

Science AMA Series: Scientists are on board the R/V JOIDES Resolution for two months to drill into the ocean floor to investigate geochemical, tectonic, and biological processes occurring in undersea mud volcanoes in an active subduction zone.

IODP <sup>1</sup> and r/Science AMAs<sup>1</sup>

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### Abstract

The International Ocean Discovery Program (IODP) conducts scientific ocean drilling expeditions throughout the world's oceans in search of clues to Earth's structure and past. The current expedition is Expedition 366: Marina Convergent Margin, aboard the U.S. vessel for scientific ocean drilling, the JOIDES Resolution. The scientists embarking on this expedition hope to learn (1) how sediments, fluids and chemicals move and cycle through the earth's crust; (2) the role of tectonics and mud volcanoes in transporting fluids and sediments in subduction zones; and (3) how these physical and chemical movements impact living organisms. The research team will use deep sea drilling technology to drill into undersea mud volcanoes near the Mariana Trench, taking core samples of sediments and fluids that they can study on board the ship. By analyzing the chemicals, sediment layers, and microorganisms within the core sample, scientists can answer questions about how rocks, fluids, and chemicals cycle through the earth's crust, and this affects life on the seafloor and beyond. Studying sediment layers, geochemical cycles, and fluid dynamics in the earth's crust can tell us a lot about how geological formations (like volcanoes, canyons, and mountains) are formed, and how they change over long periods of time. By extracting cores in subduction zones, scientists can answer questions about how the earth's crust moves and changes through plate tectonics, and how this impacts life in the ocean and on land. Collecting biological samples of living (and past) organisms in these seismically active regions allows us to study how life on earth may have begun, and how organisms have evolved to survive in extreme environments. A team of 30 scientists from around the globe are on board for two months to work on these questions. Hand-in-hand with the amazing technology required to drill deep into the ocean floor, we are collecting the core samples that hold clues to answer these questions. Thank you to everyone today for your great questions! Our Live session is officially over, but we will check back in the following days in case there are any follow-up questions for us to answer. Thanks everyone, science rocks!

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IODP [R/SCIENCE](#)

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CORRESPONDENCE:

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Thank you so much for taking the time to speak with us today!

Given we know so little about sea life at that depth it may be likely you see an undescribed organism. Are you expecting this? It's an exciting prospect. If so, what are the steps to describing and naming a new species?

Which animal group is the most likely to be found/most abundant at those depths? New or otherwise.

How long does it take to reach your destination?

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Thank you again!

[FillsYourNiche](#)

Thanks for your question! I would say that finding undescribed or unknown organisms in these samples would not be unexpected as these environments haven't been very thoroughly studied. Along with this, we also expect (or hope, at least!) to find out something about how these organisms are able to cope with life in these extreme environments. Describing a new organism can be tricky, as you must be able to grow this organism in the lab and perform tests on it in order to characterize (describe) it. There are a number of tests involved - from determining its generation time (growth rate), its ideal growth temperature, various carbon sources it can use for growth, etc. There are a number of rules that must be followed when naming a new species, as the name typically reflects some characteristic of the organism, and of course these names are subject to scrutiny during the review process. However, today's technology will allow us to look at the genetic material of these communities and get a better understanding as to who is there and what they are doing. We could even potentially discover new groups of microbes using these techniques, but won't necessarily be able to identify new species (and certainly not describe them thoroughly) this way. Previous studies have told us that Archaea are the dominant group of microbes found in these environments. As for how long it takes to reach our destination (I assume you mean how long it takes to get to the bottom of the seafloor), it really just depends on how deep the sediment is. Typically, it takes about an hour for us to "catch" the core from the seafloor once it has been drilled! --Kelli Mullane (PhD student at Scripps Institution of Oceanography, UC San Diego)

Thank you so much for taking the time to speak with us today!

Given we know so little about sea life at that depth it may be likely you see an undescribed organism. Are you expecting this? It's an exciting prospect. If so, what are the steps to describing and naming a new species?

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We use a camera sled that can go down the drill pipe (it has a sleeve that fits around the pipe) to within a few meters of the end of the pipe. We use it when we need to see either the sea floor to pick a place to start coring, or to see an instrument installation that we are preparing. The camera produces high-definition images and, in fact, once I saw how good the images were, I contacted some marine biology colleagues to let them know that I have observed many kinds of animals in the water column as the camera is being lowered. Most of the video is deleted because the drillers only need to record the targets that are related to the operations on a given expedition. However, the video could be saved to an external hard drive, if the biologists provide the ship with one that can keep all the many (many, many!) terabytes of data that is collected on a given expedition. The thing is, that almost every time that I have been on a deep submarine dive, or on an expedition where I get to use a remotely operated vehicle, we see an animal nobody has ever seen before. The diversity is amazing! It even surprises the biologists. For your other question, the drill pipe is deployed at a rate of 750 m per hour and the camera sled we use can go down at between 30 to 40 meters per minute. We have been coring the sea floor at depths between 1,200 m and 4,500 m. On other expeditions the sea floor targets have been much deeper.

I always wondered as there is huge amount of pressure at ocean floor, how does the samples of organisms (eg. bacteria) behave at standard atmospheric pressure? What are the culturing techniques you use or plan to use? (Or can they adapt to the conditions at standard atm pressure)

Thank you for the AMA. E.

[sirsoydemir](#)

Great question! The ability of microbes living on the ocean floor to survive at atmospheric pressure truly depends on the organism itself. While some are extremely piezophilic (high-pressure loving) and will burst and die if brought up to the surface, others are more piezotolerant (able to tolerate a range of pressures). On this expedition, our sampling technique selects for microorganisms that can withstand atmospheric pressure as well as high pressure, since the samples are being brought on board at atmospheric pressure. However, other people in my lab have recently been using what we call a pressure-retaining sampler, which allows us to take water samples from the deep parts of the ocean and keep it at high pressure as the sample is brought up to the ship. This way, we do not lose as many of extremely pressure-sensitive microbes as we believe we do using our normal sampling technique! -- Kelli Mullane (PhD Student at Scripps Institution of Oceanography, UC San Diego)

Thank you for doing this AMA!

How well is DNA preserved in your sea floor samples? Are you able to sequence genetic material from sediment or rock samples? What is the process of taking a sample actually like?

[neurobeegirl](#)

As far as microbiology goes, we begin our sampling process by taking what we call a "whole round", or a section of core, and bringing it into our lab. We use sterile tools to take out the center of the core, as we assume the exterior is potentially contaminated from the drilling process, and preserve our samples in a number of ways. Depending on what we plan to do with the sample, we store them at 4C, at -80C, can add preservatives to them, and much more. This allows us to do both DNA analysis and culturing (growing these microbes in the lab) later on. While we have not yet attempted to sequence the DNA from these particular samples - this is something we will do once we get back to our labs on shore - we do expect it to be more difficult than your normal sample for a few reasons. First, from previous studies in this area we expect there to be low biomass (not a lot of microbes in the sediment), making it difficult to get enough DNA to sequence. Also, the high pH of the sediments could potentially make DNA extraction difficult. However, we microbiologists have been discussing these potential issues and have several ideas as to how to deal with these problems! --Kelli Mullane (PhD student at Scripps Institution of Oceanography, UC San Diego)

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[neurobeegirl](#)

I would like to add that DNA is a relative stable molecule and usually quite well preserved. Sequencing of DNA from deep biosphere samples (sediments and ground up rocks) has been done before. Like Kelli mentioned, to be able to sequence the DNA or do other molecular analyses, you need to be able to extract a good amount of DNA from your matrix. From previous expeditions to serpentinite mud volcanos and quick tests on board we know that our samples from here have low cell numbers to begin with and are adsorbing DNA to the matrix after we lyse the cells and release the DNA into solution

losing them for downstream analyses. However, there are methods available for adsorption prevention and we will have to find the best DNA extraction protocol. This is planned to be done in our home labs after the cruise. --Philip Eickenbusch (Environmental Microbiology, ETH Zurich, Switzerland)

What can these samples tell us about climate change? Will it give us insight into the ways that climatic changes impact sea life and help us predict what might happen in the future?

[firedrops](#)

All expeditions have different goals and objectives. Some scientific drilling expeditions focus on climate change issues and often collect kilometers of sediment to achieve designated goals. This expedition, however, does not focus on climate change. The focus of this expedition is to understand the dynamics of a subduction zone and specifically processes that are associated deep within the crust. We can examine these processes in the Mariana forearc because mud volcanism in this setting brings deep-sourced material from the downgoing slab (15-25 km deep) to the seafloor. These mud volcanoes are "windows" to the deep.

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[firedrops](#)

Good question to ask. There are several ways that samples we are collecting inform us about climate change. One way is looking at the composition of microfossils that accumulate in the sediments that settle on the sea floor. Some microfossils have carbonate shells or anatomical parts that are made up of carbon and oxygen, plus a cation, usually calcium. The isotope composition of the atmosphere, seawater, and consequently, the shells and body parts of the planktonic organisms that live in the oceans, adjusts naturally to the amount of carbon in the atmosphere, the ocean temperature (that is coupled with the atmospheric temperature), the amount of ice in the major glacial masses, and other major global environmental markers. By studying the isotopic compositions of these microfossils in different sediment layers on the seafloor, which can only be recovered by drilling, we learn about the climate conditions millions of years ago and how it changed over time. One more quick way our studies look into climate change is that the rocks - basalts, ultramafic mantle rocks, etc - react with seawater and the CO<sub>2</sub> that is naturally dissolved in the seawater, and new, stable mineral carbonates are formed to replace some of the silicate minerals like olivine. This natural process sequesters CO<sub>2</sub> in a stable form (the carbonates) and can naturally buffer the build-up of CO<sub>2</sub> in the atmosphere from human industrialization.

Thank you so much for taking the time to do this AMA!

What are the environmental risks of conducting scientific ocean drilling expeditions? How do you plan for limiting/ reducing the environmental impacts?

Safe travels!

[AudiWanKenobi](#)

There are risks in everything we do. IODP has a panel of experts that review all of the drilling proposals and potential operations prior to drilling. We also discuss potential issues and means to avoid or mitigate those issues. Each expedition includes a summary of such risks in the official prospectus that is published about 6 months prior to the expedition. All risks, not just environmental, are discussed in

detail prior to drilling.

Can you explain how deep sea drilling actually works? Is there essentially one long drill bit attached to the ship, or does the drilling start from the seabed? Where is the rotation force coming from, and does the ship have to counteract this so that it doesn't rotate in the sea? How much can the ship move while drilling before it's a problem? Thanks!

[enervation](#)

Deep sea drilling works in both of the ways that you suggested: one long drill string from the ship and there are remote systems that drill on the seafloor. We are on a ship that hangs the drill string from the ship. The drill string is made of drill collars at the bottom and ~5" steel pipe for the rest of the drill string. The drill collars are at the bottom to apply weight and to keep the drill string in tension - the drill string does not do well in compression. The drill sting is assembled with a bit at the bottom. This bit is set for the material that will be drilled. Once the drill sting is assembled (it can weight 500,000 pounds) it is connected with the top drive. The top drive provides rotation and can pull the pipe up. Weight on the bit is provided by the weight of the drill string. When drilling, the top drive rotates the drill string and pumps seawater into the borehole to wash cuttings from the hole. Sometimes the friction between the drill collars and the formation cause the drill string to stop rotating at which time the drillers increase the torque to get the drill collars free. Even though the top drive applies torque, the torque that is applied does not affect the ship's movement. The ship has a ~12 thrusters to keep it in place, using a bottom transponder and dynamic positioning. The ship's crew keeps the ship to within 10 meters of the borehole at all times. We have re-entered borehole multiple times and recovered portions of an old observatory. For the latter the ship had to position a 3000-m-long drill string over a 10 inch OD pipe with a 20 inch ID funnel. Amazing!!!

At what depths are you drilling and how does the process for drilling at extreme depths differ from more conventional ocean drilling? What type of mapping resources do you utilize?

[shiruken](#)

We have been drilling several seamounts that are serpentinite mud volcanoes. The shallowest seamount drilled during this expedition is at a water depth of ~1200 m. The deepest ones are >3000 m. Right now we are on the flanks of a serpentinite mud volcano (seamount) at a water depth of 3296 m. The bit on the drill string is currently at a depth of 79.5 meters below the sea floor. Scientific drilling on this ship uses a single drill string. Commercial (oil and gas) operations use a nested set of pipes as part of the drill string, called riser drilling. Riser drilling allows them to control the pressure in the well, preventing a blowout. Scientific drilling on this ship does have riser capabilities and does not drill into areas that may be over-pressured (with gas and oil).

Naive question - Would it be possible to predict future earthquakes or tsunamis based on your technology data?

[denzil\\_correa](#)

WOW, what a question! The short answer is yes, but it is going to take some time. The biggest unknowns in subduction zones are the temperature and the physical properties of the downgoing plate as it rubs against the overriding plate. The problem is that all of our estimates for these parameters are based on seismic results. Material has been recovered from this boundary, but at shallow depths that are quite cool and difficult to extrapolate to much warmer and deeper depths. There is a current project off Japan to drill into the boundary where the boundary is much warmer, but they have yet to reach this

boundary. The really cool thing about the serpentinite mud volcanoes in the Mariana forearc is that the mud volcanoes bring the material from the boundary to the seafloor! Thus by sampling materials (rock, mud, and water) we can constrain the temperature and physical properties at depth where these materials originated. Also there are a number of seamounts in the forearc at different distances from the trench and different depths to the underlying plate boundary. Thus by sampling a number of these serpentinite seamounts we can track the temperature and physical properties of the downgoing material as a plate is subducted. This is the first step, providing data for models of subduction. In the future such models will be able to better describe and predict plate movement and tsunami potential.

Thanks for taking the time do this AMA!

I have always been fascinated by deep sea creatures and what they may tell us about the origin of life on Earth. Could you share with us some surprising facts about deep sea creatures that we may not be aware of?

[edwinksl](#)

There is a similar question posted above that may answer your question. We have a team of ~25 scientists and ~15 technical staff that are conducting a variety of geophysical, geological, chemical, and microbiological measurements. None of us are experts in deep sea creatures.

What are some of the biggest challenges associated with getting samples from depth, or away from shore, and how do you get around them?

Just as the CTD is a staple of physical Oceanography sampling, what is your main piece of equipment? I'm assuming it's a piston corer drill bit, as you don't want to disturb the sediments, but how do you deal with different types of rock?

What are the other cool, interesting or unique bits of equipment you have at your disposal?

What got you into your respective specialised branches of science, and do you enjoy it?

[RaveAndRiot](#)

We use a lot of different tools, but the backbone is the drill string. We can attach a variety of coring bits and samplers/sensors to the drill string. As you noted the advanced piston corer has been our primary bit to recover "soft" material. Right now we are using a rotary bit to recover harder material (rocks). We have used a variety of other tools to deploy casing, which forms the foundation for future observations and experiments.

Welcome to [/r/science!](#)

Two quick questions.

What's involved in choosing the ideal sampling locations? And how has technological/methodological advancements over the past decade influenced the type of work you'll be doing and the insights you hope to achieve?

[IceBean](#)

A great deal of work on the part of many marine scientists goes into deciding what will be done with the drill ship for any expedition. The IODP has a protocol for submission of requests for an expedition. A group of proponents designs a set of experiments, based on an hypothesis regarding a certain type

of work, for a particular part of the ocean that would require a drill ship or platform. They must write and submit a proposal for an expedition to address the work they are interested in doing. The proposal goes to the science advisory panels of the IODP where it is examined by experts in variety of marine science fields and is evaluated based on the nature of the scientific hypotheses proposed, and on the readiness of the work to be performed. The proponents need to have acquired a great deal of information about the area they want to drill. For instance, each site must satisfy a readiness examination and is ranked on completeness of site-survey data that exists. If a proposal meets all of the scientific requirements and is deemed worthy of consideration for being scheduled, it must then pass a safety evaluation. This entails consideration of issues that hinge on whether the objectives of drilling the sub-sea-floor formations are likely to be successfully and safely drilled and/or cored. Once that examination has been passed, the proposal moves on to a scheduling panel. Then the proposal must be fit into the region of the ocean where other projects are scheduled. Also, the work that the proponents want to accomplish must be considered from the point of view of the overall budget of the program. If a proposal makes it to that point, and is scheduled, then a series of preparatory actions quickly move into gear. The hardest part of all of this is obtaining the background data for the area one wants to drill. The technological advances in sea-floor imaging, for instance, high-resolution side-scan sonar capabilities, multi-channel seismic profiling, and deep-capability submersibles and remotely-operated vehicles with sophisticated manipulators, give marine scientists the type of ground-truthing ability that a geologist can achieve on land. The next generation of scientists, the graduate students and post-docs on this cruise, will have a far easier job of justifying their inquiries than ever before.