IODP-MI OPERATIONAL REVIEW REPORT

IODP EXPEDITIONS 309 AND 312
"SUPERFAST II and III"

Co-Chief Scientists' Report

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OVERVIEW OF IODP EXPEDITIONS 309 AND 312 OBJECTIVES AND ACCOMPLISHMENTS:

The primary operational objective of the Superfast mission was to drill a section of intact upper ocean crust down into gabbros. ODP Leg 206 and IODP Expeditions 309-312 (IODP Proposal 522-Full3) had four principal scientific objectives (Table 1):

1. Test the prediction from the correlation of spreading rate with decreasing depth to the axial melt lens that gabbros representing the crystallized melt lens should be encountered at a depth of 900-1300 m subbasement at Site 1256.

2. Determine the lithology and structure of the upper oceanic crust for the superfast spreading end-member

3. Correlate and calibrate remote geophysical seismic and magnetic imaging of the structure of the crust with basic geological observations.

4. Investigate the interactions between magmatic and alteration processes, including the relationships between extrusive volcanic rocks, the feeder sheeted dikes, and the underlying gabbroic rocks.

Site 1256 was selected because it lies on crust formed at a superfast spreading rate (~220 mm/y), where the depth to the axial melt lens, now crystallized to gabbros, should be shallowest (Figures 1 and 2). ODP Leg 206 set up the infrastructure for deep drilling at Site 1256 in November-December, 2002, by coring the 250 m thick sediment section in Holes 1256A,B, and C, and setting a reentry cone, 95 m of 20 inch casing, and 269.5 m of 16 inch casing cemented into the uppermost basement in the reentry Hole 1256D. Coring Hole 1256D during Leg 206 penetrated 502 m into volcanic basement, with 47.8% recovery, followed by a complete suite of logging in basement. Basement comprises a massive lava pond and underlying sheet and massive flows, with minor pillows (Figure 3). For detailed documentation of the scientific achievements of IODP Expeditions 309 and 312 the Review Panel is referred to the Expeditions' Preliminary Reports (Expedition 309 Scientists, 2005; Expedition 309 and 312 Scientists, 2006), and the recent expedition-related Science paper (Wilson et al., 2006). The combined IODP Expedition 309-312 Report has been edited and publication is anticipated early 2007 (Teagle, Alt, Umino, Miyashita, Banerjee, Wilson et al., 2007).

Achievements of Expedition 309

The primary operational objective of Expedition 309 was to drill Hole 1256D as deeply and as cleanly as possible, and Expedition 309 was highly successful in this. Expedition 309 began in July, 2005, with borehole water sampling and temperature measurement (WSTP, APCT, TAP) in Hole 1256D, followed by a logging run to assess hole conditions (triple combo, FMS-sonic). Twenty-seven m of fill was cleared from the hole and coring proceeded using nine C-9 RCB bits (~33 days). The hole was deepened by ~503 m to 1255.1 mbsf (~1005.1 msb). Basement cored on Expedition 309 comprises sheet and massive flows down to 1004.2 mbsf, a transition zone of lavas, massive basalts, and dikes down to 1060.9 mbsf, and sheeted dikes down to 1255.1 mbsf (Figure 3).

Reconsideration of cores recovered during Leg 206 identified two lava subdivisions that were erupted off-axis with a ~100 m thick massive ponded lava overlying ~184 m of lava flows with rare inflation textures that require eruption onto a subhorizontal surface.

This total thickness of ~284 m of off-axis lavas is very close to our preferred estimate (~300 m) for the lavas that buried the axial magma chamber on the ridge flanks and agrees well with geophysical interpretations (e.g., Hooft et al., 1996; Carbotte et al., 1997a). Accounting for this thickness of off-axis lavas and 250 m of sediments, our best estimate of the depth where gabbros will occur at the end of Expedition 309 was refined to between 1275 and 1550 mbsf.

Core recovery during Expedition 309 was 36%, although the final bit run sampled 40 m of massive basalts at a recovery rate of 73% (Table 2, Figure 4). The overall recovery rate of 36% is less than that achieved in the upper portion of Hole 1256D drilled during Leg 206 (48%), but that figure is skewed by very high rates of recovery in the ponded lava flow (93%; 250–350 mbsf); recovery of lavas beneath this unit (39%) was similar to that of Expedition 309. These recovery rates are far superior to those achieved in Hole 504B, with average core recovery of ~30% in volcanic rocks and a miserly 14% from the dikes. **Poor core recovery of hard, fractured formations such as MORB continues to be a major operational obstacle to scientific progress by ocean drilling.**

As expected for crust formed at a fast spreading rate (>80 mm/y), sheet and massive flows are the dominant extrusive rocks at Site 1256 (Figure 3). The exact nature of the sheeted intrusives was open to debate on Expedition 309, however. Common subvertical chilled margins below 1061 mbsf, and steeply dipping fractures in wireline acoustic and electric images in this zone led to the preferred interpretation that the hole had penetrated a sheeted dike complex. It was considered possible, however, that some of the massive basalts could be subvolcanic sills crosscut by thin dikes. The absence of recovered subhorizontal chilled contacts weighs against the presence of sills, but such contacts could have been preferentially lost due to low core recovery, and the possibility of sheeted sills could not be unequivocally dismissed.

The intimate association of brecciation, dike intrusion, hydrothermal alteration, and mineralization becomes increasingly common below ~1000 mbsf and is a new observation. In these cores, there is a clear linkage between the intrusion of magmas and the contemporaneous incursion of mineralizing fluids during dike injection at a magmatically robust spreading ridge, as has been suggested from recent seismic anisotropy experiments undertaken at 9°N on the EPR (Tong et al., 2004).

Establishment of the contribution of different layers of the oceanic crust to marine magnetic anomalies is a primary objective of Expeditions 309 and 312. Unfortunately, all cores recovered to date from Hole 1256D suffer from very strong magnetic overprints and measurement of true paleomagnetic vectors and intensities remains extremely difficult. **Being able to sample hard rocks without the drilling operations inducing a very strong magnetic field would assist in the fulfillment of magnetic objectives.**

Calibrating in situ physical properties with remote geophysical measurements, in particular seismic velocity, is a major objective. Physical properties show marked changes across the transition from lavas to dikes: porosity decreases, thermal conductivity increases, and P-wave velocities increase from <5.5 to >6 km/s at 1240 mbsf in the dikes (Figure 3).

The Expedition 309 wireline logging program generally returned good data, although only preliminary results were available onboard ship. Drilling-induced hole enlargement due to the transit of the drill string has led to the erosion of the upper borehole walls in places, resulting in inferior data for tools that require eccentralization and good contact with the borehole wall (Accelerator Porosity Sonde [APS], Hostile Environment Litho-Density Sonde [HLDS], UBI, and FMS). The WST failed to enter Hole 1256D past the casing, and the VSP experiment could not be conducted. The deployment of this short, light tool should probably not have been risked in this deep basement hole, particularly when superior wireline VSP tools are available.

Achievements of Expedition 312

As outlined above, the primary objective of Expedition 312 was to penetrate through the sheeted dikes of Hole 1256D and into gabbros representing the frozen melt lens imaged by geophysical observations at mid-ocean ridges. Expedition 312 successfully achieved its scientific objectives, penetrating through the 345.7 m thick sheeted dike complex and 100.5 m into gabbroic rocks (Figure 3). Expedition 312 began in November, 2005, with attempted borehole water sampling, but required ~5.5 days of remedial washing and reaming to pass an obstruction at 1179 mbsf, clear the hole, and reach the bottom of the hole. Rotary coring of basement proceeded for ~23 days, interrupted by ~5 days of fishing and milling when the cones were lost from a C-7 RCB coring bit. Seven RCB bits (six C-9 and one C-7) were used to deepen the hole by 252.0 m to 1507.1 mbsf (1257.1 msb). The hole was exited cleanly and remains open for further drilling.

Sheeted dikes were cored down to 1406.6 mbsf on Expedition 312, with the lowermost dikes (1348.3 to 1406.6 mbsf) exhibiting granoblastic textures resulting from contact metamorphism by underlying gabbros. The 100.5 m thick Plutonic section extends to 1507.1 mbsf and consists of a 52.3 m thick Gabbro 1 unit and a 24 m thick Gabbro 2 unit separated by a 24.2 m thick screen of granoblastic dikes Gabbros were first encountered at 1406.6 mbsf, near the middle of the depth range predicted from geophysical observations. This confirms the prediction from the inverse correlation of spreading rate with depth to axial melt lenses. Importantly this prediction was extrapolated to a superfast spreading rate, significantly faster than any spreading presently occurring on Earth today.

Coring in the dikes was extremely difficult, with generally slow ROP (<1 m/h) and low recovery (~15%; Figure 4). Penetration and recovery rates were higher in the gabbro (~1.5 m/h and ~30%). These are still below the rates in other deep gabbro holes, however. This may be related to the transitional nature of the rocks (dikes and gabbro), but could also be affected by the depth of Hole 1256D, and/or the condition of the upper hole.

A major objective of Expedition 312 was to document the lithology through a section of upper ocean crust and the relationship between magmatic, structural, and hydrothermal processes. Cores recovered from the sheeted dike complex during Expedition 312 include chilled dike margins grading to microcrystalline and fine-grained doleritic material, confirming the sheeted dike lithology, which remained equivocal at the end of Expedition 309. The thicknesses of the sheeted dikes and the lithology of the dike-gabbro transition were also determined.

Sheeted dikes of Hole 1256D record a steep temperature gradient. Generally similar hydrothermal alteration is present in the dikes of Hole 1256D and Hole 504B, indicating similar hydrothermal conditions. However, because the dike section in Hole 1256D is only ~300 m thick, compared to the 1 km of dikes in Hole 504B, the thermal gradient at Site 1256 was much steeper (~50°C/100 m versus 15°C/100 m). An important new finding in Hole 1256D is the presence of ~60 m of lower dikes with granoblastic textures resulting from contact metamorphism by intrusion of underlying gabbros. Similar metamorphism has been described locally in ophiolites but never before from the seafloor. This process indicates the intertwined relationship between magmatism, hydrothermal alteration and metamorphism.

An important scientific question to be addressed was the nature of the melt lens (e.g., does it have the composition of a basaltic liquid or is it a cumulate?). Gabbroic rocks in Hole 1256D are diverse and range from gabbro to oxide gabbro and gabbronorite and include differentiated rocks (trondjhemite and quartz-rich oxide diorite). Bulk compositions of the two gabbroic bodies fall at the primitive end of the range of compositions for the lavas and dikes but are evolved compared to primitive melts in equilibrium with olivine in the mantle. This means that cumulates must form elsewhere, within the lower crust or at the crust/mantle boundary, and the lower crust cannot form by subsidence of such high-level evolved melt lenses as so far penetrated in Hole 1256D.

Determining the contribution of different layers of the oceanic crust to marine magnetic anomalies is a primary objective of the Expeditions. However, the cores from Hole 1256D suffer from very strong magnetic overprints, and measurement of true paleomagnetic vectors and intensities remains extremely difficult.

The wireline logging programs generally returned good data, although only preliminary results were available onboard ship and for this report. Logging tools did not penetrate past an obstruction at 1432 mbsf (1182 msb). Drilling-induced hole enlargement due to the transit of the drill string has led to the erosion of the upper borehole walls in places, resulting in inferior data for tools that require eccentralization and good contact with the borehole wall (APS, HLDS, UBI, VSI, and FMS). The VSI otherwise performed well during the VSP experiment (Figure 3).

Calibrating in situ physical properties with remote geophysical measurements of seismic layering is a major objective. Downhole velocity measurements end at the top of gabbro, but we interpret the gabbro intervals as within layer 2 because a smoothed extrapolation of the downhole velocities will either have velocities <6.5 km/s, still characteristic of layer 2 (Figure 3), or will have an exceptionally high gradient to higher velocities, also characteristic of layer 2. Encountering gabbro at a depth clearly within layer 2 reinforces previous suggestions that factors including porosity and alteration are more important than rock type or grain size on controlling the location of the layer 2/3 boundary. The position of the dike-gabbro boundary, therefore has little control over the seismic velocity structure of the crust

PRECRUISE:

Expedition Scheduling: IODP Proposal 522-Full3 requested one drilling expedition of 58 days, but two shorter expeditions adding up to greater time on site (~56 coring days) were scheduled. This turned out to be either brilliant foresight on part of the Science Planning Committee/Operations Committee or simply good luck! Given the significant slowdown in penetration rates in the lower sheeted dikes on Expedition 312 (<1 m/h compared to predicted 1.5 m/h), and the time lost to problems encountered (~10 days of reaming, milling, hole conditioning), the scientific objectives would not have been achieved in one 58 day Expedition. Suffice it to say that unpredictable problems are commonly (nearly always?) encountered during deep basement drilling, and it is essential to take into account that time will almost certainly be lost to such problems when estimating times for reaching depth objectives and scheduling deep basement drilling Expeditions.

Although the scheduling of two shorter expeditions to Site 1256 provided enough time on site for Hole 1256D to be deepened to gabbro, there was a serious and unexpected deterioration in hole conditions from the end of Expedition 309 and the beginning of Expedition 312 (~2 months). Core recovery at the end of Expedition 309 was excellent (final bit ~74%), but five days of hole conditioning were required at the beginning of Expedition 312 to reach the bottom of the open hole, and recovery in the dikes remained low throughout the Expedition. Subtle changes in formation *may* account for some of the deterioration of drilling conditions, but thermal rebound, and lack of continual condition were also probably significant contributors. Similar difficulties were encountered during re-entries of DSDP/ODP Hole 504B.

Suggestion: Where possible, we recommend that the longest possible time on site be allocated to expeditions with deep drilling objectives, in preference to short repeat visits.

Staffing: There was a short lead time for Staffing Expedition 309 (3 months), which probably contributed to under-staffing the Expedition, and to staffing with a disproportionate number of junior scientists. This is clearly the result of timing of budgets, but longer lead times are needed for efficient staffing. The continued "transitional" nature of the program has mean staff shortages in many parts of the program. Although, science and operations on Expedition 309 were highly successful, combining a new "Staff Scientist" with new "Operations Manager" meant that at times there was poor communications between "operations" and the Co-Chiefs' office. Most major decisions were taken following consultation with the Co-Chiefs, but only after their insistence to be involved in such decisions. Some decisions were made without involving Co-Chiefs, however, such as the decision to end the logging program without running a tool specifically requested by the Co-Chiefs.

Dr Neil Banerjee is an experienced shipboard scientist and did an excellent job on both Expeditions 309 and 312, despite being a raw Staff Scientist recruit. However, with continued personnel change the possibility could exist of having a cruise with NO experience amongst key personnel (Co-Chiefs, Staff scientist, Operations Manager, Yeoperson) and this should be avoided!

During staffing for Expedition 312 there were difficulties in balancing required expertise, e.g., too many igneous petrologists were nominated from all partners. There was a general lack of information about JDESC applicants (seniority, experience, no CV available) making it more difficult to obtain a balance among disciplines and seniority/experience. Allowing member nations to pre-select candidates greatly hinders the development of a balanced science party.

Suggestion: The Co-Chief scientists are by far the best qualified persons to design the shipboard party to ensure an appropriate balance of expertise, experience and nationality. Member groups should send a prioritized list of shipboard candidates with full CVs/standard application forms for the Co-Chiefs to select from. More candidates than available slots should be submitted if possible and scientists must be from a range of appropriate disciplines. CVs and applications should be available by the pre-cruise meeting as this is the most efficient occasion for establishing the initial staffing requirements and highlighting any holes in the available talent.

JOI/USSSP, for apparent political reasons, forced the US science party to accept a scientist that the Co-Chiefs and staff scientist thought was unsuitable for the Expedition. This scientist only wanted to participate on an ocean drilling cruise, had no interest in the science to be gained from the expedition, and was mainly interested in sediment coring. Expeditions 309-312 were this scientist's last choices for participation. The Co-Chiefs wrote a letter to JOI/USSSP stating their objections, but they were overruled. JOI insisted that we invite this scientist rather than our first choice for the position, who had been the main proponent on the drilling proposal and who was a Co-Chief scientist on the first drilling leg to Site 1256 (and lead author of the 309-312 Science paper!). It turned out that the scientist forced on us by JOI did little work on Expedition 309, and worse, in addition to bothering other working scientists during the expedition, all data that this scientist had generated during Expedition 309 was incorrect, and had to be recalculated and corrected at the first editorial post-cruise meeting. This took two scientists working 2 days full time at this meeting to correct work that should have been done on board the ship. Thus, at JOI's insistence, we were forced to accept a scientist that not only did not perform his job, but was a detriment to the Expedition, causing extra work and irritation for other scientists.

Suggestion; Co-Chiefs MUST have the final say about scientist participation. They are the best placed to assess the personnel requirements for the achievement of the Scientific objectives. Co-Chiefs must not be forced by shore-based science administrators to accept personnel against their wishes. Proponents on the drilling proposals should be given priority for participation.

Logging Scientists: Because of the short lead time before the expeditions and the shortage of Logging personnel at Lamont/Leicester, we didn't know at the time of the pre-cruise meeting who would be the Logging scientist for Expedition 312. It would have been beneficial for the logger to participate from the beginning. The logging representative at the meeting exhibited scientific engagement in the Expeditions, and lacked initiative, which probably contributed to misunderstandings and slow progress on some issues.

One point of misunderstanding in particular dragged on for ~4 months, until near the end of Expedition 309. At the precruise meeting the Co-Chiefs requested information about a downhole magnetometer, but this was not forthcoming until a new logging scientist was hired some three months later (when Expedition 309 was underway). The misunderstanding arose because the Co-Chiefs believed it Lamont's responsibility to provide information about the magnetometer. It was not made clear until near the end of Expedition 309 that the tool is a third-party tool and Lamont has no responsibility for such tools, although they are perhaps the most qualified group in the wider program to provide informed opinions on such third party tools. It turned out that the tool had major problems and would not fit through the bit anyway, but better communication between logging scientists and Co-Chiefs would have prevented such misunderstandings dragging on for many months without resolution. This problem was related to specific personnel and to understaffing of Logging scientists at Lamont.

Suggestion: The roles of the "Logging Staff Scientist" needs to be upgraded to fit their new title and apparent status. The experience of ODP Leg 206, and Expeditions 309-312 is that presently loggers sail as "logging technicians" rather than research active scientists. Little or no analysis of data was made available from the wireline logs run on Expedition 309 to help inform decisions on Expedition 312 (or even prepare an AGU presentation!) Even the scheduling of wireline tool runs so that these occurred in an appropriate order and during appropriate times of the days required Co-Chiefly intervention and re-arrangement on Expedition 309. Key issues of interest, such as images of subvertical margins in the Expedition 309 dikes were not even addressed. There appeared to be little interest in further analyzing the Expedition 309 data during Expedition 312, despite 6+ weeks without any data. It is important to have logging scientists that are active researchers interested in the scientific objectives to be addressed by the Expedition, rather than merely logging technicians.

Format for Multi-Expedition Report: There was a general lack of information about expectations for the format of Expedition Report, particularly how to integrate the two expedition reports into one.

Suggestion: Either Co-Chiefs of individual expeditions must be given the authority to design their own formats for integrating multiple expeditions, or there needs to be some kind of guidelines set up for this. We feel the former Co-chief design to suit the experiment is preferable to regulation from IODP-MI. Clearly there is a timing factor here, as Expeditions to the same site but widely spaced in time (more than ~1 year) will not have combined reports, whereas those more closely timed (a few months) have the option of combining reports. Back to back expeditions likely have different problems than those separated by a few months.

Staffing multiple-expedition "Missions"

Suggestion: Combined science parties can be beneficial, providing access to samples for scientists interested in the entire mission but unable to participate on all of the expeditions. Combining science parties appears to work for expeditions closely-spaced in time (Expedition 309 and 312), but those separated by more than a few months (~1 year) may encounter different problems that requires some thought to address: e.g., the requirements to publish reports; the sampling moratorium versus the need to start working on samples.

Continuity of personnel can be important for multi-expedition missions to a single deep hole, for both operations and science. Operations personnel will be familiar with particular problems with a deep hole (e.g., borehole stability, clearing of cuttings, coring conditions, etc), and scientists will be familiar with the cores, scientific interpretations, and report formats.

Suggestion: On multi-expedition missions to single deep hole, it is desirable to have some key personnel (scientists, operations superintendent, technicians) participate on all legs of the multiple expeditions. Although there may be benefits to scheduling multiple expeditions back to back, this suggestion would require at least one intervening expedition.

SYN-EXPEDITION:

Drilling Mud: On Expedition 312 we were undersupplied with drilling mud because this was the last cruise of Phase I, and the inventory was purposely allowed to diminish in order not to have unused mud remaining. This strategy greatly affected coring and put Hole 1256D at unnecessary risk, as insufficient mud was circulated to clear cuttings from the deep hole. Large amounts of mud were necessary because each reentry required circulation to clear fill from the bottom of the hole, and circulation of larger than typical mud plugs was found to help clearing cuttings. However, circulation of mud plugs was limited and strategically scheduled because of the lack of mud on board. The lack of mud could potentially have been disastrous, had larger rock fragments fallen into the hole and jammed the bit. Remedial operations that occurred during Expedition 312 (reaming, milling broken roller cones) also required large amounts of mud that were not planned for.

Suggestion: The program should avoid short-term savings (less than full inventory of mud) that might jeopardize major scientific investments (3 ocean drilling expeditions to Hole 1256D). It is imperative that ALL expeditions sail with the best supplies required to complete their objectives. Regular large mud-sweeps appear to significantly improve the clearing of cuttings from deep drill holes. Surplus stocks (i.e., more than what is calculated to be "enough") of mud should be carried on deep basement drilling expeditions.

Penetration and Core Recovery: Coring in sheeted dikes results in extremely slow coring and very low recovery. This appears to be related to our inability to clear debris from the hole, the very hard, fine grained dike rocks, the abundant natural fracturing of the very fine grained chilled dike margins, and to drilling-induced decompression fracturing, which produces sub-horizontal, saddle-shaped, fine open cracks. Future drilling in sheeted dikes would benefit from improved penetration rates and recovery. It was discovered during Expedition 312 that drill bits ("C-11") exist for drilling in harder rock than the hard formation C-9 bits available to IODP. Presently these ultra-hard formation bits are only available as drilling but not coring bits. The decision on Expedition 312 of moving to a C-7 bit (with a more aggressive cutting structure) to penetrate the very hard granoblastic dikes, resulted in complete bit destruction after only ~20 hrs rotation, risk to the hole and lost of ~5 days drilling time.

Suggestion: Investigate the possibility of obtaining coring bits for harder formations than C-9 bits if coring in sheeted dikes is planned. Investigate strategies for improved coring rates and recovery in deep basement holes. Avoid the temptation to use more aggressive bits in very hard formations.

Logging Tools: On Expedition 309 the WST (Well Seismic Tool) failed to enter Hole 1256D past the casing, and the VSP experiment could not be conducted. The tool apparently hung up in the rat-hole beneath the 16-in casing. This possibly could have been avoided by monitoring tool noise with the oscilloscope to see when noise stopped and the tool got hung up. This short, light tool should never have been run in a basement hole >1000 m deep, especially when a modern tool better suited to the conditions was available to LDEO, but not carried on Expedition 309. The deployment of the WST, and its subsequent entanglement in the rat-hole, risked equipment loss in Hole 1256D and out at jeopardy the expedition objectives, and future drilling on Expedition 312. The VSI (Versatile Seismic Imaging) tool, used on Expedition 312 is longer and heavier and has tool/wireline tension monitoring to avoid such problems. On Expedition 312 there was some question as to what the allowable airgun settings were, although this was resolved via communication to the beach.

Suggestions: Always use the best available tools for the task required and avoid short-term cost saving measures particularly in deep holes that represent many months of ocean drilling investment.

Airgun/Marine Mammal Protocol: It is potentially of great benefit for VSP experiments in deep holes to change the present airgun/VSP protocol. Currently the airgun can only be operated during daylight so a marine mammal watch can be posted according to the present Marine Mammal Protocol. The original plan for Hole 1256D was to reach a depth of up to 1750 mbsf (1500 msb), which would have required up to 25 hours to complete the VSP experiment. At such a depth there would be insufficient time to pull the VSI tool out of the hole and rig up and run another logging tool during the darkness, so the ship would have had to sit idle for ~10 hours waiting for daylight. The ability to shoot the airgun at night could have potentially saved valuable ship time, shortened the logging program and allowed more time for coring. Because of coring problems, the unexpected shallower depth of the hole meant that logging times were shorter than predicted but compromises had to be made in terms of wider spacings of VSP stations, and VSP stations in the volcanic section, which was logged during Leg 206, were not re-shot. Thus the VSP experiment could be accomplished during daylight in a single run. In future deep basement holes, however, being able to shoot the airgun during nighttime hours could potentially save valuable ship time. In contrast to IODP policy, shooting airguns at night is common practice on marine geophysical cruises.

Communications between proponents, Co-Chief Scientists with TAMU, JOI, IODP-MI

There were two issues that the Co-Chiefs/522Full-3 Proponents submitted lengthy justifications to the IODP-SAS structure and JOI-TAMU but received NO official feedback. In July 2005 during Expedition 309, Teagle and Wilson re-assessed the site survey data for the GUAT-3B region and sent a request to the SAS/SSP structure for approval of a number of better alternative sites, should drilling in Hole 1256D be terminated. Although we believe that these alternative sites were "approved" for operations we received no official confirmation that this was the case.

Similarly, Banerjee (on behalf of Expedition 309-312 Co-Chiefs and Scientific Parties), submitted a case to JOI-TAMU (Sept 2005) requesting that the option of shooting the VSP experiment overnight be considered and investigated. Although this is a contentious political issue, no progress was made, very little information was made available to the Co-Chiefs, and very little feedback was provided. We did not receive a reply until the middle of Expedition 312. Although, in the end this did not affect Expedition 312 because of the low penetration during that cruise, with IODP planning to drill increasingly deeper holes, this option must be investigated thoroughly and not just swept under the carpet.

Communication between Cochiefs and Operations, Logging Scientists: As pointed out in the Precruise section, there were some problems on Expedition 309 with Cochiefs not being informed about decision making by the Operations Superintendent and Logging Scientist. This may be attributed to inexperience on the part of the Operations superintendent. On Expedition 312, we had a more experienced Operations Superintendent, and communication with Cochiefs was excellent. The logging scientist on Expedition 312 was a novice, but communication with the cochiefs was good. Communications within the logging group appears to be excellent. In consultation with the beach, the Schlumberger Engineer was able to repair two tools that malfunctioned at the end of Expedition 312, enabling achievement of all scientific logging objectives.

Educator at sea: The role of the "Educator at Sea" needs to be more clearly outlined and they need to have specific, pre-determined deliverables appropriate to the expedition. On Expedition 312 the educators' roles were completely undefined by the sponsoring agencies (JOI, JDESC). One educator began by writing a personal Blog that contained inappropriate comments about personnel, including comments about the food supply and obesity aboard the ship, etc. This was never sent ashore, but points out the need for defining the role of these observers, and a need to ensure that appropriate personnel who will be engaged in the Science are given the opportunity to go to sea. Further conflicts arose regarding the moratorium on science information. The Educator was writing stories to be sent ashore that contained photographs of samples and plots of chemical data. These, too, were never sent ashore, but caused mutual irritation between the Educator and the Cochief/Staff Scientists. Clearly, the Educator at Sea is a potential benefit to the program by conveying science to the public, but greater thought and directions as to their duties at sea are essential. Although the wider program has a duty to improve its public outreach, this must be done without compromising the achievement of the scientific objectives of the expedition.

Shipboard Sampling for combined science parties of multi-expedition mission: Shipboard sampling for shipboard and shore-based scientists on Expeditions 309 and 312 went reasonably smoothly, despite the combined science parties. Preference on an individual Expedition was given to the shipboard scientists of that expedition, with a representative set of samples given to shore-based scientists (the shipboard scientists of the companion expedition). This allowed scientists from one expedition to obtain samples from the companion expedition and at least start their research. Additional samples were taken by some shore-based scientists at the core repository post-cruise.

Shared "POOL" samples: Beginning on ODP Leg 206, a subset of the science party with complementary interests in basement geochemistry started taking shared "POOL" samples. The idea was that each investigator could perform his own specific geochemical or isotopic analyses, but that the analyses would all be on the same samples, maximizing the information to be gained from the samples and analyses. This is particularly important for intervals with very low core recovery and for rare samples (e.g., mineralized dike margins). The POOL samples were generally given priority over individual scientist's sampling. Investigators also took some of their own personal samples. This sampling protocol was continued on Expeditions 309 and 312.

Having scientists that were involved in all legs/expeditions helped with this sampling, providing continuity and ability to explain the approach and its benefits to subsequent science parties. This was especially helpful where recovery was low and many scientists were interested in the same samples and similar types of geochemical analyses.

Suggestion: We suggest that such a sampling strategy be suggested for future deep basement holes. This should not be made mandatory, but priority for sampling unique intervals could be given to such POOL sampling, providing access for all scientists.

Shipboard Life: The goal of IODP expeditions is obviously science, but personal life aboard ship is important for morale during long times spent at sea, particularly over holiday seasons. We point out that communication with family on shore via email and satellite phone is important. Internet access is critical for scientific work. Positive recreational diversions include the gym and movies, which contribute greatly to the well-being of scientists on board.

Suggestion: Replace the stolen DVD of "Team America".

POST CRUISE:

Multi-expedition report format: There was a lack of information about required format for reports for multiple expeditions at a single hole. The Co-Chiefs submitted an outline for a report that would integrate the results from the two Expeditions into one report one year before the final Expedition Report received editing. A year later, the Co-Chiefs received a last minute request from IODP-MI that the report must be re-formatted to eliminate any separation between the two expeditions. This was a year after the report format was proposed, 4 months after the report was written, and only a week before the final editing meeting.

Post cruise meeting: There was some confusion as to which sections of the report were finished with editing and corrections. Report sections kept getting returned to the filing boxes for further reading and editing, making for unnecessary changes. There needs to be a system whereby there is some indication when sections of the report are finished. Such a system was in place in the past but was not for our post-cruise editing meeting.

Press release: Great pressure was applied on the Co-Chiefs and Staff Scientist to provide a cruise "press release" despite JOI, IODP-MI, TAMU being informed that *Science* was interested in publishing an article on our shipboard results (Wilson et al., 2006). In the end, the only recourse to this pressure was non-cooperation as the Co-Chiefs had little confidence that the *Science* media embargo would be respected by ALL parties. High profile research articles in high impact multidisciplinary journals such as *Science* and *Nature* are essential to the success and continuation of all aspects of scientific ocean drilling. All personnel involved in outreach must be aware of and respect scientific publication requirements over "public outreach".

Publication conflict: We encountered a conflict where we were required to publish the Preliminary Report, but were writing a manuscript for publication in *Science*, which required an embargo on all scientific publications from the Expeditions. The publication of the Expedition 312 Preliminary Report was postponed to avoid this conflict but there is a need for a clear policy for how to deal with such conflicts.

Continuing multi-Expedition Missions for Deep Drilling: Following the successes of Expedition 312 there was some confusion as to whether the proponents needed to write a new proposal for deepening Hole 1256D or whether an addendum to the previous proposal was sufficient. Clearly there is much to be gained from a prompt return to Hole 1256D, the first hole in intact ocean crust that extends to gabbro (see Table 1). Although unofficial advice was offered by the SPC chair, there was no immediate official response from the SPC and the proponents received conflicting advice from individual members of that panel follwing its March meeting. Although perhaps the major objective of the Expeditions was achieved (penetrating into gabbro) many of the scientific objectives of IODP Proposal 522Full-3 are yet to be achieved and fundamental goals of the IODP Initial Science Plan regarding the accretion of the ocean crust are now within range (see Table 1). The proponents ended up submitting a new proposal (IODP Proposal 522Full-4) under a short time constraint for the April 1 deadline. This proposal must now pass, once again, through SSEP review, external peer-review before eventual consideration by SPC.

IODP-MI has recently been promoting the concept of "Missions" for multi-cruise experiments than can not be achieved by a series of individual expeditions. Of all the experiments so far attempted by the IODP, the Superfast experiment best fits the "Mission" concept, yet our successes are rewarded by requests for yet more proposals and further external review, as also occurred following the successful construction of the casing infrastructure for deep drilling on ODP 206. Better guidelines are required for multiple expeditions to the same deep drill site to assist the progress of experiments that have already passed through multiple rounds of nurturing and external review

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Table 1. Summary of Scientific Objectives, Achievements, and Outstanding goals.

OBJECTIVES (522-Full3)	ACHIEVEMENTS AND OUTSTANDING GOALS
1. Drill an intact section of in situ upper ocean crust. Current knowledge is based predominantly on exotic, tectonically exposed sections and supra-subduction zone ophiolites. These may not be representative of typical ocean crust, which comprises 60% of the earth's surface.	• **Complete penetration of the lavas and**, for the first time in the history of scientific ocean drilling, the **sheeted dike complex**. • **Significant penetration** (>500 m) of the upper **gabbros**.
2. Test the relationship between ocean ridge spreading rate and depth to the LVZ, and investigate the geological nature of the LVZ. Assuming that the LVZ is a melt lens that crystallizes to gabbro, the observed spreading rate-depth to the axial LVZ relationship predicts that the dike-gabbro transition should be 1025 to 1300 msb at Site 1256, given a spreading rate of 220 mm/yr.	• **The dike-gabbro boundary was drilled at 1157 msb at Site 1256**, within the predicted LVZ depth range. This confirms: (i) the LVZ is a melt lens, and (ii) the spreading rate-LVZ depth relationship can be extrapolated to superfast spreading rates. • The **dike-gabbro boundary drilled** for the **first time** in in-situ normal ocean crust.
3. Characterize the structure of superfast spreading rate crust, including: i) the lithology, thickness, structure and geochemistry of the lavas and sheeted dikes, and the nature of the lava-dike transition zone. ii) the textures, chemistry and magmatic structure of the upper gabbros. And hence, determine the processes of crustal accretion (gabbro glacier vs. sheeted sills models).	• Complete penetration of the **lavas and dikes**, allowing **comparison with Hole 504B** crust. • Upper **~ 100 m of plutonics recovered** (gabbro, oxide gabbro, qz-rich oxide diorites and trondjhemite dikelets, with dike screens and stoped dike clasts). • **The upper gabbros have chilled upper and lower contacts**, and are on average slightly more primitive than the dikes and lavas, but still **within the EPR MORB field**. They are **NOT cumulates** or **representative** of the entire lower crust. This evidence favours the sheeted-sill model. However, given that the gabbros are fractionated (requiring a deeper magma chamber) and that 100 m represents only ~2 % of the gabbro, **further drilling is essential to determine the mode of accretion of lower ocean crust.**
4. Correlate lithology and rock properties with remote geophysical measurements, in particular: (i) what do seismic layers 2 and 3 correspond to? *(generally assumed to be the dike-gabbro boundary, but it was intercepted within the sheeted dikes in Hole 504B, at an alteration boundary*) (ii) which crustal layers contribute to the marine magnetic anomalies?	• **Dike-gabbro boundary intercepted within L2 at Site 1256.** Here the dike-gabbro boundary in NOT the L2-L3 boundary, or an alteration boundary within the dikes. • **Intercept the layer 2 - 3 boundary at Site 1256**, and determine its' geological nature. • Sample a longer, more representative gabbro section, determine the magnetic properties of the gabbros, and **complete the crustal "magnetic budget"**
5. Investigate the interactions between magmatic and alteration processes, including the nature and extent of water rock interaction, including: (i) the alteration stratigraphy and chronology, fluid flow paths, and the nature of reaction/mixing zones. (ii) the variability of thermal, fluid, and chemical fluxes, the balance between low and high temperature alteration, and the implications for global geochemical budgets. (iii) the alteration of the dike-gabbro transition (the conductive boundary layer between the magma chamber and the hydrothermal system).	• Alteration of the lavas, dikes, upper gabbros and transition zones described and compared to 504B and ophiolites. A **Contact metamorphism** zone was **discovered in the lower dikes**, due to intrusion of the **upper gabbro**, which was **altered by high temperature fluids**. • Sample the entire hydrothermally altered portion of the crust, to **complete the crustal geochemical budgets**. • **Determine the depth of hydrothermal fluid penetration**, and temperatures of interactions as this influences processes of crustal accretion and heat removal from the lower crust (significant to global heat output).

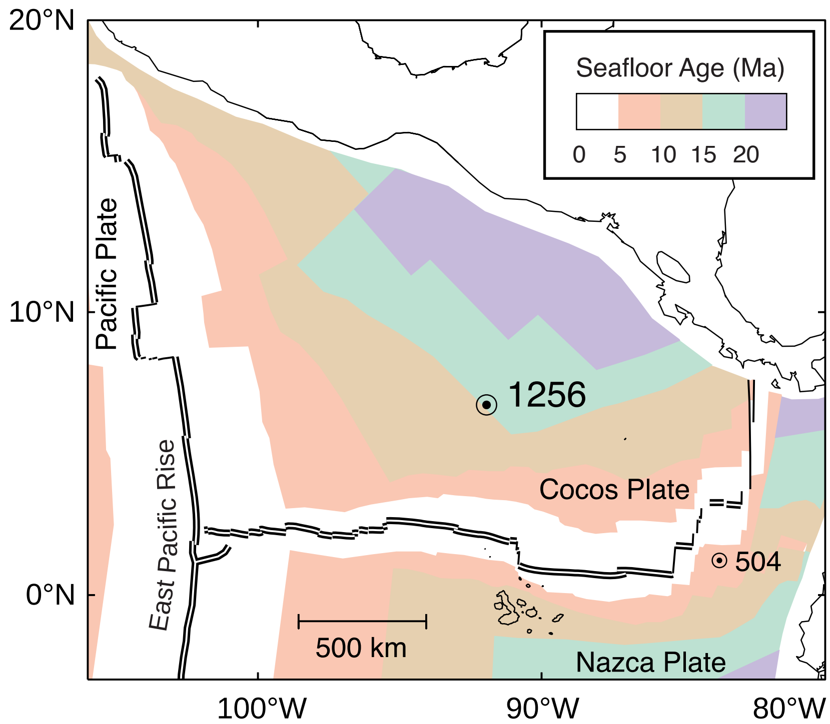

Figure 1: Age map of the Cocos plate and East Pacific Rise with isochrons at 5-Ma intervals, converted from magnetic anomaly identifications according to timescale of Cande and Kent (1995). The wide spacing of 10–20 Ma isochrons to the south reflects the extremely fast (200–220 mm/y) full spreading rate. The locations of deep drill holes into the oceanic crust at Sites 1256 and 504 are shown.

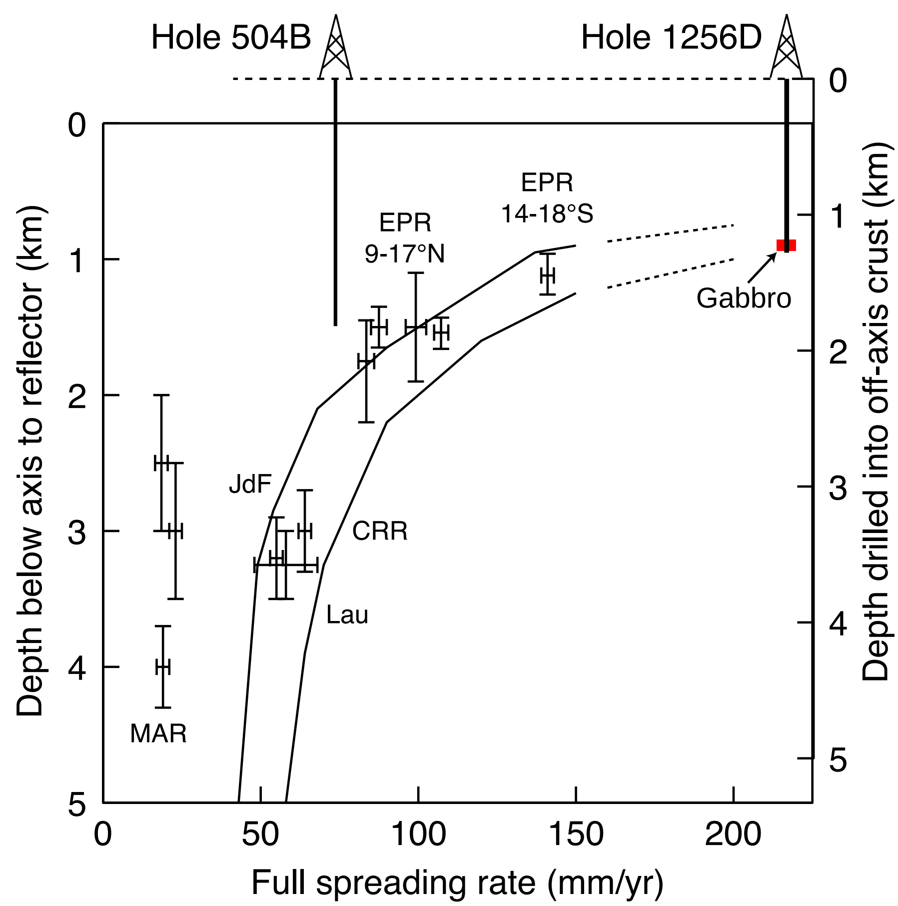

Figure 2: Depth to axial low-velocity zone plotted against spreading rate (modified from Carbotte et al. (1997) and Purdy et al. (1992). Depth versus spreading-rate predictions from two models of Phipps Morgan and Chen (1993) are shown, extrapolated subjectively to 200 mm/y (dashed lines). Penetration to date in Holes 504B and 1256D is shown by solid vertical lines, with the depth at which gabbros were intersected indicated by the red box. Following core descriptions a thickness of ~300 m of off axis lavas is shown for Hole 1256D and assumed for Hole 504B. EPR = East Pacific Rise, JdF = Juan de Fuca Ridge, Lau = Valu Fa Ridge in Lau Basin, CRR = Costa Rica Rift.

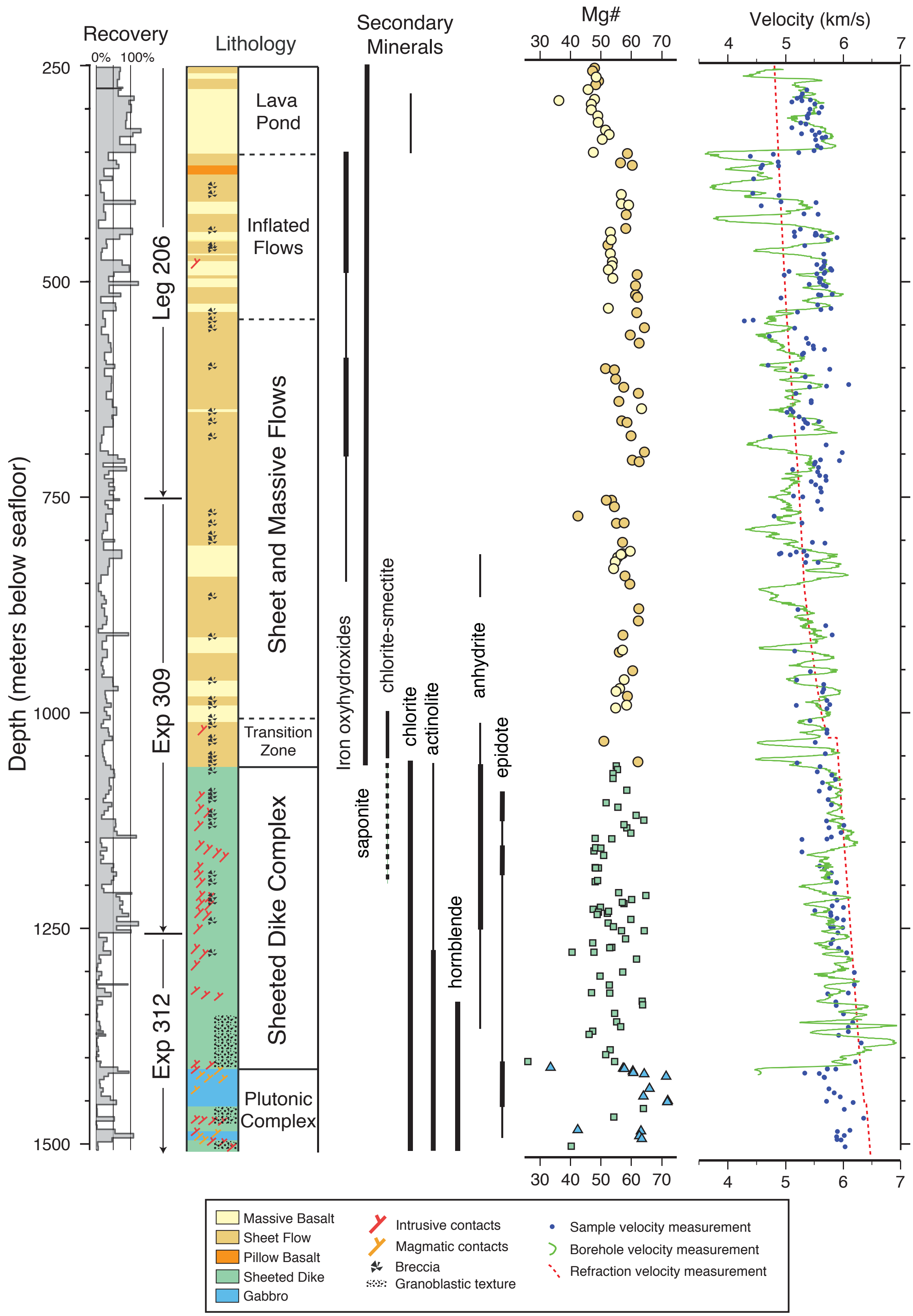

Figure 3: Summary lithostratigraphic column of the basement drilled to date at Site 1256 showing recovery, major lithologies, downcore index alteration mineral distribution (thick lines = abundant; thin lines = rare), downcore distribution of Mg-number (where Mg# = 100 × Mg/(Mg + 0.9 × Fe) atomic ratio; symbols as in Fig. 5), and seismic velocity measured on discrete samples, wireline tools, and seismic refraction (from Wilson et al., 2003b)

Table 2: Rates of Recovery and Rate of Penetration (ROP) in Hole 1256D

Interval	Cored Interval (m)	Average Recovery (%)	Average ROP (m/hr)
Hole 1256D Cores 2R-234R	1231	37	1.2
Lavas and TZ (Cores 2R-128R)	785	41	1.5
Upper dikes (Cores 129R-191R)	287	37	0.9
Granoblastic dikes (Cores 192R-213R)	63	7	0.5
Plutonic complex (Cores 214R-234R)	96	29	1.1
Gabbros (Cores 214R-224R; 230R-234R)	72	35	1.2

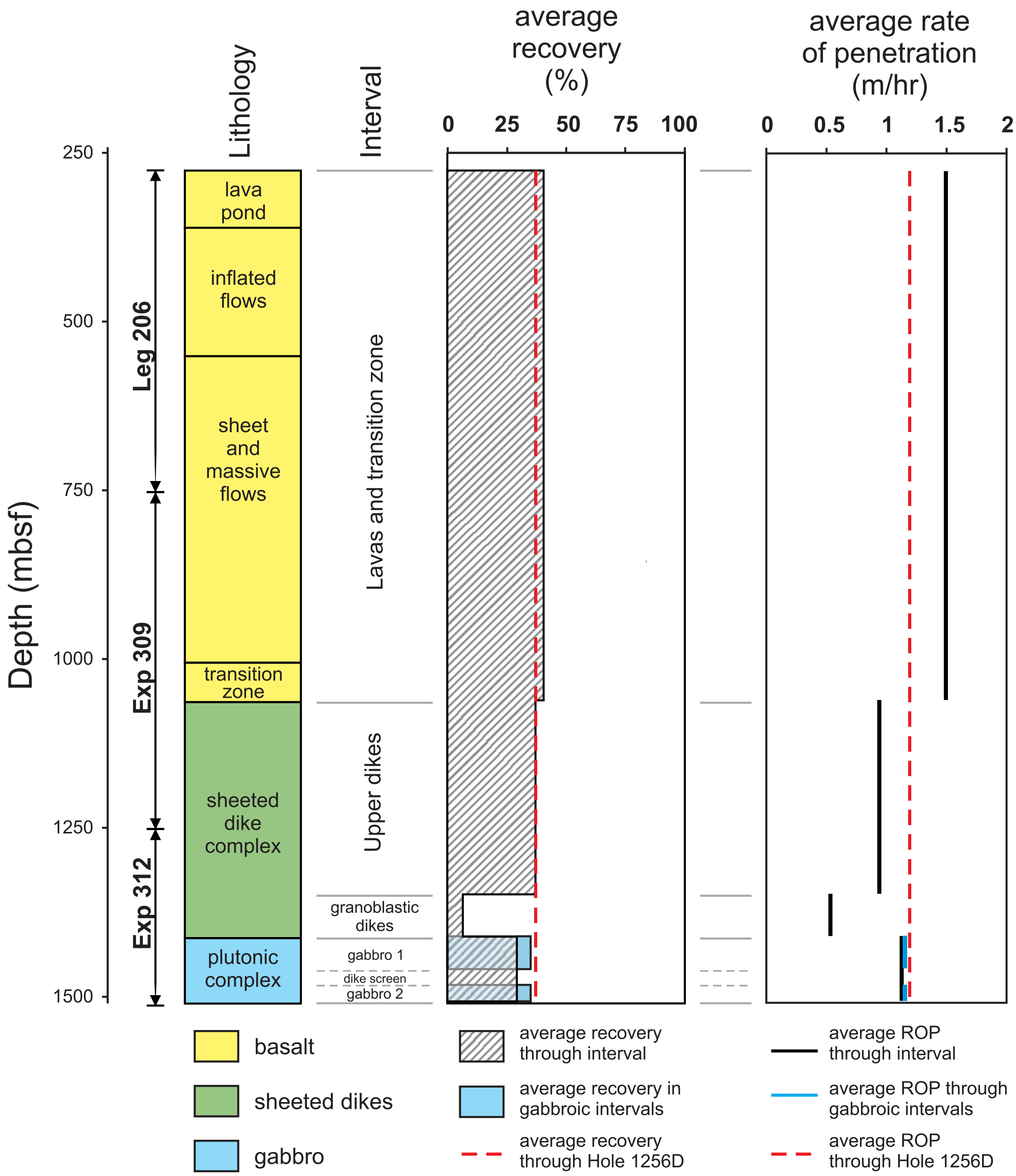

Figure 4. Average rate of recovery and penetration for drilling in Hole 1256D. Note the improvement in both parameters in gabbroic rocks back to near average rates for the whole hole (~35% recovery; ~1.2 m/hr penetration rate). Recovery was very low (6.5%) and penetration excurciatingly slow (0.5 m/hr) in the granoblastic dikes.