IODP Proposal Cover Sheet

980 - APL 2

Guatemala Basin Hydrothermal Pits

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Title	Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?
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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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980 - APL 2

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.

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

We thank the SEP for such a thorough review of 980-APL, and our JRSO contacts (E. Estes, K. Grigar) for being so responsive to our queries as we prepared 980-APL2. We have added more detailed discussion to clarify the following matters noted by SEP:

- The sediment velocity model to estimate depths to basement (also see below);
- Differentiating effects of (1) formation of pits by past hydrothermal discharge through basement highs and (2) possible continuing circulation within basement;
- The proposed basement penetration in pit site GB-01A (now reduced to 60 m) versus no basement coring in reference site GB-02A;
- A better description of our deep biosphere objectives and approaches.

We acknowledge our oversight in using an unrealistic constant sediment velocity model of 1.5 km/s. A detailed model was developed in the Site 844 Chapter and used successfully to create a synthetic seismogram that closely matches the reflector sequence there. That model suggests an average velocity of ~1.6 km/s for the section, and comparing TWT to basement (360 ms) and actual cored depth to basement (290 m) in Hole 844B yields an average velocity of 1.61 km/s. Using the last, our estimated depths to basement at GB-01A and GB-02A are now deeper by 10 and 18 m, respectively. Using those depths and the reduced request for GB-01A basement penetration, the JRSO time estimate is down to 7.1 days on site for the proposed 980-APL2 program.

The SEP concern about using 1.5 km/s may have contributed to an apparent misconception in the review that our reflection data are true MCS data. We explained this in the SSDB pages when submitting the data files, but that doesn't appear on the site forms so it may have been overlooked. The 2010 reflection data were collected with a multi-receiver streamer, but it was quite short (100m) relative to water depth (>3km) so it is functionally equivalent to SCS data. With multiple receivers, the data could be processed with MCS software and presented with CDP's, but they do not contain any wide-angle information to resolve depth variation of sediment velocities. Thus, the velocity model from Site 844 is the best reference.

Hopefully this will allay the SEP concern that shallower basement beneath the pit may be a processing artifact. With an average velocity of 1.61 km/s elsewhere, it would require an unrealistically high pit sediment velocity of ~2.8 km/s to drop pit basement depth down to the basement depth in the surrounding area.

We endorse the SEP suggestion that we work with JRSO in recalibrating their downhole temperature probes at our expected temperatures. We have already been in contact, and JRSO has alerted us to two relevant matters: First, there is an updated SET2 tool with high-resolution electronics that we think is the best tool for our purposes up to its current limit of ~50°C. Second, the SETP is being upgraded, retaining its higher upper temperature limit of ~100°C. Accordingly, in the revision we have replaced SETP with SET2/SETP as appropriate.

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.