IODP Expedition 330: Louisville Seamount Trail

Site U1374 Summary

Background and Objectives

Background

Site U1374 (Alternative Site LOUI-6B) was the third site completed during Integrated Ocean Drilling Program (IODP) Expedition 330 and the second of the two sites that were drilled on Rigil Guyot (Sites U1373 and U1374). Site U1374 represents one of the older seamount targets with an age of ~73 Ma and only is a few million years younger than Site U1372 on Canopus Guyot to the northwest. If the Louisville hotspot experienced a paleolatitude shift similar to the recorded ~15° southern motion of the Hawaiian hotspot between 80 and 50 Ma, this shift is expected to be largest for the oldest seamounts in the Louisville seamount trail. Because Sites U1373 and U1374 target two disparate sequences of ancient lava flows on the same volcanic edifice and because Rigil Guyot is only slightly younger than Canopus Guyot, it is expected that these three sites together will significantly strengthen our determinations of the Louisville paleolatitude at the old end of the trail.

Alternate Site LOUI-6B was requested during Expedition 330 to provide more flexibility while drilling Rigil Guyot. If comparable borehole instabilities were encountered as during the drilling of Site U1372 on Canopus Guyot, or if drilling at Site U1373 was to be abandoned for other unforeseen reasons, then we could divert to Site U1374 to continue the drilling of Rigil Guyot and still attain our most important scientific objective. Because re-entry using a free-fall funnel failed for Hole U1373A, the first site at Rigil Guyot had to be abandoned and Hole U1374A was spudded about 5.6 nmi away on the western portion of its summit plain in 1259 m water depth.

The original drilling plan was to recover the soft sediment using a gravity-push approach with little or no rotation using a Rotary Core Barrel (RCB), followed by standard coring into the volcaniclastic materials and 350 m into igneous basement. A full downhole logging series was planned including the standard Triple Combo and FMS-Sonic tool strings, the Ultrasonic Borehole Imaging (UBI) tool, and the third-party Göttingen

Borehole Magnetometer (GBM) tool. Drilling and logging were successfully accomplished after drilling to 522 mbsf and carrying out the full logging program. Coring was in particular successful with a record-breaking 88% average recovery in igneous basement.

Objectives

Drilling during ODP Leg 197 provided the first compelling evidence for the motion of mantle plumes by documenting a large ~15° shift in paleolatitude for the Hawaiian hotspot (Tarduno et al., 2003; Duncan et al., 2006). This lead to two geodynamical end-member models that are being tested during Expedition 330, namely that the Louisville and Hawaiian hotspots moved coherently over geological time (Wessel and Kroenke 1997; Courtillot et al. 2003) or, quite the opposite, that these hotspots show considerable inter-hotspot motions, as predicted by mantle flow models (Steinberger, 2002; Steinberger et al., 2004; Koppers et al., 2004; Steinberger and Antretter, 2006; Steinberger and Calderwood, 2006). The most important objective of Expedition 330 therefore was to core deep into the igneous basement of four Louisville seamounts to sample a large number of in situ lava flows ranging in age between 80 and 50 Ma. With a sufficiently large number of these independent cooling units high-quality estimates of their paleolatitude can be determined, and any recorded paleolatitude shift (or lack thereof) can be compared with seamounts in the Hawaiian-Emperor seamount trail. For this reason Expedition 330 mimicked the drilling strategy of ODP Leg 197 by drilling Louisville guyots equivalent in age to Detroit (76-81 Ma), Suiko (61 Ma), Nintoku (56 Ma) and Koko (49 Ma) in the Emperor seamounts. Accurate paleomagnetic inclination data are required for the drilled seamounts to establish a record of the past motion of the Louisville hotspot, and together with high-resolution $^{40}Ar/^{39}Ar$ age dating of the cored lava flows, these data will help us to constrain the paleolatitudes of the Louisville hotspot between 80 and 50 Ma. These comparisons are of fundamental importance to determine whether these two *primary* hotspots have moved coherently or not, and to understand the nature of hotspots and convection in the Earth's mantle.

Expedition 330 also aimed to provide important insights into the magmatic evolution and melting processes that produced and constructed Louisville volcanoes while progressing from their shield to post-shield, and maybe post-erosional, volcanic stages. Existing data from dredged lavas suggest that the mantle source of the Louisville hotspot has been remarkably homogeneous for as much as 80 m.y. (Cheng et al., 1987; Hawkins et al., 1987; Vanderkluysen et al., 2011). In addition, all dredged basalts are predominantly alkalic and possibly represent a mostly alkalic shield-building stage, which is in contrast to the tholeiitic shield-building stage of volcanoes in the Hawaiian-Emperor seamount trail (Hawkins et al., 1987; Vanderkluysen et al., 2011). Analyses of melt inclusions, volcanic glass samples, primitive basalts, high-Mg olivines and clinopyroxene phenocrysts will provide further constraints on the asserted homogeneity of the Louisville plume source, its compositional evolution between 80 and 50 Ma, potential mantle plume temperatures, and its magma genesis, volatile outgassing and differentiation. In addition, incremental heating $^{40}Ar/^{39}Ar$ age dating will allow us to establish age histories within each drill core delineating any transitions from the shield-building phase to the post-shield capping and post-erosional stages.

Another important objective of Expedition 330 at Site U1374 was to use new paleolatitude estimates, $^{40}Ar/^{39}Ar$ ages and geochemical data to decide whether the oldest Louisville seamounts were formed close to the 18-28°S paleolatitude determined from ODP Leg 192 basalts for the Ontong Java Plateau (Riisager et al., 2003) and whether this Large Igneous Province (LIP) was genetically linked to the Louisville hotspot or not. This would prove or disprove the hypothesis that the Ontong Java Plateau formed by the preceding plume head of the Louisville mantle upwelling (e.g. Richards and Griffiths, 1989; Mahoney and Spencer, 1991).

Finally, basalts and sediments cored at Site U1374 were planned to be used for a range of secondary objectives such as searching for active microbial life in the old seamount basements and to find fossil traces of these microbes left behind in volcanic glasses and biofilms on the rocks. We also planned to determine $^{3}He/^{4}He$ and $^{186}Os/^{187}Os$ signatures of the Louisville mantle plume to evaluate its potential deep mantle origin, to use oxygen and strontium isotope measurements on carbonates and zeolites to assess the magnitude of carbonate vein formation in aging seamounts and its role as a global CO_2 sink, to age date celadonite alteration minerals for estimating the total duration of low-temperature alteration following seamount emplacement, and to determine the hydrogeological and seismological character of the seamount basement.

Operations

After Hole U1373A on the eastern side of the summit plain of Rigil Guyot had to be abandoned, the vessel was offset in dynamic positioning (DP) mode to the recently approved Alternate Site LOUI-6B located in 5.6 nmi distance on the western site of the summit plain. After arriving on the new location, the bit tagged the seafloor at a depth of 1570.0 mbrf (1559 mbsl).

Hole U1374A was spudded with the rotary core barrel (RCB) drill bit at 2035 hr on 5 January. After penetrating a thin (~7 m thick) sedimentary cover, the bit penetrated igneous rocks at 16.7 mbsf. Rotary coring in Hole U1374A advanced to a depth of 130.4 mbsf by 0345 hr on 10 January with an average recovery of 84%. At this time, the bit had acquired 81.3 rotating hours and needed to be replaced. A free fall funnel (FFF) was made up and deployed at 0550 hr on 10 January. Bit extraction from the hole and re-entering into the FFF at 1635 hr was conducted without incident and coring resumed at 1900 hr on the same day.

Rotary coring in Hole U1374A continued until 0545 hr on 18 January when erratic pump pressure indicated that there was a problem at the bottom of the drill string. Instead of continuing to core with a bit that far outlasted its expected life with 133.4 rotating hours, we decided to end coring at a final depth of 522.0 mbsf. The penetration into basement was 505.3 m with an average recovery of 88.0% and an average rate of penetration of 2.5 m/hr. The average recovery for the entire hole was 87.8% with an average penetration rate of 2.4 m/hr.

After a routine wiper trip, which suggested that the hole was in good condition, the rotary shifting tool was deployed to release the bit. However, several attempts to release the bit failed. It was eventually decided to trip the drill pipe, remove the bit and mechanical bit release on the rig floor, and make up a shorter logging bottom hole assembly with a 9¼" diameter logging/clean-out bit that would allow more of the open hole to be logged.

The end of the pipe cleared the rotary table at 2015 hr on 18 January. The shorter logging bottom hole assembly was made up and deployed at 0145 hr. The bit entered FFF at 0430 hr on 19 January and was positioned at a logging depth of 101.2 mbsf. The standard Triple Combo suite was made up and run in at 1045 hr. Unfortunately, the tool was not able to advance into the open hole because of a bridge only ~7 m further down. The logging tool was recovered and the bit lowered to 143.6 mbsf to clear the bridge. The bit was then pulled back and placed at 110.8 mbsf. When the Triple Combo logging tool was unable to advance past 138.0 mbsf, the tool was again recovered and reconfigured to a shorter assembly using only the density and gamma ray sensors in the hope that this would more easily negotiate an entry into the hole. After this attempt was unsuccessful, the drill pipe was recovered with the bit clearing the rotary table at 1115 hr on 20 January.

Since downhole logging at this particular deep hole was considered very important, a 4-stand RCB coring assembly was made up with a new mechanical bit release and a used bit. The drill string entered the FFF at 1540 hr on 20 January. From 1730 hr to 2315 hr, the hole was washed and reamed to bottom (522 mbsf), flushed with mud, and then displaced with 165 barrels of heavy (10.5 ppg) mud. The bit was dropped at the bottom of the hole and the end of pipe placed at a logging depth of 128.1 mbsf, which was ~18 m deeper than the previous logging attempt and below a potentially unstable zone in the formation. An extra stand of drill collars was added to the bottom hole assembly (BHA) to keep the tapered drill collar as close to the seafloor as possible, which is the usual "choke point" where a BHA gets stuck.

The Triple Combo logging tool was made up and deployed again at 0540 hr on 21 January and succeeded in logging the hole up from 520 mbsf. The tool suite was recovered and laid out. The second instrument deployed was the Göttingen Borehole Magnetometer (GBM), which made one full pass down from the rig floor to 520 mbsf and back up. The communication with the GBM was lost while being retrieved in the pipe, however because a sighting of the tool was carried out at the start of deployment, the rotation history of the GBM is still obtainable. The third logging run was performed with the Formation MicroScanner (FMS)-sonic, which also successfully came within 2 m of the bottom of the hole. The fourth log was conducted with the Ultrasonic Borehole Imager. The fifth log was a re-deployment of the GBM tool. All runs were successful.

While the GBM was deployed for the second time, the driller noticed that the suspended string weight was getting slightly lighter indicating that the formation was starting to squeeze the BHA. To compensate for this, the driller picked up the string an additional 3 m. After the logging tool was retrieved, the driller attempted to free the drill string from 2215 hr on 22 January to 0930 hr on 23 January. Although circulation was maintained, there was no rotation and the drill pipe could not be raised or lowered. Realizing that further efforts would be fruitless, the crew made the necessary preparations to sever the drill string directly above the tapered drill collar. The top of the tapered drill collar was ~13 m below the seafloor. The drill pipe was severed at 1500 hr on 23 January. Once the drill pipe was recovered and the beacon retrieved, the vessel departed for Prospectus Site LOUI-2B at 1945 hr on 23 January.

Scientific Results

Sedimentology

Sediment at Site U1374 on Rigil Guyot occurs in (1) the uppermost sedimentary cover of the seamount; (2) three intervals within a predominantly volcanic basement; and (3) basalt breccias (volcanic or sedimentary in origin) as finer-grained, interclast infill deposits, thin-bedded sedimentary layers, or peperitic intervals. Fourteen stratigraphic units and subunits were defined based on macroscopic and microscopic observations.

The uppermost part of the seamount (0-6.64 mbsf) includes a young (Pleistocene) sedimentary cover composed of sandy foraminiferal ooze, which was deposited in a pelagic environment on the flat-topped seamount. An older sedimentary cover occurs between 6.64 and 16.70 mbsf, which includes, from top to bottom (1) ferromanganese-phosphate encrustations ~6.64 mbsf; (2) a layered, monomict volcanic sandstone without fossils between 6.64 and 13.59 mbsf; (3) an upper Maastrichtian bioturbated volcanic sandstone with abundant gastropods and shell fragments, and rare possible ammonite fragments between 13.59 and 15.05 mbsf; (4) an upper Campanian bioclast foraminiferal limestone with ferromanganese-phosphate encrustations and burrows filled with upper Maastrichtian volcanic sandstone between 15.05 and 15.31 mbsf; and (5) an upper Campanian or older basalt conglomerate with shallow-marine bioclasts (e.g., shell fragments, calcareous alga, and bryozoan) from 15.31 to 16.70 mbsf. Bedding dips in the sedimentary cover are generally subhorizontal.

The underlying upper Campanian (or older) volcanic sequence is composed of minor basalt lava flows and abundant basalt breccias. The interclast spaces in the basalt breccia are partly filled with finer grained, basalt and volcanic sandstone with a local, shallow marine bioclast component. Three thick-bedded sedimentary intervals were identified between 37.60 and 116.45 mbsf. The first interval occurs between 37.60 and 41.84 mbsf and is composed of, from top to bottom, a polymict basalt sandstone with abundant vitric fragments and few shallow marine bioclasts, a layered volcanic sandstone with rare fossils, and a monomict basalt breccia with larger, shallow marine bioclasts. The second sedimentary interval extends from 63.67 to 84.70 mbsf and is devoid of fossils. It includes two polymict basalt breccias and a volcanic sandstone. The third sedimentary interval occurs between 109.87 and 116.45 mbsf and is composed of a volcanic sandstone with few bioclasts, and a basalt conglomerate with abundant shallow marine fossils. Volcanic deposits below 116.45 mbsf include only minor occurrences of thin-bedded layers of grain-supported, poorly sorted basalt sandstones-breccias interpreted as sediment intervals. The last occurrences of shallow water fossils at Site U1374 were found in two intervals of sedimentary basalt breccia between 256.75 to 257.49 mbsf and 290.32 to 291.27 mbsf. These intervals correlate to changes in the nature of volcanic desposits downhole. Contrary to the sedimentary cover, orientation of beddings in the volcanic basement is characterized by consistent, moderately dipping values.

Eight lithofacies were defined in the sedimentary cover and thicker sedimentary intervals of the volcanic basement, which permit an overall characterization of the environment of deposition at Site U1374. The volcanic basement below 116.45 mbsf is interpreted to have deposited in a submarine environment on the slope of a former oceanic island. Within this basement the lowermost occurrence of fossil-bearing sediment at 291.27 mbsf possibly corresponds to an unconformity indicative of the shoaling of the island. Higher up within the sequence, the volcanic interval between 116.45 and 16.70 mbsf was interpreted to have deposited in a shallow marine to subaerial environment on the slope of this former island. A major, erosional surface likely occurs at 16.70 mbsf, as notably suggested by changes in the dip of sediment bedding between the volcanic basement and sediment cover. We interpreted this surface as a product of summit erosion and original flattening of the drilled guyot. The erosional surface is capped by a shallow marine basalt conglomerate between 16.70 and 15.31 mbsf, which is followed by a condensed interval from 15.31 to 15.05 mbsf with ferromanganese encrustations. The age of the limestone found in the condensed interval was assigned to the late Campanian (see Biostratigraphy below) and interpreted as the record of the initial drowning of Rigil Guyot. Volcaniclastic sediment between 15.05 and 6.64 mbsf was assigned to the late Maastrichtian and was interpreted to represent a record of rejuvenated volcanism. A second (undated) condensed interval occurs ~6.64 mbsf, which is capped by Pleistocene pelagic sediment.

Biostratigraphy

Based on calcareous nannofossil and planktonic foraminiferal biostratigraphy, a preliminary age of Pleistocene-Holocene is assigned to the unconsolidated sandy foraminiferal ooze of Unit I (Core 330-U1374A-1R), and late Cretaceous to the volcaniclastics and limestone of Unit II (Cores 330-U1374A-2R and -3R). Because the underlying Unit III through XIX yielded no age-diagnostic microfossils, their ages are undetermined. An unconformity between Units I and II represents more than fifty million years of missing sediment. In addition to microfossils, fragments of ammonoid specimens were observed in Unit II, also constraining it to the Cretaceous, consistent with the microfossil analyses.

Igneous Petrology

Hole U1374A penetrated a total of 474.89 m of igneous rocks comprising a succession of volcaniclastic breccias capped by lava flows and intruded, in its lower part, by a suite of intrusive sheets or dikes. The igneous sequence has been divided into 148 Lithologic Units, which have been grouped into 15 Stratigraphic Units (Units III to VIII, X, and XII to XIX). The basement succession also includes two sedimentary units (Units IX and XI; 21.03 and 6.59 m thick, respectively, see above). Magmatism recorded at Site U1374 started in a clearly submarine environment and, in the time interval considered here, progressed to a shallow marine and then subaerial environment. This progression is clearly seen in the various breccia types recovered at this site, which range from green hyaloclastite breccia with frothy basaltic clasts (marine) through blocky breccia (shallower marine) to scoriaceous (near sea level or subaerial). Blocky breccia probably accumulated as talus deposits through the transportation down slope of volcaniclastic debris that was shed from the fronts of submarine lava flows. The scoriaceous breccia is probably the product of hydrovolcanic eruptions resulting from the interaction of magma with shallow water or wet sediment. The proportion of lava flows increases toward the top of the section and peperite is found at the margins of the upper lava flow units (Units III-XII). Distinct eruptive packages are often separated by intervals of background sedimentation, five of which were identified at Site U1374. A dramatic increase in the thickness of these intervals at Unit XI indicates the point at which parts of the seamount near Site U1374 had emerged above sea level and erosion could proceed more rapidly. The phenocryst assemblage in the breccias and lava flows changed from plagioclase-dominated in the lower part of the succession (Units XIV-XIX) to olivine-dominated in the upper part (Units III-XIV) suggesting that the magmas became generally more basic with time. The magma erupted at Site U1374 was alkalic throughout the drilled interval.

Alteration Petrology

The entire section of Hole U1374A has undergone secondary alteration by low temperature water-rock interactions and/or weathering. The alteration of the volcanic rocks ranges from slightly to highly altered (between 5% and 95%). Several basaltic lava flows and intrusive sheets are relatively well preserved (10% or less alteration). Core descriptions and thin section observations allow the definition of two main but overlapping alteration intervals showing different dominant alteration colors that relate to the oxidation state during the alteration processes. From the top of Hole U1374A to ~300 mbsf the sequence has dominantly reddish and/or brownish alteration colors, indicating oxidizing conditions under subaerial to transitional shallow marine environments. At depths greater than ~370 mbsf, the basalt display a range in alteration from slightly to highly altered, showing greenish colors indicating more reducing conditions related to a submarine emplacement environment. Nevertheless, occurrences of gray and relatively unaltered basalt were encountered throughout Hole U1374A.

Plagioclase and augite are generally well preserved, both as phenocrysts and in the groundmass throughout the entire igneous portion of the core. Plagioclase shows minor alteration to sericite/illite in some rocks, but is generally well preserved. Augite is almost always unaltered. Olivine is typically completely altered to iddingsite, hematite, carbonates and Fe-oxyhydroxide, but some sections in the core contain slightly to moderately altered olivine. Some olivines in greenish altered rocks are replaced by green clay, Fe-oxyhydroxide and/or carbonates (calcite/magnesite).

Overall, three main groups of alteration phases can be distinguished: carbonates (Mg-calcite), clay minerals (saponite, nontronite, celadonite), zeolites and other secondary phases (iddingsite, Fe oxyhydroxides, goethite, pyrite/chalcopyrite, thaumasite). The type of zeolite varies from phillipsite in the upper portions of the core to analcite and gmelinite at depth, apparently indicating a thermal alteration gradient. Additionally numerous vesicles, veins and voids can be found that are mainly filled with carbonates and clay minerals at depths less than 300 mbsf, and zeolites at depths greater than 380 mbsf.

Structural Geology

Structural features at Site U1374 are dominated by veins (n=1229), vein networks (n=515, with 3225 individual veinlets), and fractures (n=356). Veins are found mostly within lava flows, although veins also occur in larger fragments within the volcanic breccia units. The maximum vein width is 25 mm, but most are considerably smaller, with average widths of 0.8 mm. Fractures are also most common in lava units, especially the lowermost 14 meters of the hole with over 14 fractures per meter. Structural measurements were also undertaken for intervals with sedimentary bedding (n=46), 35 geopetals, 18 igneous contacts, 35 vesicle bands, and 80 cases of magmatic flow textures. The orientations of bedding change downhole and correspond to important lithofacies variations. All geopetal structures are horizontal, indicating this part of the seamount has not been tilted since deposition of the geopetal infilling material. Excellent examples of baked contacts and chilled margins were recorded from ~335 to 500 mbsf, from a series of steeply dipping sheet intrusions. These intrusions also contain steeply inclined vesicle bands and/or flow textures, which indicate mostly near-vertical magma flow. In addition, several lava flow units have flow textures, but their orientations are mostly sub-horizontal.

Geochemistry

Major and trace element data for igneous samples from Site U1374 overlap considerably with data from Sites U1372 and U1373. However, the Site U1374 samples tend to have slightly lower SiO_2 at similar total alkali (Na_2O+K_2O) contents, and thus are slightly more alkalic as a group. On a total alkalis vs. SiO_2 diagram, most of the Site U1374 samples are classified as alkalic basalts, but data for nearly a third fall in the field of basanite and tephrite. No transitional compositions were found, in contrast to Sites U1372 and U1373. Most of the Site U1374 samples are relatively evolved, with MgO concentrations between 2.78 wt% and 8.54 wt%. Major element and Sc variations indicate that olivine and clinopyroxene were the main mineralogical controls on magmatic differentiation. Incompatible element concentrations display somewhat greater overall variability relative to TiO_2 than seen for Sites U1372 and U1373, consistent with greater variability in the amount of partial melting and/or in source composition at Site U1374. Despite the compositional overlap and close proximity of Sites U1373 and U1374 (which are located 10.4 km apart on Rigil Guyot), the rocks from the two sites cannot be correlated, and probably represent distinct eruptive events. Likewise, the intrusive sheets at Site U1374, although compositionally within the range of the lava samples, cannot be correlated with any specific lava unit at this site.

Physical Properties

Physical property characterization was performed for samples recovered from Site U1374 and the different datasets are mutually consistent and show clear contrasts between unconsolidated sediments, massive basalts, and breccias. The intrusive sheets or dikes recovered at this site have a characteristic physical property signature distinct from the majority of the basalt flows, lobes, and clasts, and are marked by high natural gamma ray radiation, magnetic susceptibility, density, and p-wave velocity and low porosity. More subtle contrasts between olivine- and plagioclase-dominated units are observed in natural gamma ray radiation and magnetic susceptibility. The downhole appearance of hyaloclastites at 327 mbsf is marked by a subtle decrease in L* (lightness) and a more marked decrease in p-wave velocity and increase in porosity. The changes in both p-wave velocity and porosity become more pronounced below 470 mbsf, where a shift in color reflectance towards more green and yellow spectra is also observed. This correlates with the occurrence of a high proportion of clasts and fragments of frothy basaltic glass.

Paleomagnetism

The natural remanent magnetization (NRM) of samples from Hole U1374A ranges from 10^{-3} A/m to ~20 A/m (geometric mean = 0.82 A/m) with the highest values associated with lava flows, intrusive sheets, and basalt clasts in the volcanic breccia/conglomerate units. Relatively well-defined principal component directions were obtained for 5496 intervals from archive half-core measurements (for pieces >9 cm in length). These directions are generally consistent with stepwise alternating field (AF) and thermal demagnetization results from 236 discrete samples. Both data sets reveal a small interval of reversed polarity magnetization in the top ~45 m of the hole and dominant normal polarity from ~45-522 mbsf.

Downhole logging

Four tool strings were deployed in Hole U1374A on Rigil Guyot. Three tool strings took measurements of natural gamma ray radioactivity, density, neutron porosity, elastic wave velocity, acoustic images and borehole resistivity. The fourth tool string, the (third-party) Göttingen Borehole Magnetometer (GBM), measured three-component magnetic field, inclination and declination in the drilled seamount formation. Measurement depths were adjusted to match across different logging runs, obtaining a wireline matched below seafloor (WMSF) depth scale. The logged depth interval for Hole U1374A was 128.1 to 520 m WMSF.

The downhole log measurements (resisitivity, density, velocity and neutron porosity) were used to identify a total of nine log units in Hole U1374A with two in the section covered by the bottom hole assembly (BHA) and seven in the volcanic sequences in the open hole interval. Log Unit I (0 to 20 m WMSF) shows a spike in gamma ray; Log Unit II (20 to 128.1 m WMSF) has generally low gamma ray values; Log Unit III (128.1 to ~240 m WMSF) exhibits fluctuating values for density, resistivity, porosity and velocity; Log Unit IV (240 to 278 m WMSF) shows more consistent values for density, velocity, porosity and resistivity; Log Unit V (278 to 358 m WMSF) is characterized at its top by a dramatic decrease in resistivity and velocity and an increase in porosity; Log Unit VI (358 to 380 m WMSF) exhibits a marked decrease in density, resistivity and velocity; Log Unit VII (380 to 469 m WMSF) has relatively consistent density values higher, stable resistivity values, lower porosity and higher velocity values; Log Unit VIII (469 to 490 m WMSF) is characterized by a significant decrease in resistivity, density and velocity and increase in porosity; and Log Unit IX (490 to 507 m WMSF) shows a marked increase in density, velocity and resistivity and a decrease in porosity.

The GBM was run twice in Hole U1374A and collected good quality magnetic data, which will be reoriented postexpedition. The raw data correlates well to the changes downhole in lithology observed in the core. Lithological and structural features were well imaged with both the Formation MicroScanner (FMS) and Ultrasonic Borehole Imager (UBI). By combining the FMS and UBI datasets a complete picture of the borehole wall in terms of fractures, clast distribution, amount of alteration and contrasts in resistivity and "hardness" can be obtained.

Microbiology

Twenty-nine whole-round samples (5-13 cm long) were collected for microbiological analysis. Lithologies of the samples collected were unconsolidated sediments (one), sedimentary conglomerate (two), volcanoclastic breccia (twenty-four) and aphyric basaltic lava flows (two). All samples were preserved for shore-based cell counting, deoxyribonucleic acid (DNA) analyses and $\delta^{34}S$ and $\delta^{13}C$ analyses. Eleven samples were used to inoculate culturing experiments with up to seven different types of cultivation media. Growth was detected in samples as deep as 400 mbsf with media targeting sulfur oxidizing bacteria and general heterotrophs. Five samples were used to set up stable isotope addition bioassays to determine rates of carbon and nitrogen utilization by subsurface microbes at Rigil Guyot. Two cores were seeded with fluorescent microspheres. Samples from these cores were collected for shipboard analysis of contamination via fluorescent microsphere counts, which revealed that microspheres are released into the drill fluid, but all counts are reduced to zero after the three sterile seawater rinses to which all microbiology whole round samples are subjected. This indicates that the microspheres were not able to penetrate into the whole round samples, and therefore the chance for microbial contamination is low.

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