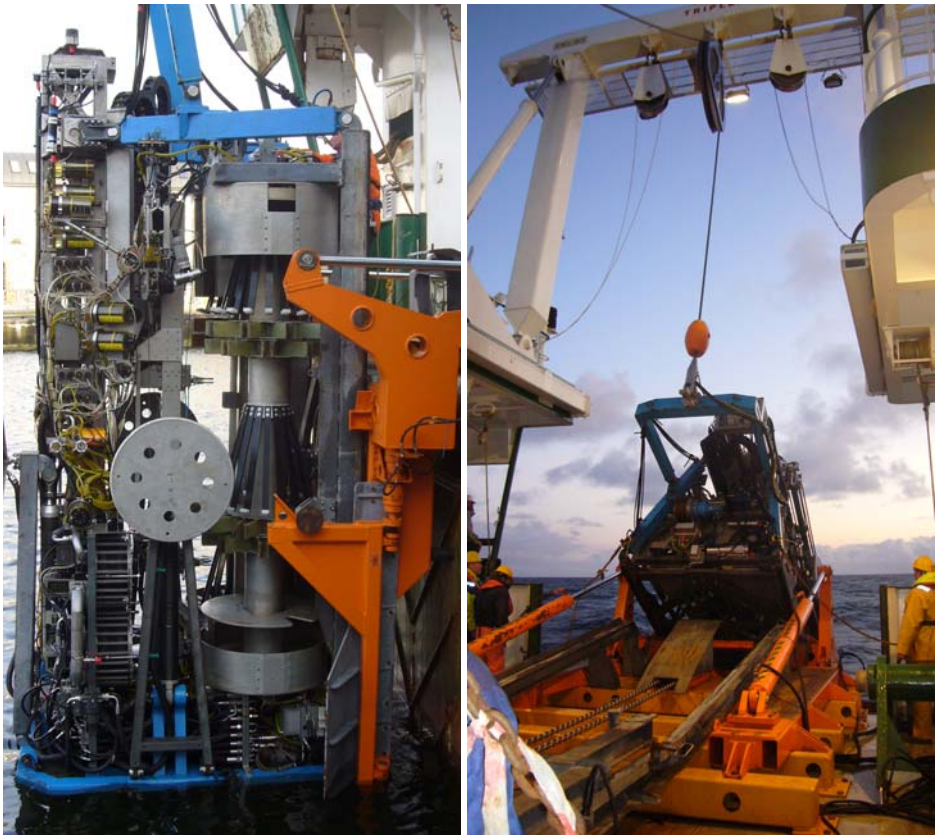
Report
for the Irish Shelf Petroleum Studies Group (ISPSG)
of the Irish Petroleum Infrastructure Programme (PIP)

RV Celtic Explorer Cruise CE0810 (MeBo2008)
"Integrated National Strategic Deep-Water
Seabed Drilling Campaign (INS DeepDrill)"



MeBo on board RV Celtic Explorer

Galway - Galway
10th of August - 8th of September 2008

by Dr. Claudia Wienberg
September 2008

A cruise within the framework of European Science Foundation
EuroCORES-EuroMARC CARBONATE project.

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2 Objectives

2 .1 Expedition Background

INS DeepDrill targets Ireland's national strategic needs for deep-water seabed drilling and full core recovery at intermediate seabed penetration (down to 70m). This is accomplished through the mobilisation of the advanced portable seafloor drilling rig MeBo financially facilitated through the European Science Foundation EuroCORES - EuroMARC CARBONATE seabed drilling programme and the Irish Shelf Porcupine Studies Group (ISPSG) of the Petroleum Infrastructure Programme (PIP) – Ireland's joint Government-Industry research programme, which comprises hydrocarbon exploration companies active in offshore Ireland and the Petroleum Affairs Division (PAD) of the Department of Communications, Energy and Natural Resources. The key objective of the expedition is to cost-effectively collect full-recovery core sequences in lithified substrates in support of the ESF-CARBONATE programme and ISPSG Rock Drilling program. The background and objectives of these two programmes are outlined on Chapters 2.2 and 2.3 below.

2.2 CARBONATE Project and Sites

Along the European Atlantic continental margin, cold-water corals and cold-water coral carbonate mounds occur from northern Norway to the Gulf of Cádiz. The mounds differ considerably in size (5-380 m) and present day 'activity' (covered with abundant living corals at the SW Rockall Trough margin to fully buried mounds in the Porcupine Seabight). Up to now the carbonate stored in these mounds has not been considered in the global carbon budget. A challenge exists to quantify the amount and flux of carbon stored in these structures. Previous investigations of short sediment cores revealed that all mounds possess different growth histories depending on the environmental setting and the involved faunal associations. These previous cores penetrated only the upper few metres of the mounds thus limiting the research to the very late stage of mound development. By understanding how biogeochemical processes control the development of these carbonate mounds and their response to climate change, CARBONATE (Mid latitude carbonate systems: complete sequences from cold-water coral carbonate mounds in the northeast Atlantic) aims at quantifying their role as mid-latitude carbonate sinks.

The main aim of the CARBONATE and INS DeepDrill is to drill through several mounds (in total six carbonate mound locations in Porcupine-Rockall area; see Figure 2.1, Table 2.1) at various locations in order to understand the role of the environmental parameters on mound formation and the role of the mounds in the global carbon cycle. Overall scientific objectives of CARBONATE:

- to recover complete mound sequences through a range of carbonate mounds in different settings;
- to elucidate the timing and factors controlling carbonate mound genesis;
- to generate a robust carbonate mound development model for different environmental settings;
- to estimate the influence of climate change in carbonate mound development;
- to assess the role of cold-water coral carbonate mounds in the global carbon cycle;
- to derive palaeo-environmental signals from carbonate mound sequences.

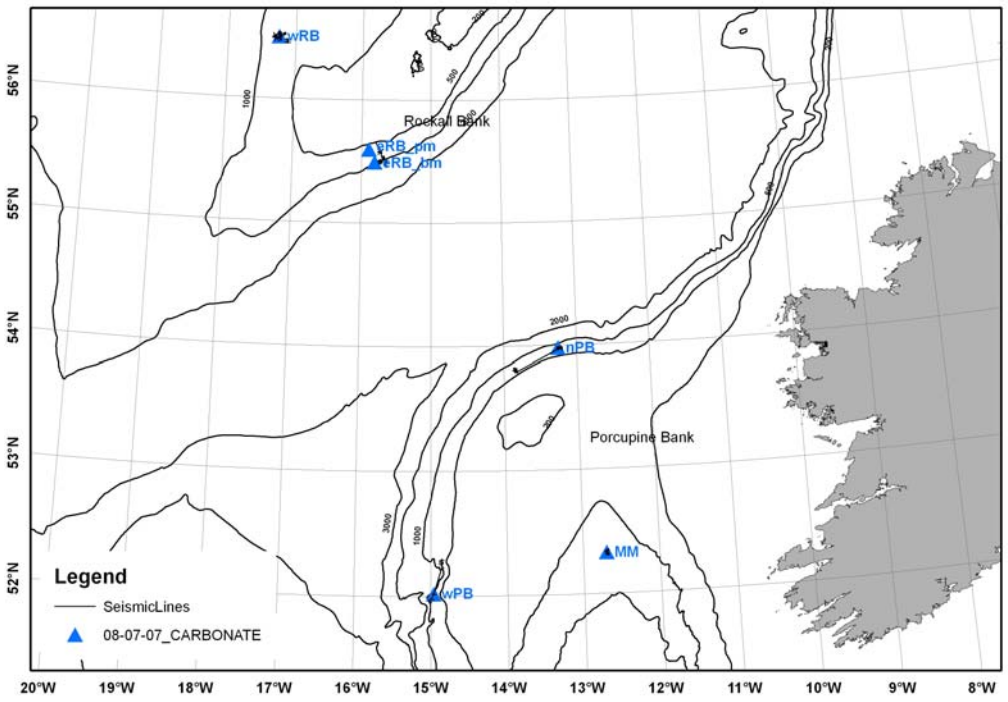


Figure 2.1: Overview map of proposed CARBONATE MeBo drill sites (provided by UCC).

Table 2.1: Metadata of proposed CARBONATE MeBo drill sites.

Site	Latitude [N]	Longitude [W]	Water Depth	Site Information
Porcupine Bank				
wPB	52°01.122'	14°57.609'	658m	Small carbonate mound at the western Porcupine Bank covered with silty to sandy sediments and coral debris.
MM	52°19.644'	12°41.394'	647m	Buried carbonate mound of the Magellan Mound Province at the northern slope of the Porcupine Seabight, which is covered with at least 20m of muddy overburden.
nPB	53°58.678'	13°15.006'	817m	Small carbonate mound at the northern Porcupine Bank covered with sand, few pebbles/boulders and very few living soft corals.
Rockall Bank				
eRB_bm	55°29.630'	15°48.240'	572m	Large carbonate mound at the eastern Rockall Bank covered with silty to sandy sediments, sponges and mostly dead corals.
eRB_pm	55°35.893'	15°53.513'	567m	Proto mounds at the eastern Rockall Bank covered with lithic and biogenic sand, gravel and some dead corals.
wRB	56°30.113'	17°14.634'	624m	Small carbonate mound at the western Rockall Bank covered with muddy to sandy sediments and coral debris.

2.3 ISPSG Project and Sites

In 2002, ISPSG was set up by the PAD and concentrates on the regional exploration elements of the Petroleum Infrastructure Programme (PIP) objectives with an aim to address common industry problems anywhere in the Irish Offshore, including regional geological and geophysical data gathering and studies aimed at improving knowledge of petroleum systems and exploration potential.

The geological objective of the ISPSG project IS07/07 is to drill shallow borehole sites on Porcupine Bank and Rockall Bank that will penetrate and identify unknown geology and provide additional geological control west of Ireland. The selected borehole targets will address some of the following geological objectives:

- confirm basement age, lithology, composition (reservoir provenance);
- stratigraphic markers identification that when extrapolated will aid interpretation of basin fill (reservoir, seal, source) or penetrate sediment cover over highs and ultimately assist in basin prospectivity;
- identify age and composition of igneous bodies (understanding geological history of the area).

For selecting suitable ISPSG borehole sites for drilling with MeBo following points were considered:

- find locations where there is outcrop at seabed or areas where there is little/no sediment cover (<50m);
- locate proposed sites were to be on a seismic line;
- avoid volcanics;
- choose sites with flat seabed;
- obtain a spread of locations to penetrate any variation in lithology across the study area.

A set of priority, first order and second order, ISPSG MeBo drilling sites were selected by PAD and provided to the scientific crew together with alternative locations for each site. For each proposed borehole location (six first priority sites, six second priority sites; see Figure 2.2) the predicted geology was described on a borehole data sheet which includes details such as seismic line and shotpoint (on which the proposed location is based), latitude/longitude location co-ordinates, water depth, listing of existing technical data, geological objective, predicted geology at the site and comments. A stratigraphic column was produced and depth to seabed and top basement depths calculated (see Tables 2.2 and 2.3 for summary). The geological prognosis at borehole sites is tentative and relies on available scientific data and technical judgement. The accuracy of seismic times for depth conversion is dependent on seismic data quality and resolution of subsurface imaging.

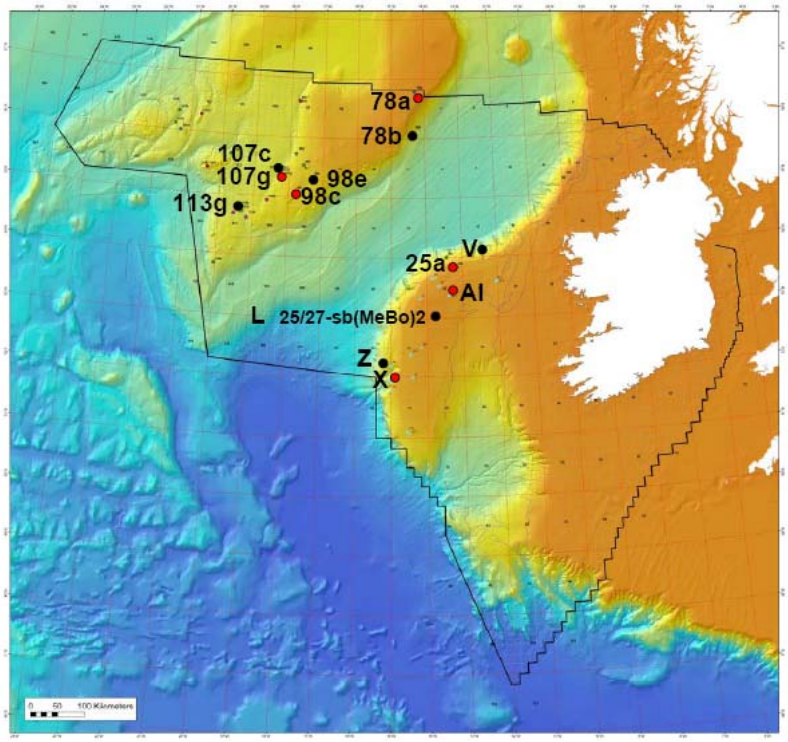
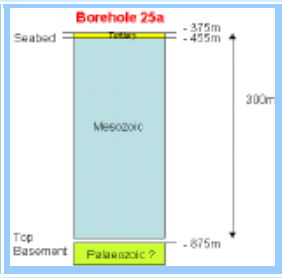
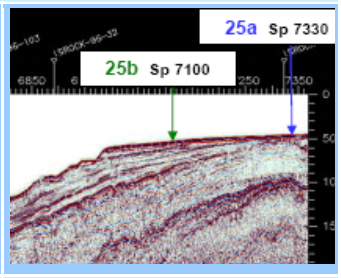
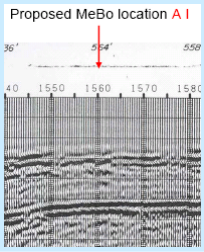
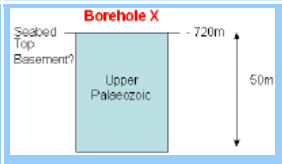
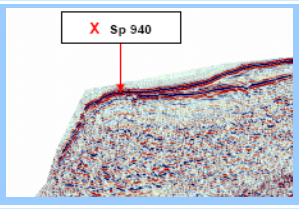
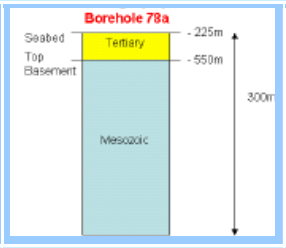
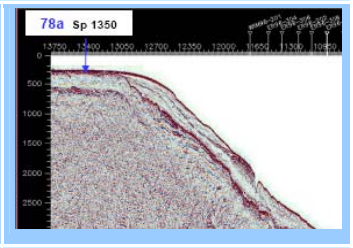
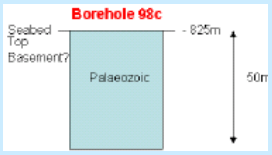
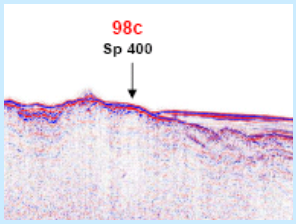
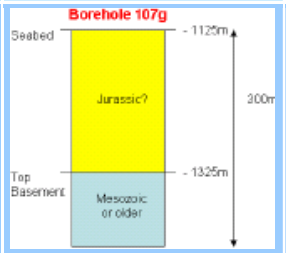
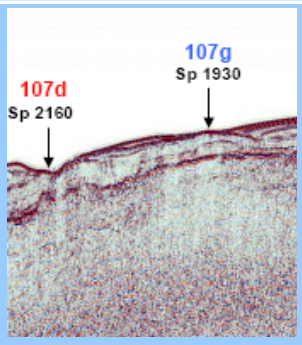


Figure 2.2: Overview map of proposed ISPSG MeBo drill sites (red dots: first order sites, black dots: second order sites). Map provided by PAD.

Table 2.2: ISPSG first priority sites - required drill depth, predicted lithology, seismic line (provided by PAD).

Name	**Drill Depth** [depth below seabed]	**Predicted Lithology** [depth below seabed]	**Stratigraphic Column** [depth below sea surface]	**Seismic Line** (cut-out)
Porcupine Bank				
25a	dd: 70m (wd: 335m)	overburden: thin layer of sand/gravel basement: layered sedimentary rock 335-415m: Tertiary 415m+: Mesozoic		
A1	dd: 5-10m below over-burden (wd: 177m)	overburden: <20m of sand/gravel basement: ~20m-197m: Carboniferous? Upper Palaeozoic?	Estimated overburden thickness and basement lithology are speculative!	
X	dd: 50m; reduce to 5-10 if basement (wd: 677m)	overburden: <32m: layered sediments basement: ~32-709m: Upper Palaeozoic		
Rockall Bank				
78a	dd: 70m (wd: 188m)	overburden: thin layer <1m of smooth glacial deposits basement: 0-250m: Tertiary sediment & volcanics 250m+: Mesozoic basement		
98c	dd: 5-10m (wd: 797m)	overburden: none; rock outcrop basement: 0-797m: massive Palaeozoic basement (or older)		
107g	dd: 70m (wd: 1125m)	overburden: none; rock outcrop basement: Tertiary? Mesozoic? layered sandstones and shales, overlying an igneous layer that can be picked regionally, beneath which the layered section may be Mesozoic?.		
107d	*dd: 70m (wd: 1275m)*	*107d: contingent on failure of 107g; both target similar sections.*		

* dd: drill depth, wd: water depth

Table 2.3: Metadata and objectives of proposed ISPSG first priority MeBo drill sites (provided by PAD).

Site	Latitude [N]	Longitude [W]	WD	Objective
Porcupine Bank				
25a	53°49.544'	13°11.540'	335m	Define the stratigraphy of the SE Rockall Basin margin. Identify the seismic stratigraphic markers that extrapolate into the Macdara basin. Determine basement lithology, composition & age as potential provenance source for the Macdara Basin (and Porcupine Basin?)
A1	53°22.581'	13°23.138'	177m	AI lies on a gravity high that sits within the postulated basin to the NW of the Porcupine basin.
X	52°01.864'	14°56.604'	677m	Identify stratigraphy. Data from this location may provide information on sediment input to the Brona Basin and a possible provenance for the Porcupine Basin.
Rockall Bank				
78a	56°46.323'	14°15.615'	188m	Define the stratigraphy of the NW Rockall Margin. Identify the seismic stratigraphic markers that extend into the Rockall Basin. At 600ms identify the basement lithology and age to determine possible provenance into the Rockall Basin.
98c	55°05.165'	17°48.710'	797m	Penetrate and identify basement outcrop at seabed as a possible provenance for the Rockall Basin to the SE in an area of poor seismic reflectivity.
107g *107d*	55°23.620' *55°23.726'*	18°15.132' *18°15.278'*	1125m *1275m*	Identify the layered sequence of seismic reflectors and basin extent. *107d: contingent on failure of 107g; both target similar sections.*

*WD: water depth

3 Narrative of the Cruise

The RV Celtic Explorer cruise CE0810 lasted for 22.5 days, starting on the 15th of August after 4.5 days of mobilisation of MeBo in Galway, Ireland, and ended there again on the 6th of September 2008 followed by 2 day of de-mobilisation of MeBo.

3.1 Embarkation / Mobilisation

On **10th August**, eight of the technicians of the deep-sea drilling rig MeBo (MARUM, Bremen, Germany) arrived in Galway, where they started directly on the morning of **11th August**, the mobilisation of MeBo on board RV Celtic Explorer. Until the 14th of August, the launch and recovery system "LARS" was installed on the afterdeck and the winch, the drill rig, the workshop, control and refrigerated core storage containers were loaded on deck by a 300-tonnes-crane. Finally, the drill tool container was unloaded and the drill tools loaded on a pipe rack on the working deck. The MeBo system was installed; power and communication lines were connected. On **13th August**, two further MeBo technicians and six scientists of four nationalities (Ireland, Belgium, The Netherlands, and Germany) embarked on RV Celtic Explorer to complete the scientific/MeBo crew. The **14th August** was spent with unloading the scientific equipment that was sent from Bremen (MARUM) and Cork (UCC) and with the installations of the equipment in the onboard laboratories. In the

evening, a test of the high voltage system as well as a first test for the launch and recovery of the MeBo was conducted in the harbour of Galway (Figure 3.1). As some problems with the hydraulics occurred during the first launch and recovery test, the test was successfully repeated in the morning on the **15th August**.

Figure 3.1: (a) Berth of RV Celtic Explorer in Galway harbour (photo: N.Joseph). (b) MeBo launch and recovery test (photo: C. Wienberg).

3.2 Cruise CE0810

*NOTE: all times given are related to ship's time/Irish local time

Waiting for high tide, RV Celtic Explorer set sail in the afternoon (3.30 pm) of **15th August** and start transit to the first drill site of this cruise, **ISPSG site A1** on Porcupine Bank (see Figure 3.2 for cruise track and station locations). We arrived there at 8.30 am of **16th August**. For ground truthing purposes short surveys with the multibeam echosounder and the 3.5kHz sub-bottom profiler were conducted accompanied by grab sampling (station-no. **INSDD1**). Four grab samples (two Shipek and two Day grabs) taken at site A1 revealed medium sand with some gravel. At 11.00 am the first deployment of MeBo during the cruise started. After two hours MeBo was landed safely on the flat sandy seabed. However, shortly after the landing, the MeBo technicians recognized an oil leakage and one of the legs did not function properly. As a consequence, MeBo became unstable and toppled over, which made an immediate recovery inevitable. After recovery, the MeBo technicians detected that the manifold of one leg was damaged causing a leakage of hydraulic into the compensation oil system which subsequently blew. The hydraulic-compensation-system could be repaired quite easily, but the damage of the manifold was a more serious problem and required support from onshore to either repair it or to replace it by an old spare one in sheltered water.

Therefore, it was decided to go into Galway Bay close to Rossaveel, where we arrived at 10.00 am of **17th August** after a transit of 14.5 hours. During the day, the MeBo technicians replaced the damaged manifold by an old spare one. But unfortunately, a further problem occurred as the air conditioning of the MeBo control container was not working anymore, which would have been a problem for its electronics and the computer hardware. In addition, the RV Celtic Explorer had a crucial problem as all GPS inputs to the dynamic positioning failed. Without a working dynamic positioning system any drilling was impossible. As both problems had to be fixed on-shore, and the weather conditions and sea state were predicted to be too rough for drilling until the 19th anyway, it was decided to go back to Galway.

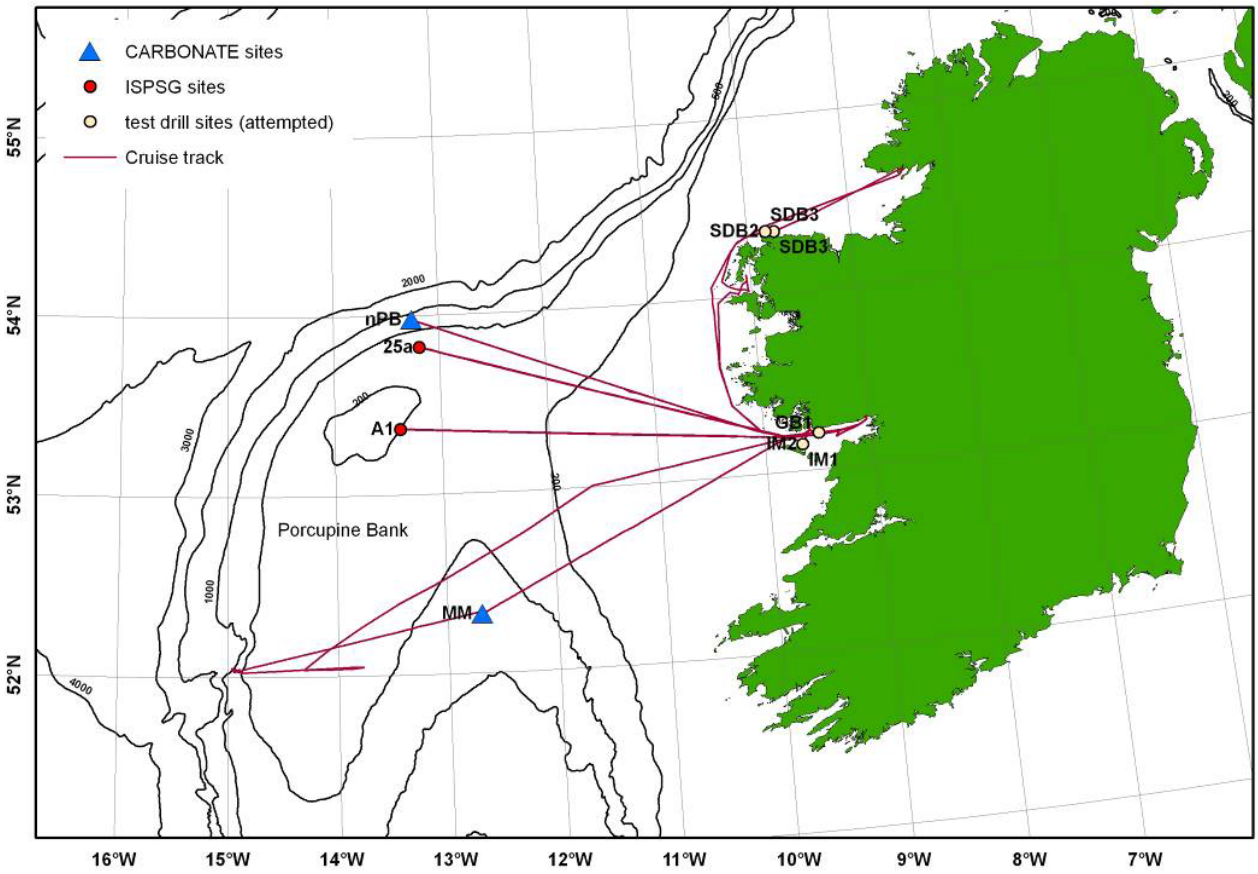


Figure 3.2: Cruise track and station locations of RV Celtic Explorer cruise CE0810. Note that at sites SDB2 and SDB 3 (south Donegal Bay) only grab sampling were conducted. At site GB1 two attempts of deploying MeBo failed, whereas at sites IM1 and IM2 (Inishmore Island, Galway Bay) two test drills were conducted (map provided by UCC).

We arrived in Galway harbour on **18th August** at 5.00am, where everything was fixed in time that we could set sail at 5.30 pm (high tide) to leave Galway harbour again. As the bad weather window still was predicted to last on for the next 40 hours, it was decided to go to Rossaveel, Galway Bay to do a shallow-water test drill (water depth: <30 m). We arrived there at 8.00 pm (transit time: 2.5 hours) and directly started to deploy MeBo (station-No. **INSDD2**). But right after the start of the deployment the drill head of MeBo slipped forwards and the MeBo team had to stop the deployment. It turned out, that there was a problem with the hydraulic system which was caused by contamination with metallic (aluminium) drill cuttings or swarf, which appears to have resulted from modification work carried out on the leg manifolds prior to mobilisation of MeBo to Ireland by an external company. The MeBo team worked all night to isolate the failure of the hydraulics. The next day (**19th August**), the MeBo team did a 2nd attempt to deploy MeBo for a test drill (station-No. **INSDD3**), but again similar hydraulic failures as the day before appeared. It became obvious that the problems with the hydraulics were more severe than expected and that a flushing of the hydraulics was needed to get rid of all swarf inside the system. As this could only be done by a specialised company, we started transit to Killybegs, Donegal Bay.

We berth in Killybegs harbour on **20th August** at midday after a transit of 16 hours. The 2nd officer of RV Celtic Explorer requested to leave the ship due to personal problems. This request was granted and he was replaced by a stand-in temporary 2nd officer. The MeBo team dismounted three of the manifolds for flushing separately by a hydraulics company. Initially, it was estimated that the flushing will last about 24 hours, but it turned out that

the contamination of the manifolds, valves and filters by swarf was more severe than expected; moreover, one valve was broken and had damaged the manifold. The valve needed to be replaced and the manifold re-bored. At the end, the flushing and re-mounting of all three manifolds lasted in total 58 hours.

The worst consequence of this delay was that we completely missed a good weather window as the weather conditions changed to a rough sea state on the evening of 21st August. Therefore, on **22nd August** at 9.30 pm, we set sail to the south-western part of Donegal Bay, where it was intended to do a full-water system check of MeBo and a sheltered test drill. The early morning of **23rd August** started with four Shipek grab samples at three different sites (station-No. **INSDD4 to INSDD6**) to find a suitable shallow-water test drill site. But unfortunately during the morning, the wind direction changed making any MeBo operations within Donegal Bay impossible. Therefore, it was decided to go back to Rossaveel, Galway Bay to do all tests in the shelter of the Arann Islands. Rounding the Mullet Peninsula wind speed and currents became stronger than expected and RV Celtic Explorer couldn't go faster than 3-4 knots. Therefore, it was decided to change the course once more and to go to Blacksod Bay (close to Achill Island), where we arrived at 2.00 pm. After the 2nd attempt, the MeBo systems were successfully checked in the water.

A test drill in Elly Bay (located on Mullet Peninsula, north of Blacksod Bay) was scheduled for the early morning of **24th August**, but the swell and wind speed (20 knots) were too high resulting in a heave of 3-4 m making a deployment of MeBo impossible. At 6.40 am, we started transit to Galway Bay to get more shelter in the back of the Arann Islands (Inishmore Island). After 8 hours of transit, the test drill (station-No. **INSDD7**) started with the collection of one Shipek grab sample for ground truthing purposes, which revealed that the surface sediments are composed of shell hash with gravel, sand and mud. MeBo was successfully deployed at 4.50 pm for a further attempt to do a shallow-water test drill. During the night problems occurred with the handling of connecting the outer core barrels, one barrel sustained damage to its screw thread (Figure 3.3a), which made it impossible to properly adopt a recovery core, and one of the claws, which grabs the core barrels, was damaged (Figure 3.3b). Therefore, the test drill was stopped and MeBo was recovered. The 1st core liner revealed a recovery of only 30 cm (~13%) of soft sediment (greyish mud with oyster shells) as most of these soft sediments were flushed out during drill operation. The 2nd core liner also revealed only 8 cm (~3%) of Carboniferous limestone (Figure 3.3d): due to the problems with adapting the 2nd core barrel, most of the drilled core remained in the borehole.

On **25th August**, we crossed from the Arann Islands to Rossaveel to relieve the stand-in temporary 2nd officer (see 20th of August) with a new 2nd officer. During the replacement, the MeBo technicians fixed the damaged claw and outer core barrel. In the evening, we steamed back to Arann Islands (Inishmore Island) for a 2nd test drill (station-No. **INSDD8**). During this 2nd test drill, which started at 9.00 pm no further problems occurred, all systems (hydraulics, electrics, mechanics) worked well. But in the very early morning (4.00 am) of **26th August**, MeBo was just drilling the 3rd core pipe when the RV Celtic Explorer had some serious and crucial problems. The GPS dropped out for several minutes and the dynamic positioning didn't get any signal so fixed position by dead reckoning. As a consequence, the ship went off position (~30 m) and the cable of MeBo got under the ship's keel and was strongly pulled. The captain of RV Celtic Explorer took over dynamic positioning system manually to get back on position (which lasted ~30 minutes)

and to stay as close to MeBo as possible. The MeBo technicians themselves had to pull out additional 50m of cable not to loose MeBo. Back on board after an emergency recovery, it turned out that MeBo had no visible physical damage and also the electrics of the winch still work well. But the MeBo team lost one outer core barrel, and the cable received a kink, however, not seriously affecting its functionality. Overall, as the loss of GPS signal caused a crucial situation for the ship and the MeBo, we were lucky that nothing was seriously damaged. The problem was caused by the loss the differential GPS signal to the forward GPS. The dynamic positioning system therefore rejected this signal but should have adopted the aft GPS signal. It is probable that this signal had drifted so the dynamic positioning rejected that also. With no GPS it adopted dead reckoning which was 30 m out. The fault was rectified by turning of the differential signal to the forward GPS which should stop the dynamic positioning rejecting the GPS in future. Nevertheless, it was decided to be prudent and avoid drilling in shallow-water for the rest of the cruise. In deep-water settings, loosing dynamic positioning would not have been so crucial so we continued the cruise. At 7.30 pm we set sail to the next regular drill site of this cruise: CARBONATE drill site nPB on northern Porcupine Bank.

Figure 3.3: (a) Flared screw thread of outer core barrel. (b) Broken claw. (c) Diamond studded "Surface Set" drill bit for drilling limestone. (d) Limestone recovered during the first test drill (Inishmore Island, Galway Bay) (photos: C. Wienberg).

On **27th August** at 2.40 pm, we arrived at northern Porcupine Bank. The transit from Galway Bay to Porcupine Bank lasted much longer than predicted (19 hours instead of 10 hours) as due to the swell and strong head winds the RV Celtic Explorer could just reach maximum speeds between 6.5-7.5 knots instead of 9-10 knots. Station work at CARBONATE drill site **nPB** started with a CTD cast accompanied by water sampling, followed by a short multibeam survey (station-No. **INSDD9**). In the afternoon a 1st deployment of MeBo was conducted, but directly after MeBo was landed on the seafloor, a leakage of compensation

oil was detected and MeBo was recovered. On **28th August**, two further attempts of deploying MeBo were conducted, but again failed due to compensation oil problems. In between the two deployment attempts, a so-called "yo-yo CTD" station was carried out, in which the CTD was continuously lowered and raised for 3 hours without leaving the water. Finally, the 4th attempt to deploy MeBo on drill site nPB was successful. Unfortunately, the seabed at the proposed drill site was unsuitable as it had a slight a slope. Therefore, the position of MeBo was relocated four times try to find flat ground. On the 4th landing, MeBo tilted about 40° and the piston ram on one leg became bent (Figure 3.4), which made an emergency recovery of MeBo necessary. Back on board, it turned out that the damage of the leg was not repairable on board; instead a spare is needed from onshore. As also the weather was predicted to become quite rough in the course of 29th August, it was decided to go to Rossaveel, Galway Bay, to get shelter against the bad weather and to get support from onshore.

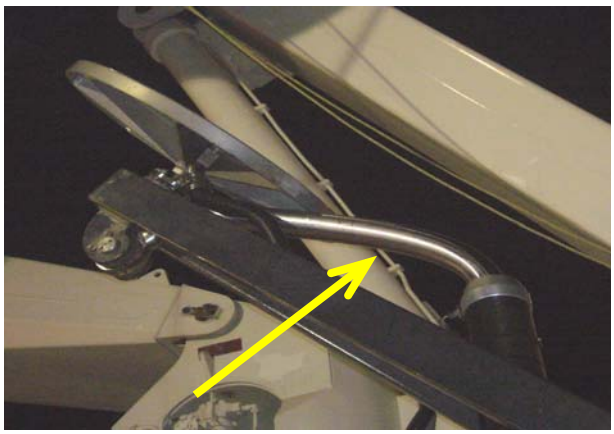


Figure 3.4: Piston ram with MeBo leg following adverse seabed landing (photo: C. Wienberg).

On **29th August** at 3.30 pm, we arrived at Rossaveel, Galway Bay. Already in the early morning, a company in Galway was contacted for fabricating a fixed arm as replace for the damaged hydraulic piston (Figure 3.5). Fortunately, they could manage to bring it to Rossaveel already in the early afternoon, where it was picked up by some crew members and immediately fitted by the MeBo technicians. At 7.30 pm, we set sail back to the Porcupine area for drilling CARBONATE site MM (Magellan Mounds).

Figure 3.5: (a) Bent piston ram from MeBo leg. (b) Spare leg (photos: C. Wienberg).

After a transit of 14 hours, we arrived at CARBONATE drill site **MM** on **30th August**. The MeBo drill started with a multibeam echosounder survey for ground truthing purposes, and a CTD cast accompanied by water sampling (station-No. **INSDD10**). At 12.30 pm MeBo was deployed and successfully landed on the sea. But shortly after start drilling, it turned out that the drill head could not be moved down as the bracket of one leg was in the way, in all likelihood because it was skewed during the last failed landing of MeBo. Therefore, MeBo was recovered, part of the bracket was cut-off by grinding and MeBo was deployed a 2nd time at 7.50 pm the same day. The drilling lasted until midday on **31st August** (~14 hours) and reached a drill depth of 35.6 m below seabed. Ten core liners were retrieved, but no cold-water coral carbonate mound sediment was found in the core despite correct

given coordinates for buried mound. During recovery of the drill barrels, the MeBo team had to leave the outer core barrel at the drill site as they couldn't get it out of the drill hole. Moreover, one claw was broken as they attempted to get the barrel out.

As it was predicted that the weather would become too rough for drilling, we set sail to ISPSG site X on the western Porcupine Bank, where it was intended to collect 1-2 Day grab samples and to conduct a CTD cast. Shortly before we arrived at ISPSG site X, on the early morning of **1st September**, a power surge demand from the bow thruster caused an overload of the main generator and engine resulting in a blackout. Power was restored promptly but a full check was required. We transited slowly to shore to stabilise the ship with a following sea so repairs/check could be done and also in case we needed on-shore assistance or a dry dock. At 3.15 pm it was clear that there was nothing wrong with the bow-thruster or engine so it was safe to continue with the survey. It is likely that a combination of full thrust and strong heave (lifting the thruster out of the water and violently back in) caused the power demand surge. We transited back to ISPSG site X. At 7.45 pm the sea had made it too rough to do anything at X and also transiting to 25a was not possible (gale warning) so we turned and headed back to Galway Bay for shelter arriving Galway Bay (Rossaveel) in the afternoon of **2nd September**.

On **3rd September** at 11.30 am, we set sail to ISPSG drill site **25a** at the northern Porcupine Bank and arrived there on **4th September** at 6.00 am. For ground truthing purposes surveys with multibeam echosounder and sub-bottom profiler were conducted, before MeBo was successfully deployed at 8.10 am (station-No. **INSDD11**). Whereas, the two first core barrels showed a rather good drill progress, during drilling the 3rd core barrel some problems occurred with the flushing of the drill cuttings and the drill progress significantly decreased, the MeBo team couldn't manage to pull out the inner core barrel as it was stuck into the outer barrel. Therefore, the drilling had to be aborted (Figure 3.6). At 9.00 pm we started transit back to Galway as bad weather precluded any further operations, where we arrived at the evening of **5th September**.

Figure 3.6: (Left) Recovery of MeBo after drilling ISPSG site 25a. (Right) Diamond studded drill bit used for drilling, filled with weathered calcareous sandstone.

3.3 De-Mobilisation / Disembarkation

Already on the 5th of September the MeBo team started with the de-mobilisation of MeBo. They disconnect all power and communication lines and loaded the workshop container. This

work was continued on **6th September**. On **7th September** all MeBo containers, the launch and recovery system "LARS" and the core storage container were unloaded from deck by a 300-tonnes-crane. The scientific participants and MeBo technicians disembarked either on 7th September or on **8th September**.

3.4 Weather Diary

Weather conditions during the cruise (summarized in Table 3.1) determined whether we could deploy and recover MeBo. The vertical acceleration at the aft of the vessel due to heave determine the dynamic load on the MeBo umbilical. Dynamic loads of 25 kN (25 tonnes) were experience with swell wave-heights of 2-3 m depending on wave period. Such loads were beyond the umbilical tolerance and not safe. This means that MeBo (depending on water depth and how much it is loaded) could not be deployed in swell heights exceeding much more than 2.5 m maximum. This therefore defined our operational weather window for MeBo deployment.

Bad weather restricted the ship's programmes on the following days:

- **18th-19th August**:
  Bad weather outside Galway Bay made transit and drilling at ISPSG site A1 not possible. We therefore prudently attempted test drilling in Galway Bay.
- **23rd August**:
  Strong winds swinging around to the west precluded the opportunity to find shelter in Donegal Bay to do a test drill. We attempted transit to Galway Bay for a sheltered test drill but windage made transit very slow. With the sea picking up very quickly we sought shelter in Blacksod Bay where a water testing of MeBo could be performed.
- **24th August**:
- We could not find shelter for a test drill in water more than 25 m in Blacksod Bay so continued transit to Galway Bay now head wind had dropped and started test drilling behind Inishmore Island. Transit and drilling on Rockall and Porcupine Banks still prohibited by the weather. Eventual transit to north Porcupine Bank in time for good deployment conditions on 26th August at 7.30 pm.
- **27th August**:
- MeBo deployed by dynamic load on cable excessive due to swell.
- **31st August**:
  Building swell determines when MeBo needed to be recovered after drilling CARBONATE site MM.
- **1st-3rd September**:
  4-5 m swell from the west made any work at ISPSG site X impractical. Increasing swell and squalls followed by major winds and 6-7 m swell made transit to ISPSG site 25a unsafe with ship's load (MeBo, MeBo winch and three containers (2 double stacked)) as we would have to take swell side on. Riding out storm at site X was also not an option as site X has ~32 m of overburden. Therefore we ran to shelter in Galway Bay and transited out into weather in the latter part of the storm on 3rd September.
- **4th September**:
  Gale force winds & swell from the north hampered transit back to Galway.

Table 3.1: Weather log (data to nearest sound recording).

Time Stamp	Wind Direction [degrees]	Wind Speed [knots]	Pressure [kbars]	Air Temperature [°C]
15-08-2008 12:00*	279	(1)	1.011	14.2
16/08-2008 00.00	52	17	0.995	14.2
16/08-2008 12:00	323	19	1.001	17.1
17/08-2008 00.00	268	17	1.000	14.3
17/08-2008 13:00*	138	(19)	0.996	14.9
18/08-2008 00.00	143	13	0.992	15.1
18/08-2008 12:00*	64	(4)	0.989	18.4
19/08-2008 01:00*	326	(5)	0.999	15.9
19/08-2008 13:00*	288	(15)	1.005	16.7
20/08-2008 00.00	285	14	1.006	15.1
20/08-2008 12:00*	289	(6)	1.006	18.1
21/08-2008 00.00*	308	(2)	1.009	13.2
21/08-2008 09:00*	354	(7)	1.013	15.4
23/08-2008 04:00	192	17	1.012	14.2
23/08-2008 11:00	184	38	1.002	15.1
24/08-2008 00.00*	254	(18)	1.000	14.9
24-08-2008 12:00*	223	(13)	1.004	15.8
24-08-2008 23:00*	218	(25)	1.002	15.8
25-08-2008 14:00*	257	(9)	1.008	17.7
25-08-2008 23:00*	234	(17)	1.012	15.9
26-08-2008 10:00*	232	(20)	No data	No data
26-08-2008 19:00	243	23	1.017	16.2
27-08-2008 01:00	247	21	No data	No data
27-08-2008 12:00	263	21	No data	No data
28-08-2008 00.00	258	17	No data	No data
28-08-2008 13:00	253	16	1.020	16.5
29-08-2008 00:00	207	17	1.017	15.7
29-08-2008 10:00	209	11	No data	No data
29-08-2008 22:00	204	18	No data	No data
30-08-2008 11:00	355	14	1.012	14.1
31-08-2008 00.00	267	13	1.013	14.1
31-08-2008 12:00	196	22	1.009	15.8
31-08-2008 23:00	250	20	1.006	14.7
01-09-2008 11:00	248	19	1.005	14.4
02-09-2008 01:00	279	28	0.998	13.7
02-09-2008 11:00	332	22	0.997	14.3
02-09-2008 23:00*	285	(8)	1.000	12.2
03-09-2008 12:00	275	12	0.993	15.9
04-09-2008 00:00	318	10	0.996	14.3
04-09-2008 11:00	71	9	0.995	14.8
05-09-2008 01:00	50	28	0.995	13.8

*: vessel in shelter

3.5 Comments on Downtime

The objectives and success of this cruise were significantly affected by downtime. Only limited retrieval of overburden was retrieved for CARBONATE and just one core for ISPSG. Downtime can be attributed to inclement weather (which was exceptional bad for the time of year) and technical issues with MeBo and the ship (Figure 3.7).

Downtime accounted for 75.8% of the cruise with the remainder of the time spent in transit or achieving objectives. A breakdown of the downtime shows that 33.7% of downtime can be attributed to adverse weather, 39.3% to MeBo technical problems and 2.8% to ship technical problems. Note that these calculations contain an element of subjectivity arising when downtime is due to multiple problems e.g. 17th August when both MeBo, the vessel and the weather precluded operations. Assigning downtime to one factor under such circumstances is on the basis of perceived dominant responsibility for precluding operations. As such, the percentage statistics should be taken as a guide only.

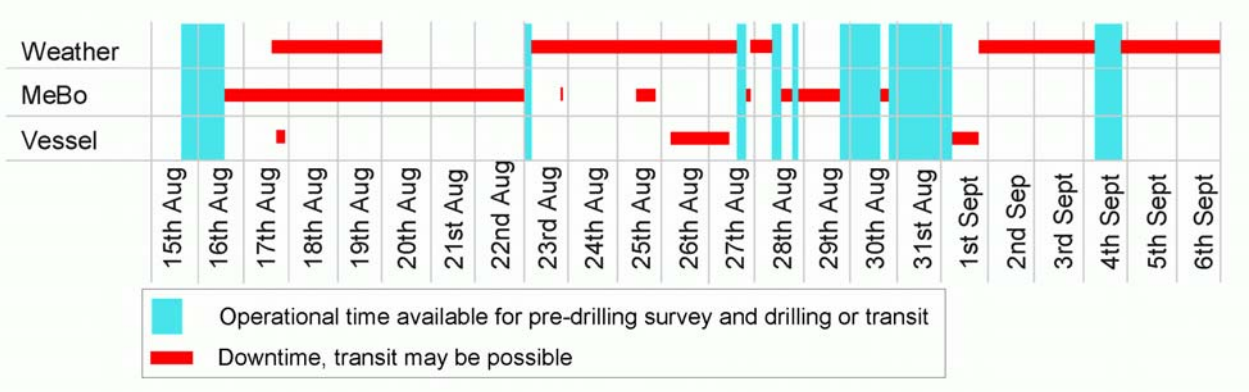


Figure 3.7: Summary of downtime showing downtime overlaps and operational windows (provided by Andy Wheeler, UCC, chief scientist on RV Celtic Explorer cruise CE0810).

4 Equipment and Deployments

4.1 MeBo – Sea Floor Drill Rig

In order to bridge the gap between the use of expensive drill ships and standard primitive sampling tools, MARUM, University of Bremen has developed the sea floor drill rig MeBo ("Meeresboden-Bohrgerät", German for "sea floor drill rig"; Figure 4.1). This drill rig is capable of sampling soft sediments and hard rocks down to 70 m at the sea floor and it can be operated in water depths up to 2000 m. MeBo can be deployed from standard research vessels like RV Celtic Explorer. The development of the drill was funded by the German Ministry of Education and Research and by the Bremen State Government.

MeBo is a portable drill rig which is remotely operated from the vessel. A steel armoured umbilical is used to lower the MeBo to the sea bed. Copper wires and fibre optics in the umbilical core are used for energy supply and for communication. The MeBo uses the Remote systems Engine from Schilling Robotics as telemetry system. This company also developed the loading arm and the rotating magazines that are used for storage of the required drill tools on the rig. Prakla Bohrtechnik was responsible for the drill technology

and the hydraulics. Project management, sensor integration, control hard- and software development and integration were done at the Marum.

Figure 4.1: The MeBo seafloor drilling rig on the launch and recovery system over the stern of the RV Celtic Explorer in Galway Dock at the start of the cruise. Clearly visible facing the camera is one of the four hydraulic legs and circular footplate which are lowered before seabed landing, the rotary magazine into which empty and filled core barrels are stored (currently empty).

The central parts of the drill are the drill head and the feeding system. The drill head is a rotary unit that provides the required torque and rotation speed for rotary drilling and for making or breaking the threads of the drill string. The feeding system consists on the mast along which the drill head mounted on a guide carriage moves up and down. Cores are taken from the sea floor by simple pushing a push core barrel (push coring suitable for soft sediments) or by rotating and pushing a rock barrel (rotary drilling for hard rocks). A water pump provides sea water for flushing the drill string for cooling of the drill bit and for removing the drill cuttings. The core length for each push and rock barrel is 2.35 m. When

the barrel has finished sampling it is recovered out of the drilled hole and stored by the loading arm in a magazine. The next barrel is lowered into the drill hole, a 2.35 m rod is added and the next 2.35 m can be sampled. The drilled hole is stabilised by another set of casing tubes (Figure 4.2)

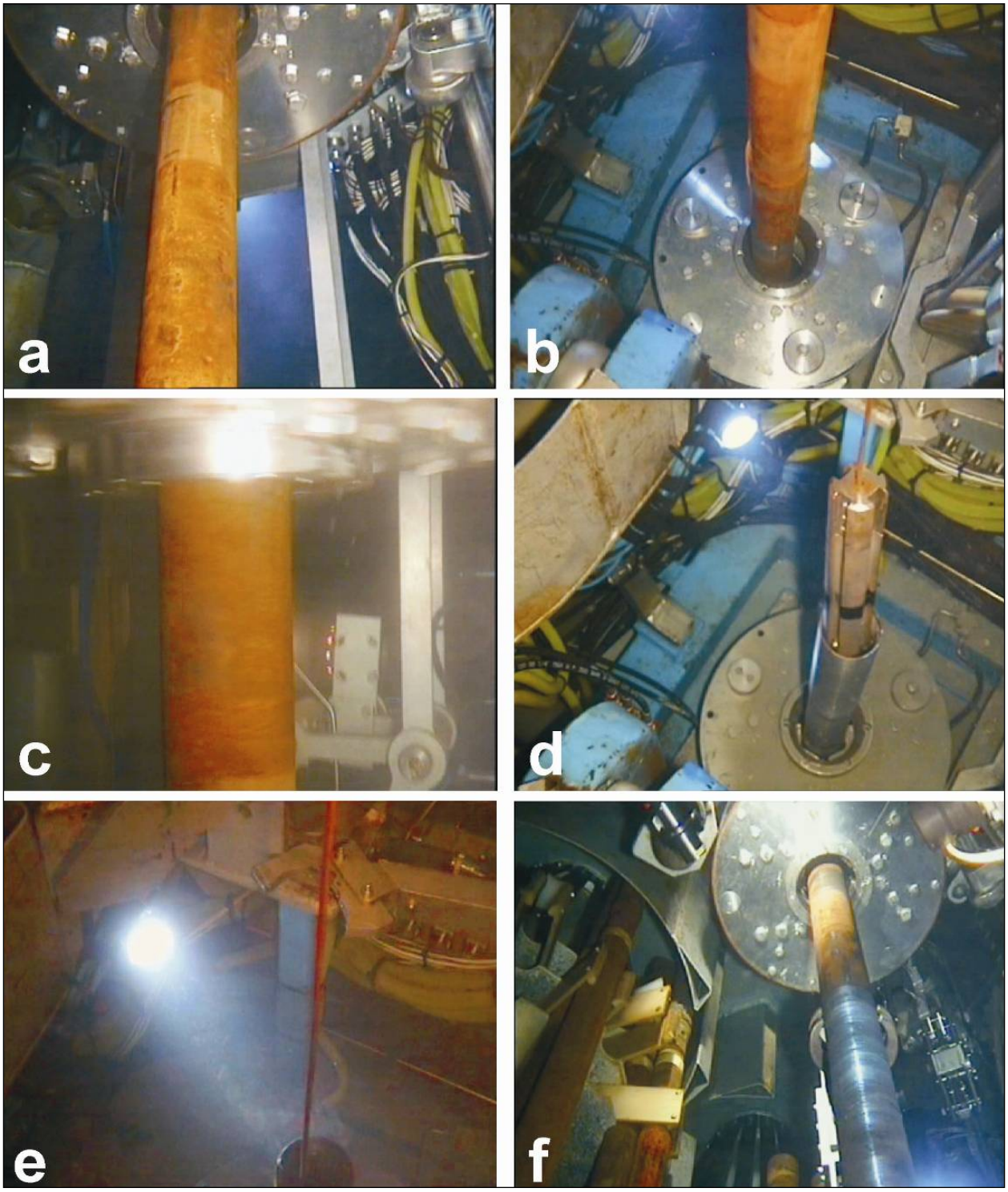


Figure 4.2: MeBo drilling operations during RV Celtic Explorer cruise CE0810. (a) Top of drill barrel loaded into drill head ready for drilling. (b) Base of drill barrel lowered in basal chuck. (c) Drilling. (d) Core recovery cone lowered into outer barrel (e) and clips into inner core barrel containing the rock sample that is then retrieved. (f) New outer core barrel loaded and drilling continues deeper.

4.1.1 Drilling Overview

During RV Celtic Explorer cruise CE0810, MeBo was deployed for twelve times, of which MeBo was eight times successfully landed on the seafloor, whereas four deployments were already aborted before landing due to technical failures. In addition, four times the drill operation was aborted shortly after landing, again due to technical problems (Table 4.1). In total, MeBo started to drill for four times: two shallow-water test drills close to Inishmore Island (IM) in Galway Bay, one drill at CARBONTE site MM at the northern slope of Porcupine Seabight, and one drill at ISPSG site 25a at the northern Porcupine Bank.

Table 4.1: MeBo drilling stations during RV Celtic Explorer cruise CE0810.

Station-No.		Site*	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Comment
INSDD1	9	A1	16-08-2008	10:31	53°22.049'	13°23.169'	174.9	In water
INSDD1	10	A1	16-08-2008	12:00	53°22.042'	13°23.173'	172.1	On bottom
INSDD1	11	A1	16-08-2008	12:15	53°22.042'	13°23.173'	173.0	Hydraulic failure - Recovery
INSDD1	12	A1	16-08-2008	13:20	53°22.038'	13°23.171'	172.5	On-deck
INSDD2	1	GB1	18-08-2008	19:15	53°12.306'	09°29.599'	31.7	Start deployment
INSDD2	2	GB1	18-08-2008	19:25	53°12.321'	09°29.579'	31.6	Hydraulic failure - Abort deployment
INSDD2	3	GB1	18-08-2008	19:40	53°12.319'	09°29.573'	30.8	On-deck
INSDD3	1	GB1	19-08-2008	15:20	53°12.311'	09°29.574'	29.3	Start deployment
INSDD3	2	GB1	19-08-2008	16:55	53°12.312'	09°29.571'	30.6	Hydraulic failure - Abort deployment On-deck
INSDD7	2	IM1	24-08-2008	16:30	53°08.965'	09°38.943'	32.6	In water
INSDD7	3	IM1	24-08-2008	17:03	53°08.965'	09°38.943'	31.8	On bottom
		IM1	24-08-2008	**18:29**				Start 1st test drilling
		IM1	25-08-2008	**05:30**				Mechanical failure - Abort drilling
INSDD7	4	IM1	25-08-2008	09:30	53°08.968'	09°38.995'	34.5	Start recovery
INSDD7	5	IM1	25-08-2008	10:20	53°08.967'	09°38.956'	34.7	On-deck
INSDD8	1	IM2	25-08-2008	20:28	53°08.944'	09°38.986'	28.8	In water
INSDD8	2	IM2	25-08-2008	20:56	53°08.944'	09°38.987'	28.4	On bottom
		IM2	25-08-2008	**21:54**				Start 2nd test drilling
		IM2	26-08-2008	**03:00**				Ship's dp failure - Abort drilling
INSDD8	3	IM2	26-08-2008	04:55	53°08.935'	09°38.983'	27.6	Emergency recovery
INSDD8	4	IM2	26-08-2008	05:30	53°08.934'	09°38.985'	26.3	On deck
INSDD9	4	nPB	27-08-2008	16:32	53°58.677'	13°15.006'	797.0	In water
INSDD9	5	nPB	27-08-2008	18:33	53°58.669'	13°15.035'	811.0	On bottom
INSDD9	6	nPB	27-08-2008	18:46	53°58.668'	13°15.036'	810.0	Compensation failure Abort deployment
INSDD9	7	nPB	27-08-2008	20:18	53°58.661'	13°15.046'	818.0	On deck
INSDD9	8	nPB	28-08-2008	09:43	53°58.691'	13°15.040'	820.0	In water
INSDD9	9	nPB	28-08-2008	11:20	53°58.689'	13°15.039'	794.2	Compensation failure Abort deployment
INSDD9	10	nPB	28-08-2008	12:29	53°58.688'	13°15.036'	794.9	On deck
INSDD9	15	nPB	28-08-2008	16:45	53°58.696'	13°15.044'	795.5	In water
INSDD9	16	nPB	28-08-2008	17:15	53°58.695'	13°15.040'	792.1	Compensation failure Abort deployment On deck
INSDD9	17	nPB	28-08-2008	19:06	53°58.685'	13°15.040'	792.9	In water

Table 4.1 (continued).

Station-No.		Site*	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Comment
INSDD9	18	nPB	28-08-2008	21:00	53°58.684'	13°15.040'	792.0	On bottom
INSDD9	19	nPB	28-08-2008	21:56	53°58.673'	13°15.040'	790.9	Mechanical failure Abort deployment
INSDD9	20	nPB	28-08-2008	23:45	53°58.671'	13°15.040'	790.9	On deck
INSDD10	4	MM	30-08-2008	11:34	52°19.660'	12°41.405'	639.7	In water
INSDD10	5	MM	30-08-2008	13:06	52°19.658'	12°41.410'	640.1	On bottom
INSDD10	6	MM	30-08-2008	14:55	52°19.653'	12°41.420'	-	Drill head failure Abort deployment
INSDD10	7	MM	30-08-2008	16:10	52°19.653'	12°41.420'	642.8	On deck
INSDD10	8	MM	30-08-2008	18:49	52°19.645'	12°41.425'	641.5	In water
INSDD10	9	MM	30-08-2008	19:56	52°19.639'	12°41.399'	642.3	On bottom
		MM	30-08-2008	**20:24**				Start drilling
		MM	31-08-2008	**09:46**				Stop drilling
INSDD10	10	MM	31-08-2008	13:05	52°19.626'	12°41.413'	641.1	Start recovery
INSDD10	11	MM	31-08-2008	14:30	52°19.622'	12°41.310'	639.0	On deck
INSDD11	5	25a	04-09-2008	07:17	53°49.393'	13°11.332'	331.5	In water
INSDD11	6	25a	04-09-2008	08:44	53°49.385'	13°11.306'	333.5	On bottom
		25a	04-09-2008	**09:17**				Start drilling
		25a	04-09-2008	**16:42**				Stop drilling
INSDD11	7	25a	04-09-2008	19:07	53°49.395'	13°11.282'	333.0	Start recovery
INSDD11	8	25a	04-09-2008	19:53	53°49.395'	13°11.283'	333.5	On deck

*A1, 25a: ISPSG drill sites; nPB, MM: CARBONATE drill sites; SDB: South Donegal Bay; IM: Inishmore Island; GB: Galway Bay; WD: water depth

Excluding failed deployments, MeBo was operated for 60.5 hours. About 14% of the operation time was used for core drilling, whereas 50% was spent for pipe handling. However, drilling through hard rock takes much longer as drilling/pushing through soft sediments, as during this cruise it was mostly drilled trough muddy to sandy overburden the percentages of effort for the different tasks during drill operation are misleading (Table 4.2).

Table 4.2: Overview on time (hrs:min) of different tasks during (successful) MeBo deployments.

Station-No.	Area	Water Depth	Launch & Levelling	Pipe Handling	Net Drilling Time	Borehole Dismounting	Recovery	Total
INSDD7-IM1	test drill site Inishmore Island Galway Bay	~33m	01:59	07:17	03:44 penetration depth: 505cm	04:00	00:50	17:50
INSDD8-IM2	test drill site Inishmore Island Galway Bay	~28m	01:26	02:11	02:55 penetration depth: 505cm	01:55 loss of outer drill barrel due to ship's dp failure	00:35	09:02
INSDD10-MM	CARBONATE site Magellan Mounds Porcupine Seabight	~641m	01:35	14:20	00:50 penetration depth: 3560cm	03:51	01:25	22:01
INSDD11-25a	ISPSG site 25a Porcupine Bank	~333m	02:00	06:14	01:11 penetration depth: 555cm	01:25 core barrel problems	00:46	11:36
		Σ (hrs:min)	07:00	30:02	08:40	11:11	03:36	60:29
		Σ (%)	11.57	50.48	14.33	18.49	5.59	100.00

4.2 Shipek Sediment Sampler and Day Grab

For ground truthing purposes, two different kinds of sediment samplers were applied: a Shipek sediment sampler and a Day grab (Figure 4.3). In total, nine grab samples were collected (two with Day Grab, seven with Shipek Sediment Sampler) at five different sites (Table 4.3) during RV Celtic Explorer cruise CE0810.

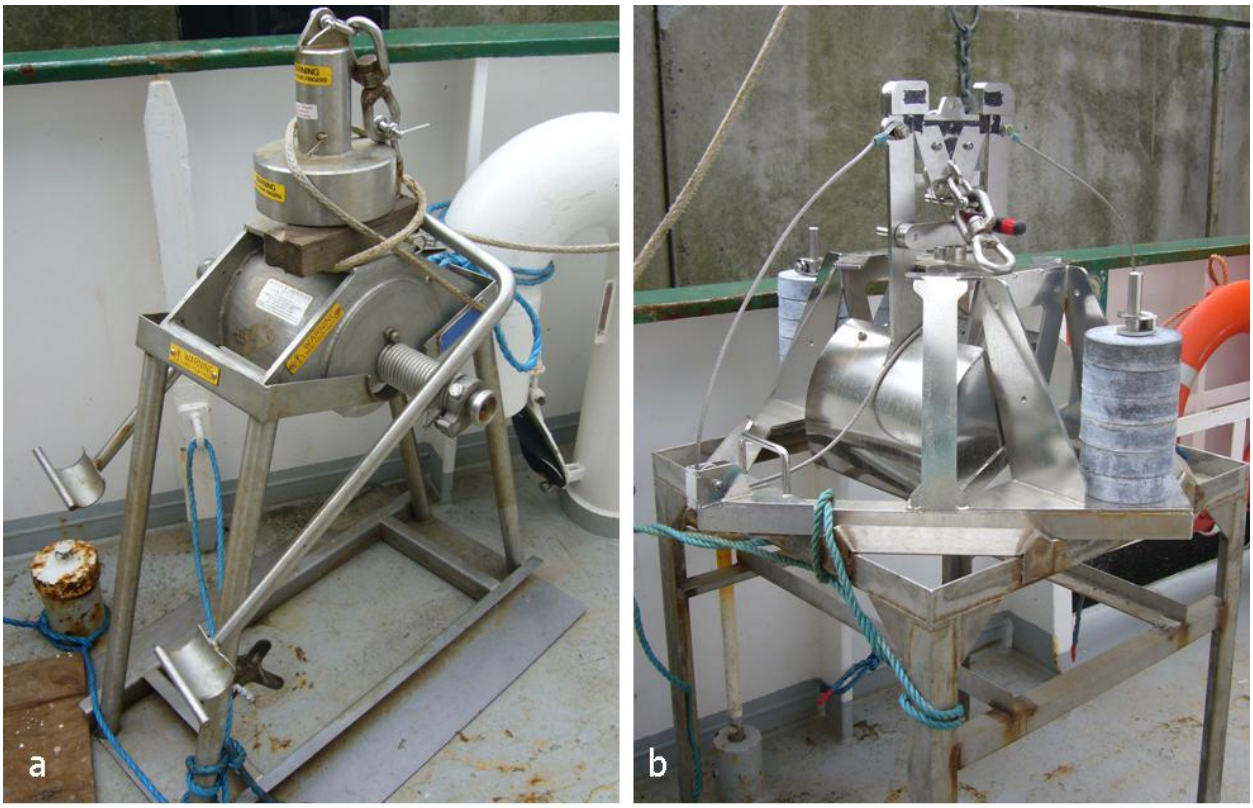


Figure 4.3: (a) Shipek sediment sampler, (b) Day grab.

Table 4.3: Metadata of grab samples collected on RV Celtic Explorer cruise CE0810 (data are related to time of bottom contact).

Station-No.		Site*	Operator	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Description
Day Grab									
INSDD1	5	A1	Wienberg	16-08-2008	08:37	53°22.037'	13°23.168'	174.3	stone
INSDD1	6	A1	Wienberg	16-08-2008	08:52	53°22.039'	13°23.168'	172.6	medium sand with gravel
Shipek grab sampler									
INSDD1	7	A1	Wienberg	16-08-2008	09:12	53°22.038'	13°23.170'	173.0	medium sand
INSDD1	8	A1	Wienberg	16-08-2008	09:25	53°22.038'	13°23.167'	172.6	sand, few stones
INSDD4	1	SDB3	Dorschel	23-08-2008	05:05	54°20.039'	09°44.304'	42.3	sorted fine gravel
INSDD4	2	SDB3	Dorschel	23-08-2008	05:12	54°20.869'	09°44.313'	42.5	sorted fine gravel
INSDD5	1	SDB2	Dorschel	23-08-2008	05:56	54°21.436'	09°46.798'	42.7	released but empty
INSDD6	1	SDB2	Dorschel	23-08-2008	06:24	54°21.159'	09°49.241'	48.8	sorted gravel (<5cm well-rounded clasts)
INSDD7	1	IM1	Dorschel	24-08-2008	13:56	53°08.962'	08°962'	32.4	shell hash, some mud, sand and gravel

*A1: ISPSG site; SDB: South Donegal Bay; IM: Inishmore Island, Galway Bay; WD: water depth

4.3 EM 1002 Multibeam Echosounder

The Kongsberg EM 1002 multibeam echosounder installed on board the RV Celtic Explorer has a 95 kHz nominal frequency and a 2x2 degree beam opening angle. It uses 111 beams with a maximum coverage sector of 160°. The transducer head is mounted in a drop keel which is placed at the centre of the vessel. The motion of the vessel is registered by a Kongsberg MRU-5 motion reference unit. Ship's position and heading is determined with two GPS antennas. The motion and position information is combined in a Seapath 200 ship's attitude processing unit and send to the transceiver unit (TRU). The system is synchronized by means of a 1 pulse per second (1 PPS) signal produced by the Seapath 200 which is also sent to the TRU. The received signal and the ship's attitude are sent through an ethernet connection to the acquisition computer (SUN Microsystems Sunblade 150). Data acquisition is done using the Kongsberg SIS (Seafloor Information System, UNIX version) software. The near-transducer sound velocity is measured with a sensor. On board the data was processed using the SIS data processing and imaging options. There were no technical issues with the EM 1002. See Table 4.4 for survey protocol.

Table 4.4: EM1002 Multibeam echosounder lines surveyed on RV Celtic Explorer cruise CE0810.

Station-No.		Site	Operator	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Comment
INSDD1	1A	A1	de Haas	16-08-2008	07:15	53°22.076'	13°19.750'	185.2	Start of line (W-E)
INSDD1	2A	A1	de Haas	16-08-2008	07:39	53°22.004'	13°24.210'	175.1	End of line
INSDD1	3A	A1	de Haas	16-08-2008	07:48	53°21.462'	13°23.009'	178.3	Start of line (S-N)
INSDD1	4A	A1	de Haas	16-08-2008	08:17	53°22.157'	13°22.990'	172.6	End of line
INSDD9	2	nPB	de Haas	27-08-2008	15:05	53°58.480'	13°14.620'	817.3	Start of line
INSDD9	3	nPB	de Haas	27-08-2008	15:12	53°58.800'	13°14.420'	850.0	End of line
INSDD10	1	MM	de Haas	30-08-3008	08:45	52°20.966'	12°37.170'	639.3	Start of line
INSDD10	2	MM	de Haas	30-08-2008	09:00	52°19.305'	12°42.360'	639.3	End of line
INSDD11	1	25a	de Haas	04-09-2008	05:04	53°49.066'	13°09.248'	-	Start of line
INSDD11	3	25a	de Haas	04-09-2008	05:24	53°49.500'	13°12.250'	-	End of line

*A1, 25a: ISPSG drill sites; nPB, MM: CARBONATE drill sites; WD: water depth

4.4 3.5kHz Sub-Bottom Profiler

Sub-seabed sediment profiles were made using a Coda DA200 profiler. The transducers are installed in the drop keel of the vessel. In order to allow sufficient penetration the system was operated at its lowest frequency (3.5 kHz) and maximum power output. Ship's motion is registered by a Kongsberg MRU-5 sensor, and sent to the Seapath 200 attitude processing unit. Ship's position is determined with two GPS antennas. The motion and position information is combined in a Seapath 200 ship's attitude processing unit and send to the recording PC. During recording (in SEGY format) heave compensation, time-varying filtering and time-varying gain were applied. In spite of the maximum power output and applied processing routines it was not possible to observe any sub-seabed structures in the non-mound areas due to the strong backscatter of the energy at the coarse sandy seabed. There were no technical issues with the EM 1002. Only at ISPSG site A1, sub-bottom profiler surveys were conducted as kind of pre-drill investigation. See Table 4.5 for survey protocol.

Table 4.5: 3.5kHz sub-bottom profiler lines surveyed on RV Celtic Explorer cruise CE0810.

Station-No.		Site	Operator	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Comment
INSDD1	1B	A1	de Haas	16-08-2008	07:15	53°22.076'	13°19.750'	185.2	Start of line (W-E)
INSDD1	2B	A1	de Haas	16-08-2008	07:39	53°22.004'	13°24.210'	175.1	End of line
INSDD1	3B	A1	de Haas	16-08-2008	07:48	53°21.462'	13°23.009'	178.3	Start of line (S-N)
INSDD1	4B	A1	de Haas	16-08-2008	08:17	53°22.157'	13°22.990'	172.6	End of line
INSDD11	2	25a	de Haas	04-09-2008	05:04	53°49.066'	13°09.248'	-	Start of line
INSDD11	4	25a	de Haas	04-09-2008	05:24	53°49.500'	13°12.250'	-	End of line

*A1, 25a: ISPSG drill sites; WD: water depth

4.5 CTD and Water Sampling

A Sea Bird Electronics SBE 911plus CTD with a rosette sampler consisting of 24 Noex bottles of 10 litre capacity (Figure 4.4) was used to measure variations in salinity, temperature and dissolved oxygen in the water column as well as to take water samples. The CTD was equipped with the following sensors: a SBE3plus temperature sensor, a SBE4plus conductivity sensor, a Digiquartz Pressure sensor, a SBE 43 dissolved oxygen sensor. The sampling rate was 24 Hz and the CTD data was acquired using the SeaSoft Win32 software version 5.28c. There were no technical issues with the CTD. Sub-samples from the water samples were taken at selective depths.

The CTD was solely deployed at CARBONATE drill sites nPB and MM. In total, three casts were conducted comprising two CTD casts accompanied by water sampling and one "yo-yo" CTD station (Table 4.6).

Figure 4.4: SBE 911plus CTD on board RV Celtic Explorer.

Table 4.6: Metadata of CTD casts collected on RV Celtic Explorer cruise CE0810 (data are related to time of bottom contact).

Station-No.		Site	Operator	Date [ddmmyy]	Time [UTC]	Longitude [N]	Latitude [W]	WD* [m]	Comment
INSDD9	1	nPB	Dorschel	27-08-2008	13:50	53°58.678'	13°15.055'	800.0	6 water samples
INSDD9	11	nPB	Joseph	28-08-2008	12:48	53°58.694'	13°15.041'	797.7	830m cable out; yo-yo
INSDD9	12	nPB	Joseph	28-08-2008	14:09	53°58.693'	13°15.045'	799.0	830m cable out; yo-yo
INSDD9	13	nPB	Joseph	28-08-2008	14:56	53°58.689'	13°15.040'	796.0	830m cable out; yo-yo
INSDD9	14	nPB	Joseph	28-08-2008	15:42	53°58.697'	13°15.045'	796.0	830m cable out; yo-yo
INSDD10	3	MM	Dorschel	30-08-2008	09:53	52°19.659'	12°41.403'	639.3	670m cable out 6 water samples

*nPB, MM: CARBONATE drill sites; WD: water depth

5 Results

5.1 Shallow-Water Test Drill Sites

A first attempt to do a shallow-water test drill was conducted in south Donegal Bay (SDB). For ground truthing purposes grab sampling by a Shipek sediment sampler were conducted revealing sorted fine gravel to coarse well-rounded gravel (Figure 5.1). However, MeBo could not be deployed due to adverse weather conditions (see Chapter 3).

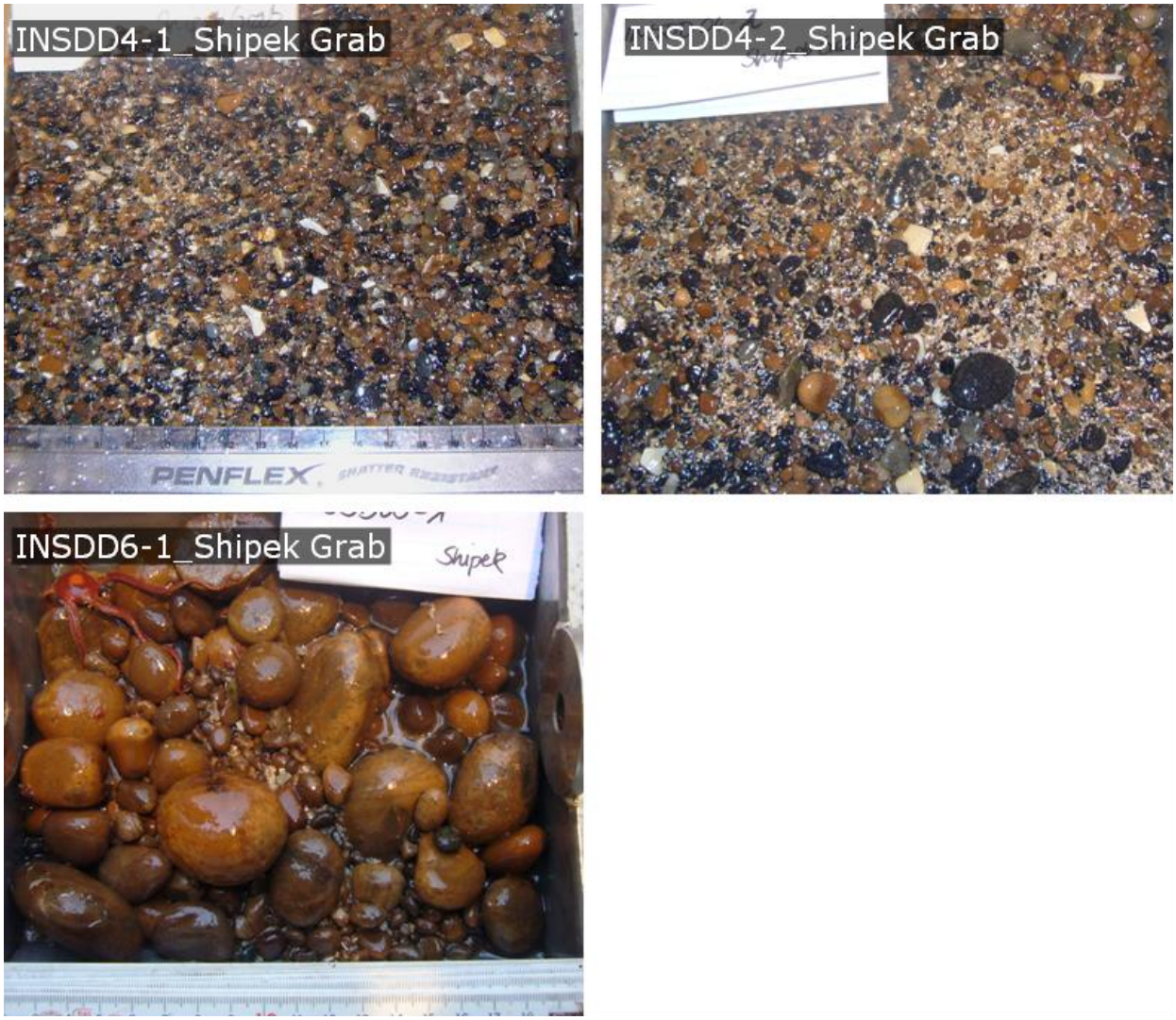


Fig. 5.1: Grab samples collected at potential test drill sites for ground truthing purposes. Samples INSDD4-1, INSDD4-2 and INSDD6-1 were collected in south Donegal Bay (SDB; site not drilled).

Two further attempts for a shallow-water test drill were conducted in Galway Bay close to Inishmore Island (IM; 28-32 m water depth). Prior to drilling, one grab samples was collected revealing shell hash admixed with sand and fine gravel (Figure 5.2). Both drills in Galway Bay had to be aborted due to (1) problems with the pipe handling and (2) a failure of the dynamic positioning system of the RV Celtic Explorer (see Chapter 3; Tables 5.1 and 5.2). However, the recovery of both drills showed soft sediments overlying Carboniferous? limestone (Figure 5.3).

Fig. 5.2: Grab sample INSDD7-1 was collected east of Inishmore Island (IM), where two test drills were conducted.

Table 5.1: Drill protocol of station INSDD7-IM1 / GeoB 13407 on RV Celtic Explorer cruise CE0810. 1st shallow-water test drill east of Inishmore Island, Galway Bay.

Core-No.	Drill Bit	Slot	Drill Start [UTC]	Drill End [UTC]	Duration [hrs:min]	Top [mbsf]	Bottom [mbsf]	Recovery [cm]	Comment
1R	Surface Set	10i	24-08-2008 18:29	24-08-2008 18:38	00:09	0.00	2.70	L: 21 CC: 9	Soft sediments
2R		10a	24-08-2008 19:48	24-08-2008 21:08	01:20	2.70	5.05	L: 0 CC: 6-8	Limestone in CC
-		-	25-08-2008 03:15	25-08-2008 05:30	02:15	5.05	./.	./.	Problems with pipe connection; no inner core barrel

*L: Core Liner, CC: Core Catcher, mbsf: meter below seafloor

Table 5.2: Drill protocol of station INSDD8-IM2 / GeoB 13408 on RV Celtic Explorer cruise CE0810. 2nd shallow-water test drill east of Inishmore Island, Galway Bay.

Core-No.	Drill Bit	Slot	Drill Start [UTC]	Drill End [UTC]	Duration [hrs:min]	Top [mbsf]	Bottom [mbsf]	Recovery [cm]	Comment
1R	Surface Set	3i	25-08-2008 21:54	25-08-2008 22:16	00:22	0.00	2.70	L: 31 CC: 9	Soft sediments
2R		3a	25-08-2008 22:51	24-08-2008 23:48	00:57	2.70	5.05	L:87 CC: 9	Soft sediments 2cm limestone in CC
-		-	25-08-2008 01:24	25-08-2008 03:00	01:36	5.05	./.	./.	Abort of drilling; dp failure

*L: Core Liner, CC: Core Catcher, mbsf: meter below seafloor

Figure 5.3: Limestone drilled during shallow-water test drill in Galway Bay, Inishmore Island, station INSDD7-IM1.

5.2 ISPSG Drill Sites

A1 – Porcupine Bank

For ground truthing purposes four grab samples (INSDD1-5 to -8) were collected at ISPSG site A1. The samples revealed medium sand admixed with gravel (Figure 5.4), which is in line with the predicted lithology for the overburden at this site.

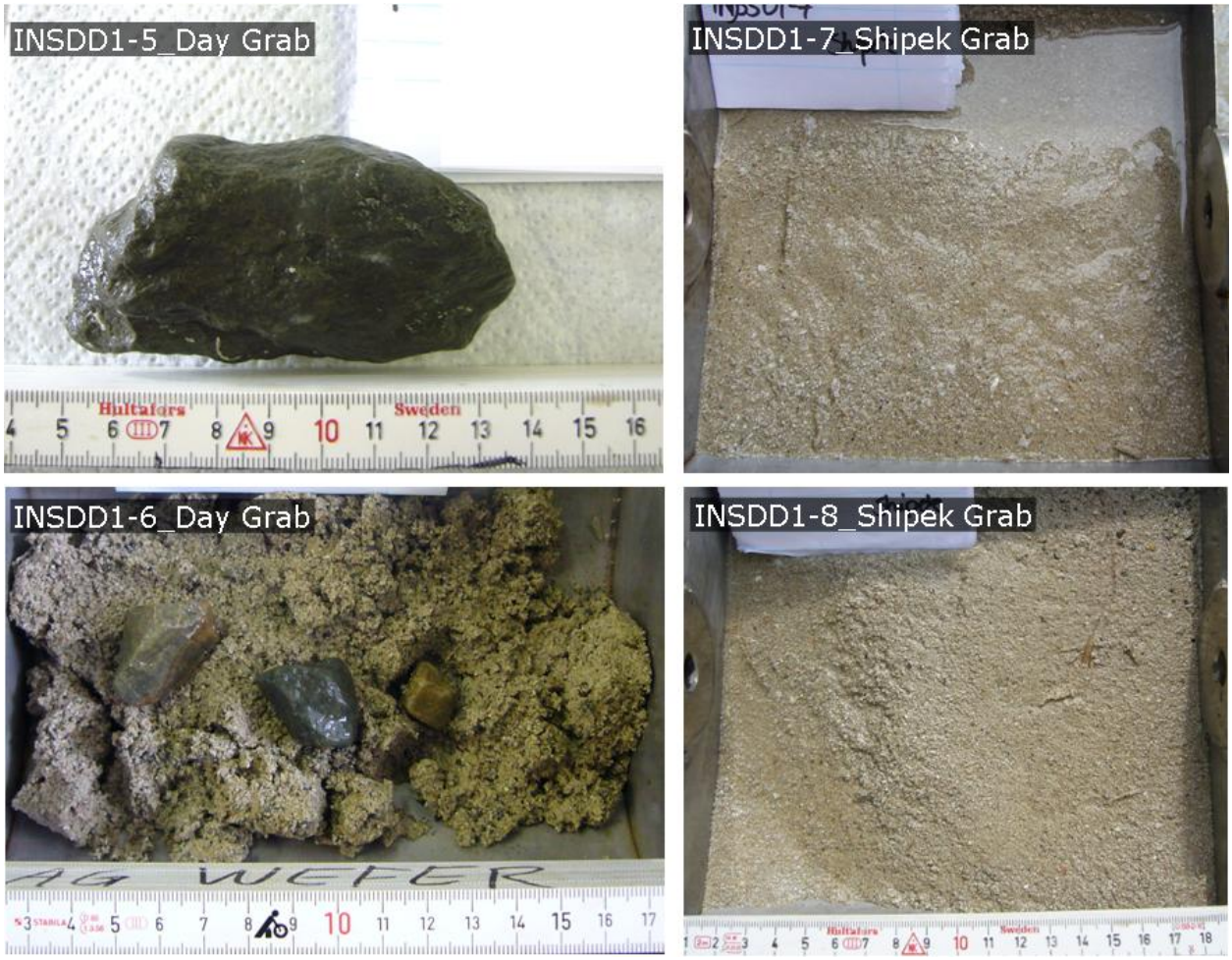


Fig. 5.4: Grab samples collected at ISPSG drill site A1 for ground truthing purposes.

Drilling at ISPSG site A1 failed as problems with the hydraulic system occurred directly after MeBo was successfully landed on the seafloor, thus the drilling operation had to be aborted. As the weather conditions also changed for the worse, no further drill attempt could be conducted at this site.

25a – northern Porcupine Bank

For ground truthing purposes, surveys with the multibeam echosounder and the sub-bottom profiler were conducted (INSDD11-1 to INSDD11-4) at ISPSG site 25a, which confirmed that the proposed site is, as expected, characterised by a flat seabed. A photograph taken shortly after the landing of MeBo showed that the seabed surface is made up of sandy sediments (Figure 5.5).

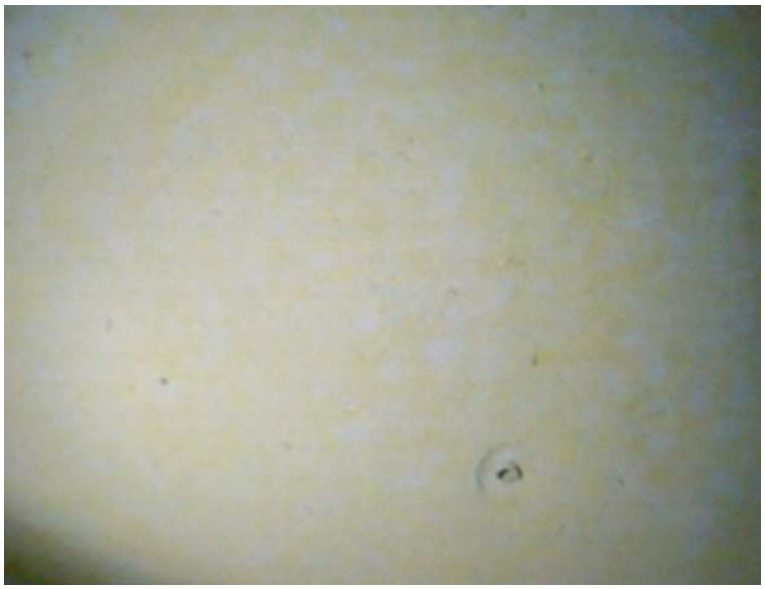


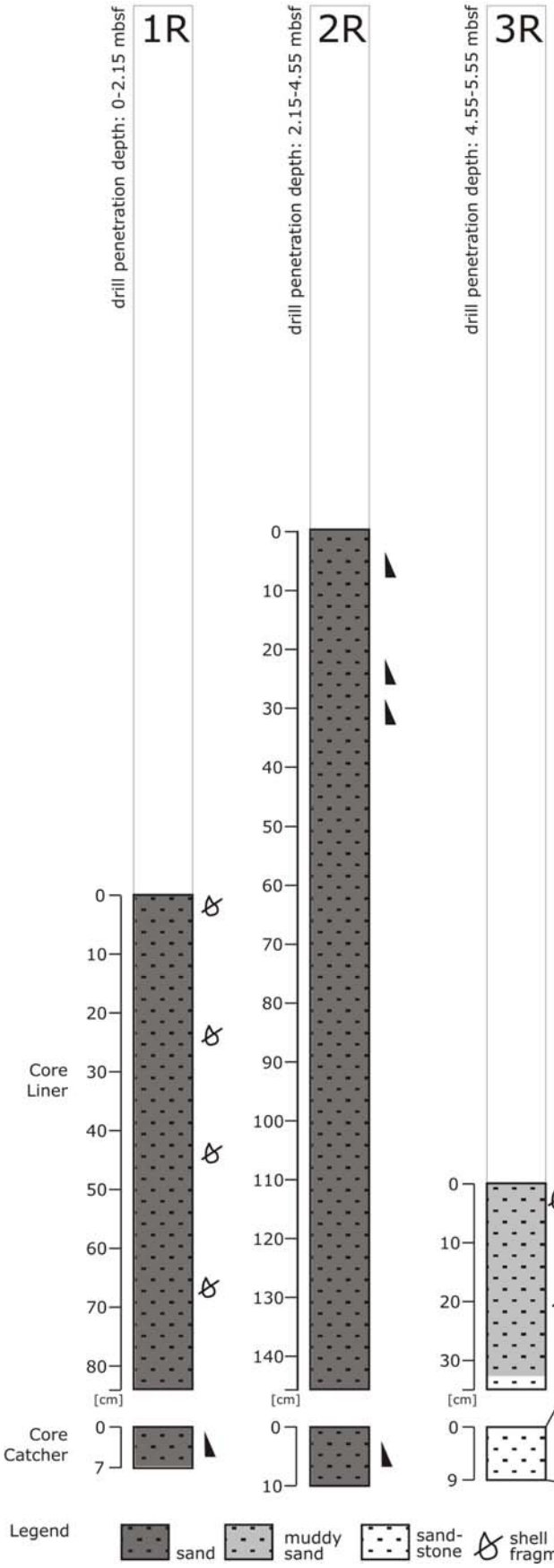
Figure 5.5: Photograph taken shortly after the landing of MeBo at ISPSG drill site 25a. The seabed surface is most probably made up of sandy sediments; note the burrow in the lower right corner, which most probably originated from a polychaet or a small crustacean.

Table 5.3: Drill protocol of station INSDD11-25a / GeoB 13411 on RV Celtic Explorer cruise CE0810. ISPSG drill site 25a, northern Porcupine Bank.

Core-No.	Drill Bit	Slot	Drill Start [UTC]	Drill End [UTC]	Duration [hrs:min]	Top [mbsf]	Bottom [mbsf]	Recovery [cm]	Comment
1P&R	Surface Set	1i	04-09-2008 09:17	04-09-2008 09:22	00:05	0.00	2.15	L: 84 CC: 7	Fine sand (sorted) with foraminifers, shells, quartz and volcanic glass
2R		1a	04-09-2008 10:34	04-09-2008 11:45	01:11	2.15	4.55	L: 146 CC: 10	Fine sand (sorted) with quartz, volcanic glass, few foraminifers and shells, dropstones
3R		2i	04-09-2008 13:28	04-09-2008 16:42	03:14	4.55	5.55	L: 31 CC: 9	Very coarse sand with quartz and volcanic glass. 2cm of liner + CC: Calcareous sand-stone with shell and grit, weathered.

*L: Core Liner, CC: Core Catcher, mbsf: meter below seafloor

In total, 291 cm of core material were recovered (including 26 cm core recovery of the core catchers) from ISPSG drill site 25a, and the seabed was penetrated down to a depth of 5.55 m below seafloor (Table 5.3), which results in a recovery rate of 51.71%. The upper 247 cm core material comprising cores R1+CC and R2+CC revealed sorted fine sand; in the upper 70 cm mainly composed of benthic and planktonic foraminifers and a minor content of quartz, volcanic glass and shell fragments, whereas this composition changes downcore to a dominance of quartz and volcanic glass (Figure 5.6). An obvious colour change from grey to light grey is remarkable in core 1R at 70cm core depth accompanied by the occurrence of dropstones, which might be attributed to a change from Pleistocene to Holocene deposits. Core 3R+CC revealed very coarse sand composed of quartz and volcanic glass overlying an 11 cm thick weathered calcareous sandstone with shell and grit.



Core description

1R
0-84cm: Greyish sorted fine sand mainly composed of benthic and planktonic foraminifers. Quartz, volcanic glass and shell fragments (e.g. echinoid spines, sponge spiculae, bivalves, gastropods) are minor constituents.

70cm: Colour change from grey to light grey (transition zone from Holocene to Pleistocene deposits?).

1R CC
0-7cm: Fine sand mainly composed of quartz and volcanic glass. Very few foraminifers and shell fragments. Some small-sized dropstones.
(Note: Sand of the core catcher was completely dried by the heat of the drill bit!)

2R
0-146cm: Fine sand composed of mainly quartz and volcanic glass. Dropstones.

4-9cm: Dropstone made up of calcareous material.

22-36cm: Very large blackish dropstone, probably basalt.

118cm: Colour change from light grey to olive grey.

2R CC
0-10cm: Fine sand composed of quartz and volcanic glass. Few small-sized dropstones.
(Note: Sand of the core catcher was completely dried by the heat of the drill bit!)

3R
0-33cm: Muddy very coarse sand composed of quartz, volcanic glass (e.g. olivine), shell fragments (e.g. echinoid spines, bivlaves, bryozoans) and foraminifers in decreasing content.
33-35cm: Weathered calcareous sandstone.

3R CC
0-9cm: Calcareous sandstone with shell and grit, weathered.

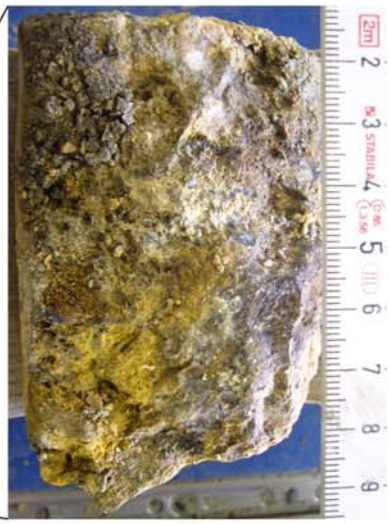


Figure 5.6: Core description for core INSDD11-25a / GeoB 13411 collected from ISPSG drill site 25a, Porcupine Bank.

5.3 CARBONATE Drill Sites

nPB - Northern Porcupine Bank

In total, four attempts were made to start drilling at CARBONATE site nPB. But all attempts failed as the site was too steep – most probably due to the rather irregular shape of the top of the carbonate mound which is covered by cold-water coral rubble and dead coral framework (Figure 5.7) causing a tilted position of MeBo on the seafloor, which made any drilling impossible. Moreover, during the last attempt to land MeBo, one of its legs was seriously damaged, stopping any further drilling at this site (see Chapter 3).

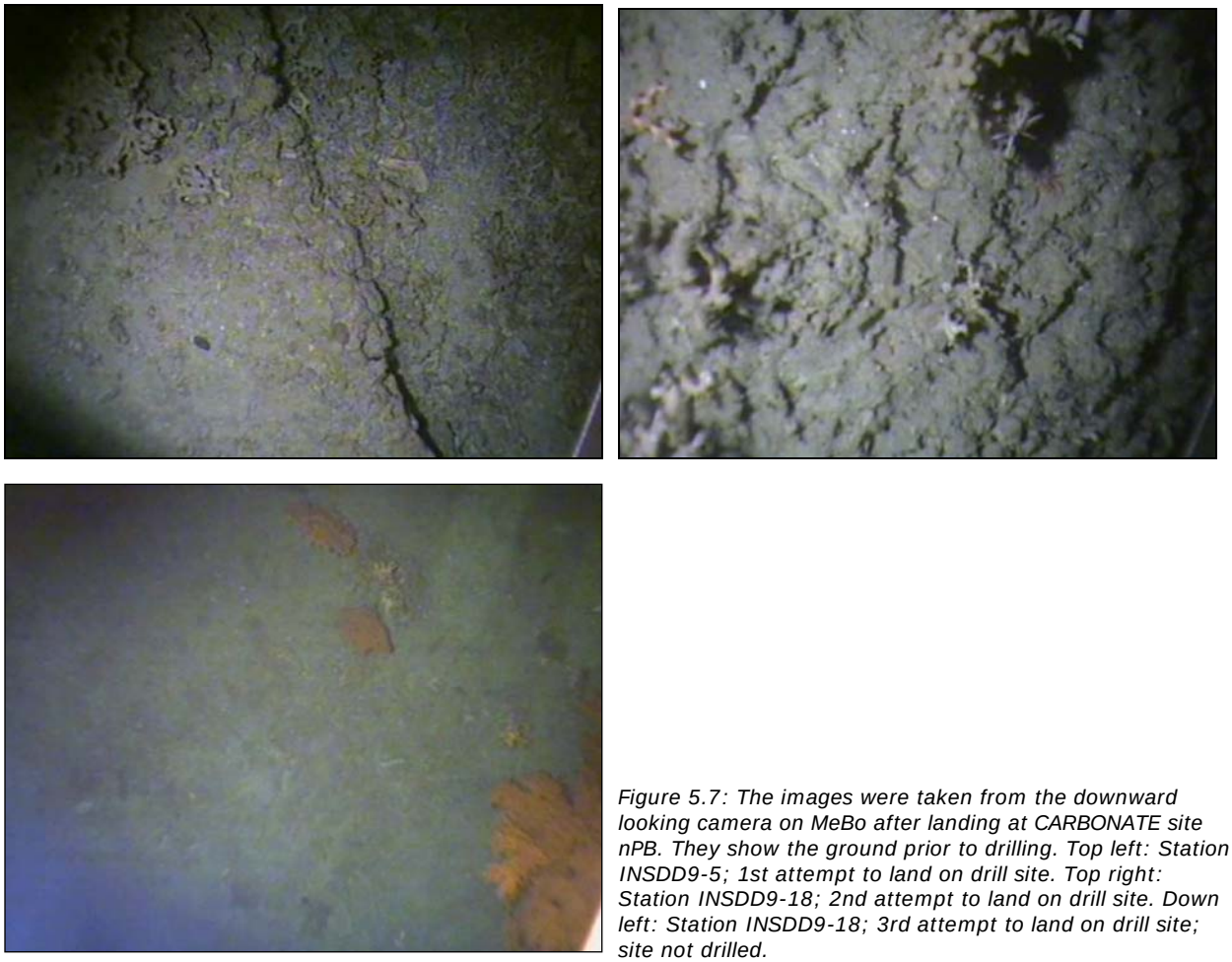


Figure 5.7: The images were taken from the downward looking camera on MeBo after landing at CARBONATE site nPB. They show the ground prior to drilling. Top left: Station INSDD9-5; 1st attempt to land on drill site. Top right: Station INSDD9-18; 2nd attempt to land on drill site. Down left: Station INSDD9-18; 3rd attempt to land on drill site; site not drilled.

MM - Magellan Mounds

The first attempt of drilling CARBONATE site MM failed. During the 2nd attempt, 118 cm of core material were recovered (including 70 cm core recovery of the core catchers), and the seabed was penetrated down to a depth of 35.6 m below seafloor (Table 5.4), which results in a poor recovery rate of only 3.31%. Unfortunately, no sediments containing cold-water corals could be drilled, the entire material consisted of hemipelagic mud.

Table 5.4: Drill protocol of station: INSDD10-MM / GeoB 13410 on RV Celtic Explorer cruise CE0810. CARBONATE drill site Magellan Mounds, Porcupine Seabight.

Core-No.	Drill Bit	Slot	Drill Start [UTC]	Drill End [UTC]	Duration [hrs:min]	Top [mbsf]	Bottom [mbsf]	Recovery [cm]	Comment
1P&R	Surface Set	1i	30-08-2008 21:53	30-08-2008 21:58	00:05	0.00	14.45	L: 0 CC: 4	Hemipelagic mud
2R		1a	30-08-2008 23:25	30-08-2008 23:30	00:05	14.45	16.80	L: 18 CC: 3	Hemipelagic mud
3R		2i	31-08-2008 00:11	31-08-2008 00:14	00:03	16.80	19.15	L: 0 CC: 9	Hemipelagic mud
4R		2a	31-08-2008 01:18	31-08-2008 01:22	00:04	19.15	21.50	L: 6 CC: 9	Hemipelagic mud
5R		3i	31-08-2008 02:52	31-08-2008 02:53	00:01	21.50	23.85	L: 0 CC: 9	Hemipelagic mud
6R		3a	31-08-2008 03:48	31-08-2008 03:51	00:03	23.85	26.20	L: 14 CC: 9	Hemipelagic mud
7R		4i	31-08-2008 05:22	31-08-2008 05:27	00:05	26.20	28.55	L: 0 CC: 9	Hemipelagic mud
8R		4a	31-08-2008 07:04	31-08-2008 07:08	00:04	28.55	30.90	L: 0 CC: 9	Hemipelagic mud
9R		5i	31-08-2008 08:17	31-08-2008 08:23	00:06	30.90	33.25	L: 8 CC: 9	Hemipelagic mud
10R		5a	31-08-2008 09:39	31-08-2008 09:46	00:07	33.25	35.60	L:2 CC: 9	Hemipelagic mud

*L: Core Liner, CC: Core Catcher, mbdsf: meter below seafloor

6 Acknowledgement

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7 Station list – RV Celtic Explorer cruise CE0810 – INS DeepDrill

Station		Site	Equipment	Operator	Date	Time	Latitude		Longitude		Water depth	Comment
Number					ddmmyy	UTC	Deg	Min	Deg	Min	m	
INSDD1	1A	A1	EM1002	de Haas	16.08.08	07:15	53	22.076	-13	19.750	185.2	SOL W-E
INSDD1	1B	A1	3.5kHz	de Haas	16.08.08	07:15	53	22.076	-13	19.750	185.2	SOL W-E
INSDD1	2A	A1	EM1002	de Haas	16.08.08	07:39	53	22.004	-13	24.210	175.1	EOL W-E
INSDD1	2B	A1	3.5kHz	de Haas	16.08.08	07:39	53	22.004	-13	24.210	175.1	EOL W-E
INSDD1	3A	A1	EM1002	de Haas	16.08.08	07:48	53	21.462	-13	23.009	178.3	SOL S-N
INSDD1	3B	A1	3.5kHz	de Haas	16.08.08	07:48	53	21.462	-13	23.009	178.3	SOL S-N
INSDD1	4A	A1	EM1002	de Haas	16.08.08	08:17	53	22.157	-13	22.990	172.6	EOL S-N
INSDD1	4B	A1	3.5kHz	de Haas	16.08.08	08:17	53	22.157	-13	22.990	172.6	EOL S-N
INSDD1	5	A1	Day Grab	Wienberg	16.08.08	08.37	53	22.037	-13	23.168	174.3	Stone
INSDD1	6	A1	Day Grab	Wienberg	16.08.08	08:52	53	22.039	-13	23.168	172.6	Medium sand with gravel
INSDD1	7	A1	Shipek	Wienberg	16.08.08	09:12	53	22.038	-13	23.170	173.0	Medium sand
INSDD1	8	A1	Shipek	Wienberg	16.08.08	09:25	53	22.039	-13	23.167	172.6	Sand, few stones
INSDD1	9	A1	MeBo	Freudenthal	16.08.08	10:31	53	22.049	-13	23.169	174.9	In water
INSDD1	10	A1	MeBo	Freudenthal	16.08.08	12:00	53	22.042	-13	23.173	172.1	On bottom
INSDD1	11	A1	MeBo	Freudenthal	16.08.08	12:15	53	22.042	-13	23.173	173.0	MeBo failure, recovery
INSDD1	12	A1	MeBo	Freudenthal	16.08.08	13:20	53	22.038	-13	23.171	172.5	On-deck
INSDD2	1	GB1	MeBo	Freudenthal	18.08.08	19:15	53	12.306	-09	29.599	31.7	MeBo deployment starts
INSDD2	2	GB1	MeBo	Freudenthal	18.08.08	19:25	53	12.321	-09	29.579	31.6	Abort deployment - Fault
INSDD2	3	GB1	MeBo	Freudenthal	18.08.08	19:40	53	12.319	-09	29.573	30.8	MeBo on deck

Station Number		Site	Equipment	Operator	Date ddmmyy	Time UTC	Latitude Deg	Latitude Min	Longitude Deg	Longitude Min	Water depth m	Comment
INSDD3	1	GB1	MeBo	Freudenthal	19.08.08	15:20	53	12.311	-09	29.574	29.3	MeBo deployment starts
INSDD3	2	GB1	MeBo	Freudenthal	19.08.08	16:55	53	12.312	-09	29.571	30.6	MeBo on deck Deployment aborted MeBo failure
INSDD4	1	SDB3	Shipek	Dorschel	23.08.08	05:05	54	20.865	-09	44.304	42.3	Sorted fine gravel
INSDD4	2	SDB3	Shipek	Dorschel	23.08.08	05:12	54	20.869	-09	44.313	42.5	Sorted fine gravel
INSDD5	1	SDB2	Shipek	Dorschel	23.08.08	05:56	54	21.436	-09	46.798	42.7	Empty - assumed stone or rock
INSDD6	1	SDB2	Shipek	Dorschel	23.08.08	05:24	54	21.159	-09	49.241	48.8	Sorted gravel (<5cm well-rounded clasts)
INSDD7	1	IM1	Shipek	Dorschel	24.08.08	13:56	53	08.962	-09	38.942	32.4	Shell hash (some sand, mud and gravel)
INSDD7	2	IM1	MeBo	Freudenthal	24.08.08	16:30	53	08.965	-09	38.943	32.6	MeBo in water
INSDD7 GeoB 13407	3	IM1	MeBo	Freudenthal	24.08.08	17:03	53	08.965	-09	38.943	31.8	MeBo on bottom and start drilling
INSDD7	4	IM1	MeBo	Freudenthal	25.08.08	09:30	53	08.968	-09	38.995	34.5	MeBo coming in (technical problem)
INSDD7	5	IM1	MeBo	Freudenthal	25.08.08	10:20	53	08.967	-09	38.956	34.7	MeBo on deck
INSDD8	1	IM2	MeBo	Freudenthal	25.08.08	20:28	53	08.944	-09	38.986	28.8	MeBo in water
INSDD8 GeoB 13408	2	IM2	MeBo	Freudenthal	25.08.08	20:56	53	08.944	-09	38.987	28.4	MeBo on bottom and start drilling
INSDD8	3	IM2	MeBo	Freudenthal	26.08.08	04:55	53	08.935	-09	38.983	27.6	DP failure MeBo coming in
INSDD8	4	IM2	MeBo	Freudenthal	26.08.08	05:30	53	08.934	-09	38.985	26.3	MeBo on deck
INSDD9	1	nPB	CTD	Dorschel	27.08.08	13:50	53	58.678	-13	15.055	800.0	CTD and 6 water samples
INSDD9	2	nPB	EM1002	de Haas	27.08.08	15:05	53	58.480	-13	14.620	817.3	SOL
INSDD9	3	nPB	EM1002	de Haas	27.08.08	15:12	53	58.800	-13	14.420	850.0	EOL
INSDD9	4	nPB	MeBo	Freudenthal	27.08.08	16:32	53	58.677	-13	15.006	797.0	MeBo in water
INSDD9	5	nPB	MeBo	Freudenthal	27.08.08	18:33	53	58.669	-13	15.035	811.0	MeBo on bottom

Station		Site	Equipment	Operator	Date	Time	Latitude		Longitude		Water depth	Comment
Number					ddmmyy	UTC	Deg	Min	Deg	Min	m	
INSDD9	6	nPB	MeBo	Freudenthal	27.08.08	18:46	53	58.668	-13	15.357	810.0	MeBo coming up (fault compensation fluid)
INSDD9	7	nPB	MeBo	Freudenthal	27.08.08	20:18	53	58.661	-13	15.046	818.0	MeBo on deck
INSDD9	8	nPB	MeBo	Freudenthal	28.08.08	09:43	53	58.691	-13	15.040	820.0	MeBo in water
INSDD9	9	nPB	MeBo	Freudenthal	28.08.08	11:20	53	58.689	-13	15.039	794.2	MeBo coming up (fault compensation fluid)
INSDD9	10	nPB	MeBo	Freudenthal	28.08.08	12:29	53	58.688	-13	15.036	794.9	MeBo on deck
INSDD9	11	nPB	CTD	Joseph	28.08.08	12:48	53	58.694	-13	15.041	797.7	830m cable out
INSDD9	12	nPB	CTD	Joseph	28.08.08	14:09	53	58.693	-13	15.045	799.0	830m cable out
INSDD9	13	nPB	CTD	Joseph	28.08.08	14:56	53	58.689	-13	15.040	796.0	830m cable out
INSDD9	14	nPB	CTD	Joseph	28.08.08	15:42	53	58.697	-13	15.045	796.0	830m cable out
INSDD9	15	nPB	MeBo	Freudenthal	28.08.08	16:45	53	58.696	-13	15.044	795.5	MeBo in water
INSDD9	16	nPB	MeBo	Freudenthal	28.08.08	17:15	53	58.695	-13	15.040	792.1	MeBo on deck (aborted)
INSDD9	17	nPB	MeBo	Freudenthal	28.08.08	19:06	53	58.685	-13	15.040	792.9	MeBo in water
INSDD9	18	nPB	MeBo	Freudenthal	28.08.08	21:00	53	58.684	-13	15.040	792.0	MeBo on bottom
INSDD9	19	nPB	MeBo	Freudenthal	28.08.08	21:56	53	58.673	-13	15.040	790.9	MeBo failure, recovery
INSDD9	20	nPB	MeBo	Freudenthal	28.08.08	23:45	53	58.671	-13	15.040	790.9	MeBo on deck
INSDD10	1	MM	EM1002	de Haas	30.08.08	08:45	52	20.966	-12	37.170	639.3	SOL
INSDD10	2	MM	EM1002	de Haas	30.08.08	09:00	52	19.305	-12	42.360	639.3	EOL
INSDD10	3	MM	CTD	Dorschel	30.08.08	09:53	52	19.659	-12	41.403	639.3	670m cable out
INSDD10	4	MM	MeBo	Freudenthal	30.08.08	11:34	52	19.660	-12	41.405	639.7	MeBo in water
INSDD10	5	MM	MeBo	Freudenthal	30.08.08	13:06	52	19.658	-12	41.410	640.1	MeBo on bottom

Station		Site	Equipment	Operator	Date	Time	Latitude		Longitude		Water depth	Comment
Number					ddmmyy	UTC	Deg	Min	Deg	Min	m	
INSDD10	6	MM	MeBo	Freudenthal	30.08.08	14:55	52	19.653	-12	41.420	-	Abort deployment - Fault drill head
INSDD10	7	MM	MeBo	Freudenthal	30.08.08	16:10	52	19.653	-12	41.420	642.8	MeBo on deck
INSDD10	8	MM	MeBo	Freudenthal	30.08.08	18:49	52	19.645	-12	41.425	641.5	MeBo in water
INSDD10 GeoB13410	9	MM	MeBo	Freudenthal	30.08.08	19:56	52	19.639	-12	41.399	642.3	MeBo on seabed (GAPS position)
INSDD10	10	MM	MeBo	Freudenthal	31.08.08	13:05	52	19.626	-12	41.413	641.1	MeBo off bottom
INSDD10	11	MM	MeBo	Freudenthal	31.08.08	14:30	52	20.216	-12	41.310	639.0	MeBo on deck
INSDD11	1	25a	EM1002	de Haas	04.09.08	05:04	53	49.066	-13	09.248	328.5	SOL
INSDD11	2	25a	3.5kHz	de Haas	04.09.08	05:04	53	49.066	-13	09.248	328.5	SOL
INSDD11	3	25a	EM1002	de Haas	04.09.08	05:24	53	49.500	-13	12.250	330.7	EOL
INSDD11	4	25a	3.5kHz	de Haas	04.09.08	05:24	53	49.500	-13	12.250	330.7	EOL
INSDD11	5	25a	MeBo	Freudenthal	04.09.08	07:17	53	49.393	-13	11.332	331.5	MeBo in water
INSDD11 GeoB 13411	6	25a	MeBo	Freudenthal	04.09.08	08:44	53	49.385	-13	11.306	330.5	MeBo on bottom (GAPS position)
INSDD11	7	25a	MeBo	Freudenthal	04.09.08	19:07	53	49.395	-13	11.282	333.0	MeBo off bottom
INSDD11	8	25a	MeBo	Freudenthal	04.09.08	19:53	53	49.395	-13	11.283	333.5	MeBo on deck