IODP Proposal Cover Sheet

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Guatemala Basin Hydrothermal Pits

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Title	Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?
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Keywords	hydrothermal, sedimentary depressions, Cocos Plate
Area	Guatemala Basin

Proponent Information

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Abstract

Roughly circular depressions or pits <3 km in diameter occur in thick, carbonate-rich sediments of the central and eastern Pacific Ocean. These are hypothesized to result from a "hydrothermal siphon" related to seamounts and sediment-covered basement highs, in which large seamounts act as recharge entry points for active hydrothermal circulation into permeable upper oceanic basement and smaller seamounts act as discharge points even as they become covered with calcareous sediments. Due to the retrograde solubility of calcite, the recharged and circulating fluids precipitate calcite in basement, become under-saturated as they are warmed in basement, and then dissolve some of the calcareous sediments as they discharge, thereby resulting in depressions or pits in the sediment cover above basement topographic highs. This kind of hydrothermal siphon process seems especially pronounced in the Cocos Plate, which has been cooled far below conductive plate heat flux predictions.

In 2010, an R/V Sonne cruise conducted detailed surveys of several seamounts and pits in an area of the Cocos Plate near Site 1256 where crustal age is 15-18 Ma. Survey results confirmed that low heat flux is associated with the seamounts, heat flux is high within the depressions, and most depressions are associated with underlying basement highs. However, pore water analyses show no indications for advection, suggesting that the pits are mostly sealed today with a pelagic sediment cover. A modified model for their formation accounts for passage with age of the sites northwestward through the equatorial high-productivity region, with more active hydrothermal discharge at young ages dissolving some of the older sediments, producing initial depressions that have not yet been completely filled with pelagic sediments.

The APL requests 7.1 days of JOIDES Resolution time to test this model by coring sediments and basement in a prime example of a hydrothermal pit with high heat flux over an underlying basement high, and by comparing results to a reference site ~2 km away outside the pit with thicker sediments and low heat flux. The programs at both sites are designed to assess the significance of present-day and past hydrothermal processes and their potential effects on sedimentology, microbiology, and geochemistry. The results should be of high relevance to hydrothermal aspects of Challenges 5, 10, and 14 of the current IODP Science Plan as well as Strategic Objectives 1, 2, and 6 and Flagship Initiative 5 of the new 2050 Science Framework.

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Scientific Objectives

Test the hydrothermal model for formation of depressions or pits in carbonate-rich sediments of the equatorial Pacific by coring, downhole temperature measurements, and fluid-sampling at two representative locations:
(1) A well-surveyed example of a large pit with high heat flux and sediment cover of ~146 m. Here the program would include APC/XCB coring to basement with detailed temperature measurements and dedicated whole-round sampling for microbiology and pore water chemistry, plus RCB coring of uppermost ~60 m of basement with temperature and borehole fluid sampling.
(2) A reference site ~2km from the pit site, with low heat flux and a complete sediment cover of ~270 m. Here the program would include APC/XCB coring to basement with detailed temperature measurements and dedicated whole-round sampling for microbiology and pore water chemistry.
The programs at both sites are designed to assess the significance of present-day and past hydrothermal processes and their potential effects on sedimentology, microbiology, and geochemistry. The results should help explain the unusually cool state of the Cocos plate, with implications for its subduction at the Middle America Trench and potential effects on Central American arc volcanism. The results should be highly relevant to hydrothermal aspects of Challenges 5, 10, and 14 of the current IODP Science Plan as well as Strategic Objectives 1, 2, and 6 and Flagship Initiative 5 of the new 2050 Science Framework.

Non-standard measurements technology needed to achieve the proposed scientific objectives

WSTP (listed by JRSO as available on request).
Use of perfluorocarbon tracers to monitor potential contamination during drilling APC and RCB operations, as is routine during microbiological sampling.
KOACH clean air system in the microbiology lab area, or in the temperature controlled lab, for processing whole round core for microbiology.

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

We thank the SEP watchdogs for such a thorough, detailed review of 980-APL2. We have substantially revised our main "Sampling Rationale" section in an attempt to meet the SEP requests for further detail on the approaches and techniques we would apply for pore water and sediment geochemistry, basement geochemistry, and microbiological analyses. We have also replaced figure 4 to better illustrate the rationale and expectations for the proposed microbiological analyses. We hope we have achieved sufficient detail to satisfy the SEP comments within the APL word limits.

There was one SEP request we did not address in the revised text but discuss instead in this response letter: assessing the extent of possible lateral flow in the sediments. This is mainly because we expect the primary direction of any flow through sediments would be vertical given that the primary pressure gradients driving flow are dominantly vertical between permeable basement and ocean bottom water. In addition, properly assessing the possibility of lateral flow within the sediments would require an array of multiple holes, which is well beyond the scope of this APL. We would respectfully remind SEP that our strategy with this APL is to conduct an initial test of the main hypothesis that equatorial Pacific sediment pit formation is associated with dissolution of young carbonate sediments by predominantly vertical hydrothermal flow. We would thereby utilize as efficiently as possible a precious commodity at the end of the current IODP: a few days of JR ship time.

Thus, our strategy is to first attempt to constrain the main processes that led to the formation of pits in the past. Nevertheless, we can indeed envision scenarios in which there may have been lateral components to flow within the sediments at certain stages in the evolution of the pits, e.g., (1) shallow recharge entrained through the sediments surrounding original vertical discharge locations, or (2) following development of horizontal permeability barriers to vertical flow within the sediments (for which there could be evidence from core and physical properties data as noted in the revised APL). Should this APL be scheduled and verify the main hydrothermal hypothesis, then the results would provide the participant team and scientific community a stronger basis for developing a full proposal for an extensive revisit to the area – a well surveyed natural laboratory with no weather or safety issues - to fully document the evolution of its hydrothermal system with particular attention to the role of seamounts.

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Proposed Sites (Total proposed sites: 2; pri: 2; alt: 0; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
GB-01A (Primary)	7.964827 -90.562110	3517	146	60	206	APC/XCB sediments to basement, RCB to ~60 m in basement. Whole-round sampling for microbiology and pore water chemistry. APCT-3 and SET2/SETP sediment temperature measurements. WSTP temperature/ fluid sampling in near-basement section. If time allows and conditions warrant, WSTP at end of RCB coring for temperature and borehole fluid sampling in basement section.
GB-02A (Primary)	7.948736 -90.546078	3445	270	0	270	APC/XCB sediments to basement. Whole-round sampling for microbiology and pore water chemistry. APCT-3 and SET2/SETP sediment temperature measurements.