Integrated Ocean Drilling Program
Expedition 340T Scientific Prospectus

Atlantis Massif Oceanic Core Complex

Velocity, porosity, and impedance contrasts within the domal core of Atlantis Massif: faults and hydration of lithosphere during core complex evolution

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Abstract

Integrated Ocean Drilling Program (IODP) Expedition 340T will conduct borehole logging in Hole U1309D, on the domal core of Atlantis Massif just west of the spreading axis of the Mid-Atlantic Ridge, 30°N. Seismic imaging shows considerable reflectivity within the footwall of this oceanic core complex. Results from IODP Expeditions 304 and 305 suggest two geologic reasons for such impedance contrasts: (1) variable alteration between lithologic units or (2) narrow fault zones with significant porosity and possibly pore fluids. We will obtain seismic and temperature logs throughout the hole. Any change in seismic velocity associated with altered olivine-rich troctolite intervals would favor the former hypothesis, whereas any temperature deviation within three previously mapped fault zones would favor the latter hypothesis. The new borehole data will guide design of a vertical seismic profile (VSP) experiment. If the hole is clear, the first phase of the VSP program (zero-offset shooting) will be carried out during this expedition. Ideally, wall rock magnetic susceptibility will also be logged to further document the characteristics and distribution of serpentinization in various depth intervals.

During Expedition 305, borehole seismic data were obtained in the 30–800 mbsf interval, but instrument and weather problems precluded velocity measurements at the end of the expedition, when the hole had been deepened to 1415 mbsf. Postdrilling research has addressed many of the initial questions about average velocity structure and magmatic accretion during core complex formation. In the process, new interest in hydration and localized deformation processes within slow-spread lithosphere has arisen, as reflected at the May 2010 Chapman Conference on Oceanic Detachments. Although Expedition 340T work alone cannot answer all questions about what is responsible for the reflectivity seen, particularly at wide-angle source-receiver offsets, it does represent a crucial initial step that is required in order to plan optimal seismic experiments (e.g., walk-away VSP and new large-offset or three-dimensional multichannel seismic tests) that can fully document the potential pattern of lithospheric hydration.

Schedule for Expedition 340T

Integrated Ocean Drilling Program (IODP) Expedition 340T is based on IODP drilling proposal number 779-APL (available at **iodp.tamu.edu/scienceops/expeditions/atlantis_massif.html**). Following ranking by the IODP Scientific Advisory Structure, the expedition was scheduled for the research vessel *JOIDES Resolution*, operating under contract with the US Implementing Organization (USIO). At the time of publication of this *Scientific Prospectus*, the expedition is scheduled to start in Lisbon, Portugal, on 17 January 2012 and to end in St. John's, Antigua, on 6 February 2012. A total of 3 days is scheduled for downhole logging operations on site, with 12 days of transit to and from the site, as described in this prospectus (for the current detailed schedule, see **iodp.tamu.edu/scienceops/**). Further details about the facilities aboard the *JOIDES Resolution* and the USIO can be found at **www.iodp-usio.org/.**

Background

Slow-spread ocean lithosphere accretes and evolves via temporally and spatially variable magmatic and tectonic processes (e.g., Bonatti and Honnorez, 1976; OTTER, 1984; Dick, 1989; Lin et al., 1990; Sinton and Detrick, 1992; Cannat, 1993; Lagabrielle et al., 1998). Oceanic core complexes (OCCs), in particular, mark significant periods (1–2 m.y.) where a distinct mode of rifting/accretion persists, in contrast to the more typical interplay between magma supply and faulting that generates the ubiquitous abyssal hills. Long-lived displacement along detachment faults active within the ~20 km wide axial zone of a spreading center exhume the characteristic domal cores of an OCC, often capped by spreading-parallel corrugations (e.g., Cann et al., 1997; Tucholke et al., 1998). Beneath this exposed fault zone, gabbroic rocks with lenses, and possibly more significant volumes of mantle peridotite, are present, providing access to a major component of Earth's deep lithosphere for detailed chemical and physical property investigations. Conditions of OCC development are documented by igneous and metamorphic assemblages, as well as by deformation recorded during evolution of the footwall.

Geological setting

Atlantis Massif is a young OCC where contextual data from regional geophysical surveys, as well as seafloor mapping and sampling, is good and major structural blocks within the faulted lithosphere have been identified (Fig. **F1**). The domal core of Atlantis Massif was unroofed via detachment faulting that occurred within the rift zone of the Mid-Atlantic Ridge at ~1.1–0.5 Ma (Blackman et al., 2011; Grimes et al., 2008). Atlantis Massif was initially hypothesized to be an OCC on the basis of morphologic and backscatter mapping and dredging results that documented the shallow, corrugated, and striated domal core underlain by intrusive mafic and ultramafic rocks

(Cann et al., 1997). The spreading-parallel corrugations are equated with similar-scale features mapped on continental detachment faults (John, 1987) and suggest it was a slip surface associated with the detachment fault that unroofed the dome. Schroeder and John (2004) and Karson et al. (2006) document deformation within a zone that confirms the existence of a long-lived normal fault at the top of the Southern Ridge, with at least a few kilometers extent. The juxtaposition of volcanic eastern blocks against the corrugated dome, where southern ridge samples include gabbroic rocks (~30%) and serpentinized peridotite (~70%), supports the OCC model. Gravity and seismic data indicate that significant portions of the footwall to the detachment contain rocks with anomalously high density (200–400 kg/m^3 greater than surrounding rock; Blackman et al., 2008; Nooner et al., 2003) and velocities (4–6 km/s in the upper kilometer, compared to average Atlantic upper crust at ~3–5 km/s) (Canales et al., 2008; Collins et al., 2009). The active serpentinite-hosted Lost City hydrothermal vent field (Kelley et al., 2001; Früh-Green et al., 2003) is located just below the peak of the massif, the apex of the Southern Ridge. The Central Dome extending smoothly to the north is several hundred meters deeper, and it is against only this part of the footwall that the juxtaposed volcanic hanging wall exists. It is assumed to overlie the detachment where it extends at depth.

Differences between the Central Dome and the domal Southern Ridge (Karson et al., 2006; Boschi et al., 2006; Blackman et al., 2006, 2011; Ildefonse et al., 2007; Canales et al., 2008) raise questions about how axial magmatism, the detachment system, and subseafloor alteration may have progressed in space and time as this core complex formed. If we can determine the geologic cause(s?) of reflectivity within the uplifted footwall to the detachment, future seismic imaging could provide definitive tests of models for along- and across-strike variation in the structure/development of oceanic core complexes. The availability of the 1415 m deep borehole at IODP Site U1309 provides a unique opportunity to groundtruth properties measured at seismic wavelengths.

Seismic studies/Site survey data

Multichannel seismic (MCS) data (Canales et al., 2004; Singh et al., 2004) shows significant reflectivity throughout the Central Dome and Southern Ridge (Fig. F2), but its cause is difficult to explain based on what is known about the dominantly gabbroic primary lithology at Site U1309. Results from Hole U1309D indicate that alteration varies quite rapidly downhole and there are a number of sharp changes in borehole resistivity, two of which coincide with the boundaries of tens-of-meters thick, highly altered olivine-rich units (Fig. **F3**). The strong D reflection, noted by Canales et al. (2004) to be pervasive throughout the dome and apparently an isolated event at 0.2–0.5 s two-way traveltime (TWTT) using initial processing, has been shown via a wide-angle reflection processing method (Masoomzadeh et al., 2005; Jones et al., 2007) to most likely be the first in a series of reflections (Fig. **F2;** Singh et al., 2004). This reflective zone may be associated with altered olivine-rich units (Fig. **F2C**). However, this needs to be investigated more carefully using a better in situ velocity model and the best-possible ties to the core/borehole data.

Modeling of near-bottom explosive source (NOBEL) (Collins et al., 2009) and MCS streamer refraction traveltimes (Canales et al., 2008; Henig et al., 2009, 2010) indicates that at least parts of the dome are capped by a 100–200 m thick low-velocity layer (< 4 km/s; Fig. **F2D**). Obtaining reliable first arrival times for VSP stations in the 50–200 m depth interval would provide groundtruth in this crucial interval, where imprints of detachment zone processes may extend beyond the very narrow, high deformation documented by talc-schist fault rock sampled only in the upper few meters at Site U1309 (Blackman et al., 2006, 2011; McCaig et al., 2010). Sonic logging in the 800–1415 mbsf interval will provide velocity constraints on the 1080–1200 mbsf highly altered olivine-rich troctolite interval (Fig. **F3A**). The V_P/V_S ratio of the ~350 mbsf olivine-rich units appears to be higher (~2.0) than average (~1.8) and the new data will show whether this is characteristic of these units. Also, the velocity of the 1100 mbsf fault zone, which is marked by a density low (Fig. **F3C**), will be measured for the first time.

Previous drilling at Site U1309

IODP Expeditions 304 and 305 cored and logged a 1.4 km, dominantly gabbroic section at Site U1309 (Fig. **F3A**). The presence of many thin interfingered petrologic units (Blackman et al., 2006; John et al., 2009), together with age dating (Grimes et al., 2008), indicates that the intrusions forming the domal core were emplaced over a minimum of 100–220 k.y. and not as a single magma pulse. Isotopic and mineralogical alteration is intense in the uppermost 100 m but decreases in intensity with depth (Blackman et al., 2006; Nozaka et al., 2008; McCaig et al., 2010). Below 800 m, alteration is restricted to narrow zones surrounding faults, veins, and igneous contacts and to an interval of locally intense serpentinization in olivine-rich troctolite (Beard et al., 2009; Nozaka and Fryer, 2011). Hydration of the lithosphere occurred over the complete range of temperature conditions from granulite to zeolite facies but was predominantly in the amphibolite and greenschist range. Deformation of the sequence was remarkably localized (Blackman et al., 2006; Michibayashi et al., 2008; Hirose and Hayman, 2008), despite paleomagnetic indications that the dome has undergone at least 45° rotation (Morris et al., 2009), presumably during unroofing via detachment faulting.

The main geochemical characteristics of Site U1309 rocks are consistent with formation as a cumulate sequence built from a series of parental mid-ocean-ridge basaltic (MORB) melt injections (Godard et al., 2009). Self-intrusion of cooling, partially crystallized magma likely occurred, and infiltration of evolved melt from a given intrusion into preexisting mafic cumulate rock certainly occurred. The age of zircon-bearing core samples (Grimes et al., 2008) is consistent with formation in the axial zone and a period of asymmetric spreading, with the footwall to a detachment fault moving at or near the full spreading rate for the segment. The few thin peridotite intervals transected at Site U1309 are residual, but petrographic and geochemical evidence indicate that later-formed or injected melts fluxed the residuum (Godard et al., 2009) or infiltrated it as dikelets (Tamura et al., 2008). Olivine-rich troctolites are the product of intense melt-rock interactions between an olivine-rich protolith (either ultramafic cumulate or mantle peridotite) and basaltic melt (Suhr et al., 2008; Drouin et al., 2009, 2010). They cannot simply be the primitive, first-crystallized cumulate within cooling magma. Such melt-rock interaction processes are expected to play a significant role in crustal accretion at slow-spreading ridges and to contribute through melt-rock interactions to MORB chemistry (Lissenberg and Dick, 2008; Drouin et al., 2010).

Alteration, via reaction with seawater, is pervasive in the upper few hundred meters of the core, but the lower part of the section, particularly at depths below 800 meters below seafloor (mbsf), has several intervals with very little alteration (Fig. **F3B**). Instances of alteration of the recovered core being 50% or greater are very rare below 750 mbsf (except in the 1080–1200 mbsf interval) but are common at shallower depths. By depths of 800 mbsf, instances of 40% or higher overall alteration are uncommon. By 850 mbsf, many instances of <10% alteration are reported (although less commonly in the 1080–1200 mbsf interval). Throughout, intervals with higher olivine content (e.g., olivine-rich troctolites) show greater overall alteration than surrounding lithologies (gabbro and less common diabase).

Wall rock density and resistivity were logged throughout the hole, and seismic data (check shot with ~50 m station spacing and sonic logging) were obtained in the uppermost 800 m of the borehole (Fig. **F3C–F3E**). Compressional velocity averages

5.62 ± 0.03 km/s in the 272–477 mbsf interval and 6.01 km/s in the 522–792 mbsf interval, with check shot–determined velocities tracking the average logged wall rock and core sample velocities (Collins et al., 2009).

A temperature log at the end of Expedition 305 shows small dips (a few degrees) in each of the 170, 750, and 1100 mbsf fault zones (Blackman et al., 2006), but given the disturbed condition immediately following drilling, these dips could simply reflect pooling of cool flushing fluid in local breakouts. Obtaining a (relatively) undisturbed temperature log will allow confident interpretation of any such dips near fault zones that are measured and provide a reliable indication of general borehole temperature at depth (previous maximum of 119°C was measured by the Temperature/Acceleration/Pressure [TAP] tool at 1400 mbsf).

Supporting site survey data for Expedition 340T are archived at the **IODP Site Survey Data Bank** and at the Marine Geoscience Data Center (**www.marine-geo.org/tools/search/entry.php?id=MAR:30N_Blackman**) and the Academic Seismic Portal at the University of Texas at Austin's Institute for Geophysics (**www.ig.utexas.edu/sdc/cruise.php?cruiseIn=ew0102; www.ig.utexas.edu/sdc/cruise.php?cruiseIn=ew9704**).

Scientific objectives

Two observations will be valuable for ocean lithosphere studies in general, and these must be made with minimum possible disturbance:

1. Visual observation of whether the well is "producing" (flow out of the hole) or not: addresses fluid flow within the crust and chemical exchange with seawater in maturing lithosphere.
2. Measurement of temperature throughout the borehole: assesses conditions that may be encountered by future ultradeep drilling/logging of an intrusive oceanic section; tests for possible fluid flow (temperature dips) within fault zones of Atlantis Massif's footwall.

Focusing on our main objectives, obtaining new caliper measurements throughout the hole is necessary so that we can select VSP station depths where borehole diameter/condition is optimum for instrument coupling. The aim is for station spacing of 25 m throughout the hole, including depths as shallow as ~50 m if hole conditions warrant. The VSP data should increase our knowledge of local reflectivity for near-vertical waves, thereby improving core-log integration. Information on the condition of the borehole is crucial for determining whether a future single-ship, wireline reentry experiment is viable or whether the drillship and a second vessel will be needed to complete the VSP experiment by conducting a walk-away component. Ultimately, this full data set will enable core-log-survey integration at as high a level as possible with current geophysical data.

Sonic logs will be extended to cover the full hole. The upper part of the hole (<800 mbsf) will be relogged, including Stoneley wave measurements, which can provide additional information on permeability/fracturing and any contrast thereof, between lithologic/alteration intervals.

Magnetic susceptibility logs will target downhole variation in magnetite that is a product of serpentinization, so providing constraint on extents/style of alteration that may have been missed with the finite (although very good) core recovery (non-white portion of Fig. **F3A**).

Logging/Downhole measurements strategy

Downhole logging will be the primary operation to achieve the scientific objectives of Expedition 340T by providing continuous, in situ geophysical measurements of the drilled basement at Site U1309. The logging program will establish the current temperature profile in the borehole fluid, which will provide information on active fluid flow in previously observed faulted intervals and temperature gradient changes that may be associated with lithologic variations. In addition, sonic logging and a zero-offset VSP will extend into the deeper interval (>800 mbsf) of the borehole, where no such data were previously recorded because of weather and instrument problems encountered during Expedition 305. These new velocity data will allow for direct, high-resolution correlation of wireline measurements with core measurements made during Expeditions 304 and 305.

The operations schedule for Expedition 340T is limited to 3 days on site (Table **T1**), based on ancillary project letter (APL) guidelines. As a result of the time limitation, the logging program is designed to be flexible and to include as many as four different tool strings:

1. Triple combination (triple combo) tool string with Modular Temperature Tool (MTT),
2. Sonic tool string,

3. Versatile Seismic Imager (VSI) tool string for VSP, and
4. Magnetic Susceptibility Sonde (MSS) tool string.

Following two phases of drilling during Expeditions 304 and 305, Hole U1309D penetrated to a total depth of 1415.5 mbsf, with 13⅜ inch casing to 20.5 mbsf to provide stable reentry. The hole was left in good condition at the end of Expedition 305, so we anticipate reasonably good hole conditions for logging operations. We will reenter the hole with a logging bit and maintain the pipe within the casing, if possible. The first logging run will be the triple combo tool string with the MTT in order to recover an equilibrium temperature profile of the hole, which has been undisturbed since Expedition 305 logging operations concluded on 26 February 2005. The caliper on the triple combo will be used to assess hole size and condition and to identify favorable intervals for anchoring the VSI during the VSP. The logging bit will allow for rotation, if a need for minor clean-up of the hole is indicated by the caliper log. The order of the other tool strings will be adjusted to (1) ensure that the VSP is acquired during daylight operations to accommodate marine mammal observations while using the seismic source and (2) optimize time on site to collect the full suite of logging data within the 3 days available for operations.

Characteristics of the tools are described briefly below. For more information on specific logging tools, please refer to **iodp.ldeo.columbia.edu/TOOLS_LABS/.**

Triple combo tool string

The triple combo consists of five main tools:

1. The Accelerator Porosity Sonde (APS) uses an electronic neutron source to measure the porosity of the formation.
2. The Hostile Environment Litho-Density Sonde (HLDS) measures bulk density. It includes a caliper that will provide hole diameter and an assessment of hole quality.
3. The Hostile Environment Gamma Ray Sonde (HNGS) measures the natural radioactivity of the formation and provides estimates of Th, U, and K concentrations.
4. The High-Resolution Laterolog Array (HRLA) measures electrical resistivity of the formation at five different penetration depths.
5. The Lamont-Doherty Earth Observatory (LDEO) MTT measures borehole temperature. It is attached at the bottom of the triple combo.

Sonic tool string

The main component of the sonic tool string is the Dipole Shear Sonic Imager (DSI), which records a full set of acoustic waveforms to measure the compressional (V_P) and shear velocity (V_S) of the formation. In addition to V_P and V_S, the DSI will be run with different modes to allow the estimation of properties such as anisotropy and permeability. V_P can also be combined with the density log from the triple combo to generate synthetic seismograms and provide high-resolution seismic/well integration. A gamma ray tool will be run in the sonic tool string in order to depth match the different logging runs, as well as potentially the MTT, to record temperature rebound in the borehole.

Versatile Seismic Imager tool string

The VSI will be used to acquire a zero-offset vertical seismic profile (VSP) for high-resolution integration of borehole and seismic data. The tool string will be lowered into the hole and anchored at specified intervals against the borehole wall to record the waves emitted by the seismic source. The survey is planned with 25 m spacing of stations over the entire open hole interval (~20 mbsf to total depth of ~1415 mbsf). Spacing may be adjusted based on hole condition/size determined from the caliper log. If a full period of daylight is available, under optimal conditions the entire open hole VSP may be acquired during a single run. However, given the uncertainty of arrival time on site, VSP operations may require two daylight phases of logging. Phase 1 would capture the deeper interval (~800–1415 mbsf) where no VSP has been acquired, and Phase 2 would investigate the shallow interval (~20–800 mbsf) with closer station spacing than obtained during the Expedition 305 VSP. If time is limited, the deeper interval below ~800 mbsf is the higher priority. The seismic source for the VSP will be a parallel cluster of two 250 in^3 Sercel G guns (Table T2), positioned 2–7 m below sea level and offset by ~50 m from the side of the ship. VSP operations are subject to the IODP marine mammal policy and may be postponed or cancelled if policy conditions are not met.

Magnetic Susceptibility Sonde tool string

The MSS measures magnetic susceptibility, which would provide an assessment of formation alteration (serpentinization) and could be correlated with magnetic susceptibility measurements from Expedition 304/305 cores. LDEO is currently building a replacement for the MSS that was deployed and lost during IODP Expedition 320.

Current production and testing timelines indicate that the MSS will be available for Expedition 340T. The MSS will be run in a modified triple combo (MSS replaces HRLA) or in a condensed tool string (MSS with HNGS and/or HLDS). Temperature considerations may prevent or limit the deployment of the MSS (rated up to 80°C); measurements at the end of Expedition 305 indicate a temperature of at least 119°C at ~1400 mbsf. Magnetic susceptibility data are lower priority than temperature and velocity data from the other tool strings; therefore, temperature and time constraints will be used to determine whether the MSS tool string is run. Even a partial run of the MSS tool string in the shallower, presumably cooler interval (e.g., ~20–800 mbsf) would likely provide scientifically valuable data.

Risks and contingency strategy

Three principal factors could affect the implementation of the logging plan:

1. Adverse hole conditions at Site U1309 (e.g., encountering collapsed intervals where basement rock has blocked the hole or extremely high borehole temperatures);
2. Weather conditions that limit the ability to conduct logging operations; and
3. Time delays arising from equipment breakdowns, measures taken to respond to hole conditions, or weather conditions.

Hole conditions

Narrow bridges indicated by the caliper log or high borehole temperatures (>175°C) indicated by the temperature log on the first logging run may be addressed by minor remediation. Minor remediation activities include rotation of the logging bit to clear bridges and circulation of seawater to cool the hole, both of which require lowering the pipe into the open hole to be effective. Prohibitively poor hole conditions would require a bit change to the rotary core barrel (RCB) system to remediate and would lead to a significant time penalty that would severely reduce the planned logging program. The advantages and disadvantages of this remediation strategy will have to be evaluated at sea should the need arise.

Weather conditions

Expedition 305 to Site U1309 experienced favorable weather conditions up until the last day of operations. Expedition 340T is scheduled in the same weather window as Expedition 305, so we expect weather-related risks to be minimal.

Timing

Any time gained during the transit from Lisbon to Site U1309 will be used to augment the 3 days allotted to Expedition 340T operations. Once on site, time spent on hole remediation, marine mammal observation activities, or weather-related delays will be considered part of the time allotted to operations and may result in reducing the logging program. Expedition 340T operations should be concluded in order to allow a timely departure for Antigua by midnight on 31 January 2012.

Data sharing strategy

Shipboard and shore-based researchers should refer to the IODP Sample, Data, and Obligations policy posted on the Web at **www.iodp.org/program-policies/.** This document outlines the policy for distributing IODP samples and data to research scientists, curators, and educators. The document also defines the obligations that sample and data recipients incur. The Sample Allocation Committee (SAC; composed of the Chief Scientist, Staff Scientist, and IODP Curator on shore and the curatorial representative on board ship) will work with the entire scientific party to formulate a formal expedition-specific plan for shipboard and postcruise data use.

This expedition involves downhole logging in an existing borehole with no new coring; therefore, no samples will be collected during this expedition.

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Table T1. Operations and time estimates, Expedition 340T.

Site No.	Location (Latitude Longitude)	Seafloor Depth (mbrf)	Operations Description	Transit (days)	Drilling Coring (days)	Log (days)
Lisbon			Begin Expedition 5.0	port call days		
			Transit ~1699nmi to Hole U1309D @ 10.5 knots	6.7		
Hole U1309D	30° 10.12' N	1656	Hole U1309D - Supplemental Wireline Logging (w/VSP) -			3.1
	42° 7.11' W		1. Triple Combo with MTT (temperature)			
			2. DSI (Sonic tool)			
			3. VSI for VSP			
			4. MSS (Magnetic Susceptibility Sonde) (time permitting)			
			Sub-Total Days On-Site: 3.1			
			Transit ~1334nmi to Antigua @ 10.5 knots	5.2		
Antigua			End Expedition	11.9		3.1

Port Call:	5.0	Total Operating Days:	15.0
Sub-Total On-Site:	3.1	Total Expedition:	20.0

VSP = vertical seismic profile, triple combo = triple combination, MTT = Modular Temperature Tool, DSI = Dipole Sonic Imager, VSI = Vertical Seismic Imager, MSS = Magnetic Susceptibility Sonde.

Table T2. Air gun source levels for zero-offset vertical seismic profile, Expedition 340T.

Source	Specification
Energy source	One or two 250 in^3 G air guns
Source output (downward) (1 × 250 in^3)	0-pk is 3.1 bar·m (229.8 dB re 1 µPa·m_p)* pk-pk is 6.4 bar·m (236.2 dB re 1 µPa·$\text{m}_\text{p-p}$)
Source output (downward) (2 × 250 in^3)	0-pk is 5.2 bar·m (234.3 dB re 1 µPa·m_p) pk-pk is 10.8 bar·m (240.7 dB re 1 µPa·$\text{m}_\text{p-p}$)
Deployment depth of energy source (m)	2–7
Air discharge volume (in^3)	250 or 500
Dominant frequency components (Hz)	0–256

* = The source level is a measure of the effective sound pressure at a given distance from the source array, relative to a reference value. It is commonly expressed in decibels at 1 m from the source relative to µPascal-m, or dB re 1 µPa·m. 0-pk = peak energy. pk-pk = peak-to-peak energy.

Figure F1. Atlantis Massif on the western Mid-Atlantic Ridge flank of the ridge-transform intersection. Main tectonic features and locations of Hole U1309D (black circle) and seismic lines are indicated: white = multichannel seismic, dark gray = refraction from NOBEL deep source/OBS, light gray = refraction from traditional air gun/OBS. Corrugations on domal core mark exposed detachment fault, well-mapped along the southern edge of the Southern Ridge and inferred from morphology and talc schist fragments recovered in upper few meters (only) on Central Dome. Volcanic hanging wall block(s) are also shown.

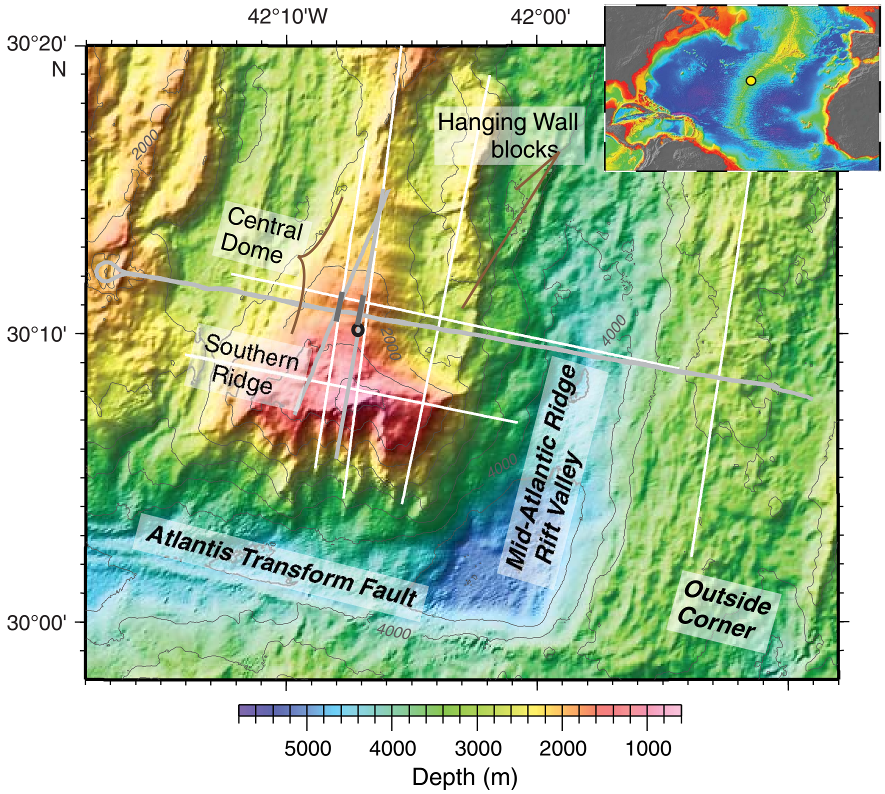


Figure F2. MCS data at Atlantis Massif. **A.** Migrated stack of Meg 10 across Central Dome (Canales et al., 2004). TWTT = two-way traveltime. **B.** Unmigrated section (Singh et al., 2004) reveals a more complex band of wide-angle reflectivity starting at the D reflector and extending ~0.5 s. Tomography model (Blackman et al., 2009) is overlain. **C.** Snapshots from Fledermaus scene show Singh wide-angle record sections and Hole U1309D lithology (depth converted to time using average check shot velocity). **D.** Velocity depth profiles for NOBEL (Collins et al., 2009) and MCS refraction traveltime inversions (Canales et al., 2008) overlain on envelope (gray) of average young Atlantic crust (White et al., 1992). CD = Central Dome, SR = Southern Ridge.

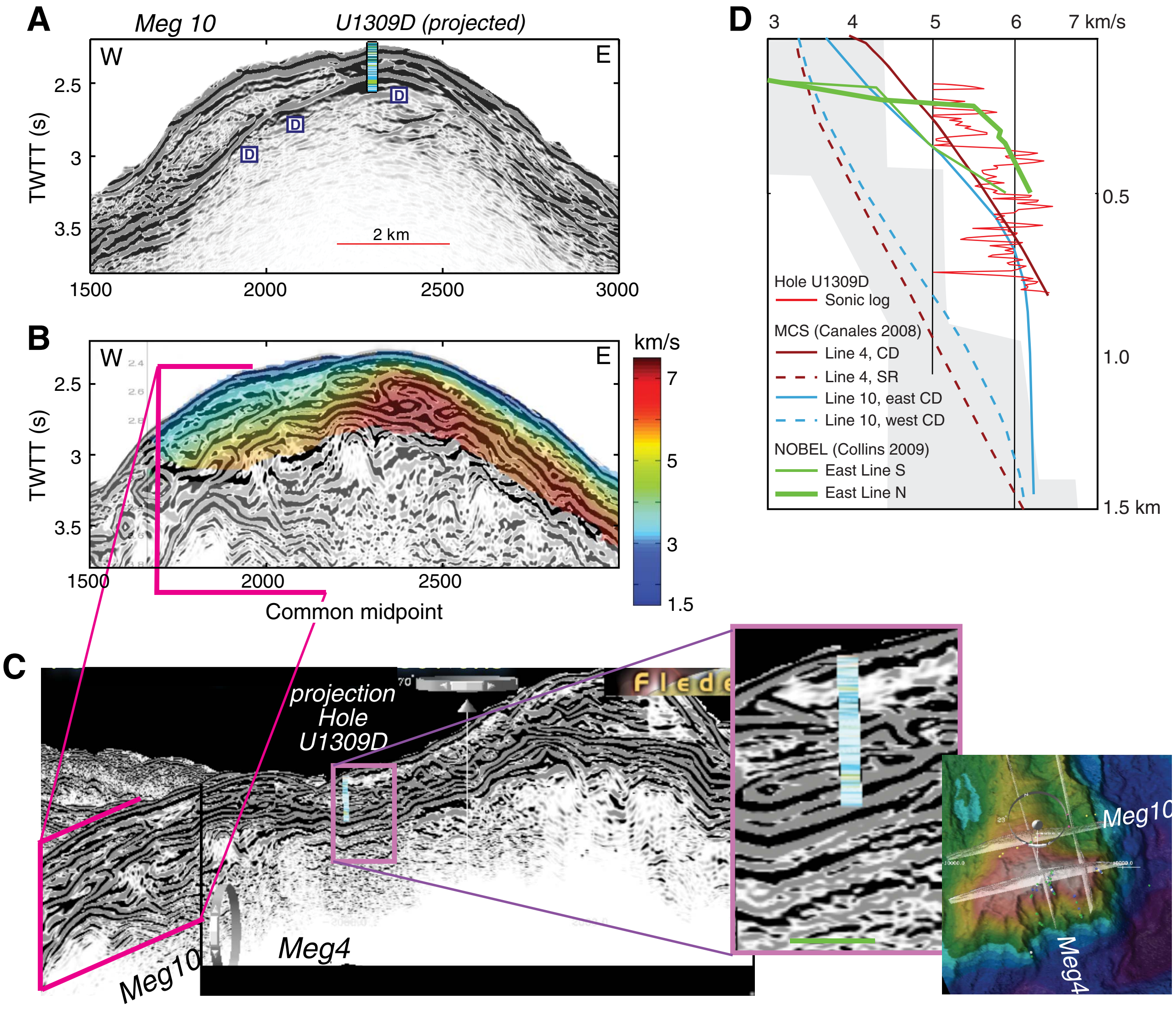
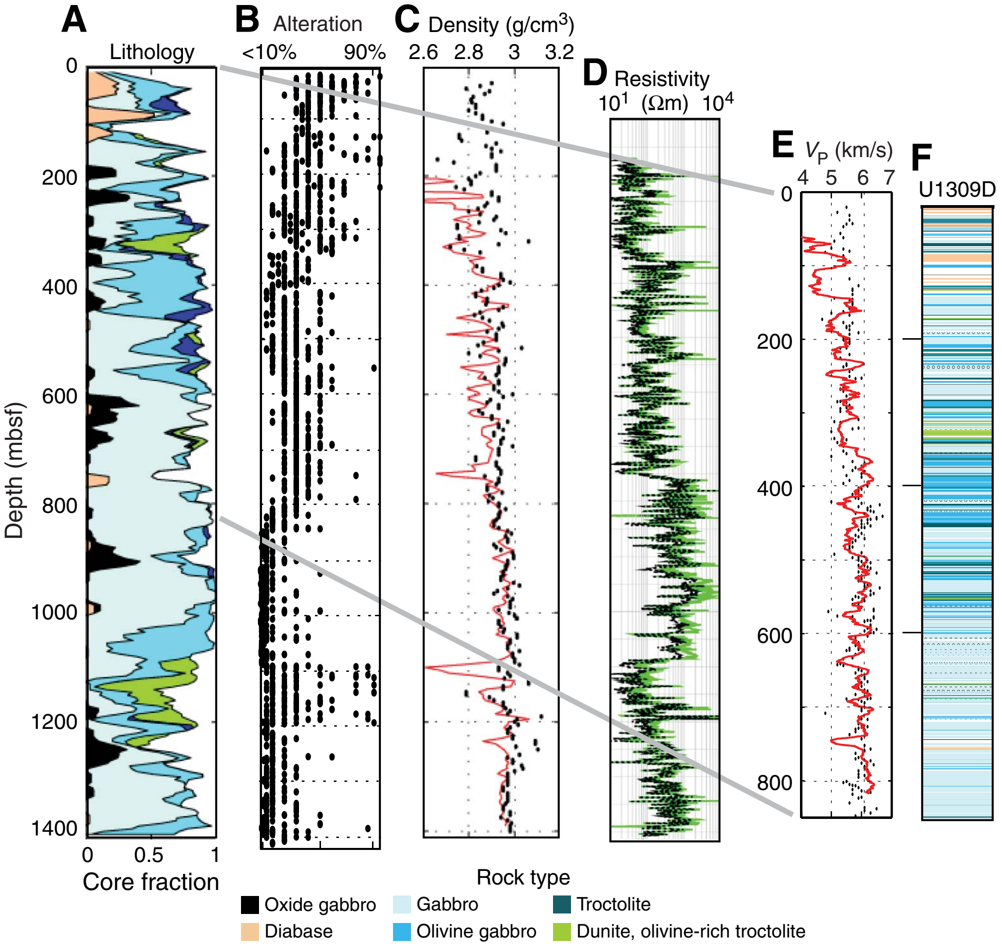


Figure F3. Downhole data, Hole U1309D. **A.** Lithology is dominantly gabbroic with intervals of greater olivine content. **B.** Alteration of core pieces determined by shipboard description. **C.** Density: red line = logged, black dots = shipboard core samples. **D.** Logs of wall rock resistivity. **E.** *P*-wave velocity: red line = logged, black dots = core sample at room temperature/pressure. **F.** Expanded lithology in uppermost 800 m where seismic data currently exist.



Site summary

Site U1309

Priority:	1
Position:	30°10.12′N, 42°7.11′W
Water depth (m):	1645
Target drilling depth (mbsf):	Not applicable, reoccupy existing hole, no new penetration
Approved maximum penetration (mbsf):	Not applicable, reoccupy existing hole, no new penetration
Survey coverage (track map; seismic profile):	Primary line: Meg 4, CMP 4145 closest, ~400 m to east Crossing line: Meg 10, ~1.8 km north (Track map Fig. F1, Seismic profiles Fig. F2)
Objective(s):	Borehole logging in existing Hole U1309D: Undisturbed temperature profile Assess condition of hole for future wireline reentry and seismic work Sonic logging and zero-offset VSP Magnetic susceptibility logging
Drilling program:	Not applicable, reoccupy existing hole, no new penetration
Logging/downhole measurements program:	Triple combo including MTT to determine borehole condition and temperature, and to identify intervals for positioning VSI. Order of following tool strings to be determined by timing of operations, so that VSP is conducted during daylight hours. Sonic tool string VSI tool string for zero-offset VSP MSS tool string, time and temp permitting
Nature of rock anticipated:	Not applicable, reoccupy existing hole, no new penetration

Expedition scientists and scientific participants

The current list of participants for Expedition 340T can be found at **iodp.tamu.edu/scienceops/precruise/atlantismassif/participants.html.**