Delayed 1\textsuperscript{st} Weekly Report of AL567 – MineMoni III

On the foggy morning of 18\textsuperscript{th} October we left the west shore of GEOMAR at 7:45 to load some additional equipment on the east shore. The winch of the MagWing needed to shift on its basement for which our colleague Matthias Wieck very quickly supplied us with two additional beams to move it the needed additional 15 cm to port side of the ship. This done and cables pulled through the block we left the east shore at 10:00 am and are now steaming towards Kolberger Heide to test all our equipment, of which we have plenty. On board are 12 scientists from Belgium and Germany, from VLIZ, g-Tec and GEOMAR to continue investigations as part of the EU-funded BASTA and EXPLOTECT munition projects.

... I wrote these sentences in good hope of submitting the weekly report on time, one week after the start of the cruise on the 18\textsuperscript{th}. Right now, it is 23:25 on 26\textsuperscript{th} October which means I didn’t manage to write the report in time—why? Well, quite easy, many things happened in the meantime, we started off working in Kolberger Heide, the munition dump site just around the corner of Kiel and GEOMAR. This is an area that we know very well and have also been during cruises POSS30 in 2018 and AL548 in 2020 and many other cruises with Littorina in between and before. We study the remnants of the second World War, meaning we are looking at old munition that has been dumped in the Baltic after the war and is now rotting away at many known and also unknown locations in the Baltic. It is cruise MineMoni III and we have already learned a lot about the amount, type and location of munition ranging from small to large caliber, including 6 m long torpedoes, depth charges, sea mines, ground mines, 50 and 250 kg bombs, FLAK munition, and many, many small wooden boxes with other munition types. Munition in the sea potentially is among the longest-lasting physical remains of war activity that will be with us for the next decades. Saying this, due to our activities since 2016 (the UDEMM project), the public but also governmental perception on munition in the sea changed and has been taken up as an important topic for the future. Let’s hope and see.

Coming back to the cruise; there are three main foci for this cruise, one is to extend our knowledge about location, amount and burial depth of munition in the munition dump sites at Kolberger Heide, Lübeck Bay and Falshöft south of the Flensburger Förde. For this we installed a high resolution multibeam in the moon pool of ALKOR to map the seafloor hydroacoustically at 25 cm resolution (RESON T50-P). We use a high-resolution sub bottom profiler system (SBP, the INNOMAR SES2000 Quatro) on a pole to look into the sediment, and we have the MagWing with us that uses four magnetometers to see the disturbance of the earth’s magnetic field by metallic objects. All together, these are the classical methods to search for munition. In addition, we brought GEOMAR’s AUVs ANTON and LUISE, both capable of taking photos at low altitude and at very slow speed which enables creating photomosaics by merging ca. 10,000 images into one large photo of 50 by 50 m or more with a pixel resolution of only a few millimeters. LUISE is additionally equipped with three magnetometers to survey small areas at very high resolution. This is actually a technical development of the BASTA project and we hope to develop knowledge that later on can be used in tandem with the MagWing mapping that covers much larger areas. A second technical system that is developed in the EXPLOTECT project are two systems to analyze munition compounds (i.e., TNT, RDX, ADNT, and DNB) in more or less real time on the ship. The new systems are running well and are either used to analyze the seawater pumped in by the ship continuously, or to measure discrete water samples taken by the CTD/water sampler. It has been shown that munition compounds can find their way
into the ecosystem and into biota, and most of these chemicals are toxic and particularly carcinogenic. Thus, knowing in addition to where munition is, we want to know how large the impact to the environment already is. To answer this, we also take sediment samples with a TV-guided small multicorer. This is something we haven’t done in the past, but with our very precise pre-surveys we can be sure to avoid any munition object on and in the ground. The last piece of equipment is the extended version of an ocean floor observation system, the XOFOS. The XOFOS is actually designed to work in up to 6000 m water depth and is equipped with several video and still cameras, ADCPs, CTDs and a multibeam system. It is linked through a fiber optical cable to the ship allowing high data rates. The XOFOS is a challenging piece of equipment and rather new, but during the cruise it is developing into a well manageable and successful tool with many options to add additional sensors.

With all this equipment, what have we done? As said, we started in Kolberger Heide by putting all gear in the water and testing their functionality (in case something does not work, GEOMAR would just be around the corner). All tests went well and we did a couple of AUV deployments and water sampling, but also ran several MagWing and SBP profiles to look into the sediment. Tuesday evening, we transited towards Lübeck Bay where we arrived Wednesday morning after taking 23 CTDs on the way. These CTD stations were repetitions of the 2018 and 2020 monitoring campaign. Upon arrival, the Navy vessel BAD RAPPENAU from the 3rd Mine Hunting Squadron of the Germany Navy was already on site to deploy their AUVs (REMUS 100) and dive at some of the munition box piles we mapped before. This was not a co-incident because one month before, during the Kiel Munition Clearance week, GEOMAR got into contact with the Commander of the 3rd Mine Hunting Squadron, and over a beer the idea was born to join forces to investigate the rather unknown munition boxes in Lübeck Bay. The BAD RAPPENAU is the diver support vessel of the squadron and thus had six additional mine divers from Eckernförde on board all eager to take a close look at pre-selected locations we discussed jointly beforehand. Unfortunately, taking a close look was very challenging as the sight under water was very bad and with less than 50 cm visibility, closer inspection was not possible. Despite this, the Navy did all of the planned sidescan surveys with the REMUS 100 and also recovered four mussel moorings of our colleagues from the toxicological institute at UKSH. Upon recovery the bags were broadught to ALKOR by the very quick Boomranger boats. Both crews used the opportunity to visit the other vessel for getting an idea about the equipment, the ship itself, life on board and exchange first news about the findings. On Thursday 13 crew members from ALKOR visited the BAD RAPPENAU, getting a bumpy, wet but safe ride with the Boomranger. The stay on BAD RAPPENAU took longer than expected and we continued working at 18:00 on Thursday. Typically during night, we performed joined multibeam, MagWing and SBP surveys and during day time the AUVs and the XOFOS are used. This was not the case for Friday, since wind gusts between 10 and 11 beaufort made it very difficult to keep the ship on track or at station so that for some hours we could not work at all. Luckily Lübeck Bay is very sheltered and waves were not high so that the ship kept very stable. We continued working with lots of mapping and AUV dives, which finally became even more successful after the visibility improved and images could be merged to large photomosaic.

However, we have results to show, e.g from the SBP. Sub-bottom profiles were acquired with both the high (100 kHz) and low frequency (~10kHz) signal Around 437 SBP profiles (counting transits and turns) were collected during survey so far (71 from Kolberger Heide and 366 in Lubeck Bay), equivalent to about 294 km. Different buried objects were found in Kolberger Heide, most of them showing indications that the sunk into the sediments others show signs of sediment coverage at the seafloor (Figure 1). As SBP and MagWing were run in parallel, several of these objects could be linked to magnetic anomalies.
Figure 1. A SBP profile from Kolberger Heide during the current campaign. Blue arrows indicated buried targets, the red arrow a target laying at the seafloor and the yellow arrow shows that there is a partially buried object, probably related with the one indicated above it.

In the Lübeck Bay areas Pelzerhaken and Haffkrug, objects occur on the seafloor over a hard glacial till acoustic horizon. Most of the features represented as diffraction hyperbolas are related with boulders from the glacial till. However, these objects could be mixed with munition related objects which complicates the accurate detection. On top of this a large number of objects are (partially) buried within the soft Holocene top sediments which are probably related to munition (Figure 2). This shows that for the first time of our studies that munition also occurs in the sediment and cannot be detected with multibeam and optical means.

Figure 2. A low frequency SBP from Haffkrug during the current campaign. The red arrows indicate objects laying on the seafloor and the blue arrows indicated buried objects in the soft Holocene sediments.
During the first week we also managed to conduct twelve individual missions with AUV Luise and the magnetometers attached (four missions at Kolberger Heide, eight missions in Lübeck Bay). The magnetic system deployed on Luise consists of three submersible 3-axis fluxgate magnetometers attached to the tip of the AUV in 2 m distance. The two lower sensors form a transverse-horizontal gradiometer and a vertical gradiometer is realized together with the third sensor above. The "analytic signal" is a general tool for the localization of anomaly sources. It is calculated at each point of a survey grid from the different spatial gradients. The third (longitudinal) gradient is taken as the difference of two measurements between two points in time. Figures 3 show the vertical magnetic gradient and the corresponding analytic signal of one of Luise’s mission at Kolberger Heide (85 x 32 m). The magnetic signatures can be referred to medium-sized, yet unclassified, munition objects on the seafloor that have been dumped in a circular shape.

Figure 3: Top left shows the vertical gradient of one of Luises survees in Kolbrger Heide, top right shws the analtical signal. Bottom left shows the very flat seafloor with a anker mark in the NW area and small objects on the seafloor; georeferenced the magnctic survey shows clearly that the objects are magnetic.

We are now on our way to Trollegrund in Mecklenburg-Vorpommern where we will start in about 6 h and 30 Minutes to perform tests with LUlESE for in depth magnetometer calibration and noise level determination. After that we will have 24 h of CTDs and transit to Falshöft where we plan to work two full
days before we head south towards Kolberger Heide and Kiel again. A second report will follow. But for the time being take a look at the other images below.

Many greetings from sea, nautical and scientific crew are well and we are looking forward to coming days

Jens Greinert