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Site U1315[1]

Expedition 306 Scientists[2]

Chapter contents

Background and objectives

Ocean Drilling Program (ODP) Site 642 (Integrated Ocean Drilling Program Site U1315), located on the Vøring Plateau in a water depth of ~1280 m, was visited during ODP Leg 104 (Fig. **F1**). The main objectives of Leg 104 were to investigate the paleoceanographic and tectonic history of the Norwegian-Greenland Sea (Eldholm, Thiede, Taylor, et al., 1987). A total of five holes were drilled at Site 642. In Hole 642E, a 1229 m deep sequence was drilled that is composed of upper Eocene–Quaternary biogenic and terrigenous sediments with volcaniclastics in the lower part (Units I–IV; 0–315 meters below seafloor [mbsf]) and Eocene tholeiitic (upper series) and andesitic (lower series) basalt flows with interbedded volcaniclastic sediments (from 315 to ~1229 mbsf) (Fig. **F2**). The location of Site 642 was revisited during Expedition 306 to install a borehole observatory in a new hole close to this site (Hole U1315A) to record the bottom water temperature (BWT) variability over the last ~100 y.

The northern North Atlantic is the primary deep ventilator of the oceans, and it is now recognized that production of deep water in the northern North Atlantic is intimately related to global climate (Broecker, 1987; Dickson, 1997; Woods et al., 1999). Changes in the production of North Atlantic Deep Water (NADW) may be the result of, or lead to, regional or global climatic changes. Unfortunately, there is a lack of long-term observations and those that do extend back in time are concentrated at or near the surface. Oceanographic observations indicate that the thermohaline structure of the North Atlantic has changed over the past 20–30 y suggesting the presence of significant variations in BWT (Roemmich and Wunsch, 1984; Antonov, 1993).

It is hypothesized that subbottom temperature-depth profiles can be used to construct BWT histories at timescales on the order of decades to a century. The conductive thermal regime of oceanic crust comprises the superposition of two processes: the outward flow of heat from the Earth's deep interior and perturbations to the deep regime by changes of BWT at the seafloor. The latter effects operate on a relatively short timescale (decades, centuries, and millennia), whereas the former process operates on a geologic timescale, with secular changes taking place over millions of years. In the context of the short-term BWT perturbations, the outward flow of heat from the interior is seen as a quasi-steady-state process. Because oceanic sediments have a low thermal dif-

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[2] **Expedition 306 Scientists' addresses.**

fusivity, changes in BWT diffuse slowly downward by conduction, perturbing the background thermal regime. These measurable anomalies are a direct thermophysical consequence of BWT variations and as such are a straightforward measure of temperature, not a proxy. Resolution analysis indicates that 100 y of temperature change is potentially recoverable from high-precision temperature-depth logs in boreholes 200 m deep.

To capture thermal transients associated with temporal variations in BWT, we established a borehole observatory in a new 170 m deep hole (Hole U1315A) close to Site 642, consisting of a circulation obviation retrofit kit (CORK) to seal the borehole from the overlying ocean and a thermistor string and data logger to make and record the temperature measurements. This configuration allows high-precision temperature measurements as a function of both depth and time.

Site 642 represents an ideal candidate to test this hypothesis for two reasons:

1. It is located near Ocean Weather Ship Station (OWS) *Mike* (Fig. **F3**) which has been in continuous operation over the last 50 y. Weekly temperature and salinity measurements at >2000 m depths have been made since 1948 (Gammelsrød et al., 1992). These measurements represent the longest homogeneous time series from the deep ocean. They will be used to check the efficacy of our measurements and analysis as well as to provide a direct test of our hypothesis.
2. It is located on the eastern margin of the Norwegian Sea (Fig. **F3**), a climatically sensitive area that records the changing hydrographic character and horizontal exchange of deep water from the Greenland Sea, Arctic Ocean, and Norwegian Sea. As such, BWT histories will yield insight into the complex interplay between these important water masses.

The operational plan for the new hole near Site 642 precluded a logging program in that hole. To assess current background thermal conditions in the region, however, a downhole logging of temperature was carried out in Hole 642E using the Lamont-Doherty Earth Observatory (LDEO) high-temperature tool. In addition to the temperature tool, the triple combination (triple combo) and Formation MicroScanner (FMS) logging tool strings were run.

Operations

We arrived at Site U1315 (proposed Site 642) on the morning of 15 April 2005 after a 1190 nmi transit from Site U1314. By 1120 h, the positioning beacon was deployed and operations at the site officially began.

Hole U1315A

After we verified the seafloor depth with the television/sonar system (1283.0 meters below rig floor [mbrf]), the drill string was recovered back to the drillship and we prepared to assemble and deploy the "elevated" reentry cone assembly and 10¾ inch casing string. Following assembly, the drill string with the reentry cone structure, 10¾ inch casing, and the mud motor and underreamer drilling assembly were tripped to the seafloor, spudding Hole U1315A at 2130 h on 15 April. The base of the reentry cone reached the seafloor at 0515 h on 16 April, resulting in an average rate of penetration of 21.9 m/h. The drill string was released from the reentry cone/casing assembly at 0550 h and then recovered back to the ship.

The drill string was reassembled with a cementing bottom-hole assembly and reentry cleanout bit and tripped to the seafloor, and Hole U1315A was reentered at 2026 h on 17 April. A 5 bbl, 15.8 ppg cement plug was displaced to bottom. The pipe was pulled clear of the seafloor/reentry cone, and the vessel was offset 30 m south where the drill pipe was thoroughly circulated clean. After the cement set, we reentered the hole and lowered the pipe, tagging the top of the cement at ~164.2 mbsf or ~11.6 m above the casing shoe, which was within 1.6 m of our 10.0 m target height for the top of the cement column. After the casing string was displaced with bentonite mud, the drill string was retrieved in preparation for the CORK deployment in Hole U1315A.

CORK deployment

The CORK running tool was made up to a 2.0 m drill collar pup joint and was laid out on the rig floor. The antitorsion ring, a recent modification that is designed to prevent accidental release of the tool during deployment, was installed along with the seal stinger. The Hole U1315A CORK head was moved from the core tech shop roof to the starboard side of the pipe stabber using the number 2 crane. From there, the load was transferred to two tugger lines and the head was placed through the rotary table with the bushings removed. The head was supported using 13⅜ inch casing slips with a dog collar installed above. The running tool was picked up with the drawworks elevators and was easily installed on the CORK head.

Two stands of 8¼ inch drill collars were made up to the top of the running tool, and the CORK assembly was lowered to the seafloor. During the pipe trip, the subsea television/vibration-isolated television (VIT) frame was being lowered when the video was suddenly lost. The VIT frame was recovered, and troubleshooting identified a cleared power circuit breaker resulting from water leakage. In addition, a broken strand of outer armor was discovered ~360 m above the cable head termination. The resulting snarl in the armor was cut off, and the ends were secured. Once the cable head was on deck, we discovered that water had entered the oil-filled section of the cable head. The cable head connection was repaired rather than spending costly time completely reheading the cable. The VIT camera was ready to deploy once again at 0345 h on 19 April. A total of 3.25 h was required to make the necessary repairs.

Hole U1315A was reentered for the third and final time at 0448 h on 19 April. Space out was tight given the short length of the CORK stinger (20.85 m). For thermistor string deployment, the CORK head was left 9.0 m shy of landing out in the 16 inch casing hanger. This left ~12.3 m of stinger in the hole and allowed the pipe to be hung off at the rotary table to break the drill pipe connection and deploy the thermistor string.

Thermistor string deployment

A total of 5.75 h was required to make up and deploy the thermistor string. This string was specially designed for long-term monitoring of the upper 150 m of the sediment column from the seafloor down. The thermistor string was premade with a ¼ inch diameter Spectra (Kevlar) rope attached to the thermistor cable with tie wraps and duct tape. The Spectra line (153.84 m) was designed to carry the load as a tension member and was terminated with a ~250 lb sinker bar (3.73 m). The thermistor cable was plugged into a battery pack/data logger assembly (0.97 m) at the top. This package was suspended from another short section of Spectra rope (2.22 m) with thimbles at each end and the XN latch assembly (0.31 m to landing shoulder). Cable “grips” were used to lift the thermistor string in ~50–60 ft lifts using a double sheave assembly and two tugger lines. This was the same process used on earlier thermistor deployments; however, this time, there were problems. For reasons yet to be fully understood, at the conclusion of each lift the thermistor cable tensed up and carried the load and the Spectra line would go slack. The weight probably transferred across the tie wraps. On most lifts, the load would eventually transfer back to the Spectra line as designed; however, on the last two lifts, the load never did transfer. Fortunately, the Hole U1315A thermistor string was relatively short, and the suspended load was fairly light. To rectify the problem, we cut loose the remaining tie wraps and duct tape. We then retied and retaped the cable and rope together as the remainder of the string was deployed. At the end, where the rope was to be attached to the bottom of the data logger/battery assembly, we had a surplus of 9 ft of Spectra rope that had to be cut off, leaving the final rope length at 151.10 m. Once made up, the thermistor string assembly was deployed via wireline at 1030 h on 19 April. The XN latch assembly was landed without incident. The latch was jarred down for setting, and a 4000 lb overpull was taken to verify proper latch-in. The sinker bars were recovered via wireline, and by 1215 h we were ready to land and release the CORK assembly.

CORK landing and release

The drill string was lowered the remaining 9.0 m (~1 knobby joint), and the CORK head landed out at exactly the correct pipe depth. About 5000 lb were put down, and then ~8000 lb of overpull was taken to verify that the CORK head was latched. This weight was slacked off, and a small amount of right-hand torque was applied to the string. The CORK running tool was observed to rotate slightly, and when the string was picked up, the running tool lifted cleanly off the head. Installation of the Hole U1315A CORK was officially completed as of 1237 h on 19 April.

The top drive was racked back and the drill string was recovered, clearing the rig floor at 1605 h. During the pipe trip, positioning beacon SN 2039 was recovered by 1440 h. The upper guide horn or “piccolo” was then reinstalled, ending operations for Hole U1315A.

Hole 642E (ODP Site 642)

Search for Hole 642E reentry cone

During the trip out of the hole, the drillship moved back to the original Site 642 prospectus coordinates. From there, a search began for the Hole 642E reentry cone. A 100 m × 100 m box pattern search in 15 m swaths was initiated. The operations report for ODP Leg 104 indicated that the reentry cone base was left ~1.0 m below the seafloor, leaving ~1.5–2 m of cone above. Other entries in the report indicated that the last few reentries were difficult and the crew questioned whether future reentries would be possible because they felt that the cone may have been buried in drilled cuttings. It should be noted, however, that all reentries at that time were made using sonar and were not aided by any subsea television capability. The search for the reentry cone began at 2045 h on 19 April 2005 and extended through the night without success. The following morning, the ship returned to a target that was not close to where the reentry cone should have been; however, an obvious man-made object was visible on the seafloor and was detected on sonar as well. The object appeared to be an old-style reentry cone reflector. Four of these reflectors were mounted on the older-style reentry cones in the past. Convinced that the cone was buried, we spent several hours attempting to define where a cone might be relative to the single visible reflector. Ultimately a stab into the seabed was made with the drill string; however, this was to no avail as the driller noted drill string resistance after lowering the drill string only 9 m into the seabed. Upon reflection, we decided that the object was not the cone we were searching for; the sonar should have identified the remaining cone and reflectors even if submerged. Considering this and coupled with the fact that we were not even close to the area that the cone should have been, we decided to continue on with the search. In so doing, we revisited all that we knew about the location of the target cone and realized that we had started our search pattern at a longitude of 2°55.7′E, failing to recognize that Hole 642E had in fact been spudded at 2°55.8′E, a full tenth of a minute off. After entering new offsets into the dynamic positioning system, we finally located the reentry cone on sonar and then ultimately with the subsea television system as well. The cone was fully visible and was not submerged or covered in cuttings. The rim and all four reflectors could be clearly identified, and the cone rim appeared to be, as reported, 1.5 to 2.0 m above the seafloor. Using the new undithered Global Positioning System capabilities of the ship, the ultimate coordinates for Hole 642E are 067°13.1850′N, 002°55.7789′E. The cone was actually located 548 m south of Holes 642A and 642B on a bearing of 173°. According to the documentation, the cone should have been located 450 m to the southeast (a bearing of 135°). The drill string was spaced out, and Hole 642E was reentered at 1305 h on 20 April, a total of 16.5 h after the search was initiated.

Wireline logging

The primary goal of our return to Hole 642E was to obtain a high-resolution continuous temperature log of the hole that had been left undisturbed for nearly 20 y. This hole was drilled to a total depth of 1229.4 mbsf during Leg 104. It was left cased (with 11¾ inch 54 lb/ft casing) 62.5 m into basement, placing the casing shoe at 371.5 mbsf. To minimize disturbance in the hole, the end of the pipe was placed at only 15.3 mbsf. The LDEO Temperature/Acceleration/Pressure (TAP) tool was deployed with the standard triple combo (Dual Induction Tool model E [DIT-E]/Hostile Environment Litho-Density Sonde [HLDS]/Accelerator Porosity Sonde [APS]/Hostile Environment Gamma Ray Sonde [HNGS]) tool string at 1710 h. A good temperature log was obtained on the first run downhole; however, ledges and/or chunks of basalt falling in from above the tools proved to be problematic. After the tools were "mouse trapped" between two such zones for nearly an hour, they were recovered, having only reached a depth of ~1888 mbrf (~599 mbsf) or ~228 m into the open hole below the casing shoe. The first tool suite was recovered at 2225 h on 20 April.

After rigging down the first tool suite, the second suite of tools consisting of the FMS-sonic tool string were made up and deployed. These tools were run in at 0135 h on 21 April and were recovered at 0700 h after reaching a depth of ~1878 mbrf (~589 mbsf) or ~218 m into the open hole.

The FMS-sonic tool string was rigged down, and a final run was made only to 1200 mbsf to test the Multi-Sensor Spectral Gamma Ray Tool (MGT) pressure case. This tool leaked during a logging run earlier in the expedition; however, nothing unusual was found to explain the leak. After cleaning the pressure case thoroughly, new O-rings were installed and the body was deployed without electronics to test its pressure integrity. The tools were run in at 0750 h and recovered by 0900 h. The limited test (relatively shallow depth) was successful, and the MGT was recovered without any signs of leakage.

All wireline tools and the Schlumberger logging sheaves were rigged down by 1000 h, and preparations began for drill string recovery. The bit cleared the seafloor/reentry cone at 1005 h, and by 1310 h, all drill pipe had been recovered and all drill collars were laid out to the main deck tubular rack. During the pipe trip, positioning beacon SN 2199 was recovered on deck at 1100 h. The rig floor was secured, all thrusters and hydrophones were raised, and the drillship was under way for Dublin, Ireland, by 1315 h on 21 April 2005.

Downhole measurements

Logging operations

After a successful CORK deployment in Hole U1315A on the Vøring Plateau, downhole logging operations were carried out in a nearby legacy hole from ODP Leg 104, Hole 642E. Hole 642E had been drilled in 1985 to a total depth of 1229 mbsf (~40% recovery) with the upper 370 m cased into basalt basement. The entire drilled sequence consists of Eocene-age interbedded lava flows and volcaniclastics with estimates of up to 135 lava flows. The main operational goal was to obtain a good downhole temperature profile at this site because one could not be obtained at the new CORK site. In order to not disturb the hole, no hole preparation (i.e., wiper trip) or mud was circulated through the hole prior to logging. A secondary objective was the relogging of a legacy site to both evaluate hole conditions after 20 y and to use a new generation of downhole tools, particularly the FMS imaging and sonic tools. The drill pipe was set just ~15 mbsf (1304 mbrf) prior to logging. During logging operations, the sea state was very calm with a typical heave of 1 m or less (see **"Operations"**). The Lamont-Doherty Earth Observatory-Borehole Research Group (LDEO-BRG) wireline heave compensator (WHC) was used throughout the logging operations in the open hole.

The plan was to use two tool string configurations, the triple combo tool string with an additional General Purpose Inclinometer Tool and the FMS-sonic tool string (see **"Downhole measurements"** in the "Sites U1312–U1315 methods" chapter). The TAP tool was deployed with the triple combo tool string and we logged down slowly, stopping every 5–10 m over the upper 100 m, and then logged continuously at 1800 ft/h to total depth of 588 mbsf. While collecting the downhole temperature data, we also logged down with the triple combo tool string. At 588 mbsf, we reached an impassable obstruction and stopped the downhole logging. We then logged the hole up into casing to a depth of 335 mbsf. Details of the intervals logged are shown in Figure **F4.**

After the triple combo tool string, the FMS-sonic tool string was also deployed to ~580 mbsf after again reaching the same hole obstruction as before. The second pass of the FMS-sonic tool string was only able to reach a total depth of ~440 mbsf before reaching an obstruction. So, a shortened second run was made from that depth into casing until 310 mbsf. Upon finishing the main logging operations, testing of new software for the Schlumberger WHC system was carried out to continue performance improvements made earlier during Expedition 306. After rigging down all logging tools, we lowered the empty instrument housings (with new O-rings) of the MGT that had leaked previously at Site U1313 to the seafloor (1277 mbsf) for testing. The housings remained dry at pressures equivalent to 2500 psi (four times more than when they had leaked at the previous site). Both the MGT and the housings appear to be sound with possibly a faulty O-ring responsible for the earlier failure.

Data quality

The temperature data collected by the TAP tool yielded detailed results based on ~3 h of continuous down logging (3600 measurements/h). The temperature profile results are discussed in detail below. Initial examination of the logging data from the triple combo tool string showed good quality data for several logs including natural gamma radiation, density, resistivity, and porosity. The centimeter-scale results from the FMS resistivity imaging were quite good and should be very useful in delineating flow boundaries, fracture densities, lithology, and the relationship to physical properties. The sonic waveform data appear to be of good quality, but analysis of waveforms will be performed postcruise onshore and will not be discussed further here.

The hole conditions, despite short intervals of obstructions, were generally fairly good. The intervals with obstructions could be clearly linked with high-porosity, low-resistivity zones in volcaniclastic layers scattered through the sequence. This is supported by the caliper data, which show that the diameter of the borehole (drill bit size = 9.75 inches) ranged over just a few inches from ~10 to 15 inches over the entire interval (Fig. **F5**). The density and porosity tools require good borehole contact and are held against the borehole wall by an eccentralizer that is only effective in the open borehole below the drill pipe and casing. Density and porosity data are also less reliable when the caliper has been closed before the tool string enters the base of the casing (i.e., above ~370 mbsf) (Fig. **F5**). Resistivity data from the formation are quite consistent between shallow (spherically focused resistivity), intermediate (medium induction phasor-processed resistivity), and deep (deep induction phasor-processed resistivity), indicating that the tool is getting reliable results.

Results

The downhole logging data suggest that the formation is made up of two main lithologies that can be delineated in almost every downhole log. The individual basalt flows have lower density at the top (~2.0–2.2 g/cm^3) and higher density at the bottom (2.6–2.9 g/cm^3). The pattern in resistivity appears to mimic the density with higher resistivities (20–200 Ωm), corresponding to higher densities. The peaks in gamma ray data correspond with low-density and high-porosity volcaniclastic intervals and relatively low resistivity values (<20 Ωm). The total spectral gamma ray (HSGR) data show that these higher gamma ray intervals are characterized by up to 1.5 ppm U and Th and up to 1 wt% K, probably driven by higher clay contents.

As is usual, the density and porosity logs are generally inversely related to each other and show a cyclical pattern of increasing density across lava flows, as noted above, and decreasing porosity (50%–10%). Intervals with very high porosities (>80%) correspond to the volcaniclastic layers. Photoelectric effect factor values increase from 3.0 b/e⁻ (clay-rich) in the high porosity-low density-low resistivity intervals to as high 5.5 b/e⁻ in the fine-grained basalts, consistent with the lithologies. Gamma ray values from the HSGR log vary between 3 and 35 gAPI throughout the entire 220 m interval (Fig. **F6**).

Log(new)-log(old) comparisons

An important part of revisiting this ODP legacy site is an evaluation of hole conditions after 20 y. Caliper data provide a quick measure of changes in hole shape that may yield important information related to weathering downhole. The rotary bit size used for coring this site was 9.75 inches. The original caliper log is compared against two calipers from the FMS tool (Fig. **F7**). As can be seen, the original caliper (density tool) was not very reliable in showing a much larger than bit size hole for almost the entire length of the cored interval. What might be useful information from the old caliper data is the lack of any zones showing intervals much larger than 12 inches, as in the new caliper logs. Most of the intervals with hole sizes larger than 12 inches in the new caliper logs correspond to high-porosity, low-resistivity zones.

A comparison of porosity logs shows a very good correlation downhole. The overall variability of porosity is much larger (10%–95%) than the original measurements (15%–70%) (Fig. **F7**) and is attributed to a more sensitive porosity sonde. In combination with detailed FMS resistivity measurements and imaging and sonic data, it should be possible to obtain reliable permeability estimates. Understanding the permeability should allow better understanding of fluid flow and temperature gradients observed in the borehole.

Measured total gamma ray data from the old and new logs in Hole 642E are generally close overall; however, the original Th portion of the spectral gamma ray logging data showed typically more variable and lower Th in the formation relative to U and K. The new logs show Th and U values almost equal and more consistent, if not higher than Th, across the interval we examined (Fig. **F7**). This may be attributable to how the energy windows were processed or improvements in the natural gamma tool. Density logs (not shown) from both studies also appear to be reliable between the two data sets, with most values ranging between 2 and 3 g/cm^3.

Whereas the basic physical property logs from the triple combo tool string confirmed the previous results in Hole 642E, most new information will come from the FMS-sonic tool string, which was not available (FMS) or has been significantly upgraded (sonic). FMS imaging of the hole yielded good measurements and will allow easy correlation to existing core data and filling in the gaps (~60% of the formation). Examples from the volcaniclastic and fine-grained basalt intervals are shown in Figures **F8** and **F9**, respectively. The fine-scale (centimeter) resistivity data will allow high-resolution studies of fracture density of basalts and porosity within the sequence. Combined with new shear wave data from the sonic tool, it should be possible to construct more reliable permeability estimates as well as revised synthetic seismograms that may yield better depth-velocity correlations.

Temperature log in Hole 642E

A temperature log (Fig. **F10**) was obtained in Hole 642E using the LDEO-BRG TAP tool. This tool logs at a rate of 1 Hz, has a precision of 5 mK, and has an accuracy of 1 K. The temperature was logged on the downhole run. The TAP tool was held off of the seafloor for a few minutes and indicated a bottom water temperature of ~0.2°C. The top 10 m of the borehole has a very steep thermal gradient (~2500°C/km). Below this section, the borehole has a relatively low gradient of ~22°C/km. The borehole is cased to a depth 370 mbsf. At a depth of ~500 mbsf, a positive temperature excursion may indicate in-flow. This excursion may correlate with a high-permeability zone indicated in the other logs. The temperature log as a whole indicates significant fluid discharge that may be as much as tens of meters per year.

Instrumentation

The instrumentation in Hole U1315A consists of two pressure cases and a thermistor string. The top pressure case houses salinity and temperature sensors exposed to bottom water and designed to monitor variations in bottom water. The sampling rate is set at a 30 min interval based on battery constraints and should have battery power for the 5 y expected life of the experiment. The bottom pressure case houses the data logger connected to 150 m of armored cable with 24 thermistors. The spacing between thermistors increases downhole to take advantage of natural diffusion length scales. Thermistors are calibrated to better than 1 mK. Power to this data logger is supplied with both internal batteries and external batteries. Data are collected every hour, again based on expected battery life and the 5 y life of the experiment.

Data are recorded internally with 24-bit resolution to solid-state memory. Thermistors have a resolution of $<5 \times 10^{-5}$°C. Thermistors are calibrated using National Institute of Standards and Technology traceable reference standards. Typical thermistor uncertainties are <0.2 mK.

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Figure F1. A. Map of the Vøring Plateau with locations of Deep Sea Drilling Project Leg 38 and ODP Leg 104 sites. **B.** Schematic geological transect across the Vøring Plateau (from Eldholm, Thiede, Taylor, et al., 1987).

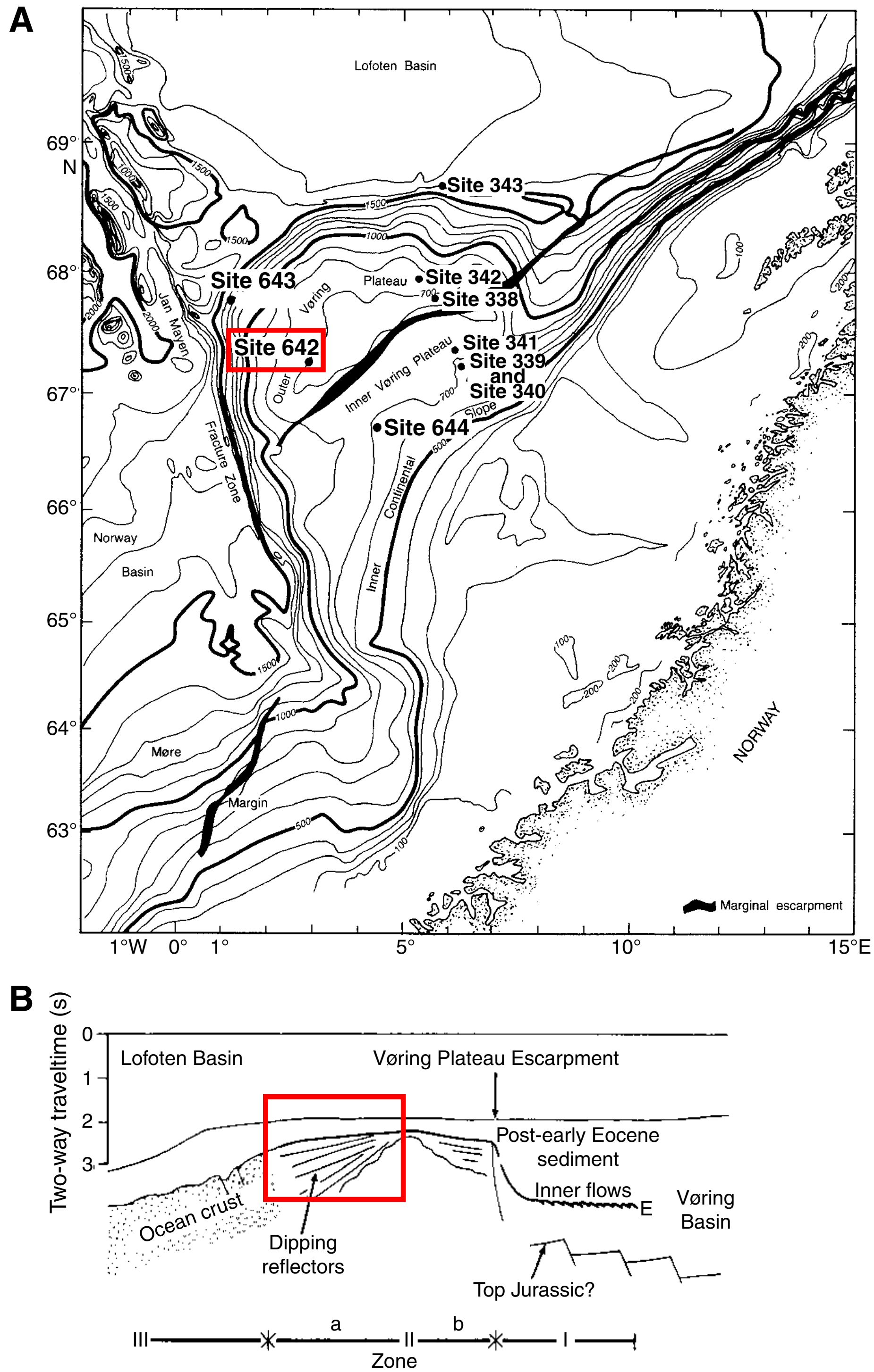

Figure F2. Main lithologies in Hole 642E (Eldholm, Thiede, Taylor, et al., 1987). TD = total depth.

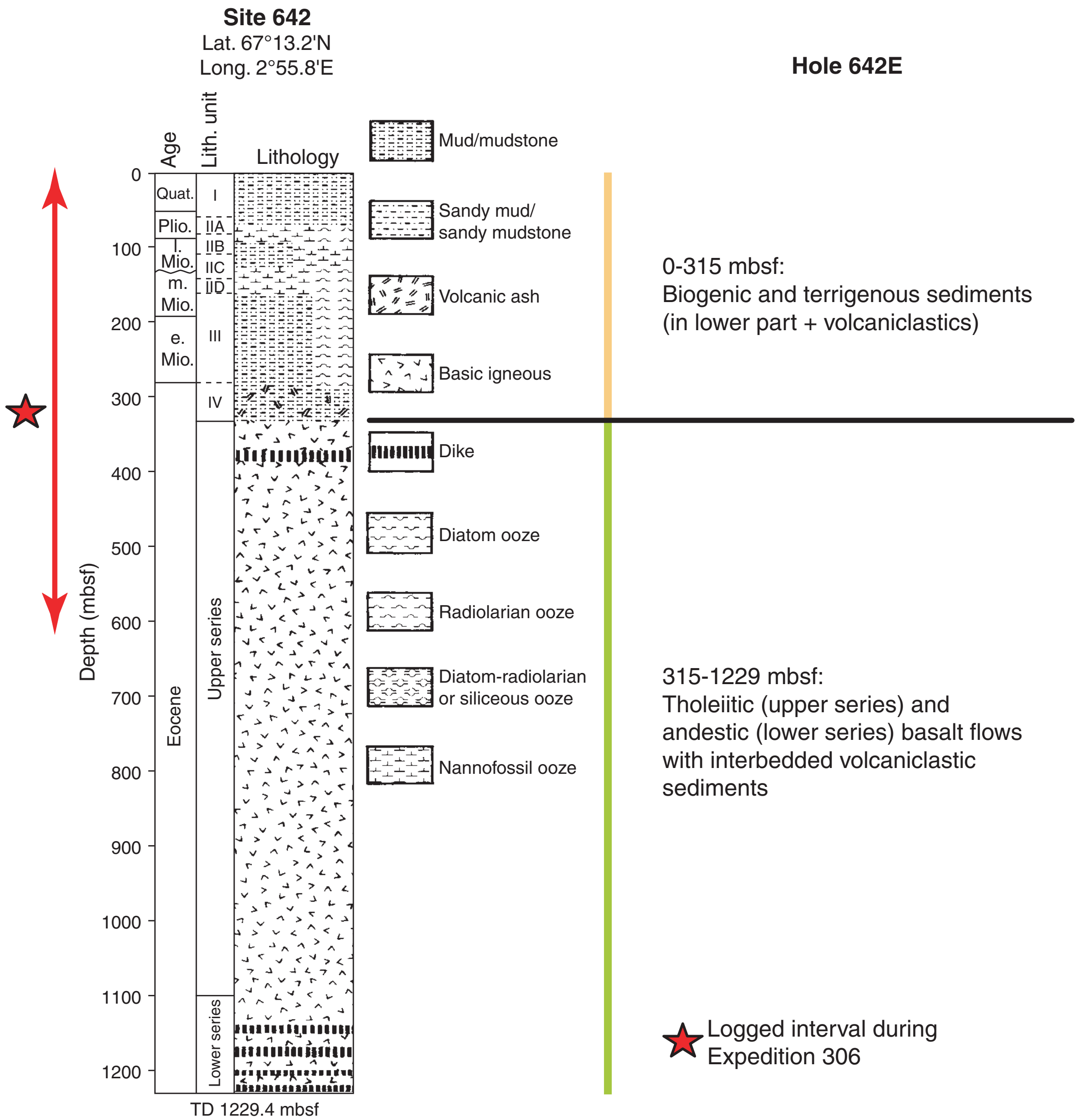

Figure F3. Location map of the Norwegian Sea and Vøring Plateau showing ODP Site 642 and location of Ocean Weather Ship Station (OWS) *Mike* (modified from Gammelsrød et al., 1992).

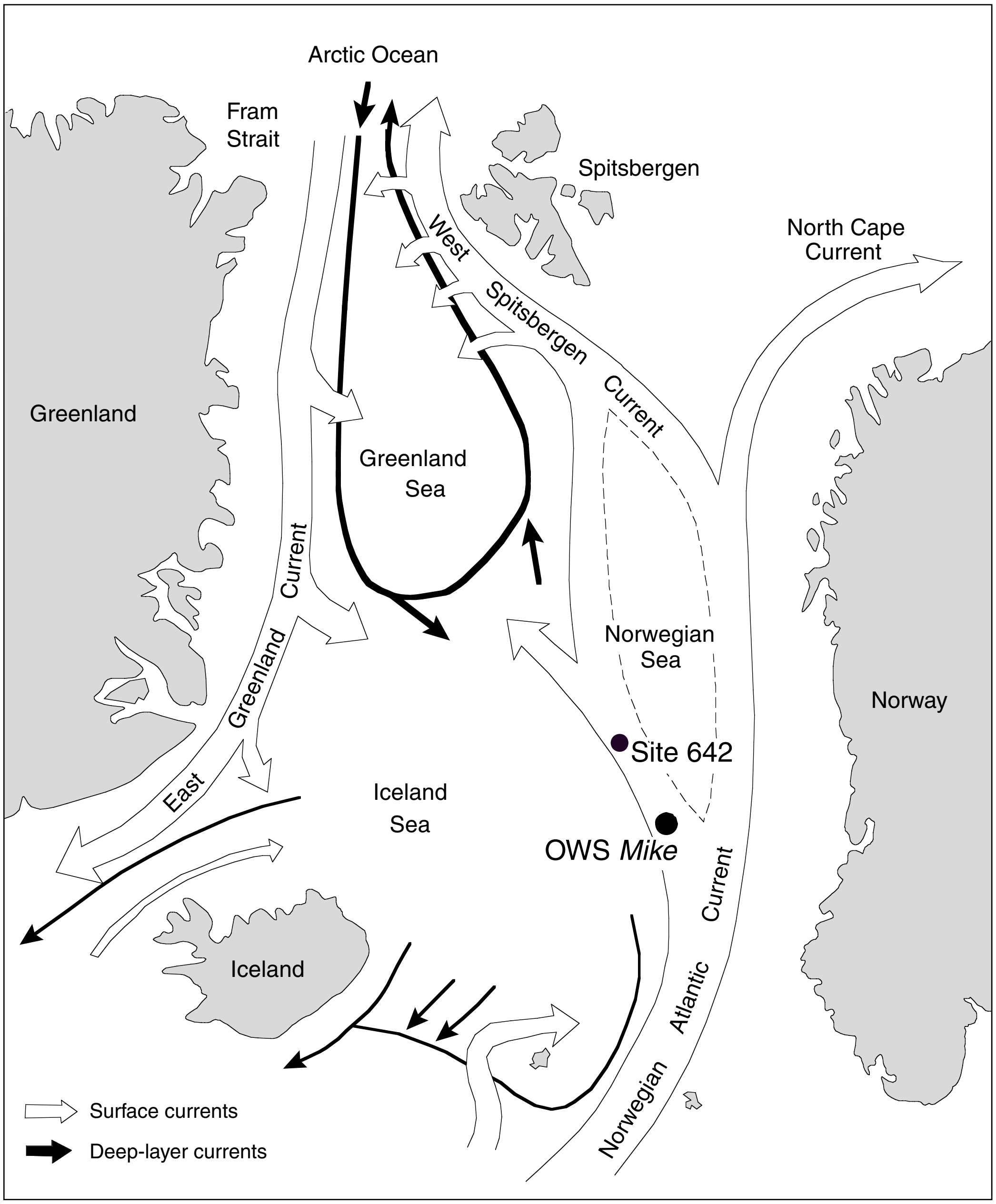

Figure F4. Details of important depths recorded during logging tool string deployment in Hole 642E. Triple combination (triple combo) = DIT-E + APS + HNGS + HLDS tools, FMS = Formation MicroScanner. See **"Downhole measurements"** in the "Site U1312–U1315 methods" chapter for details on tools.

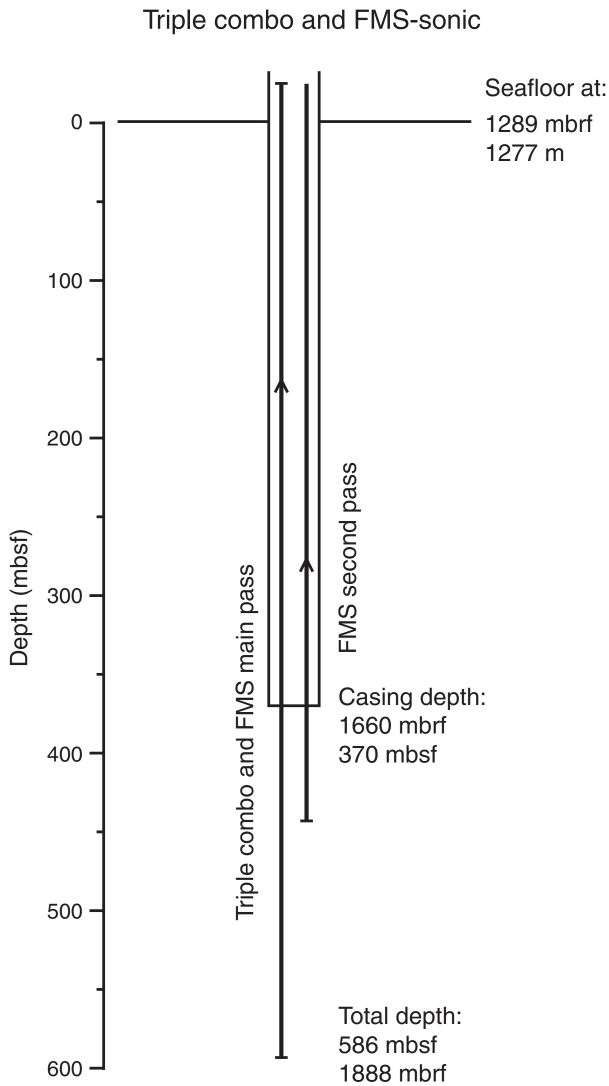

Figure F5. Caliper, density, porosity, electrical resistivity, and photoelectric effect factor (PEF) data of Hole 642E. FMS = Formation MicroScanner, IMH = medium induction phasor-processed resistivity, IDPH = deep induction phasor-processed resistivity, SFLU = spherically focused resistivity.

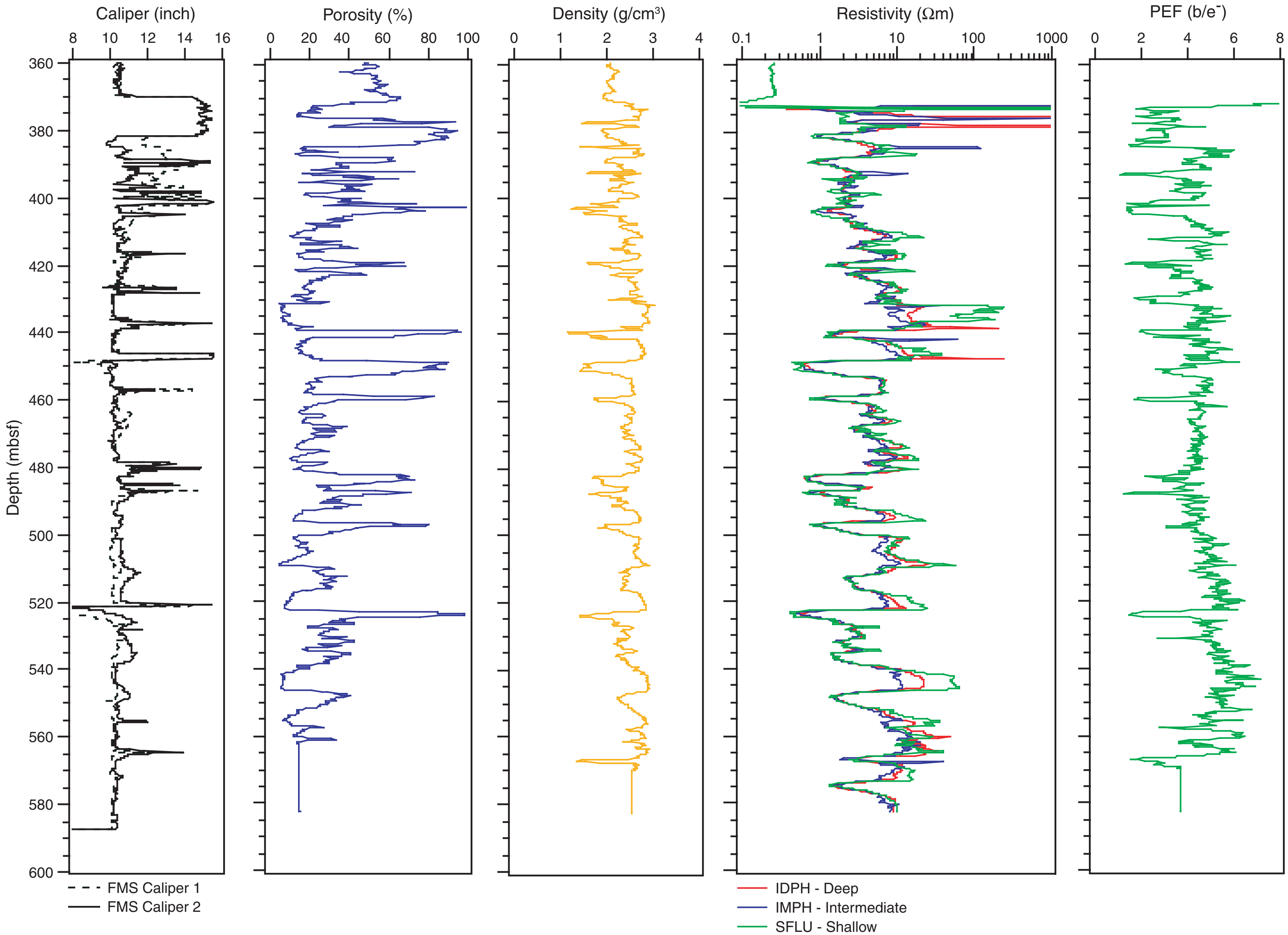

Figure F6. Caliper, total gamma ray, and spectral gamma ray data (K, Th, and U) for Hole 642E. FMS = Formation MicroScanner, HCGR = computed gamma ray (Th + K), HSGR = total spectral gamma ray.

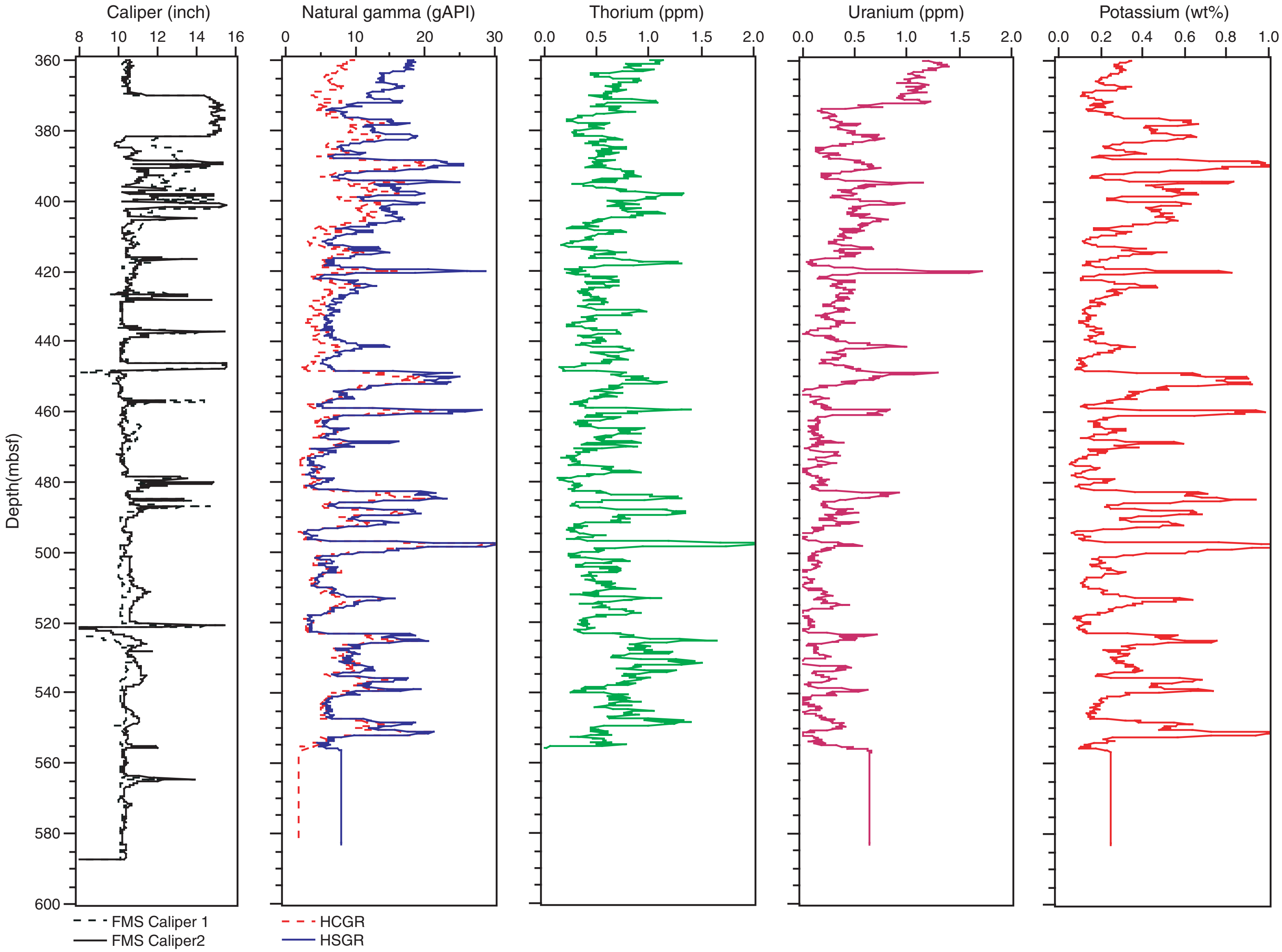

Figure F7. Comparison of old and new physical properties from Hole 642E. Blue = new data, red = old data. FMS = Formation MicroScanner.

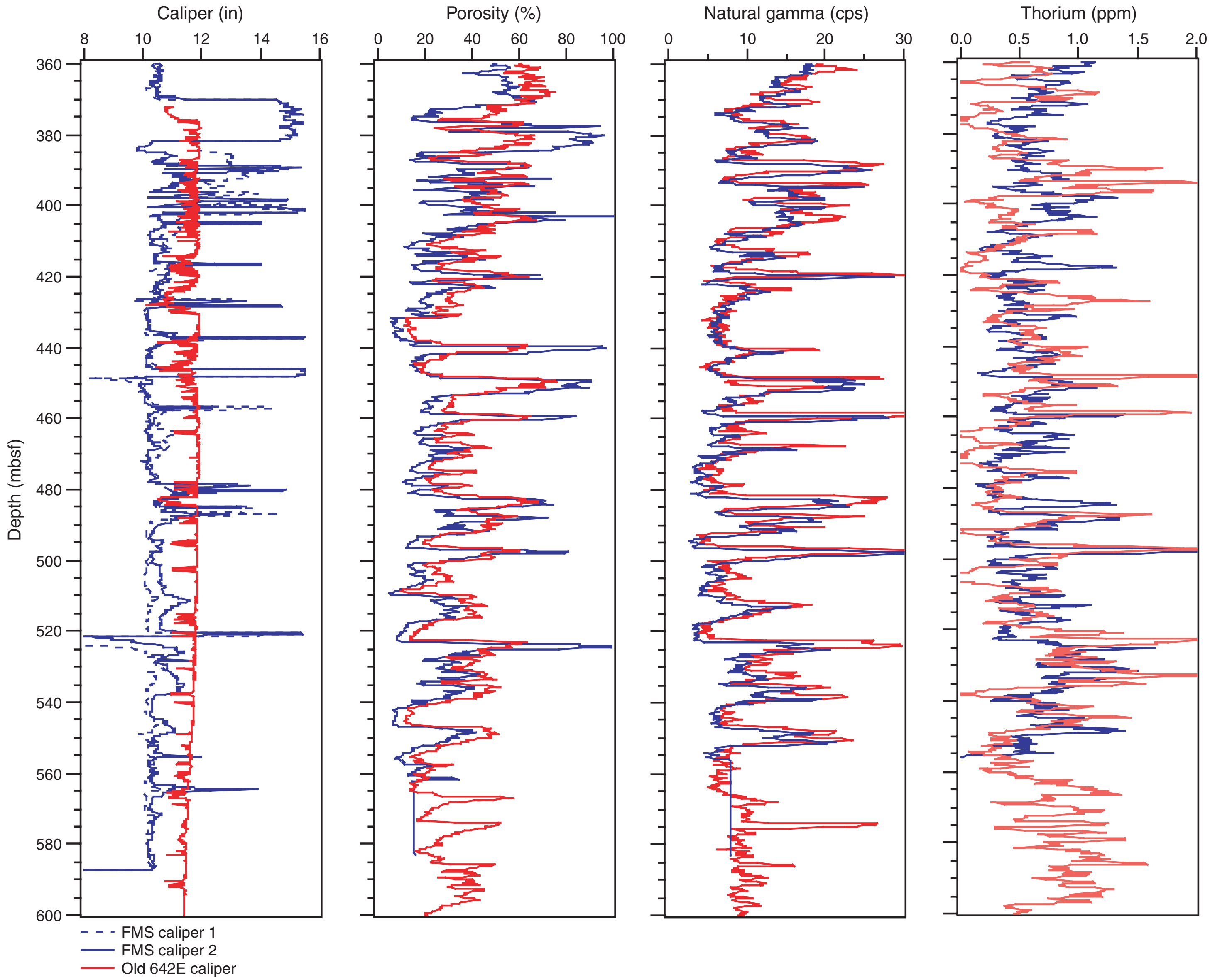

Figure F8. Detailed resistivity profile of Hole 642E showing a pattern of basalt flows with lower resistivity at the top and increasing toward the bottom. An enlarged portion of a Formation MicroScanner (FMS) image showing volcaniclastic (basaltic vitric tuff) interval beneath one flow and at the top of the next between 546 and 548 mbsf. SFLU = spherically focused resistivity.

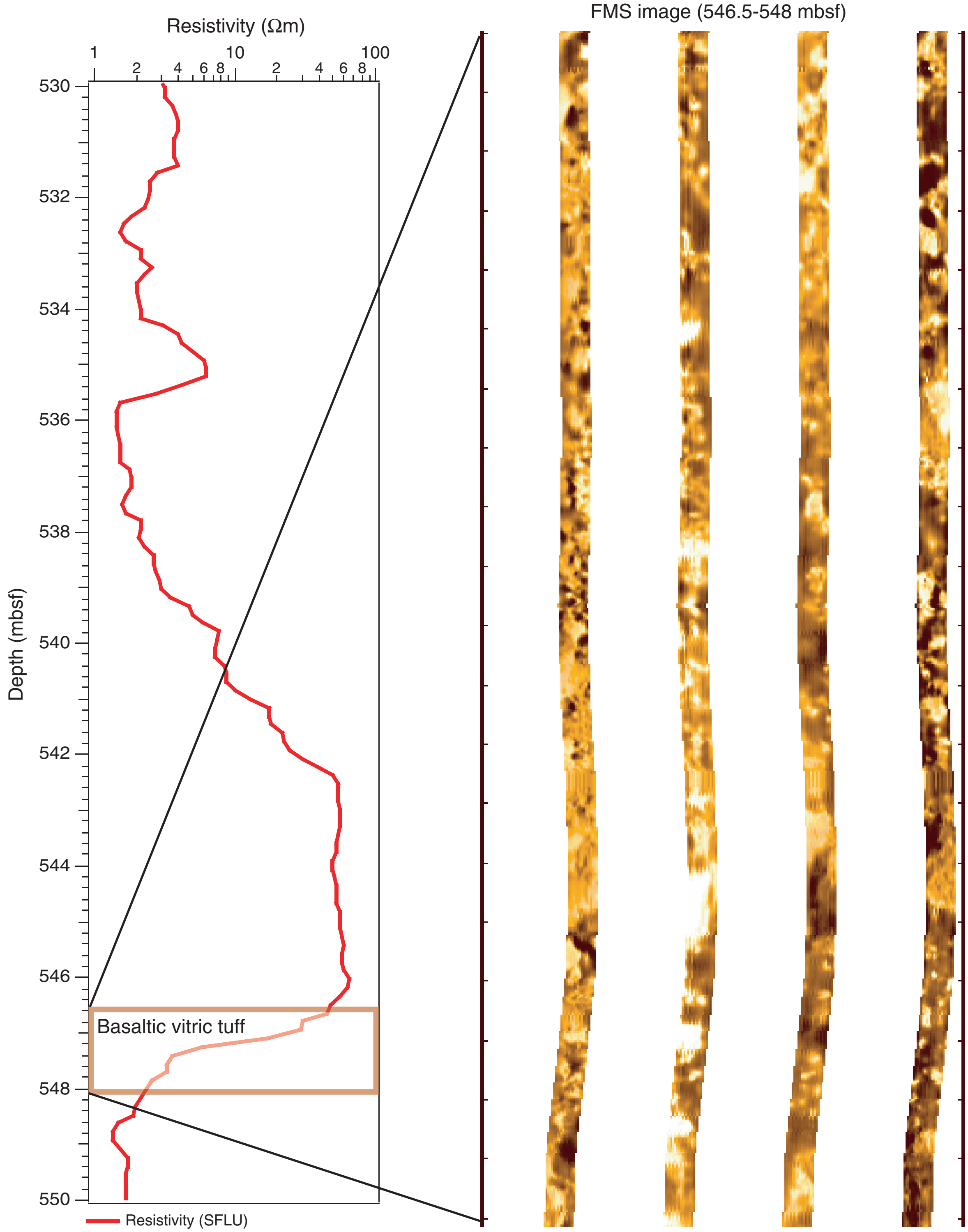

Figure F9. Detailed resistivity profile of Hole 642E showing the pattern of basalt flows with a lower resistivity at the top and increasing towards the bottom. A blowup of a Formation MicroScanner (FMS) image showing fine-grained basalt interval between 542 and 545 mbsf. SFLU = spherically focused resistivity.

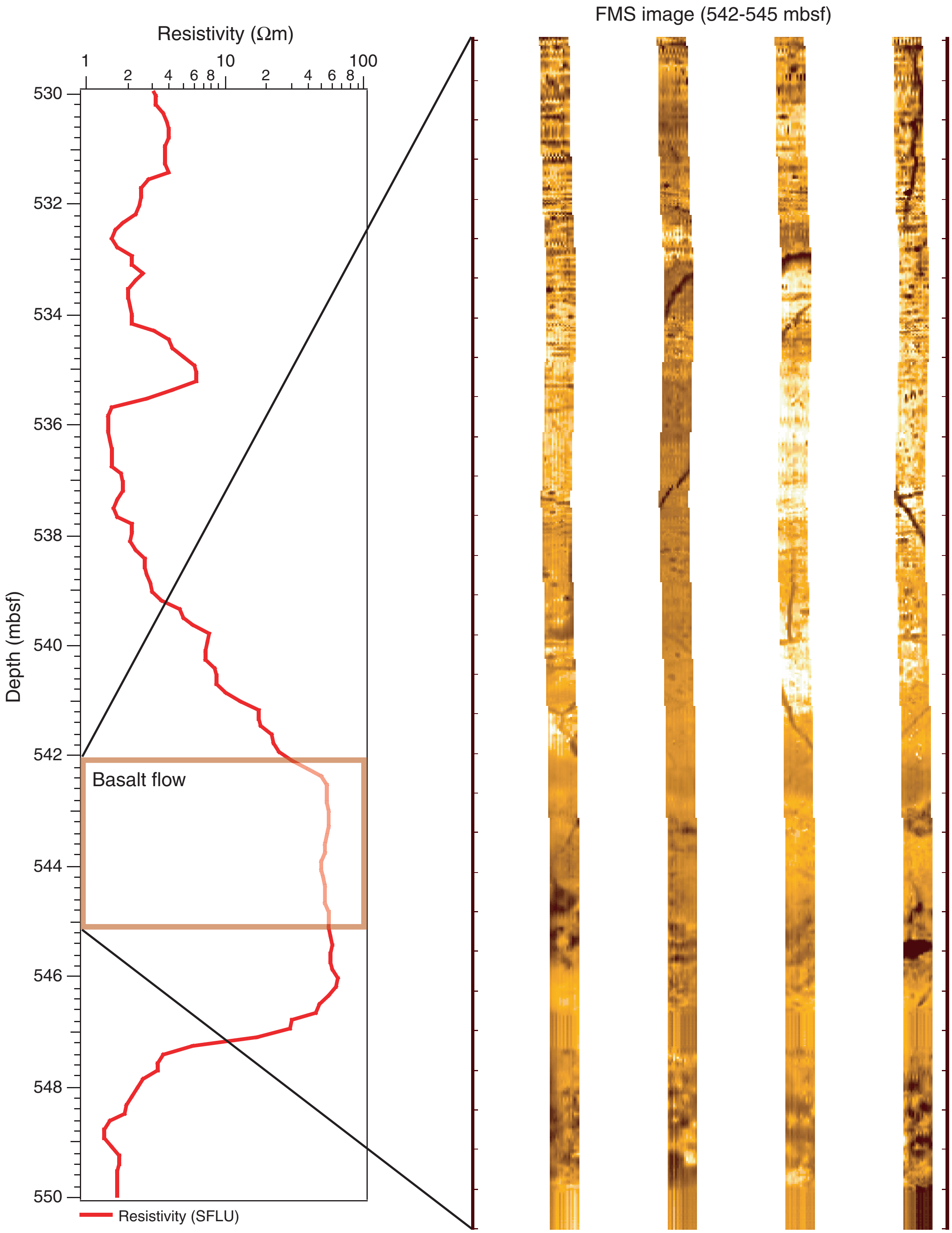

Figure F10. Temperature log profile versus depth of Hole 642E collected using the LDEO TAP tool. BWT = bottom water temperature.