DSR/V SONNE Expedition SO247 SlamZ
– Slide activity along the Hikurangi Margin, NZ

1. Weekly report: 21.03. – 27.03.2016

After seven successful weeks at sea, the German deep-sea research vessel SONNE arrived in Wellington Harbour. The scientists aboard voyage SO246 made use of the transit to New Zealand's capital city to pack up the scientific equipment and prepare the working laboratories for the next voyage. As the first 9 scientists of voyage SO247 arrived at the ship on Tuesday morning there were 11 containers on the pier with scientific equipment ready to be loaded on board. Among the equipment was the German seafloor drilling rig from Bremen, „MeBo 200". With support from the crew and crane operator, all of the scientific equipment was able to be lifted on board and stored within two days; a total of 120 tonnes of scientific material and equipment has found its place on and under the ship's deck.

Despite this rather hectic period of work, the crew of the SONNE (and in particular the vessel's captain Oliver Meyer) found the time on Tuesday afternoon to invite on board and greet New Zealand's minister of business, innovation and employment Steven Joyce, as well as the German ambassador Dr. Anne-Marie Schleich. Both were visibly impressed by the technology and diverse research capabilities the ship offers.

Fig1: Dr Anne-Marie Schleich, Captain Meyer und NZ`s minister Steven Joyce (from left).

On Thursday afternoon, a crowd of approximately 90 guests were invited to a special reception on board DSR/V SONNE by Dr Schleich together with Captain Meyer.

After several interesting presentations that gave insight into German-New Zealand marine research collaborations, the guests were able to get to know the vessel better during a guided tour of the ship. NZ colleagues from universities, research institutes and the ministry were also suitably impressed. Within the next five years there are already at least five approved expeditions in New Zealand waters where German, New Zealand and international scientists will, collectively, spend more than 220 days investigating various research questions.

On Friday a total of 39 scientists met at the SONNE, with participants from MARUM, the Universities of Jena and Bremen, and the New Zealand-based research institutes NIWA and GNS Science. By Saturday afternoon the labs were set up and boxes were stowed away, and with the final arrival of some New Zealand students the process of boarding the ship was completed.

Sunday afternoon saw the first major operation, with MeBo 200 being deployed into the water for a harbour test. Major aim of the upcoming cruise will be to investigate distinct submarine landslides utilizing MeBo sediment cores. These data will enable to gain a deeper insight into potential trigger mechanisms, ages of slid masses as well as slide mobility. Therefore, geochemical, sedimentological, mineralogical, as well as geotechnical samples will be collected directly on board.

In addition, hydro-acoustic data and in-situ heat flow measurements will be conducted. These will shed light on one hand on the internal structures of distinct slid bodies as well as on the other hand on the thermal structure of the Hikurangi margin.

Fig.2: MeBo200 harbour test.

A thorough test of all systems showed the system to be fully operational. Around midday we set sail under the heat of the sun and a light breeze with the hope of continued good weather for our first working area at the Tuaheni Landslides further north on the margin.

At this point we would like to thank the entire crew of DSRV SONNE for their warm welcome on board and for their excellent support with setting up equipment.

On behalf of all on board SO247, greetings from

Katrin Huhn & Nina Kukowski

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2. weekly report: 28.03. – 03.04.2016

Less than a day after RV Sonne left Wellington, scientific work began in the Tuaheni slide region on the 28th with a CTD, high-resolution bathymetric mapping, and the first gravity coring. The initial goal was to determine the optimum location for the first drill hole GeoB20802-4 with MeBo200. Here, undisturbed sediments of the slope should be drilled as a reference. At the same time, a transect of 9 gravity cores was accomplished from the undisturbed slope through the scarp edge down to the slumped material. Average core lengths ranged from close to a meter in shallower water, to up to 4.20 m – 5.70 m in slumped material (Fig.2).

During the first two deployments of MeBo200, at the reference site, two cores of more than 17.5 meter and 28 meter length, respectively, (and more then 85% core recovery) were drilled as a reference. These reference cores are the longest sediment cores so far obtained from the Hikurangi continental margin. Deployment and recovery of MeBo went without any problems, due also to the splendid cooperation with RV Sonne's deck crew.

At the moment, MeBo is drilling slumped material at position GeoB20803-2 – the drill bit is already in a depth of more than 70 m and drilling parameters suggest that the material being drilled is markedly different from that obtained from gravity cores at this location. A first pressure core has also been taken as part of this drill hole. Everybody is excited and all scientists look forward to the new week and the chance to welcome completely new material from this working area.

A central aim when planning the first week of scientific work was to provide work and data/material for all working groups. Infrared photos have already been taken from the first gravity cores as well as the first MeBo cores; they were then opened and scanned with a smartCIS 1600 Line Scanner as well as described sedimentologically.

The working halves were sampled (Fig.1) in multiple ways. Sampling comprises very different disciplines such as the extraction of pore water, taking smear slides for spectroscopic and sedimentological analyses, sampling for biological investigations, and many more.

Fig.1: Sampling the first MeBo200 cores in the hangar of RV Sonne.

Further, geotechnical measurements to determine moisture density and mechanical properties, among other parameters, was immediately undertaken on the working halves.

The first work on the sediments of the shallowest four meters, both of the undisturbed sequences as well as of the slumped material, show regionally very similar results as expected with fine grained, cohesive sediments. Tephra layers drilled in many of the cores will allow for age dating and estimation of recent accumulation rates.

Besides coring, 32 successful heat flow measurements were undertaken along three transects over the slumped material (Fig. 2). Initial results suggest it might be possible to distinguish hydrate-bearing areas from those without hydrates. Some of the temperature-depth profiles show a complicated temperature distribution, which has been observed at other continental margins. On the other hand, mainly uniform values of thermal conductivity reveal the similarity of the material obtained in the cores. Sections rich in quartz differ from these uniform values.

The scientists of SO247 meet every day to discuss progress and the upcoming working programme. Often, there are also talks on themes associated with the SlamZ-expedition or about other projects. During the weekend, the scientists of SO247 took the opportunity to explore deeper parts of the vessel as part of a guided tour through the machine rooms.

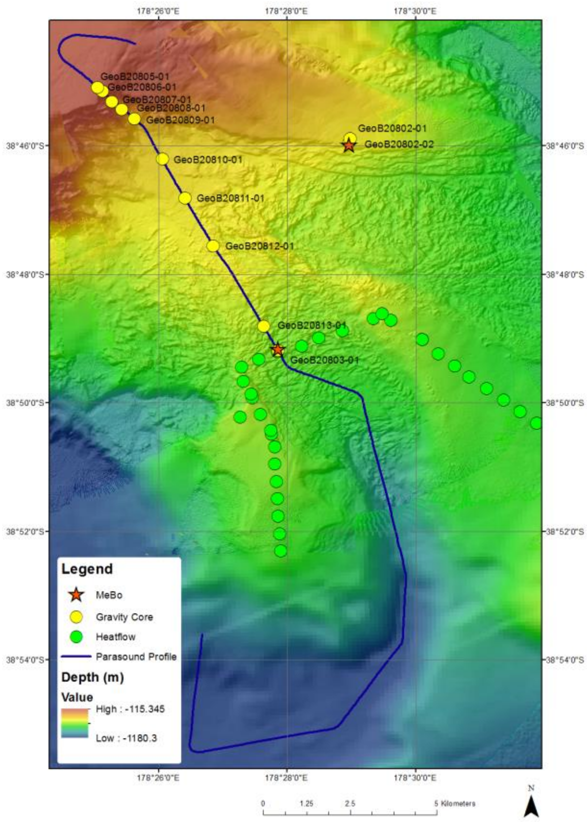

Fig. 2 shows the Tuaheni working area with positions of already recovered cravity and MeBo cores as well as locations of heat flow measurements.

With good weather conditions, the 10 scientific working groups are cooperating efficiently and in a good mood, which is also due to the excellent support through the crew of RV Sonne.

Many greetings from the Sonne on behalf of all participants from

Nina Kukowski & Katrin Huhn

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3. Weekly report: 04.04. – 10.04.2016

And here we are approaching the end of the second week. After having reached a sub-seafloor depth of 50 metres at our second MeBo station last Sunday, we reached a maximum borehole depth of 82.3 metres on the following Monday. We were quite surprised as we removed the liner from the core barrel: very good core recovery of more than 60% up to a depth of ~23 metres, but unfortunately followed by a large gap to ~65 metres sub-seafloor depth. Deeper than 65 metres the liners were again filled with sediments. After splitting the cores it was apparent that the bounding core segments were characterized by interbedded sandy material and repeating layers of clayey-silty ash layers. Our initial suspicion is that the missing depth segments in the core might have been caused by thick turbidite sequences with high sand content that are likely difficult to recover during drilling.

On the bright side however, our borehole has provided the first insight into the nature of material at sub-seafloor depths of more than 80 metres on the Hikurangi slope margin. The sedimentology group led by Alan Orpin (NIWA) described the material as greenish-grey, very stiff, clayey silt. These deep core segments also show repeating regions of massive, disturbed sand material. The colleagues estimate that the clay contents in these regions are up to 20-40%. The disturbed regions in the core are highly likely to have formed during the dissolution of gas – an interpretation that is supported by both the methane analyses and pore water anomalies. These methods confirm the presence of methane in the core, but in such low concentrations that the formation of massive gas hydrate at these depths is very unlikely. It is more likely that if hydrate formed at these depths it would be dispersed and finely disseminated, and any hydrates that might have existed in the core would have dissociated into free gas during recovery.

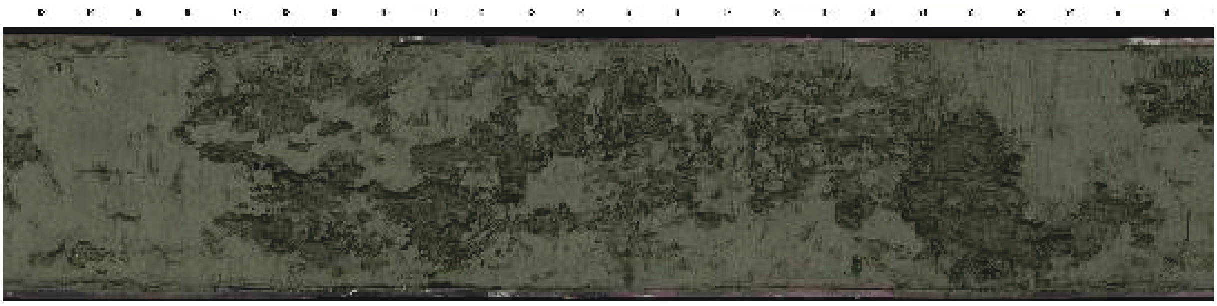

Fig.1: A scan of the sediment core GeoB20803-2 from a depth of 79 metres shows clear zones of disturbance caused by the gas dissolution.

After MeBo was recovered on deck, we used the following night to continue our heat flow mapping of the Tuaheni landslide. The survey went off without a hitch and was completed relatively quickly in the shallow water depths of up to 750 metres. The geophysicists in charge were able to complete two long profiles with a total of 23 stations and are already evaluating and modelling the acquired data.

On Tuesday morning we then left the northern working area and made our way south to our second working area, Rock Garden. The general work programme at Rock Garden is very similar to that of Tuaheni. First up, on Tuesday evening, we ran a CTD profile to calibrate the echo-sounder systems. We followed this with a high-resolution mapping survey of Rock

Garden. Based on the multibeam and Parasound datasets acquired during this survey we then chose gravity core sites to test for the best locations for a MeBo deployment. The periods of time between MeBo deployments during the week were, as previously during the voyage, used for mapping and heat flow measurements. The data are being processed and we will give more information about the results in the next weekly report.

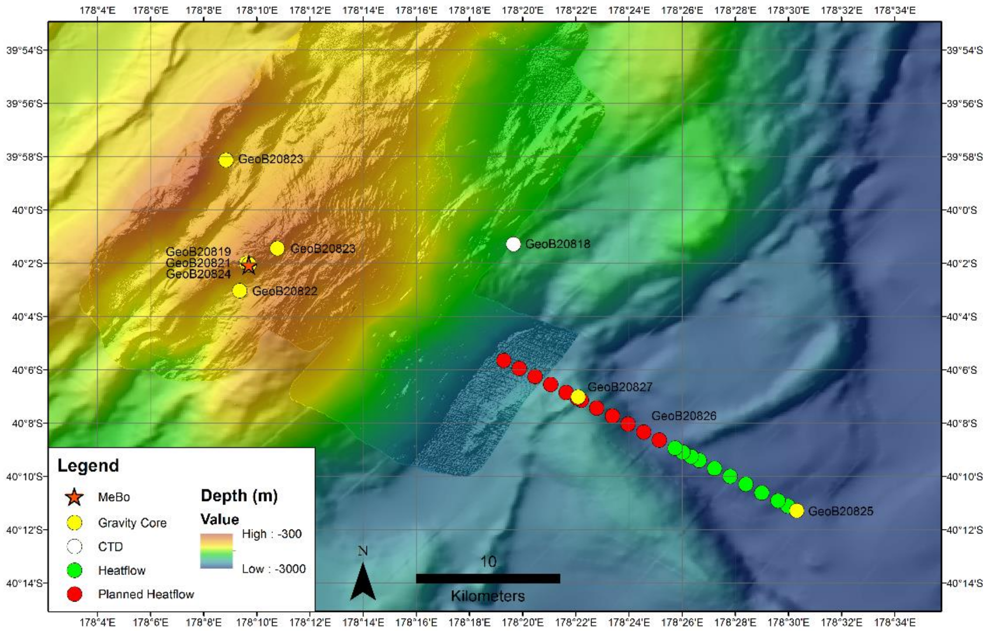

Fig. 2: The Rock Garden working area showing the locations of cores and heat flow measurements.

Two gravity cores GeoB20819 and GeoB20823 taken at the top of Rock Garden exhibited only a thin sediment cover of approximately 1 meter. In contrast, we reached coring depths of approximately 1.6 meters at the stations GeoB20821 and GeoB20824. The cored sediments consisted of mainly stiff clayey silts with frequently embedded tephra layers. Although we had some initial concerns about whether MeBo would be able to land on the presumably very hard material of the accretionary ridge, the location we chose turned out to be an ideal landing spot. After 14 meters of the first drilling attempt we had not intercepted the expected hard rock. What was drilled, were clayey silts with interbedded ash-rich sediments. A second rotary-drilled borehole at the same location, 35 meters long this time, painted the same picture. Since we were expecting hard rocks at ~20 meters beneath the seafloor, and had based our drilling strategy on that assumption, the core liners were only ~25% filled with sediment. Based on this result, we made the decision yesterday afternoon to go for a third attempt at this hole, but this time using a "push-core" drilling strategy to recover core. For both of these last two attempts the hole was (or will be, in the case of the current hole) logged with gamma ray and dual induction. These logging data will enable us to correlate both cores with each other to produce an image of the sub-surface that is as continuous as possible. The correlation will be made easier by the fact that the two drill holes are only 14 meters apart. The positioning system of the SONNE and the navigating skills of those on the bridge are truly impressive!

Greetings from all cruise participants on board SO247 on behalf of

Katrin Huhn & Nina Kukowski

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4. Weekly report: 11.04. – 17.04.2016

The fourth week began with the successful completion of the first MeBo drill hole at Rock Garden (GeoB20824-4). The total depth of approximately 35 m was at a position above the bottom-simulating reflection (BSR), which marks the base of gas hydrate stability. As soon as MeBo was back on board, the liners were removed from the core barrels and samples were taken for gas analyses. After cutting out whole round segments from the core for porewater geochemistry, the cores were halved so that we could gain the first understanding into the nature of material at depth beneath Rock Garden. We were pleased with the very good total core recovery of well over 90% in eight of the eleven core liners, and recovery of about 50% in the remaining three liners (Fig. 1). In addition, we recovered two pressure cores deployed in this hole and measured gamma ray and dual induction properties with the core logging tool.

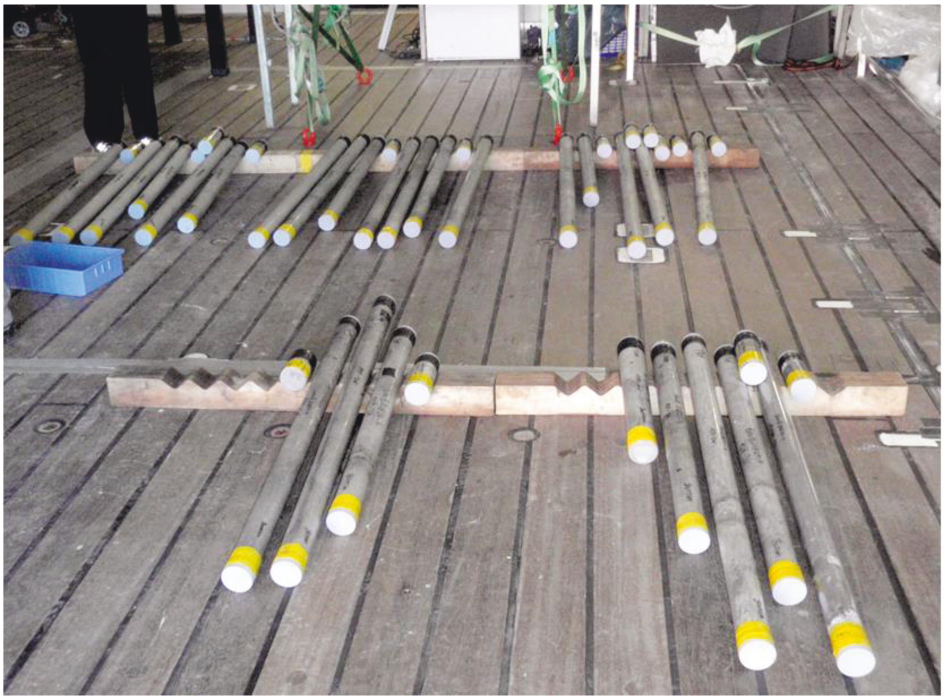

Fig. 1: Cores from MeBo Hole GeoB20824-4 laid out in the Hanger for geochemical sampling and division into working and archive halves.

Up to a drilling depth of ~20 m the sediments consisted of hard, greenish-grey, clayey silt with sections of turbidite material as well as embedded tephra layers. Below ~20 m the facies changed significantly; from here on we encountered laminated and very hard clayey silts. The material drilled will help us to understand the behavior of the sediments during uplift and erosion and thereby test a hypothesized mechanical weakening process on the ridge top that has been likened to the terrestrial frost heave process. Understanding the methane profile through the drill hole might prove to be a hard nut to crack, given that we observed practically no methane in the upper 20 m of the core and then unusual concentration gradients deeper than 20 m.

Over the night from Monday to Tuesday, we continued with the heat flow profile along the lower slope of Rock Garden. In total 22 heat flow measurements were successfully recorded. These data reveal stable background values typical for subducting oceanic crust. The measured heat flow of 50 mW/m² indicates a crustal age of approximately 100Ma. Along the same transect several gravity cores were taken and the hydro-acoustic mapping was finalized before we left this region to return to Tuaheni. Two gravity cores taken from an active as well as inactive former gas flare structure which exhibits typical features indicating the presence of gas hydrates, eg carbonate facies and gas-induced fractures (Fig. 2).

Fig. 2: Typical seep-carbonate facies in gravity core GeoB20830-1

The Tuesday evening on the transit to Tuaheni, we have used the short break to celebrate the „Bergfest" – halftime – with delicious pizza in the Hangar.

After arrival in Tuaheni, additional gravity cores were taken at the outer edge of the slide masses of southern Tuaheni as well as further down in the deeper canyon seaward of the landslide. Here, we could recover material from the potential glide plane on top of which the sediments were transported downslope. Cores showed a typical sequence of interbedded fine sand and coarse silt layers. Significant changes in dip angles of stratified lithologies as well as thin frequently occurring cavities with sandy fillings are remarkable and were observed here for first time. These sands are also present in most of the MeBo cores from the Tuaheni landslide and are assumed to cause the loss of MeBo core recovery when drilling the slid mass. So, the core recovery rate was again good with 42% when we drilled another leg at the Tuaheni landslide down to 77 mbsl on Thursday and Friday. Unfortunately, a few liners had very little recovery (<5%) between 37 and 60 mbsl. However, we have recovered with this core the first direct observations of the glide plane composition and can test a couple of hypotheses regarding slide mobility. In addition, gas sampling was intensified for the MeBo core to analyse the gas composition and gain a deeper insight into the gas hydrate system.

In the meantime, was also made heat flow measurements north of the Tuaheni landslide. The major aim of this profile was to gain a better understanding of a recently mapped double BSR. These structures are observed in previously acquired seismic data. A dense heat flow profile along the outcropping BSRs should enable us to test conceptual models for their origin.

After this very busy and core-rich week, MeBo has just been deployed again at the undeformed reference site in Tuaheni. With this, hopefully, successful core recovery to look forward to in the upcoming days we send greetings on behalf of all cruise participants on board SO247

Nina Kukowski & Katrin Huhn

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5th weekly Report: 18.04. – 24.04.2016

The final week began with a further MeBo drill hole in the area of the undisturbed sediments above the Tuahini landslide (Fig. 1). MeBo drilled without any issues and after almost 40 hours we had reached a depth of 105.4 m. After recovering the core we were more than satisfied: core recovery of more than 98%. This excellent continuous core gives us a long record for the region that did not exist prior. In addition to the original objectives from this core addressing mechanics of sliding and a better understanding of sediment physical properties of potential material that has failed, the core will open up other research topics. Of particular interest is the possibility for tephra-chronology. In addition to the exceptional core recovery, we also recovered the first successful pressure core from the hole at a depth of 25 m below seafloor. Degassing of the core the following morning was also successful and the initial analyses promise interesting results. With this core we also concluded our primary work programme in the Tuaheni work area. The last four gravity cores in the area of the basal slide surface as well as heat flow measurements in the region of the deformation front on the coming Monday will bring a final close to the work programme.

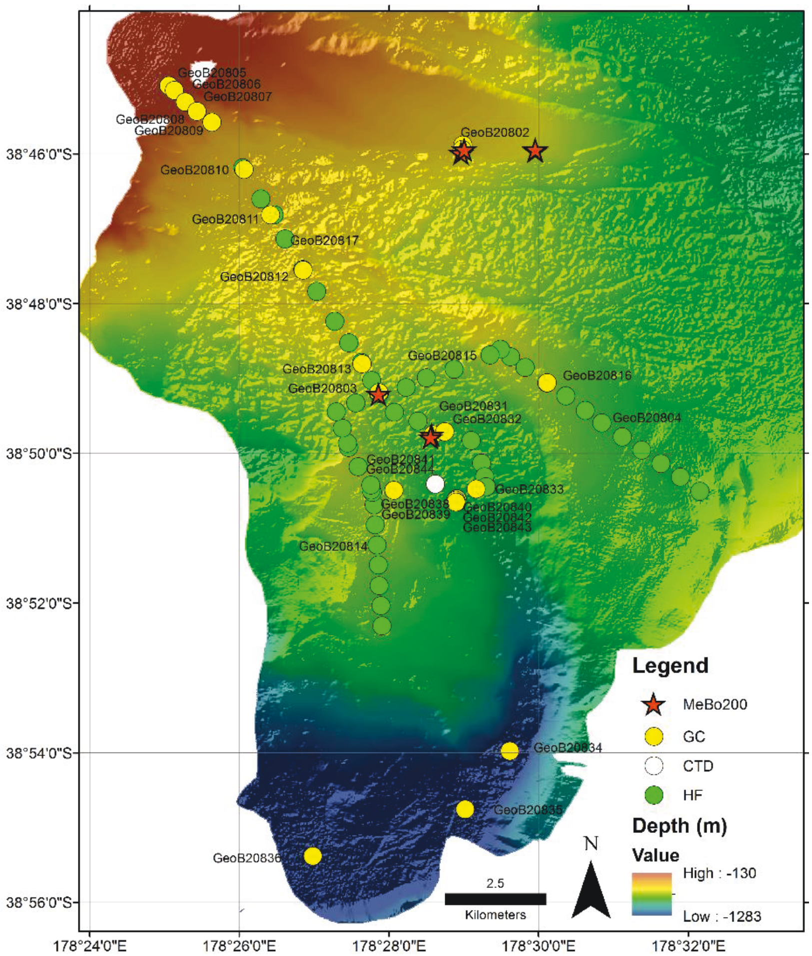

Fig. 1: All acquired data in the area of the Tuaheni Landslide Complex.

The second deployment of MeBo (GeoB208-31) in the Rock Garden working area was, like previously, focused on drilling the top of the accretionary ridge, but this time in shallower water depths than the first drill hole (i.e. GeoB204-24) on the ridge top (Fig. 2). In the shallower water depths, GeoB208-31 was outside the gas hydrate stability zone, and we hope that the results will give better understanding into the interplay between ridge uplift, gas hydrate stability and sediment destabilization. Like at Tuaheni, the MeBo drilling at this location was also made more difficult by interbedded sand layers. On Friday morning, we recovered a core with a maximum depth of 35.3 m below seafloor and a core recovery of ~50%. Several gravity cores were also taken to supplement this MeBo core, with the focus being to sample active seep sites. Unfortunately, these cores did not result in the recovery of any gas hydrates, but the cores show all typical signs of methane seep sites. The planned heat flow measurements along the landward flank of Rock Garden had to be abandoned unfortunately, due insufficient penetration of the heat flow lance. The conclusion of work at Rock Garden came in the form of a second MeBo drill hole (GeoB208-46) in a basin structure landward of Rock Garden, at the foot of a separate ridge known as Paoanui Ridge. Unfortunately the drilling had to be abandoned on Sunday at a depth of 28 m below seafloor due to ongoing sand influx into the drill hole.

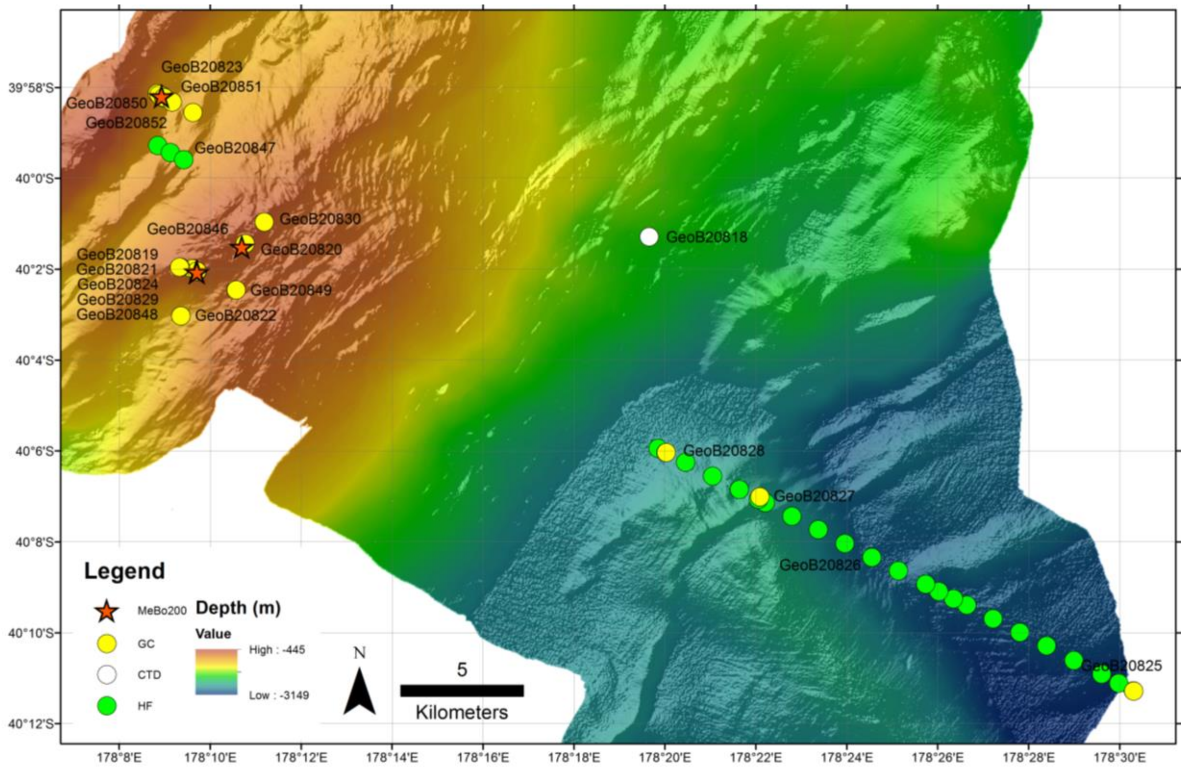

Fig. 2: All acquired data in the area of the Rock Garden research area.

After four good weeks, on Monday we will complete our work programme and head home with a total of 2 CTD profiles, 109 in-situ heat flow measurements, 54 gravity cores and 12 MeBo200 deployments. The cores represent a total of 638.86 m of sediment, of which 481.9 came from MeBo200. This material will surely provide us great opportunities to address exciting scientific questions in the coming years.

Finally we would like to thanks Captain Meyer and the crew of the DSRV SONNE for their excellent work and support of the SO247 expedition.

Greetings on behalf of all cruise participants of SO247,
Katrin Huhn & Nina Kukowski

P.S. On Monday early afternoon we finally recovered some sought-after gas hydrates in our last gravity core (Fig. 3).