International Ocean Discovery Program Expedition 395C Preliminary Report

Reykjanes Mantle Convection and Climate: Crustal Objectives

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Ross Parnell-Turner, Anne Briais, Leah J. LeVay, and the Expedition 395 Scientists

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Expedition 395C participants

Expedition 395C scientists

Ross E. Parnell-Turner
Co-Chief Scientist Expedition 395
Institute of Geophysics and Planetary Physics
Scripps Institution of Oceanography
University of California, San Diego
USA
rparnellturner@ucsd.edu

Anne R. Briais
Co-Chief Scientist Expedition 395
Laboratoire Géosciences Océan
Centre National de la Recherche Scientifique (CNRS)
Institut Universitaire Européen de la Mer
France
anne.briais@cnrs.fr

Leah J. LeVay*
Expedition Project Manager/Staff Scientist
International Ocean Discovery Program
Texas A&M University
USA
levay@iodp.tamu.edu

Ying Cui
Organic Geochemist
Earth and Environmental Studies
Montclair State University
USA
cuiy@montclair.edu

Anita Di Chiara
Paleomagnetist
Scripps Institution of Oceanography
University of California, San Diego
USA
adichiara@ucsd.edu

Justin P. Dodd
Inorganic Geochemist
Geology and Environmental Geosciences
Northern Illinois University
USA
jdodd@niu.edu

Deborah E. Eason
Petrologist
Department of Earth Sciences
University of Hawaii at Manoa
USA
deborahe@hawaii.edu

Sarah A. Friedman
Paleomagnetist
Department of Biological and Physical Sciences
Montana State University
USA
sarah.friedman@msubillings.edu

Katharina E. Hochmuth
Downhole Tools/Physical Properties Specialist
School of Geography, Geology and the Environment
University of Leicester
United Kingdom
kh355@leicester.ac.uk

Boris T. Karatsolis
Micropaleontologist (nannofossils)
Department of Earth Sciences
Uppsala University
Sweden
boris.karatsolis@geo.uu.se

Danielle E. LeBlanc
Sedimentologist
Department of Earth and Environment
Boston College
USA
leblandf@bc.edu

Melody R. Lindsay
Inorganic Geochemist
Deep Bioshere Laboratory
Bigelow Laboratory for Ocean Sciences
USA
mlindsay@bigelow.org

David D. McNamara
Physical Properties Specialist
Department of Earth and Ocean Sciences
University of Liverpool
United Kingdom
d.mcnamara@liverpool.ac.uk

Sevasti E. Modestou
Sedimentologist
Department of Earth Science
University of Bergen
Norway
sevasti.modestou@uib.no

Bramley Murton
Petrologist
Marine Geoscience Group
National Oceanography Centre
United Kingdom
bjm@noc.ac.uk

Suzanne B. O'Connell
Sedimentologist
Department of Earth and Environmental Sciences
Wesleyan University
USA
soconnell@wesleyan.edu

*Shipboard participant

Gabriel T. Pasquet
Petrologist
Complex Fluids and Reservoirs Laboratory
University of Pau and Pays de l'Adour
France
gabriel.pasquet@univ-pau.fr

Paul N. Pearson
Micropaleontologist (planktonic foraminifers)
School of Earth and Ocean Sciences
Cardiff University
United Kingdom
pearsonp@cardiff.ac.uk

Sheng-Ping Qian
School of Ocean and Earth Science
Tongji University
China
qianshengping@126.com

Yair Rosenthal
Physical Properties Specialist/Stratigraphic Correlator
Institute of Marine and Coastal Sciences
Rutgers, The State University of New Jersey
USA
rosentha@marine.rutgers.edu

Sara Satolli
Paleomagnetist
Department of Engineering and Geology
University of Chieti-Pescara
Italy
sara.satolli@unich.it

Jamie L. Shamrock
Micropaleontologist (nannofossils)
Earth and Atmospheric Sciences
University of Nebraska, Lincoln
USA
s-jshamro1@unl.edu

Takuma Suzuki
Micropaleontologist (foraminifers)
Department of Geoscience
Shimane University
Japan
zaku142@gmail.com

Saalim M. Syed
Sedimentologist
Antarctic Science Division
National Centre for Antarctic and Ocean Research (NCAOR)
Polar Micropaleontolgy & Past Climate NCPOR
India
saalim@ncpor.res.in

Nicholas J. White
Physical Properties Specialist
Bullard Laboratories
Department of Earth Sciences
University of Cambridge
United Kingdom
njw10@cam.ac.uk

Alexandra Yang Yang
Inorganic Geochemist
Guangzhou Institute of Geochemistry
Chinese Academy of Sciences
China
yangyang@gig.ac.cn

Outreach

Jose M. Cuevas
Outreach Officer
Department of Earth and Environment
Boston College
USA
cuevasjo@bc.edu

Operational and technical staff

Siem Offshore AS officials

Harm Nienhuis
Master of the Drilling Vessel

Wayne Lambert
Drilling Supervisor

JRSO shipboard personnel and technical representatives

Tiago Biller
Marine Laboratory Specialist

Etienne Claassen
Marine Instrumentation Specialist

Lisa Crowder
Laboratory Officer

Doug Cummings
Publications Specialist

David Fackler
Marine Computer Specialist

Fabricio Ferreira
Marine Laboratory Specialist

Kevin Grigar
Operations Superintendent

Luan Heywood
Marine Laboratory Specialist

Sarah Kachovich
Imaging Specialist

Jan Jurie Kotze
Marine Instrumentation Specialist

Nick Logan
Marine Computer Specialist

Zenon Mateo
Assistant Laboratory Officer

Erik Moortgat
Assistant Laboratory Officer

Jenna Patten
Marine Laboratory Specialist

Vincent Percuoco
Marine Laboratory Specialist

Doris Piñero Lajas
Marine Laboratory Specialist

Alexander Roth
Marine Laboratory Specialist

Ionela Samolia
Marine Laboratory Specialist

Katy Smith
Curatorial Specialist

Johanna Suhonen
Marine Laboratory Specialist

Kerry Swain
Logging Engineer (Schlumberger)

James Zhao
Applications Developer

Abstract

The five primary sites proposed for International Ocean Discovery Program (IODP) Expedition 395, which was postponed because of the COVID-19 pandemic, were cored during IODP Expedition 395C. The Expedition 395C operations, shipboard measurements, and sampling were adjusted to account for the absence of a sailing science party. The Expedition 395/395C objectives are (1) to investigate temporal variations in ocean crust generation at the Reykjanes Ridge and test hypotheses for the influence of Iceland mantle plume fluctuations on these processes, (2) to analyze sedimentation rates at the Björn and Gardar contourite drifts, as proxies for Cenozoic variations of North Atlantic deepwater circulation, and for uplift and subsidence of the Greenland-Scotland Ridge gateway related to plume activity, and (3) to analyze the alteration of oceanic crust and its interaction with seawater and sediments. During Expedition 395C, basalt cores were collected at four sites: U1554, U1555, U1562, and U1563. Sediment cores were also collected from these sites as well as from Site U1564, and casing was installed to 602 m at Site U1554. The amount of recovered cores, their preliminary descriptions, and the analyses of shipboard samples show that the results of Expedition 395C will fulfill a significant part of the Expedition 395 objectives. Basalts were collected from two V-shaped ridge and trough pairs, which will allow the investigation of the variability in mantle source and temperature causing this ridge/trough pattern. Basalt cores span an expected age range of 2.8–13.9 Ma, which will allow us to investigate the hydrothermal weathering processes. Sediments from the Björn drift were cored to basement, along with the uppermost 600 m of sediments from the Gardar drift. The data provided by Expedition 395C are a major advancement in achieving the work of Expedition 395.

1. Introduction

Mantle plumes bring significant amounts of mass and heat up from Earth's deep interior, causing melting and volcanism in places like Iceland and Hawaii and long-wavelength uplift at the surface. Tracking plume behavior through geologic time is difficult; however, where a plume intersects a plate-spreading mid-ocean ridge (MOR), direct observations of the composition and fluid dynamical behavior of such upwellings are feasible. Basaltic rocks continuously erupted near the spreading axis record the geochemical signature of the underlying mantle, providing a record of the composition and dynamics of the mantle plume. In addition, over time, basalts spread away from the ridge and interact with the overlying seawater and sediments, becoming progressively altered due to hydrothermal circulation and chemical exchanges.

One such plume-ridge system can be found in the North Atlantic Ocean, where the Iceland mantle plume is bisected by the Reykjanes Ridge, the submarine portion of the Mid-Atlantic Ridge southwest of Iceland. Basins around the Reykjanes Ridge are blanketed by rapidly accumulating sediments that record the oceanographic conditions on thousand-year timescales, providing some of the most detailed climate records on Earth. The Reykjanes Ridge flanks host a series of V-shaped crustal ridges and troughs whose origin has been long debated. These ridges could be explained if the Iceland mantle plume was pulsing at a frequency of several millions of years, causing melt anomalies, and driving transient uplift of the surrounding North Atlantic region on geological timescales. Vertical motions caused by this pulsing behavior could have altered the depth of the oceanic gateways connecting the Norwegian and Greenland Seas into the North Atlantic Ocean, with implications for deepwater circulation, sediment deposition, and climate. The unique juxtaposition of a mantle plume, a spreading ridge, oceanic gateways, and rapidly accumulating sediment provide an ideal natural laboratory to test multidisciplinary ideas about the interactions between Earth's deep and surficial domains.

2. Background

2.1. Geological setting

As new basaltic oceanic crust is formed, it draws material from the underlying mantle, so rocks recovered from MORs have long been used to measure the thermal and compositional properties of the mantle (e.g., Krause and Schilling, 1969; Hart et al., 1973; Schilling, 1973). Where MORs intersect mantle plumes, such as along the Reykjanes and Kolbeinsey Ridges near Iceland, oceanic crustal accretion is thought to be influenced by plume activity (e.g., White, 1997). Close agreement between models of dynamic topography and seismic tomography supports the idea that mantle upwelling beneath Iceland influences the entire North Atlantic region today (Hartley et al., 2011; Rickers et al., 2013; Schoonman et al., 2017) (Figure **F1**). A possible sign of time-dependent plume behavior is the set of diachronous V-shaped ridges (VSRs) and V-shaped troughs (VSTs) that straddle the Reykjanes Ridge south of Iceland (Figure **F1**). Vogt (1971) first suggested that the VSRs reflect variations in crustal thickness caused by pulses of hotter asthenosphere advecting horizontally away from the Iceland plume that episodically increase the thickness of crust formed at the axis.

Oceanic crustal accretion is sensitive to small temperature perturbations, which can change the thickness of newly formed material by hundreds of meters to kilometers (White et al., 1995). The ratios between incompatible trace elements such as Nb/Y are largely insensitive to crustal processes such as fractional crystallization and reflect the depth and degree of melting. A southward decrease of Nb/Y on the Reykjanes Ridge correlates with deepening of the axis, a decrease in crustal thickness, and decreasing source enrichment estimated by isotopic indicators such as $^{87}Sr/^{86}Sr$ (Murton et al., 2002; Shorttle and Maclennan, 2011). Two complete cycles of variation in incompatible trace element ratios that can be observed along axis correlate with patterns in gravity anomaly, bathymetry, and earthquake seismicity (Parnell-Turner et al., 2013; Jones et al., 2014). Compositional variations associated with VSRs cannot be explained by fractional crystallization alone because a corresponding variation in Mg number is absent. Because enrichment in incompatible trace elements is inversely correlated with crustal thickness over the past 12 My, mantle temperature variation is thought to play an important role in controlling crustal thickness, in addition to changes in mantle source fusibility (Poore et al., 2011; Parnell-Turner et al., 2017).

Since Vogt's early thermal pulsing hypothesis, the origin of the VSRs has been debated (Figure **F2**) (e.g., Parnell-Turner et al., 2014). One alternative idea is that the VSRs may be tectonic in origin and have no requirement for hotspot melt anomalies (Briais and Rabinowicz, 2002; Rabinowicz and Briais, 2002; Benediktsdóttir et al., 2012). In this hypothesis, a sequence of propagating rifts and southward migrating discontinuities, suggested by the observed asymmetric accretion at the ridge axis, explains the formation of VSRs and VSTs, which are thought to represent ridge segments and pseudofault scarps, respectively (Figure **F2B**). A third hypothesis, in which shallow buoyant mantle upwelling instabilities propagate along axis to form the observed crustal structure,

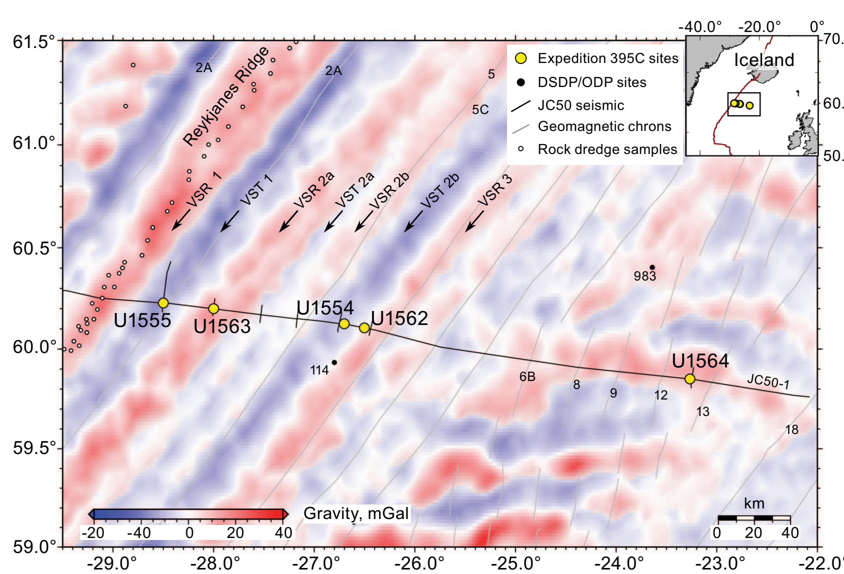

Figure F1. Satellite free-air gravity anomaly map, Expedition 395C. Solid black lines = seismic reflection profiles, labeled gray lines = magnetic polarity chrons, arrows = VSRs and VSTs. Inset: North Atlantic region (box = location of main panel).

has also been suggested; it avoids the requirement for rapid mantle plume flow (Martinez and Hey, 2017; Martinez et al., 2020) (Figure **F2C**).

Crust on the Reykjanes Ridge was last drilled in 1978 during Deep Sea Drilling Project (DSDP) Leg 49 when basalts were recovered at three sites (407–409) located on VSRs. A total basalt thickness of 453 m was penetrated (Luyendyk et al., 1979), leading to a series of breakthroughs in our understanding of the nature and scale of mantle heterogeneity and crustal accretion under the influence of a mantle plume (e.g., Wood et al., 1979; Dupré and Allègre, 1980; Fitton et al., 1997). The deepest basement penetration was at Site 409, located 23 km from the ridge axis, where 240 m of vesicular basalt was drilled in the 2.4 Ma crust; however, the other Leg 49 sites are on older crust (36 and 20 Ma) and did not attempt to recover basalts from a VST. Hence, Leg 49 basalts alone are not able to unravel the origins of VSRs and VSTs and do not provide detailed stepwise information about the aging of oceanic crust.

The North Atlantic Ocean is separated from the colder, more dense waters of the Arctic Ocean and Norwegian-Greenland Sea by the Greenland-Scotland Ridge, which represents a critical gateway affecting Cenozoic deepwater circulation patterns and climate. The Greenland-Scotland Ridge is generally less than 500 meters below sea level (mbsl) and is only ~1000 mbsl at its deepest point, making the overflow flux sensitive to small variations in the ridge depth. Reconstructions of Neogene mantle plume activity correlate with deepwater circulation patterns in the North Atlantic (Wright and Miller, 1996). Times of high mantle plume activity are linked to low Northern Component Water productivity, increased current strength, and sedimentary deposition rates (Wright and Miller, 1996; Poore et al., 2006; Parnell-Turner et al., 2015). Southward-flowing deepwater currents in the North Atlantic Ocean deposit fine-grained sediments called contourite drifts, which accumulate at rates of hundreds of meters per million years. Two contourite drifts, Gardar and Björn, were successfully drilled during Ocean Drilling Program (ODP) Leg 162 (Jansen and Raymo, 1996), providing a record of drift sedimentation back to early Pleistocene times (1.7 Ma). High sedimentation rate combined with near 100% core recovery rates means that these sites contain some of the highest resolution records of ocean circulation and climate to date (Kleiven et al., 2011; Thornalley et al., 2013). These records can be directly compared to atmospheric records

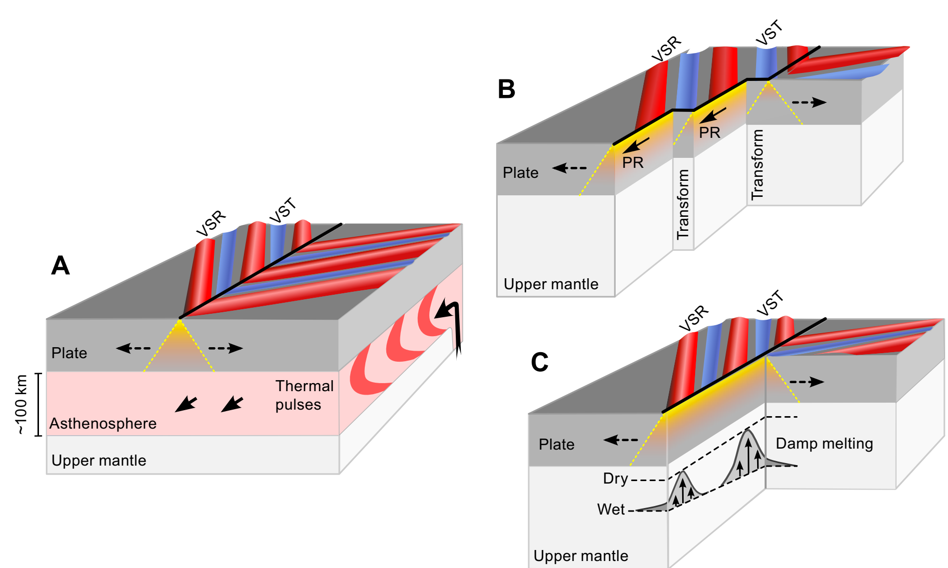

Figure F2. Competing hypotheses for VSR formation (Parnell-Turner et al., 2017). A. Thermal pulsing hypothesis (Vogt, 1971). Dark gray blocks = lithospheric plates, pink block with red patches = asthenospheric channel containing thermal pulses, light gray block = upper mantle, solid arrows = propagation direction of thermal pulses, dashed arrows = plate spreading direction, yellow shading = melting region, red/blue ribs = VSRs/VSTs, black line = mid-ocean ridge. B. Propagating rift hypothesis (Hey et al., 2010). Solid arrows = propagating rift direction. VSRs regarded as propagating rifts with thicker crust and VSTs are regarded as pseudofaults that propagate along axis generating thinner crust. C. Buoyant mantle upwelling hypothesis (Martinez and Hey, 2017). Gray blobs = buoyant upwelling cells that generate damp melting and thicker crust in absence of thermal anomaly, vertical arrows = vertical upwelling in a given cell, dashed lines = dry/wet solidi.

from ice cores and provide a unique, high-resolution insight into the Earth's climatic past (Barker et al., 2019).

2.2. Site survey data

A detailed geophysical survey of the Reykjanes Ridge and its flanks was conducted in June–July 2010 during RRS *James Cook* Cruise JC50, collecting more than ~2400 km of 2-D multichannel reflection seismic data (Parnell-Turner et al., 2015, 2017). The survey consisted of two basin-spanning regional seismic reflection profiles, oriented parallel to plate-spreading flow lines, and a series of 19 shorter perpendicular crossing lines. These multichannel data are of sufficient quality to identify the sediment/basement interface as well as potential drilling hazards such as faults, gas accumulations, and stratigraphic discontinuities. Primary and alternate sites were positioned on thick sediment or in localized sedimentary basins that are imaged on seismic reflection profiles so that holes can easily be established. Sites were chosen as close to crossing seismic profiles as possible while avoiding sedimentary disturbances, faults, and basement discontinuities. Sediment thicknesses are estimated using interval sediment velocities from Leg 162 where possible, and stacking velocities are used for deeper levels.

3. Scientific objectives

In March 2021, the *JOIDES Resolution* Facility Board, the *JOIDES Resolution* Science Operator (JRSO), and the National Science Foundation (NSF) decided to postpone International Ocean Discovery Program (IODP) Expedition 395 because of travel risks associated with the COVID-19 pandemic. Instead, IODP Expedition 395C was scheduled to undertake Expedition 395 operations that could be completed without a science party on board. These restrictions prevented the usual laboratory analysis and core description efforts. For example, it was not feasible to collect and analyze high-resolution ephemeral properties through the analysis and collection of interstitial pore water fluid samples or possible to generate the usual at-sea products such as a preliminary biostratigraphic age model. All core description will take place during a shore-based postcruise meeting. In light of these limitations, operational and laboratory objectives for Expedition 395C were adjusted so that they were achievable by the shipboard JRSO technical staff during a single expedition, with remote input from the scientific party.

Expedition 395C had three central objectives: (1) to test contrasting hypotheses for the formation of VSRs, (2) to understand temporal changes in ocean circulation and explore connections with plume activity, and (3) to reconstruct the evolving chemistry of hydrothermal fluids with increasing crustal age and varying sediment thickness and crustal architecture.

To address these objectives, Expedition 395C was planned to obtain basement cores at four sites that represent two VSR/VST pairs and also install a reentry system and core and log the rapidly deposited sedimentary section of Björn drift deposits that lie above the basement. Expedition 395C also tentatively aimed to core the sedimentary section of the Gardar drift (Site U1564) to allow further drilling to basement at that site at a later date. The majority of operations at the sediment drift sites (Sites U1554 and U1562) were postponed to Expedition 395 because high core recovery necessitates the presence of a sailing science party. Single advanced piston corer (APC) holes were planned at each site, with the expectation that triple APC coring would follow during a later expedition. At each site, 200 m of basement penetration was initially planned in light of depth-increasing trends in basalt composition (e.g., Ti concentration and Zr/Y) observed in IODP Expedition 384 Hole U1555G. A portable X-ray fluorescence spectrometer (pXRF) scanning unit was planned to be used to monitor basement cores for this trend to decide whether 200 m of basement was necessary at other sites (see **Site summaries** for details).

3.1. Objective 1: origin of V-shaped ridges

We will use the composition of basaltic samples to understand crustal formation south of Iceland at two temporal scales. First, on ~5–10 My timescales, we seek to test three alternative hypotheses for the formation of VSRs: (1) thermal pulsing, (2) propagating rifts, and (3) buoyant mantle upwelling. Drilling will allow us to test these hypotheses, which predict differing depths, temperatures, and degrees of melting between VSRs and VSTs recorded in basalt composition. Dredged samples are restricted to the ridge axis because deep-sea corals and sediments cover off-axis areas (Jones et al., 2002; Murton et al., 2002). Hence, off-axis VSRs and VSTs can only be sampled by drilling. Our objective of understanding how crustal formation responds to mantle temperature, degree of melting, and plume activity will be achieved by comparing the geochemistry of basalts from smooth and segmented crustal domains. Expedition 395C sites, located along a spreading-parallel flow line, avoid the issue of variable distance from the plume. Incompatible trace element concentrations and ratios (e.g., Nb/Y and La/Sm) will be used to constrain melting models, building upon previous work on the axis. Indirect reconstruction of axial depth is possible using volatile elements such as carbon, water, and sulfur, which degas when erupted at the seafloor. For example, advances in understanding the CO_2 concentration in ridge basalts enable quantification of eruption pressure (Le Voyer et al., 2017). Recovery of glass (achieved during Leg 49) will enable electron and ion-probe analyses to measure volatile elements and therefore estimate eruption pressures and test the plume pulsing hypothesis.

3.2. Objective 2: oceanic circulation, magnetic paleointensity, and sedimentation

We plan to quantify how oceanic circulation in the North Atlantic Ocean has varied since Oligocene times. Deepwater flow in the North Atlantic is dominated by two oceanic gateways, the Iceland-Faroe Ridge and the Denmark Strait, that control the southward flow of water from the Norwegian Sea and exert a major influence on global ocean circulation (Figure **F1**). The rate of accumulation of contourite drift sediments in the North Atlantic Ocean is primarily controlled by deepwater flow along bathymetric rises; hence, the strength and pathways of deepwater currents are recorded by these drift sediments (Figure **F3**) (e.g., Wright and Miller, 1996). These deposits provide an indirect proxy for temporal variations in deepwater flow. Additionally, short-term climatic effects relating to the location of oceanic fronts during both glacial–interglacial and (shorter) stadial–interstadial cycles may play a role in circulation patterns on shorter timescales (thousands of years). It has been suggested that uplift and subsidence of the Iceland-Faroe Ridge and Denmark Strait is influenced by mantle upwelling beneath Iceland and that there may therefore be an indirect connection between ocean circulation and mantle plume behavior (Poore et al., 2011; Parnell-Turner et al., 2015). We plan to test the correlation between mantle plume activity and ocean circulation by using sediment accumulation rates as a first-order proxy for deepwater current strength. In addition, high sedimentation rates of contourite drift deposits in the North Atlantic Ocean (12–16 cm/ky) have led to paleomagnetic and isotopic records that are among the most detailed available (Channell et al., 2002). Existing boreholes provide high-resolution climate records back to 1.7 Ma (ODP Site 983), and Expedition 395C aims to extend the high-resolution climate record further into late Pliocene times.

3.3. Objective 3: time-dependent hydrothermal alteration of oceanic crust

Expedition 395C will investigate the nature, extent, timing, and duration of hydrothermal alteration in the Reykjanes Ridge flank. Hydrothermal circulation along MORs and across their flanks is responsible for one-third of the heat loss through the ocean crust. Fluid circulation influences tectonic, magmatic, and microbial processes on a global scale and is a fundamental component of global biogeochemical cycles. There is also growing evidence that the long-term carbon cycle is influenced by the reaction of seawater with the oceanic crust in low-temperature, off-axis hydrothermal systems, perhaps representing an important mechanism for carbon drawdown (e.g., Gillis and Coogan, 2011). The relative contribution of this process remains controversial because we don't know how much low-temperature alteration takes place off axis. Although the nature of the individual hydrothermal fluid rock reactions is generally understood, the magnitude and distribution of chemical exchange remain poorly quantified, as does the partitioning between high- and low-temperature exchange with crustal age. Consequently, the role of the production, hydrothermal alteration, and subsequent subduction of ocean crust in key global geochemical cycles remains uncertain. Drilled sections of hydrothermally altered crust from the Reykjanes Ridge flank will provide time-integrated records of geochemical exchange between crust and seawater

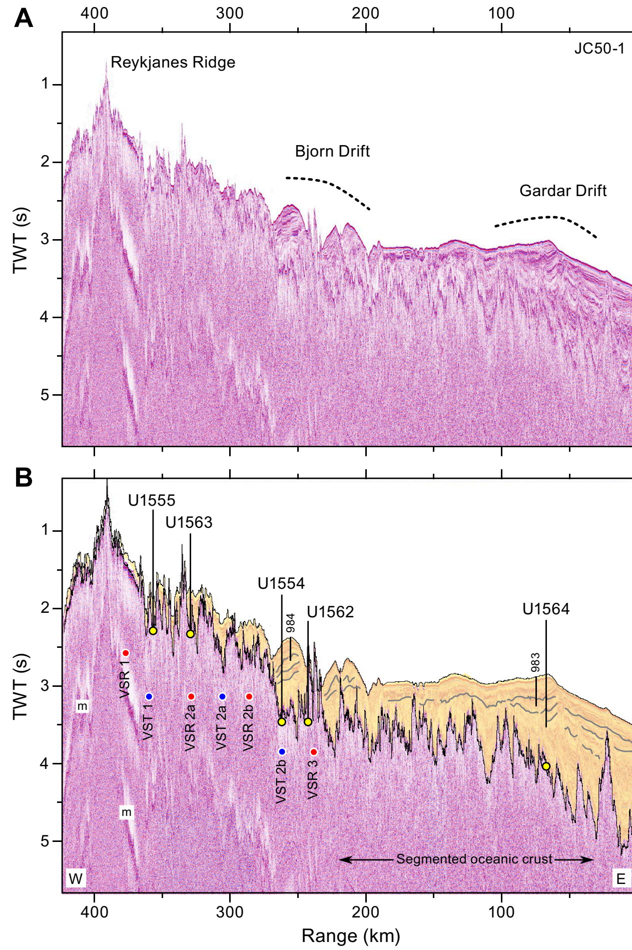

Figure F3. Portion of Seismic Reflection Profile JC50-1. TWT = two-way traveltime. A. Uninterpreted time-migrated image. Dotted lines = sedimentary drifts. B. Interpretation. Yellow shading and gray lines = sedimentary strata, solid line = sediment/basement interface, red dots = VSRs, blue dots = VSTs, yellow dots = Expedition 395C sites, m = water-bottom multiple reflections. Lines 983 and 984 = projected locations of Leg 162 drilling sites.

along an age transect from 2.8 to 13.9 Ma (Figure **F3**). These sections will enable us to quantify the timing and extent of hydrothermal fluid–rock exchange across the Reykjanes Ridge flank and to assess the hydrothermal contributions of a rapidly sedimented slow-spreading ridge flank to global geochemical budgets. Expedition 395C sites comprise a crustal flow line transect across the eastern flank of Reykjanes Ridge. The recovered cores will sample the uppermost ~130 m of lavas produced at 2.8, 5.2, 12.7, and 13.9 Ma at the slow-spreading Reykjanes Ridge, which will provide a unique opportunity to quantify the timing and extent of hydrothermal fluid–rock exchange in a slow-spreading ridge flank that experienced rapid sedimentation and variations in tectonic architecture.

4. Site summaries

4.1. Beginning of expedition and transit

Expedition 395C officially began at 0818 h on 5 June 2021 with the first line ashore at Skarfabakki Harbor in Reykjavík, Iceland. The JRSO team and ship's crew isolated in their hotel rooms in Reykjavík, following the JRSO's COVID-19 quarantine and testing procedures prior to boarding on 8 June. During the quarantine period, the off-going crew handled freight and virtual crossover meetings took place. The majority of the JRSO staff and ship's crew moved onto the vessel the morning of 8 June. The remaining staff and crew, who arrived in Reykjavík a day later, joined the vessel on 9

June. The final member of the JRSO staff boarded the vessel the morning of 11 June, and the pilot boarded the ship at 0852 h. After some difficulties with the mooring lines, the ship left the dock with the last line away at 0948 h. At 1000 h, the pilot departed and the ship began the 312 nmi transit to Site U1555. The ship averaged 11.6 kt and arrived at Site U1555 at 1225 h on 12 June. The thrusters were lowered, and the vessel switched to dynamic positioning (DP) mode, beginning Hole U1555H at 1300 h.

4.2. Site U1555

4.2.1. Background and objectives

Site U1555 (proposed Site REYK-13A of Expedition 395) is located in the North Atlantic Ocean along the Reykjanes Ridge south of Iceland. Site U1555 is located at the intersection of Seismic Lines JC50-1 (common midpoint [CMP] 57881) and JC50-C7 (CMP 3720), obtained in 2010 during RRS *James Cook* Cruise JC50 (Parnell-Turner et al., 2017). Site U1555 is located on VST-1 with an estimated basement age of 2.8 Ma. Cores and data from this site will address two of the primary science objectives: (1) crustal accretion and mantle behavior and (2) time-dependent hydrothermal alteration of oceanic crust.

The operational objectives for this site were to core the sedimentary section using the APC and extended core barrel (XCB) systems to the sediment/basement interface, use the rotary core barrel (RCB) system to core ~200 m into the basement, and use downhole wireline tools to log the borehole. All of the planned operations are in support of Expedition 395, which was postponed twice because of the COVID-19 pandemic.

Operations at Site U1555 first occurred in August 2020 during Expedition 384 (Blum et al., 2020). Holes U1555A–U1555E were drilled through the sedimentary section and into the underlying basement to test different hard rock drill bits. Holes U1555F and U1555G were cored in support of Expedition 395 objectives and recovered 68.64 m of basalt basement. In addition to coring, Hole U1555G was logged with downhole tools.

4.2.2. Operations

4.2.2.1. Transit to Site U1555

The R/V *JOIDES Resolution* departed Reykjavík, Iceland, on 11 June 2021. The pilot boarded the ship at 0852 h, and after some difficulties with the mooring lines, the ship left the dock with the last line away at 0948 h. At 1000 h, the pilot departed and the ship began the 312 nmi transit to Site U1555. The ship averaged 11.6 kt and arrived at Site U1555 at 1225 h on 12 June. The thrusters were lowered, and the vessel switched to DP mode, beginning Hole U1555H at 1300 h.

4.2.2.2. Hole U1555H

Hole U1555H (60°13.6924′N, 28°30.0240′W) was positioned 12 m northwest of Hole U1555F. The crew began to assemble the drill collars until the weather deteriorated with winds blowing up to 40 kt. From 1645 to 2045 h on 12 June 2021, the vessel waited on weather. After the wind subsided, the crew continued to assemble the drill collars and made up the drill bit. The drill string was advanced to 1518.6 mbsl and positioned to fire the first APC core to establish the seafloor depth.

Coring in Hole U1555H was initiated at 0650 h on 13 June. Core 395C-U1555H-1H recovered a good mudline with 5 m of sediment, placing the seafloor depth at 1523.6 mbsl. Cores 1H–10H were cored to 90.5 m drilling depth below seafloor (DSF). Following Core 10H, 150 m of the core winch line was cut to remove a damaged section. Coring continued with Cores 11H–15H to 138 m DSF. Coring was interrupted when the core winch line became stuck in the oil saver sub on the top drive. After removing, cutting, and reheading the line, coring continued with Cores 16H–18H (138–166.5 m DSF). The XCB system was deployed for the remaining cores. Core 19X was only advanced 6 m to ensure that Core 20X would drill through the sediment/basement interface, which was encountered at 176.5 m DSF. The final depth of Hole U1555H was 177.5 m DSF. The crew began tripping the pipe, and the bit cleared the seafloor at 1525 h on 14 June. At 2000 h, the bit cleared the rotary table, ending Hole U1555H.

All APC cores were collected using nonmagnetic core barrels and oriented using the Icefield MI-5 core orientation tool. Formation temperature measurements were collected on Cores 395C-U1555H-4H, 7H, 10H, and 13H using the third-generation advanced piston corer temperature (APCT-3) tool.

A total of 180.06 m of core was recovered from Hole U1555H with 101% recovery. The APC system collected 18 cores over a 166.88 m interval with 166.58 m recovered (100%). Two cores were taken using the XCB system over a 12.67 m interval with 13.48 m recovered (106%).

4.2.2.3. Hole U1555I

The ship was offset 24 m east-southeast of Hole U1555H for operations in Hole U1555I. As the crew worked to assemble the drill string and RCB bottom-hole assembly (BHA), the weather deteriorated, and at 0315 h on 15 June 2021, operations paused while the vessel waited on weather. Winds picked up to over 30 kt with waves up to 5.5 m over the course of the day. After 30 h, operations resumed at 0900 h on 16 June.

Hole U1555I (60°13.6897′N, 28°29.9984′W) was spudded at 1000 h on 16 June and drilled without core recovery to 159.3 m DSF (drilled interval 395C-U1555I-11). The RCB system was used to cut all cores from Hole U1555I. Cores 2R and 3R were collected from 159.3 to 178.7 m DSF with 77% sediment recovery, and the sediment/basement interface was encountered at 176.5 m DSF. Cores 4R–6R (178.7–207.8 m DSF) were cut using 9.7 m coring advances. Beginning with Core 7R, the drill string advances alternated between 5 and 4.7 m for each core to prevent the core from jamming inside the barrel and improve core recovery. Mud sweeps were performed following Core 8R because hole conditions had deteriorated. Coring continued with Cores 9R–26R (227.2–304.8 m DSF). After cutting Core 26R, the drill bit reached 49 rotating hours and needed to be switched out.

At 0320 h on 20 June, a free-fall funnel (FFF) was installed to allow reentry into the hole. The subsea camera was deployed to observe the placement of the FFF and to ensure that the pipe did not move it out of position when the bit exited the hole. The Conductivity-Temperature-Depth (CTD) sonde was run on the subsea camera frame to collect temperature, pressure, and conductivity measurements of the seawater. The bit cleared the seafloor and the FFF at 0450 h, the subsea camera was retrieved, and the bit cleared the rotary table at 0930 h. After changing the drill bit, the drill string was reassembled and the subsea camera deployed for the reentry of Hole U1555I. The FFF remained in position, and the bit reentered Hole U1555I at 1605 h. After recovering the subsea camera, the center bit was dropped and the drill string advanced to 304.8 m DSF. Mud sweeps were used to clean the hole of debris.

Cores 395C-U1555I-27R through 41R were cut from 304.8 to 376.5 m DSF with 30.9 m of basalt recovered (43%). Core recovery significantly decreased in Cores 38R–40R (358.3–372.7 m DSF) with only 10% of the basalt section retrieved. After reaching 376.5 m DSF (200 m into basement), coring concluded on 22 June.

A total of 40 RCB cores were recovered from Hole U1555I with 48% core recovery (77% sediment recovery and 45% basalt recovery). Cores were collected over a 217.2 m long interval with 104.19 m recovered.

Following coring operations, the borehole was prepared for downhole wireline logging operations. A high-viscosity mud sweep was used to clean the hole of debris. The drill bit was dropped at the bottom of the hole, and the drill pipe was brought up to 75.6 m DSF. The triple combo logging tool string was assembled and deployed at 1720 h on 22 June. The tool descended to the bottom of the hole and began making its first pass up the hole. At 1755 h, the triple combo became stuck. After several attempts to pull the tools free using the Schlumberger logging line winch, the decision was made to lower the drill pipe over the tools to clear the obstruction. The drill pipe was lowered, and the top of the triple combo was encountered at 183.5 m DSF, ~7 m below the sediment/basement interface. The obstruction in the hole was at 225.5 m DSF. The drill pipe was lowered until the obstruction was pushed past the base of the tool string. At 1015 h on 23 June, the tool string was free and the rig floor crew began pulling the tools up using the core winch line. At 1400 h, the tools were at the rig floor and were disassembled. Hole conditions prevented any other logging operations. The drill pipe was pulled from the hole. At 1700 h, the pipe cleared the seafloor, and it cleared the rotary table at 2015 h. The vessel was secured for transit to Site U1554, and the thrusters were raised at 2036 h, ending Hole U1555I and Site U1555.

4.2.3. Principal results

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

Sediment cores from Hole U1555H (Cores 395C-U1555H-1H through 19X; 0–179.17 m core depth below seafloor, Method A [CSF-A]) were run through the whole-round (WR) physical properties tracks, which include magnetic susceptibility (MS), gamma ray attenuation (GRA) bulk density, *P*-wave velocity, and natural gamma radiation (NGR) measurements. WR core sections near the sediment/basement interface were imaged using the X-Ray Imager (XRI). The split section halves were imaged, measured for point MS and color reflectance, and scanned for magnetic remanence using the superconducting rock magnetometer (SRM). Thermal conductivity measurements and moisture and density (MAD) samples were collected at a resolution of one per core.

Samples were collected on the catwalk for shipboard and shore-based interstitial water (IW), gas, microbiology, and micropaleontology analyses. Headspace gas samples for shipboard hydrocarbon safety analysis and postcruise research were collected from every core, and the resolution increased to two samples per core ~30 m above the sediment/basement interface. IW samples, 5–10 cm in length, were collected from each core, and three samples per core were collected in the ~20 m above the sediment/basement interface. Microbiology samples were extracted using a sterile syringe, with 4 cm^3 of sediment frozen in the syringe and 1 cm^3 of sediment added to a glycol solution and flash frozen using liquid nitrogen. Microbiology samples were paired with IW samples. X-ray diffraction (XRD) and carbonate samples were taken from the IW squeeze cake sediment residues. Additional carbonate samples were collected beginning ~30 m above the sediment/basement interface.

RCB Cores 395C-U1555I-2R through 41R (159.3–374.4 m CSF-A) were run through the WR tracks to collect the same physical properties measurements as for Hole U1555H, with the exception of *P*-wave velocity, which was not recorded because the space between the liner and the core for RCB cores prevents meaningful measurements. The split section halves were imaged; measured for point MS, color reflectance, thermal conductivity, and *P*-wave velocity using the caliper; and scanned using the SRM. Section halves from Cores 2R–4R (159.3–185.39 m CSF-A) were imaged using the XRI. Each basalt core section was scanned using the handheld pXRF device. Sediment Cores 2R–4R were sampled for micropaleontology. WR samples of basalt for postcruise microbiology studies were collected immediately after the core was received from the rig floor at a resolution of one sample per ~10 m. Samples for inductively coupled plasma–atomic emission spectroscopy (ICP-AES) and thin sections were selected by the shore-based petrologists using core photos, also at ~10 m resolution.

The split core images of the basalt sections and pXRF data were sent to science party members on shore. Postcruise analysis of samples obtained from Expedition 384 Hole U1555G showed a downhole trend in the chemical composition of the basalts. The Expedition 395C shipboard pXRF data were compared to the shore-based inductively coupled plasma–mass spectroscopy (ICP-MS) data to see if the trend could be reproduced on board the ship and to determine if the basement coring depth needed to be extended past the 130 m initial plan. The pXRF data did show the same trends as the ICP-MS data and allowed the science party to determine what depth was required for coring.

Sediments at Site U1555 are clay to silt. Cores 395C-U1555H-1H through 2H (0–15 m CSF-A) alternate between brown and gray clay and silt and contain dropstones. From 15 to 176.5 m CSF-A, sediment ranges from gray to dark gray (Figure **F4A**). Sponge spicules and foraminifers are visible in the split core sections. Coring disturbance varies, with some core tops heavily disturbed by heave of the ship (Figure **F5D**). The recovered basalts display varying degrees of alteration including calcite veins, infilled vesicles, and staining (Figure **F6A**). Glass rinds are observed on some of the core pieces. The formation changes at the very base of the hole (~374 m CSF-A) to vesicular basalt.

Physical properties of the cores primarily reflect changes in the lithologic composition. MS and NGR values differ greatly between sedimentary and igneous rocks (Figure **F7**). MS of the sedimentary section (0–178 m CSF-A) ranges 8–485 instrument units (IU) with an average value of 237 IU. Basalt cores (178–375 m CSF-A) have much higher MS values, up to 2600 IU. NGR values in the sediments average 12 counts/s, whereas the basalts have an average NGR value of 3 counts/s. Porosity of the sediments averages 75%, with values decreasing from 82% at the top of the hole to 75% near the base of the section. The deepest sample, obtained from Core 395C-U1555H-20X, has a porosity of 62%. Red-green-blue (RGB) color and color reflectance does not vary greatly because the cores are relatively homogeneous in color. *P*-wave velocity increases downhole to the sediment/basement interface. *P*-wave caliper measurements on basalts average 5300 m/s.

Downhole measurements at Site U1555 consisted of wireline logging and in situ temperature. Formation temperature measurements increase linearly from 8.3°C (33.5 m DSF) to 18.4°C (119 m DSF) in Hole U1555H. Despite the difficulties with the downhole logging, the triple combo collected data on the way downhole and over the lowermost ~180 m of the hole during its first and only pass uphole prior to becoming stuck.

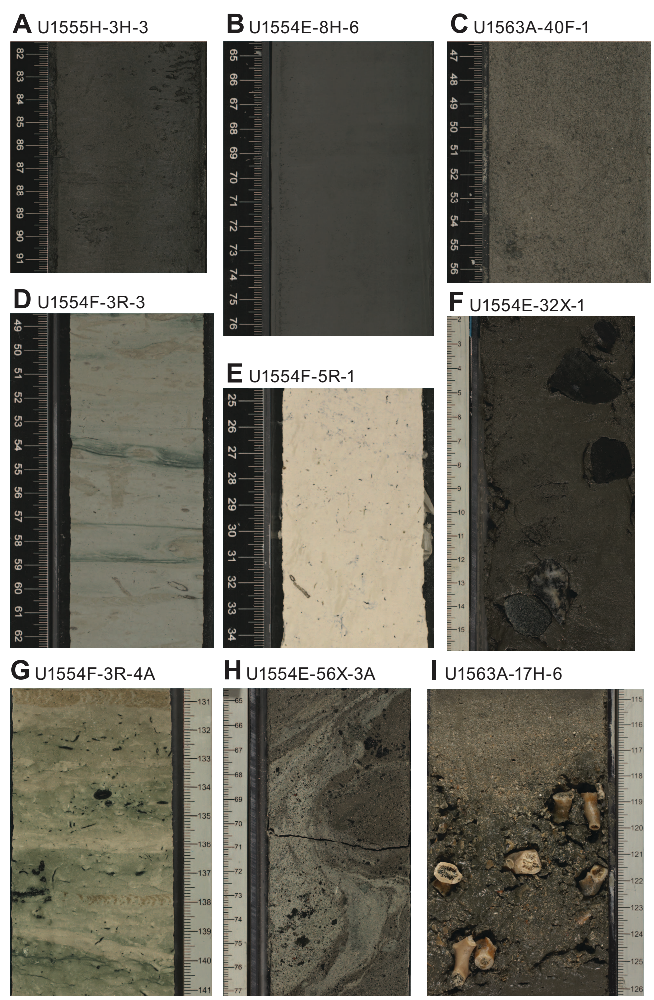

Figure F4. Primary sedimentary (A–E) lithologies and (F–I) features recovered, Expedition 395C. A. Dark gray silty clay. B. Dark gray clay. C. Medium unconsolidated brown sand. D. Green, clay-rich carbonate with bioturbation. E. White ooze to chalk. F. Dropstones. G. Bioturbation and mottling. H. Soft-sediment deformation. I. Graded sand bed with coral fragments.

Core sections were run through the SRM, which measured natural remanent magnetization (NRM) before and after alternating field (AF) demagnetization. Sediment cores were demagnetized up to 35 mT at 1 cm spacing, and basalt cores were demagnetized up to 30 mT at 2 cm spacing. Both NRM and MS obtained by point measurement on section halves show a cyclicity between 100 and 170 m. The magnetic inclination displays strong changes in polarity, which allowed for the identification of 11 normal and 10 reversed magnetic polarities. The magnetostratigraphy was correlated to the geologic timescale, allowing us to locate the base of the Matuyama (2.595 Ma) at ~172.5 m CSF-A. Most of the basalts show normal polarity and are not fully demagnetized at 30 mT. Measurements on the basalts show two behaviors, with some displaying over 80% magnetization loss before 25 mT (soft magnetic component) and others showing no signifi-

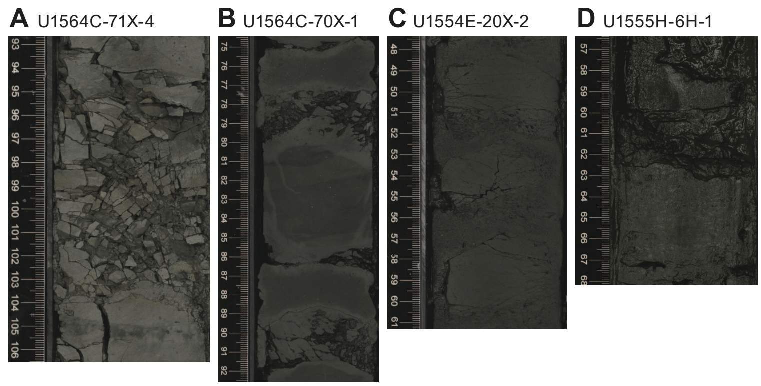

Figure F5. Coring disturbance caused by APC and XCB systems, Expedition 395C. A. Core fracturing caused by XCB coring. B, C. Biscuiting caused by XCB coring. D. Disturbed sediment at top of core Section 1 likely caused by heaving of the ship before firing an APC core barrel.

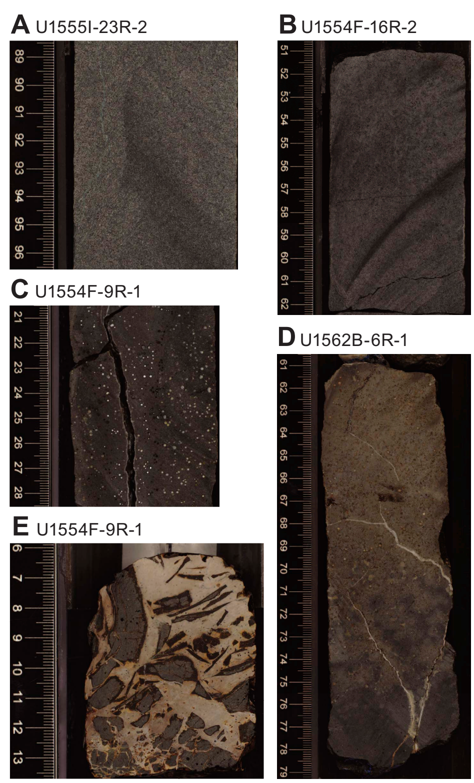

Figure F6. Basalt and features recovered, Expedition 395C. A, B. Basalt. C. Basalt with vesicles infilled with secondary mineral. D. Piece of basalt that shows brown staining, cross-cutting veins, and infilled vesicles. E. Basalt fragments in carbonate sediment.

cant loss of magnetization at 25 mT (hard magnetic component) that correlates with the point MS range.

Hydrocarbon concentrations in gas samples and sediment and pore water geochemistry were measured in the chemistry laboratory. Methane concentrations are low throughout the sedimentary section, with an average of 1.9 parts per million by volume (ppmv). Methane peaks at 3.14 ppmv at 103 m CSF-A. The average calcium carbonate and total organic carbon (TOC) content of the sediments in Hole U1555H is 11.0 and 0.3 wt%, respectively. Neither profile varies significantly downhole. Pore water alkalinity and calcium concentration slightly increase downhole. Ammonium and sulfate display opposing trends with ammonium initially increasing downhole before decreasing near the sediment/basement interface. Sulfate decreases downhole but increases within ~20 m of the basement. Dissolved B, Mg, and K concentrations decrease downhole, whereas Li, Si, and Sr increase downhole.

4.3. Site U1554

4.3.1. Background and objectives

Site U1554 (proposed Site REYK-6A of Expedition 395) is located in the North Atlantic Ocean along the Reykjanes Ridge south of Iceland and on the Björn drift. Site U1554 is located on Seismic Line JC50-1 (CMP 41740) near the intersection with Line JC50-C3 (CMP 1005), both obtained in 2010 during RRS *James Cook* Cruise JC50 (Parnell-Turner et al., 2017). Site U1554 is located on

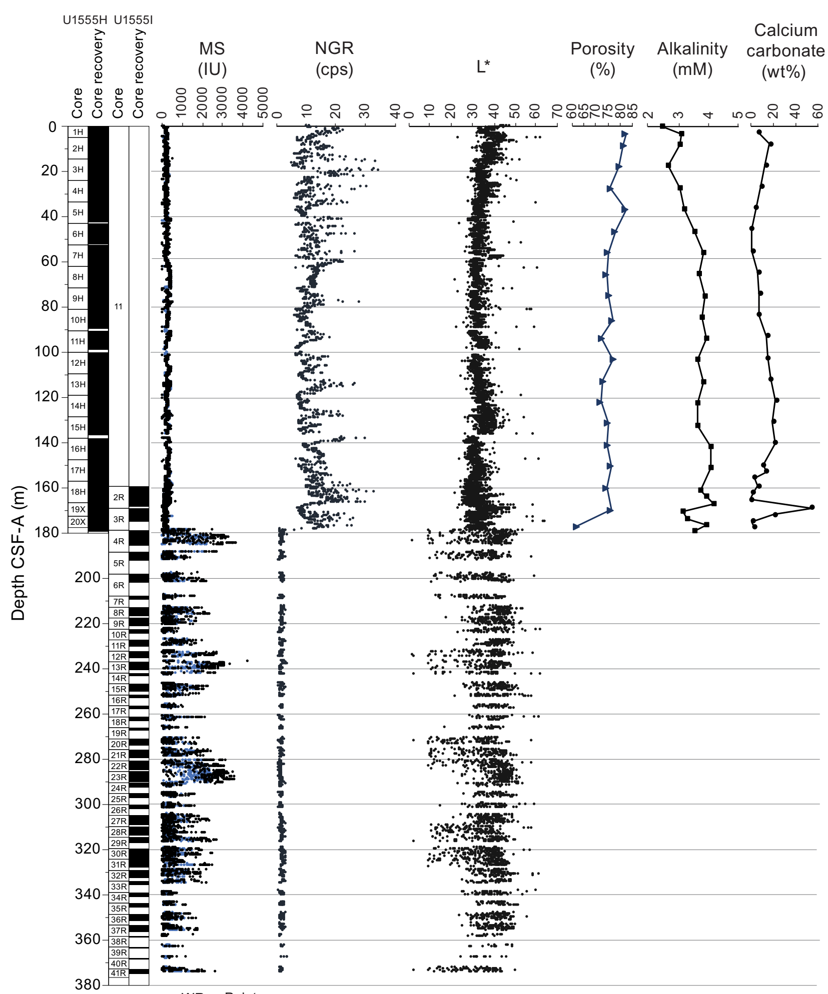

Figure F7. Core recovery and selected physical properties and geochemistry, Site U1555. Core recovery: black = recovery, white = no recovery. cps = counts per second.

VST-2b with an estimated basement age of 12.7 Ma. Another target for Site U1554 is to obtain a continuous sedimentary record of the Björn drift, which will offer millennial-scale climate records. The sedimentation rate of this drift can serve as a proxy for deepwater current strength, providing information on oceanic gateways and their potential ties to mantle plume pulses.

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 operational objectives for this site were to core the sedimentary section using the APC and XCB coring systems to the sediment/basement interface, install a reentry system with casing and use the RCB system to core ~130 m into the basement, and use downhole wireline tools to log the borehole.

Operations at Site U1554 first occurred in July 2020 during Expedition 384 (Blum et al., 2020). Holes U1554A–U1554D ranged in depth from 23.5 to 76.0 m DSF. The recovered cores were used to create a stratigraphic splice of the section. Paleomagnetic data from these cores were used to test and resolve issues with the Icefield tools.

4.3.2. Operations

4.3.2.1. Hole U1554E

Following a 54 nmi transit from Site U1555, the vessel arrived at Site U1554 early on 24 June 2021. The ship's thrusters were lowered at 0124 h, and the vessel switched to DP mode at 0136 h. The APC/XCB BHA and drill string were made up and run to the seafloor (1870 mbsl). At 0754 h, Hole U1554E (60°7.5235′N, 26°42.1324′W) was spudded and drilled without recovery to 66.3 m DSF. Coring during Expedition 384 recovered three copies of the uppermost ~75 m DSF, and coring this interval was not required for safety monitoring. Coring using the APC system progressed from 66.3 to 218.3 m DSF (Cores 395C-U1554E-2H through 17H) with 157.92 m of sediment recovered (104%). While taking Core 17H, the core barrel could not be pulled out of the sediment using the core winch line, marking APC refusal. The barrel was drilled over using the drill string to free the core.

Formation temperature measurements using the APCT-3 tool were collected on Cores 395C-U1554E-2H, 5H, 8H, and 11H. All APC cores were oriented and collected using nonmagnetic core barrels.

The XCB system was deployed following Core 395C-U1554E-17H. Cores 18X–62X (218.3–647.7 m DSF) were collected with 383.15 m of core recovered (89%). The basement was encountered at ~647 m DSF while drilling Core 62X; the core contained 1 m of basalt interlayered with carbonate sediment. The final depth of Hole U1554E was 647.7 m DSF. A total of 61 cores were collected from Hole U1554E, with 541.07 m of core collected over a 581.4 m interval (93% recovery).

Following coring operations, the hole was cleaned and displaced with heavy mud and the drill string was pulled up to 72.8 m DSF. The triple combo logging tool string was made up and run in the hole at 2100 h on 27 June. The tool string was able to descend to the base of the hole (~647 m DSF), and the triple combo made two passes of the borehole. The first attempt to pull the triple combo through the bit and into the drill pipe occurred at 0115 h on 28 June. The lockable float valve (LFV) at the bit had closed, preventing the tool string from reentering the pipe. After several hours of pumping seawater and rotating the drill string, the triple combo was pulled past the LFV, and the tools reached the surface at 0845 h. The Formation MicroScanner (FMS)-sonic string was assembled and deployed at 1120 h. A go-devil was attached to the top of the tool string to lock open the LFV. After two passes of the borehole, the FMS-sonic was unable to pass through the LFV and reenter the pipe. After additional pumping, the tools were successfully recovered, and the FMS-sonic tool string reached the rig floor at 2055 h. Based on the caliper results from the triple combo, which showed that the borehole was washed out to >14 inch diameter for the majority of the hole, the decision was made to not run the Versatile Seismic Imager (VSI). Following logging operations, the drill string was pulled out of the hole, with the bit clearing the seafloor at 2210 h on 28 June. At 0245 h on 29 June the bit cleared the rotary table, ending the hole.

4.3.2.2. Hole U1554F

The ship was positioned over the Hole U1554F coordinates (60°7.5136′N, 26°42.1140′W) ~25 m southeast of Hole U1554E, and the rig floor crew began assembling the casing and reentry system (Figure **F8**). The mud skirt of the reentry system was moved over the moonpool, and the hydraulic release tool (HRT) was made up and racked in the derrick. A 602.3 m long casing string, composed of 52 joints of 10¾ inch casing, was assembled. The HRT running tool was attached to the casing and lowered to the mud skirt. The HRT running tool was then detached and put back into the derrick. The mud motor, underreamer, and bit were assembled and tested. The first mud motor rotated too freely and was replaced with a second mud motor. After a successful test, the crew made up the BHA with the HRT running tool assembly and the reentry cone. At 0638 h on 30 June 2021, the HRT reentry system was deployed through the moonpool. The casing and drill string were run to 1552 mbsl, and the subsea camera system was deployed to observe the casing operations. Hole U1554F was spudded at 1345 h at a water depth of 1870 mbsl, and the casing was drilled in to 602 m DSF. Once the casing and reentry system were in place, a go-devil was pumped down the pipe to activate the HRT running tool and release the drill string from the casing. The drill string, including the HRT running tool assembly, was pulled from the hole, with the bit clearing the seafloor at 1610 h on 1 July. The rig floor crew broke down the HRT running tool assembly.

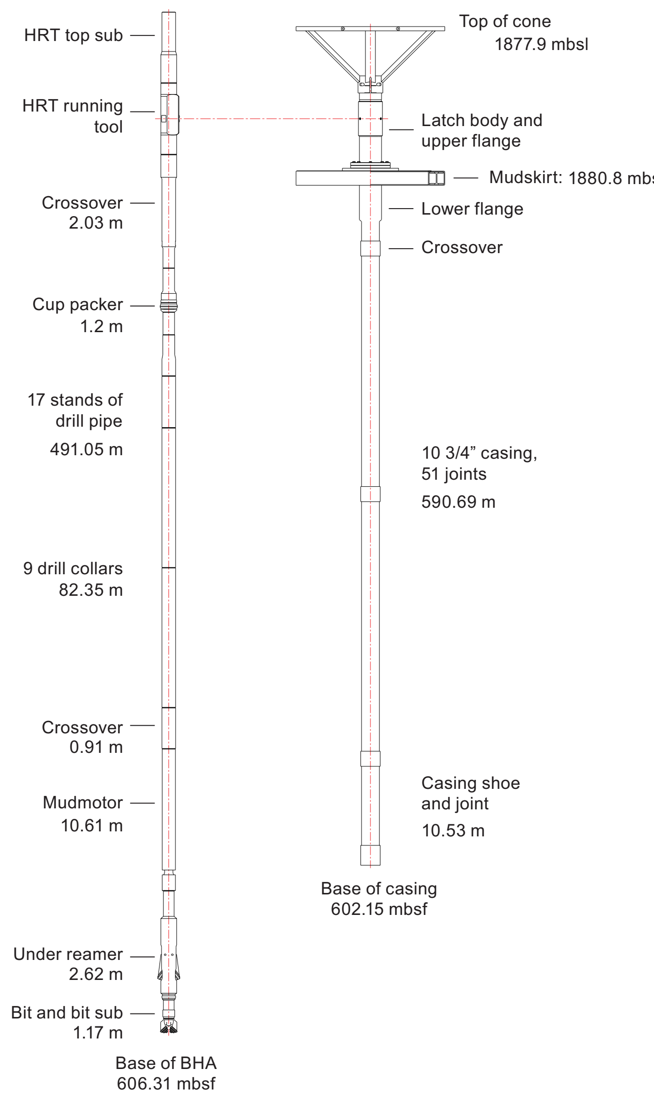

Figure F8. Casing and reentry system installed, Hole U1554F. Left: BHA includes HRT, which disconnects BHA from casing and reentry system following installation. Right: reentry system consists of 601 m of casing, mud skirt, and reentry cone.

An RCB BHA with a C-4 RCB bit and the drill pipe were made up and run to 1836.5 mbsl. The subsea camera, along with the CTD sonde, was run to the end of the drill string to observe the bit reenter Hole U1554F. The bit entered Hole U1554F at 1057 h on 2 July. The subsea camera was retrieved, and the drill string advanced to the base of the casing string (602 m DSF). The center bit was dropped into the RCB bit, and Hole U1554F was drilled without recovery to 620 m DSF. Two drilled intervals, 395C-U1554F-11 (0–606.3 m DSF) and 21 (606.3–620 m DSF), were recorded for the hole. The center bit was retrieved, and an RCB core barrel was deployed. Cores 3R–5R advanced from 620 to 649.1 m DSF with 19.86 m of core recovered (68%). Core 5R contained the sediment/basement interface at ~647 m DSF. Cores 6R–20R advanced from 649.1 to 721.7 m DSF with 45.91 m of basalt recovered (63%).

Following Core 395C-U1554F-20R, the drill bit had reached 50 rotating hours. The drill string was pulled from the hole to change the drill bit, and the bit cleared the seafloor at 1840 h and rotary table at 2210 h on 5 July. A new C-7 RCB drill bit was made up to the BHA. The drill string was assembled, and the subsea camera, along with the CTD sonde, was deployed for the reentry. The bit reentered Hole U1554F at 0405 h on 6 July. The subsea camera was recovered, and the drill string advanced to 721.7 m DSF. RCB coring resumed from 721.7 to 779.9 m DSF with the recovery of Cores 21R–32R.

A total of 30 cores were recovered from Hole U1554F over an interval of 159.9 m. Core recovery for this hole was 100.15 m (63%). Basement cores advanced at an average rate of 1.76 m/h.

Following coring operations, the hole was conditioned for downhole wireline logging with a 50 bbl high-viscosity mud sweep. The drill pipe was pulled out of the hole, and the subsea camera was deployed to observe operations. The drill bit cleared the seafloor at 0643 h on 8 July, and the ship was offset 20 m to the northeast. A rotary shifting tool (RST) was run to release the drill bit and allow the logging tools to exit the drill pipe. The bit was released at 0756 h, and at 0955 h, the pipe reentered Hole U1554F. The subsea camera was recovered, and the drill string was deployed to 589.2 m DSF (inside casing string). The triple combo logging tool string was made up and run for two passes of the borehole from 602 m DSF (base of casing string) to the bottom of the hole at 779 m DSF. At 2010 h, the triple combo tool string reached the drill floor and was broken down. The FMS-sonic tool string was made up and run at 0410 h on 9 July. After making two logging passes, the FMS-sonic tool string was recovered to the rig floor, disassembled, and laid out. The Ultrasonic Borehole Imager (UBI) tool string was then made up and deployed to the bottom of the hole. The UBI made two logging passes, taking 360° images of the borehole wall. The UBI tool string was recovered and laid out at 1425 h. The drill pipe was pulled up from 588 to 69 m DSF in preparation of running the VSI from the base of the hole up through the casing string. However, foggy conditions throughout the afternoon and evening inhibited visibility and prevented the start of the protected species observation (PSO) protocols. At day break, visibility had worsened, and conditions were not forecasted to improve until evening. Because of the time already allocated to Site U1554, the decision was made to abandon the VSI logging run and begin operations at Site U1562. The drill pipe was pulled up and cleared the seafloor at 0755 h on 10 July, ending Hole U1554F.

The vessel returned to Hole U1554F on 21 July to complete the VSI logging operations. The ship completed the 6.1 nmi transit in DP mode from Site U1562 to Hole U1554F at 0730 h. The subsea camera was deployed, and the drill pipe was lowered to 1836 mbsl. The drill pipe was positioned over the reentry cone and reentered Hole U1554F at 0930 h. The subsea camera was retrieved, and pipe was run to 68.5 m DSF (in casing string) in preparation for downhole logging with the VSI tool. At ~1030 h, fog had formed around the vessel and reduced visibility. The vessel waited on the fog to clear, and at 1250 h, the VSI was deployed to the base of the casing string (602 m DSF), the air guns were set in the water, and the PSO protocols were initiated. Nearly immediately, whales were spotted in the exclusion zone, which delayed the start of the VSI operations. After 2 h of tracking whales in the vicinity of the vessel, foggy conditions reduced visibility, prohibiting the continuation of the PSO watch. With the fog forecasted to worsen throughout the evening and into the next day, the planned VSI operations were canceled at 1600 h in favor of coring at the next site. The VSI was pulled from the drill pipe, and the tool reached the rig floor at 1700 h. While retrieving the tool string, visibility briefly improved only to reveal that the whales had come closer to the ship. The drill pipe was pulled out of the hole, and the end of the pipe cleared the seafloor at

1840 h and the rig floor at 2210 h. The rig floor was secured for transit, and the thrusters were raised. The vessel began the 39 nmi transit to Site U1563 at 2236 h, ending Hole U1554F and Site U1554.

4.3.3. Principal results

Sediment cores obtained from Holes U1554E and U1554F (Cores 395C-U1554E-2H through 60X [66.3–645.23 m CSF-A] and 395C-U1554F-3R and 4R [620.0–636.9 m CSF-A]) were run through the WR physical properties tracks, which include MS, GRA bulk density, *P*-wave velocity, and NGR measurements (Figure **F9**). WR core sections near the sediment/basement interface (Cores 395C-U1554E-56X through 61X) were imaged using the XRI. The split section halves were imaged, measured for point MS and color reflectance, and scanned for magnetic remanence using the SRM. Thermal conductivity measurements and MAD samples were collected at a resolution of one per core.

Samples were collected on the catwalk and at the sample table for shipboard and shore-based IW, gas, microbiology, and micropaleontology analyses. Headspace gas samples for shipboard hydrocarbon safety analysis and postcruise research were collected every core, and the resolution increased to two samples per core ~30 m above the sediment/basement interface. Samples for postcruise biostratigraphy were collected from each core catcher, and additional split core samples were collected from 500 to 645 m CSF-A at 3–4 m resolution. Catwalk sampling for IW analysis and microbiology began at Core 395C-U1554E-31X (~350 m CSF-A). The overlying sedimentary

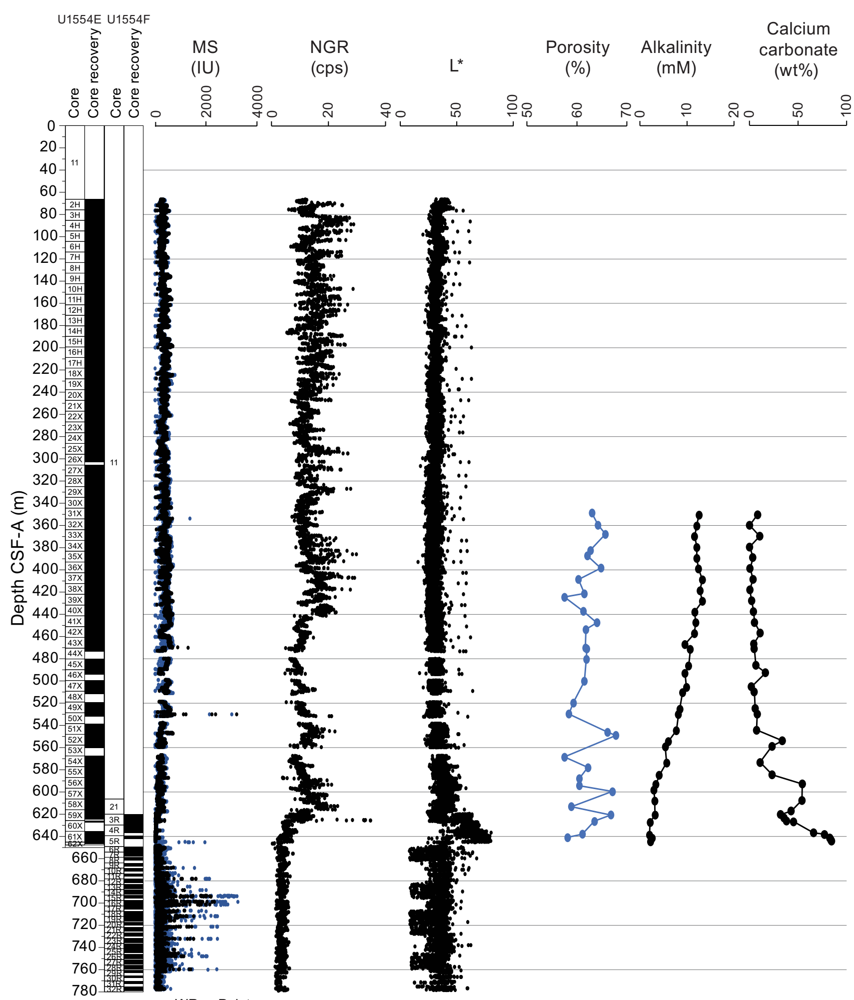

Figure F9. Core recovery and selected physical properties and geochemistry, Site U1554. Core recovery: black = recovery, white = no recovery.

section will be sampled for IW water chemistry and microbiology during Expedition 395 when the section is recored and a sailing science party is available to assist with the measurements. IW samples, 10 cm in length, were collected from each core below 350 m CSF-A, and three IW samples per core were collected in the ~20 m above the sediment/basement interface. Microbiology samples were extracted using a sterile syringe, with 4 cm^3 of sediment frozen in the syringe and 1 cm^3 of sediment added to a glycol solution and flash frozen using liquid nitrogen. Microbiology samples were paired with IW samples. XRD and carbonate samples were taken from the IW squeeze cake sediment residues. Additional carbonate samples were collected beginning ~30 m above the sediment/basement interface.

RCB Cores 395C-U1554F-5R through 32R (639.4–778.8 m CSF-A) were run through the WR tracks to collect the same physical properties measurements as for Hole U1554E, with the exception of *P*-wave velocity, which was not recorded because the space between the liner and the core for RCB cores prevents meaningful measurements. The split section halves were imaged; measured for point MS, color reflectance, thermal conductivity, and *P*-wave velocity using the caliper; and scanned for magnetic remanence using the SRM. Section halves from Cores 395C-U1554F-3R through 5R (620–642.4 m CSF-A) were imaged using the XRI. Each basalt core section was scanned using the handheld pXRF device. WR samples of basalt for postcruise microbiology studies were collected immediately after the core was received from the rig floor at a resolution of one sample per ~10 m. Samples for ICP-AES and thin sections were selected by the shore-based petrologists using core photos, also at ~10 m resolution.

The lithology of the sedimentary cores changes downhole, with terrigenous sediment dominating the majority of the section and transitions to biogenic carbonate at the base of the drift. Cores 395C-U1554E-2H through 14H contain clay and silt that alternate between dark gray, light gray, and light greenish gray intervals. These cores display mottling and bioturbation (Figure **F4B**). Cores 15H–55X are dark gray and do not display the color changes observed in the upper section of the hole. These cores contain gastropod shells, some of which are pyritized. Foraminifers and biogenic silica can be seen in the split core sections using a hand lens, and dropstones of varying composition are occasionally observed (Figure **F4F**). The XCB cores have prevalent biscuiting from the coring process (Figure **F5D**).

Core 395C-U1554E-56X records a lithology change to lighter material with soft-sediment deformation and erosional surfaces (Figure **F4H**). Cores 395C-U1554E-57X through 60X and 395C-U1554F-3R contain sediments that alternate between light green and dark gray with varying amounts of calcium carbonate (32–54 wt%) and clay content (Figure **F4D**, **F4G**). Sharp, erosional contacts and burrows are observed in these cores. Core 395C-U1554E-61X transitions from the dark gray material to a light green and white nannofossil chalk with higher carbonate content (66–85 wt%). Chalk was also recovered in Cores 395C-U1554F-4R and 5R (Figure **F4E**).

The sediment/basement interface was recovered in Cores 395C-U1554E-62X and 395C-U1554F-5R. The uppermost basement is composed of basalt alternating with carbonate beds. Cores 395C-U1554F-6R through 10R consist of basalt that is interlayered with thin beds of carbonate. The basalt contains glass and shows varying degrees of alteration with several veins present (Figure **F6C**). Some of the carbonate intervals contain brecciated basalt clasts (Figure **F6E**). Cores 395C-U1554F-11R through 32R (673.5–778.8 m CSF-A) are composed of basalt that contains glass and has varying degrees of alteration that includes calcite veins, infilled vesicles, and staining (Figure **F6B**). The shore-based petrology group provided sampling intervals for ICP-AES measurements and thin sections.

Physical properties of the cores primarily reflect changes in lithology. MS and NGR show cyclic patterns from 66 to ~450 m CSF-A. At ~450 m CSF-A, the values of both properties decrease and remain reduced to the base of the sediment section in Hole U1554E. MS values of the basalts in Hole U1554F average ~200 IU, with a peak value of over 2300 IU. NGR values of the basalts average ~3.5 counts/s. RGB color shows the most variance between 66 and 200 m CSF-A, and RGB and color reflectance increase from 520 to 646 m CSF-A. The average porosity of samples collected between Cores 395C-U1554E-31X and 61X (344.4–645.23 m CSF-A) is 62%.

The collection of measurements downhole at Site U1554 was successful. Four formation temperature measurements from 75.8 to 161.3 m DSF linearly increase from 5.6° to 8.3°C. The triple combo logging tool collected good measurements of porosity, density, NGR, resistivity, and MS throughout the sediment and basement sections. The FMS-sonic collected resistivity images for the entire length of the cored section, and the UBI collected 360° images of the basement.

Core sections were run through the SRM, which measured NRM before and after AF demagnetization. Sediment cores were demagnetized up to 25 or 35 mT at 1–2.5 cm spacing, and basalt cores were demagnetized up to 25 mT at 2 cm spacing. The lower part of Hole U1554E shows a decrease in both NRM and MS, which correlates well with the lithologic change. The magnetic inclination displays strong changes in polarity. However, the presence of strong biscuiting and drilling-induced remanence in the XCB cores prevents the construction of a full magnetostratigraphy, which will be reconstructed postcruise with the integration of paleontological data. The basalts from Hole U1554F are not demagnetized at 25 mT and mainly show normal polarities, with few reversed polarities localized in correspondence to fractures.

Hydrocarbon concentrations in gas samples and sediment and pore water geochemistry were measured in the chemistry laboratory. Methane concentrations increase from 3 ppmv at the top of the hole to 11000 ppmv at 205 m CSF-A. From 205 to 301 m CSF-A, the values plateau before decreasing to 0 ppmv at the sediment/basement interface (646 m CSF-A). Pore water sulfate is less than 2 mM from 350 to 400 m CSF-A and then linearly increases to 27 mM at 646 m CSF-A. Alkalinity decreases from 12.5 mM at ~350 m CSF-A to 2.3 mM at the base of Hole U1554E. Dissolved Ca, Mg, K, and Sr increase downhole, whereas B decreases downhole. Br and Si fluctuate over the sampled interval. Li concentration peaks at 492.8 m CSF-A with a value of 41 µM. Mn has a local peak of 7.4 µM at 510 m CSF-A and increases to 12.7 µM at the base of Hole U1554E. Sulfate, phosphate, and ammonium were measured on the spectrophotometer. Ammonium and phosphate decrease downhole, whereas sulfate increases downhole. Carbonate results from sediments in Hole U1554E show an increase in calcium carbonate at the base of the hole. Cores 395C-U1554E-31X through 51X have an average calcium carbonate concentration of 5.4 wt%. Below Core 51X (~550 m CSF-A), carbonate concentrations increase steadily to a maximum value of 85 wt% at the base of the sedimentary section (646 m CSF-A). TOC values average 0.47 wt% and show a slight increase downhole.

4.4. Site U1562

4.4.1. Background and objectives

Site U1562 (proposed Site REYK-3B of Expedition 395) is located in the North Atlantic Ocean along the Reykjanes Ridge south of Iceland. Site U1562 is located on Seismic Line JC50-1 (CMP 39920) near the intersection with Line JC50-C2 (CMP 685), both obtained in 2010 during RRS *James Cook* Cruise JC50 (Parnell-Turner et al., 2017). Site U1562 is located on VSR-3 with an estimated basement age of 13.9 Ma.

Cores and data from this site will address two of the primary science objectives: (1) crustal accretion and mantle behavior and (2) time-dependent hydrothermal alteration of oceanic crust.

The operational objectives for this site were to core the sedimentary section using the APC, half-length APC (HLAPC), and XCB systems to the sediment/basement interface; use the RCB system to core ~130 m into the basement; and use downhole wireline tools to log the borehole.

4.4.2. Operations

Site U1562 consisted of two holes, U1562A and U1562B, ranging in depth from 429.8 to 561.5 m DSF.

A total of 96 cores were recorded for Site U1562. They collected 484.12 m of sediment and basalt over a 583.2 m cored interval (83% recovery).

The APC system was used to collect 21 cores over a 192.0 m interval with 199.45 m of core recovered (104%). The HLAPC system was deployed for 36 cores and recovered 173.8 m of sediment from a 169.2 m interval (103% recovery). The XCB system was deployed over a 68.6 m interval, and the 8 XCB cores recovered 37.79 m of sediment and basalt (55% recovery). The RCB system was deployed for 31 cores over a 153.4 m interval with 73.08 m of core recovered (48%). Downhole wireline logging operations using four logging tools took place in Hole U1562B.

The total time spent at Site U1562 was 10.45 days.

4.4.2.1. Hole U1562A

The vessel began the 6.1 nmi transit from Hole U1554F to Site U1562 in DP mode on 10 July 2021. The crew continued to pull up the drill pipe following the completion of operations in Hole U1554F during the transit. The end of the pipe cleared the rotary table at 1130 h. At 1306 h on 10 July, the vessel arrived at Site U1562 and the APC/XCB BHA was made up. The drill pipe was run to 1996 mbsl to take the first APC core.

Hole U1562A (60°06.3030′N, 26°30.1245′W) is located 21 m west of the site coordinates and was spudded at 2115 h. Core 395C-U1562A-1H recovered the mudline and 2.08 m of core, establishing a seafloor depth of 2003 mbsl. APC Cores 2H–21H advanced from 2.0 to 192.0 m DSF. Core 21H experienced significant overpull and was drilled over with the drill string to release the core barrel. HLAPC core barrels were made up, and coring continued with Cores 22F–57F (192.0–361.2 m DSF) using 4.7 m long advances. HLAPC refusal was met at Core 57F, which also required the drill string to drill over the core barrel to release it from the sediment. The XCB core barrels were made up, and coring continued with Cores 58X–64X (361.2–429.1 m DSF). After drilling Core 64X, the XCB cutting shoe was severely damaged and slightly melted and the base of the core catcher contained basalt. Another core barrel was deployed, and Core 65X was advanced to ensure that the bit had reached basement. The bit advanced 0.7 m over 1 h, and Core 65X contained 0.68 m of basalt, confirming a basement depth of 429.1 m DSF. The final depth of Hole U1562A was 429.8 m DSF. The drill string was pulled from the hole, with the bit reaching the seafloor at 1535 h on 13 July. Hole U1562A ended when the bit reached the rotary table at 1935 h.

All of the full-length APC cores were oriented, and formation temperature measurements using the APCT-3 tool were collected on Cores 4H, 7H, 10H, and 13H. Samples for IW, microbiology, micropaleontology, and gas analyses were routinely collected on the catwalk.

A total of 411.04 m of core was recovered over a 429.8 m interval (96% recovery). The average recovery for piston cores was 104% with the APC system and 103% with the HLAPC system. The XCB system had an average recovery of 55%.

4.4.2.2. Hole U1562B

Following the end of Hole U1562A, an RCB BHA with a C-4 RCB bit was made up and the drill string was lowered to the seafloor. The ship was offset 21 m east-southeast of Hole U1562A, near the site coordinates, and Hole U1562B (60°6.2993′N, 26°30.1026′W; water depth = 2003 mbsl) was spudded at 0320 h on 14 July 2021 and advanced without coring to 408.1 m DSF. The center bit was recovered, and an RCB core barrel was deployed. Cores 395C-U1562B-2R through 13R advanced from 408.1 to 474.2 m DSF, recovering 48.65 m of sediment and basalt (55% recovery). The sediment/basement interface was recovered in Core 4R at 429.0 m DSF. Coring rates sped up from ~2 m/h to over 7 m/h while drilling Core 14R. The driller noted that there was a ~3 m long interval that drilled extremely quickly. It was soon revealed that Core 14R recovered 0.6 m of chalk bracketed by basalt. Coring continued with Cores 15R–19R advancing from 479.2 to 500.7 m DSF with 47% recovery. While drilling Core 19R, the rate of penetration (ROP) dropped to 1 m/h and there was erratic torque on the bit. It was suspected that the drill bit was damaged, and the rig floor crew began pulling the pipe out of the hole. An FFF was deployed at 0220 h on 17 July to allow for the reentry of Hole U1562B. The bit cleared the seafloor at 0312 h and the rotary table at 0708 h. The bit was indeed damaged. A new C-7 RCB coring bit was made up to the BHA, and the crew assembled the drill string. The subsea camera, along with the CTD sonde, was deployed at 1130 h to observe the reentry of Hole U1562B, which occurred at 1450 h. The subsea camera was retrieved, and the drill string advanced to 500.7 m DSF. After cleaning the hole with a high-viscosity mud sweep, Cores 20R–28R advanced from 500.7 to 561.5 m DSF. Coring operations concluded in Hole U1562B after coring 132.5 m into the basement. The final depth of Hole U1562B was 561.5 m DSF.

A total of 73.08 m of core was recovered over a 153.4 m cored interval from Hole U1562B (48% recovery), and 31 RCB cores were collected from this hole. The average ROP while coring the basalt was 2.1 m/h.

Following coring, the RST was run to release the bit into the bottom of the hole. The drill string was pulled up, and the end of the pipe was set at 89 m DSF. The triple combo logging tool string was made up and deployed at 1755 h on 19 July. After completing two successful passes of the entire hole, the tools were retrieved and reached the rig floor at 2310 h. After the triple combo tool string was laid out, the FMS-sonic was made up and deployed at 0100 h on 20 July. Following two passes that extended to the base of the hole, the FMS-sonic was pulled from the hole and reached the rig floor at 0645 h. The next logging run used the VSI tool. The PSO protocols began at 0730 h, and the IODP technical staff ramped up the air guns starting at 0834 h. The VSI was lowered to the base of the hole, and a total of four depth stations (420.5, 426, 459.9, and 556.6 m DSF) were completed: two in the basement section, one at the sediment/basement interface, and one in the lowermost sediment. The VSI could not be successfully run throughout the sedimentary section because of the wide diameter (>16 inch) of the borehole. Following the VSI run, the air guns were put away, and the tool reached the rig floor at 1320 h. The final logging run, using the UBI tool, began at 1445 h. The UBI made two passes of the basement section, acquiring 360° borehole images. The UBI was recovered at the rig floor at 2130 h. The drill string was pulled out of the hole to ~1489 mbsl, and the ship began the transit in DP mode to Hole U1554F at 2355 h on 20 July, ending Site U1562.

4.4.3. Principal results

Sediment cores obtained from Holes U1562A (Cores 395C-U1562A-1H through 64X; 0–427.82 m CSF-A) were run through the WR physical properties tracks, which include MS, GRA bulk density, *P*-wave velocity, and NGR measurements (Figure **F10**). The split section halves were imaged, measured for point MS and color reflectance, and scanned for magnetic remanence using the

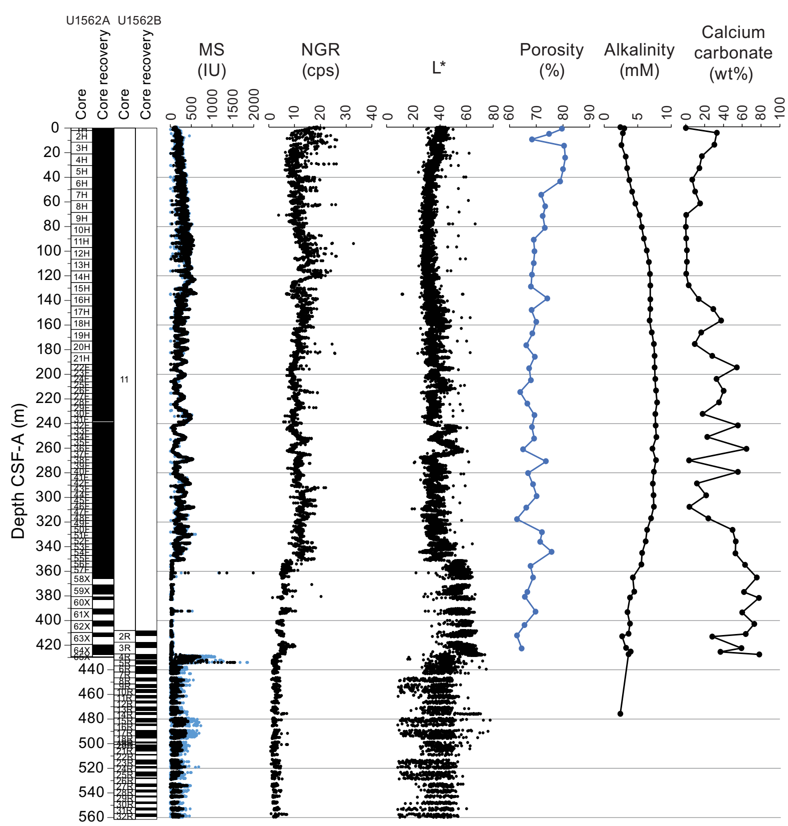

Figure F10. Core recovery and selected physical properties and geochemistry, Site U1562. Core recovery: black = recovery, white = no recovery.

SRM. Thermal conductivity measurements and MAD samples were collected at a resolution of one per core.

Samples were collected on the catwalk and at the sample table for shipboard and shore-based IW, gas, microbiology, and micropaleontology analyses. Headspace gas samples for shipboard hydrocarbon safety analysis and postcruise research were collected every core, and the resolution increased to two samples per core ~30 m above the sediment/basement interface. Samples for postcruise biostratigraphy were collected from each core catcher. IW samples, 10 cm in length, were collected from each core, and three IW samples per core were collected in the ~20 m above the sediment/basement interface. Microbiology samples were extracted using a sterile syringe, with 4 cm^3 of sediment frozen in the syringe and 1 cm^3 of sediment added to a glycol solution and flash frozen using liquid nitrogen. Microbiology samples were paired with IW samples. XRD and carbonate samples were taken from the IW squeeze cake sediment residues. Additional carbonate samples were collected beginning ~30 m above the sediment/basement interface.

RCB cores from Hole U1562B were run through the WR tracks to collect the same physical properties measurements as for Hole U1562A, with the exception of *P*-wave velocity, which was not recorded because the space between the liner and the core for RCB cores prevents meaningful measurements. The split section halves were imaged; measured for point MS, color reflectance, thermal conductivity, and *P*-wave velocity using the caliper; and scanned using the SRM. Section halves from Cores 395C-U1562B-3R and 4R were imaged using the XRI. Each basalt core section was scanned using the handheld pXRF device. WR samples of basalt for postcruise microbiology studies were collected immediately after the core was received from the rig floor at a resolution of one sample per ~10 m. Samples for ICP-AES and thin sections were selected by the shore-based petrologists using core photos, also at ~10 m resolution.

Sediments in the uppermost ~250 m (Cores 395C-U1562A-1H through 34F) are primarily composed of clay and silt with fine sand beds and dropstones interspersed through the section. The cores are mostly gray to dark gray but contain brown and greenish gray intervals as well. A transition from the overlying gray clay and silt to a lighter gray clay occurs in Core 35F (253.1–257.9 m CSF-A). This core contains notable soft-sediment deformation. Cores 36F–54F (257.8–347.2 m CSF-A) range from light gray to dark gray clay with bioturbation and discrete intervals of soft-sediment deformation. Core 55F (347.1–356.06 m CSF-A) captures a transition between the overlying clays and silts to a finer grained, carbonate-rich greenish gray sediment with abundant bioturbation that continues to Core 64X. Cores 58X and 60X contain large (~5 cm) basalt clasts (Figure **F11E**). The lithology in Core 64X (419.4–427.82 m CSF-A) transitions from greenish gray, bioturbated, fine-grained sediment to a white carbonate ooze. Section 64X-CC and Core 65X (427.4–429.8 m CSF-A) are composed of dark gray, vesicular to avesicular basalt that contains white to green veins and infilled vesicles (Figure **F11D**). The XCB cores are fractured and disturbed.

Core 395C-U1562B-2R through Section 4R-1 (408.1–428.57 m CSF-A) contain greenish gray, fine-grained, carbonate-rich, bioturbated sediment. The interval from Section 4R-2 through Core 32R (428.57–559.6 m CSF-A) is composed of dark gray to brown basalt (Figure **F6D**). The basalt displays varying degrees of alteration with infilled vesicles, calcite veins, and staining (Figure **F11A**, **F11B**). Glass rinds are observed on many of the core pieces. Section 14R-2 (475.54–476.2 m CSF-A) contains a 0.6 m long interval of nannofossil ooze bracketed by basalt flows, and intercalated carbonate beds are found in Cores 5R, 6R, and 15R–19R.

Physical properties of the cores primarily reflect changes in lithology. Porosity of the sediments linearly decreases downhole from ~80% at the top of the section to 63% above the sediment/basement interface (427 m CSF-A). MS and color reflectance values in the sediments align with color changes in the cores, potentially indicating changes in carbonate content. MS values of the uppermost basalt cores (395C-U1562B-4R and 5R) are higher than the rest of the cored section at Site U1562. The average MS value of basalts in these two cores is ~400 IU with a maximum value of 1535 IU. The average MS value for Cores 6R–32R is 124 IU. The average *P*-wave velocity of the basalts is 5400 m/s.

The downhole measurements program at Site U1562 consisted of downhole wireline logging and formation temperature measurements. All four downhole wireline logging tool runs were successful. The FMS-sonic and UBI recorded images of the borehole wall. Four formation temperature measurements from 30.5 to 116 m DSF show a linear increase with depth from 4.3° to 7.3°C.

Core sections were run through the SRM, which measured NRM before and after AF demagnetization. The cores were demagnetized up to 25 mT at 2.5 cm resolution for APC and HLAPC cores and 2 cm resolution for XCB cores. Both NRM and MS show a clear cyclicity between 100 and 300 m in Hole U1562A. The magnetic inclination shows clear intervals of normal and reversed polarity, which will be used postcruise to establish the magnetostratigraphy for the site. The basalts from Hole U1562B are usually not demagnetized at 25 mT and mainly show a normal polarity.

Chemistry measurements were made on gas, pore water, and sediment samples. Hydrocarbon gases in Hole U1562A are present in very low concentrations. Methane peaks at 2.61 ppmv at ~223 m CSF-A. Sediments from the uppermost 150 m of Hole U1562A contain little carbonate, with values ranging 0.04–33 wt%. At 150–300 m CSF-A, carbonate values range 4–65 wt%. Below 300 m CSF-A, values are consistently elevated with a maximum of 78 wt%. TOC has an average value of 0.59 wt% with a maximum concentration of 5.23 wt% at 413 m CSF-A. Pore water alkalinity increases downhole from ~2.5 mM at the top of the hole to a maximum value of 7.5 mM at 223 m CSF-A. Below 223 m CSF-A, alkalinity decreases to ~3.5 mM above the sediment/basement interface (~427 m CSF-A). Ammonium increases from 33 mM at the top of Hole U1562A to a maximum value of 635 mM at 100 m CSF-A and then decreases to 263 mM at the bottom of the hole. Sulfate decreases from 29 to 19 mM between 0 and 270 m CSF-A before increasing to the base of the hole. Boron decreases downhole, whereas Si and Sr increase with depth. Bromine, Ca, Mg all show an initial decrease with depth followed by an increase to the sediment/basement interface.

4.5. Site U1563

4.5.1. Background and objectives

Site U1563 (proposed Site REYK-11A of Expedition 395) is located in the North Atlantic Ocean along the Reykjanes Ridge south of Iceland. Site U1563 is located at the intersection of Seismic Lines JC50-1 (CMP 53393) and JC50-C6 (CMP 888), obtained in 2010 during RRS *James Cook* Cruise JC50 (Parnell-Turner et al., 2017). Site U1563 is located on VSR-2a with an estimated basement age of 5.2 Ma. Cores and data from this site will address two of the primary science objec-

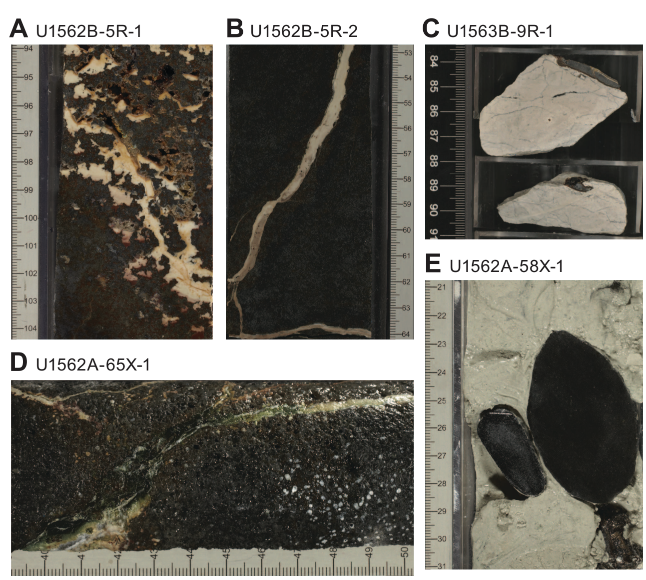

Figure F11. (A, B, D) Veins, (C) intercalated carbonate beds in basalt flows, and (E) basalt clasts in carbonate ooze, Expedition 395C.

tives: (1) crustal accretion and mantle behavior and (2) time-dependent hydrothermal alteration of oceanic crust.

The operational objectives for this site were to core the sedimentary section using the APC, HLAPC, and XCB systems to the sediment/basement interface, use the RCB system to core ~130 m into the basement, and use downhole wireline tools to log the borehole.

4.5.2. Operations

Site U1563 consisted of two holes, U1563A and U1563B, ranging in depth from 327.6 to 456.6 m DSF.

A total of 80 cores were recorded for Site U1563. They collected 397.36 m of sediment and basalt over a 482.8 m cored interval (79% recovery).

The APC system was used to collect 21 cores over a 197.4 m interval with 207.05 m of core recovered (105%). The HLAPC system was deployed for 26 cores and recovered 122.35 m of sediment from a 122.2 m interval (100% recovery). The XCB system was deployed over a 8.0 m interval, and the 2 XCB cores recovered 5.58 m of sediment and basalt (70% recovery). The RCB system was deployed for 31 cores over a 155.2 m interval with 44.38 m of core recovered (29%). Downhole wireline logging operations using three logging tool strings took place in Hole U1563B.

The total time spent at Site U1563 was 8.51 days.

4.5.2.1. Hole U1563A

The vessel completed the 39 nmi transit from Site U1562 on 22 July 2021. The thrusters were lowered at 0212 h, and the ship entered DP mode at 0235 h, marking the start of Site U1563. The APC/XCB BHA was made up, and the drill string was deployed to 1415.7 mbsl. Hole U1563A (60°11.9985′N, 28°00.0209′W) was spudded at 0800 h. Core 395C-U1563A-1H recovered 7.4 m of sediment, placing the seafloor at 1417.8 mbsl. Cores 2H–16H advanced to 149.9 m DSF, with 105% core recovery. During the collection of Core 16H, the core barrel became detached from the sinker bars and GS overshot tool when the shear pin in the GS overshot tool evidently failed. The sinker bars and GS overshot tool were recovered, the GS overshot tool was replaced, and the core barrel was retrieved. However, the APC piston rods had twisted while the core barrel was in the BHA, and the rods required replacement. Coring continued with Cores 17H–21H advancing from 149.4 to 197.4 m DSF. APC refusal was reached at Core 21H when the core barrel became stuck in the sediment and required 130,000 lbs of overpull to release the barrel from the formation. The HLAPC system was deployed for Cores 22F–47F (197.4–319.6 m DSF) and was switched out for the XCB coring system when the bit neared the estimated depth of the basement. Core 48X (319.6–326.6 m DSF) recovered the sediment/basement interface, and the basement was encountered at 326.4 m DSF. Core 49X was deployed to ensure that basement had in fact been reached. The core advanced 1 m to a final hole depth of 327.6 m DSF and recovered 0.42 m of basalt. Following Core 49X, the drill string was pulled out of the hole. The bit cleared the seafloor at 0400 h and the rotary table at 0715 h on 24 July, ending Hole U1563A.

A total of 334.98 m of core was recovered over a 327.6 m interval (102% recovery).

4.5.2.2. Hole U1563B

The ship was offset 21 m east of Hole U1563A ~3 m from the proposed site coordinates, and the RCB BHA was made up with a C-7 RCB drill bit. The drill string was made up and deployed to 1403 mbsl. The center bit was lowered into the RCB bit, and Hole U1563B (60°11.9946′N, 27°59.9996′W) was spudded at 1605 h on 24 July 2021.

Hole U1563B was advanced without coring to 301.4 m DSF. The center bit was retrieved, and Cores 395C-U1563B-2R through 5R advanced from 301.4 to 325.8 m DSF. The sediment/basement interface was encountered at ~315 m DSF but was not preserved in Core 3R. While drilling Core 5R, winds had increased to sustained speeds of 35 kt, gusting up to 45 kt, which created hazardous conditions on the rig floor. The vessel began waiting on weather at 0800 h on 25 July. It was noted that there was an unusual noise emanating from a transformer for three of the thrusters. The vessel resumed operations at 1330 h once the wind speeds had died down. Core 5R was recovered, and the drill string was pulled up to 90 m DSF to work on the thrusters. The three affected thrusters were shut down, and it was discovered that the insulation around a transformer cable was loose. Once this was repaired, the ship was able to resume operations at 1845 h on 25 July. The crew deployed a wash barrel into the BHA and lowered the bit to 325.8 m DSF. After a high-viscosity mud sweep to clean the hole, the wash barrel was retrieved and a core barrel was deployed for Core 6R. Coring continued with Cores 6R–32R advancing from 325.8 to 456.6 m DSF. Following Cores 25R–32R, the crew cleaned the hole with high-viscosity mud because of deteriorating hole conditions. After Core 32R was recovered, the drill pipe became stuck in the hole and unable to rotate, circulate fluid, or move. Coring operations were terminated, and after ~1.5 h, the pipe was freed and the drill string was pulled up to 363.9 m DSF. The hole was prepared for downhole logging operations with another high-viscosity mud sweep. The RST was deployed to release the drill bit and allow logging tools to exit the drill pipe. The RCB drill bit was released in the hole at 2325 h on 28 July.

A total of 44.38 m of core was recovered over a 155.2 m cored interval (29% recovery). Coring of the basalts advanced at an average ROP of 3.6 m/h.

The drill pipe was pulled up to 87.6 m DSF in preparation for downhole logging operations. The triple combo tool string was assembled and deployed at 0410 h on 29 July. The tool string made two passes of the borehole, reaching 313.9 m DSF. At 0900 h, the triple combo reached the rig floor and was broken down. The second logging tool run was the VSI. At 1045 h, the VSI tool was deployed and the PSO protocols began. Whales were sighted in the area, delaying the start of operations. Once it was deemed safe to fire the air guns, the VSI was lowered to three stations: 283.9, 292.9, and 308.9 m DSF. Only the bottom two stations recorded successful measurements. At 1652 h, the PSO watch ended and the tool was pulled out of the hole, reaching the rig floor at 1810 h. After the VSI tool was broken down, the FMS-sonic tool string was assembled and deployed at 1935 h. The FMS-sonic tool descended to 311.0 m DSF and recorded resistivity images of the borehole. The tools were pulled up to the rig floor at 2325 h, and the day ended while breaking down the FMS-sonic tool string. The crew pulled the drill pipe up, and the end of the pipe cleared the seafloor at 0105 h on 30 June and the rotary table at 0513 h. The rig floor was secured, and the thrusters were raised. The vessel began the 144 nmi sea passage to Site U1564 at 0518 h on 30 July.

4.5.3. Principal results

Sediment cores obtained from Holes U1563A (Cores 395C-U1563A-1H through 48X; 0–324.7 m CSF-A) were run through the WR physical properties tracks, which include MS, GRA bulk density, *P*-wave velocity, and NGR measurements (Figure **F12**). The split section halves were imaged, measured for point MS and color reflectance, and scanned for magnetic remanence using the SRM. Thermal conductivity measurements and MAD samples were collected at a resolution of one per core.

Samples were collected on the catwalk and at the sample table for shipboard and shore-based IW, gas, microbiology, and micropaleontology analyses. Headspace gas samples for shipboard hydrocarbon safety analysis and postcruise research were collected every core, and the resolution increased to two samples per core ~30 m above the sediment/basement interface. Samples for postcruise biostratigraphy were collected from each core catcher. IW samples, 10 cm in length, were collected from each core, and three IW samples per core were collected in the ~20 m above the sediment/basement interface. Microbiology samples were extracted using a sterile syringe, with 4 cm^3 of sediment frozen in the syringe and 1 cm^3 of sediment added to a glycol solution and flash frozen using liquid nitrogen. Microbiology samples were paired with IW samples. XRD and carbonate samples were taken from the IW squeeze cake sediment residues. Additional carbonate samples were collected beginning ~30 m above the sediment/basement interface.

RCB cores from Hole U1563B were run through the WR tracks to collect the same physical properties measurements as for Hole U1563A, with the exception of *P*-wave velocity, which was not recorded because the space between the liner and the core for RCB cores prevents meaningful measurements. The split section halves were imaged; measured for point MS, color reflectance, thermal conductivity, and *P*-wave velocity using the caliper; and scanned using the SRM. Each basalt core section was scanned using the handheld pXRF device. WR samples of basalt for post-cruise microbiology studies were collected immediately after the core was received from the rig floor at a resolution of one sample per ~10 m. Samples for ICP-AES and thin sections were selected by the shore-based petrologists using core photos, also at ~10 m resolution.

The primary lithologies in Hole U1563A are clay and silt with occasional fine sand beds and dropstones. Core 395C-U1563A-1H alternates between brown and gray layers, and Cores 2H–44F (7.2–305.44 m CSF-A) show light gray to dark gray banding. Cores 13H, 17H, and 19H each contain a ~20 cm thick coarse sand bed (Figure **F4I**). Core 40F and the tops of Cores 41F and 43F contain brown, unconsolidated fine sand (Figure **F4C**). In Core 45F (305.5–310.34 m CSF-A), the lithology transitions to a light gray silt and clay with gray and green mottling. This extends down to Core 47F (314.9–319.87 m CSF-A) where there is a sharp transition to yellow to white chalk. Core 47F contains three large (~3 cm diameter) basalt clasts. The calcareous ooze extends to the basalt basement, which is found in Section 48X-CC. Core 49X is dark gray basalt with intercalated carbonate beds.

Cores from Hole U1563B are primarily composed of basalt. Core 395C-U1563B-2R (301.4–301.94 m CSF-A) contains 0.54 m of carbonate ooze with basalt clasts. The sediment/basement interface in this hole was at ~315 m CSF-A, nearly 11 m shallower than in Hole U1563A. Cores 3R–32R (311.1–452.91 m CSF-A) are composed of dark gray basalt with vesicles and calcite veins. The basalts have some brown staining and contain infilled vesicles. Many of the basalt cores contain thin intercalated carbonate beds (Figure **F11C**). Cores 15R and 17R contain carbonate pieces with brecciated clasts of basalt.

Physical properties of the cores reflect changes in their composition. NGR values of the sediments range 5–32 counts/s from 0 to 212 m CSF-A, with the exception of a maximum peak of 46 counts/s at 136.7 m CSF-A. Below 212 m CSF-A, NGR values decrease from ~10 to 5 counts/s at the base of the sedimentary section. NGR values of the basalt cores from Hole U1563B are low, with an average of 2 counts/s. MS values of the sediments range 15–541 IU in the uppermost 280

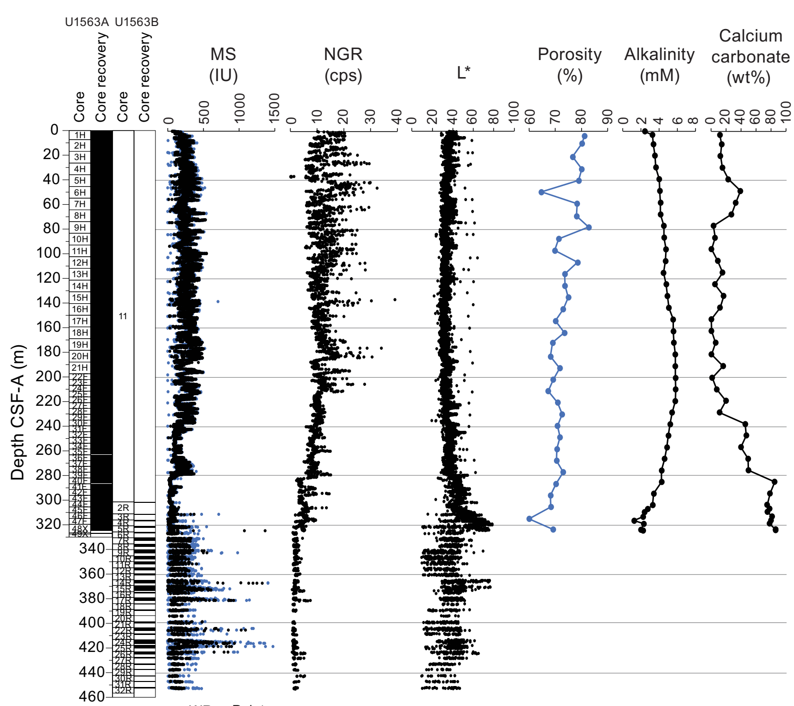

Figure F12. Core recovery and selected physical properties and geochemistry, Site U1563. Core recovery: black = recovery, white = no recovery.

m of the section. Below 280 m CSF-A, MS values are consistently below 100 IU to the sediment/basement interface. The average MS value of the basalt cores is 177 IU. MS peaks occur in Cores 395C-U1563B-15R, 17R, and 24R. The average *P*-wave velocity of the basalts is 5500 m/s. Sediment porosity decreases from 81% at the top of Hole U1563A to 69% at 323 m CSF-A.

The downhole measurements program at Site U1563 consisted of downhole wireline logging and formation temperature measurements. The triple combo, FMS-sonic, and VSI tool strings were all run successfully. Four formation temperature measurements from 35.9 to 121.4 m DSF show a linear increase with depth from 5.3° to 8.7°C.

Core sections were run through the SRM, which measured NRM before and after AF demagnetization. Cores were demagnetized up to 25 mT at 2.5 cm resolution for APC, HLAPC, and XCB cores and 2 cm resolution for RCB cores. The NRM shows significant variations with depth, with lower intensities in the lowermost part of Hole U1563A, corresponding to the lithologic transition. The magnetic inclination shows clear intervals of normal and reversed polarity, which will be used postcruise to establish the magnetostratigraphy for the site.

Chemistry measurements were made on gas, pore water, and sediment samples. Methane values in Hole U1563A range 0–2.15 ppmv. From 0 to 229 m CSF-A, calcium carbonate values range 0.4–39 wt% (average = 12 wt%). Below 229 m CSF-A, concentrations show a stepped increase with values between 238 and 276 m CSF-A averaging 46 wt% and values between 285 and 324 m CSF-A averaging 80 wt%. The average TOC concentration of the section is 0.35 wt%. Pore water was analyzed using titration, chromatography, ICP-AES, and spectrophotometry. Alkalinity increases from ~3 mM at the top of Hole U1563A to a maximum value of 5.8 mM at 210 m CSF-A and then decreases to ~2 mM at the base of the sediment section. Ammonium broadly increases downhole from 7.3 to 565.9 mM at 200 m CSF-A. Below this depth, ammonium linearly decreases to 62.7 mM near the sediment/basement interface (324 m CSF-A). Sulfate linearly decreases from 0 to 105 m CSF-A, with values decreasing from 33 to 26 mM. Sulfate then fluctuates between 24.3 and 28.7 mM from 105 to 266 m CSF-A before increasing to 33 mM at the base of the section. Lithium increases downhole, and Sr and Si initially increase downhole before decreasing to the sediment/basement interface. Magnesium and Ca display the opposite trend of decreasing downhole and then increasing to the sediment/basement interface. Manganese decreases downhole, whereas B, Br, Na, and phosphate do not display any downhole trends.

4.6. Site U1564

4.6.1. Background and objectives

Site U1564 (Proposed Site REYK-2A of Expedition 395) 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 (Parnell-Turner et al., 2017).

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. The Gardar drift was cored at Site 983 during Leg 162, and a sedimentary sequence was obtained back to 1.7 Ma (early Pleistocene) (Jansen and Raymo, 1996). Samples from Site 983 have resulted in several publications that have documented the paleoclimate and oceanography of the North Atlantic Ocean (e.g., Barker et al., 2019). 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 included coring a hole to ~650 m followed by installing a 600 m long casing string and reentry system. We did not have time to complete the planned casing operations at Site U1564 during Expedition 395C because coring the basalt sections at the other sites took more time than anticipated and we lost time because of weather. Operations were scaled to the time available at the end of the expedition. The site was cored to 628.9 m DSF and then logged with the triple combo and FMS-sonic logging tools to obtain preliminary data for Expedition 395.

4.6.2. Operations

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

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

The total time spent at Site U1564 was 5.29 days.

4.6.2.1. Hole U1564A

The vessel arrived at Site U1564 at 1748 h on 30 July 2021. The thrusters were lowered, the ship entered DP mode, and the drill string was made up with an APC/XCB BHA. The drill string was run to 2220.0 mbsl to spud Hole U1564A (59°51.0377′N, 23°16.0071′W) ~20 m west of the proposed 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 395C-U1564A-1H recovered a full core (9.89 m), prohibiting the establishment of the seafloor depth.

4.6.2.2. Hole U1564B

The ship was offset 20 m to the east (directly over the proposed site coordinates), and Hole U1564B (59°51.0372′N, 23°15.9868′W) was spudded at 0342 h on 31 July 2021. Core 395C-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 in 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).

4.6.2.3. 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 2021. The seafloor depth was calculated at 2208.1 mbsl based on the recovery of Core 395C-U1564C-1H (7.02 m). Coring continued with the APC system recovering Cores 2H–17H (7.0–159.0 m DSF). Core 17H required significant overpull (90,000 lbs) to release the core barrel from the sediment. Coring with the full-length APC system was terminated, and the crew began making up the HLAPC barrels. Cores 18F–35F advanced from 159.0 to 243.6 m DSF. The overpull when retrieving Core 35F was over 80,000 lbs, and coring switched to the XCB system. Cores 36X–75X were collected to 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 were 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, and the remaining thruster pod was raised.

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 tool. Formation temperature measurements were collected on Cores 395C-U1564C-4H, 7H, 10H, 13H, and 15H; however, the APCT-3 tool flooded during the Core 4H deployment, and no data were collected.

A total of 618.71 m of core was recovered from Hole U1564C (98% recovery). A total of 17 APC cores were collected over a 159.0 m interval with 164.90 m of sediment recovered (104%). Recovery with the HLAPC system was also 104%, with 87.77 m of core recovered over 84.6 m. The XCB system was deployed for 40 cores and recovered 366.04 m of sediment over a 385.3 m interval (95% recovery).

4.6.3. Principal results

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 WR physical properties tracks upon retrieval without being thermally equilibrated. MS, GRA bulk density, and *P*-wave velocity were measured at 2.5 cm, and NGR was measured at one position (20 cm resolution). The split section halves were imaged and measured for point MS and color reflectance (Figure **F13**). Sections were then scanned for magnetic remanence using the 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 395C-U1564A-1H, 395C-U1564B-1H, and 395C-U1564C-1H (0 to ~7 m CSF-A) are composed of clay to silt with brown, gray, and

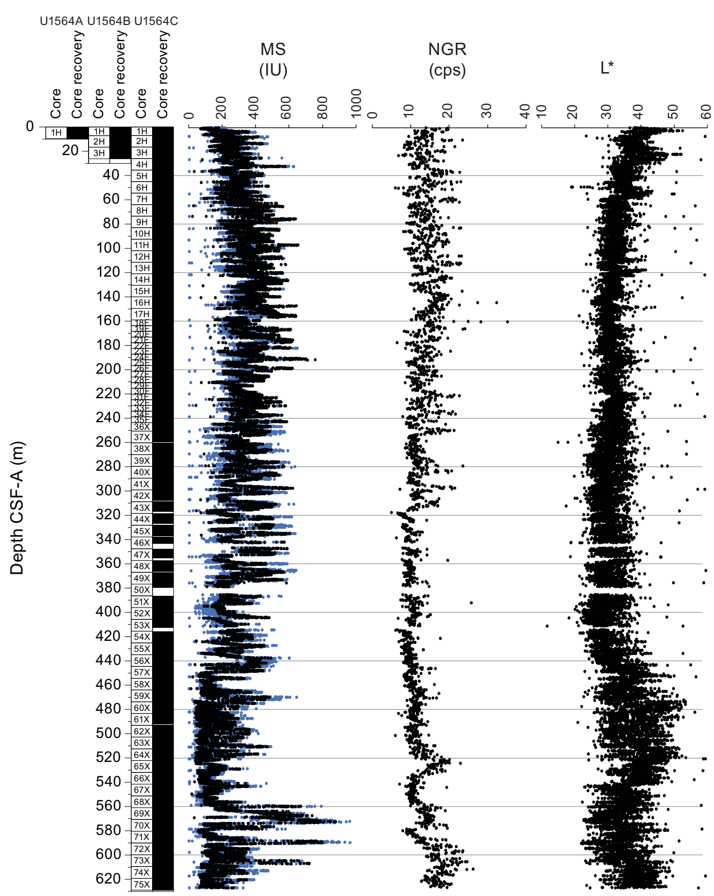

Figure F13. Core recovery and selected physical properties, Site U1564. Core recovery: black = recovery, white = no recovery.

light gray banding. Cores 395C-U1564B-2H and 3H and 395C-U1564C-2H through 6H (~7–54.82 m CSF-A) are a light gray to gray clay to silt. In Core 395C-U1564C-7H (54.5–64.62 m CSF-A), the sediment transitions from a lighter gray to a dark gray. In Cores 8H–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–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 (Figure **F5A**, **F5B**).

Physical properties of the cores primarily reflect changes in their composition. MS values increase from an average of ~200 to ~400 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. NGR values are lower from 316 to 500 m CSF-A with an average of 10.2 counts/s. Three prominent NGR peaks occur 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 associated with the lighter, green cores. The cores were not allowed to thermally equilibrate to room temperature before scanning, possibly impacting 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 NRM before and after AF demagnetization. The cores were scanned at 5 cm resolution and demagnetized up to 20 mT. The XCB cores show a strong radial drilling overprint on the first two demagnetization steps that is not completely removed at 20 mT. Notwithstanding the overprint, 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 0 ppmv for the uppermost 170 m. From ~170 to 242 m CSF-A, methane increases to a maximum of 1263 ppmv and then gradually decreases to 158 ppmv at the base of the hole.

4.7. End of expedition

The ship completed the 293 nmi transit from Site U1564 to Reykjavík, Iceland, on 6 August 2021. The pilot boarded the vessel at 0748 h. The first line ashore at Skarfabakki Harbor was at 0842 h, marking the end of Expedition 395C.

JOIDES Resolution operated in 12 holes across 5 sites (Table **T1**). Overall, 2866.6 m of sediment and basalt was cored with 2444.36 m of core recovered (85%) from 406 cores. In addition, 1555.1 m was drilled without coring.

Table T1. Expedition 395C operations summary. mbsl = meters below sea level, mbsf = meters below seafloor. APC = advanced piston corer, HLAPC = half-length APC, XCB = extended core barrel, RCB = rotary core barrel; VSI = Versatile Seismic Imager.

Hole	Latitude	Longitude	Water depth (mbsl)	Total penetration (mbsf)	Drilled (m)	Cored (m)	Recovered (m)	Recovery (%)	Cores (*N*)	APC cores (*N*)
U1555H	60°13.6924′N	28°30.0240′W	1523.65	177.5	0.0	177.5	180.06	101.44	20	18
U1555I	60°13.6897′N	28°29.9984′W	1523.59	376.5	159.3	217.2	104.19	47.97	40	0
			Site U1555 totals:	554.0	159.3	394.7	284.25	72.02	60	18
U1554E	60°7.5235′N	26°42.1324′W	1869.83	647.7	66.3	581.4	541.07	93.06	61	16
U1554F	60°7.5136′N	26°42.1140′W	1869.71	779.9	620.0	159.9	100.15	62.63	30	0
U1554F										
			Site U1554 totals:	1427.6	686.3	741.3	641.22	86.50	91	16
U1562A	60° 6.3030′N	26° 30.1245′W	2003.35	429.8	0.0	429.8	411.04	95.64	65	21
U1562B	60° 6.2993′N	26° 30.1026′W	2003.35	561.5	408.1	153.4	73.08	47.64	31	0
			Site U1562 totals:	991.3	408.1	583.2	484.12	83.01	96	21
U1563A	60°11.9985′N	28° 00.0209′W	1417.92	327.6	0.0	327.6	334.98	102.25	49	21
U1563B	60°11.9946′N	27° 59.9996′W	1417.92	456.6	301.4	155.2	44.38	28.60	31	0
			Site U1563 totals:	784.2	301.4	482.8	379.36	78.57	80	21
U1564A	59°51.0377′N	23°16.0071′W	2208.14	9.5	0.0	9.5	9.89	104.11	1	1
U1564B	59°51.0371′N	23°15.9868′W	2207.94	26.2	0.0	26.2	26.81	102.33	3	3
U1564C	59°51.0374′N	23°16.0087′W	2208.14	628.9	0.0	628.9	618.71	98.38	75	17
			Site U1564 totals:	664.6	0.0	664.6	655.41	98.62	79	21
			Expedition 395C totals:	4421.7	1555.1	2866.6	2444.36	85.27	406	97

Hole	HLAPC cores (*N*)	XCB cores (*N*)	RCB cores (*N*)	Start date (2021)	Start time UTC (h)	End date (2021)	End time UTC (h)	Time on hole (days)	Time on site (days)	Comment
U1555H	0	2	0	12 June	1300	14 June	2000	2.29		
U1555I	0	0	40	14 June	0245	23 June	2030	9.01		Free-fall funnel
Site U1555 totals:	0	2	40						11.33	
U1554E	0	45	0	24 June	0145	29 June	0245	5.04		
U1554F	0	0	30	29 June	0245	10 July	0800	11.22		Reentry system installed
U1554F				21 July	0730	21 July	2230	0.63		Attempted VSI run
Site U1554 totals:	0	45	30						16.89	
U1562A	36	8	0	10 July	1306	13 July	1935	3.27		
U1562B	0	0	31	13 July	1935	21 July	0000	7.18		Free-fall funnel
Site U1562 totals:	36	8	31						10.46	
U1563A	26	2	0	22 July	0230	24 July	0715	2.2		
U1563B	0	0	31	24 July	0715	30 July	0518	5.92		
Site U1563 totals:	26	2	31						8.11	
U1564A	0	0	0	30 July	1757	31 July	0318	0.39		
U1564B	0	0	0	31 July	0318	31 July	0630	0.13		
U1564C	18	40	0	31 July	0630	5 August	0100	4.8		
Site U1564 totals:	18	40	0						5.29	
Expedition 395C totals:	80	97	132						52.08	

5. Preliminary scientific assessment

Despite the difficult conditions due to the COVID-19 pandemic, the technical staff and crew of Expedition 395C managed to collect cores from all five primary sites of the Expedition 395 original plan. This achievement is remarkable given the extraordinary challenges faced by all members of the Siem, JRSO, and Entier personnel. The amount of recovered cores, their preliminary descriptions, and the analyses of shipboard samples show that the results of Expedition 395C will fulfill a significant part of the Expedition 395 objectives (Figure **F14**). A more comprehensive description of the cores is scheduled postcruise with the Expedition 395C/395 science party. Also, the biostratigraphic analysis was not performed on board the ship and is still ongoing at this time.

The first objective of Expedition 395/395C is to better understand the interaction between the Reykjanes Ridge and the Iceland plume and its fluctuations and to test several hypotheses for the generation of VSRs observed on either side of the ridge. During Expedition 395C, four sites reached the basement and collected cores from a series of flow units, allowing the measurement of the basalt geochemical composition. Sites U1555 and U1563 sampled basement at VST-1 and VSR-2a, respectively, and Sites U1554 and U1562 sampled basalts from VST-2b and VSR-3, respectively. The analysis of the basalt and basalt glass major and trace elements and isotopic compositions from these two pairs of VSRs/VSTs will allow us to estimate, for example, the variations in mantle source, potential temperature, and depth of melting. These cores will thus reveal the controlling factors at the origin of the VSR/VST variability and allow us to test the hypotheses for their formation. The basement at Site U1564 will be drilled and sampled during Expedition 395 and will complement our understanding of the factors controlling the crustal formation along the Reykjanes Ridge at the same distance from the Iceland plume. Sites U1555, U1563, and U1562, for which the objectives were mostly the basement sampling, will not be revisited during Expedition 395 because all necessary operations have been completed there (Figure **F14**).

The second objective of Expedition 395/395C is to estimate the temporal variations of the strength of the North Atlantic oceanic circulation, reflecting the intensity of the southern flow of deep water from the Norwegian Sea at the oceanic gateways east and west of Iceland, and to compare it with the fluctuations of the Iceland plume. This objective will be addressed through the analysis of the sediment cores collected at Sites U1554 and U1564, which sampled the Björn and Gardar drifts, respectively. The accumulation rate of sediments at these contourite drifts is thought to be moderated by the height of the oceanic gateways. The very good recovery of sediments from these sites, the presence of micro- and nannofossils (still under identification), and the excellent magnetic record measured along the cores ensure that we will obtain a good control on the age of the sediments. We will thus be able to estimate the variations in sedimentation rates with age with a high degree of accuracy. Coring at Site U1554 reached the basement, estimated to be 12.7 Ma, and the analysis of the cores will reveal the sedimentation history at the Björn drift during that period. Further coring at Site U1554 is required to produce a complete stratigraphic splice. Sediment cor-

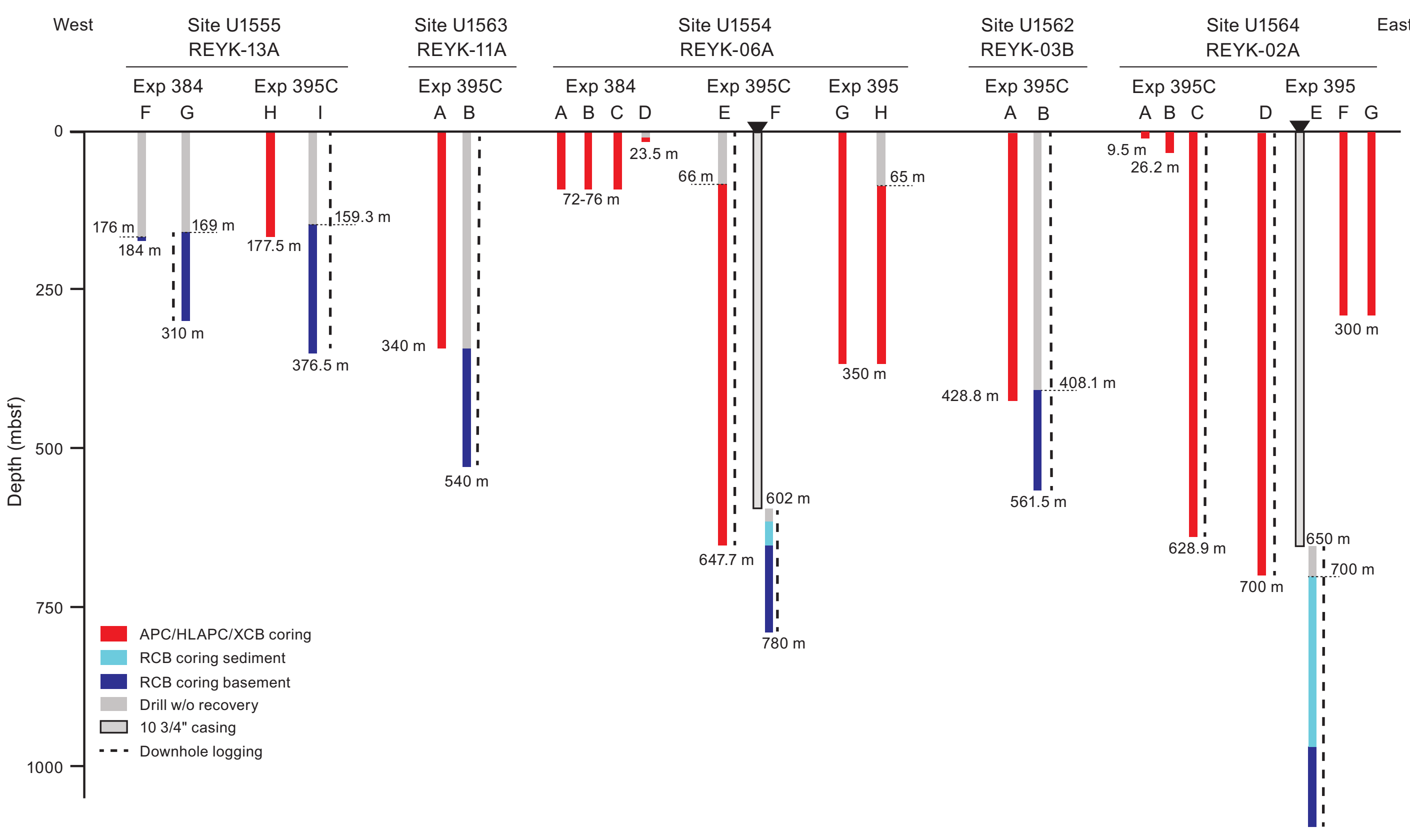

Figure F14. Completed (Expeditions 384 and 395C) and planned (Expedition 395) operations for Expedition 395 science plan.

ing at Site U1564 reached 628 meters below seafloor (mbsf), and we will need to core at this site during Expedition 395 to reach and core the basement, which is estimated to be 32.4 Ma, and core multiple sediment holes to investigate the history of the Gardar drift since Oligocene times. The analysis of the cores from Expedition 395C will allow us to reconstruct the contourite deposits back in time compared to the 1.7 Ma sedimentary sequence cored at Site 983. The analysis of dropstones and ice-rafted debris in the sediment cores at all sites will also allow us to decipher the dynamics of glaciers in the North Atlantic in the Quaternary.

The third objective of Expedition 395/395C is the analysis of hydrothermal processes affecting the ocean crust through interaction with seawater. During Expedition 395C, the sediment/basement interface was reached at four sites and basalt from the uppermost 130–200 m of the oceanic crust were cored. From the youngest to the oldest sampled basement, the ages of basalts inferred for Sites U1555, U1563, U1554, and U1562 are 2.8, 5.2, 12.7, and 13.9 Ma, respectively. Such a range of crustal ages for basement created at the same location along the MOR (i.e., along a plate-spreading flow line) has seldom been sampled before. The sediment and basalt cores will allow us to investigate the fluid circulation and hydrothermal alteration with age. Hydrothermal alteration products have been identified in veins within the recovered basalts. A comparison of the different sites will provide us with an exceptional view of the evolution in time of the hydrothermal processes.

On top of the main objectives of the expedition, the wealth of data collected during Expedition 395C will allow us to address many other fundamental questions, including the microbiological activity in the sediment and basalt, the evolution of climate conditions in the North Atlantic since Neogene times, and the dynamics of MOR eruptions, for example. We are optimistic that the efforts of the technical staff and crew of Expedition 395C and the patience of the scientific party during the 2 y between the staffing of the expedition and the description of the cores have a good chance of yielding invaluable scientific dividends.

6. Outreach

Because of the COVID-19 pandemic, the Education and Outreach program for Expedition 395C was adapted to include primarily shore-based activities so that the goals of the expedition and IODP could still be communicated to general audiences. Expedition 395C had one shore-based Outreach Officer, Jose Cuevas, based in Boston, Massachusetts (USA). Jose is currently at Boston College and was previously affiliated with the Birch Aquarium at Scripps in San Diego, California (USA), as an informal science educator.

The typical ship-to-shore events carried out during previous expeditions could not be undertaken. To overcome this limitation, the Outreach Officer enlisted the assistance of the shore-based science party and conducted seven "shore-to-shore" broadcasts with audiences including summer camps, NSF-funded Research Experiences for Undergraduates (REU) programs, and teaching workshops. A total of 118 individuals attended these events. The Outreach Officer also connected with a live audience twice via Facebook Live and YouTube Live. The first broadcast aired on 17 June 2021. The Outreach Officer interviewed the Co-Chief Scientists about the scientific objectives of Expedition 395C. This broadcast has 112 lifetime views on YouTube and 660 lifetime views on Facebook. The second broadcast aired on 23 July. The Outreach Officer highlighted the efforts of the Filipino crew members of *JOIDES Resolution*. This live broadcast has 68 lifetime views on YouTube and 878 lifetime views on Facebook, including over 220 Facebook views from the Philippines.

The expedition blog (**https://joidesresolution.org/expedition/reykjanes-mantle-convection-and-climate**) was maintained through guest entries by members of the science party. Two blogs discussed conducting science from shore during an expedition.

The Outreach Officer also acted in support of the JRSO's efforts to highlight the different shipboard roles available by conducting brief interviews with four science party members who had previously sailed. The footage collected will be used to produce scientific role videos for the JRSO.

Table T2. Total number of original posts, impressions, and engagements, Expedition 395C. Totals do not include replies or retweets and only reflect number of impressions and engagements for first week they were posted.

	Posts	Impressions	Engagements
Facebook	136	253,907	15,812
Twitter	215	893,645	30,355
Instagram	58		3,650

The social media program during Expedition 395C was extremely successful based on metrics (Table T2), which includes original posts (retweets not included); impressions, which are the number of times a post has been displayed; and engagements, which includes likes, shares, and comments. The social media posts spanned Twitter, Facebook, and Instagram and were a collaboration between the Outreach Officer and the imaging specialist on the ship, Sarah Kachovich. Expedition 395C saw record numbers for posts, engagement, and impressions on Twitter. When considering both original posts and replies, 310 posts generated over 35,000 engagements and over 1,150,000 impressions. Part of the success of this social media outpouring can be attributed to the Tweets and support of the shore-based science party and shipboard technical staff.

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