCEAN, Cerege	dark grey sediment cemented by fine grained carbonate; cm sized conduits (gaz chimneys ?)
R-1650-1 (BB1)	Y	CDF, LOCEAN, ITU	black sediment with concretion from an active venting chimney
R-1650-2 (BB2)	N	LOCEAN	carbonate crust with fixed living fauna
BCS-1650-7	N	LOCEAN	carbonate concretion in black sulfidic sediment
R-1652-1	Y	ITU, Cerege	breccia
R-1652-2	N	ITU	breccia
R-1652-3	Y	ITU,Cerege	breccia
R-1652-4	N	ITU	red to white orthoquartzite
R-1652-5	Y	ITU, Cerege	sedimentary rock
R-1652-6	N	ITU	calcareous shale
R-1652-7	Y	ITU, CDF	calcareous shale
R-1652-8	N	ITU	calcareous shale
R-1652-9	N	ITU,Cerege	calcareous shale
R-1652-10	Y	ITU	coral
R-1652-11	Y	ITU,Cerege	recent gray mustone breccia
R-1652-12	N	ITU,Cerege	yellowish brown mud
R-1653-1	Y	ITU,Cerege	Rock sample
R-1653-2	Y	ITU,Cerege	Rock sample
R-1653-3	Y	ITU, CDF, LOCEAN	carbonate crust
R-1653-4	Y	ITU,Cerege	Rock sample
R-1653-5	Y	ITU, CDF, LOCEAN	light beige vacuolar carbonate
R-1654-1	Y	ITU,Cerege	angular rock sample, black shale
R-1654-2	N	ITU	pebble
R-1654-3	Y	ITU,Cerege	rock sample, calcareous shale
R-1657-1	N	ITU, Cerege	pink sediment - Deepest Cinarcik-Izmit canyon
R-1657-2	N	ITU,Cerege	black sediment- Bottom of the Canyon
R-1657-3	N	ITU, Cerege	sediment
R-1657-4	N	ITU, Cerege	grey sediment
R-1658-1	Y	ITU, Cerege	various pieces: carbonate fragments, sedimentary rocks, urchin test
R-1658-2	Y	ITU, Cerege	sedimentary rock
R-1658-3	Y	ITU, Cerege	sedimentary rock

R-1658-4	Y	ITU, Cerege	sedimentary rock
R-1658-5	Y	ITU, Cerege	sedimentary rock
R-1658-6	Y	ITU	sedimentary rock
R-1659-1	Y	LOCEAN	Delicate carbonate concretions and tubes sampled at a bubble emission point within a black patch, below the sediment surface
R-1660-1	Y	Cerege, LOCEAN, ITU	black shale
PCS-1660-5	N	LOCEAN	small crust in push core 6-8 cm
PCS-1660-4	N	LOCEAN	crust 9-15 cm
R-1661-1	Y	LOCEAN	Spongy textured gray carbonate crust with local black to brown coating; 10 cm size
R-1661-2	Y	ITU	Same as sample 1, but larger (20 cm)
R-1661-3a	Y	ITU	Sample 3a: Two corals; one dark brown and the other brown (3 and 7 cm long).
R-1661-3b	Y	ITU, LOCEAN	Sample 3b: A large platy, carbonate cemented mud crust, with smooth surface covered with white tube worms and stained with brown to dark brown coating (size: 45 cm x 60 cm)
R-1661-4	Y	IITU, LOCEAN	Horizontally banded, dark brown to black carbonate crust;1-3 cm thick, 5 pieces
R-1661-5	Y	ITU, LOCEAN	Carbonate crust with nodular and cavernous surface texture and buff to black surface staining; the broken surface shows a rough banding with one buff and one gray band
R-1661-6	Y	ITU, LOCEAN	Platy light gray carbonate crust bored by tube wurms; smooth surface; 0.6-0.8 cm thick and 4 to 8 cm long four pieces. One piece shows a double banded structure
R-1661-7	Y	ITU, LOCEAN	Gray carbonate crust, with local dark brown to black surface staining
R-1661-8	Y	ITU	Mud clast collected from the fault scarp. It is green mud with a chaotic structure and rare white shell fragments; it has dark brown staining
R-1662-1	Y	LOCEAN, ITU	carbonate crust
R-1662-2	Y	LOCEAN (2), ITU	carbonate crust and cemented shell fragments
R-1662-3	Y	LOCEAN	carbonate crust
R-1662-4	Y	LOCEAN, ITU	carbonate crust
R-1662-5	Y	LOCEAN, ITU, Cerege	carbonate crust
BCS-1663-8	N	DEEP	carbonate
BCS-1663-7	N	LOCEAN	carbonate
R-1663-1	Y	LOCEAN	carbonate crust
R-1664-1	Y	ITU, LOCEAN	small sample of carbonate crust from carbonate platform, 8x4 m wide, ooutcroppping by 30 cm above sediments
R-1664-2	Y	ITU,LOCEAN	carbonate crust sample from same carbonate platform
R-1665-1	Y	LOCEAN	carbonate crust
R-1665-2	Y	LOCEAN	carbonate crust
R-1665-3	Y	LOCEAN	carbonate crust
R-1666-1	Y	ITU	carbonate chimney piece
R1667-1	Y	LOCEAN	carbonate fragments
R1667-2	Y	LOCEAN	carbonate fragments
R1667-3	Y	LOCEAN	carbonate fragments



Legend
dives
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N
1646
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0 5 10 20 30 40
Kilometers

2.2 Heat flow measurements

A total of 45 heat flow measurements were collected during leg 1 and 2, along 3 profiles, using 7 Micrel autonomous digital temperature probes fitted on a 10 cm-diameter gravity corer *(Fig. 2.2.1)*. The tube length was 10 m for the first 5 measurements on profile HF1, and penetration was up to 6.5m, but the tube bent and was replaced by a 5 m long core tube. Full penetration was always achieved in the following measurements. Intercalibrations were realized in the water column at 100m and 50m above seafloor to correct the near-surface temperature gradients from bottom water temperature variations. The corer was located with the ultra short base (BUC), in order to know its exact inclination. Preliminary determinations of temperature gradients are shown on Figures 2.2.2, 2.2.3 and 2.2.4. The locations of heat flow measurements are given in *Table 2.2.1* and shown on *Fig. 2.2.5*.

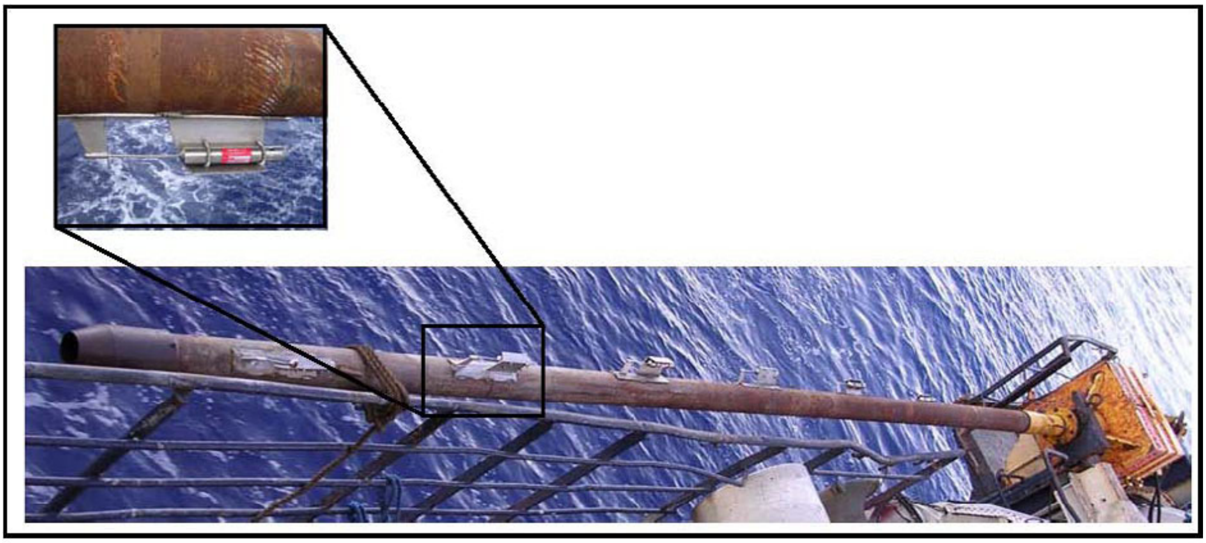


Fig. 2.2.1: Gravity corer equipped with micrel autonomous probes

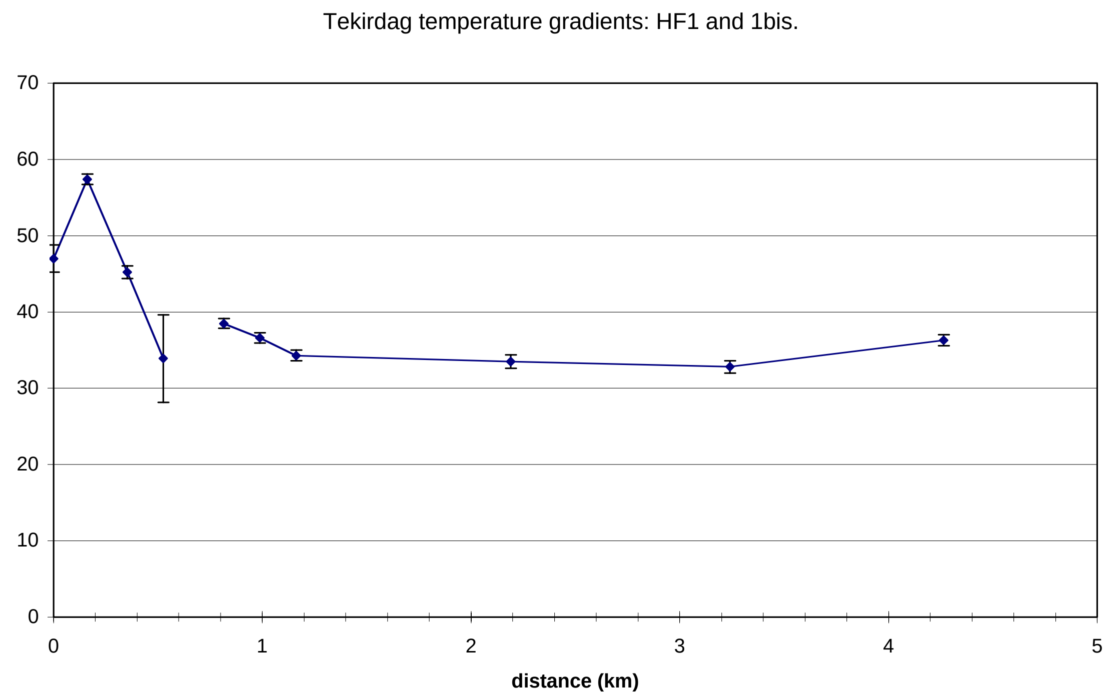


Fig. 2.2.2: Temperature gradients from heat flow probe measurements in Tekirdag Basin

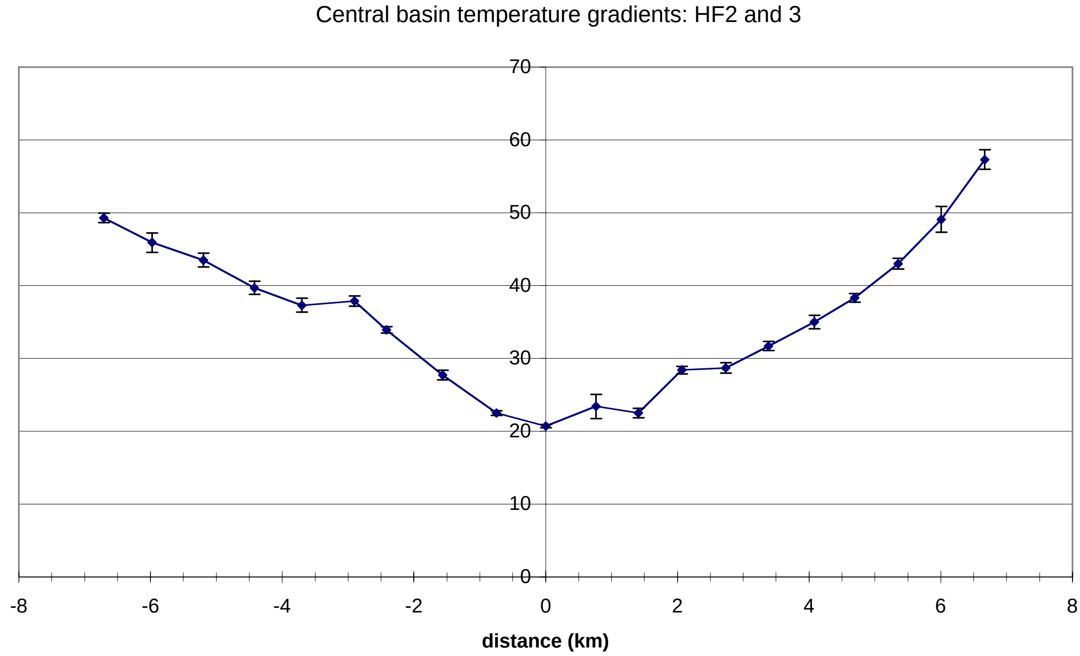


Fig. 2.2.3: Temperature gradients from heat flow probe measurements in the Central Basin

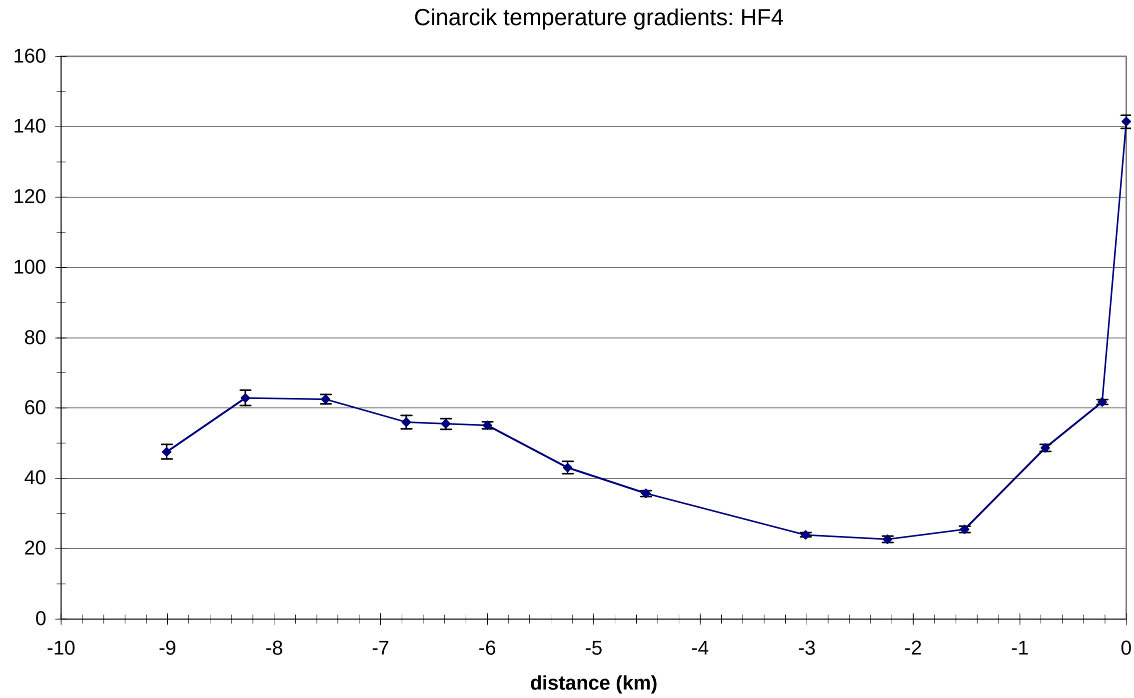
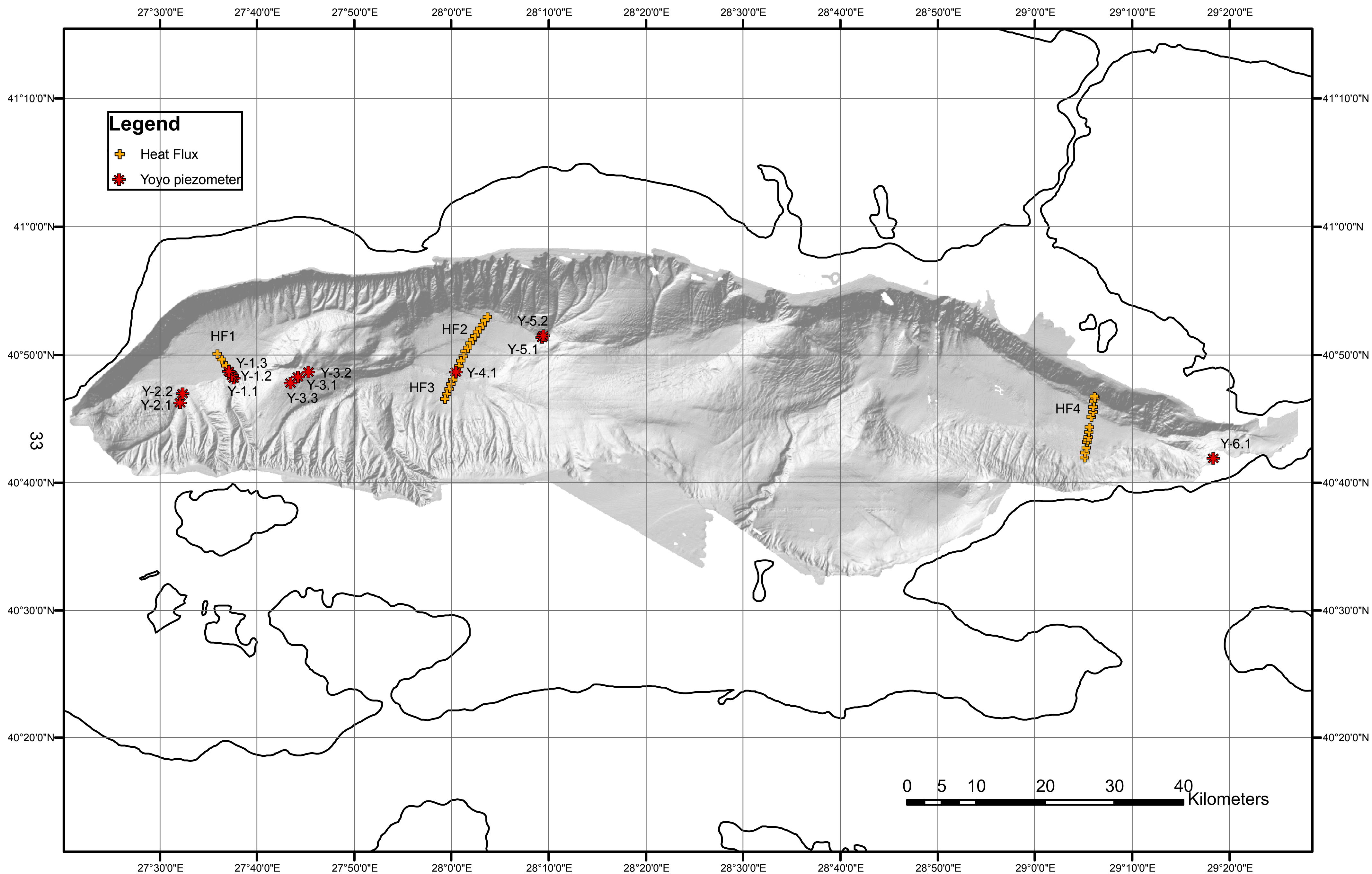


Fig. 2.2.4: Temperature gradients from heat flow probe measurements in Cinarcik Basin

Table 2.2.1 : Location of heat flow measurements

	Lat	Long	depth (m)	Penetration (m)
Tekirdag Basin				
HF1-1	40,80400	27,62813	1123	6,5
HF1-2	40,80517	27,62700	1127	6,4
HF1-3	40,80658	27,62572	1118	6,5
HF1-4	40,80778	27,62440	1122	6,5
HF1-5	40,80888	27,62343		bent
HF1-6 HF1B-1	40,80998	27,62252	1126	5
HF1-7 HF1B-2	40,81107	27,62102	1122	5
HF1-8 HF1B-3	40,81248	27,62007	1121	5
HF1-9 HF1B-4	40,82002	27,61297	1126	5
HF1-10 HF1B-5	40,82768	27,60565	1127	5
HF1-11 HF1B-6	40,83515	27,59852	1132	5
Central Basin				
HF3-10	40,77687	27,98857	1190	5,85
HF3-9	40,78292	27,99202	1196	5,85
HF3-8	40,78933	27,99570	1200	5,85
HF3-7	40,79570	27,99948	1203	5,85
HF3-6	40,80172	28,00275	1209	5,85
HF3-5	40,80838	28,00628	1254	5,85
HF3-4	40,81243	28,00842	1258	5,85
HF3-3	40,81933	28,01292	1260	5,85
HF3-2	40,82607	28,01673	1264	5,85
HF3-1	40,83227	28,02020	1267	5,85
HF2-1	40,83860	28,02373	1267	5,85
HF2-2	40,84350	28,02802	1268	5,85
HF2-3	40,84853	28,03213	1261	5,85
HF2-4	40,85345	28,03673	1250	5,85
HF2-5	40,85842	28,04083	1246	5,85
HF2-6	40,86373	28,04520	1240	5,85
HF2-7	40,86828	28,04935	1236	5,85
HF2-8	40,87325	28,05362	1231	5,85
HF2-9	40,87823	28,05778	1230	5,85
HF2-10	40,88327	28,06198	1217	5,85
Cinarcik basin				
HF4-1	40,69988	29,08470	1198	5,85
HF4-2	40,70642	29,08647	1220	5,85
HF4-3	40,71310	29,08780	1234	5,85
HF4-4	40,71982	29,08947	1247	5,85
HF4-5	40,72310	29,09018	1252	5,85
HF4-6	40,72655	29,09092	1260	5,85
HF4-7	40,73323	29,09242	1270	5,85
HF4-8	40,73978	29,09370	1274	5,85
HF4-9	40,75310	29,09673	1282	5,85
HF4-10	40,75977	29,09973	1278	5,85
HF4-11	40,76635	29,09965	1277	5,85
HF4-12	40,77307	29,10097	1250	5,85
HF4-13	40,77787	29,10295	1220	5,85
HF4-14	40,77985	29,10232	1200	5,85

Following page:
Fig 2.2.5: Location Map of the Heat Flow profiles and of the piezometer yoyo transects


Legend
Heat Flux
Yoyo piezometer
HF1
HF2
HF3
HF4
Y-1.1
Y-1.2
Y-1.3
Y-2.1
Y-2.2
Y-3.1
Y-3.2
Y-3.3
Y-4.1
Y-5.1
Y-5.2
Y-6.1
0 5 10 20 30 40 Kilometers
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N

2.3. Yoyo-piezometer

Six sessions of pore pressure measurements with Ifremer Piezometer took place during leg 1 and 2 *(Tab. 2.3.1 and Fig. 2.2.5)*. Pressure sensors measure the difference between the pore pressure and the hydrostatic pressure at a given depth. Targets were cold seep flow systems (Yoyo-1, -3, -4 and -5), and slope instability sites (Yoyo-2 and -6). Each piezometer measurements took 3 hours for transect 1 and 2, and 4 hours for transect 3 to 5. Preliminary analysis with pressure vs 1/t plots suggested that the relaxation of the initial pressure increase was too slow for extrapolating the equilibrium pressure with a 3-4 hour deployment. Yoyo-6 stayed into the sediments for 8 hours. The piezometer was deployed for long term monitoring at the end of the cruise and details on instrument design and deployment are given in section 2.8.

	Date	**Hour**	**Min**	**Sec**	**Date**	**Hour**	**Min**	**Sec**	**Lat**	**Long**	**Depth**
	IN	IN	IN	IN	OUT	OUT	OUT	OUT			(m)
YOYO-1.1	14/05/07	21	34	46	15/05/07	0	28	6	N 40°48,24288'	E 27°37,67124'	1119
YOYO-1.2	15/05/07	1	37	26	15/05/07	4	42	36	N 40°48,41418'	E 27°37,52916'	1122
YOYO-1.3	15/05/07	5	31	6	15/05/07	7	16	6	N 40°48,75744'	E 27°37,2159'	1126
YOYO-2.1	16/05/07	18	32	54	17/05/07	21	32	49	N 40°46,289'	E 27° 32,159'	1074
YOYO-2.2	16/05/07	23	0	29	17/05/07	2	6	49	N 40°47,039'	E 27°32,430'	1107
YOYO-3.1	17/05/07	20	21	13	18/05/07	0	27	14	N 40° 48,341	E 27° 44,30886'	598
YOYO-3.2	18/05/07	1	32	24	18/05/07	5	44	59	N 40°48,732	E 27°45,385	678
YOYO-3.3	21/05/07	20	21	3	21/05/07	0	22	53	N 40° 47,824	E 27° 43,515	610
YOYO4.1	22/05/07	3	46	19	22/05/07	6	46	39	N 40°48,728	E 28° 0,520	1255
YOYO5.1	22/05/07	20	40	38	22/05/07	23	53	18	N 40° 51,430	E 28° 09,381	1186
YOYO5.2	23/05/07	0	20	48	23/05/07	4	24	58	N 40° 51,570	E 28° 9,519	1151
YOYO6.1	24/05/07	23	10	4	25/05/24	7	3	24	N 40° 41.950	E 29°18.398	251
WARNING : PENETRATION TIME VARY FROM ONE SENSOR TO THE OTHER.											

Tab. 2.3.1: Location of piezometer measurements

2.4 Coring operations

Coring operations from the ship took place during leg 3 and 4. Three different corers were used:

- the Kullenberg corer retrieved up to 10 m long core;
- the Interface corer could sample up to 1 m of sediment while preserving the interface and isolating a bottom water sample;
- the Multitube corer.

During MARNAUT, we retrieved 35 Kullenberg cores, 13 Interface cores and 3 Multitubes cores (see *Tab. 2.4.1 and Fig. 2.4.1*). Core site surveys (bathymetry and 3.5 kHz) for cores KS 1 to 21 are in Annex **cores_site_figures1_21.pdf.**

Depending on planned post-cruise work and use of each core (see *Tab. 2.4.1*), cores are stored either at Cerege in Aix-en-Provence or at ITU in Istanbul. Thirteen 25 cm whole round samples were shipped to Ifremer for geotechnical studies (ANR project ISIS).

MSCL and thermal conductivity measurements

It was not planned to open the cores during the cruise. Kullenberg cores were split into 1 m long section, and were run through a Geotek Multi Sensor Core Logger (MSCL). Interface Cores were also run through MSCL. Measurements include Magnetic susceptibility, P-wave velocity and gamma densitometry. Graphs are given in Annex **cores_MSCL_figures.pdf**.

Additionally, thermal conductivity was performed on cores MNTKS01, 02, 03, 18 and 29 with a needle probe. Measurements spacing was 20 cm (5 per section) on MNTKS01, 02, 03, but only 3 measurements were done per section on MNTKS18 and 29 (15 cm, 50 cm, 85 cm).

Pore fluid sampling and onboard analysis

Pore fluid extraction was performed in a cold room at 15°C. MNTKS cores (see *Tab. 2.4.1*). Two methods were used. Pore fluid extraction on the first Kuellenberg MNTKS01 was performed with a pore water squeezer provided by ITU, under a nitrogen pressure of 3.5 Bars. Rhizons were used on 12 subsequent Kuellenberg cores. Rhizons are small polymer tubes (2.5mm diameter) with 0.15 micron diameter micropores and armed with a glass fiber epoxy wire for rigidity. These moisture samplers were originally designed for chemical monitoring of soils (Rhizosphere Research Products, Wageningen NL; Meijboom and Van Noordijk 1992). We used CSS rhizons modified for use on Marine cores (Kölling et al. 2005). Small volumes (typicaly 10 ml) of filtered pore water samples can be extracted from sediments by connecting the rhizon to a syringe or to a vacuum tube. Pore fluid extraction from Nautile push cores was performed either with rhizons on pierced tubes or in a centrifuge on core slices.

Pore water sulfate, chloride and salinity were analysed onboard. Analytical results are available with the cruise data

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Following pages:

Tab. 2.4.1: List of the MARNAUT Kullenberg, Interface and Multitubes cores

Fig. 2.4.1: Location map of the MARNAUT cores

Core	Depth (m)	length (cm)	Latitude		Longitude		Destinatio	Use	Comments
Kuellenberg cores (10 m tube)									
MNTKS01	1213	880	40°	46,791'	029°	06,099'	Cerege	thermal conductivity and pore fluid extraction	squeezing
MNTKS02	1280	810	40°	44,698'	029°	07,493'	ITU	thermal conductivity and seismoturbidites	rhizon after MSCL
MNTKS03	1273	910	40°	44,054'	029°	06,943'	ITU	thermal conductivity and seismoturbidites	
MNTKS04	250	720	40°	41,950'	029°	18,390'	Cerege	geotechnics - 5 WRs for ifremer	piezometer 6.1 site
MNTKS05	1267	845	40°	42,991'	029°	09,966'	ITU	seismoturbidites	rhizon after MSCL
MNTKS06	1274	925	40°	44,028'	029°	07,494'	Cerege	seismoturbidites	
MNTKS07	1215	1000	40°	42,941'	029°	06,849'	Cerege	pore fluids and microbiology	rhizon sampling
MNTKS08	608	615	40°	43,095'	029°	17,269'	ITU	geotechnics - 2 WR for Ifremer	
MNTKS09	340	860	40°	41,041'	029°	11,802'	Cerege	geotechnics - 1 WR for Ifremer	
MNTKS10	1265	905	40°	44,034'	029°	10,782'	ITU	seismoturbidites	
MNTKS11	637	680	40°	45,480'	029°	13,627'	ITU	geotechnics - 2 WR for Ifremer	
MNTKS12	1262	960	40°	50,191'	027°	59,860'	ITU	seismoturbidites	
MNTKS13	1248	920	40°	48,641'	027°	59,491'	ITU	seismoturbidites	rhizon after MSCL
MNTKS14	655	905	40°	49,052'	027°	46,767'	Cerege	pore fluid chemistry and microbiologgy	rhizon sampling
MNTKS15	1105	935	40°	51,601'	027°	35,723'	ITU	seismoturbidites	
MNTKS16	1118	915	40°	51,110'	027°	35,977'	ITU	seismoturbidites	
MNTKS17	1123	900	40°	48,240'	027°	36,999'	ITU	seismoturbidites and pore fluid chemistry	rhizon after MSCL
MNTKS18	1260	920	40°	49,398'	028°	00,831'	ITU	thermal conductivity and seismoturbidutes	
MNTKS19	1168	710	40°	51,508'	028°	09,444'	Cerege	pore fluid chemistry	rhizon sampling
MNTKS20	335	795	40°	51,724'	028°	35,005'	Cerege	pore fluid chemistry	rhizon sampling
MNTKS21	835	855	40°	52,284'	028°	30,217'	ITU	seismoturbidites	
MNTKS22	1112	335	40°	51,276'	028°	10,187'	Cerege	pore fluid chemistry	rhizon sampling
MNTKS23	1204	820	40°	51,131'	028°	08,308'	ITU	seismoturbidites	
MNTKS24	326	810	40°	55,825'	028°	08,965'	Cerege	geotechnics - 2 WR for Ifremer	
MNTKS25	667	715	40°	48,894'	027°	46,641'	ITU	pore fluid chemistry - gas hydrates	rhizon sampling
MNTKS26	667	792	40°	48,740'	027°	46,053'	Cerege	pore fluid chemistry	rhizon sampling
MNTKS27	669	710	40°	48,892'	027°	46,640'	Cerege	pore fluid chemistry - gas hydrates	rhizon sampling
MNTKS28	770	225	40°	46,074'	027°	25,552'	ITU	geotechnics - 1 WR for Ifremer	
MNTKS29	1117	930	40°	48,512'	027°	37,328'	ITU	thermal conductivity and seimoturbidites	
MNTKS30	1118	980	40°	48,216'	027°	37,786'	Cerege	pore fluid chemistry	rhizon sampling
MNTKS31	1101	125	40°	48,155'	027°	37,774'	Cerege	pore fluid chemistry	rhizon sampling

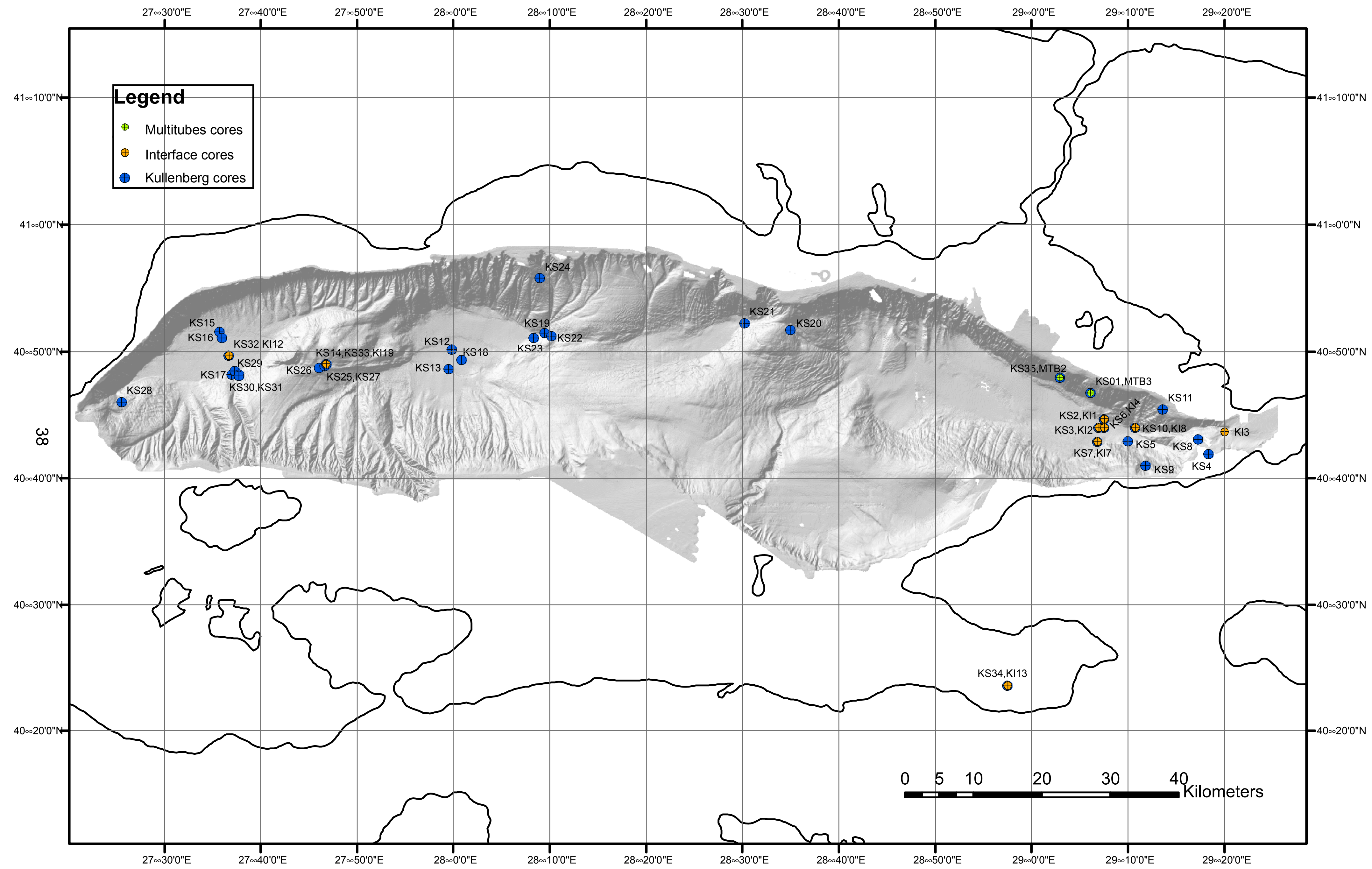
MNTKS32	1123	945	40°	49,737'	027°	36,678'	ITU	seismoturbidites	
MNTKS33	658		40°	49,046'	027°	46,813'	Cerege	pore fluid chemistry - gas hydrates	gassy core
MNTKS34	105	940	40°	23,597'	028°	57,522'	ITU	seismoturbidites	
MNTKS35	1150	200	40°	47,968'	029°	02,940'	Cerege	pore fluid chemistry	rhizon sampling

Interface cores

MNTKI01	1274	42	40°	44,702'	029°	07,489'	ITU	seismoturbidites	
MNTKI02	1275	100	40°	44,050'	029°	06,956'	ITU	seismoturbidites	
MNTKI03	305	89	40°	43,715'	029°	20,011'	ITU	seismoturbidites	
MNTKI04	1270	30	40°	44,027'	029°	07,496'	ITU	seismoturbidites	
MNTKI05		EMPTY	40°	47,932'	029°	02,956'			
MNTKI06	1160	EMPTY	40°	47,848'	029°	03,313'			
MNTKI07	1220	87	40°	42,942'	029°	06,847'	Cerege	pore fluids and microbiology	
MNTKI08	1265	83	40°	44,033'	029°	10,782'	ITU	seismoturbidites	
MNTKI09	660	73	40°	49,047'	027°	46,771'	Ifremer	pore fluids and biology	
MNTKI10	1124	EMPTY	40°	51,260'	028°	10,155'			
MNTKI11	1117	EMPTY	40°	51,278'	028°	10,186'			
MNTKI12	1123	94	40°	49,741'	027°	36,680'	ITU	seismoturbidites	
MNTKI13	105	87	40°	23,599'	028°	57,519'	ITU	seismoturbidites	

Multitube cores

MNTMTB01			40°	43,990'	029°	10,001'		technical test	
MNTMTB02	1140		40°	47,967'	029°	02,939'	LOCEAN	microbiology	small sample taken
MNTMTB03	1200		40°	46,789'	029°	06,136'	sliced	pore fluids and microbiology	sliced on board


Legend
Multitubes cores
Interface cores
Kullenberg cores
KS28
KS15
KS16
KS32,KI12
KS29
KS17
KS30,KS31
KS26
KS14,KS33,KI19
KS25,KS27
KS12
KS13
KS18
KS19
KS23
KS22
KS24
KS21
KS20
KS35,MTB2
KS01,MTB3
KS11
KS2,KI1
KS3,KI2
KS6,KI4
KS10,KI8
KS7,KI7
KS5
KS9
KS8
KS4
KI3
KS34,KI13
0 5 10 20 30 40 Kilometers
27∞30'0"E
27∞40'0"E
27∞50'0"E
28∞0'0"E
28∞10'0"E
28∞20'0"E
28∞30'0"E
28∞40'0"E
28∞50'0"E
29∞0'0"E
29∞10'0"E
29∞20'0"E
41∞10'0"N
41∞0'0"N
40∞50'0"N
40∞40'0"N
40∞30'0"N
40∞20'0"N

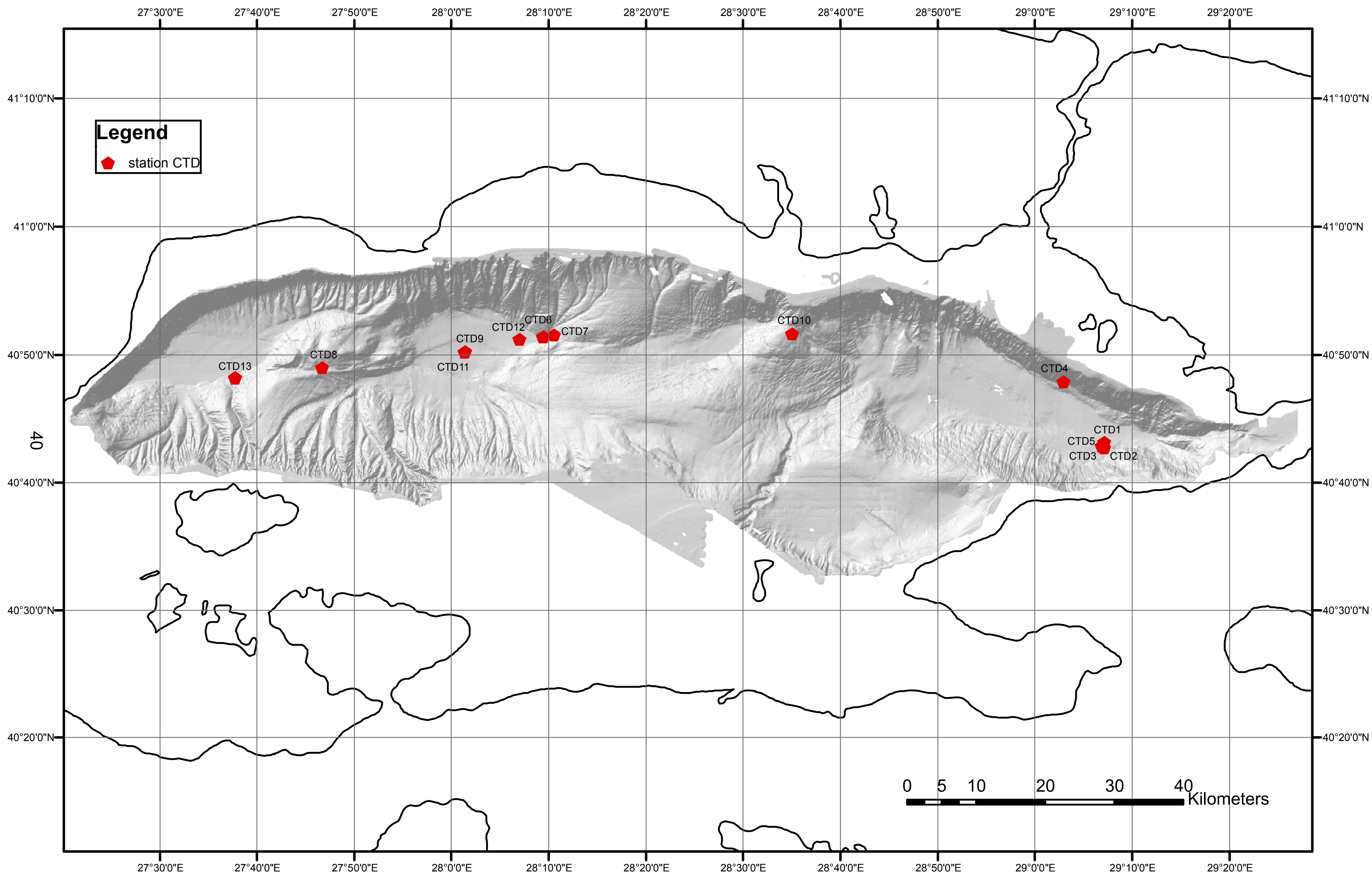
2.5 CTD - Rosette

The CTD instrument was used to measure the salinity, temperature, dissolved oxygen and the turbidity of the sea water depending on depth and to collect sea water samples on 13 stations. For 3 stations (CTD 6, 11 and 13), an additional high-resolution profile was collected over the 30 first meters. Plots of CTD data are given in Annex **CTD_plots.pdf**. Lists of water samples taken for microbiological and for biogeochemical shore based work are given in Annexes **CTD_samples_microbio.pdf** and **CTD_samples_org_geochem.pdf**. Dissolved methane concentrations were determined shore based but are available as cruise data.

Tab. 2.5.1: Location of CTD stations

station	CTD	Latitude	Longitude	date	heure
station1	CTD1	40,72	29,1195	29/05/2007	02:20
station2	CTD2	40,7131667	29,1193333	29/05/2007	04:16
station3	CTD3	40,7143333	29,1168333	30/05/2007	01:37
station4	CTD4-1	40,7986667	29,0491667	30/05/2007	03:49
station4	CTD4-2	40,7991667	29,049	29/05/2003	05:22
station5	CTD5	40,7153333	29,1146667	31/05/2007	14:27
station6	CTD6-1	40,858	28,1571667	02/06/2007	01:45
station6	CTD6-2	40,8576667	28,1575	02/06/2007	03:36
station7	CTD7	40,8598333	28,1756667	02/06/2007	05:34
station8	CTD8	40,8173333	27,7783333	03/06/2007	02:28
station9	CTD9	40,8381667	28,023	04/06/2007	03:33
station10	CTD10	40,8617833	28,5835667	05/06/2007	13:41
station11	CTD11-1	40,8381167	28,0232167	06/06/2007	04:03
station11	CTD11-2	40,83775	28,0222667	06/06/2007	05:39
sation12	CTD12	40,8541833	28,1166	06/06/2007	07:10
station 13	CTD13-1	40,8045	27,6285	09/06/2007	02:13
station 13	CTD13-2	40,8036667	27,6293333	09/06/2007	03:36

Following page:
Fig. 2.5.1: Location map of the CTD stations



Legend
station CTD
CTD1
CTD2
CTD3
CTD4
CTD5
CTD6
CTD7
CTD8
CTD9
CTD10
CTD11
CTD12
CTD13
0 5 10 20 30 40 Kilometers
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N

2.6 Operation of the SIMRAD EK60 scientific echo sounder

David Volker, GEOMAR and Louis Geli, IFREMER

Purpose and technical layout

On cruise legs 2 & 3, the scientific echo sounder SIMRAD EK60 was used to detect anomalies in the water column related to either gas bubble emission or fluid seeps. The EK60 system consists of a transducer unit mounted in a fish, which is towed on a cable alongside of the ship, the general purpose transceiver unit, and the processor unit (a conventional laptop computer). Both communicate via an Ethernet connection. The operating frequency is 38 kHz, which is commonly used for fisheries surveys. We had the transducer fish towed on the starboard side 5 m off the ship and at approximately 10 m depth in order to keep it out of the turbulent aerated boundary layer produced by the ship's hull. The soundings are recorded digitally and written continuously to hard disk. The opening angle of the acoustic lobe is 7.1°, producing a footprint with a diameter of approximately 12% of the water depth. The strategy was to run profiles at low ship speed of 2-3 knots across lineaments and particular spots where possible gas emissions had been noted before, in order to locate anomalies in the water column close to the seafloor, trace them to potential gas and fluid seeps, and record the exact localities for diving waypoints.

Observed anomalies

Altogether 16 profiles, corresponding to 220 km were recorded during leg 2 along profiles in the Tekirdag, Central and Cinarcik Basins and on the Western High. 25 profiles were recorded during the whole cruise. The system worked without major problems. We were successful in detecting a number of acoustic anomalies, as listed below.

(1) Vertical columns of diffuse reflectivity which extend from the seafloor to more that 100 m above. These anomalies are some 100 m to a few km wide and get thinner with height. In one case, the feature extends from 1100 m to about 800 m water depth (type 1, *fig 2.6.1*). This kind of anomaly was detected 14 times during Leg 2 (anomalies A2, A3, A5, A7, B4, B5, D3, D4, G4, G5, J1, J6, J8, J9, see tables in the Annex). At total of 113 anomalies, including weaker ones in terms of reflectivity and height above seafloor were described during the whole cruise. They are listed with coordinates is annexes **EK60_AAs.xls** and **EK60_AAs.pdf**.

(2) Swarms of individual lines of higher reflectivity in the water column which show a common directional trend downward and in direction of the ship's heading and have a convex hyperbolic shape (type 2, *fig. 2.6.3*). These anomalies were observed in the vicinity of and between the individual columns described above, and in the uppermost 100 m of the water column. Their angle in respect to the seafloor is dependant of the ship's velocity in a way that their inclination decreases with decreasing velocity. On one occasion, when the ship stopped, the lines became horizontal.

(3) Vertical columns made of dense accumulations of the before mentioned inclined reflective streaks (type 3, *fig. 2.6.3*).

(4) Subhorizontal concentrations ("clouds") of diffuse reflectivity about 100-200 m above the seafloor (type 4, *fig. 2.6.4 b*). In most of the observed cases, the cloudy anomaly follows the seafloor bathymetry. In one example, the feature seems to be connected to the seafloor by a thin vertical column of similar appearance (*fig. 2.6.4 a*)

(5) Regions of higher reflectivity close to the seafloor. These anomalies extend horizontally for some km but do not project from the seafloor more than some 10 m (type 5, *fig. 2.6.5*).

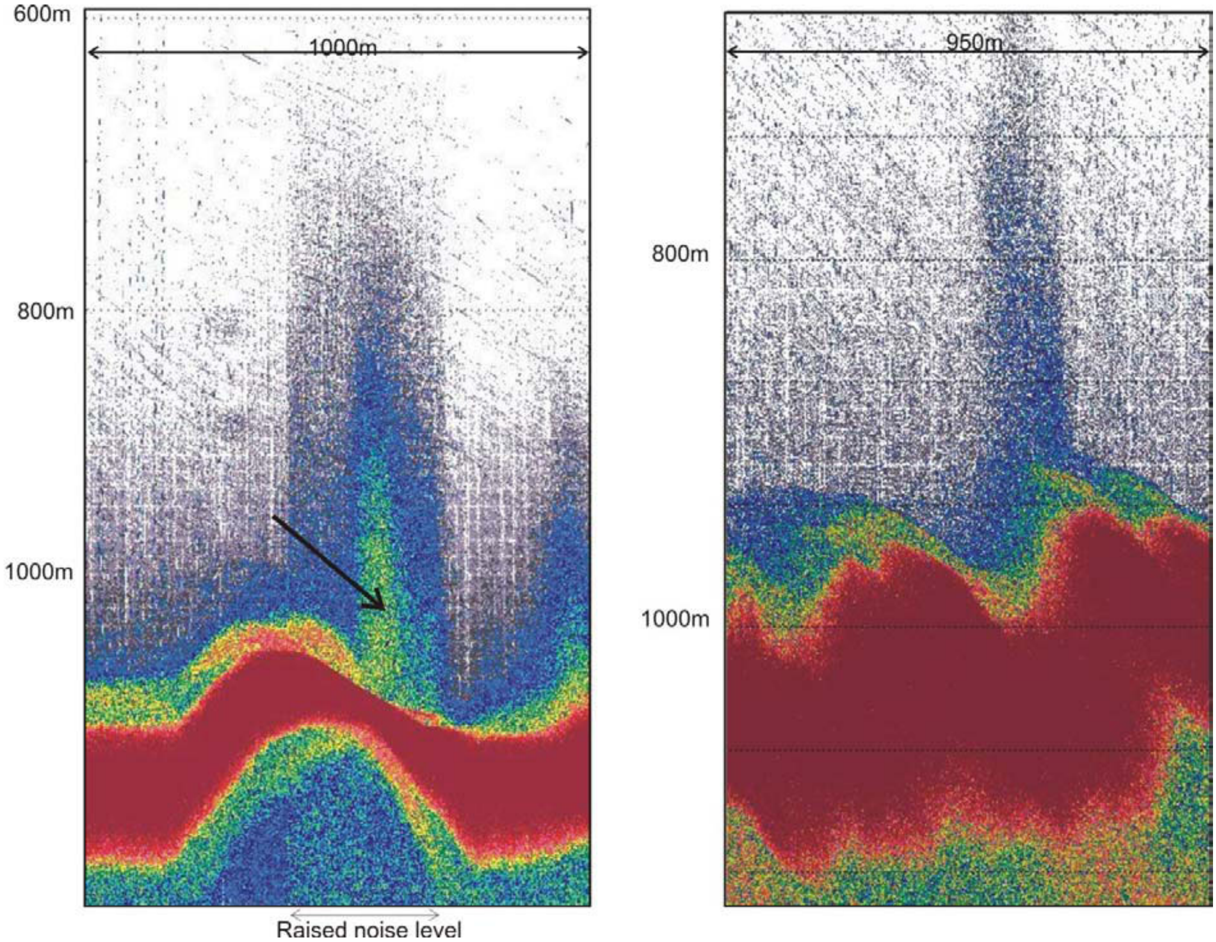


Fig. 2.6.1: Vertical column of high backscatter in the water column reaching from the seafloor to some hundred meters above the seafloor (type 1 anomaly). With properly adjusted colour scale it is traceable to 600 m water depth. Its width at the basis is 200 m, getting less with height thus giving rise to a "cypress" shape.

Interpretation of anomalies

Our first interpretation explains the **type 1 anomalies** as columns or plumes of rising gas bubbles emanating from locally constrained gas seeps. The vertical sharp boundaries of the plumes are seen as indicator of the rapid rise of the bubbles. The high reflectivity of the most prominent of type 1 anomalies point to a distinct change in acoustic impedance, whereas the vertical extension indicates a high rate of emission and/or large volume of the emitted gas. Similar features which appear fainter and are less prominent in height may be smaller plumes or plumes which were captured off-centered (*fig. 2.6.1b*).

The most prominent of the type 1 anomalies were found at the Western High and made targets for Nautile dives 1648 and 1662 targets. Only for dive 1662, were we successful in ground-truthing our interpretation by direct observations of major gas emission (see section 5 hereafter).

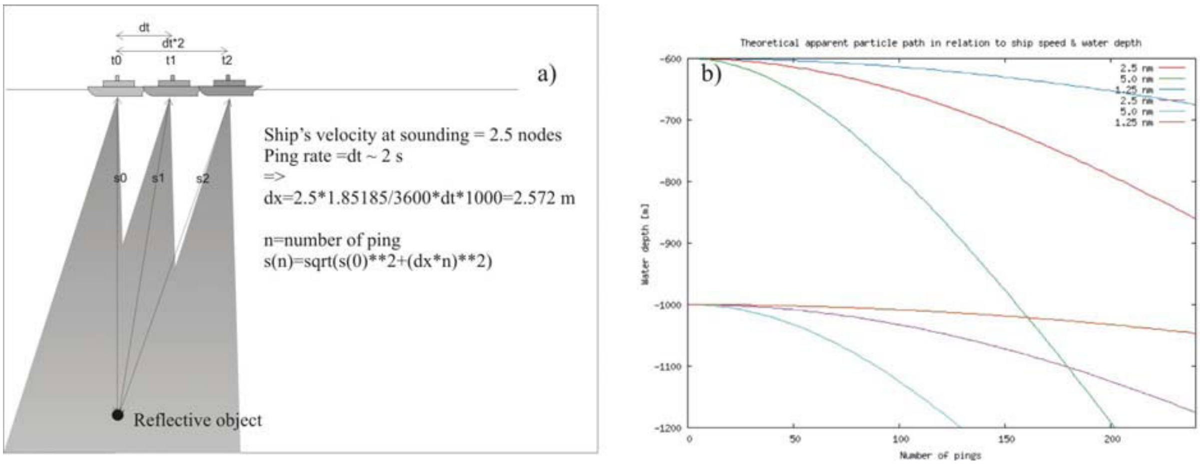


Fig 2.6.2: Geometry of ship and object and resulting theoretical apparent trajectory of particles at different ship speed and water depth, resulting in type 2 anomalies.

Type 2 anomalies are interpreted as apparent trajectories of single particles or gas bubbles which result from the superposition of a) the real vertical motion of the particles and b) a geometric effect resulting from the object being “caught” by several consecutive pings while the ship is moving away. While the objects are within the major cone of emitted acoustic energy, they are “shot at” several times with the ship’s distance increasing non-linearly (*see fig. 2.6.2 a*). In the EK60 profiles, each ping (fired at a rate of ~ 1 per 2s) is displayed as a vertical, color-coded, 1 pixel-wide bar. As a consequence, the growing distance to the object is displayed as increasing depth. The resulting apparent trajectory, when calculated satisfies the observations in that it has a hyperbolic, downward plunging shape, and in that the plunge depends on the water depth and ship’s speed in the observed way (*fig. 2.6.2 b*). The observation that we only see downward plunging hyperbolae (ship is gaining distance to the object) and no upward plunging branches of hyperbolae (ship approaches object) points to a acoustic beam geometry in which only objects below and behind the ship are “seen”. This might be an error in the adjustment of the transducer unit or trimming of fish. The nature of the objects (bubbles or particles) cannot be determined directly. In the uppermost 100 m of the water column the reflections may be most likely due to macroplankton. In the lower water column, the causes may be flocculated particulate matter, fish or gas bubbles. In the one observed case, in which the ship came to station, the objects seemed to have a neutral buoyancy, as they were recorded as horizontal lines.

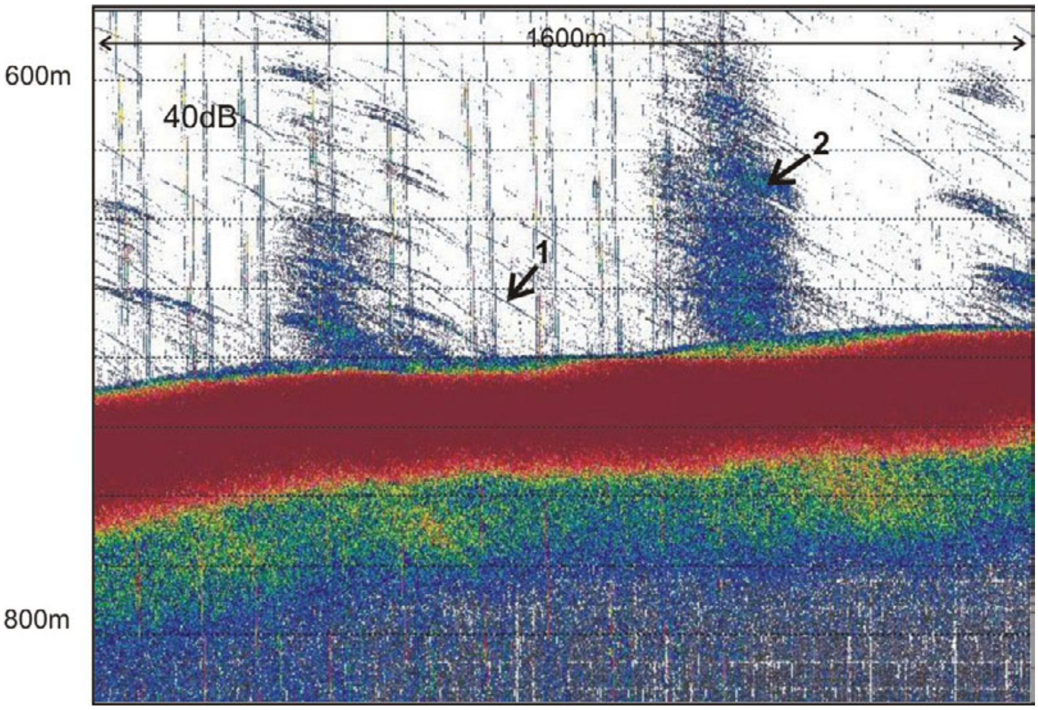


Fig 2.6.3: Type 2 anomalies (arrow 1) and type 3 anomalies (arrow 2).

According to the interpretation of type 2 anomalies given above, **type 3 anomalies** could be localized regions with a higher concentration of particles or gas bubbles. The shape of the features suggests a vertical plume. As these features were found in close vicinity to the type 1 features we tend to interpret them as gas bubble plumes drifted off the main ejection points.

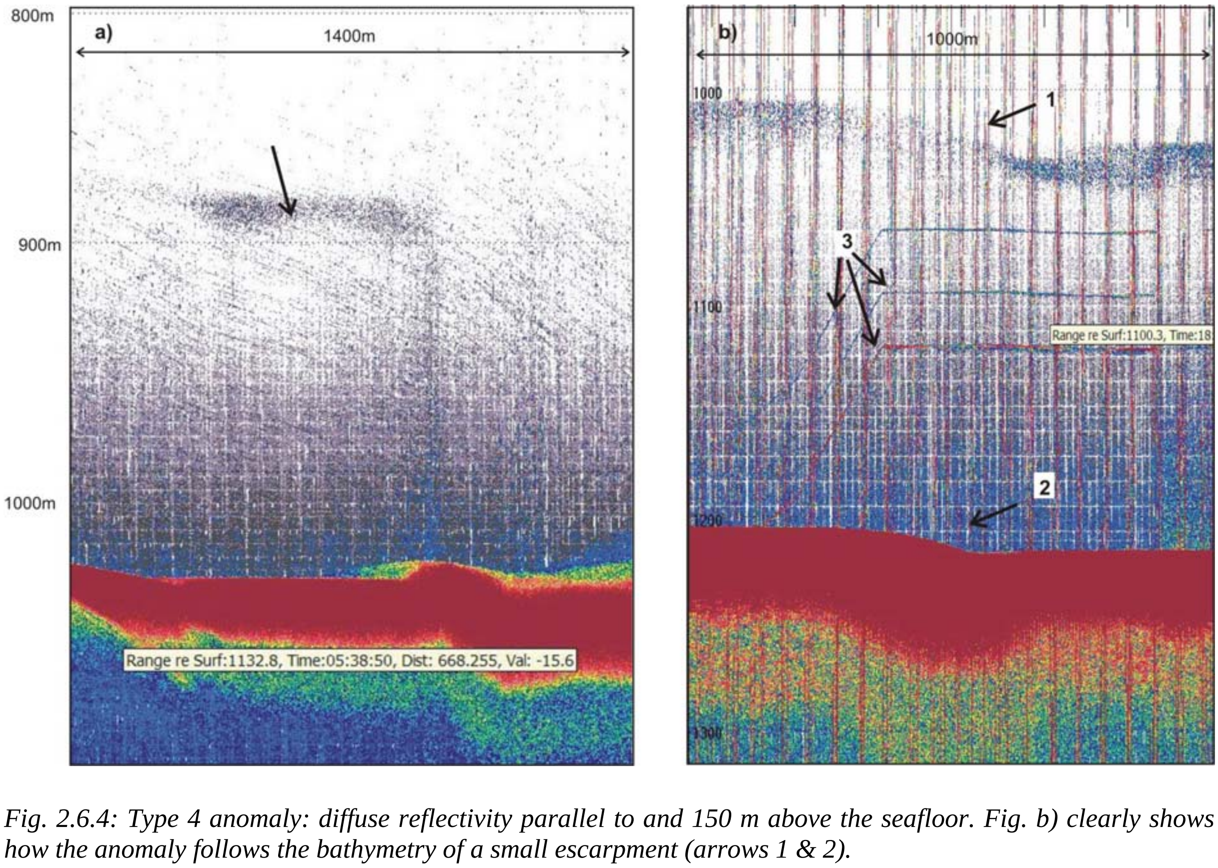


Fig. 2.6.4: Type 4 anomaly: diffuse reflectivity parallel to and 150 m above the seafloor. Fig. b) clearly shows how the anomaly follows the bathymetry of a small escarpment (arrows 1 & 2).

Type 4 anomaly is somewhat enigmatic. The general appearance could suggest suspended particulate matter or concentrations of biomass. On the other hand, the observed trend to follow the bottom like in *fig 2.6.4 b*) raises the suspicion that it is a phantom or multiple of the bottom echo, although we cannot explain its position some 150 m above the seafloor. Similar phantom echoes of the seafloor in a position above the bottom are frequently observed in 3.5 kHz echosounder data of shelf areas.

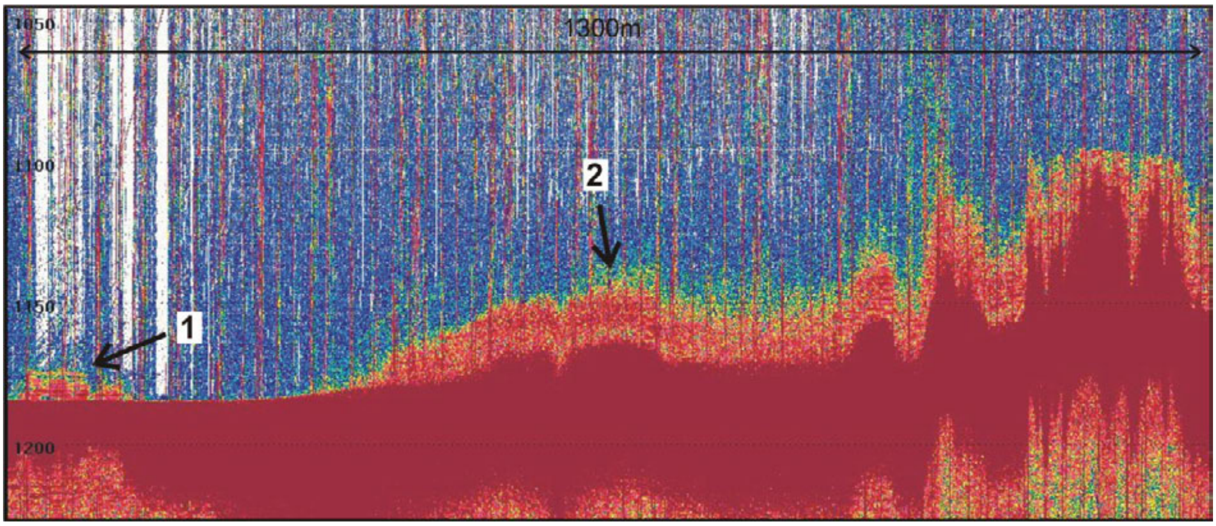


Fig. 2.6.5: Type 5 anomaly: diffuse reflectivity pattern raising some 10 m above the seafloor. In the figure, arrow 1 points to a singular feature which may be a real phenomenon, whereas the continuous diffuse anomaly shown by arrow 2 is an artefact, caused by the side echos from a slope parallel to the ship's course. The record is polluted by the transponder signal of a piezometer which was carried 100 m above the seafloor.

We see **type 5 anomalies** as more homogenous gas/seawater, porewater/seawater or suspended particulate matter mixtures which do not have the buoyancy to rise but form plumes which are carried away horizontally. In any case a careful examination of the ship's track is necessary, since side echoes, bouncing off slopes within the signal's footprint produce similar features, when the ship's course parallels bathymetric contours. *Figure 2.6.5* possibly shows both forms.

Ground truth from dive observations

At least four Nautile dives were dedicated to ground truth the interpretation of the observed acoustic anomalies and sample gases in different environments. In addition, a number of acoustic anomalies were detected near sites where gas bubbles have been found :

- **Dive 1659** explored the area located in the southern part of the Cinarcik Basin, where a cluster of acoustic anomalies was detected, through densely spaced EK-60 profiles. The acoustic anomalies found at this site are relatively weak but well defined, of height ranging between 40 and 150 m above seafloor (e.g. Anomaly B5, *fig. 2.6.6*). A series of large black batches (of ~8 x 4 m)) were discovered on the seafloor, aligned in the N130 direction that parallels the extensional, en-échelon features located at the basin slope foot. The trains of bubbles were coming out from small (1 cm in diameter) carbonate cemented chimney like conduits buried inside these black patches.

- **Dives 1648 and 1662** explored the Western High where large, bright acoustic anomalies (of Type 1) were detected using the Simard EK-60 echo sounder. The strongest anomaly (J1) is up to 500 m in height above seafloor, almost reaching the sea surface (*fig. 2.6.9*). The origin of this anomaly was identified only during Dive 1662, which showed streams of gas bubbles escaping from black dots through small, carbonate chimney conduits.

- **Dive 1664** explored the eastern rim of the Central High, near 40°51.73'N and 28°51.73'E. A cluster of strong acoustic anomalies were observed, ~10 km south of the fault, near the summit of the Central high, by 350 m water depth (*fig. 2.6.10*). During Dive 1664, almost no black dots were identified on the seafloor. Instead, the gas bubbles were found as small streams escaping from isolated carbonate mounds through small chimneys.

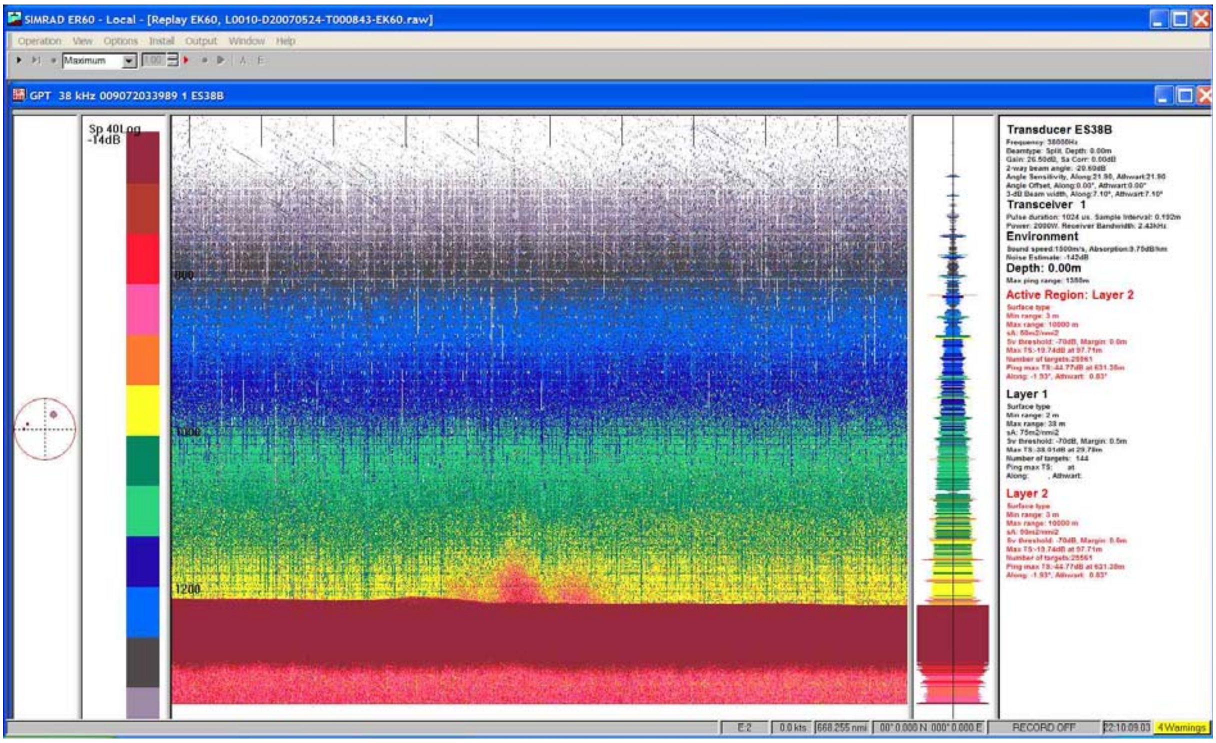


Fig. 2.6.6 : Example of acoustic anomaly (N5 and N6) detected in the south Cinarcik basin. Nautile dive 1659 showed that these anomalies result from small gas bubbles escaping from black patches found on the seafloor.

	
Fig. 2.6.7 : Example of black patch found during Dive 1659. Weak, but numerous streams of bubbles escape from this type of patch.	*Fig. 2.6.8 : Close up view of PEGAZ system sampling gas bubbles during Dive 1659. Gas is escaping from the black patch through a small chimney, 1 to 2 cm wide.*

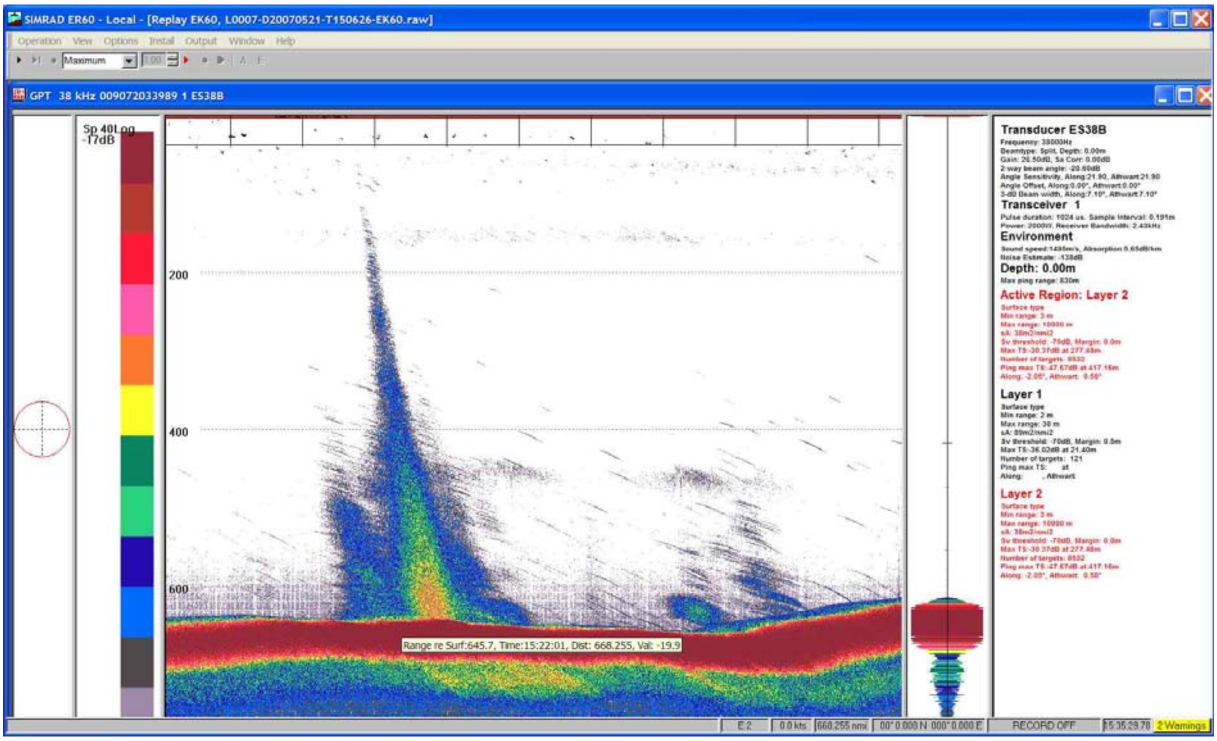


Fig. 2.6.9 : The above acoustic anomaly (J1) was detected on the western high and ground truthed during Nautile Dive 1662.

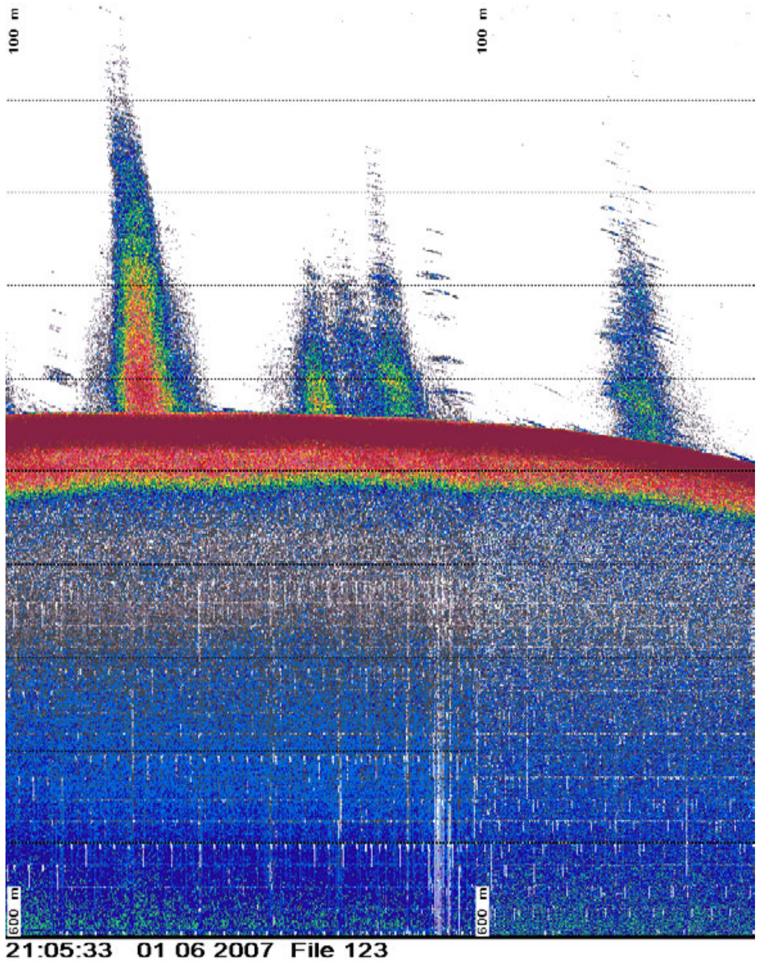


Fig. 2.6.10 : Acoustic anomalies detected with the Simrad EK-60 echosounder on the eastern rim of the Central High (Line T). The anomalies were ground truthed during dive 1664 and found to result from small streams of gas escaping out from carbonate mounds through small chimney conduits.

Spatial distribution of anomalies

Cinarcik Basin. In the North Cinarcik basin, some gas seeps were found along the fault escarpment (Q1 and N13). In the south Cinarcik Basin, a systematic survey was performed, indicating that the seeps are distributed along two preferential trends :

- the main trend (N100) corresponds to the orientation of the fault that ruptured during the 1999 Izmit earthquakes
- the secondary trends is parallel to the transtensional features located at the slope foot of the basin's southern margin.

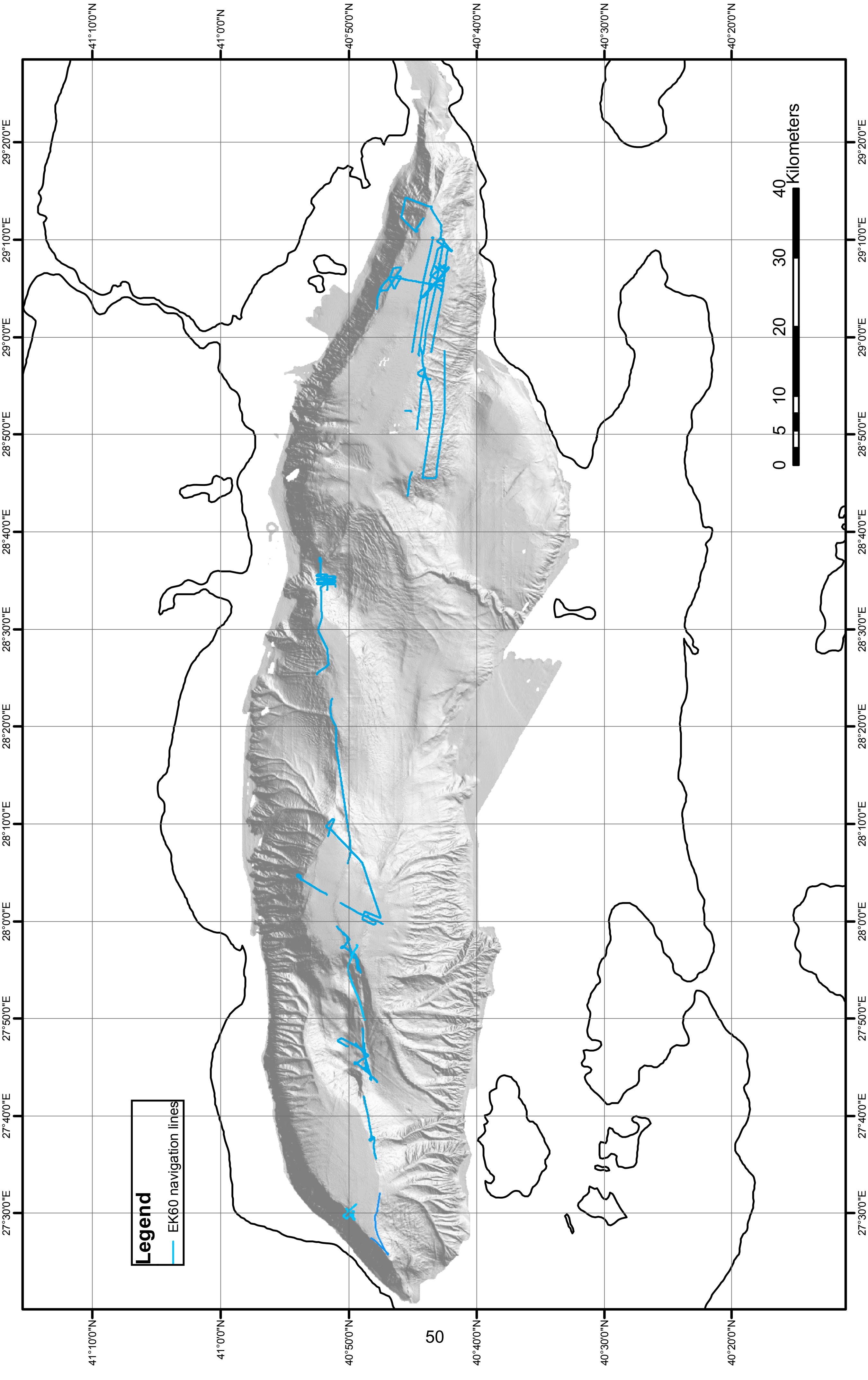
This distribution suggests that the gas seeps could be related to the prolongation of the fault that ruptured in 1999 into the Cinarcik Basin, which was identified as fs2 (southern boundary fault) by Carton and Singh, 2007. The presence of seeps and their geographical distribution suggest that there could be direct pathways for fluids to escape from the main transtensional fault zone up to the surface through extensional faults or cracks oriented N130.

Central Ridge and Kumburgaz basin. Only one profile is available along the main fault. No acoustic anomalies were detected. Instead, a cluster with very strong and well defined acoustic anomalies was detected at about 1 km away from the fault, on top of a high – which appears to be the summit of an anticline.

Western Ridge and Central Basin. The strongest acoustic anomalies were not observed within the fault valley, but on top of the neighbouring ridges, most particularly on top of a high located near 40°49'N, 28°46.8'E at about 500 m away from the fault. Chirp profiles suggest this structure may be a mud volcano.

Tekirdag Basin. EK-60 lines targeted the northern and southern escarpments. Acoustic anomalies were systematically found in the surveyed areas, indicating the presence of gas seeps at fault escarpments.

Following pages:
Fig. 2.6.11: Location map of the EK60 lines
Fig. 2.6.12: Location map of the EK60 map and recognized acoustic anomalies


Legend
EK60 navigation lines
0 5 10 20 30 40
Kilometers
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
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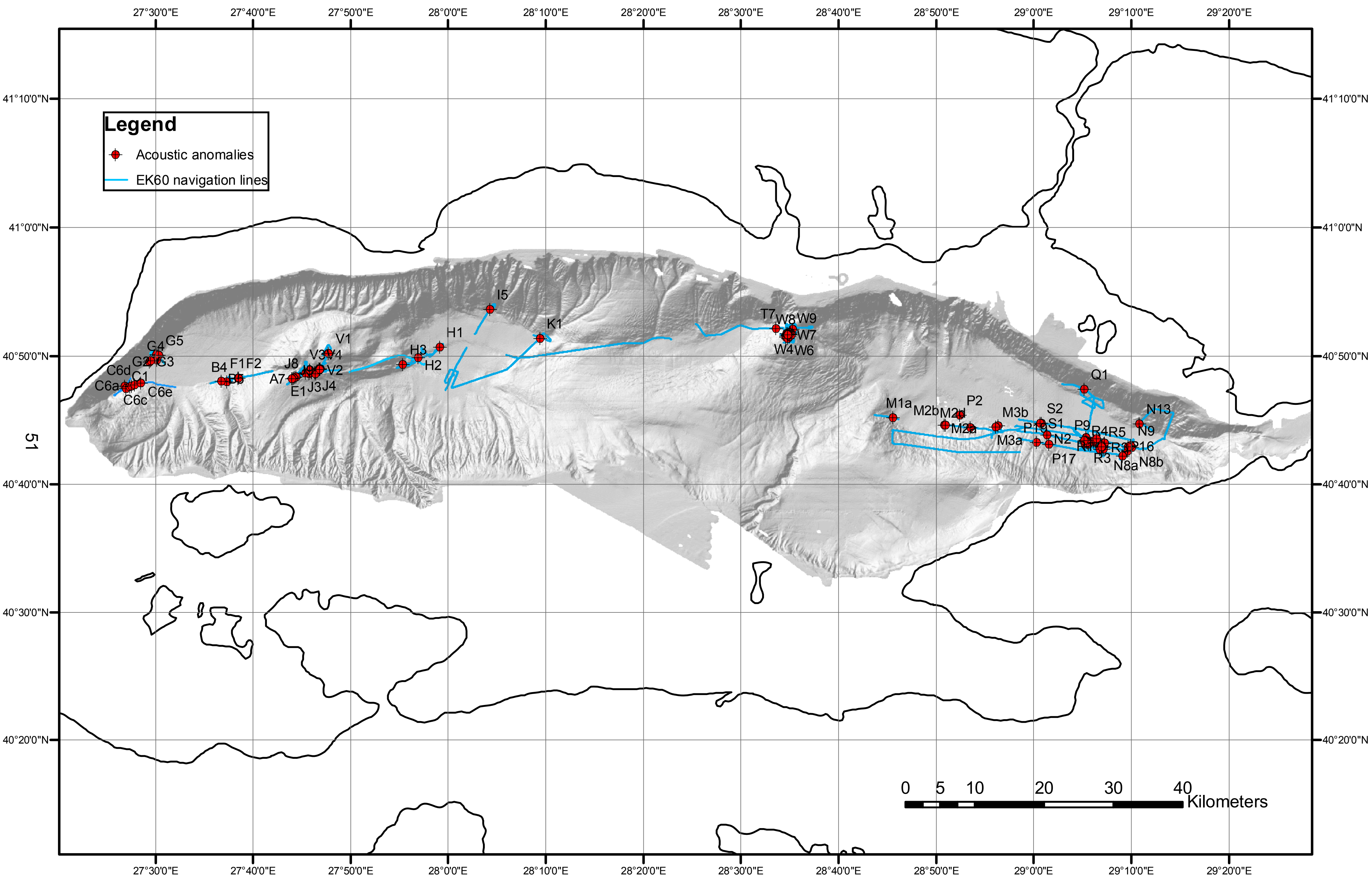
29°20'0"E


Legend
Acoustic anomalies
EK60 navigation lines
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N
C6a
C6d
C6c
C6e
C1
G2
G3
G4
G5
B4
B5
F1
F2
A7
E1
J8
J3
J4
V1
V2
V3
V4
H1
H2
H3
I5
K1
T7
W8
W9
W7
W4
W6
Q1
M1a
M2b
M2d
M2a
P2
M3b
M3a
S2
S1
P19
P9
N2
P17
R4
R5
R3
P16
N8a
N8b
N9
N13
0
5
10
20
30
40
Kilometers

2.7 Chirp data

Bernard Mercier de Lépinay, Géosciences Azur

127 chirp lines have been recovered during MARNAUT, in order to complement the coverage from previous cruises and as site surveys for coring sites. 49 chirp lines have been recorded during MARNAUT Leg 1 and 2 and 78 during MARNAUT Leg 3 and 4.

The signal sent is a "chirp", with a scan of frequencies between 2.5 to 4.5 kHz during 20ms, leading to a theoretical resolution of about 50cm. The signal is sent with a cadency varying according to the depth (2 or 4 per sec.) when in station, or more often according to the distance, when on line. We perform most of the lines at 10 knots (chirp data was not a first priority data for this cruise, a better vessel ship would be 5 knots).

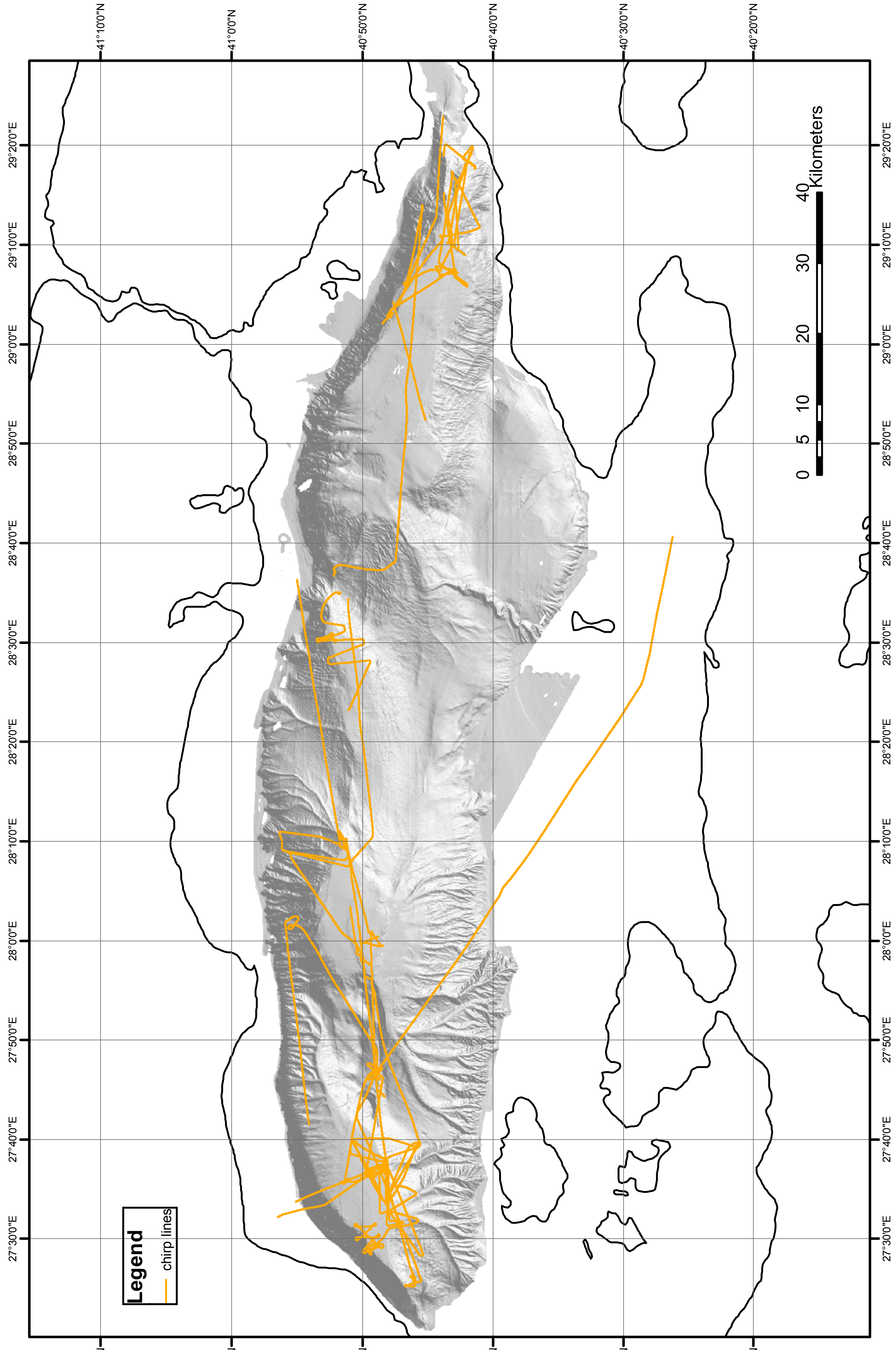
The data are pre-processed using the CHEOPS soft, version 3.2. CHEOPS ("Calculateur Hôte Echantillonneur Opérant en Pénétration de Sédiments") performs all the navigation and attitude corrections (latitude/longitude, heading, displacement of the vessel, speed, waves, etc.). It could be interfaced with the EM12 swath bathymetry sonar for depth calibration. The received data is correlated with the theoretical sent signal, digitized (6 bit resolution dynamic of 96 db), filtered (High-pass: 1.5 KHz/ Low-Pass: 5.5 KHz) and included, with all the geographical information in a standard SEGY format file. The files are recorded in that format.

In this configuration, it seems to be difficult, may be impossible, to obtain the original received signal, after geometrical corrections (navigation, etc..) but before correlation and filtering (in order to correlate not with the sent signal but with, for example, with the response of the seafloor).

The on-board graphic representation is realized in a Dowty graphic device, with a digital signal reduced to 8 bit, an automatic gain control (agc with a windows of 0.05s) and a vertical exaggeration of about 30.

Plots of all chirp profiles from Leg 1 and Leg 2 are given with location maps in Annex **chirp-leg1-2.pdf**. Chirp data acquired at coring sites KS1 to 21 are displayed in Annex **cores_site_figures1_21.pdf**.

Following pages:
Fig. 2.7.1: Location map of the 3.5kHz lines



Legend
chirp lines
Kilometers
0 5 10 20 30 40
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E

2.8 Long term instruments

A/ Combined recording of microseismicity and sediment pore pressure

Rationale

The Marmara Sea area is surrounded by a network of on shore seismological stations, which provides a high quality location of the regional seismicity. However, land stations alone are not sufficient to assess the low level seismicity within the fault zone and its relation with fluid migration. To monitor the micro-seismicity within the fault zone, it is of critical importance : 1) to lower the detection threshold of the micro-earhquakes and 2) to deploy the instruments near the deformation zone in order to improve the depth determinations. To assess the relations with fluid circulation, it is necessary to monitor other parameters simultaneously, such as: fluid flow, sediment pore pressure, water temperature variations and geochemistry.

During the Marnaut cruise, a test has hence been proposed to monitor simultaneously the microseismicity and the sediment pore pressure in the Tekirdag Basin, for a duration of 4 months. Four **O**cean **B**ottom **S**eismometers (OBS) were deployed at the end of Leg 4 at the 3 summits and at the middle of a triangle centred on Jack the Smoker. Because our objective is to record the micro-seismicity, and also considering cost issues, we have used short period (4.5 Hz), 3-component seismometers.

At the center of the target, we have also deployed during Leg 4 a piezometer to measure interstitial pore pressure at 5 different depths within the upper, 8-m thick sediment layer. This instrument was successfully used by Ifremer in a number of different environments to study the potential role of sub-seabed hydraulic activity in slope instability *[Sultan et al, 2006*]. We propose to use it to monitor potential variations in sediment pore pressure within the fault zone. Because pore pressure is measured at 5 different depths within the upper sediment column, valuable information will be obtained on the vertical fluid motion, by means of Darcy's law. This unprecedented dataset will be analyzed jointly with the seismological data.

The instruments will be recovered in september 2007, with R/V Seismik-1. After this four-months deployment, the seafloor seismological data will be integrated to the land seismological network. The present test will be very useful : 1) to assess the true benefit of deploying seafloor stations in the Marmara Sea ; 2) to assess the ambient noise in the Marmara Sea ; 3) to better identify the active segments of the Marmara Sea faults system.

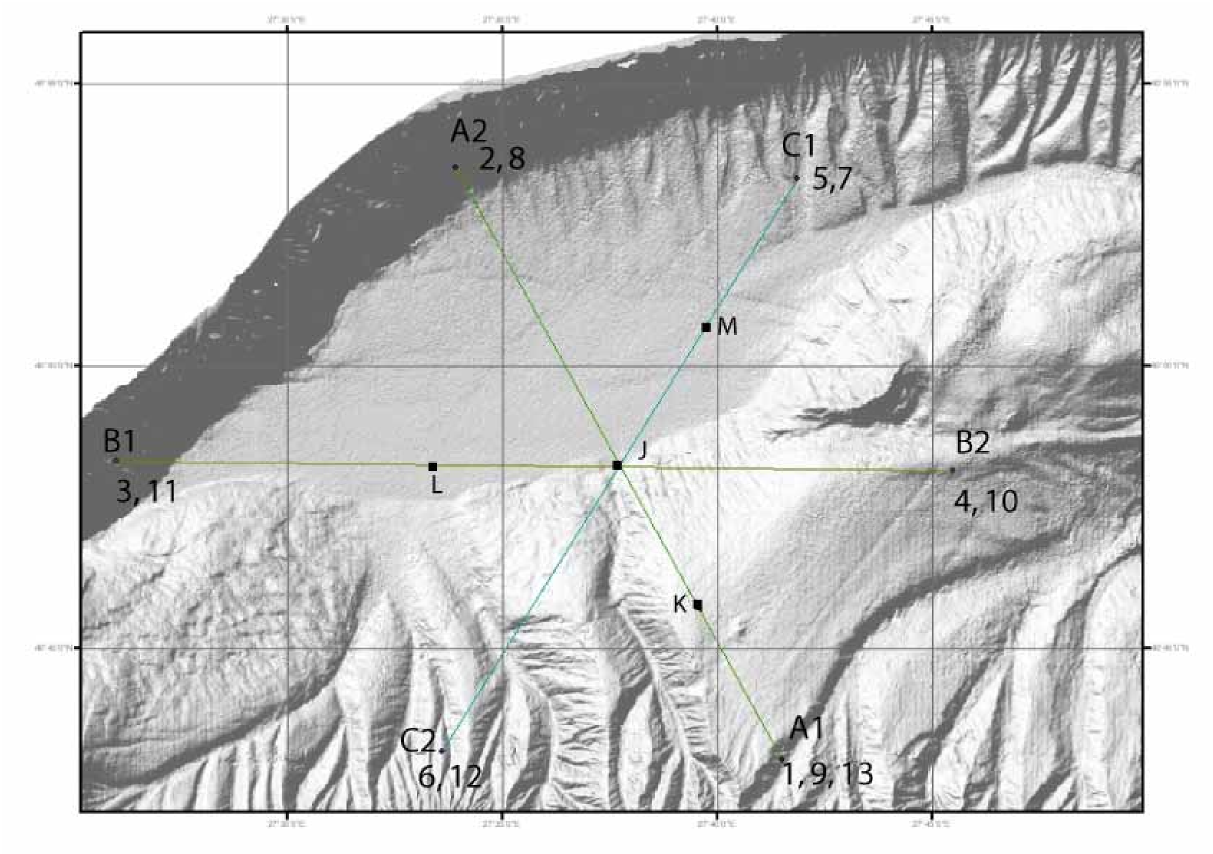


Fig. 2.8.1 : OBS locations (Points K, J, L, M) and seismic lines (A1-A2, B-1B2, C1-C2) shot by R/V Sismik-1 on may 23rd and 24. Two OBSs deployments were performed during the MarNaut cruise : 1) a four weeks deployment, with recovery during leg 4 ; 2) a four months deployment, with recovery in september 2007 with R/V Sismik-1. The piezometer has also been deployed during leg 4 in Point J, less than 40 m away from an OBS, for a duration of 4 months.

OBS deployments and characteristics

Deployments. Two series of OBS deployments were performed :

Deployment 1: 4 OBSs were deployed during Leg 1 and recovered during Leg 4, providing 4 weeks of seismological recordings. No piezometer was deployed during this period. On may 23rd and may 24th, 2007, the OBSs recorded shots fired by R/V Sismik-1.

Deployment 2 : The OBSs were redeployed at the end of the cruise for a duration of 4 months.

OBS characteristics. The Ifremer OBSs deployed during the MarNaut cruise have the following characteristics :

Maximum depth	6000 m
Acoustic release	MORS AR 671-CE – Aluminium 7075 T6 – 12 kHz
Data logger pressure case	Titanium cylinder – diameter : int. = 150 mm ; ext. = 172 mm
Connectors	SUBCONN BH 2F et BH 8F - titanium
Data logger electronics	MicrObs-2004
Numérisation	24 bits, numerical filter DSP CRYSTAL ; max. sampling frequency = 250 Hz ; used during MarNaut = 250 Hz
Clock	TCXO – Precision 3 x 10^{-7}
Memory	100 Go
Power Consumption	0.7 W – Tension : 10-36 V
Autonomy	120 days with 48 cells (Lithium LSH 20)
Hydrophone	OAS – E-2PD 0-5000 Hz
Geophones	Oyo Geospace XYZ-Phone ; 4.5 Hz ; in separate container on seafloor
Flash	Novatech ST 400-A
Gonio	Novatech ST 700-A
Frame	Aluminium AG 4 MC
Floatability	4 cylindric syntactic floats providing 64 kg of floatability each
Weight in air	240 kg
Weight in	-15 kg
Weight	60 kg

During dive 1668, Nautile had the opportunity to take pictures of LOTOBS J deployed near Jack the smoker. The picture (*Fig. 2.8.2b*) clearly showed that after 4 weeks on the seafloor, the geophone was covered by a thin sediment layer. This is good news.

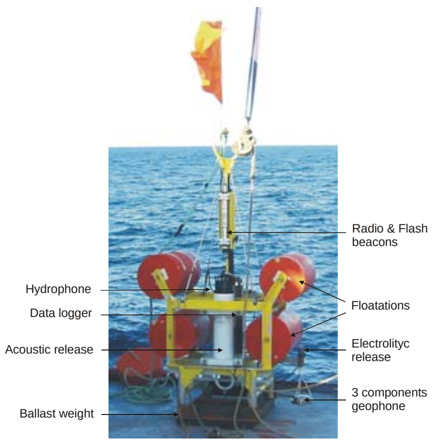


Fig. 2.8.2a : OBS on deck ready for deployment. The 3 components geophone will be released after deployment on the seafloor.

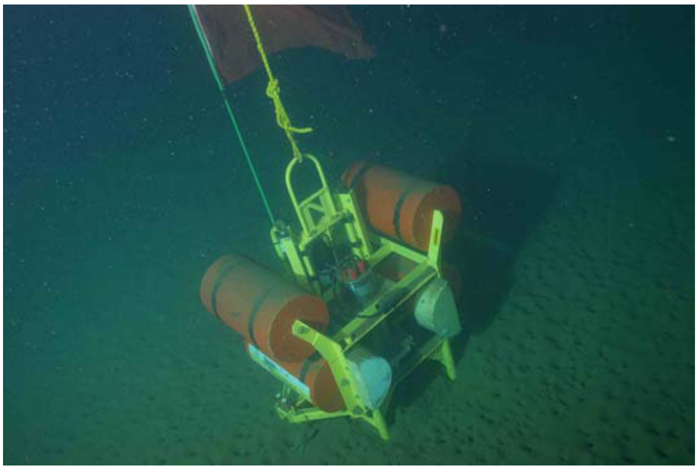


Fig. 2.8.2b : OBS on the seafloor near Jack the Smoker. Photography taken by Nautile, during dive 1668. Note that the seismometer is buried below a thin sediment cover.

Description of piezometer

The piezometer will be used to measure the differential pore pressure at 5 different levels (*Fig. 2.8.3a*). Pressure sensors measure the difference between the pore pressure and the hydrostatic pressure at a given depth.

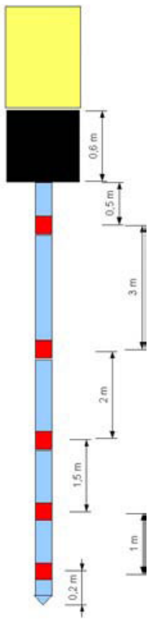


Fig. 2.8.4 : Position of the 5 differential pressure sensors along the piezometer tube.

Fig. 28.3 : Piezometer on the seafloor near Jack the Smoker. The upper part of the piezometer (including the data logger, the floatability, the acoustic release transponder, the flash and radio beacons) will be recovered in september 2007 with R/V Seismik-1. Photography taken by Nautile, during dive 1668. Coordinates are :
40°48.205' N – 27°37.725' E

Deployments coordinates

Point	Type	OBS name	Depth	Lat	Lon	Data	Deployment date	recovery date
FOUR WEEKS DEPLOYMENT								
J	Microbs	J2	1124	40°48.248'	27° 37.769'	2Go	19/05/07 15:49	04/06/07 00:30
J	LotOBS	J	1121	40°48.235'	27° 37.741'	9Go	14/05/07 02:09	09/06/07 08:00
K	LotOBS	K	540	40° 45.676'	27°39.650'	9Go	14/05/07 00:23	09/06/07 00:20
L	LotOBS	L	1132	40° 48.263'	27°33.871'	9Go	14/05/07 01:00	09/06/07 01:32
M	LotOBS	M	1110	40° 50.794'	27° 39.824'	9Go	14/05/07 01:38	08/06/07 23:10
FOUR MONTHS DEPLOYMENT								
J	LotOBS	J3	1116	40° 48.255'	27° 37.752'		9/06/07 15:00	sept. 2007
K	LotOBS	K3	546	40°45.693'	27° 39.685'		9/06/07 15:45	sept. 2007
L	LotOBS	L3	1128	40° 48.247'	27° 33.853'		9/06/07 16:55	sept. 2007
M	LotOBS	M3	1107	40° 50.816'	27° 39.690'		9/06/07 18:00	sept. 2007

Coordinates of long-term piezometer are :

Ship coordinates during penetration : 40°48.197’ N – 27°37.734’ E

Relocation using Nautile short-base positioning system: 40°48.205’ N – 27°37.725’ E

B/ Monitoring by Chemical and Aqueous Transport (CAT) meters

Michael D. Tryon, Scripps Institution of Oceanography

Concept: Seismic and aseismic deformation and fluid flow are related

Fluid flow and pressure distribution within active faults are essential but poorly constrained parameters that affect fault zone processes. Observations on active margins have shown that manifestations of fluid seepage at the seafloor are commonly associated with active tectonic features and that episodic flow occurs in fault zones [*Carson and Screaton*, 1998]. Notably, geochemical and geophysical evidence for rapid flow from seismogenic depths channelled along thrusts has been obtained in ODP drill holes on the Cascadia margin [*Davis et al.*, 1995; *Sample*, 1996]. A number of physical models have been proposed to explain pressure transients or fluid discharge associated with seismic (and aseismic) slip: poroelasticity and pressure diffusion [*Davis et al.*, 2001; *Ge and Stover*, 2000; *Muir-Wood and King*, 1993], damage and fluidization due to ground shaking [*Gavrilenko et al.*, 2000; *Wang et al.*, 2001], fracturing/sealing cycles [*Barton et al.*, 1995; *Husen and Kissling*, 2001; *Renard et al.*, 2000; *Sleep and Blanpied*, 1994] and solitary waves [*Henry*, 2000; *Rice*, 1992]. However, in general, the relationship between episodes of fluid flow and occurrences of fault sliding remains to be defined. While any or all may occur, the differences can potentially be resolved through long term flow monitoring. For example, permeability changes affect the tidal response of a seep while poroelastic effects do not (e.g., [*Elkhoury et al.*, 2006; *Tryon et al.*, 2002]).

Coupling between deformation and fluid flow may lead to post seismic fluid release, precursor events, and/or systematic variations of flow rates, fluid chemistry and pore pressure during inter-seismic phases. Evidence for changes in subsurface water chemistry associated with tectonic activity has been noted in a wide variety of geological environments [*Biagi et al.*, 2004; *Italiano et al.*, 2001; *Sano et al.*, 1998]. A several year record from a 100 m deep water well exhibited an exponential change in Cl^-, Mg, SO_4, and Sr^{2+} leading up to the 1995 Kobe earthquake event [*Tsunogai and Wakita*, 1995]. He isotopes have been used recently on the North Anatolian Fault system [*Gulec et al.*, 2002] and the San Andreas system [*Kennedy et al.*, 1997; *Kulongoski et al.*, 2003] to better understand the nature of the fault system and the complex interaction between it and regional groundwater. An important aspect of the proposed work is that the gas and geochemical data obtained will be compared with an extensive suite of chemical and isotopic data collected as part of the MARNAUT project (2007-2008) and a monitoring program of geothermal localities located along the on-land portion of the NAFZ (Gulec and Hilton, 2002-2004).

Objectives: Constraining temporal variations of venting and its relationship with earthquakes

In order to increase our understanding of the relationship between tectonic activity and fluid migration/expulsion processes along this active fault zone, we will provide both a temporal record of fluid flux rates of submarine seeps associated with faulting in specific regions of the basin, and a complementary long-term temporal record of fluid and gas chemistry of the seeps by deploying Scripps CAT meters (see below) for one year. The time series of flow and seep aqueous and gas chemistry provided by these unique instruments will be related to seismic events, aseismic creep recorded by local seismic and GPS arrays, and the long-term piezometer data.

Even if no "large" earthquake (>M5) occurs during the program, we expect to record measurable strain and fluid flow events associated with microseismicity and aseismic creep. We do not need to have a major earthquake for this program to be successful. The MARNAUT project has multiple objectives, one of which is to establish a baseline for hydrologic activity for future long-term observatory monitoring. Continuous sampling of flow and pore fluids are essential to this goal.

Because the tectonic context, the sedimentation history, and the timing of earthquakes varies along the fault, fluids from different sedimentary and crustal depths may be drained by the MMF. Information on the lateral variations of fluid chemistry are needed for the purpose of identifying fluid sources and migration processes (e.g., [*Henry et al.*, 1996]). It is thus necessary to investigate how fluid chemistry varies along strike, notably between the basins and highs. This involves determining the concentration of chemical and isotopic species, which are affected by temperature- and depth-dependent diagenetic processes.

Methodology: Strategy for sampling

We hypothesize that vents fed by high permeability conduits located within fault zones are sensitive to the state of stress in the fault zone and, thus, may exhibit an amplified hydrologic response to processes occurring at depth much as on-land wells do. In order to monitor this response we will deploy 8 CAT meters on the most active features. These sites will also provide the most useful chemical records due to the relatively fast rate of flushing of the sampler. Instruments will be recovered after approximately one year via their acoustic release mechanisms.

The choice of deployment sites is based on a number of criteria: 1) current apparent fluid expulsion, 2) potential source(s) of the fluids, 3) fault location and activity history, and 4) adequate surface sediment cover to seal the meter's collection chamber. The sites chosen were: 1) the "Jack the Smoker" site located at a recent fault scarp in the south of Tekirdag Basin that may be related to the 1912 Ganos fault earthquake, 2) the base of the fault scarp at the north side of the Cinarcik Basin, approximately half way between the western termination of the Kocaeli earthquake of 1999 and Istanbul, and (3) the Western High hydrocarbon seep discovered during the cruise. Comparing observations at these three sites will bring insight on the relationship between venting and the seismic cycle as they correspond to different phases of the seismic cycle and on the relative contribution of shallow and deep fluid sources.

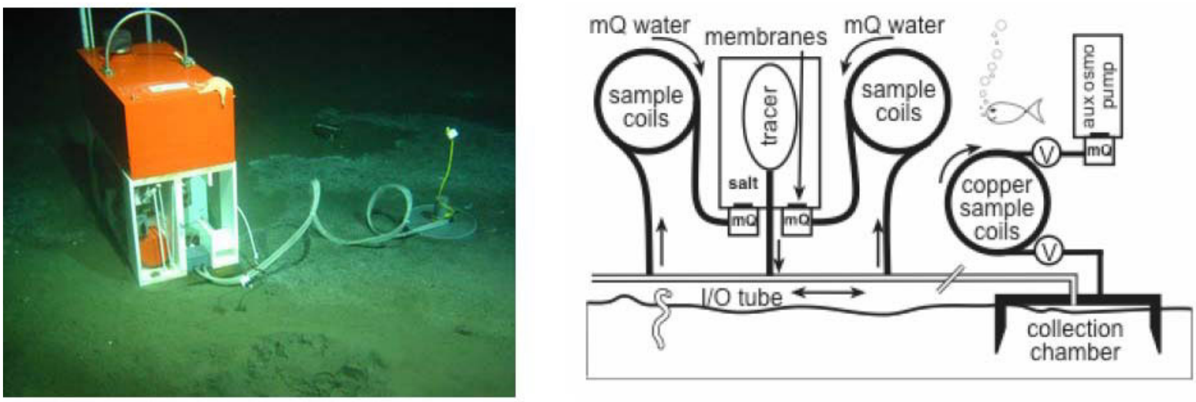


Fig. 2.8.5: CAT meter (left) and CAT meter schematic (right) Tryon et al. 2001)

Instrumentation: The Chemical and Aqueous Transport (CAT) meter

Fluid flow measurements at the sediment-water interface and time series fluid sampling will made using the Chemical and Aqueous Transport (CAT) meter developed at the Scripps Institution of Oceanography, USA *(Fig. 2.8.5)*. The equipment is designed to quantify both inflow and outflow rates on the order of 0.01 cm/yr to 100 m/yr. At high outflow rates, a time series record of the outflow fluid chemistry may also be obtained. These instruments have been in use since 1998 and have been very successful in monitoring long term fluid flow in both seep and non-seep environments. The CAT meter uses the dilution of a chemical tracer to measure flow through the outlet tubing exiting the top of a collection chamber *(Fig. 2.8.5)*. The pump contains two osmotic membranes that separate the chambers containing pure water from the saline side that is held at saturation levels by an excess of NaCl. Due to the constant gradient, distilled water is drawn from the fresh water chamber through the osmotic membrane into the saline chamber at a rate that is constant for a given temperature. The saline output side of the pump system injects the tracer while the distilled input side of the two pumps are connected to separate sample coils into which they draw fluid from either side of the tracer injection point *(Fig. 2.8.5)*. Each sample coil is initially filled with deionized water. Having two sample coils allows both inflow and outflow to be measured. A unique pattern of chemical tracer distribution is recorded in the sample coils allowing a serial record of the flow rates and chemistry to be determined in the laboratory. Upon recovery of the instruments the sample coils are subsampled at appropriate intervals and analyzed via ICP-AES. Both tracer concentration and major ion concentration (Na, Ca, Mg, S, K, Sr, B, Li) are determined simultaneously. The typical resolution is 2 days for flow and 3-5 days for chemistry. The instruments are equipped with an auxiliary osmotic pump connected to copper coils and high pressure valves so that they can be returned to the surface at ambient pressure, maintaining the gas composition of the fluids for time series analysis of $^{3}He/^{4}He$, $CO_2/^{3}He$, delta^{13}C and CO_2 and He concentration. Important sections of the records are additionally analyzed for B and Li isotopes and deltaD and delta^{18}O.

Instrument deployments

Dive 1645: During dive 1645, on May 17, two CAT meters were deployed at the Jack the Smoker site. Meter N was deployed away from the scarp on background sediment near the long term OBS and piezometer deployment site. Meter K was deployed on a ~1 m patch of sulfidic sediment at the base of the scarp ~100 m to the west of Jack. The core taken near the meter indicated that there are low salinity fluids coming up at this location though no visible microbial mat was evident. My impression is that, in spite of the high activity of Jack, this is not a very active site currently and the activity that exists is not conductive to the sampling techniques we are employing. There are a large number of black patches of sediment but they rarely indicate current activity as evidenced by their lack of visible live biology. The white spots seen on video and photos that were thought to possibly be bacteria were actually small white shells. These sites are most likely inactive or dead seep sites where the sulfidic sediment persists but the chemosynthetic communities have died or moved on. The indicators of current fluid flow activity appear to be restricted to the escarpment itself, typically exiting the face of the scarp or at the scarp-slope intersection. There appears to be a carbonate cap on the exposed scarp face with seepage primarily coming from the base of this cap. The fluid flow paths are likely along horizontal permeable pathways in the lithified sediment of the slope and vertically along fault controlled pathways. The latter may be diverted laterally along the base of the carbonate cap to exit at the scarp or their intersection with the fault.

Dive 1656: During dive 1556, on May 28, two CAT meters, M and J, were deployed below the escarpment on the northeast Cinarcik basin margin in an area of widespread diffuse fluid flow. An additional CAT meter, R, was deployed but its ballast came off and it was returned to the surface. Meter M was deployed on black sulfidic sediment with diffuse white microbial mat and other biology on its surface and meter J was deployed on black sulfidic sediment with thick yellow microbial mat on its surface. The area of seepage seen at this site has an extent of approximately 100 m along strike of the escarpment and 50 m across. Generally, indicators of seepage such as black sediment and microbial mats appeared to cover the entire surface of this area with the exception of where large boulders from the upper slope were blocking flow. Within the sediment cover there appeared to be a ~15 cm cover of soft water-rich sediment overlying a hard layer that could not be penetrated by the push cores. It is unknow whether this is a carbonate cemented layer or stiff sediments, though evidence from some coring leads me to think that the latter is the case here. No outcrops of carbonate were seen in the area.

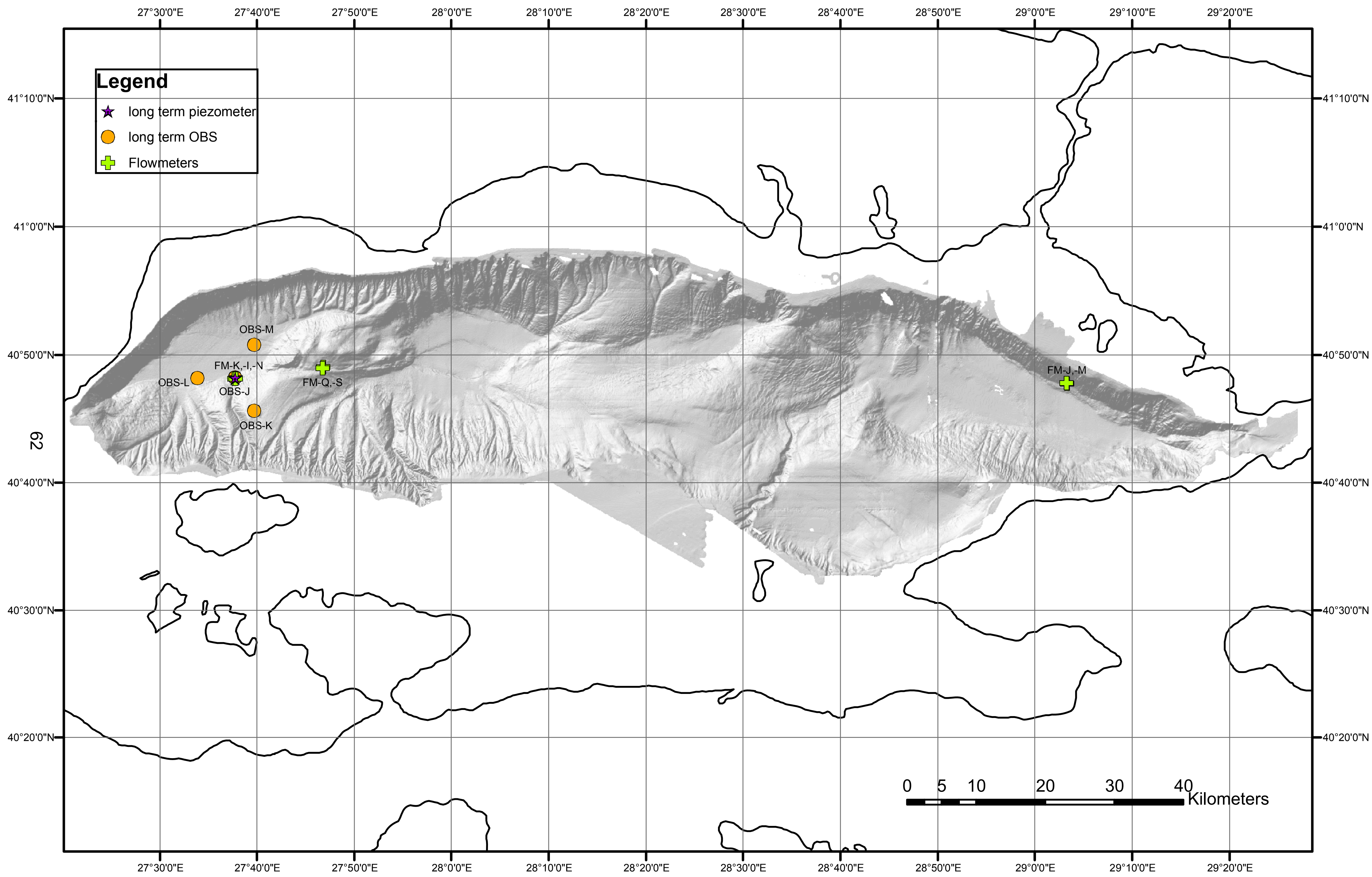
Dive 1666: During dive 1662 a seep site with bubbling vents and oil was found on the Western High. Below the top of the slope a pair of seeps with very thick and dense microbial mat were also seen and sampled. These seeps and an additional one discovered later in dive 1666 have the morphology of downslope flow similar to a mud volcano. They have what appears to be an outlet at the top with thick white microbial mat extending downslope and spreading, exhibiting a dendritic channel morphology. No active flow was seen but the pattern of microbial mat clearly indicates downslope flow of either dense fluid or mud which likely is emitted episodically, with microbial growth ensuing. The pore fluids from these cores and a Kullenberg core taken at the site were found to be significantly more saline than bottom water (>50). These observations led us to choose this site for flow meter monitoring because it may represent our best location for monitoring a deep source. A single flow meter, Q, was deployed at the summit of the site where bubbles were seen actively venting. A double meter, S, was deployed at one of the seeps on the slope with the thick mat.

Dive 1667: During dive 1667 a flow meter (I) modified to be an osmosampler was deployed in the throat of the "Jack the Smoker" vent. This flow meter will not monitor flow rate but will retain a time series of both aqueous and dissolved gas samples for monitoring the chemical output of this vent for a year.

time	designation	lat deg	lat min	lon deg	lon min	depth
17/05/2007 9:30	FM-N	40	48.253	27	37.816	1110
17/05/2007 11:35	FM-K	40	48.164	27	37.690	1113
28/05/2007 8:40	FM-M	40	47.815	29	3.332	1159
28/05/2007 10:26	FM-J	40	47.825	29	3.314	1173
07/06/2007 9:25	FM-Q	40	49.074	27	46.834	658
07/06/2007 10:55	FM-S	40	48.987	27	46.755	659
08/06/2007 0:00	FM-I	27	37.782	40	48.186	1121

Tab 2.8.1 : Flowmeter location.

Following pages:
Fig. 2.8.1: Location map of the long term instruments(Flowmeters, OBS and piezometer)


Legend
long term piezometer
long term OBS
Flowmeters
OBS-M
OBS-L
FM-K,-I,-N
OBS-J
OBS-K
FM-Q,-S
FM-J,-M
0 5 10 20 30 40
Kilometers
27°30'0"E
27°40'0"E
27°50'0"E
28°0'0"E
28°10'0"E
28°20'0"E
28°30'0"E
28°40'0"E
28°50'0"E
29°0'0"E
29°10'0"E
29°20'0"E
41°10'0"N
41°0'0"N
40°50'0"N
40°40'0"N
40°30'0"N
40°20'0"N

3. Participant list

surname	name	sex	nationality	institution	speciality	leg 1	leg 2	leg 3	leg 4
Akcer	Sena	F	Turkey	ITU	geochemistry	1	1		
Al-Samir	Muna	F	Germany	Berlin Free University	geochemistry		1	1	1
Angely	Marie-Agnes	F	France	IUT Marseille	physical measurements		1	1	
Apprioual	Ronan	M	France	Ifremer, Brest	piezometers	1	1	1	1
Bignon	Laurent	M	France	Ifremer, Brest	gas sampling		1	1	
Bouloubassi	Ioanna	F	France	CNRS, LOCEAN	biochemistry			1	1
Bourlange	Sylvain	M	France	CNRS, CRPG	geology and geochemistry		1	1	
Burnard	Pete	M	France	CNRS, CRPG	geochemistry		1		
Çagatay	M Namik	M	Turkey	ITU	geochemistry/sedimentology			1	
Caprais	Jean-Claude	M	France	Ifremer, DEEP	chemistry			1	1
Chevalier	Nicolas	M	France	CNRS, LOCEAN	biochemistry			1	1
Conin	Marianne	F	France	M2, CRPG	geochemistry			1	
Constanty	Hélène	F	France	Geo France	journalist	1			
Dancy	Emre	M	Turkey	ITU	geophysics			1	1
Dikce	Deniz	F	Turkey	ITU	sedimentology			1	1
Donnier	Christophe	M	France	CdF	computer ing.	1	1		
Estival	Rémi	M	France	ISITV/CGG	OBS	1			1
Fichen	Lionel	M	France	INSU	marine ing. (CTD)			1	1
Floch	Gilbert	M	France	Ifremer,DRO/GM	MSCL/Geotek			1	1
Gasperini	Luca	M	Italy	ISMAR	geophysics and tectonics			1	1
Geli	Louis	M	France	Ifremer, Brest	seismology	1	1	1	1
Gerigk	Christoph	M	Germany	Geo	photography	1			
Görür	Naci	M	Turkey	ITU	geology			1	
Harmegnies	François	M	France	Ifremer, Brest	instrumentation/ heat flow	1	1		
Henry	Pierre	M	France	CNRS, CEREGE, CdF	geophysics	1	1	1	1
Imren	Caner	M	Turkey	ITU	geophysics	1	1		
Karagozoglu	Senen	F	Turkey	Radikal	journalist		1		
Lara	Enrique	M	France	CNRS,ESE	microbiology			1	1
Le Pichon	Xavier	M	France	CdF	geodynamics				1
Lévèque	Claude	M	France	Ifremer, Toulon	OBS	1			
Lopez-Garcia	Purificacion	F	France	CNRS, ESE	microbiology			1	1
Massol	Alain	M	France	Ifremer,Toulon	OBS	1			1
Mercier de Lépinay	Bernard	M	France	CNRS, Geosciences Azur	geophysics and tectonics	1	1		
Natalin	Boris A.	M	Turkey	ITU	tectonics	1	1		

Noël	Philippe	M	France	Ifremer, DEEP	sampling tools		1		
Ozeren	Sinan	M	Turkey	ITU	physics	1	1		
Pelleau	Pascal	M	France	Ifremer, Brest	OBS	1			1
Pierre	Catherine	F	France	CNRS, LOCEAN	geochemistry (carbonates)	1	1		
Possemeyer	Ines	F	Germany	Geo Allemagne	journalist	1			
Ritt	Benedicte	F	France	Ifremer, DEEP	biologist		1	1	
Sancar	Ummuhan	F	Turkey	ITU	geochemistry/sedimentology			1	1
Schrutzi	Reinhard	M	Norvege	CGG	OBS	1			1
Şengör	A M Celâl	M	Turkey	ITU	geology	1	1		
Tryon	Michael D	M	USA	Scripps Institution	cold seeps instrumentation	1	1	1	1
Ukarcus	Gulsen	F	Turkey	IPGP & ITU	tectonics	1	1		
Völker	David	M	Germany	Geomar	geophysics	1	1		
Zitter	Tiphaine	F	France	CNRS, CEREGE, CdF	geophysics, GIS	1	1	1	

4. Data distribution

Cruise data are available from the marnaut web page, in the data directory
http://cdf.u-3mrs.fr/~henry/marmara/data
This directory is password protected. Shipboard scientists have password access and the password will be removed 2 years post-cruise.

Part of the data set is included on the report CD
-Fluid chemistry
-CTD
-Heat Flow
-Positions of long term instruments
-Multisensor core logger data
-Nautile tools: microcat and water sampler temperature probe
-Piezometer yoyo data and graphs
-Ship navigation and parameter data.

Sounder (chirp, EK60, EM12), Nautile data (navigation, sensors, photos) and photos of samples are not included on the CD but are on the web site.

Samples were shared on board (see Table 2-1-2 for Nautile samples, Table 2-4-1 for core samples), photos of samples are not included on the CD but are on the web site.

The following digital data were given to the Turkish team on board

At the end of Leg 2:

TITLE	PART	SOURCE
Nautile Dive DVDs and CDS	**1641**	6DVD 1CD
	1642	6DVD 1CD
	1643	6DVD 1CD
	1644	6DVD 1CD
	1645	6DVD 1CD
	1646	6DVD 1CD
	1647	6DVD 1CD
	1648	6DVD 1CD
	1649	6DVD 1CD
	1650	6DVD 1CD
	1651	6DVD 1CD
	1652	6DVD 1CD
	1653	6DVD 1CD
	1654	6DVD 1CD
	1655	6DVD 1CD
	1656	6DVD 1CD

At the end of Leg 4 (see next page):

11/06/2007

I confirm that the acquired data during Marnaut Project between dates 15 May-11 June 2007 was taken, is listed below.

Emre DAMCI

Chief Scientist
Pierre HENRY

TITLE	PART	SOURCE
Nautile Dives DVDs and CDs	1655	6 DVD 1 CD
	1656	6 DVD 1 CD
	1657	6 DVD 1 CD
	1658	6 DVD 1 CD
	1659	6 DVD 1 CD
	1660	6 DVD 1 CD
	1661	6 DVD 2 CD
	1662	6 DVD 1 CD
	1663	6 DVD 1 CD
	1664	6 DVD 1 CD
	1665	5 DVD 1 CD
	1666	6 DVD 1 CD
	1667	6 DVD 1 CD
	1668	6 DVD 1 CD
	1669	6 DVD 1 CD
	1670	4 DVD 1 CD
EK60 Data		1 DVD 1 CD
OBS Data	Subtech and Software	1 DVD
	ARNSS	3 DVD
	SPAN Data	1 DVD
	MicrOBS	1 DVD
	LOTOBS	4 DVD
MISSION Data	Leg 1 and 2	External Hardisk
	Leg 3 and 4	External Hardisk
Marnaut Data	Chemistry	External Hardisk
	Cores	External Hardisk
	Dives	External Hardisk
	Heatflow	External Hardisk
	MST logging	External Hardisk
	Samples	External Hardisk
	Water sampler temperature	External Hardisk
	Chirp	External Hardisk
	CTD	External Hardisk
	EK60	External Hardisk
	MAP	External Hardisk
	MicroCat	External Hardisk
	SeisPro	External Hardisk
MARNAUT Report	Cores	External Hardisk
	Dives	External Hardisk
	Instruments	External Hardisk
	Organic Geochemistry	External Hardisk
	Sounding	External Hardisk
	EK60	External Hardisk
	Operations	External Hardisk
	Samples	External Hardisk

5. List of Annexes

MARNAUT_dive_reports.pdf
Compilation of individual dive reports

Marnaut_sample_database.xls
Spreadsheets with all samples taken during Marnaut cruise.

chirp_cores_locator.pdf
Plots of core locations on chirp navigation

chirp-leg1-2.pdf
Plots of chirp lines and location map of chirp profiles from leg 1 and leg 2

cores_MSCL_figures.pdf
Plots of MSCL data for cores: gamma ray density, P wave velocity and magnetic susceptibility

cores_site_figures1_21.pdf
Preliminary core site survey for core KS01 to KS21: chirp profile, location map and core target coordinates

CTD_plots.pdf
Plots of CTD data (oxygen, temperature, salinity, fluorimetry) for CTD station 1 to 13.

CTD_samples_microbio.pdf
Water samples from CTD for microbiological purposes

CTD_samples_org_geochem.pdf
Water samples from CTD for organic chemistry purposes

microcat_figs.pdf
Plots of microcat data (temperature and salinityfrom dives 1645, 1648, 1650, 1653 to 1667, and 1669.

EK60_AAs.xls, EK60_AAs.pdf
Location and description of EK60 acoustic anomalies

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