IODP Proposal Cover Sheet

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Mariana Trench Water-Rock Interaction

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Title	Southern Mariana Deep Drilling: Tectonic, geochemical and biological activities triggered by bending of the incoming plate at the world's deepest trench
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Keywords	outer rise, water-rock interaction, life
Area	Mariana subduction zone

Proponent Information

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Abstract

Plate subduction is of critical importance for the transport of materials, e.g., carbon, water, and other materials, from the surface of the Earth into the mantle, which is the most important aspect of the global matter and energy cycling. Increasing evidence indicates a direct linkage of important features of the subduction zone with the incoming plate, especially with the so-called outer rise just at the trench-ocean slope right before subduction. However, the majority of studies on subduction zones have been mainly focused on the structure and processes related to the plate interface and the overriding plate, and limited knowledge has been obtained on the subducting plate. The outer rise is a consequence of the flexure of the subducting lithosphere, where plate bending caused by subduction has sometimes generated numerous normal faults that gradually intensify on approaching the trench axis. These tectonically induced normal faults can provide pathways for seawater to penetrate deeply into the ocean crust and upper mantle, which might trigger low-temperature basalt alteration in the mafic crust and serpentinization in the upper mantle. The Mariana subduction zone is located at the Western Pacific, under one of the least productive ocean waters, so it is an ideal place to investigate the relationship between the tectonic activity and the processes and extent of water-rock interactions, and their relationships with and influence on deep life within the altered basaltic crust and the overlying sedimentary ecosystems. The southern Mariana outer rise is also potentially an end member case to explore the bend-fault hydration processes, because of its wide-spread faulting zone (>120 km), and newly formed horst-and-graben faults with large fault throws. Thus, it is an unique place to investigate the dynamic processes and water cycling within the "type example" of a non-accretionary intra-oceanic subduction zone. This proposal aims to drill through the thin sediment cover (average sediment thickness is ~100 m and <200 m locally) into the oceanic crust across the outer rise of the southern Mariana Trench, where there is intensive bending faults with large offset and throw, and associated significant crustal and mantle hydration. Proposed drilling will examine processes of mass transportation and cycling, and their relationships to and interactions with life along the outer rise, associated with bending initiation and fracturing.

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Scientific Objectives

Scientific Objective Set 1:
Age, structure, and material circling. To determine the exact geologic age of the subducting plate of the Southern Mariana Trench, reveal the physical and chemical variations of the subducting sediments and oceanic crust induced by bending-induced faulting. To obtain a better understanding of the slab composition entering the trench, and to examine processes of mass transportation and biogeochemical cycling along the outer rise.
Scientific Objective Set 2:
Crust hydration, alteration, and life habitability. To reveal the extent and mechanisms of accelerated hydration and alteration of the incoming basaltic oceanic crust caused by structural deformation, to ascertain their effects on mineralogy, basement fluid geochemistry, microbial compostion and activity.
Scientific Objective Set 3:
Fluid flow and influences on ecosystem. To determine the deformational pattern of fabrics and infer the current stress state of flexural bending from the seafloor to the basaltic basement layer through a fault zone, and its connection with fluid flow in the fault zone. To determine the extent and mechanism of water-rock reaction therein and to quantify the influences of these underlying tectonic/geochemical processes on shaping and driving the structure and evolution of the associated subsurface crustal and sedimentary biosphere.
Scientific Objective Set 4 (optional):
Reentry cone system and casing system. To deploy a reentry cone and casing system at 1-2 sites, no observatories will be installed during this proposed expedition, but opportunities will be provided for the future installation whenever appropriate.

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

Canonical techniques used for biological sampling such as contamination detection, and sample storage are required

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Proposed Sites (Total proposed sites: 12; pri: 4; alt: 8; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
SM-01A (Primary)	10.6350 142.5062	5153	100	500	600	objective 1,2, and 3
SM-02A (Primary)	10.5222 142.5513	4951	100	300	400	Objective 1,2,3
SM-03A (Primary)	10.3807 142.6096	4794	100	100	200	objective 1,2, and 3
SM-04A (Primary)	10.0207 142.7558	4653	100	100	200	outside of the outer rise as a control site, objective 2,3
ASM-01A (Alternate)	10.5981 142.3646	4967	100	500	600	Objective 1,2,3
ASM-02A (Alternate)	10.4849 142.4095	4777	100	300	400	Objective 1,2,3
ASM-03A (Alternate)	10.3433 142.4677	4671	100	100	200	Objective 1,2,3
ASM-04A (Alternate)	9.9822 142.6140	4541	100	100	200	outside of the outer rise as a control site, objective 2,3
ASM-05A (Alternate)	10.6722 142.6462	5264	100	500	600	Objective 1,2,3
ASM-06A (Alternate)	10.5594 142.6912	5073	100	300	400	Objective 1,2,3
ASM-07A (Alternate)	10.4177 142.7486	4878	100	100	200	Objective 1,2,3
ASM-08A (Alternate)	10.0566 142.8954	4734	100	100	200	outside of the outer rise as a control site, objective 2,3