

## **IODP Expedition 395C: Reykjanes Mantle Convection and Climate: Crustal Objectives**

### **Site U1564 Summary**

#### **Background and Objectives**

International Ocean Discovery Program (IODP) Site U1564 (proposed Site REYK-2A) is located in the North Atlantic Ocean near the Reykjanes Ridge south of Iceland. Site U1564 is located on seismic line JC50-1 (CMP 10710) near the intersection with line JC50-C1 (CMP 1019), both obtained in 2010 during RRS *James Cook* Cruise JC50.

Diachronous V-shaped features visible in bathymetry and gravity data, termed V-shaped ridges (VSR) and V-shaped troughs (VST), straddle the Reykjanes Ridge and may provide evidence of varying behavior of the Iceland mantle plume and its interaction with the Mid-Atlantic Ridge through time. Site U1564 is located on segmented crust that does not contain traces of V-shaped features, and basalt samples will provide a record with which to compare samples from VST and VSR crust. Site U1564 is located on the Gardar Drift, which will provide high-resolution, millennial-scale records for paleoceanographic research. The sedimentation rate of this drift can serve as a proxy for deep water current strength, providing information on oceanic gateways and their potential ties to mantle plume pulses. Site 983 cored the Gardar Drift during Ocean Drilling Program Leg 162, obtaining a sedimentary sequence back to 1.7 Ma (early Pleistocene). Samples from Site 983 have resulted in several publications that have documented the paleoclimate and oceanography of the North Atlantic Ocean. Cores at Site U1564 will extend this record back to the Oligocene epoch. The estimated basement age at Site U1564 is 32.4 Ma.

Cores and data from this site will address all three of the primary science objectives: (1) crustal accretion and mantle behavior; (2) ocean circulation, gateways, and sedimentation; and (3) time-dependent hydrothermal alteration of oceanic crust.

The planned operations at Site U1564 during Expedition 395C included coring a hole to ~650 m followed by installing a 600 m long casing string and reentry system. Expedition 395C did not have time to complete the planned casing operations at Site U1564 because coring the basalt sections at the other sites took more time than anticipated and because of downtime due to weather. Operations were scaled to the time available at the end of the expedition. The site was cored to 628.9 m and then logged with the triple combo and Formation MicroScanner (FMS)-sonic logging tools to obtain preliminary data for Expedition 395.

#### **Operations**

Site U1564 consisted of three holes, U1564A through U1564C, ranging in depth from 9.5 to 628.9 m drilling depth below seafloor (DSF). A total of 79 cores were recorded for Site U1564. These cores collected 655.41 m of sediment over a 664.6 m cored interval (99% recovery).

The advanced piston corer (APC) system was used to collect 21 cores over a 197.4 m interval with 201.60 m of core recovered (104% recovery). The half-length APC (HLAPC) system was deployed for 18 cores and recovered 87.77 m of sediment from an 84.6 m interval (104%). The extended core barrel (XCB) system was deployed over a 385.3 m interval. The 40 XCB cores recovered 366.04 m of sediment (95%). Downhole wireline logging operations using the triple combo and FMS-sonic logging tools took place at Hole U1564C.

The total time spent at Site U1564 was 5.29 d.

#### *Hole U1564A*

The vessel arrived at Site U1564 at 1748 h on 30 July 2021. The thrusters were lowered, the ship entered dynamic positioning (DP) mode, and the drill string was made up with an APC/XCB bottom-hole assembly. The drill string was run to a depth of 2220.0 m below sea level (mbsl) to spud Hole U1564A (59°51.0377'N, 23°16.0071'W), ~20 m west of the site coordinates. The exact site coordinates were to be reserved for future reentry system and casing installation during Expedition 395. Hole U1564A was initiated at 0245 h on 31 July and Core U1564A-1H recovered a full core (9.89 m), prohibiting the establishment of the seafloor depth.

#### *Hole U1564B*

The ship was offset 20 m to the east—directly over the site coordinates—and Hole U1564B (59°51.0372'N, 23°15.9868'W) was spudded at 0342 h on 31 July. Core U1564B-1H recovered 7.22 m of sediment, placing the seafloor at 2207.9 mbsl. Coring continued through Core 3H when the error in the ship's offset was noted and operations at Hole U1564B were terminated. The bit cleared the seafloor at 0630 h, ending Hole U1564B.

A total of 26.81 m of core was collected over a 26.2 m cored interval (102% recovery).

#### *Hole U1564C*

The ship was offset 20 m back to the west, over the Hole U1564A coordinates, and Hole U1564C (59°51.0374'N, 23°16.0087'W) was spudded at 0707 h on 31 July. The seafloor depth was calculated at 2208.1 mbsl, based on the recovery of Core U1564C-1H (7.02 m). Coring continued with the APC system recovering Cores 2H to 17H (7.0–159.0 m DSF). Core 17H required significant overpull (90,000 lb) to release the core barrel from the sediment. Coring with the full-length APC was terminated and the crew began making up the HLAPC barrels. Cores U1564C-18F to 35F advanced from 159.0 to 243.6 m DSF. The overpull when retrieving Core 35F was over 80,000 lb and coring switched to the XCB system. Cores 36X to 75X were collected to a depth of 628.9 m DSF. Following Core 75X, the crew began pulling up the drill string in preparation for downhole logging operations.

The drill pipe was raised until the bit was at 80.6 m DSF. The triple combo logging tool string was made up and deployed at 0250 h on 4 August. The triple combo descended to the bottom of the hole (628.9 m DSF) and made two passes of the borehole. The tool was recovered at 0930 h

and broken down. The FMS-sonic tool string was made up, deployed to the base of the hole, and made a single pass imaging the borehole wall. The FMS-sonic tool was brought up to the rig floor at 1640 h and broken down. The downhole logging equipment was put away and the logging tools moved to the helideck. The rig floor crew began pulling up the pipe, with the bit clearing the seafloor at 1845 h. At 1920 h, four of the five thruster pods were raised and were secured at 2236 h. The bit cleared the rig floor at 0100 h on 5 August, the remaining thruster pod was raised, and at 0106 h the ship switched from DP to cruise mode, ending Site U1564. The ship began the 293 nmi transit to Reykjavík, Iceland.

All APC cores were oriented using the Icefield MI-5 tool. Formation temperature measurements were taken on Cores U1564C-4H, 7H, 10H, 13H, and 15H; however, the third-generation advanced piston corer temperature tool flooded on Core 4H and no data were collected.

In all, 618.71 m of core was recovered from Hole U1564C (98%). Seventeen APC cores were collected over a 159.0 m interval with 164.90 m of sediment recovered (104%). Recovery with the HLAPC was also 104%, with 87.77 m of core recovered over 84.6 m. Finally, the XCB was deployed for 40 cores and cored 366.04 m of sediment over a 385.3 m interval (95%).

## **Principal Results**

The JRSO technical staff processed all cores and samples in the laboratories, following the measurement and sampling plan constructed by the shore-based Expedition 395C Co-Chief Scientists and science party. Data interpretation, core description, and biostratigraphic analyses will take place postexpedition.

With the anticipated number of cores and the short transit to port at the end of the expedition, the measurements conducted on Site U1564 cores were reduced compared to the other sites. The cores were immediately run through the whole-round physical properties tracks upon retrieval without being thermally equilibrated. Magnetic susceptibility (MS), gamma ray attenuation bulk density, and *P*-wave velocity were measured at 2.5 cm, and natural gamma radiation (NGR) was measured at one position (20 cm resolution). The split section halves were imaged and measured for point magnetic susceptibility (MSP) and color reflectance. Sections were then scanned for magnetic remanence using the superconducting rock magnetometer (SRM) at 5 cm resolution and three demagnetization steps (0, 15, and 20 mT). Samples were collected on the catwalk for headspace gas analysis and postcruise biostratigraphy.

The primary lithologies at Site U1564 are clay and silt. Cores U1564A-1H, U1564B-1H, and U1564C-1H (0 to ~7 m core depth below seafloor [CSF-A]) are composed of clay to silt with brown, gray, and light gray banding. Cores U1564B-2H to 3H and U1564C-2H to 6H (~7 to 54.82 m CSF-A) are a light gray to gray clay to silt. Within Core U1564C-7H (54.5–64.62 m CSF-A), the sediment transitions from a lighter gray to a dark gray. From Core U1564C-8H to 56X (64.0–444.46 m CSF-A) the clay to silt sediment shows gray to dark gray banding.

Foraminifers can be seen on the split core surfaces and dropstones and shell fragments are occasionally observed. Bioturbation is present in some intervals. Cores 57X to 75X (444.6–629.12 m CSF-A) are clay-rich sediments that alternate between light gray, green, and dark gray in color. These cores have dark green, yellow, and dark gray mottling, bioturbation, and erosional surfaces. The XCB cores are disturbed from the coring process and contain core biscuits and fractures.

The physical properties of the cores primarily reflect changes in their composition. The MS values increase from an average of ~200 to ~400 instrument units (IU) from 0 to 100 m CSF-A and remain relatively constant to 200 m CSF-A. Below this depth, MS slowly decreases to ~100 IU at ~470 m CSF-A. MS remains low to 560 m CSF-A, where values increase to ~750 IU at 570 m CSF-A before decreasing to the bottom of the hole. NGR values average 13.7 counts/s between 0 and 316 m CSF-A. Values are lower from 316 to 500 m CSF-A with an average of 10.2 counts/s. There are three prominent NGR peaks below 500 m CSF-A.  $L^*$  trends downhole reflect the changes in core color, with lower  $L^*$  values associated with dark gray core and higher values with the lighter, green cores. The cores were not allowed to thermally equilibrate to room temperature before scanning, possibly impacting the  $P$ -wave velocity measurements.

The downhole measurements program at Site U1564 consisted of downhole wireline logging and formation temperature measurements. The triple combo and FMS-sonic tool strings were run successfully to the base of the hole. Four formation temperature measurements from 54.5 to 140.0 m DSF show a linear increase with depth from 8.7° to 15.6°C.

Core sections were run through the SRM, which measured natural remanent magnetization before and after alternating field demagnetization. The magnetic inclination shows clear intervals of normal and reversed polarity, which will be used postcruise to establish the magnetostratigraphy for the site.

The only shipboard chemistry measurements were made on headspace gas to monitor hydrocarbon concentrations. Methane concentrations are near zero for the uppermost 170 m. From ~170 to 242 m CSF-A, methane increases to a maximum of 1263 ppmv, and then gradually declines to 158 ppmv at the base of the hole.