IODP Expedition 397: Iberian Margin Paleoclimate

Week 1 Report (11–22 October 2022)

International Ocean Discovery Program (IODP) Expedition 397, Iberian Margin Paleoclimate, began in Lisbon, Portugal, where the project was originally conceived more than a decade earlier during an ECORD Magellan workshop held in 2009. The objective of IODP Expedition 397 is to recover sedimentary sequences that accumulated at high sedimentation rates on the Iberian margin off Portugal. High-resolution measurement of paleooceanographic proxies in these sediments will be used to:

1. Document the evolution of millennial-scale climate variability during glacial-interglacial cycles of the late Pliocene and Quaternary, and
2. Study how storage of heat and carbon in the deep ocean contributes to climate and CO_2 change by drilling a bathymetric transect of sites spanning the range of the major subsurface water masses of the North Atlantic.

Four sites are planned, ranging in water depth from 1304 to 4691 m below sea level (mbsl), and including the reoccupation of Site U1385 (the "Shackleton site"), which was drilled as part of IODP Expedition 339 (Mediterranean Outflow) in 2011. The first site to be occupied during Expedition 397, Site U1586 (proposed Site SHACK-11B), as described herein, is the deepest (4691 mbsl) and farthest from shore (170 km).

Operations

IODP Expedition 397 began on 11 October 2022 at 1045 h (UTC + 1 h) upon arrival of the *JOIDES Resolution* at Rocha Pier in Lisbon, Portugal, at the end of Expedition 397T. All oncoming Expedition 397 personnel, including 25 scientists, 25 JRSO staff, one Outreach Officer, and the Portuguese Coastal Observer, moved onto the ship on 13 October following a four-day hotel quarantine. The quarantine included a PCR and an antigen test according to the JRSO COVID-19 mitigation protocol. All personnel tested negative before boarding. Once aboard, and over the next two days, all expedition participants received another antigen test and COVID-19 PCR test. Four JRSO staff and one crew member tested positive after the PCR test and were quarantined in single-person cabins for a minimum of five days, and until testing negative two consecutive times. Two individuals remain in quarantine. COVID-19 mitigation measures continue to be followed with mask wearing, social distancing, and daily antigen testing of all personnel.

Port call activities included the offloading of freight and Expedition 397T cores and samples, and the loading of supplies, fresh food, and catering consumables. Fuel also was pumped on board by two barges tied up alongside the ship over two days (one each day). At 0800 h on 16 October, the harbor pilot came aboard, two tugboats arrived to assist with the departure, and the mooring lines were released at 0830 h. The vessel proceeded to the pilot station at the mouth of the Tagus

River and the pilot departed at 0902 h. The *JOIDES Resolution* continued the sea passage and completed the 93 nautical mile (nmi) transit to Site U1586 at 1834 h on the same day. A depth reading with the ship's precision depth recorder (PDR) was taken as the vessel arrived on site, giving a seafloor depth of 4702.4 meters below rigfloor (mbrf)/4691.4 mbsl. The thrusters were deployed, and the drill string was made up with 5 inch drill pipe and an advanced piston corer/extended core barrel (APC/XCB) bottom-hole assembly with a polycrystalline diamond compact bit and lowered to the seafloor.

At 0900 h on 17 October, we installed the sinker bars and the core orientation tool, picked up the top drive, and positioned the drill bit at 4692.4 mbrf to take the first core, but the core barrel was recovered empty. The bit was repositioned to 4699 mbrf and a second core barrel was deployed, this time successfully spudding Hole U1586A at 1235 h. Based on recovery from Core U1586A-1H, the seafloor depth was calculated to be 4702.1 mbrf/4691.1 mbsl.

Coring continued with the full-length APC tools through Core U1586A-19H at 177.5 m below seafloor (mbsf). APC refusal was reached on Core 19H after recording partial strokes on Cores 16H through 19H, and excessive force (20,000 lb) was required to pull the last core barrel out of the formation. The half-length APC (HLAPC) system then was deployed from Core U1586A-20F through 26F at a depth of 205.8 mbsf. This was determined to be HLAPC refusal based on partial strokes on Cores U1586A-24F through 26F. The XCB rotary system was deployed from Core U1586A-27X at a depth of 205.8 mbsf to the target depth of 350 mbsf at Core U1586A-42X. Total recovery for Hole U1586A was 339.5 m (97%). Nonmagnetic core barrels were used for all APC and HLAPC cores. All full-length APC cores were oriented using the Icefield MI-5 orientation tools. Formation temperature measurements were taken on Cores 4H (34.9 mbsf, 4.27°C), 7H (63.4 mbsf, 4.45°C), 10H (91.9 mbsf, 5.74°C) and 13H (120.4 mbsf, 5.77°C).

With high seas moving in, the drill string was pulled back to 4657 mbrf/4646 mbsl (approximately 45 m above seafloor) to wait for the seas to subside. The bit cleared the seafloor at 0930 h on 20 October, ending Hole U1586A and beginning a period of waiting on weather.

While waiting for the seas to subside, the vessel was moved to the coordinates for Hole U1586B, approximately 100 m at 45° northeast from Hole U1586A. By 1000 h on 21 October, heave had subsided to under 3.5 m and operations began on Hole U1586B. A shot depth of 4693.0 mbrf/4682 mbsl was chosen based on the PDR reading and Hole U1586B was spudded at 1145 h on 21 October. Based on recovery in Core U1586B-1H, seafloor depth was calculated to be 4690.5 mbsl. Hole U1586B was cored to a depth of 139.5 mbsf (Core U1586B-16H) using the full-length APC coring system. This was just above the first partial stroke for the APC in Hole U1586A. We then changed to the XCB coring system at this depth. An XCB core barrel was deployed, but while making the pipe connection, the stabbing guide was damaged, and two pieces of plastic were thought to have fallen into the pipe. After Core U1586B-17X was cut, the sinker bars were lowered to retrieve the barrel. However, the GS tool at the bottom of the sinker bars was unable to latch into the fishing cup on top of the core barrels. This confirmed the suspicion that debris had fallen into the pipe when the stabbing guide was damaged. A fishing tool to latch on the outside of the GS cup was deployed on the bottom of a rotary core barrel

(RCB) and successfully latched and retrieved the core barrel, along with Core U1586B-17X. Coring resumed with the XCB system to a depth of 190.0 mbsf (Core U1586B-22X) at 2400 h on 22 October.

Science Results

To make the most of the four-day long quarantine in the hotel, the Expedition 397 scientists and JRSO staff conducted virtual expedition preparations and preboarding orientations. These meetings included an introduction to the expedition, IODP coring and logging tools and procedures, imaging resources, publications services, and preparation of shipboard reports. Laboratory teams began meeting to discuss methods and shipboard sampling strategies and continued drafting their methods chapters.

After moving aboard on 13 October, JRSO staff helped scientists familiarize themselves with the shipboard facilities, applications, and laboratory instruments, and set up their computers to access the ship's computer network and email system. The science party was divided into small groups to conduct the trainings and to watch the ship safety introduction video. They used training core material from past expeditions to learn the laboratory systems. The scientists completed the drafts of the methods chapters and the sampling and measurement plans for the expedition.

Since arriving at Site U1586, the science party has acquired and analyzed data, and described cores from Holes U1586A and U1586B.

Lithostratigraphy

All cores from Holes U1586A and Cores U1586B-1H to 19X were measured for physical and paleomagnetic properties, split, and described. The main lithology predominantly consists of greenish-brown nannofossil ooze, with varying amounts of clay, silt, carbonate, and foraminifers, intercalating with clay with varying amounts of silt and carbonate. Microscopic analysis of smear slides (two per section) supported macroscopic lithologies identified in the visual core description, attributing clay variability between 10% and 50%, and revealing the presence of detrital carbonate and authigenic grains. From the seafloor to Core U1586A-38X, most of the contacts between lithologies are color boundary or bioturbated, sharp to gradational. Most cores present color banding, and dark patches disseminate throughout as sedimentary structures. Nodules, possibly pyrite-filled burrows, are observed in many cores. X-ray diffraction (XRD) of samples collected at the same depths and one carbonate analysis for each core will provide more precise data on the minerals. The deeper sediments in Hole U1586A (Cores 39X to 42X) are marked by the occurrence of whitish, reddish-brown, and greenish sediments, a coloration that may be a result of an increase in the abundance of authigenic minerals such as glauconite and iron oxides. The whitish sandy layers are composed of foraminifera and calcite, and are structureless or thinly laminated but generally sharp-based. One sand bed shows an erosional base and fining-upward grading, a possible turbidite bed. Four thin sections were made from

selected intervals in Cores U1586A-41X and 42X to evaluate grain size and mineralogy differences between sandy and clayey intervals. Slump-like contorted beds were observed in some core intervals in Holes U1586A and U1586B.

Bioturbation is primarily moderate in sediments younger than the late Miocene, and it intensifies thereafter with numerous trace fossils of *Planulites*, *Chondrites*, and *Zoophycus* commonly observed. Coral fragments are present in Cores U1586A-20F and 21F and Core U1586B-16H. Dropstones (clasts >2 mm) are present in Core U1586A-5H. The types of drilling disturbance observed are mostly uparching in APC cores, biscuiting in some XCB cores, and fall-in in both core types.

Biostratigraphy

To attribute an age to the recovered sediments, the biostratigraphy of nannofossils and planktonic foraminifera was studied for Hole U1586A from all core catcher samples. Calcareous nannofossils are abundant to dominant with generally good preservation. Reworking is low to common, with Cretaceous–Eocene/Oligocene fossils. Nannofossils are rare and poorly preserved in Cores U1586A-39X to 42X. Nannofossil biostratigraphy places Cores U1586A-1H to 15H in the Pleistocene, Cores U1586A-16H to 24F in the Pliocene, and Cores U1586A-25F to 42X in the Miocene. The maximum age at the bottom of Hole U1586A is >13.9 Ma. Planktonic foraminifera biostratigraphy places Cores U1586A-1H to 12H in the Pleistocene, Cores U1586A-13H to 23F in the Pliocene, and the rest of the sequence is considered Miocene in age. The determination of the Pliocene–Miocene transition was problematic because of the lack of major planktonic foraminifer changes in the Atlantic Ocean at that time.

Paleomagnetism

Prior to core sample analysis, the paleomagnetism team conducted test measurements on the superconducting rock magnetometer (SRM) and JR-6A spinner magnetometer to compare background noise levels and measurements made on the two instruments, and to determine spatial resolution of continuous pass-through measurements made on the SRM. They repeatedly measured the JR-6A calibration sample on the SRM while using a 3-D printed holder to orient the sample toward/opposite to each of the three SRM measurement axes. They also developed MATLAB and Python code for processing shipboard paleomagnetic data.

Magnetostratigraphy was established based on the natural remanent magnetization (NRM) completed for all archive-half core sections collected from Hole U1586A and Cores U1562B-1H to 18X. NRM of core sections from Core U1586A-1H to Section 4H-1A were measured before and after 5, 10, 15, and 20 mT alternating field (AF) demagnetization. A steep drilling overprint appears to be largely removed after ~10 mT AF demagnetization. Due to increased core flow, NRM of core sections from U1586A-4H-1A to U1586A-6H-2A were measured before and after 10 and 20 mT AF demagnetization, and NRM of core sections from U1586A-6H-3A to the base of the hole and Hole U1586B were measured before and after 20 mT AF demagnetization. The Icefield MI-5 core orientation tool was deployed to orient 19 APC cores in Hole U1586A and 16

APC cores in Hole U1586B. One hundred and ten cube samples were collected from Hole U1586A, and seven cube samples were collected from Hole U1586B. Measurements of the cube samples are in progress. NRM intensities of Hole U1586A core sections after 20 mT demagnetization are on the order of 10^{-3} to 10^{-2} A/m for the uppermost ~300 m core depth below seafloor, Method A (CSF-A), and drop to 10^{-4} to 10^{-3} A/m below ~300 m CSF-A. There is also an apparent drop of NRM intensities (after 20 mT demagnetization) from ~10^{-2} to ~10^{-3} A/m level at ~43 m CSF-A in Hole U1586A and ~39 m CSF-A in Hole U1586B. Below these depths, NRM inclinations after 20 mT from both holes appear to vary largely between positive and negative values. Based on the inclination and orientation-corrected declination data (after 20 mT demagnetization), we tentatively identified several polarity reversals in both Holes U1586A and U1586B, including the Brunhes/Matuyama boundary, the top and bottom of the Jaramillo subchron, and the Matuyama/Gauss boundary. Complete NRM demagnetization data from the analysis of cube samples will help to verify and improve these results. After 20 mT demagnetization of XCB cores, NRM data show a large scatter in directions with declinations apparently centered around 0°, suggesting strong drilling-induced overprint that makes it difficult for magnetostratigraphic interpretations for this part of the cored sediment sequences.

Geochemistry

Fifty-six whole round samples (5–10 cm thick) were taken from Hole U1586A and processed in the Geochemistry Laboratory. Interstitial water (IW) was squeezed out and aliquoted for shipboard and shore-based analyses. Residual squeeze cakes were also split for shipboard and shore-based analyses. The IW samples were taken at the base of every section for the upper 34 m CSF-A, at the base of core Sections 2 and 6 down to 47 m CSF-A, and then at the base of Section 6 (i.e., the second-to-last section recovered from every core) until the end of the hole. Immediately upon squeezing, IW samples were measured for salinity, chlorinity, alkalinity, and pH. Samples were also measured for major and minor elemental composition by ion chromatography (IC) and inductively coupled plasma–atomic emission spectrometry (ICP-AES) and for ammonium and phosphate by spectrophotometry. IW residue and select discrete samples from the working half were measured for total sedimentary carbon (TC), nitrogen (TN), sulfur (TS), and total inorganic carbon (TIC). Total organic carbon (TOC) is calculated as the difference between TC and TIC. At a resolution of two samples per core, samples were also selected from the working half for paired analyses of ICP-AES and XRD for bulk elemental and mineralogical compositions. For every core (or every other HLAPC core), headspace gas samples were taken at the top of the last section. Methane is the only detectable gas and its concentration ranges from 0–15 ppm, with a peak around 175 m CSF-A.

Alkalinity, pH, phosphate, and ammonium increase downhole from the seafloor, reaching a peak at ~75 m CSF-A, then decreasing deeper in the hole. Correspondingly, sulfate decreases in the upper part of the hole, reaching a minimum at ~100 m CSF-A, while Ba increases. There is also a sharp decrease in Mn in the upper 25 m CSF-A and a peak in Fe at ~10 m CSF-A, after which values return to near 0.

Preliminary TOC and TN values (wt%) gradually decrease with depth. TS drops off sharply after ~25 m CSF-A, while TIC increases nonmonotonically with depth. TOC, TN, and TS values are very low, but TIC ranges from 3–78 wt%.

Physical Properties

Core density, magnetic susceptibility (MS), and *P*-wave velocity (V_P) were measured on whole-round cores using the Whole-Round Multisensor Logger (WRMSL) with a measurement interval of 2.0 cm. Measurements of V_P were performed on Cores U1586A-1H to 27H. WRMSL *P*-wave velocity was not measured in the XCB cores. Instead, *P*-wave velocity on XCB cores (Cores U1586A-28X to 42X) was measured by the caliper of Section Half Measurement Gantry (SHMG) with direct contact on film-covered working halves. Natural gamma radiation (NGR) was measured on whole-round cores at an interval of 20 cm. A triplicate measurement of thermal conductivity was conducted at one position per core for Cores U1586A-1H to 29X with a needle probe sensor, and from Cores 30X to 42X with a puck tool. Moisture and density measurements were performed on 38 discrete samples, and 56 *P*-wave velocity measurements were made on split core sections. Four downhole temperature measurements were performed with the advanced piston corer temperature tool at 35, 63, 82, and 120 m CSF-A. Downhole sediment compaction is reflected in decreasing porosity and increasing density and V_P values with depth. The gamma ray attenuation (GRA) bulk density at Hole U1586A shows a decrease at 200–210 m CSF-A where the APC coring system was switched to XCB. Cyclic variations of MS, NGR, and color reflectance are clear throughout Hole U1586A, reflecting the cyclic lithologic change. For Hole U1586B, only GRA density (2 cm measurement interval), MS (2 cm measurement interval), and NGR (20 cm measurement interval) were measured on whole-round cores. In addition to the standard measurement resolution, GRA bulk density and MS measurements using WRMSL or the Special Task Multisensor Logger were carried out at 4 cm steps on Sections 1 to 3 of Cores U1586B-1H to 4H, 15H, 16H, 18X, and 19X, as requested by the stratigraphic correlators to perform a “quick check” on whether the core breaks in Hole U1586A were bridged by Hole U1586B.

Stratigraphic Correlation

The stratigraphic correlation team focused on identifying intact segments of pelagic sedimentation between slumped intervals, finding reliable tie points between Holes U1586A and U1586B, and assessing which signals will be most useful in constructing the site’s composite section. The presence of slumps was evident in the homogenization of all physical properties measured and from examination of the split cores. A log of all slumped or disturbed intervals was initiated by the sedimentology team to help in identifying areas where good correlation between holes will be difficult.

Fortunately, strong signals in MS, color reflectance, and natural gamma allow us to tie Holes U1586A and U1586B in nonslumped intervals up to ~150 m CSF-A. At this point, drilling switched to the XCB system in Hole U1586B and it becomes difficult to match stratigraphic signals in Hole U1586B to the highly distorted equivalent APC section in Hole U1586A.

Correlation of stratigraphic signals to the global climatic rhythms of the Pliocene–Pleistocene (e.g., marine isotope stages) was possible after adding biostratigraphic and paleomagnetic constraints to construct a preliminary age model. For the Brunhes interval, we were also aided by detailed logs from Site U1385, which are well-calibrated to the oxygen isotope curve. Plotting the inverse of MS and natural gamma and plotting color reflectance resulted in a set of oscillations that could then be mapped to an isotope reference curve. The results indicated that several stratigraphic intervals in the Pliocene and Pleistocene can be well constrained from these initial measurements. However, slumping has removed or disturbed several intervals and it will not be possible to construct a stratigraphically complete Pliocene–Pleistocene section from Holes U1586A and U1586B.

Outreach

Outreach for Expedition 397 started out with the transition from Expedition 397T to Expedition 397 taking place on October 12. Amy Mayer boarded the *JOIDES Resolution* to serve as the Onboard Outreach Officer, and Maya Pincus disembarked Expedition 397T in Lisbon to carry out shore education and outreach activities for Expedition 397.

Onboard Education and Outreach

In the first week of the expedition, Amy hosted six live ship-to-shore broadcasts from the ship, reaching approximately 100 people in Portugal, the United Kingdom, and the USA. Thirteen posts were made to Twitter, earning 115,700 impressions, 3,423 engagements, 372 retweets, 2,000 likes, and 42 replies. The Twitter account gained 103 new followers. Three posts were made on Facebook, reaching 8,131 people and leading to 240 reactions, 30 comments, and six shares. Fifteen new people followed the Facebook account. Five posts were made to Instagram, reaching 1,247 people and earning 305 reactions and three shares. The Instagram account gained 29 new followers. One blog was published on the *JOIDES Resolution* website.

Shore Education and Outreach

Maya visited six secondary schools in Portugal, facilitating 12 presentations that reached approximately 660 participants. Presentations included an introduction to the history of the IODP, drilling operations aboard the *JOIDES Resolution*, and the science of Expedition 397, followed by an opportunity for students to participate in collaborative activities to learn more about scientific ocean drilling. Maya also hosted a webinar for approximately 30 members of the Associação Portuguesa de Geólogos to introduce resources available to teachers through IODP and the *JOIDES Resolution*. To date, 20 virtual broadcasts with schools in Portugal are scheduled.

Technical Support and HSE Activities

Laboratory Activities

- Laboratory preparations took place while in port and on the transit to the first site.
- The technical staff is fully engaged in core processing and science support at Holes U1586A and U1586B.
- The electronics technician performed an audio frequency sweep test of the 3.5 kHz echosounder transducer array. There was no voltage or audio response from the array. This test plus earlier testing indicates there is an electrical short or fault in the signal cable below the deck plate. The 12 kHz echosounder was used successfully for depth determination at the first site.
- Training on the scanning electron microscope (SEM) and energy dispersive spectrometry (EDS) system was provided to interested science party members and JRSO staff.
- The Staff Scientist conducted an SEM imaging session to test the instrument at different magnifications and under moderate sea conditions on site, but the imaging capabilities were disappointing. Most images came out highly distorted, and the ship's moderate movement made it extremely difficult to acquire acceptable/usable images for documenting the findings in the reports.
- An issue with the small label format used for discrete PMAG samples was identified. The barcode of the label does not provide all the information needed for the IMS software.

Application Support Activities

- Worked on SPLAT (sample planning tool) and Sample and Data Request Management System (SDRM) programs.
- Completed the import of Expedition 339 data to Laboratory Information Management System (LIMS).
- Investigated issues with IRIS (new rig instrumentation software) reported by drillers.
- GEODESC is now working with the LIVE application.
- Fixed ordering of orientation report in LIMS.

IT Support Activities

- Continued onboarding and solving minor issues with scientists and staff.
- Continued correcting permissions issues on workstations and instrument hosts with IODPLauncher.
- Corrected Scheduled Task on XRAY so that the mirror script that copies image files to DATA1 works again.
- Updated ship's web server to have new version of McAfee for Mac available for scientists.
- A 14 h long Internet outage occurred on 19 October. The issue was due to Marlink making a configuration change that triggered unexpected consequences.

- Ships Aux AC for LT Datacenter went out and was repaired by Siem Offshore. Total AC outage was about 90 min.

HSE Activities

- The weekly fire and boat drill was conducted on Sunday, October 23.
- We continued observing the COPE protocol and conducted daily COVID-19 antigen testing for all JRSO staff and scientists.
- Eyewash and showers were tested.