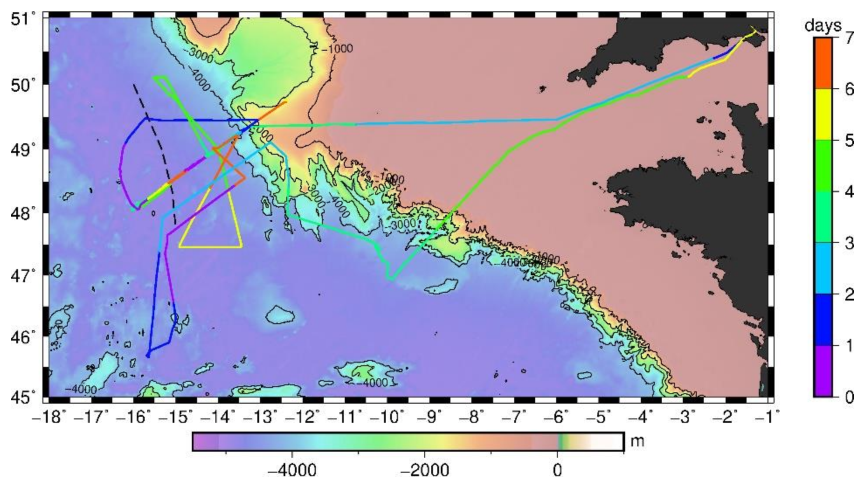
CRUISE REPORT RSS JAMES COOK JC251

Quantifying evolution of magmatism and serpentinisation during the onset of seafloor spreading



29th August to 26th September 2023

Southampton to Southampton

Gaye Bayrakci, Steve Constable, Tim Minshull and the Science Party

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1. Executive summary

Cruise JC251 (29th August to 26th September 2023) collected the multi-method geophysical dataset for the NSFGEO-NERC project "Quantifying evolution of magmatism and serpentinisation during the onset of seafloor spreading". The overall aim of the project was to quantify the evolution of serpentinisation and magmatism at magma poor rifted margins as seafloor spreading is initiated, including whether serpentinisation of exhumed mantle is focused in discrete fault zones, and whether magmatism increases abruptly or gradually.

The cruise acquired coincident high-quality controlled source electromagnetic (CSEM), Mangetoteluric (MT) and wide-angle seismic datasets along a carefully chosen profile at the magma-poor Goban Spur rifted margin. We deployed 51 multi-channel Ocean Bottom Instruments (OBI; 37 Scripps US and 14 OBIC UK) capable of recording simultaneously wide-angle seismic, electric field and magnetometer datasets, and recorded a multi-physics dataset along a ~200 km line. 14 OBIC instruments were equipped with 3-component geophones and 2-component horizontal electrode dipoles with 12 m antennas and ten of them had additional 3 component fluxgate magnetometers. 35 Scripps instruments were equipped with 2-component horizontal electrode dipoles with 10 m antennas, 2-component induction coils and hydrophones. Two Scripps LEM (Long-wire electromagnetic) devices with one 200-m horizontal electrode dipole were also deployed to investigate the deeper electric resistivity structure along the profile. All datasets were recorded at 250 Hz sampling rate.

The initial survey plan included two profiles: northern and southern, both parallel to the spreading direction and along existing legacy seismic profiles (Fig. 1; northern: PAD13-40 and southern: PAD95-16). Thanks to the legacy multi-channel seismic profile (PAD13-40), and a seismic tomography study along the WAM seismic line (Bullock & Minshull, 2005) which is co located with the PAD13-40 at its oceanward end, most of the structure along the northern line was known, though at low resolution. The structure consisted in unambiguous oceanic crust to the west, and stretched continental crust to the east, with a transitional crust in between, suitable to study the roles of magmatism and serpentinization during continental break up and initiation of seafloor spreading. We therefore prioritized the northern line and begun the acquisition with that line.

Along the northern line, OBIs were deployed using the starboard side crane, between 31st of August 11:06 and 02nd of September 09:20, except for two LEMs which are deployed using the A-frame. The LEM launcher is lowered to 10 m above the seafloor using the A-frame winch, then the LEM is released close to the seafloor.

After the deployment of OBIs, we deployed the University of Southampton's DASI electromagnetic source, which after a substantial modification to enable the use of more complex waveforms and variable amplitudes, was used for the first time in JC251. DASI had not been tested at sea and required some troubleshooting before successful data acquisition. The first few DASI deployment attempts were aborted due to the inability to transmit. In order to give time to the DASI team to fix the transmission issues, we switched to controlled source seismic acquisition.

A seismic Bolt LL airgun array of 5700 cu.in was deployed and operated using Big Shot gun controller with a shot interval of 90 s and with a boat speed of 5 kn. During this first seismic gun deployment (line 10149-001), two single guns of 700 cu.in volume did not fire and the 500 cu.in volume returned a faulty waveform and had to be turned off reducing the total volume to 3800 cu.in. Later, the second 500 cu.in volume also started to misfire, and the seismic acquisition was aborted because of the gun volume becoming too small for a crustal study. Seismic guns were recovered, fixed, then redeployed. During the second deployment (line 10149-002) all guns fired except the 500 cu.in gun with a faulty waveform which was turned off. The profile was initially acquired with a total volume of 5200 cu.in and a shot interval of 90 s, but then a 300 cu.in volume had to be turned off due to misfiring and the profile was competed with a total volume of 4900 cu.in. At the end of this seismic first full seismic line, DASI was not ready yet to be redeployed. We continued the wide-angle seismic acquisition along the same profile with a new configuration (line 10149-003): a smaller volume (3900 cu.in) and a shorter shot interval (30 s); better suited to wide-angle reflection imaging than the 90 s shot interval which was chosen for greater depth penetration.

At the end of the second seismic profile, DASI is redeployed and functioned continuously for 4 days (line 10149-004) and completed the controlled source electromagnetic acquisition along the northern line. DASI was equipped with a 300 m antenna and 15 m copper electrodes, and it was towed at 100 m altitude above the seafloor using the A-frame winch. During the deep-tow, DASI's altitude was controlled by its altimeter, and two USBL beacons (one at the front of DASI and another at 350 m back) were used for positioning. DASI transmitted the waveform-D at 0.25 Hz. During the DASI operation, a fluxgate magnetometer is also deep-towed 550 m behind DASI and operated at 250 Hz to record DASI transmissions in addition to the magnetic field, but the instrument did not record any data.

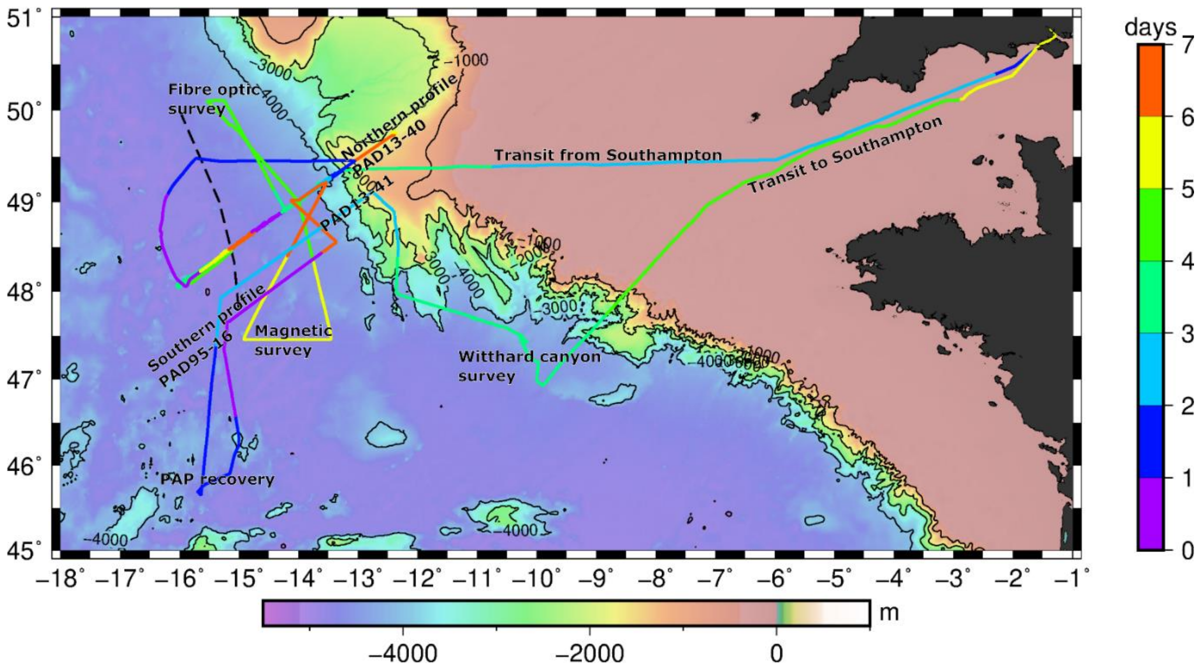


Figure 1: JC251 survey track colour coded per day.

The recovery of northern line OBIs started on the 12th of September and coincided with worsening weather conditions. On the 14th of September the recovery is interrupted for 12 h due to the bad weather, then resumed with a slower pace. After the 15th of September the weather got worse with a forecast showing non-workable weather conditions for the rest of the survey. On 17th of September, we finished recovering all seafloor instruments except three instruments: instruments 17 and 33 from Scripps and 44 from OBIC which did not respond to the acoustic releases.

Between the 17th of September and the end of the cruise, we did not have any long enough workable weather period that would allow enough time to deploy the seafloor instruments, followed by DASI or seismic guns deployment, then the recovery of the seafloor instruments. Hence, we could not acquire our planned southern line.

On the morning of the 18th of September, the weather was good enough to deploy the seismic guns for half a day and we used this time to deploy the guns and shoot on a transatlantic fibre-optic cable (Exa -South, previously called Hibernia South) that is interrogated by National Physics Laboratory for fibre optic seismology purposes using an interferometer (line 10149-005).

After the fibre optic shooting, we attempted to acquire some deep-tow magnetic data, using Scripp's LEM launcher as a tow fish. The altitude of the LEM launcher was monitored by an altimeter to prevent any collision with the seafloor. Without having any indication of a collision from the altimeter data, we lost the communication with the altimeter and decided to recover the deep-tow magnetometer. At the end of the recovery, we discovered that the magnetometer and the LEM launcher that was used as a tow fish were not attached to the fibre optic winch cable. The instruments were lost, and a portion of the fibre optic cable was also broken.

On the 12th of September, we were requested by NMF to use our weather contingency time to recover NERC's PAP SO buoy which was detached from its anchor due to bad weather. On the 21st of September, we sailed towards the PAP SO buoy where forecast showed good enough weather for the buoy recovery for the next day. After the buoy recovery on the 22nd of September, we returned to our research area, and acquired surface magnetic and gravimetric data along two legacy seismic profiles (line 10149-006 and 10149-007), close to our northern line.

In order to make a good use of the remaining science time, we sailed to the Witthard Canyon and on the 24th of September we begun a multi-beam survey at the one of the southern channels of Witthard Canyon. We sampled four cable break points. However, the weather did not improve to allow good quality multi-beam data acquisition. We therefore decided to finalise our cruise and sailed back to Southampton.

Despite all difficulties, JC251 acquired a multi-physics dataset including CSEM, magnetotelluric, seismic, gravimetric and magnetic data along one profile allowing to test the hypothesis of the project "Quantifying evolution of magmatism and serpentinisation during the onset of seafloor spreading".

2. Scientific Background

Continental breakup is a global process that leads to the formation of new ocean basins, providing a primary mechanism for Earth's heat loss. It involves a complex interplay of extensional tectonics and magmatism. Rifted continental margins are often classified according to the degree of magmatism. Magmatic margins are typically juxtaposed with thickened oceanic crust that resembles that formed at mid-ocean ridges. Conversely, over the last two decades it has been established that at many rifted margins worldwide, a region of exhumed and serpentinised (hydrated) mantle is present between hyper-extended continental crust and magmatic oceanic crust. Such margins are described as "magma-poor" margins.

At some magma-poor margins hyper-extended continental crust is now well-sampled by industry and academic seismic reflection datasets, which have shown how the crust is thinned by successive normal faulting. However, geophysical imaging of structures within exhumed mantle and first-formed oceanic crust is challenging. Evidence for the presence of exhumed serpentinised mantle is based primarily on P-wave velocity models determined from wide-angle seismic data, supported by sparse seabed sampling and ocean drilling. Such models can provide compelling evidence, for example where the velocity pattern is clearly distinct from adjacent oceanic and continental crust. However, the P-wave seismic velocities of slowly cooled magmatic rocks (e.g. gabbro) and partially serpentinised mantle rocks overlap strongly, so that ultimately the same velocities can be given different interpretations. Conversely, serpentinised mantle rocks typically have higher porosities and thus lower electrical resistivities, typically by an order of magnitude than gabbroic rocks. Particularly low resistivity values are observed for serpentinites containing a connected network of electrically conductive magnetite. We exploited these differences by conducting the first joint controlled source electromagnetic (CSEM), magnetotelluric (MT) and seismic experiment across the ocean-continent transition at the Goban Spur magma-poor rifted continental margin, southwest of the UK.

Our overall aim was to quantify the interplay between serpentinisation and magmatism at magma-poor rifted margins as seafloor spreading is initiated, including whether serpentinisation of exhumed mantle is focused in discrete fault zones, and whether magmatism increases abruptly or gradually.

Specific objectives were to: acquire coincident high-quality CSEM, MT and wide-angle seismic datasets along two carefully chosen transects at the magma-poor Goban Spur rifted margin; (i) acquire coincident high-quality CSEM, MT and wide-angle seismic datasets along two carefully chosen transects at the magma-poor Goban Spur rifted margin; (ii) use these data to obtain coincident high-resolution seismic velocity and resistivity models for the upper few to tens of kilometres of the lithosphere; (iii) interpret the resulting models to quantify regional and local variations in mantle serpentinization and magmatic addition; (iv) reconcile these observations with numerical models of lithospheric extension, mantle hydration and decompression melting. The Goban Spur margin provides a uniquely suitable location to achieve our aim because: (i) The presence of exhumed serpentinised mantle has been inferred based on seismic velocities and basement morphology. (ii) Unusually for an ancient rifted continental margin, the sediment cover overlying exhumed mantle and early oceanic crust is very thin (< 1.5 km and in places < 500 m), which facilitates high-resolution CSEM imaging. Electromagnetic energy is strongly attenuated by conductive marine sediments, particularly at higher frequencies. The thin sediment cover also results in an abrupt velocity contrast at the top of basement that facilitates the generation of converted S waves. S-wave velocities can differ significantly between mafic igneous rocks and serpentinites that have the same P-wave velocity. (iii) Unequivocal oceanic crust, represented by the magnetic anomaly A34, is present sufficiently close to stretched continental crust that both can be traversed in a single well-sampled geophysical transect. (iv) We could conduct our experiment along high-quality existing seismic reflection profiles and make use of ocean bottom seismic data from previous lower-resolution experiments.

3. Personnel

a. Ship's Officers and Crew

James Gwinnell (Master)	Phillip Douglas Gauld (C/O)
Declan Daniel Morrow (2/O)	Charlotte Frances Astbury (3/O)
Christopher Paul Uttley (C/E)	Michael Murray (2/E)
Edin Silajdzic (3/E)	Gary Slater (3/E)
Conrad Thomas Laversuch (ETO)	Paul Derrick Lucas (PCO)
Martin Andrew Harrison (CPOS)	Nataniel James Gregory (CPOD)
Iain Forbes (POS)	John Michael Allen (POD)
Brian James Burton (SG1A)	Niel Philip Channing (SG1A)
Sean Paul Angus (ERPO)	Christopher Brian Keighley (Head Chef)
Michalak Jozef Aradiusz (Chef)	Jane Bradbury (Stwd)
Marius Constantin A/Steward	

1.2 Ship Science Systems personnel

Willam Mark Richardson (seismic acquisition lead)	Juan Ward (Ship scientific systems lead)
Daniel Perry Phillips	Dean David Cheesman
Andrew John Cotmore	Jack Matthew Arnott
Jason Errington Scott	Ellis James Thompson

1.3 Science Party

Gaye Bayrakci (C/S, NOC)	Steve Constable (Scripps)
Laurence North (NOC)	Roselyn Beatrice King (Scripps)
Haydn Carrington (UoS)	Jacob Manuel Perez (Scripps)
Ben Pitcairn (OBIC)	Christopher Donald Amending (Scripps)
Anna Bird (OBIC)	Kyle Richard Ivey (Scripps)
Rafael Angel Gutierrez (Sci/Tech, OBIC)	Eliana Vargas-Huitzil (Scripps)
Thomas Patrick O'hara (OBIC)	Raghu Ram (Marum)
Hazel Kate Knight (MMO Birmingham)	Ibrahim Mohammed Yusuf (MMO, Birmingham)
Chengdong Chen (UoS)	

4. Pre-cruise Planning

4.1 Diplomatic Clearance

The study region, Goban Spur rifted margin is located southwest of the south-western limit of Irish EEZ, south of Porcupine Basin and west of Western Approaches Basin (Fig. 2). Our northern profile is in the EEZ of the Irish government and our planned southern line lies partially in the zone claimed jointly by Ireland, UK, France and Spain. Therefore, six months before siling we applied for diplomatic clearance from Ireland, UK, France and Spain. We followed the standardised application process managed by the National Marine Facilities. Initial applications were submitted to sail between the 23rd July 2023 and 21st of August 2023. Due to the delays in the ships refit (JC49), our cruise was postponed to the 28th August 2023 to 27th of September 2023. We accepted the change of dates despite the fact that the second half of September was outside the weather window, because we had already been delayed two years by Covid restrictions and did not want to wait further. We have been given an extra day of ship time to compensate for potential poor weather. We submitted an amendment to our initial dip clear applications to change our sailing dates to the 28th August 2023 to 27th of September 2023. The diplomatic clearances from Ireland, UK and Spain were attributed a week before to sailing and the French clearance came three days after sailing.

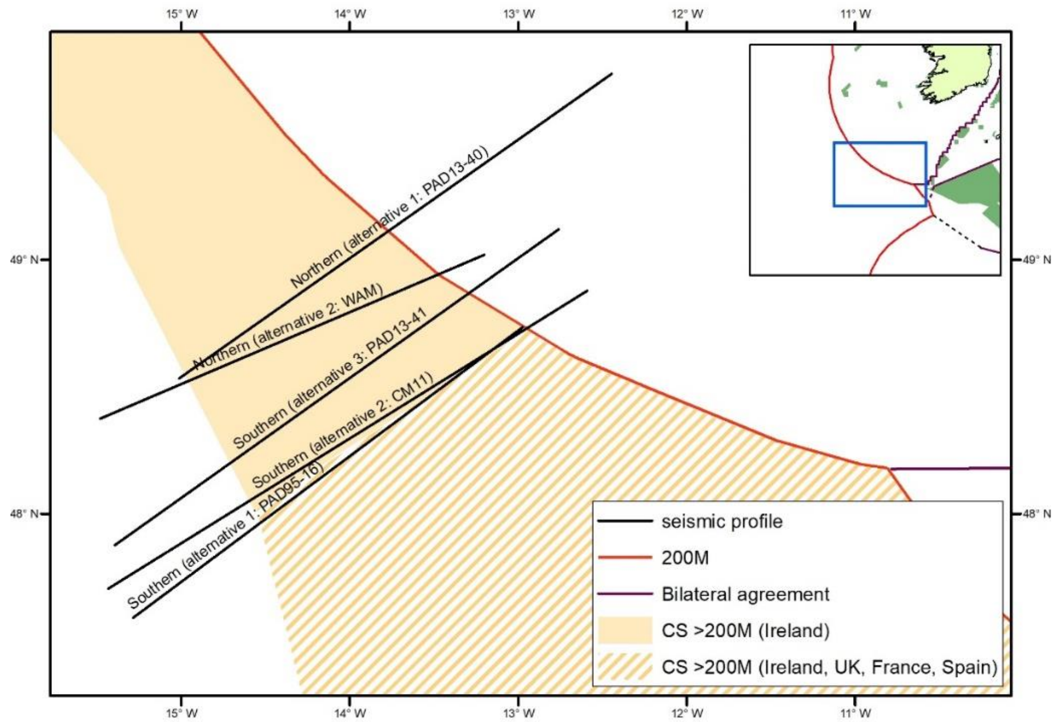


Figure 2: Map of the survey area showing the exclusive economic zones. The black lines show the preliminary locations northern and southern profiles and their alternatives. Inset shows the location of the survey area.

4.3 Environmental Impact Assessment & Marine Environment Mitigation Plan

In accordance with the Marine Environment Interaction Policy of NERC, an environmental impact assessment (EIA) was carried out by a Marine Environment Appraiser (MEA; Anna Bird). The assessment is carried out through an EIA questionnaire which gathers information on the location and aims of the project and the planned activities at sea. A Marine Environment Mitigation Plan (MEMP) containing the mitigation measures fit for our science plans was sent to us before sailing. According to MEMP we sailed with two Marine Mammal Observers with JNCC approved training certificates (Hazel Kate Knight and Ibrahim Mohammed Yusuf). Observations were conducted from the vessel's bridge deck which was the highest area accessible at sea with visibility in all directions.

All acoustic systems (sub-bottom profiler, single and multi-beam echosounders and the hull transducer) were turned on after marine mammal observations. In order to prevent interferences between instruments, systems emitting the same frequency contents are turned off during specific operations such as the sub-bottom profiler, single beam and multi-beam echosounders that were turned off during the navigation surveying to define the precise location of seafloor instruments, or sending the release commands to the seafloor instruments, done by the hull transducer. The acoustic emission was continuous between the dates the 31st of August and 26th of September where we were in our study region.

Additionally, a 60 minutes marine mammal observation was carried out three times, before the starts of seismic shooting, and the seismic surveying was always started only during daylight. The marine mammal observation was followed by a soft-start that involved increasing the total gun array volume stepwise by adding a new gun to the array every 5 min. There was only one marine mammal sighting during JC251 on the 3rd of September at 18:22, during the soft start for seismic acquisition. The observation consisted in a whale that was 2000 m away from the ship and did not required any mitigation according to the mitigation plan.

4.2 Export licensing of dual-purpose instruments

Cruise JC251 planned to use two towed three-axis electric field Vulcan receivers (Constable, 2016). NOC NMF applied for a dual-purpose export license for these instruments on the 10th of August, but the export license had not been received on time before sailing (28th of August).

In addition, NOC NMF applied for an export license for the content of the seismic container including seismic gun controllers (BIG Shot and Avalon) and the hydrophones to record the signature of the gun array. The gun recording hydrophones were mistakenly interpreted as a towed hydrophone array and an export license application for a towed gun array had been submitted on the 10th of August 2023. This export license had also not been received on the 28th of August 2023.

The PSO and the science party had not been informed about the two export license applications until PM on the last working day before sailing (Friday the 25th of August 2023). Moreover, JC251 was planned on the 28th of August 2023, on a bank holiday Monday when both at NOC and HMRC personnel were unreachable.

To prevent a delayed sailing, we decided to sail without the Vulcan electric field receivers. However, the seismic container contained the Big Shot and Avalon seismic gun controller systems without which seismic shooting would not be possible. Between the 26th and the 29st of August, we escalated the export licensing issues to the associate director of NOC. On the 29st of August (Tuesday) NOC NMF cancelled the export license application for the content of the seismic container and we sailed at 20:00 without the Vulcans and with the seismic container, with one and a half days of delay. These mitigation measures could have been implemented the previous week and the delay in sailing avoided had the PSO been informed earlier of the situation. NOC NMF agreed to use the third engine as part of the Hydrogenated Vegetable Oil trials, to regain the time lost during the export licensing issues.

5 Cruise Narrative (All times UTC)

Saturday 26th August 02023

In the afternoon of the 25th of August, the last working day before sailing, we learned that NOC applied for export licenses for the Vulcan electromagnetic (EM) recorders and for the "Seismic container" containing the seismic gun controllers and gun hydrophones. The licenses have not been received on time for sailing on Monday 28th of August (bank holiday). We had meetings with the head of NMF to understand the details of the export license applications and find solutions to avoid delayed sailing.

Sunday 27th of August 2023

After reading the UK Strategic Export Control document carefully, we discovered that NOCs export license application for a towed hydrophone array for the content of the "Seismic container", was irrelevant because only towed hydrophone arrays (streamers) of group spacings < 12.5 were subjected to a license. JC251 did not request a seismic streamer (a towed hydrophone array to record seismic reflections for seismic imaging); hydrophones were only going to be used for recording the near field signature of the airguns and be located on the single guns and gun beams at uneven intervals, larger than 12.5 m, not in an array configuration to acquire high resolution reflection data.

We suggested to NOC NMF to cancel the export license application to allow JC251 to sail without delay. NOC NMF considered our suggestion but pointed out that the gun controllers (Big Shot, Avalon etc.) might be subject to export licensing as they control the seismic guns (BOLT LL) which transmit in frequencies of 5 – 200 Hz. BOLT Airguns were qualified 6A001 by their manufacturer in US. The UK export control defines the items in a greater detail than the US equivalent. The UK code 6A001.b.1 which is a "Systems or transmitting and receiving arrays, designed for object or location detection, having a transmitting frequency below 10 kHz" is the likely UK equivalent of the US code suggested by the manufacturer, however, this code in the UK refers to higher frequency sources designed for object detection or location. Due to the ambiguity in the UK Strategic Export Control document, NOC did not want to cancel the export license application and decided to wait until the next opening day (Tuesday) and contact the HMRC to learn more about the status of their export license application.

Monday 28th of August 2023

Due to the export licensing issue, JC251 could not sail at 9:00 as initially planned.

Meetings with NOC NMF continued in order to come up with a plan of actions to sail without further delay. We learned that the export license application was submitted on the 10th of August and the HMRC export licensing could take between 20 to 90 working days.

13:00 DASI test on board, before sailing. During this first test, the fibre optic connection that allows communicating with DASI did not work. The fibre has been cleaned, the test is repeated. The communication problem was related to DASI junction box.

15:47 The fibre optic communication with DASI is fixed and the second DASI test was successful.

Tuesday 29th August 2023

07:30 In a meeting with the project CO-PIs (Tim Minshull, Steve Constable and Gaye Bayrakci) the possibility of sailing without the seismic system was discussed. Leaving the seismic acquisition system would not allow delivering the objectives of the project and so it was ruled out. In case the export licensing issues took longer and caused significant delay in sailing, reducing the science days significantly it was decided that it is best to focus on a single profile to acquire a multi-physics dataset (EM, MT, seismic, magnetic and gravimetry).

14:00 LEM launcher test successful

19:00 Everybody was back on board to get ready to sail.

20:00 JC251 sailed without the Vulcan electric field receivers and with the seismic gun controllers.

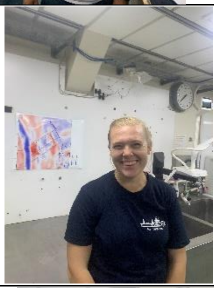
Wednesday 30th August 2023

07:30 We had our first daily meeting with the captain. In order to reduce the impact of the days lost due to the export licensing issues, NOC NMF agreed to use the third engine. The use of the third engine normally requires a permission from NERC, however, during JC251, the new Hydrogenated Vegetable Oil (HVO) fuel was tested as a potential low environmental impact fuel and we already had the permission to use the third engine for the test purposes. We sailed at 16 kn with 3 engines.

During the day we had toolbox meetings for seafloor instrument deployments including LEMs. We decided to deploy OBIC and Scripps combined CSEM/seismic instruments using the starboard winch and crane respectively and LEMs using the stern at 1.5 – 2 kn. We learned that the heave compensation is possible when using the A-frame. For LEM deployments we decided to pay off 6000 m of wire at 30 m/min speed, release the LEM at less than 10 m above the seafloor, then pull the wire back in with a speed of 60 m/min during the turn towards the next instrument (143).

In the afternoon the DASI team, together with the Scripps team worked on implementing an additional pressure gage at the back of the DASI antenna and a telemetry unit to measure the DASI dip and send this information to the boat. Although the connection with DASI was established, the implementation of the telemetry unit was not successful because the pressure sensor was broken.

In the evening the RRS James Cook entered the Irish EEZ in position 49° 25'N 009° 03'W at 1915UTC.

Noon => Midnight	Midnight => noon
Jake P 	Kyle I 
Roz K 	Chris A 
Eliana H 	Hadyn C 
Hazel K 	Ibrahim Y 
Chengdong C 	Raghu R 
Anna B 	Ben P 

Rafael GN 	Tom O 
Laurence N 	

Table 1: Pictures of science party showing noon to midnight and midnight to noon shifts.

Thursday 31st August 2023 (243)

04:00 We arrived to 1000 m contour and started to get ready for the OBIC dip test.

05:00 Dip test: OBIC releasers were deployed. The B-frame (the starboard winch) is used for the deployment.

07:00 Beginning of MMO for starting the acoustic systems (the multibeam and the SBP).

07:30 End of MMO and daily meeting with the captain.

07:40 Multibeam and SBP started.

08:00 The end of the dip test. The dip test took 1 h more than expected. We headed to the first deployment site 1-149.

We decided for a naming convention: Scripps instruments are called with a 1- prefix and OBIC ones are with a 2- prefix. The northern profile is called the profile 1 and so all the instruments on the northern profile are called with a prefix 1, followed by the instrument number (e.g. 149).

11:06 The first OBI deployed (1-149) using the crane (Fig. 3).

11:46 The second OBI deployed (2-148). The depth of this OBI needs to be extracted from multibeam later because there has been a multibeam failure between 11:20 and 12:00. We initially tested the deployment of the OBIC instruments using the starboard winch but decided to deploy the OBIC instruments also using the starboard crane.

Figure 3: a) A Scripps OBI being prepared for deployment using the starboard crane. b) The same Scripps instrument is being deployed.

12:14 OBI 1-147 deployed

12:48 OBI 1-146 deployed

13:19 OBI 1-145 deployed

13:48 OBI 2-144 deployed

14:41 We noticed that the sub-bottom profiler data collected up to now has no coordinate information in because the GPS stream was not reaching the profiler. The GPS stream is corrected and the data without the coordinates is kept because, we can write ship navigation to the headers of SBP data later.

15:00 Beginning of LEM deployment (1-150) preparations (Fig. 4).

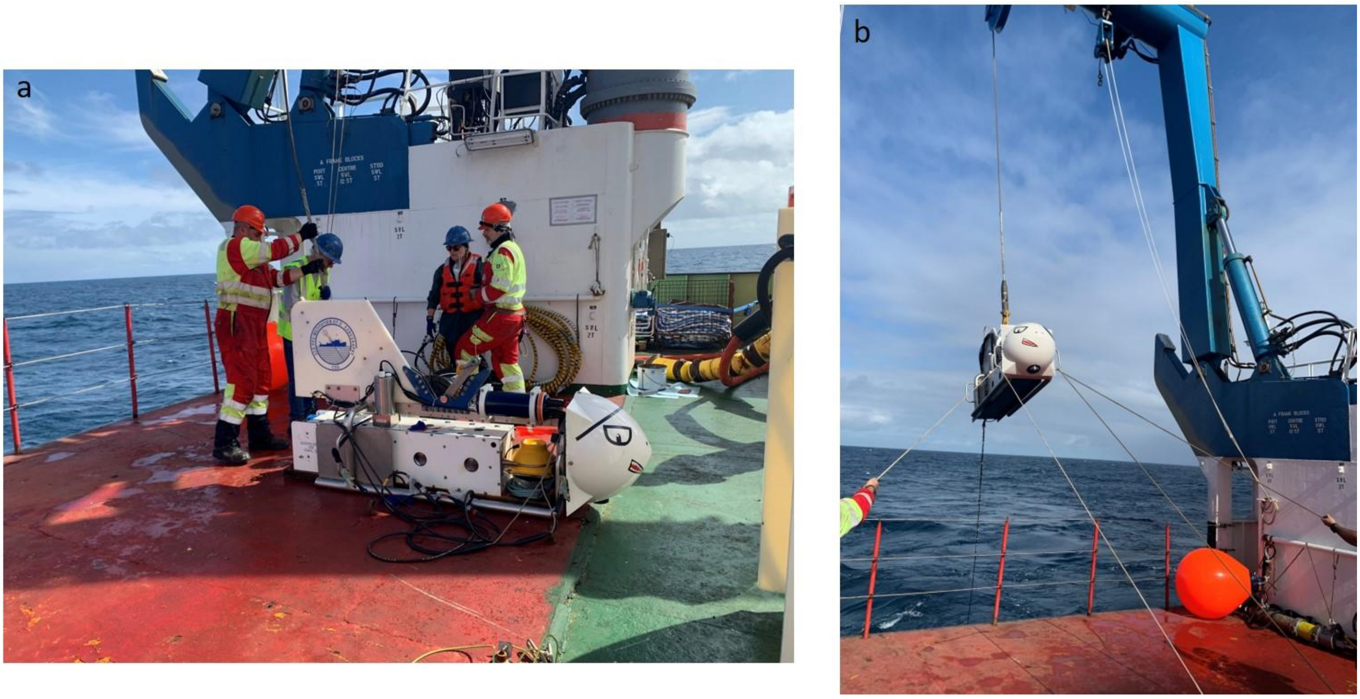


Figure 4: a) The LEM launcher getting ready to be deployed using the A frame. b) the same instrument being deployed.

15:45 LEM launcher is deployed with a cable pay off speed of 25 m/min. The speed of the winch is controlled by the tension of the wire. As the LEM is not heavy, one would not want to go faster than 30 m/min to prevent the slack wire.

Valeport CTD-V on the LEM launcher worked fine (Fig. 24) therefore no additional velocity dips are needed.

19:03 LEM released at about 10 m above the seafloor, between the 2-144 and 1-143, landward than initially planned. The LEM deployment took 3 h and 15 min approximately. We were heading to the instrument 1-143 while pulling in the wire, but the captain decided that we first need to pull the wire, then turn.

20:48 LEM launcher on deck. LEM took 1 h 45 minutes to rise so the total time for the deployment was 5 h, 1 h less than initially planned.

21:41 1-143 deployed

22:23 1-142 deployed

22:57 1-147 deployed

23:25 2-140 deployed

23:52 1-139 deployed

Friday 01st September 2023 (244)

00:38 1-138 deployed

01:16 1-137 deployed

01:20 The RRS James Cook departed the Irish EEZ at 0120UTC in position 49° 06'N 013° 47'W.

01:50 2-136 deployed

02:17 1-135 deployed

02:57 1-134 deployed

03:37 1-133 deployed

04:13 2-132 deployed

04:52 1-131 deployed

05:34 1-130 deployed

06:20 1-129 deployed

07:12 2-118 deployed

07:30 daily meeting

07:43 1-127 deployed

08:19 2-126 deployed

08:48 1-125 deployed

09:16 2-124 deployed

09:57 1-123 deployed

10:31 1-122 deployed

11:07 1-121 deployed

11:41 2-120 deployed

12:10 1-119 deployed

12:53 1-118 deployed

13:30 1-117 deployed

14:04 2-116 deployed

14:32 1-115 deployed

15:19 1-114 deployed

16:14 1-113 deployed

Figure 5: Scripps instruments were stored on the deck and OBIC instruments were stored in the wet lab.

16:54 2-112 deployed. Our initial plan was to deploy 2-112, then deploy the LEM (1-151) and turn back to 1-111, but the sea state did not allow that. Instead, we continued with the OBI deployment.

17:41 1-111 deployed

18:23 1-110 deployed

18:34 Dip test for DASI’s USBL

18: 37 End of DASI’s USBL test

19:15 1-109 deployed

19:55 2-108 deployed

20:25 1-107 deployed

21:02 1-106 deployed

21:37 1-105 deployed

22:24 2-104 deployed

22:57 1-103 deployed

23:45 1-102 deployed

Saturday 02nd September 2023 (245)

00:24 2-101 deployed. End of OBI deployment, headed to 2-108 for the deployment of second LEM (1-151).

03:10 LEM-2 launcher deployment.

03:25 LEM-2 back on deck because of a wiring issue.

03:31 LEM-2 Redeployment (i.e. launcher deployed)

07:16 LEM-2 (1-151) released. To make sure the release signal is received by the LEM, the multi-beam and the single beam were turned off (at 06:30 and 06:57 respectively). After deployment they are turned on at 07: 36 but the single beam had an issue and had to be switched off and on again at 08:10.

09:20 LEM launcher back on deck. DASI deployment preparations started, we sailed to the seaward end of the profile to deploy DASI after lunch

DASI deployment:

15:36 DASI’s parachute deployed (Fig. 6)

15:39 The deep-tow magnetometer is deployed manually and beginning of the 550 m dynema rope deployment.

15:56 Back side USBL in a Vulcan case is deployed together with a glass sphere to increase the buoyancy.

15:58 The 30 m cupper electrode is deployed,

15:59 followed by the 300 m antenna with a glass buoyancy sphere.

16:06 A strain relief is added to the junction between 100 m and 200 m antennas in order to prevent antenna damage and a glass sphere is added for buoyancy aid.

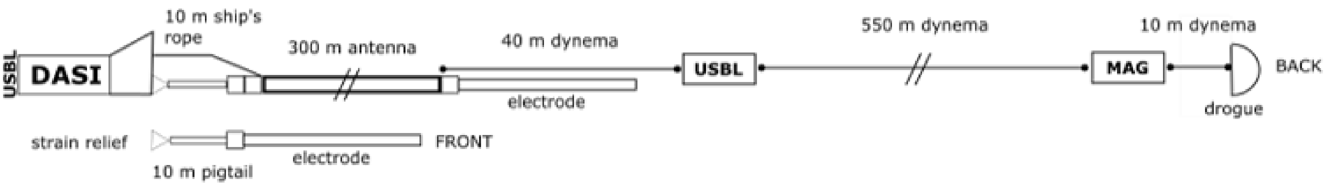


Figure 6: Scematic showing the components of DASI. Not to scale

16:21 The telemetry cable which is normally used for communication with Vulcans is rolled out and fixed to the antenna with cable ties, but is not used in this deployment.

16:23 10 m long ship's rope is attached to the near end of the long side antenna to protect the pigtails attaching the antenna to DASI from damaging during deployment.

16:25 The strain relief is attached to the winch

16:30 The strain relief is removed from the winch, the long side antenna is deployed entirely

16:34 Buoyancy is attached to the far end of the short side antenna

16:35 Short side deployed entirely, followed by DASI which is deployed with the A-frame winch.

After the deployment, the signal from two USBL is received successfully and the location of DASI was displayed on ships screens via OLEX software for navigation.

16:51 DASI is turned on. Although the fibre optic connection to DASI was working fine, we were not able to send the waveform. We decided to recover DASI and leave the antenna in the water to check the SD card located in the bottom tube (the brain) of DASI.

17:45 Earth down

17:59 DASI was on deck, with the antenna in the water. We started to sail back slowly toward the start of the profile.

22:57 DASI redeployed (2nd deployment).

23:38 The winch towing DASI stopped working. Winch is turning but the cable is not paid off.

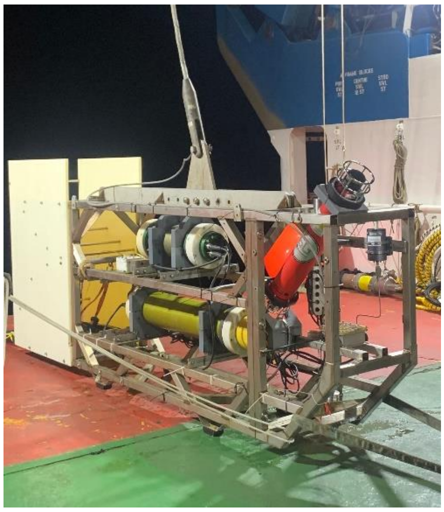


Figure 7: DASI on the aft deck before deployment. The front USBL and two tubes of DASI are visible.

Sunday 03rd September 2023 (246)

01:04 DASI Back on deck, this time for the winch repair.

04:08 DASI is redeployed (3rd deployment)

04:48 DASI on deck – This time we had a comms issue.

05:20 DASI redeployed (4th deployment)

05:40 DASI turned on for test purposes and the test was positive. DASI was transmitting the waveform D. DASI was then turned off.

08:30 DASI reached ~ 4000 m, but not transmitting.

10:30 DASI on deck, full recovery started. We decided to switch to the seismic acquisition to allow some time for fixing the transmission issue with DASI.

11:40 Full DASI recovery including the antenna and the deep-tow magnetometer. Start of the seismic preparations.

12:22 Multibeam on. Multibeam was stopped during the DASI recovery.

14:00 The seismic airguns are tested on deck. Beginning of airgun deployment.

14:16 Port inner beam lifted using the corner winch

14:26 Port inner beam is deployed

15:19 Port outer beam is deployed

15:34 MMO started about an hour before the deployment of the full gun array

15:51 Starboard inner beam deployed

16:50 – 17:00 Two 700 cu.in single guns are deployed. Start of the magnetometer deployment.

18:06 Beginning of the soft start which consist in adding guns to the gun array stepwise every 5 min.

18:42 Full array reached. End of MMO.

18:44 Two large single guns did not show the return signal generated by the solenoid after the actual shot, the aim point, 50 ms after the trigger point. The gun 3 which is the 500 cu.in gun at the outer port beam (Fig. 13) did send a signal but the waveform of the signal indicated that this gun was misfunctioning.

21:33 Start of the seismic line 10149-001 without two centre guns 8, 11 (700 cu.in each) and 18 (starboard aft 500 cu.in) lon: -15.972, lat: 48.089, total volume (5700 – 700 – 700 – 500 = 3800 cu.in). This volume is potentially too small for a crustal seismic acquisition, but we cannot recover the guns, and redeploy them after fixing at night, so we continue the acquisition with the 3800 cu.in.

Monday 04th September 2023 (247)

05:34 Gun 3 (port aft 500 cu.in) switched off due to repeat misfire. The gun is firing before the aimpoint, and Big Shot only applies a delay to correct the delayed guns. It does not apply a negative delay.

06:01 Seismic line 10149-001 aborted due to continuous insufficient power. Lon=-15.162 Lat=48.464

06:24 Start of the gun recovery. We will change the solenoids and test the guns again.

11:33 Beginning of the second gun deployment and MMO

12:55 All guns deployed, start of the gun tests (13:00)

13:05 Beginning of the soft start

13:53 Start of the seismic line 10149-02 (Lon=-15.843 lat=48.129)

16:02 Reached the start point of the profile (i.e. 50 km from the first instrument)

17:10 Gun 18 (500 cu.in) disabled due to repeat misfiring. Total volume 5200 cu.in

19:58 Magnetometer disabled following water ingress detection.

Tuesday 05th September 2023 (248)

Whilst the seismic acquisition continued, we run a DASI low voltage test, which was successful. The high voltage deck test however showed unreliably high voltages on the high voltage supply ranging between 100 V to tens of kilovolt. After this unsuccessful test, the bottom tube (Fig. 7) had to be brought to the lab again to make sure that the microprocessor and the connections are not damaged by this high voltage test. The transformer (top tube) has to be tested too. The investigations showed that the high voltage supply (in the container) had a loose connection, which is fixed. A low voltage test has been carried out successfully.

22:12 End of seismic line 10149-02 (Lon=-12.429 Lat=49.749). DASI was not ready to be deployed. We decided to acquire the same seismic line with a smaller gun volume and 30 s interval to allow better reflection imaging with the seafloor instruments. We decided to deploy DASI after the second seismic profile (line 10149-03, northern profile going seaward) to give the DASI team (which is composed of only two people) enough time to rest to be able to keep 12 h shift during the DASI acquisition.

Wednesday 06th September 2023 (249)

07:30 In the daily meeting, the captain announced bad weather starting from this afternoon and getting worse on the 7th of September, in the afternoon.

18:00 DASI high voltage test failed. The input 50 V from the top tube is reduced to 4 V to the output for the antenna. There are capacitors in the bottom tube that need to be charged. This is done at the 3 * resistors. Potentially one of those resistors is faulty.

20:43 The bottom tube is brought back to the lab to check the resistors. The analysis showed that there was a blown fuse in the bottom tube.

Thursday 07th September 2023 (250)

We carried out another DASI high voltage, which was successful this time.

08:40 We finished the second seismic line with 30 s interval. Due to bad weather we headed to NW. We couldn’t recover the guns before the start of the bad weather, due to ongoing DASI test. We decided to turn to the NE end of the line when the weather permits.

Friday 08th September 2023 (251)

08:00 We recovered the seismic guns. We continued sailing towards the NE end of the profile (DASI start, 20 km landward of the last instrument).

12:32 The RRS James Cook re-entered the EEZ of Ireland at 1232UTC 080923 in position 49° 27'N 014° 19'W.

During the day while we were sailing towards the NE end of the line, one low voltage and one high voltage DASI tests were carried out. Both tests were successful.

18:26 DASI is deployed with the copper electrodes shortened to 15 m, to increase the impedance.

19:49 Surface magnetometer is deployed towed at 50 m depth and 300 m behind the ship.

20:58 DASI went down to ~ 1880 m (approx. 80 m above the seafloor), then the coms dropped because of overheating.

21:13 We added a fan to the top side container to cool DASI started the transmission again.

Saturday 09th September 2023 (252)
DASI acquisition continued.

Seismic event in Morocco of 6.5 M.

17:15 The RRS James Cook departed the Irish EEZ at 1715UTC in position 49° 06'N 013° 48'W.

Sunday 10th September 2023 (253)
DASI acquisition continued all day (boring is good!)

Monday 11th September 2023 (254)
DASI acquisition continued all day

Tuesday 12th September 2023 (255)
01:00 We arrived to the DASI profile end 10 km seaward of the first instrument (101)
02:30 Beginning of DASI rise. We turned the magnetometer off
02:55 Beginning of magnetometer recovery
04:20 DASI is switched off
04:50 DASI on deck, beginning of the antenna recovery.
05:36 USBL on deck
06:00 Deep tow magnetometer on deck, end of DASI recovery. We headed to the station 101 for recovery.
The initial check showed that the deep tow magnetometer did not record any data due to the pressure case applying pressure on the SD card.
07:10 Beginning of the navigation survey at the site 2-101. The surveys are done at a speed of 4.7 kn. The instruments respond the acoustic pings from ~ 3 or 2 km distance.
07:48 Release signal sent to 2-101.The release signal uses battery power to burn the wire connecting the instrument and the anchor. The instrument rosed with a speed of 30 m/min. In 4844 m water depth, the rising time was 161.5 minutes (~2.69 h).

08:15 headed to the station 1-102. The raise rate of the Scripps instruments is 20 m/min. The instrument was located at 4800 m depth and the raise took 4 h. To have this instrument on surface one hour after releasing the previous one, we would have pinged it at 8:30.
09:00 The instrument 1-102 surveyed and released. Headed to 103.
09:35 Surveying the instrument 1-103
09:50 103 released. ETA 13:37, heading back to 2-101
10:28 Instrument 2-101 on surface
10:46 Instrument 2-101 on deck (Fig. 8).
13:00 Instrument 1-102 on surface
13:34 Instrument 1-102 on deck
14:06 Instrument 1-103 on deck
15:10 Survey and release the instrument 2-104
16:11 survey and release the instrument 1-105
16:59 survey and release the instrument 1-106
18:08 Instrument 2-104 on deck
20:20 Instrument 1-105 on deck
21:43 Instrument 1-106 on deck
23:00 Survey and release the instrument 2-108

Wednesday 13th September 2023 (256)
00:08 Survey and release the instrument 1-107 – problem in release had to be released again later
01:14 Survey and release the instrument 1-109
01:40 Instrument 2-108 on deck
05:40 Instrument 1-107 on deck – there is 4 h between this one and the previous one because, due to failed release command, we had to wait 4 h.
05:36 LEM2 (1-151) surveyed and released
06:14 Instrument 1-109 on deck
07:14 LEM2 (1-151) on deck
08:20 Survey and release the instrument 1-110
09:18 Survey and release the instrument 1-111
10:20 Survey and release the instrument 1-113
11:00 The instrument 2-112 surveyed, but not released.
12:43 Instrument 1-110 on deck
13:30 Instrument 2-112 released
13:56 Instrument 1-111 on deck
14:45 Instrument 1-113 on deck

16:30 Instrument 2-112 on deck
17:39 Survey and release the instrument 1-114
18:37 Survey and release the instrument 1-115
20:10 Survey and release the instrument 1-117 – but the instrument did not respond
20:10 Instrument 2-116 released by mistake – without navigation survey
22:00 Instrument 1-114 on deck
23:02 Instrument 2-116 on deck
23:37 Instrument 1-115 on deck


Figure 8: Recovery of a OBIC instruments using the starboard winch.

Thursday 14th September 2023 (257)
00:36 Giving up on the instrument 1-117, which is not responding – LOST
01:20 Survey and release the instrument 1-118
02:20 Survey and release the instrument 1-119
03:30 Survey and release the instrument 1-121
04:20 Survey the instrument 2-120
05:48 Instrument 1-118 on deck
06:45 Release the instrument 2-120
07:25 Instrument 1-119 on deck
08:25 Instrument 1-121 on deck
09:08 Instrument 2-120 on deck
10:10 Survey and release the instrument 1-122
11:00 Survey and release the instrument 1-123
13:05 Survey and release the instrument 1-125
13:36 Survey and release the instrument 2-124
14:53 Instrument 1-122 on deck
15:32 Instrument 1-123 on deck
16:29 Instrument 2-124 on deck
18:11 survey and release the instrument 2-126
20:39 Instrument 2-126 on deck
22:00 We stopped working due to incoming bad weather and had to leave the project area to avoid worst weather.

Friday 15th September 2023 (258)
01:57 The RRS James Cook re-entered the Irish EEZ in position 49° 07'N 013° 48'W.
07:30 In the daily meeting with the captain, we decided to resumed the recovery from the NE (landward) end of the profile.

09:30 Survey and release the instrument 1-148
10:00 Survey and release the instrument 2-149
11:51 Instrument 1-148 on deck
12:57 Instrument 2-149 on deck
13:40 Survey and release the instrument 1-147
15:00 Survey and release the instrument 1-146
16:05 Survey and release the instrument 1-145 – did not respond to the release command immediately.
17:23 Instrument 1-147 on deck
18:51 Instrument 1-146 on deck
21:10 Survey and release the instrument 1-143 – But the instrument did not leave the bottom
22:17 Survey and release the instrument 142
23:59 Instrument 145 on deck

We recovered 4 OBSs during the daylight. 1-145 that we released in the afternoon did not rise immediately and we had to release it again. Whilst we waited for this one, we surveyed 2-144, but as it is an OBIC instrument we did not release during night. We moved to 1-143 and 1-142 for survey and released them, then went back to 1-145 and recover it.

Saturday 16th September 2023 (259)
01:43 Instrument 1-143 on deck
02: 40 Instrument 1-142 on deck
02:50 Survey and release LEM1 (1-150)
03:50 Survey and release the instrument 2-144 - but had some difficulties in communicating with this instrument.
05:50 Instrument 1-143 on deck
09:00 Survey and release the instrument 1-141
09:30 Survey and release the instrument 2-140
10:40 Survey and release the instrument 1-139 – but the instrument did not leave the seafloor
12:09 Instrument 2-140 on deck
13:09 Instrument 1-141 on deck
13:50 release the instrument 1-139 again
15:05 Survey and release the instrument 1-138.
16:15 Survey and release the instrument 1-137
18:27 Instrument 1-139 on deck
19:27 Instrument 1-138 on deck
20:08 Instrument 1-137 on deck
21:45 Survey and release the instrument 1-135

Sunday 17th September 2023 (260)
01:20 Survey and release the instrument 1-133
02:15 Instrument 1-134 on deck
03:00 Instrument 1-135 on deck
04:13 Instrument 2-136 on deck
05:36 Survey and release the instrument 1-133


Figure 9: Seismic gun deployment

05:55 Survey and release the instrument 2-132
07:26 Survey and release the instrument 1-131
08:24 Instrument 2-132 on deck
09:40 Giving up on the instrument 1-133 that did not rise – LOST
11:31 Instrument 1-131 on deck
12:10 Survey and release the instrument 1-130
13:20 Survey and release the instrument 1-127
14:20 Survey and release the instrument 1-129
16:27 Instrument 1-130 on deck
17:54 Instrument 1-127 on deck
18:30 Survey and release the instrument 2-128
19:09 Instrument 1-129 on deck
19:40 CTD deployed
21:20 CTD on deck
22:13 Instrument 2-128 on deck

After the recovery of the least instrument, due to bad weather, we could not deploy the instruments in the planned southern line. We headed to north, to shoot on the EXA south fibre optic cable (previously named as Hibernia South) to perform seismic shooting on a fibre optic cable interrogated by the interferometry of the National Physics Laboratory. We only had a short window that allowed the deployment and recovery of the guns. We decided to start deploying the guns with the daylight tomorrow and try to go fast to reach the fibre before the daylight.

Monday 18th September 2023 (261)
06:10 MMO started before gun deployment for the fibre optic shooting
07:10 Soft start, followed by shooting on the fibre optic (line 10149-05), with 60 s shooting interval
09:04 end of the line, we are starting to recover the guns because the weather worsens in the afternoon.
We headed to the instrument 1-133 to try to recover it
19:00 Multibeam off, sending the release signal to the instrument 1-133 but no response
19:24 Multibeam on
19:43 Surface Magnetometer deployed

Tuesday 19th September 2023 (262)
We acquired surface magnetic and gravity data during the entire day as we could not deploy anything else.

Wednesday 20th September 2023 (263)
05:47 We finished the transit from the southwest magnetic box to the NE end of the profile and recovered the surface magnetometer before the turn to the line.
08:20 We deployed the deep tow magnetometer with a speed of 2 kn, using the LEM launcher. The magnetometer is towed at 200 m from the sea bottom at 25 m distance from the LEM launcher. For the data quality, we needed to tow it at 2 kn, but we decided that we may end up going faster, up to 3 kn, to escape the bed weather if required. Everything was secured safely on the LEM launcher in case we needed to go faster. The magnetometer is

operated at 125 Hz sampling frequency, along the line. But following very closely the line is not required due to the footprint of the potential filed measurements. We also deployed the surface magnetometer in order to compare the surface and deep tow datasets.
13:15 Deeptow magnetometer lost communication. We were suspecting a battery issue and started the recovery.
17:08 The fibre optic wire is pulled back and the deep tow magnetometer and the tow fish were no longer attached to the wire. A portion of the winch fibre optic cable was also broken. Surface magnetometer is redeployed and towed along legacy seismic profiles.

Thursday 21st September 2023 (264)
17:21 surface magnetometer is recovered. The weather at the PAP buoy looks good for the buoy recovery. We are heading to the buoy.

Friday 22nd September 2023 (265)

Figure 10: PAP buoy recovery.

PAP buoy recovered (Fig. 10), heading back to the survey area for more gravity survey
17:25 Surface magnetometer is redeployed to acquire data from location of legacy seismic profiles

Saturday 23rd September 2023 (266)
18:00 surface magnetometer is recovered.
End of gravity and magnetic surveying. We are heading to the Witthard Canyon for the bathymetric survey to image the cable break points

Sunday 24th September 2023 (267)
In order to make good use of the remaining science time, we started one of the southern channels of Witthard Canyon. We sampled four cable break points. However, the weather did

not improve to allow good quality multi-beam data acquisition, therefore we finalised our cruise and sailed back to Southampton

Monday 25th September 2023 (268)
Sailing back to Southampton

Tuesday 26th September 2023 (269)
Sailing back to Southampton, docking

6 Equipment and data acquisition

6.1 The electromagnetic source DASI

The Deep-towed Active Source Instrument (DASI) is an electromagnetic transmitter that is towed above the seafloor (Fig. 11), typically at a constant altitude between 50 and 100 meters. Used in conjunction with ocean bottom electromagnetic (OBEM) receivers, and/or towed receivers, Vulcans, DASI performs Controlled Source ElectroMagnetic (CSEM) surveys to infer the resistivity distribution of seafloor.

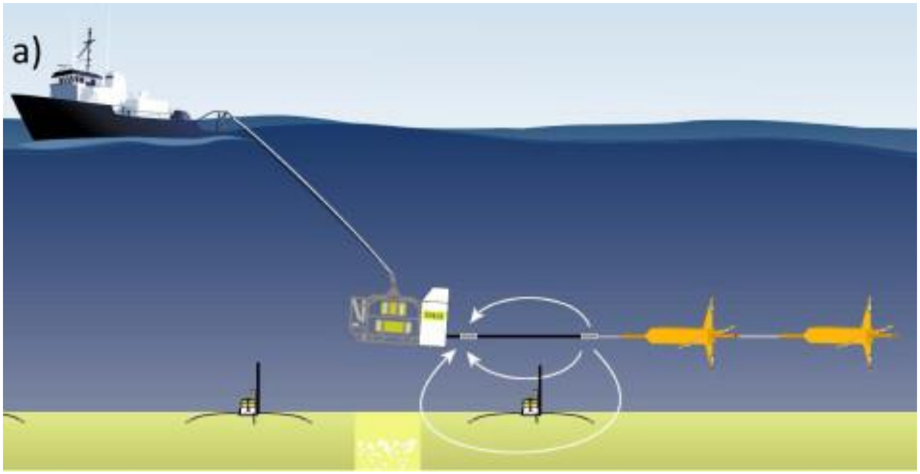


Figure 11: a) Sketch of the University of Southampton towed CSEM transmitter DASI with its two pressure tubes towing the dipole transmitting antenna array (White lines represent current streamlines generated by the 300 m antenna), and the three-axis electric filed Vulcan receiver towed behind DASI. Note that in the Goban Spur experiment, we couldn't deploy the Vulcan receivers because we did not receive the dual-purpose export licensing on time before sailing. Therefore, DASI is only recorded by the seafloor instruments. Figure Gehrmann et al, 2021.

The DASI transmits very low frequency electromagnetic waves (typically between 0.25 and 25 Hz) into the seafloor (Fig. 11). These electromagnetic waves propagate through the seafloor and are detected by the OBEM or Vulcan receivers. Using the strength and timing of these received electromagnetic signals a 2D slice or 3D map of the changing electrical resistivity in the seafloor can be produced.

The DASI system has 4 main components; a ship board power supply, a deep tow cable, the DASI transmitter itself and the shipboard control system. The shipboard power supply provides high voltage (~1.5 kV) alternating current electrical power to DASI. The deep tow cable tethers DASI to the survey ship, conducts the high voltage electricity from the power supply to DASI and, via an inbuilt optical fibre, allows real time control and monitoring of DASI during the survey. The DASI transmitter takes the high voltage electricity supplied via the deep tow cable, transforms it to a much lower voltage (~20-50 V) direct current, then switches this direct current into the antenna that trails behind DASI. The antenna has two wires that connect to two inline copper tube electrodes separated by 300 meters along the length of the antenna. The copper tube electrodes transmit the switched DC current into the water, thus producing very low frequency electromagnetic waves that propagate in the seafloor. The shipboard control system is used to control the timing of the transmitted very low frequency electromagnetic waves and its shape or waveform. The shipboard control system also logs the waveform transmitted by DASI (Fig. 12) to assist in subsequent data interpretation. Instructions on how to run DASI are in Annex A (How to run DASI).

6.1.1 DASI deployment

Before deployment the two pigtails for the near side and far side antennas are attached to DASI (Fig. 6). DASI long side antenna was rolled on a drum and it is being deployed first. The deployment started with the parachute followed by the magnetometer that was located in a Vulcan case and attached to the rope at the end of the antenna by a Vulcan harness. Then, the Vulcan case containing the back side USBL, also connected to the rope with a Vulcan harness and a glass sphere to allow neutral buoyancy were deployed. The 30 m cupper electrode is then deployed followed by the antenna of 300 m. The antenna was made of two pieces: one 100 m section followed by a 200 m section. A stain relief was added to the junction between two parts of the antenna and glass sphere for buoyancy is attached to the middle part of the 200 m section of the antenna via a rope cross rolled around the antenna that allows clipping instruments to a cable and avoids friction. A telemetry cable was rolled with the near side of the antenna, but is not used for this deployment. At the end of the antenna 10 m ship's rope (same length of the pigtail) was rolled on the winch to carry the weight of the antenna during the connection of the pig tail, which was already connected to DASI before unrolling the antenna. After the long side deployment, the short side which consists of the pig tail (10 m) and the copper electrode (30 m) is deployed manually. Then DASI is deployed using the aft winch and side ropes. The whole deployment took 1 h.

JC251 was the first deployment of the refurbished DASI system. The refurbishment was conducted by Ocean Floor Geophysics Inc. of Canada. DASI was re-engineered to allow more complex waveforms to be transmitted when compared to the previous version of DASI. Specifically, the refurbished DASI was used to transmit waveform type D (Myer, 2011) which results in a broader spread of low frequency electromagnetic waves being transmitted. This, in turn, benefits subsequent data interpretation and inference of geological structure.

6.1.2 Known faults

Several faults on the new DASI transmitter system were discovered during the cruise:

- The control electronics shield/case supplied by OFG fouls on the µC PCB supplied leading to component solder joints being compromised causing electrical/communication issues.
  Rectified by resoldering DD8 KSZ8081MNX Ethernet Transceiver.
  Also, the shield lid is removed to prevent further fouling.

- Internal wiring from µC RJ45 to MUX uses too small wire gauge for phoenix connector.
  Wires dislodge when moved.
  This disconnects the microcontroller from the fibre topside control. This has been glued in place but requires appropriate re-termination (or new cable).

- The SD card often gets electrically dismounted – likely due to the spring-loaded slot and movement from use.
  Alternative card mounts should be investigated.

- The ST-ST fibre connector mounted on the bulkhead of the PC104 stack case leads to unreliable fibre connections.
  This could be due to damage or connector tolerances. Replace connector or redesign fibre path

- The topside power supply must be run at 1.55kV.
  When transmitting at 1.5kV or below communications are lost. Current theories include 200VDC/24VDC (in/out of VICOR DC/DC) voltage sag from antenna current draw.
  When run at 1.6kV and above the system records nothing on all ADC channels (noise?)
  This means that the output current of DASI cannot be adjusted when transmitting. Current is weakly adjusted by shortening/lengthening copper electrodes to vary Antenna impedance.

- The topside power supply overheats very quickly. It requires additional cooling externally. There are two high wattage power resistors in the topside power supply which generate noticeable heat and hindering DASI’s maximum output current capability. The requirement for these resistors should be investigated. The purpose for these resistors is perhaps to damp LC oscillations on the deep tow length.

- After prolonged use (more than 1 day), Antenna current switching events occasionally generate stepped transitions (see figure 1), leading to partial deadtime between the Positive and Negative supply rails.
  Investigation further requires a new Antenna load simulator to replicate these effects on land. Previous land tests use a higher impedance coil to replicate previous Antenna designs.
  Antenna used for JC251 is #2/0 Aluminium wire supplied by Scripps. It is much lower impedance than previous Antennas (new antenna is about 0.16 Ω)

Figure 12: DASI.exe view, for monitoring output current and voltage status

6.2 Seismic airgun array

Bolt LL airguns were used for the seismic acquisition. The initially planned array consisted in 14 guns with a total volume of 5700 cu.in. The largest two 700 cu.in volumes were towed by ropes and other 12 volumes were mounted on 4 beams with 3 guns each.

According to the MEIP requirements, airgun shooting can only start during daylight. In order to be ready for shooting right after deployment, the deployment of the airgun array is conducted simultaneously with the MMO observations. The guns are deployed starting by the inner port beam, and using the corner winch (Fig. 9). First the cherry buoy that helps maintaining the guns at a constant depth is deployed, followed by the port inner beam. Then the port outer beam is deployed. The starboard side is deployed with the same order and the magnetometer is deployed from the starboard side. The two-single beam of 700 cu.in. are deployed manually. The centres of four beams were located at 66 m from the ship and the two single beams were towed at 20 m from the ship. The distance between the ships central reference point and the centre of source for this array is given in Figure 13. Deployment of the entire array took 2 hours and it was followed by soft start which consisted in adding guns to the array stepwise.

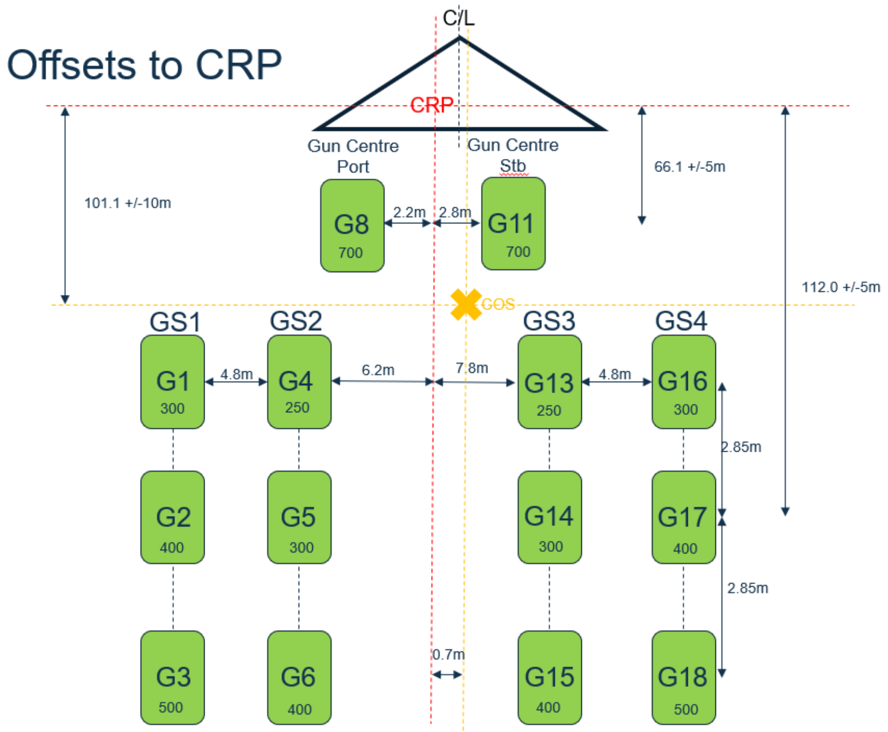


Figure 13: Source array, design configuration, with offsets to the ship's central reference point (CRP), centre of source (COS) and gun volumes.

We first explored the option of triggering the shots using Avalon gun controller which allows triggering the shots using a GPS clock and allowing to keep a constant shot interval in a greater time precision than the Big Shot gun controller. However, Avalon can only trigger shots with shot intervals shorter than 60 s. Therefore, for the lines 10149-01 and 10149-02 we used Big Shot to allow 90 s shot interval. For the lines 10149-03 and JC251-05 with 30 s and 60 s shot intervals respectively, we switched to Avalon shot controller. All shots are done with 2000 psi compressor pressure. After gun tests and soft start, the seismic acquisition started on the 3rd of September at 21:33.

*Table 2: Source parameters of each survey line. The Volume and COS are the **final** values, after guns disabled on the line. This is provided as a summary only; COS should be re-calculated at each point a gun is disabled.*

Line	Gun controller	Array Initial Config	Shot Interval (s)	Final volume (cu.in)	Final COS (m) +fwd,+stbd	First shot point	Start	Last shot point	End
JC251-10149-01	Big Shot	G1,2,3,4,5,6,8, 11,13,14,15,16, 17,18	90±1	3300	-111.74, 0.80	1	2023/09/03 21:33:48	335	2023/09/04 06:00:53
JC251-10149-02	Big Shot	G1,2,3,4,5,6,8, 11,13,14,15,16, 17,18	90±1	4900	-99.00, 1.43	1002	2023/09/04 13:56:20	2308	2023/09/05 22:59:50
JC251-10149-03	Avalon	G1,2,4,6,11,13,15,16,17,18	30	3900	-101.91, 2.67	3009	2023/09/06 03:10:20	6563	2023/09/07 08:53:55

JC251-05	Avalon	G1,2,3,8,11,16,17,18	60	3800	-95.39, 0.62	1	2023/09/18 07:32:18	93	2023/09/18 09:04:18

During the line JC251-10149-01 two large single guns (2 x 700 ci.in) did not show the return signal generated by the solenoid after the actual shot (called aim point) which was set to occur 50 ms after the trigger point. The gun 18 which is the 500 cu.in gun at the outer starboard beam did send a solenoid signal but the waveform of the signal indicated that this gun was misfunctioning. Extensive top side testing is carried out to investigate a top-side misfunctioning including changing the delay between the trigger and the aim point, the peak detection threshold, and the peak search window as well as automatic or manual detection. Channels were swapped to make sure that the problem does not lie in the Big Shot gun controller unit. Tests indicated that the misfiring and synchronisation issue was likely to be related with the hardware instead of the top side. Since seismic can only be started during the daylight, we continued shooting with a smaller total volume of 3800 cu.in. along this line, until the daylight. Around 5 am, we also lost the port aft 500 cu.in gun, which started to shoot earlier than the aimpoint. Big shot can only apply a positive delay to correct the delay between the trigger point and the actual shot. As it was not possible to correct the timing of the port aft 500 cu.in gun by applying a negative delay, the gun was turned off decreasing the total volume to 3300 cu.in. The total volume become too small for a crustal seismic acquisition and we aborted the acquisition. We recovered the seismic guns to fix them and redeploy them during the daylight. The gun repair took about 2 hours and consisted in changing the solenoids. During the gun repair we sailed back seaward, to the start of the profile in order to acquire the full profile starting at 50 km seaward of the first instrument.

The second seismic acquisition (JC251-10149-02) started at 4th of September at 13:56 with full gun array. However, the 500 cu.in gun that was misfiring during the first line kept sending back an erroneous waveform and had to be turned off reducing the total volume to 5200 cu.in. Later, one of the 300 cu.in. gun (gun 14) also started to misfire, reducing the total volume to 4900 cu.in.

At the end of the line JC251-10149-02 the DASI repair was not finished. We extended the seismic line 90 kn landward of the instrument 49, to acquire a refraction profile of the same length as the PAD13-40D multi-channel seismic line. We then continued acquiring the same line with a smaller gun volume and shot interval (JC251-10149-03) and by generating the shots via Avalon gun controller that allows better time precision for the shot interval. The analysis of the previous lines acquired using Big Shot showed that the time precision of this gun controller is ± 1 s.

The last seismic line JC251-05 was an opportunistic initiative. Due to the weather conditions, we were unable to deploy the OBIs on the planned southern line or tow the deep tow magnetometer. We therefore when we had half a day of operable weather decided to deploy the seismic guns and shoot on the Hibernia fibre optic cable interrogated by the National Physical Laboratory. As the weather was still not ideal for the gun deployment, we only deployed the guns on the beams and avoided to deploy the two central 700 cu.in guns which could have hit the boat or get tangled due to the sea state.

Table 2 summarises source parameters and start and end times and shot numbers of all seismic profiles. Table 3 gives the start and end coordinates of all profiles including seismic, electromagnetic and magnetic profiles. Additionnal information on surface magnetometer acquisition can be found in Annex B (JC251-SSS-Cruise-Report), together with information on underway geophysical acquisition. Detailed information on the shot numbers along the lines, gun volumes corresponding to each shot and gun misfiring's can be found in the Annex C (JC251-Seismic-Acquisition-Report).

Line number	Method	Start lon	Start lat	End lon	End lat	Start time	End time
JC251-10149-01	Seismic	-15.971153	48.088847	-15.528837	48.284073	03-Sep-2023 21:33:46.83	04-Sep-2023 02:11:36.52
JC251-10149-02	Seismic	-15.841573	48.130337	-12.429530	49.747243	04-Sep-2023 13:54:47.18	05-Sep-2023 22:59:03.39
JC251-10149-03	Seismic	-12.736942	49.592525	-15.806457	48.146220	06-Sep-2023 03:11:08.53	07-Sep-2023 08:53:24.07
JC251-10149-04	Electromagnetic	-13.178504	49.394926	-15.519965	48.288468		
JC251-05	Seismic (Fibre optic)	-15.174910	50.021545	-15.343393	50.107440	18-Sep-2023 07:06:16.48	18-Sep-2023 09:04:16.48
JC251-06	Magnetic	-13.6184803	48.429472	-15.166759	47.660735	18-Sep-2023 19:44:15.29	21-Sep-2023 17:14:02.50
JC251-07	Magnetic	-12.7721525	49.105756	-12.772078	49.105795	22-Sep-2023 17:37:08.73	23-Sep-2023 18:23:56.12

Table 3: Summary of acquisition.

6.3 Ocean Bottom Instrument

JC251 deployed a total of 51 Ocean Bottom Instruments: 35 Scripps instruments with horizontal electrode dipoles, MT coils and hydrophones (5-channel instruments), 2 Scripps Long wire electromagnetic (LEM) instrument horizontal electrode dipoles with 200 m long antennas, 14 OBIC instruments with 2 horizontal EM dipoles, 3 component geophones and hydrophones (12-channel instruments) with 4 of them with additional 3 component fluxgate magnetometers. The Fig 14 shows the location of the instruments. Tables 2 summarises the deployment and recovery positions of the instruments and the Table 3, the instrument positions from the navigation surveying.

OBS no	1=Scripps 2=OBIC	deployment time	dep lon	dep lat	dep depth	recovery time	rec lon	rec lat
1	2	2023:245:00:27	15 24.697	48 20508	4838	2023:255:10:46	15 25.409	48 20.519
2	1	2023:244:23:45	15 22.085	48 21.791	4840	2023:255:13:35	15 22.983	48 22.025
3	1	2023:244:22:57	15 19.451	48 23.077	4839	2023:255:14:46	15 20.435	48 23.285
4	2	2023:244:22:24	15 16.838	48 24.352	4839	2023:255:18:08	15 18.464	48 24.673
5	1	2023:244:2137	15 14.215	48 25.635	4846	2023:255:20:20	15 15.670	48 26.008
6	1	2023:244:21:02	15 11.601	48 26.920	4835	2023:255:21:43	15 13.025	48 27.318
7	1	2023:244:20:25	15 08.983	48 28.186	4839	2023:256:05:04	15 10.316	48 28.391
8	2	2023:244:19:55	15 06.360	48 29.461	4834	2023:256:01:54	15 05.651	48 30.035
9	1	2023:244:19:15	15 03.742	48 30.722	4814	2023:256:06:14	15 05.164	48 31.026
10	1	2023:244:18:23	15 01.128	48 31.998	4770	2023:256:12:43	15 01.878	48 32.328
11	1	2024:244:17:40	14 58.494	48 33.275	4817	2023:256:13:56	14 59.096	48 33.744

12	2	2023:244:16:54	14 55.886	48 34.556	4728	2023:256:16:30	14 56.330	48 35.318
13	1	2023:244:16:14	14 53.233	48 35.819	4767	2023:256:14:45	14 53.714	48 36.325
14	1	2023:244:15:19	14 50.592	48 37.096	4758	2023:256:22:00	14 51.295	48 37.280
15	1	2023:244:14:30	14 47.962	48 38.362	4734	2023:256:23:37	14 48.351	48 38.047
16	2	2023:244:14:04	14 45.432	48 39.636	4726	2023:256:23:02	14 45.545	48 39.379
17	1	2023:244:13:30	14 42.694	48 40.895	4625			
18	1	2023:244:12:53	14 40.046	48 42.164	4722	2023:257:05:48	14 40.948	48 42.549
19	1	2023:244:12:10	14 37.399	48 43.425	4592	2023:257:07:25	14 38.965	48 43.735
20	2	2023:244:11:42	14 34.775	48 44.677	4663	2023:257:09:05	14 35.312	48 44.743
21	1	2023:244:11:07	14 32.115	48 45.936	4631	2023:257:08:20	14 46.145	48 46.143
22	1	2023:244:10:31	14 29.463	48 47.205	4656	2023:257:14:53	14 29.363	48 46.968
23	1	2023:244:09:57	14 27.292	48 48.235	4632	2023:257:15:32	14 27.394	48 48.034
24	2	2023:244:09:16	14 22.553	48 50.486	4615	2023:257:16:28	14 22.546	48 50.404
25	1	2023:244:08:48	14 21.494	48 50.978	4625	2023:257:17:00	14 21.580	48 50.803
26	2	2023:244:08:19	14 18.834	48 52.235	4607	2023:257:20:38	14 19.297	48.51.993
27	1	2023:244:07:43	14 16.152	48 53.474	4611	2023:260:17:54	14 16.453	48 53.238
28	2	2023:244:07:09	14 13.502	48 54.751	4577	2023:260:22:13	14 13.557	48 54.544
29	1	2023:244:06:26	14 10.836	48 55.998	4562	2023:260:18:20	14 11.783	48 55.827
30	1	2023:244:05:34	14 08.154	48 57.245	4546	2023:260:16:27	14 08.256	48 56.854
31	1	2023:244:04:52	14 05.440	48 58.509	4517	2023:260:11:10	14 05.79	48 57.678
32	2	2023:244:04:13	14 02.716	48 59.744	4506	2023:260:08:24	14 03.208	48 59.599
33	1	2023:244:03:37	14 00.082	49 01.009	4504			
34	1	2023:244:02:57	13 57.458	49 02.258	4490	2023:260:02:14	13 57.519	49 01.190
35	1	2023:244:02:17	13 54.773	49 03.511	4407	2023:260:03:00	13 54.916	49 02.578
36	2	2023:244:01:50	13 52.105	49 04.747	4464	2023:260:04:13	13 52.138	49 04.163
37	1	2023:243:01:16	13 49.413	49 05.989	4451	2023:259:20:08	13 49.885	49 05.578
38	1	2023:244:00:38	13 46.736	49 07.234	4417	2023:259:19:27	13 47.226	49 06.854
39	1	2023:243:23:52	13 44.040	49 08.470	4380	2023:259:18:27	13 44.065	49 08.104
40	2	2023:243:23:25	13 41.338	49 09.717	4325	2023:259:12:09	13 41.402	49 09.312
41	1	2023:243:22:57	13 38.657	49 10.961	4116	2023:259:13:09	13 38.493	49 10.688
42	1	2023:243:22:23	13 35.959	49 13.202	4113	2023:259:02:40	13 35.694	49 11.881
43	1	2023:243:21:41	13 33.265	49 13.437	4123	2020:259:05:50	13 33.566	49 13.136
44	2	2023:243:13:48	13 30.211	49 14.830	4039			
45	1	2023:243:13:19	13 27.860	49 15.916	4003	2023:258:23:59	13 28.561	49 16.177
46	1	2023:243:12:48	13 24.155	49 17.149	3903	2023:258:18:51	13 25.846	49 17.737
47	1	2023:243:12:14	13 22.440	49 18.388	3808	2023:258:17:23	13 23.036	49 18.809
48	2	2023:243:11:46	13 19.736	49 19.619	2638*	2023:258:11:50	13 19.958	49 19.542
49	1	2023:243:11:06	13 17.025	49 20.850	2975	2023:258:12:50	13 17.309	49 10.778
50	LEM1	2023:245:03:31	15 02.329	48 31.431	4798	2023:256:07:14	15 07.320	48 29.868
51	LEM2	2023:243:19:03	13 37.147	49 11.654	4069	2023:259:04:58	13 34.879	49 12.599

Table 4: Deployment and recovery time and coordinates of the instruments. The grey shaded instruments are lost and coordinates written with red fonts were not logged correctly. Scripps: 1, OBIC:2. Coordinates are in degree minute decimal.

instr	nav (E	N	Z)	nav std (E	N	Z)
01	469216.1	5354134.1	4852.9	1.5	2.1	0.2
02	472497.2	5356477.9	4850.6	1.5	2.1	0.1
03	475752.9	5358885.7	4851.4	1.4	2.6	0.1
04	478970.8	5361216.3	4856.8	3.2	4.9	0.3
05	482181.1	5363952.2	4836.7	5.7	8.6	1
06	485421.9	5366443.2	4799.2	8.3	10.7	1.1
07	488935	5368507.2	4789.9	8.7	10.3	0.9
08	492122.2	5371244.9	4840.4	1.5	1.9	0.2
l02 (50)	491790.5	5370777.7	4846.9	2	3.2	0.3
09	495560.1	5373011.8	4293.7	9.9	14	1.9
10	498210.5	5376009.3	4775.7	3.8	7.6	1.3
11	501499.2	5378317.3	4830.1	1.3	2.5	0.4
12	505065.2	5380139.7	4785.9	20.9	27.8	1
13	507970.4	5383142	4763.5	1.2	2	0.3
14	511221.2	5385498.2	4772.6	1.1	1.5	0.3
15	514501.5	5387760.5	4748.1	1	2	0.3
16	517742.2	5390032.1	4769.1	199.2	272.6	2.6
18	524213.9	5394659.7	4682.3	2.9	4.2	0.4
19	527528.2	5396931	4596.9	1.3	1.9	0.2
20	530753.3	5399192.5	4677.6	1.4	1.9	0.1
21	534116.5	5401447.2	4655.4	1.3	1.7	0.1
22	537382.2	5403816.8	4669.6	1.6	2.2	0.2
23	540065.3	5405655.6	4655.5	2.3	3.1	0.3
24	545908.7	5409779.9	4640.2	1.4	2	0.2
25	547151.8	5410759.8	4634.5	1	2	0.2
26	550389.5	5413073.6	4634.7	1	1.4	0.1
27	553623.1	5415422.9	4628.1	85.85	117.4	74.6
28	556713.1	5417993.7	4602.3	9.09	12.47	0.7
29	560178.7	5420179.1	4567.9	20.47	28.05	19.8
30	563252.8	5422807.7	4565	9.5	13	0.3
31	566540.6	5425125.8	4536.3	5.1	6.5	0.6
32	569826.7	5427559.1	4527.6	2.8	4.6	0.3
34	576225.4	5432189.7	4514.3	3.8	5.8	0.3
35	579535.4	5434355.4	4500.9	4.4	5.9	0.5
36	582930.6	5436466.9	4470	2.8	3.2	0.5
37	586304.2	5438692.2	4440	4.9	5.2	1.2
38	588649.7	5442251.5	4390.3	3.1	4.4	1
39	592585.6	5443635.6	4416.5	4.4	7.8	1.1
40	595369.8	5446731.5	4356.8	3.2	4.3	0.6
41	598955.1	5448335	4119.7	2.4	3.7	0.1
42	601842.7	5451261.7	4112.3	7.1	12.2	0.3
l01 (51)	604318.1	5452347.3	4107.9	10.6	13.4	0.4
43	605144.3	5453654.4	4059.1	5.4	8.8	2.1

44	608570.4	5456482.5	4015.3	4.2	5.6	2
45	611539.3	5458481.5	4006.2	9.2	13.1	1.9
46	614962.3	5460562.1	3910.5	4.2	5	0.4
47	618086.6	5462948	3805.7	2.3	3.2	0.1
48	621735.1	5464633.9	2660.8	6.7	9.9	2.5
49	624697.4	5467290.8	3149.8	2.6	2.9	0.7

Table 5: Instrument coordinates obtained after the navigation survey. Instruments 16 and 27 with higher location uncertainties could only be surveyed during the seismic acquisition. A dedicated navigation survey could not be carried out for these instruments.

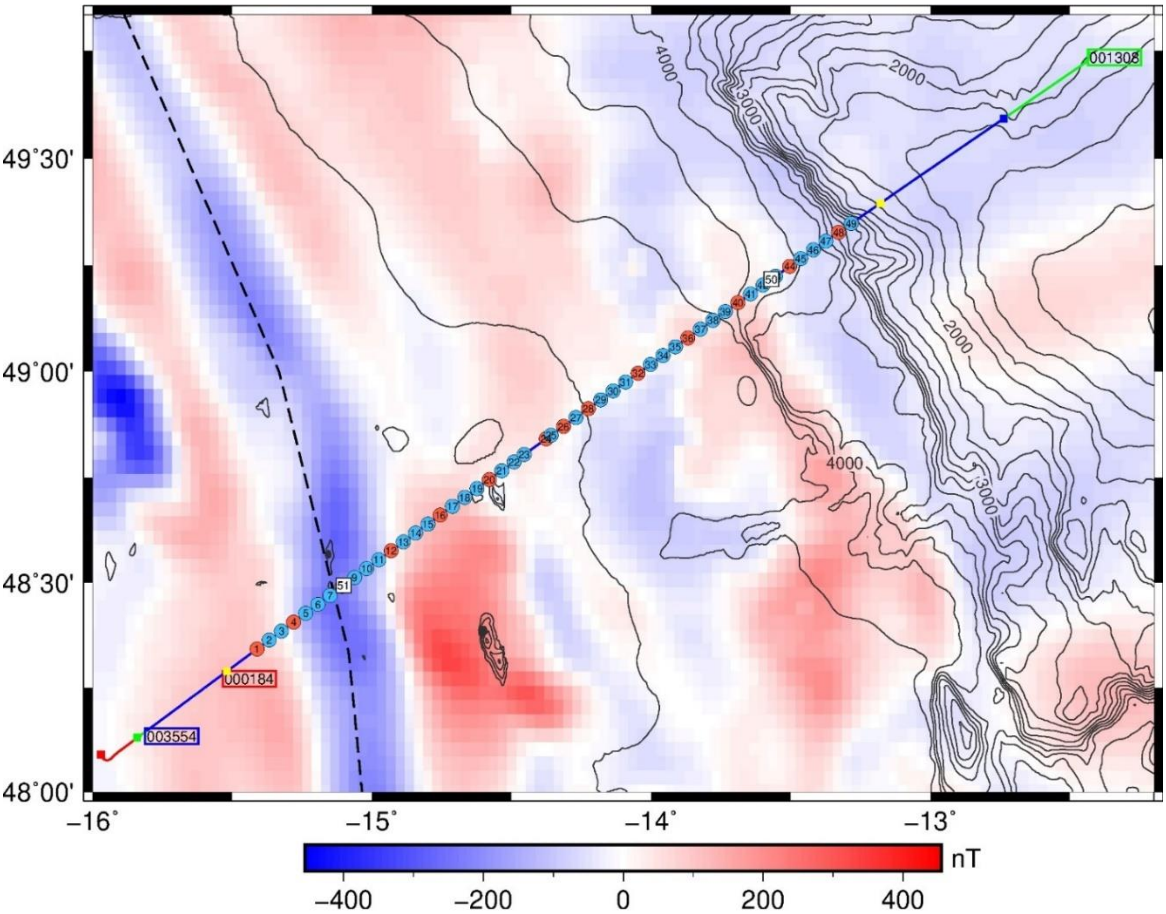


Figure 14 : Location of Scripps (blue) and OBIC (orange) instruments and two Scripps LEM (white squares) instruments. The yellow squares show the beginning and end of the DASI line (JC251 004). The red, green and blue squares show the beginning of the seismic lines and the numbers in the coloured boxes indicate the last shot number in the lines. Red: JC251 001 line that has been aborted due to gun failure. Green: JC251 002 line acquired with 90 s shot interval and 4900 cu. in. gun volume, with a landward direction. Blue: JC251 line 003 acquired with a shot interval of 30 s and a gun volume of 3800 cu. in, with a oceanward direction. The dashed black line shows the magnetic anomaly a 34. The background colours are the magnetic anomalies.

The instrument deployment started on the 31st of August 2023 at 9:30 after the OBIC dip test where the acoustic releasers of all instruments were attached to a frame and deployed to

2000 m deep. All instruments apart from LEMs are deployed from the starboard side. The starboard side crane is used for the deployment and recovery of the Scripps instruments and B-frame and crane were both tested for the deployment of OBIC instruments but later the deployment is done with the crane. LEMs are deployed using the LEM launcher of Scripps which is a tow fish deployed and recovered using the A-frame winch. Once close to the sea-bottom (~10 m altitude) LEMs are released from the launcher by burning the wire attaching them to the launcher. The deployment of 51 instruments took ~ 2 days. Figure 14 shows the location of all deployed instruments.

The recovery of Scripps instruments is carried out using the crane whereas the recovery of the OBIC instruments is done using the starboard winch (B-frame) that was closer to the wet lab where the OBIC instruments were stored (Fig. 5) and gave enough space for the dismantlement of both OBIC and Scripps instruments. The OBIC instruments rose with a speed of 30 m/min whereas Scripps instruments rose at 20 m/min. Since the Scripps instruments contained a GPS, and so they were unlikely to be lost once they surface, we stacked them in the water column by releasing two or three of them consecutively then by releasing only one OBIC instruments and returning back to recover the released Scripps instruments. The order of surveying followed by the release of the instruments can be found in the cruise narrative.

We lost three instruments, two Scripps (1-117 and 1-133) and one OBIC instrument (2-144). The OBIC instrument has responded to both secondary and primary release commands, and the response patterns lead OBIC to believe the problem was in the cables from the release to the burn wire which would imply that the instrument is likely to be attached to the anchor. One of the lost Scripps instruments responded well to acoustics surveying carried out during the airgun tow, but did not respond to the acoustic during recovery, potentially indicating that it has either drifted away or has had a catastrophic failure - flooded release or glass ball implosion. The second Scripps instrument never responded to acoustics on the airgun tow or recovery which may similarly indicate that either the instrument drifted away or had catastrophic failure, or it might have a failed acoustics from the start, in which case it still on the anchor. The weather did not support dragging, and using the ship time for dragging an instrument would not be the best use of ship time.

All instruments were equipped to record both the seismic BOLT LL airgun source and DASI electromagnetic source as well as mangetotelluric data. The data recorded by OBIC instruments are reduced by OBIC engineers and delivered in SEG-Y format of 90s trance length for each channel, daily MSEED files for each channel and netcdf files per instrument. Information on the naming conventions and the directory tree of the data recorded by OBIC instruments can be found in the Annex 2 (OBIC File Description). The dataset recorded by Scripps instruments is processed by Steve Constable and delivered as L-cheapo format with .bin extensions. A Matlab scrip suit is also delivered with the raw data to allow reading the L-cheapo .bin files in Matlab. The conversion to .mat files allows then converting the files in SEGY, MSEED and netcdf formats. The conversion from .mat to SEGY is carried out on land, and SEGY files of 50 s trace length per instrument and per channel were obtained.

Instruments were relocated acoustically, using the hull transducer that emits 12 kHz and the Edgetech top unit. Acoustic survey is carried out with a boat speed of 4.7 kn and the instruments replied to the acoustic ping from the boat at offsets between 3 and 2 km offsets.

The navigation is carried out in a four-shaped survey (Fig. 15) which allowed pining the instruments in two perpendicular lines. Table 5 shows the relocated position of the instruments and the relocation uncertainty.

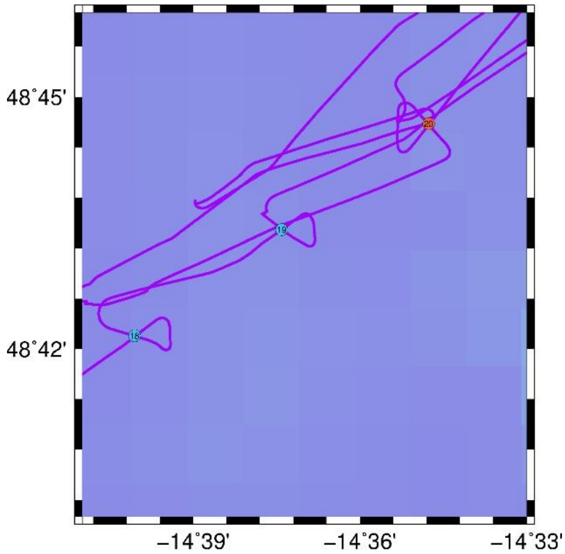


Figure 15: Zoom on the ship's track to illustrate the acoustic navigation surveying for instrument relocation.

6.3.1 SIO OBEM Instruments

Summary

The Scripps OBEM instruments were used with a standard configuration for EM (AC coupled AgCl electrodes with induction coil magnetometers, horizontal components only) but with a HiTech hydrophone operating on the 5th channel for all instruments. Data recovery and quality were somewhat better than average, with zero channels of EM data lost and only one channel of hydrophone data lost. There is tidal motional noise evident on many instruments but not particularly large. A couple of electrode channels havethe occasional spikes that we associate with poor electrode connectors, but far fewer than we have had in the past. Quite a few electrode channels have elevated noise at longer periods for reasons not yet clear, but in the CSEM band the noise is back down to the level of the amplifiers.

We selected a high sample rate (250 Hz) for CSEM recording that would fill the flash cards in 12 days, expecting to have recovered and redeployed them on the second line by then. Fortunately, this was long enough to record the DASI tows, but because of delays in getting DASI working all instruments stopped recording before they were recovered, missing a sizable magnetic storm on the 12th September.

Two instruments were lost: one responded to acoustics during the navigation carried out during the airgunprofile, but did not respond during recovery, and one never responded to acoustic interrogation. These haveeither surfaced prematurely or have had a catastrophic failure (flooding or glass ball implosion).

Two instruments were deployed as Long-wire ElectroMagnetic recorders, or LEMs, with 200 m antenna. They were equipped with 2 parallel redundant electrode pairs, both sampled with AC and DC coupling. These were deployed with our new LEM launching system that uses current loop communication to telemeter depth and altitude to the ship. We used a Valeport CTD-V sensor for depth, so a sound velocity profile wascollected during each deployment. The new deployment system worked very well.

Our instrument fleet included a newly developed deep-towed fluxgate magnetometer, recording data on a standard SIO logger mounted in a neutrally buoyant tow frame. During an initial shallow deployment of DASI it briefly worked very well, but during the main deployment the pressure case pressed down on the flash card causing the socket to break. The logger was swapped and the logger moved in the pressure caseto prevent this happening again, but unfortunately during a later deployment the entire LEM launcher and magnetometer system broke loose from the deep tow cable and was lost.

Magnetotelluric Data

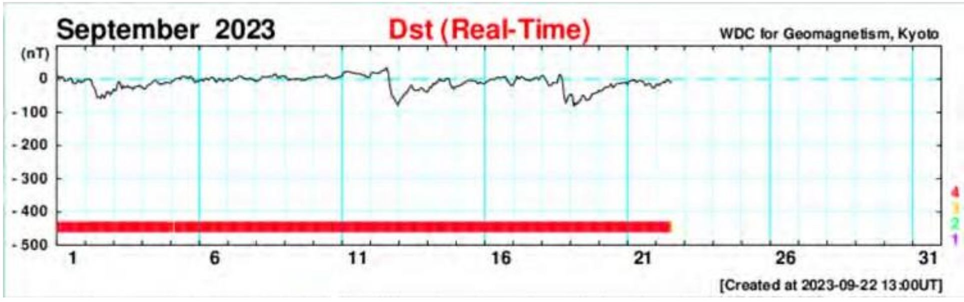


Figure 16: Dst as recorded by Kyoto World Data Center for Geomagnetism

There were two small magnetic storms (50–75 nT) at the start and end of our data recording. The first storm was captured by our instruments but unfortunately the second storm started exactly at noon on the 12th September when the flash cards filled and recording stopped.

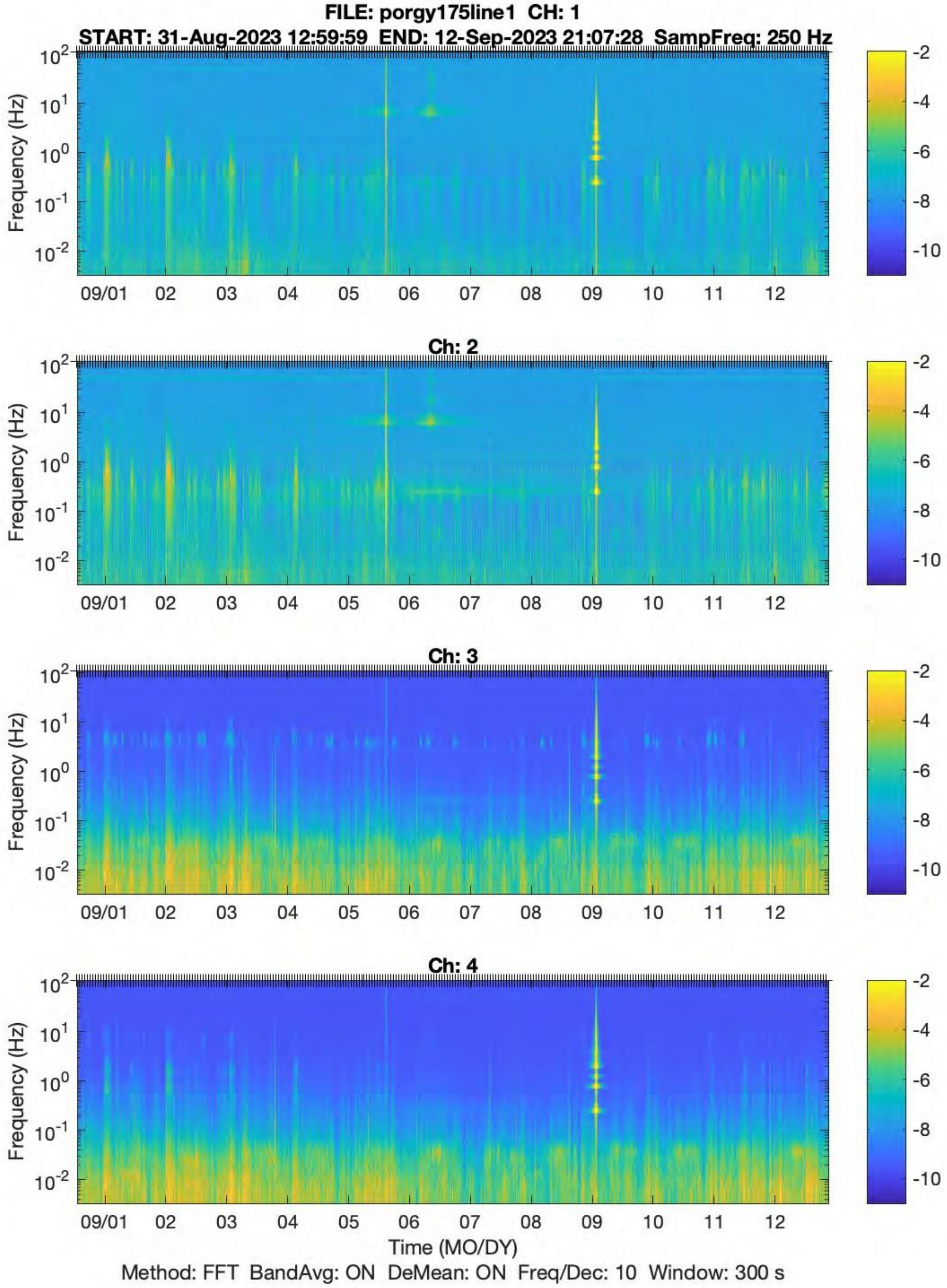


Figure 17: Typical spectrogram of magnetic (Ch 1 and 2) and electric (Ch 3 and 4) fields. The DASI tow on the 9th is evident as the characteristic "Christmas tree" and the airgun signals can be seen on the magneticchannels around the 6th. Tidal signals are evident at the long periods, creating some strumming noise at around 4 Hz.

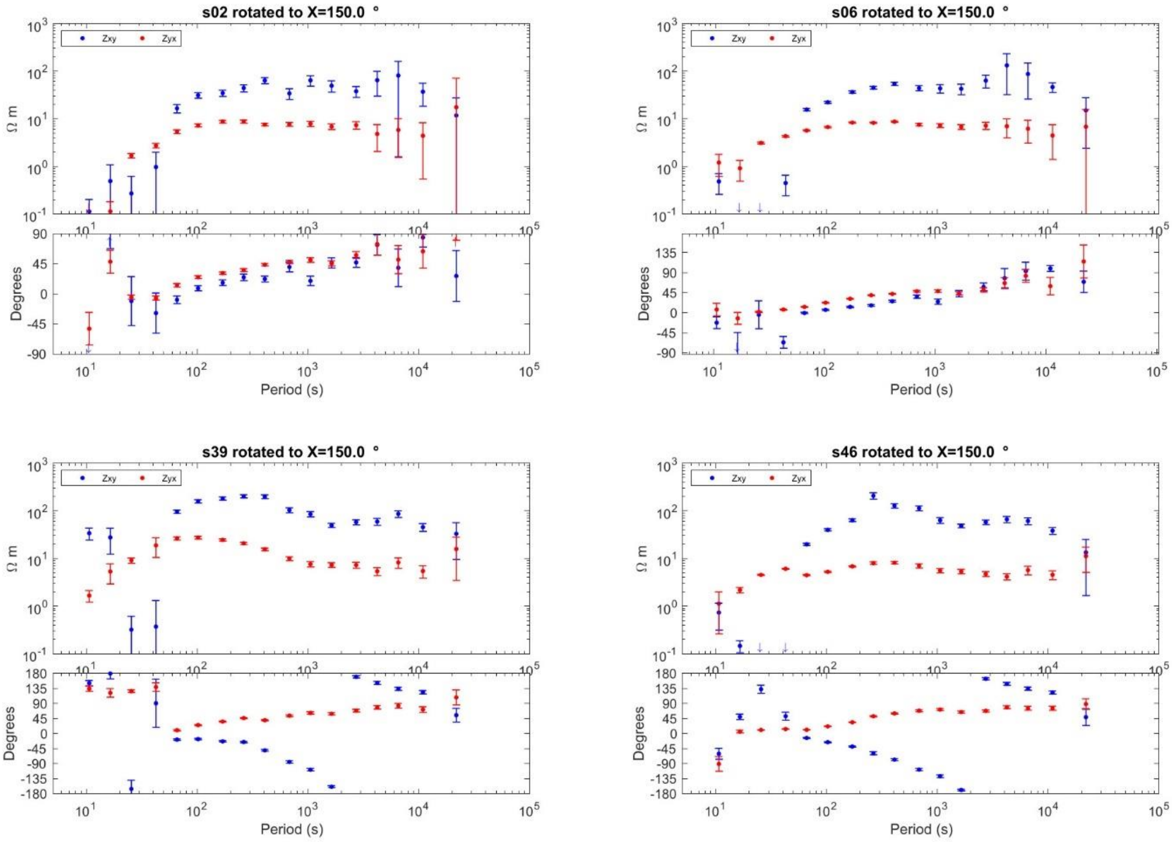


Figure 18: MT sites from the continental shelf end of the profile (s02 and s06) and the abyssal plain (s39 and s46), rotated into the profile direction. TE mode = Zxy (blue) and TM mode = Zyx (red).

The magnetometer channels recorded the airgun signals quite strongly, probably not cleanly enough for seismic processing but enough to compromise MT data processing. Preliminary processing was restricted to the period before the airguns started operating. As expected, periods shorter than 20–30 seconds were lost to source field attenuation in the deep water. All sites show depressed TM mode resistivities associatedwith the galvanic TM coast effect. The deepwater sites on the abyssal plain show negative TE mode phasesat long period and peaks in resistivity around 300 seconds period, associated with the inductive TE mode coast effect. A decrease in resistivity at the longest periods may be associated with mantle conductivity.

CSEM Data

All electric field channels collected processable CSEM data, mostly with noise floors consistent with previous studies: scaling the Scarborough noise floors by the relative dipole moments of the two projects (2.1) we would expect a noise floor of 10^{-14} V/Am^2 × at 0.25 Hz and 1.5 10^{-15} V/Am^2 at the higher frequencies. Most of the variability in noise floor was in the 0.25 Hz data, where long period noise in someelectric field channels was evident. As expected, the noise floor of the LEM instruments was about an order of magnitude lower than the OBEM instruments, except at 0.25 Hz where electric field noise from water motion and MT signals starts to occur. By design, waveform D has the highest power at the 3rd harmonic (0.75 Hz in this case), where the noise floor is lower.

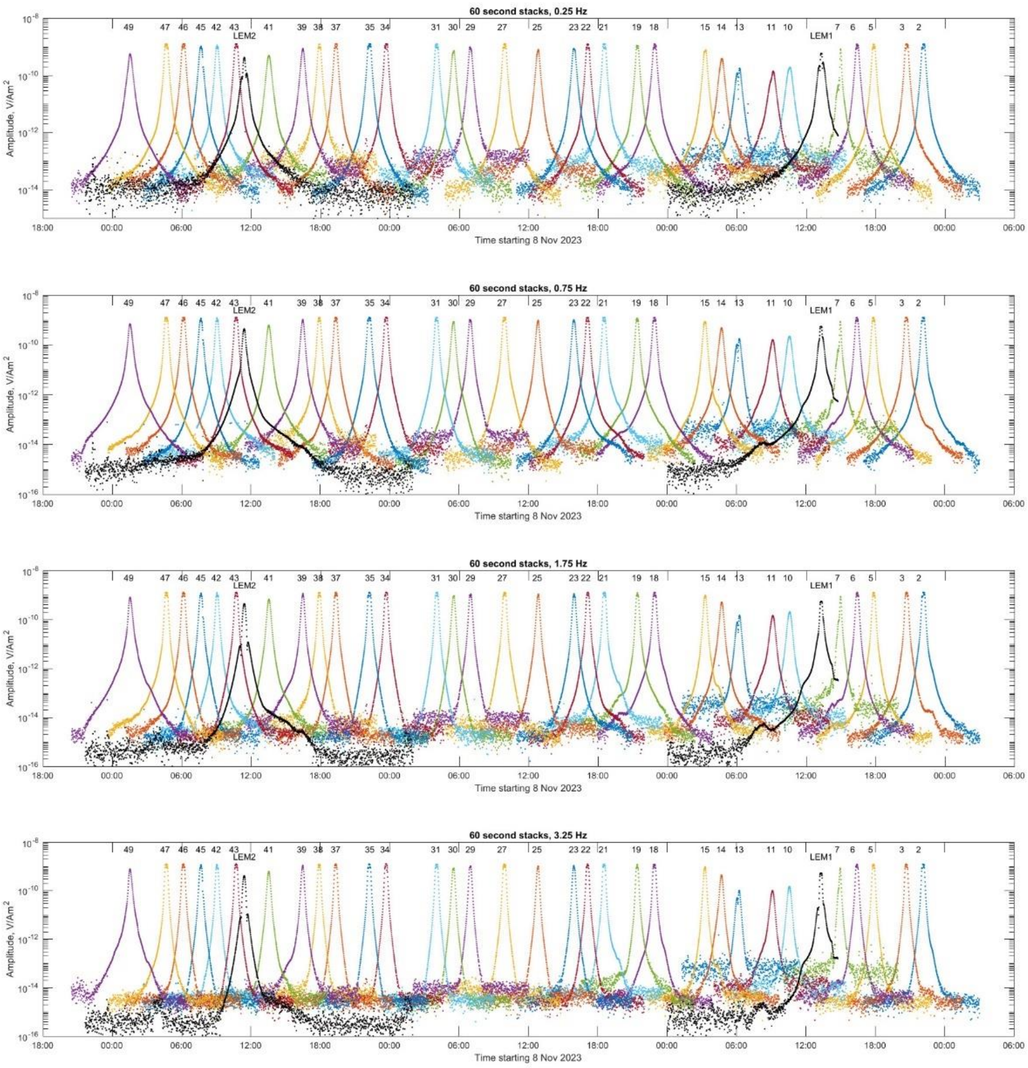


Figure 19: CSEM data: 60 second stacks of polarization ellipse maxima at the 4 largest amplitude frequenciesof waveform D. LEM data are in black.

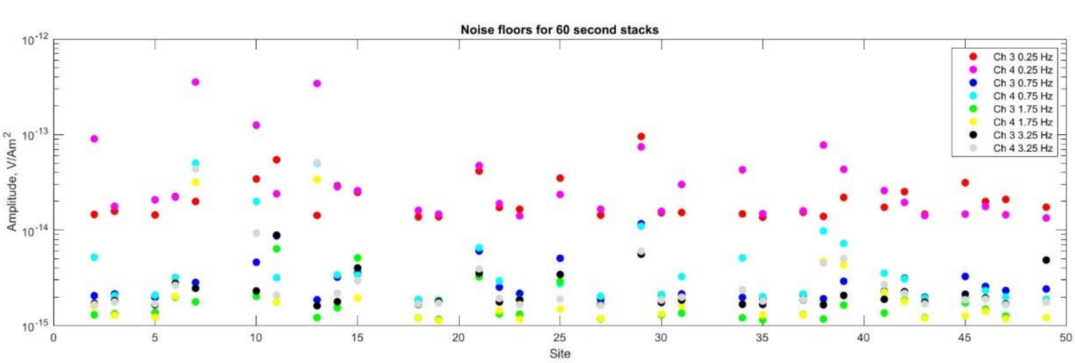


Figure 20: Noise levels from data collected prior to DASI operation, for 60 second stacks.

The OBEM instruments collected usable data out to ranges of about 7 km, and the LEM data extend to abouttwice that distance. Increasing the stacking window will increase this a little.

Hydrophone Data

Every Scripps OBEM was equipped with a High Tech HTI-90-U hydrophone. Only one instrument didn't collect hydrophone data (site 30), although site 29 stopped recording early. Otherwise, based on the spectrograms, the hydrophone data are excellent, with obvious microseism energy and airgun signals evident.

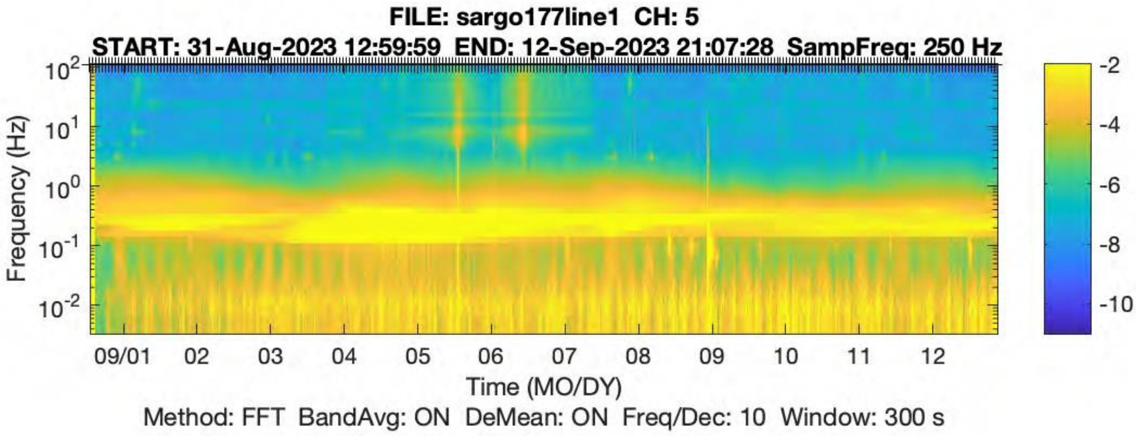


Figure 21: Spectrogram of the hydrophone data collected at site 45

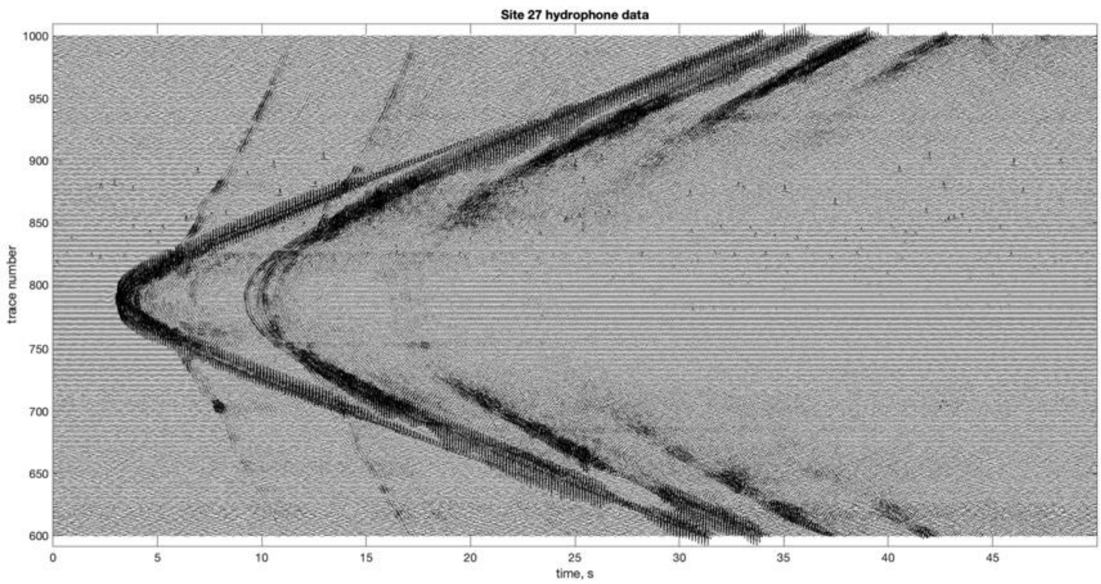


Figure 22: Shot gather of hydrophone data collected at site 27. 5–30 Hz bandpass and scaled by maximumamplitude by shot.

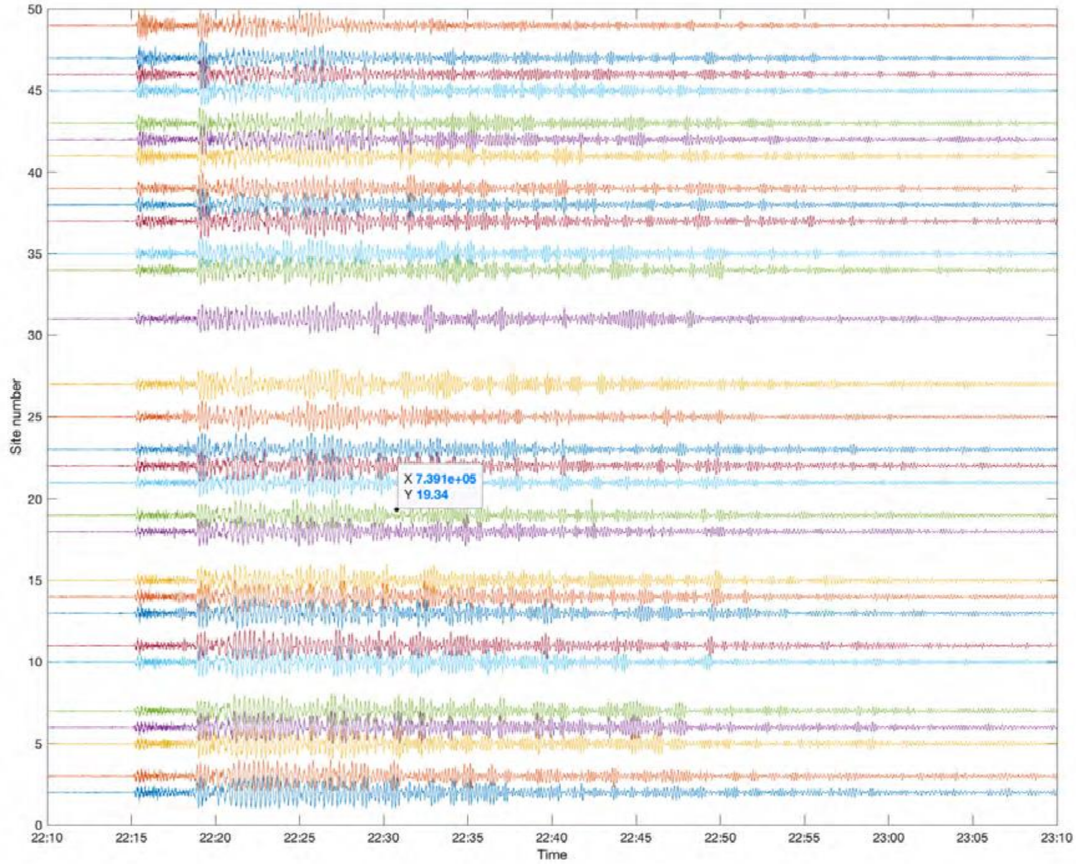


Figure 23: Moroccan earthquake recorded by SIO hydrophones

The launcher used for the deployment of the LEM instruments recorded also the sound velocity profile via Valeport CTD-V.

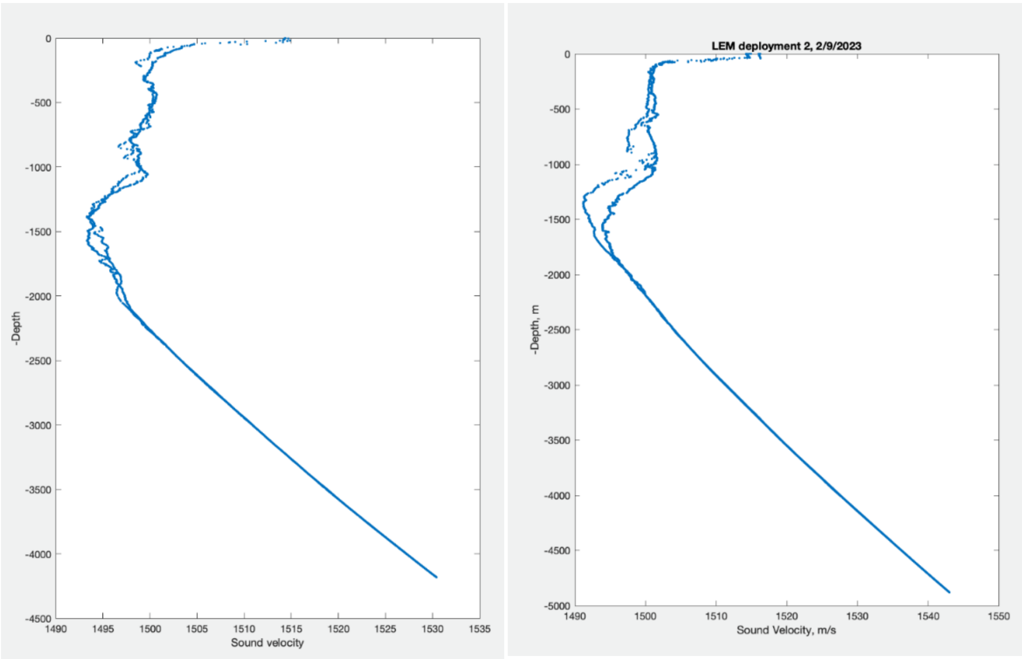


Figure 24: Two sound velocity profiles acquired using Valeport CTD-V instrument on the LEM launcher, at LEM1 (left) and LEM2 (right) deployment locations.

site	name	head	pitch	roll	notes
02	wobby20	314.2	0.2	1.3	some spikes on E2, OK data
03	cero173	116.0	1.7	0.1	good data
05	escolar174	339.2	0.8	3.2	low motion, good data, took a day for electrodes to settle
06	spit28	276.6	0.3	5.7	slight motion, good data
07	shark32	53.9	3.8	-0.9	slight motion, E2 very noisy after one day, hydrophone didn't start until 7th
09	alaihi161	76.2	0.2	2.4	flash card failure - no data
10	palometa147	69.9	1.4	0.3	slight motion, E signal noisy at long periods
11	hilu152	104.3	1.4	1.4	moderate motion, E signal noisy at long periods
13	bogong27	30.4	-0.4	3.3	moderate motion, high noise on E2
14	bonito141	344.0	0.1	-0.2	slight motion, good data
15	mooneye146	200.4	1.7	1.4	moderate motion on B, good E
17	tigerfish139				responded clearly during seismic nav, but not for release. LOST.
18	stripey180	326.9	0.3	0.1	good data
19	blenny172	00	00	00	good E, high motion on B, noise during airguns and CSEM, motion noise on hyd
21	makua162	83.3	-0.1	3.2	slight motion, E signal noisy at long periods
22	kole171	108.5	1.1	1.5	good data
23	splittail168	115.9	-1.0	-1.9	moderate motion, higher B noise during airguns and CSEM
25	manini155	351.1	-1.1	1.9	moderate motion on B, good E
27	tautog169	345.4	-0.5	1.4	good data
29	numbat44	217.9	0.2	1.4	slight motional noise. E signal noisy at long periods. Hyd stopped after 4th
30	echidna25	146.5	0.3	3.2	good EB data. Hyd bad.
31	lainihi154	372.1	-0.4	3.8	E2 noisy at long periods
33	hakibut144				never responded to acoustics. LOST.
34	margate164	112.6	-0.6	3.8	E fields noisy at long periods
35	cubbyu179	355.8	1.1	4.8	good data
37	tomcod176	246.9	-0.3	0.9	good data
38	weke160	241.5	1.1	1.4	E2 noisy at long periods
39	redfish108	357.4	0.6	0.1	slight motion, good data
41	kupipi145	290.5	-3.1	-8.5	slight noise on E, good data
42	coho142	212.6	1.8	2.1	HF noise on B1, good data (timing problem)
43	kahala170	40.4	35.4	-2.1	slight motion, good data
45	sargo177	207.4	-1.0	1.0	slight motion, disk write noise on B, good data
46	nohu156	229.7	-1.9	2.4	good data
47	albacore178	50.3	-2.2	-0.1	some noise on E1, OK data
49	porgy175	36.5	-2.5	9.1	some motion, OK data
20	cassowary05				LEM2, good data
42.5	quokka03				LEM1, good data

Table 6. Summary of instrument performance and the compass information by site number.

Scripps 5-channel instruments	102, 103, 105, 106, 107, 109, 110, 111, 113, 114, 115, 117, 118, 119, 121, 122, 123, 125, 127, 129, 130, 131, 133, 134, 135, 138, 139, 141, 142, 143, 145, 146, 147, 149	01 = mx 02 = my 03 = ex 04 = ey 05 = hy
OBIC 12-channel instruments	101, 104, 108, 116, 120, 126, 132, 136, 144, 148	00=xf , 01=yf , 02=zf , 03=na, 04=zg , 05=yg , 06=xg , 07=hy , 08= ex, 09=ey , 10=na , 11=na
OBIC 8-channel instruments	112, 124, 128, 140	00=zg , 01=yg , 02=xg , 03=hy , 04= ex, 05=ey , 06=na , 07=na

Table 7: List of Scripps and OBIC instrument channels. ex and ey are the electric filed channels and hy is the hydrophone for both, Scripps and OBIC instruments. mx, my are the two coiled magnetometer channels of Scripps instruments. xf, yf, zf are the three component fluxgate magnetometer channels and xg, yg and zg are the three component geophone channels of OBIC instruments. Figures 25 and 26 show the channel orientations for Scripps and OIBC instruments respectively.

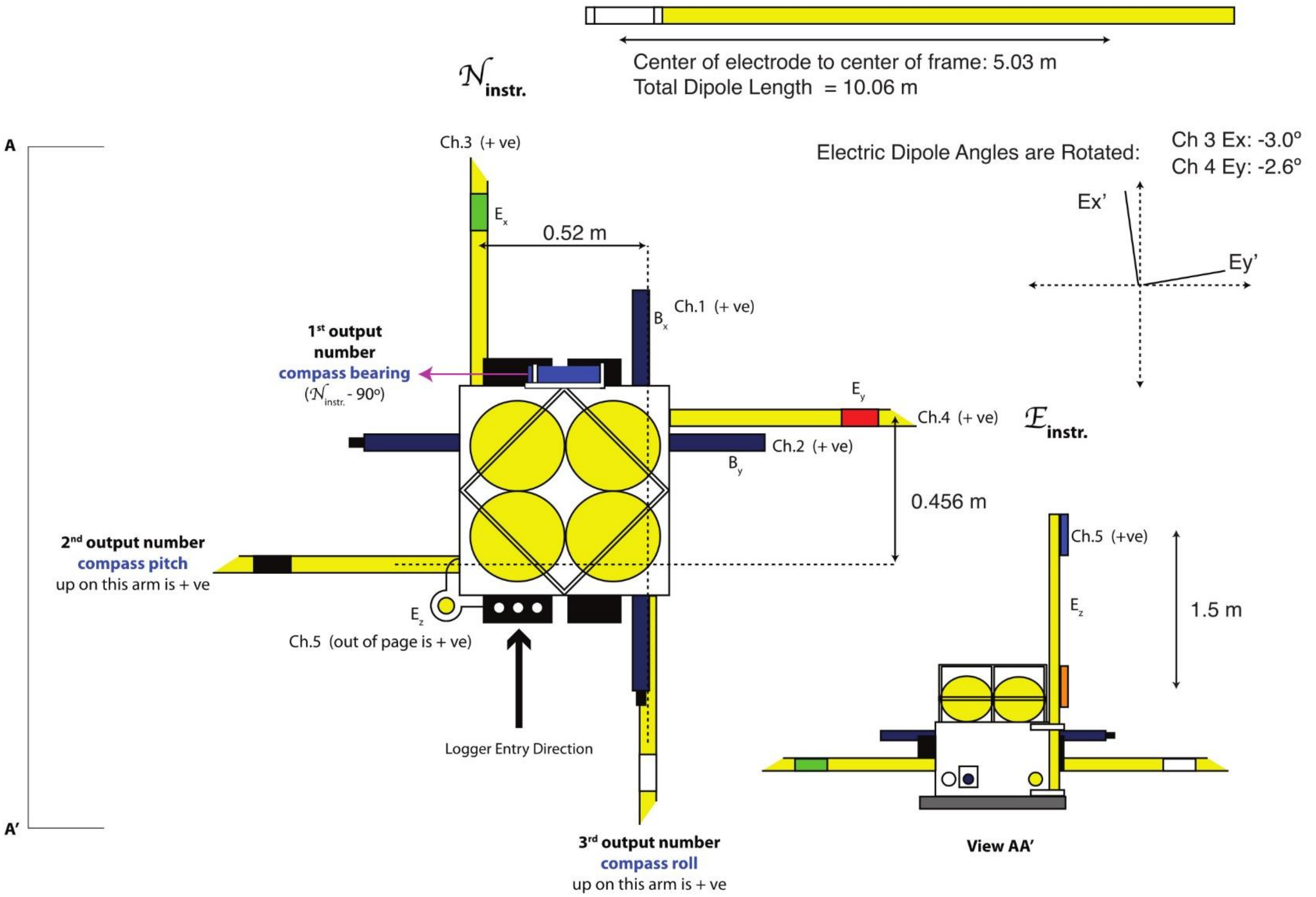


Figure 25: Schematic illustrating the channel orientations of Scripps instruments.

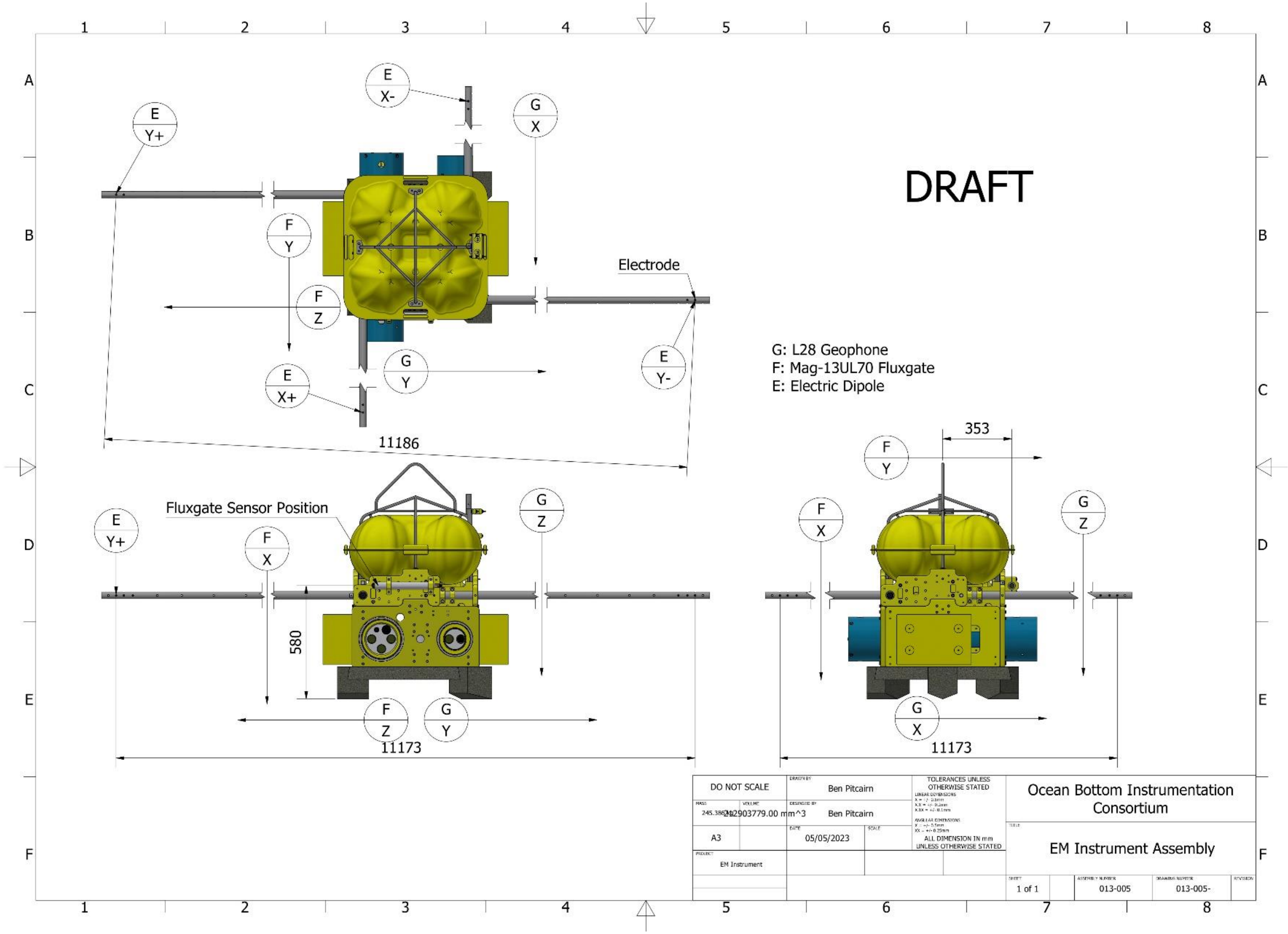


Figure 26: Schematic illustrating the channel orientations of OBIC instruments.

6.3.2 OBIC Instruments

Ten of the fourteen OBIC instruments were equipped with 12 channel recorders and recorded three component magnetotelluric data, two component electric filed, three component geophone data and hydrophone data (9 recording channels). JC251 was the first cruise that used these Combo OBIC instruments. The remaining 4 instruments were equipped with eight channel reorders and recorded the horizontal component of the electric filed, three component geophone data and hydrophone (6 channel recording). All instruments recorded with a sampling rate of 250 Hz. The 12-channel instrument 2-144 was lost.

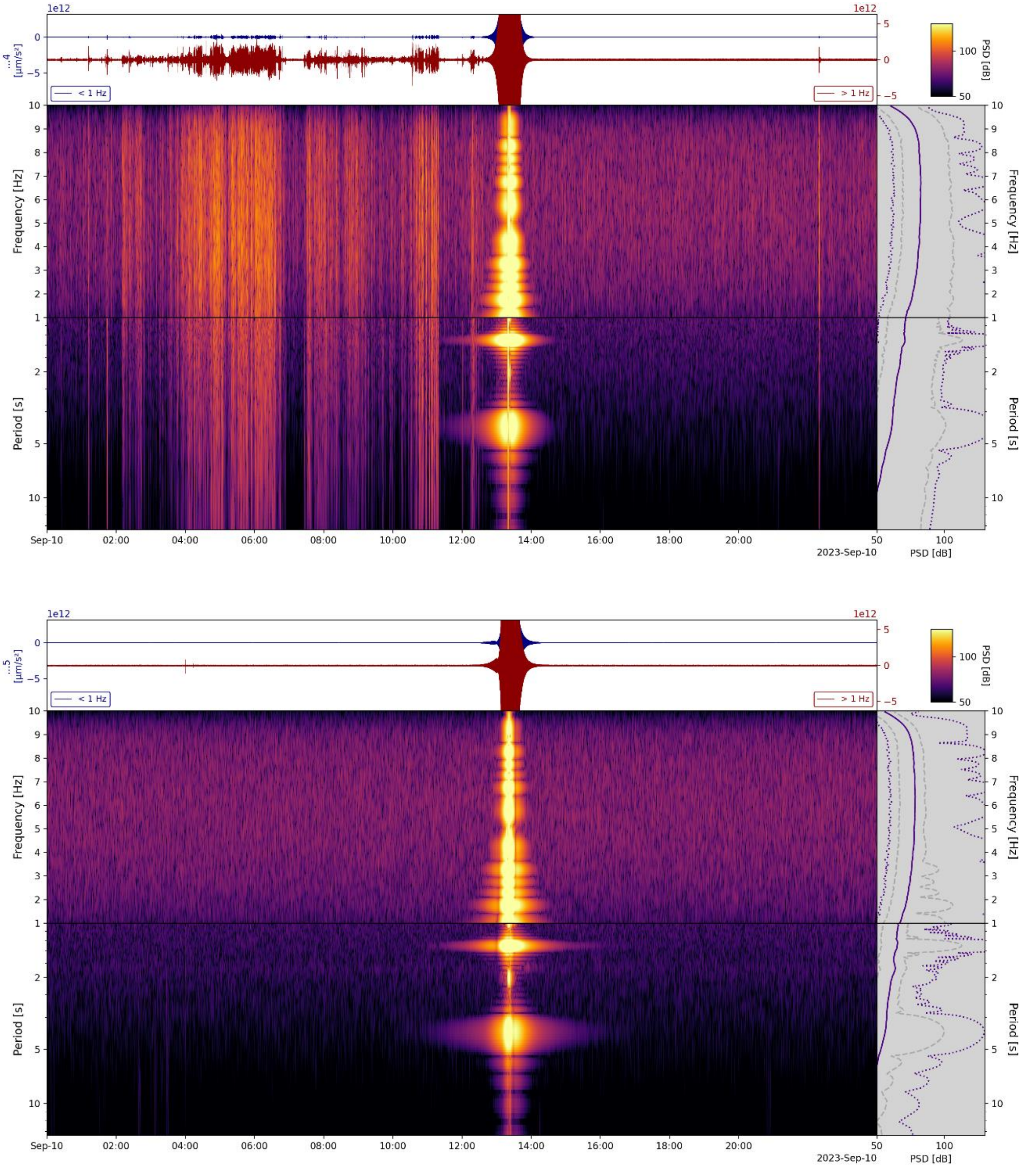


Figure 27: ex and ey electric filed components recorded by the instrument 8-channel 124.

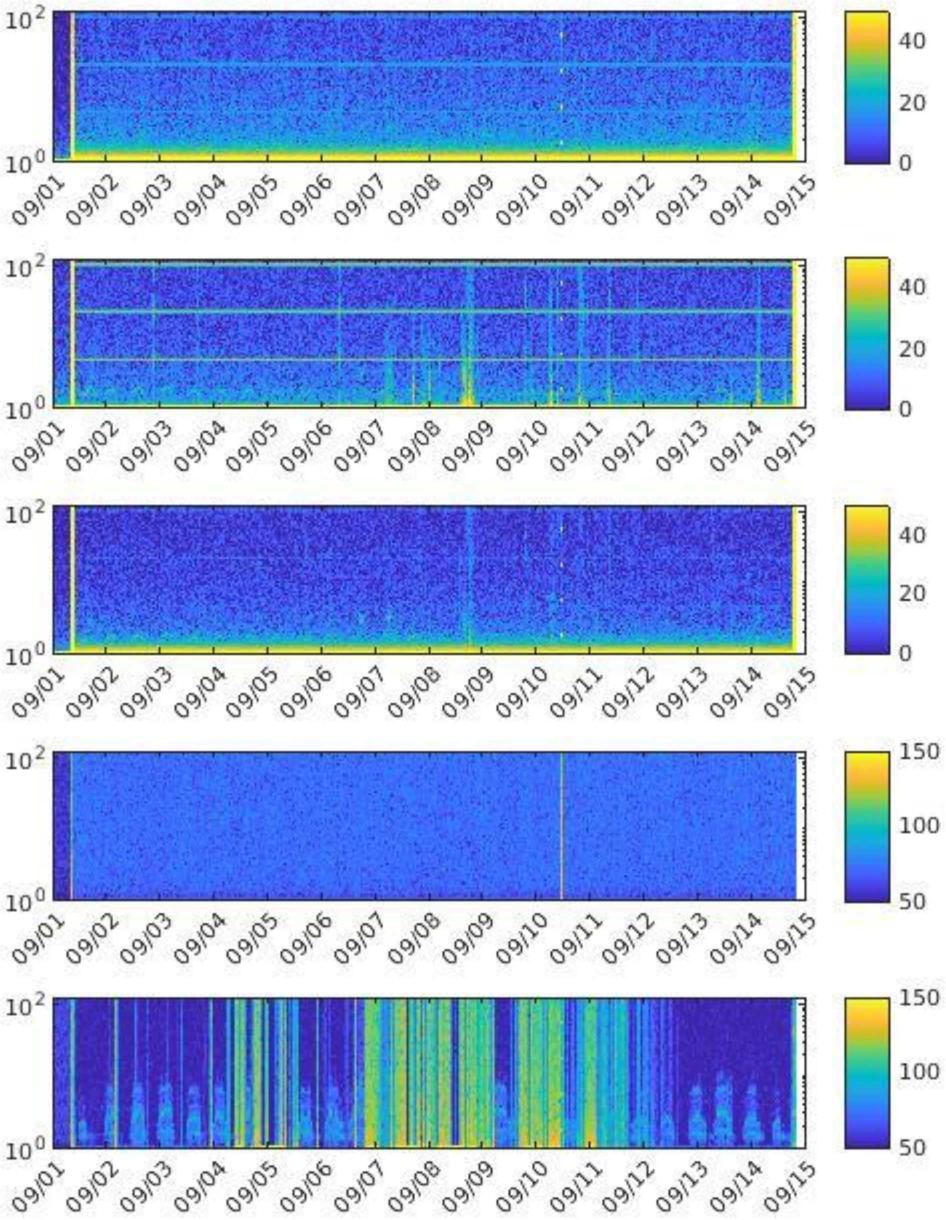


Figure 28: top to bottom 3 fluxgate (xf, yf, zf) and 2 e-filed (ex, ey) channels of the 12-channel instrument 126. The colour scale shows the power density spectrum. Y-axis is log scale frequencies and the X-axis is the time (days). DASI is observed on all channels, but masked by noise in ey channel. Some tidal signal is observed on both, yf and ey channels.

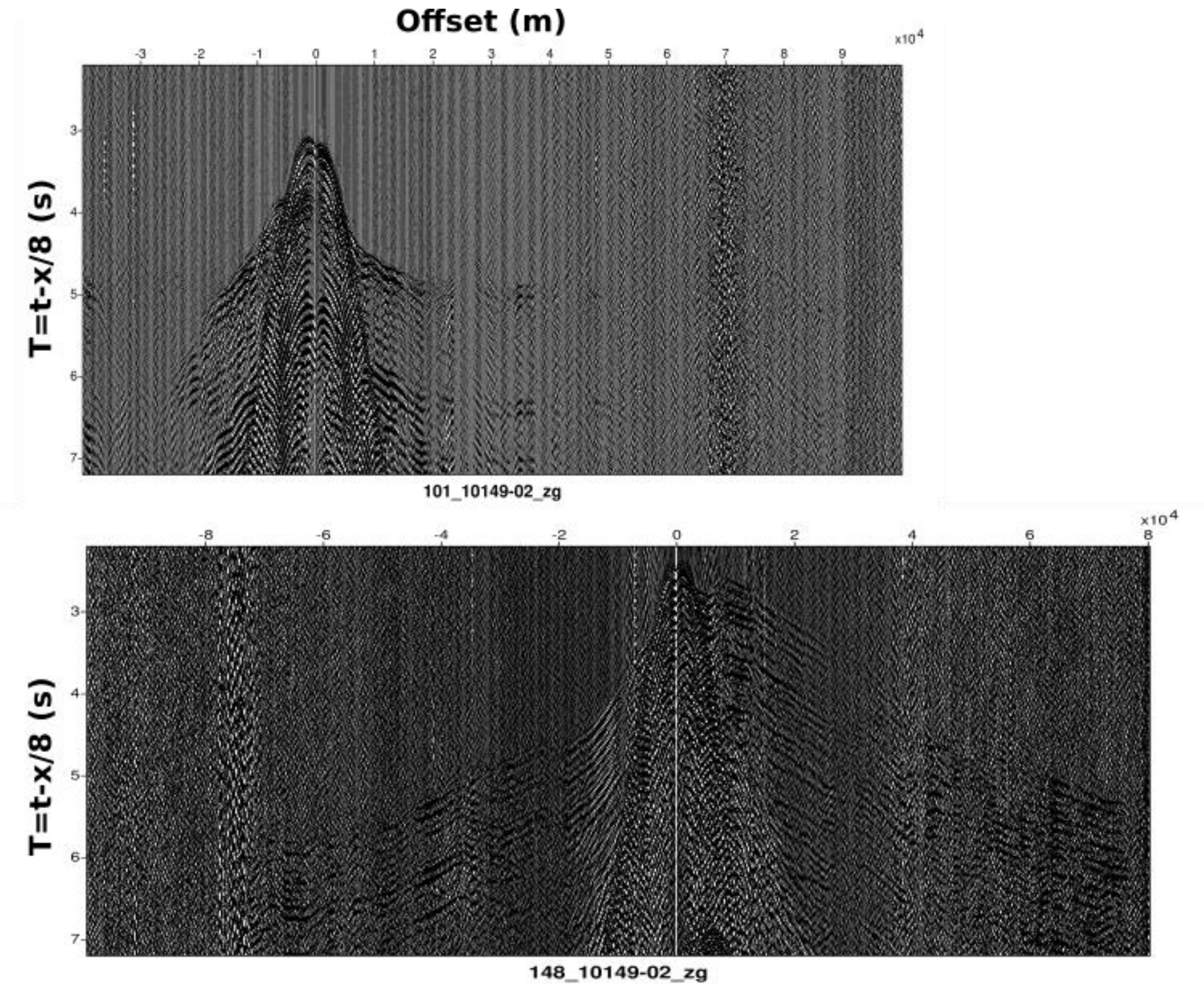


Figure 29: Two examples of vertical geophone data; OBI 2-101 and 2-148 that are the most oceanward and landward OBIC instruments respectively. The first arrivals are visible up to offsets larger than 80 km.

The hydrophone component of all instruments recorded data successfully. Instruments 104 (12-channel) and 124 (8-channel) failed recording usable geophone data. The performance of the fluxgate mangetometers was good. Between ten new 12-channel instruments only the instrument 116 failed recording magnetometer data. The electric field recording was in general very poor on 12-channel instruments. The maximum voltage generated by the electric field pre-amps was larger than the maximum voltage that the A:D boards could handle, and if these large voltages were applied, the A:D boards failed permanently. The threshold voltages were reached in some cases when DASI approached the instrument (we would expect always to saturate at short offsets) and in others when the instruments were first put into the water (due to transient voltages generated then). As a result, only one 12-channel instrument (126) and three of the four 8-channel instruments (112, 124 and 140) fully recorded the electric filed. On other instruments, the recordings are saturated either at the deployment, the seismic acquisition or the DASI transmission. The instruments that saturated at the DASI transmission recorded partially the DASI signal.

inst no	xf	yf	zf	xg	yg	zg	xe	ye	hy
101	ok	ok	ok	ok	ok	ok	ok - cut	ok – cut	ok
104	ok	ok	ok	no data	no data	no data	no data	no data	ok
108	ok	ok	ok	ok	ok	ok	no data	no data	ok
112	nan	nan	nan	ok	ok	ok	ok	ok	ok
116	no data	no data	no data	ok	ok	ok	ok – cut	no data	ok
120	ok	ok	ok	ok	ok	ok	no data	no data	ok
124	nan	nan	nan	no data	ok	no data	ok	ok	ok
126	ok	ok	ok	ok	ok	ok	ok	ok	ok
128	nan	nan	nan	ok	ok	ok	no data	ok	ok
132	ok	ok	ok	ok	ok	ok	no data	ok -cut	ok
136	ok	ok	ok	ok	ok	ok	no data	no data	ok
140	nan	nan	nan	ok	ok	ok	ok	ok	ok
144	lost	lost	lost	lost	lost	lost	lost	lost	lost
148	ok	ok	ok	ok	ok	ok	no data	no data	ok

Table 8: Summary of OBIC channel QC.

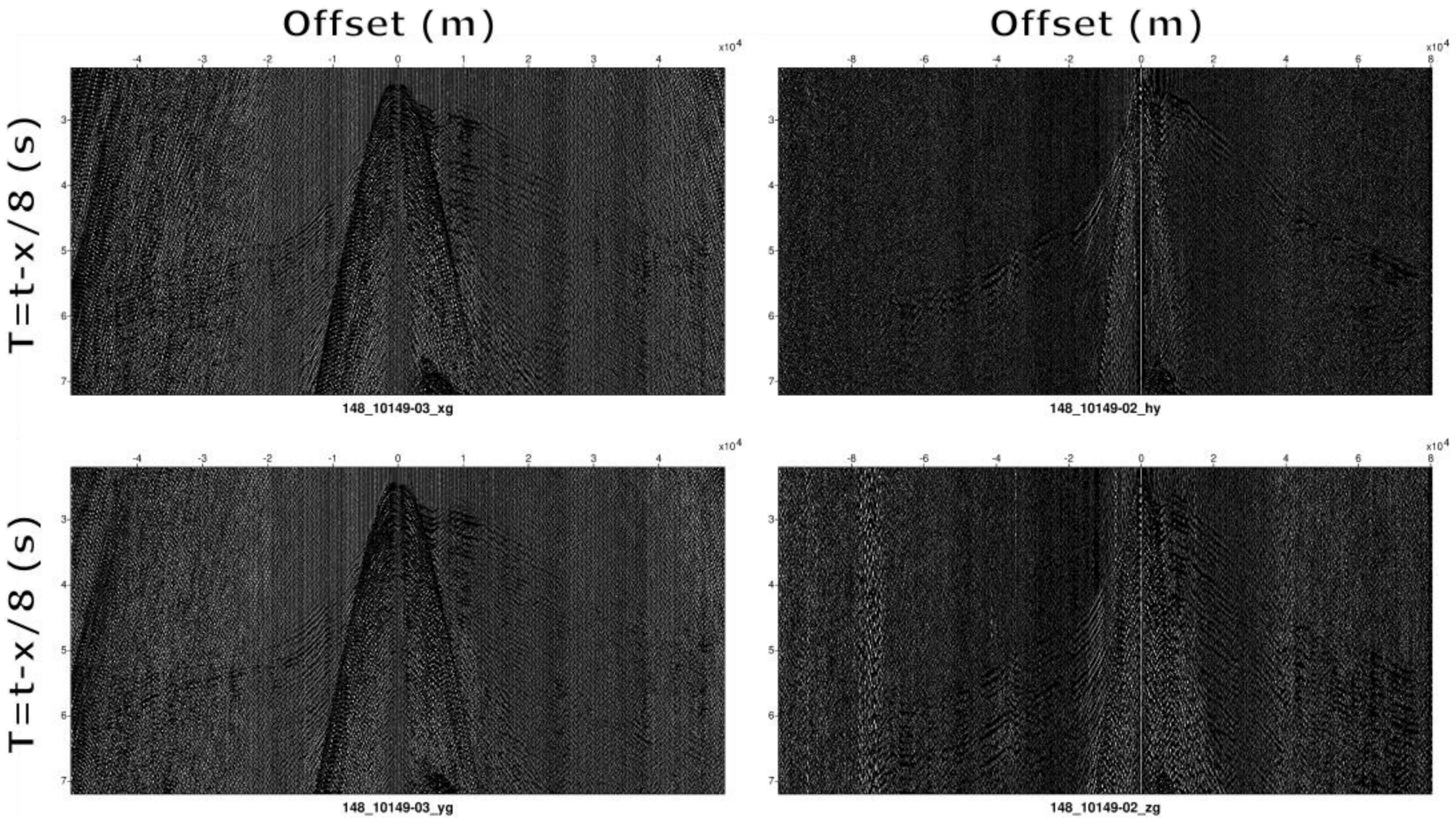


Figure 30: Plots of the 3 geophone and the hydrophone components of the instrument 148. The first arrival times can be seen up to 90 km offset. Left panel horizontal geophones, Right, top: hydrophone, bottom: vertical geophone

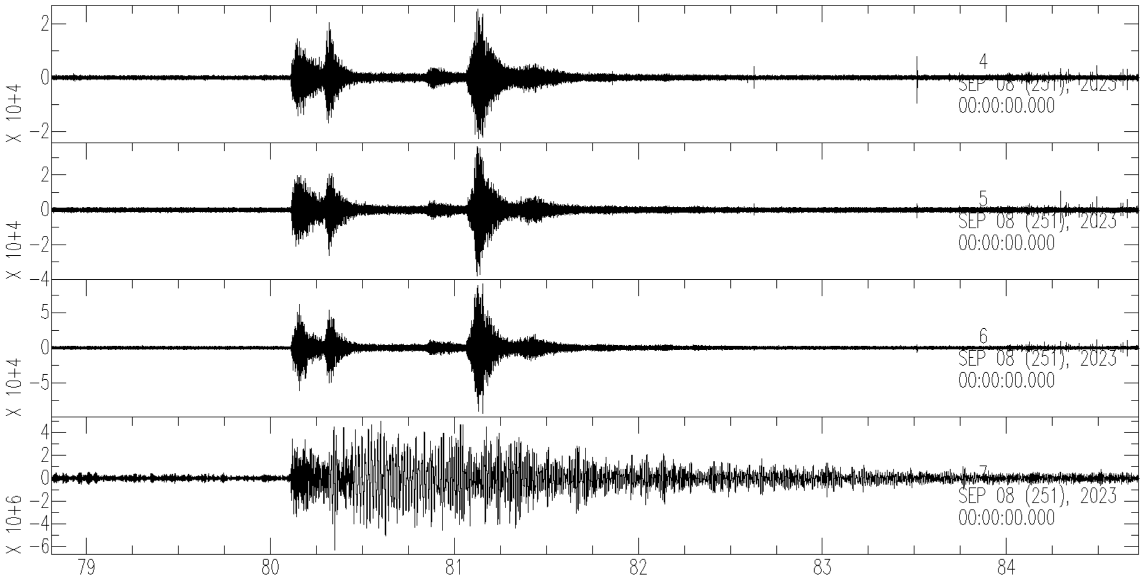


Figure 31: 8 September 2023 Morocco earthquake recorded by the x, y and z geophones and the hydrophone (from top to bottom) of the instrument 2-101.

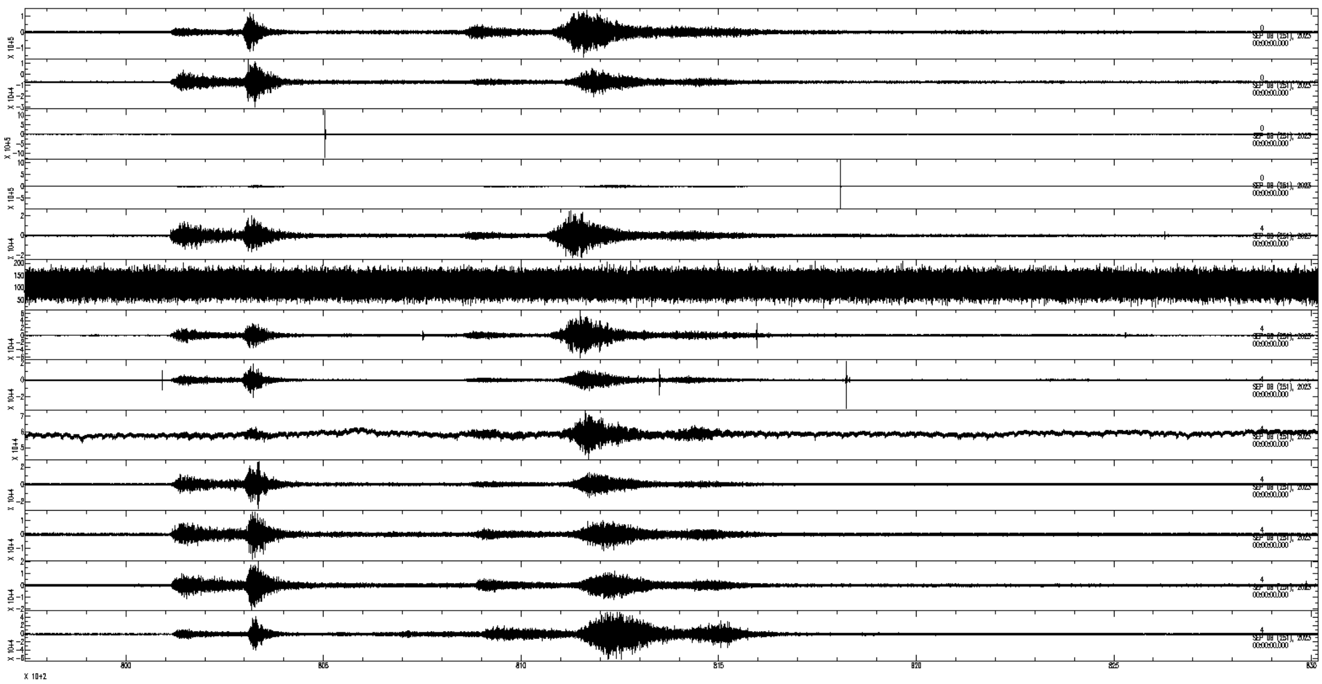


Figure 32:The 8th of September 2023 Morocco earthquake recorded on the vertical geophones of all OBIC instruments.

6.4 Underway geophysics data

In addition to the user supplied equipment, we collected underway geophysical data using the equipment provided by NMF, including GPS, multibeam and split beam echosounders, sub bottom profiler, magnetometer, gravimeter and occasionally USBL.

Swath bathymetry data is acquired using a Kongsberg EM120, full ocean depth multibeam echosounder with a nominal sonar frequency of 12 kHz. The instrument is turned on after MMO and acquired continuous data except during OBI navigation surveys where the hull transducer was also emitting 12 kHz. Two grids are surveyed; the Goban Spur and Witthard Canyon. In Witthard Canyon a short bathymetric survey is carried out to image the cable brakes along one of the southern branches of the Witthard Canyon.

SeaSpy towed magnetometer fish is used for the magnetic data acquisition. The instrument is deployed four times, during the aborted seismic line JC251_101_149_001, the DASI line (JC251-101-149_004) and two magnetic surveys JC251_101_149_006 and JC251_101_149_007, the aborted southwestern magnetic box and the profile PAD13-41 respectively. The acquisition along the line JC251_101_149_001 is stopped due to water ingression. Other profiles were acquired with the second surface magnetometer. The instrument missed recording a 12 h time period whilst we were on the PAD13-41 line. There was no GPS input to the magnetic recordings. The GPS navigation had to me merged with the time stamped magnetic data in post-processing.

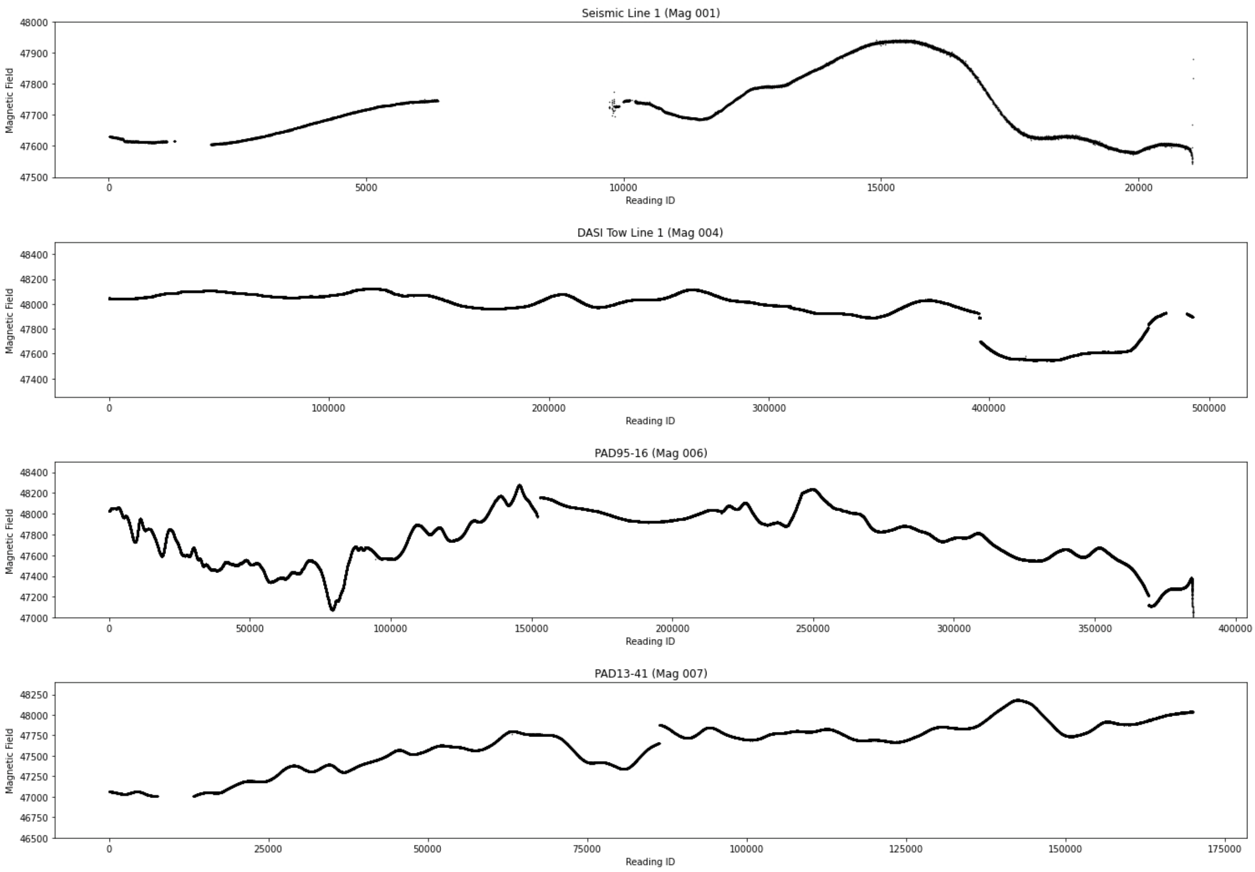


Figure 33: Four magnetic surveys acquired during JC251 cleaned. NaNs and bad quality readings are removed. Then outliers are removed by windowing data and removing any values greater than 2 std from the windows mean.

Before sailing a gravity, tie is carried out at the quayside using an L&R gravimeter to measure the relative gravity difference between the base station and the quayside. Underway gravity is measured with the DgS AT1M-12U Marine Gravimeter. A second gravity tie is carried out once back. The wrong baud rate was used for the GPS stream. The GPS navigation is merged with the gravimetric data with post-processing.

USBL Data is acquired using Sonardyne Ranger2 USBL system configured to operate in responder mode and used to track DASI. The sound velocity profiles acquired using the CTD-V on the LEM launcher are fed to the USBL system. The USBL stream was visualised on the ship via OLEX plotting software for navigation.

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