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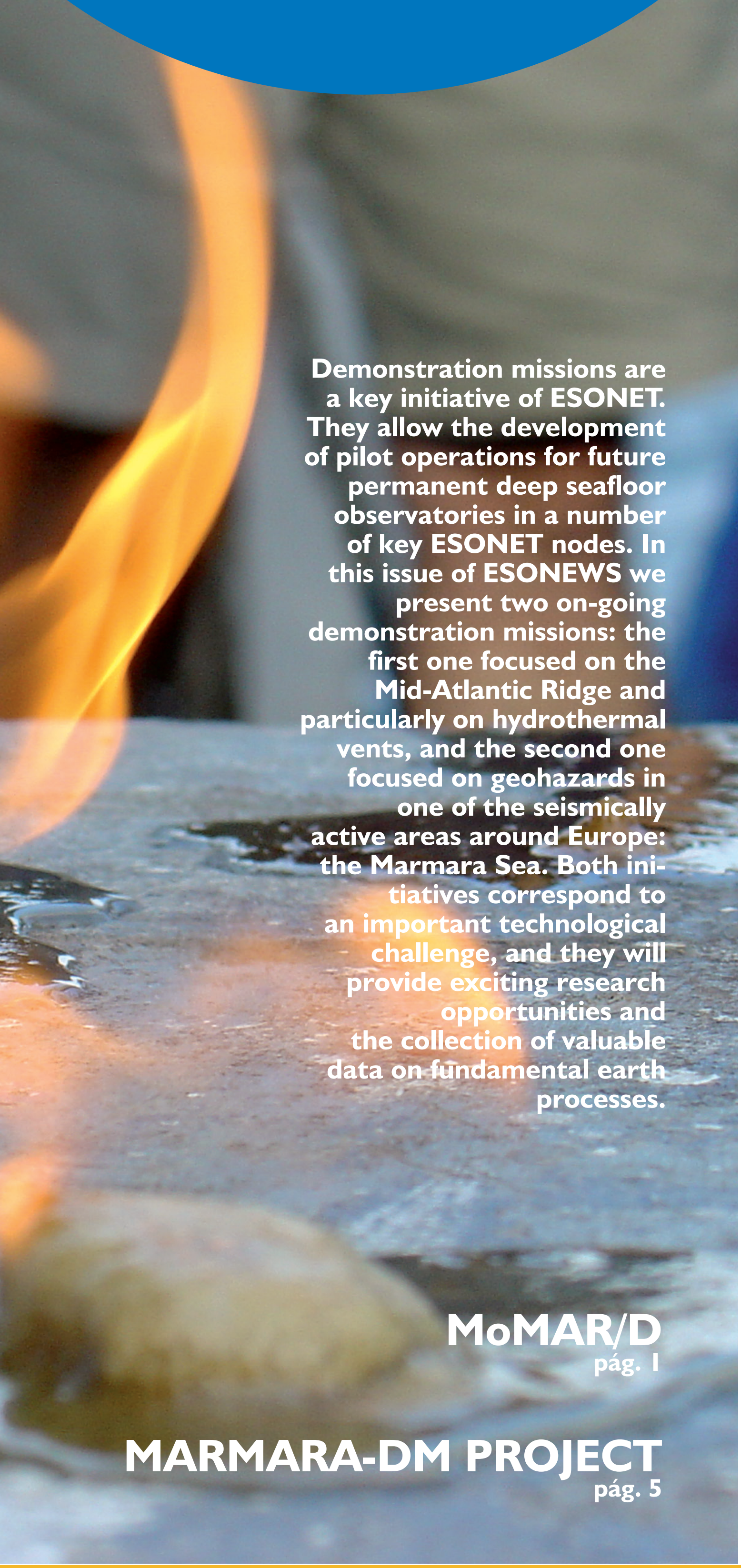

Demonstration missions are a key initiative of ESONET. They allow the development of pilot operations for future permanent deep seafloor observatories in a number of key ESONET nodes. In this issue of ESONEWS we present two on-going demonstration missions: the first one focused on the Mid-Atlantic Ridge and particularly on hydrothermal vents, and the second one focused on geohazards in one of the seismically active areas around Europe: the Marmara Sea. Both initiatives correspond to an important technological challenge, and they will provide exciting research opportunities and the collection of valuable data on fundamental earth processes.

MoMAR/D

A demonstration mission to establish a multidisciplinary observatory at hydrothermal vents on the Mid-Atlantic Ridge

Pierre-Marie Sarradin, Jozée Sarrazin and MoMAR/D team

1. Introduction

Hydrothermal circulation at mid-ocean ridges is a fundamental process that impacts the transfer of energy and matter from the interior of the Earth to the crust, hydrosphere and biosphere. The unique faunal communities that develop near these vents are sustained by chemosynthetic microorganisms that use the chemicals in the hot fluids as a source of energy. Environmental instability resulting from active mid-ocean ridge processes can create changes in the flux, composition and temperature of emitted hydrothermal fluids and thus influence the structure of hydrothermal communities. Approximately 10 years ago, the InterRidge Program initiated the MoMAR project (Monitoring the Mid-Atlantic Ridge) to promote and coordinate long-term multidisciplinary monitoring of hydrothermal vents on the Mid-Atlantic Ridge (Figure 1a). The goal of this multidisciplinary project is to study vent environmental dynamics from geophysics to microbiology. In 2006, this area was chosen as one of the 11 key sites of the ESONET NoE (coordinator: R. Person, Ifremer).

In 2008, a MoMAR/D proposal (PI's: Sarradin, PM, Ifremer; Colaço, A., University of Azores) was submitted to the ESONET committee as a candidate demonstration mission in the frame of WP 4. This project was selected and granted 500k€ to deploy and manage a multidisciplinary observing system at Lucky Strike vent field during one year (Figure 1b). This large hydrothermal field is the focus of several pluridisciplinary studies since the mid-90's. It is located in the center of one of the most volcanically active segment of the MAR.

The scientific objectives of the MoMAR/D proposal are to link the temporal variability of active processes such as hydrothermalism, volcanism, seismicity and ground deformation to better understand the dynamics of mid-ocean ridge hydrothermal systems and their impacts on the faunal assemblages. To achieve this, the challenge is to deploy a multidisciplinary observing system, with satellite connection to shore, and to demonstrate its management during 12 months.

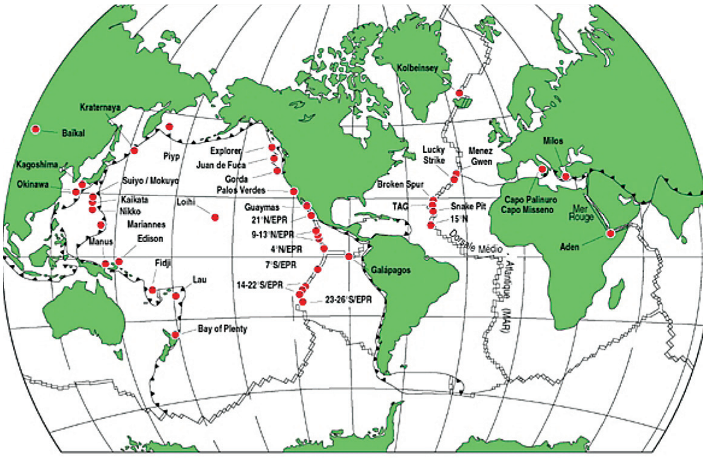

Fig.1a - Distribution of the known hydrothermal vents in the world oceans.

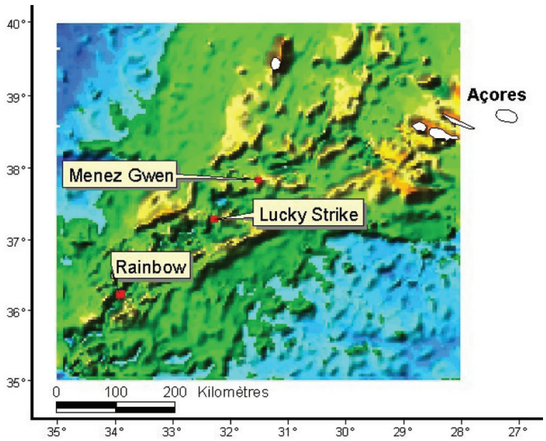

Fig.1b - Location of the Lucky Strike vent field on the Mid-Atlantic Ridge.

The SEAMON technology (Blandin & Rolin 2005) will be used on two nodes acoustically linked to a surface buoy which will ensure satellite communication to a land base station at Ifremer, Brest center. The first node will be dedicated to large scale geophysical studies and will be moored in the center of the Lucky Strike lava lake. The second node will be deployed at the base of the Tour Eiffel edifice to study the links between faunal dynamics and physico-chemical factors. Temperature probes will be moored on the buoy line to give insights on the local water circulation.

2. Description of the operational systemn

The MoMAR/D experimental design combines autonomous instruments which will store data over the duration of the mission (1 year), and instruments that will be connected to shore via the SEAMON system.

2.1 The SEAMON / BOREL technology

The SEAMON system includes a set of long-term, non-cabled sub-sea observatory components, initially developed by Ifremer during the EU ASSEM project (2002-2004). These components have since been upgraded and made more reliable. SEAMON is the generic name of the seabed stations serving a local set of sensors, whereas BOREL (Bouée relais) is the surface data transmission relay. The SEAMON stations are rated for 4000 mwd operations and each node can provide 8 kWh, allowing for the sensors operation and for a daily data transmission of ca. 40 – 400 kbytes.
The main components of SEAMON include:

a. COSTOF (Communication and Storage Front-end). This electronic unit serves a set of local sensors by providing them with data storage, communication channels and optionally energy. COSTOF communicates with the ROV via CLSI (see below), and the BOREL buoy via acoustic modems. The COSTOF robustness and modularity rely on the use of a low power field bus (CAN) linking a set of simple identical boards, each board devoted to one sensor. The measurement sequencing is left to each sensor to insure that a COSTOF failure does not prevent data acquisition at the sensor level. Conversely, data duplication at the COSTOF level is a safety factor in case of sensor damage. SEAMON can duplicate this data storage for a volume up to 2 Gbytes per year.

b. CLSI (Contact-Less Serial Interface) is a small device made of two parts, allowing serial communication between two units, without electrical connection. If one part is connected to a ROV, and the other part to the COSTOF, communication can be established between the ROV and any connected sensor. This methodology will be used after deployment to check or fine tune a sensor functioning before the ROV leaves the area.

c. A BOREL buoy – This buoy is the data transmission relay between the SEAMON seabed stations and the Iridium satellite constellation (Figure 2). It is moored within acoustic range of the SEAMON stations and is composed of two identical independent data transmission channels. Channel 2 can be activated from shore in case of a failure of channel 1. Each data transmission channel is powered independently and comprises an acoustic modem, control electronics and an Iridium modem. The communication is bi-directional and BOREL supports three data transmission modes: periodic (typical rate 6 hours), triggered by events detected on the seabed, and triggered from shore. BOREL has now been used for two years in the Mediterranean Sea, where it was moored at 2000 m depth. The Mediterranean mooring will be modified for MoMAR/D to take into account the sea conditions prevailing in the mid-Atlantic ocean. Its position and the local sea/wind state will be monitored throughout the experiment. The robustness of this mooring is clearly one of the technical challenges of the MoMAR/D experiment.

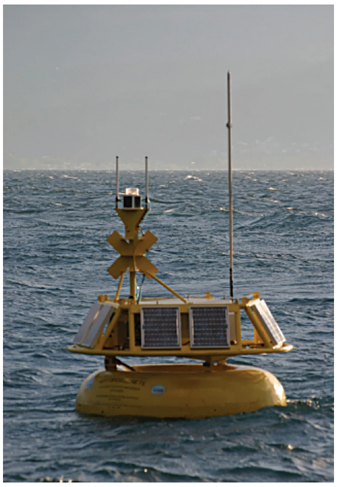

Fig.2 - The BOREL buoy

2.2 Acoustic data transmission

For five years now, successive SEAMON/BOREL systems have been using the same type of acoustic modems. Their reliability has now reached a satisfying level, but their energy requirement per transmitted bit (a key parameter for non-cabled observatories) can probably be significantly lowered. Ifremer is currently working on this issue. This work started in 2007 with a selection of five modems available on the world market. Among the selection criteria, the lowest energy necessary to transmit 1 bit at a given distance was sought. In 2008, three of these five modems were tested at sea, between a sub-sea station at a depth of 2200 m, and the research vessel L'Europe. This test demonstrated that the more recent modems required at least 15 times less energy to transmit one bit than the ones used on SEAMON until now.

Longer term tests of the two best modems are planned in 2009, between the 2200 m-deep subsea station and a relay buoy. The MoMARSAT experiment will directly benefit from these improvements. Only a subset of data will be periodically transmitted to shore via the BOREL buoy. The subsampling step will be designed specifically for each sensor. Simple subsampling operations can be perfomed by SEAMON such as temporal subsampling, simple statistics or thresholding (Figure 3).

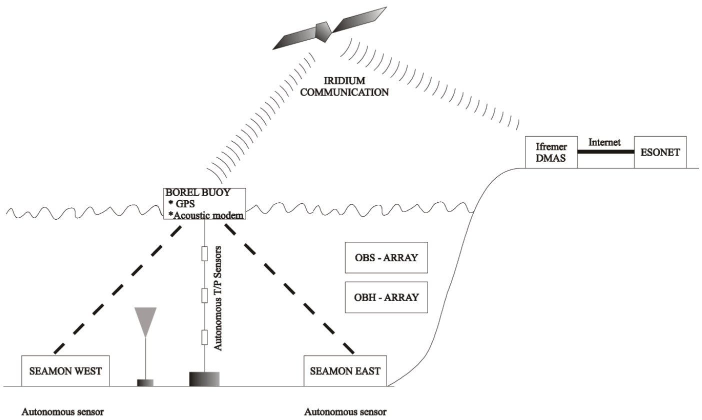

Fig.3 - Sketch of the MoMAR/D experiment with the two SEAMON nodes on the bottom and the surface buoy at the sea surface. The surface buoy is the data transmission relay between the SEAMON seabed stations and the Iridium satellite constellation. Data are sent to a to a land base station at Ifremer, Brest center.

2.3 Location and configuration of the nodes

Two SEAMON nodes will be deployed in the Lucky Strike vent field. The BOREL buoy will be moored at acoustic range of the 2 nodes, on the volcano heights. The geophysical node (Seamon Ouest) will be moored in the lava lake on a flat surface. The photomosaic of the area obtained by Escartin et al. (2008) will be helpful to find a convenient place. Finally, the ecological node (Seamon Est) will be located at the base of the Tour Eiffel active edifice, to continue the study started by the TEMPO module in 2006 (Sarrazin et al. 2007, Figure 4).

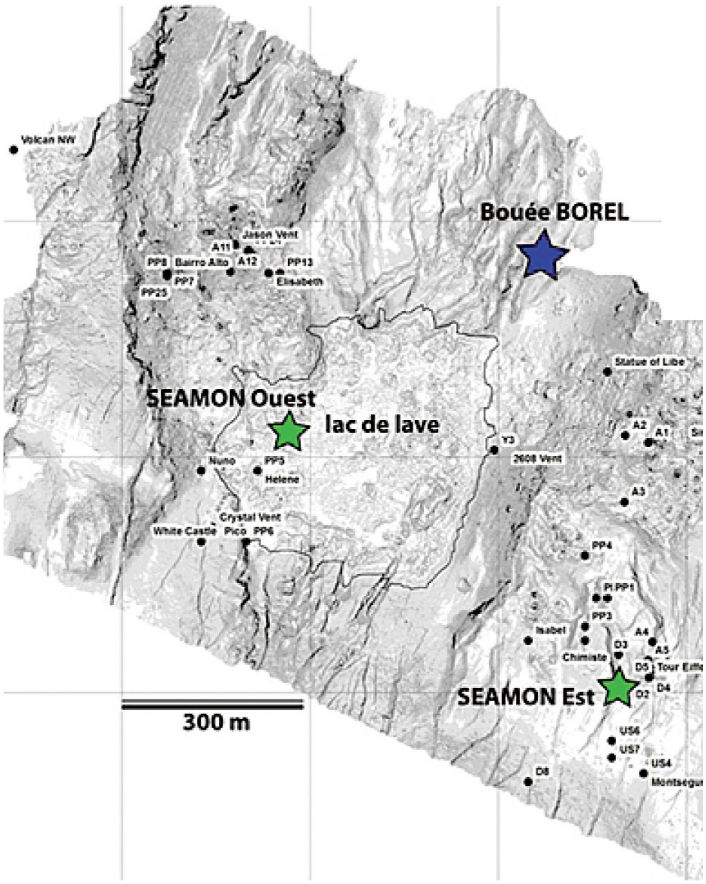

Fig.4 - Sketch map of the Lucky Strike hydrothermal field, with slope map in background. Black contour is the limit of the lava lake. Black lines outline the principal scarps. The blue star represents the target location of the BOREL buoy while the green stars represent the locations of the geophysical (SEAMON Ouest) and ecological (SEAMON est) nodes. From Ondreas et al. 2009.

SEAMON-Est will be primarily devoted to thematic experiments 3 (Chemical fluxes), 4 (Ecology) and 5 (Physical oceanography). It will connect a video camera, chemical sensors and the CTD/ADCP package. This node will be moored at the base of the active hydrothermal edifice Tour Eiffel, near the location of the autonomous TEMPO station deployed during the MoMARETO cruise in 2006 and recovered in 2008.

SEAMON-Ouest will be primarily devoted to thematic experiments 1 (Seismicity and hydrothermal activity) and 2 (Seafloor deformation). It will connect the pressure probe and one OBS. This second node will be moored in the western part of the lava lake, near the present location of the pressure probe installed since 2006.

2.4 Underwater connection devices

To ease the deployment, the OBS will be connected to SEAMON underwater using a low cost connection device (CdC,) specially developed and validated during the ASSEM project (Figure 5).

Fig.5 - The underwater connection-deconnection device developed at Ifremer.

2.5 Data storage

Each connected sensor will independently store data over the 12 months duration of the project. When possible (volume < than 2Gbytes per year), the data storage will be duplicated by SEAMON. The Ecology package (TEMPO) and the pressure gauge have already tested operational SEAMON connections. Development will be carried out for the connected OBS (IPGP), the NOCS chemical flow analyzer and the CTD/ADCP mooring. Other sensors will be deployed as autonomous instruments, storing data that will be recovered at the end of the 1 year experiment.

2.6 Biofouling

Biofouling is a major issue in the vent ecosystem. Biofilms form on every available surfaces and trap the mineral particles emitted by the hot fluids. The method used successfully for preventing bio-fouling on the lens of the TEMPO video camera and on an Aanderaa oxygen optode relies on localized microchloration (Exomar, 2005 and MoMARETO, 2006 cruises). This method does not modify the image, and the concentrations of chemicals released are negligible.

3. The sensors

The project relies on the mooring of various sensors to acquire time series related to the seismic activity of the system, floor deformation, chemical fluxes, faunal dynamics and physical oceanography. Part of the sensors will be connected to the SEAMON nodes and will transmit a subset of data to the BOREL buoy and the DMAS on shore. The complete data set will be stored in the sensors and in SEAMON when possible. The other sensors will be used in an autonomous mode. The complete set of data will be downloaded at the end of the experiment when the sensors are recovered. All the sensors will be synchronized at the beginning of the experiment. The drift will be measured after the recovery of each sensor against the GPS clock.

4. Planning

The project planning is described in Figure 6. The instruments adaptation phase correspond to the modification of the instruments prior to their connection to SEAMON. The SEAMON adaptation phase will allow the development of specific drivers for each instrument. During the instruments integration to SEAMON, the sensors will be integrated (mechanically and electrically) to SEAMON. The system test will be performed on shore using the complete system: from the sensor to the DMAS. Ultimately, the MoMAR/D observatory should be deployed in 2010 during the MoMARSAT cruise (PI's: Cannat, M, Blandin, J., Sarradin, PM).

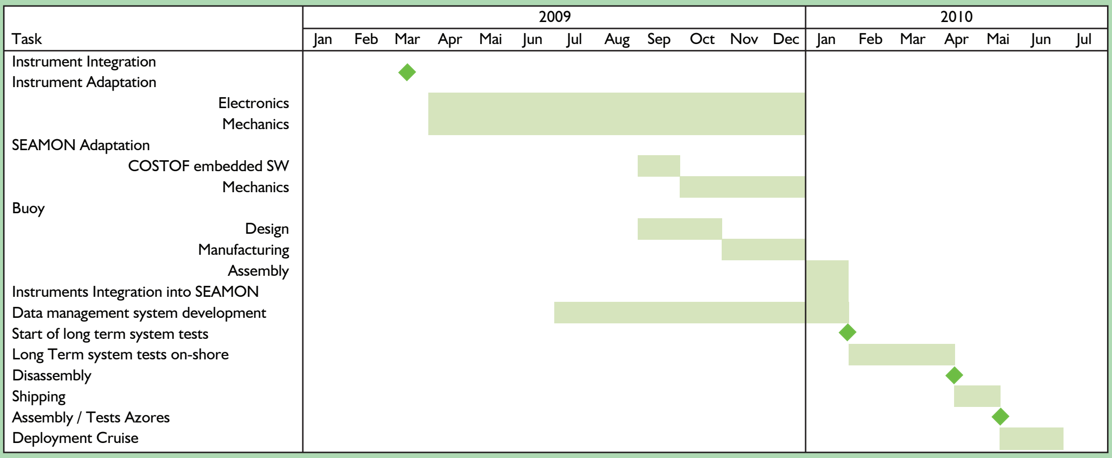

Fig.6 - Planning of the development and integration of the MoMAR/D observatory on the Lucky Strike vent field in 2010.

5. Recent news

A first meeting took place in Brest March 18-19 and gathered engineers and scientists from 4 different European countries (France, Germany, Portugal, United Kingdom). The objectives of this meeting were to present the scientific objectives of the different participants, to plan the land integration and trials of the instruments in Brest (coordinator: J. Blandin) and finally, to work on the communication plan and data management policy. The next "rendez-vous" is given in Brest next fall.

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J. Sarrazin, responsible for the MoMAR/D communication plan

MARMARA-DM PROJECT

A demonstration mission to establish a deep sea observatory, with emphasis on fluid and seismic activity interaction, in a major transform plate boundary

Namik Çagatay, Louis Gelli and MARMARA-DM team

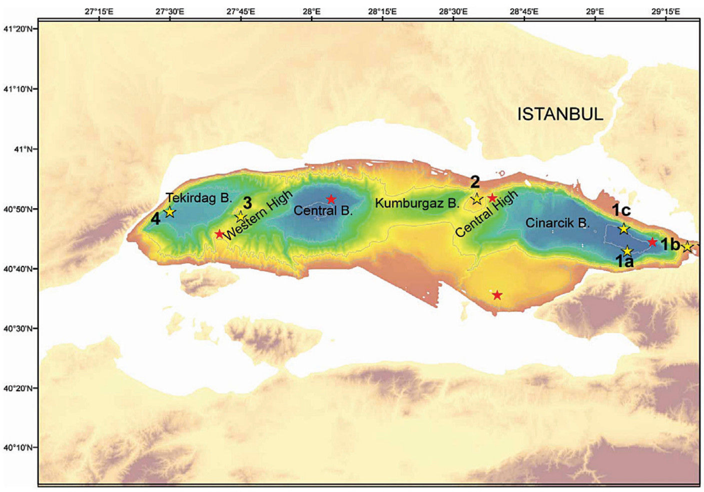

Fig.1 - Map the Sea of Marmara, based on the bathymetry collected by Le Pichon et al. (2000). Red stars indicate the 5 cabled seafloor observatories that are planned to be deployed in 2009 by KOERI as part of the Turkish national seismological network. observatories to monitor fluids and seismicity within the ESONET MARMARA-DM project. Yellow stars indicate those sites selected for implementing multi-disciplinary seafloor.

Scope and Objective

Marmara-Demonstration Mission (DM) project, funded by the ESONET-NoE, aims at collecting long-term multi-disciplinary data in the Sea of Marmara (SOM), with special emphasis on the fluid- and seismic-activity interactions. The ultimate objective of the project is to establish the most suitable sites and parameters for permanent multi-disciplinary earthquake observatories in the SOM.

Geohazard Risks

The SOM is located on the North Anatolian Fault (NAF) zone in NW Turkey, a major transform-plate boundary that has produced devastating historical earthquakes along its 1600 km length (Ambraseys & Jackson, 2000). After the 1999 Izmit and Düzce earthquakes, the next large (Mw>7) earthquake is expected in the SOM close to İstanbul, an important cultural centre and a mega-metropole with 15 million inhabitants (Parsons, 2004). The SOM has three ~1250 m-deep strike-slip basins that are separated by NE-trending transpressional highs (Fig. 1). The slopes leading to the deep basins are steep (>18°) with unstable areas on the upper slope that may slide during future seismic events. The future earthquake and tsunami (Yalçıner et al., 2002) hazards would have devastating effect not only in Istanbul, but also in the whole of the SOM coastal areas in which more than Turkey's 20% population and 50% of industry are located. Hence, the high tectonic activity with geohazard risk, as well as the special oceanographic setting as a gateway between the Mediterranean and Black Seas, makes the SOM a natural laboratory for multidisciplinary seafloor observations for geohazards and oceanographic monitoring, with unique specificities concerning the relationship between fluids and seismicity.

Fluids and Seismicity

In the deeper parts of the SOM, fluid outflow sites manifested by carbonate crusts, black patches, and bacterial mats are commonly observed along or near active faults (Armijo et al, 2005; Zitter et al., 2008). Free gas emissions are common and appear to be influenced by earthquake occurrence. In the Gulf of Izmit, repeated surveys showed that the intensity of methane emissions increased after the August 17, 1999 earthquake (Alpar, 1999). The distribution of gas seeps in the main part of the SOM has been found to be unevenly distributed, with less activity on the linear fault segment crossing the Central High, which has not ruptured since 1766 (Géli et al, 2008). In contrast bubbling was observed above a buried transtensional fault zone along the southern edge of the Çınarcık Basin, which displayed micro-seismic activity after the 1999 events (Karabulut et al., 2002). While the hydrocarbon (HC) gases emitted from the Çınarcik basin is predominantly of relatively shallow origin, the gases expelled from faults cutting the highs are of deep thermal origin (Bourry et al., 2009).

Observatory Sites and Sensors

To determine whether there is a hydrogeologic connection between some gas seeps and the seismogenic zone, seafloor observatories with specific sensors, such as seismometers, flowmeters (Tryon et al, 2001), piezometers, acoustic stations for gas bubble monitoring and in-situ geochemical sensors, will be deployed at 4 selected sites.

• **Site 1** is located in the eastern Çınarcık Basin (Fig.1), which is presently affected by aseismic slip on faults resulting in extension rates of the order of 10-7 yr-1, not accounted for by interseismic loading models (e.g,. Ergintav et al, 2007).

• **Site 1a** is where active gas emission sites have been found during the 2000 and 2007 surveys, above a buried transtensional zone extending in the prolongation of the fault that ruptured during the 1999 İzmit earthquake (Figs. 1, 2a).

• **Site 1b** is located at the entrance of the Gulf of Izmit, where the principal deformation zone of the North Anatolian Fault is less than some tens of meters wide.

• **Site 1c** is located at the base of the northern escarpment of the Cinarçik Basin, where cold seeps were observed, near the base of a steep slope exposing cliffs of Paleozoïc rocks (Fig.1).

• **Site 2** is located on the Central High, 15 km SW of İstanbul (Fig. 2). This site is situated on a fault segment constituting the “seismic gap” that did not rupture since at least 1766. There is little evidence for fluid emission along the fault itself, but there is thermal HC gas outflow from an anticlinal axis, a few km south of the main fault trace (Bourry et al, 2009). It is therefore of critical importance to deploy instruments such as seismometers and piezometers on top of the Central High and within the fault valley, in order to establish comparisons between these two different environments.

• **Site 3** is centered on the Western High, an area where gas hydrates have been discovered during the 2007 MarNaut cruise onboard R/V L’Atalante (Bourry et al, 2009; Figs. 1, 2a, b, d). HC gases from this site have gas and isotopic compositions similar to those of the gases from the Thrace Basin. This suggests that that the fault is acting as a conduit for the transfer of gases from the deep HC reservoirs. Hence, this site is particularly suited to address the question on the hydrogeologic connection between the gas seeps and the seismogenic zone of the NAF.

• **Site 4** is located on a secondary fault at the base of the Ganos slope in the Tekirdağ Basin, where strong gas bubbling with 70% mantle helium (3He) and deep crustal seismicity are observed (Figs. 1, 2a,c; Burnard et al, 2008). Combined geochemical sampling and monitoring of gas flux and microseismicity is important at site 4.

Marine Operations

The following activities will be carried out under MARMARA-DM project:

a) From August 23rd to October 2nd, 2009, site surveys will be conducted with R/V Le Suroit for micro-bathymetry (EM-2000) and acoustic bubble detection (EK-60) using an AUV at all sites. A 3D, high resolution seismics is planned at Site 2 and a prototype instrument for the acoustic monitoring of gas bubble emissions in the Çınarcık Basin.

b) In September-October 2009, six piezometers and 10 short-period (4.5 Hz) OBSs will be deployed for 6 months (October 2009 – March 2010) with R/V Urania, The SN-4 station (Favali et al, 2006) will be deployed at Site 1b in the entrance of the Gulf of Izmit. SN-4 will be equipped with several sensors, including a broad-band, three-component seismometer and CONTROS-type methane sensor.

c) An additional seismic site survey will be conducted at Site 3 with R/V Piri Reis in October 2009.

Other Activities

Other planned MARMARA-DM activities include:

1) Symposium on “An Overview of the Research in the Sea of Marmara Region Over the Last 10 Years”, the 10th Aniversary of 1999 Earthquakes: 17 August 2009.

2) ESONET Training course on “Seafloor Observatories for Geohazard Monitoring”:18-19 August 2009. Both activities will be held at Istanbul Technical University. For more information about these events see ESONET website, or write to: ucarkus1@itu.edu.tr

KOERI Initiative

Marmara Sea Bottom Observatory (MSBO) project of by the Kandilli Observatory and Earthquake Research Institute (KOERI) is funded by the Turkish Telecom, independently of ESONET. It plans to deploy a total of 5 cabled seafloor observatories in the year 2009 (Fig. 1). The observatories will be operated by the Kandilli Observatory and Earthquake Research Institute (KOERI) as part of the Turkish national network for earthquake and tsunami hazards monitoring. The planned seafloor observatories consist of three-component broad band velocity sensor with a natural period of 360 s and digitizers, three component accelerometer, differential pressure meter, hydrophone, temperature meter, three-D current meter, camera, Flux Gate Compass and a tiltmeter sensor.
Each seabottom observatory will be connected to land by a fibre optic cable and be fully integrated to the land seismic network, providing capability for:

a) early warning of earthquake related tsunami,
b) detailed earthquake source studies and tomography of the source,
c) determination of the crustal structure,
d) highly accurate determination of the earthquake magnitude and epicentre,
e) reduction in the earthquake location treshold less than M=1.0,
f) determination of the source of noise and nature of deformation and faulting.

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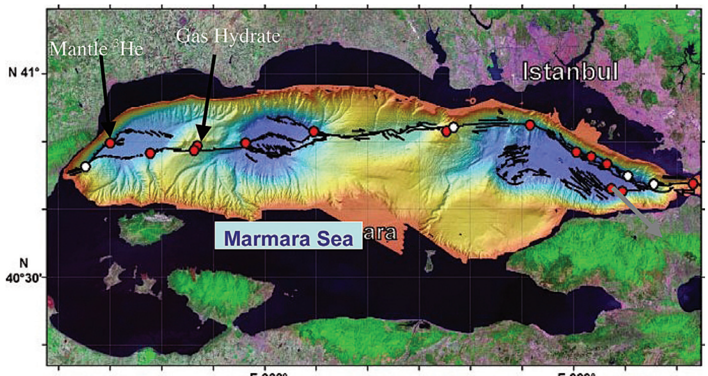

Fig.2a - Bathymetric map of the Sea of Marmara and active fault trace over a Landsat image of the area. The Nautile dive sites explored during Marnaut are shown in red dots where fluid seepage were observed, and in white dots otherwise. Numbers refer to dive sites and follow the definition of dive targets in the cruise plan.

http://cdf.u-3mrs.fr/~henry/marmara/marnaut_web/meeting1.html

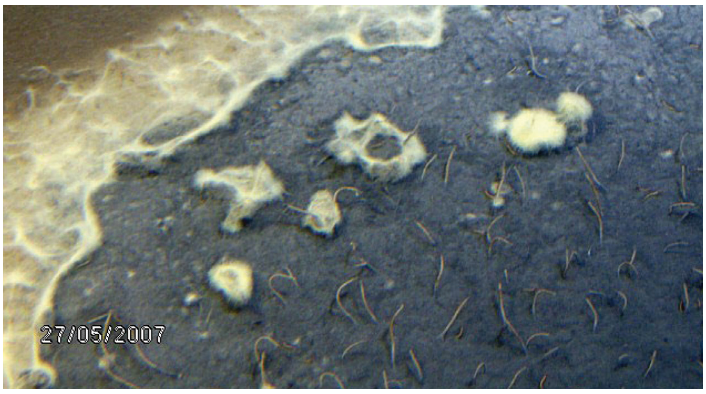

Fig.2b - Bacterial mat (white) and polychaetes tubes colonizing black sulphidic sediments.

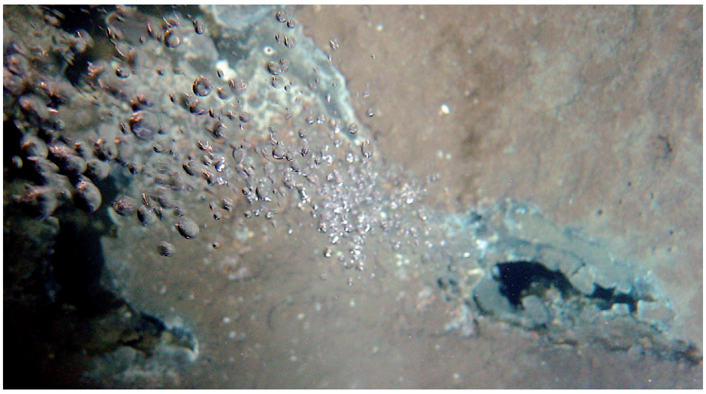

Fig.2c - Mantle He bubblig from tensional fracture, westeren Tekirdağ Basin

Fig.2d - Gas Hydrate burning on ship deck, which was recovered from Kullenberg core located on Western High

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