IODP Operations Review Task Force Meeting

Expedition 331
DEEP HOT BIOSPHERE

16 – 17 November 2011
Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Tokyo

EXPEDITION 331 OPERATIONS REVIEW TASK FORCE (ORTF)

PARTICIPANTS

Expedition 331 ORTF Meeting Members

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MEETING FORMAT

The IODP-MI Operations Review Task Force (ORTF) met on 16 – 17 November at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Tokyo, to review the operational aspects of IODP Expedition 331 (DEEP HOT BIOSPHERE). The review concentrated on "lessons learned" from the expedition with an emphasis on "what should be done differently in the future." ORTF review was based upon confidential reports submitted by the Center for Deep Earth Exploration (CDEX) and the Expedition 331 Co-chief scientists.

The meeting began with oral presentations by CDEX Operations Superintendents (Ikuo Sawada), Co-Chiefs Scientists (Ken Takai and Mike Mottl) and CDEX Staff Scientist (Sean Toczko) summarizing the Co-chief Scientists and CDEX reports respectively. Following the presentations, External Reviewers and IODP-MI personnel had Executive Session to identified specific pre-expedition, during expedition, and post-expedition phase topics/issues for discussion and formulate a number of draft recommendations. On the second day of the meeting, ORTF reviewed and finalized the draft recommendations from the Executive Session. These recommendations are presented here.

EXPEDITION SUMMARY

Expedition 331: 1 September – 4 October 2010
Co-Chief Scientists (CCs): Ken Takai, Mike Mottl
Expedition Project Manager (EPM): Simon Harder Holm Nielsen
CDEX Operations Superintendents (OSI): Tomokazu Saruhashi, Ikuo Sawada

IODP Expedition 331 "Deep Hot Biosphere" aboard the Deep-Sea Drilling Vessel *Chikyu*, Expedition drilled into the Iheya North hydrothermal system located in the middle Okinawa Trough to investigate metabolically diverse subseafloor microbial ecosystems and their physical and chemical settings. Four new hydrothermal vents were created by drilling operations and all the hydrothermal vent emissions were confirmed to be >240 ˚C. These are the first artificial hydrothermal vents of high temperature fluids built during DSDP/ODP/IODP history.

Expedition 331 drilled 24 holes at five sites and cored 21 holes (total 559.9 m) and recovered 311.9 m (66.8% recovery) during the expedition. These comprised: the active hydrothermal vent site and sulfide-sulfate mound at North Big Chimney (NBC) (Site C0016); three sites east of NBC at distances of ~100, 450, and 1550 m from the active vents (Sites C0013, C0014 and C0017, respectively); and one site on a hill ~600 m northwest of the active vents that represents a potential migration path for hydrothermal fluid (Site C0015). The maximum penetration was 151 meters below seafloor (mbsf) at recharge Site C0017. Expedition 331 used heavy, triangular, gimbaled guide bases at three holes, one each at Sites C0013, C0014, and C0016, for reentry, casing, and capping, including installation of a steel mesh platform with valve controls for post-cruise sampling of fluids.

At Site C0016, drilling at the summit of the active hydrothermal mound failed to recover core, and drilling at the base of the mound yielded only 2.1 m of core from 45 m of penetration, but the core included the first Kuroko-type, sphalerite-rich black ore ever recovered from the modern seafloor. The other four sites yielded interbedded hemipelagic and volcaniclastic sediment and volcanogenic breccias and pumice that are variably hydrothermally altered and mineralized, in the zeolite to greenschist facies. Temperature gradients decrease greatly with distance from the active vents at Site C0016, from >7 °C/m at Site C0013, to 3 °C/m at Site C0014, to 0.6 °C/m at Site C0017. Detailed temperature profiles at Sites C0014 and C0017 display irregularities suggestive of lateral flow. The profile at Site C0017 is concave-upward, consistent with recharge of cold seawater into the hydrothermal system at this site.

Analyses of interstitial water and headspace gas yielded complex patterns with depth and laterally at most sites over distances of only a few meters. Documented processes include: formation of brines and vapor-rich fluids by phase separation and segregation, uptake of Mg and Na by alteration minerals in exchange for Ca, leaching of K at high temperature and uptake at low temperature, anhydrite precipitation, microbial oxidation of organic matter and anaerobic oxidation of methane utilizing sulfate, microbial methanogenesis, abrupt changes in composition with depth that result from sealing by relatively impermeable cap rock, and generation of hydrogen at depth, apparently by hydrothermal rather than microbial processes.

Shipboard analyses have not confirmed the presence of an active deep hot biosphere. Cell abundances are much lower than those found in previous Ocean Drilling Program/IODP sites on continental margins, and attempts at culturing were generally unsuccessful. They did find ample evidence for microbial activity supported by sedimentary organic matter, but only in sediments within the upper 10–30 mbsf where temperatures were relatively low. A community of Fe-oxidizers was found at the recharge Site C0014, and subsequently successfully cultured.

See http://www.jamstec.go.jp/chikyu/eng/Expedition/okinawa/exp331.html for more details regarding the background and objectives, the preliminary scientific results, and conclusions of Expedition 331.

RECOMMENDATIONS OF THE EXPEDITION 331 ORTF

Overall, the Expedition 331 ORTF found that the DEEP HOT BIOSPHERE Expedition was very successful. The success resulted from a combination of factors including, "Lessons Learned" from the previous expeditions, experience gained by CDEX working in the "IODP environment", close collaboration between the CCs and operators, and professionalism, willingness, and hard-work shown by all parties to work through issues as they arose at sea and onshore. All parties involved in these operations are to be congratulated on this successful expedition. In particular, the Science Party and the ship operator successfully carried out operations in very active subseafloor hydrothermal systems with high levels of H_2S gas on core samples and created four new artificial hydrothermal vents for future research by drilling.

Expedition 331 shed a bright light on the future of scientific drilling at subseafloor hydrothermal systems.

Acknowledgement 331-01: Wellhead completion

ORTF Exp 331 acknowledges CDEX for successful wellhead completion in extreme conditions at Sites C0013, C0014, and C0016 with using heavy triangular, gimbaled guide bases to allow reentry for deepening the holes and for post drilling operations, including casing and specially designed corrosion capping. This wellhead corrosion cap makes it possible for future scientists to retrieve indigenous subseafloor fluids and microbes at the seafloor through these cased holes using an ROV.

Acknowledgement 331-02: High core recovery rate

ORTF Exp 331 acknowledges CDEX for the high core recovery rate (77%) - the best ever recorded on active subseafloor hydrothermal areas drilling in DSDP/ODP/IODP history.

Acknowledgement 331-03: High quality staffing and operational preparations

ORTF Exp 331 acknowledges CCs and CDEX who successfully conducted high quality Science Party staffing and operational preparations (e.g., core flow schemes) despite the short lead-time.

CCs acknowledge/admire ship-board personnel, including especially, Operations Superintendent (Ikuo Sawada, Tomokazu Saruhashi), EPM (Simon H.H. Nielsen), Curator (Satoshi Hirano), Laboratory Officer (Hiroaki Muraki) and Dynamic Positioning Systems Operators for their outstanding work.

ORTF also identified a few areas of improvement for future *Chikyu* operations including: pre-expedition planning/preparations, during-expedition operations and post-expedition reporting. Many of the issues discussed during this review were related to communication/information sharing and operation protocols and procedures. Specifically, the ORTF identified/expressed the importance of communication between CCs and CDEX in sharing operational and scientific decision-making during the expedition-planning phase and during the expedition to successfully achieve expedition goals. To make it easier to find solutions, ORTF have made specific recommendations around the situations discussed.

While the primary focus of this review was on CDEX operations during Expedition 331,

many recommendations in this report are equally valuable for other IODP operators and some recommendations are directed towards them.

Overall

Recommendation 331-01: Remaining Scientific Objectives
ORTF Exp 331 recommends the remaining objectives of IODP Proposal 601, which have been approved by SAS, should be addressed by a future expedition.

Routing: CCs, SAS, IODP-MI
Background: There were 11 drilling sites in the original proposal (IODP Proposal 601). Only five sites during Expedition 331 could be occupied because the total operation was reduced to 34 days and they had to reduce the number of target sites to fit into this schedule. As a result, Expedition 331 could only achieve part of the scientific targets in the proposal. The part carried out achieved great success. However, after the expedition, SPC deactivated the proposal and the opportunity of revisiting the area to complete the remaining scientific objectives of the proposal has disappeared in the current program. The CC/Proposal PI is willing to submit a new proposal to the new IODP to complete remaining scientific objectives. The results from Expedition 331 will be used to demonstrate the importance of completing the original proposal.

Recommendation 331-02: ROV availability
Whenever possible, the use of the ROV should be utilized to meet the scientific objectives, and not be solely for use in drilling. ORTF Exp 331 recommends that the IO should make available to the scientific community, without a commitment or promise of use, a summary of the capabilities of the ROV.

Routing: CDEX
Background: *Chikyu* has an onboard deep sea ROV normally used for assistance in drilling operations. Its use during science operations was valuable on Expedition 331. Before the expedition, the CCs had no information regarding the ROV aboard *Chikyu* and were not informed about any ROV availability for scientific operations from CDEX. If the information were available in advance, better expedition planning would be possible, or at least considered to add/achieve some more scientific objectives.

Recommendation 331-03: Freezer capacity for sample processing
ORTF Exp 331 recommends that additional -80 ˚C freezer capacity should be supplied onboard *Chikyu*.

Routing: CDEX
Background: During Expedition 331, scientists suffered a delay in the processing of microbiological samples because of limited capacity of -80 ˚C freezer space in the laboratory area. *Chikyu* has several freezers for freezing, processing and storing samples, but some of those were not fully used during the expedition because the temperature settings were different from that required for the processing. External Reviewer and CCs pointed out that those freezers on *Chikyu* may be able to change their temperature setting and may provide more flexibility/capacity on the sample storage for microbial research on future expedition.

Pre-Expedition

Recommendation 331-04: Drilling tools selecting
ORTF Exp 331 recommends that when drilling is likely to be very complex, a rigorous review system should be in place to ensure that the best tools are chosen from the range available.

Routing: CDEX
Background: Drilling operation on site C0016 at Expedition 331 were expected to be difficult because of hard rock coring under high temperature. Site C0016 was drilled with a conventional/industry hard rock coring system leased by Baker-Hughes Inteq (BHI) to CDEX for Expedition 331. CDEX contacted several drilling equipment companies to select suitable drilling tools for Site C0016 condition. However, the BHI coring system, which CDEX selected, recorded very poor performance at Site C0016. Firstly, the system does not support wireline-type coring and the entire drill string had to be tripped every time to recover core sample, which took much more time than IODP coring system. Secondly, the friction-type core catcher on the system had problems holding core samples under strong vibration on drill pipe caused by sea current when recovering core sample. As a result, *Chikyu* could recover only 2.1 m of material from 45 m of penetration (4.7% recovery) at Site C0016.

Recommendation 331-05: Staffing
ORTF Exp 331 recommends that staffing, especially the selection of CCs and other critical scientists, should be completed at least 6-12 months before the expedition.

Routing: CDEX
Background: Expedition 331 had a very short lead-time (less than 6 months) in which to prepare everything for the expedition, due to uncertainty of JAMSTEC

operation budget, and Japanese budgeting system/timeline. This very short preparation period made it difficult to find appropriate non-Japanese CC candidates and onboard scientists until very late in the preparation period. As a result, those selected scientists/CCs could not participate as fully as would have been wished in the expedition planning process.

Recommendation 331-06: Science Party Training
ORTF Exp 331 recommends that sufficient time needs to be scheduled for training scientists in the use of lab facilities. This can be a combination of port call and transit time.

Routing: CDEX
Background: Many of the scientists at Expedition 331 were new to an IODP expedition and they were lacking in experience on onboard measurement tools, standard measurements, sample requesting, IODP obligations and cruise reports. However, training in those items to scientists was not implemented in an effective and efficient manner by CDEX during the five days port call and one day transit. This insufficient training allowed for some confusions, delay on measurement and unnecessarily rushed work in the latter part of the expedition.

During Expedition

Recommendation 331-07: Communications 1 [Shipboard and Shore-based decisions]
ORTF Exp 331 recognizes that CDEX needs to issue clarification of protocols and procedures and to shipboard and shore-based decisions.

Routing: CDEX
Background: Overall decision making on *Chikyu* during Expedition 331 functioned quite well. However, some critical communication errors and opaque operation protocols and procedures of CDEX critically affected some operational decisions and its operation results.

Recommendation 331-08: Communications 2 [Time sensitive decisions]
ORTF Exp 331 recognizes that chain of command of *Chikyu* for time sensitive decisions need to be clarified and implemented.

Routing: CDEX
Background: During Expedition 331, CDEX found that one of the holes (INH-6B) to be drilled at Site C0017 had been erroneously omitted from Scientific Prospectus of Expedition 331 and assumed that the hole was not approved by the Environmental Protection and Safety Panel (EPSP). CDEX rapidly requested EPSP

approval for drilling Hole INH-6B, but they had to wait to spud the hole until they received this response from EPSP. Therefore, Expedition 331 lost a few hours of rig time for this extra process. However, Hole INH-6B - although not in the final Scientific Prospectus - had been included in the Site C0017 safety package to EPSP and was already approved with other holes before the expedition. The error was due to miscommunication between the EPM and CDEX.

Recommendation 331-09: Communications 3

[Critical decisions at executive committee]

ORTF Exp 331 recognizes that critical decisions should be made by consensus of the executive committee, which consists of CCs, OIM, OSI, and EPM. When shore-based input is required, the communication should go through this committee.

Routing: CDEX

Background: During Expedition 331, CDEX had held daily executive committee meetings, which included CCs, OIM, OSI, and EPM to discuss and decide the daily operation plan. However, some of the important decisions at the executive committee were overruled by onboard operation people without any consultation with CCs and EPM. For example, once the committee decided to use the hydrolift-type core catcher on BHI tools in Site C0016 after experiencing low recovery problems with using the friction-type core catcher (Recommendation 331-04), the decision was later overruled by onboard operation staff because the high temperatures from hydrothermal fluids could cause serious damage to the hydrolift-type core catcher seals. This important change was not related to, or discussed with the CCs and EPM, and resulted in continued poor core recovery. However, before making any decision the committee needs to have all the facts to make a decision. In this case, there was no guarantee that the hydrolift-type core catcher would work. The operational constraints, particularly with regard to heat, should have been made available to the committee. Then the committee would have been able to make an informed decision on whether the hydrolift-type core catcher should have been used. And the decision would have to be accepted by all parties.

Recommendation 331-10: Decisions for special scientific requirements or unforeseen scenarios in lab measurement protocols

While scientific measurements generally follow set protocols, provisions should be made for special scientific requirements or unforeseen scenarios. In this case, ORTF Exp 331 recommends that the decision of the CCs and EPM is the final word, and changes must be documented in writing.

Routing: CDEX, MWJ

Background: Expedition 331 had some problems with calibration and standardization on sample analysis in the various lab-equipments. Scientists found that the technicians on *Chikyu* were simply following a set of standard protocols from the instructions in the manuals, which did not provide useful measurement calibration for Exp 331. Technicians did not follow instructions from the CCs and EPM to use different calibrations, ones more appropriate for Exp 331. This miscommunication regarding calibration instruction resulted in some meaningless measurements in the early part of the expedition, but the situation was later resolved.

Recommendation 331-11: Time and temperature sensitive sampling

ORTF Exp 331 recommends that time and temperature sensitive sampling on the catwalk should be allowed to be undertaken by scientists (e.g., high H_2S levels), provided that they had approval from the ships Chief Safety Officer (CSO).

Routing: CDEX

Background: There was difficulty on handling core samples collected from the hydrothermal area at Expedition 331 because many of core samples contained H_2S gas. The H_2S gas measurement was conducted on most of the core samples for safety reason by *Chikyu* technicians immediately after the core sample arrived at the core deck. However, this process took too long. In some cases, scientist received core samples for first measurement six hours after the core sample had arrived on the core deck. Because *Chikyu* H_2S safety regulations typically prevent scientists from performing time- and temperature-sensitive sampling on the core deck, H_2S safety officers on *Chikyu* had trained some scientists to be able to work on core samples including H_2S gas for their measurement. However, this information was not shared with all relevant personnel, so that the scientists were unfortunately denied access to the core deck and catwalk.

Recommendation 331-12: Core liners on high temperature coring operations
ORTF Exp 331 recommends that for high temperature coring operations, plastic core liners should not be used. Aluminum, Fiberglass, Steel or other appropriate material should be used instead.

Routing: CDEX
Background: At the beginning of drilling and coring operations on Expedition 331, HPCS, EPCS and ESCS, regular plastic core liners were used. Immediately on penetrating beyond several meters below the seafloor, greater than 150 ˚C hydrothermal fluids were discovered, catastrophically melting the plastic core liners. In the latter half of the expedition, the plastic core liners were replaced with aluminum ones by CDEX. These were very effective in the high temperature environment. External reviewers recognized that CDEX still needs more research to introduce new materials for future expeditions.

Recommendation 331-13: Downhole temperature measurement
ORTF Exp 331 recommends that the availability of, or research on, downhole temperature measurement instrumentation should be periodically reviewed (including temperature above 100 ˚C). Temperature sensitive strips should be provided as standard equipment on every drilling expedition, but not as a general replacement for the APCT-3. This information also needs to be shared with the other IO's.

Routing: CDEX
Background: Frequent downhole temperature measurement was required for monitoring hydrothermal activity on drilling depth at Expedition 331. At the beginning of the expedition, temperature measurements were only available via the APCT-3 tool during coring operations. The APCT-3 can only measure temperatures up to 55 ˚C due to electrical component specifications. This 55 ˚C limitation was too limited a range for use in Expedition 331, where the formation temperatures were often greater than 150 ˚C.
Conveniently, one CC brought Temperature Sensitive Strips, which are capable of a very wide range of temperature measurements. This strip is impregnated with plastic beads with different sets of melting temperatures in its surface and can be easily affixed on to the surface of core liners. This strip provided very useful downhole temperature measurement data during the expedition.

Post-Expedition

Recommendation 331-14: Preliminary report deadline

It is the responsibility of the CCs and the EPM to finish the preliminary report ideally before disbandment. ORTF Exp 331 recommends that where this is not possible, it should be submitted no later than 1 month after the expedition.

Routing: CDEX

Background: It is standard procedure for every IODP expedition that all shipboard scientists are required to submit their sections of the Preliminary & Expedition Reports to the CCs and EPM/PA before disembarking. Usually scientists complete their report during transit to port at the end of each expedition. However, in the case of Expedition 331, scientists only had a day or less of transit to port. Better attention needs to be made on getting these report completed on time and adhering to the IODP publishing schedule.