# IODP Proposal Cover Sheet

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Guaymas Proposal

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| Title | Guaymas Basin: Feedbacks between continental rifting, magmatism, sedimentation, thermal alteration of organic matter, and microbial activity |
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| Keywords | Guaymas Basin, carbon cycling, microbiology |
| Area | Gulf of California |

## Proponent Information


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## Abstract


The Guaymas Basin in the Gulf of California is a young, marginal rift basin characterized by active seafloor spreading and rapid deposition of organicrich sediments from highly productive overlying waters. The combination of active oceanic crust production and thick sediment cover has resulted in a dynamic environment, where tightly linked physical, chemical, and biological processes regulate the cycling of sedimentary carbon. At Guaymas Basin, magmatism takes the form of deeply-emplaced volcanic sills that indurate and alter the surrounding sediments, and shape hydrothermal circulation patterns. Hydrothermal alteration and mobilization re-injects buried carbon into the hydrosphere and potentially atmosphere, a process linked to major shifts in global climate and mass-extinction events in Earth history. Subsurface microbial populations can intercept and process these hydrothermally generated and mobilized carbon sources, esp. hydrocarbons and methane. Guaymas Basin provides a model system for exploring the extent, activity, biogeography and metabolic capabilities of subsurface microbial life within extensive chemical, temperature and lithological gradients, and an active analog to understand mechanisms of carbon remobilization implicated in global-scale rapid climate change. This new expedition will take full advantage of modern drilling tools and samplerecovery techniques (e.g., Advanced Piston Coring) that have improved tremendously since DSDP Leg 64 exploration and allow the recovery of undisturbed –and critically, microbially uncontaminated –sediment samples throughout much of the drilling operations. Moreover, approaches and options for chemical and microbial analysis have evolved and improved dramatically, enabling tremendous scientific returns once fresh, highquality samples are available.

## Scientific Objectives

The fate of carbon deposited in Guaymas Basin, throughout the Gulf of California, and more broadly within similar marginal seas throughout the world, depends on the relative efficiencies of interacting microbial and chemical processes, some working to sequester carbon, and others working to release carbon back to the ocean and the atmosphere. In this revised version of IODP proposal 833, our scientific objectives focus on these chemical and microbial processes, their interactions, and their ultimate consequences for carbon cycling. To link sediment accumulation, sill emplacement, sediment alteration, fluid expulsion, and microbial utilization and sequestration of carbon along subsurface fluid pathways, we propose to drill towards and through seismically imaged sills of varying age and temperature into the intercalated sill-sediment package, to explore the physical and chemical gradients along present and extinct fluid pathways associated with sill emplacement, and to investigate subsurface microbial communities that are sustained by alteration products, in order to determine their efficiency at capturing carbon-bearing alteration products and to further our understanding of the conditions that limit life in the deep biosphere. Drilling sill/sediment sections will provide an integrated record of magmatic accretion as well as baseline data of carbon flux, including unaltered near surface sediments and those that have experienced multiple generations of sill intrusion at depth. The physical properties (e.g., porosity/permeability) of these domains will also provide constraints on crustal fluid flow and heat exchange that are fundamental controls on this system.

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

We will use microbiological and geochemical approaches that are mostly shorebased: Gene sequencing, environmental genomics, nucleic-acid based quantifications, cultivations for microbiology: advanced analytical organic chemistry, biomarker analysis, radiotracer rate measurements, stable C- or S-isotope analysis. However, samples can be adequately prepared and/or conserved in the shipboard microbiology and chemistry labs, and are then shipped to the investigators home institutions. This approach worked well on ODP Leg 201 and IODP Leg 1301.

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Proposed Sites (Total proposed sites: 8; pri: 6; alt: 2; N/S: 0)

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---|---|---|---|---|---|---|
| | | | Sed | Bsm | Total | |
| GUAYM-01B (Primary) | 27.637192 -111.888993 | 1600 | 600 | 0 | 600 | Site GUAYM-01A is located ~52 km NW from the spreading center (2.1Ma spreading age). The site represents undisturbed, non-thermogenically altered sediments on the Guaymas ridge flank at the edge of sill emplacement, and will provide information on background hemipelagic sedimentation influenced by normal diagenetic processes. This site contrasts with GUAYM-02A at which the same sediment package has been impacted a young sill at ~350 mbsf. We propose drilling to a depth of ~600 mbsf, with the objective to recover the full off-axis sediment sequence and including the depth horizon that corresponds to the upper strong reflector at GUAYM-02A. |
| GUAYM-02B (Primary) | 27.631406 -111.879936 | 1600 | 350 | 250 | 600 | Site GUAYM-02A was chosen to investigate the consequences of sill emplacement in a thick sequence of organic-rich sediments on the northwestern Guaymas Basin ridge flanks. In contrast to GUAYM-01 (1.5km to the NW), the sediments here have been disturbed and presumably altered by recent sill intrusion at ~350mbsf (~120 ka). The site objective is to recover this complete sequence at our oldest (spreading age) off-axis endmember site, most removed from hydrothermal influence, and to document the geochemical and microbiological endmember state of mature, ~50 km off-axis Guaymas Basin sediments and sills. |
| GUAYM-03B (Primary) | 27.504081 -111.681139 | 1750 | 150 | 250 | 400 | At site GUAYM-03A (spreading age 1.1 mya, 28.5 km NW of the spreading center), shallow sills ~150 m below the sediment surface appear to drive active hydrothermal fluid flow and alteration of buried organics; fluids released at the seafloor containing hydrocarbons and other gases create a seafloor expression of seep-related biota and produce conspicuous thermal anomalies in the water column. This site will provide a link between a shallow sill on overlying seafloor seepage on the outer ridge flank of Guaymas Basin. Holes A through D at this site will cross the ~1km wide feature, with hole D recovering sub-sill sediments. |
| GUAYM-04B (Primary) | 27.208855 -111.223624 | 1850 | 650 | 0 | 650 | Site GUAYM-04A (~29 km SE of rift, ~1.15 Ma) is located in the center of a deep (~650m) saucer-shaped sill that drove ancient hydrothermal outflow. The sill driving this hydrothermalism is located within a sedimentary sequence with physical and chemical properties inferred to be distinct from NW Guaymas. This site will provide an important lithological, biogeochemical and microbiological counterpart to the NW Guaymas ridge flank, illustrating how hydrothermal systems interact with sedimentary sequences that have higher terrigenous content and different types and concentrations of organic matter as well as different physical properties. |
| GUAYM-11A (Alternate) | 27.200906 -111.211370 | 1821 | 450 | 0 | 450 | Site GUAYM-04B (~29 km SE of rift, ~1.15 Ma) is located at the edge of the saucer-shaped sill and passes through an 'eye structure' that marks the location of hydrothermal outflow at an ancient sediment surface horizon. The sill driving this hydrothermalism is located within a sedimentary sequence with physical and chemical properties inferred to be distinct from NW Guaymas. This site will provide an important lithological, biogeochemical and microbiological counterpart to the NW Guaymas ridge flank, illustrating how hydrothermal systems interact with sedimentary sequences that have higher terrigenous content and different types and concentrations of organic matter. |
| GUAYM-06B (Primary) | 27.255734 -111.505558 | 2000 | 175 | 75 | 250 | Site GUAYM-06A reoccupies previously drilled site DSDP 481. This site lies at the southern end of the northern Guaymas Basin spreading center, ~5km NW of the local maximum in heat flow. This site will allow investigation of the early stages of geochemical and microbiological transformations of buried carbon (incl. org. acid release) under the conditions of the hydrothermal spreading center. We propose drilling to 150 mobs, which is above the first sill with improved tools, increased resolution, and substantially improved recovery from earlier drilling efforts. |

Proposed Sites (Continued; total proposed sites: 8; pri: 6; alt: 2; N/S: 0)

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---|---|---|---|---|---|---|
| | | | Sed | Bsm | Total | |
| GUAYM-09A (Primary) | 27.469613 -111.473531 | 1843 | 200 | 200 | 400 | Site GUAYM-09A is located 8.3 km NW of the spreading center on ~0.4 Ma crust. This site resembles GUAYM-03A, with disrupted sediment stratification indicating gas upflow, and seafloor images indicating seep communities; it is distinguished from its sibling site by closer proximity to the ridge axis, by the deeper position of its sill at ~450 mbsf, and by a conspicuous shallow BSR layer with possible methane accumulation below. This site provides an opportunity to link a specific shallow sill to seafloor fluid flux on the outer ridge flanks of Guaymas Basin. |
| GUAYM-10A (Alternate) | 27.555766 -111.548059 | 1845 | 200 | 0 | 200 | Site GUAYM-10A is located ~23.5 km NW of the spreading center on crust ~1 Ma where there is hydrate-rich sediment overlying deep sills. This site provides an opportunity to study the geochemical and microbial changes throughout the gas hydrate stability zone into the sediment below, and finally towards the underlying sill at ~700 mbsf. Together with GUAYM-03A and 3B, we will capture the geochemical and microbiological contrasts of hydrothermally driven seepage, with and without hydrates as an intermediate C storage buffer, in order to calculate carbon budgets within the basin. |