IODP Proposal Coversheet

Guatemala Basin Hydrothermal Pits	Received for: 2020-10-01

Title

Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?

Proponents

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Keywords

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Area

Guatemala Basin

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Permission granted to post the coversheet/site table on www.iodp.org

Yes

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.

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)	Sed	Bsm	Total	Brief Site-Specific Objectives
GB-01A primary	7.964827 -90.56211	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.

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Heinrich	Villinger	University of Bremen	Germany	Other Lead	subseafloor hydrogeology, marine geophysics
Norbert	Kaul	University of Bremen	Germany	Data Lead	marine geophysics
Geoff	Wheat	University of Alaska	United States	Other Lead	porewater geochemistry, subseafloor hydrogeology
Beth	Orcutt	Bigelow Laboratory	United States	Other Lead	geomicrobiology
Wolfgang	Bach	University of Bremen	Germany	Other Lead	petrology, alteration
Earl	Davis	Geological Survey of Canada	Canada	Other Proponent	subseafloor hydrogeology, marine geophysics
Ivano	Aiello	Moss Landing Marine Lab	United States	Other Proponent	sedimentology
Steffen	Jorgensen	University of Bergen	Norway	Other Proponent	geomicrobiology
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Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?

Motivation

A compilation of seafloor heat flux and sediment thickness for the Cocos Plate reveals that it is cooled significantly below conductively predicted values before being subducted at the Middle American Trench (Heesemann et al., 2009). This heat deficit is attributed to numerous seamounts on the plate that penetrate through the sediment layer, providing pathways for cold seawater to enter and cool the permeable upper crust. Detailed heat flux measurements on the Cocos Plate (Hutnak et al., 2007, 2008) show that larger seamounts act as recharge sites, with discharge at smaller seamounts, consistent with the "hydrothermal siphon" model (Fisher et al., 2003).

Observations of roughly circular depressions in the sediment cover in equatorial Pacific regions may show another effect related to the hydrothermal siphon model. Mayer (1981) first surveyed such depressions in the central equatorial Pacific, suggesting an erosional origin related to basement topographic highs that seemed to underlie the pits. Michaud et al. (2005) and Moore et al. (2007) reported similar depressions farther east, also associated with underlying basement highs. Moore et al. (2007) suggested that dissolution of carbonates may play a role in the formation of the pits, linked with hydrothermal discharge through underlying basement highs or faults.

Bekins et al. (2007) developed a conceptual carbonate dissolution model linking seamounts to hydrothermal formation of these depressions. In this model, cold seawater circulates into basement via seamounts and is gradually heated up as it flows laterally in the permeable uppermost crust, precipitating calcite in the pore spaces due to its retrograde solubility. As the fluids flow laterally, upwelling of warm water through the carbonate-rich sediments may occur if permeability or basement structure allows, as at a sediment-covered basement high. The upwelling fluid is undersaturated with respect to calcite, so it dissolves some of the carbonate-rich sediments it contacts above the basement high, thereby creating the pit.

We request ~7 days of *JR* ship-time to test a refined model of pit formation with coring, downhole temperature measurements, and formation-fluid sampling in a carefully surveyed "hydrothermal pit" in the eastern equatorial Pacific and a reference location ~ 2 km away from the pit. By testing the role of hydrothermal circulation on pit formation, and its impacts on biogeochemical processes and deep biosphere diversity, results will directly address Challenges 5, 10 and 14 of the 2013-2023 IODP Science Plan. By targeting hydrothermal circulation processes in 10-20 Ma crust and its impacts on overlying sediment biogeochemistry, about which little is currently known, results will also contribute to Strategic Objectives 1, 2, and 6, and Flagship Initiative 5, of the new 2050 Science Framework.

Survey Data and Hypotheses

Villinger et al (2011, 2017) conducted detailed surveys of pits and seamounts in the Guatemala Basin in 2010 to test the Bekins et al. (2007) model, using swath mapping, sediment echo-sounding, single-channel seismics (SCS), gravity coring, and seafloor heat flux measurements (Figure 1). These were co-located in the three areas where Wilson et al. (2003a,b) had conducted earlier site surveys for Site 1256. The model suggested that down-flow of cold seawater at exposed seamounts and up-flow through sedimented basement structures under pits should result in a halo of depressed seafloor heat flux around seamounts and elevated heat flux inside the pits. The model also suggested that pore water profiles of cores taken inside pits should show indications of advective fluid transport.

The survey results (Villinger et al., 2017) were generally consistent with these model predictions (Figure 2). Bathymetry, sediment-echo sounding, and SCS records show that most of the surveyed pits are associated with underlying basement highs and that significant amounts of the carbonate-rich sediments inside the pits are missing. Low heat flux values adjacent to all surveyed seamounts indicate recharge of cold seawater into the upper crust. Heat flux within the pits is always elevated, in some cases up to three times relative to values nearby. However, none of the geochemical pore water profiles from cores up to 12 m long from within or around pits show evidence of presently active fluid flow.

These results largely support the Bekins et al (2007) model for hydrothermal origin of the pits, but they suggest that the pits are no longer hydrothermally as active as in the past. Plate motion reconstructions indicate that the Guatemala Basin sites originated near the equator and migrated northeast to their present locations (Gripp and Gordon, 2002). Therefore Villinger et al. (2017) proposed a modified model illustrated and described in detail in Figure 3. This model involves two main inter-related hypotheses: First, that the pits were formed originally by off-axis hydrothermal discharge through basement highs in the carbonate-rich equatorial high productivity zone, and second, that there may be less active ridge-flank hydrothermal circulation still continuing in basement underlying the pit. By sampling within a hydrothermal pit and a nearby reference site, we can test the hypotheses that result from this modified model:

- upper basement rocks under the pit show an alteration history resulting from hydrothermal discharge and interaction with seawater, with higher basement temperatures beneath the pit;
- pit sediment near basement shows advective influence of hydrothermal discharge, including dissolution of foraminifera;
- microbial community structure within the pit shows influence from past and/or current advection;

Sampling Rationale

<u>Sediment Pore Waters and Geochemistry:</u> As shown in past studies (e.g., Mottl and Wheat, 1994), vertical variations in pore water chemistry, in combination with sediment geochemistry, can provide clear indications of vertical advection through the sediments, whether it occurred in the past or is ongoing. For determining past flow history at the basement high beneath the pit, the composition of basal sediments and basement alteration products are the most critical objectives. For elucidating current exchange and reaction processes at each site, profiles from the entire sediment column are required (i.e., one IW sample from every core plus WSTP sampling runs deep in the section), and such continuous profiles are also crucial for microbiological objectives. Based on experience from nearby Site 844, we will be able to compare carbonate content proxies (e.g. XRF) on an individual bed scale between dissolution-affected Site GB-01A and reference Sites GB-02A and 844, thus allowing a detailed determination of dissolution and diagenesis processes.

<u>Basement Coring:</u> We propose basement coring only at the pit site, where the alteration record in the top 50-60 meters of basement should be diagnostic of the evolution of formation fluid chemistry and temperature. Hole 896A, in a sediment-covered basement high in ~ 6 Ma crust on the southern flank of the Costa Rica Rift, may be analogous to Stages 2/3 on Figure 3. Core from

its upper basement section recovered a significantly higher proportion of calcite veins and alteration than in nearby reference Hole 504B. Analysis of these alteration products allowed Teagle et al. (1996) to deduce several alteration stages and a hydrothermal discharge history at the Site 896 basement high. This experience suggests that coring ~50-60 m would provide sufficient vein material for a similar analysis of discharge history at GB-01A, and it would not require comparison basement coring in our reference site GB-02A. We will use chemical and isotopic (C, O, Sr, Ca) composition of calcite veins to reconstruct the composition and temperature of basement fluids (Coggon et al., 2004) and date the calcite veins from microbeam analyses of $^{238}U/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios with laser-ablation mass spectrometry (Coogan et al., 2016). This will provide an account of how the composition of circulating fluids and basement temperature have changed with time, allowing reconstructing the temporal and spatial evolution of hydrothermal flow in the upper basement underneath the pit.

Microbiological objectives will determine how microbial biomass, diversity, and functional potential vary as a function of past or present fluid circulation. We hypothesize that microbial biomass will be higher in pit versus reference sediments due to a higher relative percentage of organic carbon in the pit resulting from the loss of the dilutant carbonate from fluid-driven dissolution and due to heat and solute transport from basement (Figure 4). We also hypothesize that the microbial communities within pit sediment and upper basement will more closely resemble those of anaerobic basaltic environments like the Juan de Fuca Ridge flank as compared to oxic basaltic environments like North Pond (Orcutt et al., 2020). Results will contribute to understanding of the deep biosphere by establishing linkages between heat flow, sediment organic content, fluid transport, and cellular biomass in sediments around ~15 Ma. To our knowledge, there are no sediment cell biomass measurements from the eastern flank of the East Pacific Rise. Thus, our results will contribute to global sediment biomass datasets (Kallmeyer et al., 2012) and existing efforts to model global biogeochemical provinces in the deep biosphere (D’Hondt et al., 2019).

Evaluating these hypotheses requires fresh sediment and basement samples. We request to use synthetic fluorocarbon tracers during coring operations for estimating possible drilling contamination (Orcutt et al., 2017). For sediment biomass, diversity, and functional potential, sterile syringes will be inserted into APC and XCB core interiors immediately adjacent to interstitial water samples and then subsampled and preserved for shore-based tracer concentrations, bulk DNA extraction for amplicon-based microbial diversity surveys, and flow-cytometric-based sorting for cell counting and/or genome analysis, following methods used successfully on Exps. 357 and 360. We plan to collect one sample per APC/XCB core, with potentially higher resolution near the sediment-basement interface. Samples for carbonate/organic carbon will be collected at a similar frequency for comparing biomass and diversity to carbon content. Sediment dissolved oxygen concentrations will be measured on the remainder of the core prior to splitting using third-party oxygen optode sensors (Orcutt et al., 2013). During basement coring, we will collect one representative 10-15 cm-long intact piece per core; its exterior will be cleaned following established procedures before being split to collect and preserve subsamples for similar biomass, diversity, and functional potential analyses.

Temperatures: We propose multiple temperature probe deployments in both sites, using APCT3, WSTP, and SET2 (or upgraded SETP if appropriate). We would conduct all standard physical properties laboratory measurements on both sediment and basement cores, with special emphasis on detailed profiles of thermal conductivity to combine with the downhole temperatures to determine true heat flux and constrain possible present-day vertical fluid flux rates.

Proposed Operational Strategy

We propose to core and sample two sites through the complete sediment cover to basement, one inside a pit and one at a nearby reference hole, followed by coring basement to ~60 m at the pit site (Table 1). Our primary pit site GB-01A lies in ~3517 m water depth within the GUATB-01 survey area; it is the largest pit investigated in 2010, where heat flux up to 300 mW/m^2 was measured and basement temperature is estimated at ~50-60 °C (Figure 2). We propose the location of the highest heat flux measurement for GB-01A, although it is slightly offset from the intersection of the two crossing SCS lines over the pit. The reference site GB-02A is located in ~3445 m water depth ~2 km southeast of the pit, where heat flux is low and the complete sediment profile can be correlated to Site 844 ~6 km away.

To estimate depths to basement at the two sites, we applied the detailed velocity model developed at Site 844 to create a synthetic seismogram that successfully simulated the seismic sequence there (Shipboard Scientific Party, 1992). That model can be represented well by an average velocity of 1.61 km/s through the sediment section, consistent with 360 ms TWT and 290 m actual depth to basement at Hole 844B. Using that velocity, estimated depths to basement are 146.5 m at GB-01A (182 ms TWT) and 270 m at GB-02A (336 ms TWT).

We propose a single pipe trip of the APC/XCB BHA for sediment sampling of the complete sediment section within the hole at each site, including downhole temperature measurements with APCT-3 until APC refusal, then SET2/SETP or WSTP in deeper sections. We would then change BHA's for RCB basement coring to 60 m at the pit site GB-01A. If time allows, before pulling out of the hole we would run WSTP into the upper basement section, to check for possible establishment of up-flow of warm basement fluids and sample those fluids. Experience at other examples of ridge-flank producing holes (e.g. Hole 896A, Becker et al., 2004) suggests this is not likely so soon after RCB coring, so this is a lower-priority objective.

We do not plan wireline logging, because reasonable logs were collected at the nearby Site 844. The proposed sites should pose no safety or hydrocarbon risks, as the working areas have passed previous EPSP reviews for Legs 138 and 206.

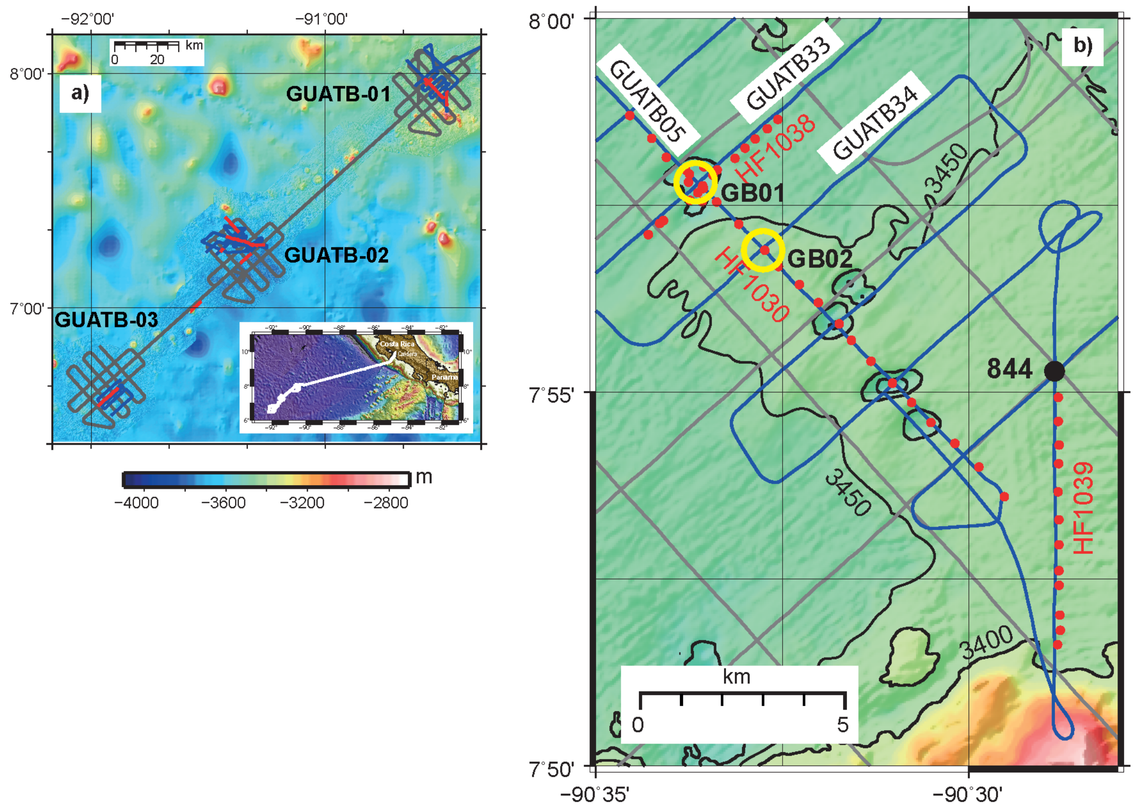


Figure 1. (a) GUATB survey areas in the Guatemala Basin, showing regional position. (b) Detailed map for proposed sites GB-01A and GB-02A, shown in yellow circles. Gray solid lines are GUATB01 multi-channel seismic (MCS) profiles of Wilson et al. (2003b). Blue solid lines are single channel seismic (SCS) profiles and red solid circles are locations heat flow measurements, both from Villinger et al. (2017). Colour scale is the same as in Figure 1a.

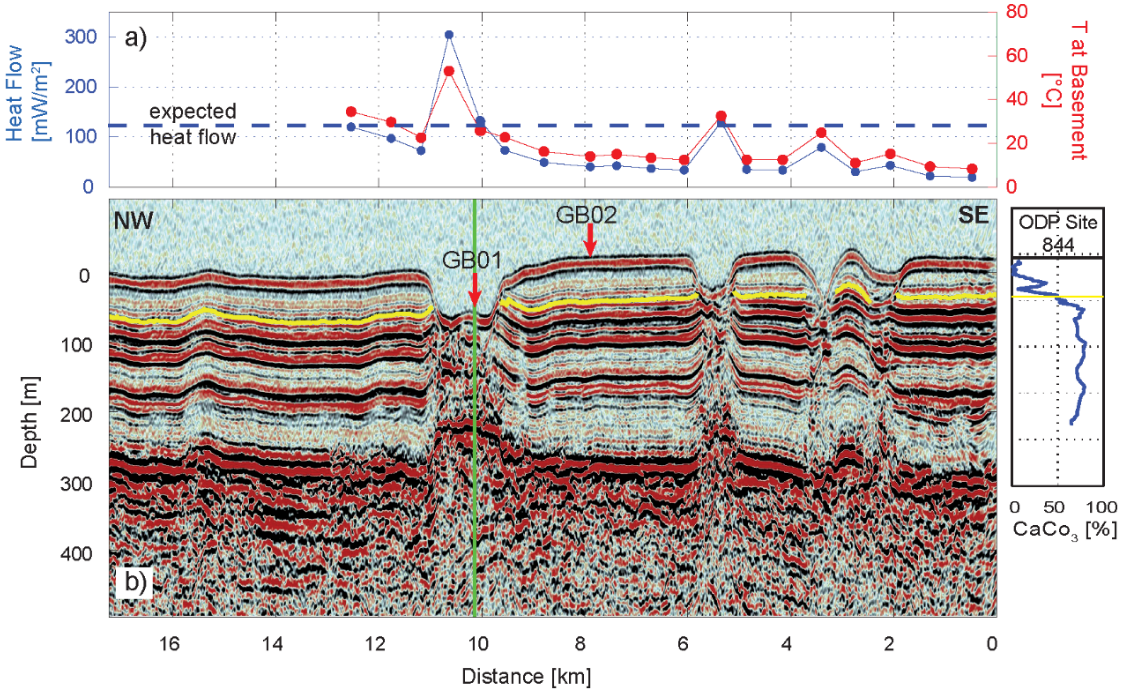
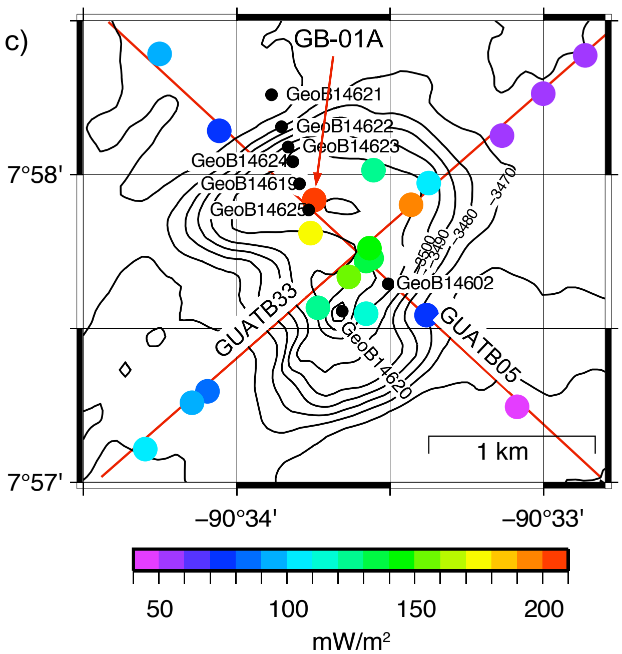


Figure 2. Survey data at proposed sites GB-01A and GB-02A from Villinger et al (2017).

a) and b): Measured heat flow and estimated temperature at sediment-basement interface along SCS profile GUATB05. Estimated temperatures are calculated assuming purely conductive heat transfer. Green vertical line marks the intersection with SCS profile GUATB33. Yellow solid line marks the change of carbonate-rich to carbonate-poor sedimentation derived at Hole 844B (Shipboard Scientific Party, 1992).



c). Variation of heat flux in and around the GB-01A pit. Colour-coded solid circles denote measured heat flux values. Site GB-01A is located at the highest measured heat flux ~200 m northwest of the intersection of seismic line GUATB05 and GUATB33. Solid black circles mark locations of gravity cores.

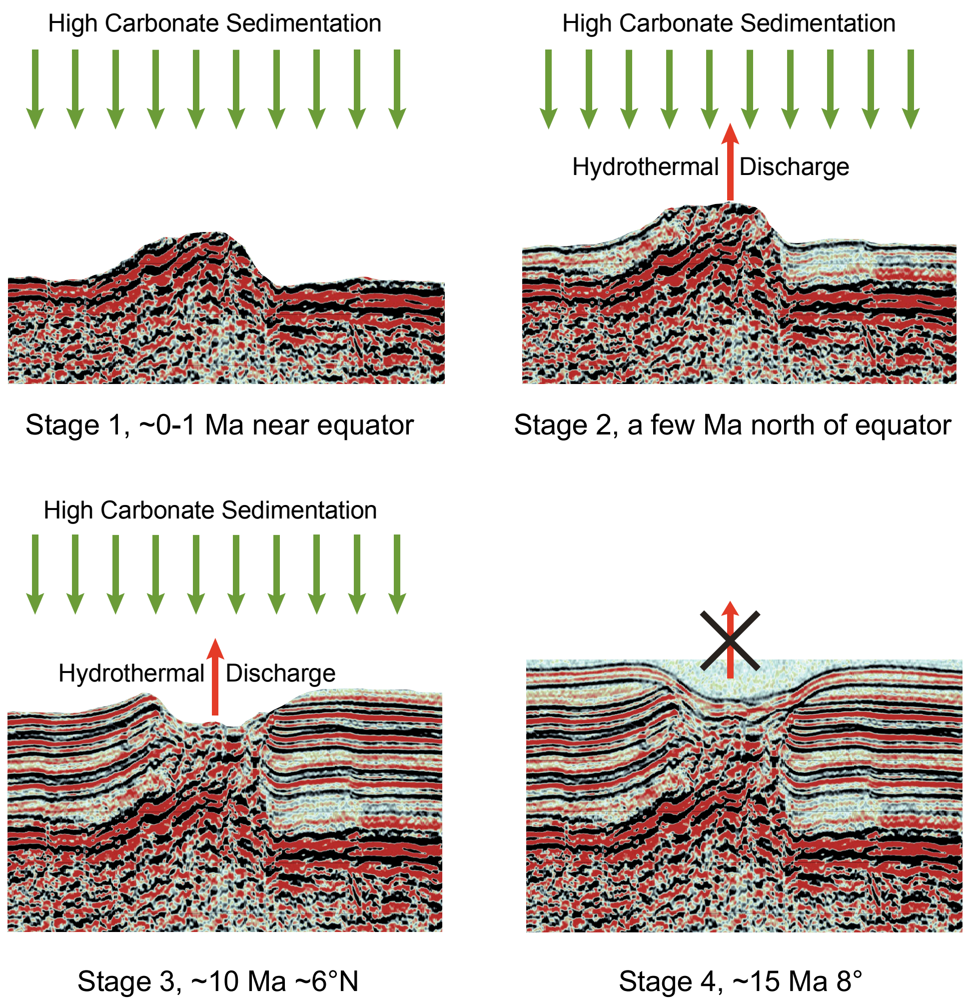


Figure 3. Modified model for hydrothermal formation of pits from Villinger et al. 2017, with past structure approximated by masking present-day seismic reflection data. Stage 1: The site lies within the high carbonate sedimentation zone, but insufficient sediment cover has accumulated to inhibit diffusive exchange of bottom water and formation fluids through most of the seafloor. Stage 2: The sediment accumulation has reached a threshold to seal most flat-lying seafloor. This threshold focuses hydrothermal discharge through thinly-sedimented basement highs, beginning partial dissolution of overlying carbonates. Stage 3: As the site migrates northeast within the region of high carbonate sedimentation, focused discharge continues along with dissolution of carbonates. Stage 4: Once the site migrates outside of the high productivity region, the accumulation of carbonate rich sediments wanes, pelagic sediments slowly seal the hydrothermal sediment depression, and discharge wanes.

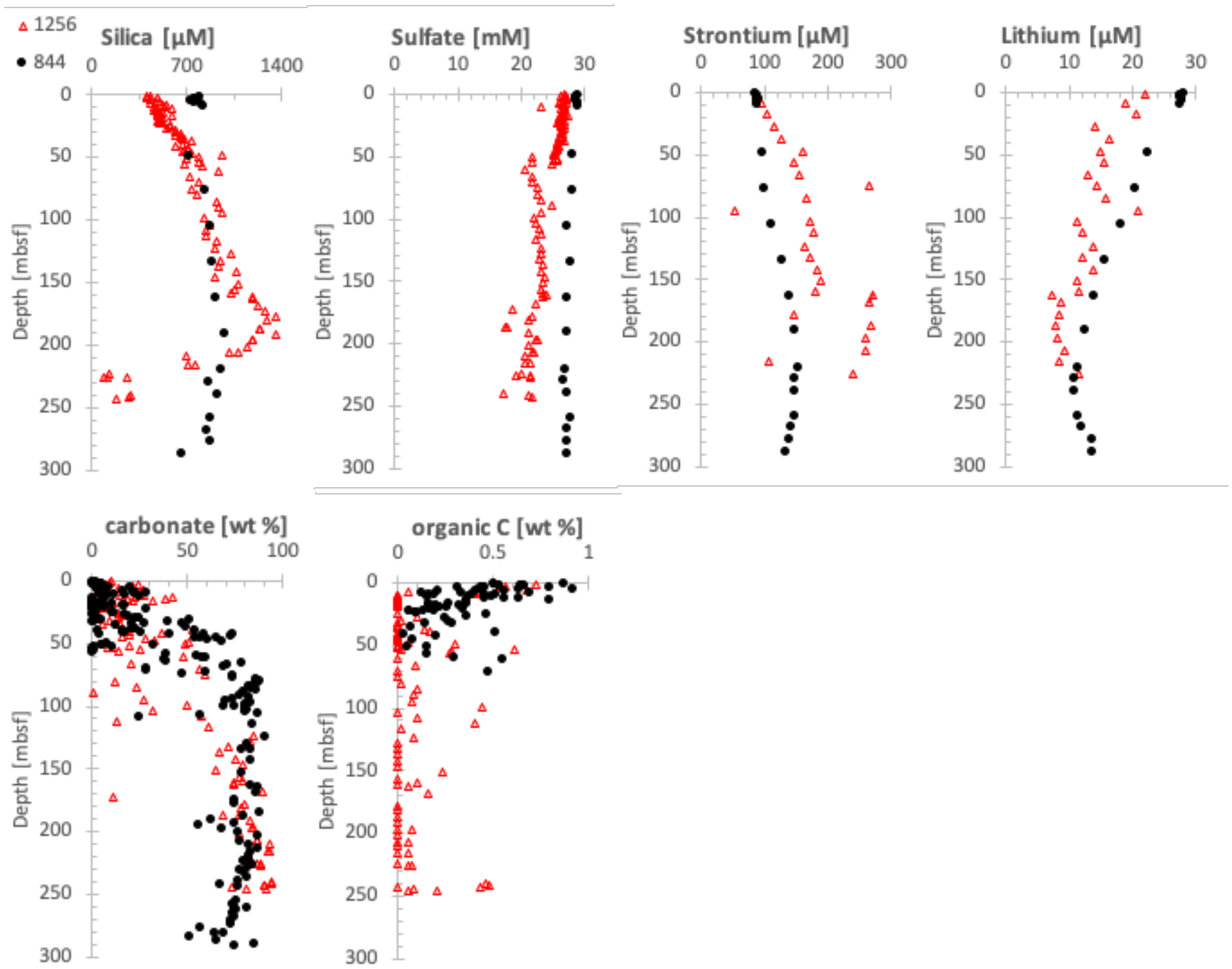


Figure 4. Sediment geochemical profiles from Sites 844 (black circles) and 1256 (red triangles) reveal: solute transport across the sediment-basement interface (i.e. decreases in silica and strontium and slight increase in lithium); minimal sulfate reduction, which may indicate oxic and/or suboxic conditions in part of the sediment column; and low organic carbon content in reference sediments.

Table 1. Proposed operational sequence.

GB-01A hydrothermal pit, 3517 m water depth, 146.5 m sediment part 1	JRSO time estimate (K. Grigar, 4 Sept 2020)
RIH with APC/XCB BHA to seafloor	1.7 days
APC to refusal with APCT-3 every other core starting with #4, then XCB to top of basement	
During coring, 3 runs SET2/SETP or WSTP in deeper part of hole	
POOH to seafloor	
DP ~2km to GB02A	0.1 days
GB-02A reference site, 3445 m water depth, 270 m sediment	
APC to ~175 mbsf with APCT3 every third core starting with #4, then XCB to top of basement	2.4 days
During coring, 3 runs SET2/SETP in deeper part of hole	
POOH to rig floor	
Subtotal, both sites with APC/XCB BHA	4.2 days
GB-01A hydrothermal pit, 3517 m water depth, 146.5 m sediment, part 2	
RIH with RCB BHA	2.9 days (does not include WSTP)
Wash through sediments, RCB basement to 60 m	
(Only if time allows and conditions indicate, pull back BHA to upper basement, run WSTP into basement)	
POOH to rig floor	
Subtotal, GB-01A part 2 with RCB BHA	2.9 days
Total estimated time on site	7.1 days

980-APL2 References

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IODP Site Forms

General Site Information

Section A: Proposal Information

Proposal Title:	Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?
Date Form Submitted:	2020-09-29 11:34:35
Site-Specific Objectives with Priority (Must include general objectives in proposal)	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.
List Previous Drilling in Area:	ODP Leg 138 (Site 844). ODP Leg 206, IODP Expeditions 309, 312, 335 (Site 1256).

Section B: General Site Information

Site Name:	GB-01A	
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#:		
Latitude:	7.964827	
Longitude:	-90.56211	
Coordinate System:	WGS 84	
Priority of Site:	Primary ☑	Alternate ☐

Area or Location:	Guatemala Basin
Jurisdiction:	international
Distance to Land (km):	575
Water Depth (m):	3517

Section C: Operational Information

Proposed Penetration (m):

Sediments	Basement	Total Sediment Thickness (m)	Total Penetration (m)
146	60	146	206

General Lithologies:

eastern equatorial Pacific calcareous sediments like Site 844	basalt

Coring Plan (Specify or check):

APC/XCB full sedimentary section to basement. RCB upper basement to ~60 m.

APC ☑ XCB ☑ RCB ☑ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurement		Special Tools	
Wireline Logging	☐	Magnetic Susceptibility	☐
Porosity	☐	Borehole Temperature	☑
Density	☐	Formation Image (Acoustic)	☐
Gamma Ray	☐	VSP (walkaway)	☐
Resistivity	☐	LWD	☐
Sonic (Δt)	☐		
Formation Image (Res)	☐		
VSP (zero offset)	☐		
Formation Temperature & Pressure	☐		
Other Measurements: APCT-3 and SET2 or SETP temperature measurements in sediment section		Other Tools: WSTP	

Estimated Days:

Drilling / Coring	Logging	Total On-Site
4.6	0	4.6

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan:

Potential Harzards/Weather:

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Preferred weather window: Flexible. Very little risk of tropical cyclones.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g.sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H2S	☐	High Dip Angle	☐	Ice Conditions	☐	
CO2	☐					
Sensitive marine habitat (e.g. reefs, vents)						
Other:						

IODP Site Forms

Site Survey Detail

980–APL2 for Site GB-01A Submitted 2020-09-29 11:34:35

Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: GUATB05 Position CDP 1060 Filenames already uploaded: GUATB05mig.sgy, GUATB05navigation.dat
1b High resolution seismic seismic reflection (crossing)	yes	Line: GUATB33 Position CDP 599 Filenames already uploaded: GUATB33mig.sgy, GUATB33navigation.dat
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity		
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry	yes	Sonne SO207 swath bathymetry Filename: SO207BathymetryGrid.grd
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow	yes	Sonne SO207 multipenetration heat flux lines 1030 and 1038 Filename: HF1030&1038_decDegrees.txt
11a Magnetics		
11b Gravity		
12 Sediment cores		
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation	yes	GUATB05navigation.dat GUATB33navigation.dat
17 Other		

IODP Site Forms

Environmental Protection

980–APL2 for Site GB-01A Submitted 2020-09-29 11:34:35

Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC/XCB to basement, RCB in basement to bit destruction, up to 10 temperature deployments in sediments, WSTP deployment in basement section
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None encountered at nearby Sites 844 and 1256.
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	Not applicable
4. Indications of gas hydrates at this location	None encountered at nearby Sites 844 and 1256.
5. Are there reasons to expect hydrocarbon accumulations at this site?	Not expected in eastern Pacific pelagic carbonate sediments. None encountered at nearby Sites 844 and 1256.
6. What "special" precautions will be taken during drilling?	Not applicable
7. What abandonment procedures need to be followed?	If necessary, RCB bit release in basement
8. Natural or manmade hazards which may affect ship's operations	Not applicable.
9. Summary: What do you consider the major risks in drilling at this site?	Uncertain basement penetration rates.

IODP Site Forms

Lithologies

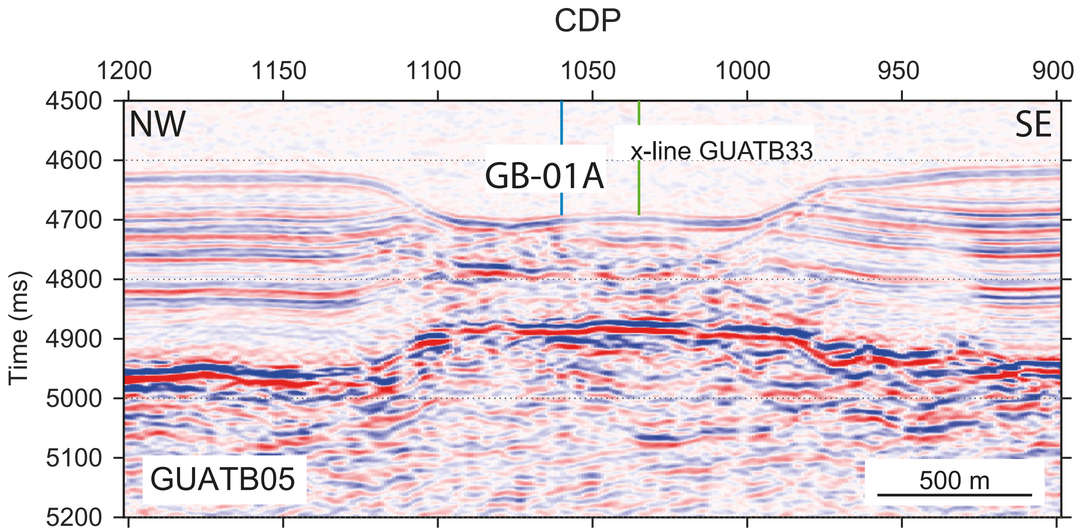
980–APL2 for Site GB-01A Submitted 2020-09-29 11:34:35

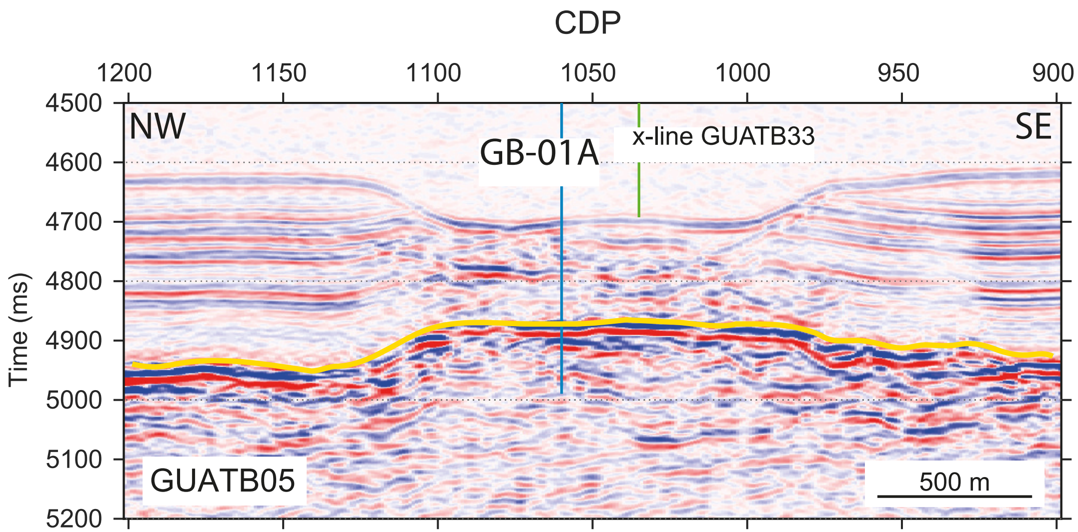
Subbottom depth (m)	Key reflectors, unconformities faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate(m/My)	Comments
0 - 206	Basement reflector at ~146.5m	18	1.61	Calcareous ooze over basaltic basement	abyssal plain, mid-ocean ridge	8.1	Early calcite sediment accumulations probably partially or completely dissolved by discharging fluids.

Site Summary Form

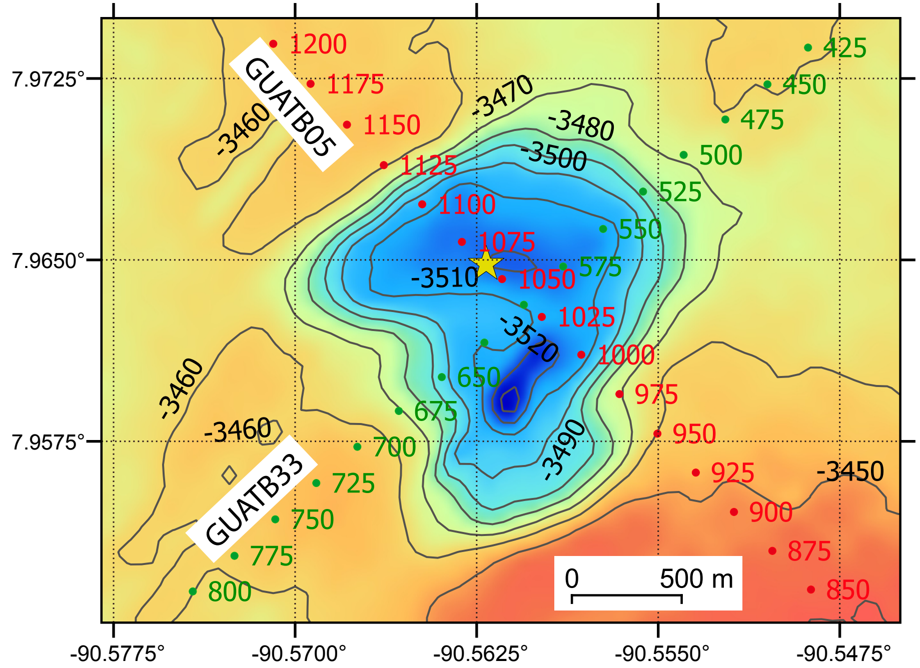
980-APL2 Are sedimentary depressions in the Eastern equatorial Pacific of hydrothermal origin?

Site GB-01A





yellow solid line: sediment-basement interface



Site GB-01A

Latitude: 7.964827
Longitude: -90.562110
Seismic profile (SCS): GUATB05, CDP 1060 Cross Profile GUATB33, CDP 599
Water depth: 3517 m (4689 ms @ 1500 m/s)
Sediment thickness: 146.5 m (182 ms @ 1610 m/s)
Basement penetration: 60 m (48 ms @ 2500 m/s)

SSDB Files
SO207_Bathymetry_Grid.grd
GUATB05_mig.sgy, GUATB05navigation.dat
GUATB33_mig.sgy, GUATB33navigation.dat
HF1030&1038_decDegrees.txt

IODP Site Forms

General Site Information

Section A: Proposal Information

Proposal Title:	Are Sedimentary Depressions in the Eastern Equatorial Pacific of Hydrothermal Origin?
Date Form Submitted:	2020-09-29 11:34:35
Site-Specific Objectives with Priority (Must include general objectives in proposal)	APC/XCB sediments to basement. Whole-round sampling for microbiology and pore water chemistry. APCT-3 and SET2/SETP sediment temperature measurements.
List Previous Drilling in Area:	ODP Leg 138 (Site 844). ODP Leg 206, IODP Expeditions 309, 312, 335 (Site 1256).

Section B: General Site Information

Site Name:	GB-02A	
If site is a reoccupation of an old DSDP/ODP Site, Please include former Site#:		
Latitude:	7.948736	
Longitude:	-90.546078	
Coordinate System:	WGS 84	
Priority of Site:	Primary ☑	Alternate ☐

Area or Location:	Guatemala Basin
Jurisdiction:	international
Distance to Land (km):	575
Water Depth (m):	3445

Section C: Operational Information

Proposed Penetration (m):

Sediments	Basement	Total Sediment Thickness (m)	Total Penetration (m)
270	0	270	270

General Lithologies:

calcareous ooze much like ODP Site 844	basalt

Coring Plan (Specify or check):

APC/XCB full sedimentary section to top of basement.

APC ☑ XCB ☑ RCB ☐ Re-entry ☐ PCS ☐

Wireline Logging Plan:

Standard Measurement		Special Tools	
Wireline Logging	☐	Magnetic Susceptibility	☐
Porosity	☐	Borehole Temperature	☐
Density	☐	Formation Image (Acoustic)	☐
Gamma Ray	☐	VSP (walkaway)	☐
Resistivity	☐	LWD	☐
Sonic (Δt)	☐		
Formation Image (Res)	☐		
VSP (zero offset)	☐		
Formation Temperature & Pressure	☐		
Other Measurements: APCT3 and SET2 or SETP temperature measurements in sediment section		Other Tools:	

Estimated Days:

Drilling / Coring	Logging	Total On-Site
2.4	0	2.4

Observatory Plan:

Longterm Borehole Observation Plan/Re-entry Plan:

Potential Harzards/Weather:

Shallow Gas	☐	Complicated Seabed Condition	☐	Hydrothermal Activity	☐	Preferred weather window: Flexible. Very little risk of tropical cyclones.
Hydrocarbon	☐	Soft Seabed	☐	Landslide and Turbidity Current	☐	
Shallow Water Flow	☐	Currents	☐	Gas Hydrate	☐	
Abnormal Pressure	☐	Fracture Zone	☐	Diapir and Mud Volcano	☐	
Man-made Objects (e.g.sea-floor cables, dump sites)	☐	Fault	☐	High Temperature	☐	
H2S	☐	High Dip Angle	☐	Ice Conditions	☐	
CO2	☐					
Sensitive marine habitat (e.g. reefs, vents)						
Other:						

IODP Site Forms

Site Survey Detail

980–APL2 for Site GB-02A Submitted 2020-09-29 11:34:35

Data Type	In SSDB	Details of available data and data that are still to be collected
1a High resolution seismic reflection (primary)	yes	Line: GUATB05 Position CDP 809 Filenames already uploaded: GUATB05mig.sgy, GUATB05navigation.dat
1b High resolution seismic seismic reflection (crossing)	yes	Line: GUATB34 Position CDP 323 Filenames already uploaded: GUATB34mig.sgy, GUATB34navigation.dat
2a Deep penetration seismic reflection (primary)		
2b Deep penetration seismic reflection (crossing)		
3 Seismic Velocity		
4 Seismic Grid		
5a Refraction (surface)		
5b Refraction (bottom)		
6 3.5 kHz		
7 Swath bathymetry	yes	Sonne SO207 swath bathymetry Filename: SO207BathymetryGrid.grd
8a Side looking sonar (surface)		
8b Side looking sonar (bottom)		
9 Photography or video		
10 Heat Flow	yes	Sonne SO207 multipenetration heat flux lines 1030 and 1038 Filename: HF1030&1038_decDegrees.txt
11a Magnetics		
11b Gravity		
12 Sediment cores		
13 Rock sampling		
14a Water current data		
14b Ice Conditions		
15 OBS microseismicity		
16 Navigation	yes	GUATB05navigation.dat GUATB34navigation.dat
17 Other		

IODP Site Forms

Environmental Protection

980–APL2 for Site GB-02A Submitted 2020-09-29 11:34:35

Pollution & Safety Hazard	Comment
1. Summary of operations at site	APC/XCB to top of basement, up to 10 temperature deployments in sediments.
2. All hydrocarbon occurrences based on previous DSDP/ODP/IODP drilling	None encountered at nearby Sites 844 and 1256.
3. All commercial drilling in this area that produced or yielded significant hydrocarbon shows	Not applicable
4. Indications of gas hydrates at this location	None encountered at nearby Sites 844 and 1256.
5. Are there reasons to expect hydrocarbon accumulations at this site?	Not expected in eastern Pacific pelagic carbonate sediments. None encountered at nearby Sites 844 and 1256.
6. What "special" precautions will be taken during drilling?	Not applicable
7. What abandonment procedures need to be followed?	Not applicable
8. Natural or manmade hazards which may affect ship's operations	None.
9. Summary: What do you consider the major risks in drilling at this site?	Premature failure of XCB bit.

IODP Site Forms

Lithologies

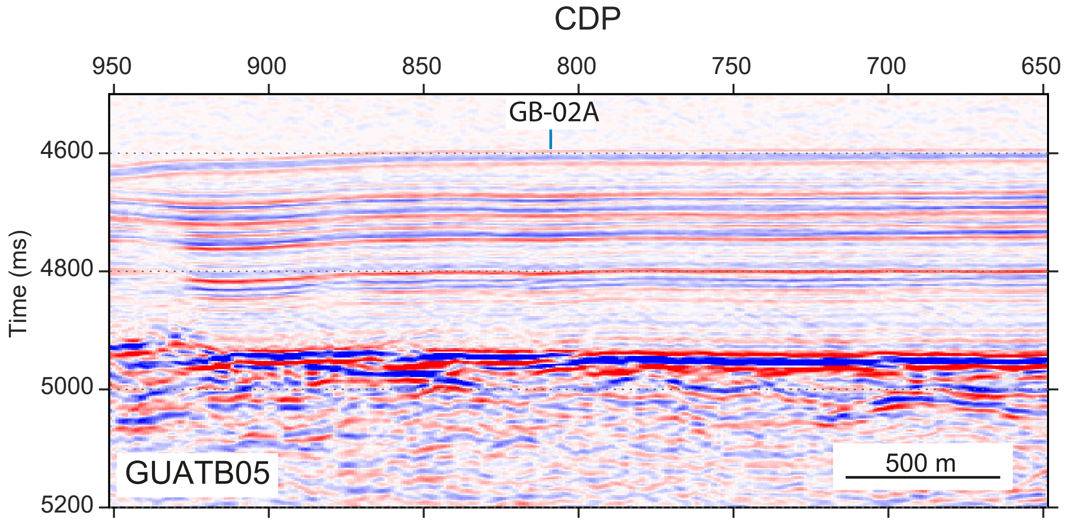
980–APL2 for Site GB-02A Submitted 2020-09-29 11:34:35

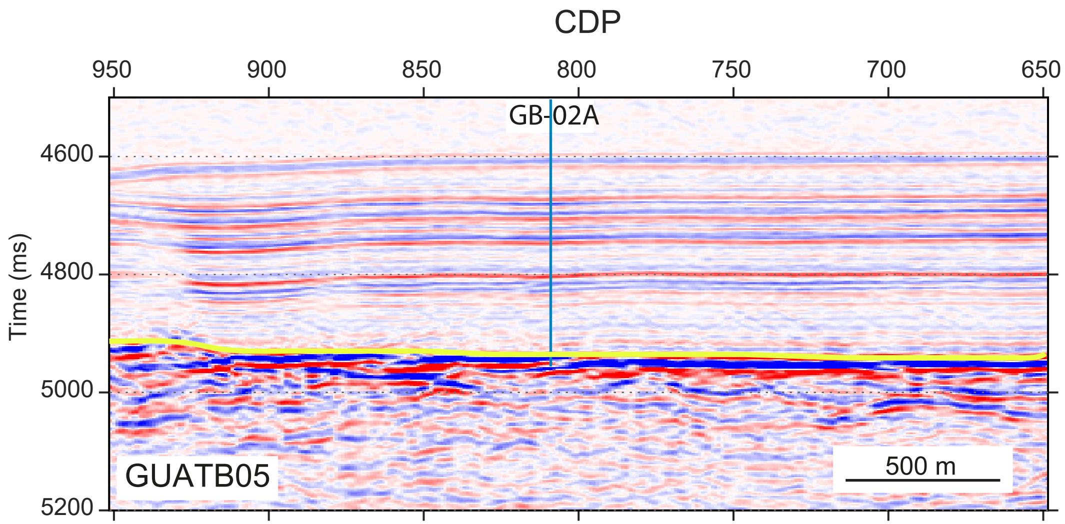
Subbottom depth (m)	Key reflectors, unconformities faults, etc	Age (My)	Assumed velocity (km/s)	Lithology	Paleo-environment	Avg. accum. rate(m/My)	Comments
0 - 270	Basement reflector at ~270m	18	1.61	Calcareous sediments over basaltic basement	Abyssal plain, mid-ocean ridge	15	Section should be very similar to Site 844

Site Summary Form

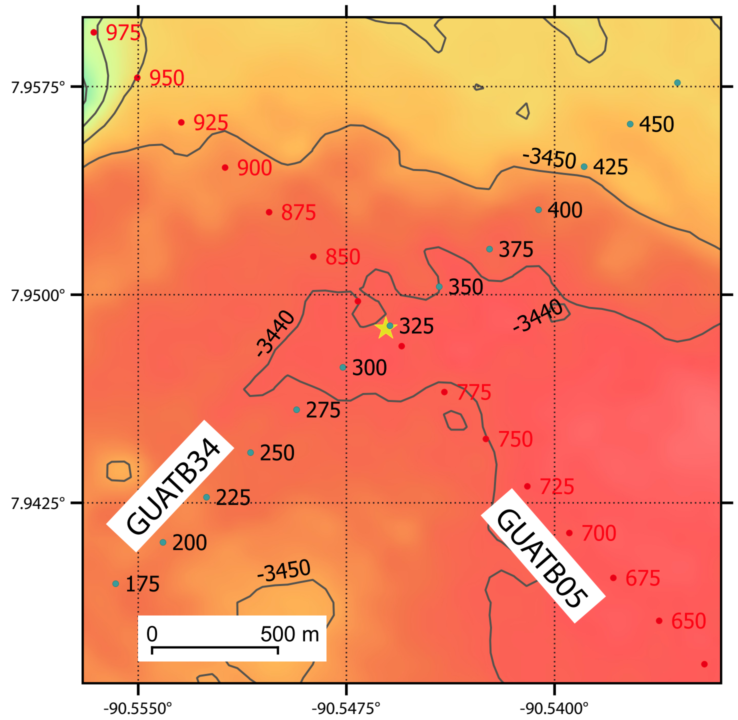
980-APL2 Are sedimentary depressions in the Eastern equatorial Pacific of hydrothermal origin?

Site GB-02A





yellow solid line: sediment-basement interface



Site GB-02A

Latitude: 7.948736
Longitude: -90.546078
Seismic profile (SCS): GUATB05, CDP 809
Cross Profile GUATB34, CDP 323
Water depth: 3445 m (4593 ms TWT @ 1500 m/s)
Sediment thickness: 270 m (336 ms TWT @ 1610 m/s)

SSDB Files
SO207_Bathymetry_Grid.grd
GUATB05_mig.sgy, GUATB05navigation.dat
GUATB34_mig.sgy, GUATB34navigation.dat
HF1030&1038_decDegrees.txt