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REPORT ON THE MORPHOBATHYMETRIC, OCEANOGRAPHIC, GEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS DURING CRUISE MNG01_09 (19-27 April 2009, R/V *URANIA*)

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Report on the morphobathymetric, oceanographic, geological and geophysical investigations during cruise MNG01_09 (19-27 april 2009, R/v *URANIA*)

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Abstract - We present the shipboard activities and results of Cruise MNG01_09 on R/V *Urania* (19-27 april 2009) on Southern Adriatic Sea. Morphobathymetric, geological and geophysical works were performed on the montenegrinian margins within the framework of international Projects ADRICOSM-STAR and MEDPOL. The cruise was scheduled to continue the systematic mapping of the montenegrinian shelf areas by Multibeam and CHIRP SBP, sample the seabottom by box-corer and gravity corer and acquire classic hydrological data on the water column. Most of the proposed work have been performed, and some results are presented hereinafter, alongwith tecnical details on procedures and instrumentation.

Sommario - Vengono presentate le attivita' ed i risultati preliminari della crociera MNG01_09 con R/V *Urania* (19-27 aprile 2009). Sono stati raccolti dati morfobatimetrici e SBP sul margine montenegrino e nalla baia di Cattaro, all'interno dei progetti internazionali ADRICOSM-STAR e MEDPOL. Di seguito vengono mostrati alcuni dei risultati ottenuti, assieme alle metodologie e alle strumentazioni impiegate.

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ACRONYMS

ACRONYM	DESCRIPTION	URL-email
CNR	Consiglio Nazionale Delle Ricerche	www.cnr.it
ISMAR	Istituto di Scienze Marine	www.ismar.cnr.it
ISMAR-BO	Istituto di Scienze Marine, Bologna	www.bo.ismar.cnr.it
UNIMODENA	University, Modena, Italy	www.unimodena.it
IBMK	Inst.Marine Biology, Kotor	
GSM	Geol.Survey Montenegro, Podgorica	www.geozavod.cg.yu
UNIBELG	University, Belgrade, Serbia	www.bg.ac.yu
SOPROMAR	SOPROMAR, Fiumicino, Italy	www.sopromar.it
ADRICOSM	ADRIatic sea integrated COastal areaS	gnoo.bo.ingv.it/adricosm
ADRICOSM-STAR	ADRICOSM integrated river basin an coastal zone management system: Montenegro coastal area and Bojana river catchment	gnoo.bo.ingv.it/adricosm-star
MEDPOL	Program for the Assessment and Control of Pollution in the Mediterranean region	http://195.97.36.231/medpol
PDS-2000	RESON	www.reson.com/sw1738.asp
SIS	Sea Floor Inf. System	www.kongsberg.com
NEPTUNE	Multibeam Processing	www.km.kongsberg.com
SBE	Sea Bird Electronics	www.seabird.com
BENTHOS	Teledyne Benthos	www.benthos.com
SWAN-PRO	Communication Technology	www.comm-tec.com
GMT	Generic Mapping Tool	gmt.soest.hawaii.edu/gmt
MBES	Multibeam Echosounder System	
SBP	Sub Bottom Profiling	
SVP	Sound Velocity Profile	
CTD	Conductivity/Temperature/Depth	
ADW	Adriatic Deep Water	
LIW	Levantine Intermediate Water	
GPS-DGPS-RTK	Global Positioning System	samadhi.jpl.nasa.gov
DTM	Digital Terrain Model	en.wikipedia.org

Table 1: Acronyms of Organizations, Manufacturers and Products

ACKNOWLEDGMENTS

We are particularly indebted to the Master C.L.C. Emanuele Gentile, the officers and crew members of R/V *Urania* for their professionalism and efforts in assuring the success of the cruise. We thank also Dr.Zoran Kljajić of IBMK for continuous help in planning the cruise. Work done in the framework of the Adricosm-Star Project.

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1 INTRODUCTION

Cruise MNG01_09, coordinated by ISMAR-CNR of Bologna, has been dedicated to the ADRICOSM-STAR project (coordinating Institution CMCC, scientific Coordinator Prof. Nadia Pinardi) and to MEDPOL activities. ADRICOSM-STAR "... aims at the development and partial implementation of an integrated coastal area and river and urban waters management system that considers both observational and modelling components." The research area is the Montenegro and Albanian coastal and marginal zone, inclusive of Kotor Bay (Boka Kotorska). The project involves 19 public and private partners from Italy, Montenegro, Serbia and Albania and has a duration of 3 years starting from March 2007.

This is the third cruise in the area of Montenegro, following the cruise ADR08 R/V Dalla Porta July 2008 and ADR02_08 R/V Urania of October 2008 [Bignami et al.(2008)]. The cruise objectives were:

- To continue the systematic mapping of the study zone sea bottom and sub-bottom with Multibeam and CHIRP technology
- To collect sediment samples in selected stations for sedimentological and chemical analysis
- To collect meteorological and continuous on-going CTD data.
- To provide on-field training

Multibeam and CHIRP data will be used to assess the geological and surficial and subsurficial morphological setting, other than help to update bathymetric maps. Among the settings we may cite sediment transport pathways, such as accumulation and erosion areas, and risk and hazard studies. In addition, high resolution bathymetric data will be used to construct digital terrain models useful for regional modelling of wave and current dynamics. As a result of this investigation the owners of the data will also be able to produce environmental and geological maps at variuos scales. In particular, Kotor Bay data, along with pollution data from sediment samples, will be used to optimize the wastewater disposal effort in environmentally safe conditions.

This paper reports the shipboard activities during the cruise, including description of the ship, equipment and their usage, along with details of the general settings, performances and some scientific and technical results.

CHIRP SBP and Multibeam bathymetric data were acquired allover planned routes or during transits, from the SE to N, and the seafloor was sampled by box-corer and gravity corer in predetermined stations in front of the Bojana River and S of Bar. In particular, the planning of routes were dictated by the aim of obtaining full coverage multibeam images.

Hydrological measurements include CTD vertical profiles (pressure, temperature, conductivity, dissolved oxygen, light transmission, fluorimetry). Among the many parameters, T, S, Pressure were used to provide to the MBES the necessary water column speed of sound profile (Chen and Millero). Data were extracted from the 1 or 2 m averaged profiles, and input on the MBES console. A procedure was set up in order to make easier the handling of the procedure, in particular for the extension of data to the depth of 12000m, as required by the SIS Kongsberg's software. The procedure is explained in Appendix **??**.

1.1 Geological and Oceanographical Setting

Geological setting

The Montenegrinian and Northern Albanian margins and coastal areas are part of the seismically active W-verging Dinaride/Albanide fold-and-thrust belt along the eastern Adriatic basin boundary (see Fig.1). The margins have relict shelf edge, with sediment stored on the albanian coastline, and evidence of large-scale mass wasting [Argnani et al.(2006)], [Roure et al.(2004)]. The continental shelf is very narrow from N in Croatia to C. Patamuni S of the Bay of Kotor, near Budva, where it develops offshore down to C.Rodonit.

The seismic activity is present in the study area as moderate to strong intensity events. In particular, it must be cited the M6.9 destructive event of 1979-04-15 and aftershock in the Bar region

[Console and Favali(1981)], [Boore et al.(1981)], whose epicenter was located offshore 5-10 NM, at the most external thrust. The area south of the mouth of Bojana River to W and SW of Cape Rodonit is also seismically active, being interested by a WNE pure-compression thrust and by ENE trending strikeslip faults [Aliaj et al. (2004)], [Aliaj (2008)]. According to [Tiberti et al.(2008)] and therein cited authors, the events have large potential for generating tsunamis.

Because of karst environment in the Dinaric range, especially in N Montenegro, coastal aquifers may also develop at sea with submarine syphons, springs and resurgences, within a geological and hydrogeological setting strongly related to tectonics and to past and future climate and sea level fluctuations [Fleury et al.(2007)]

Oceanographical Setting

The dynamics of the Southern Adriatic is dominated by the presence of a quasi-permanent cyclonic gyre that in the winter season creates the conditions for the open-ocean convection and the production of dense and oxygenated waters. Studies show that two types of dense water formation processes occur during winter within the Adriatic Sea: the major portion of the Adriatic Deep Water (ADW) is formed through open ocean convection inside the Southern Adriatic Pit (SAP) within the cyclonic gyre, while the remaining dense water is formed on the continental shelf of the Northern and Middle Adriatic that moves southward and ultimately sinks to the bottom of the SAP ([Ovchinnikov et al. (1985)][Bignami et al. (1990)] [Malanotte-Rizzoli (1991)]). The eastern margin is characterized by the influence of the incoming water of Ionian origin which flow northward being restricted mainly to the continental slope. This area is interested by the Levantine Intermediate water (LIW) that occupies the layer between 150 and 600m.

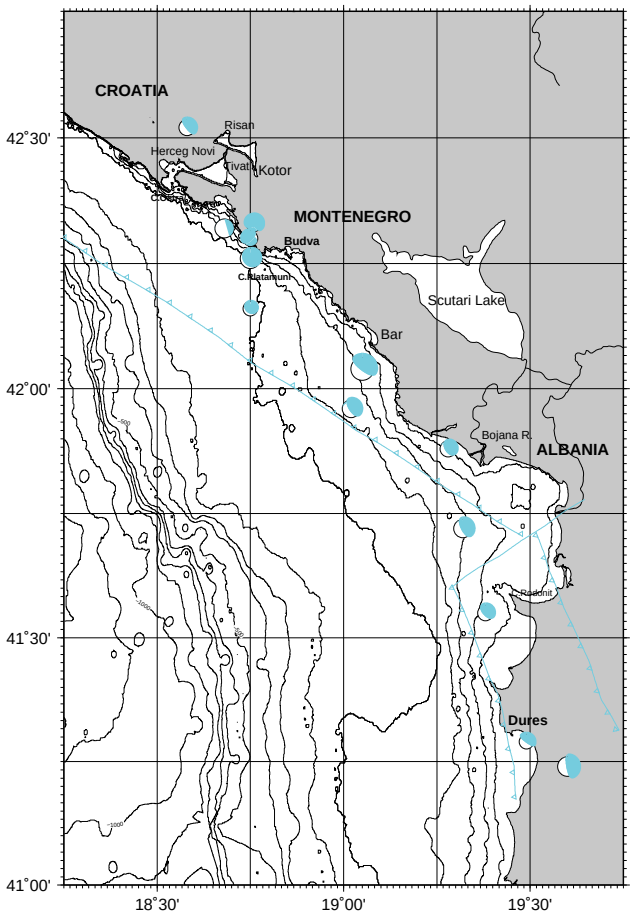

Figure 1: Geological setting of Montenegro-Albania. Structural lineaments, left and rigth fronts, strike-slip transform fault from [Aliaj et al. (2004)] and [Aliaj (2008)]. Centroid moment tensor solutions by [Pondrelli et al.(2006)]. Bathymetry by GEBCO.

2 CRUISE SUMMARY

SHIP: R/V *Urania*
START: 2009-04-11 PORT: Catania
START-OF-LEG : 2009-04-19
END: 2008-10-27 PORT: Ravenna
SEA/OCEAN: Southern Adriatic Sea, Mediterranean Sea
LIMITS: NORTH 42:40 SOUTH: 41:00 WEST: 18:00 EAST: 19:30
OBJECTIVE: MORPHOBATHYMETRIC AND GEOLOGICAL SURVEY
COORDINATING BODIES: ISMAR-CNR
CHIEF OF EXPEDITION: Mr. Giovanni Bortoluzzi
CONTACT: G.Bortoluzzi@ismar.cnr.it
DISCIPLINES: PHYSICAL AND BIO-GEOCHEMICAL OCEANOGRAPHY, SWATH BATHYMETRY, GEOPHYSICS
WORK DONE: , 1700 KM SBP, about 1000KM^2 Of SWATH MULTIBEAM, 15 CTD STATIONS, 8 BOX-CORERS, 4 CORES.

LOCALIZATION:

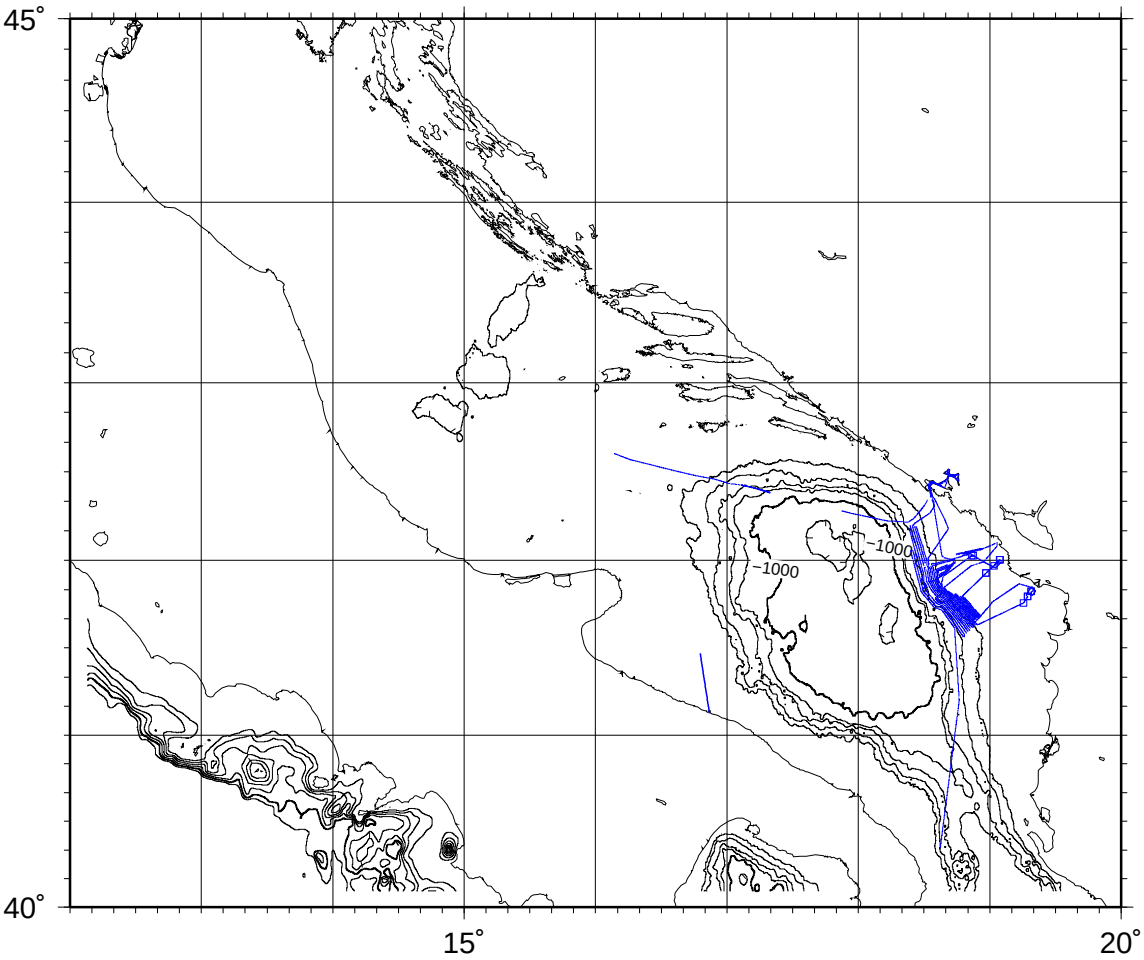

Figure 2: Whole ship track during Cruise MNG0109 in the Southern Adriatic Sea. Blue circles are CTD stations. Red squares are Grab Stations.

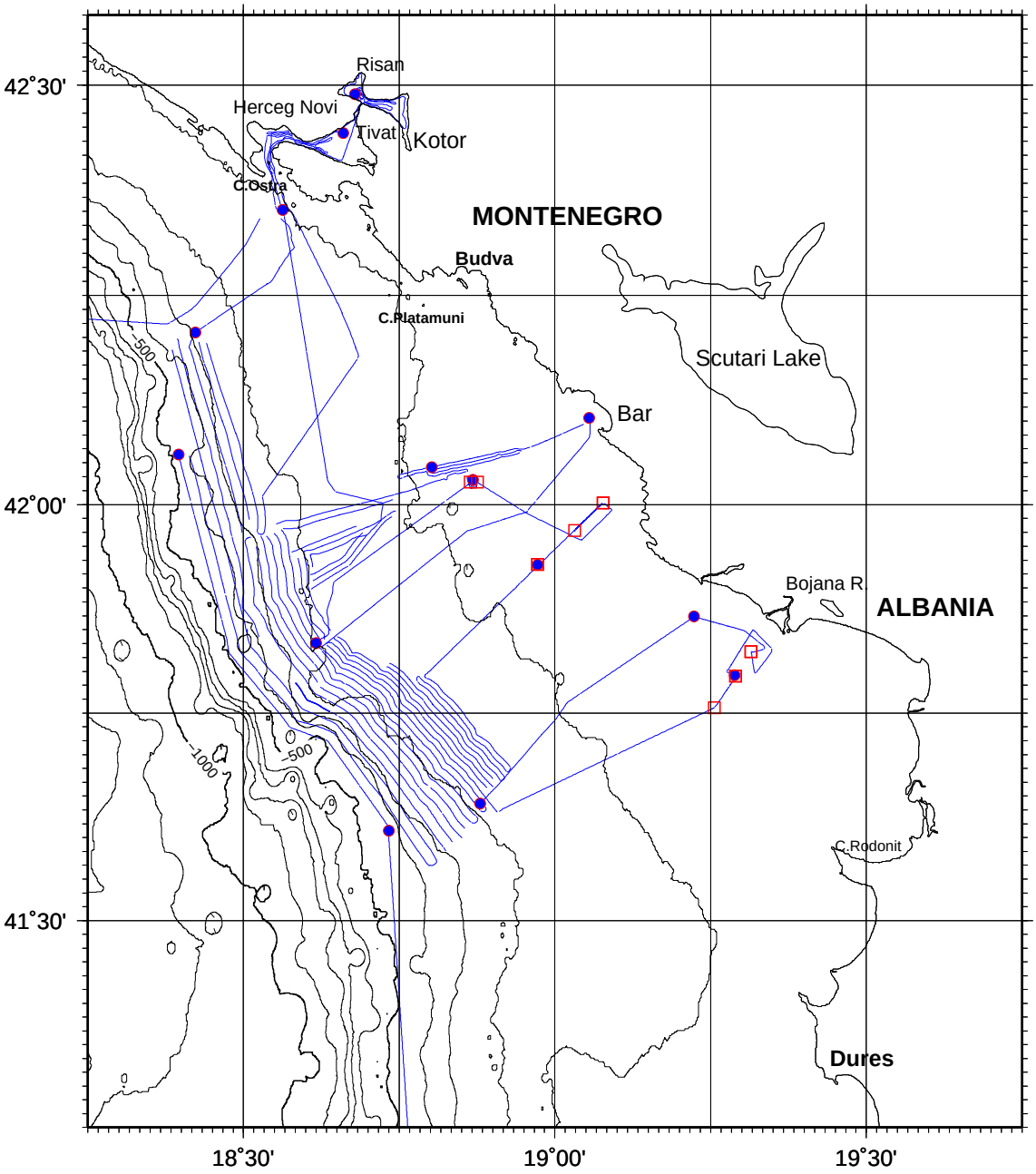

Figure 3: Whole ship track during Cruise MNG0109 in the Montenegro Area. Blue circles are CTD stations. Red squares are Grab Stations.

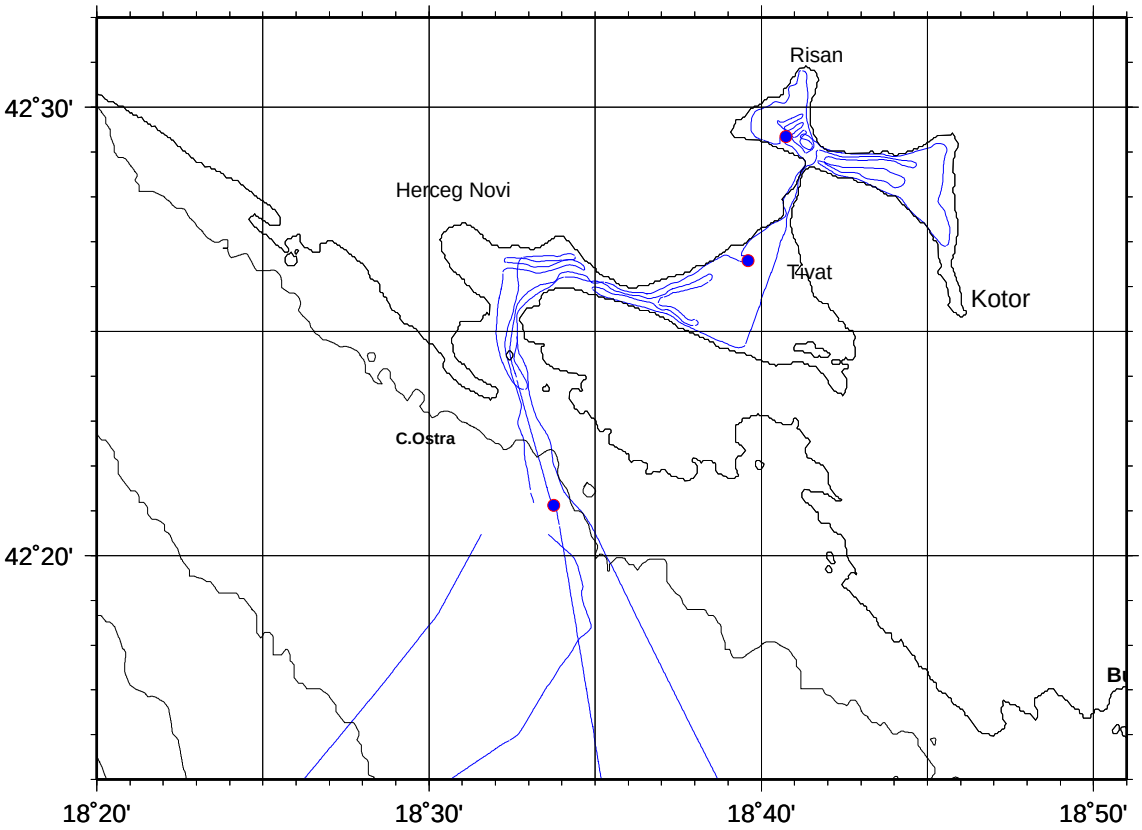

Figure 4: Whole ship track during Cruise MNG0109 in the Kotor Area. Blue circles are CTD stations. Red squares are Grab Stations.

SCIENTIFIC AND TECHNICAL PARTIES

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Table 2: Scientific and technical parties

3 MATERIALS AND METHODS

The research cruise was carried out with the 61 meter R/V *Urania* owned and operated by SO.PRO.MAR. and on long-term lease to CNR. Ship is normally used for geological, geophysical and oceanographical work in the Mediterranean Sea and adjoining waters, including but not limited to, the Atlantic Ocean, the Red Sea, and the Black Sea.

R/V *Urania* is equipped with DGPS positioning system (satellite link by FUGRO), single-beam and multibeam bathymetry and integrated geophysical and oceanographical data acquisition systems, including ADCP, CHIRP SBP and other Sonar Equipment, other than water and sediment sampling. Additional equipment can be accommodated on the keel or towed, e.g. Side Scan Sonars.

3.1 NAVIGATION, SWATH BATHYMETRY, CHIRP SBP DATA ACQUISITION

The vessel was set-up for data acquisition and navigation with PDS-2000 software by RESON, interfacing by a multiserial and Ethernet link several instruments, among them the DGPS (Fugro), the Atlas-Krupp Deso-25 single-beam echosunder, the MAHRS MRU and the meteorological station. The position and depth data were also distributed to the CTD data acquisition console. A Kongsberg processor running the SIS software, collected the multibeam data, including a SEAPATH MRU, compass, and DGPS. The MBES was the 70kHz, 400 1x2°, 150°aperture EM-710 (2000 m range) model by Kongsberg. The sonar head is positioned on the ship's keel using a V-shaped steel frame. A Sound Velocity probe at the keel 1m above the Sonar Head is interfaced directly to the MBES processor, thus providing the necessary real-time data for the beam-forming. CTD casts were normally used for input of the sound velocity profile to the system.

POSITION	ACROSS	ALONG	HEIGHT
REFERENCE POINT	0.00	0.00	0.00
DGPS	1.64	14.30	14.18
MBEAM	0.00	14.36	-4.96
MAHRS	0.00	0.0	-3.40
ECHO SOUNDER 33	5.50	-1.85	-3.80
CHIRP	-1.0	11.80	-4.00
A-FRAME	6.5	-6.70	0.0
STERN	0.00	-30.60	0.00

Table 3: Instrumental Offsets of PDS2000 on Ship Urania (PDS2000). The GPS antenna (primary positioning system) is located on point DGPS.

POSITION	ACROSS	ALONG	HEIGHT
REFERENCE POINT	0.00	0.00	0.00
SEAPATH_GPS	-4.039	0.163	-18.211
MRU	-0.341	-1.342	-1.596
MBEAM_TX	0.0936	10.2964	5.0623
MBEAM_RX	-0.0031	11.0144	5.0600
SEALEVEL	0	0	-0.0875

Table 4: Instrumental Offsets on Ship Urania (EM710). The DGPS antenna (primary positioning system) is located on point SEAPATH_GPS.

MULTIBEAM BATHYMETRY

The SIS (EM-710) was able to build real-time DTM at the resolution of 20 and 5 m during the acquisition of the entire surveyed areas. The data from these production DTMs were exported and used for planning and update of the SIS projects. The raw data were instead saved in the Kongsberg's .all format, for postprocessing with packages like NEPTUNE or MB-SYSTEM or other. The processed data will therefore be used for an up-to-date regional and local bathymetric compilation.

CHIRP SBP

A Teledyne Benthos CHIRP SBP system (16 hull-mounted transducers) was used. The data were acquired by the SWANPRO software by Communication Technology, with direct interfacing to the DGPS, therefore actual positioning data have to be converted according to the offsets of Tab.3. The system setting (multiping mode) was: power full, length 20ms, trigger rate variyng from 0.5 to 0.687 s,gain 9dbm preamp gain ranging from 1.5 to 3 db. The data were recorded in the XTF format and converted also into the SEG-Y format for processing with ISMAR's SEISPRHO package [Gasperini and Stanghellini(2008)]. Several examples of the data can be viewed in Chapter.4.

3.2 BOTTOM SAMPLING

Bottom samples were taken by a OCEANIC 60cm diameter box-corer. Some samples were washed and sieved on board. On 4 stations a 1.2T, 6m pipe, gravity corer was used. Table 5 shows the positioning data of the stations. The sediment recovered by the box-corer was subsampled using 4 to 6 plastic liners (80mm and 40mm diameter), that were sealed and put in refrigerator at +5℃ and deep-frozen at -20℃. Some levels were sampled on the exposed sediment column (surface, mid depth and bottom) and stored in sealed plastic bags. Photographs in Fig. 5 and following show some of the operations.

LON	LAT	STATION	SAMPLE	DATE	TIME	WHERE	RECOVERY
1915.335	4145.331	01	B-01	22-04-2009	13:12:54	S-Bojana	0.25
1917.398	4147.618	02	B-02	22-04-2009	14:25.25	S-Bojana	0.29
1917.403	4147.624	03	C-02	22-04-2009	14:49:03	S-Bojana	2.20
1918.880	4149.372	04	B-03	22-04-2009	17:15:53	S-Bojana	0.30
1918.880	4149.370	05	C-03	22-04-2009	17:25:59	S-Bojana	2.70
1858.336	4155.657	06	B-04	23-04-2009	11:27:54	SE-Bar	0.30
1858.340	4155.651	07	C-04	23-04-2009	11:38:38	SE-Bar	1.20
1901.909	4158.075	08	B-05	23-04-2009	12:36:46	SE-Bar	0.30
1904.642	4200.085	09	B-06	23-04-2009	13:21:25	SE-Bar	0.30
1904.636	4200.084	10	C-06	23-04-2009	13:25:46	SE-Bar	2.15
1851.839	4201.553	11	B-07	23-04-2009	16:15:30	SW-Bar	0.17
1852.542	4201.564	12	B-08	23-04-2009	17:11:43	SW-Bar	0.29

Table 5: Stations positions. Lat/lon data expressed as DDMM.xxxx (WGS84). B=Box-corer,C=gravity core. Recovery in m.

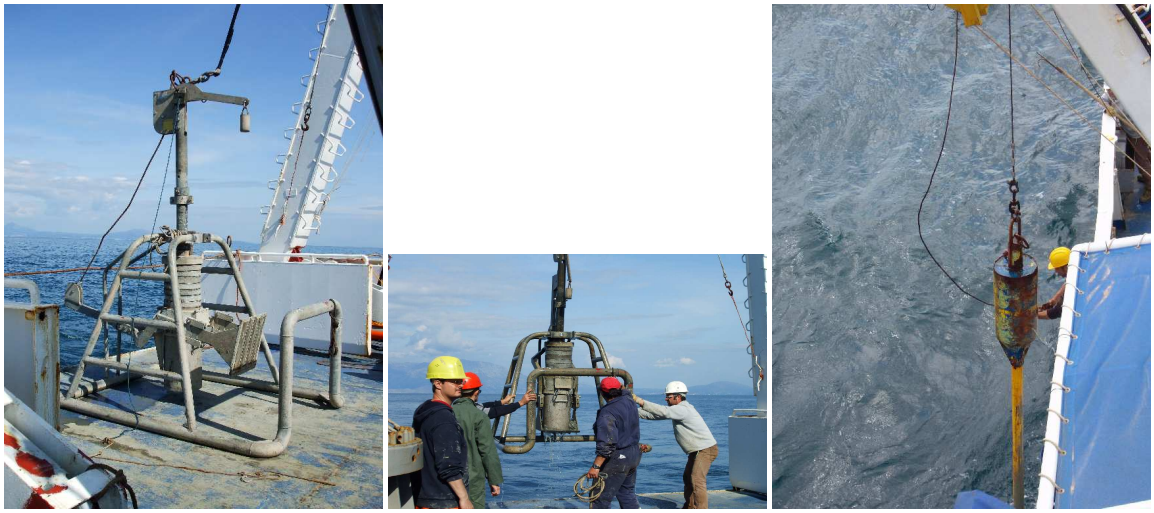

Figure 5: Cruise MNG01_09. ISMAR's OCEANIC box-corer, 1T weight and 1.2 6m gravity corer.

Figure 6: Cruise MNG01_09. ISMAR's OCEANIC box-corer, top surface sediments.

3.3 CTD CASTS AND WATER SAMPLING

CTD and rosette sampling casts were taken on surveyed area. Conductivity (SBE-4,3x10^{-4} S/m initial accuracy), temperature (SBE-3/F, 1.0x10^{-3} °C) and oxygen (SBE-13, 4.3x10$\mu\lambda$l^{-1}), PAR (depth $<$ 1000m), light transmission and fluorimetry data were collected by a Seabird SBE 11 PLUS using the SEASAVE V5.33 software. The pressure data were measured by a ParoScientific Digiquartz (0-6000m, accuracy 0.1%). Data were acquired at 24Hz and the descent rate was aproximately 1 m/s, much less when close to bottom or on interesting interfaces. To facilitate the handling of the equipment during the coring operations, the Bottle Caroussel and some sensors were removed.

The conversion from pressure to depth on the SEA-SAVE software was done at latitude 42N. The WHOI-UNESCO package was also used for converting to the 42N for comparison. DGPS NMEA Position data were interfaced directly to the CTD acquisition systems (see Tables 6and Fig. 3).

The binary data were converted to the CNV and ASCIIOUT (for CTD) formats and further plotted with the ODV software [Schlitzer(2004)]. The Sound Velocity data from the acquired profiles were made available for import into the SIS Software for multibeam data acquisition and corrections.

Lon	Lat	Date Time	Station
01844.63	4103.54	2009-04-19T12:03:28	CTD01
01843.98	4136.50	2009-04-19T16:53:02	CTD02
01823.77	4203.60	2009-04-19T21:14:30	CTD03
01903.31	4206.23	2009-04-21T11:37:53	CTD04
01848.12	4202.68	2009-04-21T19:49:01	CTD05
01917.30	4147.71	2009-04-22T13:07:17	CTD06
01913.37	4151.96	2009-04-22T16:56:25	CTD07
01852.79	4138.46	2009-04-22T19:47:01	CTD08
01858.33	4155.65	2009-04-23T09:16:57	CTD09
01852.09	4201.77	2009-04-23T13:33:09	CTD10
01836.97	4150.05	2009-04-23T17:35:23	CTD11
01833.76	4221.12	2009-04-24T05:36:04	CTD12
01839.61	4226.58	2009-04-24T07:26:15	CTD13
01840.74	4229.35	2009-04-24T08:36:11	CTD14
01825.37	4212.35	2009-04-24T20:54:33	CTD15

Table 6: CTD Stations, MNG01_09 . Lat, Lon expressed as DDMM.xxx. Time is UTC.

Magnetometry

A Marine Magnetics Sea Spy magnetometer was towed astern on the port side, at distance of 180m. The data were collected with ISMAR's Magrec software.

3.4 DATA PROCESSING SEQUENCES

Multibeam and CHIRP data

Multibeam data will be processed by industry-standard software, in addition to the O.S. MB-System package. DTM data will be produced, further analyzed and mapped by the O.S. GMT package [Wessel and Smith (1995)]. The CHIRP data will be processed by the ISMAR's O.S. SEISPHRO package [Gasperini and Stanghellini(2008)], to produce enhanced images of the subsurface seafloor, strata geometry, isopachs etc.

Sediment analysis (at ISMAR, Bologna)

The sediments will be analyzed for:

- physical properties (granulometry, density, mineralogy)
- chemical properties (N,C by CHN) and stable isotopes of C and N, heavy metals, short (^{210}Pb and ^{137}Cs, ^{7}Be) and medium (^{1}4C) life radionuclides to obtain the chronology of thesediemntary sequences.

CTD data (at ISMAR)

CTD data will undergo the following post-processing steps:

- application of pressure, fluorimeter, transmissometer offsets measured on board via dry casts on deck (CTD only)
- de-spiking and eventual linear interpolation of missing data in profiles; Winkler - CTD O2 regression coefficient calculation and correction of oxygen sensors (CTD only)
- production of final 1 dbar and 1 m averaged CTD downcast database

3.5 MAPPING AND MISCELLANEOUS

The datum was set to WGS84 and the UTM (zone34) was chosen for navigation, display, and data acquisition. The time zone was set to the UTC for the instrumental data acquisition.

The 1Km resolution bathymetric data of the SRTM30-PREDICTED dataset by [Becker et al.(2008)] and the XXX were used for preplanning. The lat-lon data were used to produce GMT Netcdf grids, and, after conversion to the UTM Projection, for input to the PDS-2000 ans SIS packages.

The positioning maps and bathymetric images were produced with GMT [Wessel and Smith (1995)]. The multibeam data were pre processed on board by the MB-System [Caress and Chayes(2009)] and GMT software and ISMAR's routines and scripts, using the SIS production DTMS or XYZ ASCII converted data.

ISMAR's computing center employed several INTEL based PC running the GNU-Linux and the Microsoft O.S., in addition to a SUN-SPARC workstation for multibeam data processing (NEPTUNE).

Photographs and video were taken by digital cameras and video-camera.

4 INITIAL RESULTS

Some initial results are presented, in order to address processing sequence of the data acquired and the importance of the preliminary findings.

4.1 SWATH BATHYMETRY

On planned routes and every opportunity, e.g. transits to stations, multibeam and chirp runlines were performed, with the aim to obtain full coverage mapping of the seafloor and to find interesting features on the sea bottom, that could be representative of the different geological settings. Bathymetric data were collected mainly on two areas, (a) the Bay of Kotor and shelf, (b) the shelf in front of Bar to the Bojana River (border between Montenegro and Albania). We devoted a significant portion of our time to map the slope and shelf aiming at collecting data up to the contour of -130m, to make profitable the use of shallow water high resolution multibeam systems toward full coverage maps. Sediment samples of the most significant sequences were collected in the Bojana and Bar regions, in order to characterize the surficial seismic reflectors and to evaluate the different sedimentary domains.

Bar region and southern Montenegro shelf and slope

The upper slope is covered by a thick sedimentary fine grained sediments, with evident instabilities and mass sliding processes. A shallower semicircular, compressional structure, bordered by sediment drift depositional morphologies dominates the region. Paleoshorelines and dune fields are also present, particularly at -120 and -80-70 m depth. The area in front of Bar, mapped during the ADR0208 Urania cruise, shows the presence of an elliptical morphological high, with an intriguing, truncaded cone feature on the west, and bordered to the SW by dune and sand-bar morphologies (Fig.7). The truncated cone, which elevates 20-30m from the surrounding sea floor, was mapped and sampled in detail (Fig.8).

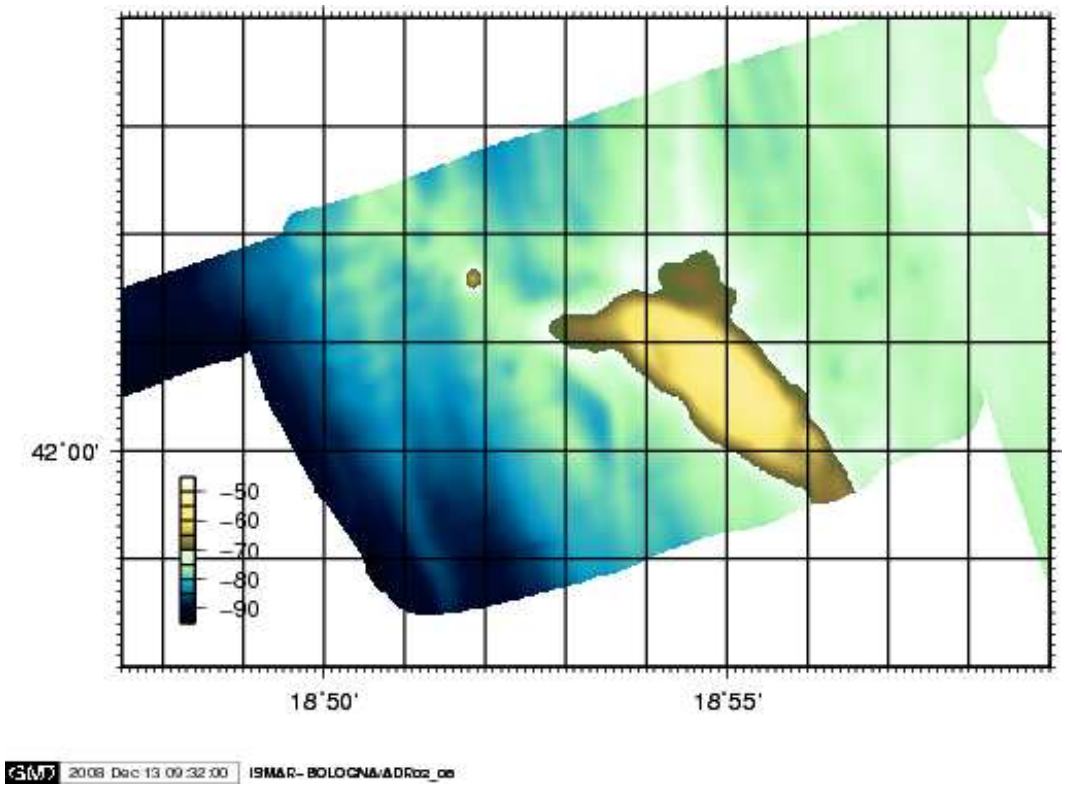

Figure 7: Bar Area. Data from Cruise ADR02_08 [Bignami et al.(2008)]

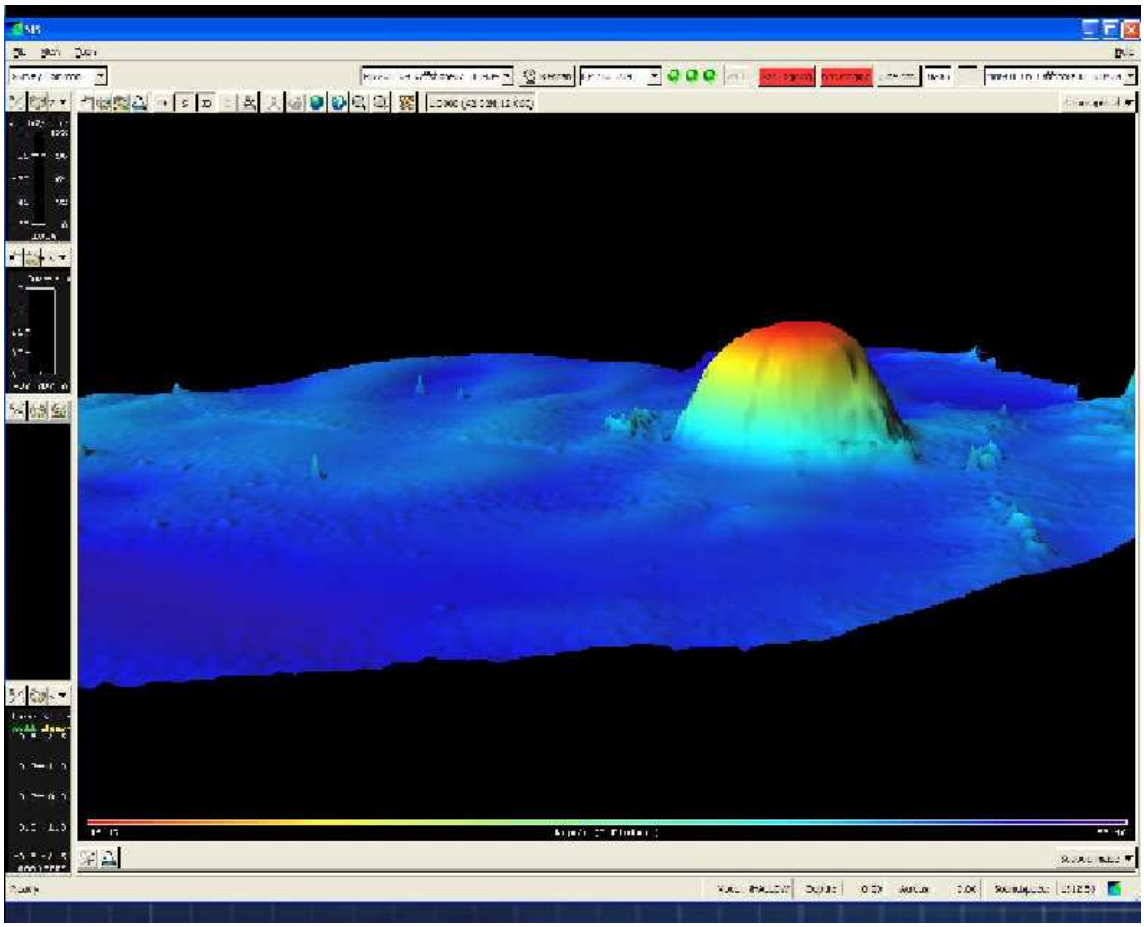

Figure 8: Bar, truncated cone relief, 30m high from 80m depth. Pictures taken from Kongsberg's SIS software (EM-710)

Bay of Kotor

The Bay of Kotor, considered to be the southernmost fjord of Europe, is composed by three embayments, with average depths ranging from 20 to 40m, connected by shallower and narrow straits (e.g. the Verige S., 350m wide), and dominated by mountains of the Dynarides Range as high as 2000m (Mt.Orjen, NW the Bay of Risan, 1894m), with well expressed karst entirety and aquifers discharging on the coast and also below the sea level. During the ADR0208 cruise with Urania [Bignami et al.(2008)] we were able to pick most interesting structures and morphologies, among them the the karst resurgences in the Risan and Kotor bays, and the straits. We had the possibility of spending one day of work in the Bay, and were able to collect more interesting data. Some examples of unprocessed bathymetric data are reported in Figs.12, 9 and 10. It is interesting to note that the fresh water flowing from the sea bottom was also recorded on the multibeam and CHIRP (see for example Fig.11.

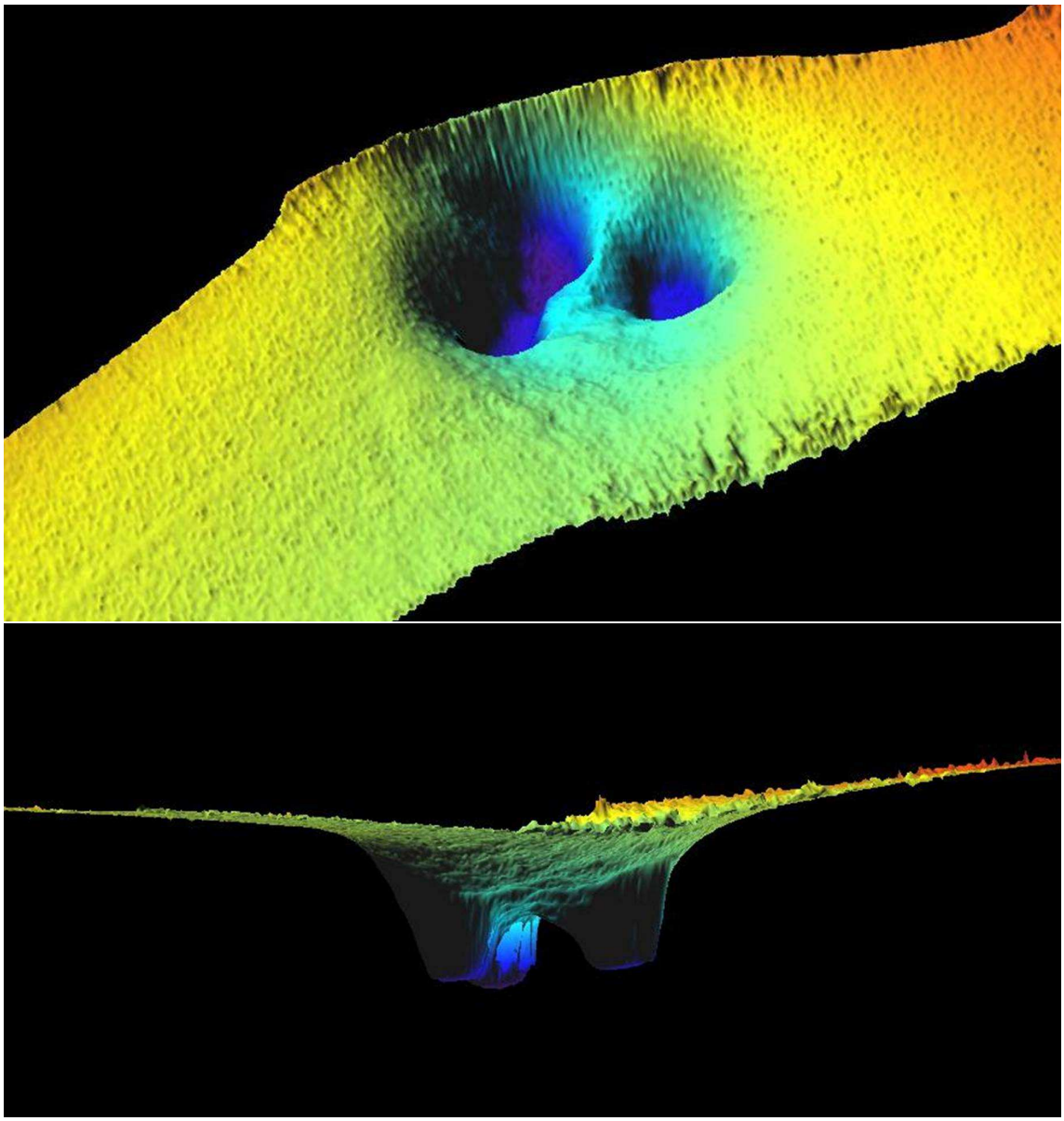

Figure 9: Karst depression, Morinj. 3D topography (up) and cross section. Pictures taken from Kongsberg's SIS software (EM-710)

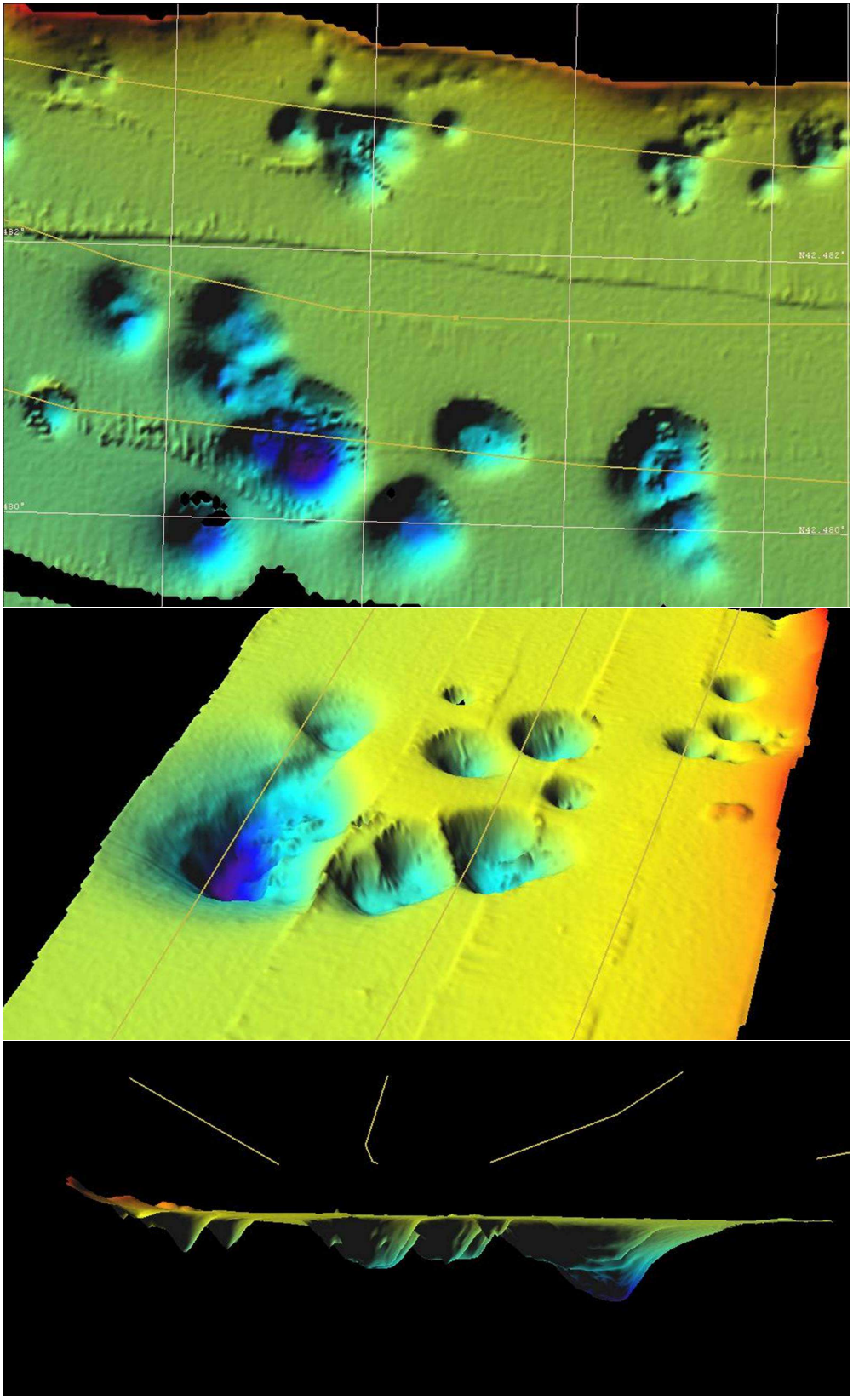

Figure 10: Cluster of karst depressions, Perast. 3D topography (up) and cross section. Pictures taken from Kongsberg's SIS software (EM-710)

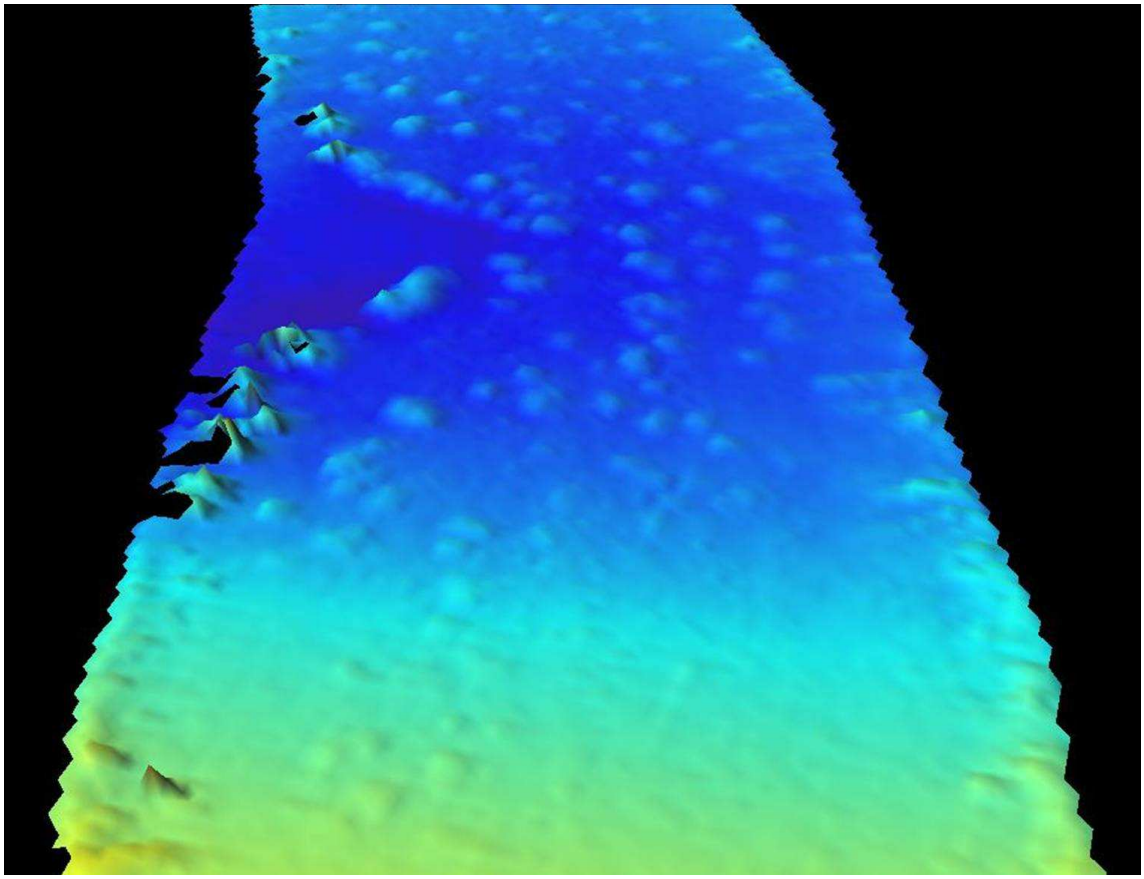

Figure 11: Bay of Risan, multibeam image of water flowing from the seafloor, SE of Sopot. Pictures taken from Kongsberg's SIS software (EM-710)

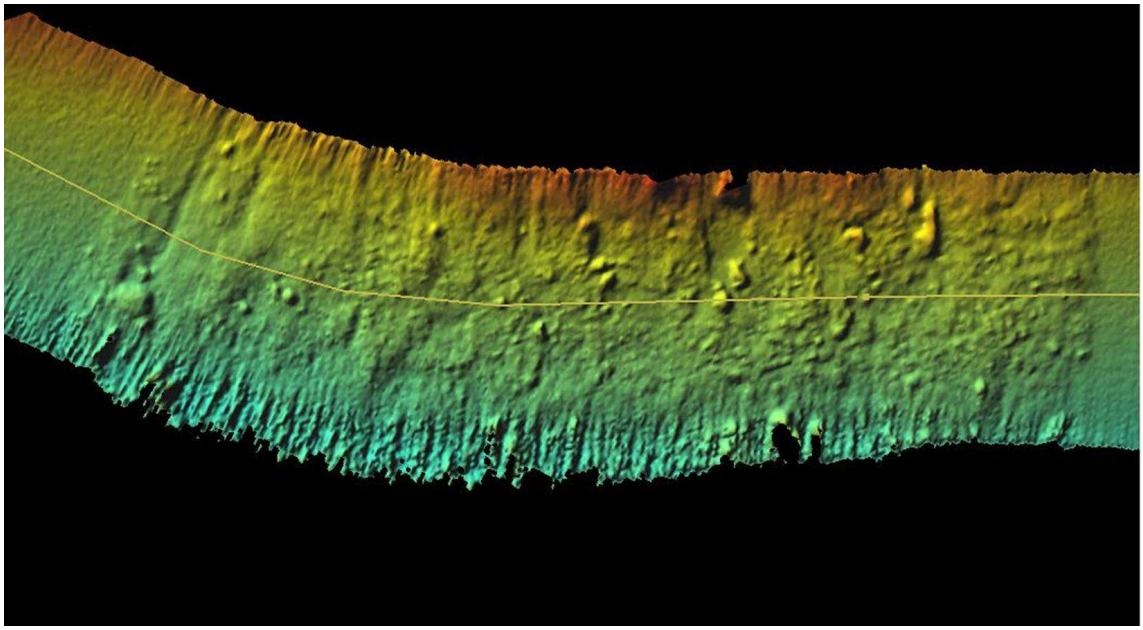

Figure 12: Bay of Kotor. Landlide in front of C.Markov. Pictures taken from Kongsberg's SIS software (EM-710)

4.2 CHIRP SBP PROFILING

Chirp data showed extremely interesting subbottom geometries, in all of the studied areas. Among many others, we present some of them, as examples of data quality and potential for further studies and interpretation.

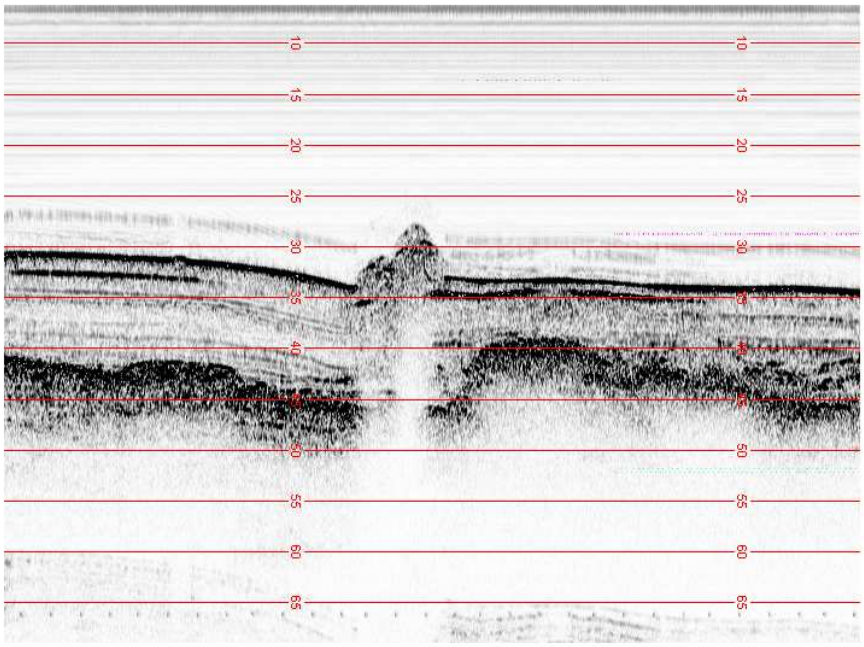

Figure 13: Possible freshwater spring, Risan Bay

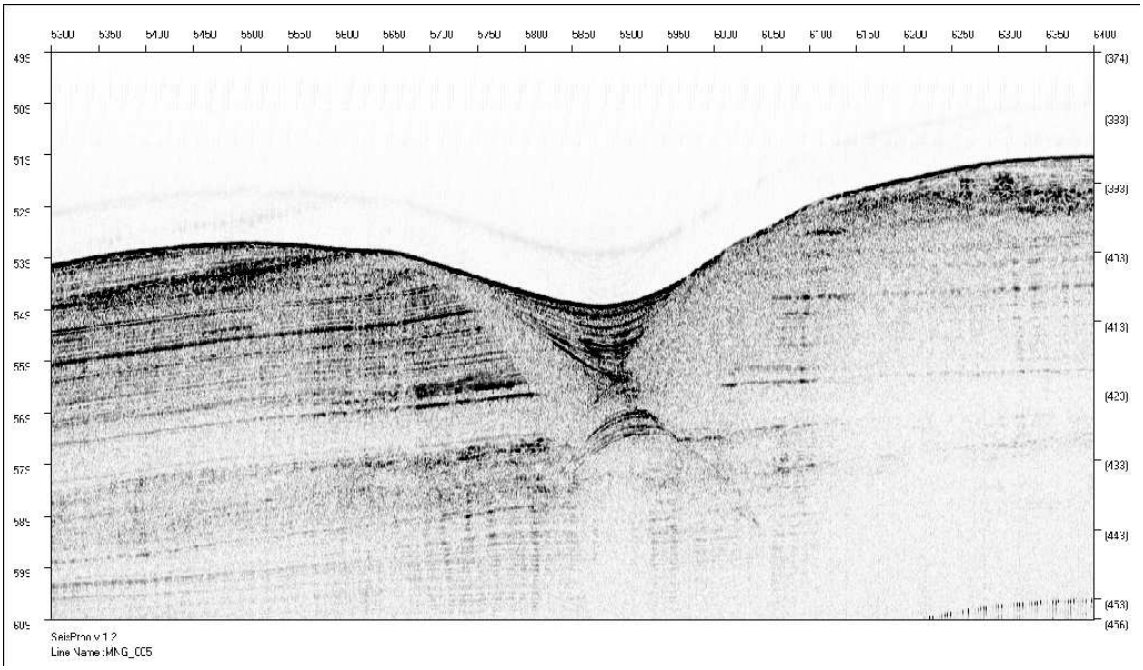

Figure 14: Channel cutting a thick sedimentary sequence, upper slope

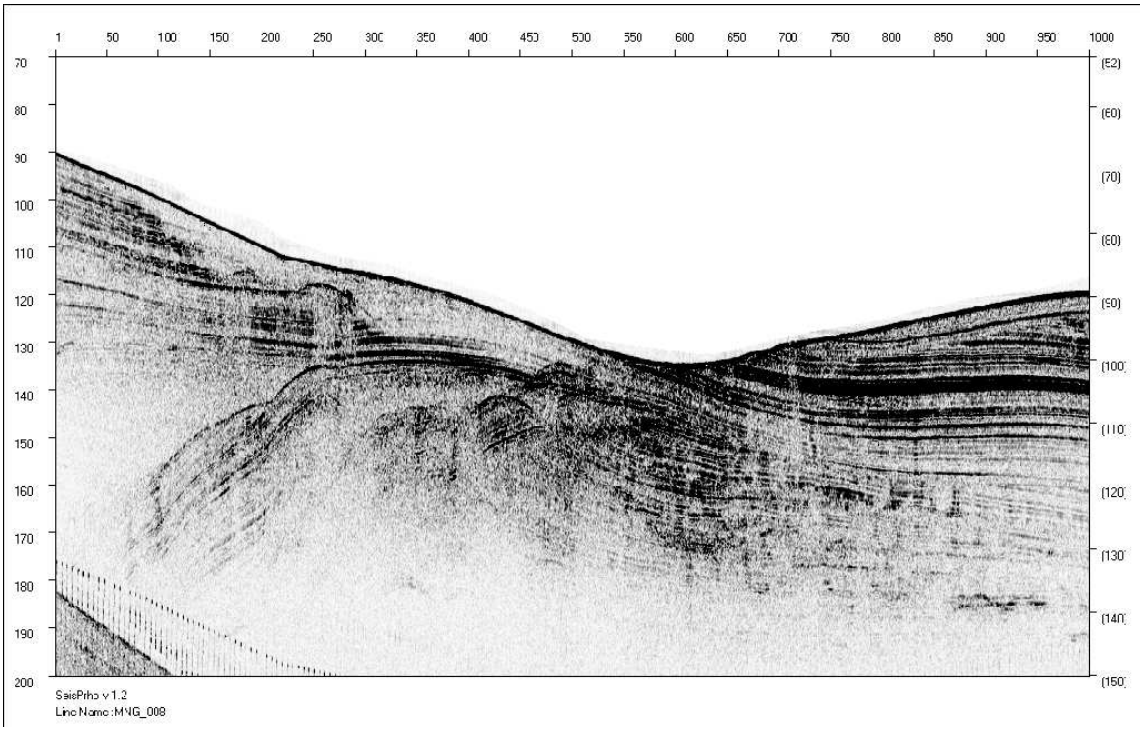

Figure 15: Sediment mass failure, upper slope.

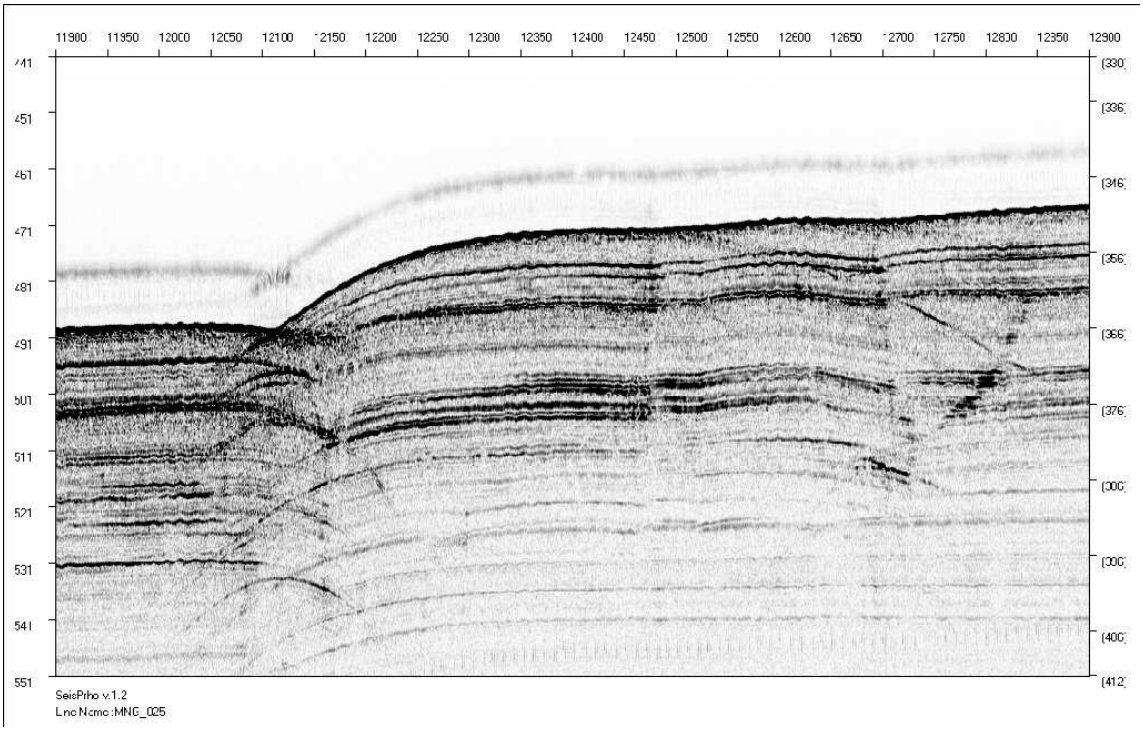

Figure 16: Fault or landslide.

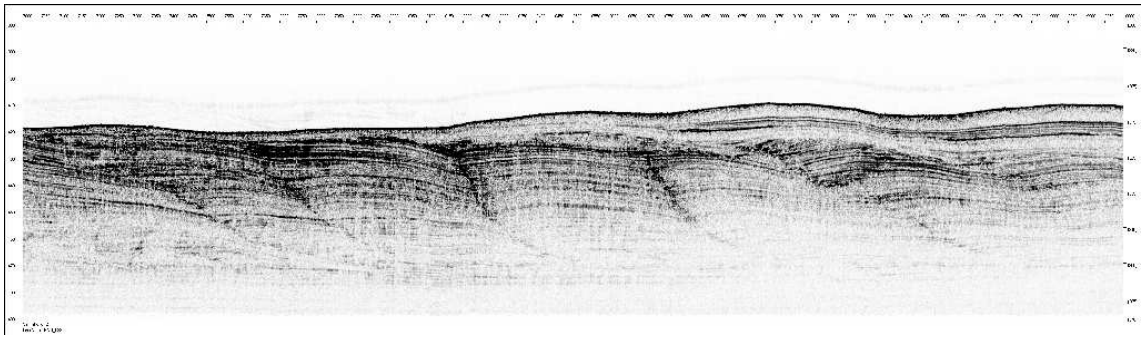

Figure 17: Sedimentary features

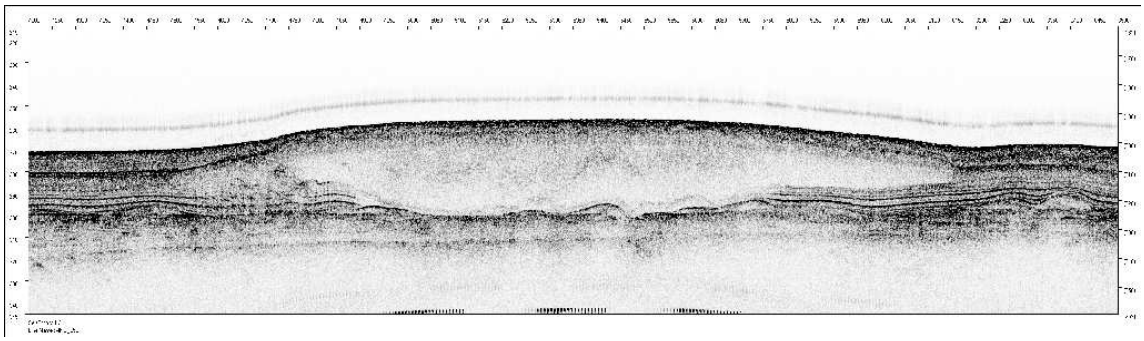

Figure 18: Landslide Cross section, upper slope.

4.3 BOTTOM SAMPLING

Table 7 shows the description of bottom samples.

STATION	SAMPLE	WHERE	DESCRIPTION
01	B-01	S-Bojana	Clay sediment. Very hydrated in the first 2 cm. Compact, lower water content from 2 to 25 cm. Plastic. No (or very low) Bioturbation. No smell. Colors:Top (0-2 cm) yellow/Brown; 2-25 cm Olive green (very uniform); No clast and no shell fragment.
02	B-02	S-Bojana	Clay sediment. Very hydrated in the first 2 cm. Compact, lower water content from 2 to 29 cm. Plastic in the bottom (22-29). Some signal of Bioturbation (warms). No smell. Colors: Top (0-2 cm) yellow/Brown; 2-22 cm Olive green; 22-29 cm Gray/Olive green; No clast and no shell fragment
03	C-02	S-Bojana	Cut information Sp I Bottom (cm 220) silty-clay with shell fragment. Compact, low water content. Color: Gray Olive. Sp II 120 cm Fine Clay sediment; Color Olive/olive gray; Sp III 20 cm Olive green, clay sediment, hydrated.
04	B-03	S-Bojana	Clay sediment. Very hydrated in the first 2 cm. Compact, lower water content from 2 to 30 cm. Plastic in the deepest part (25-30). Some signal of Bioturbation by polychaetes. Colors: Top (0-2 cm) yellow/Brown; 2-30 cm Gray/Olive green; Rare clast and shell fragment.
05	C-03	S-Bojana	Sp I Bottom (cm 220) sandy clay with shell fragment. Compact, high water content. Color: Gray Olive Sp II 120 cm Fine Clay sediment. Seems to be very oxidized Color Black gray, Sp III 20 cm Olive green, clay sediment, hydrated.
06	B-04	SE-Bar	Clay sediment. Very hydrated in the first 3 cm. Low water content 3-18 cm. Compact, lower water content from 18 to 28 cm. Plastic clay on the bottom. Bioturbation, polychaetes. No oxidation. Colors: Top (0-2 cm) yellow/Brown; 2-18 cm Olive green/gray; 18-28cm gray/green.
07	C-04	SE-Bar	Sp I Bottom (cm 120) sandy-clay very dark (Tephra level?) with probably shell fragment. Color: Gray/black Sp III 20 cm Olive green, clay sediment, hydrated. Yellow brown.
08	B-05	SE-Bar	Fine clay sediment. Very hydrated in the first 2 cm. Compact and with low water content from 2 to 20 cm. Compacted (over-consolidated?) in the deepest part (20-31). Worms-Bioturbation. No clast, but rare shell fragment on the bottom. Colors: Top (0-3 cm) Brown/yellow, 2-20 cm Olive green, 20-31 olive green/gray
09	B-06	SE-Bar	Clay sediment. Very hydrated in the first 3 cm. Lower water content 3-25 cm. Quite uniform. At c.10-12 cm seems to be a fracture zone with an high water content (Heart-quake??). Possible Bioturbation but not so much evident. No oxidation.
10	C-06	SE-Bar	
11	B-07	SW-Bar	Very coarse sandy/gravel sediment with many reworked biology: Shell fragment and live, corals Bryozoa, sponge living crustacea. Colors:Top (0-17 cm) Dark and gray sandy clasts,
12	B-08	SW-Bar	Clay sediment. Very hydrated in the first 3 cm. Lower water content 3-18 cm. Very homogeneous. 18-29 cm Silty clay with progressive increase od coarse fraction. Bioturbation Shell and worms.. Colors: Top (0-3 cm) yellow/Brown, 3-18 cm Olive green/gray, 18-29 Gray/green

Table 7: Bottom samples description. B=Box-corer,C=gravity core.

4.4 CTD

Figure 19 shows the CTD data of all the samples collected.

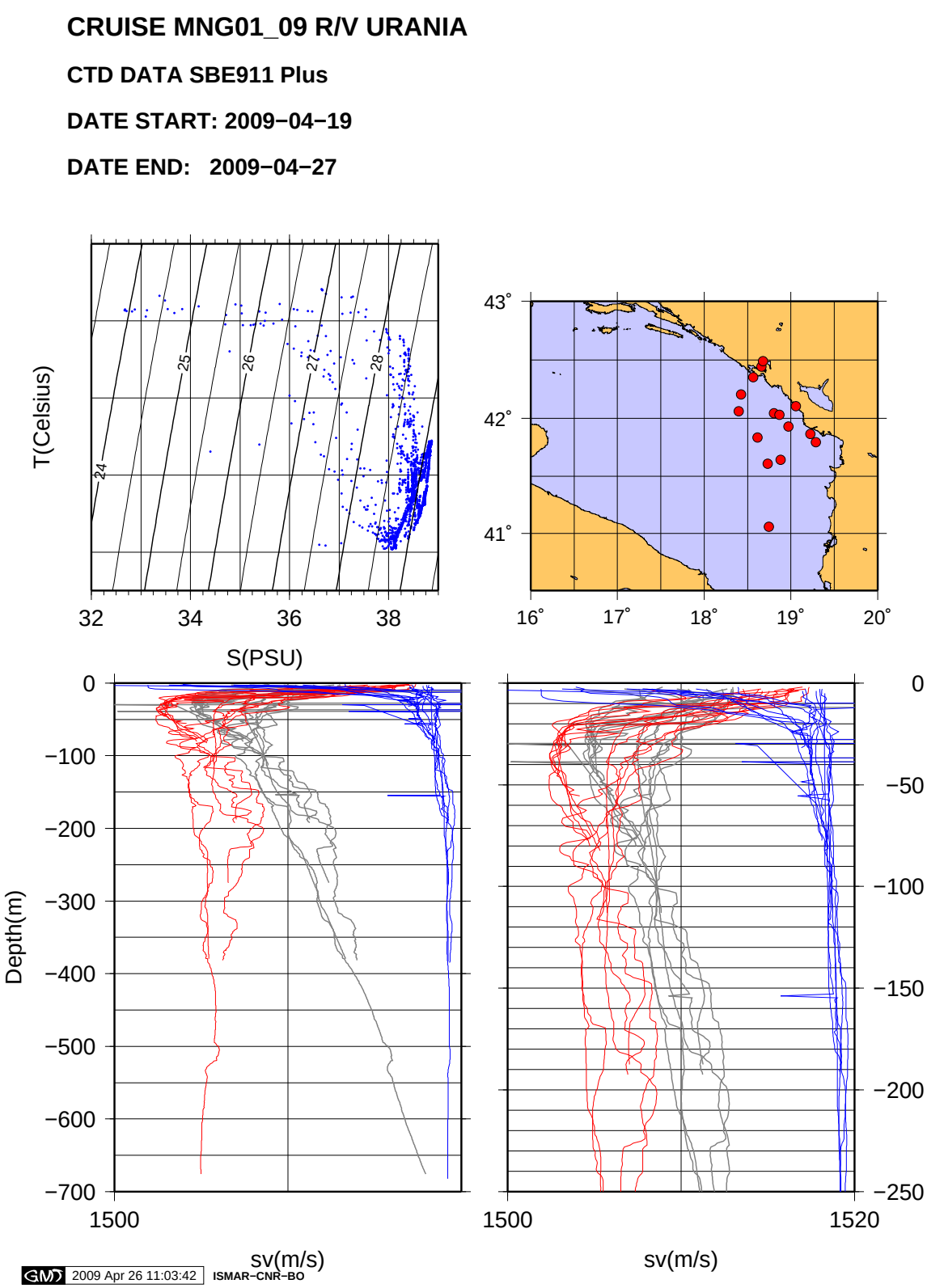

Figure 19: Cruise MNG0109. CTD data.

5 CONCLUSIONS

During the 7 days of cruise MNG0109, including transits and port calls, we obtained:

- aproximately 1200KM^2 of swath bathymetry, 1700KM of high resolution SBP profiles and of single beam bathymetry, aproximately 1000KM of megnetic lines.
- sampling of the sea bottom on 8 stations
- measurements of the water column on 15 CTD stations,

Several morphological features were revealed by the swath bathymetry and Chirp SBP mapping, providing good chances to further explore, finalize and better detail a very interesting marine area.

Analysis of the data collected during the expedition is under process, and will continue during the forthcoming several months.

No problems were encountered regarding neither the people nor the environment during the cruise.

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6 APPENDIX

6.1 CTD EQUIPMENT CONFIGURATIONS

6.1 CTD+ROSETTE

```
Date: 04/26/2009

Instrument configuration file: C:\Campagne CTD\Magic_09\Magic09_Ligi\CTD_11_080409.CON

Configuration report for SBE 911plus/917plus CTD
------------------------------------------------

Frequency channels suppressed : 2
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
Surface PAR voltage added     : Yes
NMEA position data added      : Yes
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4440
   Calibrated on : 02feb09
   G             : 4.37098042e-003
   H             : 5.74207362e-004
   I             : -2.59658483e-005
   J             : -8.26775404e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3172
   Calibrated on : 02feb09
   G             : -1.04160349e+001
   H             : 1.33918262e+000
   I             : 6.90711792e-003
   J             : -4.12540349e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 99750
   Calibrated on : 6-3-2006
   C1            : -4.166608e+004
   C2            : -8.892178e-001
   C3            : 1.284000e-002
   D1            : 3.730200e-002
   D2            : 0.000000e+000
   T1            : 3.007260e+001
   T2            : -5.789086e-004
```

```
   T3            : 3.894030e-006
   T4            : 3.366760e-009
   T5            : 0.000000e+000
   Slope         : 0.99985000
   Offset        : -2.62900
   AD590M        : 1.250000e-002
   AD590B        : -1.000000e+001

4) A/D voltage 0, Altimeter

   Serial number :
   Calibrated on :
   Scale factor  : 15.000
   Offset        : 0.000

5) A/D voltage 1, Free

6) A/D voltage 2, Free

7) A/D voltage 3, Free

8) A/D voltage 4, Oxygen, SBE 43

   Serial number : 1029
   Calibrated on : 02feb09
   Equation      : Murphy-Larson
   Coefficients for Owens-Millard:
   Soc           : 3.7290e-001
   Boc           : 0.0000
   Offset        : -0.4822
   Tcor          : 0.0014
   Pcor          : 1.35e-004
   Tau           : 0.0
   Coefficients for Murphy-Larson:
   Soc           : 3.72900e-001
   Offset        : -4.82200e-001
   A             : -1.79350e-003
   B             : 1.69860e-004
   C             : -2.43690e-006
   E             : 3.60000e-002
   Tau           : 2.00000e+000

9) A/D voltage 5, Free

10) A/D voltage 6, Transmissometer, Chelsea/Seatech/Wetlab CStar

    Serial number : 954DR
    Calibrated on : 30mar06
    M             : 21.5840
    B             : -1.3382
    Path length   : 0.250

11) A/D voltage 7, Fluorometer, Chelsea Aqua 3

    Serial number : 065600-001
    Calibrated on : 12ott07
```

```
    VB            : 0.206400
    V1            : 2.100600
    Vacetone      : 0.302300
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

12) SPAR voltage, Unavailable

13) SPAR voltage, SPAR/Surface Irradiance

    Serial number     :
    Calibrated on     :
    Conversion factor : 0.00000000
    Ratio multiplier  : 0.00000000
```

6.2 CTD

```
Date: 04/24/2009

Instrument configuration file: C:\Campagne CTD\Magic_09\MNG01_09\CTD_220409.CON

Configuration report for SBE 911plus/917plus CTD
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Frequency channels suppressed : 2
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
Surface PAR voltage added     : Yes
NMEA position data added      : Yes
Scan time added               : No

1) Frequency 0, Temperature

   Serial number : 4440
   Calibrated on : 02feb09
   G             : 4.37098042e-003
   H             : 5.74207362e-004
   I             : -2.59658483e-005
   J             : -8.26775404e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity

   Serial number : 3172
   Calibrated on : 02feb09
   G             : -1.04160349e+001
   H             : 1.33918262e+000
   I             : 6.90711792e-003
   J             : -4.12540349e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
```

```
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 99750
   Calibrated on : 6-3-2006
   C1            : -4.166608e+004
   C2            : -8.892178e-001
   C3            : 1.284000e-002
   D1            : 3.730200e-002
   D2            : 0.000000e+000
   T1            : 3.007260e+001
   T2            : -5.789086e-004
   T3            : 3.894030e-006
   T4            : 3.366760e-009
   T5            : 0.000000e+000
   Slope         : 0.99985000
   Offset        : -2.62900
   AD590M        : 1.250000e-002
   AD590B        : -1.000000e+001

4) A/D voltage 0, Free

5) A/D voltage 1, Free

6) A/D voltage 2, Free

7) A/D voltage 3, Free

8) A/D voltage 4, Oxygen, SBE 43

   Serial number : 1029
   Calibrated on : 02feb09
   Equation      : Murphy-Larson
   Coefficients for Owens-Millard:
   Soc           : 3.7290e-001
   Boc           : 0.0000
   Offset        : -0.4822
   Tcor          : 0.0014
   Pcor          : 1.35e-004
   Tau           : 0.0
   Coefficients for Murphy-Larson:
   Soc           : 3.72900e-001
   Offset        : -4.82200e-001
   A             : -1.79350e-003
   B             : 1.69860e-004
   C             : -2.43690e-006
   E             : 3.60000e-002
   Tau           : 2.00000e+000

9) A/D voltage 5, Free

10) A/D voltage 6, Free

11) A/D voltage 7, Free
```

12) SPAR voltage, Unavailable

13) SPAR voltage, SPAR/Surface Irradiance

```
    Serial number     :
    Calibrated on     :
    Conversion factor : 0.00000000
    Ratio multiplier  : 0.00000000
```