

# Science AMA Series: Scientists are on board the R/V JOIDES Resolution for two months to drill into the ocean floor west of Indonesia trying to figure out why earthquakes happen where and when they do.

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

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April 17, 2023

## Abstract

Hi Reddit, 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 362: Sumatra Seismogenic Zone, aboard the U.S. vessel for scientific ocean drilling, the JOIDES Resolution <http://www.joidesresolution.org>. We want to know why earthquakes happen where and when they do. When earthquakes happen in the ocean, they can displace huge volumes of water and cause tsunamis, such as the 26 December 2004 Sumatra earthquake and the 11 March 2011 Tohoku-Oki (Fukushima) earthquake. The combination of ground shaking and flooding is destructive and deadly. Very large earthquakes like these are typically at subduction zones, places where tectonic plates converge and one plate gets pushed down beneath the other. Yet these earthquakes, as well as several others in the past 15 years, surprised earth scientists in terms of their size and the amount and location of the fault slip during the earthquake. Subduction zone earthquakes can happen many tens or even hundreds of kilometers below Earth's surface. The shallower and larger the earthquake, the more damage it can cause by shaking. It is even more dangerous if it occurs under the ocean floor because it can trigger a tsunami. We can't predict earthquakes, but we can learn more about what happens below the Earth's surface and why rocks break and cause earthquakes that trigger tsunamis. 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. We will be back at 12 pm ET, Join us to ask us anything about this intriguing science, how we got here, what we hope to discover, and our lives on board the ship! AMA!

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IODP [R/SCIENCE](#)

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Hi! What do you expect to find by drilling? What do you look for? Is it a chemical analysis like the mars rover or is it more like ice cores where you examine the geological history of the sample?

Thanks for being science nerds and doing the difficult and underappreciated work of making our world a safer place to be!

[\\_give\\_a\\_rats\\_ass](#)

Howdy! While we have specific scientific objectives -- our main focus is why this region is so susceptible to large earthquakes -- a large part of the reason for being out here is to explore. So you could say that we're trying to understand the mechanical properties of the sediments that might affect earthquakes, but we're always on the lookout for other fun science. For example, the person answering this question (Brian) is the Organic Geochemist, so I'm on the mars rover side of things.

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But part of the fun of looking at marine sediments is the geologic history they represent. We can learn about conditions now and in the recent past (like earthquake-related things) as well as how the Earth worked well into the past. So I guess my long answer basically amounts to a concerted yes to each of the parts of your question.

We're thoroughly and sincerely delighted to be your friendly neighborhood science nerds!

Is there any chance that drilling can trigger an earthquake?

[abstractgoomba](#)

We've seen this question several times. The short answer is 'no'. There are several reasons we are confident of this: we are not pumping fluids into the hole; we are more than 200 km away from the big fault; we are not drilling into any faults (in this case we have endeavored specifically to avoid faults); we are not drilling very deep (max 1.5 km); the hole diameter is around 15 cm and cannot create stresses at the scale of earthquakes.

It looks like you will be very close to the inferred ruptures of the 2012 M8.6 and M8.2 strike-slip earthquakes. These two events are very interesting to earthquake scientists due to their large size (the 8.6 is the largest strike-slip earthquake recorded on modern day instruments), possible deep rupture into the lithosphere (~40-60km), and their complex faulting along multiple N-S and/or E-W faults. Will there be high resolution bathymetric surveys of this area, or other studies specific to these large and interesting but not mega-thrust earthquakes?

[seis-matters](#)

Yes, we are close to those events. JR isn't really equipped for studies like bathymetry (and is a lot more expensive to run than ships that are more able to do those kind of surveys!) There was a swath bathymetry survey done of the rupture area a couple of years back on the Falkor - you can get the data from that from [ngdc.noaa.gov](http://ngdc.noaa.gov) or find it in the Google earth imagery of the region. A survey was also completed a couple of months ago on the Marion Dufresne - search for Singapore blog mirage should do the trick!

How often does the drill (head?) need to be replaced. What's it made out of, and how can it possibly survive drilling under intense high heat and pressure. Is it diamond or something exotic like wurtzite boron nitride.

Thanks for taking the time to do this AMA!

[chainedmayhem](#)

several different kinds of drill bits. Most of them have carbide cones, though some do have a type of compact diamond coating. On this expedition, we've used 3 drill bits. We're drilling about 1.5 km into subsurface ocean sediments. This is deep for a drill hole, but relatively shallow in terms of Earth's crust. Temperatures are not very extreme--about 60°C at the deepest part of the hole. Pressures are also not extreme in geologic terms. The pressures are extreme in human terms, though: we've been drilling in 4200 m water depth. At the seafloor, the pressure is already 400x atmospheric pressure!

Any reason why the team choose this particular spot to study? I know it's the spot of the 2004 Boxer Day Tsunami, but is there anything specific to this region or is it representative of other earthquake

hotspot?

[Xenovore](#)

Yes, a lot of effort has gone into selecting our drill site. We are seeking to understand the rocks that host the big fault at the trench, but we cannot drill those directly because they are too deep (beneath the seafloor; 4-5 km into the subsurface). At our present drill site seismic data indicate that we could reach these critical rocks that potentially host the fault at the trench.

Hello,

Will you all be attempting to drill into the Wadati-Benioff Zone? Do you all plan on drilling cores perpendicular to the subducting plate and establishing a gradient of the degree of metamorphism? I feel like a plot of this cross referenced with a historic earthquake map would be pretty enlightening for your study. Thanks for taking the time to do an AMA.

[ANAHOLEIDGAF](#)

Well, we'd have a bit of trouble drilling quite that deep. The Benioff Zone is typically > 600 km, and we finally, after about a month, reached 1.5 km. It's the shallow earthquakes that tend to be the most destructive, so those are the ones we're primarily focused on. And in this part of the world, the seafloor sediments are the ones that get into the shallow seismogenic zone of the Sunda subduction zone. Thus they're likely to be very important for earthquake generation. Keep in mind megathrust earthquakes in subduction zones nucleate at depths ~30-40km. As to metamorphic grade: It's difficult to drill a hole deeper than 7 km. We run into issues with temperature and pressure.

Hi. I'm in South Bali at the moment and the Indo Australian plate and Sunda plate have a subduction zone that runs just to the south of here. Given what happened west of Sumatra are there similar pressures built up along the fault lines that extend south eastward from where you will be drilling.

Other than the 2004 earthquake what is the history of significant quakes in the region? Particularly ones that caused tsunamis in the other Indonesian islands like Java and Bali. Is there likely to be one eventually?

I know there are preparedness studies detailing safe and unsafe areas in the south of Bali so there is an awareness of a potential threat. I'm interested to know if the region is "over due" some activity.

Good luck with the drilling. Don't trigger anything by mistake.

[AreWeDreaming](#)

The first geologist's answer is yes, there will be earthquakes along the subduction zone fault. However, this is true on a geologic timescale rather than something we can pinpoint during a short time like your vacation (which we hope you're enjoying!). There have been some other questions about earthquake prediction on this AMA. We can come back to this topic, too.

In terms of tsunami risk: It's a very complicated oceanographic system that contributes to when and how tsunamis happen on shore. You can get a sense of that this website, where scientists model potential tsunami hazard: <http://ptwc.weather.gov/>

Wherever you are, it's important to be familiar with local emergency preparedness protocol. If you're in an airplane, you check for the nearest emergency exits right when you sit down. Similarly, have a plan for how to get to higher ground if you're in a tsunami-hazard area.

We won't trigger any earthquakes or tsunamis. The drill pipe is less than 30 cm in diameter--that's tiny in the geologic scheme of things!

Hi thanks for this AMA. Do you think we will ever be able to predict earthquakes? What is the main reason why we can't?

[mistymountainz](#)

In principle, it could be possible. However, the system is very complex and we don't have the subsurface data density to make predictions, similar to, say, weather predictions. We are still trying to understand the key parameters that control earthquakes in different tectonic settings. Much basic science needs to be done.

Are you leaving any measuring equipment in the drill sites? Possibly to track any slight underwater movements, pre trembling before an earthquake, ect.

[bazooked](#)

We're not doing this here because we're too far from the big fault to monitor it. However, we have colleagues who have made these kinds of fault monitoring installations offshore Japan and other places.

Thanks for doing an AMA! It's definitely an area of interest of mine. I actually do similar work, but with paleohurricanes instead. As such, my question stems from the sites and methods we use to study storms: Are you also going to core a few coastal environments to see what the paleotsunami and paleoquake record looks like and get a better sense of event frequency?

[stormgasm7](#)

We are not doing that on this expedition, but there are people doing that on land in Sumatra and environs. One of the scientists on board studies earthquake records in sediments, and he's curious to find out if he can relate the turbidites we find to seismic history in this region. Clearly this is a tricky question because turbidites (underwater debris flows) can be triggered by a variety of events, like storms, landslides, gravity... So the challenge will be to discern the cause of the turbidite. Stay tuned for publications!

This sounds like a prequel to Pacific Rim.

[hemandingo](#)

Yes. We'll call it Indian Rim. But we'll have fewer enormous creatures from the deep...

(Still Brian, the Organic Geochemist...)

Are these earthquakes you speak of similar to the earthquakes that happen when they frack for oil? If so, it sounds like the drilling itself causes the earthquakes for some reason.

[egalroc](#)

Subduction zone earthquakes are very different from the earthquakes related to hydraulic fracturing and wastewater injection. In general, earthquakes happen when strain builds in earth's crust beyond the limit of the strength of the rocks, and the rocks break. There are many factors that contribute to the strength of rocks, such as the concentration of fluids inside pore spaces, the composition of the rocks, the size of the pore spaces, the temperature at which they sit, the stresses on the region. The conditions in a subduction zone plate boundary are very different from the conditions in the middle of tectonic plates where most fracking operations exist. There's a wealth of literature investigating possible links between fracking-related waste water injection wells and induced seismicity. Here's a good place to start: <https://earthquake.usgs.gov/research/induced/>

Our research drilling is extremely unlikely to cause earthquakes. We're not significantly changing any of those variables that lead to earthquakes (pore fluid pressure, strength, stress, etc.).

Is there a contingency plan if you unleash an unknown horror from the depths?

All jokes aside, how much preparation goes into an operation such as this? There are 30 scientists involved but how many people had to chip in to get something like this on the road?

[MediocreBandito](#)

Yes, but we only have plans for large squid-like creatures and monsters made of all the socks that are lost in the laundry. Short of that, we just wing it. --Brian, the Organic Geochemist

But all jokes aside, you're right, a huge amount of preparation goes into expeditions like this. The original proposal to conduct this expedition was submitted in 2006, but even preparing the proposal took years. The cruise was scheduled in 2014, and from there the wonderful folks at the IODP and Texas A&M sorted out the logistical details.

It's hard to say exactly how many scientists have been involved, but we'd guess at least 50. And that doesn't include the ship's crew of ~100. Plus the samples and data we collect are far too much for us to work through, so the cruise will have a long legacy. All the cores and data are archived, and scientists decades in the future will be able to continue the work we've just barely begun.

If all the planning and the experiment goes exactly as planned. With how much accuracy will you be able to predict the time and magnitude of an earthquake?

[Apa300](#)

We have human records of many, many small earthquakes and a few big earthquakes. From this history, we can make average calculations about how frequently the smaller and more common earthquakes happen. One of the most challenging aspects of the big, destructive earthquakes is that we don't have a lot of them in human history that we can study. We can make meaningful estimates of the probability of small earthquakes happening. This isn't quite like predicting the weather, but gives a statistical chance that an earthquake will happen in a particular time period. But that always means that there's some chance no earthquake will happen in that time frame. Magnitude, frequency, and probability are the three factors we'd like to be able to tie down with certainty. But these factors have very complex combinations of variables that contribute to them. The natural processes that cause earthquakes, make them big, control their frequency--that's what we're trying to figure out as earthquake scientists. What we hope to do is uncover a portion of the problem that will prove to be helpful in figuring the larger problem. We can compare this to weather prediction, also a complicated problem. We've gotten much better at weather prediction by studying small parts of weather systems and pooling our observations over time and distance. The weatherman might still not be able to tell you with 100% certainty that it will rain tomorrow (and be right about it). But she can tell you that it would be

good to bring an umbrella. So in terms of earthquakes, we can encourage people to build well and be prepared, even if we cannot say exactly when and how big the next earthquake will be.

To what extent has the scientific community used seismic surveying techniques employed by the oil and gas industry for locating potential drill sites to better visualize the sub-floor geology/structure?

[ozzimark](#)

Every site drilled by this program (now IODP) requires that there be seismic data available in order for the site to be planned and drilled. Many IODP expeditions go to areas where there isn't oil and gas industry data. This makes sense because oil and gas industry is interested in oil and gas--but we have different goals, and we avoid these areas for safety reasons. Sometimes we do have project overlap, so we would share resources in those cases and use industry-provided data. It goes the other way, too! Industry also uses publicly available data that we use and produce!

How similar/different is it to oil & gas drilling?

[partyturtles](#)

We use some of the same technology, but our goals are very different. We're actually trying to avoid any oil and gas, so we constantly monitor the methane, ethane, and other gas content in our cores. We also retain the core but leave the cuttings that come up around the core from the drill bit cutting down into the sediments and rocks. Often oil and gas companies do exactly the opposite: they just look at the cuttings. But we also have 24-hour operations with teams of earth scientists who rotate through in shifts to describe the sediments and rocks as well as we can while we're out here.

Could you explain the technical aspect of this expedition? What kind of a drill are you using; How does it work; How do you get there with all that equipment :D; Is it remote controlled or is somebody actually going down there?

Oh, and also, what kind of surveys/explorations will you conduct? By that I mean what equipment will you use and what do you hope to find out?

Thank you very much for doing this AMA, you guys are awesome! And I apologize if my questions are crude and ignorant. I have absolutely no knowledge of seismology/geology and this is what I wish to know.

All the best and good luck!

[fckn\\_moonmoon](#)

You can read a bit more about the technical aspects of drilling in some of our operations blog posts: [joidesresolution.org/blog](http://joidesresolution.org/blog) It's controlled on the rig floor, on the ship. We've been drilling a 1500 m -deep hole into the subsurface under 4200 m of water. That's way to deep for people to go down.

We've done some swath sonar surveys as well as magnetic surveys. Our operations specialist is asleep right now, but I'll ask him more about this when he comes on shift!

Why not drill San Andreas? It's highly active right now.

[denissimov](#)

I'm Naomi, one of the Educators, and I'm from CA! Yes, the San Andreas Fault is certainly active. There was a project to drill through the San Andreas Fault. You can find out more about it here: <http://www.earthscope.org/science/observatories/safod>

What is the lowest academic degree that one of these 30 scientist hold? Maybe you have a Blue Collar Scientist in your midst?

[FUCKSOFFATWORK](#)

Well, I didn't finish high school, though I'm now working on my PhD and sailing as the Organic Geochemist. But I suppose that might be a slightly non-traditional route...

My father did research on the JOIDES Resolution years and years ago. He loved that funky boat!

Are you taking cores to look at, or just poking holes? Can you explain the process a bit more?

I did not follow in my father's footsteps and go into earth sciences, can you tell? :D

[knitwasabi](#)

How fun! Please send your father greetings from the ship! We've collected cores from all the holes on this expedition. We did a combination of coring and "poking holes". At each site on Exp 362, one hole involved both drilling (without coring) to a depth 750-800 m below seafloor so that we could then more efficiently recover core from deeper in the sedimentary package. We have a few blogs we've written about the drilling process. Check them out on [joidesresolution.org/blogs](http://joidesresolution.org/blogs). You might need to go back a few pages.

Do you have any advice for an aspiring research geologist like myself?

[StealerofSuns](#)

Keep asking questions. Find questions about the earth that are exciting for you to answer. Read papers. Work with people who support your curiosity and help you move in the direction you want to go. Take field trips, go to lectures, go to conferences, see as many rocks as you can so you can learn the patterns and processes of geology. Build a network and collaborate with people you find interesting to work with. Stay curious.

Do you have any advice for an aspiring research geologist like myself?

[StealerofSuns](#)

We've asked a few more people. Additional advice includes "learn maths". I (Naomi) particularly suggest differential equations, linear algebra, advanced calculus, and a programming class. One of the technicians suggests working on the JR as a tech so you can meet many geologists from all over the world!

Hi, how much do you get paid?

[dissenter\\_the\\_dragon](#)

There are 124 people on board, in several different teams. I can speak for the scientists. We don't get paid anything extra to be out here, though our food and travel expenses are covered. The rest of the technicians and crew work full time on the JR, usually in two-month rotations of two months on, two months off or back at a related job with IODP on land. They make a very livable salary with lots of travel opportunities!

How many earthquakes in SE Asia are caused by oil and gas production? Is it difficult to know which quakes are caused by these activities?

[x-event](#)

I'm not sure about the first part of your question since that's not part of our goal on this expedition. As to the second part: that's an active area of research. So far, it's difficult to discern tectonic earthquakes from induced earthquakes. But earth scientists are working on it!

Are there any plans to compare cores between drill sites near Sumatra, Japan, and/or Chile?

[box-of-stars](#)

Yes! Some of the scientists on Exp 362 have been on research cruises to the Nankai Trough and other sites offshore Japan. Several of the other scientists will also use samples from other subduction zones around the world to find out more about subduction processes.

Hi, I hope the weather is good for you. As I understand it, this expedition is mainly drilling in order to measure some of the material properties of the deep sediments that eventually host the megathrust when they are finally subducted beneath the accretionary wedge. Do you have any specific hypotheses about what these measurements might mean, or is this an exploratory study that seeks to reveal new basic information that was previously lacking? Is there a clearly defined expectation that some of the measurements you make could exclude specific hypotheses about the mechanical properties of the megathrust? Thanks!

[Geognosy](#)

While we have some specific hypotheses on board, we're also trying to understand everything we can about the sediments and rocks in an exploratory way. How strong and how weak are they? Where did the sediments come from? How old are they? What are they made of? We have a lot of big questions on board with lots of hypotheses that inform them.

There are many characteristics of different rocks that respond to the way stress is applied to them. For example, friction is a property that's important for earthquake studies. Different sediments and rocks we've recovered have different frictional properties, but we won't know those specifically until we go back to our labs and run friction experiments. But to properly understand these results, we need to know the bigger context of all the observations we've made across all the different research groups.

Hopefully we are on our way to stopping these menaces once and for all!

[moby\\_dick](#)

If the menaces are lack of knowledge and data, then we're on our way! If the menaces are earthquakes, then that's not quite right. We are not trying to stop earthquakes--nor would we want to in

a geological sense. Plate motions will continue no matter what we do (within the limits of my imagination, at least). Of course from a human perspective, we want to reduce the risk of disaster. We can accomplish this much more easily by learning about earthquakes and how to build well and prepare for them than by trying to stop them from happening.

Has any equipment broken causing massive delays? If so, what happened?

[FUCKSOFFATWORK](#)

Yes, actually we had an unusual mechanical failure: one of the brakes that stops the drill pipe from moving broke. We can fix most things on the ship ourselves, but this was too big a job even for our talented crew. We had to go to Singapore to get it fixed, which took ~8 days out of our science operating time. We were still quite successful with the rest of the expedition!

Hey! My brother is on your ship! I. I can't give you his name (obviously) but he left CS, TX today (Oct 3rd) -- he has a pretty good size beard, and is mostly bald, about 6ft. First name starts with a D. I know Phil and I used to work for Jennifer when she was with Geos.

Can you say hello to him from Reddit from his brother?

[kickasstimus](#)

We'll try! This crew is only on for a few more days, but we'll try to catch Mr. D in cross over in Singapore!

Are you deploying any long term sensors/cameras on the seafloor to be retrieve at a much later date?

[trepping](#)

Not here. Other expeditions will install "observatories" in the holes they drill. Here's one coming up: [https://iodp.tamu.edu/scienceops/expeditions/hikurangi\\_subduction\\_margin.html](https://iodp.tamu.edu/scienceops/expeditions/hikurangi_subduction_margin.html)

How is the food on that ship? How about sleeping arrangements?

[FUCKSOFFATWORK](#)

Check out some of our Life at Sea posts on our blog! [joidesresolution.org/blog](http://joidesresolution.org/blog)

Food's great and beds are comfortable! We share cabins with one other person. Each person has their own bed and storage spaces. Two cabins share a toilet and shower. Roommates are on opposite shifts, so each person has the room to themselves while they are asleep.

I keep reading R/V Joides as "Joy Ride"

Need more coffee

[illradhab](#)

Come by and use the espresso machine on the bridge deck!

