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Short Cruise Report

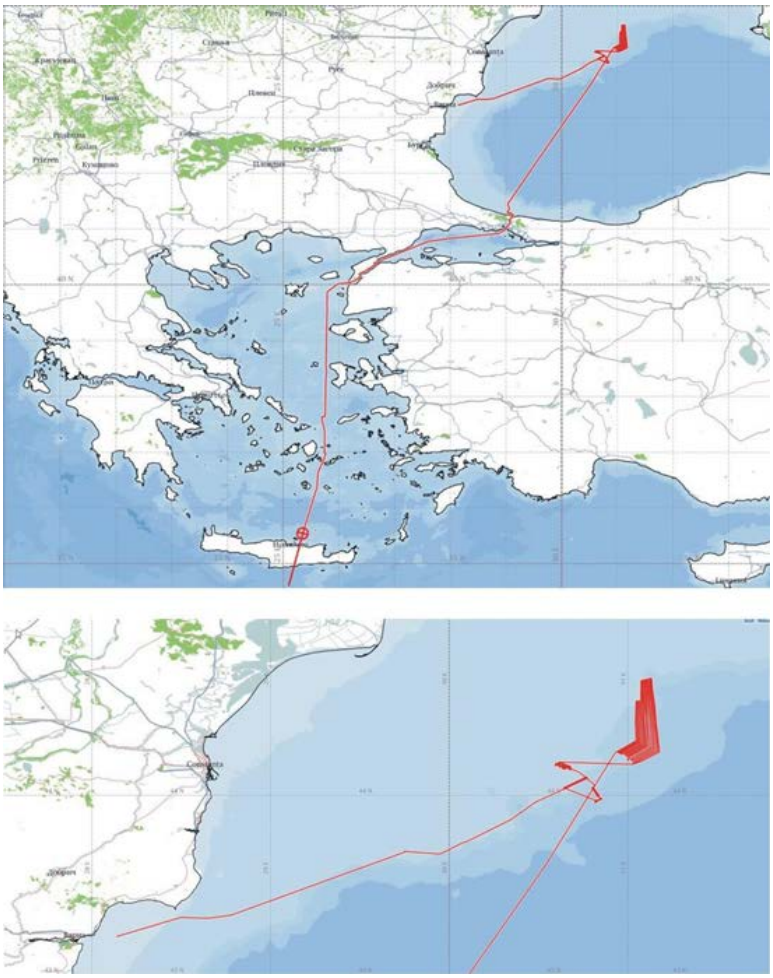
METEOR M143

12.12.2017–22.12.2017

Varna – Heraklion

Chief Scientist: Michael Riedel

Captain: Rainer Hammacher



1 Background and Objectives

Recent findings from MSM-34 seismic data showed that mass transport deposits did occur with up to 600 km^3 volume within the Danube Delta, Black Sea. The deposition sequences do influence the continuation of vertical gas migration pathways and may cut them off preventing active methane gas release at the seafloor. Data from the Bulgarian margin did show that vertical gas migration outside the gas hydrate stability zone form elongated seafloor depressions weakening the sediment layers and developing into headwalls of future slope failures. Cruise M-143 SLOGARU aims to investigate possible areas of seafloor depressions and slope failure along the shallow part of the Black Sea margin in the Danube Delta by bathymetry mapping and water column observation. A second emphasis is on collecting 38 kHz echo sounder data in combination with multibeam water column images for quantification of gas emissions.

2 Cruise narrative

After departure of the port of Varna at 10:00 on Tuesday, December 12, 2017, we started data recording after crossing the border between Bulgaria and Romania at ca. 18:00. We completed survey lines using bathymetric mapping with the two multibeam echosounders EM710 and EM122 as well as the PARASOUND sub bottom profiler. On Wednesday morning (December 13, 2017) we arrived at the Lander station (from expedition M-142) and deployed the 38 kHz sounder through the moon pool. Until 13:00 we completed recording a first set of survey lines (without PARASOUND) to get an overview of the gas flares at this location. The afternoon of Wednesday (December 13, 2017) was dedicated for calibrating the 38 kHz sounder, which was completed in 4 hours. A small metallic sphere was deployed using fishing rods through the moon pool and was held at 8 – 10m below the sounder.

After calibration we completed a tight grid of survey lines along the eastern flank of the S2 channel, where we mapped numerous gas flares during M-142 until Thursday (December 14, 2017) morning. A short transit was completed in 2 hours to a third survey location for gas flare mapping with the 38 kHz sounder in shallow water depths (120 m). At 14:00 on Thursday (December 14, 2017) we started a series of survey lines to image numerous gas flares occurring at prominent seafloor expressions of faults, part of a larger graben-system. Here, we finished recording data on Friday (December 15, 2017) morning 08:00. The 38 kHz sounder was dismounted from the moon pool within half an hour and we started a 2 hour transit to the last survey region in the east, to fill in a larger area of missing data in the bathymetric grid of the region. In this survey region, we completed 32 survey lines

using the two multibeam sounders EM710 and EM122 as well as the PARASOUND sub bottom profiler. Data recording was completed on Sunday, December 17 2017, at 17:20 and we started the transit to the Bosporus. A complete track log of all lines acquired is given in Figure 1. During the 4-day long transit we completed processing of the acquired PARASOUND and multibeam data. The expedition M-143 was successfully completed on Thursday, December 21, in Heraklion.

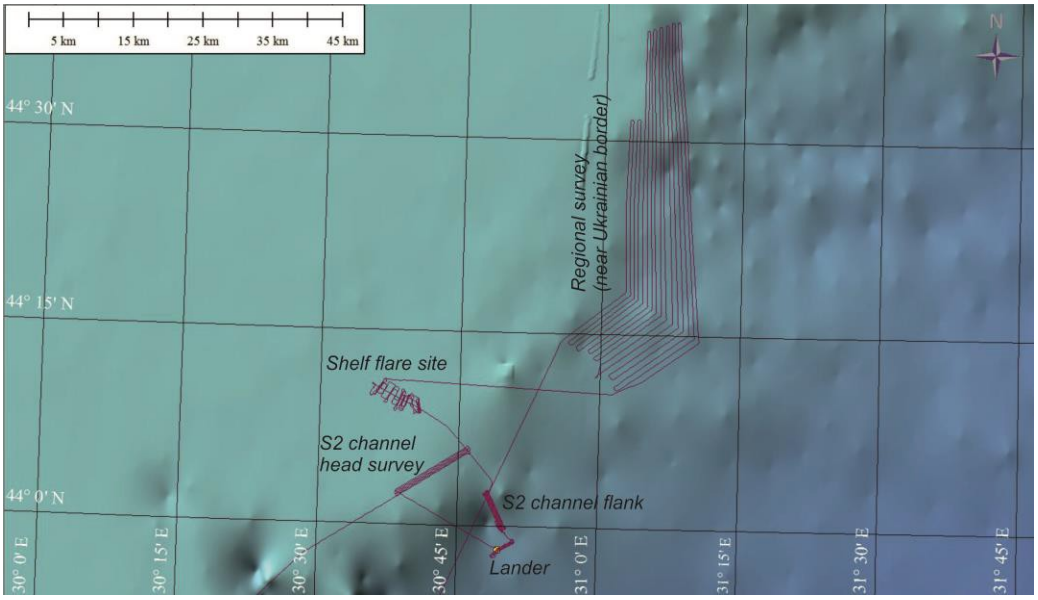


Figure 1: Detailed view of track log of M143 with five sub-survey regions identified.

3 Results

3.1Single-beam echosounder mapping of gas flares

During the expedition M143 we used a Simrad EK80 with a 38 kHz Simrad ES38-7 transducer in combination with EM710 Multibeam to assess a new methodology for quantitative estimates of benthic gas bubble streams. The 38 kHz transducer was installed in the moonpool of the R/V METEOR (Figure 2). The calibration was carried out on Wednesday, December 13, 13:00 – 17:00 local time. During this time period there were little wind and waves, and the ship was drifting with the existing currents. Prior to the calibration, a SVP cast was used to obtain the latest environment parameters for the EK80 (water temperature, salinity, and sound speed).

For the assessment of the method, we ran three surveys which were planned using the initial flare positions determined by the previous cruise M142. The setup and line spacing were optimized for water column imaging. The first survey (13.12. 2017, 07:47 – 18:14, local time) was planned over the location where a lander mounted with an EK80 from Kongsberg was placed during M142. During this survey only the EK80, EM122 and the EM710 were turned on, while the PARASOUND was turned off. With the second survey (13.12. 2017, 18:50 – 14.12. 2017, 09:58, local time) we mapped a larger area at the eastern flank of the S2 canyon were we could cover many bubble streams in different water depths (300m – 600m) with a very small line spacing of only 60 m. This survey was also run with the EK80, EM122 and the EM710 systems. With the third survey (14. 12. 2017, 11:27 – 15. 12. 2017, 06:38, local time) we covered a shelf area (115 m – 135 m water depth) with some known bubble stream locations along bathymetric depressions. During this survey the interferences in EM710 and EK80 data could be reduced significantly compared to the previous surveys by turning off the EM122.

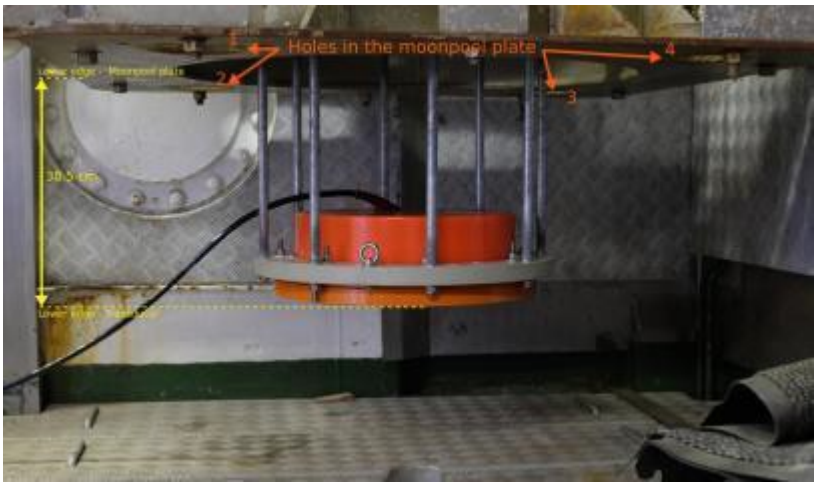


Figure 2: ES38-7(orange) attached to the moonpool plate with 50 cm long spacer elements. (Photo credit: Peter Urban)

During the last survey on the shelf the background noise of the EM710 became unnoticeable and the quality water column images increased (Figure 3). Because the EM122 was turned off and the EK80 pulse-shape was set to slow ramping, the visible interferences in the EM710 could be reduced significantly, such that specifically the inner sector of the EM710, which looks downwards, is nearly free of interferences.

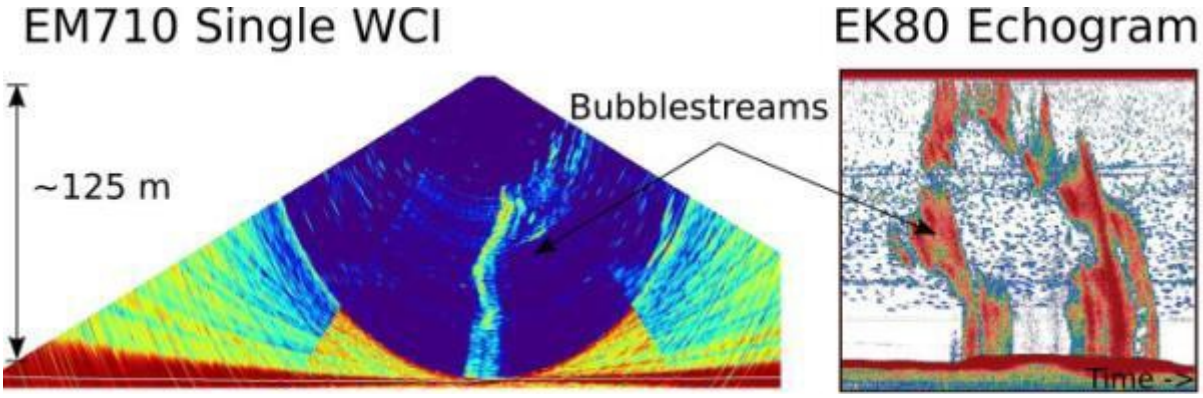


Figure 3: Example for a bubble stream (acoustic flare) in an EM710 WCI and the EK80 Echogram in ca. 125m depth.

3.2 Multibeam mapping

During the cruise M143 multibeam data were acquired across the Danube Delta, Black Sea. In total 1,189 km (642 nautical miles) of survey lines were acquired. Along these lines we always acquired multibeam echo sounders EM710 data and at selective lines we added the EM122. The EM710 was the primary multibeam echo sounder system (MBES) of this survey. Five sub-regions were visited during M143 (Figure 4a – 4e): An area around the lander location from M142, along the eastern flank of the S2 channel, at a shallow shelf area with a prominent graben-like seafloor depression, the S2 channel head and a larger region at the eastern border towards the Ukraine.

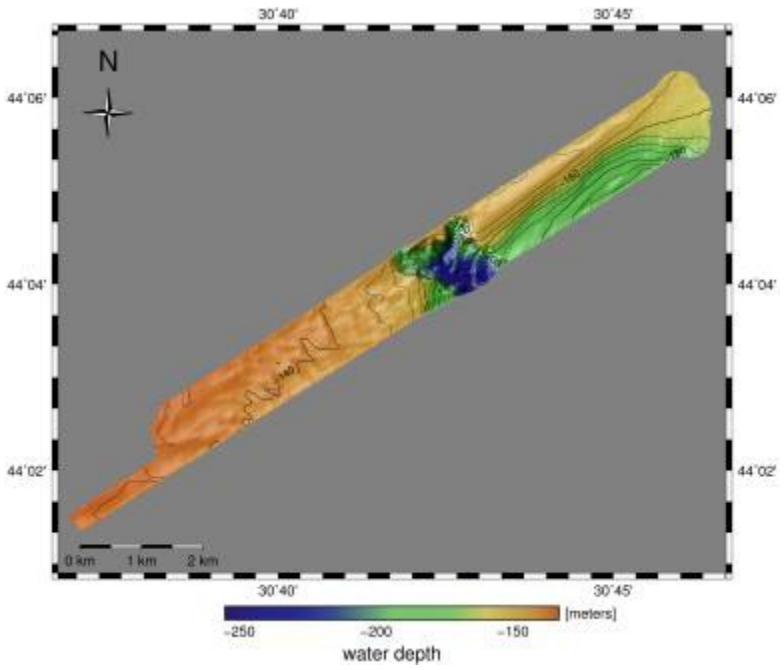


Figure 4a: Bathymetric map of S2 canyon head (EM710).

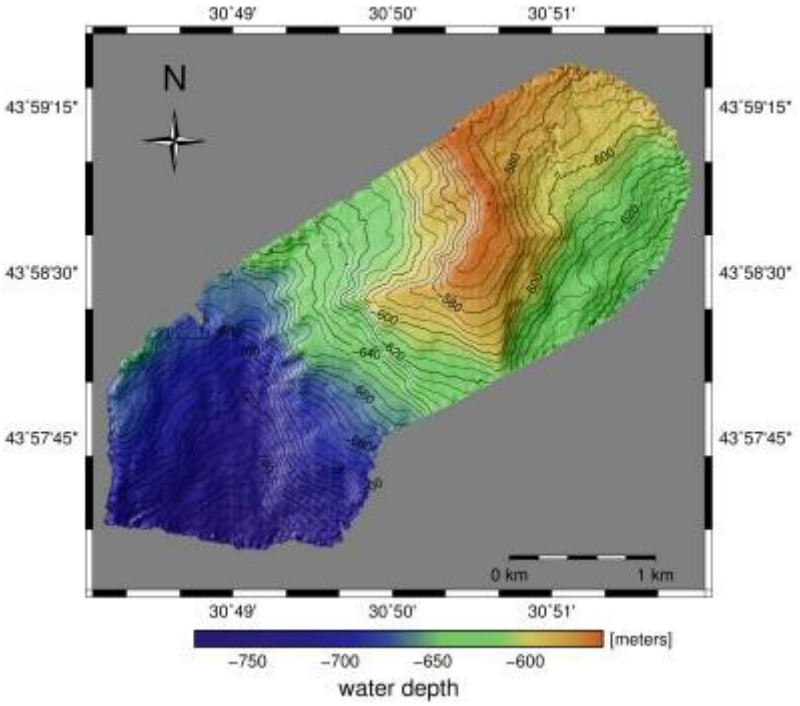


Figure 4b: Bathymetric map at the Lander-Site (EM710).

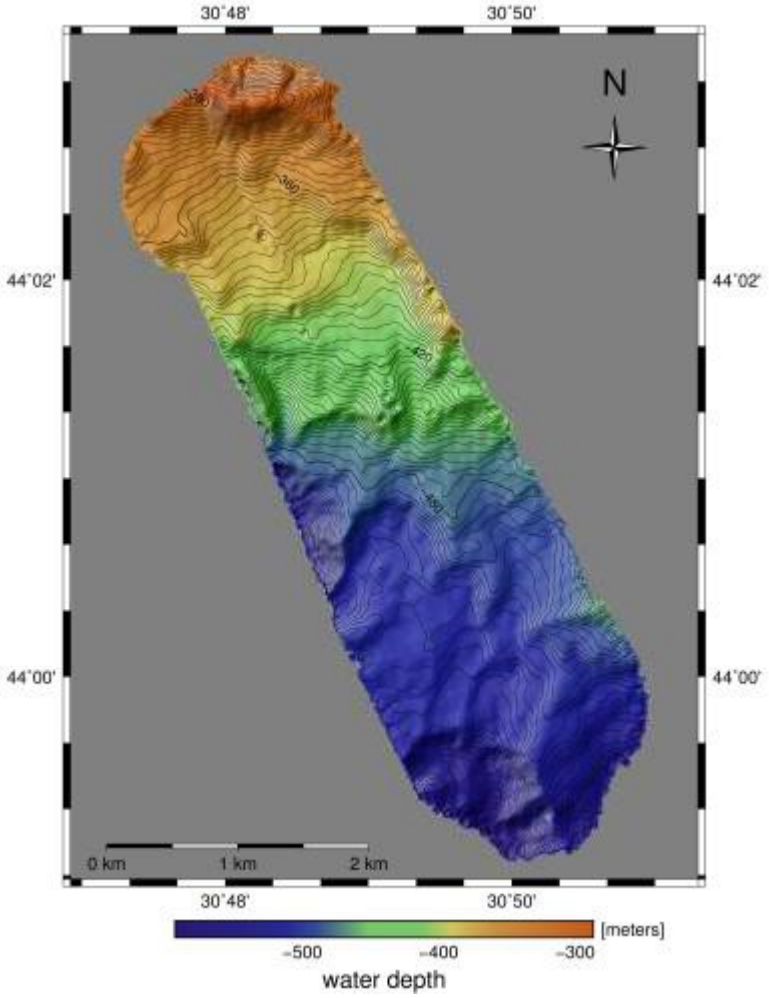


Figure 4c: Bathymetric map of the area at the eastern flank of the S2 channel (EM710).

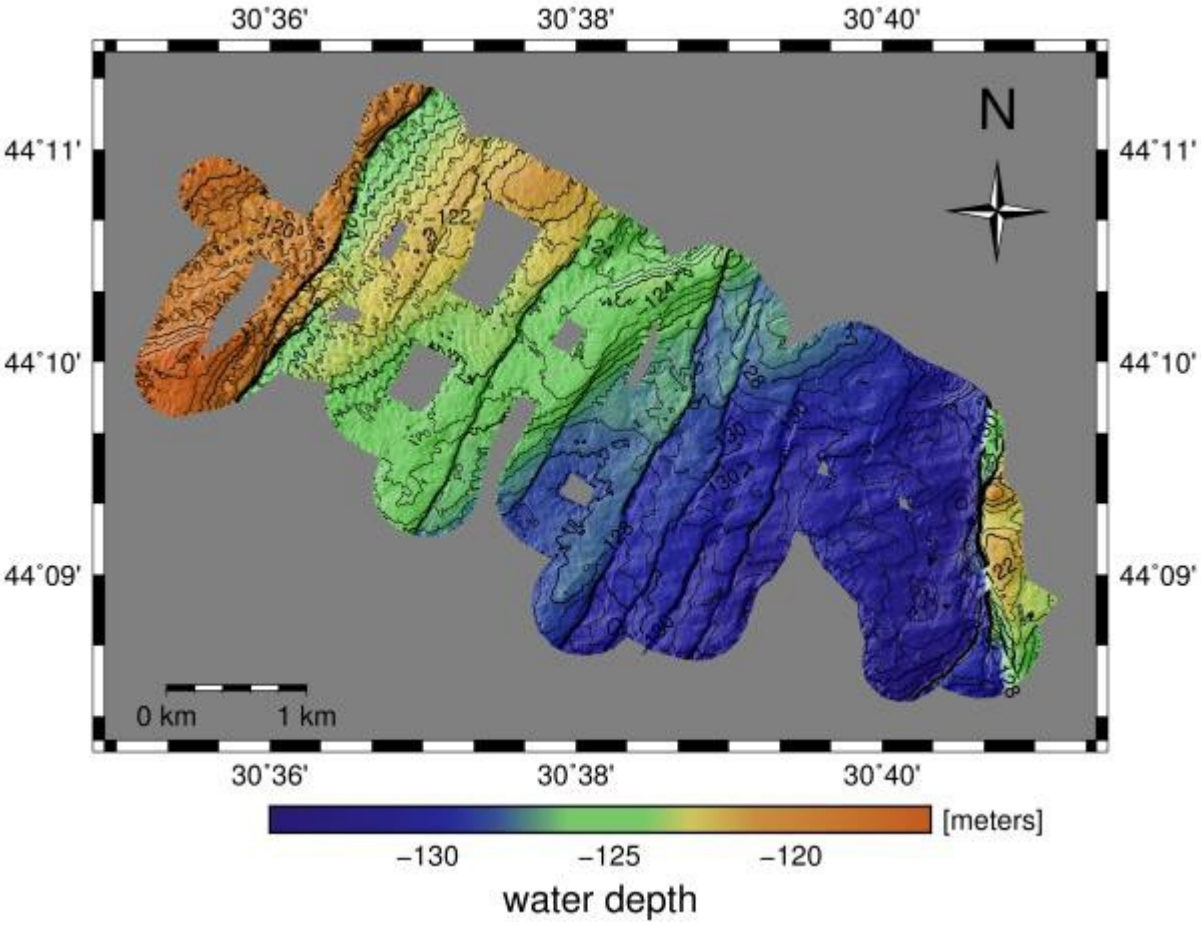


Figure 4d: Bathymetric map of sites on shelf (EM710).

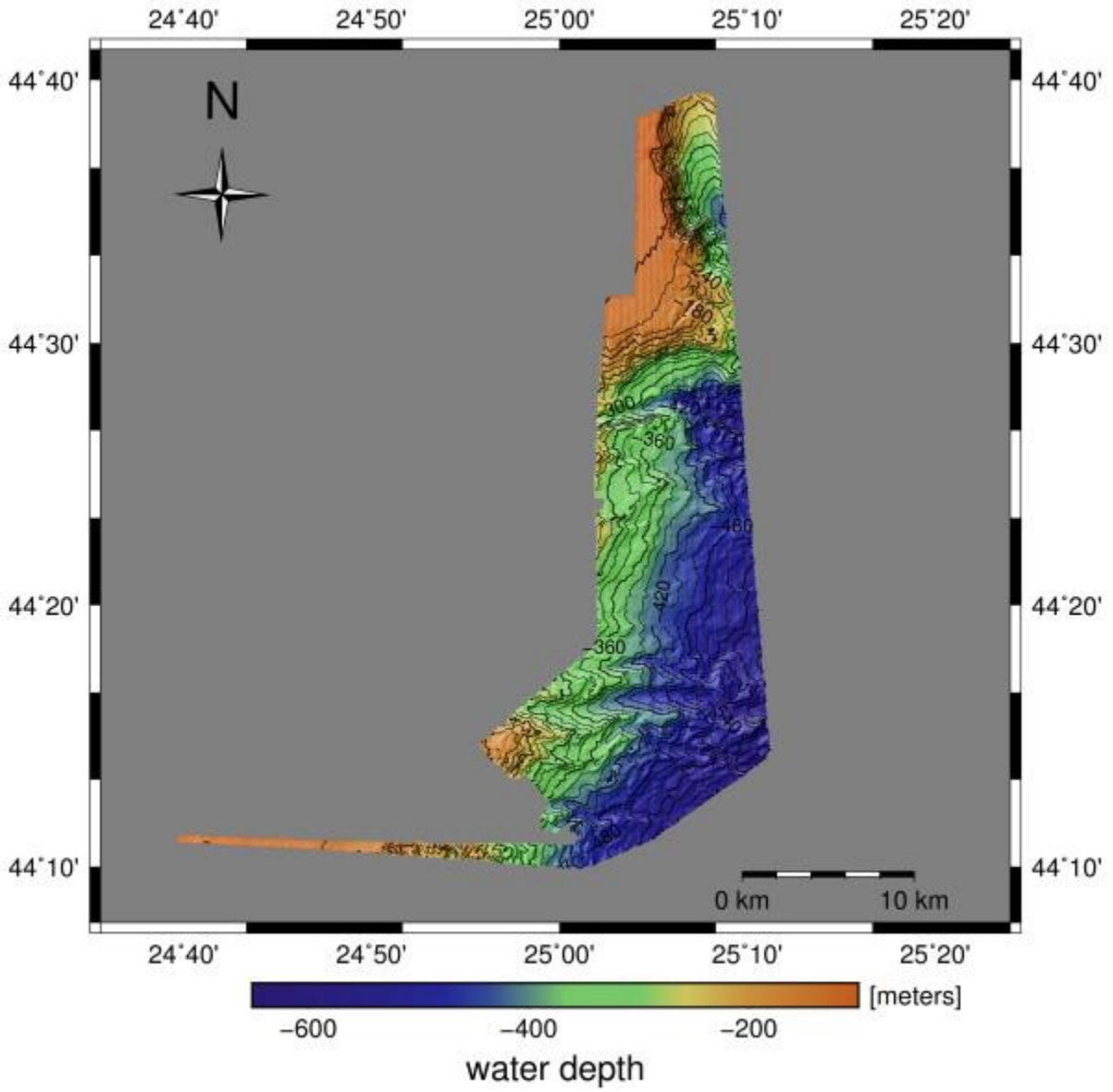


Figure 4e: Bathymetric map near the Ukrainian border (EM710).

3.3 Sub-bottom profiling (PARASOUND)

The PARASOUND echosounder utilizes the parametric effect based on the nonlinear relation of pressure and density during sonar propagation. Two high intensity acoustic waves with frequencies of 18-20 kHz (called primary high frequency, PHF) and 22-24 kHz were used to create a secondary high (40-42 kHz) and a secondary low (~4 kHz) frequency (referred to as SLF). While the SLF is used for the sub bottom profiling, the PHF can be used to image gas bubbles, plankton or fish in the water column. However, for the purpose of expedition M143, we focus on the SLF for profiling, as the 38 kHz single beam

echo sounder provided imaging of the water column and the EM710 and EM122 multibeam systems are used for gas flare location detection.

The sub bottom profiler data show penetration depths varying from only 20 m across the shelf region to > 100 m in deeper water settings. Abundant evidence for seafloor pockmarks, elongated depressions and slope failures were found (Figure 5), indicating that processes described by Xu et al. (2018) based on the SPUX data also occur along the eastern margin of the Danube delta region off Romania.

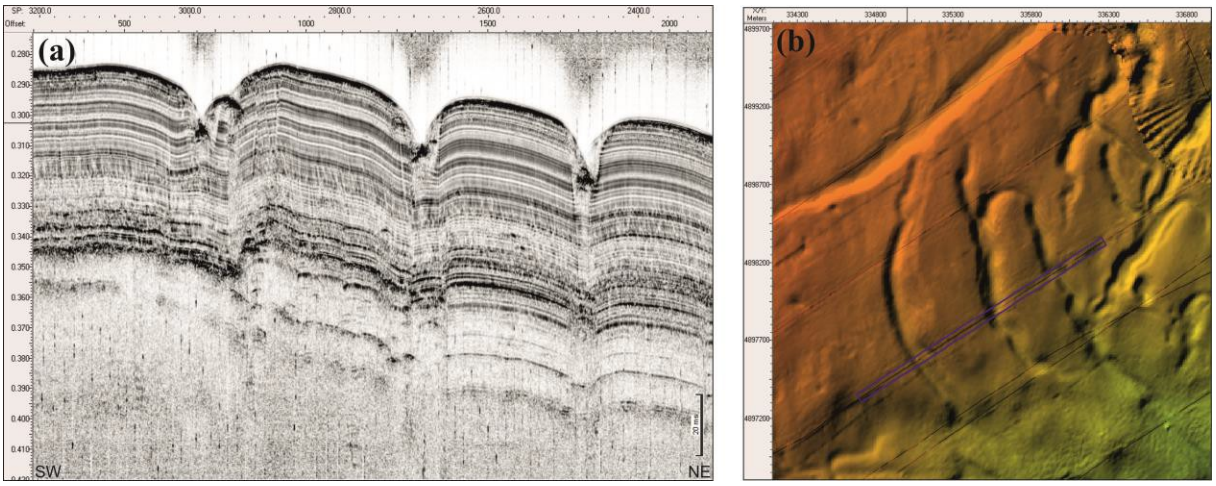


Figure 5: **(a)** Example of a PARASOUND profile (shown is envelope) with processing included an automatic gain control with a window length of 50 ms across an area shown in (b) with prominent elongated seafloor depressions (blue rectangle shows extent of line shown in (a)), similar in shape and nature described in Xu et al., (2018), demonstrating that the processes described in the region off the southern Bulgarian margin are also acting on the slope off the Danube Delta region.

Acknowledgements

We would like to thank Captain Rainer Hammacher and his entire crew for the great support during expedition M143, especially during installation of the 38 kHz sounder, which was never done before on board the R/V METEOR. Additional thanks go to the German Research Fleet Coordination Centre at the University Hamburg for granting ship time, as well as our staff at GEOMAR (especially Anne Völsch) in helping to coordinate travel, shipping, and overall logistics.

Cruise Participants

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DWD Deutscher Wetterdienst

Table 1 Station List for Sound Velocity profile measurements

Station	Date	Time (UTC)	Device	Latitude	Longitude
M143_4-1	13/12/2017	11:28	SVP01	43° 58.094' N	030° 49.351' E
M143_5-1	13/12/2017	12:49	SVP02	43° 58.222' N	030° 49.348' E
M143_5-1	13/12/2017	12:49	SVP03	43° 58.222' N	030° 49.348' E
M143_8-1	14/12/2017	11:40	SVP04	44° 10.492' N	030° 35.728' E

Appendix List of survey regions, stations with sound-velocity measurements, and transit profiles

Station/Profile ID		Date / Time (UTC)	Device	Action	Latitude	Longitude	Depth (m)	Speed of vessel (kn)	Course (°)
M143_1-1	Transit to research region	12/12/2017 16:03	Multibeam and Parasound Profile	profile start	43° 41,197' N	029° 45,197' E	82.2	7	95.6
M143_1-1		12/12/2017 23:07	Multibeam and Parasound Profile	profile end	44° 05,498' N	030° 45,813' E	172.3	7	61.5
M143_2-1	Survey region "S2 channel head"	12/12/2017 23:14	Multibeam and Parasound Profile	profile start	44° 05,683' N	030° 46,008' E	165.9	5	231.4
M143_2-1		12/13/2017 4:15	Multibeam and Parasound Profile	profile end	44° 02,683' N	030° 38,511' E	136.7	7	239.2
M143_3-1	Survey region "Lander Position"	12/13/2017 7:32	Multibeam and Parasound Profile	profile start	43° 57,977' N	030° 49,039' E	662.9	4	47.3
M143_3-1		12/13/2017 10:52	Multibeam and Parasound Profile	profile end	43° 58,592' N	030° 50,781' E	576.4	4	240.4
M143_3-1		12/13/2017 15:48	Multibeam and Parasound Profile	profile start	43° 57,957' N	030° 49,469' E	679.2	3	21.7
M143_3-1		12/13/2017 16:13	Multibeam and Parasound Profile	profile end	43° 58,636' N	030° 50,920' E	592	3	62.8
M143_4-1		12/13/2017 11:28	Sound Velocity Profiler	in the water	43° 58,094' N	030° 49,351' E	687.2	0	126.4
M143_5-1		12/13/2017 12:49	Sound Velocity Profiler	in the water	43° 58,222' N	030° 49,348' E	687.2	0	43.8
M143_6-1	Survey region "S2 channel flank"	12/13/2017 18:18	Multibeam and Parasound Profile	profile start	43° 59,924' N	030° 49,571' E	521.8	3	333.1
M143_6-1		12/14/2017 7:59	Multibeam and Parasound Profile	profile end	44° 02,530' N	030° 48,372' E	360.8	3	330.3
M143_7-1	Transit to shelf survey region	12/14/2017 8:17	Multibeam and Parasound Profile	profile start	44° 03,654' N	030° 48,488' E	310.3	5	320.3
M143_7-1		12/14/2017 11:20	Multibeam and Parasound Profile	profile end	44° 10,681' N	030° 35,834' E	119.8	3	298.6
M143_8-1		12/14/2017 11:40	Sound Velocity Profiler	in the water	44° 10,492' N	030° 35,728' E	120	1	205.4
M143_9-1	Survey region 1 on shelf	12/14/2017 12:14	Multibeam and Parasound Profile	profile start	44° 10,048' N	030° 35,919' E	119.3	4	43.5
M143_9-1		12/14/2017 15:38	Multibeam and Parasound Profile	profile end	44° 08,673' N	030° 40,289' E	131.8	3	211.2
M143_10-1	Survey region 2 on shelf	12/14/2017 16:07	Multibeam and Parasound Profile	profile start	44° 09,778' N	030° 39,027' E	129.4	3	194.7
M143_10-1		12/14/2017 22:07	Multibeam and Parasound Profile	profile end	44° 09,772' N	030° 39,510' E	129.7	3	22.5
M143_11-1	Survey region 3 shelf	12/14/2017 22:25	Multibeam and Parasound Profile	profile start	44° 09,467' N	030° 40,597' E	130.9	4	180.9
M143_11-1		12/15/2017 5:58	Multibeam and Parasound Profile	profile end	44° 10,966' N	030° 36,717' E	125	3	33.8
M143_12-1	Survey region Eastern slope	12/15/2017 8:07	Multibeam and Parasound Profile	profile start	44° 10,640' N	031° 02,090' E	492.4	7	68.1
M143_12-1		12/17/2017 15:19	Multibeam and Parasound Profile	profile end	44° 14,531' N	030° 55,954' E	182	8	230.9