

Chapter 6

Preliminary Report on Underwater Survey in the Farasan Islands by the R/V Aegaeo, May–June 2013

Chapter 6

Preliminary Report on Underwater Survey in the Farasan Islands by the R/V Aegaeo, May–June 2013

Dimitris Sakellariou¹, Geoffrey N. Bailey^{2,3}, Garry Momber^{2,4}, Matthew Meredith-Williams^{2,5}, Abdullah M. Alsharekh⁶, Grigoris Rousakis¹, Ioannis Panagiotopoulos¹, Ioannis Morfis¹, Spyros Stavrakakis¹, Ioannis Pampidis¹, Panagiotis Renieris¹, Panos Georgiou¹, Stefanos Kalogirou¹, Prokopis Mantopoulos¹, Vassilis Stasinou¹, Manolis Kallergis¹, Leonidas Manousakis¹, Salem M. Al Nomani⁷, Maud Devès⁸

¹ Hellenic Centre for Marine Research, P.O. Box 712, 19013 Anavyssos, Greece Email: sakell@hcmr.gr

² Department of Archaeology, University of York, The King's Manor, York, YO1 7EP, UK

³ College of Humanities, Arts and Social Sciences, Flinders University, GPO Box 2100, Adelaide, SA 5001, Australia

⁴ Maritime Archaeology Trust, Room W/195, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, UK.

⁵ Department of Archaeology and History, La Trobe University, Bundoora, VIC 3086, Australia

⁶ Department of Archaeology, King Saud University, P.O. Box 2627, Riyadh 12372, Saudi Arabia.

⁷ Saudi Geological Survey, G.P.O. Box 54141, Jeddah, 21514, Saudi Arabia.

⁸ Laboratoire Tectonique, Institut de Physique du Globe, 4 place Jussieu, 75252 Paris, France

6.1 Aims and Cruise Objectives

The Farasan Islands cruise of the research vessel R/V AEGAEO (HCMR) is the first stage in a sub-project of DISPERSE (Work Package 3), concerned with offshore and underwater investigation of the submerged landscapes in the southern Red Sea. The Farasan Islands cruise is a joint mission with the Hellenic Centre for Marine Research (HCMR), Greece. The cruise took place between 29th May and 13th June, with a research team of 22 personnel from the HCMR, the University of York, King Saud University, King Abdul Aziz University and the Saudi Geological Survey, 20 of whom took part in the on-board activities (Appendix 1; Figure 1). This is a Cruise Report on the survey works accomplished and the achievements during the 2-week marine survey. The cruise took place between 29th May and 13th June.

DISPERSE – Dynamic Landscapes, Coastal Environments and Human Dispersals – is a 5-year (2011–2016) Advanced Grant (Agreement No. 269586), funded by the European Research Council under the ‘Ideas’ specific programme of the EU Seventh Framework Programme, with Prof. Geoff Bailey (University of York) as Principal Investigator, Prof. Geoffrey King (Institut de Physique du Globe de Paris) as co-Investigator, a small team of postgraduate and postdoctoral researchers funded by the project, and a wider team of participating international specialists, including Saudis, in archaeology, geochronology, geology, geophysics, tectonic geomorphology and palaeoclimatology. The project is concerned with a wide range of research including fieldwork in East Africa, Saudi Arabia and the Eastern Mediterranean. The Saudi Arabian work is a joint Saudi-UK project co-directed by Prof. Geoff Bailey (University of York), and Prof. Abdullah Alsharekh (King Saud University), in partnership with the Saudi Commission for Tourism and Antiquities.

The general aims of the cruise were as follows:

- Undertake a preliminary underwater survey of selected areas of the offshore continental shelf in the Farasan-Jizan region
- Reconstruct the broad outlines of the now-submerged landscape and identify specific locations that might have preserved archaeological evidence of past human settlement when sea level was lower than present, down to approximately the -120 m bathymetric contour – the approximate position of sea level at its maximum regression 20,000 years ago.

- These aims were realised through the following specific objectives and activities:
- Reconstruct specific features of the submerged landscape as it would have existed when sea levels were lower than the present, focusing on geological structure, geomorphology and topographic features such as hill and valley systems, drainage basins palaeoshorelines, stream channels, lake basins, spring lines, sediment-filled valleys, cliff lines, caves, and rockshelters, of potential significance for understanding the prehistoric landscape and its potential for human occupation
- Identify more localised features that might have been focal points for repeated human activity and the deposition and accumulation of archaeological materials such as stone tools and shell mounds, e.g. rockshelters, caves, undercut shorelines, flat areas close to stream channels and water sources, and elevated plateaux with good views over the surrounding terrain
- Select particular localities that might be rewarding for more detailed examination by diver investigation at a later phase of the DISPERSE project.
- Take measurements, sediment cores, and dating samples to provide data on the palaeoenvironment and new benchmarks for reconstructing a more detailed sea-level curve.

6.2 Target Areas and Locations

For the Farasan survey, we have selected general target areas so as to sample a number of different types of geological and environmental features on the seabed. Areas of particular interest are the shorelines that would have been formed at different sea-level stands during the glacial cycle, major valley systems and drainage channels, areas of topographic complexity that might have trapped sediment and water and provided ecological diversity and tactical advantage for prehistoric hunters and gatherers, and deep solution hollows resulting from the solution of salt deposits (evaporites), which would have formed potential traps for sediment and freshwater when exposed on the pre-inundation land surface. In the light of survey in these areas, we aim to identify more localised features for more detailed inspection.

Initial strategy included the target areas shown as black boxes on the hydrographic chart of Figure 2. This map was submitted along with the application form

for a permit from the Hydrographic Service of the Saudi Ministry of Defense.

With such a large potential area to cover, the DISPERSE team has studied the existing bathymetry available from satellite and chart data in York and Paris, particularly SRTM30PLUS data and standard navigational charts, to produce preliminary maps of the shelf area, and to define more specific target areas within the general area covered by our permit from the Ministry of Defense. These target areas have been defined in the light of what would be feasible within the constraints of our available time and resources (Figure 3). We have also used our knowledge of archaeological site locations on the mainland and on the Farasan Islands discovered in our previous fieldwork campaigns, on the assumption that these should provide a good analogy in the search for archaeological material on the submerged landscape.

- **Target Area 1:** Outer edge of shelf, expected to have relatively limited cover of later marine sediments over the original terrestrial land surface. Possibility of identifying the shoreline formed at the Last Glacial Maximum (at c. –120 m and 20,000 BP), of finding spring lines – often located at the foot of low cliffs and fault scarps – and of finding sediment-filled basins that show the transition from marine to terrestrial sediments in the early stages of sea-level rise.
- **Target Area 2:** An area with a major valley system and complex topography that appears to drain into a deep solution hollow. This could have been a freshwater trap at lowered sea level, and may contain a sediment sequence showing the transition from marine to terrestrial/lacustrine conditions with changing sea levels.
- **Target Area 3:** An area of complex topography close to the present-day Farasan Islands with a deep solution hollow.
- **Target Area 4:** Similar to Target Area 4.
- **Target Area 5:** An area showing the confluence of different drainage systems draining water and sediment from the Jizan mainland, and also an area of interest in defining the history of land connections between the mainland the Farasan Islands.
- **Target Area 6:** An area of complex topography and deep solution hollows between the outer shelf and the Farasan Islands, with palaeoshorelines potentially protected from exposure to the open sea. This is also an area that was

examined by deep-diving in 2006.

Within these general target areas, our objective is to obtain an overview of topography and geomorphology and to identify and examine local features, as described above.

6.3 Methodology and Survey Techniques

In the search for prehistoric archaeological sites on land, we know that three factors need to be taken into account: (1) the distribution of areas within a broader region that are especially attractive to the concentration of human population because of their general ecological and physiographic characteristics; (2) specific locations that are likely to act as a focus for repeated human activity and the deposition of artefacts and food remains such as shells because of highly localised features such as shelter, water supplies, raw materials for making stone artefacts, and concentrations or localised patches of food resources; (3) locations where archaeological material has been well preserved but is also sufficiently visible to be identified.

Similar principles apply to the search for underwater sites. The main differences are that it is much more difficult and costly to traverse and inspect at close quarters large areas of the seabed compared to survey on land, and that archaeological material is likely to be more vulnerable to destruction or dispersal during the course of inundation by surf action and vigorous marine currents in shallow water, or to burial by a thick overburden of marine sediments after inundation.

Nevertheless, we know from the successful survival and discovery of many hundreds of underwater prehistoric archaeological sites in other parts of the world that underwater material can survive inundation during sea level rise, either because its location is protected from the full force of wave action during inundation by local topographic conditions, because of partial burial in sediments that accumulate during the course of sea-level rise, or because of shallow gradients that moderate the destructive effects of wave action (Masters and Flemming, 1983; Flemming, 1998; Bailey and Flemming, 2008; Flemming et al., 2017).

Of course, factors of differential preservation and visibility apply almost as much, if not equally so, to site survey on dry land, requiring the development of predictive models and careful sampling strategies. Under water, these requirements apply with even more force. As on land, so in underwater survey it is essen-

tial – alongside the application of judgemental searches and opportunistic hunches – to develop a systematic methodology of exploration, which can be applied in a staged manner from the general examination of regional characteristics to the localized search for individual sites, and a systematic record of the results, including a photographic record, details of survey methods, transects, locations and time spent in exploration, and curation of a digital archive, so that the survey results can be evaluated independently by others, and serve as a foundation for future work (see Devès et al., 2013).

The marine survey conducted in the Farasan area aboard R/V AEGAE0 comprised a wide variety of geological-geophysical techniques (Figure 6.4):

1. Swath bathymetry (multi-beam) mapping was performed by using two hull-mounted multi-beam systems (20kHz and 180 kHz) operating simultaneously.
2. High-resolution sub-bottom profiles were acquired with a 3.5 kHz pinger to obtain precise images of the structure and stratigraphy at shallow depths (<20 m) below the seafloor.
3. Mapping of the acoustic character of the seafloor was implemented by using a deep-towed, 110/410 kHz, digital side scan sonar. Acoustic images (sonographs) of the seafloor helped to better understand the various structures exposed on or developed on the seafloor.
4. Deep penetrating seismic profiles were recorded with a 10 cubic inches air-gun. Penetration of the profiles reached locally >500–800 m below the seafloor and provided insight into the geological and tectonic structure of the surveyed area.
5. Gravity cores, 3–5m long, were used for coring and sampling the subseafloor sedimentary layers.
6. A box core, 40 x 40 x 60 cm, was used to take undisturbed samples of the topmost seafloor sediments.
7. A CTD device was used to obtain vertical profiles of the physical parameters of the seawater column (sound velocity, temperature, salinity, density, conductivity). The sound velocity profile was entered into the swath bathymetry software to calculate precisely the water depth.
8. A remotely operated vehicle (ROV) was used for underwater missions at

sites identified from the bathymetric, acoustic and profiling data, aimed at inspecting visually seafloor structures of palaeo-morphological or archaeological interest.

Our survey strategy during the Farasan cruise followed the methodology below:

Within each target area the general approach adopted was to conduct swath bathymetry at 9 knots cruising speed in contiguous and slightly overlapping transects, in order to produce a continuous digital elevation model (DEM) for all or selected parts of the target area. This gave an immediate overview of the general topography of the seafloor (Figure 6.5).

Transect lines were then identified for the deployment of the sub-bottom profiler, to obtain high-resolution profiles of the stratigraphy and the sedimentological and geological structure of the shallow substrate of the seafloor and to locate sediment-filled depressions suitable for coring (Figure 6.6).

The side-scan sonar was deployed simultaneously with the sub-bottom profiler to provide more detailed 3-D information on topographic features and the acoustic character and nature of the seafloor in a narrow corridor either side of the transect line (Figure 6.6).

Air-gun seismic survey was also conducted, in order to provide deeper penetrating seismic profiles of the geological structure, showing features such as faulting and layering that can help to identify the nature of the bedrock and structural and geomorphological alterations caused by tectonic activity or other processes (Figure 6.4).

Shorter transects were run over areas of particular interest in order to narrow down the search for local features of particular potential significance, where ROV inspection could provide additional information including collection of seabed samples.

Sub-bottom profiling, side scan sonar prospecting and airgun seismic profiling were performed at 4 knots cruising speed.

The scheduling of work and the choice of areas for running continuous transects was also determined by the need to choose areas for night-time work that avoided hazards best dealt with during daylight hours, such as variable and shallow bathymetry, and local fishermen and their nets. Coring was also best done early in the morning or late in the evening when temperatures were cooler.

Coring sites were identified on the high resolution sub-bottom profiles. The selection of precisely located coring sites served the need for understanding the nature of the seafloor sediments and aimed at reaching the oldest possible layers below the recent Holocene marine drape (Figure 6.3).

6.4 Research equipment

6.4.1 Research Vessel “AEGAE0”

The cruise was conducted aboard the HCMR owned research vessel “AEGAE0” (Chalkis 19 Ship Registry). R/V AEGAE0 was built in 1985 at the Chalkis shipyard and started her scientific operations in the Eastern Mediterranean. In 1987 the scientific expeditions extended to the western Mediterranean Sea. It was refitted in 1997 and comprises a completely modernized floating laboratory, equipped with state of the art technology, able to support HCMR’s multidisciplinary research projects and operations. R/V AEGAE0 is the mother ship for the submersible THETIS and the ROVs (Remotely Operated Vehicles) Max Rover and Super Achilles (Figures 6.7 and 6.8).

R/V AEGAE0 is a dedicated research vessel equipped for underwater research in all aspects of marine science including oceanography, marine biology, geology and underwater archaeology. The ship is 62m long and 173 tonnes weight, with a crew of 21, on-board scientific laboratories, and accommodation for up to 21 scientific personnel. It is equipped for this cruise with remote sensing and coring equipment including hull-mounted multi-beam (for swath bathymetry), a tow-fish with side-scan sonar, a sub-bottom profiler, an air gun for deep-penetrating seismics, a gravity corer for sediment sampling, the Max Rover ROV equipped with lights and cameras, and GPS recording equipment. Normal cruising speed is 9 nautical miles per hour (9 knots) when conducting swath bathymetry, and 4 nautical miles per hour (4 knots) when conducting higher resolution measurements using side-scan sonar and sub-bottom profiling. Underwater measurements are continuously recorded, and converted into digital maps and images that are displayed on computer monitors in real time. The ship is organised to operate continuously 24 hours per day, with shift working by the crew and by the scientific team, to ensure continuous measurement and monitoring of equipment, and maximum coverage, with stoppages only to deploy and retrieve underwater equipment and to undertake sediment coring.

6.4.2 Detailed Specifications

Name:	AEGAEO
Built:	1985
Classification Society:	American Register
Class:	+H100 A1 R
Type:	Marine Research Vessel
Length:	61.51 m
Breadth:	9.60 m
Draft:	2.9 m
GT:	778 tons
Fuel capacity:	80 tonnes
Consumption:	6 tonnes/day
Cruise speed:	12 knots
Autonomy:	20 days
Main Engines:	2 x 950 BHP MAN B&W 20/27 VO
Bow Thrusters:	Schottel ski-87 unit, 2 knots/hr
Propellers:	2 x twin V.P.P.
Generators:	2 x MAN 331 Kw/370 KVA (296 Kw) 450 BHP
Emergency generator:	1 x MAN DO2006ME 46 Kw / 62.5 BHP / 45 KVA - 36 Kw

Navigation Equipment

Autopilot: 1 A/P NECO 728, D-GPS TRIMPLE, GPS NORTH STAR 941X, gyrocompass SPERRY, 1 magnetic compass SH-165-A, 1 Furuno 96 mil. and 1 RACAL DECCA 96 mil. radar, electronic chart system TELECHART 2026, echo sounders OCEAN DATA BATHY 1000 & FURUNO FE824ET, log Doppler SIM-RAD NL, INMARSAT-C, NAVTEX NMR 108.

6.4.3 Swath Bathymetry – Multi-Beam

Multi-beam or swath bathymetry sonars transmit a broad acoustic pulse from specially designed transducers across the full swath across the track. The swath width is determined by the depth of the seafloor being surveyed. The ping is emitted in a fan shape outward from the transmitter. If the speed of sound in the water column is known, the depth and position of the return signal can be determined from the receive angle and the two-way travel time. In order to determine the transmit and receive angle of each beam, a multi-beam echosounder requires accurate measurement of the motion of the sonar (heave, pitch, roll, yaw, heading).

The sound frequencies used in multi-beam usually range from 12 to 500 kHz. A higher frequency device provides better resolution and accuracy than a lower frequency one for a certain water depth. Multi-beam sonars can provide highly accurate charts of the bottom bathymetry. The accuracy will depend not only on the frequency but also on the precision of the position of the transducer and the precision of the sound speed. In general the latest multi-beam sonars have a horizontal resolution in the decimeter range, in some cases even up to the centimeter-range in shallow water depths.

R/V AEGAEO is equipped with two, hull-mounted, multi beam systems: 1) SeaBeam 2120, 20kHz and 2) Seabeam 1180, 180kHz. Both systems have been used for the acquisition of swath bathymetry data during the Farasan cruise.

6.4.4 SeaBeam 2120

is a multi-beam system for complete swath bathymetry survey in deep and shallow water depths. It is based on a cross-fan beam-forming technique employing Mills Cross-type T-shaped arrays (transmitter and receiver arrays) and electronically steering sound beams in a fan-shaped plane. The transmitter array (Figure 6.9) is mounted along the vessel's hull, and transmits echo signals (pings) in the form of downward fanning beams (swath). The receiver array (hydrophones, Figure 6.10) is mounted perpendicular to the transmitter array projectors, and therefore receives multiple reflections representing seafloor pixels which are aligned parallel to the ship-track (along track) and narrow ones perpendicular to it (across-track). Thus, each received beam comprises only echo signals lying within that area where transmit and receive beams intersect (Figure 6.11). Taking all receive beams together, a complete cross-section of the bottom, perpendicular to the di-

rection of the vessel travel (across-track), is measured on each ping cycle. Ping cycles, bottom depth and other information related to the returned signals are displayed on an operator control station (OCS), whilst real-time viewing of the sea floor characteristics is accomplished.

The array elements have short pigtail cables with wet mateable connectors, which interface through the hull to the dry side. System electronics are contained within a single cabinet (Figure 6.12).

The SeaBeam 2120 system is supported by the L3 ELAC NAUTIK, located at Kiel, Germany, and its technical characteristics are referred to below:

- Operating frequency of 20 kHz.
- Optimum performance within 100-5500 m.
- 149 beams (maximum), beam width 2 degrees or less. The transmitter array comprises fourteen transmitters and the receiver array eight 8-element hydrophones.
- Maximum swath width of 148 degrees. The swath coverage may range from ~750 to ~6500 m (depending on the water depth).
- Measured depth error lies within 0.5% of the actual water depth.
- Horizontal position error lies within ± 5 m depending on the accuracy of the GPS.
- Optimum vessel speed during acquisition is 4 to 6 knots.
- The system fulfils the standards for hydrographic surveys of the International Hydrographic Organization (IHO).

The 180 kHz SeaBeam1180 multi-beam system (L3 ELAC Nautic) has been designed for operation at water depths down to 500 m and transmits 126 beams arrayed over a maximum arc of 153° . The acoustic signal is transmitted and, subsequently, received by two transducers, hull mounted and fixed symmetrically at 52° from the vertical axis perpendicular to the ship's length. The spacing between soundings (beam footprint) is a function of received beam width, water depth and beam incidence angle, resulting in beam dimensions of $1.2^\circ \times 1.2^\circ$. The swath coverage may range from ~600 to ~1000 m, depending on the water depth (Figure 6.13). A TSS/DMS (Teledyne) motion sensor is used to compensate for the vessel's motion (i.e., roll, pitch and heave) during transmit and receive cycles with an accuracy of $\sim 0.05^\circ$ for the roll and pitch and ~ 5 cm for the heave. Finally, the

measured depth error lies within 0.5% of the actual water depth.

Acquisition of swath bathymetry data requires accurate sound-velocity profiles of the water-column. For that, a CTD system (Sea Bird E-9 with dissolved oxygen probe and Sea-Tech transmission-meter) (Figure 6.14) has been used during the cruise and multiple sound-velocity profiles have been measured at different stations and on different time-points.

6.4.5 High-Resolution Sub-bottom Profiler

The conventional echosounders (also called ‘pingers’) are single frequency sub-bottom-profilers. They employ a signal with a narrow bandwidth (= a narrow ‘peak’) normally within the range 3–10 kHz (Figure 6.15).

Vertical resolution achieved by high-resolution sub-bottom profilers ranges typically between 20 to 50 cm, while the maximum penetration rarely exceeds 30 to 50 m in soft, fine-grained sediments and is significantly lower in coarse-grained sediments. The fact that the transducer is also used as a receiver allows for a higher precision in the horizontal positioning of features observed than if the reflected signal was picked up by a separate hydrophone array located some distance away from the source.

High-resolution sub-bottom profiles have been obtained during the Farasan cruise utilizing a 3.5kHz sub-bottom profiler of GEOACOUSTICS LTD (U.K.) with a 4 transducer towing vehicle (fish) (Figures 6.16 and 6.17). The expected maximum sub bottom penetration is about 15–20 m in a muddy bottom with a vertical resolution of 0.2–0.8 m.

6.4.6 Side-scan Sonar

Side-scan sonars emit conical or fan-shaped pulses across a wide angle perpendicular to the path of their towed sensors (‘towfish’). The received signals create a detailed image of the reflectivity of the sea floor (“sonograph”) and its anomalies within the swath (coverage width) of the beam. The reflectivity of the seafloor depends on its roughness and the nature of the topmost material: coarse-grain sediments display higher reflectivity than fine-grain deposits, rocky outcrops reflect higher than sediments, etc.

Side-scan sonars are very useful for mapping archaeological features that are

visible on or above the bottom (wrecks, exposed pole and rock structures, etc.) They are unable to penetrate the sediments and can therefore only provide information about the exposed surface of the sea floor. Normally frequencies between 100 and 1000 kHz are used. Higher frequencies yield better across-track resolution (perpendicular to the direction of movement) but involve a narrower swath. Depending on the frequency of the emitting signal, a resolution of up to a few centimetres can be achieved. Along-track resolution (parallel to the direction of movement) depends on the cruising speed and the triggering rate of the emitted signal. Slow cruising speed and high triggering rates enable higher resolution along track.

Side-scan sonar survey of the seafloor in the Farasan area has been conducted using a 110–410 kHz digital side-scan sonar (Geoacoustics Ltd, U.K.) with towing coaxial cable of 2,000 m (Figure 6.18). The dual frequency operation provides high-resolution imaging (when scanning in 410 kHz). The side-scan sonar system consists of the tow fish, the electro-hydraulic winch with the tow-cable, and the deck unit, which hosts the data acquisition and image processing unit. Side-scan sonar data were digitally acquired by using the SonarWiz Map software of Chesapeake Technology Inc. (Canada). Real time and post-acquisition raw-data mosaics were produced and used during the cruise to better understand the nature of the seafloor and locate sites for visual inspection with the remotely operated vehicle (Figure 6.19).

6.4.7 Seismic Profiling

Seismic profiling during the Farasan cruise was conducted with the use of an Air Gun (Bolt, USA) seismic profiling system (Figure 6.20). An air chamber of 10 in³ volume and air pressure of 2000 psi was used. A Sauer Compressor Type WP4351 (J.P. SAUER & SOHN, DE) was used for the supply of compressed air to the airgun chamber.

This configuration produces a sound signal with a frequency between 40–250 Hz and provides penetration of up to 1 second two-way travel-time (>750 m) in sedimentary deposits.

The reflected signal was received by a SIG (FR), Model 16.48.65 streamer, of 65m active length, and 48 hydrophones (1m spacing). The SBLogger seismic acquisition software (Triton Imaging, USA) was used for the acquisition of the seismic data and the SBInterpreter software was used for post-processing the seismic

profiles (Figure 6.21).

6.4.8 Gravity and Box Coring

Gravity coring was carried out with a BENTHOS-type gravity corer with core barrels 3 to 5 m long (Figure 6.22). Box coring was carried out with a box corer with a 40x40x60 cm box (Figure 6.23).

6.4.9 Remotely Operated Vehicle (ROV) Max Rover

The remotely operated vehicle (ROV) Max Rover was used during the cruise for the visual identification of selected side-sonar targets. Max Rover was purchased in 1999 and upgraded in 2011. It is rated for 2000 m depth, and is a working class ROV (Figures 6.24 and 6.25).

6.4.10 Detailed Specifications

Constructor: Deep Sea Systems International Inc. (USA)

Type: Max Rover Mark II

Maximum depth: 2000 m

Weight: 850 kg

Length: 2.2 m.

Width: 0.90 m

Height: 2.2 m

Payload: 50 kg

Flotation: syntactic foam floatation

Power: ROV 14kW, 220V

Hydraulic winch: 380 V, 25 hp, slip ring assembly, dimensions 2 X 2 : 2 m., 4.5 tonnes.

Tow cable: fibre optics cable 2200 m.

Motos: 6 electrical motors : 2.0 hp, internal, brushless, DC

Speed: 1.0 knot (horizontal), 1.5 knots (vertical)

Lifting capacity: 160 kg.

Autopiloting: direction, depth, height above seafloor

Positioning: Trackpoint II USBL,- LinkQuest-Tracklink 10.000 m
Positioning system & georeferencing through Hypack Max software

Sonars: Tritech Dual Frequency Scanning Sonar (675/1200 kHz) &
Tritech Side-Scan Sonar (910 kHz)

Cameras: 3 Color CCD video cameras (wide angle, pan & tilt, macro-
zoom pan & tilt), 2 full HD video cameras, digital Still Camera (3.2
Mpixel, 1Gb) with 4 π lasers.

Scaling: two red Laser beams 10 cm apart.

Lights: 4 100 W HID lights 4 X 150 W Quartz lights

Arms: two electro-hydraulic arms Hydrolek of 5 degrees of freedom

Mother ship: R/V AEGAEO

6.5 Cruise achievements

R/V Aegaeo sailed from Jeddah early in the morning of Thursday, May 30th and arrived in the Farasan area in the morning of Friday, June 1st. Research work lasted till the evening of Monday, June 10th. During the 12 days of survey, two main areas (FARASAN 1 and FARASAN 2) were systematically surveyed with all the techniques described above (Figure 6.26). In addition, two seismic transects (TRANSECT 1 and TRANSECT 2) were conducted with the use of Airgun and multi-beam. In total, about 450–500 square kilometers of the seafloor have been mapped with the multi-beam systems. A total length of 170 nautical miles (315 km) of airgun seismic profiles has been acquired in areas FARASAN 1 and FARASAN 2 and along TRANSECT1 and TRANSECT 2. A total length of 250 nautical miles (460 km) of 3.5kHz sub-bottom profiles has been acquired in areas FARASAN 1 and FARASAN 2, and a total length of 140 nautical miles (260 km) of side-scan sonar tracks at 200 m and 100 m swath in both areas. We have also recovered 18 gravity cores and 2 box cores from areas FARASAN 1 and FARASAN 2. Finally, 5 dives of the remotely operated vehicle Max Rover took place with a total duration of 10 hours and 25 minutes.

Preliminary results of the cruise are presented in brief here. Final conclusions

and results are expected in the next months, after thorough processing of the acoustic and geophysical data obtained and interpretation of the acoustic and seismic profiles as well as after the completion of laboratory analyses and dating of the sediment cores.

6.5.1 Survey area FARASAN 1

FARASAN 1 survey area is located on the outer edge of the continental shelf, northwest of the Farasan Islands (Figure 6.27).

The objectives of the survey included the following:

1. Understanding the role of tectonics in the shaping of the general geological structure of the outer continental shelf and therefore in the development of the submerged prehistoric landscape.
2. Mapping submerged terraces as indicators of paleo-sealevels during previous periods in the Pleistocene
3. Mapping recent sedimentary deposits covering the submerged landscape
4. Investigating the seafloor to locate landscape features suitable for prehistoric habitation
5. Sampling of sedimentary deposits for paleo-oceanographic analyses.
6. Visual inspection of the seafloor for paleo-sealevel indicators and possible traces of prehistoric human and animal presence.

Characteristic examples of high-resolution sub-bottom profiles and airgun seismic profiles are shown in Figures 6.28 and 6.29 respectively. Ten cores have been recovered from the FARASAN 1 area. Figure 6.30 shows a typical side-scan sonar image of coral reefs developed on the 80m terrace, and Figure 6.31 a detail of the deep shelf photographed by the ROV.

Preliminary interpretation of the collected data shows the presence of two prominent terraces at about 75–80 m and 38–40 m depth and one more terrace at 120m depth observed locally along the outer slope.

Preliminary results allow us to suggest that during lower sea-level periods several lakes existed on the 80 m platform of the outer continental shelf. We suspect that some of the recovered cores have penetrated the Holocene marine drape and reached the lacustrine sediments deposited in these lakes. Laboratory analyses on these cores will be performed after the cruise.

6.5.2 Survey area FARASAN 2

FARASAN 2 survey area is located in the inner part of the continental shelf, north of the Farasan Islands. The continental shelf is characterized by shallow platforms at 70–75m depth and numerous deep sinkholes, presumably formed by the dissolution of evaporite deposits.

The FARASAN 2 area includes one deep sinkhole (>200 m depth) and one NW–SE trending, elongate, 120 m-deep basin.

The objectives of the survey in this area included the following:

1. To investigate if the deep sinkhole and the elongate basin were transformed into isolated lakes during low sea-level periods
2. To understand the role of tectonics in the creation of the sinkholes and basins on the shallow platform and map possible faults.
3. To map submerged terraces as indicators of paleo-sealevels during Pleistocene low sea-level periods
4. To map recent sedimentary deposits covering the submerged landscapes
5. To investigate the seafloor and locate landscape features suitable for prehistoric habitation
6. To sample sedimentary deposits for paleo-oceanographic analyses.
7. To inspect visually the seafloor for paleo-sealevel indicators and possible traces of prehistoric human and animal presence.

An overview map of the FARASAN 2 survey area is presented in Figure 6.32. Figure 6.33 shows the backscatter obtained from the multi-beam system for the northern half of the FARASAN 2 area.

Characteristic examples of high-resolution sub-bottom profiles and airgun seismic profiles are shown in Figures 6.34 and 6.35 respectively. Eight cores have been recovered from the FARASAN 1 area.

Preliminary interpretation of the collected data shows the presence of one prominent terrace at about 70–75m depth on top of which coral reefs have been developed, forming circular, up to 10–15m high mounds. One more terrace has been mapped along the flanks of the elongate basin at about 112m depth. Figure 6.36 shows the side scan sonar mosaic obtained from this terrace and Figure 6.37 the

use of the ROV to collect a sample of coral from the seabed.

Preliminary results allow us to suggest that during lower sea-level periods several lakes existed on the 80 m platform of the outer continental shelf. Gravity coring in the 120 m deep elongate basin penetrated the Holocene marine drape and reached its substrate. Short cores indicate that gypsum deposits form the floor of the depressions. Laboratory analyses on these cores will be performed after the cruise.

6.6 Conclusions

No firm conclusions about the interpretation of the observations made during the cruise should be drawn at this time. The acoustic data needs much processing work before it can be used to produce final maps, and the sediments from the cores need to be extracted, described, examined, and subjected to a variety of palaeoenvironmental and geochronological analyses in the laboratory. The major stages of this work will take place in the laboratories of the HCMR in Athens in the coming months, with sediment samples made available to the Saudi Geological Survey, and to other members of the DISPERSE team in the UK and Australia. The acoustic data will be made freely available to the Department of Hydrography. No archaeological material has yet been recovered and it is unlikely (though not impossible) that artefacts will be found in the sediment cores. Nevertheless, preliminary indications suggest that the cruise has been successful in meeting its principal objectives. This is one of the first attempts anywhere in the world to apply a suite of underwater techniques to the purposeful and systematic exploration of a submerged land surface across the whole depth range of the continental shelf exposed at maximum lowering of sea level. Our strategy of investigation, and the techniques we have used to implement it, have proved a successful starting point, and have clarified ways in which improvements in approach and the deployment of additional technologies can be applied in future work. It is clear that a landscape with interpretable features of geological structure, geomorphology, topography, and potential for human settlement lies now submerged on the extensive shelf region surrounding the Farasan Islands, and that this forms a promising basis for future investigations.

Acknowledgements

This research is funded through a five-year research grant (2011–2016) to G. N. Bailey and G.C.P. King from the European Research Council (ERC) as Advanced Grant 269586 ‘DISPERSE: Dynamic Landscapes, Coastal Environments and Human Dispersals’ under the ‘Ideas-specific’ Programme of the 7th Framework Programme (FP7). We thank the Hydrographic Department of the Saudi Ministry of Defense, and HRH Crown Prince Salman bin Abul Aziz Al Saud, Minister of Defense, for granting permission to undertake the cruise. We also thank HRH Prince Sultan bin Salman bin Abdul Aziz al Saud, President of the Saudi Commission for Tourism and Antiquities (SCTA), Dr Ali Al Ghabban, Vice-President, and Jamal S. Omar, Director General, for their continued support of our work. We thank Professor Costas Synolakis, President of HCMR, Dr. Vassilis Lykousis, Director of the Institute of Oceanography, HCMR, and Dr. Vangelis Papathanassiou, HCMR, for supporting the expedition. We also thank the personnel of SETE, in particular Captain Costas Papaliolios, for their untiring efforts in ensuring the successful implementation of the cruise, and Professor AbdulAziz Suwailem of KAUST for his valuable cooperation. We are grateful to Lt Fahad Al Shwish, Observer from the Hydrographic Department of the Saudi Ministry of Defense, for his support and his valuable assistance in overcoming unexpected logistical difficulties during the cruise. Last but not least, we thank Captain Theodoros Kanakaris and the crew of R/V Aegaeo for their untiring efforts to ensure the smooth running of the scientific operation and for supporting the research team throughout the survey work conducted during the cruise, This is DISPERSE contribution no. 52..

References

- Bailey, G.N., Flemming, N.C. 2008. Archaeology of the continental shelf: marine resources, submerged landscapes and underwater archaeology. *Quaternary Science Reviews* 27 (23–24): 2153–65.
- Bailey, G.N., King, G.C.P., Devès, M., Hausmann, N., Inglis, R., Laurie, E., Meredith-Williams, M., Momber, G., Winder, I., Alsharekh, A., Sakellariou, D. 2012. DISPERSE: dynamic landscapes, coastal environments and human dispersals. *Antiquity* 86 (334). <http://antiquity.ac.uk/projgall/bailey334/>.
- Bailey, G.N., Sakellariou, D. & members of the SPLASHCOS network. 2012. Submerged prehistoric archaeology & landscapes of the continental shelf. *Antiquity* 86 (334). <http://antiquity.ac.uk/projgall/sakellariou334/>.
- Devès, M.H., Inglis, R.H., Meredith-Williams, M.G., Al Ghamdi, S., Alsharekh, A.M., Bailey, G.N. 2013. Palaeolithic survey in southwest Saudi Arabia: methodology and preliminary results. *Adumatu* 27: 7–30.
- Flemming, N.C. 1998. Archaeological evidence for vertical movement on the continental shelf during the Palaeolithic, Neolithic and Bronze Age periods. In Stewart, I. S. and Vita-Finzi, C. (eds) *Coastal tectonics*. London, Geological Society Special Publications 146, pp. 129–46.
- Flemming, N.C., Harff, J., Moura, D. Burgess, A., Bailey, G.N. (eds). 2017. *Submerged landscapes of the European continental shelf : Quaternary palaeoenvironments*. Chichester: Wiley-Blackwell.
- Masters, P.M., Flemming, N.C. (eds). 1983. *Quaternary coastlines and marine archaeology*. London and New York: Academic Press.

Figures



Figure 6.1: The research team with Captain Kanakaris aboard the R/V Aegaeo in Jeddah Port at the end of the cruise.

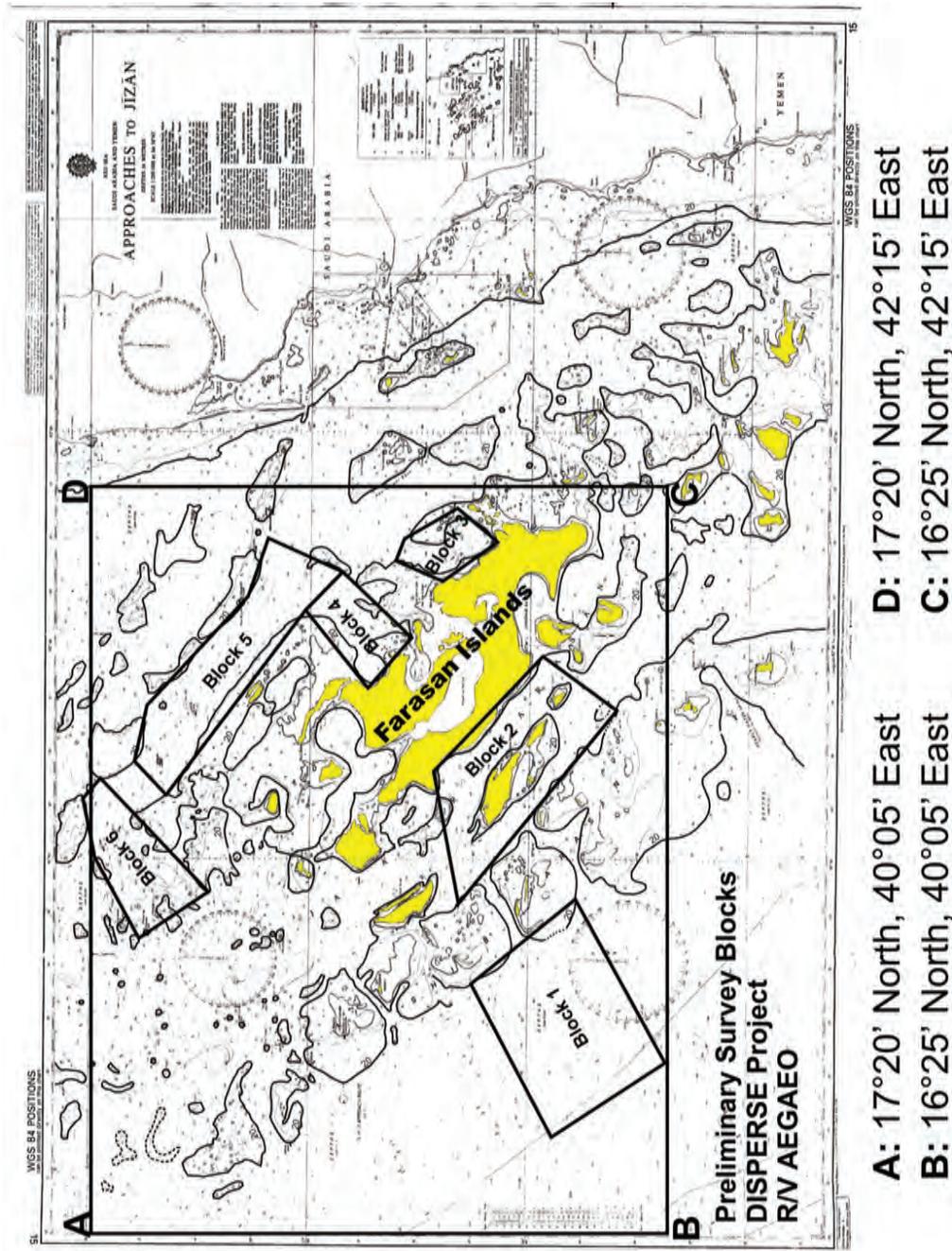


Figure 6.2: Preliminary target areas (Blocks 1 to 6) within the bigger box A-B-C-D included in the application form for a permit from the Hydrographic Service of the Saudi Ministry of Defense. Chart annotated by D. Sakellariou.

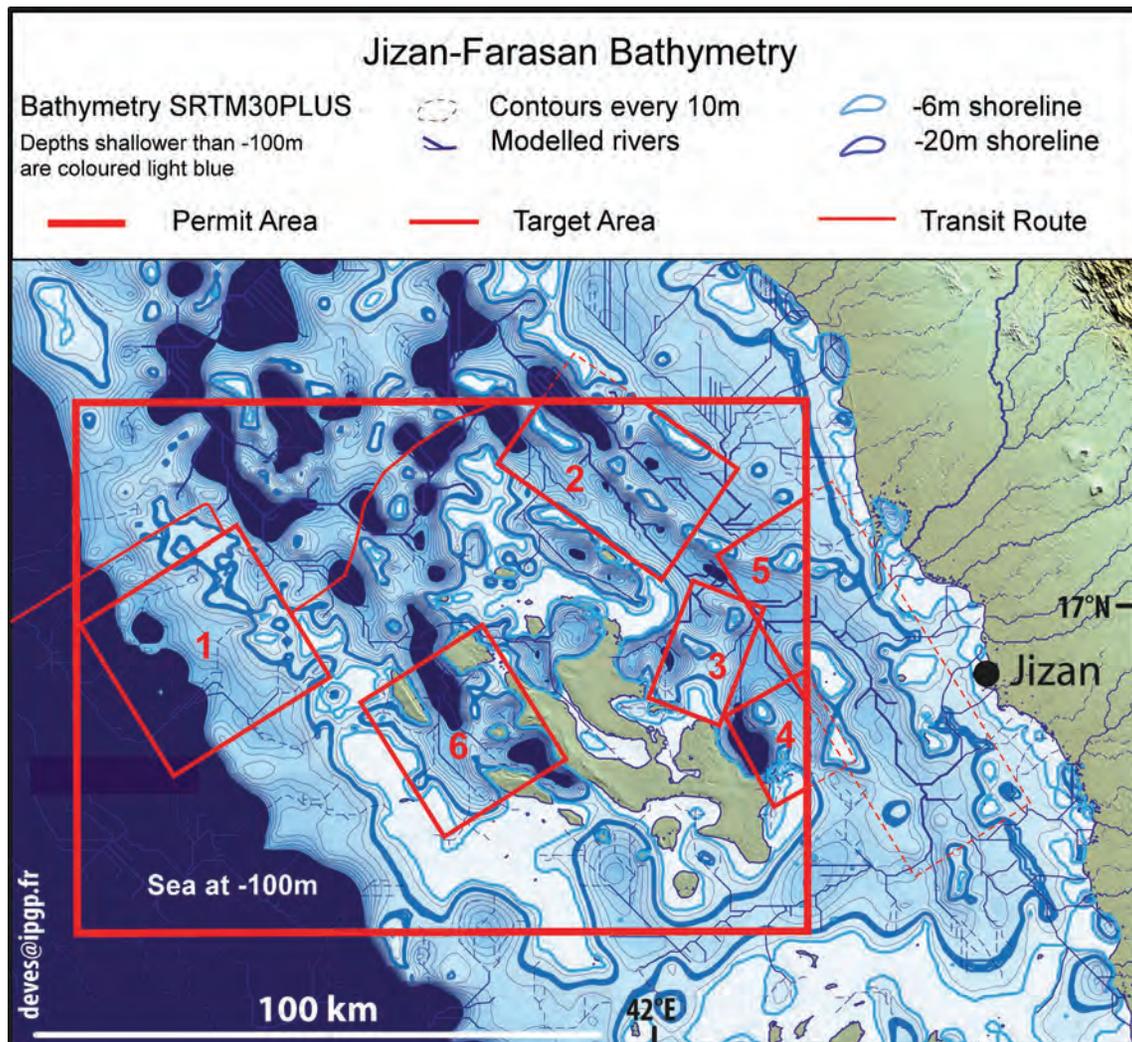


Figure 6.3: General overview of shelf bathymetry in the Farasan region, showing Target Areas for more detailed survey. Note the large number of very deep basins on the shelf area, presumably representing solution of evaporites. When sea level was low, these would have represented deep and steep-sided basins in the terrestrial landscape, with the potential to accumulate freshwater and bottom sediments with a palaeoenvironmental record of terrestrial or lacustrine conditions. When sea level rose, the sea would have entered these basins, leading to the accumulation of marine sediments stratified above earlier material, providing the possibility of dated sea-level index points for sea-level rise. Base map prepared by Maud Devès, IPGP.

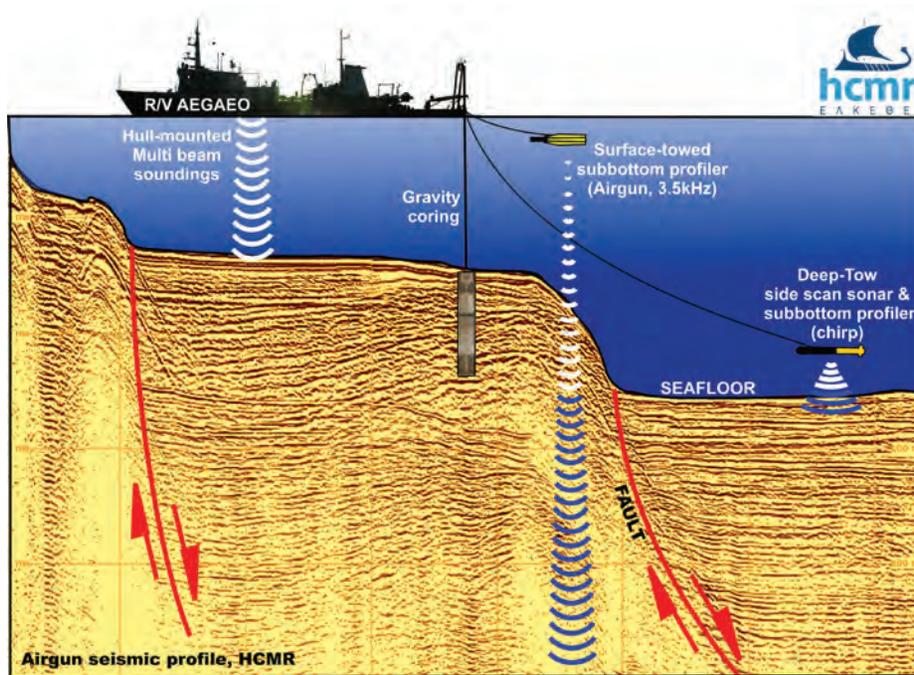


Figure 6.4: Schematic presentation of the marine geological-geophysical techniques applied during the Farasan research cruise aboard R/V AEGAEO.

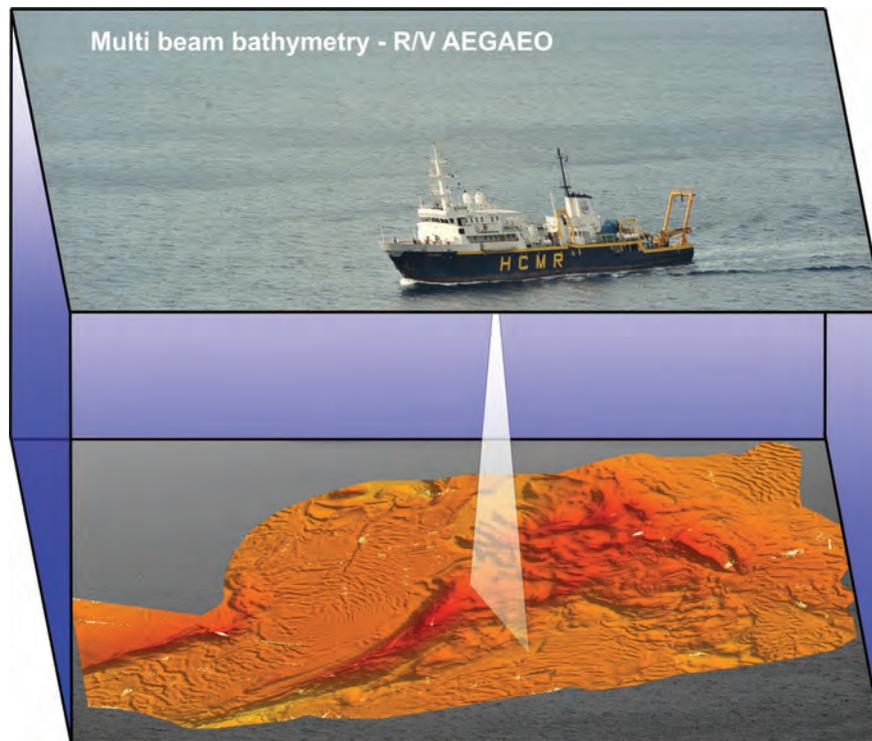


Figure 6.5: Schematic presentation of the swath bathymetry survey conducted aboard R/V AEGAEO in the Farasan area.

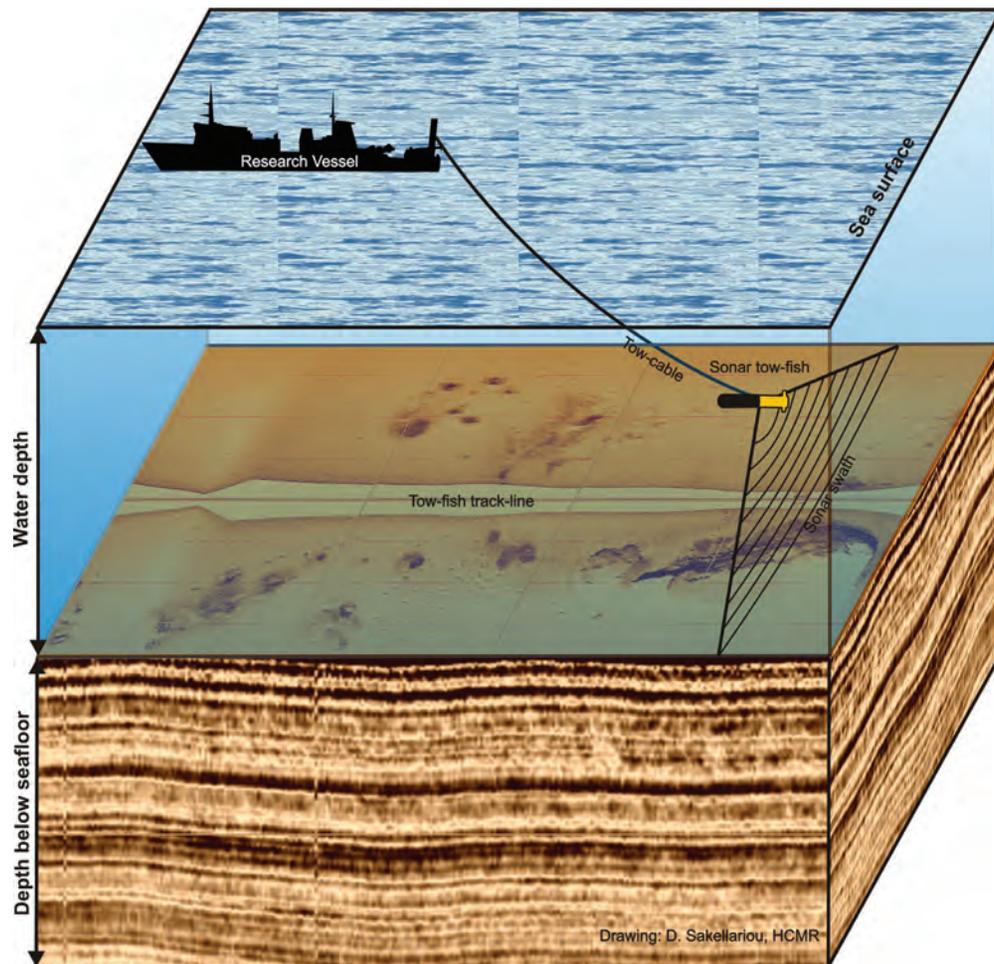


Figure 6.6: Schematic presentation of the side scan sonar and sub-bottom profiling survey conducted aboard R/V AEGAE0 in the Farasan area.



Figure 6.7: HCMR research vessel AEGAE0 birthed in Jizan port.

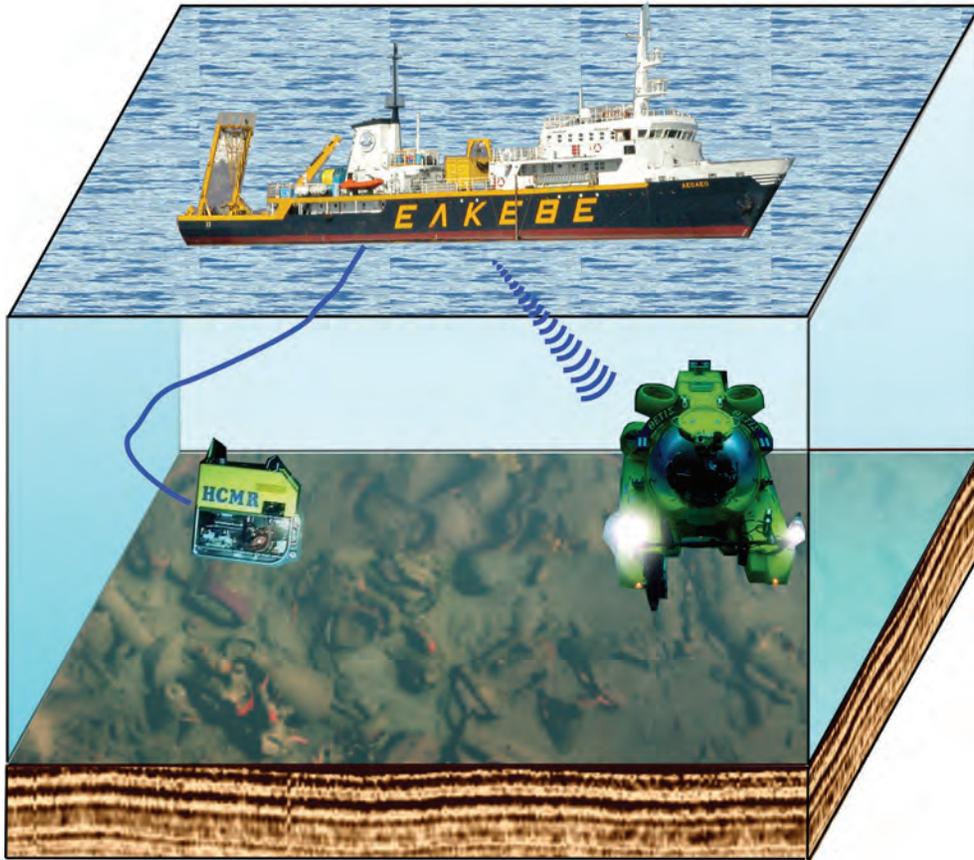


Figure 6.8: Schematic presentation of underwater vehicles (ROV, submersible) operating from R/V AEGAEO.

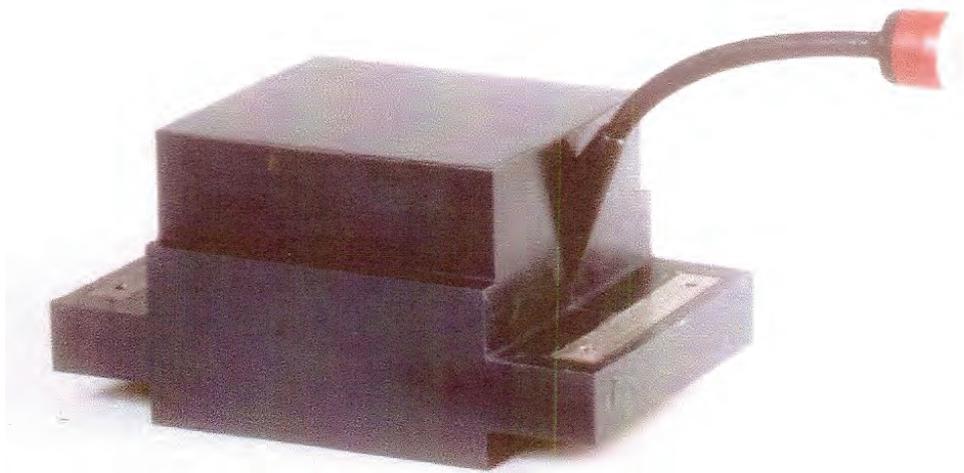


Figure 6.9: The transmitter (projector) of the SeaBeam 2120 multi-beam system.



Figure 6.10: Hydrophone of the SeaBeam 2120 multi-beam system.

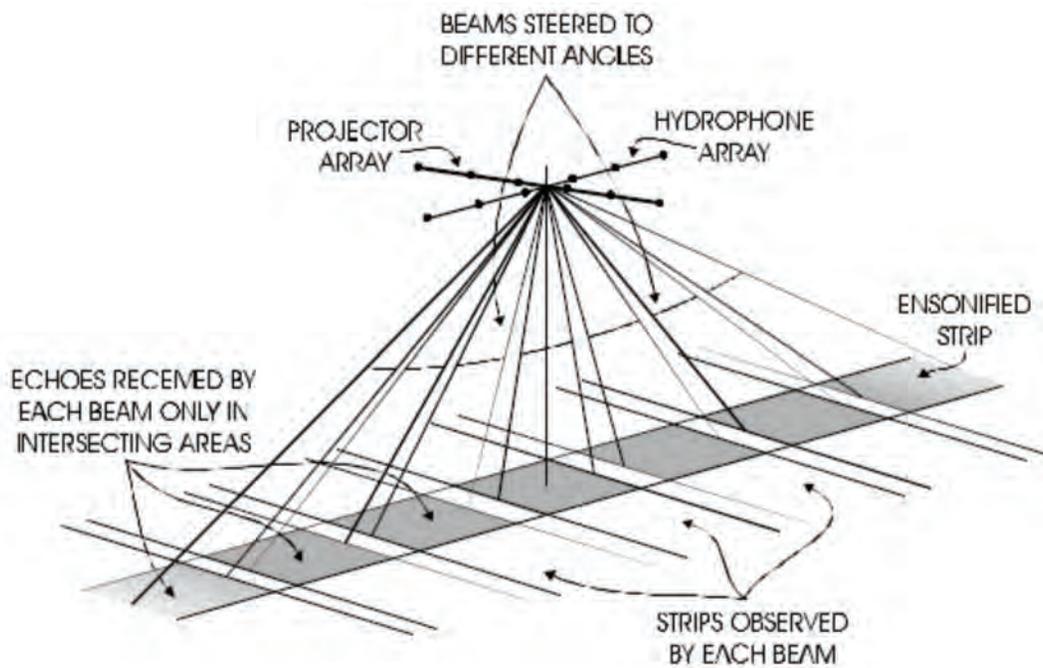


Figure 6.11: Cross-fan beam-forming technique.



Figure 6.12: SeaBeam 2120 system electronics cabinet.

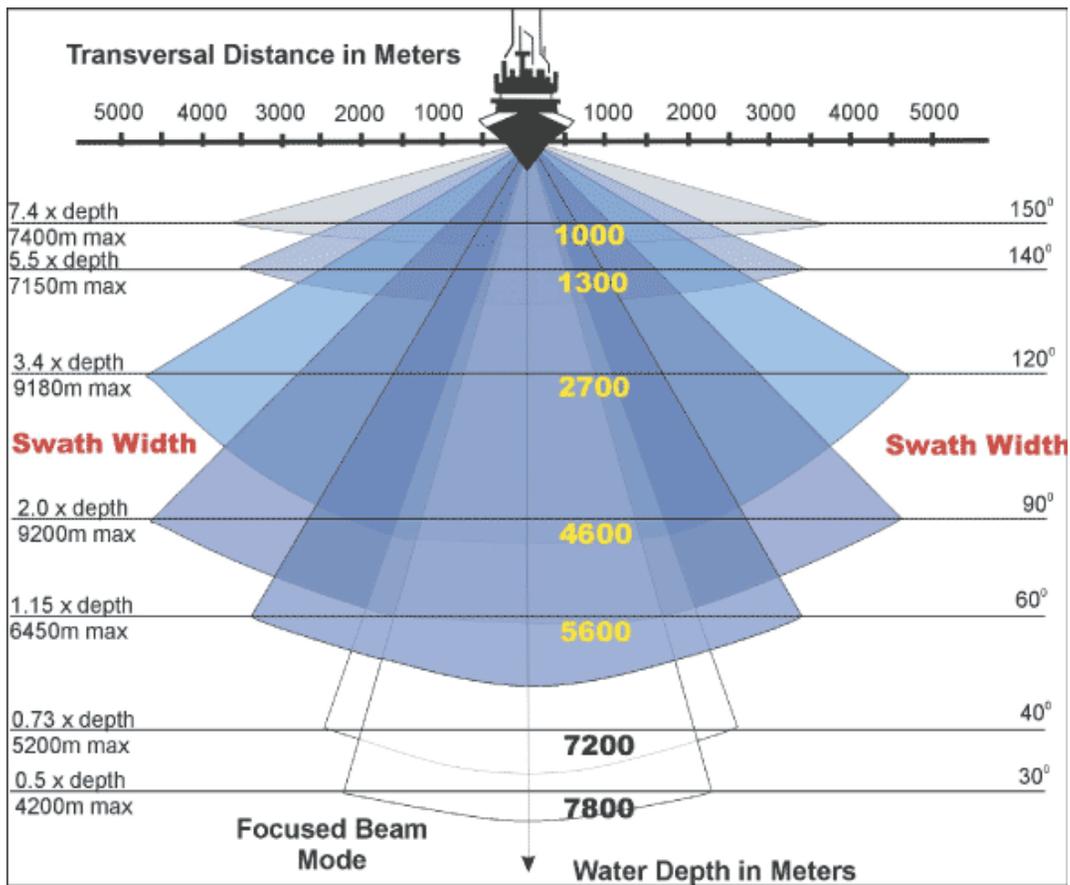


Figure 6.13: Drawing of the relationship between water depth and swath width for the SeaBeam 1180 multi beam system.

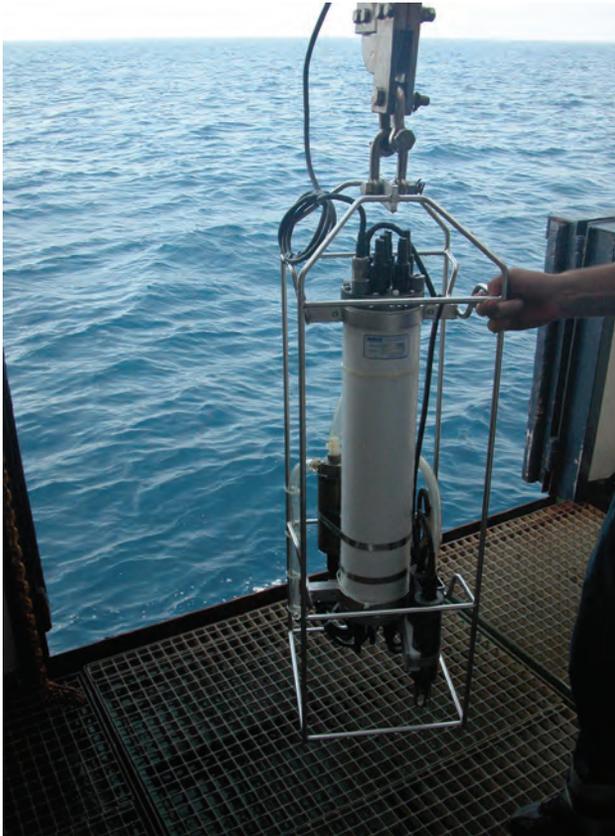


Figure 6.14: Sea Bird E-9 CTD system used during the Farasan cruise for measuring the sound-velocity profile of the water-column.

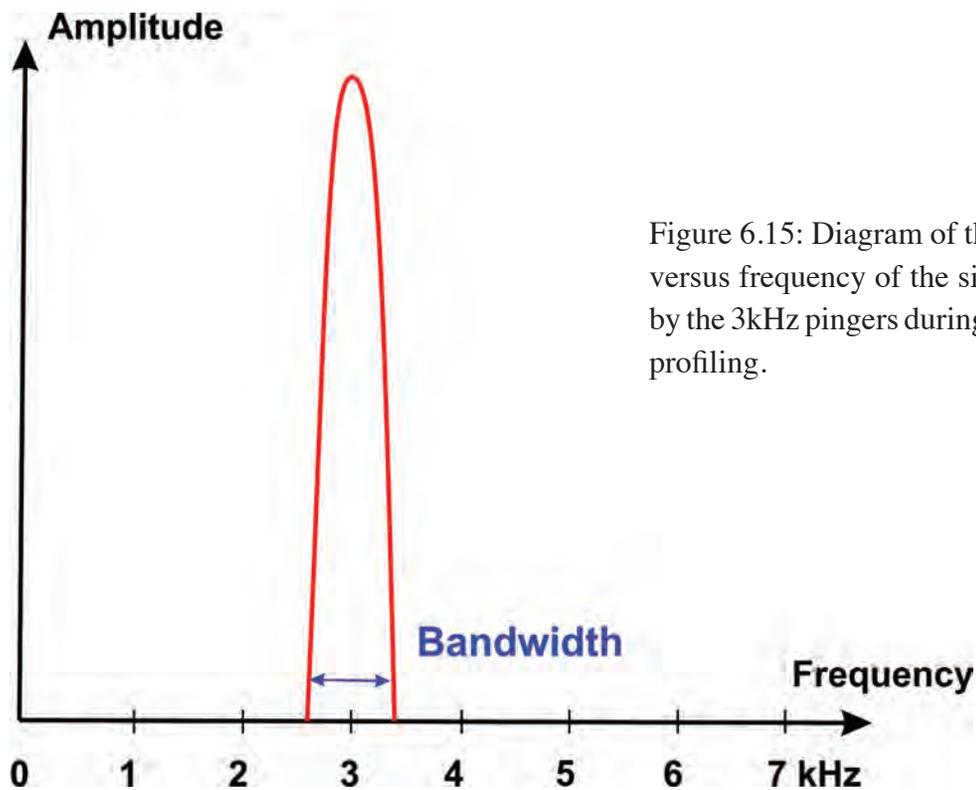


Figure 6.15: Diagram of the amplitude versus frequency of the signal emitted by the 3kHz pingers during sub-bottom profiling.



Figure 6.16: Deployment of the 3.5kHz sub-bottom profiler tow fish over the left side of R/V AEGAEO during the Farasan cruise.



Figure 6.17: Receiver and transmitter (GeoAcoustics Ltd. GB) devices used as deck units for controlling the 3.5kHz acoustic signal.



Figure 6.18: Side scan sonar tow-fish and tow-cable winch on the working deck of R/V AEGAEO during the Farasan cruise.



Figure 6.19: Acquisition of side-scan sonar data using the SonarWiz Map software.

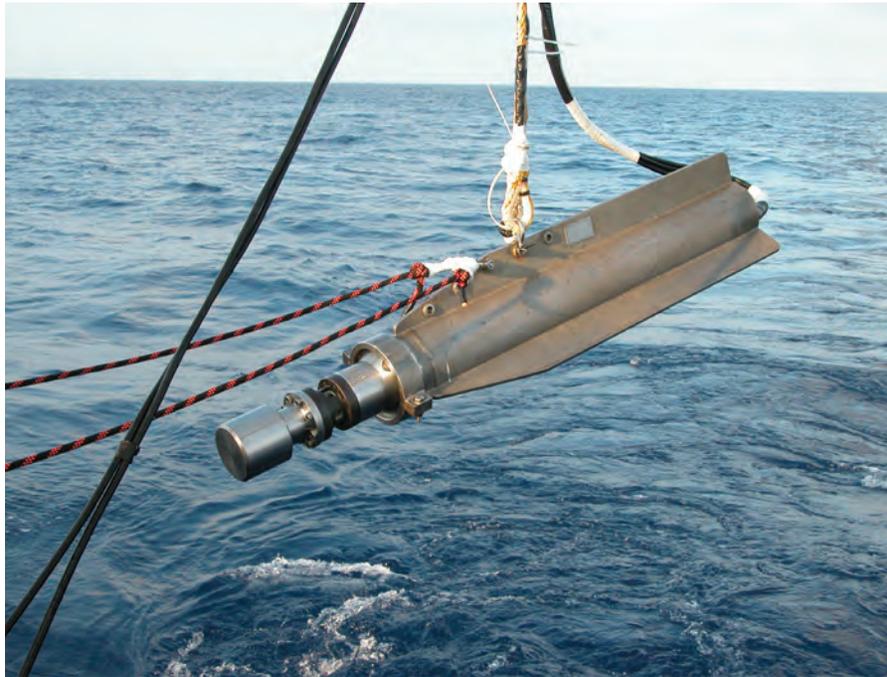


Figure 6.20: Deployment of Air Gun tow fish from the stern of R/V AEGAEO

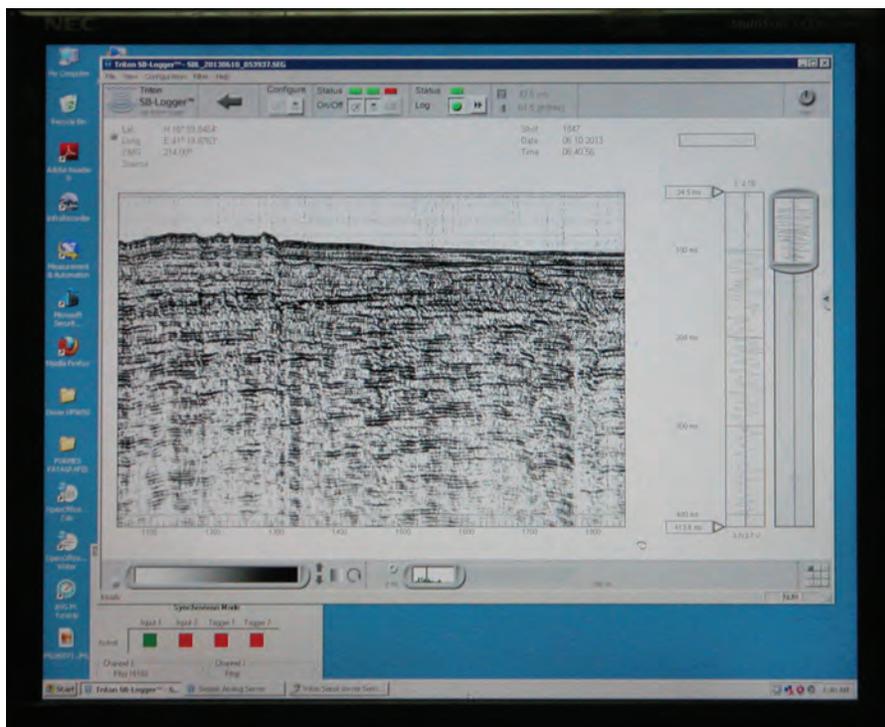


Figure 6.21: Real-time seismic acquisition using the SBLogger seismic acquisition software (Triton Imaging, USA) during the Farasan Cruise.

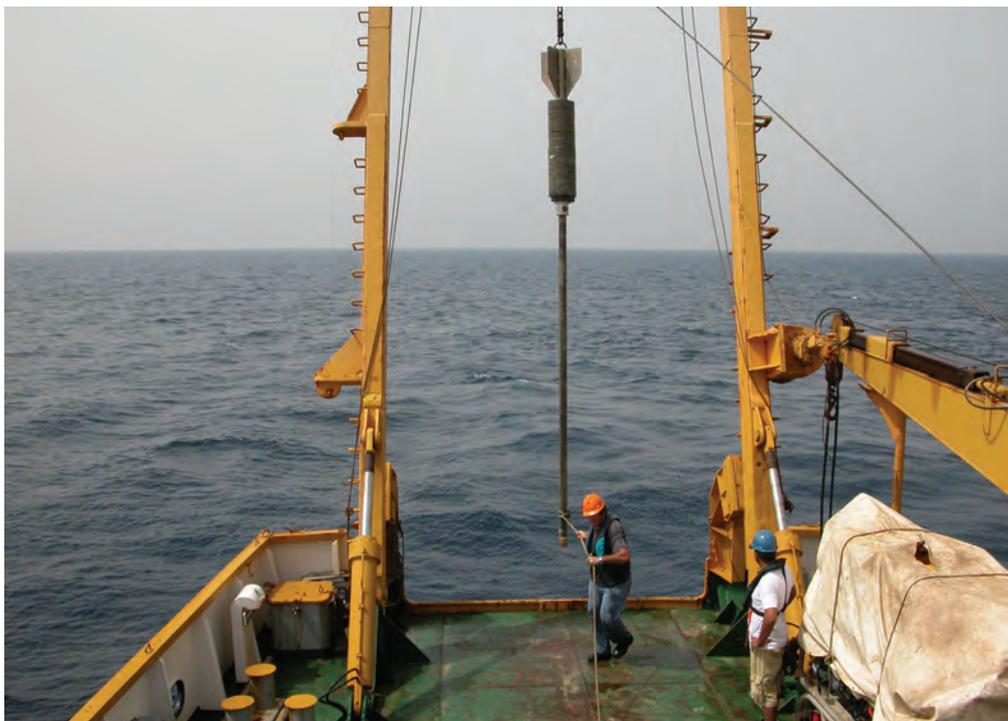


Figure 6.22: Gravity corer deployed through the A-frame at the stern of R/V AEGAEO in the Farasan area.



Figure 6.23: Box corer deployed through the A-frame at the stern of R/V AEGAEO in the Farasan area.

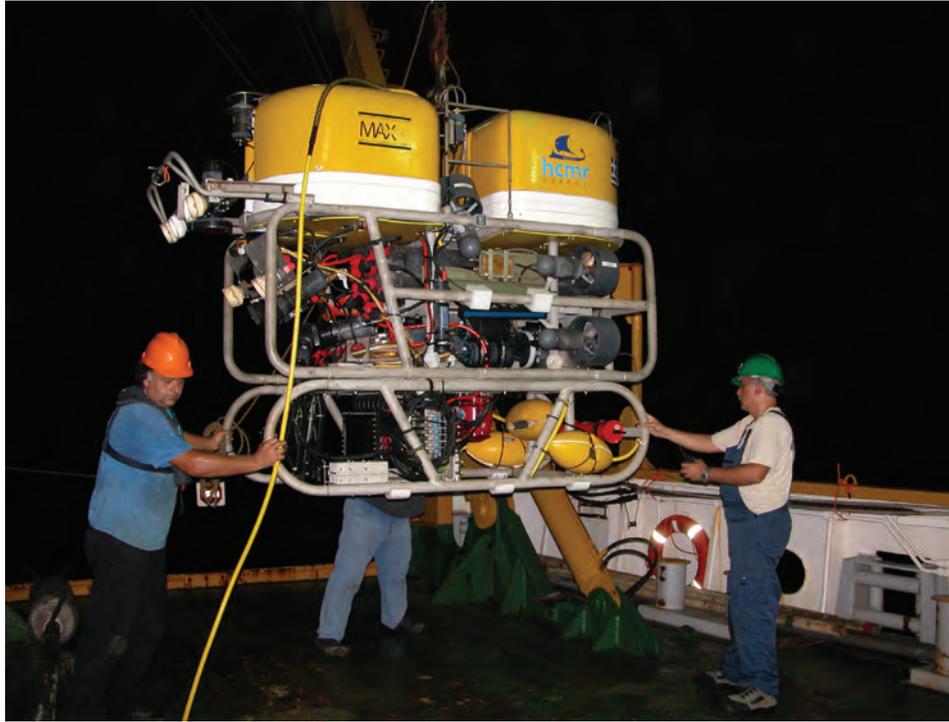


Figure 6.24: Deployment of the ROV Max Rover during the Farasan cruise.

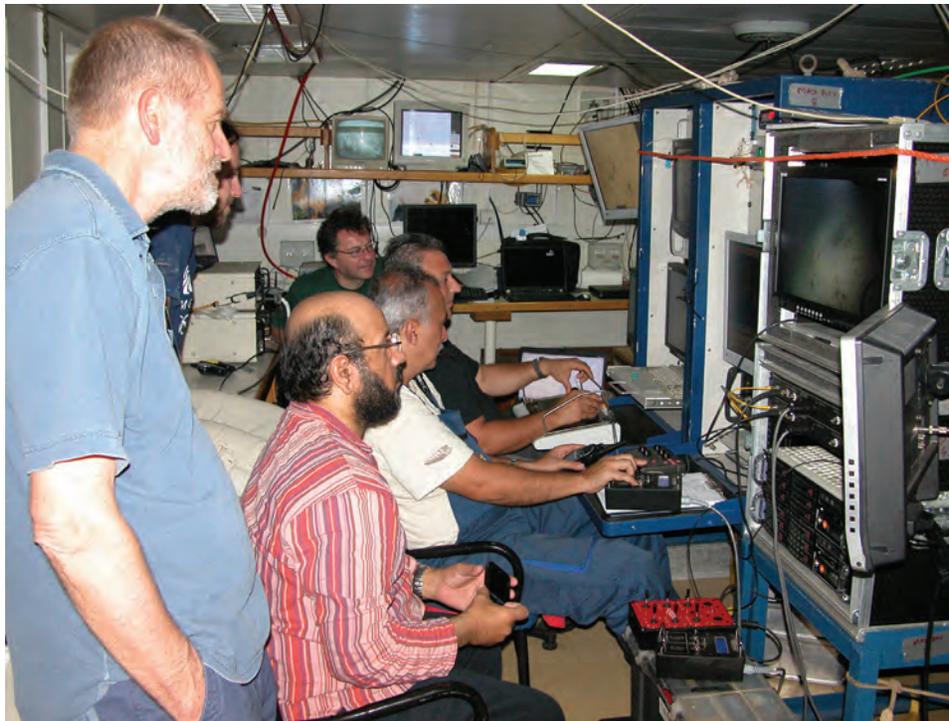


Figure 6.25: Control room of the ROV Max Rover in the electronic laboratory of R/V AEGAEO, during the Farasan cruise. L to R. Geoff Bailey, Matthew Meredith-Williams, Abdullah Alsharekh, Garry Momber, Lionidas Manusakis, Manolis Kallergis. Photo by Dimitris Sakellariou.

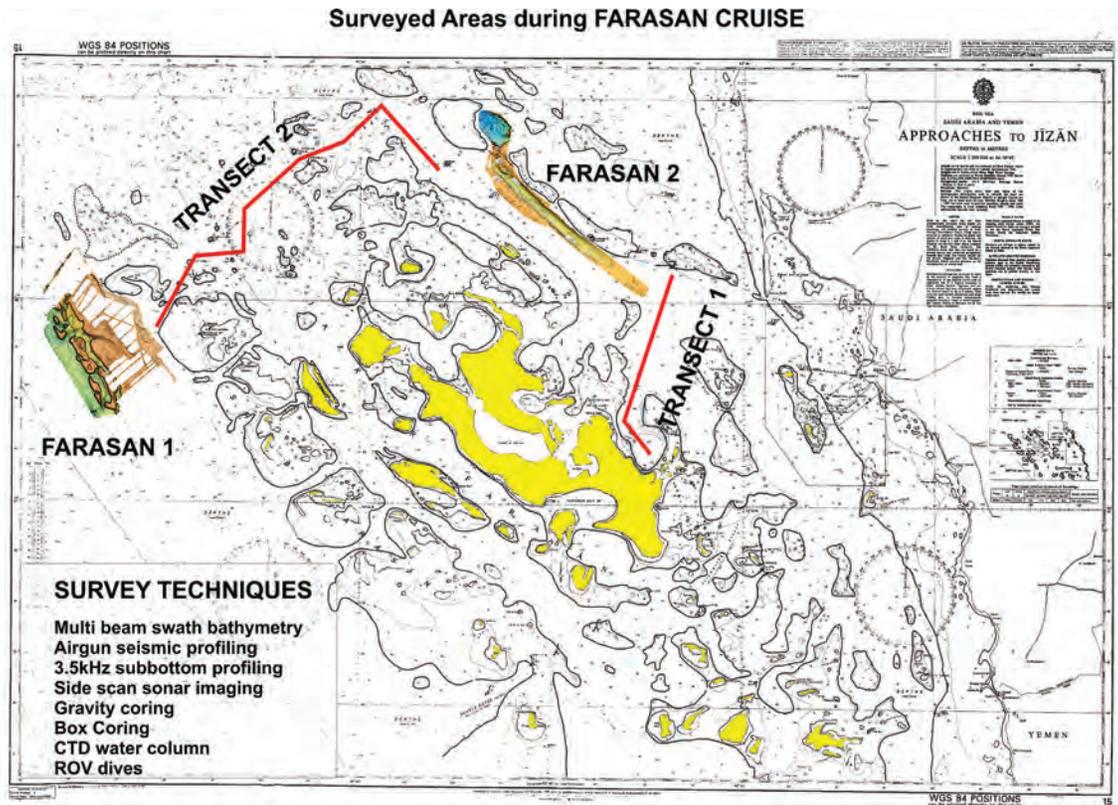


Figure 6.26: Navigational chart of the Farasan Islands, showing the location of the areas and transects surveyed.

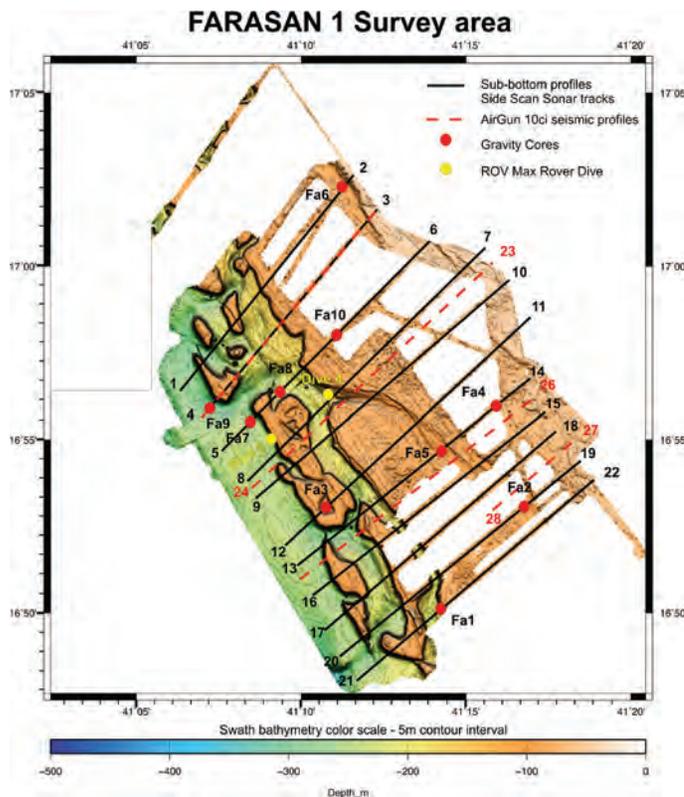


Figure 6.27: Swath bathymetry map of FARASAN 1 survey area with tracks of sub-bottom profiles, side-scan sonar survey, airgun profiles and location of coring sites and ROV dives.

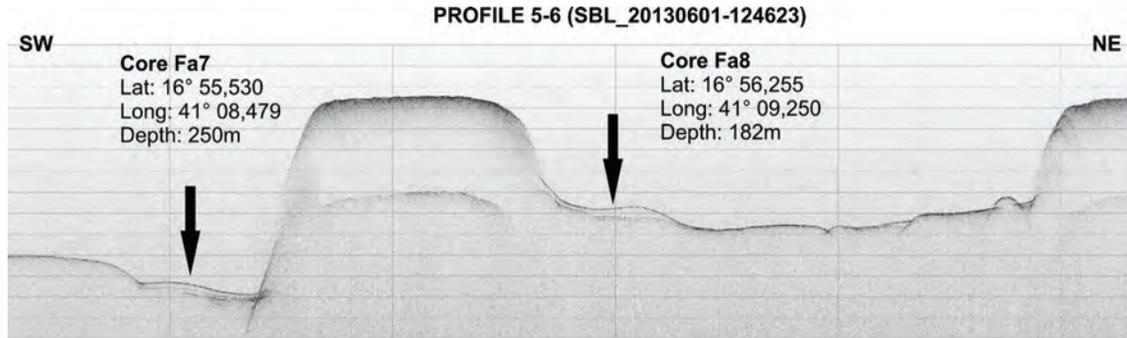


Figure 6.28: 3.5kHz sub-bottom profile in survey area FARASAN 1 with locations of coring sites. Note that coring sites have been defined on the sub-bottom profiles and served the need to core and sample the recent, Holocene marine sedimentary drape and reach its pre-Holocene substrate below.

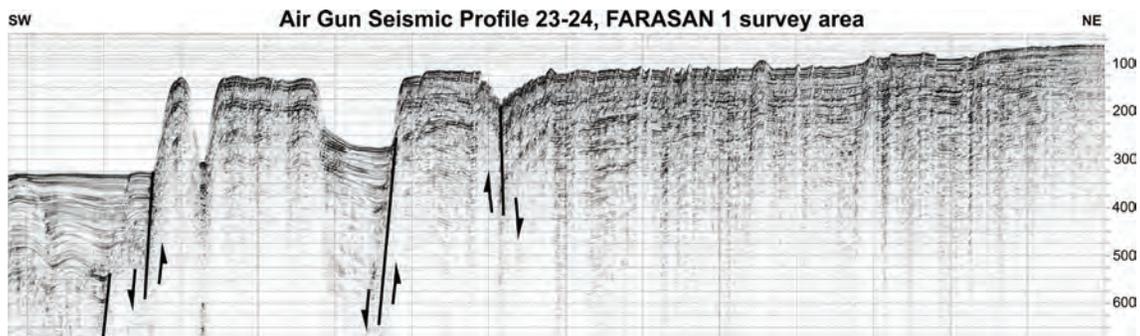


Figure 6.29: Air Gun 10ci seismic profile in survey area FARASAN 1. Note prominent, SW-facing normal faults and antithetic NE-facing normal faults, compatible with the rifting process of the Red Sea.

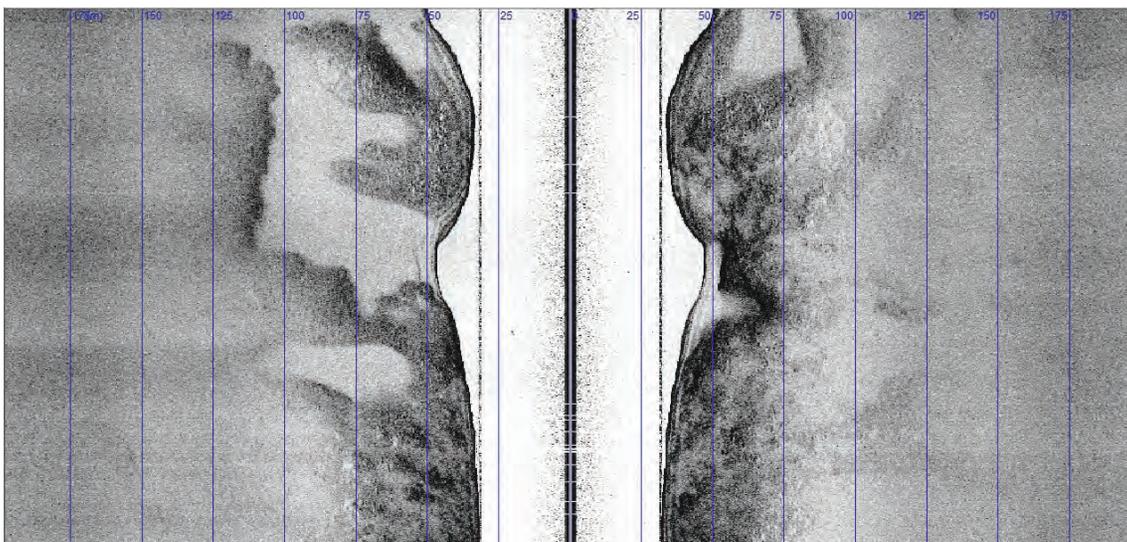


Figure 6.30: Real-time side-scan sonar image showing coral reef formations on the 80 m deep platform.

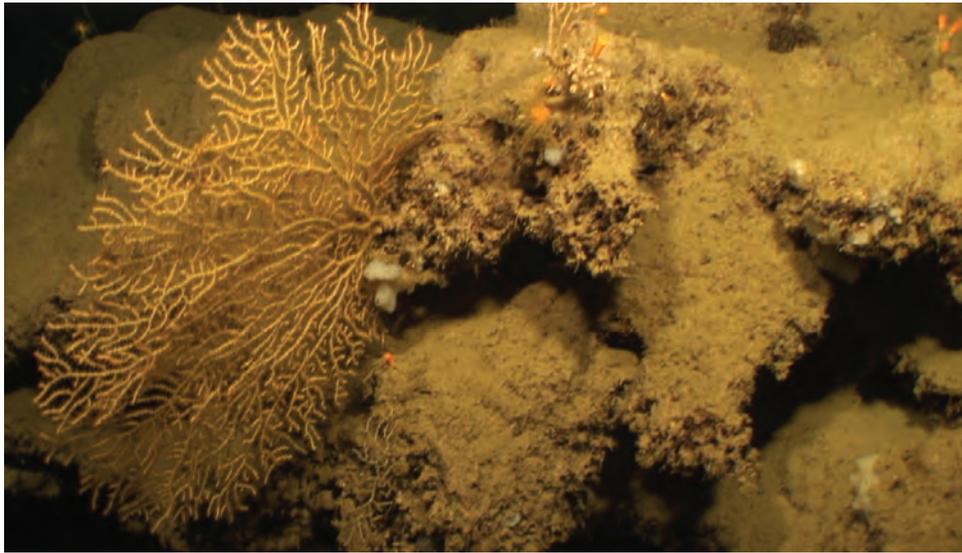


Figure 6.31: Video snapshot taken during the 5th dive of ROV Max Rover at 200 m depth on the outer SW-facing slope of the continental shelf.

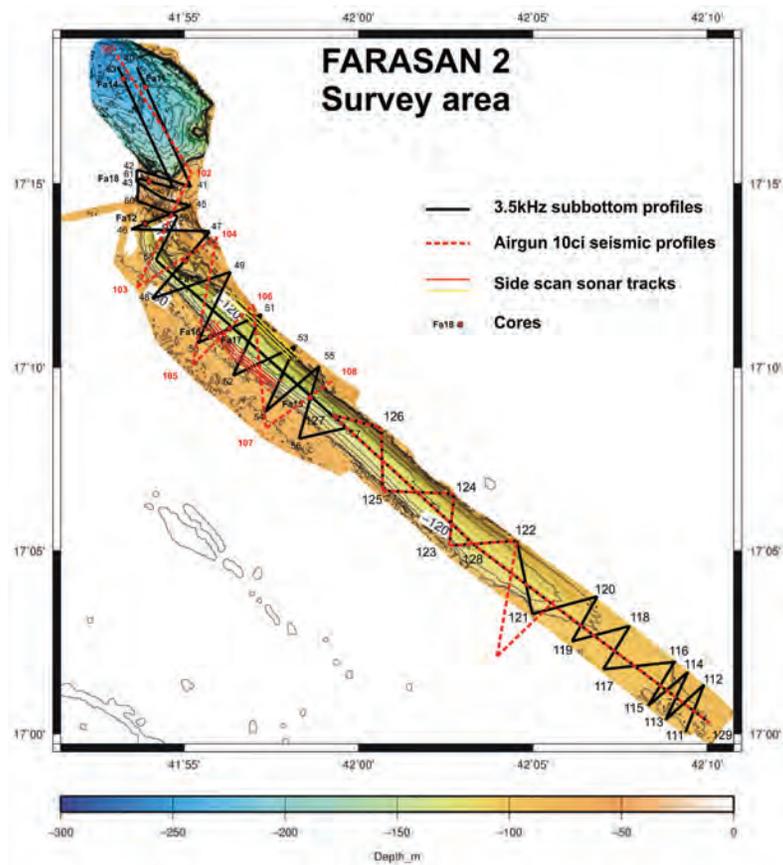


Figure 6.32: Swath bathymetry map of the FARASAN 2 survey area, showing the tracks of sub-bottom profiles, side-scan sonar survey, airgun profiles and location of coring sites and ROV dives.

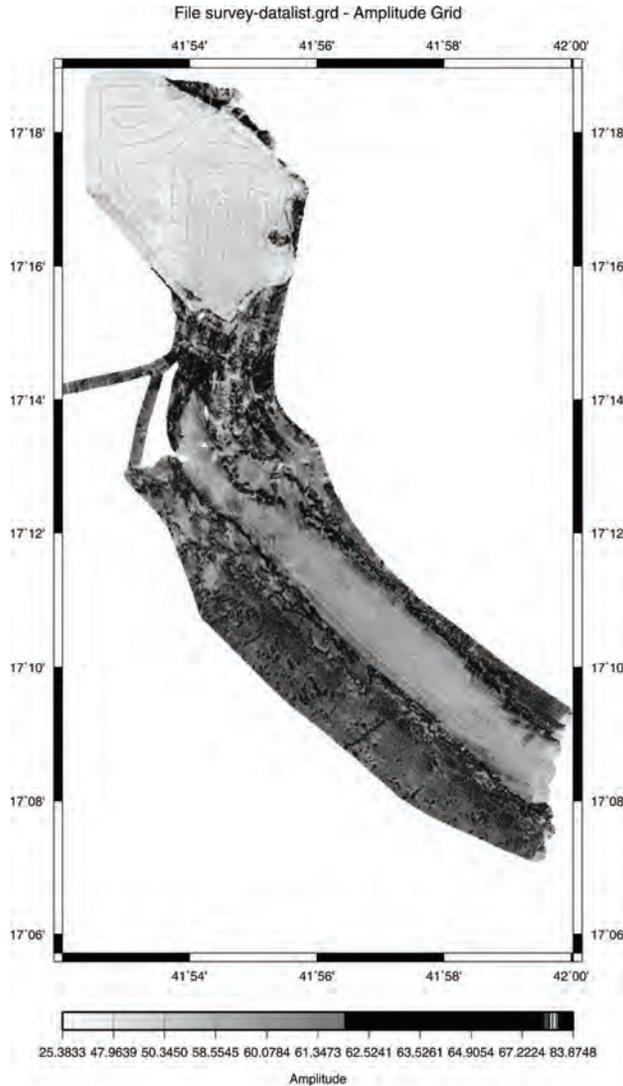


Figure 6.33: Backscatter image of the northern part of the FARASAN 2 survey area. The low reflectivity area (very light gray) to the north marks the soft sediments deposited in the deep sinkhole. Medium reflectivity (medium gray) areas indicate sedimentary deposits in the elongate basin and smaller scattered areas. High reflectivity (dark gray) derives from the shallow platform. Black spots indicate coral reef formations.

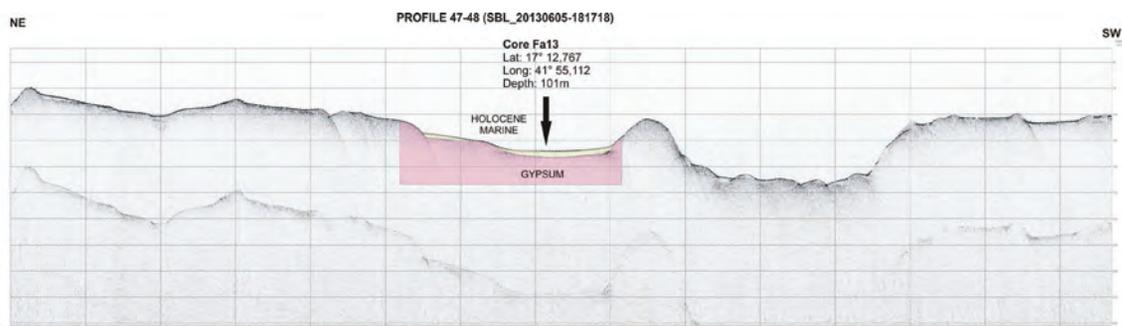


Figure 6.34: 3.5kHz sub-bottom profile in survey area FARASAN 2 with location of coring site. Note that coring sites have been defined on the sub-bottom profiles and served the need to core and sample the recent, Holocene marine sedimentary drape and reach its pre-Holocene substrate below. Core FA13 shown here reached the substrate and recovered pieces of gypsum.

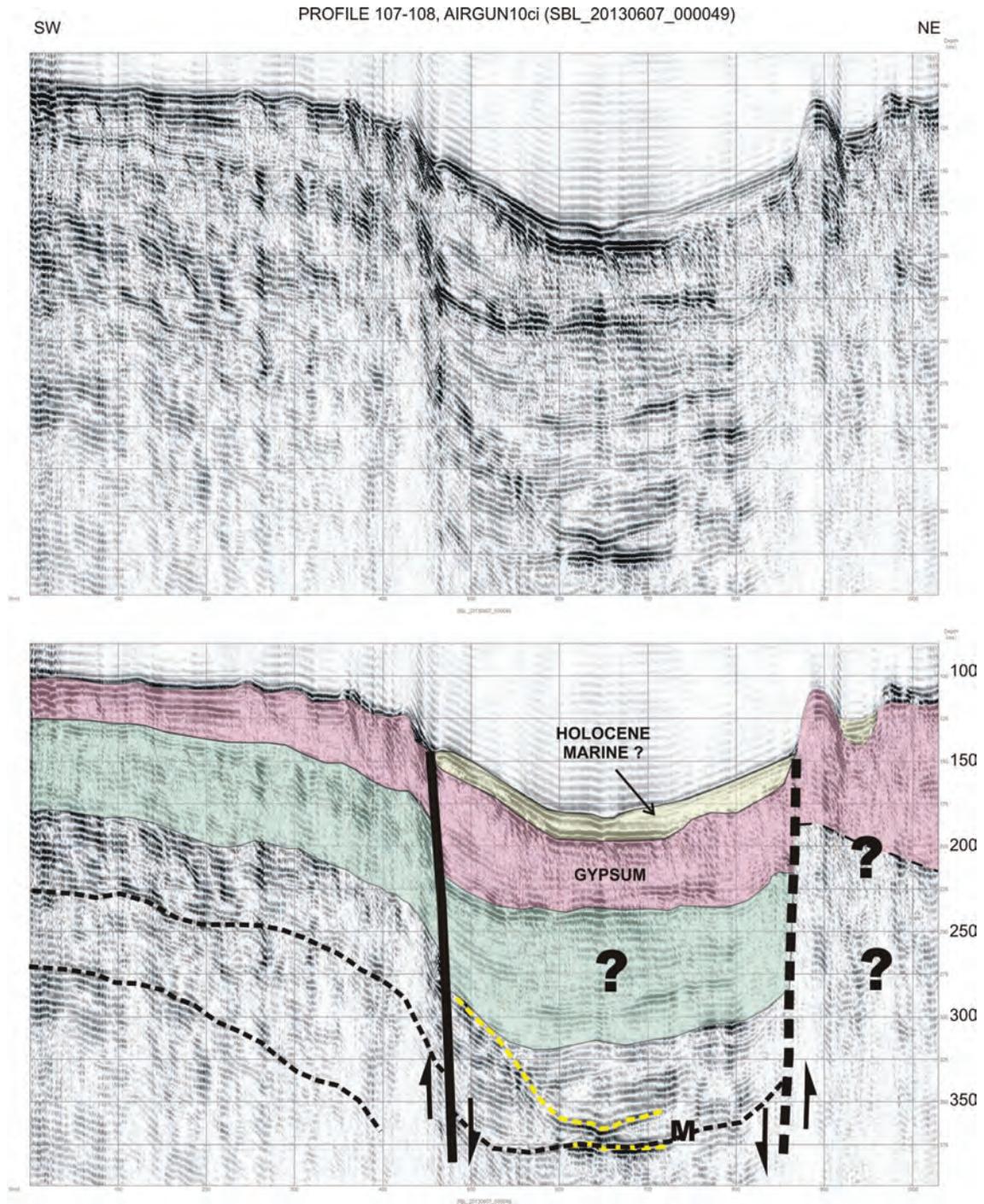


Figure 6.35: Air Gun 10ci seismic profile (top) and preliminary interpretation of the geological structure (bottom) in survey area FARASAN 2.

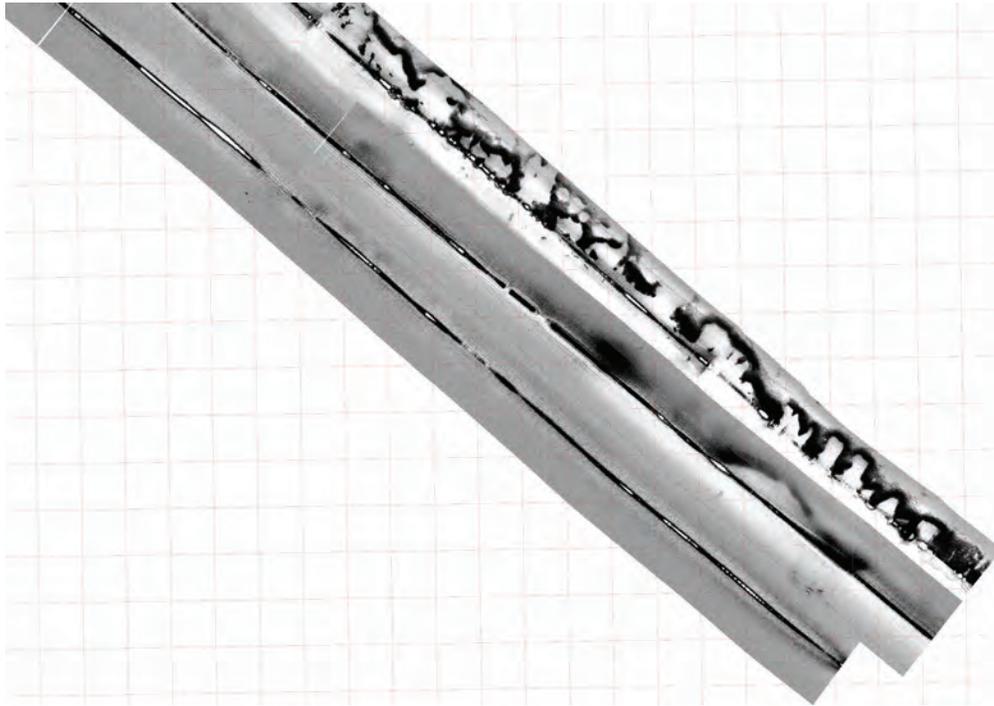


Figure 6.36: Side scan sonar mosaic of the -112m terrace along the northeastern flank of the elongate basin in the FARASAN 2 survey area. Note the strongly reflecting steep, irregular slopes (dark gray to black colour) rising from the edge of the terrace (light gray colour).



Figure 6.37: Video snapshot taken during the first dive of ROV Max Rover at 100 m depth on the northwestern flank of the elongate basin in Farasan 2 area.

Appendix 6.1: Research Team

Hellenic Centre for Marine Research, GR

Name	Surname	v
Dimitris	Sakellariou	Chief Scientist, Dr, Research Director, Structural/Marine Geology, Geophysics
Grigoris	Rousakis	Dr, Researcher, Sedimentology, Marine geology, Geophysics
Spyros	Stavrakakis	Dr, Researcher, Sedimentology, Marine geology
Panos	Georgiou	Marine Geologist, Geophysics
Ioannis	Pampidis	Engineer, seismics, coring
Prokopis	Mantopoulos	Engineer, seismics, coring
Panagiotis	Renieris	Engineer, seismics, coring
Ioannis	Panagiotopoulos	Research Assistant, Marine geology, multi-beam engineer
Ioannis	Morfis	Research Assistant, Engineer, multi-beam engineer
Stefanos	Kalogirou	Dr, Research Assistant, Marine biology, Multi-beam engineer
Leonidas	Manousakis	ROV Engineer
Manolis	Kallergis	ROV Engineer
Vasilis	Stasinou	ROV Engineer, diver

University of York, UK

Geoffrey	Bailey	Project Coordinator Professor, Prehistoric Archaeology
Garry	Momber	Maritime and Underwater Archaeology Coastal and Underwater Landscape
Matthew	Meredith-Williams	Dr, Prehistoric Archaeology, Geoarchaeology

King Saud University, Riyadh, KSA

Abdullah	Alsharekh	
----------	-----------	--

King Abdulaziz University, Jeddah, KSA

Rashad	Bantan	Dr, Marine Geology
--------	--------	--------------------

Saudi Geological Survey, KSA

Salem	Al Nomani	Sedimentology
Najeeb	Rasul	Dr, Marine Geology, Sedimentology

Department of General Survey, Ministry of Defense, KSA

Lt. Fahad	Al Shwish	Observer
Ahmad	Al Harbi	Observer's Assistant

Appendix 6.2: List of Gravity Cores

Date	Time	Core Number	Latitude (Y)	Longitude (X)	Depth (m)	Length (m)	Note
3-Jun-2013	0630	FA-3	16° 53.058	41° 10.752	121	1.46	SPLIT
3-Jun-2013	0730	FA-3	16° 53.060	41° 10.733	121	2.88	samples obtained from the catcher seem lighter in colour. probably brack-ish??!
3-Jun-2013	0815	FA-1	16° 49.904	41° 13.918	217	3.82	20 cm from Top of sample in nose of Gravity Core collected
3-Jun-2013	0900	FA-2	16° 53.276	41° 16.943	87	3.10	
3-Jun-2013	1000	FA-4	16° 56.128	41° 16.943	65	2.04	

3-Jun-2013	1025	FA-5	16° 54.647	41° 14.237	92	3.71	White sediment bottom probably biogenic, lake??!!
3-Jun-2013	1900	FA-10	16° 58.917	41° 12.083	76	3.82	Broken shells at bottom. Upper sediment lost in Barrel.
3-Jun-2013	2000	FA-10B	16° 58.873	41° 12.047	76	1.85	
4-Jun-2013	0700	FA-7	16° 55.548	41° 08.478	259	4.20	
4-Jun-2013	0730	FA-8	16° 56.261	41° 09.235	187	4.53	20 cm Top Disturbed.
4-Jun-2013	0800	FA-9	16° 56.014	41° 07.253	300	2.53	
4-Jun-2013	0900	FA-6	17° 02.357	41° 11.227	83	3.00	
6-Jun-2013	0615	FA-14	17° 18.281	41° 53.043	245	3.05	
6-Jun-2013	0700	FA-11	17° 17.215	41° 53.968	210	2.80	
6-Jun-2013	0730	FA-12A	17° 13.719	41° 54.070	105	1.24	Olive Top (Sandy) Light gray bottom with shells
6-Jun-2013	0750	FA-12B	17° 13.737	41° 54.069	105	1.32	
6-Jun-2013	0815	FA-13	17° 12.838	41° 55.131	102	2,09	Olive Top, Light gray bottom with gypsum
6-Jun-2013	0840	FA-16	17° 10.756	41° 55.622	80	1.42	Shell fragments at the bottom Biogenic formation
6-Jun-2013	0900	FA-17	17° 11.077	41° 56.421	129	2.72	
6-Jun-2013	0945	FA-15	17° 09.174	41° 58.681	130	2.24	Gray bottom with fragments of crystallized gypsum

Appendix 6.3: Daily Cruise Report

WENDESDAY, 29th MAY 2013

Local Time	Position	Activities
12:00 - 22:00	Jeddah Port	Embarkation of Research Team on R/V AEGAE0
23:00	Jeddah Port	Stand by for Departure

THURSDAY, 30th MAY 2013

02:05	Jeddah Port	Departure, heading to Farasan Islands area
	At Sea	Heading to Farasan Islands area

FRIDAY, 31st MAY 2013

07:00	WNW of Farasan Islands	Arrival on site CTD station CTD 1: Lat: 16° 53,420', Long: 41° 05,000, Depth: 1015m
09:30	Area FARASAN 1	Start Swath bathymetry (multi-beam) survey of area FARASAN 1, west of the entrance of the Northern Approach to Jizan. ELAG 2120, 20kHz ELAG 1180, 180 kHz Vessel speed: 9 knots

SATURDAY, 1st JUNE 2013

09:30	Area FARASAN 1	Stop multi-beam survey Preparations for sub-bottom profiling and side scan sonar survey
-------	----------------	--

11:00	Area FARASAN 1	Deployment of sub-bottom profiler and side-scan sonar. Continue surveying area FARASAN 1 with multi beam, sub-bottom profiler (SBP) and side-scan sonar (SSS) synchronously at 4 knots vessel speed SBP: 500 milliseconds SSS: 200m per channel, 110/410 kHz
-------	----------------	---

SUNDAY, 2nd JUNE 2013

14:00	Area FARASAN 1	Stop multi-beam, sub-bottom profiler and side-scan sonar survey Preparations for Air Gun seismic survey
20:30	Area FARASAN 1	Continue multi-beam survey

MONDAY, 3rd JUNE 2013

06:00	Area FARASAN 1	Stop multi-beam survey Preparations for gravity coring
06:30	Lat: 16°53,058 Long: 41°10,752	Start gravity coring: <u>Core FA 3a</u> (pre-split core to be sent to Saudi Geological Survey) Depth: 121m - Length: 164cm
	Lat: 16°53,060 Long: 41°10,733	<u>Core FA 3b</u> Depth: 122m - Length: 300cm
08:15	Lat: 16°49,904 Long: 41°13,918	<u>Core FA 1</u> Depth: 217m - Length: 382cm
09:00	Lat: 16°53,276 Long: 41°16,943	<u>Core FA 2</u> Depth: 87m - Length: 310cm
10:00	Lat: 16°56,128 Long: 41°16,943	<u>Core FA 4</u> Depth: 217m - Length: 382cm

10:25	Lat: 16°54,647 Long: 41°14,237	<u>Core FA 5</u> Depth: 92m - Length: 371cm
11:00	Area FARASAN 1	Continue multi-beam survey
18:30		Stop multi-beam survey
19:00	Lat: 16°58,917 Long: 41°12,083	<u>Core FA 10a</u> Depth: 76m - Length: 380cm + about 30cm left inside the core barrel
	Lat: 16°58,873 Long: 41°12,047	<u>Core FA 10b</u> Depth: 73m - Length: 185cm
20:30		Stop coring. Preparations for Airgun seismic survey
20:45		Airgun seismic survey in area FAR- ASAN 1 10 cubic inches, trigger 2 seconds, vessel speed 4 knots

TUESDAY, 4th JUNE 2013

05:30	Area FARASAN 1	Stop Airgun seismic survey Seismic lines recorded: 4-3, 23-24, 25- 26, 27-28 Preparations for Gravity Coring
06:30	Lat: 16°55,548 Long: 41°08,478	Start gravity coring: <u>Core FA 7</u> Depth: 259m - Length: 420cm
07:30	Lat: 16°56,261 Long: 41°09,235	<u>Core FA 8</u> Depth: 187m - Length: 453cm
08:00	Lat: 16°56,014 Long: 41°07,253	<u>Core FA 9</u> Depth: 302m - Length: 253cm
09:00	Lat: 17°02,357 Long: 41°11,227	<u>Core FA 6</u> Depth: 83m - Length: 300cm

09:30	FARASAN 1 area	End gravity coring in FARASAN 1 area Start multi-beam survey in shallow area
14:00	TRANSIT from FARASAN 1 to FARASAN 2	End of beam survey in the entrance of the North Approach Channel to Jizan. Start transit through the Channel to the survey area FARASAN 2
17:30	FARASAN 2 area	Multi-beam survey in FARASAN 2 area at 9 knots

WEDNESDAY, 5th JUNE 2013

18:30	Area FARASAN 2	End of multi-beam survey Start of sub-bottom profiling and multi-beam at 4 knots

THURSDAY, 6th JUNE 2013

05:00	Area FARASAN 2	End of sub-bottom profiling Preparations for gravity coring.
06:15	Lat: 17°18,281 Long: 41°53,034	<u>Core FA 14</u> Depth: 245m - Length: 305cm
06:45	Lat: 17°17,215 Long: 41°53,968	<u>Core FA 11</u> Depth: 106m - Length: 280cm
07:30	Lat: 17°13,719 Long: 41°54,070	<u>Core FA 12a</u> Depth: 106m - Length: 124cm
	Lat: 17°13,737 Long: 41°54,069	<u>Core FA 12b</u> Depth: 106m - Length: 132cm
08:15	Lat: 17°12,838 Long: 41°55,131	<u>Core FA 13</u> Depth: 102m - Length: 209cm
08:40	Lat: 17°10,756 Long: 41°55,622	<u>Core FA 16</u> Depth: 80m - Length: 142cm
09:00	Lat: 17°11,077 Long: 41°56,421	<u>Core FA 17</u> Depth: 128m - Length: 271cm

09:45	Lat: 17°09,174 Long: 41°58,681	<u>Core FA 16</u> Depth: 130m - Length: 224cm
10:15		Scientific meeting of the research team
13:00	FARASAN 2	Start side-scan sonar - sub-bottom profiling along the flanks of the elongate basin
19:00		End of side-scan sonar - sub-bottom profiling Preparations for coring
19:45	Lat: 17°14,764 Long: 41°54,177	<u>Core FA 18a</u> Depth: 70m - Length: little sediment
	Lat: 17°14,757 Long: 41°54,167	<u>Core FA 18b</u> Depth: 70m - Length: about 30 cm of disturbed fine, silty sand
	Lat: 17°14,769 Long: 41°54,162	<u>Core FA 18</u> Depth: 70m - Length: 164cm
20:45	Lat: 17°14,767 Long: 41°54,171	<u>Box Core FA 18</u> Depth: 70m - Length: no sample
	Lat: 17°14,767 Long: 41°54,166	<u>Box Core FA 18 (2nd try)</u> Depth: 70m - Length: 30cm One plastic tube to SGS One plastic to HCMR
22:00	FARASAN 2	Start Airgun seismic survey

FRIDAY, 7th JUNE 2013

03:30	Area FARASAN 2	End of Airgun survey Start of multi-beam mapping in the southeast part of FARASAN 2 area.
18:00		End of multi-beam mapping
19:00		Start sub-bottom profiling and multi-beam in the southeast part of FARASAN 2 area.

SATURDAY, 8th JUNE 2013

05:00	Area FARASAN 2	End of sub-bottom profiling and multi-beam Heading to Jizan port
09:00	Jizan	Birthed in Jizan port to embark Prof. Abdullah Alsharekh and ROV engineer Leonidas Manousakis
17:30		Sailing from Jizan port to FARASAN 2 area
20:00		Start airgun survey in the southeast part of FARASAN 2 area.

SUNDAY, 9th JUNE 2013

05:00	Area FARASAN 2	End of airgun seismic profiling Preparations for ROV dive.
06:45	FARASAN 2 Lat: 17°10,397 Long: 41°58,002	1st ROV dive North flank of elongate basin, 112m terrace Rock sample F1
09:45		End of dive, ROV on deck
10:25	Lat: 17°09,585 Long: 41°57,645	2nd ROV dive South flank of elongate basin, 112m terrace. Very poor visibility
11:05		End of dive, ROV on deck
		Heading to Farasan port
14:00	Off Farasan port	Disembarkation of Prof. Abdullah Alsharekh on a Coast Guard boat
14:30		Airgun survey along Transect 1.
19:00		End of Airgun Transect 1 Start of multi-beam survey
21:30	Lat: 17°10,280 Long: 41°56,641	3rd ROV dive South flank of elongate basin, 112m terrace.
23:30		End of dive, ROV on deck

MONDAY, 10th JUNE 2013

00:30	Transit from FARASAN 2 to FARASAN 1	Start of airgun seismic profiling along Transect 2
10:30		End of airgun survey
11:30	FARASAN 1 Lat: 16°56,444 Long: 41°11,831	4th ROV dive, FARASAN 1, 120m terrace Rock sample F2
14:50		End of dive, ROV on deck
15:50	Lat: 16°55,197 Long: 41°08,997	5th ROV dive, FARASAN 1, possible wavecut notches on the outer slop, 120m
17:30		End of dive, ROV on deck Start multi-beam survey.
19:00		End of multi-beam survey
		End of survey works Heading to Jeddah port.