# Research Vessel SONNE

SO266:
Kaohsiung – Kaohsiung
Fourth weekly report: 05 – 11 November 2018

During the weekend MeBo took rotary cores from the carbonate formation on Four-Way-Closure Ridge (Fig. 1). Unlike other sediment cores, we did not split them lengthwise, but they remained in their liners to enable a CT analysis of the entire rock sequence when we get home. As the liners are transparent, it was possible to do a first macroscopic analysis. Different bright aragonite-rich horizons could be identified between darker, micrit-rich layers. The age of the sequence will be analyzed with U / Th dating in order to correlate the temporal evolution of methane emissions with the geological development of the Four-Way Closure Ridge.

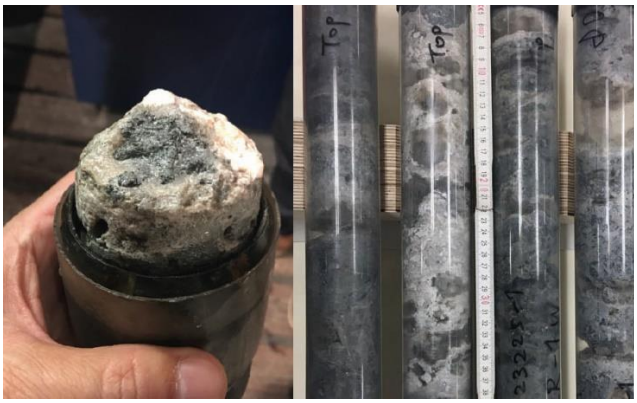


**Figure 1:** Detail of the carbonate cores drilled in the seep area of the Four-Way-Closure-Ridge with MeBo. The dating of these rocks will provide information on the evolution of the seep activity (© Andrew Lin).

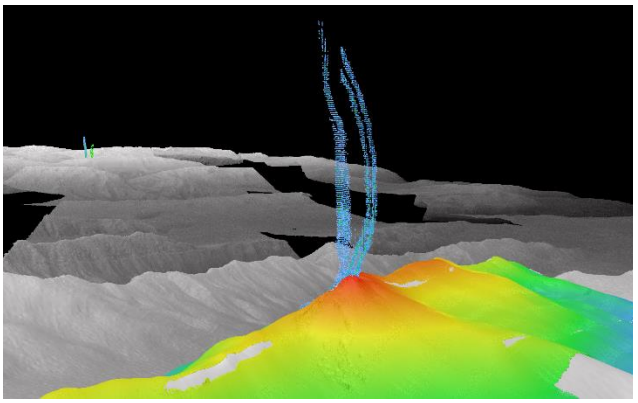

**Figure 2:** Formosa Seep is located on the summit of the Formosa Ridge and is characterized by active emission of methane gas, which appears acoustically through distinct flares (© Paul Wintersteller).

On Sunday, 4 November, we left our eastern working area and moved back to the passive continental margin of the South China Sea in the area of Formosa Ridge. A gravity corer at the MeBo station yielded astonishing results. In the 8,11 m-long sediment core of fine-grained, very homogenous mud, two to three fluid channels could be traced over large parts of the gravity corer length. These channels appear to be caused by gas bubble ascent in the sediment. Since the channels were significantly more water-rich, we believe that the channel walls were covered with gas hydrates, which have decomposed during the recovery of the core. As these observations were also made in the previously acquired MeBo core on Formosa Ridge, this suggests wide-spread gas bubble ascent in the sediments.

The next MeBo drilling began on Monday, 5 November, on the small plateau southeast of the Formosa Seeps. A first drilling at this location two weeks ago cored a sediment sequence of 108 m, where gas hydrates could be detected in two layers. In the upper layer between 15-42 m sediment depth, gas hydrates showed a saturation of the pore space of 10%, while the layer below 100 m reached a gas hydrate saturation of approximately 33%. The second hole at this location was not drilled to recover sediment cores, but it was only drilled to perform logging. In addition to natural gamma radiation, electrical resistivity was logged, which clearly imaged the two horizons of hydrate in the borehole. This measurement was able to show the presence of gas hydrate down to a depth of 120 m, which had not been sampled previously. The maximum of natural gamma radiation was between about 80 and 90 m and represents a layer with numerous carbonate nodules, which seem to change the fluid circulation pathways. Two horizons with volcanic ash at 39 and 72 m depth represent the explosive volcanic eruptions on the Philippine island of Luzon that happened 39,000 and 61,000 years ago according to dated sediment cores. Together with the

micro-paleontological examinations of our Taiwanese colleague Prof. Kuo-Yen Wei, these age determinations already give us on board a rather good age model for the sediment sequence.

During MeBo drilling on the small plateau, we have repeatedly observed gas emissions (Fig. 2) with the ship's hydro-acoustic systems on the summit area only 50-100 m to the north. The summit of this ridge segment is at 1120 m water depth and rises dome-like 15 m over the crest of the ridge. As recent publications by our Asian colleagues describe, the summit hosts one of the most interesting seeps of the South China Sea. On Wednesday, 7 November, we conducted observation profiles with the new OFOS (Fig. 3) over this seep area which is about 140 m wide. OFOS is a newly built video and photo imaging tool that was requested by the scientific community. It is operated by the ship's science officers. It showed its outstanding qualities as a new working tool. The HD camera, the high-speed camera with a resolution of 30 megapixels, very good seabed illumination, and a modern deck unit that is linked by a fiber optic cable make OFOS a very valuable scientific instrument. The video footage of the seafloor was transmitted to all possible monitors on the ship. The flash unit on the OFOS allowed us to generate a digital image every 3 seconds so that entire photo transects can be assembled via photo mosaicking. This helps tremendously when interpreting the high-resolution maps that are based on the ship's hydro-acoustic data.

**Figure 3:** The new "Ocean Floor Observation System" (OFOS), has a long tradition on R/V SONNE. It can be used for direct observation of the seabed since cruise SO265, (© Gerhard Bohrmann).

**Figure 4:** Central area of the Formosa Seep. The mussel field is almost completely covered by deep-sea crabs of the species *Shinkaia crosnieri*. The crabs are known from hydrothermal vents of the Okinawa Trough, but also live at cold seeps (© R / V SONNE, SO266).

In addition to blocky, rugged carbonate formations seep organisms are especially of interest. Mussels are ubiquitous. Apart from living mussels there is shell detritus, that is also found in the carbonate crusts. As chemosynthetic animals they depend on the dissolved methane and represent the main inhabitants of the seeps. A curiosity are the almost monospecific deep-sea lobsters, which in some places cover the entire seabed. *Shinkaia crosnieri* (Fig. 4) is mainly known from the hydrothermal vents of the Okinawa Trough, but they also live at cold seeps.

Meanwhile, we have finished eight drill holes with MeBo and hope to drill another two wells in the last week before sailing back to Kaohsiung next Sunday. We will report on this in the last weekly report. The weather seems to play along.

Everyone is healthy; it greets in the name of all cruise participants

Gerhard Bohrmann R/V SONNE, Sunday, 11 November 2018