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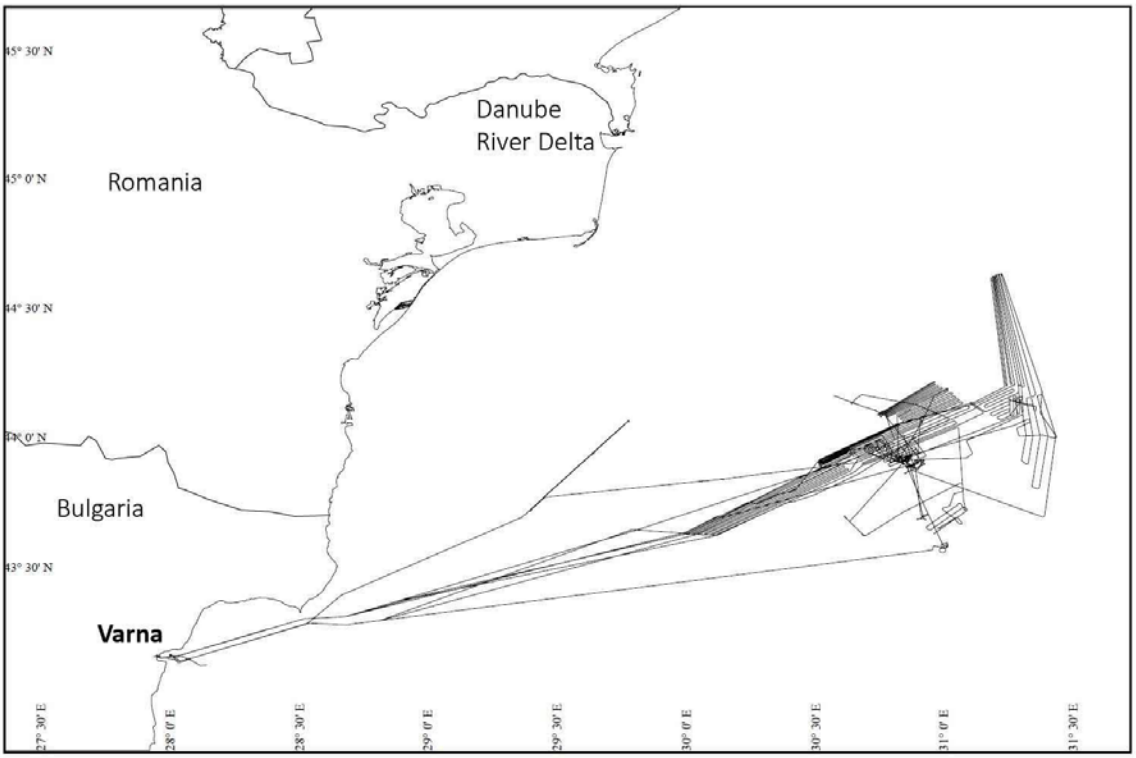
Short Cruise Report
R/V METEOR– M 142
Varna – Varna
November 04 – December 09, 2017
Chief Scientist: Gerhard Bohrmann
Captain: Rainer Hammacher



Track lines of METEOR Cruise M142 in the Black Sea from Varna to Varna.

Objectives

The overarching goal of the proposed cruise was to increase our knowledge about gas hydrate in deposits of the Danube fan of the Black Sea. Based on seismic data previously taken by GEOMAR scientists four sites were selected for drilling. The primary goal was to determine the gas hydrate stability zone and the distribution of methane hydrates within their stability zone. Besides the intense investigation of the gas emissions (occurrence, source, variability, quantity and fate), we were further interested if gas is stored in the shallow sediments. Moreover, extensive mapping of the seafloor and the sub-seafloor sediment distribution was performed to explore slumping and sliding related to the dynamic of methane hydrates.

Cruise Narrative

On **Saturday, 4 November** 2017 at 4:50 p.m. local time, RV METEOR left her berth in the flooded dry-dock of Odessos Shipyard in Varna, Bulgaria. The past 17 days in the dock were characterized by maintenance and repair work, as well as by preparations for forthcoming cruises. Works around the outer hull were quite substantial. Incrustation, color and rust that had developed after the last paint coating, were removed by sandblasting, and after three layers of grounding, the new bright blue color of METEOR was coated again. Several instruments of the vessel needed repair, and software updates were done. Mainly this referred to the electronic ocean map, the sediment echo-sounder system PARASOUND and the submarine navigation POSIDONIA. Furthermore, some technical changeover on the core handling frame and works for the MeBo subbase were acquired. The installation of the new MARUM MeBo200 turned out quite intense, as it will be deployed aboard RV METEOR for the first time. In total nine containers and one truck with tarpaulin top stuffed with scientific equipment from Germany had to be unloaded, and everything had to be stowed on the ship.

In the evening, with an exquisite light show of the sundown, many cruise participants watched the interesting undocking procedure of METEOR. After opening of the flood-gate several tug boats accompanied the sailing vessel. It took more than half an hour until METEOR left the port, and at about 12 miles outside Varna port some calibration work on the METEOR navigation system could take place. For this purpose, technicians from a company and from BRIESE ship owners were still aboard, and they left for Varna by pilot boat at 11 p.m. After a transit across the Bulgarian shelf in the Black Sea, we arrived in the Romanian sector on **Sunday morning, 5 November** where we compiled the planned tests on the PARASOUND system MK2. The weather conditions are quite good, with a moderate breeze of 4-5 and only slight swell below 1m.

During the first two days aboard R/V METEOR, we run several tests of the new PARASOUND system MK2. Profiles were recorded on the shelf, as well as along the uppper continental slope to greater water depth. Various adjustments of the sonar system were tested. Parasound records from previous cruises of R/V MARIA S. MERIAN were available, so that the improvements of the new MK2 PARASOUND could be documented - also during the „sea acceptance tests“. While those tests were done during daytime until late in the evening, we used the night to improve the scientific maps in the transition area between the shelf to the upper continental slope. From MARIA S. MERIAN cruises 34 and 35 on the continental slope up to Danube deep sea fan very good bathymetric data are available, and during our cruise we completed this region in shallower waters. Especially at the upper slope areas, above the methane stability zone above 700m water depth, methane emissions occur. Methane in this area is not stable as hydrate in the sediment anymore, but according to its density gradient can escape from the seafloor into the water column. Furthermore, we can observe headwall scarps from slope slides in this depth, accompanied by methane emissions as the methane is following the pathways along the fault lines in the underground. The 4-day-test cruise was also been used by two colleagues from KONGSBERG in order to install and test the gas lander, that shall do long-term measurements of several parameters on the gas flow at the seafloor. Beneath a ‚single beam‘-sonar for registration of gas bubble escapes in a surrounding of up to max. 300m, methane and carbon dioxide sensors, a CTD, and an ADCP for measuring the flow conditions are implemented on the lander.

Until **Tuesday, 7 November** until about 8 p.m. we were busy doing station work. Afterwards we had to start steaming to the harbor in order to arrive at Varna in the morning **of 8 November**. This worked well due to good weather conditions, so that METEOR could berth punctually at 9 a.m. at the pier of the Odessos Shipyard. We could change the personnel for the forthcoming research cruise M142. Six technicians, engineers and scientists left the ship, and 13 scientists embarked - the majority of them had arrived the day before already. They used the time in the port to arrange the labs and to prepare for the first station work. On **Thursday, 9 November**, R/V METEOR left Varna again with a free view on the city, whom Rostock in Mecklenburg-West Pomerania has a city-partnership.

As before, we sailed across the Bulgarian shelf to a location west of Danube deep-sea channel in 1400m water depth, where the ship's scientific-technical service WTD did some calibration of the submarine navigation system POSIDONIA. After this, we easily went to the selected lander station in 665m water depth. This location shows many gas emissions in a narrow spaced-area, which was intended to become investigated within several days by means of the gas lander. First, the CTD was deployed. The hydro-casts from 22 different water depths showed a methane profile that is typical for Black Sea, e.g. 10-20 nmol/l in the upper 100m of the water column, and below an increase of methane concentration to a value of 10,000 nmol/l, that is existent at this level up to the deepest basins of Black Sea. However, at our CTD station we measured higher values in the depth, between 12,000 and 15,000 nmol/l, showing the direct influence of methane emissions at the seafloor.

After having lashed the CTD aboard R/V METEOR, and the water sampler had been sampled and drained for further analyses, the gas lander was launched. It was lead down at a ship's wire, and 20m above sea floor, it was released from an acoustic signal, so that the lander for the remaining distance was in free fall. Expecting that the resuspension caused by the falling lander would have disappeared 24 hours later, the data recording started one day later. **Friday night, 10 November**, it was time to launch MeBo200 about two nautical miles further south, and it started its drilling action. This was more difficult than initially calculated due to the strong suspension caused by MeBo and its action. Consequently, the MeBo team had to act even more thoroughly as not all of the cameras in MeBo allowed for the usually visible video-controlled functions. With a drill in 860m water depth at a plateau east of the so-called S2-Canyon, we wanted to reach seismic reflectors in 100-150 m sediment depth, which might contain gas hydrates.

Today, on **Sunday afternoon12 November**, we have drilled down to a depth of 81m. We were busy with our first MeBo200 drilling until **Tuesday, 14 November**. The drilling team persistingly deployed step by step the core barrels until we had reached a final drilling depth of 147.3 m with 42 core segments, which is unique for MeBo. We are especially glad about the very good recovery and the record of drilling depth. The content of gas was very high. During heaving from 870 m water depth MeBo's video cameras observed gas bubbles sparkling from the core barrels. The intensity increased during rising up. While taking the cores from the MeBo magazines onboard METEOR, we recognized that the gas pressure was such high in several core segments that the sediments were pressed out. Due to the pressure release under atmospheric conditions, towards the pressure in the sea floor, the gas solubility is decreasing. Free gas accumulates in certain areas of the core segments at which it has also pushed apart some sediment sections. Formation of free gas could happen from dissociation of finely distributed methane hydrate, or from outgassing of former dissolved methane. Both mechanisms have the same effect of gas formation. The drilling intersected a sediment progression of at least three seismic units while we with 147.3 m drilled through deep layers with higher amplitudes.

On **Wednesday, 15 November**, during the core handling procedure, whose analysis in detail is still going on, we performed a measurement of a CTD profile downwards the slope in the so-called S2-Canyon at the sea floor, and at the same time took water samples with the hydro-casts for methane analyses. Before starting the next MeBo drilling, we successfully recovered the gas lander that had been set 5 days before in a water depth of 642 m for monitoring the surrounding gas seeps. All systems went well, and we are curious for the results. In the evening Mebo again was launched in order to drill on the S2 Canyon as there the BSR is nearer to the sea floor in about 160 m sediment depth. During the following 12 hours we tried 10 times to land on the canyon's sea floor with MeBo but failed although we had good maps of the sea floor. In seven cases, the slope angle was too steep

and the drill rig could not stand right upwards with its 4 feet. In three cases, we succeeded on more plain ground but the drill rig subsided up to 1/3 into the underground so that we could not start drilling. Alternatively, we moved to the western shoulder of the canyon to a location in 772 m water depth. There we managed a perfect landing on the sea floor and could start drilling. This went on until this morning when we observed a gas bubble rise in 143.95 m drilling depth. For safety reasons we had to stop drilling and started with the core treatment in the night, after the drill rig is back in its magazine and MeBo on deck again. Beneath drilling cores, 10 temperature analyses were measured in the drill hole, as well as taking two autoclave cores from the formation under *in situ* pressure for quantification of the gas. On dismounting the drill string a drill hole logging of natural Gamma radiation and P-wave velocity were performed.

Sunday night 19 November, a few minutes to midnight, when MeBo200 drill rig was back on deck, the scientists were busy all night until Monday morning, in handling the sediment cores appropriate. In total 36 core segments from this almost 144 m deep drilling were processed. Although we had reached the bottom simulating seismic reflector (BSR), we could not trace any direct hint on methane hydrate. This might be caused by the very fine-grained sediment substrate in the deepest 40 drill meters. In the section from 60-100m meters below seafloor we had signs for methane hydrate appearance, but no undissolved gas hydrate so far. By means of the infrared camera we could see clear temperature anomalies in a core of this depth, which doubtlessly indicated the endothermal decomposition process of methane hydrate. Further indicators were soupy, textures in some core sections that most probably resulted from water release of decomposing gas hydrates. Generally this 60-100m section in the drilling seems to be more coarse-grained so that in some layers the pore space possibly had been cemented by methane hydrates. The outstanding sonic log covering the entire bore hole shows a clearly higher P-wave-velocity in this section, which terrifically correlates with the changes in lithology.

During **Monday, 20 November** we performed hydro-acoustic mapping up to the Romanian-Ukrainian border in the East. At the evening, we steamed to Varna, where on **Tuesday, 21 November** at 9 o'clock, we berthed at the well-known pier of Odessos Shipyards. Before part of the scientific and MeBo teams disembarked, we took a photograph of the group. On forenoon, the new participants embarked so that there was enough time for a handing-over of labs on deck. Many colleagues took the opportunity to visit Varna in the evening, before METEOR punctually left in the morning of **22 November** at 9 o'clock for the 2nd leg of the cruise. On **Thursday, 23 November** before the evening operation of MeBo, several gravity cores were taken. We sampled two locations with active gas emissions at the sea floor, who contained clearly thinner gas hydrate layers, intercalated in glacial lacustrine sediments. Hydrate layers were oriented parallel to the bedding structures. During glacial times, the water level of the Black Sea was up to 150 m lower than nowadays, so that no salty Mediterranean water could enter across the 35m deep Bosporus sill, and the former saltwater sea changed to freshwater due to freshwater influx.

We had a difficult beginning of the week as the MeBo drill rig had damaged its heaving traverse on **Saturday, 25 November** when reversing on the working deck of METEOR. The traverse, that is carrying the 10 ton-drill rig, could not be repaired from resources available on board. After investigating all options, the company BAUER at record speed arranged for the construction, production and transportation to Varna of respecitve spare parts for this special equipment. In Varna we received the spare parts on **Saturday, 2 December** lying in the roadstead with METEOR. The MeBo team at once started the mounting, and on Sunday morning, **3 December**, MeBo went to the sea floor again and is drilling since then. A big Thank You to BAUER in Schrobenhausen for their great support that made MeBo fit for work again.

During the past week, we extensively sampled sediment profiles by gravity corer in order to find connections between changes in the sediment layers with slide masses and to execute biogeochemical investigations at those layers. Tuesday, Wednesday and Thursday (**28 – 30 November**) this work concentrated on two profiles east and west of the S2-Canyon. Supplement gravity cores were taken also here along the traverse. Within the 12 sediment cores the upper sediment segments are clearly structured and mark the Quarternary phases of the Black Sea evolution. A further part of our ship time was used to do hydro-acoustic measurements with both

echo-sounder EM122 and EM710, as well as the PARASOUND system. By this, we mainly could map quite exactly the mouth areas of the most important canyons in the transition area of the shelf edge to the continental slope. The relatively large-scale branched channel system at the sea floor suggests a more laminar dewatering of the shelf, which probably developed during glacial time while big parts of the shelf lay dry. Now our scientists are eagerly considering which scientific results could be achieved during the last week.

MeBo drilling started again on **Sunday, 03 December** for completion of our data set at Site MeBo17. This drilling three weeks ago intersected the bottom simulating seismic reflector (BSR) in 143 m depth, until free gas released in small quantities from the borehole. We did not encounter considerable quantities of methane hydrate above the BSR as expected. However, there were different indicators for small methane hydrate concentrations between 60-100 m sediment depths. The new drilling was performed to again core this depth interval for comparison. The drill segments below and above were washed trough for time reason, so that enough time was left to deploy four autoclave cores, so-called MDPs, for sampling of the sediments under *in situ* conditions. As bad weather was forecast, we had to decide on **Tuesday, 5 December**, to stop drilling in 134 m depth and to dismantle the drill string until the evening. While ascending, the borehole was measured with two probes that are registering the electric resistivity and the natural Gamma rays of the formation. The natural Gamma radiation is used to characterize the lithological composition, and with the electric resistance, we can calculate the gas hydrate saturation, which means a very valuable measurement for achieving our scientific aim. One further short drill that we had planned in an area with surface- near methane hydrates, could not be effected due to several reasons, and so we used the time until **Thursday, 7 December** to close the gaps in our large-scale mapping of the upper continental slope.

R/V METEOR arrived on **Friday, 8 December**, for the last time at the already known Pier No. 4 of Odessos Shipyards. The earlier arrival of course also had a positive influence on the packing activities, as we have packing pieces for 9 containers, and one 18.6 m long tractor trailer had to be packed and loaded. R/V METEOR cruise M142 was finish on **Saturday, 9 December**, and after one last stay at night on the ship, most of the scientists returned to Germany on Sunday.

Acknowledgements

This cruise was quite successful: Within 30 days at sea we deployed four drillings with MeBo200, did many measuring, sampling, new discoveries and ideas that will be presented in the future during scientific talks and publications. We owe this success in scientific work also to the outstanding and friendly support by the ship's crew. For this, we thank Captain Rainer Hammacher and the entire crew very much. R/V METEOR cruise M142 to the Black Sea was planned, coordinated and carried out by MARUM "Center for Marine Environmental Sciences" at the University of Bremen. The cruise was financed within the SUGAR project by the "Bundesministerium für Wirtschaft und Technologie" and the "Bundesministerium für Bildung und Forschung" in Germany. The shipping operator Reederei Briese Schiffahrts GmbH & Co KG provided technical support on the vessel. Many thanks to the staff of the Control Station German Research Vessels and to the Logistic Department of MARAUM.

Cruise participants

Name	Discipline	Affiliation
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Bergenthal, Makrus	MeBo	MARUM
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Betzler, Christian	Leistelle	IfM
Bohrmann, Gerhard	Chief scientist	GeoB
Brünjes, Jonas	Geology	GeoB

Deuser, Christian	Pore water	GEOMAR
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Kaszemeik, Kai	MeBo	MARUM
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Klein, Thorsten	MeBo	MARUM
Kossel, Elke	Pore Water	GEOMAR
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List of Stations

Date	St.	Instrument	Instrument	GeoB	Latitude	Longitude	Water D
2017	No.		abbreviat.	St. No.	N	E	(m)
2017/11/09	01-1	XSV-1	XSV	22601-1	43°37.144	30°55.338	1372
2017/11/10	02-1	CTD-1	CTD	22602-1	43°58.119	30°49.436	671
2017/11/10	02-2	Lander-1	Lander	22602-2	43°58.151	30°49.408	648
2017/11/10	03-1	MeBo-16	MeBo	22603-1	43°55.920	30°49.745	876
2017/11/15	04-1	CTD-2	CTD	22604-1	43°56.962	30°47.859	859
2017/11/15	05-1	Lander-2	Lander	22602-3	43°57.845	30°49.231	718
2017/11/15	06-1	MeBo-17-1	MeBo	22605-1	43°56.828	30°47.979	868
2017/11/23	07-1	GC-1	GC	22606-1	43°56.364	30°51.045	742
2017/11/23	08-1	GC-2	GC	22607-1	43°56.037	30°50.664	821
2017/11/23	09-1	CTD-3	CTD	22608-1	43°43.929	30°52.469	1400
2017/11/23	10-1	GC-3	GC	22609-1	43°43.818	30°52.652	1401
2017/11/23	10-2	MeBo-18	MeBo	22609-2	43°43.837	30°52.674	1405
2017/11/24	11-1	GC-4	GC	22610-1	43°55.923	30°49.761	877
2017/11/25	12-1	GC-5	GC	22611-1	43°56.903	30°47.018	788
2017/11/25	12-2	CTD-4	CTD	22611-2	43°56.904	30°47.019	786
2017/11/28	13-1	GC-6	GC	22612-1	43°55.808	30°49.600	878
2017/11/28	13-2	GC-7	GC	22612-2	43°55.806	30°49.595	875
2017/11/28	14-1	GC-8	GC	22613-1	43°56.078	30°50.152	901
2017/11/28	14-2	CTD-5	CTD	22613-2	43°56.078	30°50.150	863
2017/11/28	15-1	TL-01-1	TL	22614-1	43°55.524	30°49.025	951
2017/11/28	15-2	TL-01-2	TL	22614-2	43°55.652	30°49.282	893
2017/11/28	15-3	TL-01-3	TL	22614-3	43°55.813	30°49.589	873
2017/11/28	15-4	TL-01-4	TL	22614-4	43°55.908	30°49.804	875
2017/11/28	15-5	TL-01-5	TL	22614-5	43°56.087	30°50.153	864
2017/11/28	15-6	TL-01-6	TL	22614-6	43°56.199	30°50.381	839

2017/11/28	15-7	TL-01-7	TL	22614-7	43°56.398	30°50.751	759
2017/11/28	15-8	TL-01-8	TL	22614-8	43°56.486	30°50.948	712
2017/11/28	15-9	TL-01-9	TL	22614-9	43°56.542	30°51.056	730
2017/11/28	15-10	TL-01-10	TL	22614-10	43°56.618	30°51.221	740
2017/11/28	15-11	TL-01-11	TL	22614-11	43°56.747	30°51.488	754
2017/11/28	15-12	TL-01-12	TL	22614-12	43°56.941	30°51.884	754
2017/11/29	16-1	GC-9	GC	22615-1	43°56.939	30°51.882	752
2017/11/29	17-1	CTD-6	CTD	22616-1	43°58.154	30°45.161	537
2017/11/29	17-2	GC-10	GC	22616-2	43°58.151	30°45.168	537
2017/11/29	18-1	TL-02-1	TL	22617-1	43°58.152	30°45.165	537
2017/11/29	18-2	TL-02-2	TL	22617-2	43°58.058	30°45.241	543
2017/11/29	18-3	TL-02-3	TL	22617-3	43°57.949	30°45.314	588
2017/11/29	18-4	TL-02-4	TL	22617-4	43°57.768	30°45.405	631
2017/11/29	18-5	TL-02-5	TL	22617-5	43°57.617	30°45.511	639
2017/11/29	18-6	TL-02-6	TL	22617-6	43°57.473	30°45.626	646
2017/11/29	18-7	TL-02-7	TL	22617-7	43°57.249	30°45.773	668
2017/11/29	18-8	TL-02-8	TL	22617-8	43°57.113	30°45.891	672
2017/11/29	18-9	TL-02-9	TL	22617-9	43°56.869	30°46.266	699
2017/11/29	18-10	TL-02-10	TL	22617-10	43°56.790	30°46.630	718
2017/11/29	18-11	TL-02-11	TL	22617-11	43°56.729	30°46.910	766
2017/11/29	18-12	TL-02-12	TL	22617-12	43°56.690	30°47.171	778
2017/11/29	18-13	TL-02-13	TL	22617-13	43°56.723	30°47.481	831
2017/11/29	18-14	TL-02-14	TL	22617-14	43°56.748	30°47.887	871
2017/11/30	18-15	TL-02-15	TL	22617-15	43°56.765	30°48.194	831
2017/11/30	18-16	TL-02-16	TL	22617-16	43°56.784	30°48.309	776
2017/11/30	18-17	TL-02-17	TL	22617-17	43°56.800	30°48.699	802
2017/11/30	18-18	TL-02-18	TL	22617-18	43°56.809	30°48.956	808
2017/11/30	19-1	GC-11	GC	22618-1	43°56.863	30°46.256	698
2017/11/30	20-1	CTD-7	CTD	22619-1	43°57.111	30°45.881	672
2017/11/30	20-2	GC-12	GC	22619-2	43°57.113	30°45.882	672
2017/12/03	21-1	MeBo-19	MeBo	22620-1	43°56.902	30°47.011	773

MeBo: 4 MeBo200 drill sites
XSV: 1 Expandible Sound Velocimeter
CTD: 7 CTD stations
GC: 12 Gravity Cores
Lander: 1 Lander deployment and recovery
TL: 2 T-Lance profiles